Uzghor Hydro Power Company (Pvt.) Ltd

UHPCO

Ref No: UHPCO/NEPRA/TUHPP/2020/005 Dated: February 18, 2020

The Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower Attaturk Avenue (East)
Sector G-5/1,
Islamabad.

Subject: **Application for Grant of Generation License for Uzghor Hydro Power Company (Private) Limited for its 82.25 MW gross Turtonas-Uzghor Hydropower Project, located at Golen Gol, Chitral, Khyber Pakhtunkhwa**

Dear Sir,

Sinohydro-Sachal Consortium was issued Letter of Intent ("LOI") by Private Power Infrastructure Board ("PPIB") on 20th March, 2017 for the development of raw site Turtonas-Uzghor Hydro Power Project (the "Project"). Therefore, the Consortium has incorporated a special purpose vehicle Uzghor Hydro Power Company (Private) Limited ("UHPCO") to undertake the development of the Project.

We would like to submit herewith our Application for Issuance of Generation License for UHPCO. The required documents pursuant to the provisions of National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999 are attached herewith this application.

It is further submitted that Generation License Application for the subject Project was earlier submitted to NEPRA on July 3rd 2019; however, the Authority vide Letter No. NEPRA/R/LAG-30/16625, dated 16.09.2019 returned the Application due to non-submission of documents pertaining to project company registration in Pakistan and due to non-provision of draft interconnection study.

In this regard, the Sponsors of the Project have now registered the Project specific company in Pakistan i.e. Uzghor Hydro Power Company (Private) Limited. With regards to the Interconnection Study, it is submitted that NTDC which was also the member of Project's Feasibility Study Panel of Experts ("POE") has informed PPIB in writing (letters attached) that due to limited availability of power evacuation corridor in Chitral region, the Project Sponsors do not require to conduct project specific interconnection study, as NTDC/PEDO will conduct an integrated interconnection study for the purpose of power evacuation from upcoming hydropower projects in Chitral corridor and the subject Project will also be part of integrated interconnection study. In continuation of the above, PEDO with the support of NTDC has now invited expression of interest for the hiring of consultancy services to conduct feasibility study of power evacuation from Chitral to Chakdara Grid.

A pay order in the sum of Rupees Four Hundred Twenty-Six Thousand Eight Hundred and Sixty only (Rs. 426,860) and Rupees Fifteen Hundred and Forty (Rs. 1540), being the non-refundable license application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999 was earlier submitted to NEPRA on July, 3rd 2019. The Authority is requested to magnanimously allow adjusting the earlier deposited fee by the Sponsors for this fresh generation license application and a bank draft of the remaining amount (Rs 34,960) is attached herewith, calculated in accordance with the latest fee schedule as available on NEPRA's website.

Yours sincerely,

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

(Abdul Karim Qureshi)
Chief Executive Officer / Authorized Representative

Encl: *As stated above.*
Cc: *Master File.*

Uzghor Hydro Power Company (Pvt.) Ltd

UHPCO

Ref No: UHPCO/NEPRA/TUHPP/2020/004 Dated: February 18, 2020

The Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower Attaturk Avenue (East)
Sector G-5/1,
Islamabad.

SUBJECT: APPLICATION FOR GENERATION LICENSE

I, Abdul Karim Qureshi, being the duly authorized representative of the Uzghor Hydro Power Company (Private) Limited ("UHPCO") by virtue of **Board Resolution** dated 22.01.2020, hereby apply to the National Electric Power Regulatory Authority for the grant of Generation License to the Uzghor Hydro Power Company (Private) Limited pursuant to section 15 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

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

A pay order in the sum of Rupees Four Hundred Twenty-Six Thousand Eight Hundred and Sixty only (Rs. 426,860) and Rupees Fifteen Hundred and Forty only (Rs. 1,540), being the non-refundable license application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999 was earlier submitted to NEPRA on July, 3rd 2019. The Authority is requested to magnanimously allow adjusting the earlier deposited fee for this fresh generation license application and a bank draft of the remaining amount (Rs 34,960) is attached herewith, calculated in accordance with the latest fee schedule as available on NEPRA's website.

Yours sincerely,

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

(Abdul Karim Qureshi)
Chief Executive Officer / Authorized Representative

Encl: *As stated above.*

Cc:

- *Master File.*

Head Office: 59-E, Street – 7, Sector: I-10/3, Islamabad. Tel: (+92-51) 4446873-74 - 4436004
Fax: (+92-51) 4431774, Email: uhpco58@gmail.com,

1. REQUEST FOR GENERATION LICENSE

Under the Regulation of Generation, Transmission and Distribution of Electric Power Act (XL of) 1997 (the **NEPRA Act**) and the National Electric Power Authority Licensing (Generation) Rules 2000 (the **Licensing Rules**), the National Electric Power Regulatory Authority (**NEPRA**) is responsible for and has authority to *inter alia* grant licenses for the generation of electric power and other terms and conditions for the supply of electricity through generation. The National Electric Power Regulatory Authority Licensing (Application & Modification Procedure) Regulations, 1999 (**The Licensing Regulations**), specify the procedures to be adopted for application to NEPRA for grant of generation license.

Pursuant to Section 7(2)(a) and 15 of the NEPRA Act, read with other enabling provisions of the NEPRA Act, the Licensing Rules, and the Licensing Regulations, and in accordance with the GOP Power Generation Policy 2015 (**the Policy**), the Applicant hereby submits for NEPRA's kind and gracious consideration, the application for grant of generation license along with the supporting documents (the **Generation Licensing Application**) for its 82.25MW hydropower generation facility to be located at Golen Gol river, District Chitral, Khyber Pakhtunkhwa, Pakistan (the **Project**).

NEPRA is kindly requested to accept and process our Generation License Application which is hereby submitted in triplicate, and grant us Generation License, thereby enabling us to proceed further with the development process.

Check List for Examination of
New Generation Facility (Hydel) - License Application

Name of Company (Applicant): M/s Uzghor Hydro Power Company (Private) Limited
Capacity (Gross): 82.25MW
Prepared/Updated on: 12.02.2020

Regulation #	Information/Documents Required	Remarks
	Application for grant of Generation License	
3(1)	Authorization from Board Resolution for submission of Generation License Application	Attached as D/1
3(3)	Application fee (including Indexation)	Attached as D/2
3(4)	Three copies of Application	The Application is submitted in Triplicate
3(5)(a)(i)	Certificate of incorporation (SECP certified)	Attached as D/3
3(5)(a)(ii)	Memorandum and articles of association (SECP certified)	Attached as D/4
3(5)(a)(iii)	Annual Return statements or in lieu thereof (SECP certified)	UHPCO has been recently incorporated on 1.1.2020; hence the annual return statement is not applicable. D/5
3(5)(b)	Profile of experience of the applicant its management, staff and its members in power sector.	UHPCO is a newly incorporated company; however profiles of Sponsors of the Project, senior management is Attached as D/6
3(5)(c)	CVs of applicant's Senior Management and Technical professionals	Attached as D/7
3(5)(d)(i)	Bank certificates	Attached as D/8
3(5)(d)(ii)	Expression of interest to provide credit or financing along with sources and details thereof	Attached as D/9
3(5)(d)(iii)	Latest financial statements	Attached as D/10
3(5)(d)(iv)	Employment records of Engineers & Technical Staff	The Applicant has not started its business activities, so the CV's and other relevant information of engineers/technical staff will be provided to NEPRA as and when they will be hired.

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

3(5)(d)(v)	Profile of Sub-contractors	The Sponsors has not appointed any sub-contractors.
3(5)(d)(vi)	Verifiable references w.r.t. experience of the Applicant and its sub-Contractors	The Sponsors has not appointed any sub-contractors.
3(5)(g)(a)	Type of Technology	Pelton Vertical
3(5)(h)	Feasibility Report	Attached Separately
3(5)(i)	Prospectus	Attached D/11

Schedule III

1.	Location (location maps, site maps) land	Right bank of Golen Gol, at Turtonas & Uzghor Village, District Chitral, Khyber Pakhtunkhwa
2.	Plant: run of river, storage, veir	Run of river
3.	Head: Minimum, maximum	477m : 494m
4.	Technology: Francis, Pelton, etc. Size, number of units.	Pelton Vertical 2x41.125
5.	Tunnel (if proposed): length, diameter	Length:4.837km Diameter:4m
6.	ESSA (Environmental and Social Soundness Assessment)	Attached as D/12
7.	Detailed feasibility report	Attached Separately
8.	Resettlement issues	No Resettlement in accordance with approved ESSA
9.	Consents	Attached as D/13 1. Letter of Intent from PPIB 2. ESSA Approval by EPA (KPK) 3. PPIB Approval of Project Feasibility Study
10.	Infrastructure development	Details are provided in Project feasibility study report. The development will be started after the mobilization of EPC Contractor at project site.
11.	Interconnection with National Grid Co. distance and name of nearest grid, voltage level (single line diagram)	Distance of Project Switch Yard from 108 MW Golen Gol 132 kV Switchyard is about 5km, therefore in/out arrangement from one circuit of outgoing 132 kV transmission line from 108 MW Golen Gol HPP is the most optimal solution. However, NTDCL after carrying out there Integrated Power Evacuation Study for future projects in Chitral Corridor will issue approval for project power evacuation scheme. **NTDCL has issued waivers to Project Sponsors from carrying out project specific interconnection study.** Details are provided as D/13-A.

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

12.	Project cost, information regarding sources and amounts of equity and debt.	The Project shall be financed at debt to equity ratio of 80:20 as per the assumptions of the feasibility study. The total Project Cost stands at USD 204.602 Million, which requires Debt injection of USD 163.68 Million and Equity amounting to USD 40.92Million.
13.	Project schedule, expected life	Project Schedule is attached as D/16; expected life is at least 30 years.
14.	Peaking/base load operation	Base load operation
15.	Plant characteristics: generation voltage, power factor, frequency, automatic generation control, ramping rate, control metering and instrumentation	Generation Voltage: 11 kV Power Factor: 0.85 Frequency: 50 Hz Ramping Rate: N/A Static Exciters: 2 Nos with automatic voltage regulators
16.	System studies load flow, short circuit, stability	Statement in this regard is attached as D/14
17.	Training and development	Attached as D/15

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

Uzghor Hydro Power Company (Pvt.) Ltd

UHPCO

EXTRACT FROM THE MINUTES OF MEETING
OF THE BOARD OF DIRECTORS OF
UZGHOR HYDRO POWER COMPANY (PRIVATE) LIMITED
HELD AT ITS REGISTERED OFFICE ON 22nd January, 2020

"**RESOLVED THAT** Uzghor Hydro Power Company (Private) Limited, a company incorporated under the laws of Pakistan with its registered office located at 59-E, Street No.7, Sector I-10/3, Islamabad, Pakistan (the "**Company**") be and is hereby authorized to submit an application for Generation License (including any subsequent modification) and Tariff Petition (including any subsequent modifications) for submission to the National Electric Power Regulatory Authority (the "**NEPRA**") for the grant of Generation License and Tariff in respect of its 82.25 MW (Gross) Turtonas-Uzghor hydro power generation project to be located at Golen Gol, Chitral, Khyber Pakhtunkhwa, Pakistan (the "**Project**") and in relation thereto, enter into and execute all documents, make all filings and pay all applicable fees, in each case, of any nature whatsoever, as required."

"**RESOLVED FURTHER THAT** in respect of application for the Grant of Generation License (including any modification to the application for the Grant of Generation License) and for the Grant of Tariff (including any modification to the tariff petition for the Grant of Tariff) for submission to NEPRA, **Mr. Abdul Karim Qureshi** (Chief Executive Officer), **Mr. Wang Hanqing** (Director) and **Mr. Syed Zulqurnain Ali** (Director) (collectively the "**Authorized Representatives**"), be and are hereby acting singly empowered and authorized for and behalf of Company to:

i. prepare, review, execute, submit and deliver the Generation License Application and Tariff Petition (including any modification to the application for the Grant of Generation License and Tariff Petition) and related documentation required by National Electric Power Regulatory Authority, including any contracts, documents, power of attorney, affidavits, statements, letters, forms, applications, deeds, guarantees, undertakings, approvals, memoranda, amendments, letters, communications, notices, certificates, requests, statements, and any other instruments in respect to the Generation License and Tariff;

ii. represent the Company in all negotiations, representations, presentations, hearings, conferences and/or meetings of any nature whatsoever with any entity (including, but in no manner limited to NEPRA, any private parties, companies, partnerships, individuals, governmental and/or semi-governmental authorities and agencies, ministries, boards, departments, regulatory authorities and/or any other entity of any nature whatsoever);

iii. sign, certify and execute all necessary documentation, pay the necessary fees, appear before the NEPRA as needed, and do all acts necessary for the completion and processing of the application for the Generation License and Tariff (including any modifications);

iv. do all such acts, matters and things as may be necessary for carrying out the purposes aforesaid and giving full effect to the above resolution/resolutions."

Certified to be a true copy of the original.

(PVT.) LTD. ✱ UZGHOR HYDRO POWER COMPANY

(Mr. Abdul Karim Qureshi)
Chief Executive Officer
Date: 22nd January, 2020

(PVT.) LTD. ✱ UZGHOR HYDRO POWER COMPANY

Head Office: 59-E, Street – 7, Sector: I-10/3, Islamabad. Tel: (+92-51) 4446873-74 - 4436004
Fax: (+92-51) 4431774, Email: uhpco58@gmail.com

A061347

100
Rupees

۱۰۰
روپیہ

Before
The National Electric Power Regulatory Authority

Affidavit of Mr. Abdul Karim Qureshi S/o Mr. Ghulam Rasul Qureshi having CNIC No. 61101-2023916-5 resident of House # 275, Margalla Road, Sector: F-11/2, Islamabad and authorized representative of Uzghor Hydro Power Company (Private) Limited having its registered office at 59-E, Street 7, Sector I-10/3, Islamabad, Pakistan (the "Company")

I, the above-mentioned Deponent, do hereby solemnly affirm and declare that:

1. I am the Chief Executive of the Company.
2. I am the authorized representative of the **Uzghor Hydro Power Company (Private) Limited** by virtue of Board Resolution dated 22nd January, 2020.
3. The contents of accompanying Generation License Application dated 18th February, 2020, submitted to National Electric Power Regulatory Authority is ("NEPRA") along with the supporting documents are true and correct to the best of my knowledge and belief and nothing material or relevant thereto has been concealed or withheld therefrom.
4. I also affirm that all further documentation and information to be provided by me in connection with the aforesaid Generation License

Annex – D/3

Certificate of Incorporation

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

A067975

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

COMPANY REGISTRATION OFFICE

CERTIFICATE OF INCORPORATION

[Under section 16 of the Companies Act, 2017 (XIX of 2017)]

Corporate Universal Identification No. **0144794**

I hereby certify that **UZGHOR HYDRO POWER COMPANY (PRIVATE) LIMITED** is this day incorporated under the Companies Act, 2017 (XIX of 2017) and that the company is **limited by shares.**

Given under my hand at **Islamabad** this **First** day of **January, Two Thousand** and **Twenty.**

Incorporation fee Rs. **410500.0/=** only

(Syed Jamal Ahmed Zaidi)
Additional Joint Registrar
Islamabad

Company Registration Office Islamabad
SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN
SECP

No. ADI 48383
Dated 1/1/20

CERTIFIED TO BE TRUE COPY
Muhammad Tariq Rasheed
Assistant Registrar
Company Registration Office Islamabad

UZGHOR POWER COMPANY (PVT) LTD.

Annex – D/4

Memorandum and Articles of Association

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

THE COMPANIES ACT, 2017 (XIX of 2017)
(COMPANY LIMITED BY SHARES)

MEMORANDUM

OF

ASSOCIATION

OF

UZGHOR HYDRO POWER COMPANY (PRIVATE) LIMITED

THE COMPANIES ACT, 2017 (XIX of 2017)

(COMPANY LIMITED BY SHARES)

MEMORANDUM OF ASSOCIATION

OF

"UZGHOR HYDRO POWER COMPANY (PRIVATE) LIMITED"

1. The name of the company is **Uzghor Hydro Power Company (Private) Limited.**

2. The registered office of the Company will be situated in Islamabad Capital Territory.

3. (i) The principal line of business of the company is to develop, design, insure, establish, build, construct, equip, import relevant machinery, manage, operate & maintain (by themselves or through third party) and run a hydroelectric power generation plant; as well as generate, supply, transmit, deliver and sell the electricity produced by the power generation plant in accordance with the relevant governmental policies, license from regulator, permits, rules & regulations and transfer the plant (including all related assets) to relevant governmental authorities (as per concession agreement(s) & permits).

(ii) Except for the businesses mentioned in sub-clause (iii) hereunder, the company shall engage in all the lawful businesses and shall be authorized to take all necessary steps and actions in connection therewith and ancillary thereto.

(iii) Notwithstanding anything contained in the foregoing sub-clauses of this clause nothing contained herein shall be construed as empowering the Company to undertake or indulge, directly or indirectly in the business of a Banking Company, Non-banking Finance Company (Mutual Fund, Leasing, Investment Company, Investment Advisor, Real Estate Investment Trust management company, Housing Finance Company, Venture Capital Company, Discounting Services, Microfinance or Microcredit business), Insurance Business, *Modaraba* management company, Stock Brokerage business, forex, real estate business, managing agency, business of providing the services of security guards or any other business restricted under any law for the time being in force or as may be specified by the Commission.

(iv) It is hereby undertaken that the company shall not:

(a) Engage in any of the business mentioned in sub-clause (iii) above or any unlawful operation;

(b) Launch multi-level marketing (MLM), Pyramid and Ponzi Schemes, or other related activities/businesses or any lottery business;

(c) Engage in any of the permissible business unless the requisite approval, permission, consent or licence is obtained from competent authority as may be required under any law for the time being in force.

4. The liability of the members is limited.

5. The authorized capital of the company is Rs. 100,000,000 (Rupees Hundred Million only) divided into 10,000,000 (Ten Million only) ordinary shares of Rs.10/- (Rupees Ten only) each. The Company shall have power to increase and reduce its capital and divided the shares in the capital for the time being into several classes subject to any permission required by law.

Company Registration Office Islamabad
SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN
SECP

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

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 our respective names:

Sr. No.	Name and Surname (Present & Former) In Full (In Block Letters)	NIC No. (in case of foreigner, Passport No)	Father's /Husband's Name In Full	Nationality with any former Nationality	Occupation	Residential Address (in Full)	Number of shares taken by each subscriber	Signature
1	SINOHYDRO CORPORATION LIMITED (REPRESENTED BY ITS AUTHORISED DIRECTORS: 1.MR. LING JIANKE, 2. MR. WANG HANQING,	0087059 E09666748 PE0826639	N/A LING ZHIXI WANG LUOYI	CHINESE CHINESE CHINESE	BUSINESS SERVICE SERVICE	BRANCH OFFICE: HOUSE NO.18, STREET NO.56, F-7/4, ISLAMABAD HOUSE NO 18 STREET 56 F-7/4 ISLAMABAD PAKISTAN HOUSE NO 18 STREET 56 F-7/4 ISLAMABAD PAKISTAN	198	.....Sd.....
2	MR LING JIANKE	E09666748	LING ZHIXI	CHINESE	SERVICE	HOUSE NO 18 STREET 56 ISLAMABAD PAKISTAN	1	.....Sd....
3	MR WANG HANQING	PE0826639	WANG LUOYI	CHINESE	SERVICE	HOUSE NO 18 STREET 56 F-7/4 ISLAMABAD PAKISTAN	1	.....Sd.....
4	SACHAL ENGINEERING WORKS PRIVATE LIMITED (REPRESENTED BY ITS AUTHORISED DIRECTOR: 1. MR. AHMED ALI QURESHI	0022289 61101-2023919-7	N/A ABDUL KARIM QURESHI	PAKISTANI PAKISTANI	BUSINESS BUSINESS	PLOT NO. 59-E, STREET NO. 7, SECTOR I-10/3, ISLAMABAD, PAKISTAN. HOUSE # 98/1/2, LANE 13, KHAYABAAN RAHAT, PHASE 7, DHA, CLIFTON CANTT, KARACHI.	500	.....Sd.....

5	MR. ABDUL KARIM QURESHI	61101-2023916-5	S/O GHULAM RASOOL QURESHI	PAKISTANI	BUSINESS	HOUSE # 275, MARGALLA ROAD, SECTOR F-11/2, ISLAMABAD.	100	.....Sd.....
6	MR. AHMED ALI QURESHI	61101-202391[illegible]	S/O ABDUL KARIM QURESHI	PAKISTANI	BUSINESS	HOUSE # 98/1/2, LANE 13, KHAYABAAN RAHAT, PHASE 7, DHA, CLIFTON CANTT, KARACHI.	150	.....Sd.....
7	MR. SYED ZULQURNAIN ALI	61101-194[illegible]3	S/O SYED MAHMOOD HUSSAIN	PAKISTANI & CANADIAN	BUSINESS	PO KHAS MOHRI FARMAN SHAH, RAWALAKOT, POONCH, PAKISTAN.	50	.....Sd.....
TOTAL NUMBER OF SHARES TAKEN							1000	

Dated this 21st day of September, 2019

CERTIFIED TO BE TRUE COPY
Muhammad Tariq Rasheed
Assistant Registrar
Company Registration Office Islamabad

Securities and Exchange Commission of Pakistan
Company Registration Office
Islamabad
SECP

Fuzghor Hydro Power Company (Pvt) Ltd.

THE COMPANIES ACT, 2017

--: O : --

(PRIVATE COMPANY LIMITED BY SHARES)

--: O : --

ARTICLES OF ASSOCIATION

OF

"UZGHOR HYDRO POWER COMPANY (PRIVATE) LIMITED"

PRELIMINARY

1. Subject as hereinafter provided, the Regulation contained in Table "A" of the First Schedule to the Companies Act, 2017, (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.

INTERPRETATION

a) "The Act" or "the said Act" means the Companies Act, 2017,

b) ""Articles" means these Articles of Association, as originally framed or from time to time altered in accordance with law.

c) "Board" means a meeting of the Directors duly called and constituted or as the case may be Directors assembled at a Board.

d) "Chairman" means chairman of the Board of Directors of the Company.

e) "Commission" means the Securities and Exchange Commission of Pakistan.

f) "Company" means **Uzghor Hydro Power Company (Private) Limited.**

g) "Debenture" means Participation Term Certificates and Term Finance Certificates.

h) "Director" means a Director of the Company appointed from time to time pursuant to these Articles.

i) "Dividend" means distribution of profits of the Company to its members including bonus.

j) "Implementation Agreement" means the Implementation Agreement to be entered into between the Government of Pakistan and the Company in relation to the power generation project to be established by the Company.

k) "Initial Shareholder(s) or Main Sponsor" means Sachal Engineering Works (Private) Limited and Sinohydro Corporation Limited.

l) "Memorandum" means Memorandum of Association of the Company as originally framed or as altered from time to time in accordance with the provisions of the Act.

m) "Month" means a calendar month according to the English Calendar.

n) "Office" means the registered office for the time being of the Company.

o) "Seal" means the common or official seal adopted by the Company.

p) "Secretary" means the Secretary for the time being of the Company

q) "Section" means the section of the Act.

r) Words importing masculine gender include the feminine gender.

s) Words importing singular number include the plural number and vice versa.

t) Expression referring to writing shall, unless the contrary intention appears be construed as including reference to printing, lithography, photography and other modes of representing or reproducing words in a visible form.

u) Words importing persons shall include bodies corporate.

v) Unless the context otherwise requires words or expressions contained in these Articles shall bear the same meaning as in the Act

PRIVATE LIMITED COMPANY

2. The Company is a Private Company within the meaning of Clause (49) of Section 2(1) of the Companies Act, 2017 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 purpose 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.

SHARE CAPITAL AND SHARES

6. The authorized share capital of the Company is is Rs. 100,000,000 (Rupees Hundred Million only) divided into 10,000,000 (Ten Million only) ordinary shares of Rs.10/- (Rupees Ten only) each.

7. Subscribed shares shall be issued to subscribers in the first instance.

8. The shares shall be under the control of the Directors who may allot or otherwise dispose of the same to such persons, on such terms and conditions, and at such times, as the Directors think fit.

9. The amount payable on application on each share shall be the full nominal amount of the share.

10. The company shall not be bound to recognize any equitable, contingent, future or partial claim to or interest in a share on the part of any person other than the registered shareholder, save as herein provided or save as ordered by some Court of competent jurisdiction.

11. The certificates of the title to shares shall be issued under the seal of the Company and shall be signed by two of the Directors; one of them will be Managing Director/Chief Executive/Chairman.

12. Every person whose name is entered as member in the register of members shall, without payment, be entitled to receive, within thirty days after allotment or within forty days of the application for registration of transfer, issue certificate under the Seal specifying the share or shares held by him and the amount paid up thereon:

    Provided that, in respect of a share or shares held jointly by several persons, the Company shall not be bound to issue more than on certificate, and delivery of a certificate of share to one of several joint holders shall be sufficient delivery to all.

13. If any certificate be worn out or defaced, then upon production thereof the Directors may order the same to be cancelled and may issue a new certificate in lieu thereof; and if any certificate be lost or destroyed, then upon proof thereof to the satisfaction of the Directors and on such indemnity as the Directors deem fit being given, a new certificate on payment of rupees one only.

14. The certificates of shares registered in the name of two or more persons shall be delivered to the person first-named on the Register.

15. Except to the extent and in the manner allowed by section 86 of Companies Act, 2017, no part of the funds of the Company shall be employed in the purchase of, or in loans upon the security of, the Company's shares.

16. 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.

ALTERATION OF CAPITAL

17. The Company may, form time to time, by ordinary resolution increase the share Capital by such sum, to be divided into shares of such amount, as the resolution prescribe.

18. Subject to the provisions of the Act, all new shares shall, before issue, be offered to such persons as at the date of the offer are entitled to receive notices from the Company of General Meeting in proportion, as nearly as the circumstances admit, to the amount of the existing shares to which they are entitled. The offer shall be made by notice specifying the number of shares offered, and limiting a time within which the offer, if not accepted, will be deemed to be declined, and after the expiration of that time, or on the receipt of an intimation from the person to whom the offer is made that he declines to accept the shares offered, the Directors may dispose of the same in such manner as they think most beneficial to the Company. The Directors may likewise so dispose of any new shares which (by reason of the ratio which the new shares bear to shares held by persons entitled to an offer of new shares) cannot, in the opinion of the Directors, be conveniently offered under the regulation.

19. The new shares shall be subject to the same provision with reference to transfer, transmission and otherwise as the shares in the original share capital.

20. The Company may, by ordinary resolution:

    (a) Consolidate and divide its share capital into shares of larger amount than its existing shares;

    (b) Sub-divide its existing shares or any of them into shares of smaller amount than is fixed by the Memorandum of Association, subject nevertheless, to the provisions of clause (d) of Sub-section (1) of Section 85;

    (c) Cancel any shares, which, at the date of the passing of the resolution, have not been taken or agreed to be taken by any person.

21. The company may, by special Resolution, reduce its share capital in any manner and with, and subject to, any incident authorized and consent required by law.

SHARES, TRANSFER AND TRANSMISSION

22. 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. Every transfer of shares must be in writing in the form specified in Regulation 7 of Table 'A' of the first schedule to the Act or in any other form which the Directors shall approve and must be left at the Office accompanied by the certificate or, if no such certificate is in existence, the letter of allotment of the shares to be transferred and such other evidence, if any, as the Directors may require to prove the title of the intending transferor or his right to transfer the shares. Each such transferee shall truthfully disclose his nationality at the appropriate place on such transfer deed, and if shall be the national of more than one state all such nationalities shall be disclosed in the application.

23. The Directors may decline to register any transfer of share to transferee of whom they do not approve and shall not be bound to show any reasons for exercising their discretion subject to the provisions of Section 75, 76 & 77 of the Companies Act, 2017. Provide further that the Director shall not refuse to transfer any fully paid Share unless:-

a) The transfer deed is for any reason defective or invalid provided that the Company Shall within fifteen (15) days or, where the transferee is a central depository, within five (5) days from the date on which the instrument of transfer was lodged with it notify the defect or invalidity to the transferee who shall after removal of such defect or invalidity be entitled to re-lodge the transfer deed with the Company; or

b) If the Company refuses to register the transfer of any shares, owning to any attachment or prohibitory order of a competent authority or otherwise, the company shall within fifteen (15) days after the date on which the instrument of transfer was lodged with it, send to the transferee notice of the refusal indicating reasons for such refusal.

24. 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.

25. The legal heirs, executors or administrators of a deceased holder shall be the only persons to be recognized 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 recognized by the Company as having any title to the shares.

26. No Initial shareholder shall transfer any share in the company owned by it at any Time prior to the Commercial Operations Date or for a period of six (06) years after The Commercial Operation Date, except for:

(a) a transfer to other initial shareholders (if any):

(b) Subject to the national security interest of Pakistan as such interest shall be determined in the sole discretion of Government of Pakistan, a transfer to an affiliate of any initial share holder (for the purposes of this paragraph, " affiliate", in relation to any person means a company or corporation which is either (i) a holding company or a subsidiary of such person, or (ii) a subsidiary of a holding company of which such person is also subsidiary);

(c) Subject to the national security interest of Pakistan as such interest shall be determined in the sole discretion of Government of Pakistan, a transfer required by law or by the operation of law or by order of a court, tribunal or government authority or agency with appropriate jurisdiction;

(d) Subject to the national security interest of Pakistan as such interest shall be determined in the sole discretion of Government of Pakistan, a transfer resulting from the realization of a security interest in or over any shares;

(e) A transfer to which Government of Pakistan has given its approval in its sole discretion exercised reasonably; and

(f) The transfer of any share in excess of those subscribed for pursuant to fifty one percent (51%) of shares or other securities in the company committed by the intimal shareholder(s) (as defined in the implementation Agreement) for the purposes of achieving financial closing.

27. No initial share holder shall transfer any shares in the company after the expiry of a period of six (6) years from the commercial operations date except with the approval of Government of Pakistan , which shall only be withheld where Government of Pakistan determines in its sole discretion that such a transfer would be prejudicial to the national security interest of Pakistan provided that such approval shall be deemed unless it is refused within thirty days of having been requested .

GENERAL MEETING

28. The First Annual General Meeting shall be held within 16 months from the date of incorporation of the Company in accordance with the provisions of Section 132 and thereafter once at least in every year and within a period of one hundred & twenty days 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 133 of the Companies Act , 2017.

PROCEEDINGS AT GENERAL MEETING

29. Twenty one day's 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.

30. The Chairman, 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

31. 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

32. 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 141 of the Companies Act , 2017.

33. 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.

34. 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.

35. In case of an equality of votes, whether on a show of hand or on a poll, Chairman of the Meeting at which the show of hands takes place, or at which the poll is demanded, shall be entitled, to a second or casting vote.

CHIEF EXECUTIVE

36. 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

37. The number of directors shall not be less than two. The following are the first Directors of the Company.

- **LING JIANKE**
- **WANG HANQING**
- **ABDUL KARIM QURESHI**
- **AHMED ALI QURESHI**
- **SYED ZULQURNAIN ALI**

38. 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 Act, 2017, unless any one of them resigns earlier or becomes disqualified for being Director or otherwise ceases to hold office.

39. If any loan(s) in foreign and/or local currency is / are arranged and the conditions attaching to the advancing of such loan(s) provide, the loan giving agency/agencies shall have the right to nominate, from time to time, during the subsistence of such loan(s) on the Board of the Company one or more Directors, as per terms of the loan(s) agreement. The loan giving agency/agencies shall also have the right to remove the Director(s) so appointed and to appoint any substitute thereof, such Director(s) shall not be required to hold qualification shares nor can they be retired or removed from office by the company.

40. The remuneration of Directors performing extra services, including the holding of the office of Chairman shall be determined by the Directors or the company in General Meeting.

41. The Directors shall from time to time appoint any person to the office of Chief Executive for such term as provided in the Act and the with such power, and at such remuneration (whether by way of salary, or commission, or participation in profits, or partly in one way and partly in another) as they or the Company in General Meeting may think fit and such appointment shall not be for a period exceeding three years from the date of appointment.

42. Election of the Directors will be according to the procedures laid down in Section 159 of the Act.

43. The Directors may from time to time entrust to and confer upon Chief Executive for the time being such of the power exercisable under these presents by the Directors as they may think fit, and may confer such power for such time, and to exercise for such objects and purposes, and upon such terms and conditions, and with such restrictions, as they think, expedient, and they may confer such powers either collaterally with or to the exclusion of and in substitution for all or any of the powers of the Directors in that behalf, and may form time to time revoke, withdraw, alter or vary all or any of such powers.

44. If any Director being willing shall be called upon to perform extra services or to make any special exertions in going or temporarily residing out of Pakistan or otherwise for any of the purpose of the company, the Company shall remunerate such Director all charges and traveling expenses as may be determined by the Directors.

45. The continuing Directors may act notwithstanding any vacancy in their body, but if the number falls below the minimum above fixed, the Directors shall not, except for the purpose of filling the vacancies, act so long as the number remains below the minimum.

46. Save as provided in Section 153 of the Act, no person shall be appointed as director unless he is a member of the Company.

47. A Director may with the approval of the Board appoint an Alternate Director to act for him during his absence for a period of not less than three months from Pakistan

and such appointment shall have effect and such appointee while he holds office as a Alternate Director shall be entitled to notice of meetings and vacate office if and when the appointer returns to Pakistan or vacates office as Director or removes the appointee from office, and any appointment and removal under these Articles shall be effected by notice in writing under the hand of the Director making the same. The assignment of office by Directors other than the foregoing shall be subject to approval by special Resolution of the Company.

48. Subject as herein otherwise provided or to the terms of any subsisting agreement, the office of Director shall be vacated if:

(a) He becomes ineligible to be appointed a director on any one or more of the grounds enumerated in clauses (a) to (h) of Section 153;

(b) He absents himself from three consecutive meetings of the Directors or from all the meetings of the directors for a continuous period of three months, whichever is the longer, without leave of absence from the directors;

(c) He or any firm of which he is a partner or any private company of which he is a director:

I. Without the sanction of the company in general meeting accepts or holds any office of profit under the company other than that of chief Executive or a legal or technical adviser or a banker: or

II. Accept a loan or guarantee from the company in contravention of section 182.

III. If by notice in writing given to the company he resigns his office.

49. Subject to the provisions of Section 154 the Company in General Meeting may, from time to time, increase or reduce the number of Directors.

50. The company may by resolution in General Meeting remove any Director, provided that a resolution for removing a Director shall not be deemed to have been passed unless the requirements of Section 163 of the Act have been compiled with.

51. No person shall be eligible for election to the office of Director at any General Meeting unless he has at least fourteen clear days before the Meeting left at the Company's office a notice in writing duly signed signifying his candidature for the office.

52. A resolution for removing a Director shall not be deemed to have been passed unless it has been passed in the manner as provided under Section 163 of the Companies Act , 2017.

53. 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.

54. 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 forms as may be determined by the Directors subject to the provisions of the Companies Act , 2017.

55. The Director who resides out of station shall also be entitled to be paid such traveling 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 Act , 2017.

56. 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.

57. No Director shall be disqualified from his office by contracting with the Company either as vendor, purchaser or otherwise not shall any Director be liable to account for any profit realized 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

58. 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

59. 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

60. 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.

61. 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 authorized 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 discretion's 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, releases and discharges all moneys payable to the Company and for the claims and demands of the Company.

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

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

(h) To raise and borrow money from time to time for the purpose of the Company, on the mortgage of its property or any part thereof and/or on any bond or debenture payable to bearer or otherwise on interest and 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 authorize or to any other person on its behalf.

BORROWING POWERS

62. 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-stocks or other securities charged upon all or any part of the property of the Company present or future.

63. Debentures, debenture-stock, bonds 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

64. The Company shall have a Common Seal and the Director 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

65. The Directors shall cause to be kept proper books of account as required under Section 220 of the Companies Act , 2017.

66. 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 220 of the Companies Act , 2017.

AUDIT

67. 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 246 to 249 of the Companies Act , 2017.

INDEMNITY

68. 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

69. 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

70. 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 presents or of the statutes or touching any thing then or 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 or umpire under the Arbitration Act, 1940 as amended from time to time.

71. The cost of and expenses 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

72. If the Company is wound up whether voluntarily or otherwise the liquidator may, with the sanction of a special resolution, divide among the contributors in specie any part of the assets and liabilities of the Company, subject to Section 406 and other provisions of the Companies Act, 2017 as may be applicable.

We, the several persons whose names and addresses are subscribed, are desirous of being formed into a company, in pursuance of these articles of association, and we respectively agree to take the number of shares in the capital of the company set opposite our respective names.

Sr. No.	Name and Surname (Present & Former) in Full (in Block Letters)	NIC No. (in case of foreigner, Passport No)	Father's /Husband's Name in Full	Nationality with any former Nationality	Occupation	Residential Address (in Full)	Number of shares taken by each subscriber	Signature
1	SINOHYDRO CORPORATION LIMITED (REPRESENTED BY ITS AUTHORISED DIRECTORS;	0087059	N/A	CHINESE	BUSINESS	BRANCH OFFICE: HOUSE NO.18, STREET NO.56, F-7/4, ISLAMABAD	198	
	1. MR. LING JIANKE,	E09666748	LING ZHIXI	CHINESE	SERVICE	HOUSE NO 18 STREET 56 F-7/4 ISLAMABAD PAKISTAN		....Sd....
	2. MR. WANG HANQING,	PE0826639	WANG LUOYI	CHINESE	SERVICE	HOUSE NO 18 STREET 56 F-7/4 ISLAMABAD PAKISTAN		
2	MR LING JIANKE	E09666748	LING ZHIXI	CHINESE	SERVICE	HOUSE NO 18 STREET 56 F-7/4 ISLAMABAD PAKISTAN	1	....Sd.....
3	MR WANG HANQING	PE0826639	WANG LUOYI	CHINESE	SERVICE	HOUSE NO 18 STREET 56 F-7/4 ISLAMABAD PAKISTAN	1	....Sd.....
4	SACHAL ENGINEERING WORKS PRIVATE LIMITED (REPRESENTED BY ITS AUTHORISED DIRECTOR:	0022289	N/A	PAKISTANI	BUSINESS	PLOT NO. 59-E, STREET NO. 7, SECTOR I-10/3, ISLAMABAD, PAKISTAN.	500	
	1. MR. AHMED ALI QURESHI	61101-2023919-7	ABDUL KARIM QURESHI	PAKISTANI	BUSINESS	HOUSE # 98/1/2, LANE 13, KHAYABAAN RAHAT, PHASE 7, DHA, CLIFTON CANTT, KARACHI.		....Sd....

Company Registration Office Islamabad
SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN
SECP

COMPANY (PVT) LTD. ... HYDRO POWER

5	MR. ABDUL KARIM QURESHI	61101-2023916-5	S/O GHULAM RASOOL QURESHI	PAKISTANI	BUSINESS	HOUSE # 275, MARGALLA ROAD, SECTOR F-11/2, ISLAMABAD.	100	.....Sd.....
6	MR. AHMED ALI QURESHI	61101-2023919-7	S/O ABDUL KARIM QURESHI	PAKISTANI	BUSINESS	HOUSE # 98/1/2, LANE [illegible] KHAYABAN-E-RAHAT, PHASE [illegible] DHA, CLIFTON CANTT, KARACHI.	150	.....Sd.....
7	MR. SYED ZULQURNAIN ALI	61101-1942835-3	S/O SYED MAHMOOD HUSSAIN	PAKISTANI & CANADIAN	BUSINESS	PO KHAS MOHD FARMAN SHAH, RAWALAKOT, POONCH, PAKISTAN	50	.....Sd.....
TOTAL NUMBER OF SHARES TAKEN							1000	

Company Registration Office Islamabad
SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

Dated this 21st day of September, 2019

Muhammad Tariq Masood
Assistant Registrar
Company Registration Office Islamabad

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

Annex – D/6

UHPCO is a newly incorporated company; however, profiles of Sponsors of the Project are attached

SACHAL

SACHAL GROUP OF COMPANIES

A. SACHAL ENGINEERING WORKS PVT. LTD.

SACHAL Engineering Works (Pvt.) Ltd. was founded by two engineers in 1972, with the objectives to contribute for infrastructure development both in Pakistan and abroad. It has been duly incorporated as Private Company limited by shares. The company has transpired, as one of the leading construction companies in Pakistan and now, SACHAL became the name of quality and time. Total quality control; use of environment friendly technology, human safety and customer's satisfaction strategy makes SACHAL unique among its competitors.

Ever since its creation, the company is continuously expending its horizon to achieve its objectives. The scope services amplified to versatile infrastructure development. Sachal Engineering Works (Pvt.) Ltd. is duly incorporated in Pakistan as a Private Company limited by shares. It is licensed by Pakistan Engineering Council to work as a Constructor in category "C-A" (No Limit).

B. RIALI HYDRO POWER COMPANY PVT. LTD.

Seeing the vast potential present in the hydro power generation, the house of Sachal ventured into private power generation on Build Own Operate Transfer (BOOT) basis.
Riali Hydro Power Company (Private) Limited ("RHPCO") is a group concern of the Sachal Group and was incorporated as a private limited company in 2012 under the Companies Ordinance, 1984. The company, in essence, is a special purpose vehicle ("SPV") to set up a Run-Off-The-River 7.08 MW Hydropower Plant near Muzaffarabad, Azad Kashmir.

The Project is designed to operate on the stream flow on run-off-river basis. The generation capacity and energy during each month is therefore dependent on mean available flows during. The plant will be capable of operating on available discharge of the stream even lean months. The estimated total cost of the project is approximately (USD 19 million) out of which the sponsors will provide the equity equivalent to 25% of the total cost of the project. The construction work has already been started and the plant shall be operational by 2019.

Riali hydroelectric power project represent the Sachal's resolve in the green energy segment. The future lies only in developing indigenous base energy, which is abundantly available; therefore our Group is committed and focused on developing Hydro Power, which is also an overriding corporate priority.

C. SACHAL FOOD PROCESSING PVT. LTD.

Pakistan is the 5th major date producer and fourth largest date exporter of the world. There is a huge opportunity of growth in this sector, however due to lack of technical and financial sources maximum gains could not be achieved.

Therefore, in order to promote the agricultural growth and value addition in dates production, Sachal Group has decided to set up the first Dates De-hydration Plant in Pakistan, located at

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

Khairpur Special Economic Zone, Sindh. The company intends to improve the quality / longevity of dates by implementing the latest technology available and to export in middle east and European markets.

Moreover, all fruits and vegetables require specialized post-harvest treatment, appropriate temperature and relative humidity for their storage. Establishment of cold storage provides refrigerated storage and preservation facilities for several fruits, vegetables & flowers. Because of technology advancements and logistic strategies, the cold storage of perishable items has become an important stage in the distribution between manufacturers/processors and retail locations. The cold storage will ensure the increased availability and improved quality of high value perishable fruits and vegetables for both export and local sale, which would otherwise perish or deteriorate.

Sachal Group is establishing the cold storage in order to supplement their dates processing plant. This project is designed for storing of dates but it can be used to store multiple products, stored in different compartments of the unit, where relative temperatures for respective products can be maintained. The major clientele of this business will be the export houses and the local trading and marketing units of dates and other products.

ZHUZGHOR HYDRO POWER COMPANY (PVT) LTD.

SINOHYDRO

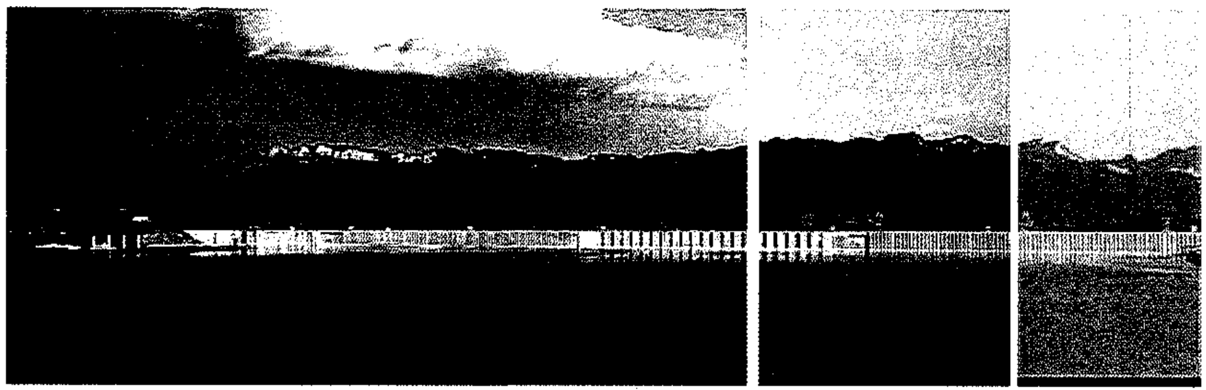
中国电建
POWERCHINA

中国水电
SINOHYDRO

BUILDING A SUSTAINABLE FUTURE

SINOHYDRO

Address: No. 22 Chegongzhuang West Road
Haidian District, Beijing, 100048, P. R. China
Website: www.sinohydro.com
E-mail: intl@sinohydro.com



UZGHOR HYDRO POWER COMPANY (PVT) LTD.

The International Business Flagship of POWERCHINA

Our Values

Integrity, Excellence, Innovation, Responsiveness, Responsibility

Our Mission

Taking it further is our approach to doing business, serving our clients, and achieving company objectives. It means demonstrating our expertise and commitment to our customers wherever they are, to deliver safe and successful energy and infrastructure projects.

Strategic Priorities

Prioritize occupational health & safety in our business.
Contribute to the economic & social life of the local communities where we operate.
Ensure our business respects the environment.
Build relationships with our clients based on quality service, transparency and innovation.
Develop local capacity and our employees' skills.

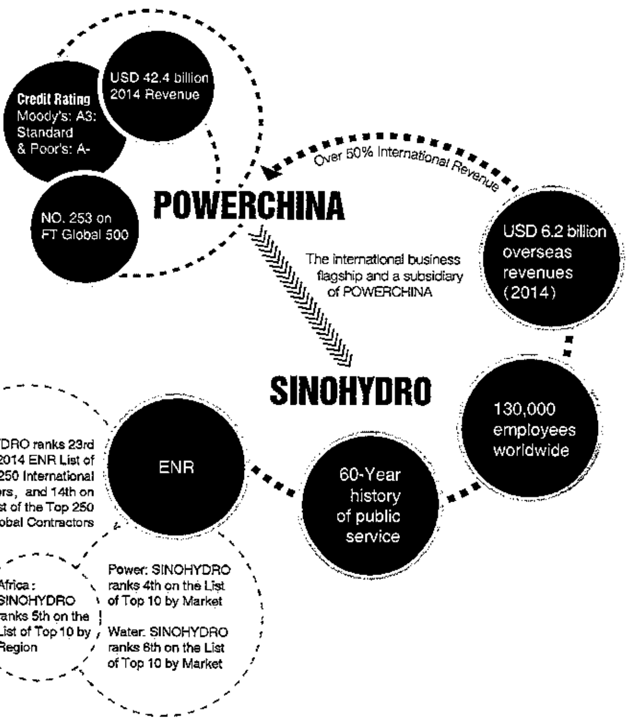
SINOHYDRO PROFILE

A leading player in global construction, SINOHYDRO designs and builds major infrastructure works and buildings around the world.

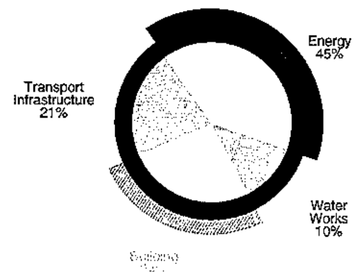
SINOHYDRO is well known as China's first brand in hydropower construction, responsible for 65% of large- and medium-scale hydropower stations in China. Today, with over 60 years of development and expertise, SINOHYDRO is the key international brand of POWERCHINA Corporation, which is a Fortune Global 500 company. In 2015, POWERCHINA was ranked No. 7 and No. 11 on the ENR lists of Top 250 Global Contractors and Top 250 International Contractors respectively.

As the international business flagship and a subsidiary of POWERCHINA Corporation, SINOHYDRO Corporation Limited is the bearer of the SINOHYDRO brand and has continuously updated its value. With diversified operations in over 80 countries, SINOHYDRO Corporation Limited is an internationally renowned and management-oriented contractor. Its businesses cover almost all areas of the construction sector, including energy, transport, water works, civil engineering and building.

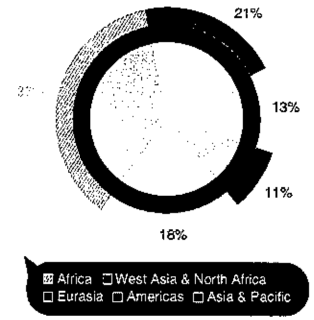
POWERCHINA ranks 11th on the 2015 ENR List of the Top 250 International Contractors, and 7th on the List of the Top 250 Global Contractors.
Africa: POWERCHINA ranks 2nd on the List of Top 10 by Region (Africa).
Asia: POWERCHINA ranks 4th on the List of Top 10 by Region (Asia).
Power: POWERCHINA ranks 1st on the List of Top 10 by Market (Power).
Sewer/Waste: POWERCHINA ranks 2nd on the List of Top 10 by Market (Sewer/Waste).
Water: POWERCHINA ranks 4th on the List of Top 10 by Market (Water).

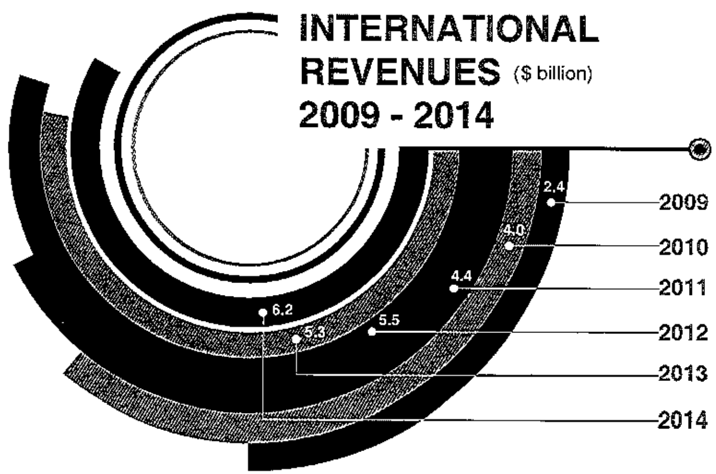


Breakdown by activities



Breakdown by geographical areas





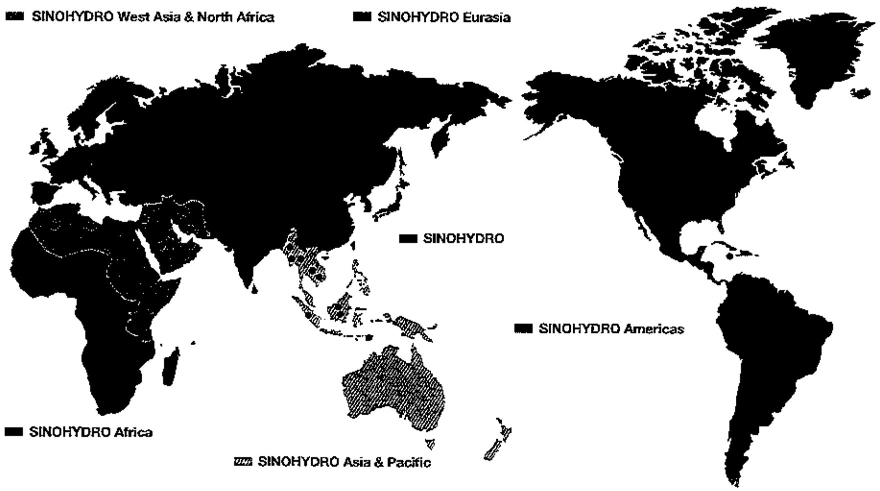
MARKETS

Operations in Approximately 80 Countries

SINOHYDRO Corporation Limited has 5 regional offices in Africa, West Asia & North Africa, Eurasia, Americas, Asia & Pacific supervising 116 overseas offices in 87 countries.

Currently, SINOHYDRO has nearly 500 international projects under construction in more than 70 countries, with a total contract value of approximately USD 41 billion.

One Belt One Road
SINOHYDRO is playing an active role in One Belt One Road (OBOR) projects. Among the approximately 64 countries along the OBOR route, SINOHYDRO has 171 projects under construction in about 29 countries, with a total contract value reaching USD 12.9 billion.



International Cooperation

To further optimize SINOHYDRO's position and to build an increasingly international brand, SINOHYDRO Corporation Limited has established strategic partnerships with leading global enterprises and maintains close cooperation with global financial institutions.

As of December 2014, SINOHYDRO has set up strategic partnerships with 31 enterprises & institutions around the world.

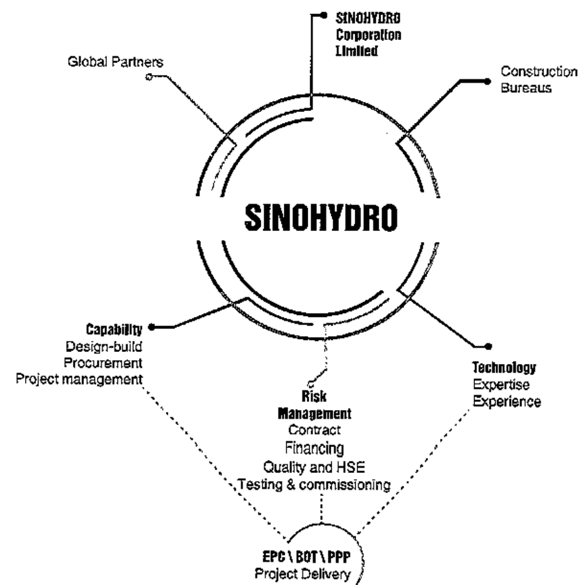
PROVIDING ONE-STOP SERVICE

Our expertise in design, procurement, financing, construction, operations and maintenance makes SINOHYDRO a reliable partner.

SINOHYDRO Corporation Limited is dedicated to providing our clients with best quality one-stop service:
- We assist our clients with project financing.
- We identify clients' needs in order to optimize projects successfully.
- We combine the strengths of large companies, institutional networks and banks with a focus on strong relationships.
- We provide all services from conceptual design to construction through value engineering and innovation.

• **Project Financing**

Multilateral Financial Institutions	Funded by Client	From Chinese Financial Institutions, China Exim Bank, Bank Of China, China Development Bank	Other
11%	42%	44%	3%



Our extensive international business network and strong organizational and managerial abilities enable us to successfully employ complex project models. By operating successful EPC, EPC+Financing, BOT, BOO, BT, and PPP projects, we have demonstrated our diverse abilities in the global construction sector.

Iran, Taleghan Dam (18 MW), received the First "Lu Ban" Award (2009) for an international project.

Zambia, Kariba Hydropower Plant, North Bank Extension (360 MW).

Ecuador, Coca Codo Sinclair Hydroelectric Project (1500 MW).

Equatorial Guinea, Djiploho Hydropower Plant (120 MW).

Pakistan, Gomal Zam Dam Multipurpose Project (17.4 MW), termed by locals as "the Project of a Century".

Malaysia, Power Transmission Project for Bakun.

ENERGY

[Hydropower, Thermal Power, Solar Power, Wind Power, Power Transmission]

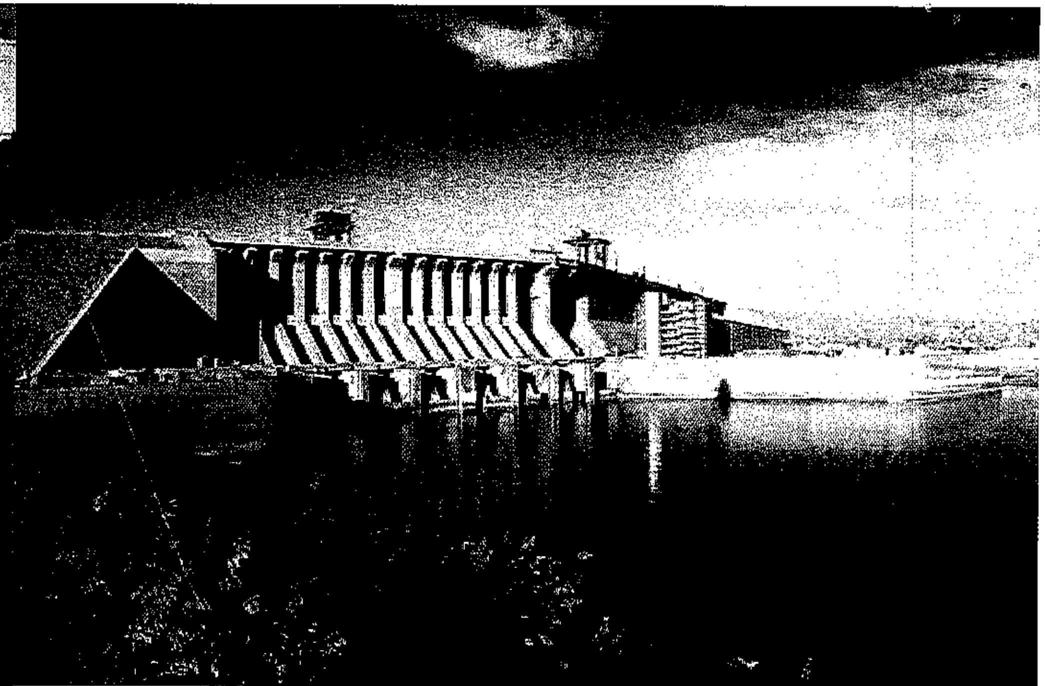
Providing Our Clients with Integrated Solutions

Our vast experience allows us to provide the optimal plan for each energy project by choosing the best engineering design and most efficient construction method.

Over the past decade, SINOHYDRO has constructed more than 78 hydropower plants overseas with a total capacity of 27,780 MW. In addition, it has built 16 thermal and renewable power plants overseas, with a total capacity of approximately 2,776 MW.

SINOHYDRO multi-purpose hydropower projects not only generate electricity, they also provide flood protection, river regulation and diversion, agricultural irrigation, tourism development and improved shipping transport.

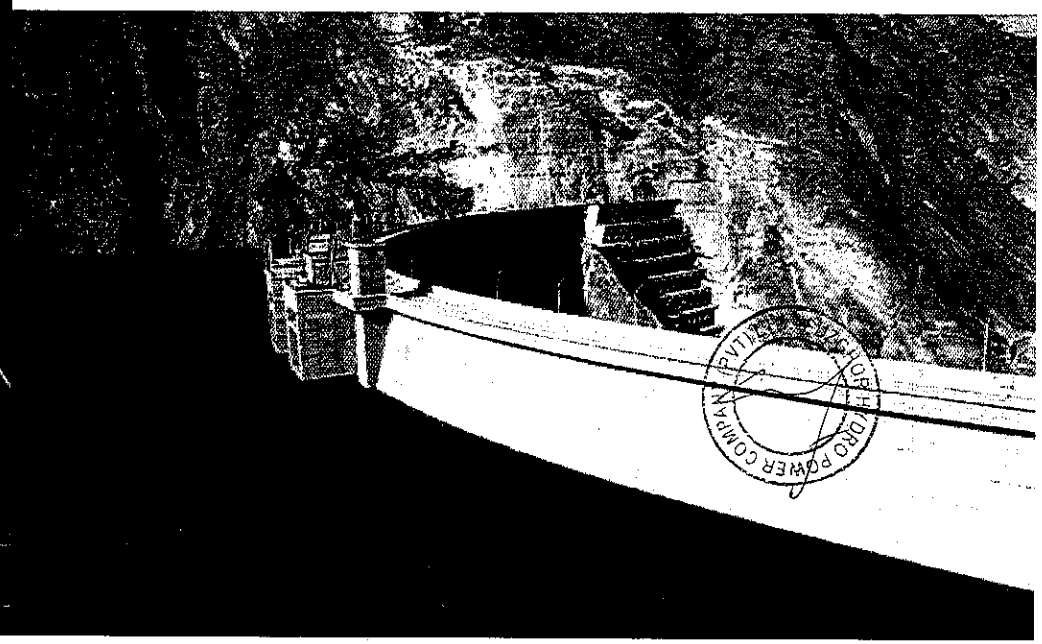
UZGHOR HYDRO POWER COMPANY (PVT) LTD.

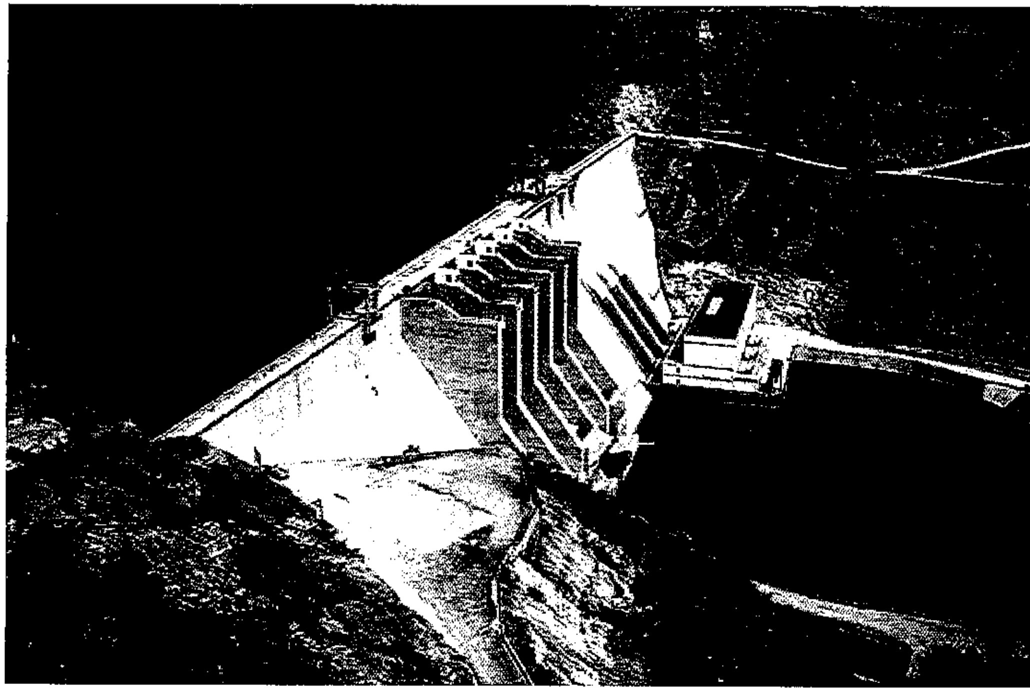


◄ Malaysia,
Bakun Hydropower Plant
(2400 MW),
the largest hydropower plant in
South Asia.

▲ Sudan,
Merowe Hydropower Plant
(1250 MW),
one of the longest dams in the
world (9800 m).

▼ Ethiopia,
Tekeze Hydropower Project
(300 MW),
highest double-curvature arch
dam in Africa (185 m).

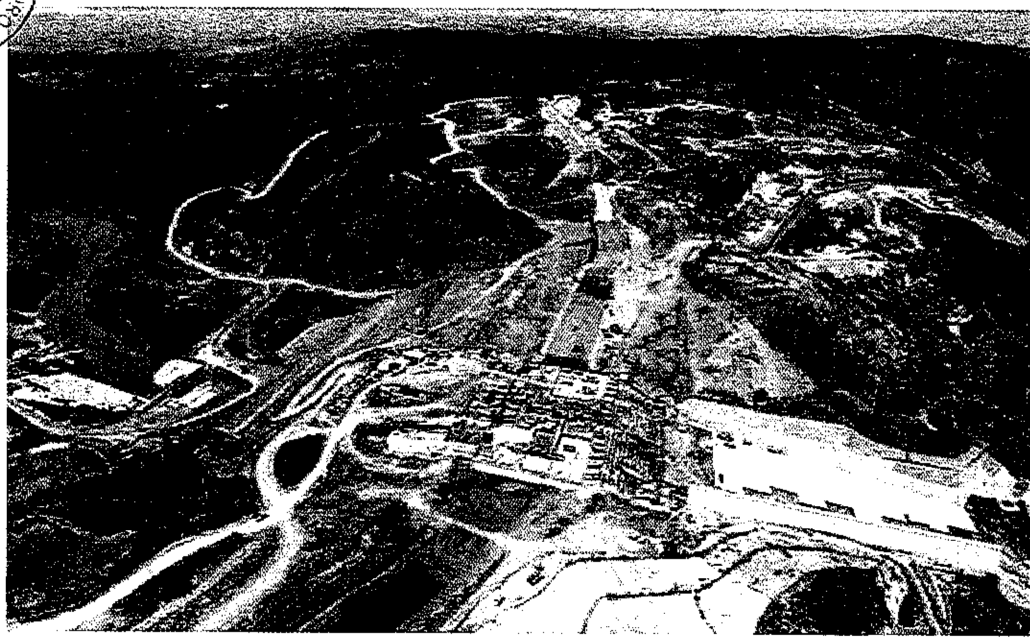




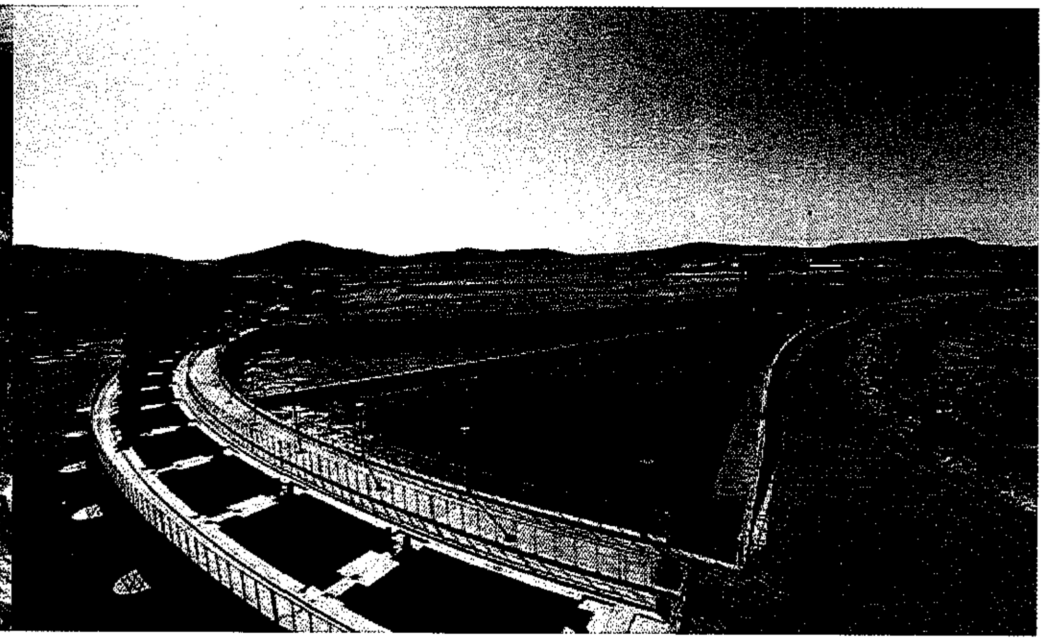
▲ Ghana,
Bui Hydropower Station (400 MW),
received 1st Engineering Excellence Award (2014) by Ghana Institution of Engineers,
Power Project of the Year (2013) by TO&GY.

▲ Ecuador,
Coca Codo Sinclair Hydroelectric Project (1500 MW),
presently the largest hydropower plant in Ecuador.

▼ Indonesia,
Jatigede Dam (110 MW),
presently the largest hydropower plant in Indonesia.

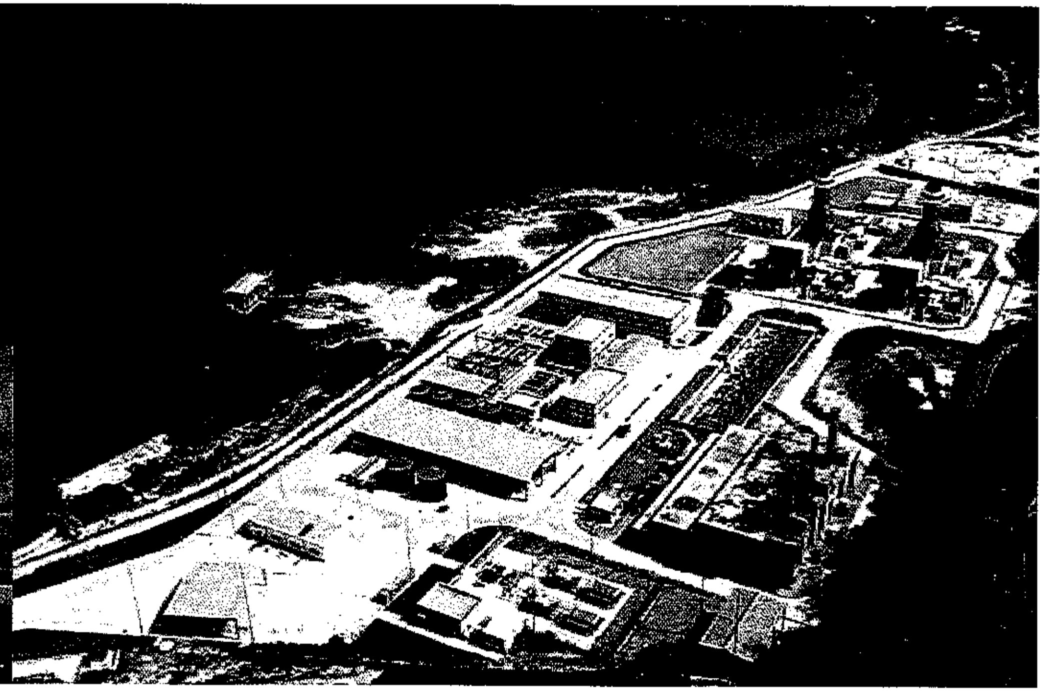


▼ Mali,
Felou Hydropower Project
(63 MW).

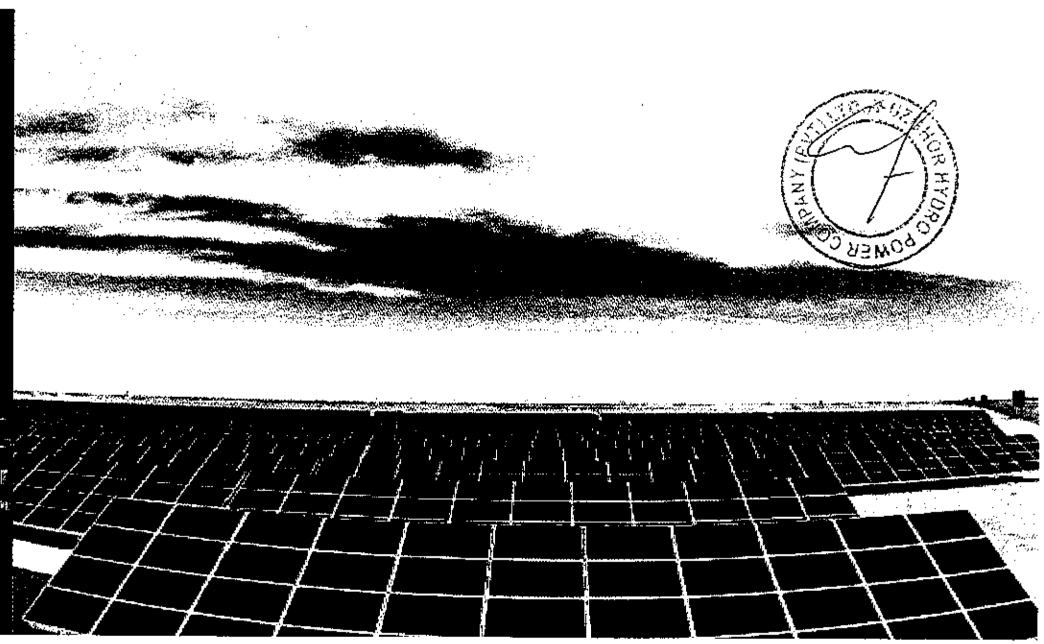


▲ Indonesia,
PLTU Nangroe Aceh Darussalam Thermal Power Plant (220 MW).

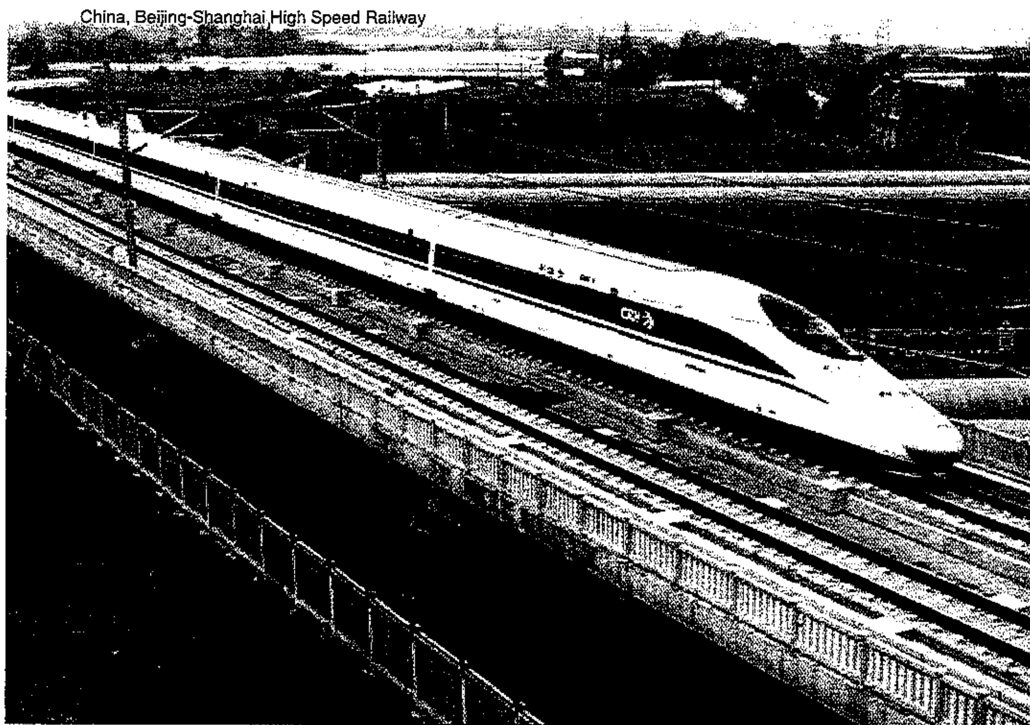
▼ Venezuela,
Carabobo II Thermal Power Project (772 MW).



▲ Venezuela,
Jose Felix Ribas Thermal Power Project (382 MW).



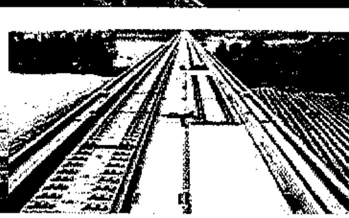
▼ Algeria,
Photovoltaic Power Station (233 MW).



China, Beijing-Shanghai High Speed Railway

Qatar, New Doha International Airport

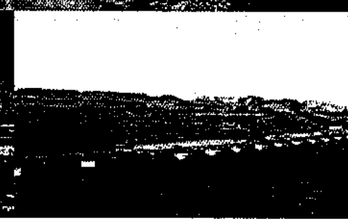
Bridge Erection, Beijing-Shanghai HSR.



Track Laying, Beijing-Shanghai HSR.

Tunnel Construction, Beijing-Shanghai HSR.

Zambia, Road Project.



Mauritania, Nouadhibou Mineral Port.

Georgia, Rikoti Tunnel on the E-60 Highway.

TRANSPORTATION

[Railways, Airports, Bridges, Roads, Tunnels, Piers, Dredging, Marine Facilities]

Multi-disciplinary teams with professional technical skills

With landmark projects in Asia, Eurasia and Africa, SINOHYDRO possesses outstanding capabilities in the design and development of large-scale transportation infrastructure.

Over the past decade, SINOHYDRO has undertaken a variety of overseas transportation projects in Asia, Africa, the Middle East, the Americas and Eastern Europe. All around the world, SINOHYDRO has constructed over 10,000 km of road and bridge projects and 1,100 km of railway and high-speed railway projects. SINOHYDRO was the main contractor of the Beijing-Shanghai High Speed Railway. In addition, SINOHYDRO has been a leading player in world airport and harbor construction.

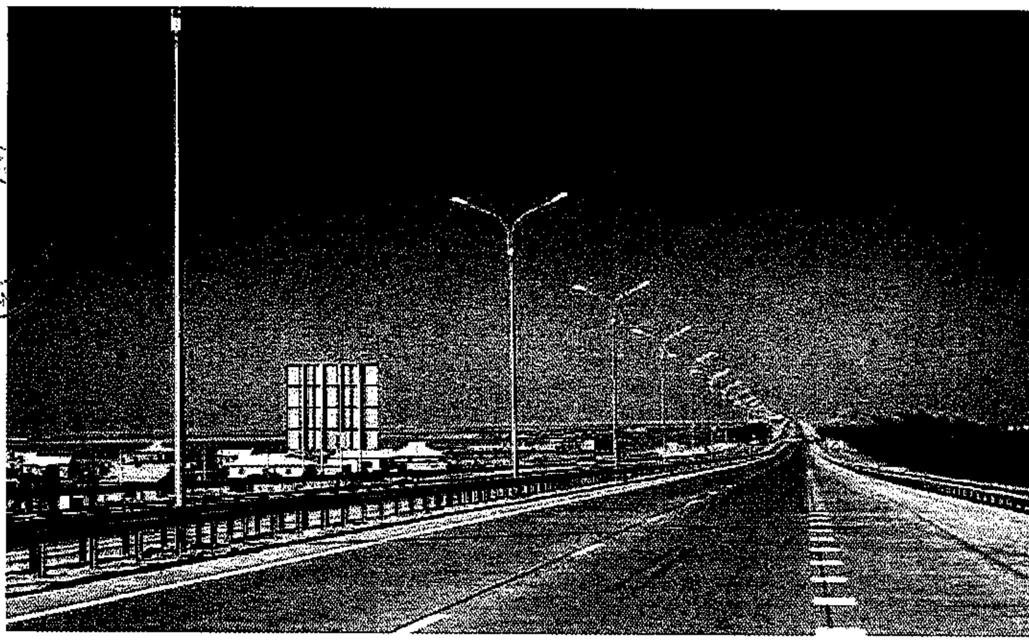
By building high quality transportation projects, we demonstrate our competences in this sector while contributing to urban development worldwide.

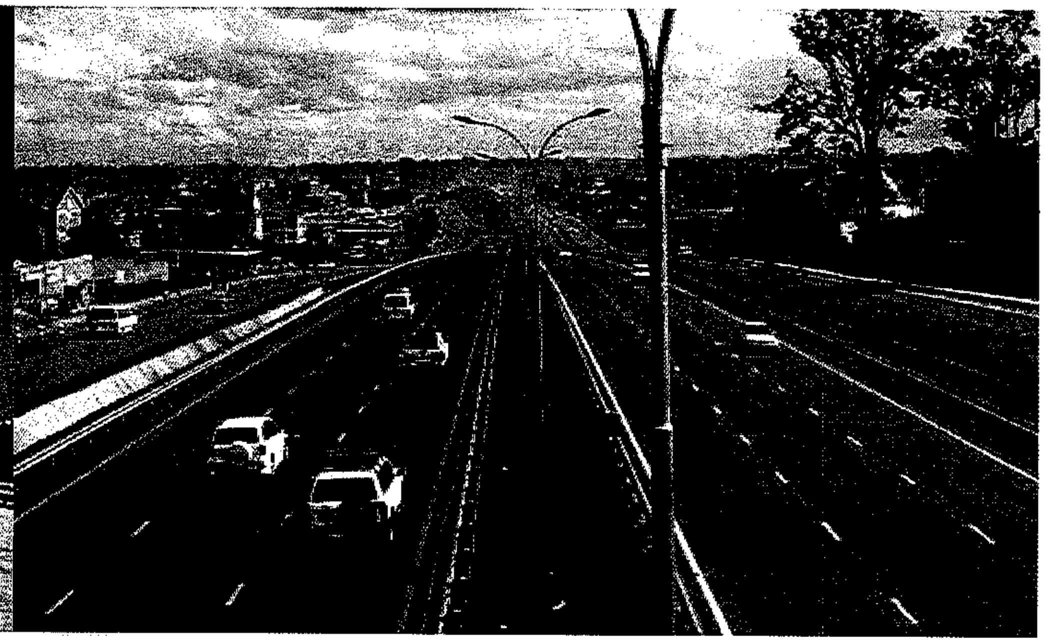
▲ Cambodia,
Koh Puos Bridge.

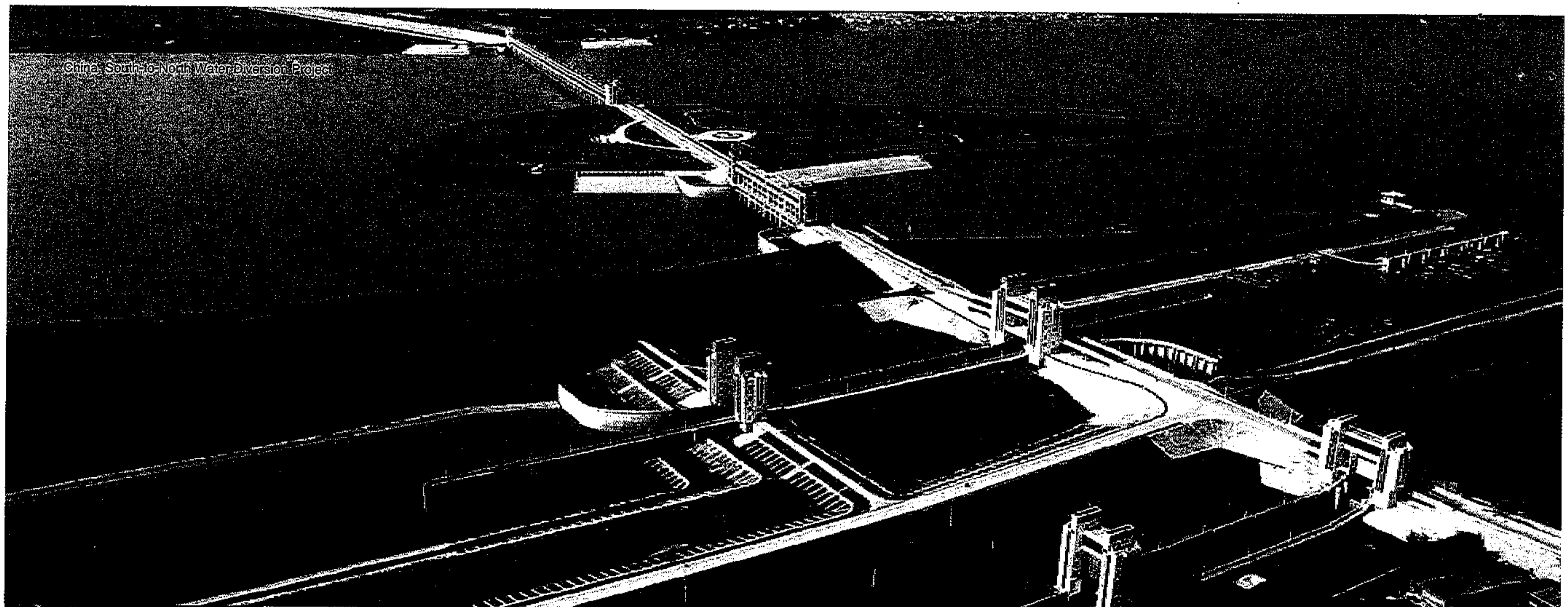
▼ Kazakhstan,
Western Europe – Western China
International Transit Corridor.

▲ Singapore,
MRT Marina South Station and
Tunnels TSL (T227).

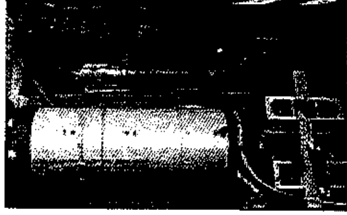
▼ Kenya,
Upgrading of Nairobi-Thika Road.



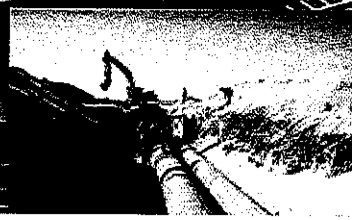




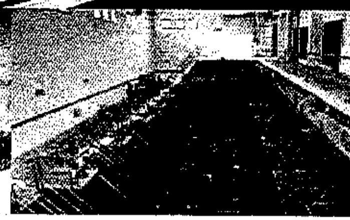
China, South-to-North Water Diversion Project



Oman, Muscat Wastewater Scheme Project-Network.



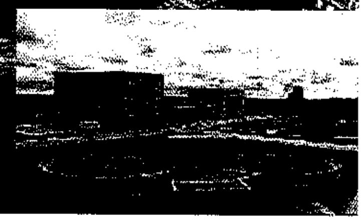
Algeria, Souf Water Supply.



Qatar, GTC182 Water Project.

Nepal, Sikta Irrigation Project.

Poland, Wroclaw Floodway System.



Angola, Kuito Water Supply Project.

WATER WORKS

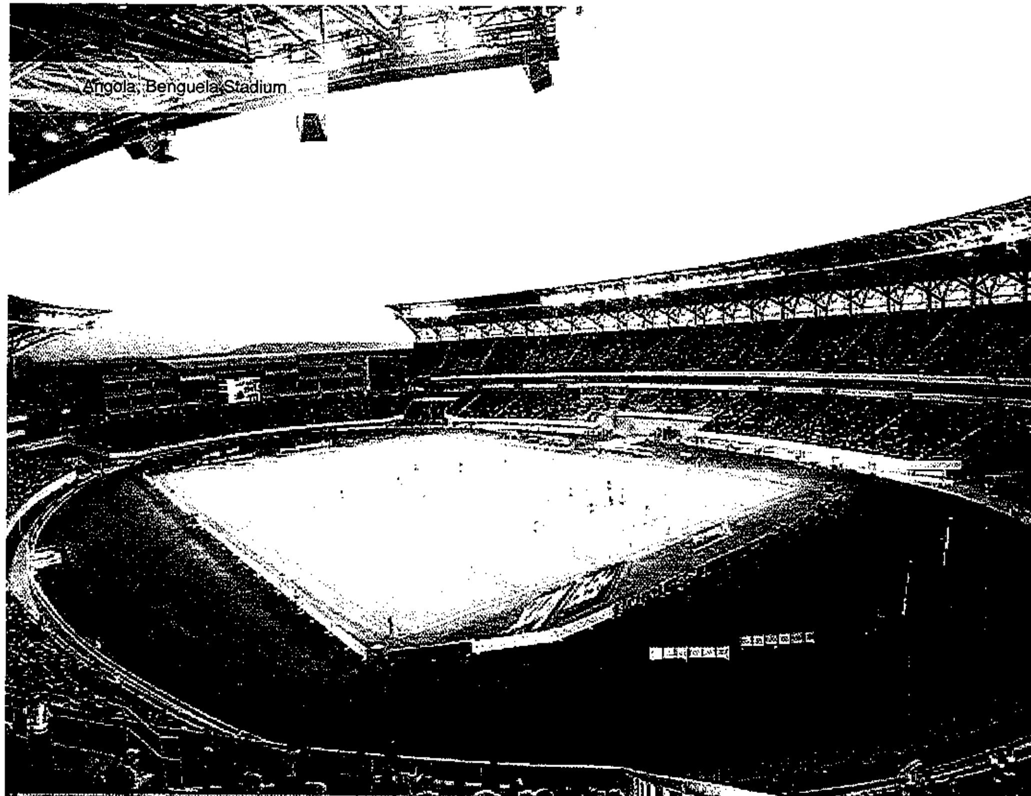
[River Control, Irrigation, Water Supply & Treatment]

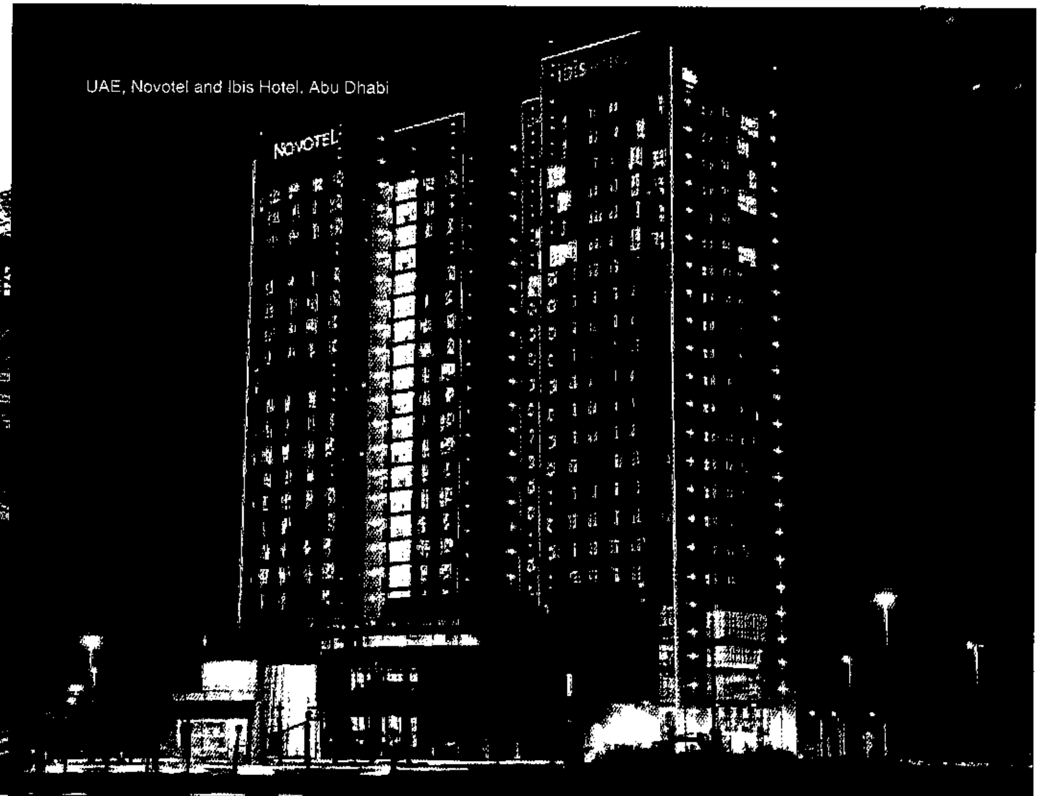
Providing our customers with total control over the water cycle.

SINOHYDRO possesses wide-ranging expertise in water resource management, including water catchment, storage and supply, water treatment, sea water desalinization and irrigation.

Currently, SINOHYDRO has 65 water projects under construction in more than 24 countries, with a total contract value of nearly 3.45 billion USD.

SINOHYDRO has a fundamental stake in the preservation of water. We apply our expertise to various water distribution projects, and by optimizing canals, drinking water systems and water treatment facilities, we bring benefits to local communities.


Angola, Benguela Stadium

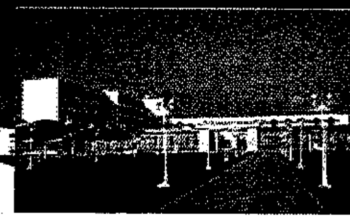

UAE, Novotel and Ibis Hotel. Abu Dhabi

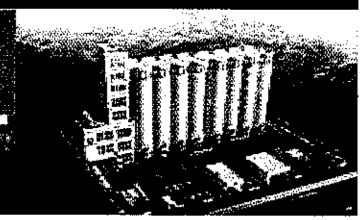

Ecuador, Panama Primary School.


Qatar, CP1 Project.


Indonesia, China-Indonesia Friendship Village.


Libya, Housing Project.


DR of Congo, Kinshasa, Central Hospital.


Algeria, Reinforced Concrete Silos for Cereal Storage.

GENERAL BUILDING

[Commercial Buildings, Offices, Educational Facilities, Stadiums, Hospitals, Hotels, Apartments]

SINOHYDRO contributes in major urban development projects including residential houses, hospitals, schools, stadiums and other public facilities. Providing responsiveness and efficiency to meet even the most complex requirements, SINOHYDRO delivers improved livelihood for local communities.

SUSTAINABILITY FIRST

Our proven experience in China and around the world is paired with our ongoing commitment to meet contractual deadlines, safeguard the environment, and strive for technological innovation.

To be seen as a true leader in our field, we build and protect our reputation for leadership in values and behavior.

We are dedicated to building an increasingly international SINOHYDRO, advancing greener business practices and living in harmony with society.

Safety As A Priority

Zero accident objectives;
Principles and procedures applied to all our companies;
Training employees in safety and first aid;
Insure that all employees are actively involved in making their worksite safer.

Management Approach

Decentralized structure;
Networked collaborative work;
Empowerment of local managers;
Development of local employees;
Responsive organization.

Around the world, SINOHYDRO has launched numerous initiatives aimed at fostering responsible development, benefiting customers, employees, neighboring residents and society as a whole.

Integrating Local Development with Our Projects

SINOHYDRO participates in local community life wherever it operates by building schools and local hospitals, providing clean water, and promoting local employment.

- Sasumu Dam Project in Kenya supported education programs in four local primary and high schools.

Our Green Action

For each project, we provide an Environment Management Plan (EMP) for issues associated with air pollution control, water/natural resource and habitat protection, site remediation, waste management and biodiversity.

- During the construction of the Merowe Dam in Sudan, SINOHYDRO built an original phyto-filtration system to recover and treat used water in order to avoid the leakage of oil-polluted water into the natural ecosystem.

Dedication To Post-Disaster Reconstruction

SINOHYDRO has dedicated itself to post-disaster reconstruction work, primarily in Africa and Asia.

For each reconstruction project, we provide houses, clinics and sanitary facilities, water and power supplies, and entertainment.

SINOHYDRO's business compliance guidelines define our basic principles with regard to business ethics.

Our Certifications

- ISO 9001 ISO
- ISO 14001 ISO
- OHSAS 18001

ENERGY

Cameroon, Memve' Ele Hydropower Station
Dr Congo, Hpp Zongo II
Equatorial Guinea, Djiploho Hydropower Plant
Equatorial Guinea, Extension Of The Electric Network Of Bata City
Ethiopia, Tekeze Hydropower Station
Gabon, Grand Poubara Hydropower Station
Ghana, Bui Hydropower Station
Ivory Coast, Soubre Hpp
Mali, Felou Hydropower Project
Nigeria, Zungeru Hydropower Plant
Sudan, Merowe Hydropower Project
Uganda, Karuma Hpp
Zambia, Kariba Hydropower Plant, North Bank Extension
Zimbabwe, Kariba Hydropower Plant, South Bank Extension
Zambia, The Itezhi Tezhi Hydropower Project
Zambia, Kariba North Bank-Kafue West(330Kv)Transmission Line Project

Bangladesh, Shikalbaha Peaking Power Plant
Iran, Taleghan Dam
Nepal, Upper Tama Koshi Project
Pakistan, Darawat Dam
Pakistan, Duber Khwar Hydropower Project
Pakistan, Ghazi-Barotha Hydropower Project
Pakistan, Gomal Zam Multipurpose Dam Project
Pakistan, Tarbela Dam 4th Extension
Serbia, Ulog Hydropower Plant Project

Bolivia, San José Hydroelectric Project
Costa Rica, Chucas Hydroelectric Project
Ecuador, Coca Codo Sinclair (CCS) Hydropower Station
Honduras, Patuca-3 Hydroelectric Project
Venezuela, Chorrin Hydroelectric Project, Cuchivero River
Venezuela, Oil Fired Power Plant of Refinery Batalla de Santa Ines
Venezuela, Jose Felix Ribas Thermoelectric Plant
Venezuela, ThermoCarabobo II Thermoelectric Plant
Venezuela, Barinas Power Plant and 115/34.5 KV Electrical Substation
Venezuela, Junin Transmission Line Project for the Orinoco Oil Belt

Indonesia, Jatigede Hydropower Plant
Indonesia, Nagan Raya Nad Coal-Fired Power Plant
Indonesia, Pangkalan Susu Unit 3 & 4 Coal Fired Power Plant
Indonesia, PLTU Kaltim Teluk Balik Papan Thermal Power Plant
Indonesia, PLTU Nangroe Aceh Darussalam Thermal Power Plant
Lao PDR, Nam Lik Hydropower Plant
Lao PDR: Nam Khan Hydropower Project
Lao pdr, Hinheup – Luangprabang transmission Line
Malaysia, Murum RCC Dam
Malaysia, Bakun Hydropower Plant
Malaysia, Hulu Terengganu HEP Lot CW2&CW3
Myanmar, Yeywa Hydropower Station
Malaysia, Murum Junction 275KV Transmission Line
Malaysia, Mukah 132/275KV Power Transmission and Distribution Project
Malaysia, 500KV Backbone Transmission Line Project
Malaysia, Connaught Bridge 384.6MW Combined Cycle Generating Plant Project
Thailand, Chao Phraya Hydropower Station
Vietnam, Song Bung 4 Hydropower Project

Main Project List

TRANSPORTATION

Angola, Luena & Saurino Airports Airfields Rehabilitation
Botswana, Rehabilitation of Kang-Hukuntsi Road
Botswana, Reconstruction of Francistown-Ramokgwebana Road
Botswana, Sir Seretse Khama International Airport
DR of Congo, Rehabilitation of RN1 & RN4
DR Congo, Kinshasa International Airport
Ethiopia, Nazareth-Assela & Nekempt-Mekenajo Road Upgrading
Ethiopia, The Asosa-Kulmok Road
Mauritius, M1 Road
Mali, Modernization and Extension of Bamako-Senou Airport
Mauritania, Mineral Port of Nouadhibou
Morocco, Rabat Highway Bypass Motorway
Morocco, North-south High-speed Rail Line
Kenya, Emali-Oloitokitok Road
Kenya, Upgrading of Nairobi – Thika Road (lot 2)
Tanzania, Puge-Tabora Road
Tanzania, Buzirayombo - Geita – Usagara Road
Tanzania, Singida-Katesh Road upgrading
Tanzania, Tanga-Horohoro Road upgrading

Qatar, New Doha International Airport
Qatar, Doha Expressway (Package 6) East Industrial Road Interchanges at Intersections with Street 10 and Street 23

Bangladesh, Dhaka-Chittagong Highway
Georgia, Construction of Kobuleti Bypass Road
Georgia, Rikoti Tunnel at the E-60 Highway
Kazakhstan, Europe – China International Transit (lot 5)
Kazakhstan, Western Europe -Western China International Transit Corridor
Kyrgyzstan, Renovation of Bishkek – Naryn – Torugart Road
Macedonia, Road Kicevo-Ohrid
Macedonia, Road Miladinovci-Sv.Nikole-Stip
Sri Lanka, the C11 A &B Road
Sri Lanka, Hambantota Port
Tajikistan, Dushanbe-Kyrgyz Border Road Rehabilitation
Tajikistan, Road Construction of Voshy-Hovalin
Uzbekistan, Tashkent International Airport

Bolivia, Ichillo-Ivirgarzama Road
Bolivia, Rail Construction from Montero to Bulobulo
Ecuador, 10 Roads Updating and Construction Project
Ecuador, Extension of Simon Bolivar Avenue
Venezuela, Santa Lucia-Kempis Highway
Venezuela, Highway System of Valles del Tuy

Cambodia, Sihanoukville, Koh Puos Bridge
Malaysia, Rawang Highway Bypass
Malaysia, Lembah Kelang MRT Project
Singapore, Thomson Line Package T217 & T227
Thailand, Bangkok MRT Blue Line Extension

China, Beijing-Shanghai High Speed Railway
China, Guangzhou Subway
China, Guiyang-Guangzhou Railway
China, Nanning-Guangzhou Railway
China, Ning-Hang High Speed Railway
China, Tianjin Subway
China, Xi'an Subway
China, Shenzhen Subway
China, Wuxi Subway
China, Chengdu Subway

WATER WORKS

Algeria, Bougous Dam
Algeria, Souf Water Supply
Algeria, Mina Irrigation Expansion Project
Angola, Kuito Water Supply Works
Angola, Irrigation Projects
Botswana, Dikgatlhong Dam Irrigation Scheme
Botswana, Lotsane Dam
Mali, Irrigation Scheme (Ala-B03)
Mauritania, Dhar North City Water Supply Project
Kenya, Nzoia Water Supply System

Oman, Muscat Wastewater Scheme Project-Network
Qatar, GTC606 Transmission Pipeline Associated with QEZ Desalination Plant
Qatar, Head Work Construction At West Bay Area, Um Slal and Al Khor Water Station GTC182/2007
Tunisia, Sousse Sewage Treatment Project
Tunisia,Sahline Sewage Treatment Project

Bangladesh, River Training Works, Padma Multipurpose Bridge Project
Nepal, Bagmati Irrigation Project
Nepal, Sikta Irrigation Project
Poland, Wroclaw Floodway System
Sri Lanka, Construction of The Headworks for The Kalu Ganga Reservoir
Sri Lanka, Moragahakanda Reservoir Headworks Project
Uzbekistan,Drainage,Irrigation and Wetlands Improvement Phase-1 Project

Trinidad and Tobago, Malabar Wastewater Treatment Plant and Collection System-Phase 1

Brunei, Ulu Tudong Dam
Indonesia, Jatigede Dam Project
Malaysia, Construction of Pantai 2 Sewage Treatment
Venezuela, Overflow Dam on the Santo Domingo River, Barinas
Vietnam, Phuoc Hoa Irrigation Project

GENERAL BUILDING

Algeria, Silos for Cereal Storage
Algeria, Touggourt Hospital
Algeria, Wilaya d' El Oued Social Housing Program
Angola, Benguela Stadium
Angola, Construction Of Two Agriculture Institutes Huambo And Bie
Angola, Hospital Projects
Dr Of Congo, Kinshasa Place De L' Independence
Dr Of Congo, Kinshasa, Central Hospital
Libya, Housing Project
Niger, Azelik Uranium Mine Infrastructures
Republic of Congo (Brazzaville), Olympic Village

Kuwait, Sabah Al-Salem University City
Qatar, Lusail Development Project Primary Infrastructure
Qatar, Sidra Village Staff Housing for Sidra Medical & Research Center
Qatar, Kahramaa Awareness Park - GTC 400
Qatar, NPP/0057 – Port Buildings and Infrastructure
Saudia Arabia, Shaybah Support Facilities To Crude Increment (IK)
UAE, Novotel and Ibis Hotel, Abu Dhabi

Tajikistan, Construction of Diar Dushanbe Project-Phase 1

Malaysia, Sarawak Ferroalloy Smelter Plant Project
Malaysia, OM Ferroalloy Project
Malaysia, Xiamen University, Malaysia Campus
Myanmar, Copper Mine Projects

BUILDING A SUSTAINABLE FUTURE

Main Project List

Annex – D/11

Prospectus

PROPECTUS

Project Status

Turtonas-Uzghor Hydropower project (the "Project") is located on River Golen Gol which is a left bank tributary of Mastuj River. It joins with Mastuj River about 22 km north-east of Chitral Town near village of Kaghozi. The identified weir site on Golen Gol is approx. 8 km upstream of the existing Golen Gol Hydropower Project intake. The power house site is proposed on the right bank of Golen Gol River near Uzghor Village just upstream of Golen Gol HPP intake. The powerhouse site is located north-east of Chitral Town at a distance of about 33 km. The project has the capacity of 82.25 MW and will generate 382.30 GWh of energy annually. Two Pelton vertical axis type Turbines would be installed.

This project site was first identified by PEDO-GTZ under Comprehensive Planning of Hydropower Resources in Khyber Pakhtunkhwa Province (1987-92). GTZ in collaboration with Serhad Hydel Development Organization [SHYDO] undertook the Comprehensive Planning of Hydropower Resources of Khyber Pakhtunkhwa Province along small streams and tributaries of main rivers flowing in the Province. This potential has been documented in Regions of Upper Chitral, Lower Chitral, Upper Swat, Lower Swat, Upper Kohistan, Lower Kohistan and Manshera, etc. The GTZ/SHYDO presented their report "Identification of Hydropower Development Potential in Chitral Valley" in February 2001. The Turtonas-Uzghor Hydropower Project was part of the identified projects presented in the report.

After the restructuring of power sector in Pakistan, the Project was later taken over by Private Power Infrastructure Board ("PPIB") and offered to private sector investors. The Sponsors was awarded the Letter of Intent ("LOI") by PPIB, after an international competitive selection process in March, 2017.

Based on aforementioned reports, studies and extensive site visits; the Feasibility Report for Turtonas Uzghor Hydro Power Project has subsequently been prepared by a joint venture comprises of M/s FICHTNER GmbH, Germany and M/S Technical, Engineering & Management (TEAM) Consultants, Pakistan (collectively, "Feasibility Consultant").

The Consultant conducted a number of studies and analyzed all the Project components viz weir, access channel, sedimentation basin, spillway, tunnel, surge chamber, penstock, tailrace channel and powerhouse including their sizing.

The Consultant, from time to time, submitted reports and gave presentations on core activities of the Feasibility Study to the Panel of Experts (POE). The POE's valuable observations and comments on the technical and financial aspects of the Project were duly acknowledged, evaluated and incorporated into the final / POE approved version of the Feasibility Study.

Subject to approval of the tariff petition and generation license by NEPRA, the indicative time lines for subsequent project development milestones are outlined below:

Date	Activity
June, 2019	Submission of Tariff Petition to NEPRA
Dec, 2019	Feasibility Stage Tariff Determination by NEPRA
Feb, 2020	Issuance of LOS by PPIB
Oct, 2020	Completion of ICB Bidding for EPC & EPC Selection Process
Nov, 2020	EPC Stage Tariff Petition to NEPRA
May, 2021	EPC Stage Tariff Determination by NEPRA
July, 2021	Financial Close
July, 2025	Expected COD

The Sponsors / Applicant

i. **Sinohydro Corporation Limited (Main Sponsor)**
Sinohydro Corporation Limited ("Sinohydro") is a wholly state-owned enterprise of Government of China with a registered capital of RMB Four Billion. Sinohydro is strategically positioned as a clean energy conglomerate specializing in development and operation of large-scaled hydropower projects. Sinohydro's principal operations include power sector investment, engineering, construction, management, electricity production and provision of related technical services for hydropower projects.

The recent decade has witnessed Sinohydro' s rapid growth in business revenue, asset volume and asset structure diversification. Currently, the company has 524 international projects in more than 74 countries, with total contract value of nearly USD 42.50 billion.

ii. **Sachal Engineering Works (Pvt.) Ltd. (Sponsor)**
Sachal Engineering Works (Pvt.) Ltd. ("Sachal") is a leading construction and civil engineering company which has been involved in the construction of various bridges, road works and civil works for hydropower projects. SEWPL holds a License of Pakistan Constructor/ Operator from the Pakistan Engineering Council. Sachal is considered a ("CA") category construction company whereby there is no restriction on the capital cost of any project undertaken. Sachal is one of the leading transportation infrastructure contractors in Pakistan, developing innovative solutions to build roads, highways, interchanges and bridges for both public and private clients.

Seeing the vast potential present in the hydro power generation, Sachal ventured into private power generation on Build Own Operate Transfer (BOOT) basis. Riali Hydro Power Company (Private) Limited ("RHPCO") is a group concern of the company and was incorporated as a private limited company in 2012 under the Companies Ordinance, 1984. The company, in essence, is a special purpose vehicle ("SPV") to set up a Run-Off-The-River 7.08 MW high head Hydropower Plant near Muzaffarabad, Azad Kashmir.

POWER COMPANY (PVT) LTD. ... HYDRO

Project Costs

Following deliberations and discussions at Project Panel of Experts meetings that *inter alia* includes Power Purchaser (CPPA-G Ltd.) as a POE member; the Sponsors propose a Project Cost of USD 204.60 Million.

Description	Amount (US$ Mil)
EPC Cost	148.93
Non-EPC Cost	23.77
Insurance During Construction	2.978
Financial Charges	3.558
Custom Duties	2.230
Interest During Construction	23.136
TOTAL PROJECT COST	204.602

The Project shall be financed at debt to equity ratio of 80:20 as per the assumptions of the feasibility study. The total Project Cost stands at USD 204.602 Million, which requires Debt injection of USD 163.68 Million and Equity amounting to USD 40.92Million.

The Project will be financed at debt to equity ratio of 80:20 as per the assumptions of the feasibility study. The total Project Cost stands at USD 204.602 Million, which requires Debt injection of USD 163.68 Million and Equity amounting to USD 40.92Million.

Equity Participation:

In accordance with LOI issued to the Applicant by PPIB under Power Generation Policy 2015, the Main Sponsor (Sinohydro) along with other Sponsor (Sachal) shall jointly hold at least 51% of Project shareholding during the "lock-in-period" which will be from the issuance date of the Letter of Support (LOS) until the sixth anniversary of the successful commissioning of the "Project". Furthermore, the Main Sponsor (Sinohydro) shall participate and hold not less than twenty percent (20%) of the equity during the Lock in Period.

Therefore, Sinohydro and Sachal will jointly participate and hold 51% of the equity during the "lock-in-period" which will be from the issuance date of the Letter of Support (LOS) until the sixth anniversary of the successful commissioning of the Project.

Other equity holder will be organized by the Applicant from other potential investor(s) to take maximum forty nine percent (49%) of the equity/project shareholding. In case, the potential investor(s) could not be found to take the remaining equity 49% of total equity; Sinohydro and Sachal will discuss and jointly contribute the remaining equity.

Debt Arrangement:

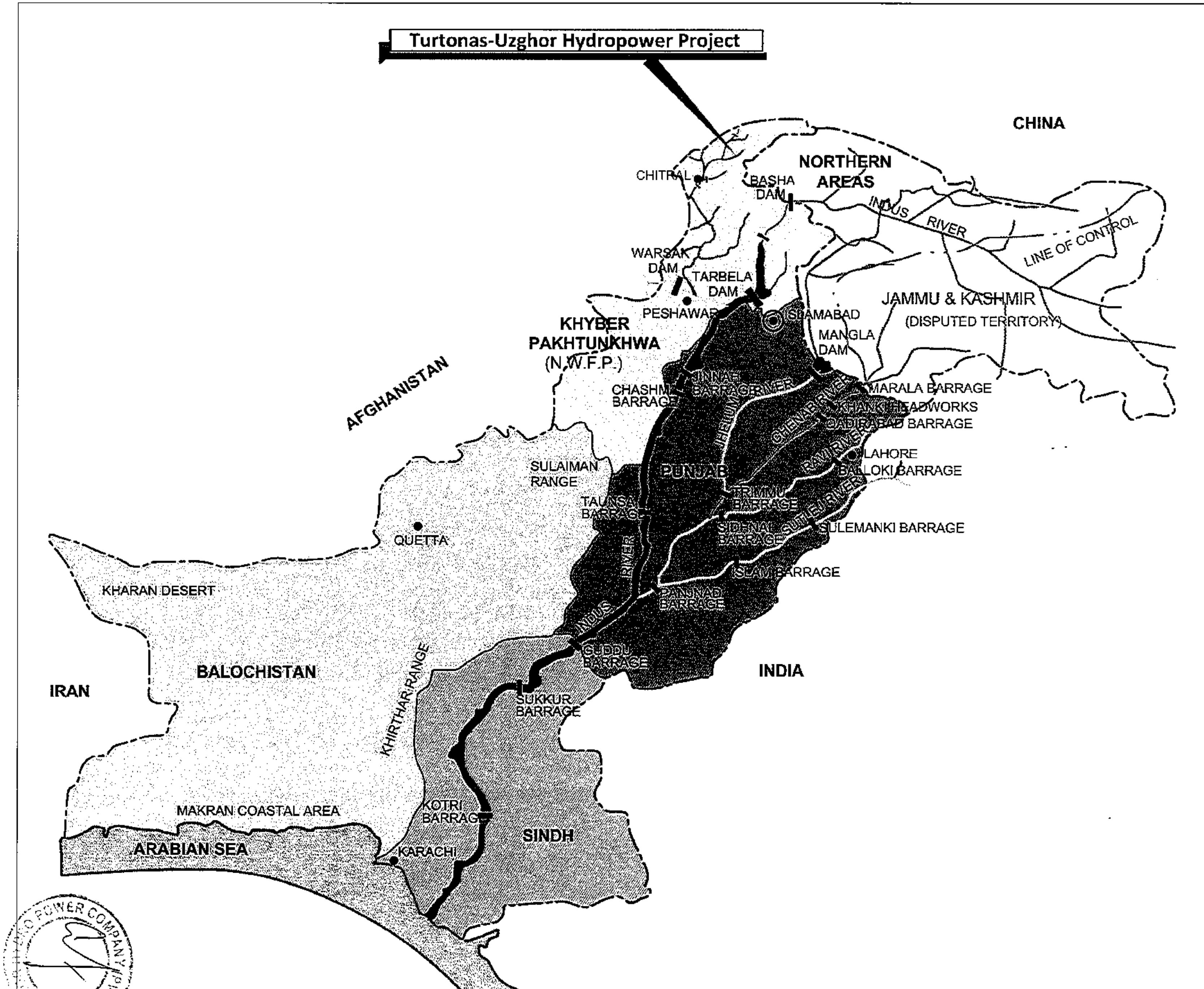
The Total Debt is USD 163.68 Million which will be raised through mixture of foreign and local lenders.

Project Salient Features

Hydrological Features at Weir Site:		
Catchment Area of Golen Gol	518	km^2
Design Discharge	20.0	m^3/s
Mean Annual Flow	18.86	m^3/s
$HQ_{1,000}$	1,025	m^3/s
Weir Structure:		
Crest Level of Weir	2582	m.a.s.l
Max. Weir Height	8.3	m above river bed
Length of Weir Crest	40.0	m
Invert of Flushing Outlet	2574.44	m.a.s.l
Spillway:		
weir Crest level	2582	m.a.s.l
Desander/Sedimentation Basin:		
Design Discharge	20.0	m^3/s
Design Particle Diameter	0.20	Mm
Number of settling chambers	3	
Effective length of chamber	91.27	m w/o transition
Total Width of chamber	25.3	M
Average depth of chamber	8.5	M
Low-pressure Headrace Tunnel:		
Length	4.837	Km
Net Diameter	4	M
Max. Flow velocity	2.7	m/s
Surge Tank:		
Diameter:	15.00	M
Pressure Shaft and High-Pressure Tunnel:		
Length of vertical shaft	440.1	M
Diameter	2.5	concrete lined
Diameter	2.5	steel lined
Powerhouse:		
No. of units	2	Pelton
Capacity each unit	41.125	MW
Installed Capacity	2 x 41.125= 82.25	MW
Max. Turbine Design Discharge	2*10=20	m^3/s
Electro-mechanical Equipment:		
No of Transformers	2	
Type of Switchyard	Outdoor, CBSF6	
Voltage	132	KV
Tailrace Tunnel:		
Total length (w/ manifold)	75	M
Access Road		
Access Road to Weir	9356	M
Access Road to surge tank	6495	M
Mean Annual Energy Generated	382.3	GWh

Schedule – III

Project Location



LEGEND

- LINE OF CONTROL (LOC)
- INTERNATIONAL BOUNDARY
- PROVINCIAL BOUNDARY
- TOWNS, VILLAGES
- CAPITAL CITY
- KARAKORAM HIGHWAY (KKH)
- G.T ROAD
- NHA ROADS
- DAM / BARRAGE
- RIVER
- RESERVOIR (EXISTING)
- RESERVOIR (PLANNED)

DISTANCE CHART

PLACES	DISTANCE
PESHAWAR TO CHITRAL	370 KM
DIR TO CHITRAL	150 KM
CHITRAL TO GRAM CHASHMA	74 KM
CHITRAL TO BOONI	55 KM
CHITRAL TO MASTUJ	105 KM
CHITRAL TO GILGIT	380 KM
CHITRAL TO DROSH	45 KM
CHITRAL TO LOWARI TOP	90 KM

PRINCIPAL DATA

PROJECT LOCATION (PH)	5 KM U/S Of Mastuj Confluence
DISTANCE FROM PESHAWAR	320 KM
TRAVELLING TIME FROM PESHAWAR	12 HOURS (APPROX.)
DISTANCE FROM CHITRAL	45 KM
NEAREST COMMERCIAL AIRPORT	CHITRAL, PESHAWAR
NEAREST RAILWAY STATION	PESHAWAR

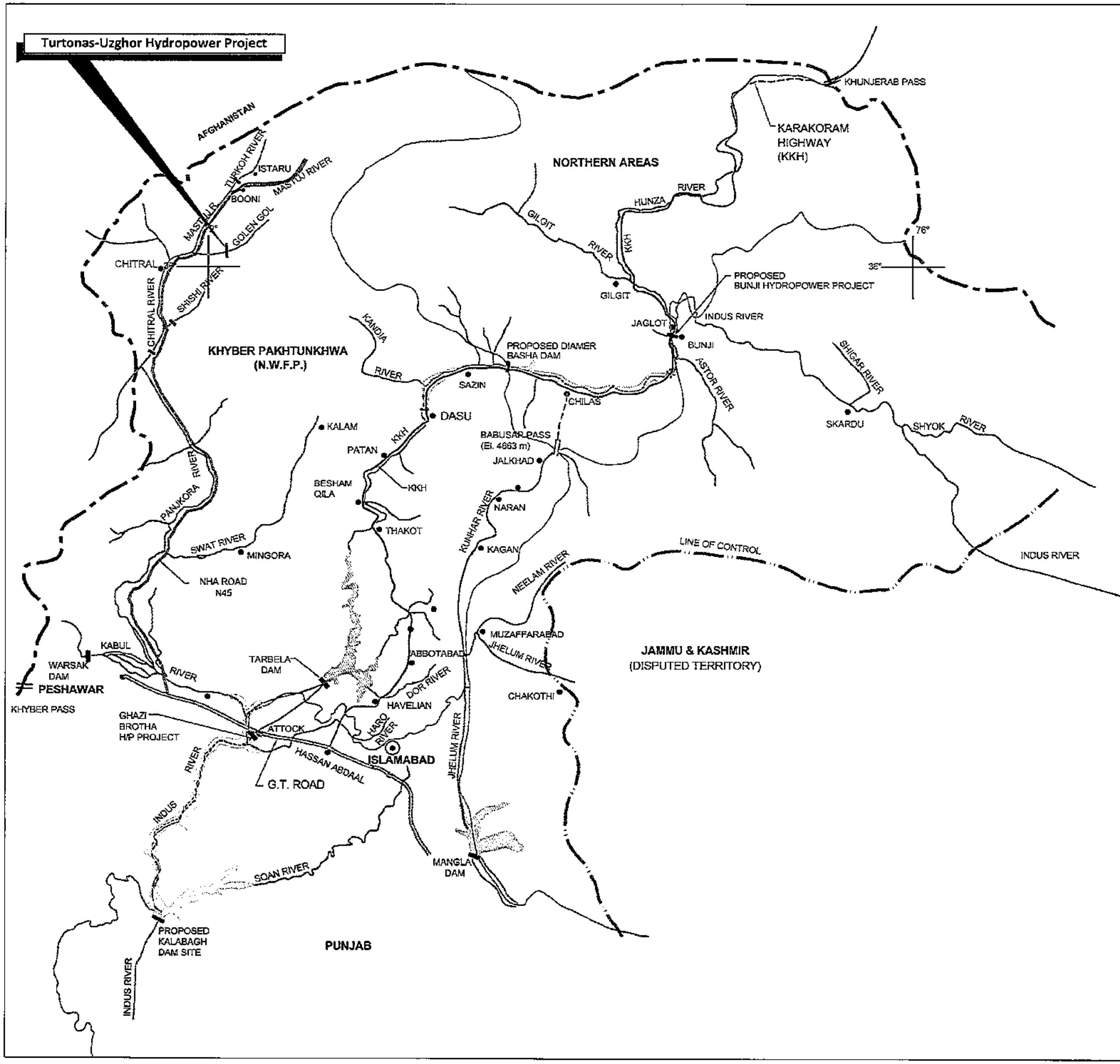
Client:	SINOHYDRO-SACHAL CONSORTIUM
Consultants:	team consultants FICHTNER - JV
PROJECT:	TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT

Feasibility Study Report

Project Location Map

Drawn.	Muhammad Shan	
Design.	Zain Ijaz	
Checked.	Umer Majeed	
Approved.	Haji Farooq	
Scale:		Drawing No.
Dated:	June-2018	TUHPP-01

UZGHOR POWER COMPANY (PVT) LTD.



LEGEND

- LINE OF CONTROL (LOC)
- INTERNATIONAL BOUNDARY
- PROVINCIAL BOUNDARY
- TOWNS, VILLAGES
- CAPITAL CITY
- KARAKORAM HIGHWAY (KKH)
- G.T ROAD
- NHA ROADS
- DAM / BARRAGE
- RIVER
- RESERVOIR (EXISTING)
- RESERVOIR (PLANNED)

DISTANCE CHART

PLACES	DISTANCE
PESHAWAR TO CHITRAL.............	370 KM
DIR TO CHITRAL...........................	150 KM
CHITRAL TO GRAM CHASHMA.....	74 KM
CHITRAL TO BOONI.......................	55 KM
CHITRAL TO MASTUJ....................	105 KM
CHITRAL TO GILGIT......................	380 KM
CHITRAL TO DROSH.....................	45 KM
CHITRAL TO LOWARI TOP..........	90 KM

PRINCIPAL DATA

PROJECT LOCATION (PH).............	5 KM U/S Of Mastuj Confluence
DISTANCE FROM PESHAWAR..........	320 KM
TRAVELLING TIME FROM PESHAWAR	12 HOURS (APPROX.)
DISTANCE FROM CHITRAL	45 KM
NEAREST COMMERCIAL AIRPORT	CHITRAL, PESHAWAR
NEAREST RAILWAY STATION	PESHAWAR

Client:	SINOHYDRO-SACHAL CONSORTIUM
Consultants:	team consultants FICHTNER - JV
PROJECT:	TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT

Feasibility Study Report

Project Vicinity Map

Drawn.	Muhammad Shan	
Design.	Zain Ijaz	
Checked.	Umer Majeed	
Approved.	Haji Farooq	
Scale:		Drawing No.
Dated:	June-2018	TUHPP-02

Annex – D/12

ESIA Report Attached Separately

Annex – D/13

Consents / Letter's

POWER COMPANY (PVT) LTD. ★ UZGHOR HYDRO

No. 1(101) PPIB-2051-02/17/PRJ /0-48530/1 20th March 2017

Mr. Liu Zhong
Passport No.P01635914
Authorized Representative
Sinohydro Corporation
No.22 Chegongzhuang West Road, Haidian District Beijing 10048,
China

Subject: **LETTER OF INTENT (LOI) FOR APPROXIMATELY 58 MW TURTONAS UZGHOR HYDROPOWER PROJECT (the "Project")**

WHEREAS

A) Expressions of Interest (EOI) were invited by the Private Power & Infrastructure Board (PPIB) through advertisements published in newspapers on 14th January 2016;

B) Proposal dated 20th April 2016 including the Statement of Qualification (SOQ) (the "**Proposal**") was submitted by the Consortium of Sinohydro Corporation, China (the "**Main Sponsor**") having its registered address at No.22 Chegongzhuang West Road, Haidian District, Beijing 10048, P.R.China and Sachal Engineering Works (Pvt) Ltd. Pakistan having its registered address at 59-E, Street 7, Sector I-10/3 Islamabad Pakistan (Main Sponsor together with Sachal Engineering Works (Pvt.) Ltd. collectively referred to herein as the **"Sponsors");**

C) PPIB issued Notice of Qualification dated 13th December 2016; and

D) The Sponsors having delivered an irrevocable, unconditional, on demand bank guarantee No. 023/17/165/LG/TC dated 6th February 2017 and Addendum No. 023/17/165/LG/TC dated 14th February 2017, on terms acceptable to PPIB, issued by Silk Bank Limited Trade Processing Centre, 14-Egerton Road Lahore, in the amount of US $ 58,000/- (United State Dollar Fifty Eight Thousand Only) valid up to 15th May 2020 (hereinafter referred to as the '**Performance Guarantee**') in favor of PPIB.

NOW THEREFORE

In terms of the provisions of the Policy for Power Generation Projects, 2015 (the "**Policy**"), the Government of Pakistan (GOP) hereby confirms its interest in the Proposal submitted by the Sponsors for conducting a bankable feasibility study (the "**Feasibility Study**") for establishing, in private sector, an approximately **58 MW**

2nd Floor, Emigration Tower, Mauve Area, Sector G-8/1, Islamabad – Pakistan
Tel: (9251)9264034-45 Fax: (9251) 9264030-31
Email: ppib@ppib.gov.pk Internet: http://www.ppib.gov.pk

POWER COMPANY (PVT) LTD. UZGHOR

Turtonas-Uzghor Hydropower Project to be located on Golen Gol River in Chitral District, Khyber Pakhtunkwa (KP), Pakistan (the "**Project**") and to perform such actions as provided hereinafter in accordance with following terms and conditions:

1. The Sponsors shall carry out the Feasibility Study, complete, at internationally acceptable standards and in accordance with the terms and conditions stipulated herein and in the Policy for the Project, **at no risk and cost to, and without any obligation on part of, the GOP and its agencies**, within **24 months** from the date of this LOI. Indicative Terms of Reference (TOR) for the Feasibility Study at **Annex-A**. The Feasibility Study shall include, but not limited to, an environmental & social impact assessment study, optimized layout of the Project components, detailed design of power house and its allied structures, load flow and stability studies, design of interconnection/transmission lines, details pertaining to infrastructure, detailed bill of quantities and rate analysis of major items, project cost, financing plan, financing terms, tariff calculations and assumptions of financial calculations including economic/financial analysis. You are advised to consult with the power purchaser while determining your plant size and site, project layout, transmission line and interconnection arrangements, etc. In addition you will also be required to liaise and coordinate with the sponsors of other upstream and downstream projects at Golen Gol River in order to ensure that the design and other parameters/features of the Project do not adversely affect such other projects.

2. The Sponsors shall carry out the Feasibility Study according to the specific milestones appended herewith at **Annex-B**, and submit monthly progress reports showing progress against these milestones. A persistent or continuous failure or delay in achieving any specific milestones as per Schedule given in Annex-B shall be treated as default under the LOI entitling the PPIB to encash the Performance Guarantee.

3. PPIB will appoint a Panel of Experts (**POE**) to monitor the conduct of the Feasibility Study and its progress, to verify attainment of the aforesaid milestones and to ensure implementation of the Project consistent with national and provincial needs. Furthermore, the approval of Feasibility Study by PPIB is subject to fulfillment by the Sponsors of, the terms and conditions under and in accordance with the Policy and commitment made under SOQ.

4. Within ninety (90) days after the approval of Feasibility Study by GOP/PPIB, Sponsors are also required to finalize and file a complete feasibility stage tariff petition before National Electric Power Regulatory Authority in accordance with NEPRA's Mechanism for Determination of Tariff for Hydropower Projects. Furthermore, within sixty (60) days after such tariff determination / approval by NEPRA of the feasibility stage tariff, the Sponsors, after meeting all requirements under the Policy including but not limited to posting of an irrevocable, unconditional, on demand bank Guarantee on terms acceptable to PPIB in an amount equal to US$ 5000/MW shall apply to PPIB for issuance of Letter of Support (LOS).

2nd Floor, Emigration Tower, Mauve Area, Sector G-8/1, Islamabad – Pakistan
Tel: (9251)9264034-45 Fax: (9251) 9264030-31
Email: ppib@ppib.gov.pk Internet: http://www.ppib.gov.pk

COMPANY (PVT) LTD.

5. In the event, the Sponsors delays, defaults or fails either to: (i) complete Feasibility Study within twenty-four (24) months in accordance with the terms hereof; or (ii) file petition before NEPRA, in accordance with NEPRA's Mechanism for Determination of Tariff for Hydropower Projects, within ninety (90) days of the approval of the Feasibility Study by GOP/PPIB, for tariff determination; or (iii) apply to PPIB for issuance of LOS within sixty (60) days of tariff determination by NEPRA; or (iv) extend the validity of the Performance Guarantee as and when required, PPIB shall be entitled to encash the Performance Guarantee and the LOI shall stand terminated without any notice.

6. If PPIB acting in its sole discretion determines that any extension is required by the Sponsor in relation to their obligations to achieve any milestone(s) under the LOI, PPIB shall be entitled acting on an application in writing made to it by the Main Sponsors at least thirty (30) days before the expiry of such milestone, to grant in writing to the Sponsors such extension as is prescribed under and subject to such conditions as provided in the Policy.

7. The Performance Guarantee shall secure the Sponsors obligations under and in accordance with the terms of this LOI. The Performance Guarantee shall remain valid and in full force until the date falling three (3) months beyond the validity of the LOI; If the Performance Guarantee is due to expire within thirty (30) days and is required to be maintained by the Sponsors, they shall renew the Performance Guarantee no later than ten (10) days before its expiry, failing which the PPIB shall be entitled to encash the Performance Guarantee in full and hold such cash as security for the obligations of the Sponsors under the LOI.

8. The Sponsors shall hold not less than fifty one percent (51%) of the equity during Lock in Period (commencing from the date of issuance of this LOI until the sixth (6^{th}) anniversary of the commissioning of the Project). The Main Sponsor shall hold not less than twenty percent (20%) of the equity during the Lock in Period.

9. This LOI shall be effective from the date hereof, and remain valid till the issuance of LOS by PPIB or unless terminated earlier in accordance with the terms hereof. **Nevertheless, this LOI shall lapse if the signed copy is not received at PPIB within fifteen (15) days of its issuance.**

10. This LOI shall in no way be construed as an award of the Project as no such vested legal or contractual rights shall accrue, in Sponsors' favor, till such time, valid Project Agreements (as defined in the LOS) are executed in accordance with the terms and conditions contained therein.

11. Issuance of this LOI or any act done in terms hereof or its termination, lapse or expiry or Sponsors' conduct of Feasibility Study hereunder cannot form the basis of any claim for compensation or damages by the Sponsors or any party claiming through

2nd Floor, Emigration Tower, Mauve Area, Sector G-8/1, Islamabad – Pakistan
Tel: (9251)9264034-45 Fax: (9251) 9264030-31
Email: ppib@ppib.gov.pk Internet: http://www.ppib.gov.pk

COMPANY (PVT) LTD. ... HYDRO POWER

them against the Government of Pakistan, PPIB or any of its agencies on any grounds whatsoever, during or after the expiration, lapse or termination of the LOI.

12. The obligations and liabilities of the Sponsors under the LOI and the Performance Guarantee shall be joint and several. Any notice or communication by or to the Main Sponsor under this LOI shall be deemed a notice or communication to or by the entire Sponsors.

13. The rights and obligations of the parties pursuant to and under this LOI shall be governed by the laws of Pakistan and the Courts of Pakistan shall have exclusive jurisdiction in relation to any dispute or matter arising out of or in connection herewith.

14. This LOI has been issued in duplicate on the date hereof. Kindly sign the attached copy of this LOI at the place indicated and return the same to us no later than fifteen (15) days.

Yours sincerely,

(Managing Director)

(Mr. Liu Zhong)
Passport No.P01635914
For and on behalf of
Sinohydro Corporation, China &
Sachal Engineering Works Pakistan

Encl.: 1) Indicative Terms of Reference (TOR) for the Feasibility Study of Hydropower Project (Annex-A)
2) Schedule of specific milestones (Annex-B)

Cc:

1. Secretary, Ministry of Water & Power, Islamabad
2. Secretary, Energy Power Department , Government of Khyber Pakhtunkhwa Peshawar
3. Chief Executive Officer, CPPA-G, Islamabad
4. Managing Director, NTDCL, Lahore (with the request to include the Project in NTDC's future Expansion Plan)
5. Registrar NEPRA, Islamabad

2nd Floor, Emigration Tower, Mauve Area, Sector G-8/1, Islamabad – Pakistan
Tel: (9251)9264034-45 Fax: (9251) 9264030-31
Email: ppib@ppib.gov.pk Internet: http://www.ppib.gov.pk

HYDRO POWER COMPANY (PVT) LTD

Environmental Protection Agency
Forestry, Environment & Wildlife Department
Govt. of Khyber Pakhtunkhwa

No.EPA/EIA/HPP/58MW/Turtonas-Uzghor/Chitral/19/ 214

Date: 24/ 5 /2019

To

Syed M. Hussain Gardezi,
Director (Development),
M/S Sachal Engineering works (Pvt) Limited,
Address:- Plot No 59-E, Street No 7,
Sector I-10/3, Islamabad.
Ph No 051-4446873-74

Subject: **SUBMISSION OF APPLICATION AND DRAFT ENVIRONMENTAL IMPACT ASSESSMENT (EIA) STUDY REPORT FOR APPROVAL OF EPA REGARDING TURTONAS-UZGHOR HYDROPOWER PROJECT ON GOLEN GOL, CHITRAL, KPK (the "Project").**

I am directed to refer to enclose herewith Environmental Approval/ Decision Note on EIA Report for "58MW Turtonas-Uzghor Hydropower Project On Golen Gol, Chitral, Khyber Pakhtunkhwa" for your information and further implementation.

Moreover, Schedule VII must be submitted to this Agency within a month on Stamp Paper as an undertaking for the compliance of terms and conditions as mentioned in the Environmental Approval as well as mitigation measures proposed in the EIA Report. (Copy enclosed)

Deputy Director (EIA)

D:\EIA\Section 2014\Hydro Power Projects\58MW HPP Turtonas Uzghor Chitral

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

SCHEDULE-VI

Decision on EIA

1.	**Name, address of proponent:**	Syed M. Hussain Gardezi, Director (Development), M/S Sinohydro Sachal Consortium, Address:- House No 95 E, Street 7, Sector I-10/3, Islamabad. Ph No 051-4446873-74
2.	**Description of Project.**	Turtonas-Uzghor Hydroelectric Power Project is located between the villages of Turtonas and Uzghor on Golen Gol Nullah, a tributary of Mastuj River in Chitral, Khyber Pakhtunkhwa. The provisional capacity of the project is 82.25 MW and will generate about 382.33 GwH of energy annually. The proposed project is a run of river scheme and is extended over an area of 06 Km length of Golen Gol River starting from weir to power house.
3.	**Location of project.**	The Project is located in District Chitral.
4.	**Date of filing of EIA.**	30/07/2018 (Ref: EPA Diary No.477)

5. After careful review, the Environmental Protection Agency, Govt. of Khyber Pakhtunkhwa has decided to accord approval of the Environmental Impact Assessment (EIA) for "Turtonas Uzhgor 58MW Hydro Power Project District Chitral" for construction phase, in line with the Khyber Pakhtunkhwa Environmental Protection Act, 2014 and IEE/EIA Regulations, 2000, subject to the following terms & conditions:-

a) The Proponent will adopt all precautionary and mitigation measures identified in EIA Report as well as any un-anticipated impacts during the construction and operation phase of project. The mitigation measures proposed in the EIA Report are considered as "commitments" and institutional arrangement for its implementation shall be finalized before the start of construction so that proposed mechanism of environment protection should work in time.

b) Arrangement for compensation to the affectees in case of loss of agriculture land, crops and property etc. will be finalized before the start of construction. Any money involved in compensation will be deposited with District Govt. /Revenue Department for disbursement among the affectees. As far as possible recommendations of a committee comprising of land/house owners and tenants shall be taken into consideration during finalizing the compensation package. All conflicting issues regarding compensation etc. to be settled before

POWER COMPANY (PVT) LTD. HYDRO

executing/commencing of the project activities and a certificate in this regard should be submitted to this Agency.

c) Ecological flow shall be maintained in the river.

d) Safety zone/adequate engineering measures should be provided to overcome fears of the residents regarding effect of pond to their houses.

e) Submergence of Road/Highway should be reconstructed in another suitable place.

f) Damage to forest should be assessed and mitigation/compensation plan be finalized with the Forest Department, prior to construction. To minimize erosion, afforestation programme in consultation with forest Department should be planned and implemented in the catchment area of the proposed dam. A copy of the proposed plan shall be submitted to EPA.

g) Existing water rights shall be protected.

h) Separate Environmental Approval is required for batching/crushing plant and construction of Town/Colony under Khyber Pakhtunkhwa Environmental Protection Act, 2014.

i) No extension would be permitted in the future in the existing hydropower project without prior approval of the EPA/Govt. of Khyber Pakhtunkhwa.

j) The Project management may consider the possibility of implementation of a social development programme in the area (health, education, communication etc) in consultation with local community and District Administration.

k) The proponent shall ensure to avoid dumping of debris into down slope or in water bodies. A proper designated area should be identified for disposal of debris and be stabilized by proper plantation, bio engineering and engineering techniques. The same should be provided to EPA.

l) In case, the blasting is inevitable, the controlled techniques, in accordance with Pakistan Explosive Act should be adopted in sliding and perspective sliding prone areas.

m) The proponent shall ensure the strict and efficient health and safety measures for the protection of workers and passersby backed by a comprehensive emergency response plan.

n) The proponent shall replace all public utilities, such as water supply pipes, power/phone lines and other infrastructures like masjids, schools, graveyards, hospitals etc to be lost by the execution of the project. If it is inevitable then alternative may be provided to the people of the area before construction with respective agencies under the intimation to Khyber Pakhtunkhwa-EPA.

o) Existing Right of Way (RoW) shall not be disturbed. Proper access track shall be developed for construction activities.

p) The issue of net hydel profit raised by Khyber Pakhtunkhwa Govt./under litigation is resolved/decided upon.

q) Non-technical jobs shall be provided to local community. Employment record for all positions shall be provided to EPA-Khyber Pakhtunkhwa and priority should also be given to local in technical jobs.

r) The proponent shall submit bi-annual progress report.

POWER COMPANY (PVT) LTD

s) The proponent shall provide the copy of this approval and EIA report to the contractor for information and compliance.

6. The Proponent shall be liable for correctness and validity of the information supplied by the environmental consultant.

7. The proponent shall be liable for compliance of Sections 13, 14,17 and 18 of IEE/EIA Regulations, 2000, regarding approval, confirmation of compliance, entry, inspections and monitoring.

8. This approval is accorded only for the installation/ construction phase of the project. The Proponent will obtain approval for operation of the hydro power project in accordance with the Section 13 (2) (b) and Section 18 of the IEE/EIA Regulations, 2000.

9. Any change in the approved project shall be communicated to EPA, Khyber Pakhtunkhwa 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.

11. This approval does not absolve the proponent of the duty to obtain any other approval or clearance that may be required under any law in force.

12. In exercise of the power under Section 13 of the Khyber Pakhtunkhwa Environmental Protection Act, 2014, the undersigned is pleased to approve the EIA Report for construction phase of the project with above mentioned terms and conditions.

Dated: Peshawar 24-5-18

Tracking/File. No.EPA/EIA/HPP/58MW/Turtonas-Uzghor/Chitral/19/ 724

DIRECTOR GENERAL,
EPA, Khyber Pakhtunkhwa,
3rd Floor, SDU Building,
Khyber Road Peshawar Cantt.

COMPANY (PVT) LTD. HYDRO POWER

PRIVATE POWER & INFRASTRUCTURE BOARD
MINISTRY OF ENERGY (POWER DIVISION)
GOVERNMENT OF PAKISTAN

No. 1(101) PPIB-2051-02/19/PRJ/0-53088 3rd June 2019

Mr. Liu Zhong
Passport No. P01635914
Authorised Represntative of Sinohydro Corporation
Local Office: Power China Pakistan Office,
5th Floor Saudi Pak Tower, Blue Area, Islamabad
Head Office: Sinohydro Corporation,
No.22 Chengongzhuang West Road, Hiadian
District Beijing 10048, China

Subject: **Approval of Feasibity Study for 82.25 Turtonas-Uzghor Hydropower Project on River Golen Gol Conducted by Consortium of Sinohydro Corporation, China and Sachal Engineering Works (Pvt.) Ltd, Pakistan**

References: (i) Policy for Power Generation Projects, 2015
(ii) Letter of Intent dated 20th March 2017 (the LOI)
(iii) Submission of revised draft feasibility study report dated 5th March 2019 and subsequent responses, presentations.
(iv) Minutes of Panel of Experts (POE) meetings

Dear Sir,

PPIB with the concurrence of POE is pleased to convey that:

The Feasibility Study for Turtonas-Uzghor Hydropower Project on River Golen Gol carried out by Consortium of Sinohydro Corporation, China and Sachal Engineering Works (Pvt.) Ltd, Pakistan with installed capacity of 82.25 MW and construction period of four (4) years is approved subject to the followings:

(i) The approval of the feasibility study shall not absolve the sponsors from their responsibility about accuracy, reliability, viability & cost effectiveness of the technical, social, environmental, financial aspects, etc.
(ii) The Sponsors/Company shall ensure procurement of equipment/machinery and other components for the Project as per the recognized international standards. The bids for selection of EPC Contractor through International Competitive Bidding (ICB) shall be based upon the design parameters approved in the Feasibility Study.
(iii) Interconnection arrangement will be finalized upon completion of integrated grid interconnection study of Chitral region by NTDC/GoKP and its approval by NTDC.
(iv) Panel of Experts (POE) certify completion of the Feasibility Study as per the terms and conditions of the Letter of Intent dated 20th March 2017 issued by PPIB. However, due to nature of data and resultant conclusions, POE jointly and/or individually will not be responsible for reliability of data, contents and data analysis etc. given in the Feasibility Study.
(v) An IRR of 17% has been assumed in feasibility study by the Sponsor whereas NEPRA has recently allowed 15% IRR in other hydropower projects, therefore, we understand that NEPRA has the mandate to finally determine the appropriate IRR at the time of determination of feasibility study stage tariff in view of current market dynamics, sectoral technological advancements and risk profile of power sector etc.

POWER COMPANY (PVT) LTD. UZGHOR HYDRO

2. In accordance with the provisions of the LOI, within ninety (90) days after the approval of Feasibility Study by GOP/PPIB, Sponsors are required to finalize and file a complete feasibility stage tariff petition before National Electric Power Regulatory Authority in accordance with NEPRA's Mechanism for Determination of Tariff for Hydropower Projects.

3. The Sponsors are therefore advised to approach NEPRA accordingly within the stipulated time period starting from the date hereof.

4. We appreciate your efforts towards completion of feasibility study of Turtonas-Uzghor Hydropower Project and expect the same pace & spirit towards further development of the Project in timely manner.

With best regards,

(Shah Jahan Mirza)
Managing Director

Copy for information:

- Secretary, Ministry of Energy (Power Division), Government of Pakistan
- CEO, CPPA-G, Islamabad
- MD NTDC, WADPA House Lahore
- Secretary Energy, Government of Khyber Pakhtukhwa, Peshawar
- Registrar, NEPRA, Islamabad
- Mr. Mahmood Hussain Gardezi, Director (development), Authorised Representative of Sachal Engg. Works (Pvt.) Limited, Islamabad

COMPANY (PVT) LTD. UZGHOR HYDRO POWER

PRIVATE POWER & INFRASTRUCTURE BOARD
MINISTRY OF ENERGY (POWER DIVISION)
GOVERNMENT OF PAKISTAN

No. 1(101) PPIB-2051-02/19/PRJ/O-53077 31st May 2019

Subject: Minutes of 5th and 6th Meetings of Panel of Experts for Monitoring Feasibility Study of Turtonas-Uzghor Hydropower Project

Fifth (5th) and Sixth (6th) meetings of the Panel of Experts (POE) were held on 15th March 2019 and 9th May 2019 respectively at PPIB office, Islamabad wherein revised draft Feasibility Study of Turtonas-Uzghor Hydropower Project submitted by the Sinohydro-Sachal Consortium was discussed and approved.

2. Enclosed please find herewith Minutes of the said Meetings for necessary compliance as may be applicable.

With best regards,

(Shah Jahan Mirza)
Managing Director

Distribution:

1. Mr. Mansoor Hussain, Chief Technical Oficer (Technical) CPPAG, Islamabad
2. Mr. Nazakat Hussain, Director (Planning) HPO, WAPDA, Lahore
3. Mr. Zainullah Shah, Chief Planning Officer, Energy and Power Deptt, Peshawar
4. DG EPA, Government of Khyber Pakhtunkhwa, Peshawar
5. Mr. Muhammad Amir Akram Rao, Assit. Engineering Advisor (Power), Office of the Chief Engineering, Advisor Ministry of Energy (Power Division), Islamabad
6. Mr. Muhammad Waseem Younas, Manager Transmission Planning, NTDCL, WAPDA House Lahore
7. Engr. Arshad Fayaz, Geology & Geotechnical Expert, Lahore
8. Engr. Azhar Masood Panni, Electro-Mechanical Expert, Abbottabad
9. Engr. Dr. Sajjad Haider, Associate Professor, NICE-NUST Islamabad
10. Engr. Munawar Iqbal, Director (Hydel), PPIB
11. Mr. Adil Sharif, Director (Legal), PPIB
12. Mr. Safeer Ahmed, Director (Finance & Policy), PPIB
13. M. Fazal ur Rahman, Regional Head (North), ACE (Pvt) Ltd, 1-C/2, M.M. Alam Road, Gulberg-III, Lahore-54660
14. Mr. Liu Zhong, Authorized Representative, Sinohydro Corporation, Power China Pakistan Office, 5th Floor Saudi Pak Tower, Blue Area, Islamabad
15. Mr. Mahmood Hussain Gardezi, Director (Development), Authorized Representative of Sachal Engg.Works (Pvt.) Ltd, Islamabad

CC:

The Chairman, National Electric Power Regulatority Authority (NEPRA), Islamabad

Encl: (as above)

Ground & 2nd Floors, Emigration Tower, Plot No. 10, Mauve Area, G-8/1, Islamabad - Pakistan.
Tel: (92-51) 9264034-41 Fax: (92-51) 9264030-31
Email: ppib@ppib.gov.pk Internet: http:// www.ppib.gov.pk

File No. 1(101) PPIB-2051-02/19/PRJ/0-53077

PRIVATE POWER AND INFRASTRUCTURE BOARD
MINISTRY OF ENERGY (POWER DIVISION)
GOVERNMENT OF PAKISTAN

****

Subject: Minutes of 5th and 6th Meetings of Panel of Experts for Monitoring Feasibility Study of Turtonas-Uzghor Hydropower Project held on 15th March 2019 and 9th May 2019

5th Meeting of POE held on 15th March 2019:

5th meeting of Panel of Experts (the "**POE**") to review the draft Feasibility Study of Turtonas-Uzghor Hydropower Project (the "**Project**") carried out by Sinohydro-Sachal consortium – (the "**Sponsors**") through their consultant, was held in the Board Room of PPIB on 15th March 2019. The meeting was chaired by Managing Director, PPIB. The POE Members, the representatives of M/s Associated Consulting Engineers -ACE (PPIB's General Consultant) and representatives of Sponsors' along-with their consultant participated in the meeting. The List of participants is at **Annex-I.**

2. The meeting started with the recitation from the Holy Quran. The Chair welcomed the participants and asked the Sponsors about their response on the comments earlier provided by the POE and General Consultant for review and incorporation in the final feasibility study. The Sponsors and their Consultant stated that most of the comments have been incorporated in Feasibility Study; however, few clarifications on some comments are being provided for the consideration of the POE and the General Consultant.

3. Subsequently, the clarifications were presented by the Sponsor/Consultant on some of the earlier comments of the POE. Mainly the aspects like hydrology, sedimentation, flood analysis method, hydraulic design, design discharge, placement of connecting canal and sedimentation basin across a fan of Nullah, Engineering implications of high permeability of the overburden forming foundations and abutments of the weir, the foundation details of powerhouse keeping in view of scree and over burden along-with necessary cost analysis, unit rate analysis of principal items of civil works, EPC & non-EPC costs and the financial analysis/tariff came under detailed discussion.

4. In the meeting the issue of waiver for carrying out load flow/grid interconnection study for the project, as it is required to be conducted as per the Letter of Intent (LOI) as part of the Feasibility Study, was also discussed. NTDC's position was that an integrated study is being carried out shortly for all hydropower projects in the region. Therefore waiver of NEPRA may also be required, in addition to its waiver, at the time of determination of tariff. The POE agreed with the point of NTDC and advised NTDC to provide a facilitation/supporting letter in this regard and the Sponsors will request NEPRA for the waiver in this respect at the time of feasibility study tariff stage as the process for carrying out of the Integrated Power Evacuation Study for Chitral, Dir and Swat Corridors may take some times to be completed.

5. In principle, POEs and General Consultant expressed their satisfaction on all the aspects of the feasibility study except few clarifications on some aspects like carrying out the design for placement of connecting canal and sedimentation basin across a fan of Nullah, engineering implications of high permeability of the overburden forming foundations and abutments of the weir, the foundation details of powerhouse, project costs, Internal Rate of Return (IRR) , pre-construction expenses, provision of data for review and re-checking of Power and Energy calculations, which Sponsors/Consultant agreed to provide.

6. It was decided that the sponsors will provide required information and the matter will be further considered by POE after getting such information.

The meeting ended with vote of thanks from the chair.

6th Meeting of POE held on 9th May 2019:

6. In light of proceedings of 5th meeting; the 6th meeting of POE was held on 9th May 2019 to review the clarifications provided by the Sponsors/Consultant of the Project. The meeting was chaired by Managing Director PPIB. List of participants is at **Annex-II.**

7. The Chair welcomed the participants of meeting and recapped major points of discussion and outcomes of last meeting. The Chair then requested Panel of Experts (POE) and the General Consultant (GC) for their inputs on the clarification provided by the Sponsors/Consultants.

8. On the issue of carrying out the design for placement of connecting canal and sedimentation basin across a fan of Nullah, the POE/GC asked the Project Consultant for further clarification during the meeting. The Consultant stated that there is no threat foreseen regarding any hit by the flood as the Nullah is dry and no water since last many years has been seen in it. He further described that even if water comes in the Nullah, there is wide space available to accommodate it. After the clarification of the Project Consultant, the POE and the GC were satisfied.

9. Regarding the clarification/data provided on Power and Energy calculation carried out by Sponsor/Consultant, POE and GC found it appropriate for the feasibility study report. Similarly, on the issue of an IRR, it was observed by POE that an IRR of 17% has been assumed in feasibility study whereas NEPRA has recently allowed 15% IRR in some other hydropower projects, therefore, it was considered that NEPRA at the time of determination of feasibility study stage tariff may give consideration to current market dynamics, sectorial technological advancements and risk profile of power sector while determining an IRR for the Project.

10. In the meeting, Manager Planning NTDC participated through phone link and confirmed that the facilitation letter regarding limitation of carrying out load flow and interconnection study for the individual project has been issued by NTDC keeping in view that integrated grid interconnection study required for power evacuation from the Project as well as other upcoming power projects in Dir, Chiral, Swat, region is under preparation. The NTDC's letter received in PPIB was shared with the POE and the Sponsors in the meeting. NTDC further suggested for an additional provision in the budget for 220 kV line for interconnection instead of 132 kV. The chair suggested that for the time being in the feasibility study level cost for interconnection may be considered for 132 kV line, however in case the inter connection voltage is changed to 220 kV, the cost may be adjusted accordingly in the tariff subsequently.

11. After clarifications provided by the Sponsor and their Consultant, the POE noted with satisfaction that their suggestions made from time to time in the previous meetings were considered and duly incorporated in the Final Feasibility Report. The POE then agreed to approve the Final Feasibility Study with a capacity of 82.25 MW for Turtonas Uzghor Hydropower Project.

12. The meeting ended with vote of thanks from the Chair.

Decision:

The Feasibility Study for Turtonas-Uzghor Hydropower Project on River Golen Gol carried out by Consortium of Sinohydro Corporation, China and Sachal Engineering Works (Pvt.) Ltd, Pakistan with installed capacity of 82.25 MW and construction period of four (4) years is approved subject to the followings:

(i) The approval of the feasibility study shall not absolve the sponsors from their responsibility about accuracy, reliability, viability & cost effectiveness of the technical, social, environmental, financial aspects, etc.

(ii) The Sponsors/Company shall ensure procurement of equipment/machinery and other components for the Project as per the recognized international standards. The bids for selection of EPC Contractor through International Competitive Bidding (ICB) shall be based upon the design parameters approved in the Feasibility Study.

(iii) Interconnection arrangement will be finalized upon completion of integrated grid interconnection study of Chitral region by NTDC/GoKP and its approval by NTDC.

(iv) Panel of Experts (POE) certify completion of the Feasibility Study as per the terms and conditions of the Letter of Intent dated 20th March 2017 issued by PPIB. However, due to nature of data and resultant conclusions, POE jointly and/or individually will not be responsible for reliability of data, contents and data analysis etc. given in the Feasibility Study.

(v) An IRR of 17% has been assumed in feasibility study by the Sponsor whereas NEPRA has recently allowed 15% IRR in other hydropower projects, therefore, we understand that NEPRA has the mandate to finally determine the appropriate IRR at the time of determination of feasibility study stage tariff in view of current market dynamics, sectoral technological advancements and risk profile of power sector etc.

LIST OF PARTICIPANTS

5^{TH} MEETING OF POE FOR MONITORING FEASIBILITY STUDY OF 58 MW TURTONAS-UZGHOR HYDROPOWER PROJECT HELD ON 15^{TH} MARCH 2019

A. POE MEMBERS

(Present)

1. Mr. Shah Jahan Mirza, Managing Director, PPIB — Chairman
2. Dr. M. Bashir Khan, Director General EPA, Khyber Pakhtunkhwa
3. Dr. Munawar Iqbal, Director (Hydel), PPIB
4. Syed Iqbal Mehdi, Dy. General Manager, CPPAG *(Represented by Mr. M. Shauqat Ali, Manager (H&S) and Amir Nigar, Assistant Manager (Technical) CPPAG)*
5. Mr. Zainullah Shah, Chief Planning Officer, Energy and Power Department, Khyber Pakhtunkhwa *(Represented by Mr. Abdur Rahim , Dy Director (PEDO))*
6. Engr. Azhar Masood Panni, Electro-Mechanical Expert
7. Engr. Dr. Sajjad Haider, Associate Professor- NICE-NUST Islamabad

(Not Present)

8. Engr. Arshad Fayaz, Geology & Geotechnical Expert (sent his comments through email)

PPIB GENERAL CONSULTANT (M/s Associated Consulting Engineers)

9. Mr. M. Mubashir Qureshi, Chief Engineer, ACE
10. Mr. Liaqat Ali, Team Leader Karot/ACE

B. SPONSORS & CONSULTING FIRM (M/s TEAM and Fichtner GmbH, Germany)

1. Syed M.H. Gardezi, Director (Dev), Sachal Engineer (Pvt.) Ltd
2. Syed Ali, Manager (Projects), Sachal Engineer (Pvt.) Ltd
3. Mr. Haji Farooq Ahmed, TEAM Consultant
4. Mr. M. Yousaf Joiya, TEAM Consultant
5. Mr. Assad Raza, TEAM Consultant
6. Mr. Faisal Rehman, Business Manager
7. Mr. Zain Ijaz , TEAM Consultant

C. OTHER PARTICIPANTS

1. Mr. Mahesh Kumar Chaudhary, Senior Manager (Projects), PPIB
2. Mr. Nadeem Uddin, Manager (Projects), PPIB
3. Mr. Shahid Mehmood, Manager Finance, PPIB

Annex-II

LIST OF PARTICIPANTS

MEETING OF POE FOR MONITORING FEASIBILITY STUDY OF 58 MW TURTONAS-UZGHOR HYDROPOWER PROJECT HELD ON 9TH MAY 2019

A. **POE MEMBERS**

(Present)

1. Mr. Shah Jahan Mirza, Managing Director, PPIB — Chairman
2. Dr. Munawar Iqbal, Director (Hydel), PPIB
3. Mr. Safeer Ahmed, Director (Finance & Policy), PPIB
4. Mr. Mansoor Hussain, Chief Technical Officer CPPAG
5. Engr. Dr. Sajjad Haider, Associate Professor- NICE-NUST Islamabad
6. Mr. Waseem Younas, Manager Transmission Planning, NTDCL (through conference call)

(Not Present)

7. Mr. Adil Sharif, Director (Legal), PPIB
8. Mr. Nazakat Hussain, Director (Planning) HPO, WAPDA
9. Mr. Zainullah Shah, Chief Planning Officer, Energy and Power Department, KP
10. Engr. Azhar Masood Panni, Electro-Mechanical Expert *(the comments were already addressed in revised FS which were sent through email dated 24th January 2019)*
11. Engr. Arshad Fayaz, Geology & Geotechnical Expert *(the comments were already addressed in revised FS which were sent through his email)*
12. Mr. Muhammad Amir Akram Rao, Assistant Engineering Advisor (Power), Office of the Chief Engineering Advisor, Ministry of Energy (Power Division)
13. Representative from EPA, Khyber Pakhtunkhwa

PPIB GENERAL CONSULTANT (M/s Associated Consulting Engineers)

14. Mr. Mubashir Qureshi, Chief Engineer, ACE
15. Mr. Muhammad Farooq Bhutta (GM), ACE

B. **SPONSORS & CONSULTING FIRM (M/s TEAM and Fichtner GmbH, Germany)**

1. Syed M.H. Gardezi, Director (Dev), Sachal Engineer (Pvt.) Ltd
2. Syed Ali, Manager (Projects), Sachal Engineer (Pvt.) Ltd
3. Mr. Wang Hanqing (Commercial Manager) Sinohydro, China
4. Mr. Haji Farooq Ahmed, TEAM Consultant
5. Mr. M. Yousaf Joiya, TEAM Consultant
6. Mr. Zain Ijaz , TEAM Consultant
7. Mr. Umar Majeed , TEAM Consultant
8. Mr. Zain Ijaz , TEAM Consultant

C. **OTHER PARTICIPANTS**

1. Mahesh Kumar Chaudhary, Senior Manager (Projects), PPIB
2. Mr. Nadeem Uddin, Manager (Projects), PPIB
3. Mr. Ahmed Sajjad, Deputy Manager (CPPAG)

Annex – D/13-A

NTDC Waivers Letters

NATIONAL TRANSMISSION & DESPATCH CO. LTD

General Manager Planning System Power, NTDC

No. GMPSP/CETRP/TRP-300/2239-43 Dated: 26-03-2019

Syed M. Hussain Gardezi
Director (Development)
M/s Sinohydro-Sachal Consortium
59E, Street No.7, Sector: I-10/3, Islamabad.

Subject: Grid Interconnection Study of Turtonas-Uzghor Hydro Power Project on Golen Gol, Chitral, KPK

Ref: (i) Your office letter Ref No: SSC/NTDC/TUHPP/2019/035 dated March 20, 2019.

(ii) Our office letter No. GMPSP/CETP/TRP-300/2057-60 dated 18-03-2019 (copy attached).

With reference to the above letter (i), it is stated that this office has already sent reply to PPIB vide above referred letter (ii) in which the need for an integrated grid interconnection study has been highlighted to propose the interconnection scheme for the subject power plant and the other power projects in the region.

26/03/2019

(Muhammad Waseem Younas)
Chief Engineer (Transmission Planning)

Cc:

1. Managing Director (PPIB), Emigration Tower, Plot No. 10, Mauve Area, Sector G-8/1, Islamabad.
2. Deputy Managing Director (P&E), NTDC.
3. P.S. to Managing Director (NTDC)
4. Mr. Liu Zhong, Representative of M/s Sinohydro Corporation Ltd., 59E, Street No. 7, Sector I-10/3, Islamabad.
- Master File

TURTONAS-UZGHOR HYDRO POWER COMPANY (PVT) LTD.

Copy.

NATIONAL TRANSMISSION & DESPATCH CO. LTD (NTDC)

General Manager Power System Planning, NTDC

No. GMPSP/CETP/TRP-300|2057-60 Dated: 18-03-2019

Mr. Shah Jahan Mirza
Managing Director, PPIB,
Ground & 2nd Floors, Emigration Tower
Plot No. 10, G-8/1, Islamabad.
Fax: 051-9264030-31

Subject: Grid Interconnection Study of Turtonas-Uzghor Hydro Power Project on Golen Gol, Chitral, Khyber Pakhtunkhwa

Ref: 5th PoE meeting held in PPIB Islamabad on 15-03-2019 for monitoring feasibility study of the subject of Turtonas-Uzghor Hydro Power Project (HPP).

With reference to above, it is stated that an integrated grid interconnection study is required to propose the interconnection scheme involving voltage level and no. of transmission lines for the power evacuation of the subject power plant while considering all the upcoming HPPs in the same region through all the available corridors. The integrated grid interconnection study for power evacuation of all the HPPs in Khyber Pakhtunkhwa involving Dir, Chitral, Swat, Mansehra, Kohistan regions, shall be carried out by engaging private consultant and shall involve route/corridor survey & interconnection studies. The said study shall jointly be conducted by PEDO and NTDC in association with other stakeholders. After completion of the said integrated study, the interconnection schemes of the subject Turtonaz-Uzghor HPP and other HPPs in Khyber Pakhtunkhwa shall be determined.

PPIB is requested to convey the above information to the relevant stakeholders of the subject HPP.

18|3|2019

(Engr. Khawaja Riffat Hassan)
General Manager Power System Planning

CC:

1. Deputy Managing Director (P&E), NTDC
2. Deputy Managing Director (AD&M), NTDC
3. P.S. to Managing Director, NTDC
- Master File

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

PESHAWAR ELECTRIC SUPPLY COMPANY
PROJECT MANAGEMENT UNIT PESCO PESHAWAR
Phone # 091-9210987, Fax # 091-9213018

No. CE (Dev)/6287-88/ TZ-50/ Dated 15/12/2017

Director (Development)
Sinohydro-Sachal Consortium
59-E, Street: 7, Sector: I-10/3, Islamabad

Subject: **TURTONAS – UZGHOR HYDRO ELECTRIC POWER PROJECT, GOLEN GOL CHITRAL KPK**

In/Out of 132 kV Transmission Line at the 132 kV switchyard of Golen Gol Hydro Power Project

Reference your letter No. SSC/NTDC-PESCO/UHPP/2017/072 dated 28.11.2017.

As mentioned in your above referred letter the generation capacity has not finalized so far. Also the subject Power Project will be connected through In/Out arrangement of about 6 KM Transmission line at the 132 kV Switchyard of Golen Gol HPP.

It is therefore, suggested that finalize the generation capacity of the project and the interconnection study may be carried out through Private Consultant as practice in vogue.

Chief Engineer (Development)
PMU PESCO Peshawar

Copy to:
1. Chief Commercial Officer PESCO Peshawar

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

Chief Technical Officer (CPPA-G)

No. CEO (CPPA-G)/DGM-V/4586-89 Dated: 26 Feb, 2018

GM (Power System Planning), NTDCL
4th Floor, PIA Tower, Egerton Road, Lahore

Subject: **REQUEST FOR PROVISION OF DATA FOR CONDUCTING GRID INTERCONNECTION STUDY OF TURTONAS-UZGHOR HYDRO POWER PROJECT ON GOLEN GOL, CHITRAL, KPK**

Ref: M/s Sinohydro-Sachal consortium letter no. SSC/CPPA (G)/ TUHPP/2018/017 dated 26.02.2018

Please find enclosed herewith the above mentioned letter vide which Project Company has requested to provide the data regarding Grid Interconnection Study to their consultants Power Planner International (Pvt.) Ltd.

The same letter is enclosed herewith for your review and necessary action at your end.

26/2

Dy. Manager Technical CPPA-G

Copy to:

1. MD PPIB, Emigration Tower, Plot No. 10, Mauve Area, G-8/1, Islamabad.
2. Power Planners International, 95 – H/2, Wapda Town, Lahore.
3. CEO, Sinohydro-Sachal consortium, Head office: 59E, Street: I-10/3 Islamabad (Tel# 00-92-51-4446873-74-4436004)

- Master File.

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

Annex – D/14

Project Interconnection

Project Interconnection

The power evacuation plan and related grid interconnection study is an important part of the feasibility study. In this regard, the Sponsors after receiving consent from PESCO and recommendation from CPPA have approached National Transmission & Despatch Company Limited ("NTDC") to issue their consent as well as sharing necessary data of nearby grid availability in order to conduct the project specific grid interconnection/load flow study. The NTDC which is also the member of Project Panel of Experts ("POE"), after several deliberations with the sponsors, PPIB as well as during POE meetings, informed the sponsors/other POE members that due to limited availability of power evacuation corridor in Chitral region, the Project Sponsors do not require to conduct project specific interconnection study, as NTDC will conduct integrated interconnection study for the purpose of power evacuation from upcoming hydropower projects in Chitral corridor. Turtoans-Uzghor hydropower project will also be part of integrated interconnection study.

However, it is pertinent to mention here that the volume of power generated by the plant shall be in the range of 80-85MW, Net power to be transferred to the nearest connection point has been considered by the feasibility study consultant at 132kV voltage level. **The nearest 132kV switchyard is at 108MW Golan Gol HPP which is about 5 km from the Project switchyard** and second nearest 132kV grid station is Jutilash which is about 35 km. Keeping in view the difference in length of transmission line ("TL") and associated cost along with other disadvantages, it is recommended by the feasibility study consultants that 132kV TL (D/C) from Project switchyard shall be connected to Golan Gol HPP switchyard or to its outgoing 132kV TL through In/Out connections.

However, the final scheme of power evacuation shall be decided by NTDC after the completion of NTDC's Integrated Power Evacuation Study for Projects located in Chitral. In this regard, the Sponsors of the Project have contacted NTDC requesting them to issue waiver for conducting project specific interconnection study. **NTDC, who *inter alia* is also the POE member of the Project, has issued the waiver on dated 18.03.2019 & 26.03.2019.**

In this regard, Pakhtunkhwa Energy Development Organization ("PEDO") has issued their Expression of Interest (EOI) for the hiring of Consultancy Services in order to carry out the feasibility study for power evacuation from Chitral to Chakdara Grid Station (the PEDO advertisement is attached).

Applicant's proposed Power Evacuation Scheme from the Project and details are mentioned as under:

Option 1:
In/Out arrangement of one circuit of outgoing TL (D/C) from Wapda owned 108 MW Golan Gol HPP is the best option due to its merits. The option is most economical as it involves no circuit breakers and allied electrical equipment at Golan Gol HPP which is almost 5 Km away from the subject project.

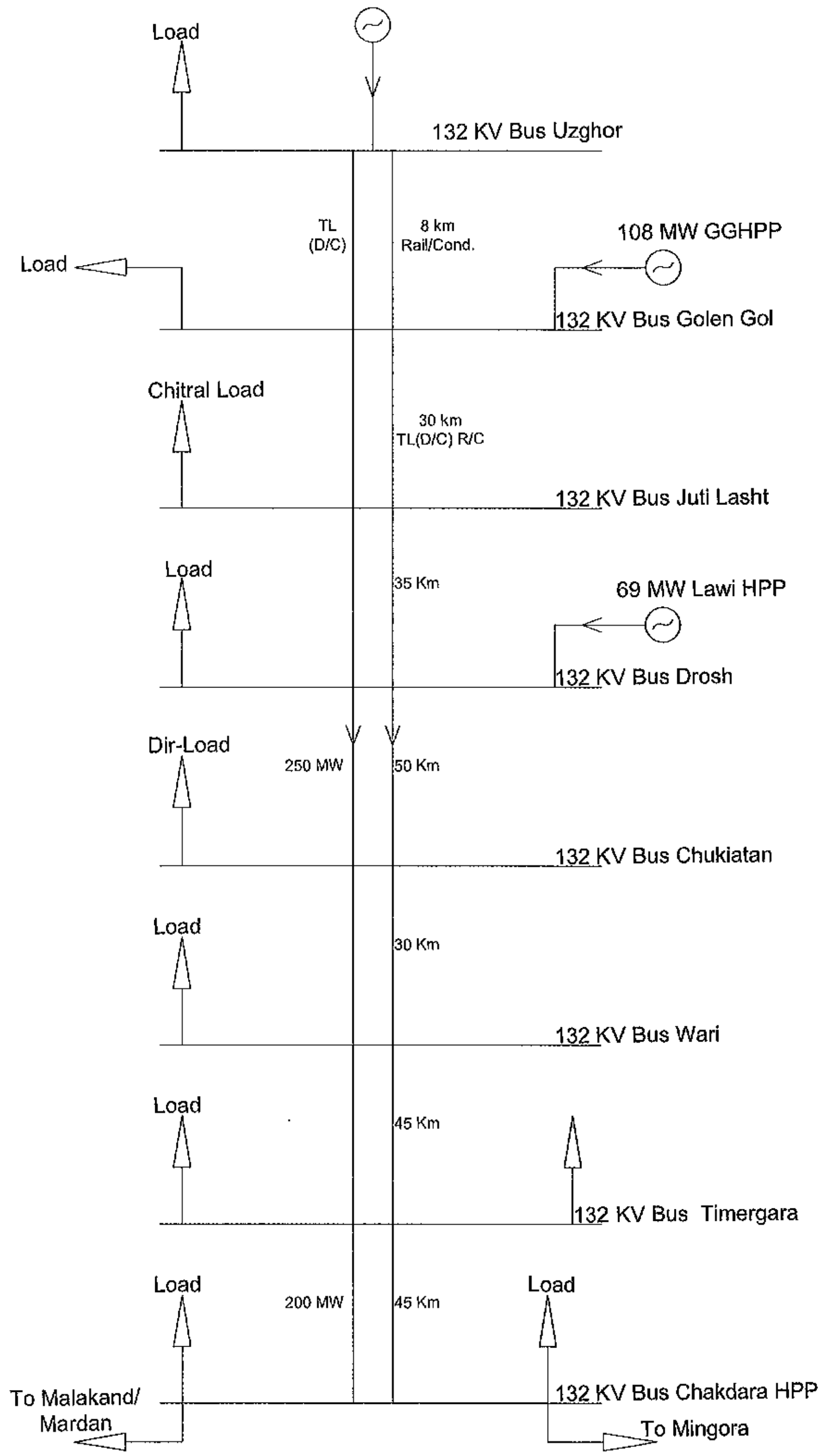
Option 2:
Connection of both the outgoing circuits of TUHEPP at Golan Gol HPP existing switchyard by its extension is also the preferable choice from technical point of view. However, it involves more capital cost as it needs extension of the existing 132kV switchyard.

Option 3:
In/out of both the circuits of Golan Gol HPP at 82.25MW TUHEPP is 3rd option which is technically viable but involves more capital cost and power losses.

Conclusion:

Based on the option 1, a complete scheme of TL delivering the power to Chitral, Dir and Chakdara 132kV Grid stations has been developed and shown in below drawings. The existing 132kV (D/C) TL on Rail conductor shall be capable for evacuation of power if it is interconnected at various towns as shown in the said drawing.

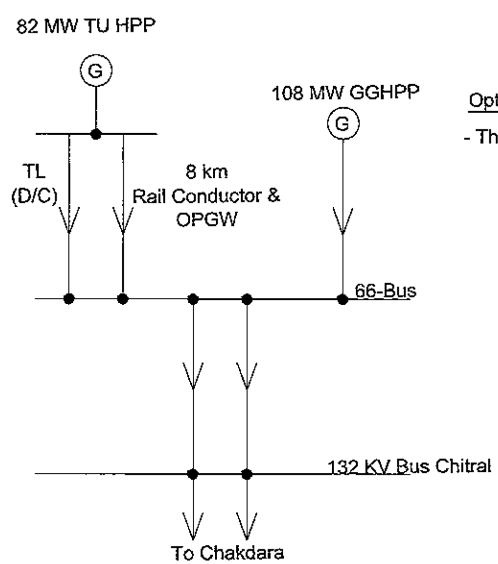
82 MW TUHPP



Client:	SINOHYDRO-SACHAL CONSORTIUM
Consultants:	tcm FICHTNER - JV
PROJECT:	TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT
	Feasibility Study Report
	Power Dispersal Scheme
Drawn.	Umar Ghafoor
Design.	M.Yousaf Joiya
Checked.	M.Parvaiz
Approved.	Haji Farooq
Scale:	
Dated:	Nov-2018
Drawing No.	**TUHPP-383**

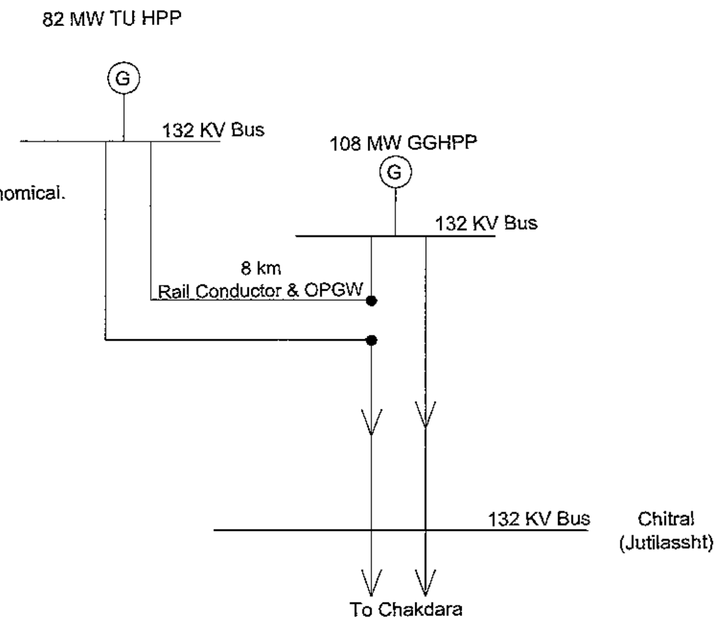
Option-2

- The Option is suitable
- It involves more capital cost at GG HPP 132 KV Switchyard.



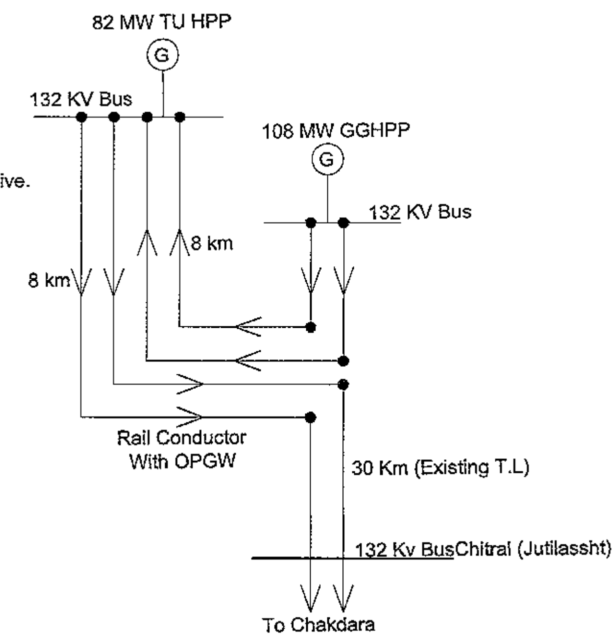
Option-1

- The Option is most economical.

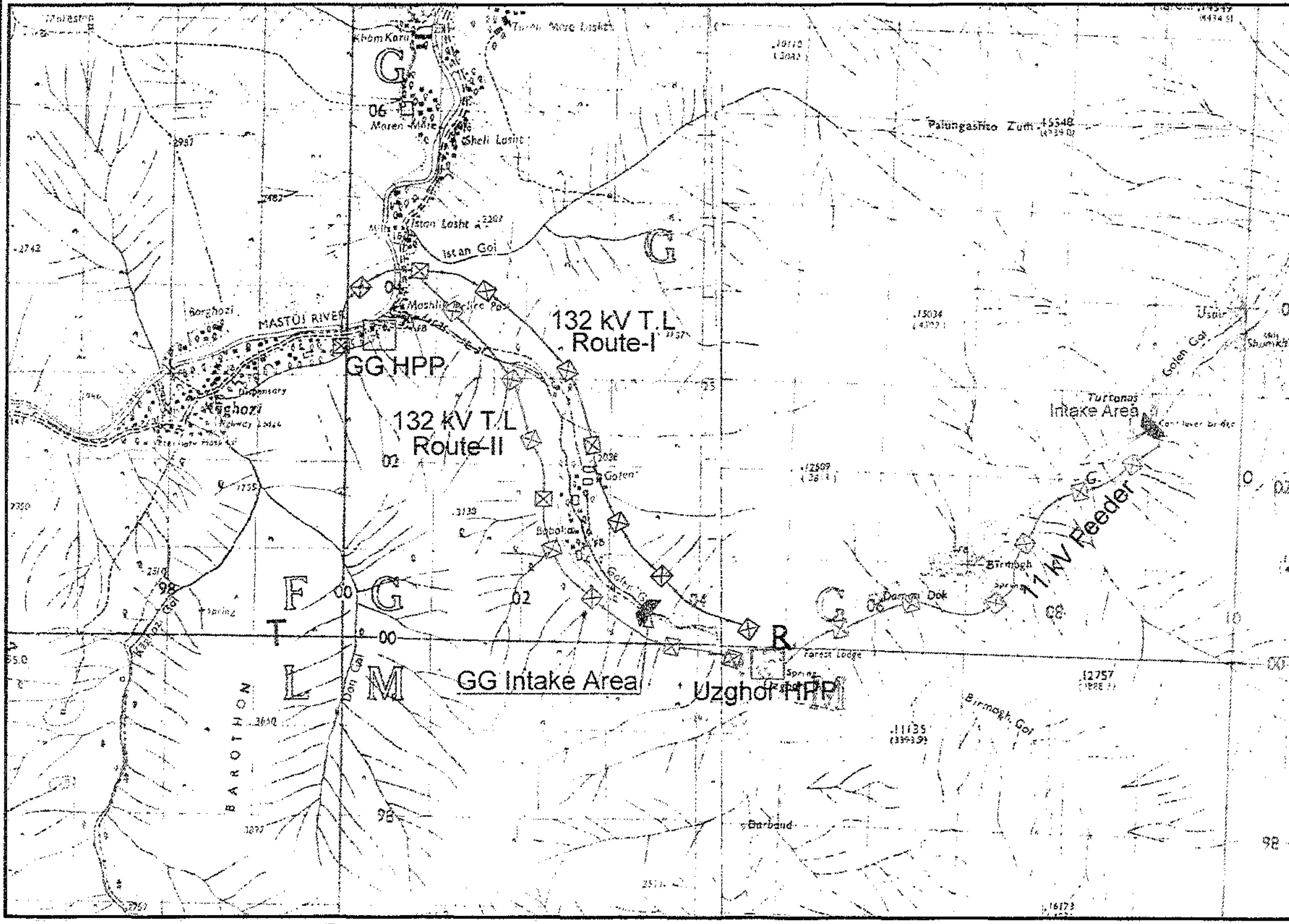


Option-3

- The Option is most expensive.



Client:	SINOHYDRO-SACHAL CONSORTIUM	
Consultants:	team consultants	FICHTNR - JV
PROJECT:	TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT	
	Feasibility Study Report	
	Interconnection Option-1,2 &3	
Drawn.	Umar Ghafoor	
Design.	M.Yousaf Joiya	
Checked.	M.Parvaiz	
Approved.	Haji Farooq	
Scale:		Drawing No.
Dated:	Nov-2018	**TUHPP-384**



Client:	SINOHYDRO-SACHAL CONSORTIUM
Consultants:	FICHTNER - JV
PROJECT:	TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT
Feasibility Study Report	
Transmission Line Route Map	
Drawn.	Muhammad Shan
Design.	Muhammad Yousaf Jaiya
Checked.	Muhammad Parvaiz
Approved	Haji Farooq Ahmed
Scale:	
Dated:	June-2015
Drawing No.	TUHPP-385

Copy

NATIONAL TRANSMISSION & DESPATCH CO. LTD (NTDC)

General Manager Power System Planning, NTDC

No. GMPSP/CETP/TRP-300|2057-60 Dated: 18-03-2019

Mr. Shah Jahan Mirza
Managing Director, PPIB,
Ground & 2nd Floors, Emigration Tower
Plot No. 10, G-8/1, Islamabad.
Fax: 051-9264030-31

Subject: Grid Interconnection Study of Turtonas-Uzghor Hydro Power Project on Golen Gol, Chitral, Khyber Pakhtunkhwa

Ref: 5th PoE meeting held in PPIB Islamabad on 15-03-2019 for monitoring feasibility study of the subject of Turtonas-Uzghor Hydro Power Project (HPP).

With reference to above, it is stated that an integrated grid interconnection study is required to propose the interconnection scheme involving voltage level and no. of transmission lines for the power evacuation of the subject power plant while considering all the upcoming HPPs in the same region through all the available corridors. The integrated grid interconnection study for power evacuation of all the HPPs in Khyber Pakhtunkhwa involving Dir, Chitral, Swat, Mansehra, Kohistan regions, shall be carried out by engaging private consultant and shall involve route/corridor survey & interconnection studies. The said study shall jointly be conducted by PEDO and NTDC in association with other stakeholders. After completion of the said integrated study, the interconnection schemes of the subject Turtonaz-Uzghor HPP and other HPPs in Khyber Pakhtunkhwa shall be determined.

PPIB is requested to convey the above information to the relevant stakeholders of the subject HPP.

18|3|2019

(Engr. Khawaja Riffat Hassan)
General Manager Power System Planning

CC:

1. Deputy Managing Director (P&E), NTDC
2. Deputy Managing Director (AD&M), NTDC
3. P.S. to Managing Director, NTDC

- Master File

TURTONAS UZGHOR HYDRO POWER COMPANY (PVT) LTD.

PEDO

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION
Government of Khyber Pakhtunkhwa Peshawar
Energy & Power Department

ADVERTISEMENT

Pakhtunkhwa Energy Development Organization Government of Khyber Pakhtunkhwa (PEDO), Hiring Consultancy Services for the Project "Feasibility Study for Power Evacuation from Chitral to Chakdara Grid"

Government of Khyber Pakhtunkhwa intends to develop Transmission Line project in the public sector through PEDO. In this regard proposals are invited from engineering consultancy firms for conducting the Feasibility Study of the ADP scheme No: 261 **"Feasibility Study for Power Evacuation from Chitral to Chakdara Grid"**

Terms & Conditions:

1. The firm(s) should be registered with Pakistan Engineering Council (PEC) as per applicable law.
2. In case of Joint Venture the foreign consultant must fulfill the requirement of Form 4(c).
3. The proposal should consist of:
   - (i) the background and experience of the firm in Feasibility Studies of Transmission Line projects having 220Kv or more than 220Kv voltage level capacity (maximum 3 projects) during last ten years.
   - (ii) Registration with Income Tax Department / NTN / Sales Tax Number with Active Status for local firms.
   - (iii) Registration with KPPRA for the purposes of sales tax on services with active status.
4. The consultant will be selected under the selection method quality cum cost based (QCBS) and procedures in accordance with the Khyber Pakhtunkhwa Procurement Regulatory Authority (KPPRA) rules.
5. Interested firms are requested to obtain Request for Proposals (RFP) on payment of Rs.2000/-(in shape of demand draft in favour of CEO PEDO) from the office of the undersigned during working hours.
6. The sealed proposals should reach at the given address before 1400 hours on December 31, 2019 and technical proposals shall opened on the same day at 1430 hours. Proposal received after this date & time will not be entertained.
7. PEDO reserve the rights to accept or reject any or all applications without assigning any reason.
8. Advertisement is also available on PEDO Website i.e. www.pedo.pk and www.kppra.gov.pk

PROJECT MANAGER TRANSMISSION LINE, PEDO

ROOM # 303, PEDO HOUSE 38/B-II, PHASE V,
HAYATABAD PESHAWAR.
PHONE: +92 91 9217446

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

P E D O
PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION
Government of Khyber Pakhtunkhwa
Energy & Power Department

CORRIGENDUM No.3

HIRING OF CONSULTANCY SERVICES FOR THE PROJECT"FEASIBILITY STUDY POWER EVACUTION FROM CHITRAL TO CHAKDARA GRID"

The above titled advertisement(INF (P) 4969, published in daily Aaj and other newspapers dated 29/11/2019 has been amended as under:

1. The closing date for the submission of proposals has been extended from 15th January 2020 to 31st January, 2020.

All other terms and conditions will remain the same.

Project Manager Transmission Line
Room # 303, PEDO House, Plot # 38, Sector B-2, Phase-V, Hayatabad, Peshawar.
Phone # 091-9217446

UZGHOR HYDRO POWER COMPANY (PVT) LTD.

Annex – D/15

Training and Development

Training & Development

The Applicant plans intensive training including teaching methods, the technology itself and the operations and maintenance ("O&M") procedures of the power plant. The training materials will include OEM Manuals and technical presentations by experienced engineers. A select group of trainees will be sent to China to acquire specialized knowledge, visit to the OEM factories followed by interaction with the Operation and Maintenance Departments of the Power Plant running on similar technology. Furthermore, site trainings will be conducted by the Sponsors and Project E/M provider.

Extensive Training materials and equipment shall be used for training:

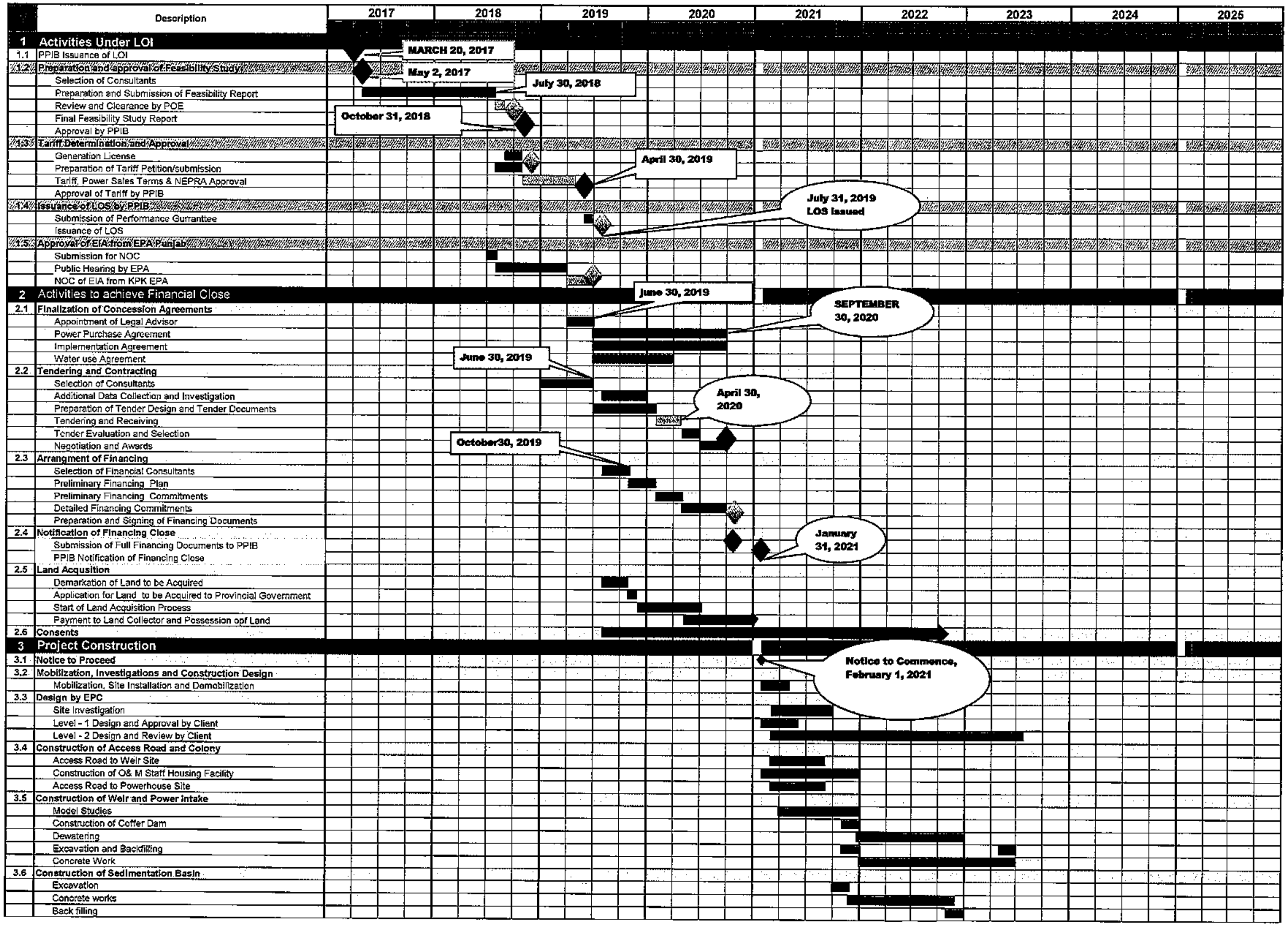
- Specially prepared training courses.
- On Job Training.
- Vendor O&M manuals.
- Engineering Standards
- Presentations and Videos
- Workshop Demonstrations

Annex – D/16

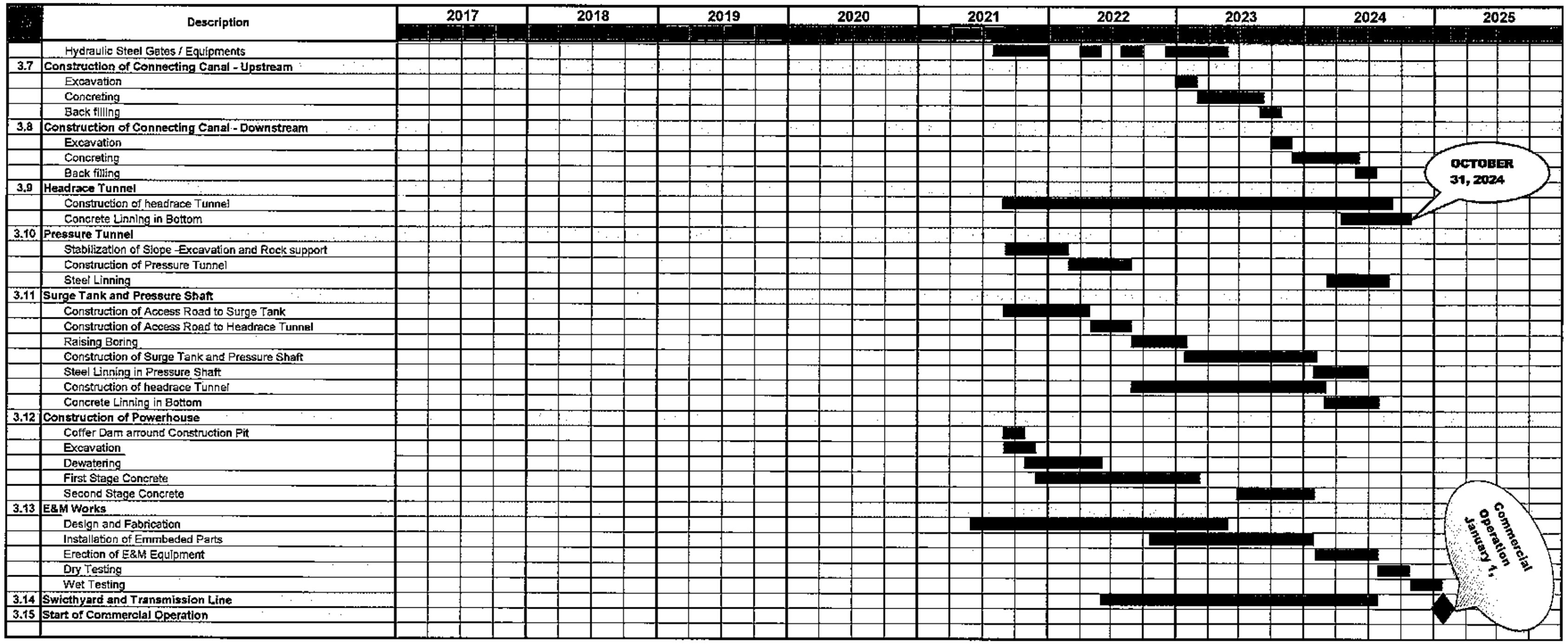
Project Schedule

FIGURE 17.1

TURTONAS UZGHOR HYDRO ELECTRIC POWER PROJECT
IMPLEMENTATION SCHEDULE



TURTONAS UZGHOR HYDRO ELECTRIC POWER PROJECT
IMPLEMENTATION SCHEDULE

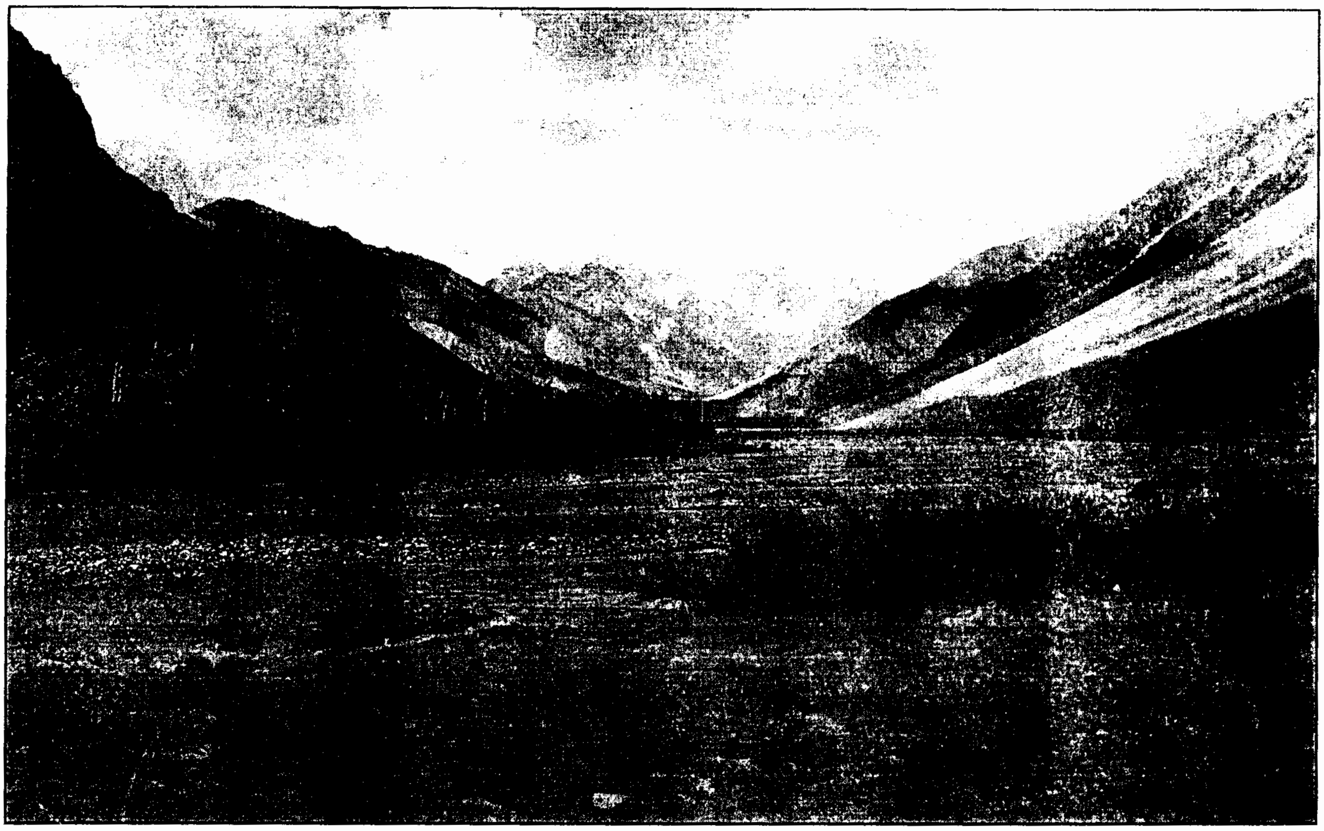


PRIVATE POWER AND INFRASTRUCTURE BOARD

Sinohydro – Sachal Consortium

TURTONAS UZGHOR HYDRO ELECTRIC POWER PROJECT

FEASIBILITY STUDY REPORT



VOLUME I

MAIN REPORT

(March-2019)

Technical, Engineering and Management (TEAM) (Pvt.) Ltd. Pakistan

FICHTNER GmbH, Germany

MAIN TABLE OF CONTENTS

TABLE OF CONTENTS

VOLUME-1
(MAIN REPORT)

CHAPTER - 1
EXECUTIVE SUMMARY

CHAPTER - 2
INTRODUCTION

CHAPTER - 3
PROJECT SITE COMMUNICATION, TRANSPORTATION AND ACCESS

CHAPTER - 4

PROJECT PRELIMINARY LOCATION AND LAYOUT ALTERNATIVES

CHAPTER - 5

TOPOGRAPHIC AND HYDROGRAPHIC SURVEY

CHAPTER - 6

METEOROLOGY, HYDROLOGY AND SEDIMENT

CHAPTER - 7

GEOLOGY, GEOTECHNICS AND CONSTRUCTION MATERIAL

CHAPTER - 8
SEISMIC HAZARD ANALYSIS

CHAPTER - 9
ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

CHAPTER - 10
DESIGN CRITERIA FOR CIVIL AND E&M COMPONENTS

CHAPTER - 11
PROJECT OPTIMIZATION STUDIES

CHAPTER - 12
PROJECT SELECTED LAYOUT - CIVIL

CHAPTER - 13

PROJECT SELECTED LAYOUT - MECHANICAL

CHAPTER - 14

PROJECT SELECTED LAYOUT - ELECTRICAL

CHAPTER - 15

HYDROPOWER GENERATION AND SIMULATION STUDIES

CHAPTER - 16
PROJECT COSTING AND BUDGETING

CHAPTER - 17

PROJECT IMPLEMENTATION PLANNING AND CONSTRUCTION METHODOLOGY

CHAPTER - 18
ECONOMIC ANALYSIS

CHAPTER - 19
FINANCIAL ANALYSIS

CHAPTER - 20
TARIFF

CHAPTER - 1

EXECUTIVE SUMMARY

Chapter - 1

EXECUTIVE SUMMARY

1.1. General

The proposed Turtonas-Uzghor Hydropower project is located on River Golen Gol which is a left bank tributary of Mastuj River. It joins with Mastuj River about 22 km north-east of Chitral Town near village of Kaghozi. The identified weir site on Golen Gol is approx. 8 km upstream of the existing Golen Gol Hydropower Project intake. The power house site is proposed on the right bank of Golen Gol River near Uzghor Village just upstream of Golen Gol HPP intake. The powerhouse site is located north-east of Chitral Town at a distance of about 33 km. The project has the capacity of 82.25 MW and will generate 382.33 GWh of energy annually. Two Pelton type Turbines would be installed.

1.2. Project Status

Upon signing of the Contract Agreement with the Client, the Consultants immediately undertook the assignment and are rendering services in accordance with the TOR attached with LOI. As per Terms of Reference attached to the LOI, the sponsors are required to carry out activities for preparation of Feasibility Study Report of Turtonas - Uzghor Hydro Electric Power Project located along Golen Gol River in Chitral District of Khyber Pakhtunkhwa Province of Pakistan. The activities involve studies and investigation to demonstrate that the site is technical sound and feasible, environmentally friendly, economical viable and financial workable project.

During the course of the Feasibility Study and prior to the completion of this feasibility Report, a number of Reports were to be produced. These reports were prepared and delivered to keep reviewing agencies, particularly Private Power and Infrastructure Board (PPIB) and its Panel of Experts (POE), appraised of the progress of the work. The reports delivered during the course of the feasibility study included: Project Preliminary Location and Layout Alternatives, Topographic and Hydrographic Survey, Geology, Geotechnics and Construction Material, Meteorology, Hydrology and Sediment, Power Potential Simulation Studies, Design Criteria for Civil and E&M Works and Environment Impact Assessment Report. These submitted reports were presented to POE and received comments were incorporated in the Final Feasibility Study Report which now submitted to the Sponsor to forward to PPIB for approval of the Feasibility Study Report.

1.3. Project Consultants

The Consultants have been selected to conduct the bankable Feasibility Report of Turtonas-Uzghor Hydro Electric Power Project. The Consultants are a joint venture comprising of M/s Technical, Engineering and Management Pvt. Limited (TEAM) Consultants, Pakistan and FICHTNER GmbH & Co. KG, Germany. The expertise and technical resources of the TEAM and FICHTNER played a key role in completing the assignment.

1.4. Project Site Communication and Access

The project site and area is accessible by a combination of transport modes that are through air, navigation/water and land comprising of roads and railway network. The transportation of heavy construction equipment (dozers, excavators, dumpers, batching plants, etc.) and mechanical & electrical equipment (stator, rotor, crane, turbine shaft, distributer, transformer, etc.) to the site is a significantly important and cumbersome issue to devise the overall transportation methodology and project planning. The transportation of these heavy equipment could be possible by the following means:

1. Port of Supplier to port in Pakistan by ocean/sea freight;
2. Port in Pakistan to project site entirely by road; and
3. Port in Pakistan to Project site by railway network to Nowshera and then by road.

The total distance from Karachi to the project site area is approx. 1750 km, From Islamabad to site it is 469 km and from Lahore to the site, it is 830 km by road. The road network up to Swat is very good, From Chakdara to site after operation of Lowari Tunnel, now site is accessible through all weathers. It is mentioned that the same road network was used for transport of E&M equipment for Golen Gol HPP even that time Lowari Tunnel was not in operation which is positive addition to road network.

1.5. Project Preliminary Locations and Alternatives Layout Study

Nine (9) Project Preliminary Location and Layout Alternatives have been studied considering all feasible options with regard to the placement of various hydraulic structures and the waterway leading to the powerhouse and ultimately discharging back to the river through the tailrace at required differential. The physical analysis and the ensuing cost estimates of each alternative provided a datum line to select one or two best alternatives for further engineering studies. A number of sites for diversion weir and powerhouse were identified in office. The data in terms of width of river, length of headrace tunnel, need of sediment basin, surge chamber, pressure shaft / tunnel, powerhouse and tailrace have been recorded.

Out of 9 numbers of alternative, Alternative: 1 was selected for study with powerhouse in open and underground. Alternative: 1 is along right bank of the Golen Gol where is diversion weir is placed about 300 me upstream of Turtonas existing Wooden Bridge along Golen Gol, power intake will be along right abutment of diversion weir. Diverted water from power intake will enter in to upstream connecting canal which will transfer the water to sedimentation basin. From there headrace tunnel lead the water to powerhouse via surge tank, pressure shaft and pressure tunnel. After generating electricity through hydro-turbine water pass to Golen Gol through open tailrace.

Powerhouse is proposed along left bank of Golen Gol near the Village of Uzghor and about 300 to 400 me upstream of diversion weir of Golen Gol HPP, a project developed and in operation with WAPDA.

The catchment area at the weir site is found to be 388 km^2 and at the powerhouse site is 412 km^2. The elevation at weir site varies from 2,581 m.a.s.l to 6,184 m.a.s.l and average elevation of the catchment is 4,262 m.a.s.l. Within the catchment area, the pattern of change in the drainage area with the change in elevation has been analyzed which indicates that the drainage area of the project site is regularly steep with no significant flat area.

1.6. Surveying and Mapping Investigation

During the feasibility study, topographic survey and hydrographic survey was conducted. 20 River cross-sections were observed at weir site while 11 No. Cross sections were observed at Power house site. This data is used in engineering design, planning and ultimately is quantities analysis. The scale of the topographic maps was selected as 1: 1000 with 1 m contour intervals for the weir and intake area, surge tank area, powerhouse, tailrace, and

Intake Portal for headrace tunnel construction and Roads etc. Based on these scaled maps all relevant design drawings of the project structures are prepared. For the area along the headrace tunnel, the scale of 1:50,000 GT Sheet having contour interval 30 meters, was selected so that the entire tunnel length is accessed.

1.7. Meteorology, Hydrology and Sediment

There is no stream flow observing station available at Turtonas-Uzghor HPP weir site but a short-term stream daily flow available at 9.2 km downstream Babuka and 12 km downstream Mastuj Bridge gauging stations and long-term stream flow are available at Chitral station. Both gauging station due to its characteristic of river basin similar to project area and considered very important for simulation flow at projects sites. The total Catchment area of Chitral River at Chitral station about 11396 Km^2 and catchment area of Golen Gol River at Babuka and Mastuj Bridge stations are reported 500 and 520 Km^2, respectively. The average annual flow recorded at Chitral station is 275 m^3/s. Therefore, the average annual flows measured at Babuka and Mastuj Bridge gauging stations are 18 m^3/s (1993 -1996) and 16m^3/s (1997-2015. Both rivers flow is mainly influenced by snowmelt, which in the region takes place from June to September. There are maximum high floods at Mastuj Bridge was reported as 212 m^3/s in 24 July 2015 and 2266 m^3/s was recorded at Chitral station in 28 July 2015, respectively.

In the downstream vicinity of the proposed Turtonas-Uzghor Hydropower Project site the climatological stations are at Chitral and located at about 36 km downstream of Turtonas-Uzghor weir site and are maintained by Pakistan Meteorological Department (PMD). In general the climate of the project area is hot in summer and cold in winter. At the Chitral station the monthly temperature is recorded from 38.4°C (in June) to -2.9°C (in January). The distribution of precipitation during the year depends very largely on the topography of the area and season. The precipitation regime in the project area is dominated by the occurrence of eastward moving extra tropical zones of low pressure, also known locally as Western Disturbances. During the summer season the frequency and intensity of the Western Disturbances normally decrease, and the precipitation on the region also decreases. The intensity of monsoon summer rainfall is hence low. The average annual rainfall at Chitral Climate station is computed 444 mm according to the observation data for the period from 1977 to 2015 and it decreases continuously towards the upstream. The relative humidity occurs maximum in the month of January with a value of 66 % and minimum in the month of June with a value of 17 %.

No in-depth sedimentation study had earlier been carried-out for Turtonas-Uzghor weir site, its reservoir and watershed area by any consultant and organization. Whereas, SWHP organization of WAPDA has measured sediment data from 11.6 km downstream to the proposed weir site on Golen Gol River at Mastuj station. Golen Gol River is the natural drainage of glaciated areas in North-Pakistan, which are the source of sediments of different gradation. Approximately 11% of the catchment area of Turtonas-Uzghor HPP extends at elevations higher than 5200 m.a.s.l. The average slope at weir site 40 % was computed with GIS and remote sensing tools. Sediment discharge data of ten sediment gauging stations was collected from the SWHP, WAPDA, and Sediment Appraisal of Pakistan Rivers publications by SWHP, Hydrology and Water Management Organization, WAPDA which has been used for estimation of the sediment yield watershed with regional analysis approach. Specific Suspended sediment yields of Golen Gol River at Mastuj sediment gauging stations was computed 133 $Tons/km^2/year$.

1.8. Geology and Geo-technical Investigation

The Project area falls in the district of Chitral, Khyber Pakhtunkhwa Province of Pakistan. Granite is the main rock unit which is exposed at the intake portal area and extends up to Ayun Fault where it is separated from Quartz Mica Schist. Granite is generally whitish grey/greenish white in color, hard and weathered on the exposed surface in general. The nature of granite appears to be changing at places and looks like to be granodiorite. It is generally massive and blocky however three sets of prominent joints have been recorded in the area of intake postal. The Consultants with the help of Brunton Compass and Geological Hammer conducted the surface geological mapping on topographic survey sheets for layout of project structures. Surface geological mapping of the project area was prepared and presented in the Feasibility Report.

Subsurface investigation and Survey were also carried through third parties (M/s Techno Time Construction (Pvt.) Ltd ("M/s TTC Ltd") and BK Consultant (SMC PVT) Limited, Islamabad, hired by the Client) under the supervision of Consultant. Sub-surface investigation and laboratory testing program was prepared. Five (05) boreholes of variable depth were drilled, out of which three are located in the weir site, one in the tailrace area and one in the Powerhouse site. Drilling was carried out by straight rotary rigs using diamond core bit. Four boreholes were drilled by straight rotary method up to a maximum depth of 25.0 m. Laboratory testing was performed on selected samples. Water samples collected from boreholes and Golen Gol River were also tested for biological and chemical analysis.

1.9. Seismic Hazard Study

The seismic hazard evaluation for the project was conducted through the study of regional geological, tectonic information collected from the available literature & maps and collection of historical & instrumental earthquake records. Uzghor hydropower project is located near the collisional zone between the Indian and the Eurasian tectonic plates. The region in which the project is located has been subjected to earthquakes in the past, therefore, it is imperative that a study of tectonic and earthquake history of the region should be conducted to have an idea of the seismic hazard to which the proposed project may be exposed to and to evaluate the realistic seismic design parameters for the safe design of the project components.

The geology of northern Pakistan is a superb example of continental collision tectonics (Shuhab D.K. and Nancy F.G., 2006). In this area, the world's three greatest mountain ranges merge, the Himalayas, the Karakoram and the Hindukush. The mountain building process that formed these ranges commenced in Cretaceous time when Indian plate started moving and was carried northward (Scotese et al., 1988). During that time (i.e. Early Cretaceous) Karakoram terrane sutured with eastern Hindukush along the Tirich Mir fault (Zanchi et el., 2000; Hildebrand et al, 2001). Soon after, the intra-oceanic Kohistan arc formed over a subduction zone that dipped beneath the arc, either to the south or to the north (Khan et al. 1997).

As the weir of the project is categorized as Low Hazard Potential Hydraulic structure, MDE may be selected lower than MCE in accordance with the recommendations of ER 1110-2-1806 - Earthquake Design and Evaluation for Civil Works Projects (May 2016). For all critical structures, the recommended ground motion for MDE is 0.42g (corresponding to a return period of 975 year). For non-critical structures, the recommended ground motion for MDE is 0.34g (corresponding to a return period of 475 year). The PGA of 0.24g having a return period of 145 year is recommended for ground shaking associated with Operating Basis Earthquake (OBE). All the water retaining components of the project should remain fully functional under the OBE associated ground motions.

1.10. Environmental and Social Assessment (ESIA)

The Environmental and Social Assessment (ESIA) is undertaken as part of the overall feasibility study of Turtonas-Uzghor Hydroelectric Power Project. The ESIA has been accomplished through studies into specific issues such as terrestrial and aquatic ecology, socio-economic and cultural environment, access provisions and resettlement requirement. The ESIA of the proposed project covers natural environment and anthropogenic influences, their interaction and how their relationship is likely to change as a result of construction and operation of the Turtonas-Uzghor Hydroelectric Power Project. A detailed ESIA report has been prepared for the project. The objectives of the ESIA are to:

- Assess the existing environmental and social conditions of the area where project is located including the identification and information of environmentally sensitive areas;
- Assess the proposed activities, identify and evaluate the potential impacts and determine their significance; and
- Propose appropriate mitigation measures that can be incorporated into the proposed activities to minimize any adverse impacts, ensure that impacts are acceptable and to propose appropriate monitoring requirements.
- Additional environmental enhancement are also to be considered and potential benefits of the project are to be maximized by appropriate planning and implementation.

The methodology used for the ESIA follows standard international best practices including scoping environmental checklist and comparative matrix. The reporting follows the standards structure of Pakistan regulatory authorities and international funding agency such as IFC. Environmental flows 2.5 m3/s is recommended to release when flows in the river is less plant design discharge. It is concluded that the project has no negative effect on the environment except during construction which will be managed through construction contract. Five trees will be planted against one trees lost due to construction.

1.11. The Project Selected Layout

The proposed project is an entirely a run of river scheme. The layout is along the right bank of the Golen Gol River. A design discharge of 20 m^3/sec has been considered based on optimization study. The difference of elevation between weir and powerhouse site was obtained from detailed topographic survey which gave a gross head of 494.1 m. The proposed layout has a headrace length of 4837 m and a provision of surface powerhouse on the right bank of river near Uzghor Village and tailrace will discharge back into the Golen Gol upstream of Diversion Weir of Golen Gol HPP.

The following are the main components of the proposed scheme. Design and drawings of all these presented in relevant Appendix attached to this Draft Feasibility Study Report:

- Diversion weir and Lateral Intake
- Upstream Connecting Canal
- Sedimentation Basin
- Downstream Connecting Canal

- Headrace Tunnel
- Surge Tank
- Pressure Shaft
- Pressure Tunnel
- Powerhouse
- Tailrace
- Access to Powerhouse and Diversion Weir
- O&M Staff Colony
- Two Number Pelton Turbine along with all E&M equipment required for robust operation of powerhouse.

1.12. Power and Energy Studies

Simulation of hydropower plant operation and the corresponding energy calculations were based on daily flow data of the available records of 52 years of Chitral gauging station which were extrapolated at Turtonas-Uzghor weir site by catchment area correlation method. The calculation of the available gross head for power generation considers the head pond level at diversion weir site and the turbine centreline level at the powerhouse outlet. The net head was determined deducting the head losses of the power waterway system from the gross head applying the head loss characteristics. The available power and energy generation were simulated applying the efficiency of the turbine units, generator and transformer.

Moreover, the calculation has been carried out by considering the project as a run-of-river scheme. Constant efficiencies for turbine (91.5%), generator (97%), and transformer (99%) were used in power and energy estimation. An ecological minimum flow need to remain in the river bed downstream of the diversion weir. A fixed minimum ecological flow of 2.5 m^3/sec shall be released and they were taken into account in calculation of the potential energy generation. The annual energy generation varies between 349.03 GWh and 395.41 GWh. The energy generation by the plant having design discharge of 20 m^3/s shall be 382.33 GWh.

1.13. Project Cost and Schedule

The cost for Civil works as well as procurement of Electro-mechanical equipment, Transportation, Erection, Testing and commissioning have estimated. Cost of temporary facilities, their running and maintenance, land acquisition & resettlement have also worked out. The cost related to engineering, administration, financial and legal for preparation of project during financial close and project construction have assessed properly. Similarly, the Interest during construction (IDC), Taxes & duties, Physical and Price Contingencies (Escalation) have estimated to arrive at a total project cost.

A number of cost estimation methods are available in the market which are very effective provided all required information are available. For example, the “unit price” basis is excellent, provided that unit prices of all items are analyzed properly.

1.14. Project Implementation Schedule

A 84 months implementation schedule consisting of 48 months for construction and 36 months for preparation of project for construction such as approval of feasibility, tariff determination by NEPRA, engineering design & tender document, issuance of Letter of Support and financial close to start the construction of project is proposed. If this schedule would be followed, the first unit would be commissioned on October 1st, 2024 while 2nd unit would be on line by January 1st, 2025.

An implementation schedule starting from approval of feasibility study, determination of Tariff by NEPRA, engineering design & tender documents, tendering and contracting, signing of concession agreements, issuance of Letter of Support leading to financial close and start of construction till plant will be put into commercial operation prepared and placed in Chapter: 17.

1.15. Economic Analysis

An economic evaluation of the proposed project clearly indicates that it can provide electricity at a long-term cost that is competitive with other electrical generation alternatives that could be implemented to serve electrical demand in the area. In the analysis, the total life-cycle economic costs of the hydroelectric project are compared to the total life-cycle economic costs of generating an equivalent amount of electricity from combined-cycle gas turbine stations. Benefit cost ratios greater than one were obtained for all conditions and alternatives investigated.

1.16. Financial Analysis

The financial analysis was designed primarily to establish a revenue stream meeting minimum criterion for financial feasibility, and to identify a tariff for generating the needed revenue. The main controlling criterion is the minimum acceptable rate of return on equity investment. The Financial analysis is undertaken to ascertain the expected returns on investment and assess the financial viability of the project. For a project to be financially viable, it is necessary that gains generated (expected returns) exceed the cost of goods and services used in the form of project investment. At least, these gains must match or yield higher returns as compared to an alternative investment plan.

The financial cost of the project includes interest during construction (IDC) and custom duties. The power projects are exempted from import duties but are subjected to custom duties @ 5% on import of plant and equipment not manufactured locally (Refer hydel policy 2015). The IDC has been charged at the rate of 11.7% on local currency and 5.8213% (LIBOR+300bps) on foreign currency components for the purpose of financial analysis. The financial cost of the project is estimated as Rs 26466.739 million. The levelized tariff has been computed over 30 years of useful life of the project, which comes to Rs 9.82 per kWh, equivalent to US Cents 7.945 per kWh.

1.17. Plant Interconnection with National Grid

The design concept assumes to connect the 132kV transmission line of Turtonas-Uzghor HPP with the 132kV transmission line of Golen Gol HPP, however, the scheme of power dispersal shall be finalised following the completion of interconnection study presently underway. Despite availability of secondary 11kV source from the Golen Gol intake weir, arrangements for black start and independent emergency power supply shall be made at powerhouse and weir/ power intake site.

The dimensions and layouts of the equipment have been developed to a detail sufficient to form the basis for a reliable cost estimate. In the present document the concepts of the electrical equipment are described. The main electrical equipment of the power station will comprise of the following:

- Two (2) 50 MVA generators complete with closed circuit cooling system, monitoring systems, safety devices and fire protection system
- Two (2) static excitation systems with automatic voltage regulators
- Two (2) generator switchgear assemblies
- Two (2) generator bus duct systems
- Two (2) main transformers (50/67 MVA, 11/132 KV)
- One (1) station service/ common service transformer (5/6.7MVA, 132/11KV) for the power supply to powerhouse, switchyard, colony and intake weir site, etc.
- Two (2) auxiliary transformers for the service building/switchyard and dam area
- LV AC auxiliary supply system for the powerhouse, switchyard and weir area
- Two (2) emergency diesel generating units installed at the service building/switchyard and weir area
- 110V DC systems for the powerhouse, switchyard and dam area
- UPS systems for the powerhouse, switchyard and intake weir site
- Protection systems for the powerhouse and switchyard equipment
- Computerized Control System (CCS)
- Communication and security systems
- Earthing and lightning protection systems
- Power and control cable systems
- Lighting and small power installations.

1.18. Conclusions and Recommendations

Turtonas-Uzghor Hydro Electric Project is found to be technically sound, environmentally manageable, economically viable, and financially workable. The next steps of the project development should include:

- Establishing third-party services agreements for professional engineering, financial, and legal advisory services necessary to support up-coming development efforts.
- Negotiating a preliminary power purchase agreement with Power Purchaser or NTDC, with transparency provisions to permit an adjusted tariff based on an agreed upon rate of return and procedure, once the project financing and procurement contracts are in place. This approach is required to avoid the fixing a tariff that cannot support financial feasibility, and is beneficial to both NTDC and Client.
- Tariff approval from NEPRA and PPIB
- Coordination with the Govt. of KPK for acquisition of land required for the project on lease or equity contribution basis.
- Approaching Government of KPK for managing and securing all necessary government clearances required for the project,

- Soliciting and securing preliminary financing commitments for the debt portion of the financing plan,
- Conduct any additional studies and investigations as may be necessary to minimize design and construction risks, and prepare tender documents for construction services and equipment procurement. Soliciting prequalification for the EPC Contractor,
- Establishing an aggressive, but reasonable, project completion schedule to minimize interest costs accumulating during construction.
- Finalizing contractor selection, concession documents, financial closure and tariff determination and proceeding with the construction, testing and commissioning of the facility as expeditiously as possible.
- The preliminary designs completed as part of this Feasibility Report are, in many respects, at a stage beyond what is customarily considered feasibility-level. Procurement can proceed based in part on the criteria, preliminary descriptions, and the drawings presented in this Feasibility Report. However, detailed performance specifications and testing guidelines need to be prepared.
- The project is consistent with current national Policy, which promotes development of economically feasible indigenous energy resources, and encourages private sector investment. The results of the financial analysis indicate that the tariffs required to support financial feasibility are in line with the real costs of other generating technologies that are available to Power Purchaser/NTDC.

SALIENT FEATURES

Hydrological Features at Weir Site:		
Catchment Area of GolenGol	518	km²
Design Discharge	20.0	m³/s
Mean Annual Flow	18.86	m³/s
$HQ_{1,000}$	1,025	m³/s
Weir Structure:		
Crest Level of Weir	2582	m.a.s.l
Max. Weir Height	8.3	m above river bed
Length of Weir Crest	40.0	m
Invert of Flushing Outlet	2574.44	m.a.s.l
Spillway:		
weir Crest level	2582	m.a.s.l
Desander/Sedimentation Basin:		
Design Discharge	20.0	m³/s
Design Particle Diameter	0.20	mm
Number of settling chambers	3	
Effective length of chamber	91.27	m w/o transition
Total Width of chamber	25.3	m
Average depth of chamber	8.5	m
Low-pressure Headrace Tunnel:		
Length	4.837	km
Net Diameter	4	m
Max. Flow velocity	2.7	m/s
Surge Tank:		

Diameter:	15.00	m
Height of surge shaft		m
Pressure Shaft and High-Pressure Tunnel:		
Length of vertical shaft	440.1	m
Diameter	2.5	concrete lined
Diameter	2.5	steel lined
Powerhouse:		
No. of units	2	Pelton
Capacity each unit	41.125	MW
Installed Capacity	2 x 41.125 = 82.25	MW
Max. Turbine Design Discharge	2*10=20	m^3/s
Electro-mechanical Equipment:		
No of Transformers	2	
Type of Switchyard	Outdoor, CBSF6	
Voltage	132	KV
Tailrace Tunnel:		
Total length (w/ manifold)	75	m
Access Road		
Access Road to Weir	9356	m
Access Road to surge tank	6495	m
Additional Project Parameters:		
Mean Annual Energy Generated	382.33	GWh
Levelized Tariff	7.95	US Cents/KWH

CHAPTER - 2

INTRODUCTION

Chapter: 2

INTRODUCTION

2.1. Introduction

This Feasibility Study Report contains the Consultant's report on the feasibility studies of the Turtonas - Uzghor Hydro Electric Power Project. The Government of Khyber Pakhtunkhwa and Pakistan has awarded development concessions for number of projects along canal falls and Rivers/Nullahs in order to encourage the private investment in the electricity generation sector.

This Feasibility Report addresses the Turtonas - Uzghor Hydro Electric Power Project, which would develop hydroelectric potential of the middle reach of Golen Gol, located upstream of Golen Gol Hydropower Project in operation with WAPDA in District Chitral of Khyber Pakhtunkhwa Province.

During the course of the Feasibility Study and prior to the completion of this feasibility Report, a number of Reports were to be produced. These reports were prepared and delivered to keep reviewing agencies, particularly Private Power and Infrastructure Board (PPIB) and its Panel of Experts (POE), appraised of the progress of the work. The reports delivered during the course of the feasibility study included: Project Preliminary Location and Layout Alternatives, Topographic and Hydrographic Survey, Geology, Geotechnics and Construction Material, Meteorology, Hydrology and Sediment, Power Potential Simulation Studies, Design Criteria for Civil and E&M Works and Environment Impact Assessment Report. These submitted reports were presented to POE and received comments were incorporated in the Draft Feasibility Study Report. The Draft Report were presented to POE and received comments from POE and Reviewing Consultant incorporated in this Final Feasibility Study Report.

As these reports are interim in nature, the content of this Feasibility Study Report superseded all prior reports as prepared as part of this feasibility studies and investigation. Relevant information from prior reports have been incorporated into this Final Feasibility Study Report.

2.2. Objectives of the Study

As per Terms of Reference attached to the LOI issued by Private Power and Infrastructure Board, Ministry of Power, the sponsors are required to carry out activities for preparation of Feasibility Study Report of Turtonas - Uzghor Hydro Electric Power Project located along Golen Gol River in Chitral District of Khyber Pakhtunkhwa Province of Pakistan. The activities involve studies and investigation to demonstrate that the site is technical sound and feasible, environmental friendly, economical viable and financial workable project.

Further, studies should meet acceptability criteria of the International and National Financing Institutions for funding of the Project. These studies shall be carried out to select a suitable project layout and to optimize hydropower potential along middle reach of Golen Gol River and other related studies required to prepare a full scale feasibility of the selected project layout. Social and Environmental impact assessment will be prepared on the basis of Guidelines issued by the International Financial Institution like World Bank, IFC, ADB, etc. Environmental and social impact assessment will to be presented to Environmental Protection Agency KP which will issue No Objection Certificate for further development. Location map of the Project area is shown in **Drawing 2.1 and 2.2**.

2.3. Identification of Project and Proponent

The Turtonas-Uzghor Hydropower Project was initially identified by GTZ/SHYDO and presented in their report "Identification of Hydropower Development Potential in Chitral Valley" in February 2001.

The Project is being implemented/accomplished by a consortium of M/s Sinohydro Corporation Limited and M/s Sachal Engineering Works (Pvt.) Limited in accordance with Letter of Interest (LOI) issued by Private Power and Infrastructure Board (PPIB), Ministry of Power, Government of Pakistan in March 20, 2017. The PPIB authorization for issuance of LOI is in accordance with the Power Policy to encourage private sector investment in developing infrastructure projects. The LOI provides the aforementioned consortium the legal right to develop the site, with diligently proceeding for feasibility investigations required for the completion of this Feasibility Study Report.

2.4. Details of Consultants

The Consultants have been selected to conduct the bankable Feasibility Report of Turtonas-Uzghor Hydro Electric Power Project. The Consultants are a joint venture comprising of M/s Technical, Engineering and Management Private Limited Pakistan - TEAM Consultants, Pakistan and M/S FICHTNER GmbH & Co. KG, Germany. The expertise and technical resources of the TEAM and FICHTNER shall play a key role in completing the assignment.

Upon signing of the Contract Agreement with the Client, the Consultants immediately undertook the assignment and are rendering services in accordance with the TOR attached with LOI.

2.5. Electric Power Development in the Country

Pakistan domestic energy resources are characterized by sizeable reserves of natural gas, substantial hydropower potential, renewable, coal and modest reserves of crude oil. The country also has a large base of traditional fuels such as fuel wood and agriculture and animal wastes that mainly meet the energy needs of rural consumers. However, the exploitation of these energy resources has been slow due to funding constraint and unsatisfactory performance of public sector entities.

Development and distribution of electricity was the responsibility of Water and Power Development Authority (WAPDA) and Karachi Electric Supply Corporation. However, the gap between demand and supply of Electricity continued to increase due to budgetary constraints and unsatisfactory performance of both entities. Therefore, reforms of the electricity sector through deregulation and restructuring and involvement of private sector was initiated.

Electricity generation plays a vital role in the socioeconomic development of the area community and the national growth of the country in terms of the industrial and manpower sector achievements in the growing and competitive markets. In order to capture the due share of the world business markets, sustainable and uninterrupted support from the energy sector is the need of the hour. Government of Pakistan in this regard has focused and taken initiative to invest on several short and long terms non-renewable, renewable and alternative electric power projects to meet the requirements of the country with an ultimate objective to bring Pakistan on track of development. The construction of these projects especially hydropower, will not only help address acute water challenge but also produce offered-able and clean hydroelectricity and will bridge the gap in circular debt which is due to thermal generation projects, wherein huge payments in foreign currency are to be made as a result of imported oil and thermal generation machinery.

Most of the Hydro Power Projects of Pakistan contributing with reliable and cost effective electricity into the national grid including the historical Tarbela and Warsak Dams are located in Khyber Pakhtunkhwa. Pakistan has a hydro potential of about 100,000 MW of which only 9,991 MW has been tapped so far with nearly more than half of it installed in this province. The Khyber Pakhtunkhwa has an estimated power potential of generating nearly 40,000 MW. While most of the hydro power projects under development are in public sector; the provincial government has embarked on a multi-pronged strategy for encouraging investment through Public, Private & Public-Private Partnership sectors.

As a result of reforms of the electric power sector through restructuring and deregulation and involvement of private sector, KESC has been privatized while WAPDA had been de-bundled into 10 distribution companies (DISCOs), 3 thermal generation companies (GENCOs), National Transmission & Dispatch Company (NTDC) and Central Power Purchase Agency Guarantee (CPPA-G).

A number of policies had been made during the past by the Government of Pakistan (GOP) such as:

- Mega Hydel Policy 2016, emphasising development of Hydel Potential on PPP mode.
- Energy Policy 2013, emphasising development of Hydel and Natural resources
- 2005: A long-term integrated “Energy Security Plan (ESP)”, covering the period up to 2030; approved by GOP in March 2005.
- 2002: “Policy for Power Generation Projects Year 2002”; approved by the GOP in October 2002.
- 2002: Hydro Power Development Plan (Vision 2025) by WAPDA
- 1998: “Policy of New Private Independent Power Producers”
- 1997: NEPRA Act: Establishing of National Electric Power Regulatory Authority
- 1995: “Policy Framework and Package of Incentives for Private Sector Hydro Power Generation Projects in Pakistan”
- 1994: “Policy Framework and Package of Incentive for Private Sector Power Generation Projects in Pakistan” – Thermal.

All policies refer to emphasis the domestic resources; coal and hydel. However, emphasis is placed for cheaper and environment friendly hydropower resources as compared to the costly and environmentally critical thermal plants. Involvement of private sector is also on top of GOP agenda.

Government of Pakistan (GOP) has set up the Private Power Infrastructure Board (PPIB) for the implementation of electric power generation projects in the private sector and the National Electrical Power Regulatory Authority (NEPRA) to regulate tariffs and to safeguard the interests of all stakeholders' on win-win basis. Provinces are also allowed to make their own policies for energy and power development.

2.6. Electric Power Development in Khyber Pakhtunkhwa

The provincial governments have also been authorized under the Constitution of Pakistan and Federal Policy for Power Generation 2002 to undertake activities in the sector of electric power generation. As such, the Government of the Khyber Pakhtunkhwa set up the Pakhtunkhwa Energy Development Organization (PEDO) under Department of Energy for development of electric power projects through private and public sector participation. Government of KP also announced Policy "KP Power Generation Policy Year 2016" to involve Private Sector in the development of hydroelectric and other source of electric power.

About seven (7) projects are developed in public sector and Six (6) are ongoing (**Table: 2.1**).

Table: 2.1 Public Sector Hydropower Project by PEDO

#	Name	River	Capacity (MW)	Status
1	Malakand III	Upper Swat Canal	81	In Operation
2	Pehur HPP	Pehur Canal	18	-do-
3	Sishi	Sishi River	2	-do-
4	Machai	Machai Canal	2.6	-do-
5	Renolia	Renolia Khwar	17	-do-
6	Reshun	Reshun Khwar	4.2	-do-
7	Daral	Daral Khwar	36.6	-do-
8	Gorkin - Matiltan	Ushu River	84	Under Construction
9	Lawi	Sishi River	69	-do-
10	Jabori	Siran River	10.2	-do-
11	Karora	Khan Khwar	11.8	-do-
12	Koto	Panjkora	40.8	-do-
13	Balakot	Khunhar	300	-do-

A number of LOI have been issued to different Sponsor through International Competitive Bidding and as raw site on first come first serve basis (**Table: 2.2**) and a number of LOI are in pipeline and will be issued during this year.

Table: 2.2 Private Sector Hydropower Project by PEDO

#	Name of Project	Capacity (MW)	District
1	Shigo Kach	102	Dir
2	Laspur Marigram	230	Chitral
3	Shushgai Zhendoli	144	Chitral
4	Shogo Sin HPP	132	Chitral
5	Booni Zaith (Toren More Kari)	350	Chitral
6	Jamshel Toren More	260	Chitral
7	Samar Gah	28	Kohistan
8	Sharmai	150	Dir
9	Kalam Alsrit	197	Swat
10	Asrit - Kedam	215	Swat
12	Mastuj	48	Mastuj
13	Barum Gol	25	Mastuj
14	Madyan	157	Swat
15	Ushu-1	43	Swat
16	Ushu-2	45	Swat
17	Gabral	45	Swat
18	Saidabad	49	Dir
19	Wari	35	Dir
20	Shalfalam	60	Dir
21	Kal Barum	65	Dir

2.7. Description of Nature, Size and Location of the Project

Turtonas-Uzghor Hydroelectric Power Project (the "Project") is located along middle reach of Golen Gol Nullah, a left bank tributary of Mastuj River in District of Chitral, Khyber Pakhtunkhwa (KPK) Province. The project shall have a provisional capacity of 82.25 MW and will generate about 382.33 GWh of energy annually. The project capacity as per LOI was 58 MW.

2.8. Organization of the Draft Feasibility Report

This Report is divided into several chapters covering the topics studied and investigated during the preparation of the Final Feasibility Study Report. These chapters contain text, tables, figures, drawings and annexures and Appendix. The Final Feasibility Study Report is bounded in Nine (9) Volumes. Volume: 1 mainly contains 20 Chapters along with tables and figures. Volume: 2 to Volume: 8 consists of Appendix and Annexure wherein details data and studies are presented and Volume: 9 Project Drawings.

This Final Feasibility Study Report (Volume-1) spread over Twenty (20) chapters as listed below:

Chapter 1. Executive Summary - Summarizes the studies and investigation carried out through the conclusion of the Final Feasibility Study Report. This also include Project Salient Features.

Chapter 2. Introduction - This introduction.

Chapter 3. Project Site Communications, Transportation and Access: This chapter present project communication means, ways and routs. Project Communication contains details about different rout of roads and railways and other ways of communication to reach and access at proposed project site from Port City and abroad.

Chapter 4. Project Preliminary Locations and Alternatives Layout Study: In this chapter, the summary of initial analysis carried out to evaluate possible Project location alternatives, alternatives layout, alternatives structures and hydro-turbine-generator-equipment, concluding with a recommendation for a specific development concept presented in this Feasibility Study Report. The details are presented in **Appendix: A**.

Chapter 5. Topographic and Hydrographic Survey: Summarizes the survey and mapping investigations in the field and present the computer generated contour maps. These maps was used for the preparation of drawings for the selected project layout studies and estimation of quantities. The details are presented in **Appendix B**.

Chapter 6. Meteorology, Hydrology and Sediment: This Chapter contains the results of the hydrological studies, including climatic data analysis, river flows and sediment transport analysis. Analysis of flood for different return period is also presented in this Chapter. Details report is presented in **Appendix: C**. The results and conclusions of these studies form the basis for the layout, operational characteristics and benefits of the proposed project.

Chapter 7. Geology, Geo-technical Investigation and Construction Material: In this Chapter, the geology of the surrounding area and geotechnical investigation leading to interpretations of geotechnical information collected during the field geological subsurface investigation program conduct during this feasibility study. This chapter also describes the source, availability and characteristic of the materials intended for use to construct the project. Details relating to this is presented in **Appendix: D**.

Chapter 8. Seismic Hazard Analysis: Contains the seismic hazard analysis based on instrumental data and geological features of the area. This chapter contains the values of g on operation base earthquake and maximum credible earthquake. Data for earthquake is presented in **Appendix: G Seismic Hazards Analysis**.

Chapter 9. Environment and Social Impact Study: Summary of the findings from the Environmental Impact Assessment, including impact on the existing population centres, the acquisition of land required, and the estimated overall budgets for compensation is presented in this section. This chapter contains summary of the complete Environmental Impact Assessment and details are presented in **Appendix: E** to fulfil the requirement of the Government of KP Environmental Protection Agency.

Chapter: 10 Design Criteria for Civil and E&M Components: Design criteria for civil structures and E&M equipment and design standard used for designing of all project components is presented in this chapter. EPC Contractor will not change design criteria without approval of the Sponsor and will base his design on this criteria. Details relating to this is presented in **Appendix: F**.

Chapter: 11 Project Optimization Studies: This chapter contains the optimization studies performed during selection of optimized discharge and hence power output. A number of discharge were used for estimation of project cost and discharge which give less cost was selected to base the selected project layout and E&M Equipment. Details relating to this is presented in **Appendix: F**.

Chapter 12. Project Selected Layout - Civil: Consists of the selected layout of the proposed project facilities considering the hydrological and geological characteristics of the proposed site. This contains the main civil structures: such as type of powerhouse, diversion weir, power intake, connecting canals, sedimentation basin, headrace tunnel and its intake portal, surge tank, pressure shaft and pressure tunnel, powerhouse and tailrace tunnel. O&M Colony is also part of this chapter. The physical configuration of the project as described in this section became the basis for the project cost estimate and the environmental impact analysis and intended for use as a guide in the technical and procurement related activities required for the next phase of project development work.

Chapter 13. Project Selected Layout – Mechanical: Consists of the selected layout of the proposed project facilities considering the hydrological and geological characteristics of the proposed site. This contains the main mechanical equipment such as; turbines, governors, cranes, hydraulic steel structures, trash rack cleaning machines, etc. and auxiliary mechanical equipment required for robust operation of powerhouse/project. The physical configuration of the project as described in this section became the basis for the project cost estimate and the environmental impact analysis and intended for use as a guide in the technical and procurement related activities required for the next phase of project development work.

Chapter 14. Project Selected Layout – Electrical: Consists of the selected layout of the proposed project facilities considering the hydrological and geological characteristics of the proposed site. This contains the main electrical equipment such as: generators, main transformers, switchgears, circuit breakers, etc. and all auxiliary electrical equipment requires for robust operation of project. The physical configuration of the project as described in this section became the basis for the project cost estimate and the environmental impact analysis and intended for use as a guide in the technical and procurement related activities required for the next phase of project development work.

Chapter 15. Hydropower Generation and Simulation Studies: Presents details regarding power and energy estimation based upon selected hydrological parameters, water levels and plant characteristics.

Chapter 16. Project Costing and Budgeting: Presents the estimated development cost of the project, including construction and the "soft costs" associated with private project development. The process of establishing unit rates for construction of the civil works is explained, and the method used for determining the cost of the electrical and mechanical works is also presented. This also yearly budgetary requirements on the basis of project construction schedule.

Chapter 17. Project Implementation Planning and Construction Methodology: Feasibility level implementation schedule for project development from the current phase of feasibility studies to project start-up and commissioning is presented in this chapter. The schedule shows the sequence, duration and interrelation among the main implementation and construction activities. Construction sequence and methodology is also presented in this chapter.

Chapter 18. Economic Analysis: Contains a study demonstrating that Turtonas - Uzghor Hydro Electric Power is an economical means of generating electricity, when compared to other potential thermal generating resources that may be developed to meet growing regional electrical demand.

Chapter 19. Financial Analysis: Presents a description of the energy tariffs required to support financial feasibility of the project using the project costs.

Chapter 20. Project Tariff – This Chapter presents a study for determination of tariff, its components based on benefits and cost. Cost will include O&M cost and interest during construction and till repayment of debt. Return of equity will be also part of tariff.

Appendices

Volume: 2	**Appendix: A**	**Project Preliminary Location and Layout Alternatives**
Volume: 3	**Appendix: B**	**Topographic and Hydrographic Survey**
Volume: 4	**Appendix: C**	**Meteorology, Hydrology and Sediment**
Volume: 5	**Appendix: D**	**Geology, Geotechnics and Construction Material**
Volume: 6	**Appendix: E**	**Environment and Social Impact Assessment**
Volume: 7	**Appendix: F**	**Project Optimization Studies & Design Criteria for Civil and E&M Works**
Volume: 8	**Appendix: G**	**Seismic Hazard Analysis**
Volume: 9	**Project Drawings**	

CHAPTER - 3

PROJECT SITE COMMUNICATION, TRANSPORTATION AND ACCESS

Chapter: 3

PROJECT SITE COMMUNICATION, TRANSPORTATION AND ACCESS

3.1. Introduction

The proposed Turtonas-Uzghor Hydropower project is located on River Golen Gol which is a left bank tributary of Mastuj River. It joins with Mastuj River about 22 km north-east of Chitral Town near village of Kaghozi. The identified weir site on Golen Gol is approx. 6 km upstream of the existing Golen Gol Hydropower Project intake. The power house site is proposed on the right bank of Golen Gol River near Uzghor Village just upstream of existing Golen Gol HPP intake. The powerhouse site is located north-east of Chitral Town at a distance of about 33 km.

This chapter contains the possible accessible rout by road, railway and air to reach site from Port City in Pakistan and abroad. The project site is accessible from Chitral Town by truck-able road (Chitral-Buni Road) up to the confluence of Golen Gol and Mastuj River and along Golen Gol River up to the diversion weir of existing Golen Gol HPP. A jeep-able road runs along left bank of Golen Gol up to the proposed diversion weir site of Turtonas-Uzghor HEPP. Further upstream from diversion weir site of Turtonas-Uzghor HEPP the road runs along right bank of Golen Gol. The road in the whole valley is very narrow and in some portions very steep also. The average speed to the proposed weir site is not more than 10 km/h. The road needs to be improved for the construction and operation & maintenance of the Project.

3.2. Project Access

The project site and area is accessible by a combination of transport modes that are through air, navigation/water and land comprising of roads and railway network. The transportation of heavy construction equipment (dozers, excavators, dumpers, batching plants, etc.) and mechanical & electrical equipment (stator, rotor, crane, turbine shaft, distributer, transformer, etc.) to the site is a significantly important and cumbersome issue to devise the overall transportation methodology during project planning. The transportation of these heavy equipment and machinery could be possible by the following means:

1. Port of Supplier to Port City in Pakistan by ocean/sea freight;
2. Port City in Pakistan to the project site entirely by road; and
3. Port City in Pakistan to Project site by railway network to Nowshera and then by road.

The air, ocean (**Figure: 3.1**), and land access routes which are best to approach the site are described below.

3.3. Site Accessibility through Sea

Arabian Sea is located in the south of Pakistan and currently there are three ports in operation that are Karachi Port, Bin Qasim Port and Gwadar Sea Port. Karachi port and Port Qasim (**Figure: 3.1**) are in or near the port city of Karachi and Port of Gwadar is in Province of Baluchistan. All of these ports are being operated by Port Trust and capable of handling all types of ships and cargo. The Project Site from these sea ports could be accessed either by railway tracks or by using road infrastructure comprising of national highway and motorways. This will be discussed under the heading of "Site Accessibility through Land".

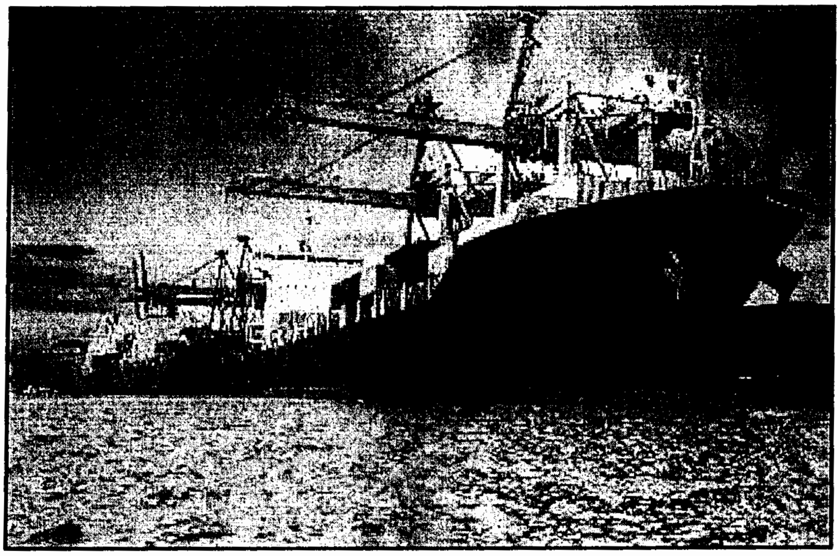


Figure: 3.1 Site Accessibility through Sea

3.3.1. Karachi Port:

At present Karachi Port (**Figure: 3.2**) is the hub of Pakistan's major trading through the sea, because 75 percent of the overall international trade is being conducted/handled at this port. It is a deep natural port with 11 km long approach channel to provide safe navigation up to 75,000 DWT tankers, modern container vessels, bulk carriers and general cargo ships. The port has 30 dry cargo berths including two container terminals and three liquid cargo-handling berths. The total port area is 100 hectares and an additional 60 hectares is available in close proximity of the port for storage of goods.

Figure: 3.2 Karachi Sea Port

3.3.2. Port Bin-Qasim

Port Qasim is one of the oldest ports but currently it is kind of a dedicated port for Pakistan Steel Mills to fulfill the increasing demand of coal. The port is well connected to all over the country through modern modes of transportation and has been playing an important role in the economic uplift of the country. Certainly one of its most important advantages is the proximity to countrywide transport services – 15 kilometers from the Pakistan national highway, 14 kilometers from the country wide Railway through six railway tracks located right behind the berths and 22 kilometers from Jinnah Airport, Pakistan's largest airport. The 45 km long navigational channel which can accommodate vessels up to 75,000 DWT class subject to adherence of the promulgated permissible draught/ dimensions.

3.3.3. Gwadar Sea Port

Gwadar Deep Water Port (**Figure: 3.3**) has just been constructed as the third port of Pakistan. Situated on the Baluchistan Coast. The port features prominently in the China–Pakistan Economic Corridor (CPEC) plan, and is considered to be a link between the ambitious One Belt, One Road and Maritime Silk Road projects.

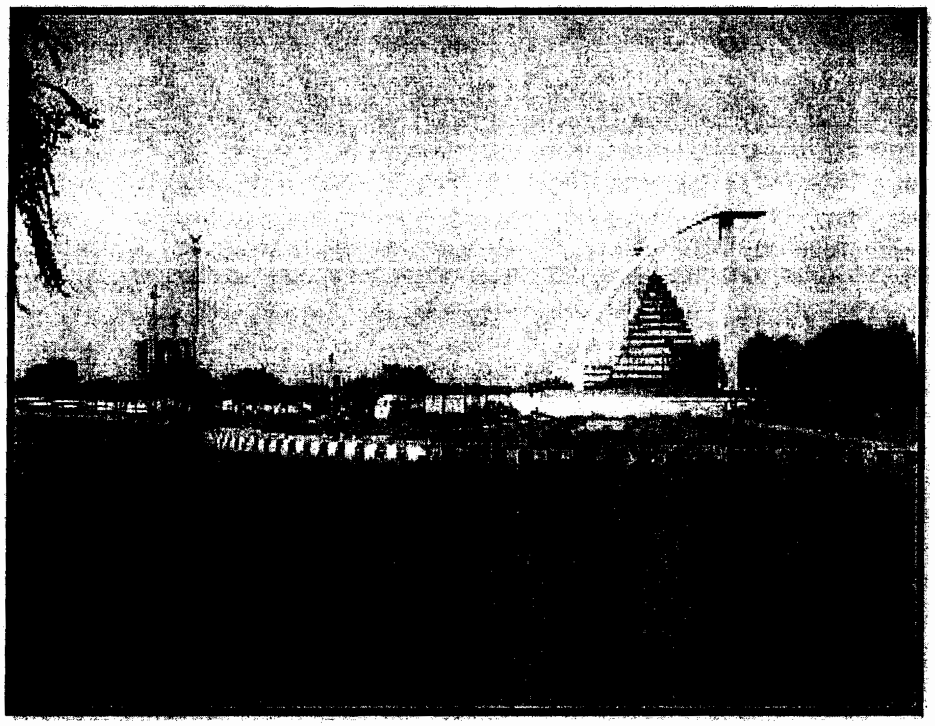


Figure: 3.3 Panoramic View of Port Qasim

Plans for construction of the port were not realized until 2007 and once complete the Gwadar Sea port will become Pakistan Largest Deep sea Port with the bulk carriers of 200,000 DWT vessels. In 2015, it was announced that the city and port would be further developed under CPEC at a cost of US$1.62 billion, with the aim of linking northern Pakistan and western China to the deep water seaport. The port will also be the site of a floating liquefied natural gas facility. Construction began in June 2016 on the Gwadar Special Economic Zone, which is being built on 2,292 acre site adjacent to Gwadar's port. In late 2015, the port was officially leased to China for 43 years, until 2059. Gwadar Port became formally operational on 14 November 2016.

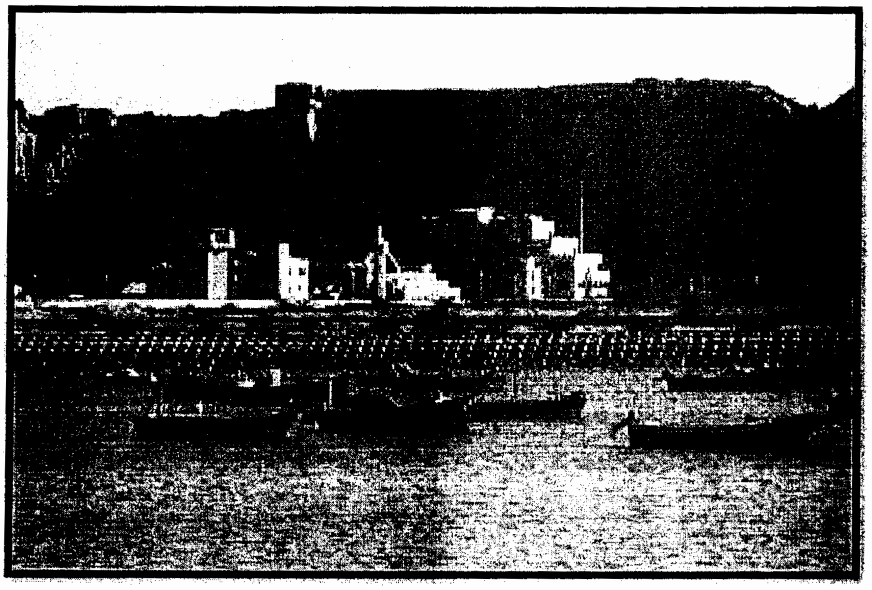


Figure: 3.4 Panoramic View of Port of Gwadar

The port (**Figure: 3.4**) is located 533 km from Pakistan's largest city, Karachi, and is approximately 120 km from the Iranian border. It is located 380 km away from Oman, and near the key oil shipping lanes from the Persian Gulf. The greater surrounding region is home to around two-thirds of the world's proven oil reserves. It is also the nearest warm-water seaport to the landlocked, but hydrocarbon rich, Central Asian Republics, as well as Afghanistan.

The port is situated on a rocky outcropping in the Arabian Sea that forms part of a natural hammerhead - shaped peninsula protruding out from the Pakistani coastline. The peninsula, known as the Gwadar Promontory, consists of rocky outcropping reaching an altitude of 168.27 m (560 feet) with a width of 4 km (2.5 miles) that are connected to the Pakistani shore by a narrow and sandy 12 kilometer long isthmus. The isthmus separates the shallow Padi Zirr bay to the west, from the deep water Demi Zirr harbor in the east.

3.4. Site Accessibility through Air

A number of national and international airports are operating in Pakistan. Bacha Khan International Airport – Peshawar and Benazir Bhutto International Airport – Islamabad are the two most nearest international airports to the site. One national airport that is Chitral Airport is located in Chitral city which is just 35 km from the project site via Chitral – Mastuj Road (N-45). PIA (Pakistan International Airport) runs daily flights from Islamabad and Peshawar to Chitral. However, big plans cannot land at the airport of Chitral and presently small jets (ATR) manufacturer by France are being used by PIA.

3.5. Site Accessibility through Land from Ports in Pakistan

3.5.1. Railways Network

The nearest operational railway station from the project location site is Nowshera Jn. Railway station. Loading and unloading of heavy equipment is possible through this

Station. The transportation of construction equipment/material and permanent M&E equipment, to the site is practicable through railway network. The main broad gauge line (**Figure: 3.4**) from Karachi to Nowshera has, as one of its design criteria, a 22.5 tons axle load.

The equipment will be unloaded at Nowshera and loaded on trucks and trailers. With regard to the transformers, they might be moved side-ways from the railway car over the trailer without lifting, provided that suitable cars are used. For all other equipment, it is assumed that the contractor will provide a mobile crane for lifting the various parts, its lifting capacity should be 20 tonnes at 8 m radius and 30 tonnes at 6 m radius.

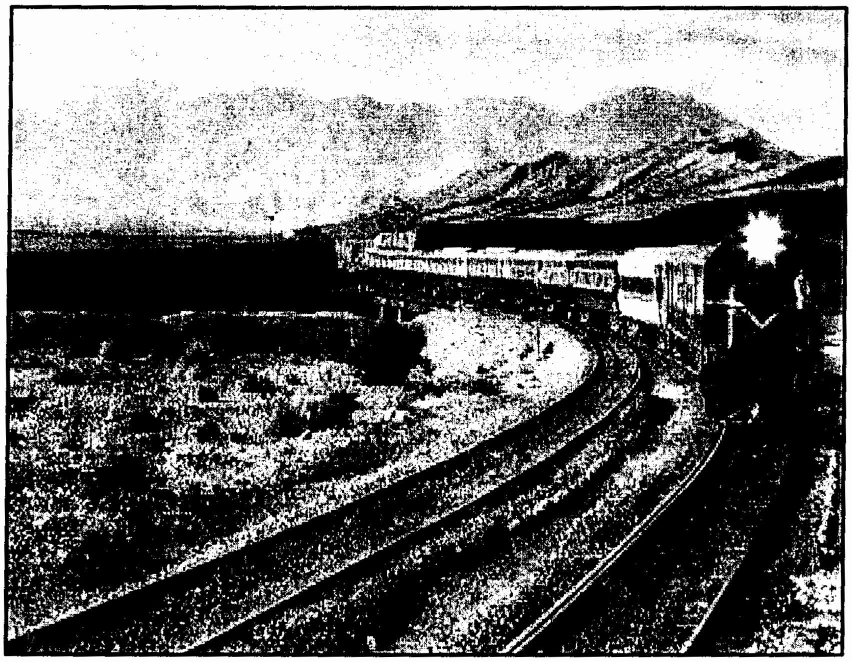


Figure: 3.5 Site Accessibility through Railway

3.5.2. Road Access Network

The following most suitable road routes are available to access the Project area and project site from port city of Karachi and Gwadar Port.

3.5.2.1. Route 1: (Gwadar Port – Burhan (M1))

From Gwadar to Burhan (M1) a 1677 km combined road track via M-8 Motorway along Western Alignment of CPEC motorway exists. M-8 is under construction in some stretches, however, after two years M-8 from Gwadar to Islamabad will be in operation. M-8 will pass from Hoshab, Surab, Zhob, D.I Khan, Banu and ultimately join M-1 near Islamabad. Transportation of light and heavy equipment till to the Project site via M-8, M-1, Swat Motorway and N-45 is possible.

The following table and the map (**Figure: 3.6**) sum up the details of highways and motorways leading to Chitral and the project.

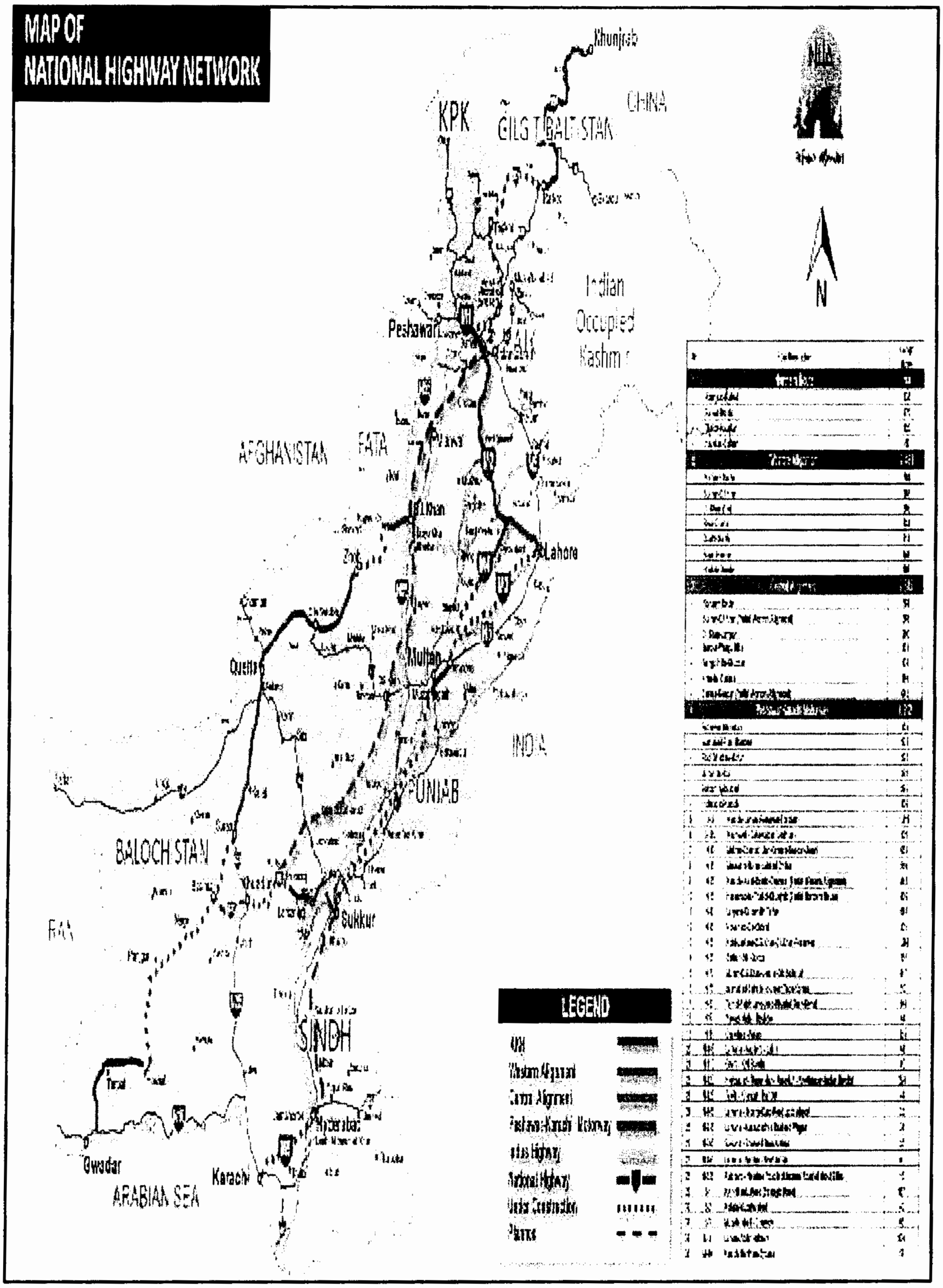


Figure: 3.6 Motorway Plan of Pakistan

3.5.2.2. Route 2: Karachi – Burhan

Karachi to Burhan Interchange has a direct national highway N-55, which is also called as "Indus Highway" a four (4) lane highway having a length of approx. 1300 km. It is a good quality road being maintained and controlled by the National Highway and Motorway Authority (NHA). The transportation of light and heavy equipment from the dock of Karachi port to the project area could be transported through N-55 road that runs along the Indus River in Pakistan connecting the Karachi port with the north-western city of Peshawar via Dera Ghazi Khan. The Indus Highway passes through the Kohat Tunnel. From Dera Ghazi Khan to Rajanpur District there is a midpoint of both districts boundary which is separated by a Link road known as **"Basti Yaray Wali Ahmadani Sheru Road"**. Karachi – Peshawar Motorway is also under construction which will pass through Hyderabad, Sukkur, Multan and from Multan will join M2 and M1. This motorway will provide a short route and will save the travel time (**Figure 3.7**).

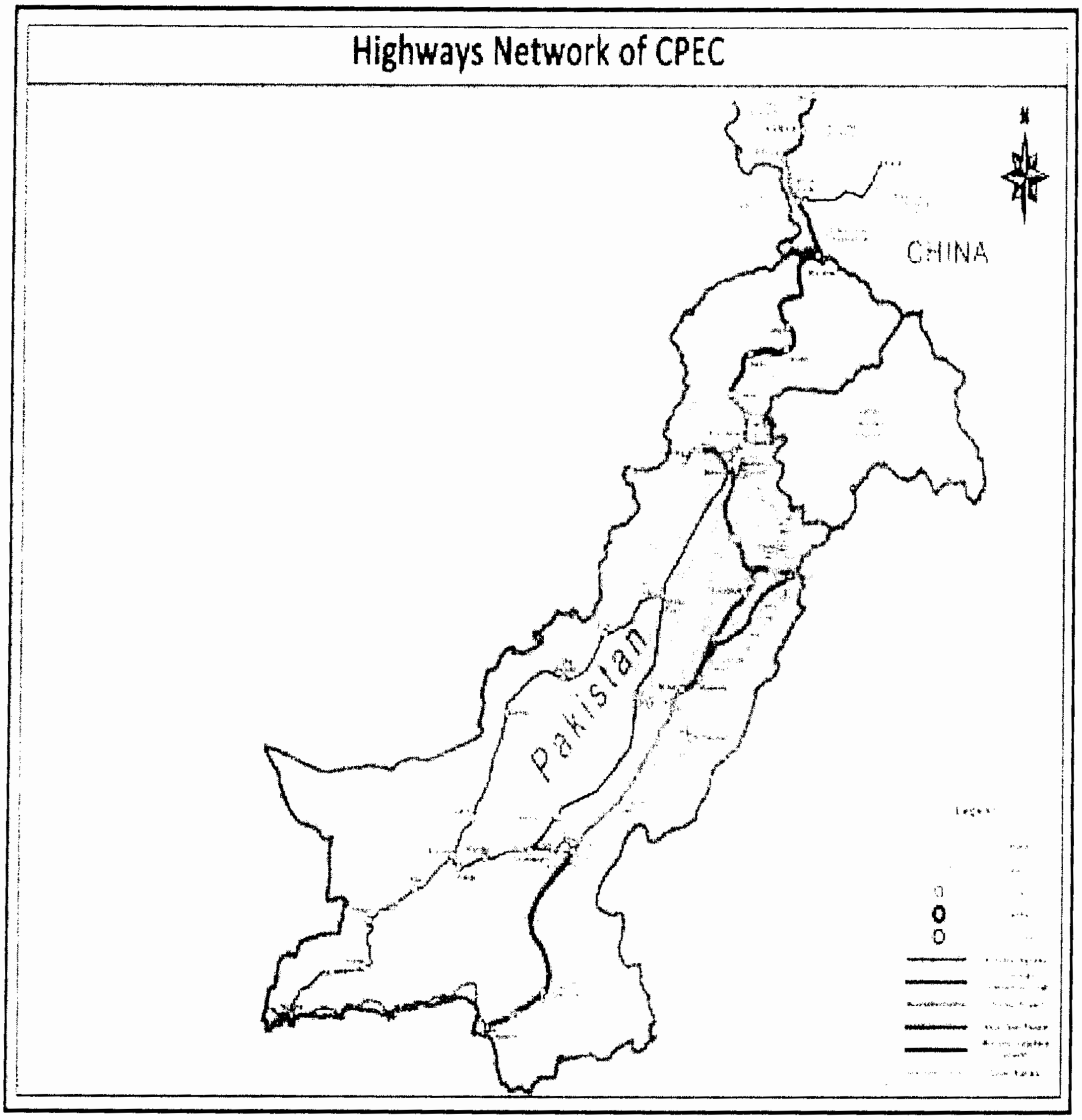


Figure: 3.7 Highway Network Plan of CPEC

- **Burhan to Project Location**

  - **Burhan Interchange – Karnal Sher Khan Interchange – Chitral – Uzghor (Proposed Site)**

The distance between Burhan Interchange to Project Site is 400 km and will be covered via combined route of Swat Motorway and National Highway N-45. The road is well asphalted and well surfaced. The road is being maintained and controlled by the National Highway and Motorway Authority (NHA). Both roads are designed to carry heavy transportation of shipments. The project site Uzghor is about 35km away on the Chitral-Mastuj road which is truck-able and jeep-able road.

The road sections and condition can be divided into the following sections;

- Burhan Interchange to Karnal Sher Khan Interchange
- Karnal Sher Khan to Chakdara section
- Chakdara to Dir section
- Dir to Chitral section
- Chitral to Uzghor section (**Figure: 3.8)**

Figure: 3.8 Chitral-Mastuj Road near Kaghozi Village

- **Burhan Interchange to Karnal Sher Khan Interchange**

The distance from Burhan Interchange to Karnal Sher Khan Interchange is about 59.6 km. This section will be covered by M1 Motorway (**Figure 3.9**).

Figure: 3.9 M1 Motorway near Burhan Interchange

➢ **Karnal Sher Khan to Chakdara (Figure: 3.10)**

The distance from Karnal Sher Khan Interchange to Chakdara is about 81 km. This newly under construction motorway named as Swat Motorway.

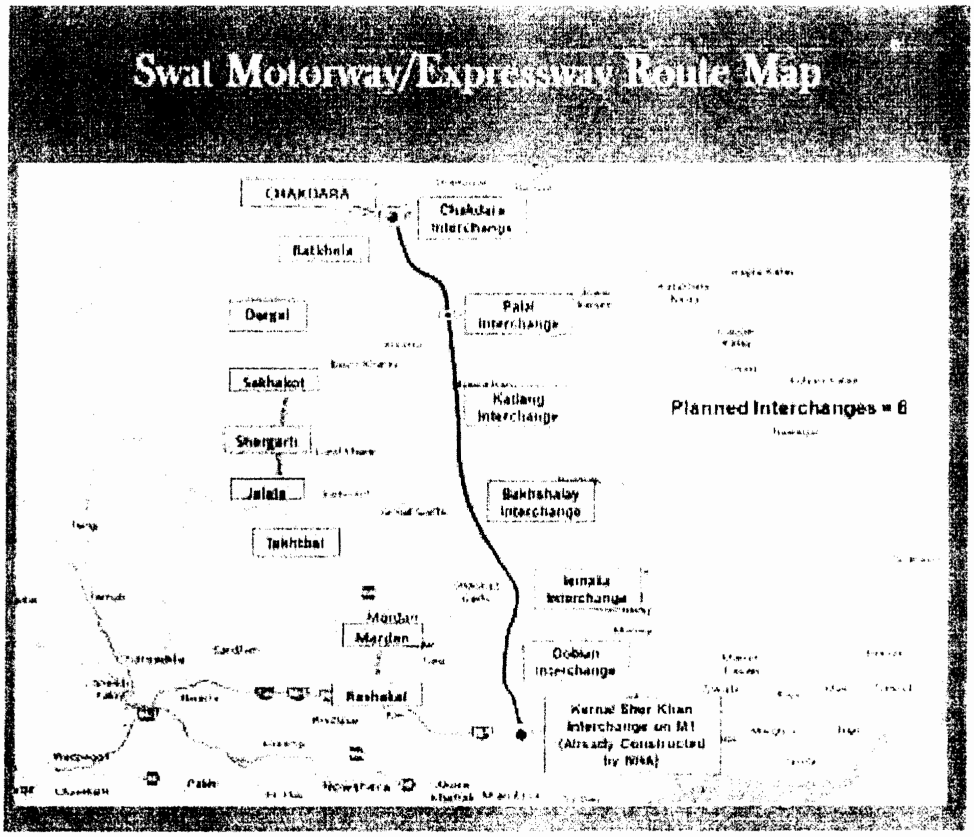


Figure: 3.10 Swat Motorway Route Map

The Pakistan Army's construction wing, the Frontier Works Organization (FWO), was handed the project under a public-private partnership. Swat Motorway is a four-lane motorway which can be extended to six lanes in future. Two kilometers of the motorway will pass through Nowshera, 18 kilometers through Swabi, 40 kilometers through Mardan and 21 kilometers through Malakand. The road will be 80 meters wide and will reduce a three-hour travel time to just 45 minutes. The motorway will have a two-kilometer-long tunnel at the Ala Dhand and Palai areas, while interchanges will exist at Dhobian, Ismaila, Bakhshalay, Katlang, Palai and Chakdara.

- **Chakdara to Dir section (Figure: 3.11)**

The road between Chakdara and Dir is about 116 km and 6.0 m wide. This road is called N.C.C (Nowshera- Chakdara- Chitral) road. This section of the road is asphalt built. All the curvatures in this road section are smooth. The clear width of bridges vary between 7.5 m to 8.5 m.

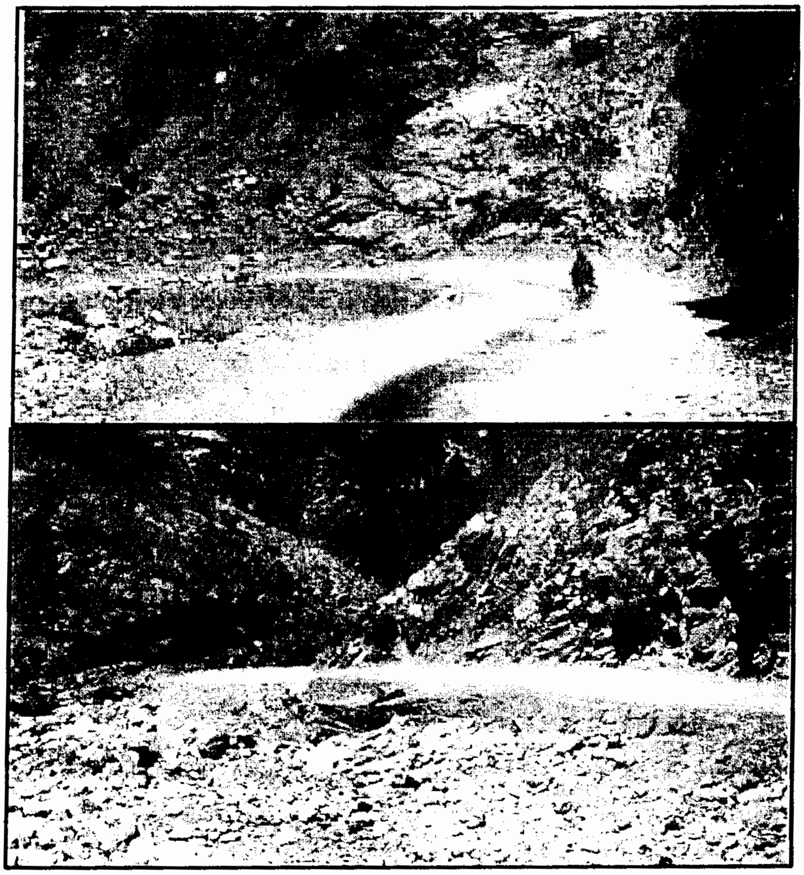


Figure: 3.11 Road Condition between Chakdara and Dir

- **Dir to Chitral Section**

The distance between Dir and Chitral is 85 km. The distance between Dir and Lowari Top is about 34km and the road is metaled but presently not in good condition. Lowari Top is at 3300m.a.s.l. The average width of road is 4.0m. Road conditions from Upper Dir to Lowari Tunnel is very poor, at some points road needs widening and few points also needs to build retaining wall for the strengthening of edges for safe passage of trailers.

Presently road is under construction and hopefully will be completed by end of this year or mid of next year.

➢ **Lowari Tunnel**

Lowari Tunnel Project include two tunnels; a long Modified Road tunnel (MRT) and a short tunnel North Access Road Tunnel (NART). The length of MRT is about 8.49 km and that of the NART is 1.88 km. The main tunnel (MRT) has a clear height of 5.0m and 7.55m width. The MRT (**Figure: 3.12 & Figure: 3.13**) has been completed and is in operation since July 2017. Link roads at both side of the Lowari Tunnel at the moment are very rough/poor, however the contract to build these roads have been awarded and hopefully by the time the consignments of the project are scheduled to pass through the tunnel, the link roads have had been constructed.

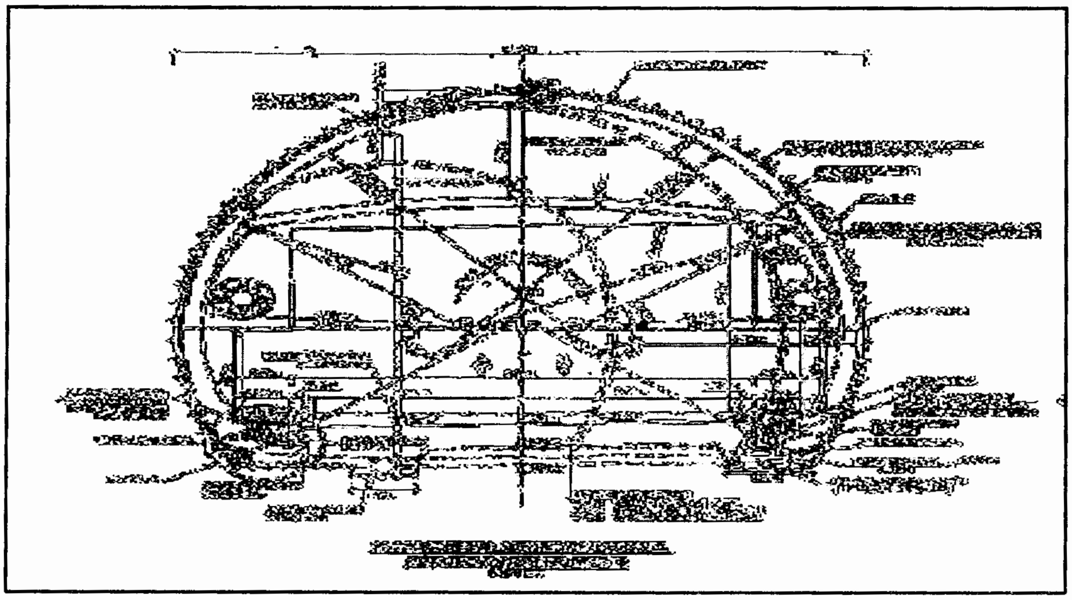


Figure: 3.12 Cross Section of Modified Road Lowari Tunnel

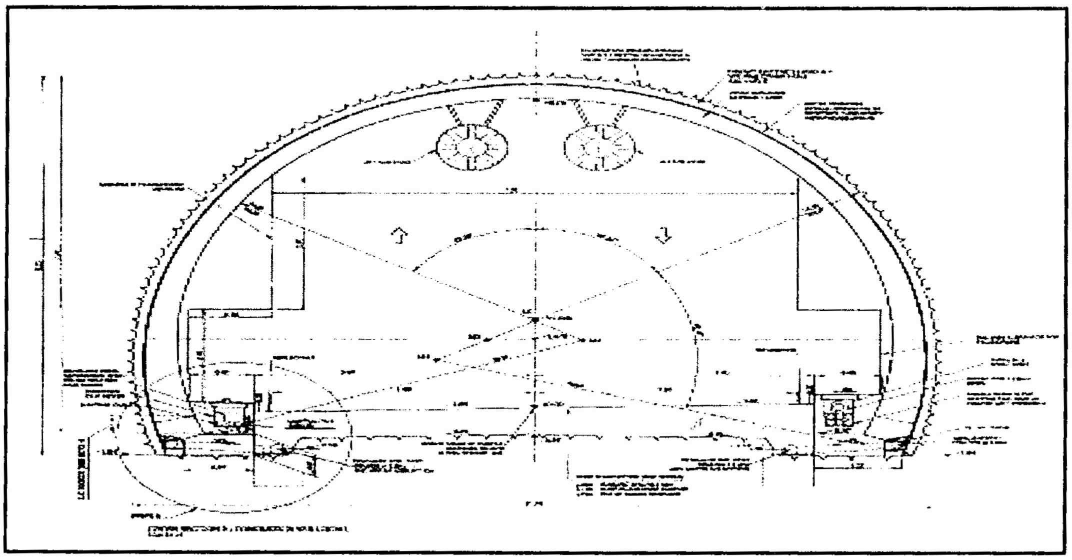


Figure: 3.13 Cross Section of Modified Road Lowari Tunnel

➢ **Lowari Tunnel to Chitral**

The road between Lowari Tunnel and Chitral is asphalted but crossing through villages and town. Presently road is narrow (**Figure: 3.14**) and congested with heavy and light vehicles and also with population. Transport of heavy equipment and machinery during day time is difficult, however, during night transport is possible due to much less traffic if compared with day time.

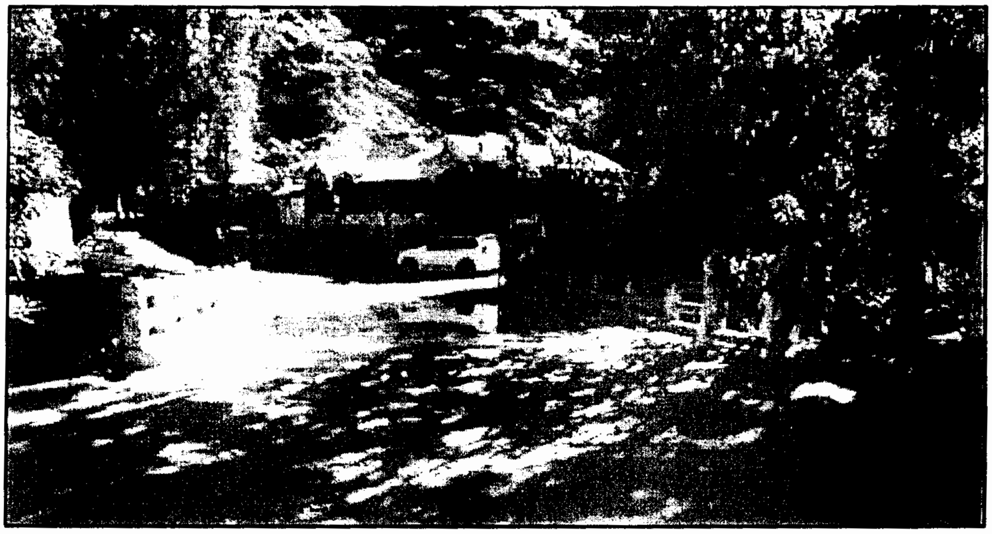


Figure: 3.14 Bridge in Chitral City

➢ **Chitral to Uzghor section**

The distance between Chitral and Uzghor is about 35km. The Chitral-Mastuj road is an asphalt construction with an average width of 4.0 m. The road is oky, however road is covered with stones came from side slopes/hills possess traffic speed issues. The road from Kaghozi to Diversion weir of Golen Gol HPP in operation with WAPDA is newly constructed with 6 m width and three concrete bridges also constructed.

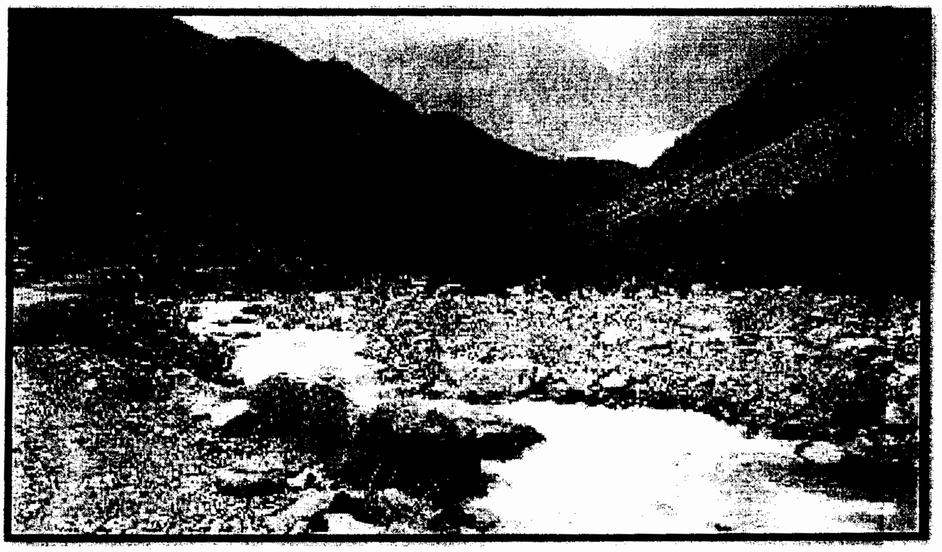


Figure: 3.15 Jeep able Road Upstream of Golen Gol Diversion Weir

Road from diversion weir of Golen Gol HPP to proposed diversion weir of Turtonas-Uzghor HEPP is presently jeep-able (**Figure: 3.15**) and would be upgraded and rehabilitated in proper slope and width during the Project construction.

3.6. Construction and M&E Equipment

As aforementioned the bridges and the culverts in Pakistan are mostly designed for Class-AA Loading (70 ton Military Tank), however practically it is understood that over time this capacity has depreciated; so there is great deal of requirement to minimize the axle loading to the bare possible level. For nearest Golen Gol project the transport carrier selected/designed a trailer having an axle load of 8 tone.

For Turtonas-Uzghor HPP, we are going to fix the plant capacity nearly 82.25MW (2x41.125MW) using a design discharge of 20 m^3/s. For this rating of the unit, we have calculated provisional weights of major equipment as under:

1. Rotor 110 tone (Φ4.85m)
2. Stator 65 tone (Φ5.92m)
3. Transformer(oil filled) 87 tone (shipping dimensions and weight 58 tone 6.3mx2.55mx3.3m) and Oil weight 28 tone

Considering the above provisional weights of the largest and heaviest parts and the corresponding culverts and bridges capacity, it is well believed that breakup assemblies have to be transported to the project loading bay of the powerhouse for complete assemblies over there considering the trailer (**Figure: 3.15**) dimensions or further modified as under:

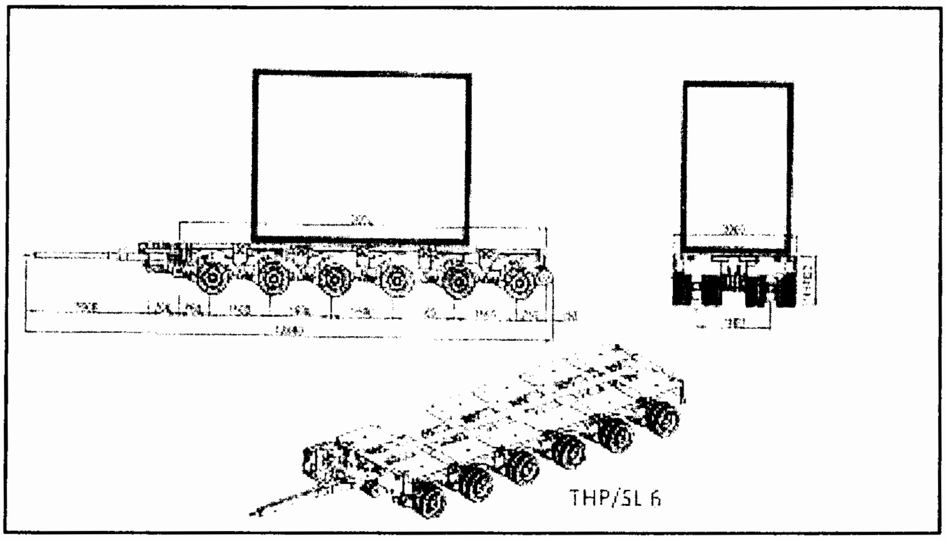


Figure: 3.16 Trailer Dimensions

3.7. Communication

The following communication facilities are available throughout Pakistan and particularly in Chitral and in the Golen Gol Project area, however such facilities could be extended to the Turtonas-Uzghor Project approaching different network provider. Such facilities could be helpful during the transportation and safe handling of the equipment.

a) Cellular mobile network
b) PTCL landline
c) PTCL broadband network

3.7.1. Telephone/Internet

Telephone, telegraph and fax facilities are available near the project area, especially in the town of Kaghozi and Chitral. Internet access is available with limited speed through the telephone network. Fast speed connections do not exist in the Chitral Town.

Further a number of Mobile Phone Companies and wireless phone companies are also operating in the project area. Now a day's mobile connection and its operation is much easier and cheaper in Pakistan.

3.7.2. Entertainment /Television

A number of television channels are being operated in Pakistan other than Pakistan Television Network. These are available via cable or dish. International channels are also available in the Project area.

3.7.3. Drinking Water

Drinking water of good quality is available in the Project area. A number of channel other than Golen Gol River flow in the project area. However, the people of the area use drinking water from springs which are common.

Ground water is also not at deep level and may be of good quality due to existence of river and channel network. However, there quality would be tested during geo-technical drilling and environmental investigation.

3.7.4. Petrol, Diesel and Lubricant

In the town of Kaghozi, Shell Pakistan and Pakistan State Oil operating fueling station. These stations are along Chitral-Mastuj road and in the city of Chitral.

3.7.5. Hotels and Restaurants

Chitral city is famous touristic valley. The people from different part of the country travel for enjoying their holidays. The summer season is very famous for tourists. A number of good quality hotel, resorts and restaurants are being operated by locals. Accommodation and good quality of food is available everywhere along the Chitral valley. Pakistan Tourism Department is also operating one lodge at Chitral Town, which offer good quality of food. WAPDA Rest House ia available in Koghozi Village for which booking shall be obtained from WAPDA House Lahore.

3.8. Conclusions

The movement of personnel's and transportation of heavy consignment in the order mentioned hereinabove is possible to the project area by conventional transport system. Since major portion of the route is through metaled and asphalt-built roads which ease the day to day transport of goods except some patches of non-metaled access roads to Lowari Tunnel which are also under construction and hope would be ready in couple of months. There are narrow roads in town center along the way between Darosh and Chitral but quite wide to pass the heavy trailers. The total distance from Karachi to the project site area is approx. 1750 km, from Islamabad to site it is 469 km and from Lahore to the site, it is 830 km by road.

The bridges and culverts between Chakdara and Uzghor are designed for 70 tone A.A (tank load) loading capacity which have depreciated to some extent, being built much earlier. The transport carrier presumably must study the route before shipment of any consignment and make his own assessment to keep the axle load to the minimum, however, recently for Golen Gol, the transport carrier used trailers having axle load of 8 tone for consignments like rotor, stator, transformer assemblies, etc.

CHAPTER - 4

PROJECT PRELIMINARY LOCATION AND LAYOUT ALTERNATIVES

Chapter: 4

PROJECT PRELIMINARY LOCATION AND LAYOUT ALTERNATIVES

4.1. Introduction

During this study, nine (9) Project Preliminary Location and Layout Alternatives have been studied considering all feasible options with regard to the placement of various hydraulic structures and the waterway leading to the powerhouse and ultimately discharging back to the river through the tailrace at required differential. The physical analysis and the ensuing cost estimates and social and environment impacts of each alternative provided a datum line to select one or two best alternatives for further engineering studies. A number of sites for diversion weir and powerhouse were identified in office. The data in terms of width of river, length of headrace tunnel, need of sediment basin, surge chamber, pressure shaft / tunnel, powerhouse and tailrace have been studied and documented.

A team of engineers, hydrologist, geologist and environmentalist visited the site for verification of identified layouts and locations. Width of diversion weir, location for sediment basin (above ground or underground) location of tunnel portal, headrace tunnel, geology of these terraces have been noted and recorded. Access to weir and powerhouse was also planned and verified during field visit.

Environmental aspect of each sites and layout was noted and made part of the layout alternatives. The possible interconnection of Turtonas-Uzghor HEP seems to be at the Golen Gol 132kV switchyard, which is approximately 5 km apart, however, it will be finalized after completion of Power System Study in collaboration with NTDC and PESCO.

4.2. Project Location

Turtonas-Uzghor Hydro Electric Power Project is located in District Chitral of Khyber Pakhtunkhwa Province of Pakistan. Chitral is the largest district in Khyber Pakhtunkhwa province covering an area of 14,850 km². It is the northernmost district of KP Pakistan. It shares a border with Gilgit-Baltistan to the east, with Kunar, Badakhshan and Nuristan Provinces of Afghanistan to the north and west, and with the Khyber-Pakhtunkhwa districts of Swat and Dir to the south. A narrow strip of Wakhan Corridor separates Chitral from Tajikistan in the north (**Drawing No. TUHEPP - 4.1**).

The town of Chitral is the main town in the district and serves as its capital. It is situated on the west bank of the Chitral River (also known as the Kunar River in Afghanistan) at the foot of Tirich Mir which is the highest peak of the Hindu Kush.

The district of Chitral is divided into twenty-four union councils and two tehsils namely Chitral and Mastuj. The district elects by direct popular vote, one member of the National Assembly (MNA) and two members of the Provincial Assembly.

The project is located in Union Council of Kaghozi which lies in Chitral Tehsil. The project is located along Golen Gol a left Bank Tributary of Mastuj River (**Drawing No. TUHEPP - 4.2**).

4.3. Hydropower Costing Software

WAPDA-GTZ cooperation during identification of hydropower resources along tributaries of Jhelum and Indus River developed a computer software for project costing purpose. This program is in Window application and very useful for costing when you planned number of alternatives. The input to the program is prices for main material and equipment and data of the proposed layout.

Data in the forms of topographic, geology, geotechnical, length, levels, etc. will be collected from the field, recorded and input during costing. The program design all project components selected during data input and calculate quantities. It calculate cost for each structures, equipment and ultimately total cost in US$.

4.4. Project Location Alternatives

Nine (9) different layout alternatives were planned and marked in the office on GT Sheets (**Drawing No. TUHEPP - 4.3**) starting from just upstream of Golen Gol Diversion Weir which is constructed and in operation. These alternatives are based on five different locations of powerhouse proposed to be constructed as near as possible to Diversion Weir of Golen Gol HPP. Out of these powerhouse location two are along right bank and three along left bank. One along left bank would be open powerhouse and all others would be in cavern.

About five (5) different locations of proposed diversion weir for nine alternatives have been marked for exploration of hydropower potential of Golen Gol between Golen Gol Diversion Weir and Ustor Village. The alternative layout with longest tunnel is named as Alternative: 9 while Alternative Layout: 4 has the shortest tunnel.

Six (6) layout alternatives have been marked along right bank of the Golen Gol while three (3) along left bank. Less alternatives layout have been planned along left bank due to existence of perennial streams, wider valley and area being full of scree deposits which are considered costly for placing and construction of project components like sediment basin, connecting canal, etc..

These layout alternatives were marked on GT Sheets and Google Pro and were checked during field visit for their suitability and confirmation and collection of maximum data.

These layout alternatives are discussed below in summaries form, for details kindly study **Appendix: A** to this Feasibility Study Report.

4.5. Project Layout Alternatives

4.5.1. Project Layout Alternative: 1

The diversion weir site is proposed some 250 m upstream of Turtonas Wooden Bridge along Golen Gol River. The diversion weir will consist of fixed and gated parts. The power intake would be located along right bank. Water from power intake will pass through the connecting canal before entering into sedimentation basin. Another connecting canal will lead water to headrace tunnel, surge chamber, pressure shaft and pressure tunnel. Water after generating power will join the Golen Gol River back through tailrace tunnel just upstream of Golen Gol HPP, Diversion Weir.

The location of Diversion Weir and Powerhouse are as follows:

Site	Latitude	Longitude
Diversion Weir	35° 56.398'	72° 3.168'
Powerhouse	35° 55' 13.74"	72° 00' 2.40"

No irrigation and water supply channel off taking from the proposed Weir, connecting canal and headrace tunnel.

The proposed alternative will generate 72 MW and is a run of river Scheme. The layout is along the right bank of the Golen Gol River. A design discharge of 20 m^3/sec has been considered for this study till finalization of detailed hydrology of the Golen Gol. The difference of elevation between weir and Powerhouse site was measured in the field with GPS and Google pro which gave a gross head of 441 m. The proposed layout has a headrace length of 4362 m and an underground powerhouse on the right bank of river near Uzghor Village and tailrace will discharge back into the Golen Gol upstream of Diversion Weir of Golen Gol HPP.

Main Data of Alternative Layout: 1

Design Capacity	:	72 MW
Design Discharge	:	20 m^3/s
Headrace length	:	4362 m
Gross head	:	441 m
Tailrace Length	:	250 m
Type and No. of Units	:	Pelton 2

Conclusions

The proposed Alternative layout No.1 on Golen Gol River is Technical Feasible and environmentally & socially viable.

4.5.2. Project Alternative Layout: 2

The diversion weir site, lateral intake, connecting canal, sediment basin and headrace tunnel inlet portal are same as of **Alternative Layout: 1** (**Drawing No. TUHEPP - 4.3**). The difference from **Alternative Layout: 1** is the location of powerhouse and location of tailrace outlet structure. The alignment of headrace is almost same. The access tunnel to powerhouse portal is also same as for **Alternative Layout: 1**.

The location of Diversion Weir and Powerhouse are as follows:

Site	Latitude	Longitude
Weir	35° 56.398'	72° 3.168'
Powerhouse	35° 55' 3.77"	72° 00' 16.81"

There is no Irrigation and water supply channel off taking from the proposed Weir and headrace tunnel.

Main Data of Alternative Layout: 2

Design Capacity	:	67 MW
Design Discharge	:	20 m^3/s
Headrace length	:	4118 m
Gross head	:	411 m
Tailrace Length	:	250 m
Type and No. of Units	:	Pelton 2

Conclusions

The proposed Alternative layout No. 2 on Golen Gol River is Technical feasible and environmentally viable.

4.5.3. Project Layout Alternative: 3

The diversion weir site is proposed about 300 m downstream of Turtonas Wooden Bridge along Golen Gol. The diversion weir will consist of fixed and gated part. The power intake would be located along right bank. Water from power intake will pass through the connecting canal before entering into sedimentation basin (**Drawing No. TUHEPP - 4.3**). Another connecting canal will lead water to headrace tunnel, surge chamber, pressure shaft and pressure tunnel.

Water after generating power will join the Golen Gol back through tailrace tunnel about 1000 m upstream of Golen Gol HPP, Diversion Weir.

The location of Diversion Weir and Powerhouse are as follows:

Site	Latitude	Longitude
Diversion Weir	35°56.303'	72° 3.083'
Powerhouse	35°55' 3.77"	72° 00' 16.81"

No irrigation and water supply channel off taking from the proposed Weir, connecting canal and headrace tunnel.

The proposed alternative of 64 MW is a Run of River Scheme. The layout is along the right bank of the Golen Gol River. A design discharge of 20 m^3/sec has been considered for this study till finalization of detailed hydrology of the Golen Gol. The difference of elevation between weir and powerhouse site was measured in the field with GPS and Google pro which gave a gross head of 392 m. The proposed layout has headrace length of 3992 m and an underground powerhouse on the right bank of river near Uzghor Village and tailrace will discharge back into Golen Gol River upstream of Diversion Weir of Golen Gol HPP.

Main Data of Alternative Layout: 3

Design Capacity	:	64 MW
Design Discharge	:	20 m^3/s
Headrace length	:	3992 m
Gross head	:	392 m
Tailrace Length	:	250 m

Type and No. of Units : Pelton, 2

Conclusions

The proposed Alternative layout No.3 on Golen Gol River is Technical feasible and environmentally viable.

4.5.4. Project Alternative Layout: 4

The diversion weir site is proposed along right side of diversion weir already constructed for 2 MW Hydropower Project of Sarhad Rural Support Program (**Drawing No. TUHEPP - 4.3**). The diversion weir will consist of fixed and gated part. The power intake would be located along right bank. Water from power intake will pass through the connecting canal before entering into sedimentation basin. Water spilled from controlling weir at end of sediment basin will enter into headrace tunnel, surge chamber, pressure shaft and pressure tunnel. Water after generating power will fall back in the Golen Gol through tailrace tunnel about 1000 m upstream of Golen Gol HPP, Diversion Weir.

Location of Weir and Powerhouse are as follows:

Site	Latitude	Longitude
Weir	35°56.304'	72° 3.073'
Powerhouse	35° 55' 3.77"	72° 00' 16.81"

There is no Irrigation and water supply channel off taking from the proposed Weir and headrace tunnel.

The proposed alternative of 60 MW is a Run of River Scheme. The layout is along the right bank of the Golen Gol River. A design discharge of 20 m^3/sec has been considered for this study till finalization of detailed hydrology of the Golen Gol. The difference of elevation between weir and Powerhouse site was measured in the field with GPS and Google pro which gave a gross head of 374 m. The proposed layout has headrace length of 3549 m and powerhouse on the right bank of river near Uzghor Village.

The headrace tunnel will follow the same alignment as of **Alternative: 2** but length would be less. The powerhouse, surge chamber and pressure shaft/tunnel and tailrace would be similar as of **Alternative: 2**, therefore no need to describe below.

The diversion weir and lateral intake and sedimentation basin have different geology and somehow also different arrangement.

Main Data of Alternative Layout: 4

- Design Capacity : 60 MW
- Design Discharge : 20 m^3/s
- Headrace length : 3549 m

- Gross head : 373 m
- Tailrace Length : 250 m
- Type and No. of Units : Pelton, 2

Conclusions

The proposed Alternative layout No.4 on Golen Gol River is Technical feasible and environment has some issues if compared to other alternatives.

4.5.5. Layout Alternative: 5

The Diversion Weir site in **Alternative No. 5** is proposed some meter upstream of Turtonas Wooden Bridge along Golen Gol River (**Drawing No. TUHEPP - 4.3**). The diversion weir will consist of fixed and gated part. The power intake would be located along left bank. Water from power intake will pass through the connecting canal before entering into sedimentation basin. Another connecting canal will lead water to headrace tunnel, surge chamber, pressure shaft and pressure tunnel. Water after generating power will fall in the Golen Gol River through tailrace open channel near Uzghor Village.

It is mentioned that almost all tributaries of Golen Gol are along left bank and there is no right bank tributary. Between Diversion **Weir site No.1** and Uzghor village two tributaries are joining Golen Gol River, while there are three tributaries joining in between Uzghor village and Weir **Site No. 4 and 5**. The planning of the layout alternative along left bank is extremely difficult due to these tributaries, however examined in detail during the course of feasibility period.

The location of Diversion Weir and Powerhouse are as follows:

Site	Latitude	Longitude
Weir	35° 56.398	72° 3.168'
Powerhouse	35° 55' 32.8"	72° 01' 57.87"

No irrigation and water supply channel off taking from the proposed Weir, connecting canal and headrace tunnel.

The proposed alternative of 60 MW is a Run of River Scheme. The layout is along the left bank of the Golen Gol River. A design discharge of 20 m^3 /sec has been considered for this study till finalization of detailed hydrology of the Golen Gol. The difference of elevation between weir and Powerhouse site was measured in the field with GPS and Google pro which gave a gross head of 369 m. The proposed layout has a headrace tunnel length of 2853 m and an open powerhouse on the left bank of river near Uzghor Village. Tailrace channel will be open canal and will discharge back into Golen Gol River near Uzghor Village.

Main Data of Alternative Layout: 5

- Design Capacity : 60 MW
- Design Discharge : 20 m^3/s
- Gross head : 369 m

- Tailrace Length : 209 m
- Type and No. of Units : Pelton 2

Conclusions

The proposed Alternative layout No.5 on Golen Gol River is technical feasible but have environment issues when compared to other Alternative Layouts due to use of agriculture land in Uzghor Village.

4.5.6. Project Layout Alternative: 6

The Diversion Weir in **Alternative: 6** is proposed some meter upstream of Turtonas Wooden Bridge along Golen Gol (**Drawing No. TUHEPP - 4.3**). The diversion weir will consist of fixed and gated part. The power intake would be located along left bank. Water from power intake will pass through the connecting canal before entering into sedimentation basin. Another connecting canal will lead water to headrace tunnel, surge chamber, pressure shaft and pressure tunnel. Water after generating power will join the Golen Gol back through tailrace open channel near Uzghor Village.

It is mentioned that almost all tributaries of Golen Gol are along the left bank and there is no right bank tributary. Between Diversion Weir site No.1 and Uzghor village two tributaries are joining Golen Gol, while there are three tributaries joining in between Uzghor village and Weir Sit No. 4 and 5. The planning of this layout alternative along the left bank would be extremely difficult due to these tributaries, however examined during the period of feasibility.

The location of Diversion Weir and Powerhouse are as follows:

Site	Latitude	Longitude
Weir	35° 56.398	72° 3.168'
Powerhouse	35° 55' 32.8"	72°01' 57.87"

No irrigation and water supply channel off takes from the proposed Weir, connecting canal and headrace tunnel.

The proposed alternative of 57 MW is a run of river Scheme. The layout is along the left bank of the Golen Gol River. A design discharge of 20 m^3/sec has been considered for this study till finalization of detailed hydrology of the Golen Gol. The difference of elevation between weir and Powerhouse site was measured in the field with GPS and Google pro which gave a gross head of 349 m. The proposed layout has headrace length of 2205 m and underground powerhouse on the left bank of river near Daman Dok Village and upstream of Birmogh Gol. Tailrace will be long tunnel and will discharge back into Golen Gol near Uzghor Village.

Diversion weir, lateral intake, connecting canals, sedimentation basin and headrace tunnel will be almost similar as in **Alternative Layout: 5**. The difference between Layout: 5 and Layout: 6 is powerhouse and tailrace are open type while in Layout: 6 these are underground.

Main Data of Alternative Layout: 6

- Design Capacity : 57MW
- Design Discharge : 20 m^3/s
- Gross head : 349 m
- Tailrace Length : 1905 m
- Type and No. of Units : Pelton 2

Conclusions

The proposed Alternative layout No.6 on Golen Gol River is technical feasible and environmentally acceptable.

4.5.7. Project Alternative Layout: 7

The diversion weir in **Alternative Layout: 7** is proposed along right side of diversion weir already constructed for 2 MW Hydropower Project of Sarhad Rural Support Program (**Drawing No. TUHEPP - 4.3**). The diversion weir will consist of fixed and gated part. The power intake would be located along left bank. Water from power intake will pass through the connecting canal before entering into sedimentation basin. Water spilled from controlling weir at end of sediment basin will enter in to headrace tunnel, surge chamber, pressure shaft and pressure tunnel. Water after generating power will join the Golen Gol back through tailrace tunnel near Uzghor village.

It is mentioned that almost all tributaries of Golen Gol are along left bank and there is no right bank tributary. Between Diversion Weir site No.1 and Uzghor village two tributaries are joining Golen Gol, while there are three tributaries joining in between Uzghor village and Weir Sit No. 4 and 5. The planning of this layout alternative along left bank is difficult due to these tributaries, however examined in detail during the feasibility period.

The location of Diversion Weir and Powerhouse are as follows:

Site	Latitude	Longitude
Weir	35°56.304'	72° 3.073'
Powerhouse	35° 55' 32.78"	72° 01' 57.87"

No irrigation and water supply channel off taking from the proposed Weir, connecting canal and headrace tunnel.

The proposed alternative of 52 MW is a run of river Scheme. The layout is along the left bank of the Golen Gol River. A design discharge of 20 m^3/sec has been considered for this study till finalization of detailed hydrology of the Golen Gol. The difference of elevation between weir and Powerhouse site was measured in the field with GPS and Google pro which gave a gross head of 321. The proposed layout has headrace length of 1068 m and power House on the left bank of river near Daman Dok Village. The tailrace will be long tunnel and will discharge back in Golen Gol near Uzghor village.

Main Data of Alternative Layout: 7

- Design Capacity : 52 MW
- Design Discharge : 20 m^3/s
- Gross head : 321 m
- Tailrace Length : 1816
- Type and No. of Units : Pelton 2

Conclusions

The proposed Alternative layout No.7 on Golen Gol River is technically feasible, however environmentally have some issues, which may have some adverse impact. The capacity of the project is smaller than allocated in LOI.

4.5.8. Project Alternative Layout: 8

The diversion weir site and lateral intake is placed upstream of Ustor Village and Upstream of Dok Gol confluence with Golen Gol. The layout is proposed along right bank. Headrace tunnel cannot be laid along left bank because existence of Dok Gol, which require much longer tunnel and ultimately, the layout would be much costly than other proposed and studied layout alternatives. To reduce the length of headrace, powerhouse may have to construct upstream of Dok Gol which then require lengthy tailrace. The powerhouse may be placed much below the bed of Golen Gol, which poses other difficulty like seepage and dewatering. Therefore layout along left bank is not planned and studied.

The diversion weir will consists of fixed and gated part. The power intake would be located along right bank. Water from power intake will pass through the connecting canal before entering into sedimentation basin. Another connecting canal will lead water to headrace tunnel, surge chamber, pressure shaft and pressure tunnel. Water after generating power will join the Golen Gol back through tailrace tunnel just upstream of Golen Gol, Diversion Weir. The powerhouse is placed at PR-1 location mentioned in drawing (**Drawing No. TUHEPP - 4.3**).

The location of Diversion Weir and Powerhouse are as follows:

Site	Latitude	Longitude
Weir	35° 57' 33.33"	72° 04' 14.80"
Powerhouse	35° 55' 13.74"	72° 00' 2.40"

There is no Irrigation and water supply channel off taking from the proposed Weir and headrace tunnel.

The proposed alternative of 67 MW is a run of river Scheme. The layout is along the right bank of the Golen Gol River. A design discharge of 15 m^3/sec has been considered for this study till finalization of detailed hydrology of the Golen Gol. The difference of elevation between weir and Powerhouse site was measured in the field with GPS and Google pro which gave a gross head of 549 m. The proposed layout has headrace length of 6514 m and power House on the right bank of river near Uzghor Village.

Main Data of Alternative Layout: 8

Design Capacity	:	67 MW
Design Discharge	:	15 m^3/s
Gross head	:	549 m
Tailrace Length	:	250
Type and No. of Units	:	Pelton 2

Conclusions

The proposed Alternative layout: 8 on Golen Gol River is technical feasible. However, it poses some environmental issues and social issues which need to be settled.

4.5.9. Alternative Layout: 9

The diversion weir site is proposed upstream of Ustor Village and upstream of confluence of Dok Gol with Golen Gol. The layout is proposed along right bank. Headrace tunnel cannot be laid along left bank because existence of Dok Gol, which require much longer tunnel and ultimately, the layout would be much costly than other proposed and studied layout alternatives. To reduce the length of headrace, powerhouse may have to be constructed upstream of Dok Gol which then require lengthy tailrace. The powerhouse may be placed much below the bed of Golen Gol River, which poses other difficulty like seepage and dewatering. Therefore layout along left bank is not planned and studied.

The diversion weir will consist of fixed and gated part. The power intake would be located along right bank. Water from power intake will pass through the connecting canal before entering into sedimentation basin. Another connecting canal will lead water to headrace tunnel, surge chamber, pressure shaft and pressure tunnel. Water after generating power will join the Golen Gol back through tailrace tunnel just upstream of Golen Gol, Diversion Weir. The powerhouse is at proposed location PR-1 (**Drawing No. TUHEPP - 4.3**).

The location of Diversion Weir and Powerhouse are as follows:

Site	Latitude	Longitude
Weir	35° 57.31' 8.2"	72° 04' 21.35"
Powerhouse	35° 55' 13.74"	72° 00' 2.40"

No irrigation and water supply channel off taking from the proposed Weir, connecting canal and headrace tunnel.

The proposed alternative of 71 MW is a run of river Scheme. The layout is along the right bank of the Golen Gol River. A design discharge of 15 m^3/sec has been considered for this study till finalization of detailed hydrology of the Golen Gol. The difference of elevation between weir and Powerhouse site was measured in the field with GPS and Google pro which gave a gross head of 571 m. The proposed layout has headrace length of 7497 m and underground powerhouse on the right bank of river near Uzghor Village and tailrace will discharge back in to Golen Gol upstream of Diversion Weir of Golen Gol HPP.

Main Data of Alternative Layout: 9

- Design Capacity : 71 MW
- Design Discharge : 15 m^3/s
- Headrace length : 7497 m
- Gross head : 571 m
- Tailrace Length : 250 m
- Type and No. of Units : Pelton 2

Conclusions

The proposed Alternative layout No.9 on Golen Gol River is Technical feasible and environmentally acceptable.

4.6. Conclusions and Recommendations

4.6.1. Introduction

Turtonas-Uzghor HPP shall be developed in cascade upstream of the Golen Gol HPP, which is implemented and in operation with WAPDA. The feasibility study of Turtonas-Uzghor Hydro Electric Power Project is final and Alternative Layout Study is part of the Bankable Feasibility Study which is approved by Panel of Experts (PoE) appointed by PPIB.

About Nine (9) different Alternatives Layout were prepared and studied in details and presented in above sections. The ranking of these alternatives was prepared based on technical, environment and cost per MW leading to selection of preferred Alternative Layout which ultimate be studied in more detail, The cost per MW of each alternative is presented in **Table: 4.1** below.

4.6.2. Cost Estimation

The cost estimates were prepared by using Hydropower Costing Software developed by WAPDA-GTZ.

Table: 4.1 Alternative Layouts – Cost per MW

#	Alternative Layout	Total Sum(US $)	Potential (MW)	Cost/MW (Million Dollar)
1	Alternative Layout No.1	173321728	72	2.41
2	Alternative Layout No.2	171989600	65	2.65
3	Alternative Layout No.3	164755584	64	2.57

4	Alternative Layout No.4	166540432	60	2.73
5	Alternative Layout No.5	174773856	60	2.85
6	Alternative Layout No.6	162532016	57	2.91
7	Alternative Layout No.7	153916080	53	2.96
8	Alternative Layout No.8	213492320	67	3.14
9	Alternative Layout No.9	201988640	71	2.84

4.6.3. Ranking

Technical and environment & social ranking of these alternatives were prepared by giving relative marking between 1 and 4. Lowest number will be allotted to alternative which is better and 4 the worst.

Technical ranking is presented in **Table: 4.2** below.

Table: 4.2 Alternative Layouts – Technical Ranking

#	Alternative Layout	Ranking
1	Alternative Layout No.1	1
2	Alternative Layout No.2	1
3	Alternative Layout No.3	2
4	Alternative Layout No.4	3
5	Alternative Layout No.5	3
6	Alternative Layout No.6	4
7	Alternative Layout No.7	3
8	Alternative Layout No.8	4
9	Alternative Layout No.9	4

Environmental and social ranking is presented in **Table: 4.3** below.

Table: 4.3 Alternative Layouts – Environment and Social Ranking

#	Alternative Layout	Rank
1	Alternative Layout No.1	1
2	Alternative Layout No.2	1
3	Alternative Layout No.3	2

4	Alternative Layout No.4	3
5	Alternative Layout No.5	3
6	Alternative Layout No.6	4
7	Alternative Layout No.7	3
8	Alternative Layout No.8	2
9	Alternative Layout No.9	2

Ranking on the basis of Cost per MW is presented in **Table: 4.4** below.

Table: 4.4 Alternative Layouts – Cost per MW Ranking

#	Alternative Layout	Cost/MW (Million Dollar)	Ranking
1	Alternative Layout No.1	2.41	1
2	Alternative Layout No.2	2.65	2
3	Alternative Layout No.3	2.57	2
4	Alternative Layout No.4	2.73	2
5	Alternative Layout No.5	2.85	3
6	Alternative Layout No.6	2.91	3
7	Alternative Layout No.7	2.96	3
8	Alternative Layout No.8	3.14	4
9	Alternative Layout No.9	2.84	3

Combined Ranking is presented in **Table: 4.5** below.

Table: 4.5 Alternative Layouts – Combined Ranking

#	Alternative Layout	Technical	Cost/MW	Environment	Combined
1	Alternative Layout No.1	1	1	1	3
2	Alternative Layout No.2	1	2	1	4

3	Alternative Layout No.3	2	2	2	6
4	Alternative Layout No.4	3	2	3	8
5	Alternative Layout No.5	3	3	3	9
6	Alternative Layout No.6	4	3	4	11
7	Alternative Layout No.7	3	3	3	9
8	Alternative Layout No.8	4	4	2	10
9	Alternative Layout No.9	4	3	2	9

4.6.4. Conclusions

On the basis of **Table: 4.5** above, the following are concluded. .

Table: 4.6 Alternative Layout - Ranking

#	Alternative Layout	Combined	Ranking
1	Alternative Layout No.1	3	**I**
2	Alternative Layout No.2	4	**II**
3	Alternative Layout No.3	6	**III**
4	Alternative Layout No.4	8	**IV**
5	Alternative Layout No.5	9	**V**
6	Alternative Layout No.6	11	**VII**
7	Alternative Layout No.7	9	**V**
8	Alternative Layout No.8	10	**VI**
9	Alternative Layout No.9	9	**V**

4.6.5. Recommendations

Consequently as a result of all the steps and exercises performed as aforementioned to find the best prospective layout, we recommend **Alternate Layout: 1** which will have the lowest cost per MW, less environment & social impact and technical most feasible. **Alternative Layout: 2** are the second ranked and may also be considered for detailed studies.

For details study kindly consult **Appendix: A**. However during course of study it was concluded that project with maximum capacity (**Alternative: 1**) may be analysis under two alternatives such as:

- Alternative: 1-A Open Powerhouse
- Alternative: 1-B Cavern Powerhouse

Therefore, detail study of **Alternative Layout: 1-A** and **Alternative Layout: 1-B** and selection of optimized Alternative is presented in **Chapter: 11** (**Project Optimization Studies)** and **Appendix: F**.

CHAPTER - 5

TOPOGRAPHIC AND HYDROGRAPHIC SURVEY

Chapter: 5

TOPOGRAPHIC AND HYDROGRAPHIC SURVEY

5.1. Introduction

This chapter will contains the information and data collected in respect of Topographic and Hydrographic Survey. The available information in the form of GT Sheets at scales of 1:250,000 and 1:50,000. These maps were used in the preliminary project assessments, e.g. to develop the Preliminary Project Location Alternative, Project Layout Alternative, Environmental issues, conduct hydrological studies of the catchment area, study of topographical and geological features, etc.

The additional efforts made during preparation of bankable feasibility study report for collection of topographic and hydrographic data is also part of this chapter. The details about topographic and hydrographic survey is presented in **Appendix: B**. This report provides the information about the applied methodology and the results of the topographic survey program.

5.2. Available Data and Information

The data and information available in the form of GT Sheets prepared by Survey of Pakistan and Feasibility Study Report of Golen Gol Hydropower Project was collected and studied in office. The following GT Sheets and report were available with the Consultants and were used for preliminary planning of location and layout alternatives.

- GT sheets at scale of 1:50,000 bearing No. 43(A/1) and 38(M/13)
- GT Sheets at scale of 1:250,000 bearing No. NI(43/1) and NI(42/4)
- Feasibility Study Report prepared by WAPDA-GTZ for Golen Gol Hydropower Project

5.3. Additional Topographic and Hydrographic Survey

After having detailed site visit by the Consultants and elaboration of Preliminary Project Location and Layout Alternative, a detailed Terms of Reference was prepared in order to facilitate the Client for selection of Survey Contractor. Accordingly, a comprehensive topographic survey program was setup and executed by a qualified subcontractor. The corresponding activities of the Consultant extended over the Pre-Feasibility and Feasibility Stage and were carried out in accordance with the requirements of the TOR.

For the development of a Terrain Model for the Turtonas-Uzghor Hydroelectric Project the following major activities were carried out:

- Setup a project trigonometric network with a system of benchmarks
- Terrestrial topographic survey of the area of the major project components such as; Diversion Weir, Powerhouse and Headrace Tunnel Portal
- Terrestrial topographic survey of river cross sections; i) River cross sections of weir area and ii) River cross sections of powerhouse area
- Terrestrial topographic survey of bore hole locations

- Terrestrial topographic survey of the road from proposed powerhouse to weir

The terrestrial topographic survey was subcontracted to an experience and pre-qualified subcontractor equipped with state of the art equipment and experienced staff. The terrestrial survey was conducted by the local company **M/S BK Consultants (SMC Pvt.) Limited**.

As specified in the TOR, the scale of the topographic maps was selected as 1: 1000 with 1 m contour intervals for the weir and intake area, surge tank area, powerhouse, tailrace, and Adits for headrace tunnel construction etc. Based on the maps scale all relevant design drawings of the project structures shall be prepared.

For the area along the headrace tunnel the scale of 1:50,000 GT Sheet was selected so that the entire tunnel can be shown with 30 m contour lines. The river cross-sections are presented in A3 format drawings at 5m intervals up to 50 meters on both side of the river.

5.4. Methodology Applied to the Topographic Survey

In view of the considerable stretch of the project area from powerhouse to diversion weir site, the following approach was adopted:

- Conventional terrestrial survey was applied for detailed topographic maps with high accuracy in coordination with the Project Sponsor.

The following activities were carried out in the Topographic Survey;

- Establishment of Bench Marks and Control Points.
- Closed loop traverse survey from SOP BM at Golan Gol HPP to the proposed Weir and Intake Structure of Turtonas-Uzghor HEPP;
- Survey of river cross-sections upstream and downstream of weir site;
- Survey of river cross-sections upstream and downstream of Powerhouse site;
- Terrestrial survey of the major project structures areas.
- Survey of lines of geophysical survey and locations of bore holes;
- Development of topographic maps at the 1:500 and 1:1000 scales and preparation of the Topographic Survey Report.

The survey team established four number of concrete monuments. These monuments are the Project Benchmarks (BMs), which forms the basis for a new triangulation system comprising of total 4 BMs, 2 at weir site and 2 at powerhouse site.

The river cross sections were observed by wedding and bed level under water was recorded after every 5 m interval. River cross sections were extended 50 m beyond river bank on both side. Before start of recording level of river beds, the temporary bench marks were established at river right bank where river cross-sections have to observe.

5.5. Reference System

Survey work sets the standard to which accurate and meaningful engineering designs can be achieved. It is important that all survey work is carried out systematically and accurately in one uniform system of co-ordinates and elevations. All surveys should be based on a network of horizontal and vertical control points covering the whole project area. Only a precise project network allows the execution of homogeneous survey works in all sections of the project area and that is the precondition for the verification and repetition of any survey activity.

The project area has a north-south extension from Turtonas town to Uzghor village (weir to powerhouse) which measures approximately 8 km. The long distance with the prevailing difficult terrain of the Golen Gol River and the valley with numerous deep cuts in tributaries (Nullahs) made the conventional terrestrial survey of the entire project area a little difficult but it was only possible with the help of experienced survey team.

The terrestrial topographic survey activities were conducted based on an existing local system of coordinates and elevations tied with SOP BM in Chitral, shifted and established at Golen Gol HPP Weir (**Table: 5.1**) during the construction of Golen Gol HPP. This system of coordinates and elevations has been followed and extended to Turtonas village through a traverse survey.

Table: 5.1 Project Area Coordinates

Name	GT Sheet	Latitude	Longitude
Golen Gol HPP Weir Site	1:50,000	1,300,402.712	3,103,065.195

The trigonometric network is formed by constructing four permanent benchmarks **(concrete monuments).** These Bench Marks were tied with Golen Gol Weir Bench Mark established by shifting SOP Bench Mark at Chitral. The features of these bench marks and secondary control points were established using transverse survey methodology and given in below **Table: 5.2** and **Table: 5.3**.

Table: 5.2 Primary Control points (Bench Marks)

Sr. No.	Name	Easting	Northing	Elevation
1	BM-1	3,104,360.24	1,299,931.02	2,155.45
2	BM-2	3,104,546.61	1,300,005.64	2,157.79
3	BM-3	3,108,949.01	1,302,696.45	2,581.93
4	BM-4	3,109,023.19	1,302,767.89	2,584.76

Table: 5.3 Secondary Control Points

Sr. No.	Name	Easting	Northing	Elevation
1	P-1	3,103,577.74	1,300,224.29	2,072.77
2	P-2	3,103,823.08	1,300,069.01	2,093.54
3	P-3	3,104,876.47	1,299,961.94	2,173.21
5	P-5	3,106,796.85	1,300,856.28	2,422.22
6	P-6	3,106,830.29	1,300,917.79	2,418.34
7	P-7	3,107,680.4	1,301,628.81	2,532.66
8	P-8	3,107,744.03	1,301,715.85	2,544.24
9	P-9	3,108,651.02	1,302,404.84	2,561.38

5.6. Terrestrial Topographic Survey

In the course of the Feasibility Study a comprehensive terrestrial survey was conducted to achieve topographic information to the required level. One of the major objectives was the elaboration of detailed topographic maps at scale 1:500 with contour lines at every 1 m of the area of the major project structures.

The terrestrial survey works carried out comprised of the following areas.

Weir Site

- 15 No. river cross sections covering upstream of the weir (**Figure: 5.2**).
- 05 No. river cross sections downstream of the weir (**Figure: 5.2**).
- 25 hectares of survey covering the project components such as; weir upstream and downstream cofferdams, diversion channel, power intake (**Figure: 5.1**).
- Golen Gol Longitudinal Section near Weir Site (**Figure: 5.3**).

Power House Site

- 06 river cross-sections between powerhouse sand Uzghor Village (**Figure: 5.5**).
- 05 river cross-sections between powerhouse and Golen Gol HPP (**Figure: 5.5**).

- 41 hectares of survey covering the permanent project components such as surge tank, pressure shaft, powerhouse, switchyard, etc. (**Figure: 5.4**).
- Golen Gol Longitudinal Section near Powerhouse Site (**Figure: 5.6**).

Headrace Intake Portal

- 19.8 hectares for intake structure, sand trap, area of tunnel portal and connection tunnel (**Figure: 5.1**).

Access Road:

- 35 Hectares for access road from Golen Gol HPP Weir to Turtonas-Uzghor Weir

Survey of the Golen Gol Valley

- Survey of the valley to plan the alignment and the design of the headrace tunnel and Road; recording hundreds of points along the Nullahs (small tributaries) on the left flank of the Golen Gol valley;

5.7. Traverse Survey

Closed loop traverse survey connecting the Benchmark shifted at Golen Gol Hydropower Project from Benchmark established by SOP in Chitral.

Closed loop traverse survey covering all permanent benchmarks and connected all topographic surveyed areas within the project area. The traverse started and ended at BM Golen Gol HPP weir site.

5.8. Instruments Used

The topographic survey was conducted using Electronic Total Stations. The conditions of the survey instruments were checked prior to start of survey to ensure high accuracy of the recorded data.

The following instruments were used for the survey works:

Table: 5.4 Detail of Instruments used in Topographic Survey

Sr. No	Type of survey	Type of Instrument	Accuracy
1	Vertical control	NIKON Auto Level Model AX-2S	0.5mm
2	Horizontal control	Leica 09+	±.5 ppm

5.9. Quality Control

With regard to published SOP Coordinates the closed loop survey achieved the following values as shown below in **Table: 5.5** and calculations are attached in **Annexure: B.1 to Appendix: B.**

Table: 5.5 Difference of closed loop survey

Name	Easting	Northing
Recorded CPD	3,103,446.566	1,300,0290.165
Published CPD	3,103,446.546	1,300,290.148
Difference	0.0204	0.0173

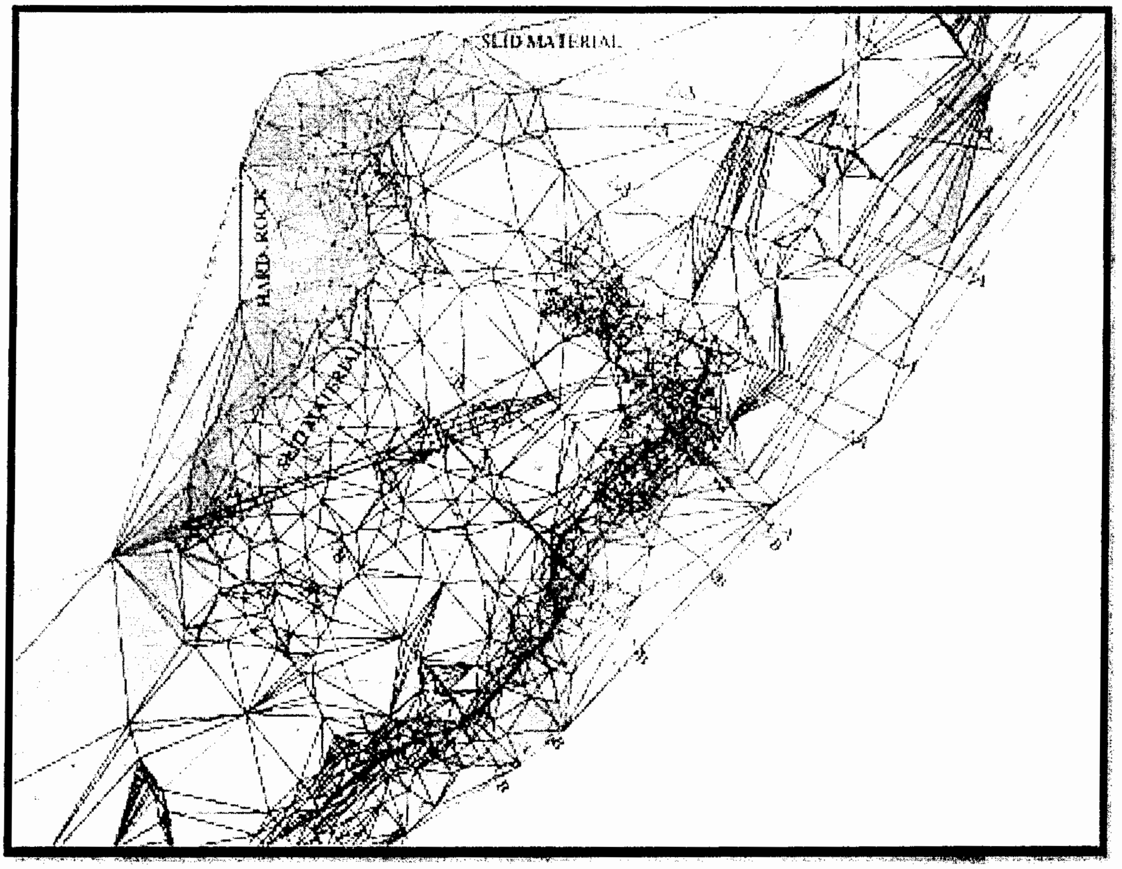


Figure: 5.1 View of Trigonometric Network view at Weir Site

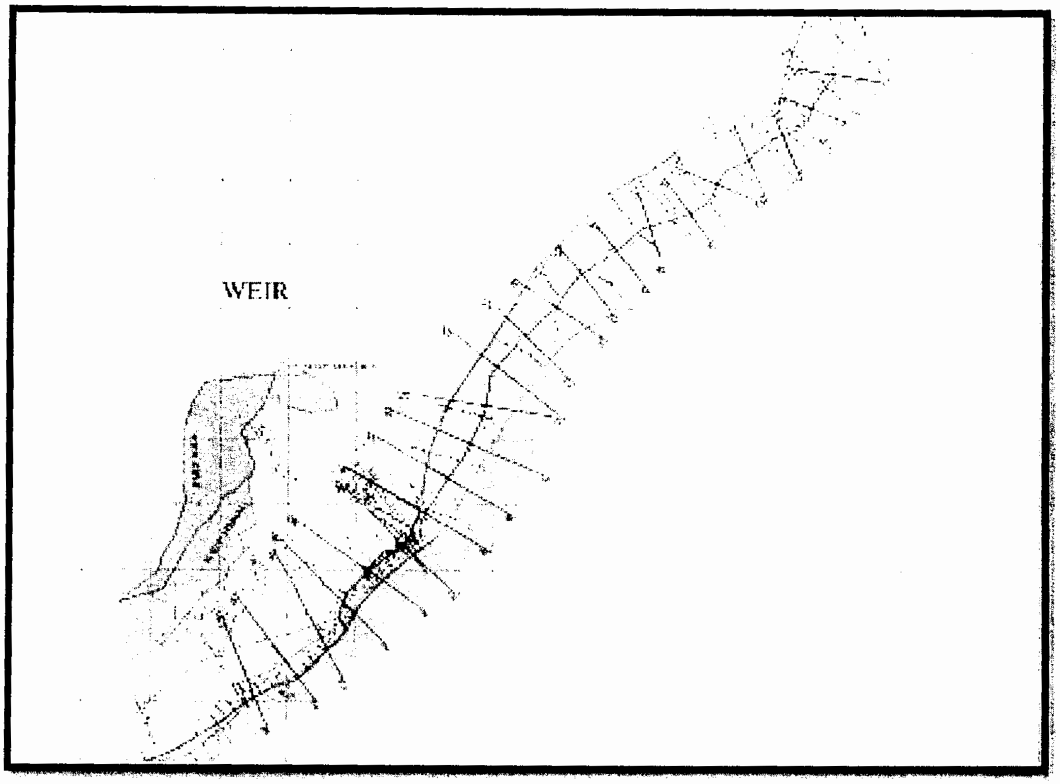


Figure: 5.2 Overview of the River Cross-sections Surveyed at Weir Site

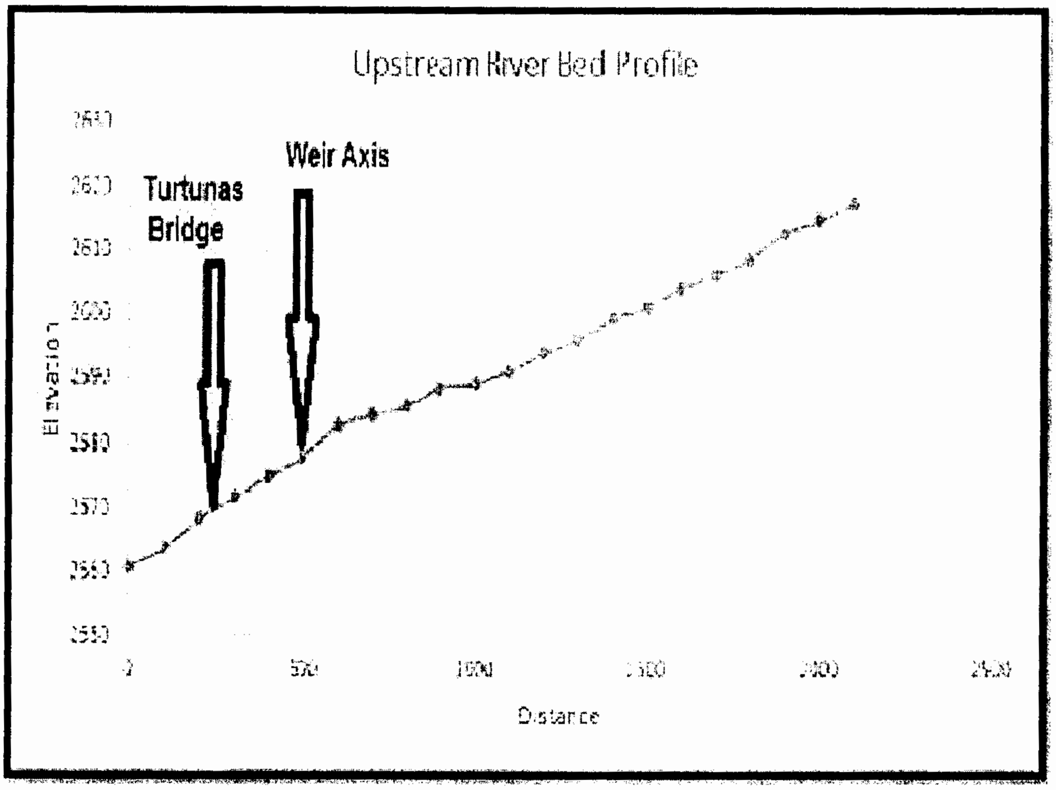


Figure: 5.3 River Bed Profile at Weir Site

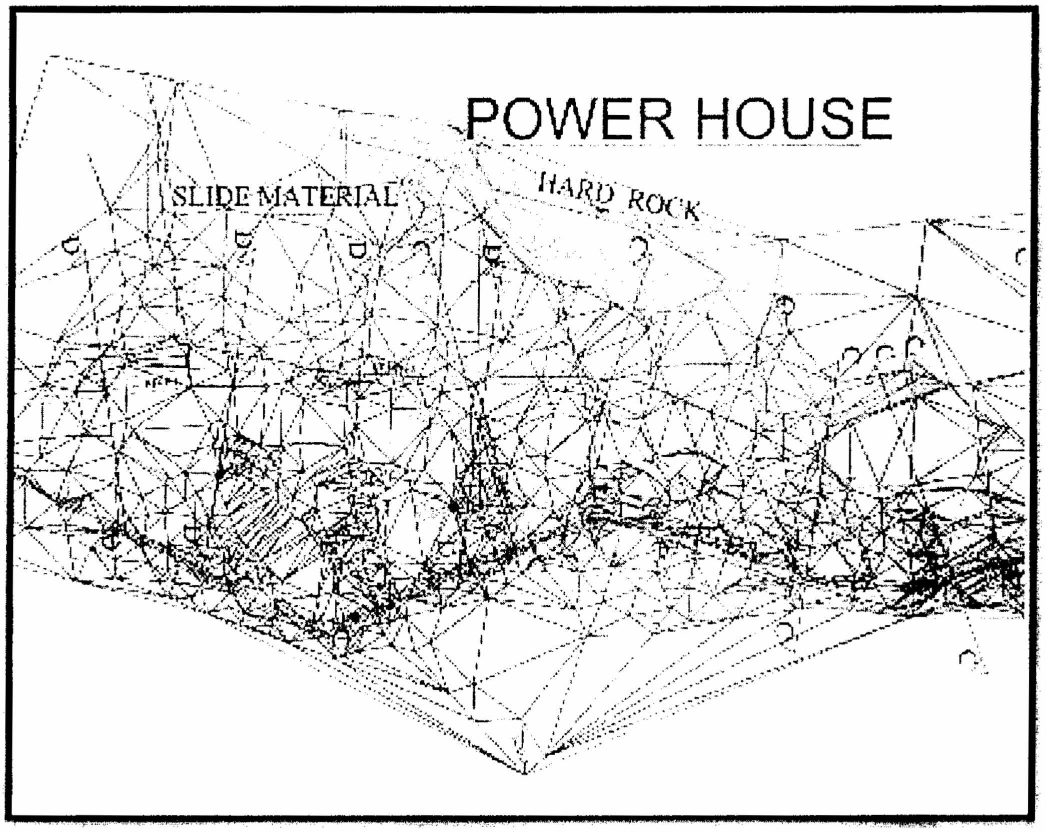


Figure: 5.4 View of Trigonometric Network at Powerhouse Site

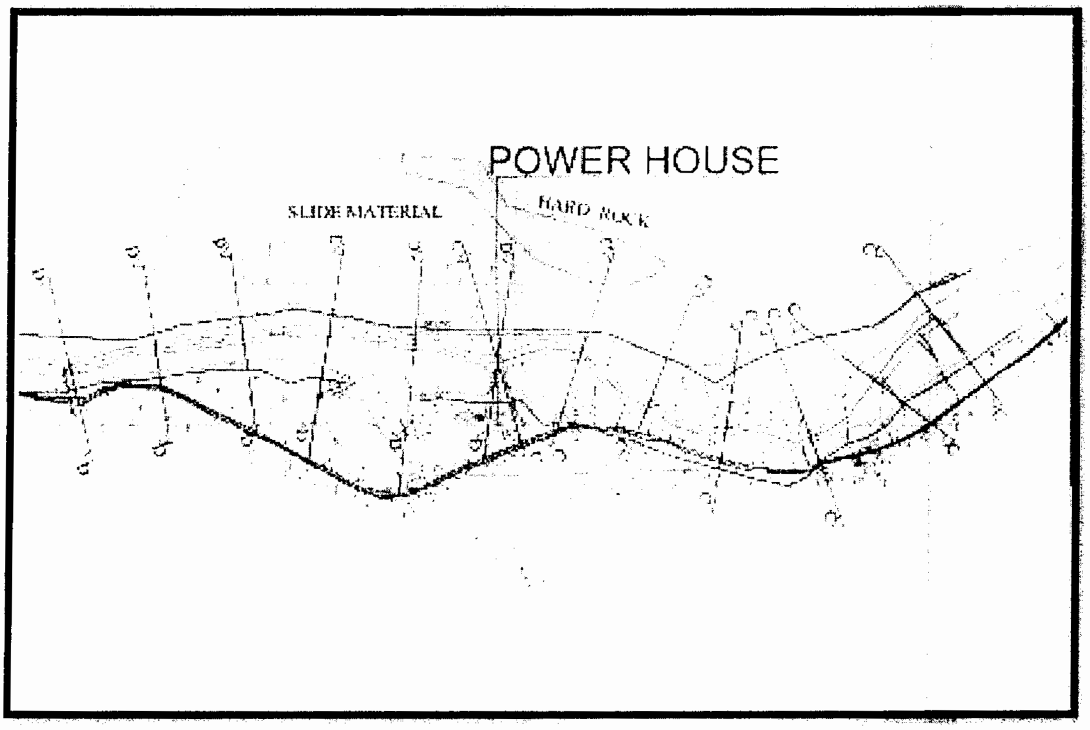


Figure: 5.5 Overview of River Cross-sections Surveyed at Powerhouse Site

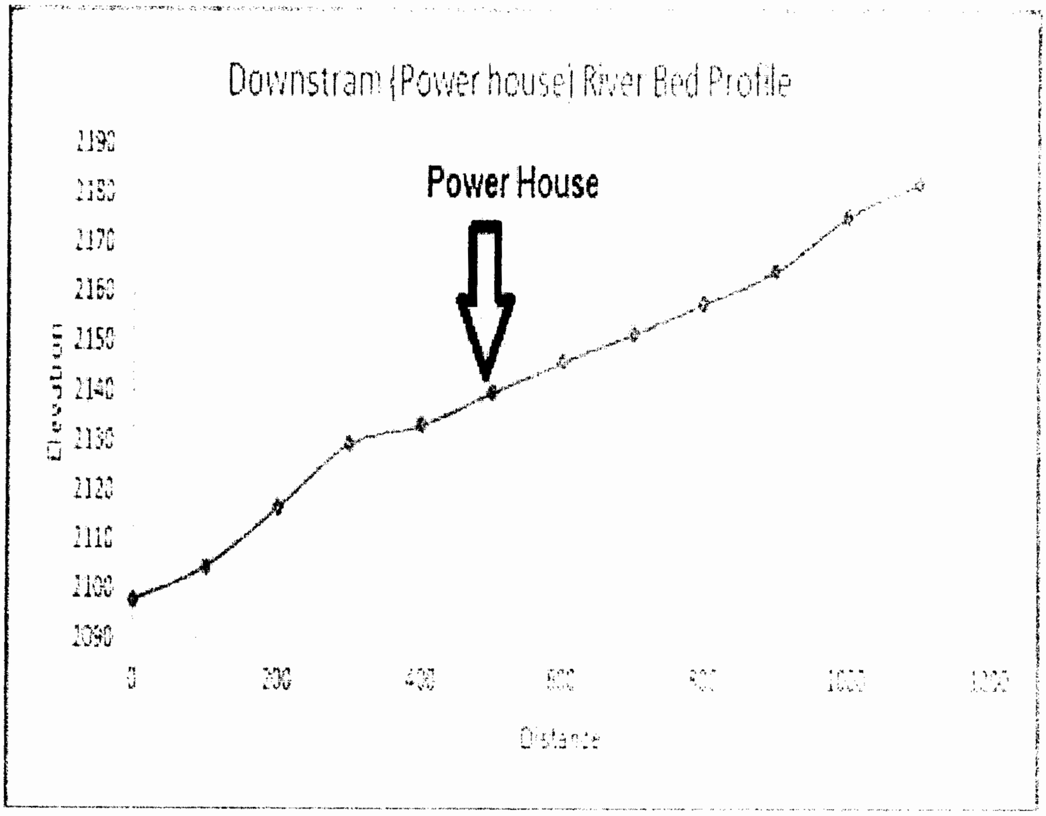


Figure: 5.6 River Bed Profile near Powerhouse Site

CHAPTER - 6

METEOROLOGY, HYDROLOGY AND SEDIMENT

Chapter: 6

METEOROLOGY, HYDROLOGY AND SEDIMENT

6.1. Introduction

This chapter contains data and processing of climatic, hydrology and sediment. Details about data availability for climate, water availability record and sediment and there processing and conclusions are presented in **Appendix: C Meteorology, Hydrology and Sediment**.

6.2. General Characteristic of the Project Area

Turtonas-Uzghor is one of the hydropower projects series taken up for study and construction in upper Golen Gol River gorge at upstream Golen Gol HPP, in Chitral district in the north of Khyber Pakhtunkhwa Province of the north-western region of Pakistan. Turtonas-Uzghor Hydropower Project is a run-of-river without storage project, planned for construction at about 12 km (river) upstream of the Mastuj Bridge gauging stations. Being a run-of-river project the operation of Turtonas-Uzghor dam will not affect the operation of the Golen Gol River in the downstream reach.

The Golen Gol River originates from a mountainous region (> 6000 m) and flows down towards south-west for about 25 km till it reaches the proposed weir site and then changes the direction towards Uzghor, where the proposed powerhouse site of the project is located.

River morphology and characteristics of catchment such as catchment area, river length, elevation, relief, time of concentration and land use pattern of the catchment was estimated from digital elevation model using spatial tools of ArcGIS which represents the continuous ground surface topography or terrain.

The catchment area at the weir site is found to be 388 km^2 and at the powerhouse site is 412 km^2. The elevation at weir site varies from 2,581m.a.s.l to 6,184m.a.s.l and average elevation of the catchment is 4,262 m.a.s.l. Within the catchment area, the pattern of change in the drainage area with the change in elevation has been analyzed which indicates that the drainage area of the project site is regularly steep with no significant flat area.

In the downstream vicinity of the proposed Turtonas-Uzghor Hydropower Project site the climatological stations are at Chitral and located at about 36 km downstream of Turtonas-Uzghor weir site and are maintained by Pakistan Meteorological Department (PMD). In general the climate of the project area is hot in summer and cold in winter. At the Chitral station the monthly temperature is recorded from 38.4°C (in June) to -2.9°C (in January). The distribution of precipitation during the year depends very largely on the topography of the area and season. The precipitation regime in the project area is dominated by the occurrence of eastward moving extra tropical zones of low pressure, also known locally as Western Disturbances. During the summer season the frequency and intensity of the Western Disturbances normally decrease, and the precipitation on the region also decreases. The intensity of monsoon summer rainfall is hence low. The average annual rainfall at Chitral Climate station is computed 444 mm according to the observation data for the period from 1977 to 2015 and it decreases continuously towards the upstream. The relative humidity occurs maximum in the month of January with a value of 66 % and minimum in the month of June with a value of 17 %.

There is no stream flow observing station available at Turtonas-Uzghor HPP weir site but a short term stream daily flow available at 9.2 km downstream Babuka and 12 km downstream Mastuj Bridge gauging stations and long term stream flow are available at Chitral station. Both gauging station due to its characteristic of river basin similar to project area and considered very important for simulation flow at projects sites. The total Catchment area of Chitral River at Chitral station about 11396 Km^2 and catchment area of Golen Gol River at Babuka and Mastuj Bridge stations are reported 500 and 520 Km^2respectively. The average annual flow recorded at Chitral station is 275.35m^3/s. Therefore the average annual flows measured at Babuka and Mastuj Bridge gauging stations are 18.55m^3/s (1993 -1996) and 15.99m^3/s (1997-2015. Both rivers flow are mainly influenced by snowmelt, which in the region takes place from June to September. There are maximum high floods at Mastuj Bridge was reported as 212.95m^3/s in 24 July 2015 and 2266.4m^3/s was recorded at Chitral station in 28 July 2015 respectively. The climate characteristic at Chitral was shown in **Table: 6.1**.

Table: 6.1 Climate characteristic at Chitral station

Month	Precipitation	Relative Humidity	Temperature		
			Maximum	Minimum	Mean
	(mm)	(%)	(°C)		
Jan	43.5	43	11.7	-2.9	4.4
Feb	62.2	45	20.5	-1.5	9.5
Mar	111.4	43	19.7	0	9.85
Apr	70.9	40	28.5	0	14.25
May	40.8	35	32.8	9.8	21.3
Jun	10.2	26	38.4	0	19.2
Jul	7.1	29	37.8	16.1	26.95
Aug	8.0	33	36.8	15.5	26.15
Sep	12.5	34	33.5	0	16.75
Oct	21.3	37	28.8	2	15.4
Nov	29.2	56	23.3	0	11.65
Dec	34.0	43	15.4	0.4	7.9

6.3. Hydrological Performed

The hydrological and sedimentation studies performed pertain to the following activities:

- Formulation of Flow Series at the Turtonas-Uzghor weir site
- Design Flood/Flood Frequency Analysis
- Sediment Load Analysis

6.3.1. Hydrology

The inflow time series at Turtonas-Uzghor weir site is required for determining the reliable flows available for power generation. It is already described above that there is no stream flow observing station available Turtonas-Uzghor HPP site situated about 12km upstream from Mastuj Bridge and 9.2 km upstream Babuka stations. In the first stage river discharge measured at Mastuj Bridge and Babuka was corrected using available data information at both G/S and which can be transposed to the weir site by indirect assessment method. The daily flow series are measured at these stations only available for few years but from the hydrological aspects, to develop the possible flow duration curve; long flow data was required for long-term energy generation by the project with adequate reliability. The long term flow computation at project site need best correlation investigation with nearby river gauging station or catchment having same climatic and geomorphic characteristic. For estimation of long term flow series at project site, four correlations were developed between nearby river gauging station having same characteristics and homogenous catchments. The Chitral River and Golen Gol River flows correlation is hydrologically well investigated and has much longer records than at Golen River. The hydrology of the Chitral River represented by those stations can be safely transposed to the project site at Golen Gol River with identical climatic, topographic and geomorphologic conditions. The low flow persists at project site from November to March and the mean flow ranges from 7.6 to 9.7m^3/s. The high flow months are July and August with mean flow tending to rise well above 31 m^3/s. The minimum, mean and maximum 10-daily flows at the Turtoas-Uzghor Weir site have been computed as 6.83, 14.4 and 33.46 m^3/s, respectively and the total annual flow at the project site are varies from minimum of 122m^3/s to the maximum of 252.5m^3/s . A flow-duration curve (FDC) represents the relationship between the magnitude and frequency of daily, weekly, monthly (or some other time interval of) stream flow for a particular river basin. The flow duration curve (**Figure: 6.1)** is calculated using the daily flows available at the project site (see Figure below) and the flow of 10%, 30%, 50%, 80% and 100% exceedance probability is computed as 31.22, 17.29, 11.62, 7.79 and 3.7m^3/s respectively.

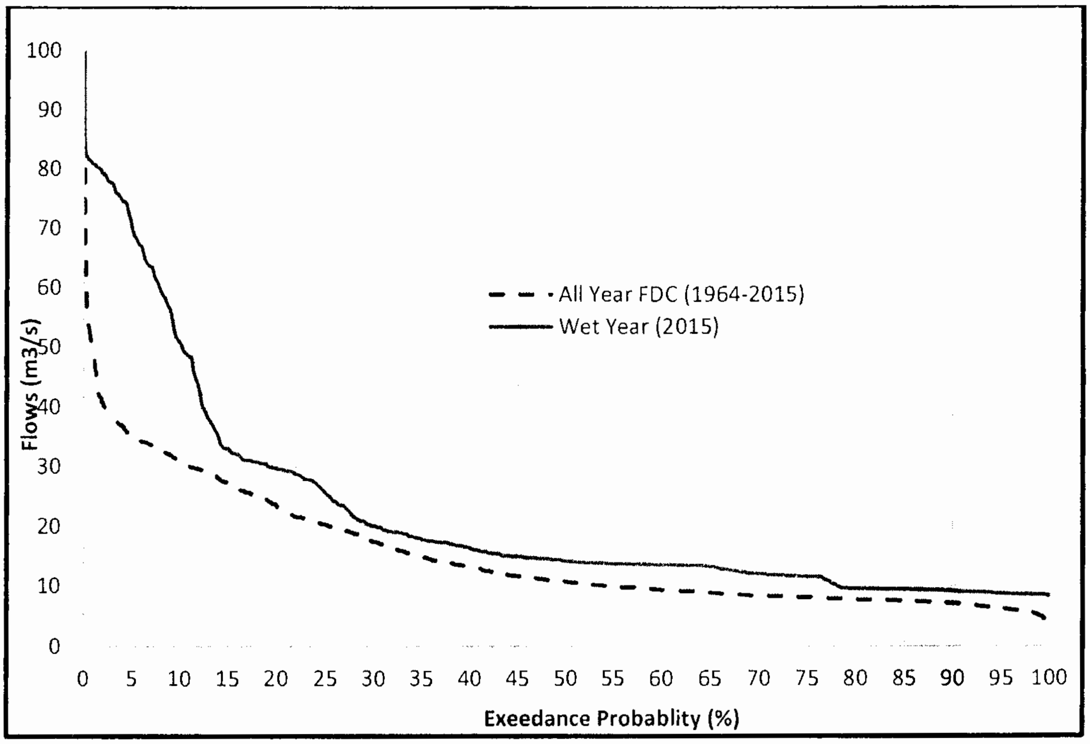


Figure: 6.1 Flow Duration Curve at Turtonas-Uzghor Weir Site

6.3.2. Flood Estimates

A Flood Study is a comprehensive technical investigation of flood behavior in a particular catchment. Estimates of flood magnitudes and probability are needed for dam/weir design and safety assessments, flood risk management and spatial planning. With this consideration the flood studies carried out Statistical flood frequency analyses based on observed data. HEC-SSP software version 2.1.1 (2017) was used to analyse flood frequency in the catchment using Pearson Type-III, Logarithmic Pearson Type III and Log Normal and HYFA software was used to evaluate the flood magnitude using the Gumbel's or Extreme Value type 1 distribution (EV1). The highest peaks in each hydrological year were arranged in descending order of magnitudes and ranks were then assigned. The three statistical tests namely, Kolmogorov Smirnov, Anderson Darling and Chi-squared were carried out with all the fitted probability distribution functions for the flood frequency analysis. The results of the statistical checks of the fitting of different probability distribution functions in the flood frequency analysis Log-Pearson-III founded best distribution for the project site but the magnitude of flood computed by FFA method is lower due to low data quality. For the evaluation of safer design flood for project area an envelope curves method was used. The envelope curve method can be applied when only an observation from a single/few flood events are available from several homogenous stations rather than complete flood series. Flood peaks of return period 100, 500 and 1000 years computed by envelop curve at weir site are 693, 790 and 1025m3/s and at powerhouse site flood peaks of above return period was computed as 706, 803 and 1042m^3/s. Flood peaks computed at weir site and powerhouse site is summarized in Table below and it was recommended for design hydraulic structure.

Table: 6.2 Recommended Floods at Weir site

Return Period	Turtonas-Uzghor Weir site	Powerhouse Site
(yrs.)	(m/3)	
10	453	463
100	693	706
500	790	803
1000	1025	1042
10000	1334	1350

6.3.3. Sedimentation study

The main purpose of this study is to determine the accuracy of total sediment load calculations based on a sediment concentration measurement which available close to proposed Turtonas-Uzghor weir site. No in-depth sedimentation study had earlier been carried-out for Turtonas-Uzghor weir site, its reservoir and watershed area by any consultant and organization. Whereas, SWHP organization of WAPDA has measured sediment data from 11.6 km downstream to the proposed weir site on Golen Gol River at Mastuj station. Golen Gol River is the natural drainage of glaciated areas in North-Pakistan, which are the source of sediments of different gradation. Approximately 11% of the catchment area of Turtonas-Uzghor HPP extends at elevations higher than 5200m.a.s.l. The average slope at weir site 40 % was computed with GIS and remote sensing tools. Sediment discharge data of ten sediment gauging stations was collected from the SWHP, WAPDA, and Sediment Appraisal of Pakistan Rivers publications by SWHP, Hydrology and Water Management Organization, WAPDA which has been used for estimation of the sediment yield watershed with regional analysis approach. Specific Suspended sediment yields of Golen Gol River at Mastuj sediment gauging stations was computed 133 Tons/km^2/year. The sediment inflow to Turtonas-Uzghor weir site has been computed by sediment rating curve method. The sediment data in terms of sediment concentrations converted into sediment transport rates in Ton/day. Using the sediment data of Mastuj Bridge station developed a sediment rating curve for the suspended sediment. The empirical equation developed by sediment rating curve was used to estimation total sediment load at weir site. Total sediment load computed by rating curve method at weir site is 0.045 Mt. Mean monthly and monthly maximum suspended sediment load at weir site were shows in Figure below.

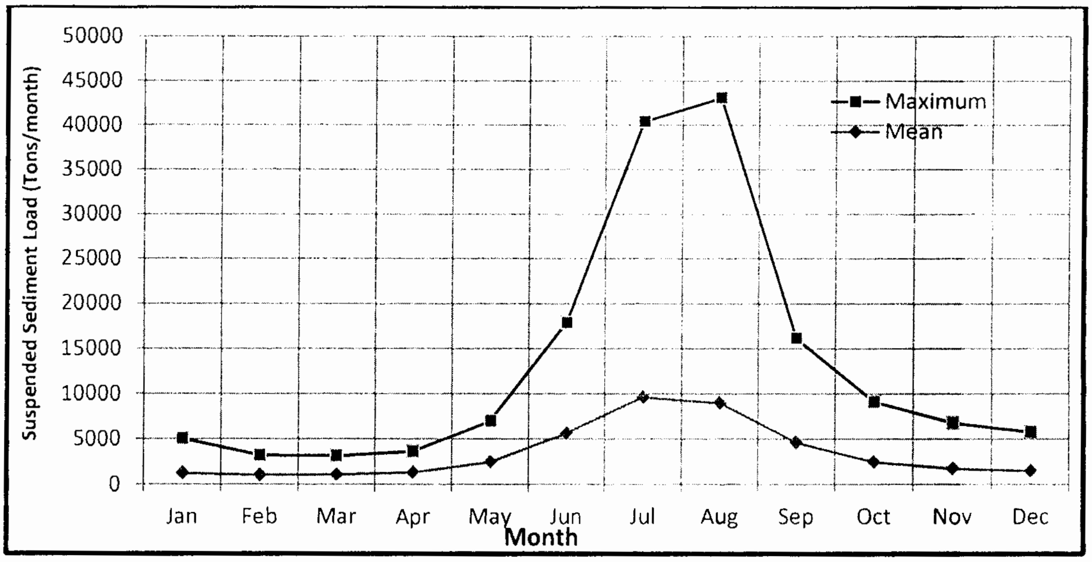


Figure: 6.3 Mean Monthly and Monthly Maximum Suspended Sediment at Weir Site

Bed load is the rate of movement of sediments along the river bed in the process of rolling, sliding and/or hopping. It is very difficult to measure bed load by sampling. As such, no practical device for measurement of bed load in the field is used by any concerned department. US Bureau of Reclamation USBR (1987) provides useful guidelines and range of the bed load in terms of suspended load is 5 to 15 %. The sediment inflow to Turtonas-Uzghor weir is estimated as 0.0486 Mt.

Table: 6.3 Sediment Load at Weir

Description	**Weight**
Annual Suspended Sediment	0.045 Mt
Bed Load (8% of Annual Suspended Sediment)	0.0036 Mt
Total Sed. Inflow	0.0486 Mt

CHAPTER - 7

GEOLOGY, GEOTECHNICS AND CONSTRUCTION MATERIAL

CHAPTER: 7

GEOLOGICAL, GEOTECHNICAL INVESTIGATIONS AND CONSTRUCTION MATERIAL

7.1. INTRODUCTION

It is proposed to develop a Hydropower Scheme on middle reach of Golen Gol River, a left bank tributary of Mastuj River. The Project area falls in the district (**Figure: 7.1**) of Chitral, Khyber Pakhtunkhwa Province of Pakistan. The current study comprises of carrying out feasibility study of the project. The basic features of the project area which comprises of main diversion weir and its appurtenant structures are proposed to be built in two sections. The overall weir length will comprise of an overflow fixed weir and under-sluice section. The fixed weir has been designed to pass a flood discharge of 1150 m^3/s which has a return period of 1000 years. The ogee shaped overflow section of weir is 40 m wide. The under-sluice section of weir has 2 no. vertical lift gates. The power intake inlet consists of 2 No. gated. Each inlet is equipped with vertical stop-logs and trash-rack inclined at an angle of 82° with the horizontal floor of intake. There is provision of stop logs at the downstream side of intake gates in order to carry out repairs of one gate in lifting position while the other gate is still open and diverting flows to the connecting channel.

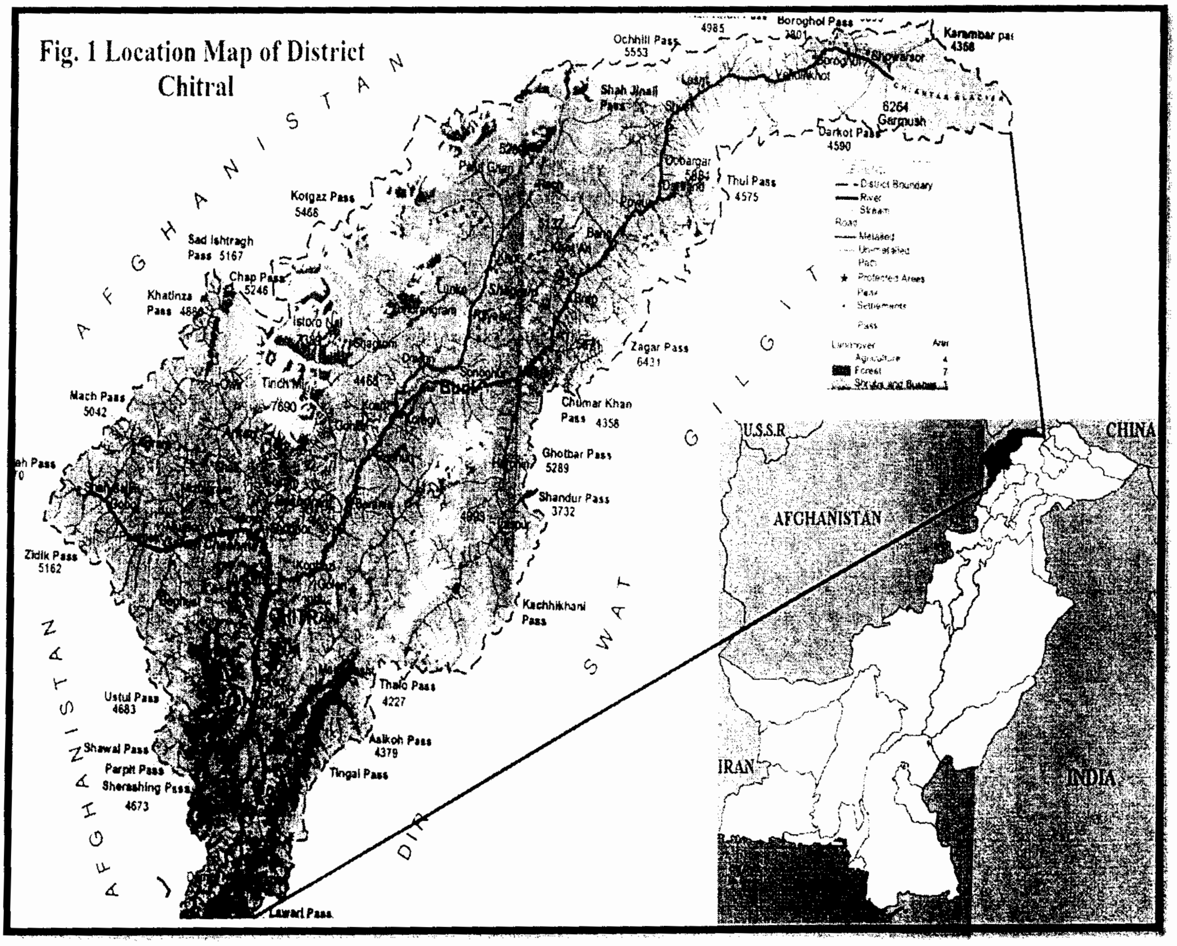


Figure: 7.1 Location Map of Project and District Chitral

The flows will then be carried through a rectangular connecting channel to the sand trap. The sand trap structure has been proposed and will be a reinforced concrete structure. The total length of sand trap will be 112.64 m; including 26.54 m long transition from the connecting cannel end. The width of combined structure is 25.30 m while its depth varies between 8.55 m and 11.5 m. The flows will resume through a rectangular connecting channel to headrace tunnel. The headrace tunnel is designed as a horseshoe shaped free flow conduit of 3.5 m diameter. It is approx. 4.5 km long and has a slope of 1 in 1000.

The headrace tunnel then shall be connected to a 2.5 m diameter vertical shaft and 2.5 m diameter horizontal pressure tunnel. The horizontal pressure tunnel will further be bifurcated to feed two turbine units having 41.125 MW and having each bifurcation a 2 m diameter. An open type powerhouse will be provided on the right bank of river. The powerhouse will be equipped with two Pelton turbine units having vertical axis. The concrete lined free flow tailrace will convey the discharge from the draft tube outlet gates up to the Golen Gol River.

This part of report comprise of geological, geotechnical and construction material aspects of the project which provides necessary information regarding project and its various components and additional investigations will be required to obtain the required information for the project design and tender documents. Location map of Chitral is shown in **Drawing No. TUHPP-01**.

7.2. PROJECT LOCATION

The Project Turtonas-Uzghor is located along Golen Gol River (lat. 35.945613° & long. 71.978342°) which is a left bank tributary of Mastuj River. It joins with Mastuj River about 22 km North-East of Chitral Town. The diversion weir site is proposed approximately 11 km upstream of Golen Gol Town. The power house site is proposed on right bank of Golan Gol River near Uzghor Village about 200 m upstream from diversion weir of Golen Gol Hydro Power Project. The powerhouse site is located north-east of Chitral Town at a distance of about 33 km. The powerhouse site is located at global coordinates of (Latitude 35^0, 55' 13.74" and Longitude 72° 00' 2.40").

The diversion weir site located at global coordinates of (Latitude 35^0 56.398' and Longitude 72^0 3.168'). The Project location and Vicinity Map are shown in **Drawing: TUHPP-01** and **Drawing: TUHPP-02**, respectively.

7.3. GEOLOGICAL AND GEOTECHNICAL INVESTIGATION

7.3.1. Previous Investigation

7.3.1.1. General

Golen Gol (in operation) Hydropower Project (GGHPP) is along the Golen Gol and located along its downstream reach. The powerhouse existing near the confluence of Golen Gol and Mastuj River and on left bank of Golen Gol and Mastuj River. The project having capacity of 108 MW is put in operation from January 2018. Diversion weir is upstream of Golain Village which divert water toward headrace tunnel having length of 5.0 km and lying along left bank of Golen Gol. Headrace ultimately transfer water to turbines unit housed in open powerhouse. After generating electric power water goes directly in to Mastuj River.

Geological Maps of Golen Gol Hydropower Project & Turtonas-Uzghor Hydro Electric Power Project prepared by Geological Surface of Pakistan is presented in **Drawing: TUHPP-05** and **Drawing: TUHPP-06.** The drawing shows that Golen Gol tunnel crosses the Ayun Fault where it enters in to Quartz Mica Schist, Marble and Calcareous Quartzite, respectively. However, in project area of Turtonas-Uzghor Hydro Electric Power Project granite exists all along its tailrace and no fault is crossing the tunnel.

Geotechnical investigations were carried out during feasibility study (July 1997) prepared by WAPDA and GTZ (German Agency for Technical Cooperation) and detailed engineering design stage (2007-2009) of Golen Gol HPP was prepared by M/S FICHTNER, Germany and Pakistan Engineering Service. Surface geological mapping and scan line reading along the project alignment was carried out. Drilling and Test Pits were performed to get the knowledge of sub-surface geological condition. No Adit was excavated. The drilling carried out along Weir and Powerhouse Site can be in layout (**Drawing: TUHPP-07** and **Drawing: TUHPP-08**).

The following information was gathered from feasibility study and detailed engineering design of Golen Gol Hydropower Project.

7.3.1.2. Drilling Record

Drilling has been performed (**Table: 7.1**) and (**Table: 7.2**) on weir, inlet portal, tunnel portal, pressure shaft, surge tank and at powerhouse location which are tabulated here below.

Table: 7.1 Drilling Record during Feasibility Study of GGHPP

Borehole	Location	Top Elevation	Total Depth (m)	Bedrock at Elevation (m)	Bedrock at Depth (m)
GGW1	Weir 2	2,050.5	10.0	none	None
GGW2	Weir 2	2,053.0	10.0	none	None
GGW3	Weir 2	2,055.0	10.0	none	None
GGT1	Inlet Portal	2,117.5	30.0	none	None
GGT2	Tunnel Portal	2,042.9	30.0	none	None
GGPS1	Pressure Shaft	2,140.0	150.23	2,139.5	0.5
GGP1	Pressure Shaft, Down	1,644.1	3.0.0	1,622.5	21.60
GGP2	Powerhouse Down	1,629.2	30.0	none	Non
GGP3	Powerhouse Down	1,612.4	46.56	1,577.5	34.90
GGPH4	Powerhouse Up	1,644.0	22.0	1,637.0	7.0
GGPH5	Powerhouse Up	1,629.0	55.0	1,578.2	50.80
GGPH6	Powerhouse Up	1,634.0	45.0	1,605.0	29.0

Table: 7.2 Drilling Record during Detailed Engineering Design of GGHPP

Hole No.	Coordinates		Bearing / Angle	Ground Elevation	Drilling Length			Soil / Rock Type
					Soil	Rock	Total	
	m	m	Degrees	m	m	m	m	
GGPS-1	1303185	3100868	90°	2140	4	146.23	150.23	Marble
GGP-1	1303581	3100397	90°	1644.12	19.9	10.1	30	Green Schist
GGP-2	1303606	3100373	90°	1629.169	30	-	30	OB
GGP-3	1303624	3100332	90°	1612.438	35.1	11.46	46.56	Green Schist
GGPH-4	1303589	3100430	90°	1644	7	15	22	Mylonized Calcareous Quartize
GPPH-5	1303626	3100397	90°	1629	50.5	4.5	55	-DO-
GPPH-6	1303603	3100417	90°	1634	29.5	15.5	45	-DO-
GPPH-7	1303631.45	3100457.31	168°/40°	1620.22	-	70.4	70.4	Calcareous Quartize
GGW-1	1300301	3103499	90°	2050.5	10	-	10	OB
GGW-2	1300327	3103528	90°	2053.5	10	-	10	OB
GGW-3	130345	3103549	90°	2055	10	-	10	OB
GGT-2	1300369	3103139	90°	2042.9	30	-	30	OB
GGT-3	1300298.12	310311.43	240°/40°	2072	-	50	50	Granite

7.3.1.3. Golen Gol Site Geology

Granite is the main rock unit which is exposed at the intake portal area and extends up to Ayun Fault (**Drawing: TUHPP-06**) where it is separated from Quartz Mica Schist. Granite is generally whitish grey/greenish white in color, hard and weathered on the exposed surface in general. The nature of granite appears to be changing at places and looks like to be granodiorite. It is generally massive and blocky however three sets of prominent joints have been recorded in the area of intake postal. Geological map of Golen Gol Hydropower Project is shown above in **Drawing: TUHPP-05** and **Drawing: TUHPP-06.**

1. NS/26° W DIAGONAL JOINT
2. N20W/58° NE TRANSVERSAL JOINT
3. N80E/85° NW LONGITUDINAL JOINT

Headrace tunnel intake portal only four out of six reported joint sets are confirmed dipping steeply to NE, SW and to NW. It can be noted that upper part of Headrace Tunnel (2775m approx.) will be passing through Granite of igneous nature and the remaining downstream (825m and 200m) will be passing through metamorphosed rock types which are Quartz Mica Schist, Marble and Calcareous Quartzite, respectively. Ayun fault separates these formation (**Drawing: TUHPP-O6**).

The **power house** is located more or less parallel to the flow of Mastuj River and will be placed almost at the foot of steep and high exposed rock. It will be a concrete structure about 79.0 m in length and 28.0 m in width with an expected height of almost 33.0 m. The surface and sub-surface geological condition together with geotechnical information gathered from carried out investigation, explained that rock is available at 7 to 30 m depth. The rock is calcareous quartzite and quartz mica schist.

7.3.2. Present Field Investigations and Laboratory Testing

7.3.2.1. General

The program of field investigations and laboratory testing undertaken on Turtonas-Uzghor Hydro Electric Power Project site incorporated the following:

- Surface geological mapping
- Scan Line and Rock discontinuity surveys
- Subsurface Drilling
- Test pits excavations
- Laboratory testing

7.3.2.2. Surface Geological Mapping

During office studies, maps prepared by Geological Survey of Pakistan and other literature available regarding geology of the Pakistan, especially Chitral Area. **Drawing: TUHPP-10** shows the regional geology of Pakistan of Golen Gol area and has been extracted from 1:100000 map prepared by **Geological Survey of Pakistan**.

The Consultants with the help of Brunt Compass and Geological Hammer conducted the surface geological mapping on topographic survey sheets for layout of project structures. Surface geological mapping of the project area so prepared is presented in **Drawing: TUHPP-15** and **Drawing: TUHPP-80 through Drawings TUHPP-188.**

7.3.2.3. Scan Line and Rock Discontinuity Survey

Scan line and rock discontinuity survey was also carried out (**Appendix: D-4.1** to **Appendix: D-4.13**) all along the headrace, pressure shaft, penstock and powerhouse. About 10 scan lines having length of 30 m each were prepared along the tunnel alignment. The data so depicted is presented in **Appendix: D-4.1** through **Appendix: D0-4.13**. Discontinuity data of Scan line 10 (**Appendix: D-4.11**), Scan line 11 (**Appendix: D-4.12**) and Scan line 12 (**Appendix: D-4.13**) having length of 70 m , 140 m and 200 m, respectively recorded at powerhouse site. While scan line maps which are shown in **Drawing: TUHPP-80** through **Drawings: TUHPP-188** and each scan line presented in **Drawing: TUHPP-32** through **Drawing: TUHPP-58** have been incorporated in main geological map (**Drawing: TUHPP-150** also. RMR assessment based on these scan lines is presented in **Appendix: D-5.1** through **Appendix: D-5.15** and while percentage RMR is presented in **Appendix: D-5.15**.

7.3.2.4. Subsurface Geological Investigation - Drilling

Subsurface investigation were also carried through third party (Techno Time Construction (Pvt.) Ltd), Islamabad, hired by the Client) under the supervision of Consultant. Sub-surface investigation and laboratory testing program was prepared (**Appendix: D-1**).

Five (05) boreholes of variable depth were drilled, out of which three are located in the weir site, one in the tailrace area and one in the Powerhouse site. One borehole in intake portal at the weir site was drilled in the bedrock and one in powerhouse where drilling was in the bedrock.

Drilling was carried out by straight rotary rigs using diamond core bit. Four boreholes were drilled by straight rotary method up to a maximum depth of 25.0 m, while one borehole in powerhouse.

Three boreholes W-01, W-02 & W-03 were drilled at weir site up to 20m depth from ground surface level, one borehole at Tailrace PH-04 drilled up to 25m depth while one borehole at powerhouse (cavern) location PH-05 drilled up to 14.0 m depth instead of 88.0m depth and had to stop due to worst weather conditions. Exploratory drilling was conducted through straight rotary drilling method by using water as drilling fluid, casing was used in overburden to avoid borehole collapsing. HQ size (inner diameter 63.5 mm & outer diameter 96 mm) and NQ size (inner diameter 47.6 mm & outer diameter 75.7 mm) drilling bit was used. Other details are mentioned on borehole logs as well.

A total of 5 boreholes having total length of 99 m were drilled at weir, sedimentation basin, tunnel intake portal, tailrace and powerhouse. The borehole logs are placed as **Appendix: D-2** and summary of boreholes is at **Table: 7.3** and **Table: 7.4**.

Table: 7.3 List of drilled Boreholes

#	B. H.	Location	Depth	Position	Dia.	In Situ Test
1.	W-01	Riverbed	20 m	Vertical	HQ/NQ	Permeability at 5m intervals or change of strata,
2.	W-02	Sedimentation Basin	20 m	Vertical	HQ/NQ	-do-
3	W-03	Intake Portal	20 m	Vertical	HQ	- Lugeon, Permeability at 5m intervals or change of strata, Pressure stages eg. 2-4-8-4-2
4	PH-04	Tailrace	25 m	Vertical	HQ/NQ	Permeability at 5m intervals or change of strata,
5	PH-05	Powerhouse/ Surge Shaft	14 m	Vertical	HQ/NQ	- Lugeon, Permeability at 5m intervals or change of strata, Pressure stages eg. 2-4-8-4-2

Borehole logs were prepared indicating core recovery and Rock Quality Designation (RQD) percentage along with the detailed description of the material encountered.

The logs include information on:

- Drill hole number, orientation, inclination and elevation of the hole.
- Length of runs and percentage of core recovery

- Overburden thickness and description of material
- Rock type distribution and degree of weathering
- Water Pressure Tests WPTs / Lugeon values in rock masses
- Degree of jointing given as Rock Quality Designation (RQD)
- Joint characteristics

Table: 7.4 Drilling Record of Present Drilling at Uzghor HPP

Hole No.	Coordinates		Bearing / Angle	Ground Elevation	Drilling Length			OB/Rock Type
	North	East			Over Burden	Rock	Total	
			Degrees	Meter	m	m	m	
W-01	1302792.94	3109062.63	90°	2582	20	Nil	20	Overburden
W-02	1302720.53	3108765.502	90°	2584	20	Nil	20	Overburden
W-03	1302649.19	3108470.95	90°	2610	4.5	15.5	20	Granite/ Granodiorite
PH-04	1300098	3103999	90°	2119	25	Nil	25	Overburden
PH-05	1300279.45	3104358.865	90°	2253	3.5	10.5	14	Granite/ Granodiorite

Lugeon, permeability, SPT and CPT in-situ testing were conducted (**Table: 7.5**) in most of the drill holes The results are shown on the borehole logs (**Appendix: D-2.1**) and all field testing is presented in **Appendix: D-2.2**. Ground water measurements were also recorded accordingly in the drill holes, however, no ground water available in all bore holes except at Weir Site.

Table: 7.5 List of In-situ Tests in Boreholes

#	Borehole No.	Drilling Depth (m)	Progress (m)	Lugeon Test (No.)	Permeability Test (No.)	SPT (No.)	CPT (No.)	Location
1	W-01	20	20	Nil	4	Nil	10	Weir/Riverbed
2	W-02	20	20	Nil	4	6	3	Weir/Sedimentation Basin
3	W-03	20	20	3	1	Nil	1	Weir/Intake Portal
4	PH-04	25	25	Nil	5	Nil	14	Tailrace
5	PH-05	88	14	2	1	Nil	1	Powerhouse
Grand Total		173	99	5	15	6	28	

Cores recovered from boreholes were placed in the core boxes and there Photographs are presented in **Appendix: D-2.3.** The core recovery in borehole W-03 is about 78% while in PH-05 is 90%. As the recovery directly influences the RQD and corrections had to be made for a correct assessment of the rock quality. The corresponding core recovery is given in each bore log protocol and the photographic documentation of core boxes is appended as in **Appendix" D-2.3**. Core recovery in each borehole is listed in **Table: 7.6**.

Table: 7.6 Average Core Recovery in Boreholes

Borehole	Average CR (%)
W-01	Overburden/Not Encountered
W-02	Overburden/Not Encountered
W-03	78%
PH-04	Overburden/Not Encountered
PH-05	90%

The **RQD** is defined as the percentage of how many core pieces longer than 10 cm are present in one drilling run (of normally 1 m). RQD assessed in each borehole is in **Table: 7.7**.

Table: 7.7 RQD in Boreholes

Borehole	Average RQD (%)
W-01	Overburden/Not Encountered
W-02	Overburden/Not Encountered
W-03	34%
PH-04	Overburden/Not Encountered
PH-05	66%

During the evaluation of the different data sources it turned out that RQD values of drill holes W-03 and PH-05 are somehow influenced by fracturing due to the drilling process and had to be verified and adjusted to account for the observed mechanical fracturing of cores during drilling which resulted in a more realistic approach of the rock quality.

In general, the RQD values from a certain depth are reasonably high (after the correction) indicating that the rock is in good and partially very good condition. This result has been regularly counter-checked by the water pressure results. The observed borehole core recovery with a mean of 84% was satisfactory, but the mean RQD- values in W-03 was 34% while in PH-05 was 66% as tabulated above.

SPT was performed in accordance with ASTM D-1586-84, generally at 5 ft depth interval below the existing level. The data obtained from these tests was utilized to assess the in-situ denseness of the subsurface materials. The SPT blow counts were recorded for 18-inch total penetration of split barrel sampler. The number of blows required to drive the sampler through the last 12 inches viz. 'N' values have been shown on the respective Borehole log sheets.

The Dynamic Cone Penetration test (CPT), a modified form of SPT was developed by Palmer and Stuart (1957) mainly for gravelly strata. The test was performed in drill holes W-01, W-02, W-03, PH-04 and PH-05 by replacing the standard split spoon shoe of SPT with a conical massive tip with an angle of 60° in the vertex. The testing procedure is exactly the same as SPT test and the blow count for every 6 inches penetration are recorded.

Constant Head permeability test performed for soil/overburden above or below ground water table. It is difficult to perform in soils of very high permeability. This test is 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 results of test are presented in **Table: 7.8**. It is recorded that permeability is high and increases with depth.

Table: 7.8 Subsoil Permeability Values

S. No.	Borehole	Test No.	Depth	Permeability(cm/sec)
1	W-01	CHP # 01	5.0m	K = 5.317 x 10^{-3} cm/sec
		CHP # 02	10.0m	K = 1.12 x 10^{-2} cm/sec
		CHP # 03	15.0m	Not conducted
		CHP # 04	20.0m	K = 1.739 x 10^{-2} cm/sec
2	W-02	CHP # 01	5.0m	K = 2.31 x 10^{-2} cm/sec
		CHP # 02	10.0m	K = 2.42 x 10^{-2} cm/sec
		CHP # 03	15.0m	K = 6.29 x 10^{-3} cm/sec
		CHP # 04	20.0m	K = 4.71 x 10^{-3} cm/sec
3	W-03	CHP # 01	4.0m	100% water loss
4	PH-04	CHP # 01	5.0m	100% water loss
		CHP # 02	10.0m	K = 9.23x10^{-3} cm/sec
		CHP # 03	15.0m	K = 6.02x10^{-3} cm/sec
		CHP # 04	20.0m	K = 3.72x10^{-3} cm/sec
		CHP # 05	23.5m	100% water loss
5	PH-05	CHP # 01	3.0m	K = 3.1 x 10^{-2} cm/sec

Lugeon tests / Water Pressure Tests were conducted in bed rock at 5.0 m interval and presented in **Table: 7.9**. In order to determine the engineering properties of bedrock in intake and powerhouse area in-situ water pressure tests (WPTs) were carried out conforming to relevant ASTM / British Standards. In total 05 tests of 5 m length test section, were carried out in the boreholes. Out of these 05 tests, a few Lugeon tests were also unsuccessful in high permeability zones as the pumps available at site were not able to deliver more than 130 liters per minute.

Table: 7.9 Results of Lugeon Tests

#	Borehole	Test No.	Depth	Flow Pattern	LU
1.	W-03	WPT#01	5.0-10.0	Turbulent	5.2
		WPT#02	10.0-15.0	Void Filling	42.2
		WPT#03	15.0-20.0	Turbulent	2.04
2.	PH-05	WPT#01	3.5-8.5	Washout	19.94
		WPT#02	8.5-13.5	Dilation	1.36

7.3.2.5. Subsurface Geological Investigation – Test Pits

Four test Pits having size of 3 m x 3 m x 5 m were excavated in order to assess the ground conditions at weir site, sedimentation basin, connecting canal and tunnel portal. The location of these Pits is given in **Drawing No: 2** the logs (**Appendix: D-3.1)** and photographs of these pits are presented in **Appendix: D-3.2.**

The sample send to laboratory test and results so obtained are presented in **Table: 7.9A**.

7.3.2.6. Groundwater OBSERVATIONS

The ground water table was encountered only in borehole W-01(Riverbed) at weir site which is 18.0m below the Natural Surface Level during the investigation (May 20th–Dec, 2017).

7.3.3. Laboratory TESTING

Laboratory testing was also carried out on selected surface samples as well as core samples. The results are available in **Appendix: D-6.2** for samples from Borehole while **Appendix: D-6.3** on samples from Test Pits. **Appendix: D-6.2.5** contains the chemical and biological analysis of water samples and **Appendix: D-6.2.6** contains petrographic analysis of bed rock samples.

Borehole No.	Sample	Grain Size Analysis & Hydrometer			Atterberg's Limits			Direct Shear Test (Soaked)		Standard Proctor Test	
		Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	PI (%)	C psi	φ (Degree)	OMC (%)	MDD (g/cm^3)
TP-1	BS-01	9.34	85.83	4.83	Non-Plastic			0	35.2	8.50	1.90
	BS-02	32.67	63.43	3.90	Non-Plastic			0.89	35.2	8.30	1.86
	CS-01	44.91	51.04	4.05	Non-Plastic			0	35.8	9.70	1.95
TP-2	BS-01	11.76	84.18	4.06	Non-Plastic			0	36.1	12.0	1.81
	BS-02	16.55	72.04	9.43	Non-Plastic			0	32.7	12.60	1.75
	CS-01	5.43	74.65	19.92	Non-Plastic			0	34.2	13.10	1.70
TP-3	BS-01	22.0	74.64	3.36	Non-Plastic			0.0242	35.9	11.20	1.83
	BS-02	22.76	75.13	2.11	Non-Plastic			0	37.0	10.70	1.87
	CS-01	38.21	58.89	2.90	Non-Plastic			0	35.9	5.50	1.98
TP-4	BS-01	45.53	53.92	0.55	Non-Plastic			0	36.7	9.50	1.87
	BS-02	50.22	46.20	3.58	Non-Plastic			-	-	7.40	2.08
	CS-01	50.93	46.22	2.85	Non-Plastic			0	38.0	7.10	1.91

Table: 7.9A Summary of Laboratory Testing Results on Test Pits Samples

Samples collected from the Boreholes were subjected to some of the following tests as per latest ASTM, BS or equivalent in standards at Geotechnical Testing Laboratory of NUST Institute of Civil Engineering, National Engineering University (NUST), Sector H-12 and Construction Material Testing Laboratory, Wapda Town, Lahore.

- Shear Test (ASTM D-3080) - **Appendix: D-6.1.9.1** & **D-6.1.9.5**
- Standard Sieve Analysis (ASTM D – 421, 422 & BS 1377 Part 2) - **Appendix: D-6.1.5.1** & **D-6.1.5.5**
- Atterberg Limits (ASTM D–4318 & BS 1377 Part 2) - **Appendix: D-6.1.8.1** & **D-6.1.8.5**
- Maximum Dry Density Test (ASTM D 1557) - **Appendix: D-6.1.1**
- Natural Moisture Content (ASTM D – 2216 & BS1377 Part 2) - **Appendix: D-6.1.6.1** & **D-6.1.6.5**
- Porosity Test of Rock - **Appendix: D-6.1.1**
- Point Load Test on Rock (ASTM D-5731) - **Appendix: D-6.1.4**
- Unconfined Compression (ASTM D – 2166 & BS 1377 Part 7) - **Appendix: D-6.1.3**
- Potential Reactivity Test (ASTM C-1260) - **Appendix: D-6.1.12.1 & D-6.1.12.6**
- Direct Proctor Test (ASTM D- 1557) - **Appendix: D-6.1.10.1 & D-6.1.10.5**
- Chemical and Bio-logical Analysis of Water Samples - **Appendix: D-6.2.5**
- Petrographic Analysis of Rock Samples - **Appendix: D-6.2.6**
- Rock Modulus Test - **Appendix: D-6.1.2.1 & D-6.1.2.3**
- Specific Gravity - **Appendix: D-6.1.7.1 & D-6.1.7.4**
- Permeability Test - **Appendix: D-6.1.11.1 & D-6.1.11.5**
- Natural Moisture Content - **Appendix: D-6.1.6.1 & D-6.1.6.5**
- Specific Gravity - **Appendix: D-6.1.7.1 & D-6.1.7.4**

The laboratory tests results are for Test Pits samples are such as;

- Sieve Analysis (ASTM D – 421, 422 & BS 1377 Part 2) - **Appendix: D-6.2.1.1** & **D-6.2.1.12**
- Atterberg Limits (ASTM D–4318 & BS 1377 Part 2) - **Appendix: D-6.2.2.1 & D-6.2.2.12**
- Direct Shear Test (ASTM D-3080) - **Appendix: D-6.2.3.1 & D-6.2.3.11**
- Standard Proctor Test (ASTM D- 1557) - **Appendix: D-6.2.4.1 & D-6.2.4.12**

The following type of samples were also collected during present investigations for laboratory testing.

- **Small Disturbed Samples:** From both boreholes through SPT split tube sampler, small disturbed samples were collected. All the disturbed soil samples were shifted to the laboratory after labeling and perseverance for necessary testing.
- **Water Samples:** Water samples were collected from river as well as in the boreholes where water table encountered.

- **Wax Samples:** Core samples have been waxed for conducting laboratory tests as in **Table: 7.10**.

Table: 7.10 Wax Core Samples from the Boreholes

S No.	Borehole	Wax Sample N0.	Depth(m)	
			From	To
1.	W-03	Sample No. 01	7.07	7.54
		Sample No. 02	11.78	12.15
		Sample No. 03	17.45	17.84
		Sample No. 04	18.53	18.69
2.	PH-05	Sample No. 01	6.30	6.68
		Sample No. 02	10.15	10.35
		Sample No. 03	11.43	11.63

These samples and other disturbed samples were tested for the following tests and from the laboratory mentioned against each test (**Table: 7.11**).

Table: 7.11 Laboratory Tests Record of Present Drilling at Uzghor HPP

#	Name of Test	No. of Tests	Laboratory Name
1	Natural Moisture Content	07	NUST Institute of Civil Engineering
2	Density Tests	02	NUST Institute of Civil Engineering
3	Porosity Tests	02	NUST Institute of Civil Engineering
4	Specific Gravity	04	NUST Institute of Civil Engineering
5	Direct Shear Tests	16	NUST Institute of Civil Engineering
6	Standard Proctor Tests	17	NUST Institute of Civil Engineering
7	Permeability Tests	05	NUST Institute of Civil Engineering
8	Point Load Strength	04	CMTL-WAPDA
9	UCS (Rock)	04	CMTL-WAPDA
10	Rock Core Modulus	03	CMTL-WAPDA
11	Atterberg Limits	17	NUST Institute of Civil Engineering
12	Sieve & Hydrometer Analysis	17	NUST Institute of Civil Engineering

13	Organic Matter Tests	02	

Core samples were got tested at the Central Material Testing Laboratory, WAPDA, Lahore (CMTL). The results are placed in the form of tables which are discussed in the subsequent part of the report.

7.4. REGIONAL GEOLOGY

7.4.1. General

The literature regarding regional geological conditions of the Chitral district and its surrounding areas were gathered from very various publications and by reconnaissance visits of the project area.

The structural framework of northern Pakistan is dominantly the result of the northward drifting of Indo-Pakistan Plate, which subsequently collided with Eurasian Plate at Main Mantle thrust (MMT). The most important tectonic elements are marked by the following units, which are chained from South to North in the following order.

- Indus Foreland Basin
- Salt Range Thrust
- Potowar Plateau
- Panjal Thrust (PT) and Main Boundary Thrust (MBT)
- Peshawar Basin and Kashmir Basin separated by Hazara Syntax's
- Main Central Thrust (MCT)
- Main Mantle Thrust (MMT)
- Kohistan Island Arc Complex
- Eurasian plate

In the Pakistan Himalayas, the Indo-Pak Eurasia Suture zone is represented by the Main Mantle Thrust (MMT). It forms, together with the Main Karakoram Thrust, probably the earliest (Cretaceous – Early Tertiary) suturing during Collision in the region. The importance of thrust was realized on the discovery of blue Schists in Upper Swat that strongly support the concept of continent to continent collisional origin of Himalayas and the recognition of the fossil Island arc, called Kohistan Island Arc (TAHIRKHELI 1979) (**Drawing: TUHPP-12**) to the west and northwest.

The arc Complex consist of calc-alkaline plutonic and volcanic rocks, meta-sediments, granulite's and amphibolite's facies, being separated by the Main Karakoram Thrust (MKT), which is described as a narrow litho-tectonic zone that is characterized by outcrops of meta-volcanic and ophiolitic mélanges.

Beyond the MKT, a series of molasses, quartzite's, green schists and carbonaceous slates are dominant lithology's. The western most exposure in Pakistan, the Chitral section, shown up to 3 km wide MKT –zone in the lower shishi valley, 2 km wide in the Harchin area, but is reduced to only a 150m wide fault in Naz Bar, before it thickens again to 4 km further east towards Gilgit – Hunza. No blue schist metamorphism has been discovered along MKT zone.

The project area of Turtonas – Uzghor scheme lies just beyond the MKT, probably within a thrust zone, which may be built – up by many individual fault zones and major faults accompanying the narrow Chitral Syncline between the Kaghozi and Tirch Mir Granite.

7.4.2. Stratigraphy

7.4.2.1. Stratigraphy of Chitral Area

The Stratigraphy of Chitral (**Drawing: TUHPP-10)** Regional Geology Adopted from Geological Survey of Pakistan 2015) is characterized by thick sequences of Ordovician, Devonian, Permian, and Mesozoic era, lie north of the Main Karakorum thrust which is therefore considered to be part of Eurasia (Reed, 1911; Desio, 1966; Talent and others, 1982). There is speculation, however, that Chitral is part of one of many fragments of Gondwana land which preceded India in northward drift across the Tethys (Talent and others, 1986). The timing of the rift and drift of the Chitral fragment is poorly constrained, but a comparison of the Early Devonian faunas of Chitral with those from Nowshera led Talent and Mawson (1979) to conclude that the two areas were on different and isolated continental blocks. The Stratigraphy of Chitral has yet to be fully deciphered due to intense tectonic shuffling; more detailed studies could reveal pre-Devonian affinities between the two regions.

MIOCENE TO CRETACEOUS ROCKS (TKK/TKB): In this age group in the Karakoram and Hindu Kush ranges the major rock types found are granite, granodiorite, diorite, granite-gneisses, etc.

PALEOCENE TO LATE CRETACEOUS ROCKS (TKR TKD): In this age group falls Reshun formation. In the Hindu Kush range it consists of conglomerate, red shale and grey micritic limestone.

CRETACEOUS ROCKS (KKG/KC): The major rock types in this age are Krinj and Gahiret limestone. In the Hindu Kush range it comprises of white fossiliferous limestone and marble with subordinate calcareous phyllites, however, in the late cretaceous age in the Hindu Kush range Chitral slate and phyllite inter bedded with some gray wackes.

JURASSIC ROCKS (JK): This age group contains Kaghozi green schists in the Hindu Kush range chlorite epidote quartz schist with minor quartzose sandstone, marble calcareous phyllites and slates are found.

JURASIC TO CARBONIFEREOUS ROCKS (Je): In the Karakoram Range it includes Agtul formation of Jurassic age, urdok formation of (late triassic), Shaksgam formation (permian age), Baltoro and K-2 gneisses and broad peak quartz and diorite formation (carboniferous age).

JURASSIC TO PALEOZOIC ROCKS (JPZD): This group is known as Darkot Karakoram metamorphic complex in Hindu Kush (Chitral Area) and comprise of rock types namely slate, phyllites, quartz and limestone.

PALEOZOIC ROCKS (Pzm): In the Karakoram Range the main rock types present are slates, phyllites and quartzite's intruded by litic stocks of gabbro, diorite, granite with aplitic and Pegmatitic veins.

PERMIAN ROCK (Ps/Pg): Two formations in the northern Karakoram Range which are shaksgam formation containing dolomite and limestone with some sandstone and marl inter beds, fossiliferous. The other is Gircha formation having shale, limestone and sandstone, as main rock types.

PERMIAN TO DEVONIAN ROCKS (Pd): In this age group in the lun formation is noted with rock type phyllite, green schists, carbonaceous and graphitic schists, marble and amphibolite. Hindu Kush Range

CARBONIFEROUS ROCKS (Cb): Mainly present Baltoro formation in the Karakoram Range with rock types consists of slates, phyllites and shales with subordinate limestone and quartzite.

CARBONIFEROUS TO DEVONIAN ROCKS (CDK): Killik formation in the northern Karakoram Range contains crinoidal limestone and dolomite with thin parting of slates and red quartzite.

DEVONIAN ROCKS (Dcs): Charun quartzite and Shogram formation, undevided in the Hindu Kush range (Chitral Area) is mainly contains prominent rock types as quartzite limestone, dolomite, shale and some volcanic tuffs, fossiliferous at places. Generation of 1:100000 Geological Mapping of Centeral Chitral (Hindu Khush, North Pakistan by Means of GIS).

7.4.2.2. Stratigraphy of The Project Area

The proposed project area mainly comprises the Chitral central complex. The Chitral Central Complex is characterized by regionally important NE-SW trending vertical to sub-vertical longitudinal faults (i-e Reshun Fault, Ayun fault, Nazbar Fault) system along contact zones of rock In-homogeneities. The proposed project area locally occupying the Granite which is bounded NNE to NNW by Ayun fault which separate Reshun formation from the Granite while bounded in SSE to SSW by the JD (Jurassic to Devonian) rocks. The granite of kaghozi forms a northeast trending linear belt along the high ridgeline between the Chitral and Shishi river, which is 6.4 km east of kaghozi . Granite body lies in the project area extent mainly SE to SW. As shown in **Drawing: TUHPP-11.**

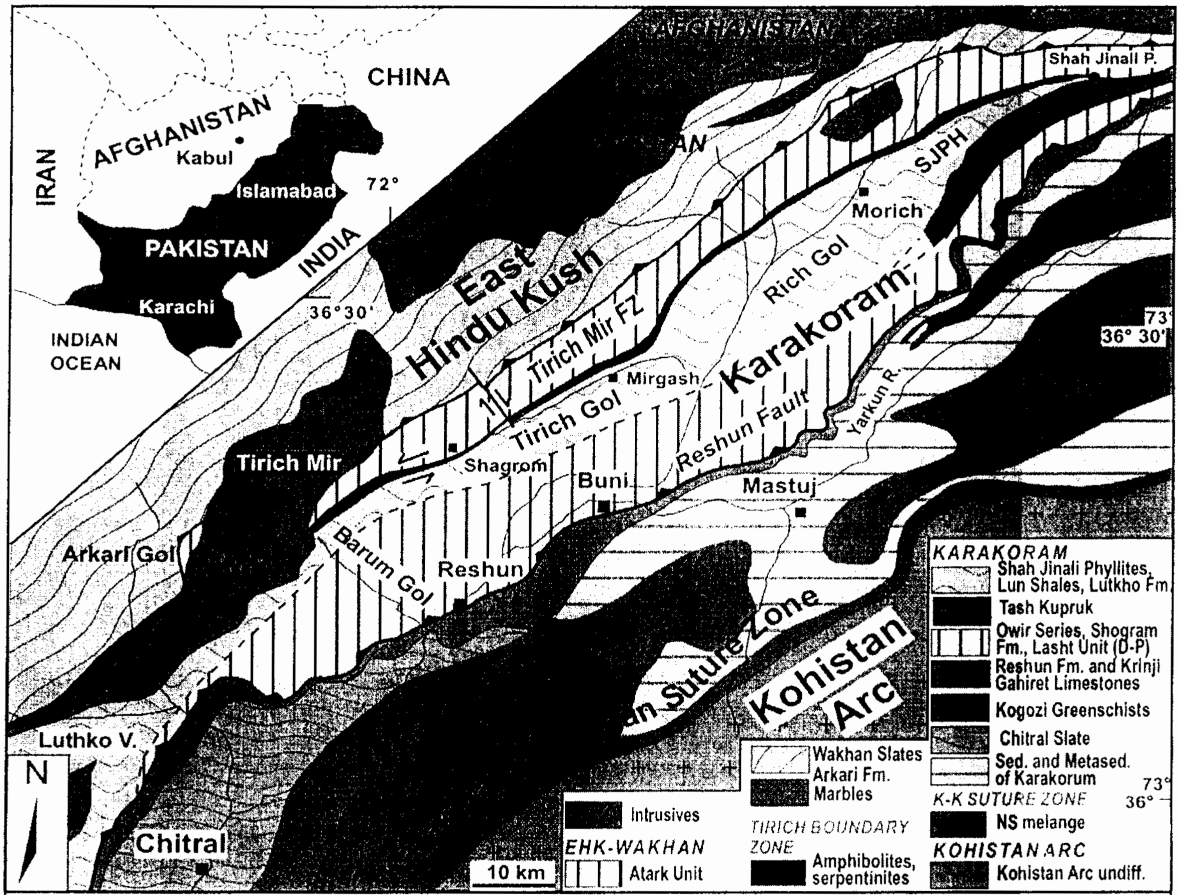
7.4.3. Regional Tectonic Setting

The simplified map of Chitral stratigraphy is presented in GSP **Drawing: TUHPP-10**.

7.4.3.1. General

It is concluded from the general study of available literature (**Figure: 7.2**) that the regional tectonic setting of the project area is characterized by the continental collision between Eurasian plate, the Indian plate and the intervening Kohistan Island Arc. It may be noted that the project area falls in the Southern part of Hindu Kush, a western segment of greater Himalayas. The region on the bases of structural evaluation has been divided into three seismic units.

- The north western unit, beginning with the Reshun fault towards NW.
- The central unit between Reshun fault and northern suture.
- The South Eastern unit or Kohistan unit between Northern Suture and main mantle thrust (MMT).



Simplified map of Chitral, modified from ZANCHI et al ii(2000).GBC:Ghamu Bar Complex.BZC:Buni Zom Complex.TMP: Tirich Mir Pluton. KB: Karakoram

Figure: 7.2 Simplified Map of Regional Tectonics

The project area is located almost in the central unit which is characterized by a system of folds overturned towards east and south (**Figure: 2**). An elongated synclinal belt, isoclinally folded internally, follows the Chitral and Mastuj river and is marked by the Chitral Syncline.

The area is effected by several reverse and thrust faults which mainly include Reshun fault, Ayun fault, Naz Bar and Shishi fault and they separate belts of cretaceous rock units from belts of older series. It is noted that the Reshun Fault separates the order Mesozoic units from the Reshun Formation and other cretaceous rock units, however the fault developed as a thrust fault between Reshun village and Partsan village dipping north word, with about 30 degrees.

At Partsan, the Reshun fault turns northwest, then swings south west and further south where it changes to reverse fault.

7.4.3.2. Reshun Fault

The Reshun fault, named after the village 'Reshun", separates the Devonian to Jurassic rocks on the west and northwest from the Reshun Formation and other Cretaceous rocks on the east and southeast. This fault is well documented in most of the map area and by Stauffer in the Reshun area (Stauffer, written commun., 1965). It is inferred to continue northeastward to the vicinity of Baroghil Pass. Between Reshun and Partsan, it is a thrust fault dipping northward at about 30°. At Partsan, the Reshun fault turns northwest for 4 miles (6.4 km), then swings southwest and south where it changes to a reverse fault. It has been traced southward past Shoghot on the Lutkho River as far as Birir Gol in Kafiristan, where it disappears. At Shoghot, the fault dips 80° W. In Awireth Gol, 1 mile (1.6 km) south of Shoghot, the fault forms a horse tail structure 1,000 ft (305 m) wide and 3 miles (3.2 km) long, containing several individual fault slices. In this area and southward to Kafiristan, the fault dips 60° W. to vertical.

7.4.3.3. Ayun Fault

The Ayun fault extends northeastward from Drosh past Koghozi and separates the Cretaceous rocks of the Chitral syncline on the west from granite and Devonian to Jurassic rocks on the east. This fault has been extended northeastward to join the Holojut fault of Matsushita and Huzita (1965, p. 10, 11, 21). At Darkot, the Ayun fault separates the large granite mass on the north from the Darkot Group (Devonian to Jurassic rocks) on the south (Matshushita and Huzita, 1965). The Ayun fault was clearly verified only at one place: namely, on the left (southeast) bank of the Chitral River 1 mile (1.6 km) southeast of Gahirat, where it forms a narrow shear zone dipping 45° W. In Golen Gol, 2 miles (3.2 km) east of Koghozi, a well-defined shear zone is not present. The only evidence for faulting is several cataclastic layers found in the granite at and near the contact with the Reshun Formation. The contact at this place appears to be more of the nature of an intrusive contact. Similarly, in Jingeret Gol, 2 miles (3.2 km) southwest of Drosh, thinly banded cataclastic layers in the Koghozi granite are the only indication of faulting. As marked shearing is absent in two of the three places observed, it is possible that the Ayun fault may not be as important a fault as is implied on the geologic maps of plates 1 and 2. Possibly the junction between the Koghozi granite and the Reshun Formation is basically an intrusive contact, largely or partly obscured by shearing. Further information is needed.

7.4.3.4. Nazbar Fault

The Naz Bar fault, so named by Matsushita and Huzita (1965, p. 76, 77, 78, 80) after Naz Bar (creek) at Yasin, separates the granite and Devonian to Jurassic rocks on the northwest from the narrow belt of Cretaceous rocks on the southeast. It extends from Drosh in a northeasterly direction and continues along the west side of the Shishi River to the edge of the area. It is well exposed at Jingeret Gol, 3 miles (4.8 km) south of Drosh; on the west bank of the Chitral River, 1 mile (1.6 km) north of Drosh; at both abutments of the bridge across the Shishi River; at Tar on the Shishi River 7 miles (11 km) from Drosh; and in the vicinity of Kalas on the Shishi River, 14 miles (23 km) from Drosh. This fault is inferred to continue northeastward to connect with the Naz Bar fault of Matsushita, which he has traced from the south of Mastuj to the north of Yasin, a distance of about 50 miles (80 km), Matsushita (Matsushita and Huzita, 1965, p. 85) found that the Naz Bar fault separates the Darkot Group (Devonian to Jurassic rocks of this report) on the north from the Yasin Group and Green Series (Cretaceous rocks of this report) on the south. In the Drosh-Shishi Valley area, the fault dips steeply to the west and is marked by a shear zone 80 to 200 ft (24-61 m) wide, made up mainly of sheared serpentine and smaller amounts of brecciated greenstone, sheared and altered talcose schist, black brecciated limestone, and other rock types.

7.4.3.5. Shishi Fault

The Shishi fault lies east of the Naz Bar fault and separates Cretaceous rocks on the west from Devonian to Jurassic rocks on the east. It extends northeastward from east of Drosh to the east edge of the mapped area. The Shishi fault is inferred to join the Naz Bar fault a few miles northeast of the mapped area, and to extend southwestward beyond the mapped area as far as the Pakistan-Afghan border. The fault was observed in Drosh Gol, Kaldam Gol, Purit Gol, and at the eastern edge of the mapped area. The fault is marked by a shear zone that dips 75° W. to vertical. In Drosh Gol, the fault zone, which is about 80 ft (24 m) wide, consists of sheared serpentine (30 ft) (9 m) and brown-weathering silica-carbonate breccia (50 ft) (15 m). In PuritGol and GawuchGol, only narrow shear zones, 3 to 10 ft (0.9-3 m) wide, are evident.

7.4.3.6. Chitral Syncline

The Chitral syncline is so named for the wide belt of Cretaceous rocks between the Reshun and Ayun fault sand occupying the Chitral and Mastuj valleys in the central part of the mapped area. The trend of this structure is slightly east of north, swinging to the northeast at the eastern edge of the map area. The Chitral syncline is inferred to continue for many miles northeastward as defined by the outcrop belts of the Chitral Slate and Reshun Formation on the regional map. In the Kafiristan, the Chitral syncline is overturned toward the east; in the Partsan area, the north limb of the syncline is overturned toward the south and is partly overridden along the north-dipping Krinj and Reshun faults by Devonian to Jurassic rocks and by the Reshun Formation. The Chitral syncline is isoclinally folded internally so that it is identifiable only in its gross aspect. Foliation, which is the dominant planar structure at the scale of the outcrop, dips generally west at steep angles. East of the Chitral River, however, the foliation dips east. Micro folds mark the overall trend of the syncline and plunge both north and south at shallow angles. Frequently, both north- and south-plunging micro folds are visible in the same outcrop. A few micro folds plunge down the dip of the foliation, but these are not abundant. In the Kafiristan area between Lut Gol and Bumboret Gol, the marble of the Reshun Formation shows a peculiar pattern in which, over a distance of 6 miles (9.6 km), the rock forms two outcrop belts along two parallel ridgelines. The western marble belt extends southward from the precipitous cliffs 2,000 ft (609 m) above Bumboret Gol, to Lut Gol, where it joins the eastern outcrop belt. The eastern outcrop belt, which extends continuously both north and south for many miles, widen into a large bulge just northwest of LutGol. The peculiar structure probably began as an S- shaped cross fold oriented perpendicular to the regional strike (sometimes referred to as a "flexure along the strike"), and subsequently, the two western parts became highly attenuated. The attenuated cross fold was then refolded into the present south-plunging folds by the dominant stress field of the area. By this interpretation, the western segment of marble forms a closed loop of two limbs of the lengthened nose of a south plunging minor syncline, and the Devonian to Jurassic rocks between the marble belts form a south-plunging minor anticline. Southward, the two limbs of the original S-shaped cross fold have been completely squeezed together to form a single outcrop belt. The northeastern extension of the Chitral syncline beyond Reshun, is based mainly upon unpublished reconnaissance maps of Tipper (Tipper, G.H., Geological Survey of India, unsub. data, 1926), who shows a continuous belt of Chitral Slate from south of Chitral to Brep, 12 miles (19 km) northeast of Mastuj. At Brep, the slate belt splits into two narrow belts around an elongate body of granite, the northern belt continuing along the Yarkhun River to Baroghil Pass. Tipper shows no faults or other structural details, and the extension of the northern faulted boundary of the Chitral syncline is mainly speculative.

7.4.3.7. Koghozi Anticline

The Koghozi anticline is the name given to the probable anticlinal structure lying between the Ayun and Naz Bar faults. An elongate body of granite, the granite of Koghozi occupies the core and is flanked on both sides by Devonian to Jurassic rocks and Cretaceous rocks. This anticlinal structure is inferred only on the basis of the apparent ascending stratigraphic sequence away from the inferred anticlinal axis and on the hypothesis that the granite bodies in this area appear to represent elongate domes. Northeast of the area, the anticlinal structure and the faulted boundaries enclosing it are extended to include the granite and the Darkot Group of Ivanac (Ivanoc and others, 1956) and Matsushita (Matsushita and Huzita, 1965). The large elongate body of granite lying between Mastuj and Darkot is considered to represent the core of the anticlinal structure of that area. Foliation, the dominant planar structure within the Koghozi anticline, follows the northeast structural trend of the map area, and dips steeply west from 60° to 90°. Small-scale folds on foliation planes plunged at shallow angles both northeast and southwest.

7.4.3.8. Krinj Fault

The krinj fault accompanies the Reshun Fault all along Chitral valley keeping always a narrow band of Reshun Formation between each other. Rock units of Pre-Cretaceous age overly Reshun Formation along Reshun Fault. The Reshun Formation in turn has overridden the Chitral slate along Krinj Fault.

7.4.4. Project Area Tectonic

The project is located in the Hindu Kush seismic province and shows mostly NE-SW trending folds and faults. The deformation within this zone is primarily the result of thrusting and of a deep decollement process associated with the collision between the Indo-Pakistan.

In Chitral valley proper, the seismic activities are generally not concentrated; however, in the northwest just 133 km from the project area, a very distinct concentration of epicenters occurs in Afghanistan.

The peak ground acceleration (PGA) and the peak ground velocity (PGV) of maximum credible earthquake (MCE) for Ayun fault as source is 0.56 g and 97.11 cm/s (rock) and 143.64 cm/s (soil) respectively. Ayun fault extends north-eastwards from Drosh town past to Kaghozi.

The project area lies within the north eastern part of the Hindukush ranges where several active faults are passing.

The Reshun fault, Ayun fault, Nazbar fault, Shishi fault and Pasti faults are located within the original window and have been the center of major destructive earthquake.

Generally the earthquake of intensity 5 & 7 have been frequently recorded along some faults and seismicity 3 and 5 is even more frequent around Chitral. The ground motion with in the study area could be governed by the following main tectonic features.

7.5. GEOLOGY OF PROJECT AREA

Turtonas-Uzghor Hydropower project has been envisaged in an area, which is topographically characterized by rugged mountains belt and deep cut (U-shaped) canyons.

The flat lands are present in the shape of minor terraces, snow avalanches, gravity related debris and narrow flood plains along Golen Gol. Altitudes range from 2150 to 2585m.a.s.l. and 4500 to 5000 m.a.s.l. along the ridge lines. Surface geological mapping covers most of the project area along Golen Gol, including the tunnel alignment at specific intervals. The main stratigraphic units are the Kaghozi Granite and the Reshun Formation, separated from each other by Ayun Fault. A generalized cross section has been developed to show the sequence of the units in the project area.

Drawing: TUHPP-10 & TUHPP-11, depicts that Kosu-Buni-Zom Pluton which is cretaceous group. This group contains dark green, foliated, medium grained diorites and granodiorites.

The soil/rock units in the project area are described below:

Young terraces in the project area consist of alluvial sand, gravel, and boulders in the stream bed of Golen Gol. They are largely spread at the mouth of Roghail Gol into Golen Gol; most of the material has been brought down by Roghail. Lithologically most of the boulders and cobbles belong to granites and granodiorite.

Older terraces in the Golen Gol valley are located above the stream bed. The composition of well consolidated old terraces in general is the same as that of the young terraces. There are many other types of recent formations, such as talus cone material, debris, sliding masses, screes, fans, all kind of slope deposits, avalanche and rock fall masses.

Talus cones are most conspicuous products of the physical weathering of cliffs, scarps, and hill sides in the valley. They are mainly composed of larger sized material and are lying on steep slopes. It is observed that talus cones in the project area have slopes varying between 35° and 45°. The major ones of the project area have been shown on the geological maps. Creeping movement occurs within different reaches in the Golen Gol valley, particularly, where talus material builds up a 45° slope angle. Solifluction takes place upon meeting the following three conditions.

A) A good supply of water from the melting snow.

B) Steep slopes free of vegetation, and

C) Rapid production by physical weathering of new rock waste.

During summer, surface material thaws to a depth of several maters, developing water saturated mass of soil and rock debris above the still frozen ground, which cause creeping down slope.

Field investigations have depicted that smaller landslides and snow or debris avalanches have occurred at places on the left bank of Golen Gol. Rock fall can be observed in the field very often, particularly on the left side of Golen Gol valley. Mainly granitic rock of up to 5 m in diameter is spread along the road along left bank.

In the project area specifically, only two stratigraphically bedrock units are existing i.e. the Kaghozi Granite and the Reshun Formation. Kaghozi Granite is the main rock unit exposed in the mapped area as it is evident from the geological map (**Drawing: TUHPP-80** through **Drawing: TUHPP-188**). The granite forms a northeast-trending linear belt along the high ridge line between Chitral and Shishi rivers; it is grey, fine to medium- grained, foliated, and non-porphyritic as being characterized especially by its generally cataclastic texture.

The lower contact with Reshun Formation is faulted (Ayun Fault), the fault zone is very well marked by a deep cut on the right flank of Golen Gol valley, caused by erosion. On the left side in the headrace tunnel area, the Ayun fault seems to have been split into several minor fault planes, causing only cuts of minor importance. Nevertheless, there is a clear evidence of a well-defined fault zone, i.e. the morphology and cataclastic layers found in the granite and at the contact. The latter ones appear to be more of the nature of an intrusive contact, largely or partly obscured by shearing, while the morphology shows very clear hints to the fault on both sides of the valley.

Anyway, the tectonic setting is characterized by this very important fault ; another one between Reshun Formation and the formerly believed Green schist Unit at the mouth of Golen Gol does not exist, as a normal sequence of rock series of Reshun Formation is evident.

Where hydrological questions are concerned, it has been observed that two springs downstream of Babuks Bridge have a temperature above the one at Golen Gol waters. This would exclude the assumption that the spring water originates at least most part of it – from water flowing within the alluvial infiltrating mainly along Golen valley downstream of Roghail Gol; infiltration may also occur further upstream of Golen Gol, seeping through the granitic mountain ridge implying, however a maximum temperature of the source equal to the annual mean temperature of the region – a very unlikely assumption. Same would apply to any retention water from large debris masses high above Golen valley. In all probability, warm or hot water with more than say 20° C at the spring (not at its reservoir) is bound to seismo-tectonic and surface related systems, such as Garam Chashma, Pechus glacier (36° 47° N 73° 15° E), Rawat village (36° 43° N 73° 22° N), all of them said to be within the Reshun and Ayun Faults domain and related to the neighboring granodiorites intrusions. Along main Karakoram Thrust (MKT), many other hot springs reported to have temperatures of 26° up to > 200° C. The spring water near Golen Gol mouth, being also somewhat warmer than Golen Gol water year round, belongs most probably to the same family. Only continuous temperature measurements and chemical water analysis could give proper answers. In connection with tunneling works, no severe influence can yet be seen from the hydrogeological point of view.

7.6. GEOLOGICAL EVALUATION AND GEO-TECHNICAL DESIGN

Turtonas-Uzghor Hydropower Project consists of a number of civil structure and E&M equipment. The final layout of the project consists of the following civil structures for which foundation design, slop stability and tunnel support system have to be designed:

- Diversion Weir and Lateral Intake
- Connecting Canal after Lateral Intake
- Sedimentation Basin
- Connecting Canal After Sedimentation Basin
- Headrace Tunnel
- Surge Tank
- Pressure Shaft
- Pressure Tunnel
- Powerhouse Open/Cavern

- Tailrace
- Switchyard

Geotechnical design for the above civil structures will be presented in the next paragraph.

7.6.1. Diversion Weir and Lateral Intake

7.6.1.1. General

Diversion weir is proposed near Turtonas Wooden Bridge across Golen Gol. Weir consists of fixed overflow weir and gated part. Fixed part is provided along left of Golen Gol while gated part is placed along right bank. These are separated by a divide wall constructed in reinforced concrete. Fixed and gated parts are bounded with concrete gravity retaining guide walls along both banks of Golen Gol. These walls guide and control the flows toward the weir and don't let the flows pass through both bank.

Lateral intake for diversion of flows toward headrace tunnel and hence powerhouse is placed in the right concrete abutment guide wall. Fixed part of the weir act as retaining structure and also equipped with stilling basin on downstream side for energy dissipation. Retaining and stilling basin will be constructed in reinforced concrete. The bed of river downstream of the stilling basin will be protected with stones over geo-textile.

7.6.1.2. Site Topography

The axis of the weir is about 150 m upstream of Turtonas wooden bridge along Golen Gol. Golen Gol flows in meandering conditions from downstream of its confluence with Lohigal Gol in the village of Ustor. The width of rover is 90 m at its confluence with Lohigal Gol and then widen up to 160 m due to meandering. After travelling 1.5 km from in meandering its confluence with Lohigal Gol its narrow down to 30 m and travel about 450 m in same width then again starts meandering till diversion of weir of Birmogh Hydropower Project. Upstream of the weir, valley becomes wider to form a natural reservoir with rock covered with scree on left bank will river deposit on right bank.

The slope of the river in meandering section and narrow section is about 2.5% and 3.5 %, respectively. The height of the banks is about 3.5 m.

7.6.1.3. Geomorphology

The weir site is proposed on Golen Gol, a left tributary of Mastuj River, near Turtonas Wooden Bridge along Golen Gol. The valley width at weir site near river bed is about 95 m. However, valley width at peaks is more than 8 km. The right is flat terraces created by small creek. These terraces are about 60 wide. After terrace rock having slope of 60^0 with unstable scree material at places which are potential slide zones.

The left side is vertical and consists of river bed material. Over river bed material unstable scree slopes over rocks having slope angle of 45^0. Rock is also exposed on both bank but are at distance and would not helpful in placing of foundation and abutments.

7.6.1.4. Lithology

On the basis of surface geological mapping **(Drawing: TUHPP-80** and **Drawing: TUHPP-100)** and borehole investigation which predicts lithology of weir site comprising two major units one is rock and another is overburdened as per site observations lithology consist entirely of (igneous) plutonic rock of high strength which belongs to Koghozi granite.

Two boreholes (**Appendix: D-2.1.1 & D-2.1.2 Borehole Logs for W01 and WO2**) were drilled at weir site and found that rock is not encountered up to 20 m depth. Ground water was encountered in W01 at 18 m from ground surface while no ground water was encountered in W02.

Major parts of both abutments of main dam above crest level are covered by scree/alluvium material. This material should be cleared and trenches be made in future at intake and powerhouse structure to expose fresh rock mass. The exposed area should be remapped and existing maps be extended and amendment made if required both upstream and downstream of dam axis.

- **Soil Unit**

The soil cover on the left side is also quite deep and composed of residual soil (talus) and scree with appreciable amount of rock masses fallen from higher steeper part. It is loosely placed and has tendency to move during rains and other natural calamities.

The right side deposits are approximately more than 20 m thick deposited by small creek which flows during first part of summer. It comprises loosely to fairly consolidated, sub-angular to angular boulders, gravel mostly of basic igneous rocks and silty clays. Higher slopes are covered with loose soil formed by weathering of the bed rock and terraces are also formed by the Small Right Bank Creek deposition.

The strata also encountered were the overburden of various natures comprising riverbed alluvium and scree/talus material. Overburden is unconsolidated, not cemented, loose and mostly dry in nature at weir axis.

The Golen Gol river bed consists of rounded to sub rounded boulder (1x1x1m), gravels with some silty sand of heterogeneous nature, loose and looks highly permeable.

- **Rock Units**

The rock exposed on both sides of the river at weir site is same both in lithology and origin. Granite is exposed on right and left banks of Golen Gol at the proposed weir and has the same lithology. But outcrops rock is at more distance and did not play role in selection of weir foundation and abutment.

The CPT and SPT values are given in **Table: 7.12**. The CPT value is more than 84 shows that subsoil strata is very compact and very dense. There is no need of any soil foundation improvement.

Table: 7.12 CPT and SPT Values in W01 Borehole

Depth(m)	Description	CPT	SPT
6.5	Gravels/Sand	13	Not Performed
8.0	Gravels	84	Not Performed
9.5	Gravels	Refusal	Not Performed

11	Gravels	Refusal	Not Performed
12.5	Gravels	Refusal	Not Performed
14.0	Gravels	Refusal	Not Performed
15.5	Gravels	Refusal	Not Performed
17.0	Gravels	Refusal	Not Performed
18.5	Gravels	Refusal	Not Performed
20.0	Gravels	Refusal	Not Performed

7.6.1.5. Hydrogeology

The nearby peaks around the weir intake and reservoir area receive heavy snow during winter in addition to normal precipitation. Mostly the rocks are deformed with interconnected joints and structural discontinuities permitting the infiltration of water. The snows during winter season on mountain peaks are melts in joints and adopt freezing and thawing phenomena this make joints open and weathering of rock occurring.

The alluvial deposits in the river bed at weir site are highly permeable and permeability values are high and ranges from $K = 5.317 \times 10^{-3}$ cm/sec to $K = 1.739 \times 10^{-2}$ cm/sec. However, permeability reduces with depth.

The ground water was encountered at depth of 18 m from ground surface. Elevation of the borehole W-01 was 2582 m.s.a.l then elevation of ground water will be 2564 m.a.s.l.

7.6.1.6. Method of Excavation

As mentioned above, the strata encountered were the overburden of various natures comprising riverbed alluvium and scree/talus material. Overburden is unconsolidated, not cemented, loose and mostly dry in nature at weir axis. Therefore, excavation can be carried out by excavator. Boulders having bigger size will be broken in to pieces by Jack Hammer attached to excavator. No blasting is required.

7.6.1.7. Foundation Design of Weir

7.6.1.7.1. General

The weir has been designed for a maximum flood discharge of 1050 m^3/s. The basic function of the weir is to divert the river flow in to intake structure at the right abutment at different discharge and pass flood safely. The reinforced concrete structure has been proposed which will be placed over the river overburden. According to the foundation condition and geology at site, safe and economical design has been carried out as shown in weir section in **Drawing: 22, Drawing: 23** and **Drawing: TUHPP-80-87**.

Overburden consists of sub rounded to rounded boulders, gravels with maximum size of 14 cm. Average value of permeability in this range is 0.02 cm/sec, which means that strata is pervious and sufficient seepage will occur through this zone. It is estimated that strata is dense to very dense from CPT/SPT more than 69 which will facilitate for less settlement of

7.6.1.7.2. Design Assumptions

Following design assumptions have been made:

- One longitudinal section in the river valley is assumed for the foundation design.
- Highest value of field permeability 0.02 cm/sec has been selected.
- No Bed rock is available.
- Isotropic condition of foundation material is assumed for the analysis.
- Steady state condition is assumed for the analysis.

7.6.1.7.3. Design Criteria

Following four main criteria have been adopted:

- Flow paths of underground seepage flows have been increased by providing the plastic concrete cutoff walls of 1.0 m thickness or steel sheet piles.
- Bottom level of cutoff walls has been established according the scouring depth of the foundation material.
- Exit gradient is assumed to be with 0.3.
- Foundation has been designed against the uplift pressure.

7.6.2. Connecting Canals and Sedimentation Basin

7.6.2.1. General

Connecting canals (Two Numbers) are project components which transfer water from lateral intake to sedimentation Basin and from Sedimentation Basin to Headrace Tunnel. Connecting canals and sedimentation basin will be placed over terraces created by Golen Gol and Small Right Bank Creek. This terrace lies along right bank of Golen Gol and has sufficient space and can accommodated all related components of sedimentation basin. Two concrete lined connecting canal would be constructed. The size of the canals would be rectangular for ease in construction, otherwise trapezoidal section is more efficient than rectangular. The length and width is given in **Table: 7.13**.

Table: 7.13 Sizes of Connecting Canals

#	Description	Width	Depth	Length
1	Connecting Canal No. 1	8	8	60.46
2	Connecting Canal No. 2	4	4.52	252.93

7.6.2.2. Topography

Terrace along right bank is almost flat, however, have slops from hills toward Golen Gol. The elevation varies between 2582 masl and 2585 masl.

7.6.2.3. Geomorphological

The structure is located on land belongs to Turtonas village. The area is surrounded from one side by high and rugged mountains. The area is devoid of forest except scattered trees/bushes. Terrace is stable and will not be eroded/washed by Golen Gol being on higher elevation starting from Ustur Village.

Further after construction of diversion weir, this terrace will be protected from Golen Gol by upstream guide wall of diversion weir. However, sedimentation basin and connecting canal shall be protected from small creek, by diverting it toward diversion weir or covering the connecting canal by concrete slabs or construction of connecting canal as box.

7.6.2.4. Lithology

These structures are placed on overburden comprises angular to sub-angular boulders and gravels with appreciable amount of fines in the form of clayey silt which are formed due to erosion, weathering and disintegration of the granite.

The strata encountered during W02 drilling is clayey silty sand gravels with majority ingenious origin boulder of maximum size of 3.5 m. The color of these stones are light grey to dark gray. Strata is poorly sorted, poorly graded, loose to moderately compacted, rounded to sub-rounded, medium grained to coarse grained boulders and gravels. The strata encountered below is silty sandy with little gravels, hard to very hard boulders of 0.2 m size, loose to moderately compacted and fine grained to medium grained.

There thickness varies more than one meter to many meters as we go away from the toe of the hill. However at sedimentation Basin location, the thickness of overburden is more 20 m as recorded in the borehole log (**Appendix: D-2.1.2 Borehole Logs W02**). The CPT and SPT values are given in **Table: 7.14**.

Table: 7.14 CPT and SPT Values in W02 Borehole

Depth(m)	Description	CPT	SPT
6.5	Gravels/Boulders	Refusal	Not Performed
8.0	Gravels/Boulders	Refusal	Not Performed
9.5	Gravels/Sand	Not Performed	Refusal
11	Gravels/Sand	Not Performed	12
12.5	Gravels/Sand	Not Performed	22
14.0	Gravels	Refusal	Not Performed
15.5	Sand	Not Performed	32
17.0	Sand	Not Performed	36
18.5	Sand	Not Performed	52

7.6.2.5. Hydrogeological

In addition to normal precipitation, the area receives snow also during winter. The small creek along right bank rocks may bring water during the months of April and May. However, there is agriculture, the local farmers use its entire water for agriculture. The bore hole W-02 drilled in the area where neither rock nor water table encountered up to 20 m total depth of borehole while the permeability test results indicates the range from 4.71×10^{-3} to 2.42×10^{-2} cm/s.

The bed of the sedimentation basin would be placed at elevation 2569 masl above the ground water level. Therefore no dewatering will be required.

7.6.2.6. Method of Excavation

As mentioned above, the strata encountered were the overburden of various natures comprising riverbed alluvium and scree/talus material. Overburden is unconsolidated, nor cemented, loose and mostly dry in nature at weir axis. Therefore, excavation can be carried out by excavator. Boulders having bigger size will be broken in to pieces by Jack Hammer attached to excavator. No blasting is required and no dewatering is required.

7.6.3. Reservoir Geology

7.6.3.1. General

River deposits which are being transported by river are exposed along the river leading to Ustore village, enlarge natural and open space is available for ideal water storage reservoir. However, it is mentioned that no reservoir has been foreseen in this project layout.

On other hand moraines/scree deposits extend up far in reservoir and continue further beyond, the material is unconsolidated and consists of coarser material (coarse sand) with poorly graded angular gravels, cobbles and boulders which are embedded in the fine fraction matrix. In dry state, the deposits (even in vertical cuts) are stable but during the rainy season and snow melt frequent sliding occurs. Upon saturation these material loss strength and slide down slope. Similarly a major risk can be arisen when reservoir is impounded. Mitigation measures are required to control potential risks of further sliding of material into the reservoir after impounding, e.g. remove part of the potential sliding material by excavation method with small loadings.

7.6.3.2. Site Topography

Terrace along Golen Gol is almost flat along right bank of the proposed reservoir area, however, along left bank have slops from hills toward Golen Gol. The elevation varies between 2588 masl and 2590 masl. The width of reservoir are varies between 50 m to more than 300 m up to confluence with Rohigol. Further up width decrease and again river start flowing in 50 m bed width.

7.6.3.3. Lithology

On the basis of surface geological mapping **(Drawing: TUHPP-11, Drawing: TUHPP-15** and **Drawing: TUHPP-19)** and borehole investigation which predicts lithology of reservoir site comprising two major units one is rock and another is overburdened as per site observations lithology consist entirely of (igneous) plutonic rock of high strength which belongs to Koghozi granite.

The exposed area should be remapped and existing maps be extended and amendment made if required both upstream and downstream of dam axis during detailed engineering design.

- **Soil Unit**

The soil cover on the left side is also quite deep and composed of residual soil (talus) and scree with appreciable amount of rock masses fallen from higher steeper part. It is loosely placed and has tendency to move during rains and other natural calamities.

The right side deposits are approximately more than 20 m thick depos ited by small creek which flows during first part of summer. It comprises loosely to fairly consolidated, sub-angular to angular boulders, gravel mostly of basic igneous rocks and silty clays. Higher slopes are covered with loose soil formed by weathering of the bed rock and terraces are also formed by the Small Right Bank Creek deposition.

The strata also encountered were the overburden of various natures comprising riverbed alluvium and scree/talus material. Overburden is unconsolidated, not cemented, loose and mostly dry in nature at reservoir area.

The Golen Gol river bed consists of rounded to sub rounded boulder (1x1x1m), gravels with some silty sand of heterogeneous nature, loose and looks highly permeable.

- **Rock Units**

The exposed rock on both abutments at reservoir site is same both in lithology and origin. Granite is exposed on right and left banks of Golen Gol at the proposed weir and has the same lithology. But outcrops rock is at more distance.

7.6.4. Headrace Tunnel Site Geology and Design

7.6.4.1. General

The headrace tunnel is considered on the right side of Golen Gol, has a length of 4.5 km and a net diameter of 3.5 meters. It will be excavated along right bank slope. The rock of granite origin is exposed on the right bank. The tunnel intake portal was investigated at the planned borehole W-03 where RQD values are poor to fair. The tunnel will excavate in bedrock of granite origin. The rock cover for headrace tunnel is varies between 100 to 400 m. At this point compact rock is exposed which will provide solid foundation but excessive blasting will be required.

At a number of locations along the headrace tunnel alignment joint orientations were measured and noted. The rock mass was classified and finally evaluated which fall in good category. Some occasional shears were also noticed during surface geological mapping and incorporated in final geological map. Also some Nullahs across the tunnel alignment have been noticed on outcrop. All of these Nullahs were found dry in nature.

Rock unit somewhere is folded and found deformed/shattered rock at places, and it was occasionally jointed and fractured as shown in L-Section of **Drawing: TUHPP-27** and **Drawing: TUHPP-101** through **Drawing: TUHPP-175**

7.6.4.2. Geomorphology

The area between Weir near Turtonas and powerhouse near Uzghor is characterized by high and rugged mountains which form water divide between Golen Gol in south east and Mastuj River in North West. No natural stream is cutting the slops. The river is flowing in the foot of hills along right bank while left side valley is wide and made of snow avalanches and scree material falls from high peaks as a result of weathering. The Birmogh Gol brings a lot of material with its flow and deposit along its banks created agriculture terraces. The highest peak along the alignment is about 2986 m.a.s.l.

The valley slope is varying between 50^0 to 80^0. Rocks are exposed in the form of cliffs making steep slopes. The mountain slopes are most stable and rock is granite. The area is devoid of forest except scattered trees/bushes near the River Bed.

The populations are settled at left side of river which will bring ease during construction phase.

7.6.4.3. Lithology

On the basis of surface geological mapping **(Drawing: TUHPP-101** through **Drawing: TUHPP-175)** which predicts lithology of headrace tunnel site comprising major units is rock as per site observations lithology consist entirely of (igneous) plutonic rock of high strength which belongs to koghozi granite. Rock unit somewhere is folded and found deformed/shattered rock at places, and it was occasionally jointed and fractured.

As tunnel alignment is not accessible, therefore, it was decided that rock slop along the tunnel alignment will be mapped and scan line survey at different location/section would be recorded. The surface geological mapping have been carried out along headrace tunnel from weir site up to powerhouse by using brunton compass, GPS and a geological Hammer for determining strength as field instruments. In surface geological mapping mostly covered the different units and with the help of GPS marked the contacts along tunnel alignment while at weir and powerhouse site marked with Total station by survey team.

Surface geological map drawing been generated and digitized also incorporates all scan line data at each desire location on map **(Drawing: TUHPP-101** through **Drawing: TUHPP-175)**. Scan line method mapping have been performed at specific interval or any change of strata while detail scan line mapping done in powerhouse area also.

The scan line geological mapping of the project area at different spot about 500m interval or at change of strata was carried out along tunnel alignment on graph with scale 1:100 of 20 to 40 m^2 for collecting information in respect of joints persistence, roughness rating, aperture or opening, infilling material (if any), spacing effects and degree of weathering.

The field scan line mapping has covered 24 sheets (**Appendix: D-4**) which have been digitalized for further work. In addition scan line discontinuity survey was also conducted, using Brunton compass and GPS, and geological Hammer for determining strength as field instruments.

Therefore, in order to obtain this information detailed engineering geological surface mapping has been initiated. It is further planned to take a minimum of 15 orientation measurement for each identified joint set and at each scan line survey. To note the orientation of joint sets present in the area, it is important to determine at least three sets of prominent joints with their typical scatter near the soil / rock contact particularly along total tunnel length as well as Powerhouse slopes.

The bedrock exposed and mapped on site was Granite and also confirmed from petrographic analysis.

As per visual site observations igneous rocks (granite) were found whitish grey to greenish, wide to very wide spaced joints, large persistence joints varying, medium to coarse grained rock, all bedding joints and random joints are mostly planer rough to undulating rough, overall wall strength of joint observed as strong to very strong the average uniaxial compressive strength of granite/ granodiorite is 125 MPa on the basis of field observation, aperture of joint found medium wide to wide, infilling between joints is iron staining, clay and somehow chlorite, mostly joint planes were dry.

The river deposits in the area consist of manly gravels in which boulders thickness up to 1 to 3m in diameter, cobbles. Fair to very favorable orientations of discontinuity were observed.

As part of the mapping, special attention was paid to the location and characteristics of rock outcrops where the recording of data was focused on

- Geological boundaries of rock and unconsolidated deposits were demarcated
- Identification of major fault or shear zones
- Weathering conditions of the rock
- Joint orientation reading
- Persistence and density of joints
- Rock wall scan-line survey
- Rock mass classifications

7.6.4.3.1. Scan Line Mapping of Tunnel Intake Portal

The scan line (**Figure: 7.3**) geological mapping at scale 1:100) has been carried out in the field using GPS. Scan line discontinuity survey carried out with scale 1:100 of 30×40m area for collecting information with respect of joints their persistence, roughness rating, aperture or opening, infilling material, spacing effects and degree of weathering. The lithological and the structural features in the Project area have been picked up and the discontinuity / joint survey data collected in the field for headrace tunnel. At a number of locations of tunnel intake portal major joint orientations were measured and noted. The rock mass was classified and finally evaluated which fall in good category. Some occasional shears were also noticed during surface geological mapping and incorporated in final geological map. The scan line discontinuity data for RMR calculation of intake portal and there Performa is appended in **Appendix: D-4.1 & D-4.13.** Performa's assessments are attached in **Appendix: D-5.1 to D-5.15.**

Figure: 7.3 Showing Scan Line Geological Mapping along Tunnel Alignment

7.6.4.3.2. Rock Mass Classifications at Intake Portal Site

The rock mass (**Table: 7.15**) is classified to be good class and compressive strength determined by geological hammer as more than 100Mpa. Rock was good class and competent as the estimated average RMR value is 62 while GSI (Geological strength Index) is 57 so RMR 62 suggests that tunnel could be excavated by full face with 1 to 1.5 m advance support. Support should be placed at maximum distance of 20 m from the face of tunnel. Locally rock bolts in crown of 3 m long, spaced 2.5 m with occasional wire mesh, also with 50 mm of shotcrete in the crown is required where required no steel sets. As RMR calculations and average percentages are appended as **Appendix: D-5.1 to D-5.15.**

Table: 7.15 Support System at Intake Portal

Support System Chart for RMR					
Rock Mass Class	**%**	**Excavation**	**Rock Bolts 20mm dia. fully grouted**	**Shotcrete**	**Steel Sets**
II-Good Rock	75%	Full face, 1-1.5m advance. Complete support 20m from face	Locally rock bolts in crown of 3 m long, spaced 2.5 m with occasional wire mesh	50 mm of shotcrete in the crown is required	None

7.6.4.3.3. Scan line Mapping of Headrace Tunnel

The scan line geological mapping (**Figure: 7.4**) at scale 1:100 has been carried out in the field using GPS. The lithological and the structural features in the Project area have been picked up and the discontinuity / joint survey data collected in the field for headrace tunnel. At a number of locations along the headrace tunnel alignment joint orientations were measured and noted. The rock mass was classified and finally evaluated which fall in good category. Some occasional shears were also noticed during surface geological mapping and incorporated in final geological map as shown in **Drawing: TUHPP-101** through **Drawing: TUHPP-175** and **Drawing: TUHPP-32** through **Drawing: TUHPP-43**. Also some Nullahs across the tunnel alignment have been noticed on outcrop. All of these Nullahs were found dry in nature. The scan line discontinuity data is appended in **Appendix-D-4.**

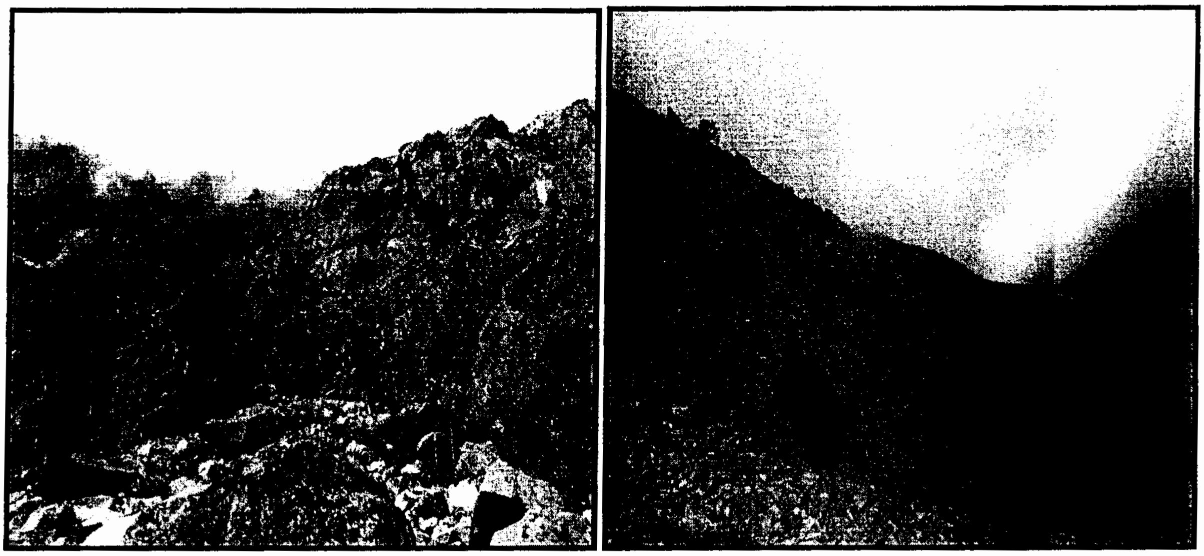


Figure: 7.4 Showing Outcrop along Headrace Tunnel Mapping

7.6.4.3.4. Measurement of Joint Orientation and Distribution at Tunnel Alignment

For the rock mechanical assessment and the corresponding conclusions for the feasibility design regarding the location and orientation of underground structures, rock slope stability etc., the knowledge of the major joint directions and their intersections is indispensable. The joints are – besides the strength of the rock – the most important elements controlling the characteristics of rock masses as regards e.g. stability and permeability. In a massive rock like the granite of the project area, the joints originate mainly from tectonic stress regimes; therefore, they usually have some well-defined predominant directions which govern the design of the underground works. Therefore, particular attention was paid to measuring a sufficient amount of individual joint planes in field outcrops and analyzing.

Along the alignment of tunnel, some major rock outcrops have been studied and more than 400 individual joint-orientation readings have been taken during the current feasibility studies which are presented here. Additionally, the standard technique "the scan line survey" was applied to get an unadulterated impression of the joints distribution, persistence and spacing.

Another clear result is that there is no uniform joint pattern all over the study area. The attempt to get a general uniform trend of the joint sets by putting the joint data in rose diagram for interpretation.

7.6.4.3.5. Joint distribution at Tunnel Intake Portal

A total of 22 and 38 joint orientation readings were taken in an outcrop of 30+30m length respectively at right bank of river in the vicinity of intake headrace tunnel portal.

They have been plotted through Rose diagram software and evaluated statistically, which predict the trend of joints propagation with respect to strike. The graphical presentation of the dominant joint orientations is given in **Figure: 7.5** and **Figure: 7.6** below.

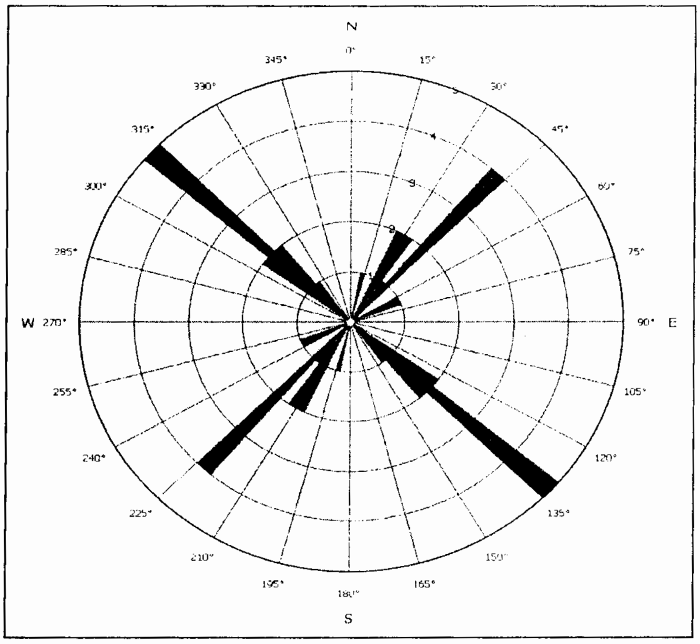


Figure: 7.5 Rose Diagram Showing the Major trend of 22 Joint Orientations

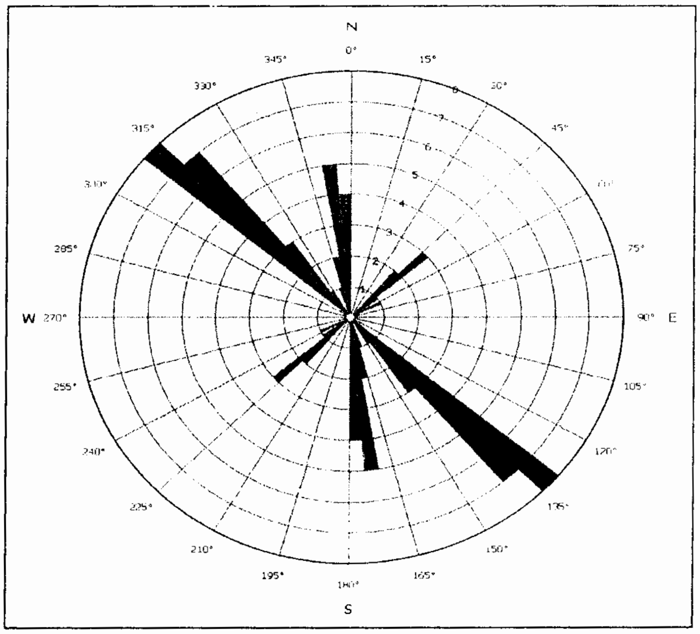


Figure: 7.6 Rose Diagram Showing the Major Trend of 38 Joints Orientations

7.6.4.3.6. Stereonet Projections of Joint Sets at Intake Portal

The major joint sets determined through the composite stereo – net study of tunnel intake portal and shown in below Table shall be the effective joints controlling the stability of the cut slopes for the Intake area. It has been determined that these cuts shall all be situated in the basic igneous rock consisting of granite/granodiorite – considered to be massive blocky and strong to very strong in nature and as suitable for high cuts with high angle of inclination.

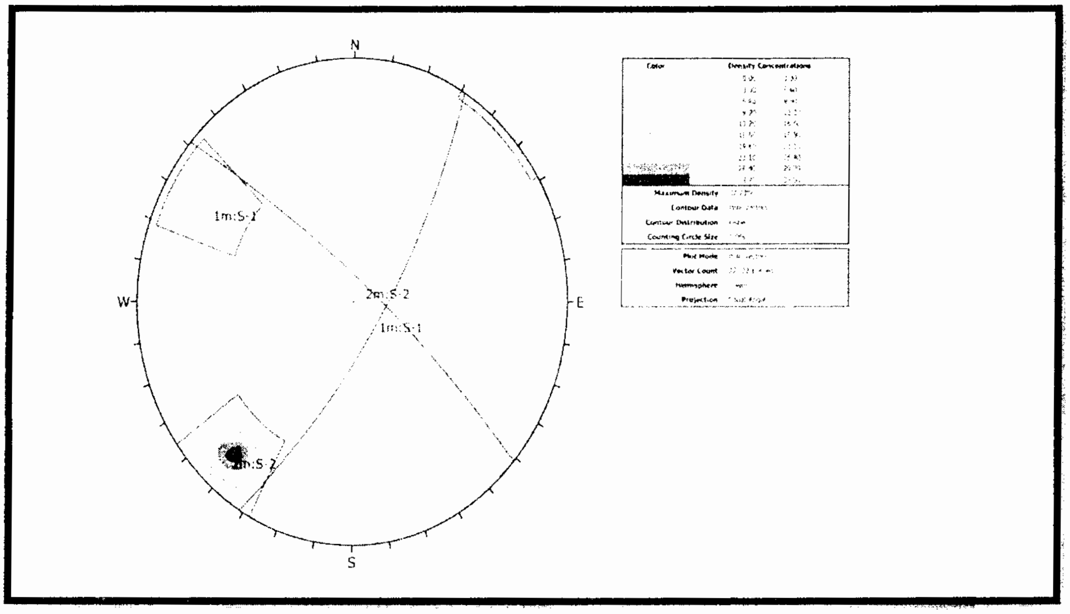


Figure: 7.7 Composite stereo plots for discontinuities encountered at Intake Portal

#	Major Joint set No.	Dip Angle	Strike	Infilling	Roughness	Aperture
1	JS-01	80°NE	N50°W	Surface Staining	Planar Rough	Open
2	JS-02	75°SE	N30°E	Surface Staining	Undulating Rough	Open
3	JS-03	55°NW	N40°E	Surface Staining	Undulating Rough	Open

Table: 7.16 Trend of Major Joint set evaluated by Stereonet Plotting

7.6.4.3.7. Joint distribution along Headrace Tunnel

Joint orientation readings were taken in an outcrop of 30+30m length respectively at right bank of river in the vicinity of intake headrace tunnel.

They have been plotted through Rose diagram software and evaluated statistically, which predict the trend of joints propagation with respect to strike. The graphical presentation of the dominant joint orientations is given in **Figure: 7.8A** through **Figure: 7.8H** below.

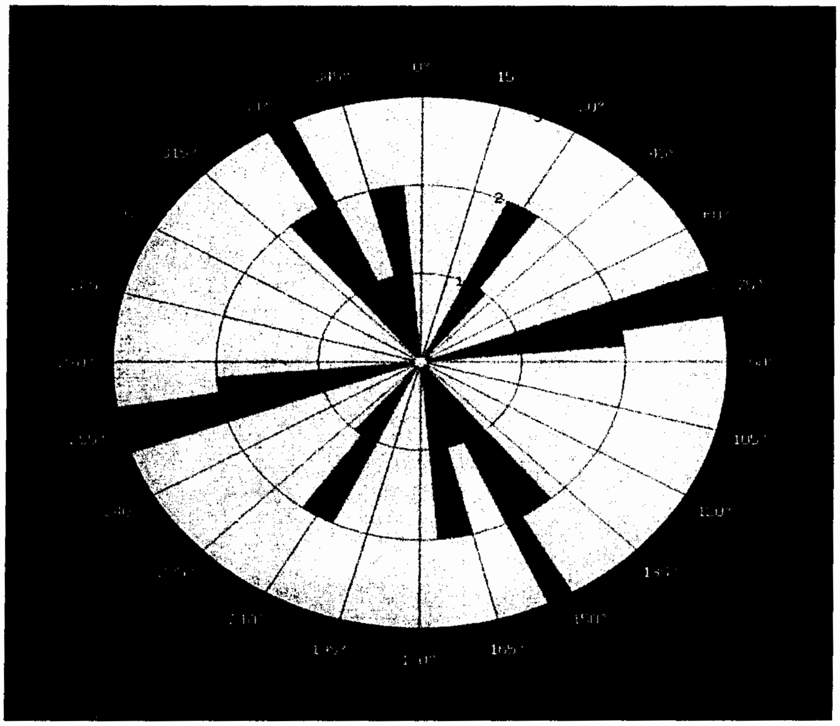


Figure: 7.8A Rose Diagram (Mapping 02) Showing the Major Trend of Joints Orientations of Headrace Tunnel

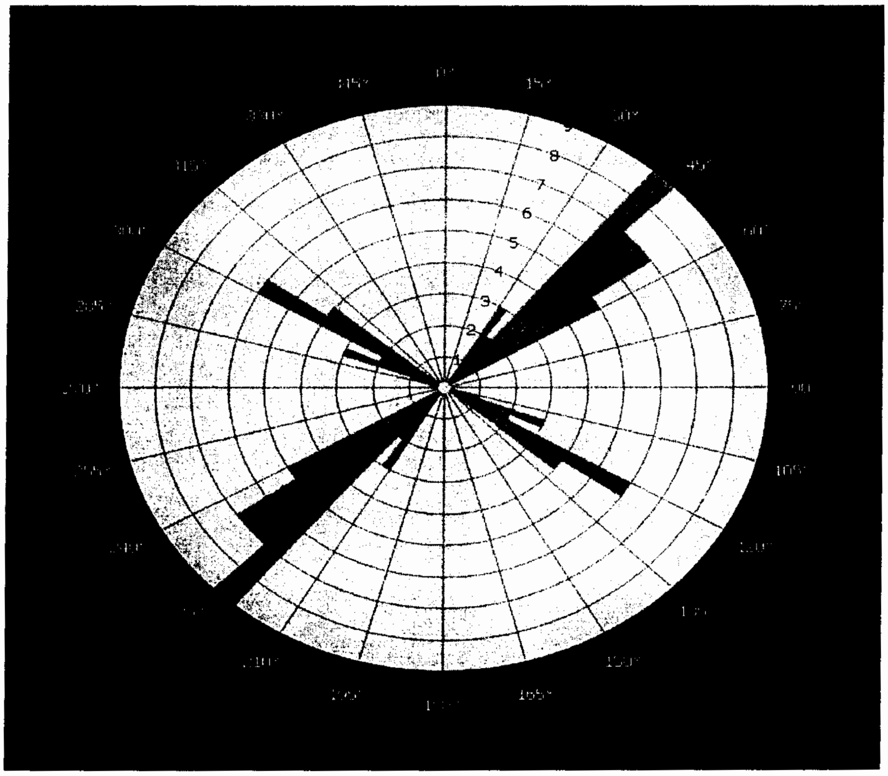


Figure: 7.8B Rose Diagram (Mapping 03) Showing the Major Trend of Joints Orientations of Headrace Tunnel

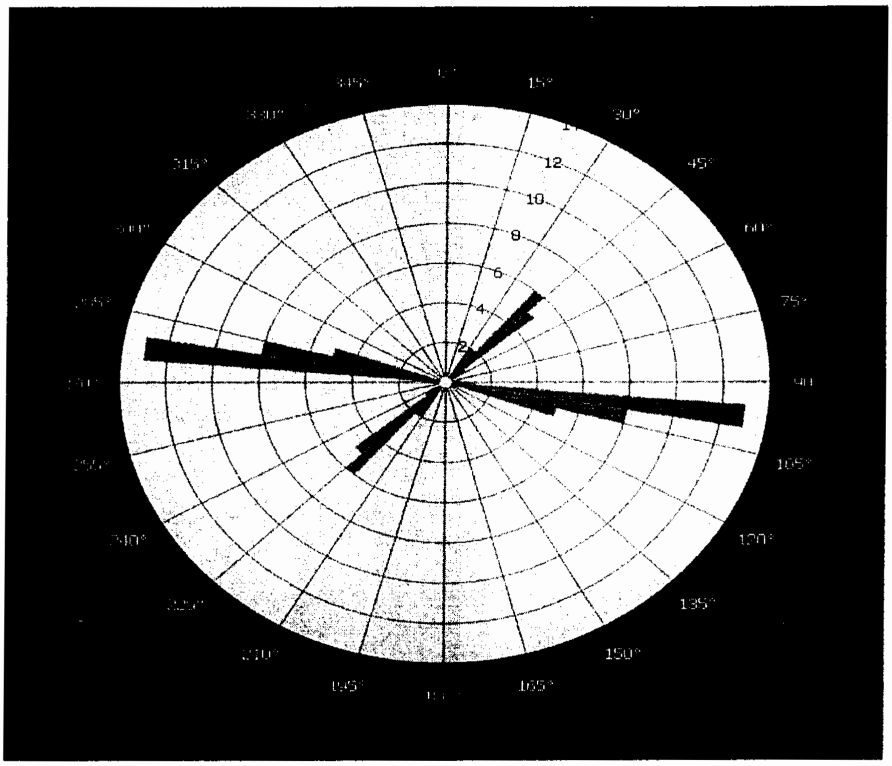


Figure: 7.8C Rose Diagram (Mapping 04) Showing the Major Trend of Joints Orientations of Headrace Tunnel

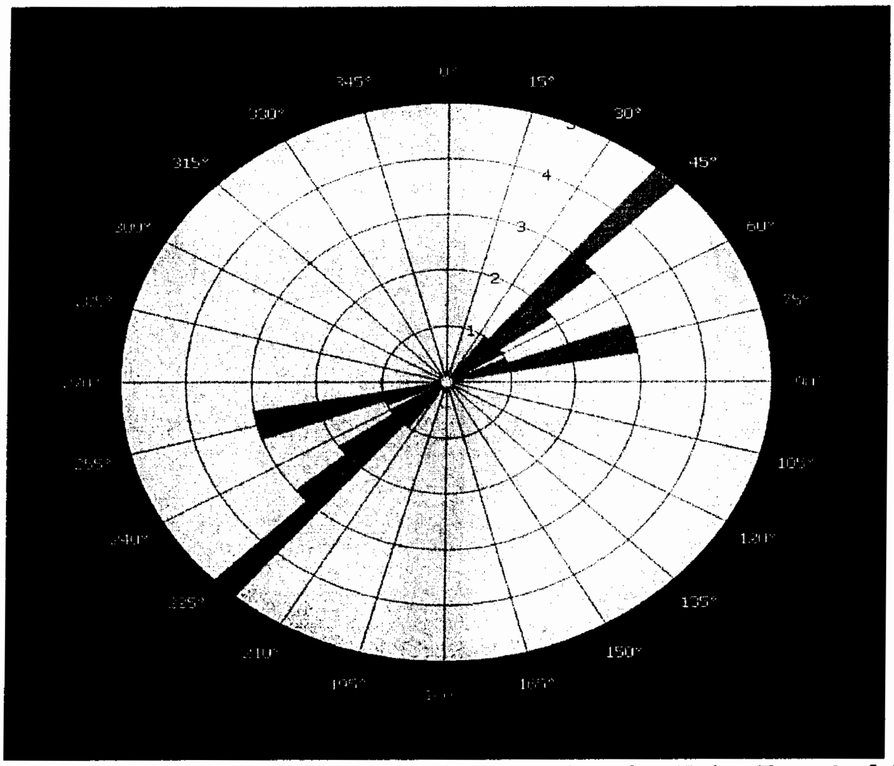


Figure: 7.8D Rose Diagram (Mapping 05) Showing the Major Trend of Joints Orientations of Headrace Tunnel

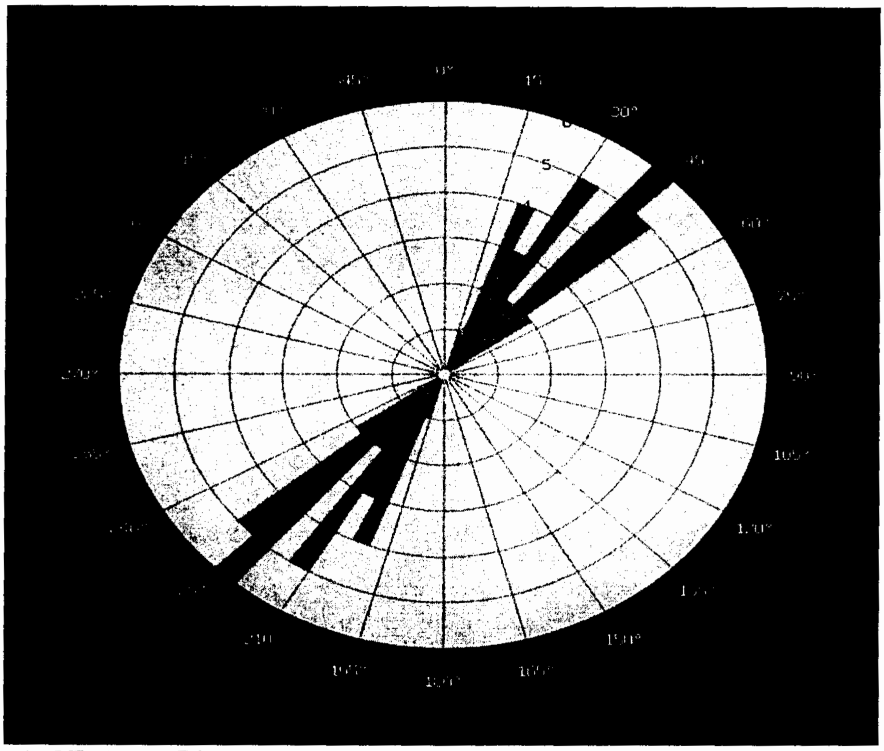


Figure: 7.8E Rose Diagram (Mapping 06) Showing the Major Trend of Joints Orientations of Headrace Tunnel

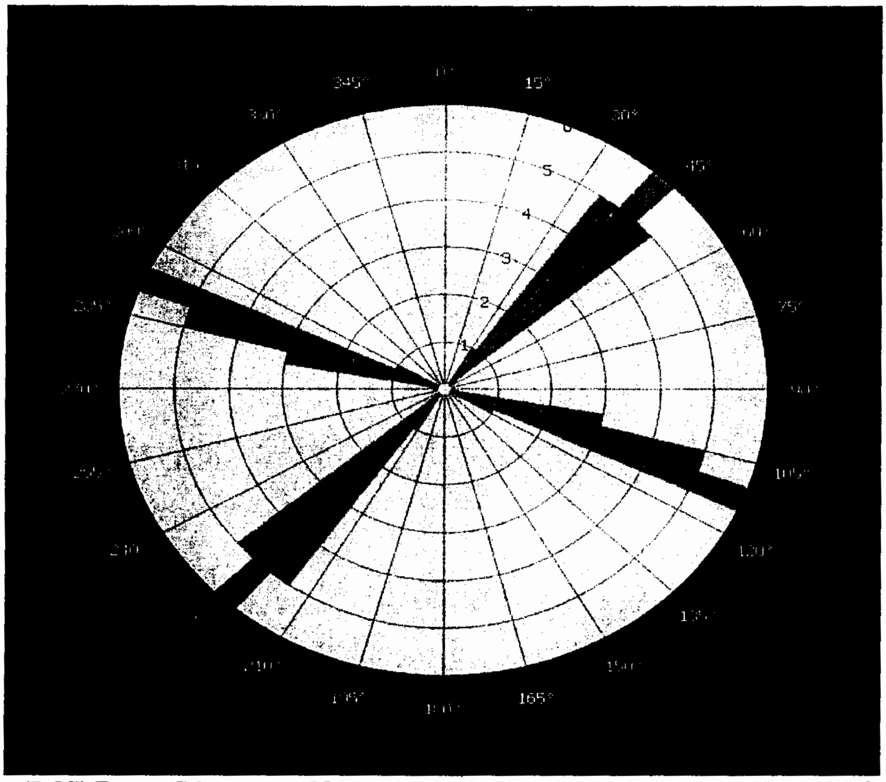


Figure: 7.8F Rose Diagram (Mapping 07) Showing the Major Trend of Joints Orientations of Headrace Tunnel

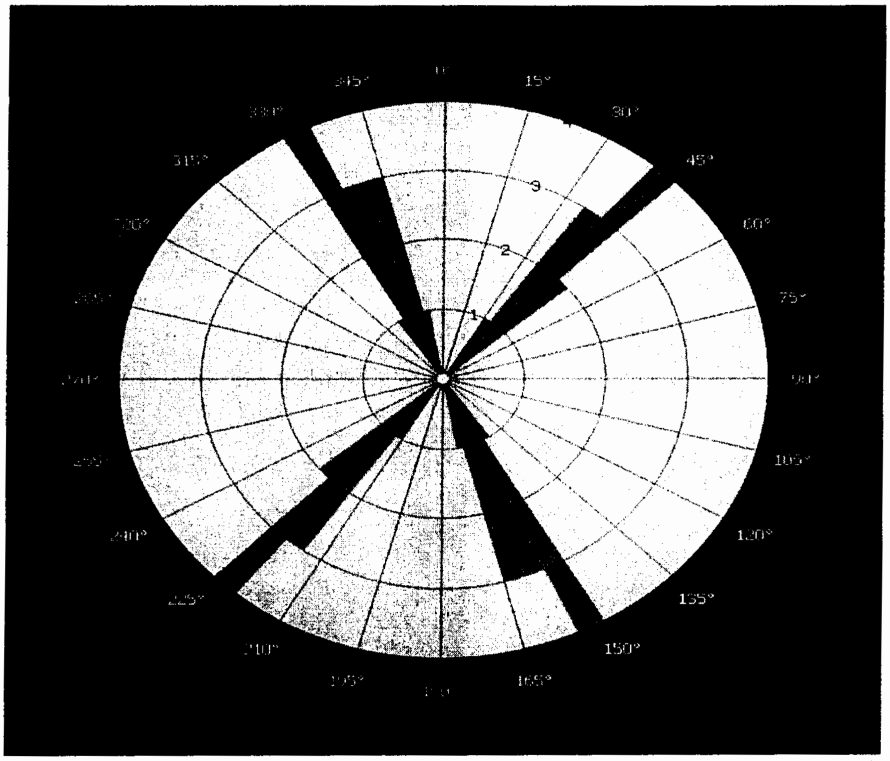


Figure: 7.8G Rose Diagram (Mapping 08) Showing the Major Trend of Joints Orientations of Headrace Tunnel

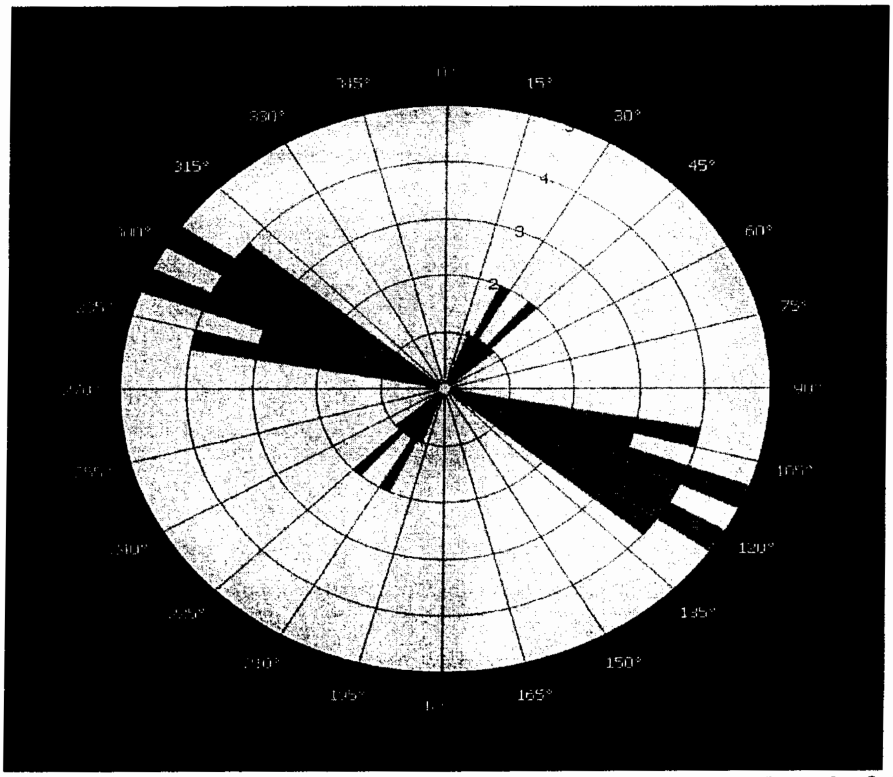


Figure: 7.8H Rose Diagram (Mapping 09) Showing the Major Trend of Joints Orientations of Headrace Tunnel

7.6.4.3.8. Squeezing Ground

At present, the maximum amount of cover is likely to be about 300 m. This represents an applied stress of about 30 MPa. The rock mass strength, particularly in highly fractured thrust zones, will be substantially less than 30 MPa. Where the strength to stress ratio is less than 0.5 there is the definite potential for squeezing and below 0.3, it is considered inevitable. There is little doubt that these conditions may well exist and therefore the tunnel rock support designs have allowed for these conditions, i.e. the poor and very poor rock classes that require lattice girders, deep rock bolts and canopy tubes and face bolts.

7.6.4.3.9. Slabbing

There is always the potential for slabbing in tunnels if there is a joint set, bedding or foliation that is relatively flat lying. These types of conditions are allowed for in the rock support classification system, i.e. those requiring patterned rock bolts and sprayed concrete.

7.6.4.3.10. Rock Burst

The potential for rock bursts is related to the strain differentials experienced during excavation. The maximum tangential compressive stress may well approach 60 MPa and in very strong massive material, e.g. granite, it is possible that as the radial stress drops to zero, then tensile stresses area experienced near the surface of the excavation which result in rapid failure of local area of rock. These can be dangerous but are not particularly common where the rock mass is jointed and blocky. In general, because of the tectonic history of the area, the rock mass for Turtonas-Uzghor is likely to be jointed and hence no major risks are anticipated.

7.6.4.3.11. Physical Characteristic of Rocks

Samples from exposed rock and from drilled holes were send to laboratory for testing for Modulus of Elasticity, Poisson's Ratio, Unconfined compressive strength, angle of internal friction and cohesion. These results are given in **Appendix: D-6** and **Table: 7.17 and Table: 7.18**.

Table: 7.17 Summary of Soil Lab Test Results

Site	Location	Sample	Material	Grain Size Analysis & Hydrometer			Atterberg's Limits			Soil / Rock Type	Direct Shear Test (Soaked)		Permeability (Hydraulic Conductivity Average K20 (cm/sec))	Specific Gravity	Standard Proctor Test		N.M.C (%)			
				Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	PI (%)		C psi	φ (Degree)			OMC (%)	MDD gm/cm³		Density (gm/cm³)	Moisture Content (%)	Porosity
Weir site	Riverbed	W1	OB	43.66	51.46	4.88	Non-Plastic			Sand with Gravels	–	–	1.36E+00	2.66	5.20	2.16	0.32			
	Sedimentation Basin	W2	OB	79.99	19.74	0.27	Non-Plastic			Silty sand with gravels	0.2175	38.75	7.36E-02	2.65	9.40	2.07	0.81	2.63	0.85	0.37
	Intake Portal	W3	OB	24.73	73.58	1.69	Non-Plastic			Silty sand with gravels	0.8702	39.6	1.20E-01	2.65	10.50	1.99	0.46			
Powerhouse	Riverbed	P1	OB	39.81	55.34	4.86	Non-Plastic			Sand with Gravels	–	–	7.50E-01	2.66	9.20	2.12	1.76			
	Slope	P2	OB	62.17	34.00	3.82	Non-Plastic			Silty sand with gravels	3.2391	39.2	8.01E-01	2.65	7.90	2.00	0.47	25.6	1.54	0.38

Table: 7.18 Summary of Rock Lab Test Results

Bore hole No.	Depth (m)	Rock Core Modulus					Unconfined Compression Strength (ASTM D7012)		Point Load Strength Index (ISRM)		
		UCS (Mpa)	Mode of Failure	Young' Modulus (Mpa)	Poisson's Ratio	Modulus of Deformation (Mpa)	UCS (Mpa)	Mode Of failure	P- KN (KN)	Is MPa	Is 50 MPa
BH-W-03	7.07~7.59	13.58	Axial	2.35E+04	0.028	1.14E+04	41.7	Diagonal	23.5	6.11	6.81
	8.54~8.72	123.79	Axial	3.40E+04	0.110	1.53E+04	–	–	–	–	–
	11.78~12.15	–		–	–	–	65.0	Diagonal	20.0	5.71	6.21
	17.45~17.84	–		–	–	–	40.3	Diagonal	20.5	5.69	6.24
BH-PH-05	6.23~6.63	–		–	–	–	45.4	Axial	26.0	6.76	7.53
	10.11~11.34	45.52	Diagonal	2.68E+04	0.019	1.31E+04	–	–	–	–	–
							–	–	–	–	–

7.6.4.4. Hydrogeology

Hills along tunnel alignment receive snow during winter in addition to normal precipitation. The rocks are fractured and well jointed, some of them are open as well causing higher rate of infiltration. Ground water was not encountered in borehole drilled at tunnel portal till 20 m. Investigation shows that there will be no ground water or very small and will not be an issue during construction of headrace tunnel.

7.6.4.5. Design Method

7.6.4.5.1. General

Three main approaches for the design of rock tunnels such;

- **Analytical**

In view of the complex nature of rock masses and difficulties encountered with their characterization, the analytical approach is the least used approach in current rock engineering practice.

- **Empirical**

The empirical approach relates to the experiences gained on previous projects to the conditions anticipated at a proposed site. The Rock Mass Classification Approach which forms the backbone of the Empirical Design is widely used in rock tunneling at present.

- **Observational**

The observational approach used now days is based on observations and monitoring of tunnel behavior during construction and selecting or modifying the designed support as the project proceeds and rock conditions warrants so. This represents essentially a "build as you go" philosophy since support is adjusted during construction to meet the change in rock condition. In fact this is the final and permanent support which may vary grossly at places from the designed support. This final support is the support agreed in the field in the light of the designed support by the consultants and the contractor.

The observational method of design and construction has been named as New Austrian Tunneling Method (NATM) and has been used in the construction of Tarbela Dam Tunnels (15m Dia 1.5 km long - 5 Nos), Malakand Auxiliary Tunnel (5 m Dia 4.0 km long), Gandaf Tunnel (3.75 m Dia 2.81 km long) and Baja Tunnel (3.75 m Dia 1.0 km long), Lakh Pass tunnel 10 m Dia, 200 m long near Quetta, and all (16 Nos) Traffic Tunnels in Makka Mokarrama (16 m Dia - various lengths) in ring roads, all Tunnels in Saudi Arabia outside Makka, Beris Dam Tunnel (5m dia-400 m long) Malaysia.

NATM is basically a construction method, but has design philosophy. The NATM integrates the principles of the behavior of rock masses under load and monitoring the performance of underground construction during construction. The NATM has often been referred to as a "**design as you go**" approach, by providing an optimized support based on observed ground conditions. More correctly it can be described as a "**design as you monitor**" approach, based on observed convergence and divergence in the lining and mapping of prevailing rock conditions. It is not a set of specific excavation and support techniques.

NATM has seven elements:

- Exploitation of the strength of native rock mass – Relies on the inherent strength of the surrounding rock mass being conserved as the main component of tunnel support. Primary support is directed to enable the rock to support itself.
- Shotcrete Protection – Loosening and excessive rock deformation must be minimized. This is achieved by applying a thin layer of shotcrete immediately after face advance.
- Measurement and monitoring – Potential deformations of the excavation must be carefully monitored. NATM requires installation of sophisticated measurement instrumentation. It is embedded in lining, ground, and boreholes. In the event of observed movements, additional supports are installed only when needed, with a resultant overall economy to the total cost of the project.
- Flexible support – The primary lining is thin and reflects recent strata conditions. Active rather than passive support is used and the tunnel is strengthened by a flexible combination of rock bolts, wire mesh and steel ribs, not by a thicker concrete lining.
- Closing of the invert – Especially crucial in soft ground, the quick closing of the invert (the bottom portion of the tunnel) which creates a load-bearing ring is important, and has the advantage of engaging the inherent strength of the rock mass surrounding the tunnel.
- Contractual arrangements – Since the NATM is based on monitoring measurements, changes in support and construction method are possible, but only if the contractual system enables them.
- Rock mass classification, ranging from very hard to very soft, determines the minimum support measures required and avoids economic waste that comes from needlessly strong support measures. Support system designs exist for each of the main rock classes. These serve as the guidelines for tunnel reinforcement.

The support system designed for all these tunnels were based on Empirical method. However NATM (observational) methods have been used to modify it during construction as the excavation proceeded as per actual rock condition exposed.

7.6.4.5.2. Empirical Methods of Design

Rock mass classification, which is the backbone of the empirical design approach, is widely employed tool in rock tunneling, is being practiced at present in USA, France, Western Europe, South Africa, Australia, New Zealand, Spain and some East European countries.

The rock mass classification has the following purpose/procedure in tunneling application.

- Divide a particular rock mass into grouping of similar behavior.
- Provide a backup for understanding the characteristics of each group.
- Facilitate the planning and the design of excavations in rock by quantitative data required for the solution of real engineering problem.
- Provide a common basis for effective communication between all persons concerned with a tunneling project whether he is a consultant or contractor or Client/Sponsor.

In rock engineering more than a dozen empirical rock mass classifications have been developed. To date, the rock mass classification systems which generally have been proposed are as follows:

- Terzaghi Rock Load Classification:1947
- Lauffers Classification.1958
- Deers Rock Quality Designation Classification (RQD).1964
- Rock Structures Rating Concept (RSR).1972
- The Geo-mechanical Classification (Rock Mass Rating) RMR.1973
- The Rock Mass Quality (Q system).1974
- CRIEPT method of Rock Classification (Japanese Method).

Terzaghi Method (1946) has been used for design at Tarbela Dam (5 Tunnels - 15m Dia each) (1967) and in southern Saudi Arabia (Dozens in number 11.0 m Dia each) at Al-Baha and Shaar Descents in Sarawat mountains including Rijal – Alma Mohail and Al – Juwa Descents(early seventies). Terzaghi Method is no more in use except for assessing the roof load if required.

Deers Rock Quality Designation Classification (RQD), Deer in 1964 proposed a quantitative index based, a modified core recovery procedures which incorporates only those pieces of core that are 10 cm or greater in length as percent of run of drilling for RQD%. Some people have used it for rock classification but it has considerable limitations. However it plays an important role in other classification as one of the parameters.

Rock Structure Rating Concept (RSR), RSR was developed in USA in 1972. It was the first complete rock mass classification system proposed since that introduced by Terzaghi in 1946. Later other developments have put it behind.

RMR was used in Pakistan for Malakand II (4.0 km), Baja Tunnel (1.0 Km) and Gandaf Tunnel (2.5 km) in ninetees for which Tunnel support system were designed by RMR and implemented by NATM method.

Q system was used for design of all the ring roads (sixteen) Tunnels in Makkah Makorrarma and all over Saudi Arabia (in eighties) for Rock Mass Classification and support Design for expected rock conditions and implemented by NATM method.

CRIEPT has been used at Beris Dam Tunnel (Malaysia) but was modified by the Pakistani Expert to bring it in line with Q system for construction using NATM method It was accepted by the Japanese Resident Engineer and the Japanese contractor.

7.6.4.5.3. Rock Mass Rating – Method for Design of Uzghor Headrace Tunnel

For Turtonas-Uzghor Headrace Tunnel, the Geo-mechanics Classification called Rock Mass Rating (RMR) has been used. This system has been developed by Bieniawski (1979, 1989). RMR system utilizes six parameters, such as:

- Uni-axial compressive strength of intact rock material (UCS)
- Rock quality designation (RQD)
- Spacing of discontinuities (Joints)

- Condition of discontinuities (joint planes)
- Ground Water Conditions
- Orientation of discontinuities (joints)

The components of this classification system are shown in **Table: 7.19**. Part A of this table shows the five basic parameters and their ranges as dependent on the rock mass condition. Together, the rating numbers for five parameters add up to the basic RMR value.

Part B gives a rating adjustment based on the orientation of discontinuities relative to the tunnel orientation. The effect of strike and dip on tunneling is shown in **Table: 20**.

Part C shows general classification of the rock mass based on RMR, ranging from very good to very poor rock. And

Part D presents some numerical predictions of stand-up time, rock mass cohesion and friction based on RMR.

Recommendations for excavation and support for 10 m wide tunnel excavated by blasting are presented in **Table: 7.21**.

Table: 19 Excavation and Support System Chart for RMR

Rock mass class	Excavation	Rock bolts (20 mm diameter, fully grouted)	Shotcrete	Steel sets
I – Very good rock *RMR*: 81-100	Full face, 3 m advance	Generally no support required except spot bolting		
II – Good rock *RMR*: 61-80	Full face, 1-1.5 m advance. Complete support 20 m from face	Locally, bolts in crown 3 m long, spaced 2.5 m with occasional wire mesh	50 mm in crown where required	None
III – Fair rock *RMR*: 41-60	Top heading and bench 1.5-3 m advance in top heading. Commence support after each blast. Complete support 10 m from face	Systematic bolts 4 m long, spaced 1.5-2 m in crown and walls with wire mesh in crown	50-100 mm in crown and 30 mm in sides	None
IV – Poor rock *RMR*: 21-40	Top heading and bench 1.0-1.5 m advance in top heading. Install support concurrently with excavation, 10 m from face	Systematic bolts 4-5 m long, spaced 1-1.5 m in crown and walls with wire mesh	100-150 mm in crown and 100 mm in sides	Light to medium ribs spaced 1.5 m where required
V – Very poor rock *RMR*: < 20	Multiple drifts 0.5-1.5 m advance in top heading. Install support concurrently with excavation. Shotcrete as soon as possible after blasting	Systematic bolts 5-6 m long, spaced 1-1.5 m in crown and walls with wire mesh. Bolt invert	150-200 mm in crown, 150 mm in sides, and 50 mm on face	Medium to heavy ribs spaced 0.75 m with steel lagging and forepoling if required. Close in-vert

Table: 21 Effect of Discontinuity Strick and Dip Orientation in Tunneling

#	Dip	Dip	Dip	Dip
	Strike perpendicular to Tunnel Axis – Drive with Dip			
	45-90^0	20-45^0	45-90^0	20-45^0
	Strike parallel to Tunnel Axis			Irrespective of Strike
	20-45^0	45-90^0		0-20^0
	Fair	Very Unfavorable		Fair

Table: 20 RMR Rating Chart[i]

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS

#	Parameter		Range of values						
1	Strength of intact rock material	Point-load strength index	>10 MPa	4-10 MPa	2-4 MPa	1-2 MPa	For this low range - uniaxial compressive test is preferred		
		Uniaxial comp. strength	>250 MPa	100-250 MPa	50-100 MPa	25-50 MPa	5-25 MPa	1-5 MPa	< 1 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core Quality *RQD*		90%-100%	75%-90%	50%-75%	25%-50%	< 25%		
	Rating		20	17	13	8	3		
3	Spacing of discontinuities		> 2 m	0.6-2 . m	200-600 mm	60-200 mm	< 60 mm		
	Rating		20	15	10	8	5		
4	Condition of discontinuities (See E)		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1-5 mm Continuous	Soft gouge >5 mm thick or Separation > 5 mm Continuous		
	Rating		30	25	20	10	0		
5	Ground water	Inflow per 10 m tunnel length (l/m)	None	< 10	10-25	25-125	> 125		
		(Joint water press)/(Major principal σ)	0	< 0.1	0.1,-0.2	0.2-0.5	> 0.5		
		General conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		15	10	7	4	0		

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS (See F)

Strike and dip orientations		Very favourable	Favourable	Fair	Unfavourable	Very Unfavourable
Ratings	Tunnels & mines	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	

C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS

Rating	100 ← 81	80 ← 61	60 ← 41	40 ← 21	< 21
Class number	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

D. MEANING OF ROCK CLASSES

Class number	I	II	III	IV	V
Average stand-up time	20 yrs for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hrs for 2.5 m span	30 min for 1 m span
Cohesion of rock mass (kPa)	> 400	300-400	200-300	100-200	< 100
Friction angle of rock mass (deg)	> 45	35-45	25-35	15-25	< 15

E. GUIDELINES FOR CLASSIFICATION OF DISCONTINUITY conditions

Discontinuity length (persistence) Rating	< 1 m 6	1-3 m 4	3-10 m 2	10-20 m 1	> 20 m 0
Separation (aperture) Rating	None 6	< 0.1 mm 5	0.1-1.0 mm 4	1-5 mm 1	> 5 mm 0
Roughness Rating	Very rough 6	Rough 5	Slightly rough 3	Smooth 1	Slickensided 0
Infilling (gouge) Rating	None 6	Hard filling < 5 mm 4	Hard filling > 5 mm 2	Soft filling < 5 mm 2	Soft filling > 5 mm 0
Weathering Ratings	Unweathered 6	Slightly weathered 5	Moderately weathered 3	Highly weathered 1	Decomposed 0

F. EFFECT OF DISCONTINUITY STRIKE AND DIP ORIENTATION IN TUNNELLING**

Strike perpendicular to tunnel axis		Strike parallel to tunnel axis	
Drive with dip-Dip 45-90°	Drive with dip-Dip 20-45°	Dip 45-90°	Dip 20-45°
Very favourable	Favourable	Very favourable	Fair
Drive against dip-Dip 45-90°	Drive against dip-Dip 20-45°	Dip 0-20-Irrespective of strike°	
Fair	Unfavourable	Fair	

7.6.4.5.4. Rock Mass Classification along Headrace Tunnel

Rock Mass Classification as per **Appendix: D-5.1 to D-5.15** along tunnel alignment is presented in **Table: 7.22** shows that Rock mass classification falls in a good, fair and poor classes and competent with the estimated average RMR values. Tunnel can be excavated by full face or top heading and bench with 1.5 to 3.0m advance support in top heading. From **Table: 7.22** it is concluded that Good, fair and poor are 37.5%, 50 % and 12.5%, respectively.

Table: 7.22 RMR Values Estimate on the Basis of Scan Line along Tunnel

Mapping	Locations	RMR	Classification	Tunnel Length in %
01A	Intake Portal	64	Good	100%
01B	Intake Portal	61	Good	
02	Headrace Tunnel	62	Good	12.5%
03	Headrace Tunnel	50	Fair	12.5%
04	Headrace Tunnel	69	Good	12.5%
05	Headrace Tunnel	43	Fair	12.5%
06	Headrace Tunnel	64	Good	12.5%
07	Headrace Tunnel	36	Poor	12.5%
08	Headrace Tunnel	59	Fair	12.5%
09	Headrace Tunnel	44	Fair	12.5%
10	Surge Chamber	66	Good	100%
11	Penstock	73	Good	100%
12	Powerhouse	55	Fair	50%
13	Powerhouse	63	Good	50%

Table: 7.22 shows the excavation and support system proposed for cost estimation purpose during feasibility study. As shown in **Appendix: D-5.1 to D-5.15.**

Rock Type and %age of tunnel length under each rock type is given in **Table: 7.23**.

Table: 7.23 Support System for Headrace Tunnel

Support System Chart for RMR					
Rock Mass Class	%age	Excavation	Rock Bolts 20mm dia, fully grouted	Shotcrete	Steel Sets

II-Good Rock	37.5%	Full face, 1-1.5m advance. Complete support 20m from face	Locally rock bolts in crown of 3 m long, spaced 2.5 m with occasional wire mesh	50 mm of shotcrete in the crown is required	None
III-Fair Rock	50%	Full face, 1-1.5m advance. Complete support 20m from face	Systematic rock bolts 4m long with 1.5 to 2m space in crown and walls with wire mesh in crown.	Shotcrete with 50 to 100mm thick in crown and 30mm thick in side walls	None
IV-Poor Rock	12.5%	Top heading and bench with 1.0 to 1.5m advance in top heading. Install support concurrently with excavation, 10m from face.	Systematic rock bolts 4-5m long with 1 to 1.5 space in crown and walls with wire mesh	100 to 150mm thick in crown and 100mm thick in side walls	Light to Medium ribs spaced 1.5m where required

7.6.4.5.5. Initial Design of Supports

- **General**

During excavation some form of initial ground support will be required for stability. These ground support are installed shortly after excavation in order to maintain a stable and safe opening during construction. Final supports are those systems that need to maintain functional opening for the design life of the project. Initial also constitute substantial part of the final support.

- **Underground Supports**

The extent of support system depends upon the type and underground structure of the rock and extent of the deformation and mechanical properties of the particular rock masses to be traversed. Since excavation and construction are not being done at this stage, the field data regarding actual subsurface rock conditions is not available. Using surface geological maps, discontinuity data, and some laboratory tests results gained from drill holes and Rock Mass Rating (RMR), maximum efforts has been made to achieve the goal for initial design of supports.

During actual excavation some modifications in the design of supports will be required depending upon the exposed rock conditions, especially in unexpected cases of heavy bursting of popping , tensioned systematics bolts with enlarge bearing plates may be used and spot bolting may also be needed. During Detail Design studies, design of rock bolts, anchors, steel ribs and shotcrete analysis will be revised and any changes in the design based on further field and laboratory information will be incorporated.

The guidelines are for 10 m wide horse shoe tunnels under a vertical stress of 25 MPA or less. At Turtonas-Uzghor Hydropower Project the headrace tunnel is 5.0 m wide clear section and will be excavated by Drill Blast method. Therefore, being on safer side, the guidelines have been considered adequate for the smaller section of Intake Portal and Powerhouse at different location.

During actual excavation some modifications in the design of supports will be required depending upon the exposed rock conditions, especially in unexpected cases of heavy bursting of popping , tensioned systematics bolts with enlarge bearing plates may be used and spot bolting may also be needed. During Detail Design studies, design of rock bolts, anchors, steel ribs and shotcrete analysis will be revised and any changes in the design based on further field and laboratory information will be incorporated.

7.6.4.5.6. Method of Excavation for Tunnel

- **General**

In principle the tunnel can be driven through the rock by two different methods such as:

- Drill and Blast
- Tunnel Boring Machine (TBM)

These methods are briefly described below and their suitability for this project is also discussed.

- **Drilling and Blasting Method**

Conventional drilling and blasting as used in Gandaf, Baja and Malakand II and III with support as designed, and modified according to the field conditions prevailing for each round using New Austrian Tunneling Method (NATM] or with that matter in Saudi Arabia. However, tunnel support system was designed based on RMR method. The particular pros and cons of the conventional drilling / blasting method with NATM and of TBM are also suggesting.

- **By Tunnel Boring Machine (TBM)**

The length and the diameter of the Head Race Tunnels warrant the use of TBM. TBM of a double shield type machine can be used. This type of machine uses gripper shoes against the walls for thrust in competent rock while supplementary thrust cylinders push against the segmental lining in unstable rock. TBM tunnel may be lined with a segmental concrete lining or shotcrete.

Probe drilling in front of the excavated face may be necessary to detect water bearing karstic zones where necessary and / or for toxic gas.

- **Excavation Method for Turtonas-Uzghor Tunnel**

In recognition of the remoteness of the site, the shortage of power supplies and the variability of ground conditions along the alignment, it is likely that drill and blast methods of excavation will be adopted for tunnel construction. This usually offer a least cost option with easier maintenance of equipment and therefore better utilization. It is expected that mucking will be by diesel based trucks but conveyor or locomotive hauled muck cars are often a better means of moving material from face as the have reduced ventilation requiremen5r and provide a better working environment.

7.6.5.5. Hydrogeology

In addition to normal precipitation, the hills receives some snow also during winter. The rocks are somehow deformed by the interconnected joints and structural discontinuities permitting the water to infiltrate.

No borehole is drilled at Surge Tank location due to very difficult access. However, drilling at powerhouse site indicate that groundwater is not encountered up to drilling depth of 20 m. Therefore, it is concluded that there will be no ground water and excavation will be done in dry. Further, when excavation of headrace would be started from downstream side and at the bottom level of Surge Tank, then any groundwater will come to lower level and upper levels in Surge Tank must be dry.

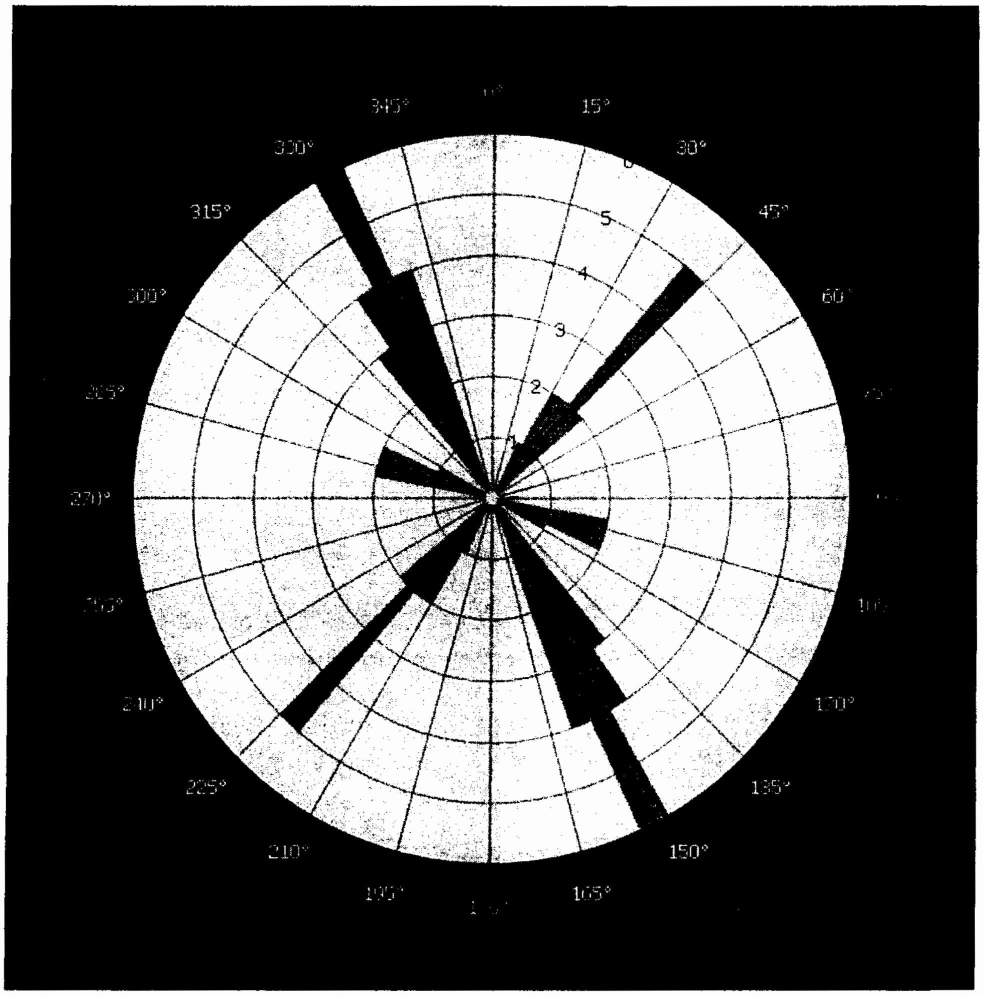


Figure: 7.9A Rose Diagram (Mapping 10) Showing the Major Trend of Joints Orientations of Surge Tank & Pressure Shaft

7.6.5.6. Surge Tank and Pressure Shaft – Geotechnical Design

7.6.5.6.1. Rock Mass Classifications for Surge Tank and Pressure Shaft

Rock mass classification falls in a good class and competent rock with the estimated average RMR value 66 while GSI (Geological strength Index) is 61 so RMR 66 suggests that tunnel could be excavated by full face with 1 to 1.5 m advance support. Support should be placed at maximum distance of 20 m from the face of tunnel. Locally rock bolts in crown of 3 m long, spaced 2.5 m with occasional wire mesh, also with 50 mm of shotcrete in the crown is required where required no steel sets.

Table: 7.24 Support System for Surge Tank and Pressure Shaft

Support System Chart for RMR					
Rock Mass Class	**%age**	**Excavation**	**Rock Bolts 20mm dia, fully grouted**	**Shotcrete**	**Steel Sets**
II-Good Rock	80%	Full face, 1-1.5m advance. Complete support 20m from face	Locally rock bolts in crown of 3 m long, spaced 2.5 m with occasional wire mesh	50 mm of shotcrete in the crown is required	None

7.6.5.6.2. Method of Excavation

Surge Tank would be 40 to 50 m in height and having diameter of 15 m. The rock in the area of Surge Tank and pressure shaft is granite. There are two method will be used. One is drill and blast from up to down and mucking will be carried out by trolley and winch method.

The second method is Raise Boring. In this method no explosive is required. Shaft upto 7.5 diameter has successfully excavated by this method. The raise borer is set up on the upper level of the two levels to be connected, on an evenly laid platform (typically a concrete pad). A small-diameter hole (pilot hole) is drilled to the level required; the diameter of this hole is typically 230mm - 445mm (9" - 17.5"), large enough to accommodate the drill string. Once the drill has broken into the opening on the target level, the bit is removed and a reamer head, of the required diameter of the excavation, is attached to the drill string and raised back towards the machine. The drill cuttings from the reamer head fall to the floor of the lower level. The finished raise has smooth walls and may not require rock bolting or other forms of ground support.

For the excavation of Surge Tank and Pressure Shaft, raise boring technique will be used. A pilot hole will be drilled first. After drilling of pilot hole, an adit at the bottom of Surge Tank and Pressure Shaft would be constructed. This adit is also needed to start excavation of headrace tunnel from downstream end. After construction of adit, the drilling bits will be removed and reamer head will be attached to drill string and raised back toward machine.

Anyhow, pressure shaft is proposed to be drilled with raise boring, while Surge Tank may be excavated by drill and blast and raised boring because the diameter of Surge Tank is 15 m.

The surface exposed will be covered with shotcrete and rock bolting for stability purpose. The rocks are of good quality, we do not propose concrete lining of Surge Tank. Shotcrete along with rock bolts, steel mesh may be sufficient.

7.6.6. Pressure Tunnel and Penstock

7.6.6.1. General

Pressure tunnel is components of hydropower project which connect the pressure shaft with hydro turbines. It is usually laid horizontally with small slope toward the turbine, just to help in dewatering and drainage during construction and may be during maintenance. As the powerhouse is planned to open on terrace along right bank of Golen Gol, therefore, pressure tunnel will have to be excavated in such a way that construction of powerhouse will not be disturbed.

The length of the pressure tunnel would be 720 m and would be steel lined, in order to cater the high pressure and high velocity.

7.6.6.2. Geomorphology

This Penstock site is located north east of Chitral town about 33 km. From Kaghozi to the reported section the distance is about 8.57 km upstream. Jeep able road runs along Golen Gol up to the Uzghore village at Penstock site.

The penstock/pressure tunnel is located on rugged and high ridges of granite / granodiorite on right bank. However the 2.5 m dia penstock will be laid in granite / granodiorite which forms steep slope.

7.6.6.3. Lithological Conditions of Penstock Area

The scree and river deposits units present in the nearby area of penstock alignment at the toe of rocky slopes. The only rock unit exposed in the surge tank area is granite/granodiorite which is hard to very hard, medium to coarse textured, whitish grey to greenish grey in color, weathers to blackish and brownish grey, moderately jointed, rock formed steep slopes. This unit belongs to Kaghozi granite. Major joint spacing varies from 200cm to 600 cm. Joint surfaces are undulating rough to planner rough. Foundation rocks are competent and fall in good category which are hard to very hard, medium to coarse grained, slightly to moderately weathered and slightly jointed. The joints are open, however tight joint are also present with clay as in filling material, and surface staining seems to be oxide and chlorite while joint planes were moderately rough.

7.6.6.4. Hydrogeological Conditions of Penstock Area

In addition to normal precipitation the area receives some snow also during winter. The rocks are highly deformed by the interconnected joints and structural discontinuities permitting the water to infiltrate. According to the geological mapping no seepage or damp zone has been observed in the vicinity of penstock area, which indicates favorable conditions regarding constructions.

PH-02 was drilled in the line with pressure tunnel and still in progress. The rock are very good and permeability values are very low.

7.6.6.5. Method of Excavation for Penstock

On the basis of site conditions like surface geological mapping and visual observations which suggests that in Penstock area having loose scree/talus material on slope embankment for this excavation method should be carried out by excavator because of loose fill / talus & scree material covering the bedrock up to riverbed level. The portion which impose problem should be removed through various means of loose materials then through excavator and the boulders then through blasting.

Also compact rock is exposed which will provide ease but excessive blasting will be required which may cause the over lying rock fall down for overcome these problem some remedial measures should be taken. The support measurement should be revised during detail design and construction in order to work done safely.

7.6.6.6. Rock Mass Classifications at Penstock Site

Rock mass classification falls in a good class and competent with the estimated average RMR value 73 while GSI (Geological strength Index) is 68 so RMR 73 suggests that tunnel could be excavated by full face with 1 to 1.5 m advance support. Support should be placed at maximum distance of 20 m from the face of tunnel. Locally rock bolts in crown of 3 m long, spaced 2.5 m with occasional wire mesh, also with 50 mm of shotcrete in the crown is required where required no steel sets.

Table: 7.25 Support System for Penstock Site

Support System Chart for RMR					
Rock Mass Class	**%age**	**Excavation**	**Rock Bolts 20mm dia, fully grouted**	**Shotcrete**	**Steel Sets**
II-Good Rock	80%	Full face, 1-1.5m advance. Complete support 20m from face	Locally rock bolts in crown of 3 m long, spaced 2.5 m with occasional wire mesh	50 mm of shotcrete in the crown is required	None

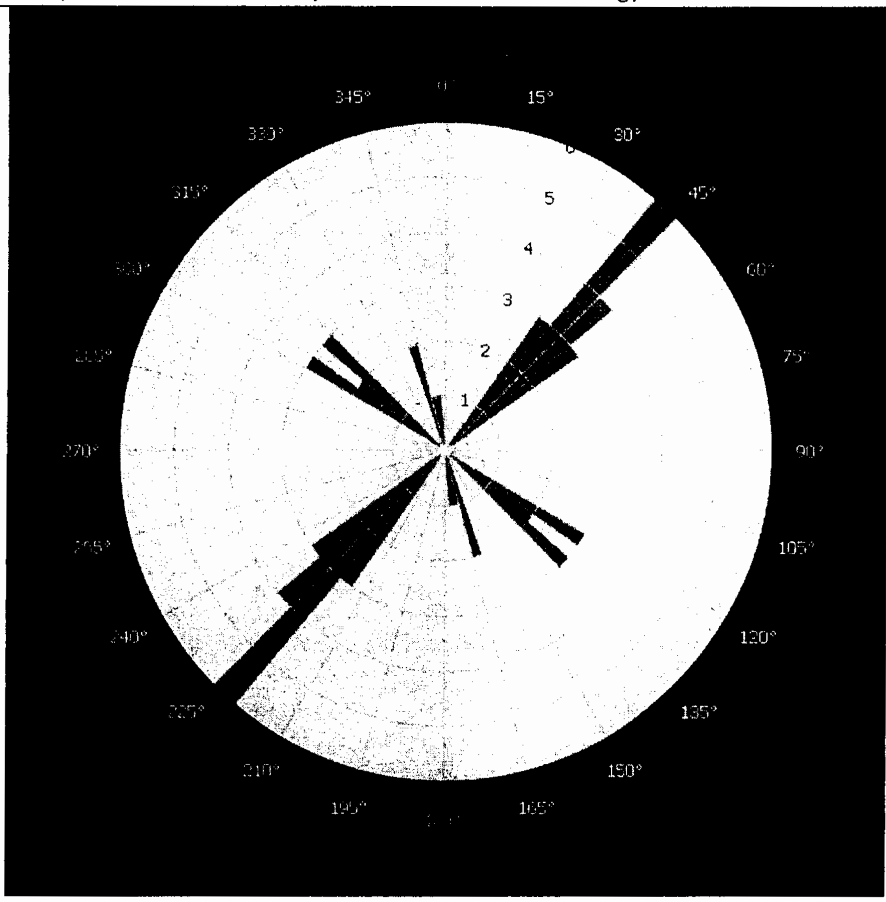


Figure: 7.9B Rose Diagram (Mapping 11) Showing the Major Trend of Joints Orientations of Penstock

7.6.7. Powerhouse and Tailrace

7.6.7.1. Topography

The powerhouse is proposed to be constructed over terraces along the right bank of Golen Gol about 400 to 500 m upstream from the Diversion Weir of Golen Gol Hydropower Project under operation with WAPDA. These terrace are composed of boulders and scree slops. Scree slops are unstable and devoid of trees, however, plan terraces are covered with forest trees and are well stable. These terraces are almost plane, however, with slop toward Golen Gol. The elevation of these terraces is 2090 masl.

The slops are well stable and devoid of forest trees. The hill slops are between 45^0 to 70^0 at places. The powerhouse building will be placed about 10 from toe of the hills and this space will act as collecting trough of scree.

7.6.7.2. Geomorphology of Powerhouse

This proposed powerhouse site is located north east of Chitral town about 33 km. A newly constructed 7 m wide road is available from Buni-Chitral road to Powerhouse site. A concrete bridge over the Golen Gol will be constructed for access toward right bank, because road exist along left bank of Golen Gol.

Golen Gol valley is U-shaped in this area and wide terraces exist on both banks of Golen Gol. The terraces along left bank are wider than terrace along right bank. Golen Gol flow in meandering form in this stretch. However, bed slops is very high and velocity of water is quite high.

Terraces along right banks are bounded by Golen Gol on left side while hills on right side. Hills slop is toward the Golen Gol and varies between 45^0 to 700. Hills are very high and receive snow during the winter season in addition to rains during winter. Hill slops are covered with scree having slops of 45^0 and less.

7.6.7.3. Lithology

On the basis of surface geological mapping and borehole investigation which predicts lithology of powerhouse site comprising two major units one is rock and another is overburdened as per site observations lithology consist entirely of (igneous) plutonic rock of high strength which belongs to Koghozi granite. The granite rock mainly composed of quartz, feldspar, mica, hornblende and pyroxene. At powerhouse and tailrace site one borehole have been drilled and now bed rock has been found. The bedrock exposed in the powerhouse area comprises of granite which is whitish grey to greenish grey, hard, and medium to coarse grained, fresh to slightly weathered, jointed. While scree/talus material laid on slope embankment area at right side of river.

7.6.7.3.1. Overburden

Both banks comprise talus and scree deposits material of angular to sub angular gravels, cobbles and boulders. The strata of unconsolidated and eroded section showed nearly vertical cuts. The alluvium in the river bed contains layers of medium to coarse grained sand with rounded to sub-rounded gravels and cobbles. The material is loose to semi consolidated and found collapsing gradually.

The geological conditions at the powerhouse site and the adjoining terraced area were noticed. At powerhouse site the slopes in western and southern direction are largely covered with scree deposits. Overburden comprises screes, rock fall masses and river deposits. There are many other types of young formation, such as talus cone material, debris, sliding masses, screes, fans, all kind of slope deposits, avalanche and rock fall masses.

7.6.7.3.2. Bedrock

The bedrock exposed in the powerhouse area comprises of Granite, which is whitish grey to greenish grey, hard, and medium to coarse grained, fresh to slightly weathered, jointed and interlocked. Major joint spacing varies from 200cm to 600 cm. Joint surfaces are undulating rough to planner rough. Foundation rocks are competent and fall in good category which are hard to very hard, medium to coarse grained, slightly to moderately weathered and slightly jointed. The joints are open, however tight joint are also present with clay as in filling material, and surface staining seems to be oxide and chlorite while joint planes were moderately rough. The joint orientations were measured and a scan line survey was carried out at several locations.

The rock in powerhouse area is folded (**Figure: 7.10**).

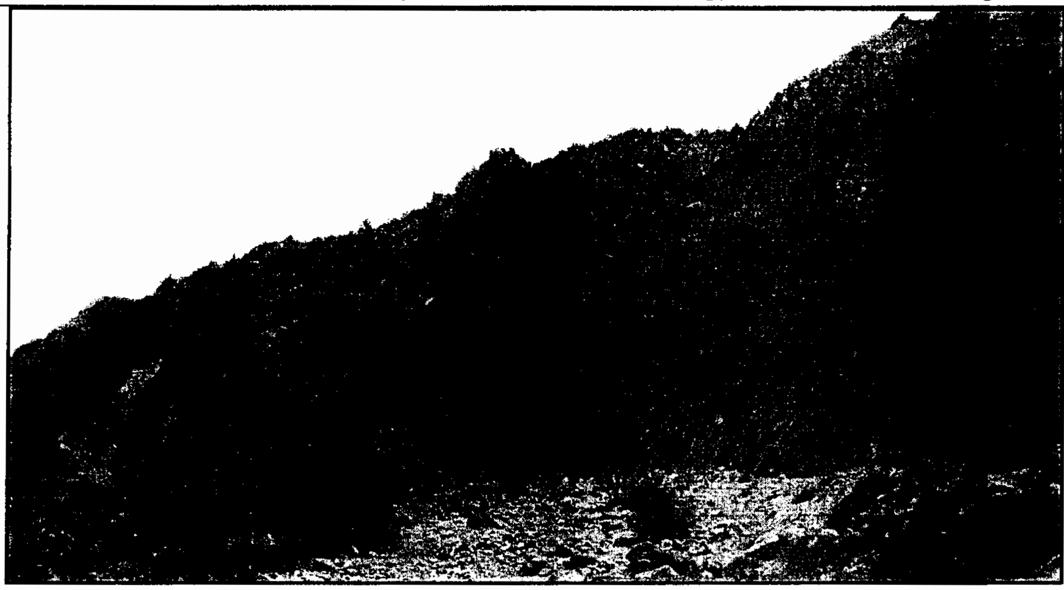


Figure: 7.10 Showing Fold Structure near Powerhouse

7.6.7.3.3. Detail Scan Line Survey

Detail scan line mapping in powerhouse area (**Figure: 7.10**) on 1:100 scale of 30×40m for collecting information in respect of joints persistence, roughness rating, aperture or opening, infilling material (if any), spacing effects and degree of weathering with complete joint pattern, joint orientation, 150 joint reading along rock profile. The scan line discontinuity data is appended in **Appendix: D-4.1 to D-4.13.**

7.6.7.3.4. Joint Distribution at Powerhouse

At the powerhouse site (**Figure: 7.11**) detail mapping have been performed where a total of 150 joint orientation readings were taken in an outcrop of 200m length at right bank of river in vicinity of powerhouse.

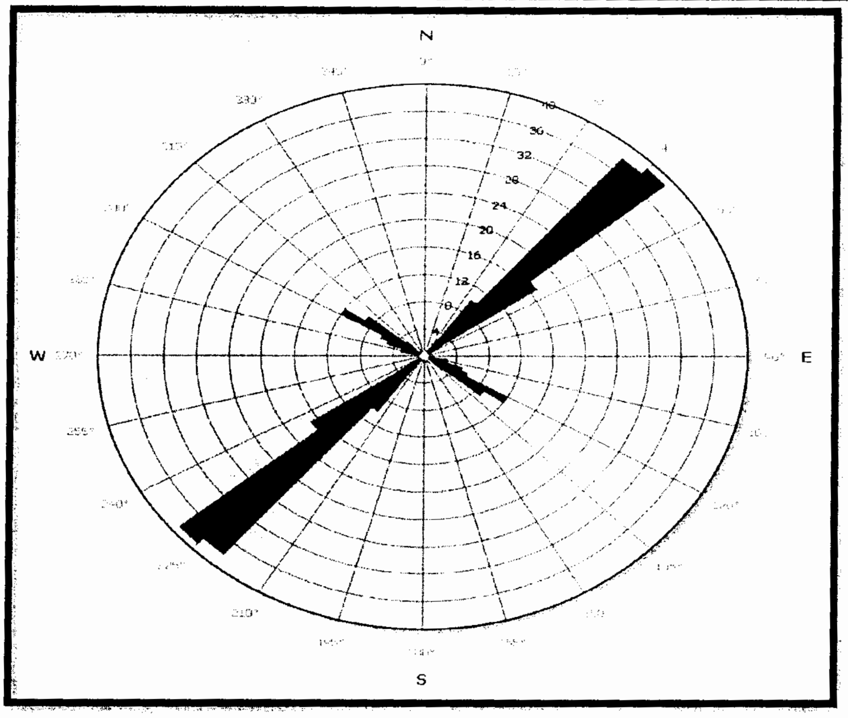


Figure: 7.11 Rose-Major Trend of 150 Joints Orientations with respect to strike

They have been plotted through Rose diagram software and evaluated statistically, which predict the trend of joints propagation with respect to strike. The graphical presentation of the dominant joint orientations is given in Figure below.

At the powerhouse site (**Figure: 7.12**) for surge chamber engineering geological mapping have been done where a total of 28 major joint orientation readings were taken in an outcrop of 140m length at right bank of river in vicinity of powerhouse.

Table: 7.26 Trend of Major Joint set evaluated by Sterenet Plotting

S.No	Major Joint set No.	Dip	Strike	Infilling	Roughness	Aperture
1	JS-01	80°NE	N30°W	Surface Staining	Undulating Rough	Open
2	JS-02	80°SW	N70°W	Surface Staining	Undulating Rough	Open
3	JS-03	55°NW	N35°E	Surface Staining	Undulating Rough	Open

#	Major Joint set No.	Dip	Strike	Infilling	Roughness	Aperture
1	JS-01	80°NE	N30°W	Surface Staining	Undulating Rough	Open
2	JS-02	80°SW	N70°W	Surface Staining	Undulating Rough	Open

3	JS-03	55°NW	N35°E	Surface Staining	Undulating Rough	Open

7.6.7.3.5. Stereonet Projections of Joint Sets at Powerhouse:

The major joint sets determined through the composite stereo – net study of powerhouse and shown in below Table shall be the effective joints controlling the stability of the cut slopes for the Intake area. It has been determined that these cuts shall all be situated in the basic igneous rock consisting of granite/granodiorite – considered to be massive blocky and strong to very strong in nature and as suitable for high cuts with high angle of inclination.

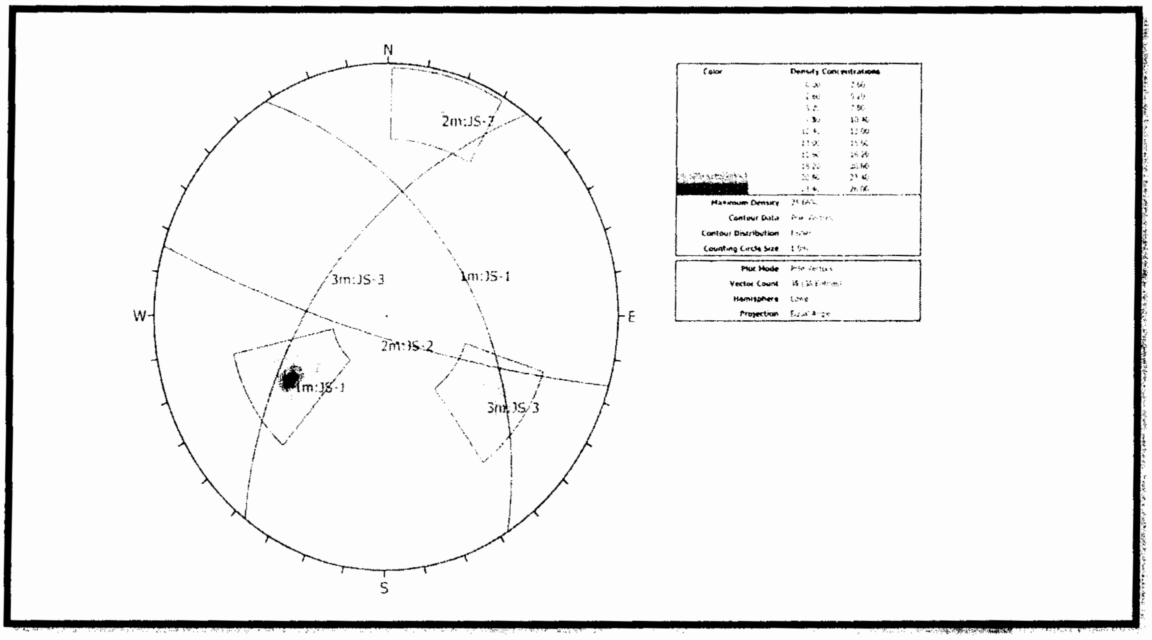


Figure: 7.12 Composite stereo plots for discontinuities encountered at Powerhouse

7.6.7.4. Hydrogeology

On the basis of surface geological mapping and ongoing borehole investigations which predicts some hydrological conditions of powerhouse site, drilling results indicates the present permeability is $K=3.1\times10^{-2}$cm/sec at 3m depth while lugeon value is 13.5 at 3.5 to 8.5m section and Lu=1.3 at 8.5 to 13.5m section in PH-05, where lugeon value classified as low to moderately which indicates partly open to open joints. In overburden drilling activities were not performed but as well assessment made from visual observations which indicates that the scree/talus material are placed over slope embankments at right side which is unconsolidated and loose in nature.

Table: 7.27 Condition of rock mass discontinuities associated with different Lugeon values (Fell et al., 2005).

Lugeon Range	Classification	Hydraulic Conductivity Range (cm/sec)	Condition of Rock Mass Discontinuities	Reporting Precision (Lugeons)

<1	Very Low	$< 1 \times 10^{-5}$	Very tight	<1
1-5	Low	1×10^{-5} - 6×10^{-5}	Tight	± 0
5-15	Moderate	6×10^{-5} - 2×10^{-4}	Few partly open	± 1
15-50	Medium	2×10^{-4} - 6×10^{-4}	Some open	± 5
50-100	High	6×10^{-4} - 1×10^{-3}	Many open	± 10
>100	Very High	$> 1 \times 10^{-3}$	Open closely spaced or voids	>100

7.6.7.5. Method of Excavation

As mentioned above, the strata encountered did the overburden of various natures comprise riverbed alluvium and scree/talus material. Overburden is unconsolidated, nor cemented, loose and mostly dry in nature at weir axis. Therefore, excavation can be carried out by excavator. Boulders having bigger size will be broken in to pieces by Jack Hammer attached to excavator. No blasting is required and no dewatering is required.

7.6.8. Design of Cut Slops

7.6.8.1. General

Headrace tunnel portal and outlet of pressure tunnel where, we need cut slops. Power house is located at 2092 masl. In addition the most important fact is that back side of the power house will be close to the steep rock slope which need to be stabilized with safe slope angle.

Foundation Condition

- Cohesion: 200 kpa
- Angle of Internal friction: 40o
- Unit weight of rock: 19 Kn/m3

Design Assumptions

Following design assumptions have been made:

- Cut slopes have been designed under drained conditions.
- Plane failure has been assumed.
- Critical failure plane has been assumed 0.5 times the sum of slope face angle and angle of internal friction.
- Seismic coefficient of 0.2g has been assumed.
- No tension crack has been assumed.

Design Criteria

Following two main criteria has been adopted:

- Cut slopes have stabilized at a factor of safety of 1.3 without considering seismic effect

- Cut slopes have stabilized at a factor of safety of 1.0 with considering seismic effect

Analysis of Cut Slopes

Plane failure analysis of cut slopes in rock have been carried out by developing a graphical relationship between slope heights and slope face angles for a given engineering properties of rock mentioned above. Maximum contour height in power house area is 103 m. For a slope height of 103m, results shows that slope face angle with a factor of safety of 1.3 is 3 V: 1H). In other word, slope is stable. For further safety berms of 3 m width have been provided at every 15m height.

7.6.9. FOUNDATION DESIGN

7.6.9.1. Objectives

Since a sound and economical foundation design cannot be accomplished without an in-depth knowledge of the engineering properties of subsurface and its response to the imposed loads of the structure. This report covers the evaluations based on the data provided by the investigated boreholes and test pits.

The following objectives have been fulfilled for the feasibility study of the subject project, with the generated data:

- Assessment/Selection of the most feasible foundation type.
- Selection of appropriate foundation depth.
- Evaluation of allowable pressures, considering shear failure & settlements, for the shallow foundations system.

Data obtained from the field as well as from the laboratory has been processed and analyzed to arrive at the foundation design parameters and recommendations, for the feasibility study of the subject project and preliminary design of foundations. The foundation proportioning curves are attached as **Appendix: D-8**.

7.6.9.2. General Considerations

Foundations for this project should meet the following essential requirements:

- These should be placed at a sufficient depth below the ground surface so as not to be affected by seasonal variations and scouring effects of flowing water.
- The foundation depth and size should be adequate to provide reasonable range of allowable load bearing values, with regard to the imposed loads.
- These must be adequately safe against the possibility of shear failure.
- These should not undergo excessive uniform and differential settlements (Analysis is done for 25 mm, 38 mm and 50 mm tolerable total settlements for individual square/strip shallow foundations and raft foundations).
- The designed foundations should not have an angular distortion in excess of 1/500.
- Foundations should not overstress the weak/compressible strata.

All the above-mentioned conditions have to be met during the life-time of the structure. Analysis has been carried out on the basis of field and laboratory testing data to ensure that the foundations would meet all the criteria of safety set-forth.

7.6.9.3. Allowable Bearing Capacity

7.6.9.3.1. Approach and Analysis

Analysis has been made both from the point of view of shear and settlements of cohesive and non-cohesive soils, supporting isolated square/strip foundation and raft foundations, using layered analysis/design procedures. The increase of stress with depth has been computed by using approximate method, which is referred to as the 2:1 method i.e. the stress from the foundation spreads out along lines with a 2 vertical to 1 horizontal slope. The foundation proportioning curves are attached as: **Appendix: D-8**.

a) Settlement Based Analysis: Non-cohesive Soils

The following relationship, put forward by Meyerhof, has been used for non-cohesive soils, for isolated footing, based upon a settlement value of 25 mm:

qa(net) = N/0.05 (Kd) For B < 1.2m

qa(net) = N/0.08 (Kd){(B+0.3)/B}2 For B > 1.2m

Where:

qa(net)	=	Net allowable bearing pressure (kN/m2)
N	=	Design SPT blows
B	=	Foundation width (m)
D	=	Depth of foundation below NSL (m)
Kd	=	Depth factor

b) Settlement Based Analysis: Cohesive Soils

The following relationship put forward by Meyerhof has been used for cohesive soils:

$\Delta H = \Delta P\ (mv)\ H$

Where:

ΔH	=	Total consolidation settlement
ΔP	=	Average increase in pressure in layer of thickness H due to contact pressure
mv	=	Coefficient of volume compressibility
H	=	Thickness of compressible layer within the stressed zone

c) Shear Based Analysis

The following relationship presented by Meyerhof has been used:

$$qa(net) = 1/FS * \{c (Nc)Sc(dc) + \gamma (D) (Nq - 1) Sq (dq) + 0.5 \gamma (B)N\gamma (S\gamma) d\gamma\}$$

Where:

qa(net)	=	Net safe bearing pressure
B	=	Foundation width
D	=	Depth of foundation below NSL
γ	=	Bulk density of soil
c	=	Average cohesion
Nq, Nγ, Nc	=	Bearing capacity factors based on Ø (angle of internal friction)
Sq, Sγ, Sc	=	Shape factors
dq, dγ, dc	=	Depth factors
FS	=	Factor of safety = 3

7.6.9.4. Recommendations

In addition to spelling-out the foundation design parameters viz. foundation type, depth and allowable bearing capacity, the following important recommendations are also made for construction of foundation because of the peculiar site conditions:

- The foundation proportioning curves are attached as **Appendix: D-8**.
- The excavations during construction may be made at a slope of around 1V:0.5 H, revised as permitted by the site conditions. In case of vertical cut necessitated due to presence of adjacent properties, or excavation cannot be made at slope, properly designed excavation support system must be adopted.
- Base of the excavation should be prepared in a sound way before pouring concrete.
- The adequacy of the foundation depth should also be checked by ensuring proper factors of safety against uplift and lateral loads.
- The spread foundations should be proportioned as per attached figures.
- The foundation excavation should be properly inspected by a geotechnical engineer before pouring lean concrete.
- If weak/soft/loose pocket of soil is present at the excavation level, it should be further excavated and replaced with approved well graded coarse granular engineered fill / select fill material, with maximum particle size in the range of 50 mm to 75 mm, and passing # 200 not greater than 10%., and compacted in layers to at least 95% of Modified Proctor Dry density or 75% of relative density, as applicable (The layer

thickness will depend upon the type and size of compaction equipment to be used) may be used to replace loose/soft/compressible onsite soils.

- Shallow foundations, if require excavation/placement below the ground water table, will in general require continuous dewatering, during the excavation, concrete pouring, and backfill placement, till the surcharge pressure is equivalent to the water uplift pressure at foundation base.

7.7. Construction Materials Evaluation

The following main construction material are required for Turtonas-Uzghor Hydro Electric Power Project:

- Concrete Aggregate; Coarse and Fine Aggregates
- Rip Rap and Stone Pitching and Stone Apron
- Cement
- Reinforcement Steel
- Bricks
- Sanitary and Sewerage
- Water Supply
- Electricity, etc.

7.7.1. Concrete Aggregate and Rip Rap

The construction material has broadly considered two groups of materials; first the materials obtained from excavation and second quarries and borrow areas considered during this stage of studies as these should comprise quality wise suitable sites and potential new areas in the vicinity of the project area which should also be suitable and should have enough quantities for required construction materials.

The construction materials required for Turtonas-Uzghor hydro Electric Power Project is mainly include fine and coarse concrete aggregates, rip rap, rock fill material (>5 through 40 cm) etc. The feasibility of the project area has been carried out. As a result it has been noted that natural construction material is available in adjacent areas of the related structures which is of suitable quality as well as in huge quantity. The potential borrow areas can be identified in the surface geological maps which exhibits large areas of over burden along the Golen Gol river in the form of low to medium high terraces. As already described earlier these terraces have been developed from the river deposits mainly comprise of gravels, cobbles, boulders and little fines.

It may be noted that a remarkable amount of coarse aggregates can be obtained as a result of excavated material from weir site, sand trap and headrace channel which are located on some of above identified area. However, to obtain suitable required sizes necessary crushing and sieving will be required. Some laboratory tests have been conducted during Feasibility Study and the results can be seen accordingly. It is gathered that the deposited material of gravels, cobbles and boulders are mostly granite and granodiorite and according to the petrographic analysis these material has been identified as reactive to Alkali Silica (ASR) potential. While the petrographic studies of both samples of (BH-W3 & BH-PH-05) are deleterious. They are alkali silica reactivity Potential. Therefore, it cannot be used as an aggregate with ordinary cement/high alkali cements; however, it can be used with slag cement. The field study shows that fine aggregate sand is very much restricted both in quality and quantity in the vicinity of the project area therefore it will have to be manufactured from the rock material obtained from tunneling as well as from the excavated material from the Power House area. It may be noted that the major part of tunnel will be passing through the granite rock type; therefore it will contribute larger quantity to produce sand from its length of 4500 meters. This rock type has been identified as Alkali Silica Reaction (ASR) potential. Therefore the material obtained from the source cannot be used as an aggregate with ordinary cement; however, it can be safely used with slag cement. The remaining part of pressure shaft will be also in rock type granite, which is also available in the power house area. Reasonable quantity of sand can be manufactured from the material recovered from tunnel and pressure shaft together with excavated material from power house and the available in the vicinity of the Power House.

In general most of the required construction material will be available in natural shape or can be manufactured at the site or excavated material from weir, tunnel and powerhouse areas.

7.7.2. Cement

Portland cement is available in quantity and quality required for the construction of the project near Peshawar, Rawalpindi, Havilian, Karachi, Mianwali, etc. Slag cement from Karachi may have to be transported. A reasonable quantity of cement is required and which should not be alkali reactive. Therefore, cement has to be transported from down country. A number of cement companies are operating in Pakistan and may take responsibility for supply. Most important are Bestway, Lucky, Gharibwal, Maple leaf, Ashari, Paidar, DG, etc. Most of them are located around Rawalpindi and Mianwali.

7.7.3. Steel

Good quality of reinforcement steel and other construction steel is not available in local market in bulk. There, Grade 60 and Grade 40 steel is available from Lahore and Islamabad. Therefore, steel will have to be procured from the nearest big cities like Lahore or Islamabad. In Peshawar Grade 60 steel will not be available.

7.7.4. Bricks

The clay burnt bricks are not available in local market. If want to use have to bring from down country. It is suggested that concrete block (solid or hallow) be precast at site and shall be used in place of bricks.

Project lies is high seismic area therefore it is recommended that all residential building shall be framed structures.

CHAPTER - 8

SEISMIC HAZARD ANALYSIS

Chapter: 8

SEISMIC HAZARD ANALYSIS

8.1. General

Uzghor Hydro Electric Power Project is located along the Golen Gol, an eastern tributary of the Mastuj River in Chitral district of Khyber Pakhtunkhwa (KPK) of Pakistan. The project site is located upstream of the existing Golen Gol Hydropower Project. The powerhouse site is located just upstream of the existing weir of the Golen Gol Hydropower Project while weir site is located about 6 km upstream.

The location coordinates of weir and powerhouse sites of Uzghor Hydro Electric Power Project are given below:

Weir Site	Latitude 35.93997°N	Longitude 72.0528°E
Powerhouse Site	Latitude 35.91879°N	Longitude 71.9922°E

The height of weir is 8.3 meters with no reservoir as project is run-of-river, so according to ICOLD definition, this weir does not fall in the category of Large Dams. So ICOLD guidelines for selection of seismic parameters for large dams (2016) are not applicable for this project. The project should therefore be designed as per requirements of design codes of concrete hydraulic structures or applicable building codes.

Uzghor hydropower project is located near the collisional zone between the Indian and the Eurasian tectonic plates. The region in which the project is located has been subjected to earthquakes in the past, therefore, it is imperative that a study of tectonic and earthquake history of the region should be conducted to have an idea of the seismic hazard to which the proposed project may be exposed to and to evaluate the realistic seismic design parameters for the safe design of the project components.

For the seismic hazard evaluation of Uzghor Hydropower Project, the following methodology was adopted:

- Study of regional geological and tectonic information collected from available literature and maps.
- Compilation of historical and instrumental earthquake data and analysis of the available earthquake record for completeness.
- Identification and characterization of potential seismic sources in the project region.
- Evaluation of seismic hazard in accordance with current practices, including:
    - ER 1110-2-1806 - Earthquake Design and Evaluation for Civil Works Projects (May 2016)
    - EM 1110-2-6053 – Earthquake Design and Evaluation of Concrete Hydraulic Structures (May 2007)

- EM 1110-2-6050 – Response Spectra and Seismic Analysis for Concrete Hydraulic structures (June 1999)

8.2. Regional Tectonic Setting

The geodynamic of northern Pakistan is characterized by the collision and coalescence of Eurasian and Indian Continental Plates, which were once separated by the oceanic domains, and creation of Kohistan island arc in late Cretaceous. The collisional process started in the late Eocene to early Oligocene with the formation of the Himalayan Ranges and this process still continues. Relative to Eurasia, the Indian plate is still moving northwards at a rate of about 4 cm/year. The subduction of Indian plate beneath the Eurasian plate has resulted in folding and thrusting of the upper crustal layers near the collisional boundary. The thrusting has been depicted from north to south in the shape of MKT (Main Karakoram Thrust), MMT (Main Mantle Thrust), MBT (Main Boundary Thrust) and SRT (Salt Range Thrust) as shown in **Figure: 8.1**. The regional tectonic features are briefly described here.

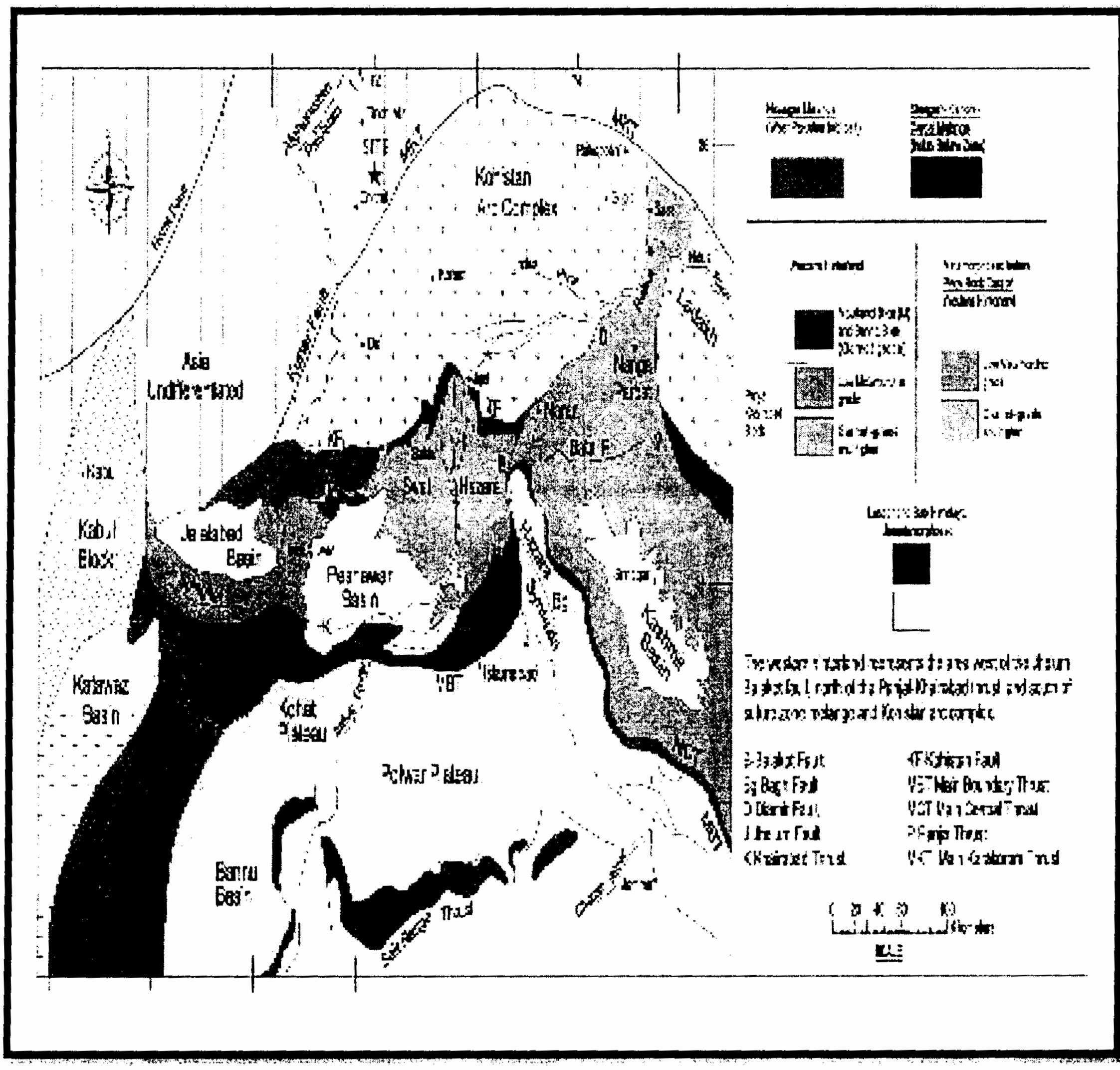


Figure: 8.1 Tectonic Map of Northern Pakistan showings major faults in Northern Part of Pakistan (After DiPettero et al., 2008).

8.2.1. Regional Tectonic Features

The geology of northern Pakistan is a superb example of continental collision tectonics (Shuhab D.K. and Nancy F.G., 2006). In this area, the world's three greatest mountain ranges merge, the Himalayas, the Karakoram and the Hindukush. The mountain building process that formed these ranges commenced in Cretaceous time when Indian plate started moving and was carried northward (Scotese et al., 1988). During that time (i.e. Early Cretaceous) Karakoram terrane sutured with eastern Hindukush along the Tirich Mir fault (Zanchi et el., 2000; Hildebrand et al, 2001). Soon after, the intra-oceanic Kohistan arc formed over a subduction zone that dipped beneath the arc, either to the south or to the north (Khan et al. 1997). It is widely accepted that the northward movement of Indian plate was concurrent with the accretion to Eurasian plate of an intra-oceanic arc system, the Kohistan arc that collided with Eurasian plate along the Shyok Suture. The southern margin of Eurasian plate, including the Kohistan arc, then became an Andean type convergent margin, until India collided with Eurasian plate. Thrusting of the Kohistan terrane southward over the northern Indian plate margin along the Main Mantle Thrust (MMT) probably took place in Late Cretaceous or Paleocene time and was completed by 55Ma, forming the Indus Suture Zone (Searle et al., 1999).

A brief description of the salient features of the Kohistan magmatic arc and the Karakoram block is given below.

8.2.1.1 Kohistan Magmatic Arc

Kohistan is an intra-oceanic island arc bounded by the Main Mantle Thrust (MMT) to the south and the Shyok suture zone or Main Karakoram Thrust (MKT) to the north. This E-W oriented arc is wedged between the northern promontory of the Indian crustal plate and the Karakoram block (**Figure: 8.1**). Gravity data modeling indicates that the MMT and MKT dip northward at 35° to 50° and that the Kohistan arc terrain is 8 to 10 km thick (Malinconico, 1989). Seismological data suggests that the arc is underlain by the Indian crustal plate (Seeber and Armbuster, 1979, Fineti et al., 1979).

The northern and western part of the arc, along MKT, is covered by a sequence of Late Cretaceous to Paleocene volcanic and sedimentary rocks. The central part of the arc terrain is mainly composed of Kohistan Batholith which comprises an early (110-85 Ma) suite of gabbro and diorite, followed by more extensive intrusions of gabbro, diorite and granodiorite (85-40 Ma) which are intruded by much younger dykes and sills of leucogranite (30-26 Ma).

The southern part of Kohistan is comprised of a thick sequence of mafic and ultramafic rocks. These rocks may be divided into three tectono-metamorphic complexes separated by major thrust zones. The Chilas Complex forms the northern and upper unit. It comprises layered norites and gabbros metamorphosed to granulite facies. It is characterized by a series of south-verging folds. It has been thrusted southwards over the Kamila Amphibolites Complex. The latter consists of amphibolites, meta-gabbro and orthogneisses. This sequence comprises a highly tectonised shear zone. Southward, it is thrusted over the Jijal Complex which forms a tectonic wedge between the Kamila Shear zone and the MMT. The Jijal Complex is largely comprised of garnet-pyroxene-granulites and ultramafic rock (Tahirkheli and Jan, 1979; Coward et al., 1986; Khan et al., 1993; Treloar et al., 1990).

8.2.1.2 Karakoram Block

This 70 to 120 km wide and 1,400 km long structural zone comprises the Karakoram crustal plate which is one of the fragments of the Cimmerian collage derived from Gondwanaland and accreted to Eurasia. In the north, the South Pamir Fault (Desio, 1979) separates it from the Southern Pamir Block. To the east it is terminated by the Karakoram Fault and to the west by the Sarobi Fault. The Shyok suture zone (MKT) forms its southern margin. Parts of Karakoram have been mapped by many workers, notably Desio (1964), Zanettin (1964), Stauffer (1975), Gamerith (1982), Calkins et al. (1981), Pudsey et al. (1985), Leake et al. (1989) and Searle (1991). They have introduced several overlapping formation names and a standard litho-stratigraphic nomenclature for this region has not been formalized. A general outline of the tectonostratigraphic sequences and their structure is given below.

a) Karakoram Batholith

The most ubiquitous feature in the Karakoram is the Axial Batholith (Desio, 1963), which forms the central part of this belt and hosts the tallest mountain peaks of the region, including K2.

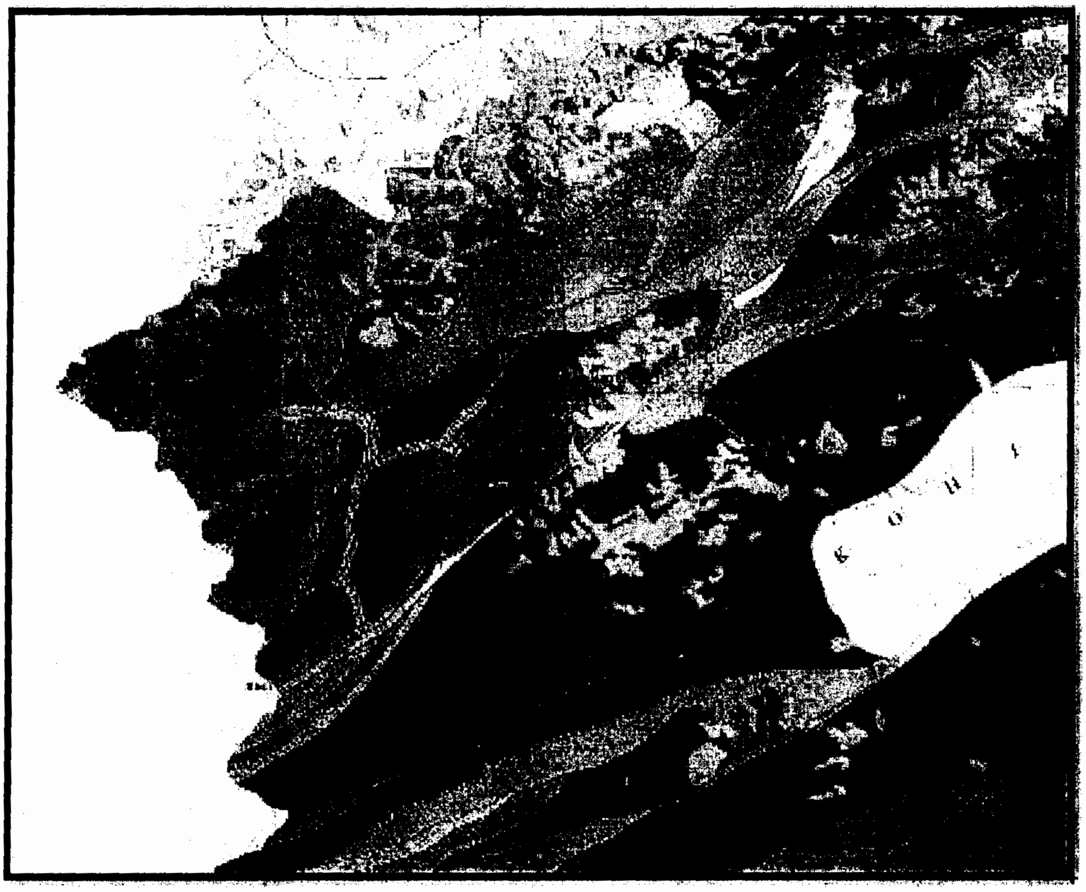


Figure: 8.2 Geological Map of Northern Pakistan after Searle M.P. & Asif M.K. (1996).

It comprises a number of large parallel or en echelon plutons. From west to east these are Buni Zom, Zagar-Umalsit-Ghamu Bar, Dobargar-Darkot, Hunza and Baltoro plutons. They range in age from Jurassic to Miocene (Searle, 1991). Along the northern margin of the Karakoram Batholith, near Baroghil Pass, there are small outcrops of pre-Ordovician granites. The granitic rocks and the surrounding sedimentary sequence have been metamorphosed to varying extent during at least three main thermotectonic events and a later retrograde phase. The Karakoram Batholith divides the region into a northern and southern sedimentary belt. The western part of the region, the Tirich Mir zone, is separated from the main body of the Karakoram belt by the Tirich Mir Fault (**Figure: 8.2**).

b) Tirich Mir Zone

This zone is largely comprised of the highly deformed and imbricated metasediments of Arkari Formation (Jurassic?) which mainly consists of dark grey phy1lites with subordinate quartzites and marbles. Southward it is intruded by numerous stocks and sills of leucogranites and the metamorphic grade increases to the amphibolite facies. The Kafiristan, Garam Chashma and Tirich Mir plutons are the largest batholiths in the region. They mainly consist of biotite granodiorite and augen gneiss.

c) Southern Sedimentary Belt

The southern belt forms an arcuate, north-verging belt of highly deformed and imbricated meta-sediments thrust southward over the Kohistan-Ladakh sequence along the Shyok suture zone or MKT. In the western part of the belt, between Chitral town and Mastuj, Late Paleozoic to Tertiary rocks are exposed. The Darkot Group is the oldest sedimentary unit with Carboniferous to Permian fossils. It consists of slates, schists and quartzite intercalated with crystalline limestone. It has been intruded by granites and is unconformably overlain by the Tertiary (?) Reshun Formation (Pudsey et al., 1985) which comprises red shale, limestone and conglomerates with clasts of underlying rocks. Near the Reshun village, the Darkot Group wedges out to be followed southward by a large anticline in which Chitral Slates (Jurassic?) are exposed. Koghozi green schist and Gahirat Limestone (Cretaceous) crop out on its southern limb and the Krinj Limestone (Createaceous) occurs on its northwestern limb. The Krinj Limestone is unconformable overlain by the Reshun Formation. The Reshun Thrust Fault juxtaposes the Paleozoic sequence of the northern sedimentary belt over the Reshun Formation and truncates the western part of the southern sedimentary belt.

In the region between Mastuj and Hunza, the southern sedimentary belt is almost entirely comprised of the Darkot Group. Large plutons of the Karakoram Batholith have intruded the Darkot Group. In the Hunza area and farther southeastward, in the Baltoro-Shigar region, portions of the Darkot Group have undergone high grade metamorphism. In this region the belt is comprised of Dumordu, Ganchen and Askore formations (Desio, 1963).

The Shyok suture melange forms a thin tectonic wedge between the Kohistan-Ladakh arc sequence and the southern sedimentary belt. It consists of grey to green slates, interbedded clastic sediments and blocks and clasts of greenstone, limestone, red shale, mélange and sheared lenses of ophiolite.

d) Northern Sedimentary Belt

The northern sedimentary belt has been studied mainly in Gilgit-Hunza area where it extends westward from Shaksgam, through Upper Hunza and Chapursan valleys, up to

Baroghil Pass. It then bends southward and follows the Yarkhun valley. In the Upper Hunza region, it consists of three tectonostratigraphic units separated by two major faults. An E-W trending reverse fault, the Upper Hunza Fault, has placed the southerly Gujhal unit over the centrally located Sost unit. The latter forms an antiformal stack and northward, across the Northern Fault, it is structurally overlain by the Misghar unit (Gaetani et al., 1990). The sedimentary sequences in these tectonostratigraphic units range from Permian to Cretaceous in age and are largely comprised interbedded limestones, shales and sandstones (Zanchi, 1993; Gaetani et al., 1995). A conspicuous feature of the northern sedimentary belt is a black carbonaceous shale which overlies the Karakoram Batholith. In different regions it has been variously named as Pasu Shale, Shimshal Shale, Singhie Shale, Baltoro and Rimo Shale. In the Upper Hunza-Chapursan region, it is overlain by fossiliferous Permian carbonates (Guhjal dolomite).

The region between Upper Hunza and Upper Yarkhun valleys (from Yashkuk to Showar Shur) is unmapped and the westward continuation of the Upper Hunza tectonostrati-graphic units is uncertain. The Baroghil region contains Early Palaeozoic rocks and it is characterized by four tectonostratigraphic units. To the northwest lies the Tas Kupruk unit which consists of Ordovician (?) to Permian metasediments, dolomites and volcanics rocks. Southeastward the Tirich Fault (?) separates it from the Karambar unit which contains a Silurian (?) to Permian (or younger) terrigenous to shallow-water carbonate sequence. Southward the Karambar unit is faulted against the Baroghil unit which comprises a Devonian to Triassic sedimentary sequence. Farther to the southeast the Baroghil unit has been thrust over the Axial unit which consists of the Cretaceous to Lower Tertiary (?) Reshun Conglomerate, unconformably underlain by Upper Permian Carbonates. South of the Baroghil Pass, the Baroghil unit unconformably overlies the pre-Ordovician Ishkarwaz Granite. This granite intrudes a metasedimentary sequence (Le Fort et al., 1994) which is also referred to as the Chikar Formation. Southward the Chikar Formation and the Ishkarwaz Granite is covered and their contact relationship with the Karakoram Batholith (Darkot pluton) is not known. It is likely to be a tectonic boundary.

Dark splintery slates with siltstone laminae unconformably overlie the Ishkarwaz Granite. At the base of the sedimentary sequence there is a conglomerate bed rich in chert followed by arkosic sandstones with brachiopods and overlain by slates containing Early Ordovician palynological assemblage. This sequence has been referred to as Baroghil sediments (Tongiorgi et al., 1994; Le Fort et al., 1994). In the upper part the slates contain metadolomites and quartzites with Middle to Late Ordovician conodonts (Talent et al., 1979). Kazmi & Qasim Jan (1997) proposed this sequence to be named Baroghil formation instead of Baroghil sediments. Above the Baroghil Formation there is an angular unconformity followed by a thick sequence of slates, dolomitic limestone and quartzites with Devonian fossils (Chilmarabad Formation). The latter is unconformably overlain by Permian carbonates (Talent et al., 1979, Tahirkheli, 1982).

How far to the west and southwest the tectonostratigraphic units of the Baroghil region extend is not known because the area between Baroghil Pass and Mastuj has not yet been adequately mapped. The northern sedimentary belt continues southwestward up to Chitral and beyond. In this region it is apparently confined to a narrow belt between the Tirich and Reshun Faults. Here it consists of an imbricate sequence of Devonian to Triassic (or Jurassic?), fossiliferous quartzites, shales, crystalline limestones and dolomites (Charun Quartzite, Shogram Formation, Lun shale). In this region the

Reshun Fault which is a north dipping reverse fault, juxtaposes the Paleozoic sequence of the northern sedimentary belt over the Cretaceous rocks of the southern sedimentary belt.

e) Structure

Structurally the Karakoram block is characterized by broad, asymmetrical to tight, isoclinals folds which are commonly imbricated. Small isoclinals, recumbent folds, chevron folds, drag folds and crenulations are common. A number of large regional scale thrust faults, e.g. the Tirich, Reshun, Baltit, Upper Hunza and Chapursan Faults and the MKT, extend for distances up to 100 km or more. Smaller thrusts commonly imbricate the metasedimentary sequences and from thrust stacks. Normal and wrench faults also occur extensively but these are less conspicuous than the thrusts and reverse faults.

The Karakoram block has undergone multiple deformations since the Cambrian. The Baroghil section bears evidence of the earliest pre-Ordovician, probably Precambrian to Cambrian deformational, magma tic and metamorphic events. There is apparently a major hiatus during the Silurian because Silurian fossils have not yet been reported. In the Baroghil section the Ordovician succession underlies the Devonian with an angular unconformity (Tahirkheli, 1982). The Batura region contains some evidence of deformation (molasses type Urdok Conglomerate), probably related to the rifting of the Karakoram block from Gondwanaland during Late Permian or Early Triassic. In Upper Hunza and Chapursan, an angular unconformity below the Middle to Late Cretaceous Tupop Formation and lack of paleontological evidence for post-Middle or Late Jurassic sedimentation, coupled with the well constrained 208-163 Ma radiometric dates (Searle, 1991) on the Hushe Gneiss Complex in the Shigar region suggest deformation during the Jurassic. In Chitral, Upper Hunza, Shaksgam and Baltoro, angular unconformities above the Lower and the Middle Cretaceous, magmatism and metamorphism well constrained with radiometric dates, provide evidence for Kohistan-Karakoram collision and a Late Cimmerian orogenic event.

Parts of Karakoram (Baltoro, Masherbrum, Mango Gausar) have undergone at least four more deformations since the Kohistan-Karakoram collision. According to Searle (1991), the early two deformations (Paleocene to Eocene) were contemporaneous with crustal thickening and regional metamorphism, the third one occurred during Oligocene as indicated by intrusion of undeformed Early Oligocene granites in sheared thrust sheets, and the last one took place during Mio-Pliocene (biotite-muscovite date 15-5 Ma) and was associated with rapid uplift.

8.2.2. Local Tectonic Features

The project site is located near the contact between Kohistan island arc and the Eurasian mass represented by Shyok suture zone (MKT). The major critical faults of the Chitral area include, from south to north, the Main Karakoram Thrust, Reshun Fault and Tirich Mir Fault (**Figure: 8.2** and **Figure: 8.3**). All these major faults of Chitral with NE-SW trend swing to the WSW in western Kohistan and merge with the Kunar Fault in the adjacent part of Afghanistan. The general description of these faults is as follows:-

Main Karakorum Thrust (MKT): This is the major regional fault representing the suture zone between the two colliding plates. This fault represents the northern boundary of the Kohistan island arc and runs eastward to join Indus suture zone in upper Himalayas and terminate at its junction with Karakoram fault. Near the project area, the rocks of Karakoram Batholith are thrusted over the rocks of Kohistan Batholith along MKT. The Shishi river follows this fault up to its confluence with Chitral river. This fault passes at a closest distance of about 10 km east of the project site.

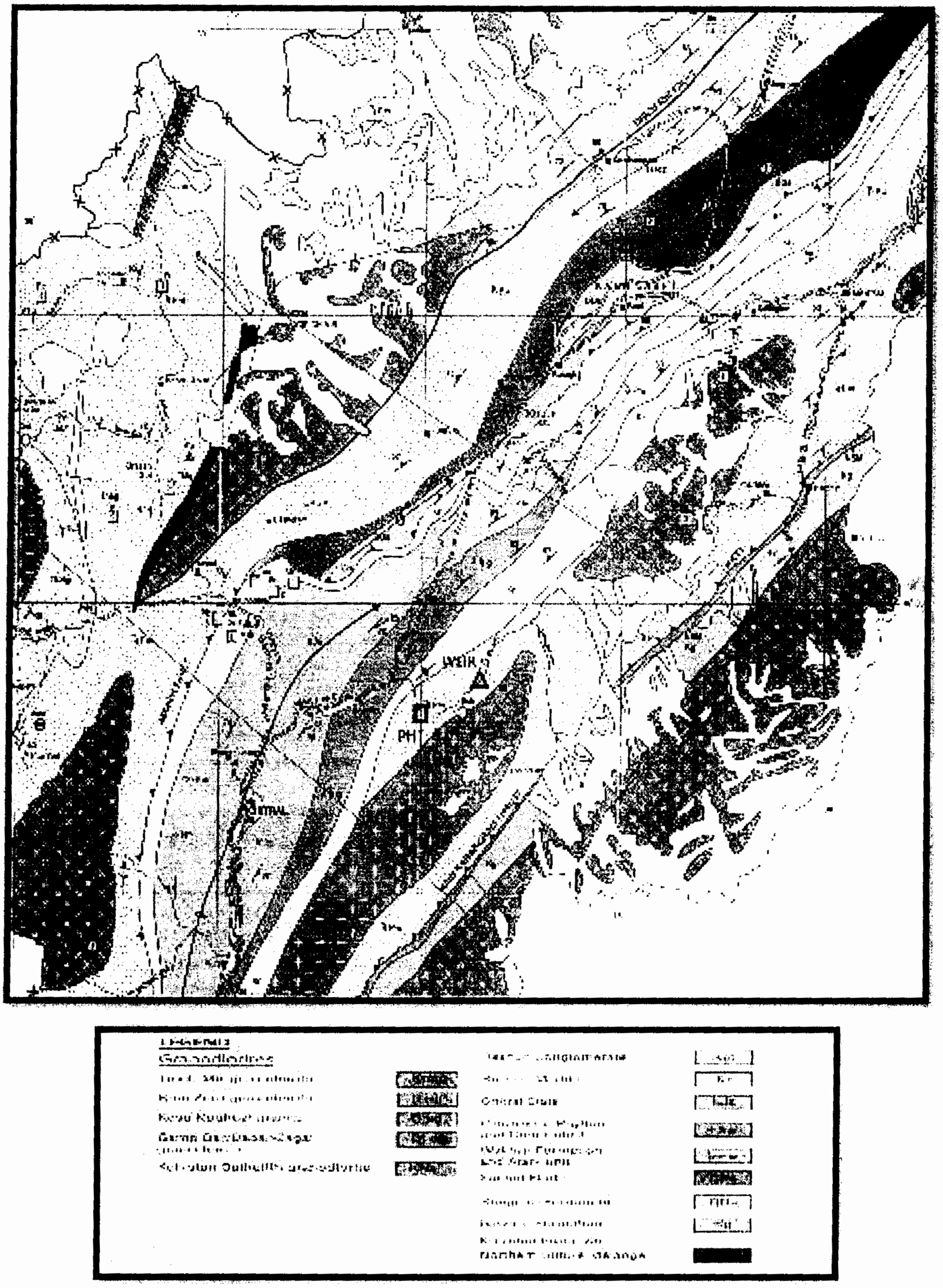


Figure: 8.3 Geological Map of Chitral by Geological Survey of Pakistan (2000).

Reshan Fault: This is a major thrust fault which is present northwest of MKT and extends parallel to MKT between Mastuj and Chitral and extends further to southwest beyond Afghanistan border. Shuhab and Nancy (2006) have recently discovered two new strike-slip faults cutting the Reshan fault. They named these faults as Kalash (Bomborat) fault and Chitral Gol fault. These faults truncate the Cretaceous marbles of the Reshun Formation against the Chitral Slates. The Kalash fault is left-lateral, whereas the Chitral Gol Fault is right-lateral, thus making a conjugate pattern to indicate that these faults are accommodating regional compression. This fault passes at a closest distance of about 15 km west of project site.

Tirich Mir Fault: This is another regional fault running parallel to Reshun fault on the northwest of the project site. The Tirich Mir Fault passes about 24 km northwest of the project site. It follows the eastern contact of the Tirich Mir pluton, which pinches near the Lutkho river upstream of Shogor. From here SW, the fault follows the eastern contact of high grade pelites of the Wakhan Slates/Arkari Formation. The fault zone is intruded by a dense network of pegmatite and leucogranite dykes and sills. The schistosity in the fault zone is NE/SW oriented with moderate dips to the NW. The foliation is folded into isoclinal folds with fold axis shallowly plunging to the NE. These syn-kinematic folds suggest a thrust sense of movement. The contact between the Tirich Mir Pluton and the phyllites downstream is clearly tectonic rather than intrusive. Local brittle faults, however carry sub-horizontal slickensides suggesting that the youngest phase of deformation is strike-slip.

8.3. Earthquake Record

8.3.1. General

Earthquakes pose a multitude of hazard to hydropower project, either by direct loading of the structures or by initiating a sequence of events that may lead to damage to the structures, or even failures unless this has been catered for in the design.

The project site is located near the collisional zone between Indian plate and Eurasian plate where subduction of Indian plate below the Eurasian plate is taking place. This collisional zone represented by the suture zone has always been generating moderate to large earthquakes that have caused large destruction and huge loss of life. The available seismicity record for the region in which the project is located can be classified into the following two types:

- Historical Seismicity
- Instrumental Seismicity

8.3.2. Historical Earthquake Record

The earthquakes originated before the advent of seismic recording instrument that have been mentioned in the literature and were located within the project region give only information about the level of damage that this region has undergone historically, though this information does not give a conclusive account about their epicentral location. These do give an understanding about the extent of structural damages and probable life loss in return. This non-instrumented data is solely dependent upon human observations. In order to perform a quantitative analysis of the effects of non-instrumentally recorded earthquakes, intensity scales have been established which categorize the effects experienced by human being into well-defined levels ranging from minimum sensations to catastrophic extremes.

The historical pre-instrument earthquake data has been collected from the description of the earthquakes given in the memoirs or records of travelers, historians and writers. Such earthquakes catalogues have been compiled by Oldham, 1893, Heukroth and Karim, 1970, Ambraseys et al. 1975 and Quittmeyer and Jacob, 1979. Due to remoteness of the project area, available historical record of earthquakes in Chitral area is very limited probably due to remoteness of the area. However, the historical earthquake record available for northern part of Pakistan is given in **Annexure: 8.1** in **Appendix: H.**

The first known historical account of seismicity in northern part of Pakistan was described in the fourth century B.C. by Aristobulus of Cassandreia, who accompanied Alexander on his expedition to India. He pointed out that the country above the river Jhelum was subjected to earthquakes which caused the ground to open up so that even the beds of rivers were changed.

An important earthquake probably occurring near Islamabad was that in 25 AD which ruined the city of Taxila. An intensity of IX to X has been assigned to this earthquake by Quittmeyer and Jacob (1979). This earthquake caused widespread havoc in the surrounding country side. The effects of this earthquake can still be seen among the excavated remains at Jandial, Sirkap and Dharmarajika.

An intensity of VIII to IX has been assigned to another earthquake which occurred on June 23, 1669 at Attock, forming a 50 yards long fissure in the ground. In the 19th century 19 earthquakes with a maximum assigned intensity of IX were felt between Lahore and Peshawar. Several damaging earthquakes have also occurred in Kashmir area which caused large scale destruction.

The most notable historical earthquake occurring within 100 km of the project site is the July 7, 1505 earthquake (repeated at same location on February 19, 1842) which occurred in Kunar province of Afghanistan having surface wave magnitude estimate of 7.5. From historical account of reported damage, this earthquake ruptured along the Kunar River between Asmar and Drosh, suggesting rupturing of the Karakoram Suture Zone (MKT). This earthquake was reported to have damaged the region from Badakhshan in the north to Swat in the south and must have been a shallow earthquake.

Another major historical earthquake associated with the Kunar Fault is Jan 3, 1503. This earthquake is named as Bajaur earthquake, after the name of Bajaur Agency, Pakistan, as it was described by Babur while conquering Bajaur. However, other records suggest that Arandu at Afghanistan-Pakistan border was damaged during this earthquake which again suggests reactivation of the Kunar Fault as well as the MKT.

On January 20, 1902, a damaging earthquake was reported in Chitral area. This event was felt as far as Punjab and Simla. An earthquake in 1929 has also reported to cause heavy destruction in Drosh and Chitral. Similarly, another earthquake on February 6, 1939 caused damage at Drosh.

The meizoseismal areas of major to large earthquakes which occurred along the collisional zone between Indian and Eurasian plates as compiled by Roger Bilham are shown in **Figure: 8.4**. The historical record shows that the northern boundary of the Indian plate has been seismically active in the past and that it continued to release tectonic stresses in the form of moderate to large earthquakes.

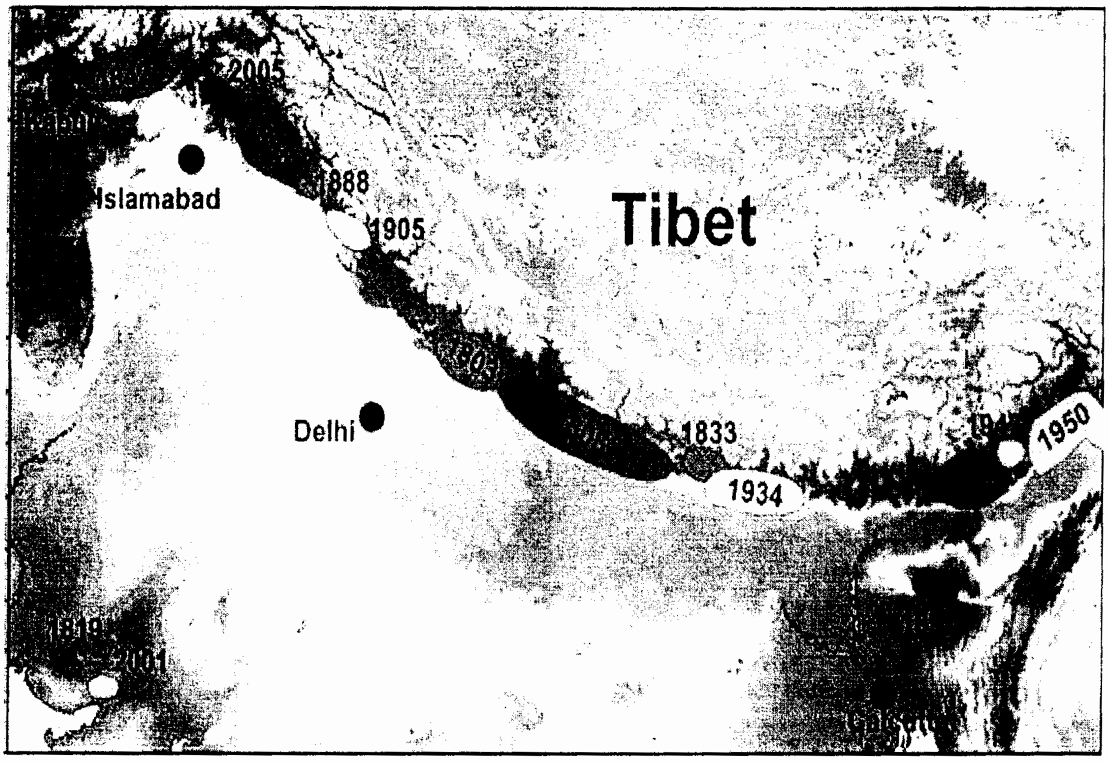


Figure: 8.4 Meizoseismal Areas of Major Earthquakes along Indian and Eurasian Plates Boundary after Bilham.

8.3.3. Instrumental Earthquake Record

The instrumental recording of earthquakes started in 1904. For the present seismic studies, instrumental earthquake data was collected from two sources. The first one is based upon earthquakes recorded by regional seismic networks and the other is compiled from local network data catalogue.

The regional data was compiled from earthquake listings of International Seismological Centre (ISC) England, National Earthquake Information Center (NEIC) of US Geological Survey, Geophysical Centre, Quetta and earthquake listing compiled by Quittmeyer and Jacob (1979). As ISC listing is based on re-evaluation of the epicentral data, this listing was given preference over the others. A close network of seismic stations was established at Tarbela dam in 1973 to monitor the micro-seismic activity around Tarbela. Another micro-seismic network was established around Islamabad by PAEC in 1976. The earthquake data recorded by these two local networks was collected and included in the regional catalogue. The duplicate events were however removed from the seismic data. The earthquake data within more than 200 km of the project site is presented in **Annexure: 8.2** in **Appendix: H** and a plot of this data is shown in **Figure: 8.5**. A review of this data shows that the number of earthquakes recorded prior to 1960 is very small which may be due to poor recording coverage of this region. With the installation of high quality seismographs under World Wide

Standard Seismograph Network (WWSSN) established by US Coast and Geodetic Survey in 1960, the quality of earthquake recording improved in this region and resulted in a better coverage of the seismic activity of this region.

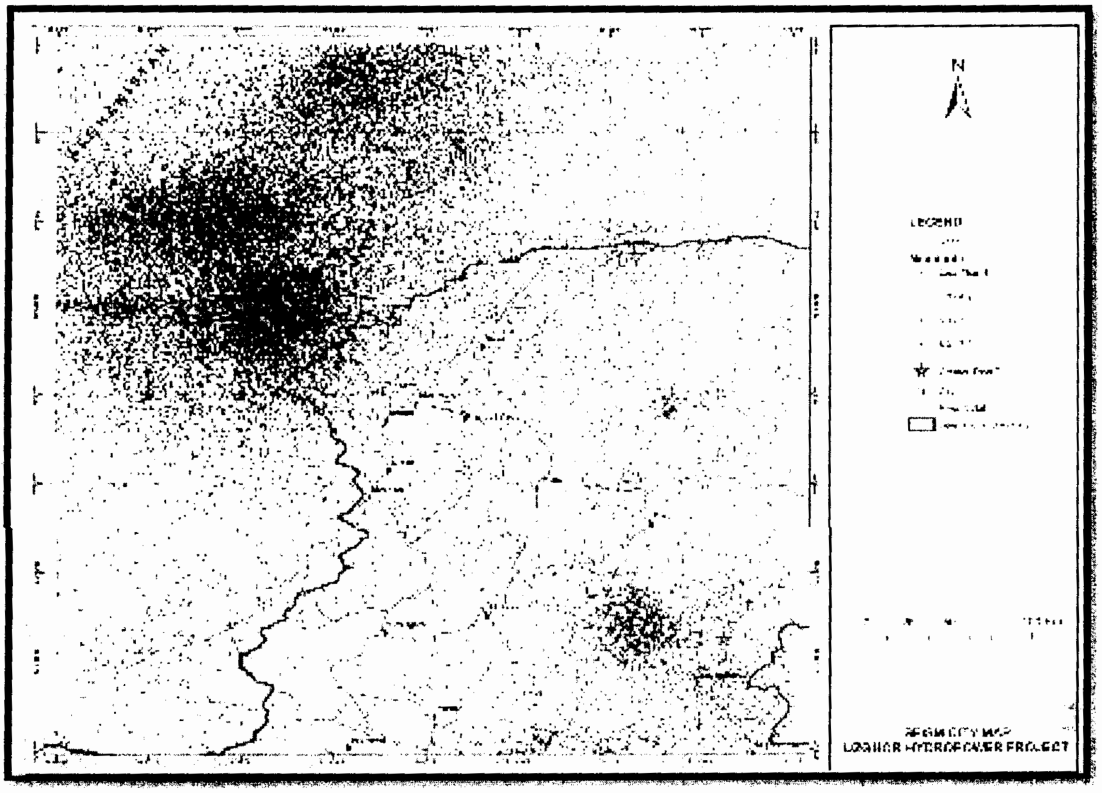


Figure: 8.5 Plot of Seismicity of the Project Region Recorded up to December 2017

The regional networks recorded 21634 earthquakes in area bounded by Latitude 34° to 38° N and Longitude 70° to 74° E up to December 2017. Majority of these earthquakes (more than 80%) were originated from the very active deep Hindukush seismic zone, which is situated in the northwest of the project site and described below in detail. Another cluster of earthquakes is related to the Indus-Kohistan seismic zone present southeast of the project site which was involved in the recent devastating earthquake in Kashmir and Hazara. Around the site area, although the seismic activity is low relative to the two very active seismic zones described above, but still the area is seismically active with frequent small to moderate earthquakes. Being close to the active plate margin, the possibility of a major to large earthquake along the active faults of the project area cannot be ruled out.

8.3.4. Hindukush Seismic Zone

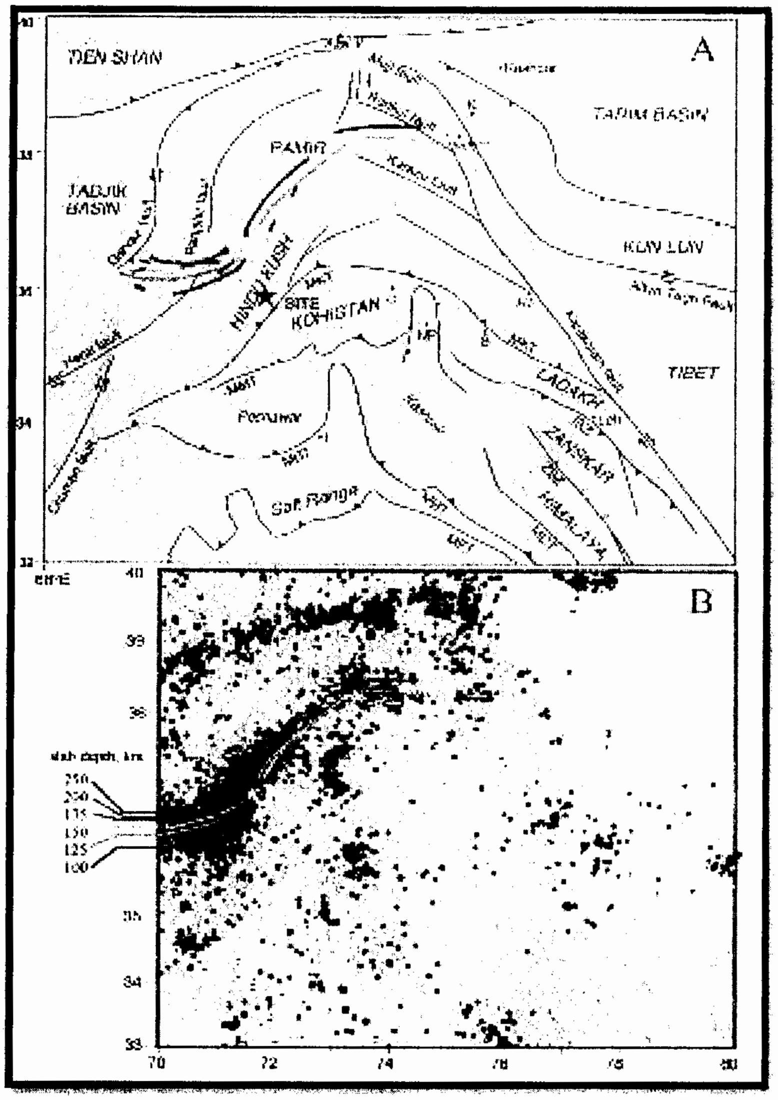
The Hindukush seismic zone along the borders of NW Pakistan, far NE Afghanistan and Tadjkistan is one of the most active regions of intermediate-depth seismicity and by far the most active such region not associated with the subduction of the oceanic lithosphere. The Hindukush seismic zone has been subject to numerous studies and a variety of models have been proposed to account for the three-dimensional pattern of observed seismicity.

The Hindukush seismic zone is associated with very low attenuation of seismic waves, as observed in the Benioff zones beneath the island arcs. Early seismic studies of this zone suggested that the prominent zone of intermediate-depth seismicity occur along thin (<30 km) and deep slab-like zones similar to oceanic subduction zones. The geology of the Pamir, Hindukush, and Tadjik Basin region clearly demonstrates that there has been no oceanic crust in the region (including the Pamir, Hindukush, Karakoram, and western Tibet) since at least the Mid- to Late Cretaceous. The youngest marine sediments along the Indus suture zone and north Indian plate margin (Himalaya) are earliest Eocene (54-50 Ma). Roecker (1982) reported lower P- and S-wave velocities near the seismic zone than outside it and suggested that some continental crust must have been subducted to at least 150-200 km beneath the Hindukush. Subsequent authors have also suggested that the seismic zone must represent subduction of thinned continental crust. Precisely located earthquakes also revealed a seismic gap between the southward-dipping Pamir and the northward-dipping Hindukush seismic zones. Quaternary deformation and a high frequency of earthquakes along the Alai Valley indicate that the Pamir subduction zone reaches the earth's surface there.

Pegler (1995) and Pegler and Das (1998) relocated about 6,000 earthquakes in this area between 1964 and 1992 and published more precise maps and depth profiles of the earthquakes (**Figure: 8.6**). They concluded that the simplest explanation was a single, highly contorted, S-shape seismic zone, 700 km long and no more than 30 km wide. Their profiles show that the north-dipping Hindukush seismic zone is active at depths of 90-280 km. Despite the more detailed knowledge of the geometry of the seismic zone, controversy continues as to whether it represents subduction of continental crust or a trapped oceanic basin (Pavlis and Das, 2000) and whether it represents a single subduction zone or two converging (Pamir and Hindukush) subduction zones. None of these previous studies of the Hindukush and Pamir seismic zones have related the pattern of seismicity to the geological evolution and structure of the Hindukush, which has only recently become well known (Hildebrand et al., 2001).

The Hindukush seismic zone is bounded in the west by a sinistral strike-slip fault system including the Darvaz and Chaman Faults and to the east by the dextral Karakoram Fault (**Figure: 8.6**). The center of the Hindukush seismic zone lies immediately northwest of the topographic high axis of the Hindukush range and cuts diametrically across active, or recently active, faults such as the Panjshir and Darvaz faults. This shows that the Hindukush seismic zone has become completely decoupled from the surface deformation.

The three-dimensional geometry of the subducting slab is not simple. The north-dipping Hindukush seismic zone steepens progressively toward the east, becoming vertical, then overturns toward its eastern end beneath the Pamirs, where it dips to the southeast. The region of earthquake is neither laterally nor vertically continuous but, instead, is characterized by clusters of earthquakes separated by several prominent seismic gaps. Oddly, there appear to be very few earthquakes at depth of 150-180 km. The Hindukush seismic zone may extend to depths as shallow as 60 km, and its projection to the surface is probably in the region of the Main Karakoram Thrust (Searle 1991). East of the Hindukush, seismicity beneath the Karakoram is considerably reduced and defines a triangular zone bounded to the south by the MKT and along the north by the southern margin of the Tarim Basin. This is consistent with the surface structure and topography of the Karakoram, which is a crustal-scale, pop-up one thrusting rocks southward over Kohistan-Ladakh and the Himalaya along the MKT zone and northward over the Tarim Basin. Interestingly, the Karakoram fault shows very little seismicity along its trace. The presence of postglacial surface offsets is presumably the result of large, infrequent earthquakes between which the fault is effectively locked. Total geological offset along the dextral Karakoram fault has been <150-200 km since 17 Ma and this has taken place mainly in the central sector of the fault (Searle et al., 1998).



A, Digital topographic elevation map and a structural map of the western Himalaya, Hindu Kush, Pamir, Karakoram, and western Tibet, which also shows the major structures and the location of the Hindu Kush deep seismic zone. NP, Nanga Parbat; MKT, Main Karakoram thrust; ISZ, Indus suture zone; MMT, Main mantle thrust; ZSZ, Zanskar shear zone; MCT, Main central thrust; MBT, Main boundary thrust; I, Islamabad; S, Skardu; K and Mi are the Kongur and Muztagh Ata gneiss domes between the central Karakoram Fault and the sinistral Altyn Tagh Fault at the far western end of Tibet. B, Map of the Hindu Kush, Pamir, Karakoram, and western Himalaya showing all seismicity covering the period 1964–1995 and depth contours, from 100 to 350 km, of the Hindu Kush seismic zone (after Pegler and Das 1998).

Figure: 8.6 Structural and Seismicity Map of Hindukush, after Pegler & Das, 1998).

8.4. Seismo-tectonic Model

From the tectonic and seismic data of the project region presented above, a clearer understanding about the seismo-tectonic set up of the project area can be developed as shown in seismotectonic map of the region (**Figure: 8.7**). Based on this understanding, the main seismogenic features which are critical for the seismic hazard for Uzghor Hydropower Project are:

- Main Karakoram Thrust (MKT),
- Reshun Fault,
- Tirich Mir Fault, and
- Hindukush Deep Seismic Zone

The other faults of the project region are less influencing the seismic hazard because of either lower magnitude or due to distance from the project site and therefore will not be controlling the seismic hazard to the project.

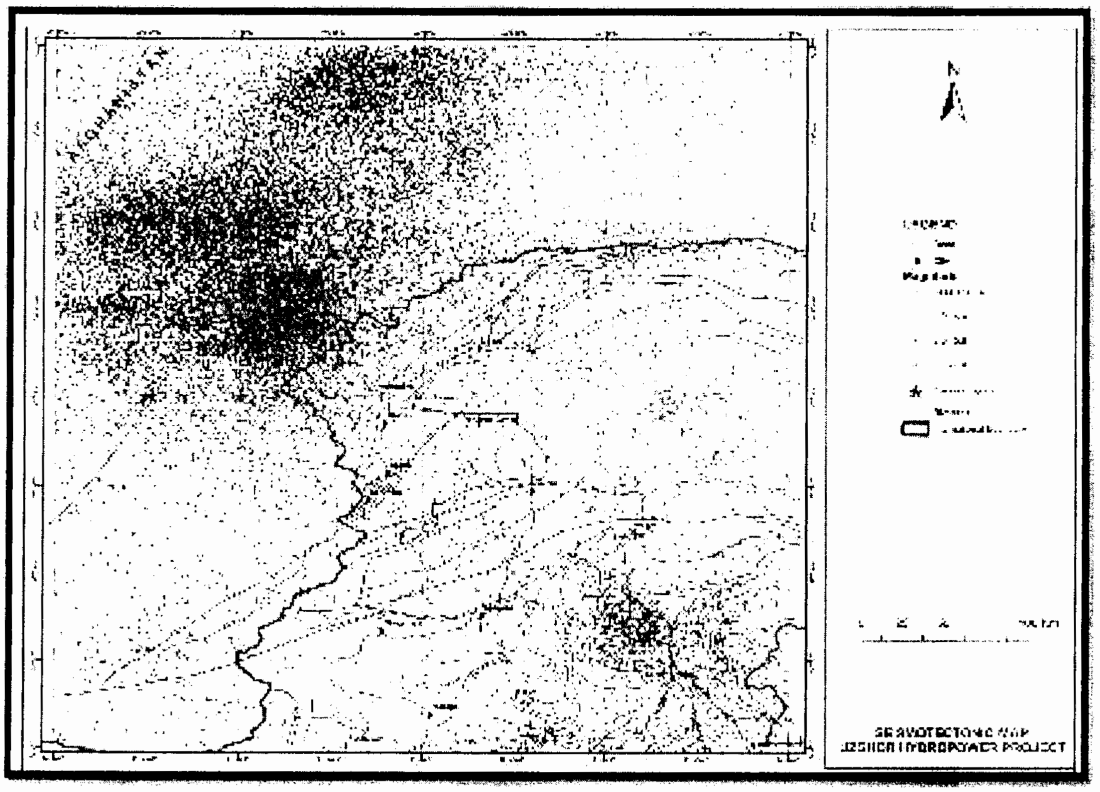


Figure: 8.7 Seismo-tectonic Map of Project Region showing Seismicity and Faults.

8.5. Seismic Hazard Evaluation Procedure

As the project is based on run-of-the-river with no reservoir, weir height is 8.3 meters and there is no chance of any downstream damage of life and property, so it can be classed as "Low Hazard Potential" as per **Annexure: 8.2** in **Appendix: H** of ER 1110-2-1806 - Earthquake Design and Evaluation for Civil Works Projects (May 2016). For seismic hazard evaluation therefore, probabilistic seismic hazard analysis (PSHA) was carried out to select the seismic design parameters. A brief description of the methodology of the approach used for the seismic hazard analysis in accordance with ER 1110-2-1806 is given below. The results of PSHA are used to select the site ground motions based on the acceptable probability of exceedance during the service life of the structure for a given return period.

8.5.1. Probabilistic Procedure

In probabilistic seismic hazard evaluation, the seismic activity of seismic source (line or area) is specified by a recurrence relationship, defining the cumulative number of events per year versus the magnitude. Distribution of earthquake is assumed to be uniform within the source zone and independent of time.

The procedure consists of subdividing the study area into a number of elementary zones (seismic sources) and computing the probability of one or several earthquakes of specified size occurring within each zone during a specified period. For each source, the probability of the earthquake being of a specified magnitude and the attenuation of the resulting ground motion are combined to derive the probabilities associated with the exceedance of different levels of ground motion at the site. The contributions of all sources are then summed up to give the total hazard in terms of probability or annual frequency of occurrence of the ground motion at the project site.

The recorded earthquake data presented in **Annexure: 8.2** in **Appendix: H** and plotted in **Figure: 8.5** was used as data base for the definition of seismic sources and determination of recurrence (frequency-magnitude) relationship.

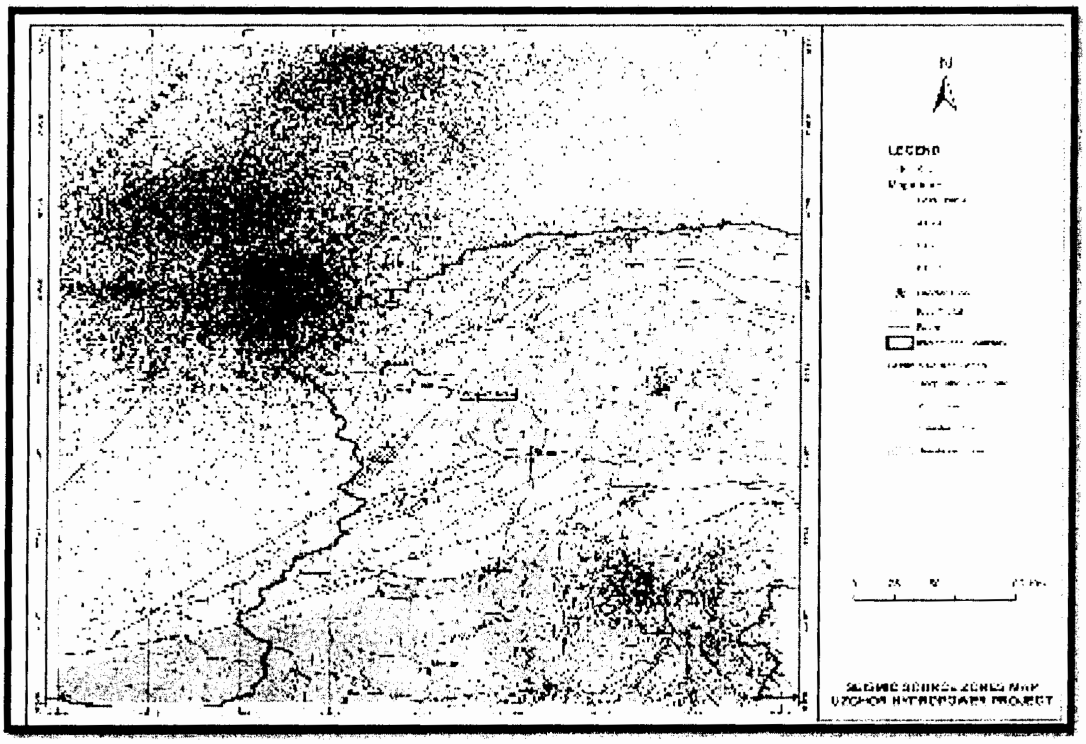


Figure: 8.8 Area Source Zones used in Probabilistic Seismic Hazard Analysis.

As the attenuation relationships to be used in the analysis is based on moment magnitude (M_W), the available seismic data in the form of body wave (m_b), surface wave (M_S) and local (M_L) magnitude was converted to moment magnitude (M_W) by using the following relationships:

a) Conversion from Ms and m_b to M_W was achieved through recently developed equation by Scordilis (2006):

$M_W = 0.67\ M_S + 2.07$ for $3.0 \le M_S \le 6.1$

$M_W = 0.99\ M_S + 0.08$ for $6.2 \le M_S \le 8.2$

$M_W = 0.85\ m_b + 1.03$ for $3.5 \le m_b \le 6.2$

b) Conversion of M_L to M_W was done by using the following equations:

$0.82(M_L) - 0.58(M_S) = 1.2$ (Ambraseys & Bommer, 1990)

$\text{Log } M_o = 19.09 + M_S$ for $M_S \le 6.2$,

$\text{Log } M_o = 15.94 + 1.5\ M_S$ for $M_S > 6.2$, and (Ambraseys & Bilham, 2003)

$M_W = (2/3) \text{ Log } Mo - 10.73$

Where M_o is seismic moment in dynes-cm

The distribution of seismicity and faults (**Figure: 8.7**) is such that it is difficult to associate the observed seismicity with a particular fault. Therefore, a source model based on seismic area sources was employed in the probabilistic analysis. The area of more than 200 km radius around the project was divided into four (4) area source zones (**Figure: 8.8**), each having similar tectonic and seismic character.

A general equation that describes earthquake recurrence may be expressed as follows:

$$N(m) = f(m, t) \qquad (1)$$

Where N (m) is the number of earthquakes with magnitude equal to or greater than m, and t is time period.

The simplest form of equation (1) that has been used in most engineering applications is the well-known Richter's law which states that the cumulated number of earthquakes occurred in a given period of time can be approximated by the relationship:

$$\text{Log } N(m) = a - b\,m \qquad (2)$$

Equation (2) assumes spatial and temporal independence of all earthquakes, i.e. it has the properties of a Poisson model. Coefficients 'a' and 'b' can be derived from seismic data related to the source of interest. Coefficient 'a' is related to the total number of events occurred in the source zone and depends on its area, while coefficient 'b' represents the coefficient of proportionality between log N (m) and the magnitude.

The composite earthquake list contains limited number of earthquakes prior to 1960 and only few of these earthquakes have been assigned magnitude values. Due to installation of WWSSN, the earthquake recording in this region improved and a better and complete recording of earthquake data are available after 1960. A basic assumption of seismic hazard methodology is that earthquake sources are independent. Thus, catalogues that are used to estimate future seismic activity must be free of dependent events such as foreshocks and aftershocks. To the extent possible such events were also eliminated, as there are insufficient data to apply rigorous procedures such as that of Gardner and Knopoff (1974) to eliminate foreshocks and aftershocks from the composite catalogue.

The completeness analysis of the overall data for the region showed that earthquake data up to about magnitude 4.0 is complete after 1960. The converted moment magnitude for the period between 1961 and 2017 was therefore used in the PSHA after excluding the aftershocks. A separate list of earthquakes occurring in each seismic area source zone was prepared through GIS software and magnitude-frequency curves were plotted for each seismic area source zone (**Figure: 8.9**). The b-value for each seismic area source zone was calculated using linear regression through least square method truncated for the maximum magnitude. The minimum magnitude for each area source zone was selected from the magnitude-frequency curve based on completeness checks suggested by Woeffner and Weimer (2005).

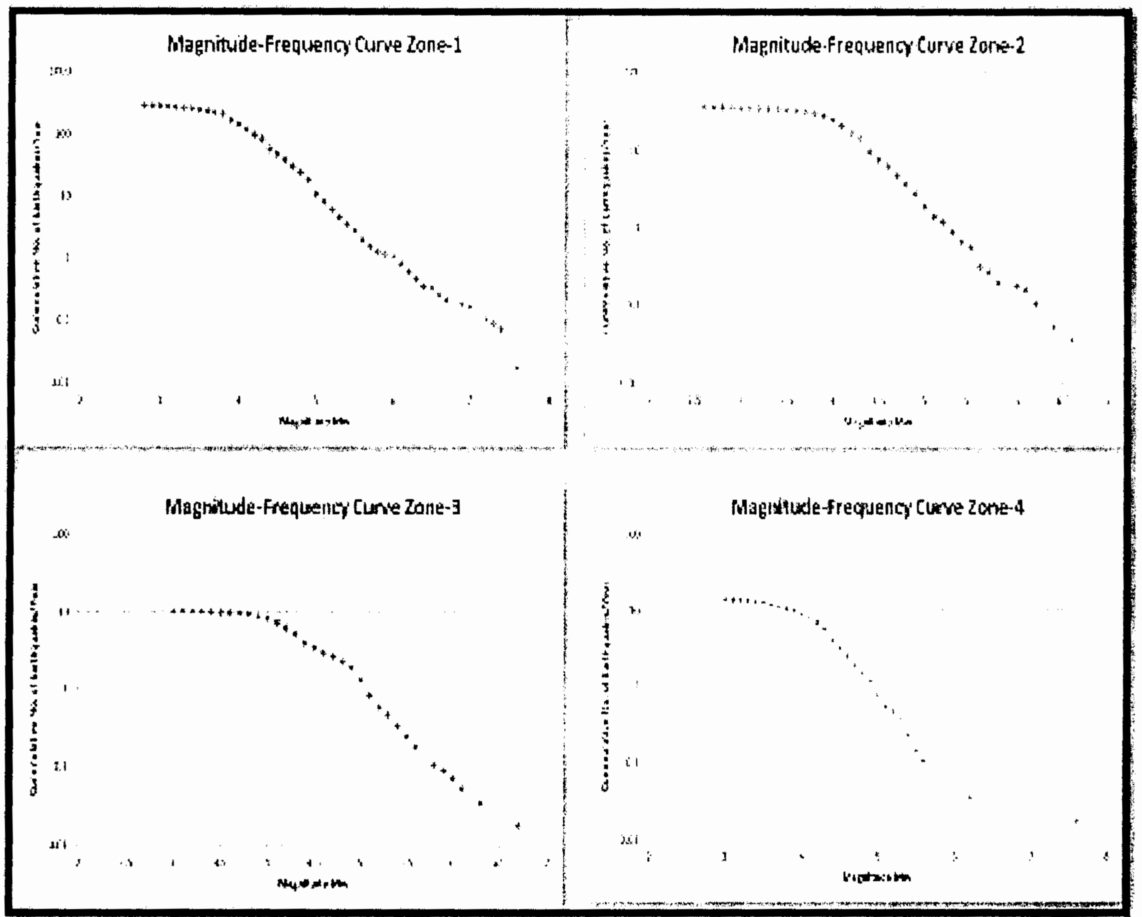


Figure: 8.9 Magnitude–Frequency Curves for four Seismic Area Source Zones.

The b–values, minimum magnitude and the activity rates for the four area source zones used in the probabilistic analysis are shown in **Table: 8.1**. The truncated maximum magnitude model was used for which the maximum magnitude is also given in **Table: 8.1**.

Table: 8.1 Area Source Parameters for Probabilistic Analysis

Zone. No.	Seismic Source Zone	No. of Earthquakes above Min. Magnitude	Minimum Magnitude Mw	Maximum Magnitude Mw	Activity Rate /Year	b-Value
1	Hindukush	8098	4.0	8.0	142.07	1.02
2	MKT	1148	4.1	7.5	20.14	1.12
3	Kohistan	348	4.2	7.5	6.105	1.11
4	Himalayas	435	4.1	7.6	7.63	1.19

The evaluation of return period of different levels of ground motions was carried using probabilistic method originally developed by Cornell (1968) and later developed by various researchers. The site foundation condition of dense gravelly soil with V_{S30}=600 m/sec was assumed for the analysis. Three New Generation Attenuation (NGA) equations developed under Pacific Earthquake Engineering Research Center (PEER) of University of California, USA were employed. These NGA equations were developed by Abrahamson-Silva (2008), Boore-Atkinson (2008) and Campbell-Bozorgnia (2008). These equations are developed for shallow crustal earthquakes in tectonic environment prevalent mainly in the project area. The attenuation equation of Youngs et al. (1997) applicable for subduction zone earthquakes was applied for calculation of ground motions from deeper Hindukush seismic zone. The probabilistic hazard analysis was carried out by using EZ-FRISK software developed by Fugro Consultants, USA. All the parameters defined in Table-1 were incorporated in the area source models. The mean total hazard curve was obtained by giving equal weighting to all the attenuation equations used. The results of the probabilistic seismic hazard analysis are presented in **Figure: 8.10** for the project (weir and powerhouse sites), showing annual frequency of exceedance of horizontal ground acceleration at the project. The major contribution to seismic hazard is from MKT zone followed by Hindukush Deep Seismic zone. The peak horizontal ground acceleration (PGA) for different return periods (inverse of annual frequency of exceedance) obtained at the project site is given in **Table: 8.2**.

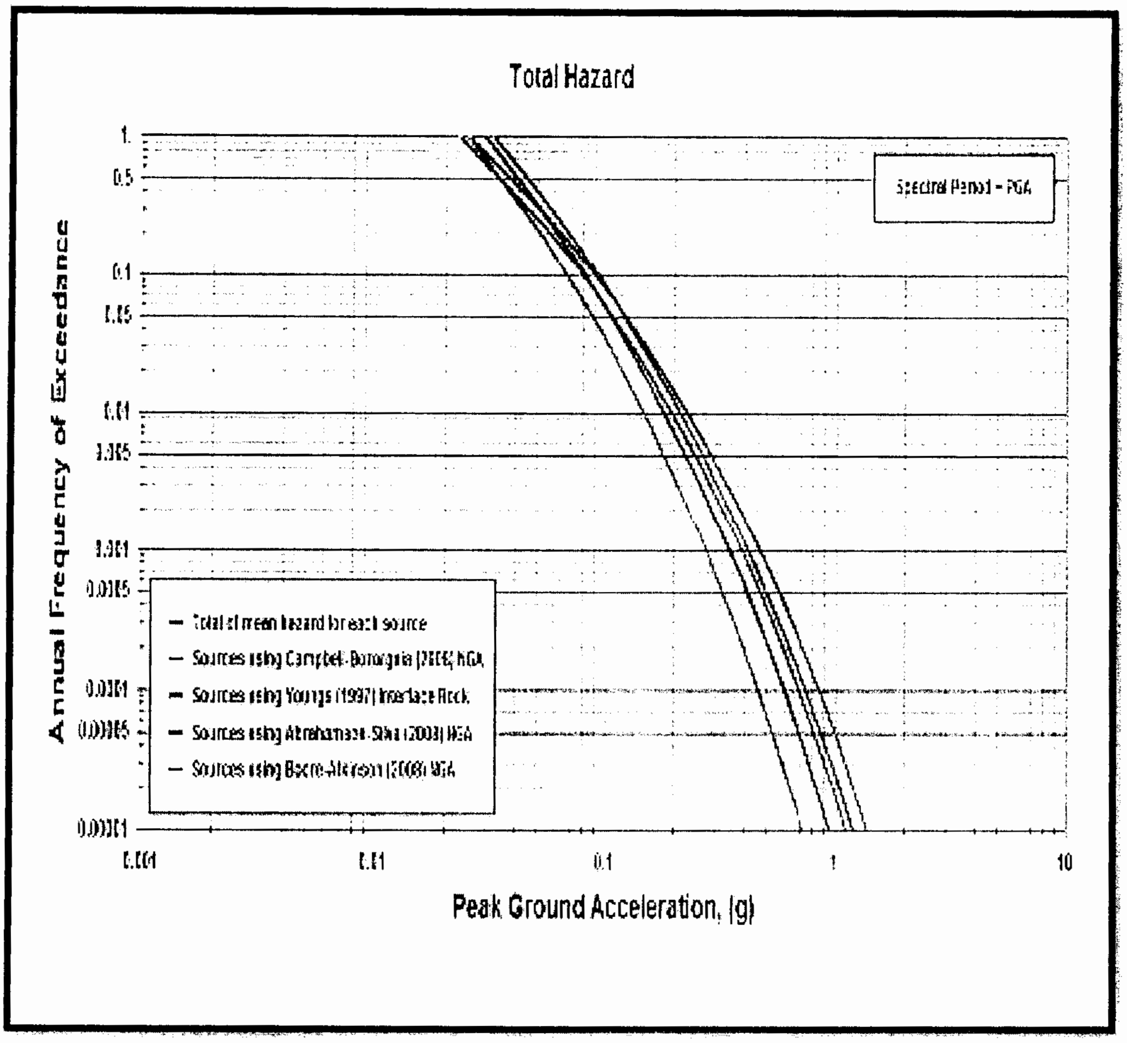


Figure: 8.10 Total Seismic Hazard Curve for the Project Site.

Table: 8.2 Peak Ground Acceleration (PGA) for different return periods obtained through Probabilistic Analysis at Project Site

Return Period (Years)	Peak Ground Acceleration (g)*
145	0.24
475	0.34
975	0.42
3,000	0.56
10,000	0.74

* PGA for very dense soil foundation condition (V_{S30}=600 m/sec)

8.6. Seismic Hazard Parameters

8.6.1. Definitions

According to the ER 1110-2-1806 - Earthquake Design and Evaluation for Civil Works Projects (May 2016), the definitions of design earthquakes for hydraulic structures are as follows.

8.6.1.1. Maximum Credible Earthquake (MCE)

The MCE is defined as the largest earthquake that can reasonably be expected to be generated by a specific source on the basis of seismological and geological evidence. Since a project site may be affected by earthquakes generated by various sources, each with its own fault mechanism, maximum earthquake magnitude, and distance from the site, multiple MCE's may be defined for the site, each with its own characteristic ground-motion parameters and spectral shape. The MCE is evaluated using DSHA methods informed by results from a PSHA. Since different sources may result in differing spectral characteristics, selection of "maximum" ground motion parameters may need to consider different sources and magnitude events to represent the full range of possible maximum loadings e.g., peak ground acceleration from one source may be higher than from another, but reversed for 1s spectral acceleration values. Therefore, both sources may need to be considered in analysis to assess the full range of potential "maximum" loadings. There is no return period for the MCE.

8.6.1.2. Maximum Design Earthquake (MDE)

The MDE is the maximum level of ground motion for which a structure is designed or evaluated. The associated performance requirement is that the project performs without loss of life or catastrophic failure (such as an uncontrolled release of a reservoir) although severe damage or economic loss may be tolerated. For critical features, the MDE is the same as the MCE. For all other features, the minimum MDE is an event with a 10% probability of exceedance in 100 years (average return period of 975 years) assessed using a PSHA informed by the results of a site-specific DSHA. A shorter or longer return period for non-critical features can be justified by the project team based on the Hazard Potential Classification for Civil Works Projects in **Annexure: 8.2** in **Appendix: H**. A project with a low hazard potential classification may consider return periods less than 975 years, while projects with a significant or high hazard potential classification may consider longer return periods. The MDE can be characterized as a deterministic or probabilistic event.

8.6.1.3. Operating Basis Earthquake (OBE)

The OBE is an earthquake that can reasonably be expected to occur within the service life of the project, typically a 50% probability of exceedance in 100 years (average return period of 145 years) assessed using a PSHA informed by the results of a site-specific DSHA. The associated performance requirement is that the project functions with little or no damage and without interruption of function. The purpose of the OBE is to protect against economic losses from damage or loss of service, therefore, alternative choices of return periods for the OBE may be based on economic considerations.

8.6.2. Seismic Design Parameters

Design seismic parameters are selected on the basis of the results provided by probabilistic seismic hazard analysis and in compliance with the recommendations of ER 1110-2-1806 - Earthquake Design and Evaluation for Civil Works Projects (May 2016).

8.6.2.1. Maximum Design Earthquake (MDE) Acceleration

As per Hazard Potential Classification for Civil Works Projects given in **Annexure: 8.2** in **Appendix: H** of ER 1110-2-1806, the project falls in Low Hazard Potential class. As failure of the project would not present any social hazard, the designer can choose a Maximum Design Earthquake (MDE) acceleration lower than MCE (which is equivalent to 10,000-year return period earthquake). ER 1110-2-1806 recommends to adopt 975 year or less return period ground motion for Low Hazard Potential Hydraulic structures. As the Uzghor Hydropower Project is categorized as Low Hazard Potential Hydraulic structure, therefore for all critical structures of the project, the recommended ground motion for MDE is 0.42g (corresponding to a return period of 975 year as per **Table: 8.2**. For non-critical structures, the recommended ground motion for MDE is 0.34g (corresponding to a return period of 475 year).

8.6.2.2. Operating Basis Earthquake (OBE) Acceleration

The OBE accelerations are selected from the results of the probabilistic analysis which is presented in **Figure: 8.11** in terms of annual frequency of exceedance of different levels of ground motion. The purpose of the OBE design is to protect against economic losses from damage or loss of service for all project structures. The performance requirement is that the project functions with little or no damage or interruption under OBE conditions.

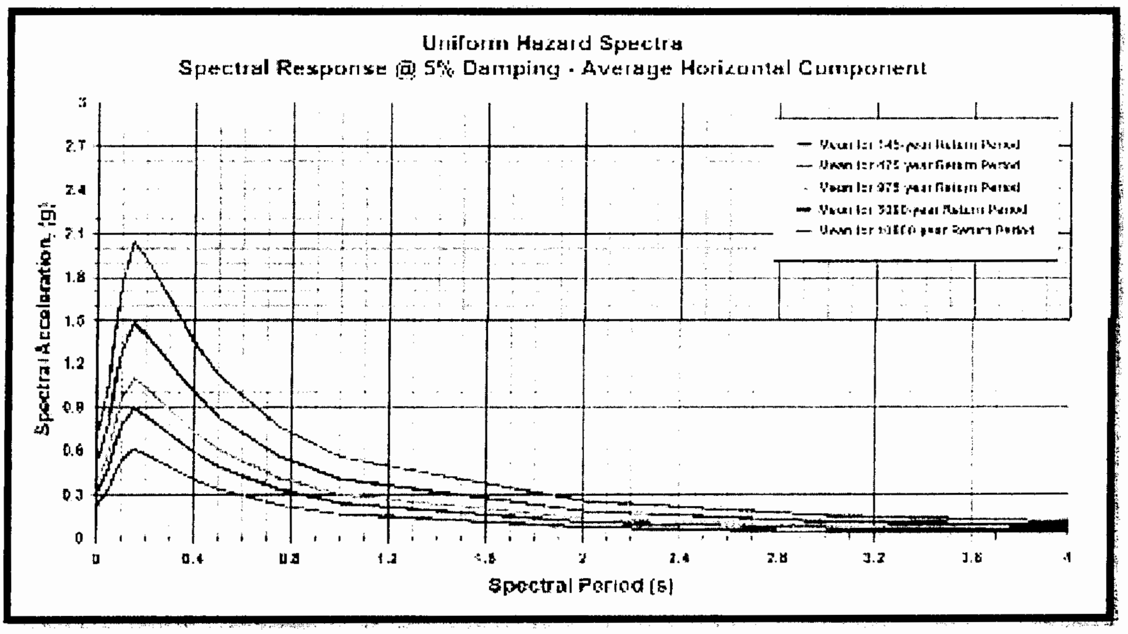


Figure: 8.11 Uniform Hazard Spectra obtained from PSHA for Project Site.

As per definition of OBE given above, OBE accelerations corresponding to 50% probability of exceedance in 100 years (i.e. a return period of 145 years) may be adopted for which PGA value is 0.24g.

8.6.2.3. Uniform Response Spectra

Uniform hazard spectra generated by EZ-FRISK software for OBE (145-year return period) and MDE (975-year return period and 475-year return period) are shown in **Figure: 8.11**.

8.7. Conclusions And Recommendations

The conclusions and recommendations regarding study of seismic hazard assessment of Uzghor Hydro Electric Power Project and the resulting seismic design parameters are as follows:

a) The project is located in a region which is seismically active due to the proximity of the collisional boundary of the Indian and the Eurasian plates and presence of very active deep Hindukush Seismic Zone. The seismicity of the area is depicted by small to major earthquake activity. The historical earthquake data shows that intensity up to IX has been felt in the project region.

b) The critical active tectonic features within 200 km of the project site, which governs the ground motion at the project site, are the Main Karakoram Thrust (MKT), Reshun Thrust, Tirich Mir Thrust and the Hindukush Deep Seismic Zone.

c) As the weir of the project is categorized as Low Hazard Potential Hydraulic structure, MDE may be selected lower than MCE in accordance with the recommendations of ER 1110-2-1806 - Earthquake Design and Evaluation for Civil Works Projects (May 2016). For all critical structures, the recommended ground motion for MDE is 0.42g (corresponding to a return period of 975 year). For non-critical structures, the recommended ground motion for MDE is 0.34g (corresponding to a return period of 475 year).

d) The PGA of 0.24g having a return period of 145 year is recommended for ground shaking associated with Operating Basis Earthquake (OBE). All the water retaining components of the project should remain fully functional under the OBE associated ground motions.

e) As the project is located in a hilly terrain which experiences frequent shaking from very active Hindukush seismic zone, all slopes of the project should be checked for slope stability against minimum shaking associated with OBE.

REFERENCES

1. Shuhab D.K. and Nancy F.G., (2006), New strike-slip faults and litho-units mapped in Chitral (N. Pakistan) using field and ASTER data yield regionally significant results, International Journal of Remote Sensing, Vol. 27, No. 20, 4495-4512.

2. Scotese et al., (1988), Plate tectonic reconstructions of the Cretaceous and Cenozoic ocean basins, Tectonophysics, 155, 27-48.

3. Zanchi et al., (2000), Mantle exhumation along Tirich Mir fault zone, NW Pakistan: pre-mid-Cretaceous accretion of the Karakoram terrane to the Asian margin, Geological Society of London, Special Publication, 170, 277-293.

4. Hildebrand et al., (2001), An old origin for an active mountain range: geology and geochronology of the eastern Hindu Kush, northwest Pakistan. Geol. Soc. Am. Bull, No. 113, 625-639.

5. Khan et al. (1997), Geochemical and isotopic constraints on subduction polarity, magma sources, and paleogeography of the Kohistan intra-oceanic arc, northern Pakistan Himalayas, Journal of the Geological Society of London, 154, 935-946.

6. Searle et al., (1999), The tectonic evolution of the Kohistan-Karakoram collision belt along Karakoram Highway transect, north Pakistan. Tectonics 18, 929-949.

7. Malinconico, (1989), Crustal thickness estimates for the western Himalaya. In Malinconico, L.L. & Lillie, R.J. (eds.), Tectonics of the Western Himalayas, Geol. Soc. Amer., Spec. Paper 232: 237-242

8. Seeber and Armbuster, 1979), Seismicity of the Hazara arc in Northern Pakistan: decollement vs. basement faulting. In: Geodynamics of Pakistan (A. Farah & K.A. DeJong, eds.) Geol. Surv. North Pakistan. J. Metam. Geol. 7, 111-125.

9. Fineti et al., (1979), The Pakistani segment of the DSS-profile Nanga Parbat – Karakul (1974-1975). Boll. Geofis. Teorica ed Applicata, 21: 159-169

10. Tahirkheli and Jan, (1979), A preliminary geological map of Kohistan and the adjoining areas, N. Pakistan. Geol. Bull. Univ. Peshawar, 11.

11. Coward et al., (1986), Collision Tectonics in the NW Himalayas. In Coward, M.P. & Rie, A.C. (eds.), Collision Tectonics, Geol. Soc. Lond. Spec. Publ. 19:203-219.

12. Khan et al., (1993), Evolution of the lower arc crust in Kohistan, N. Pakistan: temporal arc magmatism through early, mature and intra-arc rift stages. In: Himalayan Tectonics (P.J. Treloar and M.P. Searle, eds.).

13. Treloar et al., (1990), Cooling and uplift histories of the crystalline stack of Indian plate internal zones west of Nanga Parbat, Pakistan Himalaya, Tectonophysics, 180, 323-349.

14. Desio, (1979), Geologic evolution of the Karakoram, Geodynamics of Pakistan, Farah and DeJong Ed. Geological Survey of Pakistan.

15. Desio (1964), Tectonic relationship between the Karakoram, Pamir and Hindu Kush (Central Asia), 1964, in: Int. Geol. Congr. Rep, 22nd session, New Dehli Part II, p. 192-213.

16. Zanettin (1964), Geology of the Haramosh-Mango Gusor area: Desio`s Italian expeditions to the Karakoram and Hindu Kush, Scient. Rep. Vol 3 Brill. Leiden.

17. Stauffer (1975), Reconnaissance geology of the central Mastuj Valley, Chitral State, Pakistan. U.S. Geol. Surv. Open file rept. 75-556: 51 p

18. Gamerith (1982), Geologische Karta von Gilgit/Chitral/Whakhan (North Pakistan and Ost Afghanistan) 1:250,000. Private edition, Graz.

19. Calkins et al. (1981), Geology and mineral resources of the Chitral-Partsan area, Hindu Kush Range, northern Pakistan. U.S. Geol. Surv., Prof. Pap. 716-G, G1-G33.

20. Pudsey et al. (1985), Collision zone between the Kohistan arc and the Asian plate in NW Pakistan, Transactions of the Royal Society of Edinburgh: Earth Sciences, 76, 463-479.

21. Leake et al. (1989) Origin and tectonic of the Stratabound tungsten mineralization within the HinduKush of Pakistan. Geol. Soc. Lond., 146: 1003-1016.

22. Searle (1991) Geology and tectonics of the Karakoram Mountains. Chichester, Wiley.

23. Desio, (1963), Review of the Geological formations of the western Karakoram, Riv. Ital. Pal. Strat., Volume 69, 475-501.

24. Gaetani et al., (1990), The North Karakoram side of the Central Asia geopuzzle. Geol. Soc. Am. Bull., 102,54-62.

25. Zanchi, (1993), Structural evolution of the North Karakoram cover, Pakistan. In: Treloar, P.J. & Searle, M.P. (eds.) Himalayan Tectonics. Geol. Soc. Lond., Spec. Publ. 74: 21-38.

26. Gaetani et al., (1995), Permian stratigraphy in the northern Karakoram Pakistan. Riv. Ital. Pal. Strat, 101(2): 107-152.

27. Le Fort et al., (1994), Discovery of a crystalline basement and Early Ordovician marine transgression in the Karakoram Mountain range, Pakistan. Geology, 22: 941-944.

28. Tongiorgi et al., (1994), Palynological dating (Arenig) of the sedimentary sequence overlying the Ishkarwaz granite (upper Yarkhun valley, Chitral, Pakistan) Terra Nova, 6: 595-607.

29. Talent et al., (1979), Paleozoic-Mesozoic Biostratigraphy of Pakistan in relation to Biogeography and the Coalescence of Asia, Geodynamics of Pakistan, Farah and DeJong Ed. Geological Survey of Pakistan.

30. Kazmi & Qasim Jan (1997), Geology and Tectonics of Pakistan.

31. Tahirkheli, (1982). Geology of the Himalaya, Karakoram and Hindu Kush in Pakistan. Geol. Bull. Univ. Peshawar, 15: 1-51.

32. Oldham, (1893), A catalogue of Indian Earthquakes, Mem. Geol. Survey India, Vol. 19.

33. Heukroth and Karim, (1970), Earthquake history, seismicity and tectonics of the regions of Afghanistan, Seism. Centre, Kabul University.

34. Ambraseys et al., (1975), The Patan Earthquake of 28 December 1974, UNESCO Publication.

35. Quittmeyer and Jacob, (1979), Historical and modern seismicity of Pakistan, Afghanistan, northwestern India and southeastern Iran; Bull. Siesm. Soc. Am. Vol. 69, No. 3.

36. Roecker, (1982), Velocity structure of the Pamir-Hindu Kush region: possible evidence of subducted crust. J. Geophys. Res. 87:945-959.

37. Pegler, (1995), Studies in seismotectonics. Ph.D. thesis, Oxford University.

38. Pegler and Das, (1998), An enhanced image of the Pamir-Hindu Kush seismic zone from relocated earthquake hypocentres. Geophys. J. Intl. 134:573-595.

39. Pavlis T. and Das S., (2000), The Pamir-Hindukush Seismic Zone as a strain marker for flow in the upper mantle, Tectonics, 19, 103-115.

40. Searle et al., (1998), Transpressional tectonics along the Karakoram Fault zone, northern Ladakh: constraints on Tibetan extrusion. In Holsworth, R.E.; Strachan, R.A.; and Dewey, J. F., Eds. Continental transpressional and transtensional tectonics. Goel. Soc. Lond. Spec. Publ. 135:307-326.

41. Scordilis, E. M. (2006), Empirical global relation converting M_S and m_b to moment magnitude, Journal of Seismology, Vol. 10.

42. Ambraseys, N., Bommer, J. (1990); Uniform magnitude re-evaluation for the strong-motion database of Europe and adjacent areas, European Earthquake Engg, Vol. IV.

43. Ambraseys N., and Bilham R (2003).; Earthquakes in Afghanistan, Seismological Research Letters, Vol. 74, No.2.

44. Gardner J. K. and Knopoff L. (1974); Is the sequence of earthquakes in southern California, with aftershocks removed, Poissonian?, Bulletin Seismological Society of America, Vol. 64, No. 5.

45. Woessner J. and S. Weimer (2005); Assessing the quality of earthquake catalogue: Estimating the magnitude of completeness and its uncertainty, Bulletin Seismological Society of America, Vol. 95 No.2.

46. Cornell C. A. (1968); Engineering seismic risk analysis, Bull. Seism. Soc. Am., Vol. 58, No.5.

47. Abrahamson N.A. and W. Silva (2008); Summary of Abrahamson and Silva NGA Ground-Motion relations, Earthquake Spectra, Vol. 24 No.1.

48. Boore, D.M. and G.M. Atkinson (2008); Ground-motion prediction equations for the average horizontal component of PGA, PGV and 5%-damped PSA at spectral period between 0.1s and 10s, Earthquake Spectra, Vol. 24 No. 1.

49. Campbell K.W. and Y. Bozorgnia (2008); NGA ground motion model for the geometric mean horizontal component of PGA, PGV, PGD and 5%-damped

linear elastic response spectra at periods ranging from 0.1s to 10.0s, Earthquake Spectra, Vol. 24 No. 1.

50. Youngs R. R., Chiou S. J., Silva W. J., Humphrey J. R., (1997); Strong ground motion attenuation relationships for subduction zone earthquakes, Seismological Research Letters, Vol. 68, No. 1.

CHAPTER - 9

ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

Chapter: 9

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

9.1. Introduction

The Environmental and Social Assessment (ESIA) is undertaken as part of the overall feasibility study of Turtonas-Uzghor Hydroelectric Power Project. The ESIA has been accomplished through studies into specific issues such as terrestrial and aquatic ecology, socio-economic and cultural environment, access provisions and resettlement requirement. The ESIA of the proposed project covers natural environment and anthropogenic influences, their interaction and how their relationship is likely to change as a result of construction and operation of the Turtonas-Uzghor Hydroelectric Power Project. A detailed ESIA report has been prepared for the project (see Appendix E). The objectives of the ESIA are to:

- Assess the existing environmental and social conditions of the area where project is located including the identification and information of environmentally sensitive areas;
- Assess the proposed activities, identify and evaluate the potential impacts and determine their significance; and
- Propose appropriate mitigation measures that can be incorporated into the proposed activities to minimize any adverse impacts, ensure that impacts are acceptable and to propose appropriate monitoring requirements.
- Additional environmental enhancement are also to be considered and potential benefits of the project are to be maximized by appropriate planning and implementation.

The methodology used for the ESIA follows standard international best practices including scoping environmental checklist and comparative matrix. The reporting follows the standards structure of Pakistan regulatory authorities and international funding agency such as IFC.

9.2. Environmental and Social Policy and Legal Framework

Chapter 2 of the ESIA report describe in detail the legal requirements and institutional framework required for environmental and social assessment in both Pakistan and Internationally. The Turtonas-Uzghor Hydroelectric Power Project falls in category A as specified by the IFC and Pak-EPA "Policy and Procedures for filing, Review and Approval of Environmental Assessment", 2000, which deals with projects where the range of environmental issues is comparatively broad, and with those that could have adverse environmental impacts. Extensive analysis in the form of detailed Environmental Impact Assessment (EIA) is required for hydropower electric generation above 50 MW in form of an EIA report submission.

9.3. Description of Nature, Size and Location of the Project

Turtonas-Uzghor Hydroelectric Power Project (the "Project") is located on Golen Gol Nullah, a tributary of Mastuj River in Chitral, Khyber Pakhtunkhwa (KPK) Province. The project shall have a provisional capacity of 82.25 MW and will generate about 382.33

GWh of energy annually. Chapter 3 of the ESIA reports describes in detail its location and salient features.

9.4. Consideration of Project Alternatives

Various alternatives were considered during the study from no project option to alternate power generation and project location which provide their environmental and social benefits.

EIA has considered the consequences of not building the project in wider strategic planning alternatives. Pakistan is suffering from worse power and energy crisis, which is primarily caused by the increasing gap between the supply and the demand of electricity. Energy crisis is also considered a major development hurdle in Pakistan and which resulted in the energy policy formulation by the government. Shortage of power has resulted in unpredictable long load shedding for households, commercial activities and industries. This load shedding has affected the quality of life and prolonged hours of load shedding up to 8 hours a day in summer caused social unrest. It has caused serious impacts on the commercial activities and industrial growth thereby resulting in fall of economy in the country. No Project Option is unrealistic, rather country need to construct more power plants to fill in the demand and supply gap. Progressive power generation will minimize generation cost of fuel-based power plants and boost the economy.

Another alternative considered was the generation of electricity by non-renewable energy sources such as nuclear and thermal power generation. Radioactive waste of nuclear power generation and emissions of pollutants from fossil fuel burning are very damaging to the environment and also unsustainable. Well managed hydropower is environmentally least damaging and most sustainable power generation than other sources.

Five (5) alternative locations for diversion weir were identified and designated as W1, W2, W3, W4 and W5, while five (5) locations for powerhouse were identified and marked on GT Sheet. Two locations for powerhouse were on right bank of GolenGol while three locations were along left bank of GolenGol. All identified powerhouse locations envisage underground powerhouse, except one location along the left bank near Uzghor, which is open standalone.

9.5. Baseline Environmental Conditions

The baseline environmental conditions in the project area are given in detail in Chapter 5 covering physical environment, ecological resources and socio-economic and cultural environment. The moon soon hardly penetrates into the project area and main mechanism for producing rain is western disturbances. Chitral like other areas in KPK receives only 476 mm precipitation per year, of which 75% occurs in winter and spring. Average monthly precipitation ranges from about 6mm in June and July to more than 100mm in March. Winter snow fall in the town can be quite heavy with an accumulation of up to two feet being quite common; at higher elevations snowfall can reach as high as 20 meters. Loss of land through erosion by rivers, landslides and flash floods is common throughout the district because of which considerable areas go out of use every year.

The vegetal cover in the area is thin. This results in a rise in suspended particulate matter (SPM) during high winds or major traffic movement which is of temporary nature. During blasting, transportation of construction material and heavy equipment, dust levels are expected to rise in the project area. The large particles of dust will deposit in the adjoining areas and smaller particles will remain suspended in the air causing air pollution in the surrounding areas. The area is already prone to high dust levels due to thin vegetation cover and limited annual precipitation.

Water is one of the most important natural resource of the project area. Most of the socio-economic activities of the area are connected with the availability of adequate quantity and good quality of water from various springs and nullahs. The quality of river water monitored with high pH value which is not good for drinking purpose.

Chitral is highly regarded for its treasure of Fauna as well. Some endangered, near threatened and vulnerable species of the world and national conservation i.e., Snow Leopard (*Panthera uncial*), Gray Wolf (*Canis lupus*), Red Fox (*Vulpes vulpes*), Jackal (*Canisaureus*), and Markhor (*Capra falconeri*) are found in the project area. Neither of these is in 1km range of project but their protection and conservation has been considered in the mitigation process. KPK wildlife has prohibited the hunting and pouching of all these species without the permit. Among birds the hunting of the Chukar (Alectorischukar),Koklass Pheasant (Pucrasiamacrolopha), and Golden Eagle (Aquila chrysaetos) is restricted and hunting permit of PKR 2000 per year is required.

As part of the public consultation work for the EIA the existing needs of the local people have been considered, irrespective of the mitigation measures that may be required for any predicted adverse impacts that may be caused by project construction and operation. These include provision of sanitation, electricity and road access. Another key issue is very low household income which is needed to provide appropriate opportunities to address this issue.

9.6. Impact Identification and Mitigation Measures

ESIA process has identified main positive and adverse impacts that will be generated by the construction of Turtonas-Uzghor Hydroelectric Project. The identified impacts and their relative mitigation measures are described in detail in chapter 6 of ESIA.

The main positive impact is the generation of 82.25 MW of energy in an environmentally sound and sustainable manner without the consumptive use of water of Golen Gol. Availability of power would reduce consumption of fuel wood and other fossil fuels by villagers for cooking, heating and other domestic purposes thus will conserve the resources. This is the least environmentally damaging electricity production option in the country alternative to nuclear or thermal power generation by fossil fuel burning.

The project will provide jobs to the locals both in the skilled and unskilled categories during the construction phase of the project. This project will boost financial position of the locals who have to travel to various parts of the country for employment.

The Physiographic and landform of Turtonas and Uzghor sites will change gradually during pre-construction and construction stage. During pre-construction changes will be moderate to minimum only. To minimize these impacts, a landscape and plantation plan will be prepared and implemented by the Contractor. This will reduce the significance of the impacts to minimal level.

The main adverse impact centre on the need to permanently acquire 52.7 acres of land for project components and facilities. No resettlement and relocation of facilities issues are associated with the project. About 79 trees and plants will be cut to clear land for project staff colony construction. This damage will be mitigating with tree plantation especially fuel wood and fruit trees on river banks and camp area after construction. A tree planting program and its mitigating cost is given in the chapter.

Construction activities will increase large influx of workers, technicians, suppliers, businessmen, engineers and inspectors. This increasing population will exert pressure on the local environment by increasing noise, disturbances, hunting, poaching and trapping of wild fauna. To avoid pressure on local environment, contractor will maintain liaison with the concerning Wildlife Protection Department and local community to protect the wildlife and forest in the area. Tree cutting, hunting, poaching/catching of wildlife by the workers will not be allowed and public education program and worker awareness program about wildlife protection and conservation will be devised and implemented.

9.7. Environmental and Social Management and Monitoring Plan

The basic objective of the ESMP is to manage adverse impacts of project interventions in a way, which minimizes the adverse impact on the environment and people of the Project area. The specific objectives of the ESMP are to:

- Facilitate the implementation of the mitigation measures identified during the present ESIA.
- Maximize potential project benefits and control negative impacts;
- Draw responsibilities for project proponent, contractors, consultants, and other members of the Project team for the environmental and social management of the Project;
- Describe a monitoring mechanism and recognize monitoring parameters to ensure the complete implementation and effectiveness of all mitigation measures;
- Maintain and preserve biodiversity and where possible restoring degraded natural resources; and
- Assess environmental training requirements for different stakeholders at various levels.

The ESMP will be managed through a number of tasks and activities and site specific management plans. One purpose of the ESMP is to record the procedure and methodology for management of mitigation identified for each negative impacts of the Project. The management will clearly delineate the responsibility of various participants and stakeholders involved in planning, implementation and operation of the Project. An ESMP has been prepared for the project in Chapter 7 of ESIA.

9.8. Emergency Preparedness and Response

Emergency preparedness and response procedures provide measures and guidance for establishment and implementation of emergency preparedness plan. The aim of emergency response procedures is to:

- Ensure all personnel, visitors and communities to the project site are given maximum protection from unforeseen events.
- Ensure all personnel are aware of the importance of this procedure to protection of life and property.

9.9. Stakeholder Engagement

Extensive consultations were carried out at an early stage primarily through community consultations and stakeholder meetings. Community consultations involved household level interviews/survey, community meetings and focus group discussions. This step is done to improve project design, planning and implementation and ensuring that the project is both environmentally and socially viable. Objectives of consultation process are to:

- Disseminate the information about project to the community and all other stakeholders
- Analyze the local people's issues at an early stage and give consideration to resolve or mitigate the issues
- Encourage and promote participation of local community, different government stakeholders and elected representatives of local area to play their part, express their views and acquire suggestions to mitigate any anticipated impacts
- Socially prepare the community with confidence and capacity to deal with displacement, environmental and resettlement management.

Grievance Redress mechanism will be established to allow affected persons or communities appealing against any decision or activity arising out of survey, data collection, environmental and social impacts and land acquisition related grievances.

9.10. Monitoring and Review

The monitoring program has a dual purpose. It is designed

(i) to monitor the contractor's work during project implementation in order to check contractual compliance with specified mitigation measures, and subsequently
(ii) To monitor and assess the changes in environmental and social parameters of the project over the years following completion of the various project components.

Project mitigation cost and monitoring costs has measures and given in chapter 11 of ESIA.

9.11. Conclusions

The major conclusions of the ESIA are;

- During the Project implementation, environmental and social impacts are experienced primarily during the construction phase. The operation phase will have mostly insignificant impacts on the social, physical and biological environment of the area. This has been confirmed during field surveys for the environmental and social assessment as part of this report.
- The potential impacts during the construction phase of the project include land acquisition (resulting in loss of land and trees), soil erosion, water pollution, effect on ambient air quality caused by vehicle exhaust and kicked-up dust,

noise pollution, safety hazards and public health concerns for the nearby communities.

- The key environmental issues during the operation phase of the project include downstream flow variations, waste disposal, safety hazards for the plant staff.
- All the recommended mitigation measures are contained in the Environmental and Social Management and Monitoring Plan (ESMMP), which will need to be made part of the EPC Contract. The plan provides for the requisite structure of the organization during the project implementation, defining roles and responsibilities of key players. The plan defines the mitigation actions, and monitoring agencies.
- There are no resettlement issues involve during the implementation of the Project.
- The proposed mitigation measures adequately address all the concerns raised by the stakeholders.
- The project is unlikely to cause any significant, lasting impact on the social, physical and biological environment of the area.
- The overall findings of the environmental impact assessment and resettlement plan shows that the project is environmentally and socially viable provided that the proposed activities are carried out as mentioned in this report, and the mitigation measures are completely and effectively implemented.

9.12. Recommendations

On the basis of the environmental and social impact assessment and the conclusions as discussed above it is recommended that:

- The Environmental and Social Management Plan should be made a part of the EPC Contract awarded by the Company for implementation of the project.
- The Company should ensure adherence to the environmental legislation and regulations.
- Company and its contractor(s) should employ local labour as for as possible.

CHAPTER - 10

DESIGN CRITERIA FOR CIVIL AND E&M COMPONENTS

Chapter: 10

DESIGN CRITERIA FOR CIVIL AND E&M WORKS

10.1. Introduction

The availability of perennial flow, appropriate hydraulic head and favorable topographic and geological conditions offer opportunities for the development of hydropower projects. The province of Khyber Pakhtunkhwa ("KPK") and more specifically the district of Chitral is abundantly blessed with a number of sites which are identified to offer viable and feasible prospects of small, medium and large hydroelectric power projects. Most of the small and medium hydroelectric power projects are concentrated in tributaries of main rivers.

The layout of projects generally comprises of flow diversion structure / weir, intake, approach channel, de-silting chamber, headrace tunnel, pressure shaft / tunnel / penstock pipe, surge chamber, powerhouse, tailrace tunnel / channel and the access roads, etc. These structures need to be designed and constructed for optimal performance under the prescribed / required technical specifications.

This report, therefore, provides the technical basis for setting out the specifications and works out the hydraulic and structural designs of the entire civil works as well as works related to equipment & machinery of Turtonas-Uzghor Hydro Electric Power Project (the "Project") located along Golen Gol, Chitral. In other part of report we will use TUHEPP as name of the **TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT** being briefly.

10.2. Design Criteria for Civil Components

10.2.1. Topographic and Hydrographic Survey

Topographic and hydrographical surveying was carried out for preparing basic site plan and contour mapping of the project area. Mapping was used for project planning, quantity estimates, construction cost estimates and preparation of concept design documents for the Turtonas-Uzghor Hydro Electric power project. River cross sectional surveying was carried out to record the bed level and water depth in the Golen Gol. The detail design Criteria for Topographic and hydrographic survey is attached in **Appendix-F.1.** It is recommended that EPC Contractor after having site possession will established permanent bench marks will be used during construction for setting out of structures level and location. The survey levels should be tied with levels of diversion weir of Golen Gol HPP being operated by WAPDA.

10.2.2. Hydrology

10.2.2.1. General

Hydrological parameters include description climatological conditions, mean monthly flows, local canal flows estimation and sedimentation conditions at Turtonas-Uzghor HEPP. Following studies and activities for the TUHEPP was carried out.

10.2.2.2. Methodology

- Collection and evaluation of all available climatological, hydrological and sedimentation data necessary for implementation of the Project.
- Reconnaissance of the project area for collection of necessary data in relation to flow distribution from Babuka bridge to Uzghor proposed weir.
- Estimation of hydrological design parameters for various components of the project.
- Estimation of available flows, and sediment flow rate at proposed site.

10.2.2.3. Criteria

- Mean, Minimum and Maximum monthly and yearly rainfall, humidity, sun shine, wind speed and temperature is calculated.
- Recorded daily discharge data is updated, processed and used for the estimation of flows at proposed site.
- Flow duration curve based on daily updated and processed flow data is computed for minimum, mean and maximum availability.
- Flow is processed for flow hydrograph also.
- Sediment samples will be tested for quality and gradation to estimate its effect on Turbines, etc.
- Sediment transport and its deposition at structure site
- Downstream Rating curves were developed based on updated and proceed daily flow data and river cross-section at powerhouse and weir site.

10.2.2.4. Way Forward

The processed data presented in the report is reliable and was used for hydraulic design and power and energy estimation. It is recommended that after signing of contract agreement, the EPC Contractor shall collect the additional data in respect of climate, hydrology and sediment and update for further processing. The EPC Contractor shall process the data for verification and approval of design flow and floods, before entering in to level-1 design. EPC Contractor must collect the sediment samples and analysis for gradation and mineralogy for handing over this data to turbine manufacturers.

10.2.3. Geotechnical Design Aspects

10.2.3.1. Introduction

Powerhouse and weir and their appurtenant structures are the main structural components in the proposed Project. Geotechnical investigations at the selected sites was carried out to get the idea about behavior of foundation soils for the purpose of design. Foundations of the structures will be designed to resist dead loads and live loads including erection loads during construction, earthquake, wind, temperature effects, hydraulic loads, hydrostatic load and earth pressures plus any permanent superimposed loads, etc. Detail is attached as **Appendix-F.1 CIVIL DESIGN CRITERIA.**

10.2.3.2. Weir Sub-Surface Flow

10.2.3.2.1. Introduction

Excessive hydrostatic head across a regulating structure develops seepage of water through the underlying sub-soil. The seepage water causes uplift pressures underneath the structure.

The uplift pressure under a structure will be determined under steady seepage by Khosla's Theory. The percentage pressure of key points can be computed using Khosla's curves. For complex profile of the structure, the correction floor thickness and mutual interference of piles is required.

10.2.3.2.2. End Cut - Offs

Steel sheet piles or stone wall or slurry trenches as cut-offs at both ends (Upstream and downstream) are necessary to prevent failure of structure by slipping of soil due to the scour holes, etc.

10.2.3.2.3. Design Against Seepage or Piping

Seepage force is generated by the flow of water through the sub-soil of a structure and it acts on the soil particles. If the seepage force is too large at the exit gradient of the flow line, it may remove the soil particles in that region. The Khosla's theory of exit gradient is used for determination of measures to prevent piping underneath the structure. Detail of coefficient of creep length and exit gradient is attached in **Appendix-F.1.**

10.2.3.3. Weir Surface Flow

10.2.3.3.1. Introduction

In case of surface flow, the design of piers, abutments, concrete apron, block apron, inverted filter, etc. become component for design for geo-technical conditions.

10.2.3.3.2. Abutments

The abutments for the spillway will be designed as concrete retaining walls with cantilevers. The front face of the wall is provided with a small batter to allow for any small differential settlement of the base owing to earth pressure behind the wall. The earth pressures, structure stability against overturning and sliding will be calculated using conventional methods.

10.2.3.3.3. Stone Aprons

Flexible stone aprons will be provided upstream and downstream of a spill structures as protection to local scour. For determining the maximum local scour, the traditional subcontinent methods covering mainly "the regime" approach will be used and results will be checked and compared with USBR and other developed methods. The stone size/weight will be determined by using USBR curve for velocity versus stone size at the average velocity for the maximum design discharge intensity. Weight of the stone will be taken as 165 lbs/ft^2. Further detail design criteria is attached as **Appendix-F.1**

10.2.3.3.4. Slopes Protection

The stone protection for bank slopes will be designed against transverse forces due to the velocity and turbulence from flow current action. For all type of banks slope the stone size gradation of 18 kg (40 lbs) to 113 kg (250 lbs) will be used. The stone material will be composed of angular quarried stone eighty (80) percent of which by weight are equal and larger than W_{50}. The remaining twenty (20) percent quantity will be lighter rock (W_{15} to W_{30}) to fill the larger voids between larger stones. Further detail design detail is attached as **Appendix-F.1.**

10.2.4. Hydraulic Design Criteria

10.2.4.1. Hydraulic Units

The dimensions and units of properties used in solving hydraulic problems are expressed in three fundamental quantities of Mass (M), Length (L), and time (T). All analyses and designs will be carried out in the Foot- Pound-Second system of units and conversion in S.I Units will be made only of important results as necessary.

10.2.4.2. Design Flood

Design floods are defined for the following purposes and structures:

a) Weir – Spillway	Design Flood	(Pearson Type-III, Logarithmic Pearson Type III, Log Normal, Gumbel)
	Safety Check Flood	(according to Kolmogorov Smirnov, Anderson Darling, Chi-squared)
b) Powerhouse	Design Flood	(Pearson Type-III, Logarithmic Pearson Type III, Log Normal, Gumbel)
	Safety Check Flood	(according to Kolmogorov Smirnov, Anderson Darling, Chi-squared)

10.2.4.3. Design of Spillway Structure

According to ASCE design guide lines the shape of the spillway ogee can be defined for a design head less than the maximum head H_0. Selection of the design head shall account for a possible additional head of up to 30 % in case of the Safety Check Flood.

The design of the spillway downstream of the crest shall comply with international standards such as e.g. ASCE (Design of Small Dams). The thickness of retaining walls shall be selected to safely transfer forces in the main weir body and to the Foundation.

Weir will be free over flow ogee type, crest will be the maximum operation level excess water will pass over through the weir. Due to this type of weir head losses will be minimum.

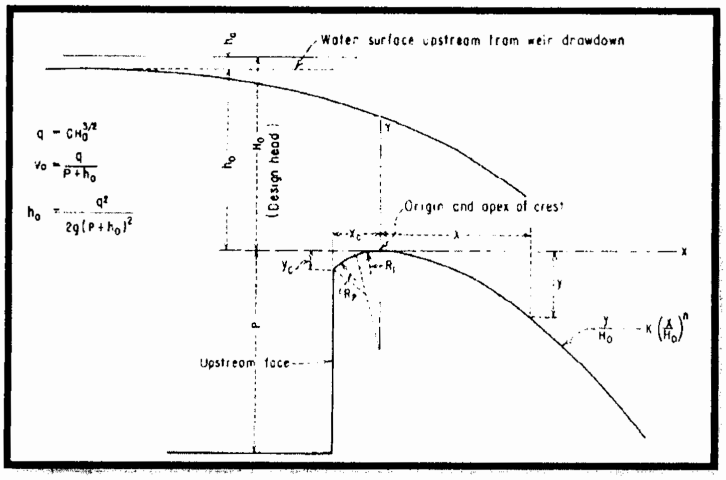


Figure 10.1. Design Chart for Spillway Ogee

The ogee crest structure is designed applying WES standard profile as defined by the Hydraulic Design Charts by USACE for the equation downstream of the crest axis.

$$\frac{Y}{H_d} = K\left(\frac{X}{H_d}\right)^n$$

Where,

X	=	horizontal distance in downstream direction
Y	=	vertical distance from crest level
H_d	=	Spillway Design Head
K_n	=	Factors defining the nappe-shape of crest
K	=	Variable depending upon upstream slope, 0.5
n	=	Variable depending upon upstream slope,

By putting the variables in above equation; $X^{1.835} = 2.0 \times H_d^{0.835} \times Y$

For the design of the spillway/weir crest structure and calculation of the discharge capacity the following effect shall be taken adequately into account:

- Effect of head on over all coefficient and hydraulic effective width
- Effect of abutment on hydraulic effective width

The spillway discharge capacity is calculated applying the following standard formula:

$$Q = CB'\sqrt{2gH_e^{3}}$$

Where,

C	=	Discharge coefficient
B'	=	Effective width

H_e = Head over the crest

The effect of piers and abutments on the hydraulically effective crest width and thus on the spillway discharge capacity is estimated using the following relationship:

$$B' = B - 2(n \times k_p + k_a) \times H_e$$

Where,

Where,	B/	=	Effective width
	B	=	Clear waterway width
	n	=	Number of piers
	k_p	=	Pier contraction coefficient
	k_a	=	Abutment contraction coefficient
	H_e	=	Head above crest level

10.2.4.4. Design of Stilling Basin

The river bed of Golen Gol River consists of large scale boulders. From the geotechnical field investigations it is came into knowledge that the thickness of alluvial material is exceed than 20 m in the riverbed, a stilling basin shall be arranged accordingly. The stilling basin is to be designed to dissipate largely the hydraulic energy generated by the drop of flow from the spillway crest and thus avoid excessive riverbed and bank erosion downstream of the weir structure.

To ensure that the hydraulic jump is maintained within the stilling basin for the entire range of river discharges the end sill is selected.

The length of the stilling basin shall be designed according to common design approaches such as that reported by USBR". Accordingly the minimum length of the stilling basin is 5 times the difference of the conjugated depth:

$$LSB = 5 \times (h_2req - h_1)$$

Where,

LSB = Length of stilling basin

h1 = Conjugated depth at begin of hydraulic jump

h2 = Conjugated depth at end of hydraulic jump

10.2.4.5. Design of Power Intake

Selection of type and size of power intake totally depend upon its intake conditions. In case of reservoir, the power intake would be submerged and air cannot be allowed. In case of lateral intake with ungated weir, the type and design of power intake totally depend upon flows behaviour in the river. The intake should be such that it will be capable to draw discharge in case of low flows in the river and will not draw more discharge during high flow.

10.2.4.6. Design of Undersluice

Undersluice is necessary part of diversion weir with lateral intake. The main purpose of the undersluice is to act as gravel trap in front of power intake and help in flushing of deposited sediment when flushing is required. The bed level of the undersluice shall be kept less than the power intake invert level so that gravels shall not enter in to power intake. Estimation of difference in level depend upon quantity of gravel in motion during high flows in the river under consideration.

The size (width) of the undersluice is always fixed in such a way that velocity in front of power intake shall be less than 1 m/s. The undersluice shall be equipped with gate/gates which will be used for flushing of gravel before deposition level reaches power intake invert level. The downstream of the undersluice shall be concrete lined with 10% slope so that flushed sediment shall not deposit.

Lateral intake with fixed weir shall be orifice type. To make intake orifice, the invert level of breast wall shall be the level of weir crest. Further, in order to reduce the head loss in the trash rack in front of power intake, the flow velocity shall be less than 1 m^3/s

10.2.4.7. Hydraulic Design of Sedimentation Basin

Sedimentation Basin is required if the river flow contains high concentrations of suspended sediment which may cause severe damage to the turbine runners.

For the design of a sand trap the following criteria have to be considered.

Design Grain Diameter: Critical Sediment Grain Size,

Grain size to be removed to 95 per cent or more

- Head 20 - 50 m D = 0.30 mm
- Head 50 - 100 m D = 0.25 mm
- Head 100 - 300 m D = 0.20 mm

Further detail design criteria is attached as **Appendix-F.1.**

10.2.4.8. Headrace Tunnel

Headrace tunnel will be considered as a low pressure tunnel. Invert of the headrace will be concrete lined whereas, wall and crown will be the shotcreted. Head losses will be calculated by the Darcy's- weisbach formula as listed above in head loss section. Thickness of the shotcrete must be quite enough to retain the loose fragments of the rock. Further detail design criteria is attached as **Appendix-F.1**

10.2.4.9. Hydraulic Surge Tank Design

Surge tanks are required in order to facilitate governing and fast start up of turbines fed by pressure tunnel/shaft. A first general criterion to conclude the necessity of a surge tank is:

$$T_w = \frac{L\,.v}{g\,.H} > 3.0s$$

Where:

Tw = starting time (if grid stabilization is required 3 s), (s)

v = flow velocity (m/s)

g = gravity acceleration constant

Different loading conditions are considered for the designing of Surge tank. Further detail design criteria is attached as **Appendix-F.1.**

10.2.4.10. Pressure Shaft and Pressure Tunnel

After the tunnel, there is transition and the tunnel adopts a circular shape. Thereafter, the headrace tunnel follow the same route until reach the vertical pressure shaft.

If a large diameter is adopted for pressure tunnels and shafts, power generation will be bigger due to lower head loss. However, this involves a high construction cost. The examination of economic diameter is based on the plant discharge, length of pressure tunnel, project life and economic energy value. The Economic flow velocity is 4 m/s in penstock.

10.2.5. Structural Design Criteria

10.2.5.1. General

All structures will be designed in accordance with the following applicable design standards and Codes of Practice. It will be made clear at the commencement of calculations for each structure, which standards are being adopted.

10.2.5.2. Material Strengths

The following grades of concrete and reinforcement given in **Table: 10.1** below will be considered in designing concrete structures.

Table: 10.1 Different Grads of Concrete and Reinforcement

Type of structure	6-inch dia. Cylinder strength at 28 days	Steel reinforcement
Powerhouse structure	27.6 MPa (4000 Psi)	Grade 60 ASTM A615
Intake and tailrace	20.7 MPa (3000 Psi)	Grade 60 ASTM A615
Spillway crest blocks and floors	20.7 MPa (3000 Psi) with top 0.3 m layer of 27.6 MPa (4000 Psi)	Grade 60 ASTM A615
Stilling basin appurtenant Connecting canals	27.6 MPa (4000 Psi)	Grade 60 ASTM A615
Flushing section	27.6 MPa (4000 Psi)	Grade 60 ASTM A615
Road and regulation bridges	27.6 MPa (4000 Psi)	Nil

- All reinforcement steel will be deformed bars of Grade 60 and 40 having minimum yield strengths of 60,000 Psi (420 MPa) and 40,000 Psi (280 MPa) respectively as per ASTM A615.
- For gates, stop logs, hoist and other structural items including superstructures, the structural mild steel designated ASTM A36, ASTM A-242 or equivalent, will be used.
- The bricks will have a minimum crushing strength of 2,000 Psi, when tested flat.

10.2.5.3. Design Loadings

Structures will 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, snow and loads imposed during construction. Further detail is attached as **Appendix-F.1.**

10.2.6. Design Criteria for the Construction and Rehabilitation of Road

1. Construction of new road from the Power house site to the surge chamber.
2. Rehabilitation of the existing unpaved road upto the weir site.

Further detail design criteria for roads is attached as **Appendix-F.1.**

Geometric standards for Roads are given in **Table: 10.2**.

Table: 10.2 Geometric Standards for Roads

Design Features	Elements	
Design Speed	20 Km/hr	30 Km/hr
Lane Width	3.6 m x 2	3.6 m x 2
Min Radius Of Curve	19 m	29 m
Maximum Grade	10%	10%
Min Stopping Site Distance	20 m	35 m
Max. Rate of Super elevation	4%	4%
Min Length b/w horizontal curve	20 m	30 m

10.3. Mechanical Equipment Criteria

10.3.1. Design Criteria

The basic data for the layout of the mechanical turbine equipment has been developed as a result of the hydrological study and calculations performed. The results of each investigation are described in the previous chapters in detail and are not repeated in this chapter.

Those design aspects with major impact on the turbine design are:

- Weir and reservoir data;
- Flow duration curve;
- Head losses in the power waterways as function of the discharge;
- Properties of the water;
- Chemical analysis of water;
- Sediment transport and grain size distribution as function of the river discharge.

10.3.2. Selection of Turbines

The application diagram of hydraulic turbines shows that for the available net heads (marginally changing) and the variable flows, Pelton turbines are best suited, therefore selected for this project. As regards to the number and size of units; considering the transport limits and Pelton turbine operational range, two units of Pelton turbines are selected.

It is always desirable to operate the turbines with the highest possible efficiency for all ranges of flows and head. For highly variable flows, a larger number of units may permit this. However, costs of civil works and equipment increases with increasing number of units.

10.3.3. Design of Pelton-Turbine Equipment

10.3.3.1. Runner

The Pelton turbine runner with buckets shall be integrally cast and finished as one piece of stainless steel containing 13% chromium and 4% nickel and suitable for field weld repair.

10.3.3.2. Turbine Shaft

The turbine shaft shall be made of open-hearth carbon or alloy steel with integrally forged upper and lower flanges for bolting to the generator shaft and the runner respectively. The shaft shall be subject to careful heat treatment after the forging process. The shaft shall have a center hole, not less than 150 mm in diameter, bored axially throughout the entire length.

10.3.3.3. Turbine Guide Bearing

The turbine guide bearing shall be of the multi-shoe(segments) Babbitt-lined, self-aligned and self-contained lubricating type capable of operating continuously at any speed from 50% to 110% of rated speed; for 30 minutes at any speed from 110% of rated to maximum runaway speed. In addition, the bearing shall be guaranteed for correct operation during 15 minutes operation without cooling water supply and for 5 minutes without oil circulation.

10.3.3.4. Spiral Distributor/Turbine Manifold

The spiral distributor/manifold distributing the turbine flow to the six nozzles/injectors shall be designed in accordance with the ASME Boiler & Pressure Vessel Code, Section

VIII, and Division 2. It shall be welded, quenched and tempered fine grain plate steel ASTM 516 Gr. 70, Normalized or equal. The manifold shall be designed for the design pressure of 5.7MPa, assuming no support from the surrounding concrete.

10.3.3.5. Injector System

The turbine shall be equipped with six nozzles of the straight-flow type with built-in servomotors, each operated by pressure oil from the governor pressure oil unit.

10.3.3.6. Operation Requirements

The injector controls shall be designed so that the needles of all nozzles in service operate simultaneously and in equal increments. Provisions shall be made for operation with a reduced number of nozzles in the event of failure of one or more nozzles and under low load operating conditions (starting, synchronizing, etc.).

10.3.3.7. Acoustic Turbine Flow Meter

An acoustic flow meter shall be provided for each turbine to indicate flow for the site turbine efficiency tests which shall be conducted in accordance with IEC 41.

10.3.4. Turbine Governor

The Pelton turbines require double regulation of the injector and deflector arrangements. Each governor system shall be composed of a digital governor, governor actuator, pressure oil system and associated control instruments. The oil/air accumulators of the three (3) pressure oil systems shall be replenished from a common compressed air system. Alternately, nitrogen/oil accumulator of the piston type shall be considered.

The speed signals shall be obtained from a voltage transformer located on the output terminals of the generator and from a toothed wheel on the turbine shaft operating with proximity transducers.

10.3.5. Mechanical Auxiliaries

The mechanical auxiliaries consist of following sub-systems:

10.3.5.1. Lubrication oil supply system of bearings

Each turbine will be equipped with one joint oil supply system for supply of bearings. The oil will be transported with the aid of one of two electrically driven oil supply pumps, which are backed up by a high pressure start-up-pump, to supply the generator axial bearing during start-up.

10.3.5.2. Cooling water system

A cooling water system will be provided for each unit with provision of standby system to ensure uninterrupted cooling water supply to turbine-generator units, the transformers, hydraulic governors, lubrication oil system, compressors, air conditioning system and any other equipment installed, which requires cooling capacity. Cooling water to each unit shall be supplied from the common header to facilitate maintenance of the system and operation during part-load operation within the winter season.

The cooling water system shall be closed loop system with its inlet from the tail-water and heat exchanger placed in the tailrace channel.

10.3.5.3. Shaft seal water supply filter system

The water for the shaft seal will be taken from the downstream side of the cooling water filter system, passed through a fine-filter and then transferred to the shaft seal for cooling.

10.3.5.4. Drainage system

A drainage system comprising of two (2) drainage pumps together with piping, fitting, valves, floats, panels etc. shall be provided for safe operation of the system.

Each drainage pump will be assigned to collect the following liquids:

- Ground water seepage.
- Leakage of water and oil from various components.
- Water of the turbine pits, provided the dewatering system is also connected with the drainage system due to some reasons.

The leakages shall be collected through gutters and conduits of the powerhouse structure to the drainage pit/sump. In case the dewatering system is connected to the drainage system then, each turbine pit shall be equipped with a dewatering pipe and a hand-operated valve to release water from the pit towards the adjacent drainage pit/sump.

10.3.5.5. Spherical Inlet Valve

Two spherical inlet valves and expansion/dismantling pipe, one for each unit shall be installed immediately upstream of the turbines. The valves shall be operated during normal starting and stopping to isolate the turbine whenever there is shut down. The valves shall further operate as shut-off valves in case of turbine breakdown and to permit dewatering of the turbines for inspection and maintenance by means of a T-Off in the bypass.

The spherical valves 1.2 m in diameter with double seals shall be able to slide relative to their foundation plates and within the downstream dismantling sleeve to compensate axial displacements.

The spherical valves can be controlled in local mode, but shall normally be incorporated in the turbine automatic control sequence. The spherical valve rotor rotation shall be pressure oil operated independent from the governor oil system. The service seals shall be operated by pressure water.

Each spherical valve shall be equipped with a bypass line for the purpose of filling and / or balancing the water pressure of the turbine manifold before opening of the spherical valve. Powerhouse Crane

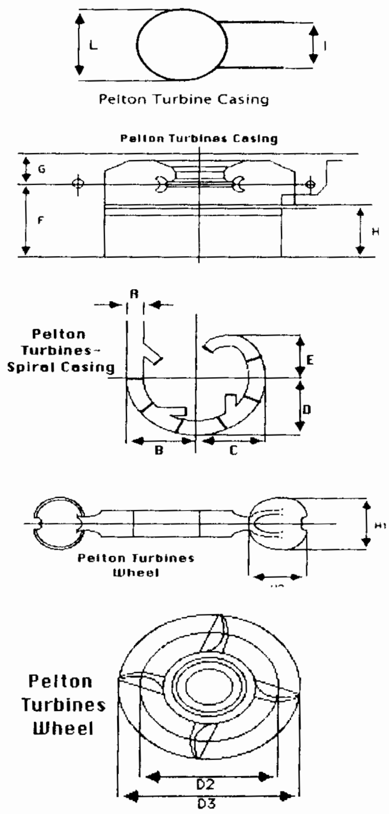
A 110/25 tons EOT powerhouse crane is determined by the generator rotor which will weigh around 95 tons. The weight of all other pieces of equipment to be handled by the main hook will be much less than 100 tons. An auxiliary hook of 25 tons capacity will be provided on the crane and will run along the main bridge beam; this will be used for handling smaller equipment and for normal maintenance work such as runner removal, etc. The proposed capacity of the crane shall be reviewed during the bidding stage when the suppliers confirm the actual weight of the generator rotor corresponding to generator inertia preliminary calculated as 392tm^2.

10.3.5.6. Balance of Plant

Detail is attached as **Appendix: F.3.**

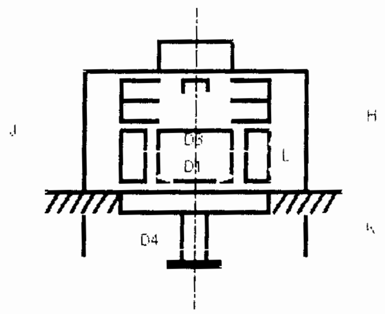
Pelton Turbine

Dj	0.16
D2	1.74
D3	2.25
H1	0.54
H2	0.48
F	4.94
G	1.04
H	3.40
HS	3.09
I	3.29
M	5.42
N	4.69
A	1.24
B	4.36
C	4.05
D	3.57
E	4.22



Generator Dimensions (500rpm)

H	5.32
J	3.70
K	2.02
L	1.21
D1	3.30
D3	4.82
D4	6.64



10.4. Design Criteria Of Electrical Equipment

10.4.1. General

This chapter describes the design criteria for the feasibility design of the electrical equipment of Turtonas-Uzghor HPP to be installed at the powerhouse and other structures. The design concept is based on the assumption to connect the 132kV transmission line of Turtonas-Uzghor HPP at the 132kV switchyard of Golen Gol, however, the scheme of power dispersal shall be finalised following the interconnection study.

Arrangements for black start and independent emergency power supply shall be made at powerhouse and weir/ power intake site. For details **Appendix: F.2**.

10.4.2. Single Line Diagram

The single line diagram of Turtonas-Uzghor either based on breaker and half scheme or double bus bar shall be finalised following completion of the interconnection study and NEPRA recommendation.

10.4.3. Main Generating Equipment

10.4.3.1. Characteristics of Generator

All windings of stator and rotor will be provided with a class "F" insulation system. As the long-term performance of the insulation system is affected by the maximum operating temperature of the windings, the rated output of the generators will be related to a temperature rise corresponding to class "B" insulation. As per IEC 60034 the permitted temperatures respectively temperature rises are (**Table: 10.3**):

Table: 10.3 Design Characteristic for Generator

Part of machine	Class B Insulation	Class F Insulation
Stator windings maximum temperature rise (measured by embedded temperature detectors ETD)	85 K	110 K
Rotor windings maximum temperature rise (measured by winding resistance)	90 K	110 K
Maximum air-inlet temperature	40 °C	40 °C

K = degree Kelvin (used for temperature differences)

The closed-cycle air-cooled generators will be equipped with air-water heat exchangers, connected to the plant cooling water system. For all load conditions maximum air temperature will be limited to 40°C.

The power and speed of the generators are dictated by the turbine, with its calculated output at the shaft coupling at design heads and design flow. Considering the respective turbine power output, a typical generator efficiency of approx. 97% and a power factor of 0.85 (which allows the generation of the necessary reactive power for voltage regulation at the 132 kV grid), the respective generator design data result in **Table: 10.4**:

Table: 10.4 Design Parameter for Generator Design

Turbine power		
P_{rated}	MW	41.125
Nominal speed	rpm	500
Rated frequency	Hz	50
Generator power		
Generator efficiency	%	97.0
nominal power factor	-	0.85
$Ps_{\_rated}$	**MVA**	**50**

The rated generator voltage will be considered with 11 kV, which is a typical standard voltage and appropriate for generators of this size.

The W41 generator bearing arrangement is suitable for vertical-shaft generators of above mentioned rated output. The combined thrust- and guide-bearing will be arranged on the upper bracket, the lower guide bearing of the generator beneath the rotor. The thrust bearing will be provided with an automatic high-pressure oil-injection, to reduce wear on the babbit-metal coated segments during start-up and shut-down of the unit.

For the dimensioning of the civil layout the following generator dimensions were estimated:

- Rotor diameter approx. 3300 mm
- Outer stator diameter approx. 4820 mm
- Weight of complete rotor approx. 95 tons

Due to the limitations of transport dimensions and weights, the stator housings will be divided and delivered in sections and the winding at the joints will be completed on site. The rotor will be assembled completely at site, including stacking of the rotor rim and fixing of the poles.

10.4.3.2. Neutral Grounding

In the case of earth-fault current flowing through the generator stator winding the current will have to be limited to a value which will not damage the winding before the protection operates.

The generator neutral will be grounded via a dry-type single-phase power transformer. The secondary winding of this transformer shall be loaded with a resistor. Detailed design of the neutral grounding will be subject to the Tender Designs stage of the Project.

10.4.3.3. Fire Protection

A water-spray fire protection system will be provided for the generators, for which provision will be made for locating the pressurized water-tank and air-compressor, and the generator pit should be provided with a suitable drainage system. The alternative of a conventional carbon dioxide gas system was considered but does not accord with modern practice and is therefore not recommended.

10.4.3.4. Excitation System

According to the state-of-art the excitation system will be of the fully static-type including digital type programmable automatic voltage regulator, thyristor rectifiers and field-suppression equipment.

The automatic voltage-regulator will be equipped with automatic and manual channels with follower allowing bump less change-over from automatic to manual control in case of fault in the automatic regulation. It will further be furnished with the necessary protection and limitation devices and with a reactive power regulator.

The excitation energy will be branched-off the generator main bus ducts through a dry-type excitation transformer.

For the initial excitation during start-up, a field-flashing equipment fed from the 400 V station supply and a back-up field-flashing from the DC system will be provided. Provision for coping with power swing in the system will be made (power system stabilizer PSS).

10.4.3.5. Generator Bus Ducts

For the connections between the generators, excitation transformers, generator circuit-breakers, unit auxiliary transformers and step-up transformers, standardized single-phase air-insulated bus ducts will be provided. This type of bus duct offers the advantage of elimination short-circuits risks and guarantees for high grade of personnel safety, since all live conductors remain inaccessible and the touchable enclosures are grounded.

The bus duct system will incorporate the required current transformers for protection and metering. The voltage transformers as well as the protective capacitors and surge arresters will be arranged in a separate fully enclosed cubicle, directly connected by tap connections to the main bus ducts.

Excitation transformer and unit auxiliary transformer (at unit No. 1 and 2) will also be installed in metal-enclosed cubicles with isolated tap connections to the main bus ducts.

Other details of the bus ducts shall be defined in the feasibility study.

10.4.4. Balance of Electrical Plant

The details of the following plant shall be finalised in the feasibility study:

- Generator Circuit Breakers Step-Up Transformers

- Step up transformers
- Unit auxiliary transformers
- Fire protection
- Switchgear and scheme of power dispersal
- 132kV XLPE cables

10.4.5. Auxiliary Electrical Equipment

The following auxiliary electrical equipment shall be finalised in the feasibility study:

- 400 V ac auxiliary power supply
- UPS systems comprising;
  - 110 V DC system
  - 24 V DC system
  - 48 V DC system(if required)
- 400 V safe AC supply
- Diesel generator set

10.4.6. Electrical Protection Systems

Detail is attached as **Appendix: F.2.**

10.4.7. Main Electrical Equipment outside the Power Cavern

Further detail is attached as **Appendix: F.2.**

10.4.8. Power Supply at Weir Site

Detail is attached as **Appendix: F.2.**

10.5. Design of Hydraulic Steel Structure Equipment

10.5.1. General

The feasibility layout and design for the Turtonas-Uzghor Hydro-electric power Project comprises of the following main components, which include hydraulic steel structure equipment:

- Concrete diversion weir structure with flushing gates of fixed wheel type
- Power intake with coarse trash rack
- Sand trap with gates at inlet and outlet
- Fine trash rack
- Power waterways
- Tailrace outlet structure

10.5.2. Design Criteria

For the feasibility design, the following hydraulic and civil design criteria have been established in coordination with the Project Sponsor: For Details refer **Appendix: F.3.**

10.5.2.1. Gates of Flushing Channel

The flushing structure is located right side of the weir in extension of the power intake structure. The two fixed wheel gates shall be operated intermittently to flush the sand and gravel which may deposit in front of the power intake into the tailrace when required. In view of the expected high sediment load during the high flow season, particular attention has to be given to a rigid and wear resistant design.

The gates shall have upstream seals (off seat arrangement) and shall close the gate opening through gravity closure against flow with adequate factors of safety against hydraulic forces and friction including a load resulting from 2 m high sediment deposition. The gates shall operate without failure or vibration under the most adverse combination of hydraulic flow and mechanical resistance due to friction, debris or other causes. The gate is designed to be opened safely under downstream water levels.

Control shall be by a rope hoisting system operating at deck. Maintenance platforms, handling equipment and dogging devices will be provided to facilitate raising and removal of the gate. All gate controls and motors shall be housed in a control building at the intake deck level. Emergency closure of the intake gate will be possible by remote control from the powerhouse and by an emergency closure control button at the intake.

Gates shall be designed, fabricated and erected in accordance with BS 5950 and DIN 19704 as applicable and equivalent standards. For Details refer **Appendix: F.3.**

10.5.2.2. Coarse Trash-rack

The coarse trash rack screen consists of 2 identical elements covering the inlet area with a clear width of 10 m and a clear height of 4.0 m each (total area of 2 x 40 m^2) each split in two segments. The frames and screen segments shall be fabricated from structural steel plates and sections which shall comply with EN 10025 or other approved and equivalent standards dealing with structural steelwork. The trash rack panels shall be supported by means of a steel beam of fish belly shape. For Details refer **Appendix: F.3.**

The design has to provide vibration-free performance and minimal head loss. A clear spacing between screen bars of 150 mm has been selected and will be re-confirmed in the detailed design in co-operation with the turbine manufacturer. The screens have vertical screen bars. The edges of the bars should be designed to prevent or suppress flow induced vibration in flow direction. The trash rack shall be designed to withstand a differential head of not less than 3 m.

Suitable differential pressure sensors will be installed to register pressure differentials across screens to waterways. The sensors shall activate an alarm, when the differential pressure reaches 0.5 m. If the differential pressure continues to rise and reaches 2 m, the sensor shall operate the fixed wheel gate closure or act otherwise to stop the flow.

10.5.2.3. Intake Fixed Wheel Gate

The intake gates located downstream of the trash rack serve as emergency closure devices in case of failures or damages of downstream structures in the sand trap or waterways, extraordinary pressure difference at the trash rack etc.

The gates shall seal upstream water passage and close through gravity against flow with adequate factors of safety against hydraulic forces and friction. The gates shall operate without failure or vibration under the most adverse combination of hydraulic flow and mechanical resistance due to friction, debris or other causes. Operation of the gates shall be by motorised rope hoisting system positioned at deck level. Temporary maintenance platforms, handling equipment and dogging devices will be provided to facilitate raising and removal of the gate. Filling of the headrace tunnel (e.g. after inspection) will be performed by opening the gates slightly. For Details refer **Appendix: F.3.**

All gate controls shall be housed in a control building at the intake deck level. Emergency closure of the intake gate will be possible by remote control from the powerhouse and by an emergency closure control button at the intake. Gates will be designed, fabricated and erected in accordance with BS 5950 and DIN 19704 as applicable.

10.5.2.4. Stop logs - Intake

To dewater the individual bays of the intake structure for maintenance of the trash-rack and the intake fixed wheel gate, stoplogs can be installed upstream of the trash-rack and immediately downstream of the fixed wheel roller gates. These stoplogs will be stored at deck level 1496 masl. Setting of these two stoplogs permits maintenance/inspection at one gate or trash-rack while flow and power plant operation may proceed via the remaining inflow sections. All stoplog elements shall have the same shape and dimensions. The stoplog elements will be installed by means of a mobile crane.

Balanced water level conditions between stoplogs and radial gate will be achieved by slightly lifting the upper stoplog element. For Details refer **Appendix: F.3.**

10.5.2.5. Main Intake Downstream Stop log

To have access to the downstream sand trap and flushing gates for maintenance purposes under any operating conditions, a stoplog will be installed. The stoplog will be stored at deck level. The stoplog elements shall have the same shape and dimension and shall be designed to withstand the pressure generated of sediment deposition of up to 2 m height. The stoplog elements will be installed by means of a mobile crane. For Details refer **Appendix: F.3.**

10.5.2.6. Sand trap Upstream and Downstream Stoplogs

The civil design provides a single headrace tunnel and a sand trap comprising of three chambers. For inspection and maintenance of each chamber stoplogs are provided upstream and downstream of the sand trap. This concept ensures inspection and maintenance of a single chamber without suspending power plant operation and emptying the entire pressure tunnel.

Two stoplogs one each on upstream and downstream of the sand trap shall be provided to isolate the sand trap and the flushing gates for inspection and maintenance.

The flushing gates shall have upstream bronze seals and close under balanced water conditions with adequate factors of safety against hydraulic forces and friction. They have to close without failure or vibration under the most adverse combination of mechanical resistance due to friction or other causes. The gate with motorised hoist will be installed in a hermetically sealed housing to prevent the chamber from flooding.

All gate controls and motors will be located on the deck. Closure of the outlet gate will be only possible by remote control from the powerhouse and by a closure control button in the gate chamber. For Details refer **Appendix: F.3.**

Gates will be designed, fabricated and erected in accordance with BS 5950 and DIN 19704 as applicable.

10.5.2.7. Fine Trash rack – Sand Trap

The fine trash rack screen consisting of 3 identical elements covering the inlet area with a clear width of 7.5 m and a clear height of 7.13 m each (total area of 3 x 53.475 m^2) each split in three segments shall be provided. The frames and screen segments shall be fabricated from structural steel plates and sections which shall comply with EN 10025 or other approved and equivalent standards dealing with structural steelwork. The trash rack panels shall be supported by means of a steel beam of fish belly shape if required.

The design has to provide vibration-free performance and minimal head loss. A clear spacing between screen bars of 60 mm has been selected and will be re-confirmed in the detailed design in co-operation with the turbine manufacturer. The screens have vertical screen bars. The edges of the bars should be designed to prevent or suppress flow induced vibration in flow direction. The trash rack shall be designed to withstand a differential head of not less than 3 m. For Details refer **Appendix: F.3.**

10.5.2.8. Pressure Shaft Steel Liner and Wye-Bifurcation

The whole pressure shaft and the pressure tunnel shall be steel lined with an internal diameter of 2.5 m starting from the bend below the surge tank and finished at Wye bifurcation.

The bifurcation will have an optimized shape to minimize head losses and an internal reinforcing structure. The splitting of bifurcation for site installation will be made depending on the size of construction and tunnel excavation. Two branches each of 1.24 m internal diameter will be site-erected and installed including the required bends to the upstream pipe of the spherical valves with nominal internal diameter of 1.24 m. The design pressure will be 57 bar. The external leakage and grout pressure shall be verified during the detailed tender design taking into consideration the latest available data at that stage. For Details refer **Appendix: F.3.**

The design method of "E. Amstutz, Schweizerische Bauzeitung No. 28, 1969" or "Buckling of circular rings and cylindrical tubes under external pressure, S. Jacobsen" will be applied. Stiffeners or anchors will be included at Tender Design stage to guarantee the required safety against buckling. The following standards may become applicable for the design of the steel liner and the wye bifurcation:

- European Standards
- DIN Standards

- American Codes, ASME, AWS, ASCE
- CECT (Recommendations for the Design, Manufacture and Erection of Steel Penstocks of Welded Construction for Hydroelectric Installations, published by the European Committee for Boiler Making and Kindred Structures)

The steel plates (stiffeners, steel liner a. s. o.) shall comply with the EN 10028-3, P355N or equivalent. Once erected the steel liner will be pressure tested with a factor of 1.5 of max. operating pressure. A corrosion allowance of 1 mm and adequate anti-corrosion protection shall be defined in the present feasibility design.

10.5.2.9. Tailrace Outlet Bulkhead Gate

The bulkhead gate located at the outlet of the tailrace, where the flow is returned to Golen River, will close the tailrace in case of an outage of the powerhouse or any maintenance works in the tailrace tunnel. For this purpose a bulkhead gate of sliding gates type is foreseen including all accessories and control cubicles, which are located in the control building integrated in the gate structure. The gate will seal to the riverside and close under gravity under balanced water conditions with adequate factors of safety against hydraulic forces and friction. Closure and opening of the gate will be possible by a mobile crane.

The gate may be slightly lifted (by a mobile crane) and a single turbine unit may be operated under partial load so that the flow is removing flushing the sediments towards the riverbed. The bulkhead gate will be designed, fabricated and erected in accordance with BS 5950 and DIN 19704 as applicable. For Details refer **Appendix: F.3.**

CHAPTER - 11

PROJECT OPTIMIZATION STUDIES

Chapter: 11

PROJECT OPTIMIZATION STUDIES

11.1. Introduction

This chapter deals with the optimization of project capacity, design discharge and numbers of turbine units. The study was based on project cost. The project capacity will vary with the variation in design discharge. Therefore, in this chapter the discharge which gives the lowest cost will be selected for further design and optimization.

Preliminary location and layout alternatives study conclude that project **Alternative: 1** and **Alternative: 2** are the best ranked among other alternatives. During ranking powerhouses for both were open and location of tailrace outlet differ and give different head. However, under this study, both Alternatives differ with each other only due to powerhouse type. Therefore, alternative: 1 has been studied under Alternative: 1-A with open powerhouse and Alternative: 1-B with cavern powerhouse. Selection of best alternative on the basis of cost is also presented in this chapter.

11.2. Alternative Layout Optimization Study

11.2.1 Introduction

Under preliminary location and layout alternatives studies (**Appendix: A**), nine (9) number different preliminary location and layout alternatives for the project have been studied considering all feasible options with regard to the placement of various hydraulic structures and the waterway leading to the powerhouse and ultimately discharging back to the river through the tailrace at required differential. The physical analysis and the ensuing cost estimates of each alternative provided a datum line to select one or two best alternatives for further engineering studies. A number of sites for diversion weir and powerhouse were identified in that report. The data in terms of width of river, length of headrace tunnel, need of sediment basin, surge chamber, pressure shaft and tunnel, powerhouse and tailrace have been recorded during office studies and checked during field visit.

A team of engineers, hydrologist, geologist and environmentalist visited the site for verification of identified layouts and locations. Width of diversion weir, location for sediment basin, location of tunnel portal, headrace tunnel, geology of these terraces has been recorded. Access to weir and powerhouse was also planned and verified during field visit.

Environmental aspect of each sites and layout was noted and made part of the layout alternatives. The possible interconnection of Turtonas-Uzghor HEPP seems to be at the Golen Gol 132kV switchyard, which is approximately 5 km toward downstream, however, it will be finalized after completion of Power System Study in collaboration with NTDC and PESCO.

Consequently, as a result of all the steps and exercises performed in preliminary location and layout alternatives study report to find the best prospective layout. **Alternate Layout No. 1** had the lowest cost per MW, less environment & social impact and technical most feasible. And furthermore, this alternative was selected and approved for the detailed study.

The opted layout was further categorized into two Layout Alternatives based on the location of powerhouse. For the prevailing topographic, hydrological and geological conditions the following powerhouse types are feasible in principal:

a. **Alternative Layout: 1-A Open Surface Powerhouse**

b. **Alternative Layout: 1-B Underground (Cavern) Powerhouse**

The Consultant studied the installed capacity, number and individual size of turbine units. As the result a powerhouse with two 2 identical Pelton turbine units with vertical axis was preferred. Therefore, for the comparison of the powerhouse types under consideration, 2 Pelton units of identical size were considered. The turbine setting might be slightly deeper in case of the underground powerhouse which would permit a minor cost saving for the electro-mechanical equipment.

11.2.2 Alternative Layout: 1-A Open Powerhouse

An open powerhouse at an elevation of 2087.9 masl, is proposed along right bank of the Golen Gol near Uzghor Village. Powerhouse will consist of a machine hall and loading and unloading bays. The machine hall will house two turbo-generator units. Loading and unloading bay is provided on one side of the machine hall.

The open powerhouse offer easy access to site and construction at powerhouse can be started at any time and may result in less construction time if compared to underground powerhouse where to get access, an access tunnel have to be constructed first. Further, open powerhouse may have merits and demerit over underground powerhouse.

A standard open powerhouse may result as the most economical solution provided sufficient space is available for construction, easily protected from flood water levels and availability of sound rock or good foundation material at reasonable depth and do not result in excessive quantities of concrete in the substructure. Of particular importance in case of free surface powerhouses in Pakistan are the aspect of slope stability in the powerhouse area and the extent of slope stabilization measures in view of frequent earthquake activities as well as security aspects in general. The slopes will be stabilized by benching and protected by shotcrete and rock bolting where required. Further, between toe of rock slope and powerhouse building, a stone wall with 1 to 1.5 m thickness and height will be constructed which will act as barrier to stones rolling down from slopes and not to hit the powerhouse wall.

11.2.3 Alternative: 1-B Cavern Powerhouse

The feasibility of a cavern type powerhouse depends largely on the prevailing geological conditions. Cost of civil works (and equipment) can be expected to be somewhat higher compared to a free surface powerhouse. Based on the Consultant's geological mapping, geophysical survey and core drilling at the powerhouse site, the geological conditions were assessed to be reasonable for an underground powerhouse with rock class B to C. An underground powerhouse requires construction of access tunnel, cable tunnels, ventilation shafts and a transformer cavern. At the selected powerhouse site, however, these tunnels can be kept short.

An underground powerhouse provides the highest level of security against earthquake and vandalism/terror. This type of powerhouse is almost good during winter season.

11.2.4 Selected / Preferred Alternative Layout

The summary of estimated quantities and costs (from HPC) for each powerhouse type are given in tabulated form below and details is attached as **Appendix F**. The comparison of costs given in **Table: 11.1** indicates that the design concept with Alternative Layout: 1-B Underground powerhouses requires higher investment costs as compared to the concept with an open powerhouse – Alternative Layout: 1-A. Based on the available knowledge of the project area, the Consultant gives preference to the open powerhouse option in view of construction cost and ease in construction.

Table 11.1: Estimated Cost for Open and Cavern Powerhouse

Type	Open Powerhouse	Cavern Powerhouse
Cost (US$)	50,651,000.00	76,973,000.00

11.3. Installed Capacity Optimization

11.3.1. Introduction

Optimization analysis with the goal to identify the most promising project configuration was performed within the scope of the Feasibility Study. Based on the discussions with PPIB and the Client, selection of the installed design discharge was based on the maximum technically and financially justifiable capacity of the plant. As a tool for ranking of the options, the levelized energy cost approach was applied for the comparison between the alternative configurations.

It has to be emphasized that the purpose of the present analysis was to identify the optimum sizing of Turtonas Uzghor Hydro Electric Power project / plant, according to the applicable approach and criteria; the optimization analyses of the individual project components are performed for the selected project configuration and will be presented in a separate chapter.

The methodology for the cost estimate and the preliminary energy production analysis are summarized below.

11.3.2. Methodology

The preliminary cost estimate is performed for the project layout, optimized and defined as described before. The dimensions (and costs) of various project components such as powerhouse, power waterway system and the generating equipment vary with the installed plant capacity (discharge), whereas others, such as the costs of the weir, spillway, transmission lines, access roads, for example, have less variation.

The cost function, consequently, might show either a continuous trend, or define the breaking point after which the increment in costs is of a greater order of magnitude than the increment in installed power/energy generation. In order to provide the basis for the assessment of the project's financial performance, the costs for the adopted project concept were preliminarily estimated. After the most promising conceptual layout is defined, the cost estimate was performed for the variety of the design/installed discharges, in order to assess the sensitivity of the cost function against the variation in design discharge.

By means of the GTZ's hydropower optimization program HPC (Hydro Power Costing) the design of the project components and the corresponding elaboration of the bill of quantities, cost estimate was performed. In order to allow for the comparison between the different considered project configurations, the same diversion weir sites and different operating regimes were considered.

This procedure was applied to design discharges in the range from 16 to 22 m^3/s, with 1 m^3/s increments.

11.3.3. Analysis

For each considered installed discharge at the Turtonas-Uzghor HEPP, the design of the project components was adjusted and a bill of quantities was established to estimate the total costs for each alternative. Estimation of costs was performed for the given set of site specific conditions such as topography, hydrology and at the present stage available geological information. The main design parameters, defined in the selected layout chapter represented the most relevant input to the preliminary cost estimate.

These are:

- Water levels (pond levels and tailwater curve)
- Discharges (powerhouse, spillway design flood)
- Access to the power plant components
- Weir: type, height, inclination of abutments, side slopes, sealing measure, assumed depth of foundation, etc.
- Spillway: type, number of gates, discharge capacity, length of chute, etc.
- Energy dissipation structure and the related geometry
- Power intake structure
- Sedimentation Basin
- Pressurized waterways (tunnels, surge shafts and pressure shafts): length, geometry, design particulars
- Powerhouse (civil works, number and type of units, hydro- and electro mechanical equipment, hydraulic steel structures)
- Tail race
- Indirect costs

For all components listed above, data collected during field visits and the conclusions derived during the previous project stage were applied; design parameters optimized in the present stage, were considered; accurate topographic maps and the high-resolution satellite photos were used; results of the performed hydrological analysis and the geological assessment were applied for the modeling. For the purpose of the evaluation of the considered conceptual layouts, certain design parameters were taken over from the performed optimization analyses, in order to rationalize the number of variables and still to retain a high level of confidence in the results.

The direct costs were estimated by multiplying the calculated quantities with the assumed unit rates for the major construction activities for each component of the project. The unit rates for civil works were derived from tender documents and feasibility studies from similar projects in the region: Jagran, Patrind, Akari Gol, Golen Gol, Lawi, Koto, etc. The corresponding rates were analyzed and escalated from the cost reference dates to the current date.

The costs for hydro- and electro-mechanical equipment and hydraulic steel structures were estimated on the basis of the extensive data from the recent bids for similar size projects. The ESIA-related costs were preliminarily estimated. The final budget for the implementation of the ESIA mitigation measures will be defined at a later stage of project development. Constant ESIA related costs were applied for all options, due to negligible influence of the variation in installed discharge. Besides the direct cost of the project, indirect costs (mobilization, contingencies - physical and price and engineering and administration costs) were estimated and added as the percentage to the direct costs of the items, due to uncertainties attributable to the preliminary design considerations applied in costing.

11.3.4. Optimization on Basis of Power Output and Annual Energy Generation

The assessment of the benefits from power generation, simulation of plant operation was carried out based on historical daily river flow data extrapolated at Turtonas-Uzghor diversion weir site by using flows records of Chitral Gauging station (1964-2015) and Mastuj Bridge Gauging Station. The power energy simulation was performed on different discharge starting from 16 m^3/s to 22 m^3/s.

Estimation of power and energy was based on daily flows available from 1964 to 2015 (**Appendix: F**). The maximum monthly power out against different plant discharges for the period 1964-2015 is presented in **Table: 11.1** while graphically in **Figure: 11.1.**

Table: 11.1 Maximum Power Output against Different Plant Discharges

Maximum Power Potential (MW) For Several discharges							
Month	22	21	20	19	18	17	16
Jan	44.6	44.6	44.6	44.6	44.6	44.6	44.6
Feb	30.4	30.4	30.4	30.4	30.4	30.4	30.4
March	29.1	29.1	29.1	29.1	29.1	29.1	29.1
April	36.1	36.1	36.1	36.1	36.1	36.1	36.1
May	64.9	64.9	64.9	64.9	74.0	69.9	65.9
June	90.5	86.4	82.3	78.1	74.0	69.9	65.8
July	90.5	86.4	82.3	78.1	74.0	69.9	65.8
Aug	90.5	86.4	82.3	78.1	74.0	69.9	65.9
Sep	90.5	86.4	82.3	78.1	74.0	69.9	66.1
Oct	68.9	68.9	68.9	78.1	74.0	69.9	65.8
Nov	57.0	57.0	57.0	57.0	57.0	57.0	66.0
Dec	49.3	49.3	49.3	49.3	49.3	49.3	49.3

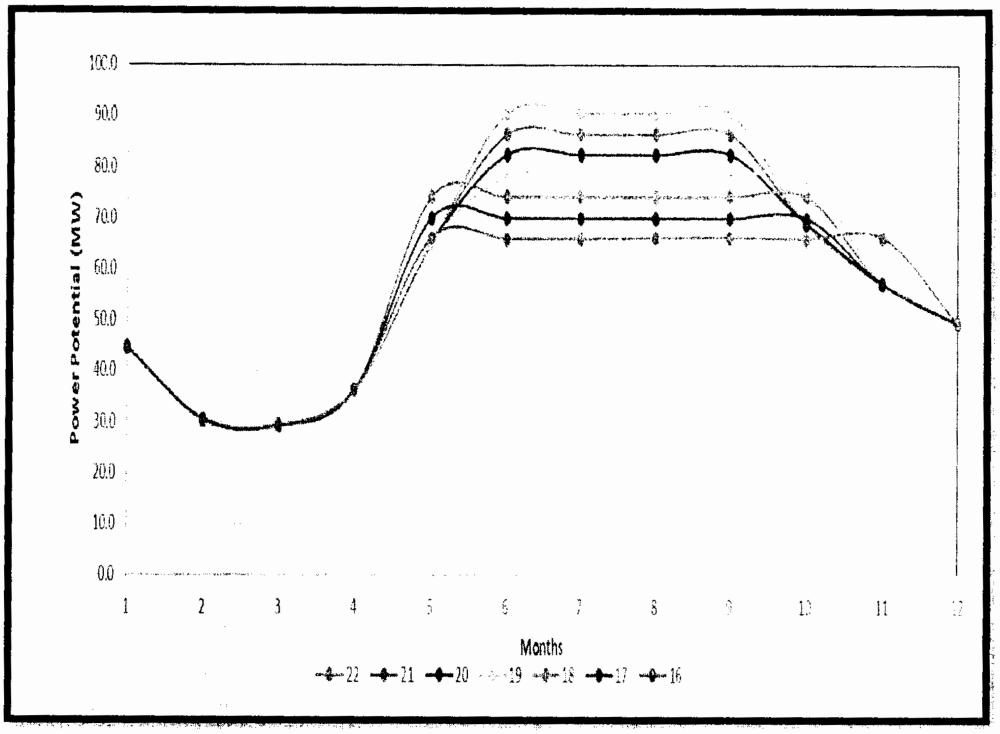


Figure: 11.1 Maximum Power Output against Different Plant Discharges

The minimum monthly power out against different plant discharges for the period of 1964-2015 (**Appendix: F**) is presented in **Table: 11.2** while graphically in **Figure: 11.2**

Table: 11.2 Minimum Power Output against Different Plant Discharges

Minimum Power Potential (MW) For Different discharges							
Monts	22	21	20	19	18	17	16
Jan	10	9.7	9.7	9.7	9.7	9.7	9.7
Feb	8	7.6	7.6	7.6	7.6	7.6	7.6
March	6	5.5	5.5	5.5	5.5	5.5	5.5
April	8	7.9	7.9	7.9	7.9	7.9	7.9
May	20	20.1	20.1	20.1	20.1	20.1	20.1
June	43	43.0	43.0	43.0	43.0	43.0	43.0
July	51	50.5	50.5	50.5	50.5	50.5	50.5
Aug	42	41.5	41.5	41.5	41.5	41.5	41.5
Sep	42	42.4	42.4	42.4	42.4	42.4	42.4
Oct	28	28.0	28.0	28.0	28.0	28.0	28.0
Nov	18	18.2	18.2	18.2	18.2	18.2	18.2
Dec	14	14.5	14.5	14.5	14.5	14.5	14.5

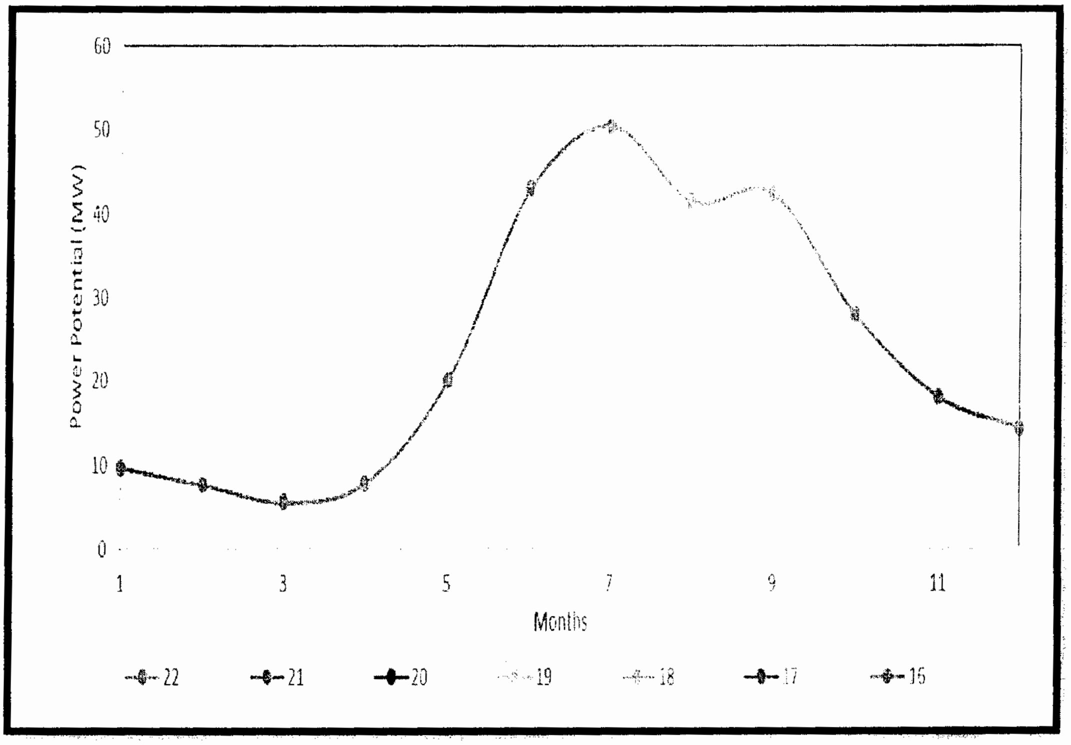


Figure: 11.2 Minimum Power Output against Different Plant Discharges

The mean monthly power output against different plant discharges for period 1964-2015 is presented in **Table: 11.3** while graphically in **Figure: 11.3**.

Table: 11.3 Mean Power Output against Different Plant Discharges

Mean Power Potential (MW) For Different discharges							
Monts	22	21	20	19	18	17	16
Jan	22	21.9	21.9	21.9	21.9	21.9	21.9
Feb	19	19.3	19.3	19.3	19.3	19.3	19.3
March	19	18.7	18.7	18.7	18.7	18.7	18.7
April	24	23.9	23.9	23.9	23.9	23.9	23.9
May	41	41.0	41.0	41.0	41.2	41.3	41.4
June	79	77.8	76.6	74.4	71.4	68.6	64.9
July	88	85.1	81.4	77.6	73.6	69.5	65.5
Aug	87	83.2	80.2	76.4	72.6	69.1	65.3
Sep	70	69.4	68.4	66.9	66.3	65.4	62.9
Oct	41	41.1	41.1	41.4	41.3	41.5	41.2
Nov	30	30.5	30.5	30.5	30.5	30.5	30.7
Dec	25	25.5	25.5	25.5	25.5	25.5	25.5

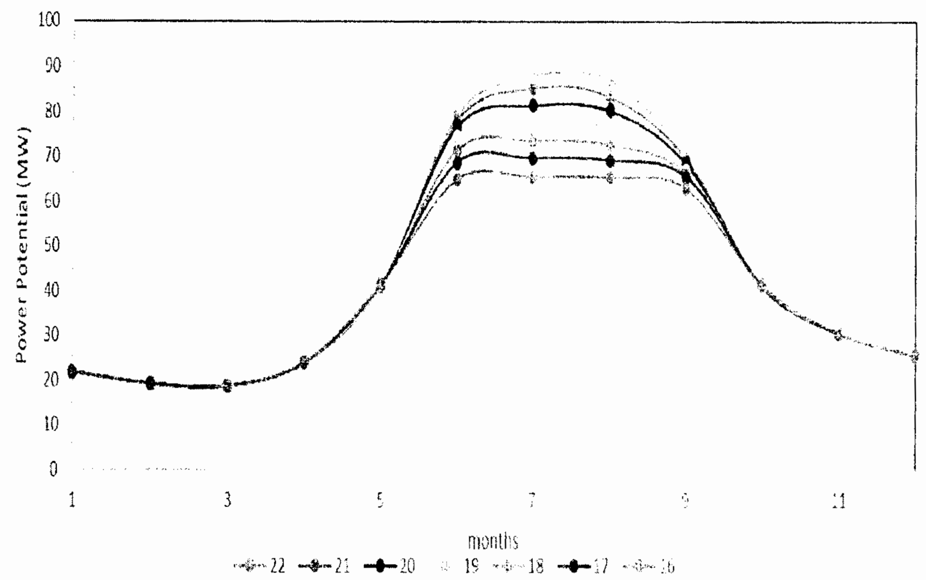


Figure: 11.3 Mean Power Output against Different Plant Discharges

The Annual Energy for the different plant discharge for each year for the period of 1964-2015 is presented in **Table: 11.4** while mean annual energy for the period 1964-2015 graphically presented in **Figure: 11.4**.

Table: 11.4 Annual Energy for Different Plant Discharges

year	Plant Discharge (m3/s)						
	22	21	20	19	18	17	16
1964	348.70	345.16	341.51	338.29	334.09	327.41	318.67
1965	397.98	390.25	382.74	375.97	365.67	355.48	345.76
1966	386.18	379.29	372.12	365.00	358.21	349.50	340.25
1967	387.49	380.96	373.43	364.73	355.80	347.67	337.25
1968	394.37	386.97	379.35	372.00	364.79	358.46	349.67
1969	425.66	419.33	411.68	403.88	395.89	385.23	374.88
1970	422.31	413.69	405.14	396.86	387.89	377.24	365.68
1971	420.61	411.70	402.00	392.13	382.19	371.59	361.74
1972	436.80	429.99	422.00	412.48	402.71	393.48	383.18
1973	452.30	441.41	429.68	417.80	406.85	396.42	384.18
1974	387.67	380.96	373.49	366.78	359.09	350.62	342.77
1975	414.29	405.10	397.00	387.66	377.04	365.67	354.32
1976	404.71	399.54	392.33	383.38	374.16	364.47	354.80
1977	375.41	368.50	361.46	355.15	347.98	341.47	333.61
1978	394.37	386.97	379.35	372.00	364.79	358.46	349.67

1979	401.11	394.80	388.87	383.19	378.28	368.96	359.88
1980	411.65	404.56	396.26	387.67	378.74	369.30	359.31
1981	411.65	405.46	398.66	391.80	384.85	378.53	368.65
1982	361.89	358.85	359.25	355.48	347.62	339.60	330.67
1983	392.71	385.56	378.06	369.20	360.18	350.95	341.66
1984	411.14	402.02	392.71	382.85	372.71	362.39	351.81
1985	402.18	395.18	390.26	381.77	371.26	360.08	349.68
1986	397.86	392.65	385.16	377.25	370.08	362.46	354.80
1987	410.03	404.49	398.65	390.45	380.82	370.00	359.56
1988	432.87	427.59	420.90	414.73	405.74	393.45	381.91
1989	396.44	390.63	385.33	379.58	375.76	364.70	354.62
1990	439.64	430.11	421.64	412.31	400.72	388.81	378.09
1991	424.98	416.13	407.32	398.16	388.48	377.33	365.81
1992	448.87	440.80	431.29	420.96	410.81	400.82	389.99
1993	448.77	439.19	428.43	416.45	404.02	390.59	377.90
1994	405.27	398.35	389.63	379.68	368.66	357.22	345.63
1995	409.63	398.70	387.30	377.53	366.14	352.94	339.05
1996	364.07	356.23	348.74	341.69	333.08	324.27	314.21
1997	389.90	381.71	372.70	362.46	352.30	341.02	329.34
1998	387.11	380.55	375.40	366.93	359.33	352.40	345.29
1999	435.28	424.72	414.86	404.40	394.95	384.10	373.02
2000	334.34	335.02	335.77	335.61	332.77	327.61	320.34
2001	281.74	281.64	281.55	282.01	282.42	283.41	284.43
2002	314.92	313.67	314.24	313.20	310.03	306.29	303.56
2003	303.90	299.18	294.78	290.13	284.59	278.37	271.02
2004	298.50	297.08	295.69	294.92	294.37	288.70	283.36
2005	383.07	376.12	370.37	362.39	354.65	345.70	335.55
2006	361.56	359.81	359.92	355.24	348.38	341.28	335.34
2007	382.52	375.41	368.38	361.80	353.26	344.92	336.72
2008	288.00	288.53	289.76	291.19	290.10	285.72	279.08
2009	346.06	341.31	336.76	331.23	324.88	319.46	313.22
2010	353.05	348.21	343.19	338.85	335.11	328.33	321.39
2011	405.43	403.36	396.17	390.28	383.10	373.62	365.33
2012	445.50	436.37	427.15	417.28	408.10	398.73	388.35
2013	445.63	436.21	426.38	415.75	406.10	395.85	383.39
2014	501.58	491.84	480.87	470.13	458.06	448.06	434.44
2015	483.70	474.32	465.39	456.18	447.20	436.84	426.73
Average Energy	**395.41**	**388.97**	**382.33**	**375.09**	**367.21**	**358.38**	**349.03**

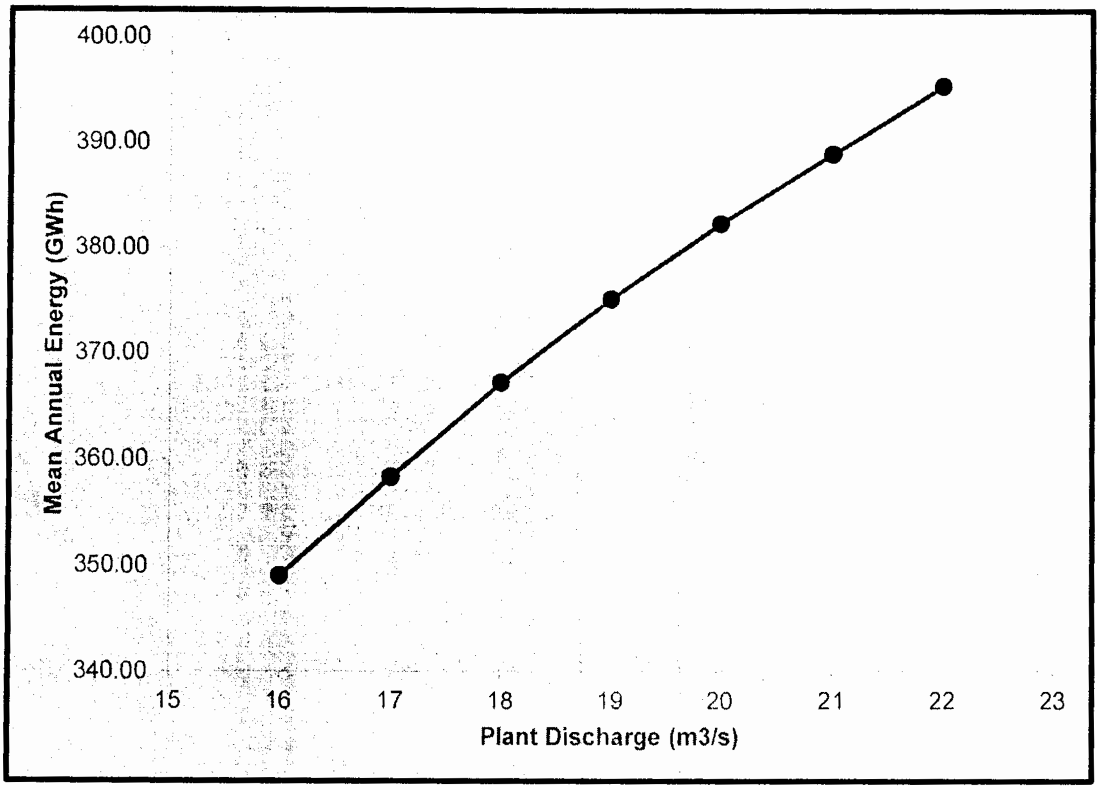


Figure: 11.4 Mean Annual Energy for Different Discharges

Figure: 11.4 Shows that the increase of annual energy generation is getting smaller with increase in plant discharge.

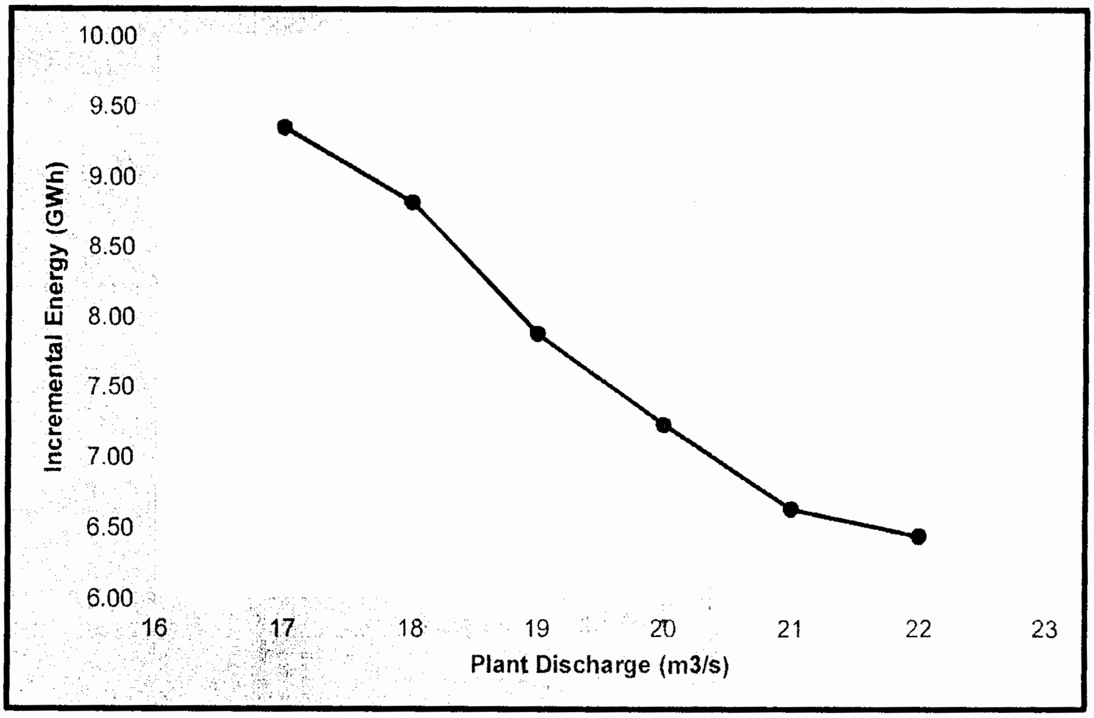


Figure: 11.5 Mean Incremental Energy for Different Discharges

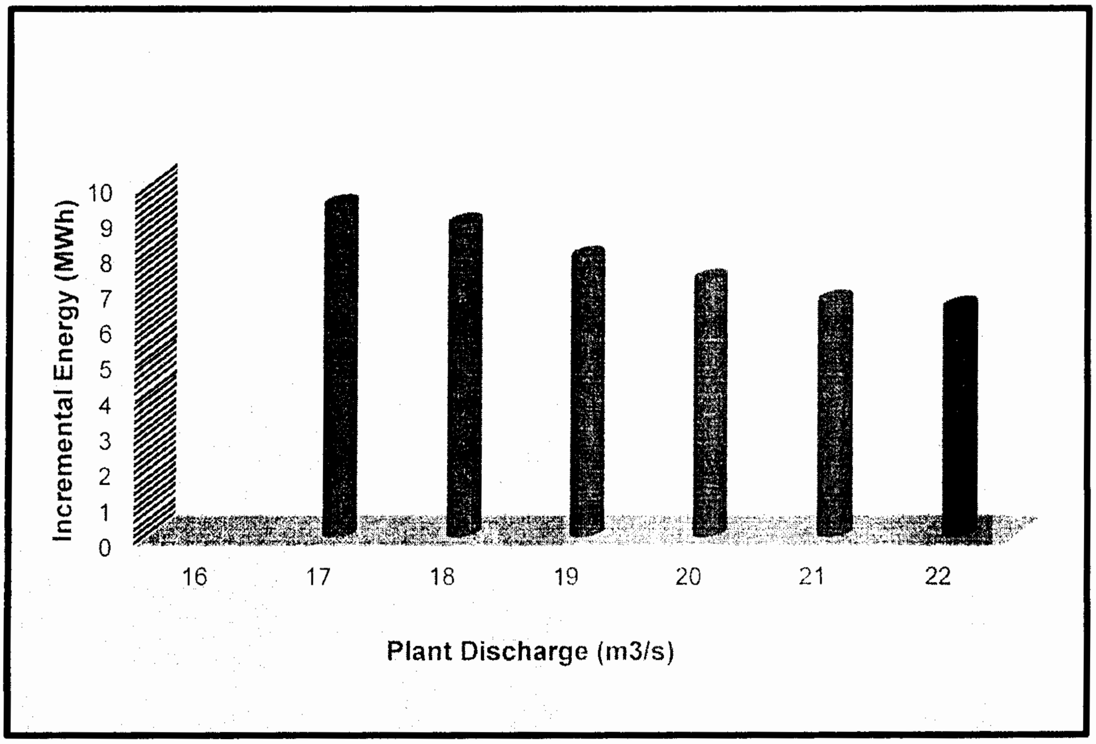


Figure: 11.6 Mean Annual Incremental Energy for Different Discharges

Figure: 11.5 and **Figure: 11.6** shows that decreasing trend in incremental energy generation with respect to increase in plant discharge in same up to plant discharge of 18 m^3/s. Plant discharge of 19 m^3/s and 20 m^3/s decrease trend in incremental energy is same while increase in discharge further will result in less incremental energy than discharge 16 to 20 m^3/s. It is therefore conclude that discharge of 20 m^3/s is best as plant discharge.

11.3.5. Plant Factor

The plant factor for each capacity was also estimated (**Table: 11.5**) based on generated energy for the discharge availability from 1964 to 2015.

Table: 11.5 Plant Factor against different Plant Discharge

Option	1	2	**3**	4	5	6	7
Installed Capacity (MW)	90.48	86.36	**82.25**	78.14	74.03	69.91	66.06
Plant Factor (%)	49.89	51.41	**53.06**	54.80	56.63	58.52	60.31
Q (m^3/sec)	22	21	**20**	19	18	17	16
Average Energy (GWh)	395.41	388.97	**382.33**	375.09	367.21	358.38	349.03

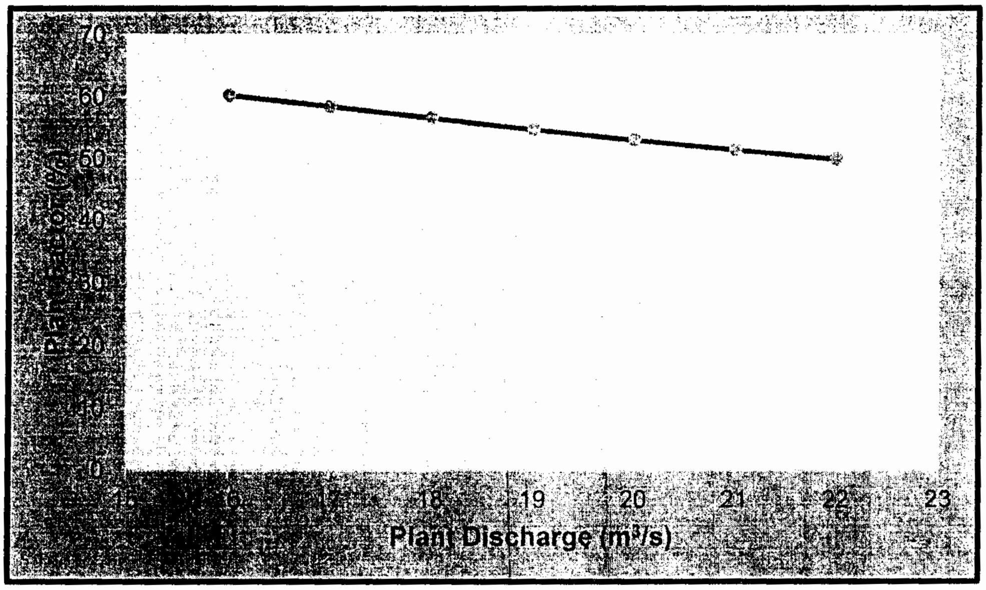


Figure: 11.7 Graph between Installed Capacity and Plant Factor

Figure: 11.7 shows that plant factor decreases with increase in plant discharge. It also show that the plant factor decreasing trend is same up to 20 m^3/s discharge and then trend is different. **Figure: 11.8** shows the graph between incremental plant factor and plant discharge. As per this figure the increment in plant factor from 16 m^3/s to 17 m^3/s is positive while increment in plant factor for other discharge is negative. It is noted that the increment in plant factor between discharge of 21 m^3/s and 22 m^3/s is less than other. It can be easily concluded that plant factor against 20 m^3/s discharge is the best and gain in energy further increasing discharge is much smaller.

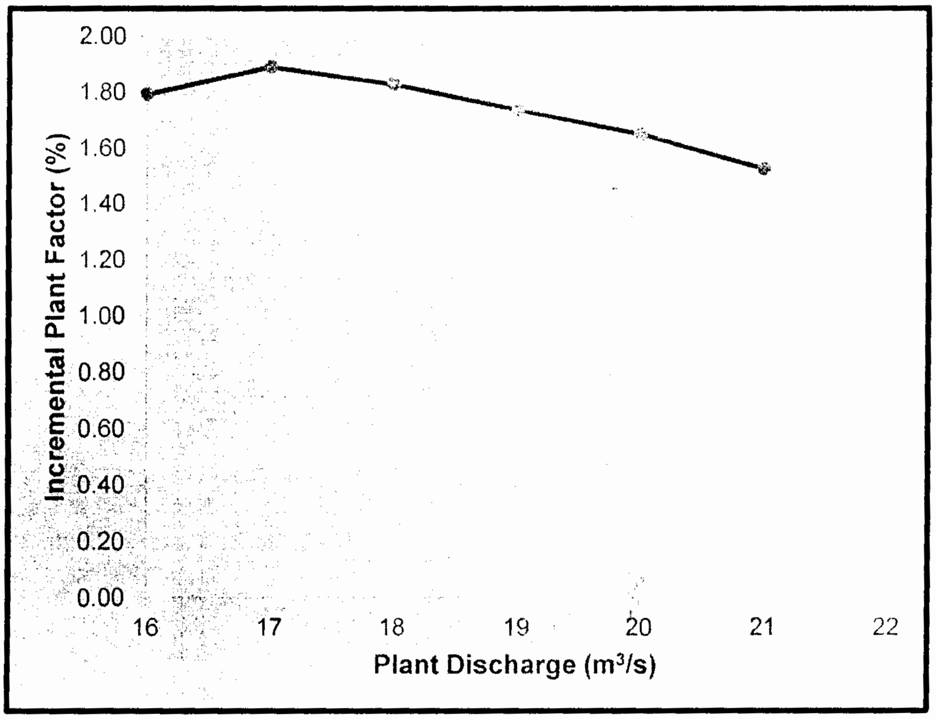


Figure: 11.8 Plant Discharge verses Incremental Plant Factor

Based on above simulations, the plant design discharge of 20 m^3/s producing 82.25 MW of power and plant factor of 53.06% is presumed to be the best option. Therefore, the discharge of 20 m^3/s may be selected as plant discharge for this study and cost estimation shall be carried through Hydropower Costing program.

11.3.6. Optimization of Capacity on the Basis of Cost/KWh

The obtained results are intended to enable comparison of the considered project alternatives on equal basis and to support the design optimization process. For the finally selected design discharge, the design will be developed to a full feasibility level and the investment cost will be determined based on actual quantities, derived from the drawings, updated unit rates and costs.

The results of optimization are shown below in the tabulated (**Table: 11.6**) as well as in graphical form in **Figure: 11.9**.

Table: 11.6 Discharge and Installed Capacity Optimization

Sr. No	Discharge (m^3/sec)	Cost In US $	Power (MW)	Energy (GWh) With eco flow 2.5 m^3/s	Plant Factor %	Cost per GWH
1	16	48,209,864	66.06	349.03	60.31	138,125
2	17	48,828,848	69.91	358.38	58.52	136,249
3	18	49,296,720	74.03	367.21	56.63	134,247
4	19	49,752,860	78.14	375.09	54.8	132,642
5	20	50,650,968	82.25	382.33	53.06	132,480
6	21	52,069,320	86.36	388.97	51.41	133,865
7	22	53,696,708	90.48	395.41	49.89	135,800

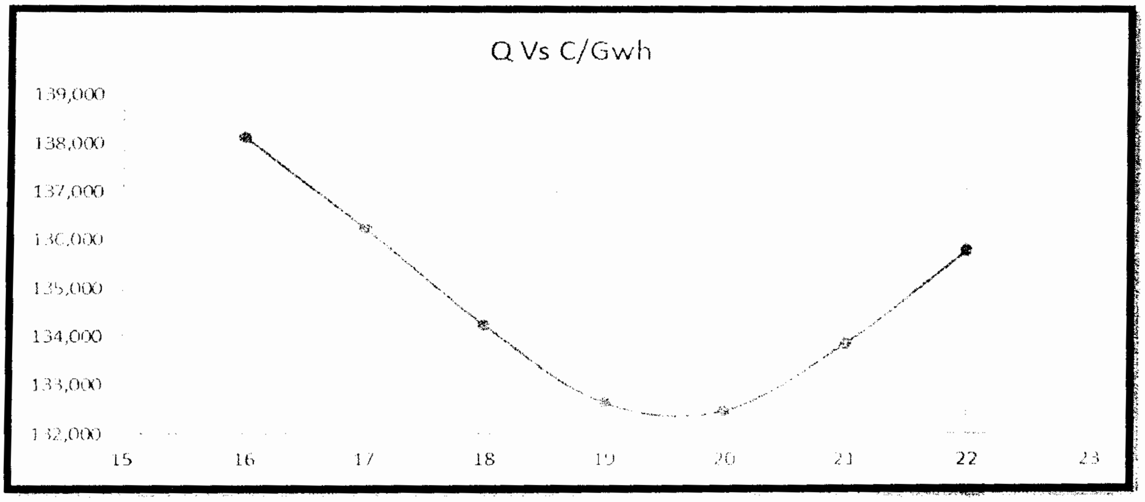


Figure 11.9: Graphical Representation of Optimization

The cost estimate worked out with HPC for each discharge is presented in **Appendix: F**. It show that Alternative with minimum cost per MWh is with discharge of 20 m^3/sec.

11.4. Optimization of Number of Turbine Units.

The above discussion concludes that a design discharge of 20 m^3/s is the most suitable due to power output, energy generation, plant factor and less cost per GWh. The available net head is 477.1 m. A per head and discharge, the Pelton type of turbine is the more suitable option, and therefore have been selected for Turtonas-Uzghor Hydro Electric Power Project.

The number of unit can be from 1 to 5. It is also important that the plant has to operate under looping system and not in isolation, therefore less number of unit are feasible. It is also clear that by increasing number of units, cost of plant will increase tremendously, while flexibility in operation will be more. Country like Pakistan which don't have manufacturing facilities installation of single unit cannot be recommended because of breakdown of single unit means loss of total benefits. Therefore, installation of 2 unit or 3 unit is the most suitable option.

In case of 2 unit or three unit, the discharge per unit would be 10 m^3/s and 6.667 m^3/s, respectively. Another criteria in availability of minimum discharge which is in the case of Turtonas-Uzghor is 4 m^3/s. Further, it is important to note that Pelton turbine start generation on 15% of unit design discharge. Therefore, if 2 unit installed, the minimum available flow is more than 40% of unit design discharge, it mean no compromise on turbine output. Installation of 3 unit will give more flexibility in to operation however with much more cost and hence higher tariff which may not be suitable for NEPRA approval.

Therefore, two Pelton Turbine Units was selected.

11.5. Conclusions

As result of optimization studies, the following can be concluded;

- The optimization results show that a design discharge of 20 m^3/sec is the most optimum design discharge as it has the least cost per GWh and better power and energy output. Therefore, a plant capacity of 82.25 MW with a plant factor 53.06% is the most optimum solution and hence selected for further studies.

- Net head available is in the range of high head, therefore Pelton Turbine is the most suitable type of Turbine.

- Turbine Units shall be 2 because of less project cost than 3 Unit and there is no compromising of power and energy out. Tariff for 2 Unit will be less than for 3 Units which will be more suitable to NEPRA for approval.

CHAPTER - 12

PROJECT SELECTED LAYOUT - CIVIL

Chapter: 12

PROJECT SELECTED LAYOUT - CIVIL

12.1. Introduction

As written in previous **Chapter: 4** that the Turtonas-Uzghor Hydro Electric Power Project is located along Golen Gol a left tributary of Mastuj River in District Chitral of Khyber-Pakhtunkhwa Province, Pakistan. The project is located in middle reach of Golen Gol. Further as per **Chapter: 4** and **Chapter: 11**, **Layout Alternative: 1-A (**Layout Alternative: 1 with Open Powerhouse**)** is selected being optimized and detailed design will be discussed in this chapter. In Alternative Layout: 1 the proposed powerhouse is just upstream of Golen Gol (in operation) HPP diversion weir while its diversion weir is further 5.5 km upstream near Turtonas existing Wooden Bridge along Golen Gol. The weir will consist of fixed and gated parts. The power intake would be located along right bank of diversion weir and off-takes from its right abutment. Water from power intake will pass through the connecting canal before entering into sedimentation basin. Another connecting canal will lead the flow to headrace tunnel, surge chamber, pressure shaft and pressure tunnel. Water after generating power will join the Golen Gol River back just upstream of Golen Gol (in operation) HPP diversion weir through tailrace canal **(Drawing No TUHPP-200)** and **Drawing: TUHPP-201.** An alignment of connecting canal and sedimentation is across a fan of Nullah. The Nullah is not perennial, however if any flows, these are diverted toward its left for use in agriculture. Connecting canals are covered. These are protected with access road (**Article: 12.15**) which is constructed at higher level so that any mud flood will not damage these structures.

The location of proposed Diversion Weir and Powerhouse of Turtonas-Uzghor Hydro Electric Power Project are as in **Table: 12.1**:

Table: 12.1 Location of Diversion Weir and Powerhouse

Site	Latitude	Longitude
Diversion Weir	35° 56.398'	72° 3.168'
Powerhouse	35° 55' 10.0765"	71° 59' 33.6618"

12.2. Multipurpose Use of Water

No irrigation and water supply channel off taking from the proposed Weir, connecting canal and headrace tunnel of selected Alternative: 1. A small 2 MW hydropower project is operating downstream of the diversion weir and upstream of the power house proposed location of Turtonas-Uzghor Hydro Electric Power Project. A uniform flow of 2.5 m^3/s will be released in low flow time to fulfill the power generation requirement of Small Hydropower Project and ecological needs.

12.3. Description of Project Components

The selected Alternative: 1 as result of studies in **Chapter: 4** and **Chapter: 11** is an entirely a run of river scheme project. The layout is along the right bank of the Golen Gol River. A design discharge of 20 m^3 /sec and two Pelton Type of Turbine have been selected based on optimization studies in **Chapter: 11.** The difference of elevation between weir and powerhouse site was obtained from detailed topographic survey which gave a gross head of 494.1 m. The selected layout has a headrace length of 4837 m and a provision of surface powerhouse on the right bank of river near Uzghor Village and tailrace will discharge back into the Golen Gol upstream of Diversion Weir of Golen Gol (in operation) HPP.

The following are the main civil components of the selected scheme:

- Diversion weir and Lateral Intake
- Upstream Connecting Canal and spill channel
- Sedimentation Basin
- Downstream Connecting Canal
- Headrace Tunnel
- Surge Tank
- Pressure Shaft
- Pressure Tunnel
- Powerhouse
- Tailrace
- Access Roads to Powerhouse and Diversion Weir
- O&M Staff Colony

A brief description of main civil components of the scheme is presented below;

12.4. Diversion Weir and Lateral Intake

12.4.1. Diversion Weir Design Concept

Diversion Weir with lateral power intake has been selected near Turtonas Wooden Bridge along Golen Gol. The course of the river is 25 m wide at this location (**Figure: 12.1**). At weir site river is narrow while just upstream river flows in very wide bed.

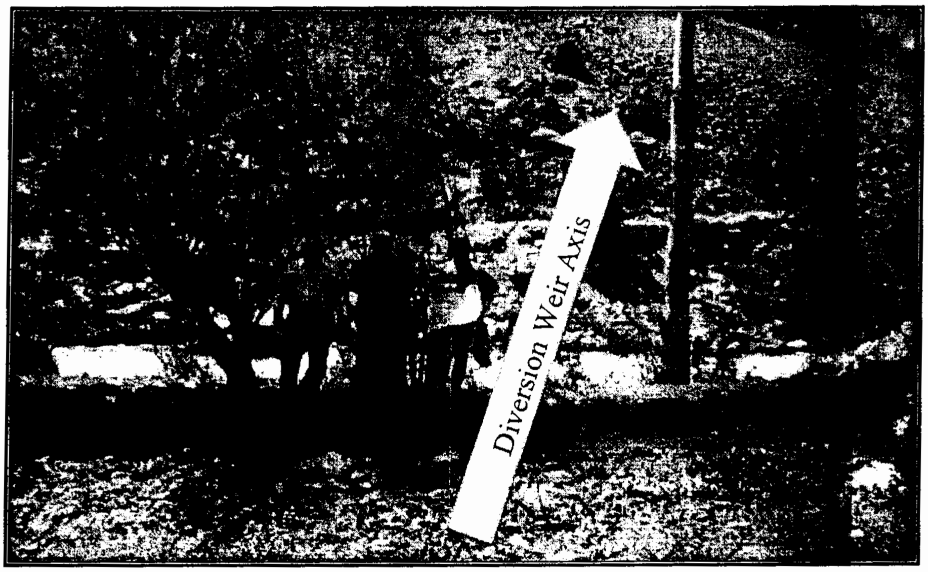


Figure: 12.1 Location of Diversion Weir and Lateral Intake Site

Due to wider bed the river flows in meandering. This wider portion is shown in **Figure: 12.2**.

Figure: 12.2 Golen Gol Bed Upstream of Diversion Weir Site

The diversion weir consists of fixed weir along left bank while gated portion (undersluice) along right bank in front of power intake. The type of diversion weir would be simple ogee type spillway weir **(Drawing: TUHPP-202** and **Drawing No. TUHPP-211)**. The weir structure has a height of 8.3 m above Stilling basin level. Diversion weir consists of following main components:

- main weir - Fixed
- under-sluices and
- Fish Ladder

Main weir is un-gated structure and consists of upstream floor, ogee shaped weir crest, downstream glacis and stilling basin made of reinforced concrete **(Drawing No. TUHPP-210 - 218)**. These would be bonded by retaining walls on left and right side. These walls may be of reinforced concrete or stone masonry. For this project concrete retaining walls were employed due to stability reason as the weir have to pass maximum flood having return period of 1000 years without damages and over topping of retaining walls. The height of retaining wall upstream and downstream of weir kept for flood having return period of 1000 years. A discharge rating curve (**Figure: 12.3**) was developed by using measured river cross-section and river bed slope and was used to fix the level of retaining wall and maximum and minimum operating water level.

River bed downstream of stilling basin would be protected with stones of required size, so that erosion of river bed could be avoided. The stones would be placed with cement sand mortar and also some would be anchored with each other's with steel rods.

A concrete dividing wall and fish leader will separate fixed and the gated portion/ under-sluices. A fish leader is placed along dividing wall to facilitate fishes to travel upstream and downstream and otherwise of the weir for spawning and habitats purposes.

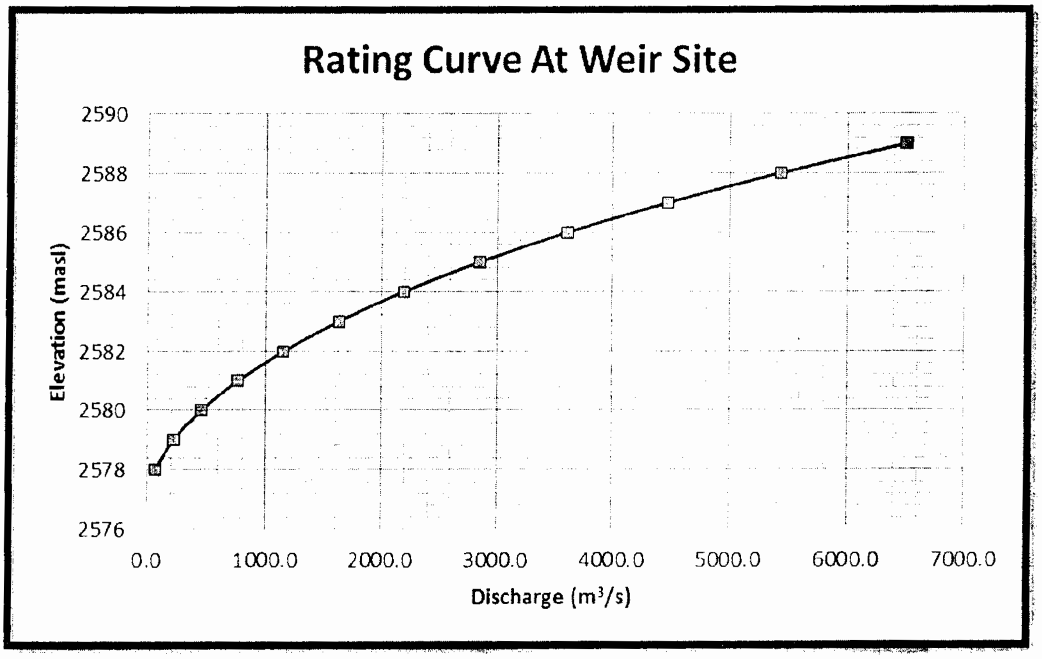


Figure: 12.3 Discharge and Water Level Rating Curve at Weir Site

Undersluice (Gated portion) is constructed in such a way that its bed level will be about 2 m below the power intake invert level and upstream floor level of in front of weir. This lowering will stop the bed load entering into power intake and be used for collection and deposition then flushed after regular interval by opening of gates according to frequency of bed loads. The flushing (or sluicing) gates discharge into a downstream chute separated from the stilling basin of the fixed weir to allow for its maintenance and repair while the stilling basin is in operation. **(Drawing No. TUHPP-210).**

Lateral intake is proposed along right bank and in the right abutment of diversion weir to divert the design plant discharge leading to the powerhouse for generation of power. Power intake will be connected to sedimentation basin through short connecting canal.

The power intake would be gated structure and placed along right bank of diversion weir and Undersluice portion. It will be equipped with coarse trash rack to stop the floating material entering in to power intake. The intake will be a bell mouth structure to facilitate entering of design discharge.

12.4.2. Design of Main Weir

12.4.2.1. Weir Ogee Structure

In accordance with the design criteria the design head was selected 30 % smaller than the head in the event of the Safety Check Flood.

The ogee crest structure is designed applying WES standard profile as defined by the Hydraulic Design Charts by USACE (**Appendix: F.1**) for the equation downstream of the crest axis.

The spillway structure was designed having one bay with a crest elevation of 2582 masl. The crest elevation was selected to be 0.5 m below the invert of the power intake to avoid intrusion of bed load into the power intakes during the high flow period (when bed load is passing the spillway crest). The spillway discharge capacity is calculated applying the standard formula given in the Hydraulic Design Criteria. The effect of piers and abutments on the effective crest width as well as the variation of the discharge coefficient with head are considered in the calculation of the spillway discharge capacity **(Figure 12.4).**

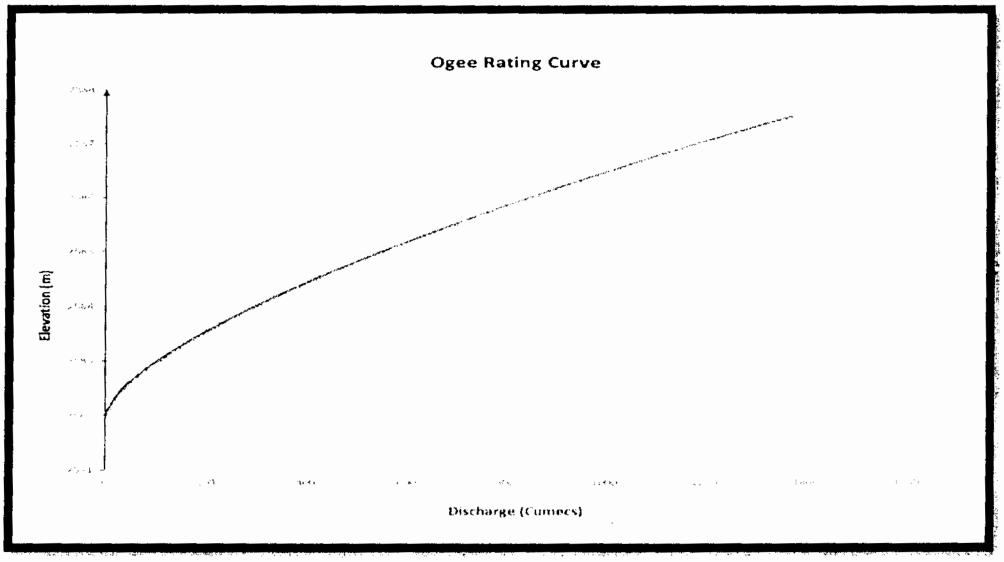


Figure: 12.4 Discharge Capacity Rating of the Weir (Fixed Part) of TUHEPP

12.4.2.2. Design of Stilling Basin

With reference to the design floods and the corresponding design criteria, the stilling basin is designed for the design flood with a return period of 1000 years (HQ1,000 = 1025 m^3/s). However, proper function of the stilling basin is reconfirmed in addition by verifying the stilling basin performance in addition for smaller floods covering return periods from 2 to 100 years.

The hydraulic stilling basin was performed as follows:

- Determine the energy head at the spillway crest for the selected spillway design at normal operation level of 2582 masl;

- Determine the hydraulic conditions along the ogee, in particular at the transition from ogee to stilling basin;
- Calculate the conjugated depth h_2 of the hydraulic jump and the required length of the stilling basin L_{STB} according to BLIND;
- Determine the relevant tailwater level and calculate the required elevation of the stilling basin floor.

For the required length of the stilling basin different approaches are given in hydraulic design manuals of the type $L_{STB} = K \times (h_2 - h_1)$ with K being in the range from 4.5 to 6. The Consultant considers the coefficient K = 5.0 proposed by BLIND ("Wasserbauwerke aus Beton") given in the Hydraulic Design Criteria. The validity of this coefficient shall be reconfirmed by testing of the structure in a mathematical or physical model in the next planning stages.

The hydraulic conditions from spillway crest to the stilling basin were determined for discharges between HQ5 and HQ1000, i.e. 130 to 1025 m^3/s and stilling basin Type IV of USBR were selected. As the result the stilling basin with the following dimensions was selected **(Drawing No. TUHPP-211** and **Drawing: TUHPP-229)**:

- Invert of stilling basin 2573.7 masl
- Width of stilling basin 40.0 m
- Elevation of river bed d/s 2575.0 masl
- Length of stilling basin 43.0 m

For the entire range of discharges considered in the present analysis, the criterion that the downstream water level exceeds the conjugated depth h_2 is maintained including a safety margin of 5%.

Downstream of stilling basin, concrete block apron and stone apron is provided to prevent erosion due to high velocity generated by design flood or medium flood. Velocity has to check on all discharges, so that provided protection shall remain intact. This is very important because most of the hydraulic structure fails due to heavy downstream scour and underneath piping due to movement of fine soil particle under hydrostatic head created by impoundment by spillway or weir structures. The stone apron were provided with stone having 160 lb/ft^2. Block apron of 1 m x 1 m x 1 m size have weight of 2.5 tons (**Appendix: F-1**) were provided over graded material or geo-textile. Geo-textile will be used due to simple construction.

12.4.3. Design of Undersluice Structures

The weir is equipped on the right side with a flushing structure consisting of two bays named undersluice **(Drawing No. TUHPP- 210-218)**. These bays are equipped with hydraulically operated sliding gates. Stop logs provision for erection, maintenance and repair of the gates is provided on upstream and downstream. The size of the undersluice is so provided that velocity in front of power intake shall be less than 1 m/s under all flows condition and will serve the following purposes efficiently.

- During the Maximum Flood the undersluice gates will remain close;
- Control device for maintenance and draw down the weir upstream water level;

- Act as pool to slow down the velocity in front of power intake;
- Facilitates fine material in suspension to settle down;
- Act as gravel trap to store and stop bed load entering in to power intake; and
- Sediment flushing facility to keep the power intake free of sediment.

No continuous flushing is foreseen at the weir structure. With progressing sedimentation and deposition of bed material may occur also in front of the power intake. The flushing structure is designed to evacuate sediment which deposits in front of the power intake thereby avoiding the entrainment of coarse sediment fractions (gravel and cobble) into the power intake at times of high river flow at normal operation level 2582 m. Flushing shall be, therefore, possible at a depth of water of approx. 6 m at the weir site. The design discharge capacity was selected to be 204 m^3/s at full supply level of 2582 masl for flushing of deposited sediment.

For the flushing section the following dimensions were selected:

Flushing Bay	No. 2
Width of Each bay	5 m

During the high flow season some 20 m^3/s will be diverted through the power intake and the remaining river flow may be released either over the fixed weir/spillway or through the flushing sections. The flushing bays is designed to be capable of removing fine and medium fractions of sediments (sand and gravel). A spilling chute instead of stilling basin constructed in high strength concrete is provided downstream of undersluice in order to avoid erosion by pebble, cobbles and gravel movement. The bed slope of spilling chute is kept at 10%.

12.4.4. Design of Fish Ladder

It was recognized long ago that obstructions in rivers such as dams, weir, culvert, fall (**Figure: 12.5**) fragment aquatic ecosystems and affect fish populations. Fragmentation of rivers can and has resulted in the decline of fish production from those waters and in some cases a complete loss of fish species. Most fish species are affected by fragmentation but species such as Steelhead, Chinook salmon, lake sturgeon, or suckers that are required to migrate to spawning grounds are particularly susceptible to declines from impassable river obstructions.

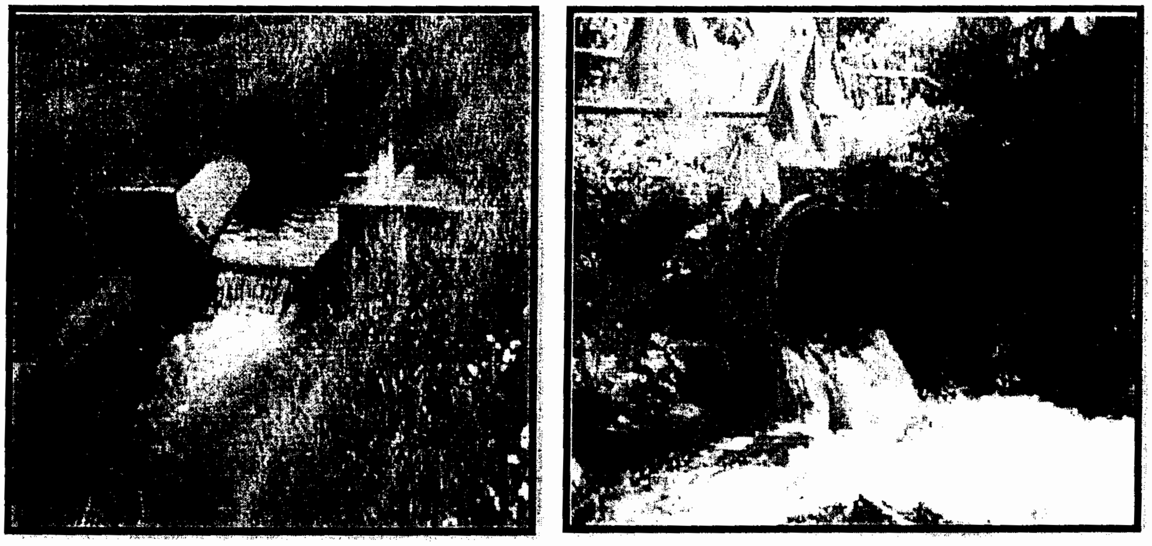


Figure: 12.5 Fall in Canal and Culvert Discharging in River

Thus, effective fish passage can be critical to the protection and recovery of many fish stocks. A fish ladder, also known as a fishway, fish pass or fish steps, is a structure on or around artificial barriers (such as dams and locks) to facilitate diadromous fishes' natural migration. Most fishways enable fish to pass around the barriers by swimming and leaping up a series of relatively low steps (hence the term ladder) into the waters on the other side. The velocity of water falling over the steps has to be great enough to attract the fish to the ladder, but it cannot be so great that it washes fish back downstream or exhausts them to the point of inability to continue their journey upriver.

Vertical slot fish way is selected **(Drawing No. TUHPP – 221)** to provide in the diversion weir of Turtonas-Uzghor Hydro Electric Power Project. Fishway is placed along the divide wall at right bank of the fixed weir. It starts from the stilling basin and end after passing the weir crest. A single vertical slot type is selected for this project. The bottom of the fish way would use to create natural bed of the river. Different size of stones available in the river bed would be embedded in the concrete bed in such a way that it gives look of the natural river bed. This type of fish way allow all size of Trout Fishes to pass upstream and downstream. The bidder will pass by jumping while small through lower slots.

Discharges in slot passes are determined by the hydraulic conditions in the slots and can be estimated using equation below and **Figure: 12.6**;

$$Q = \frac{2}{3} \times \mu r \times s \times \sqrt{2g} \times ho^{1.5}$$

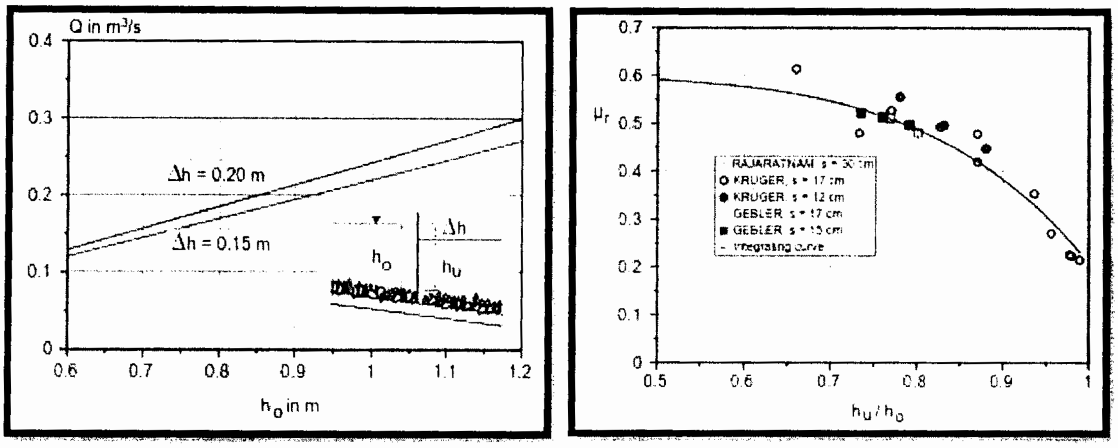


Figure: 12.6 Design Curves for Slot Fish Way

12.4.5. Design of Lateral Intake

The lateral intake is placed in the right **(Drawing No. TUHPP – 222** and **Drawing: TUHPP-229)** abutment wall of the under-sluices section or diversion weir. The invert level of power intake is kept about 0.5 m above the crest level of fixed weir. Further the invert of power intake was kept 2 m higher than the bed level of undersluice in order to avoid flood water entry in the intake.

The hydraulic design of the intake is made considering orifice type, because of level variation at fixed weir during high flow and flood condition in order to control more discharge than design. A coarse trash rack is installed to control the entry of planks or bigger floating particles. The gate is provided for regulation downstream of the breast wall in order to make orifice and to reduce the size of the gate and its hoisting system **(Drawing No. TUHPP - 226).** The shape of the intake is bell mouth. It has been designed to divert maximum discharge at the minimum water level which may be close to crest level of the Diversion Weir. The following formula has been used for its design.

$$Q = a \times k \times \mu \times B \times \sqrt{2ghu}$$

Where

Q = Design Discharge (m^3/s)

B = Width of Orifice (m)

hu = Water Depth in front of Orifice (m)

g = Acceleration due to gravity (9.81 m/s^2)

k = Coefficient of submergence for free flow is 1.00 for others it varies between 0 and 1.00

μ = Coefficient of Discharge =0.6

12.5. Connecting Canal-I Between Intake and Sedimentation Basin

An open canal is provided between the lateral intake and sedimentation basin **(Drawing No. TUHPP-231)**. The connecting canal is planned to pass through the level ground which is barren land. A design discharge of 20m^3/s has been used. For the high flow an extra 20% flow was added in the design discharge. The added flows will be used for flushing of sedimentation basin chambers at regular interval or will be passed through flushing gates continuously during period of heavy sediment load.

The connecting canal is equipped with overflow weir along its left wall. This overflow weir is designed as side weir and will act during high floods when more flows than design discharge can enter in to power intake. The spilled water from overflow weir will join Golen Gol downstream of weir through a stone pitched canal. The outlet of this canal is protected from erosion during high flow and sediment flushing through undersluice.

Hydraulic design of canal may be designed by using the following general formula;

$$Q = A \times V$$

Where

- Q = Design Discharge (m^3/s)
- V = Velocity of Water in to Canal (m/s)
- A = Hydraulic Area of Canal (m^2)

The flow velocity in any canal may be calculated by using Manning's formula such;

$$V = \frac{1 * R^{\frac{2}{3}} * S^{\frac{1}{2}}}{n}$$

Where

- V = Velocity (m/s)
- R = Hydraulic Radius (A/P) (m)
- A = Hydraulic Area of Canal (m^2)
- P = Wetted Parameter of the Canal (m)
- S = Bed Slope of Canal (‰)
- n = Manning's Coefficient depend upon surface roughness

Table: 12.2 Value of Manning and Stickler Coefficient for different Lining

#	Type of Lining	Stickler Coefficient	Manning Coefficient
1	Planed Timber, Joint Flush	80	0.013
2	Swan Lumber, Joints Uneven	70	0.014
3	Concrete, Trowel Finish	80	0.013
4	Masonry - Neat Cement Plaster	70	0.014

5	Masonry - Brickwork, Good Finish	65	0.015
6	Masonry - Brickwork, Rough Finish	60	0.017
7	Excavated - Earth	45	0.022
8	Excavated - Gravel	40	0.025
9	Excavated - Rock Cut, Smooth	30	0.033
10	Excavated - Rock Cut, Jagged	25	0.040

Concrete canal is used and “n” value of 0.013 has been used. With the bed slope of 1:1000, rectangular canal cross-section having bed width of 8 m and water depth of 4 m is designed. The length of the canal is 60.41 m.

12.6. Sedimentation Basin

12.6.1. General Aspects

Sedimentation basin is placed along right bank where sufficient open space is available. The terrain is mainly stable (**Figure: 12.7**).

It shall be born in mind that sediments in suspension will unavoidably result in a certain wear and tear, in particular at the turbine runner. The extent of the abrasion depends largely on the concentration, size and mineralogical characteristics of the sediment particles on one hand and the turbine type, materials used and runner speed on the other. This abrasion and the resulting need for overhaul and replacement of runners cannot be avoided when water with high sediment content is diverted for power generation. De-sanding facilities are arranged to control or better say to reduce the frequency of the required overhaul and change of turbine runners. During the high flow season the Golen Gol has the potential to transport large quantities of sediments in suspension as well as bed load.

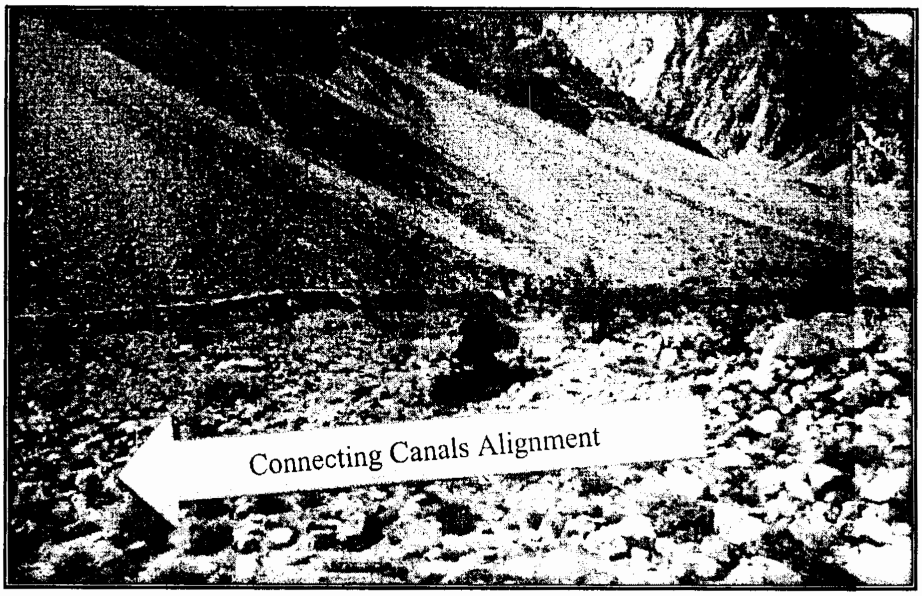


Figure: 12.7 Flat & Wider Terrace for Placing Sediment Basin & Connecting Canals

The proposed design of the weir structure and the flushing outlets ensures that coarse sediments (sand, gravel and cobble) can be prevented from entering the power intake and will be flushed through the under-sluices. Fine sand and silt fraction will remain largely in suspension in front of power intake of Turtonas - Uzghor HEPP and unavoidably enter the power intake. Sedimentation Basin facilities are, therefore, required to remove most of the sediment particles larger than the design particle diameter of 0.2 mm (**Appendix: F.1 Hydraulic Design Criteria**). Further, if these sediment are not separated, may chock water ways (Headrace) by settling during less velocities.

Sedimentation Basin are preferably arranged close to the weir structure at the free surface. The topographical and geological conditions make the arrangement of open air Sedimentation Basin possible.

12.6.2. Design of Sedimentation Basin

Sedimentation basin employed **(Drawing No. TUHPP 240** and **Drawing No. TUHPP-254)** in Turtonas - Uzghor Hydro Electric Power Project is typical one and consists of following components:

- Transition between Connecting canal and sediment basin;
- Three Settling chamber;
- Side spillway;
- Sediment Flushing System;
- Outflow Section and gate

The Consultant determined the required dimensions for the sedimentation basin by applying his own build software/program which is based on the theoretical approaches of CAMP and SARIKAYA. Hydraulic design of the settling chambers and transition between connecting canal-1 and settling chamber is made by using following formulae;

$$V_d = a\,(d)^{0.5}$$

Where

V_d	=	Flow velocity in settling chamber (cm/s)
d	=	Diameter of Particle to be removed (mm)
a	=	Coefficient as a function of d such as

a	=	36	at	d > 1.00 mm
a	=	44	at	1.00>d > 0.10 mm
a	=	54	at	d < 0.10 mm

Length of settling chamber is calculated by this formula;

$$L = \frac{Vd*h}{Vs-0.04\,Vd}$$

Where

L	=	Length of Settling Basin
Vs	=	Settling Velocity (cm/s) depend upon particle density

Width of the chamber calculated by this formula and check for length of transition = L' if L'< (1/3) x L then results are acceptable, otherwise repeat the calculation till above condition satisfied.

$$B = \frac{Q*td}{L*h}$$

Where

B	=	Width of the Settling Chamber
L	=	Length of the settling Chamber
Q	=	Design Discharge (m^3/s)

Sedimentation Basin:

Design discharge	20	m^3/s
Number of settling chambers	3	
Effective length of chamber	91.27	m (without transition)
Width of each chambers	7.5	M
Average depth of chamber	8.5	M

Mean velocity	0.2	m/s
Grain size to be excluded	0.20	Mm

Slope of terrain varies between 10° and 15°. It is a three chambers structure having inlet transition portion and outlet weir at the end of the chambers. A fine trash rack would be provided at the same location. Effective length of the sediment basin is 91.27 m. Chambers are of hopper types with small channel in the bottom for sediment collection and flushing with velocity of water. These channels will be equipped with gates for opening and closing during flushing.

A lateral spill weir is provided along left wall to spill the extra flows from design discharge back into Golen Gol River. Approximately 98 % of the sediments are removed from the water sediment mix at the de-sander works of the sediment fraction of the design particle diameter of 0.2 mm. For fractions with larger particle size the removal rate approaches 100 % and for particles of 0.1 mm diameter the removal rate is still above 50 %.

12.7. Connecting Canal II between Sedimentation Basin and Intake of Headrace Tunnel

A connecting Canal is placed along right bank between sedimentation basin and power tunnel portal. The terrain is mainly stable and consists of river over burden. Slope of terrain varies between 10 and 15 Degrees. A connecting canal is designed as free flow and would be covered for safety and prevent from spillage of sediment with water or otherwise.

A covered canal is provided between the sedimentation basin and headrace tunnel **(Drawing No TUHPP-261**and **Drawing No. TUHPP-262)**. The connecting canal is planned to pass through the level ground which is barren land.

Hydraulic design of canal may be designed by using the following general formula;

$$Q = A \times V$$

Where

- Q = Design Discharge (m^3/s)
- V = Velocity of Water in to Canal (m/s)
- A = Hydraulic Area of Canal (m^2)

The flow velocity in any canal may be calculated by using Manning's formula such;

$$V = \frac{1 * R^{\frac{2}{3}} * S^{\frac{1}{2}}}{n}$$

Where

- V = Velocity (m/s)
- R = Hydraulic Radius (A/P) (m)
- A = Hydraulic Area of Canal (m^2)
- P = Wetted Parameter of the Canal **(m)**

- S = Bed Slope of Canal (‰)
- n = Manning's Coefficient depend upon surface roughness (**Table: 12.2**)

Concrete lining is used and "n" value of 0.013 has been selected to be used in design. A design discharge of 20m^3/s has been used. With the bed slope of 1:1000, rectangular canal cross-section having bed width of 4 m and water depth of 4 m is designed. The length of the canal is 296.241 m.

12.8. Headrace Tunnel

It is proposed along the right bank of the Golen Gol River. The tunnel intake portal as is observed in the site reconnaissance visit and detailed geological mapping (**Chapter: 7**) shall be in competent rock. This rock is available at the end of flat and wider terraces where sedimentation basin and connecting canals are proposed.

Headrace tunnel will lead the water to the powerhouse with shortest distance. Headrace will be underground tunnel and will be designed as low-pressure tunnel.

Air vent(s) is placed at the tunnel portal. Headrace tunnel is terminated at surge tank and be excavated from both ends. Excavation would be done by conventional full face drill and blast method. The mucking material will be transported by vehicles. Excavated material would be sorted and stored at suitable place for its reuse. Surplus material will be placed as environment guidelines and along places selected during feasibility study. Two to three dumping areas have been selected for surplus material disposal. These areas are along Golen Gol where river is very wide and land barren and under use.

Headrace tunnel is proposed to be shotcrete lined and other support likes steel bolts, shotcrete, steel arches, wire mesh, etc. for rock stabilization would also be provided following physical examination of rock classification after excavation. Total length of headrace tunnel is 4837 m. **(Drawing No TUHPP-271** and **Drawing No TUHPP-275).**

12.8.1. Optimization of Tunnel Alignment

The alignment of the power waterways was selected aiming on the most economic overall project layout taking into account the prevailing hydrological, topographic, geotechnical and economic boundary conditions. The alignment is based on the only feasible construction of conventional drill and blast method and the anticipated time of construction.

12.8.2. Methodology

As part of the overall project optimization, the dimensions of the power waterway conduit system are optimized applying the relevant economic parameters based on the present value of cost of construction and energy and capacity forgone. For the purpose of optimizing the headrace diameter, unit rates from similar hydropower projects (Golen Gol HPP, Dubair Khwar HPP and Khan Khwar HPP, Patrind HPP) are applied after a critical review with the corresponding rates and the reference date of the present Feasibility Study for the Turtonas - Uzghor HEPP.

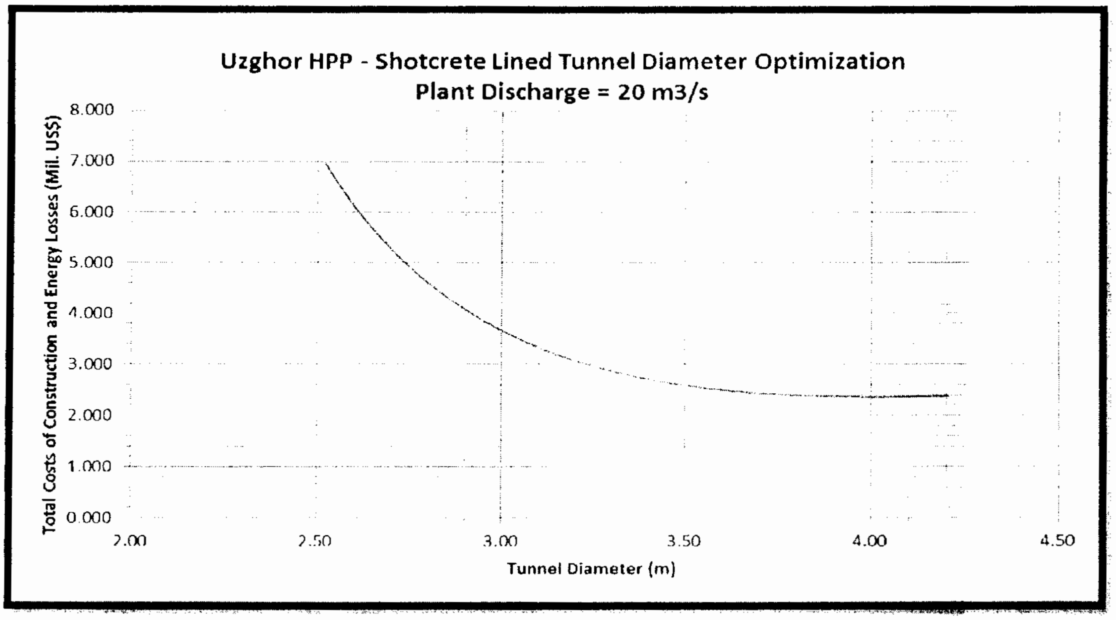


Figure: 12.8 Optimization of Headrace Tunnel Diameter

The key design parameters for optimization of the tunnel diameters are:

Headrace Tunnel	Q =	20.0 m^3/s
Operational level	=	2582 masl
Maximum Gross Head	H_{max} =	494.1 m
Minimum Net Head	H_{min} =	477 m

As indicated in **Figure: 12.8** the optimum headrace tunnel diameter is 4m. There exists a range of diameters from 3.5 to 4 m without significant variation of the optimization criterion. With the aim to minimize investment cost for an optimum project layout, a headrace tunnel diameter of 4.0 m is selected.

12.9. Surge Tank

A surge tank is proposed to meet the water hammer, wave oscillation and regulation requirements during operation of the units. The surge tank is a simple circular shaft type and located along right bank of Golen Gol (**Figure: 12.9**).

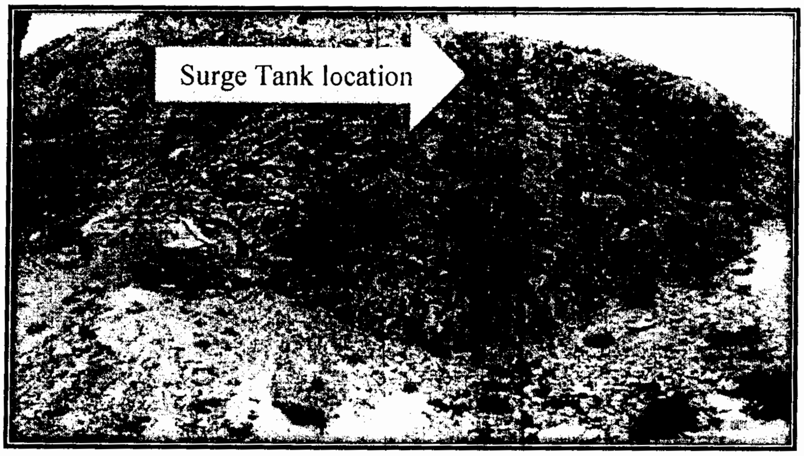


Figure: 12.9 Surge Tank Location

An independent access road is provided from right river bank leading to surge tank top and bottom and would be constructed as part of project. Bottom access road will be used for excavation of headrace tunnel and collection of excavated material coming from surge tank excavation through pilot hole drilled by raise boring. The top access will be used for drill and blast excavation of surge tank and construction of concrete lining in surge tank and other auxiliaries work. This road will be used during construction for transportation of excavated material and construction material from river banks. This road will be used during operation of the project for inspection of the surge tank on regular basis. Surge tank would be constructed by drill and blast method from top to bottom. Diameter of the surge tank is 15m **(Drawing No. TUHPP-281** and **Drawing No TUHPP-282).**

At the bottom access a maintenance gate is arranged to open the headrace tunnel during times of maintenance and inspection of the headrace tunnel, pressure shaft, pressure tunnel, surge tank and manifold system. Upstream of the maintenance gate the transition to the pressure shaft is arranged. The pressure shaft / tunnel commences with a vertical 90 degree bend and an internal diameter of 2.5 m in the steel lined section. At the lower end of the pressure shaft a vertical 90 degree bend is arranged as transition to the steel lined pressure tunnel.

12.9.1. Hydraulic Design of Surge Tank

At the intersection between headrace tunnel and surge tank a throttle with a cross-section area of not less than 50 % of the pressure shaft is arranged in accordance with common design practice to damp pressure fluctuations. In view of the expected high flow velocities at the throttle, the same shall be steel lined. In accordance with common design practice and the hydraulic design criteria, the cross sectional area of the cylindrical surge tank is selected 70 % larger than the THOMA-Criterion (actual safety factor 1.7) to ensure adequate stability of plant operation. Based on the characteristics of the upstream waterways and the design water levels, the minimum surge tank dimensions were determined as shown in **Figure: 12.10**.

UZGHOR HYDRO POWER PROJECT

Total headrace tunnel discharge	Q_T =	20.00	m^3/s
Length of tunnel	L_T =	4800.00	m
Diameter of Tunnel	D_T =	4.00	m
Cross section area	A_T =	12.57	m^2
Minimum head loss	$h_{L,min}$ =	0.01	m
Velocity in tunnel	v_T =	1.59	m/s
Velocity head	$v_T^2/2g$ =	0.13	m
Minimum reservoir level	WL_{Rmin} =	2582.00	m
Maximum tailwater level	WL_{Tmax} =	2087.90	m
Minimum head difference	$H_{o,min}$ =	494.10	m
Minimum net head	$H_{n,min}$ =	494.10	m

A_{Smin} =	117.527	1.5 A_{Smin} =	176.29	m^2
D_{Smin} =	12.233	$D_{Srequired}$ =	14.98	m
		$D_{Sselected}$ =	15.00	m

$$A_{S_{min}} = \frac{L_T \cdot A_T}{(H_{o_{min}} - H_{L_{min}}) \cdot (H_{L_{min}} + 1.0v^2/2g)} \cdot \frac{v^2}{2g}$$

Figure: 12.10 Dimensions of Surge Tank

12.10. Pressure Shaft and Pressure Tunnel

12.10.1. Pressure Shaft

It joins headrace tunnel with pressure tunnel and would be constructed vertical. The pressure shaft shall be lined with steel liner and is designed as free standing. The liner is designed and fabricated according to ASME/ASTM standard material suitable for low temperature in the order of -20°. For ease of construction by means of the raise boring method the 2.5 m diameter pressure shaft is designed vertical. In view of the expected internal tunnel pressure, the rock mass characteristics in the pressure shaft area and ease in maintenance, concrete and steel lining is required.

It will be constructed and excavated by raise boring method (RBM). A small hole will be first drilled through a pilot and then enlarged for required size by raise boring machine. Mucking will be through pressure tunnel. Concrete lining and steel lining will be placed after completing the excavation. Steel lining would be transported through pressure tunnel in pieces after rolling and welding in construction yard at site.

The height of the pressure shaft is 440.07 m **(Drawing No TUHPP- 286-287)**.

For optimization of diameters of the pressure shaft an empirical approach is applied. Based on the analysis of a large number of existing hydropower plants a strong correlation was found between optimum conduit diameter, type of lining, design head and discharge [Ref. FAHLBUSCH]. This correlation is applied for the waterways of the Turtonas-Uzghor HEPP for the diameter of pressure shaft. The conduit diameter is calculated for a design discharge of 20m³/s as follows:

Pressure Shaft – vertical, Steel lined: $D = 1.12xQ^{0.45}xH^{-0.12} = 2.27$ m

Selected $D = 2.5$ m

$v = 4.07$ m/s

The optimization of the diameter of the steel lined part of the vertical pressure shaft results in a conduit diameter of 2.5 m. The corresponding design flow velocities coincide well with prototype data of a number of similar hydropower plants.

12.10.2. Pressure Tunnel

A 791.28 m long pressure tunnel will join the pressure shaft at upstream end and with powerhouse at the downstream end. Pressure tunnel will be steel lined. At the end of pressure tunnel wye bifurcations is provided leading to water turbines.

It would be constructed by drill and blast method. The excavation would be done from powerhouse side toward pressure shaft. Concreting and steel lining would be started after completion of concreting and steel lining in pressure shaft. However, rocks would be stabilized by rock bolts, wire mesh, shotcrete, steel ribs, etc. where required just after blast.

For optimization of diameters of the pressure tunnel same approach was used as for pressure shaft. The optimization of the diameter of the steel lined part of the horizontal pressure tunnel results in a conduit diameter of 2.5 m **(Drawing No TUHPP- 291-292)**.

12.11. Power House

For the optimization studies there are two possibilities of powerhouse. An open or an underground powerhouse at an elevation of 2087.9 masl is proposed on right bank of the river near Uzghor Village as well explained in the optimization study. Powerhouse will consist of a machine hall and loading and unloading bays. The machine hall will house two turbo-generator units so that operation of the units would be done in all-weather safe and soundly **(Drawing No. TUHPP - 300** through **Drawing No TUHPP-306)**. Loading and unloading bay is provided on one side of the machine hall.

The turbines are selected based on consultants own design program which result that two Pelton wheel installed vertically are the preferred option and also optimized (**Chapter: 11**). The size of the machine hall is 16.50 m wide by 27.54 m long.

Transformer will be placed on top of Tailrace and just downstream of powerhouse. However, transformers will be separated by concrete walls in order to provide protection against fire. Powerhouse would be equipped with all type of equipment required for robust operation of a hydropower plant. Pelton turbine is best selection for this head and therefore selected for installation.

A bridge would be constructed along Golen Gol for access to Powerhouse and Surge Tank. Access road for powerhouse and Surge Tank will be constructed at very first and then excavation at powerhouse, pressure tunnel, headrace tunnel and surge tank will be started.

The powerhouse contains the machine hall, control and monitoring room, auxiliary hydro-mechanical and electrical equipment as well as store and workshop facilities. The dimensions of the powerhouse given in this report are preliminary and governed by the sizes of the turbine-generator-units and the space requirements for the electrical equipment, such as high and low voltage equipment, battery room, standby generator, auxiliary transformer etc. These may subject to variation according to the design of the particular suppliers of the electro-mechanical equipment **(Drawing No. TUHPP - 300 through 306)**.

The rock slops behind powerhouse building will be stabilized by benching, rock bolting and shotcreting. Further, a stone wall is proposed behind the powerhouse building with proper thickness and height in order to protect powerhouse from rolling stones coming from top of hills.

12.12. Tailrace

A tailrace (Open Canal Covered with Concrete slab) is arranged to convey the turbine discharge to the right-hand bank (**Figure: 12.11**) of the Golen Gol River. The dimensions of the tailrace and its rectangular exit cross-section (**Drawing No TUHPP-335**) are determined based on general turbine design principles for vertical Pelton turbine units. The following dimensions of the tailrace were selected:

Tailrace: W x H = 4 x 3.6 m

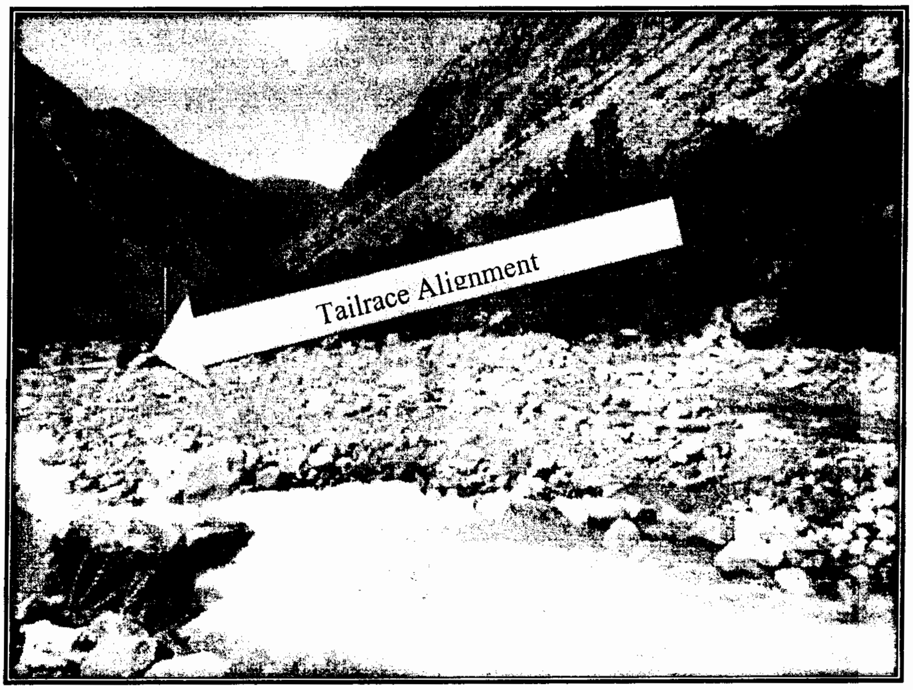


Figure: 12.11 Tailrace Outlet Location in Golen Gol Right Bank

12.13. Switchyard

Powerhouse switchyard will be placed on right side of powerhouse building. The terraces will be leveled and compacted for placing of foundation. The switchyard will protected from Golen Gol side by constructing a concrete retaining wall. The switchyard will be GIS Type which require much less space than conventional type.

12.14. Operation and Maintenance Staff Colony

The project location is in remote area where civic facilities are not available for staff during construction and operation. During construction staff can be housed in temporary arrangement while operation phase is spanned over 30 years for private sponsor, therefore, a proper housing colony which consist of all type of civic facilities is must.

Location of this colony is selected along left bank of the Golen Gol near powerhouse site. This will consist of main office, residences, dispensary, shops, vehicle stand, etc. A small setup consist of office and store room will be constructed near weir site to facilitate the O&M staff during cold weather.

For cost estimation 7530 ft^2 covered area with cost per ft^2 about PKR 6106.00 is added is cost and quantities **Chapter: 16** under head of Operation and Maintenance Staff Colony.

This colony will be constructed first and will be used during construction also by the Employer staff, the Consultant staff and may be by the Contractor staff.

12.15. Access Roads and Bridges

12.15.1. Access Roads and Bridges to Weir Site

Diversion weir is located near Turtonas wooden bridge which is capable for light traffic, however for project traffic a concrete bridge is required in place of it. The road from diversion weir of Golen Gol (in operation) HPP to Turtonas wooden bridge is suitable for four by four vehicles. This road is needed during construction and maintenance of the project for transportation of equipment and personnel. As the project main civil structures are along right bank of Golen Gol therefore, a heavy duty concrete bridge (**Drawing No TUHPP-347** and **Drawing No TUHPP-348)** will also be constructed along Golen Gol just downstream of the proposed weir for Turtonas-Uzghor HEPP. The existing road shall be upgraded for proper grade and width and carpeted for heavy traffic starting from Golen Gol HPP weir to Upstream of weir of Turtonas-Uzghor HEPP (**Drawing No TUHPP-349** through **Drawing No TUHPP-373**). From Golen Gol HPP weir road is along left bank of Golen Gol and its run along same bank till it crosses toward right bank from Turtonas Concrete Bridge. From Bridge it goes straight way till to Headrace Portal and crosses over the Connecting Canal-II and run along right bank of Sedimentation Basin and Connecting Canal-I and end at weir site. Road bifurcate near sedimentation basin to join existing shingle road for access to upstream villages and valley. This road will be constructed at high level and will act as protection barrier to connecting canals and sediment basin against if any mud flood from right bank Nullah. This road crosses two natural streams Uzghor (**Drawing No TUHPP-343** and **Drawing No TUHPP-344**) and Birmogh (**Drawing No TUHPP-345** and **Drawing No TUHPP-346**) where bridge are proposed.

12.15.2. Access Roads and Bridges to Powerhouse and Surge Tank

Powerhouse of TUHEPP is located along right bank of Golen Gol and just upstream of weir of Golen Gol HPP. A concrete bridge (**Drawing No TUHPP-341** and **Drawing No TUHPP-342**) will be constructed along Golen Gol near Uzghor Village. A road with proper width and grade will start from this bridge to powerhouse and surge tank. About 200 m before powerhouse it bifurcate into two. One leads to powerhouse and second to surge tank and traverse along slopes just behind the powerhouse building (**Drawing No TUHPP-350** and **Drawing No TUHPP-351**).

CHAPTER - 13

PROJECT SELECTED LAYOUT - MECHANICAL

CHAPTER-13

PROJECT SELECTED LAYOUT - MECHANICAL EQUIPMENT

13.1 General

The Feasibility Study layout and design for the Turtonas-Uzghor Hydropower Project comprises of the following main components including the hydro-mechanical and auxiliary mechanical plant:

- Powerhouse
- Switchyard
- Concrete weir structure with gated spillway and flushing structure
- Power intake on right bank adjacent to weir structure
- Sedimentation Basin
- Waterways including surge tank

This chapter describes the design of the mechanical plant, whereas the design of the electrical plant including the power transformers and the switchyard and the hydraulic steel structures is presented in separate **Appendix: F.2** of this Feasibility Study Report.

13.2 Mechanical Plant and Auxiliaries

The mechanical equipment and main mechanical auxiliaries in the powerhouse consist of following items:

- two vertical shaft Pelton-turbines including hydraulic/electronic turbine governors
- spherical valve for each turbine with auxiliaries

Auxiliary mechanical systems such as:

- cooling water system
- drainage and dewatering system
- ventilation and air conditioning (HVAC) system
- oil treatment plant
- compressed air system
- mechanical workshop

- powerhouse electric overhead travelling (EOT) crane
- fire fighting system

The mechanical equipment for Turtonas-Uzghor Hydro Electric Power Project is designed in a way to operate under the most unfavourable conditions in mountainous areas with sediment laden flow including wear from abrasion.

13.3 Design Criteria

The basic data for the layout of the mechanical turbine equipment has been developed as a result of the hydrological study and calculations performed. The results of each investigation are described in the previous chapters in detail and are not repeated in this chapter.

Those design aspects with major impact on the turbine design are:

- Weir and reservoir data;
- Flow duration curve;
- Head losses in the power waterways as function of the discharge;
- Properties of the water;
- Chemical analysis of water;
- Sediment transport and grain size distribution as function of the river discharge.

13.4 General Design Criteria

Gravity Acceleration:

The Turtonas-Uzghor HEPP shall be constructed upstream of Golen Gol (in operation) HPP with all its waterway and the powerhouse on right bank of Golen River According to the elevation of the project area between 2582 m at the weir structure and 2087.9 m at the powerhouse the gravity acceleration is applied as follows:

- at mean sea level 9.810 m/s^2
- at weir site (2582) 9.771 m/s^2
- at powerhouse site (2087.9) 9.775 m/s^2

Chemical and Biological Analysis of Water:

The Consultants collected two (2) water samples from Golen River for chemical and biological analysis of the same by IESE-NUST Islamabad. The analysis revealed that the samples are highly contaminated and not safe for drinking. Whereas, the pH values of the samples show acidic characteristics of the water, therefore due consideration shall be given for use in the concrete mix and while selecting turbine materials. The water samples analysis reports are attached in the **Appendix: 7 Geology and Geotechnical report**.

Sediment and Grain Size Analysis:

Substantial sediment transport takes place in the Golen Gol River in the high and low flow season around the year. The sediment study carried out separately considering the flows of Golen Gol River at Mastuj Bridge from 1997 ad 2015 and extended to 1964 to 2015 through regression study using the flows of Chitral River present the mean monthly and annual data of bed and suspended load at weir of the project.

Observing the nature of the suspended load which could travel to the turbines; a three chamber sand trap is provided to exclude particle size over 0.2 mm to limit the turbine's erosion/abrasion besides providing a finer trash rack to block debris. In any case the design of the turbine equipment has to consider and cope with the erosion and abrasion effects of such suspended water.

Hydrological and hydraulic conditions (**Table: 13.1**):

The net head and the discharge variation zone of the project are such that only vertical axis Pelton turbines are best suited for the operational regime. On the basis of the available hydrological data and the assumed operation regimes, the installed capacity of the project is presently assumed to be some 82.25 MW (ex-transformer at maximum plant design discharge of 20 m^3/s). During the present feasibility study phase the number and size of the turbines were optimised and also variants investigated considering the transport limits. Two vertical Pelton turbines with 6 jets, each rated for 41.125 MW have been adopted.

Table: 13.1 Main Hydraulic data of Turbine Layout

Characteristics	Unit	Intake/ Powerhouse
PMF	m^3/sec	1025
FSL (Full Supply Level)	m asl	2582.0
Turbine Centreline	m asl	2087.9
H_{gross} (range)	m	494.1
H_L (2 unit operation / 20 m^3/s)	m	17.01
Q_{plant} (maximum design discharge) Q_{unit}	m^3/s m^3/s	20 10

13.5 Selection of Turbines

The application diagram of hydraulic turbines shows that for the available net heads (marginally changing) and the variable flows, Pelton turbines are best suited, therefore selected for this project. As regards to the number and size of units; considering the transport limits and Pelton turbine operational range, two units of Pelton turbines are selected.

The basic consideration for the selection of number and capacity of units comprises the availability of flow throughout the year. It is always desirable to operate the turbines with the highest possible efficiency for all ranges of flows and head. For highly variable flows, a larger number of units may permit this. However, costs of civil works and equipment increases with increasing number of units.

The size of the units is affected by the diameter of the turbine runner. This is influenced in turn by the rotating speed of the runner. A basic criterion is normally to select the runner diameter for the highest possible speed in order to reduce the size of the turbine equipment.

The size of the tailrace channel is determined/calculated together with the other components of the turbine such as runner distributer, turbine pit, etc. as shown hereafter, using in house worksheets. The depth of the water at one-unit discharge from the runner centreline is kept such a way to avoid formation of vapour fumes and or negative pressure. The outlet structure of the turbine tailrace spills into the riverbed at riverbed level of 2079 masl.

Table: 13.2 Main Parameters of Turbine Layout (Capacity given ex-Turbine Unit)

Characteristic	Unit	Data
Type	-	Pelton
Number of Units	-	2
P at maximum design Q (two units operational)	MW	82.25
H rated	m	481.95
Q maximum design	m^3/s	20
Runner diameter	mm	2220
Setting	masl	+
Rated speed	rpm	500
P max. (one unit operational only) Installed capacity	MW MW	41.125 82.25

Following (**Table: 13.2**) are the basic characteristics of the turbines selected of the alternatives considered:

The units are supposed to be operated mainly as run-off-river plant. Therefore, the main operating level was set at the full supply level and it will be maintained for the most of the time.

The turbine is selected to operate continuously under part load conditions for all mean monthly inflows. The primary operation mode for this run-off-river plant will be level regulation.

In the present feasibility design provision are made for black-start and isolated grid operation.

13.6 Design of Pelton-Turbine Equipment

13.6.1 Runner

The Pelton turbine runner with buckets shall be integrally casted and finished as one piece of stainless steel containing 13% chromium and 4% nickel and suitable for field weld repair.

The design and manufacture of the runner shall be robust in size and strength to withstand safely the centrifugal forces and hydraulic jet forces on the buckets under the severe operating conditions without exceeding the allowable stresses and undue vibrations.

13.6.1.1 Turbine Shaft

The turbine shaft shall be made of open-hearth carbon or alloy steel with integrally forged upper and lower flanges for bolting to the generator shaft and the runner, respectively. The shaft shall be subject to careful heat treatment after the forging process.

The shaft shall have a center hole, not less than 150 mm in diameter, bored axially throughout the entire length. The machining of this hole shall be sufficiently smooth to permit visual inspection of the metal in the interior of the shaft.

13.6.1.2 Turbine Guide Bearing

The turbine guide bearing shall be of the multi-shoe(segments) babbit-lined, self-aligned and self-contained lubricating type capable of operating continuously at any speed from 50% to 110% of rated speed; for 30 minutes at any speed from 110% of rated to maximum runaway speed. In addition, the bearing shall be guaranteed for correct operation during 15 minutes operation without cooling water supply and for 5 minutes without oil circulation.

Cooling shall be accomplished by circulating the oil through external oil/water heat exchangers either by self-pumping or using two (2) circulating pumps, one as the service pump and the other one as a standby pump.

13.6.1.3 Spiral Distributor/Turbine Manifold

The spiral distributor/manifold distributing the turbine flow to the six nozzles/injectors shall be designed in accordance with the ASME Boiler & Pressure Vessel Code, Section VIII, Division 2. It shall be welded, quenched and tempered fine grain plate steel ASTM 516 Gr. 70, Normalized or equal. The manifold shall be designed for the design pressure of 5.7MPa, assuming no support from the surrounding concrete.

13.6.2 Injector System

The turbine shall be equipped with six nozzles of the straight-flow type with built-in servomotors, each operated by pressure oil from the governor pressure oil unit.

13.6.2.1 Operation Requirements

The injector controls shall be designed so that the needles of all nozzles in service operate simultaneously and in equal increments. Provisions shall be made for operation with a reduced number of nozzles in the event of failure of one or more nozzles and under low load operating conditions (starting, synchronizing, etc.).

13.6.2.2 Acoustic Turbine Flow Meter

An acoustic flow meter shall be provided for each turbine to indicate flow for the site turbine efficiency tests which shall be conducted in accordance with IEC 41.

13.6.2.3 Turbine Governor

The Pelton turbines require double regulation of the injector and deflector arrangements. Each governor system shall be composed of a digital governor, governor actuator, pressure oil system and associated control instruments. The oil/air accumulators of the three (3) pressure oil systems shall be replenished from a common compressed air system. Alternately, nitrogen/oil accumulator of the piston type shall be considered.

The speed signals shall be obtained from a voltage transformer located on the output terminals of the generator and from a toothed wheel on the turbine shaft operating with proximity transducers.

The signal for power control shall be obtained from the generator instrumentation.

The digital governor shall allow the following control modes:

- Speed control (PID)
- Power-frequency control (PI)
- Opening control (PID)
- Flow control
- Water level control (measuring equipment, signal transmission and water level governor shall be provided by the Contractor)
- Fault processing of measured signals in the control system
- Turbine protection
- Emergency shutdown interlocking

13.6.2.4 Mechanical Auxiliaries

The mechanical auxiliaries consist of following sub-systems:

13.6.2.5 Lubrication Oil Supply System of Bearings

Each turbine will be equipped with one joint oil supply system for supply of bearings. The oil will be transported with the aid of one of two electrically driven oil supply pumps, which are backed up by a high pressure start-up-pump, to supply the generator axial bearing during start-up.

13.6.2.6 Cooling Water System

A cooling water system will be provided for each unit with provision of standby system to ensure uninterrupted cooling water supply to turbine-generator units, the transformers, hydraulic governors, lubrication oil system, compressors, air conditioning system and any other equipment installed, which requires cooling capacity. Cooling water to each unit shall be supplied from the common header to facilitate maintenance of the system and operation during part-load operation within the winter season.

The cooling water system shall be closed loop system with its inlet from the tail-water and heat exchanger placed in the tailrace channel.

13.6.2.7 Shaft Seal Water Supply Filter System

The water for the shaft seal will be taken from the downstream side of the cooling water filter system, passed through a fine-filter and then transferred to the shaft seal for cooling.

13.6.2.8 Drainage System

A drainage system comprising of two (2) drainage pumps together with piping, fitting, valves, floats, panels etc. shall be provided for safe operation of the system.

Each drainage pump will be assigned to collect the following liquids:

- Ground water seepage.
- Leakage of water and oil from various components.
- Water of the turbine pits, provided the dewatering system is also connected with the drainage system due to some reasons.

The leakages shall be collected through gutters and conduits of the powerhouse structure to the drainage pit/sump. In case the dewatering system is connected to the drainage system then, each turbine pit shall be equipped with a dewatering pipe and a hand-operated valve to release water from the pit towards the adjacent drainage pit/sump.

13.6.2.9 Spherical Inlet Valve

Two spherical inlet valves and expansion/dismantling pipe, one for each unit shall be installed immediately upstream of the turbines. The valves shall be operated during normal starting and stopping to isolate the turbine whenever there is shut down. The valves shall further operate as shut-off valves in case of turbine breakdown and to permit dewatering of the turbines for inspection and maintenance by means of a T-Off in the bypass.

The spherical valves 1.2 m in diameter with double seals shall be able to slide relative to their foundation plates and within the downstream dismantling sleeve to compensate axial displacements.

The spherical valves can be controlled in local mode, but shall normally be incorporated in the turbine automatic control sequence. The spherical valve rotor rotation shall be pressure oil operated independent from the governor oil system. The service seals shall be operated by pressure water.

Each spherical valve shall be equipped with a bypass line for the purpose of filling and / or balancing the water pressure of the turbine manifold before opening of the spherical valve.

Table: 13.3 Main Data of Main Inlet Butterfly Valves

Characteristic	Unit	D1 (b)
Number of Units	-	2
Nominal diameter DN	mm	2500
Nominal pressure PN	bar	57

13.6.2.10 Powerhouse Crane

A 110/25 tons EOT powerhouse crane is determined by the generator rotor which will weigh around 95 tons. The weight of all other pieces of equipment to be handled by the main hook will be much less than 100 tons. An auxiliary hook of 25 tons capacity will be provided on the crane and will run along the main bridge beam; this will be used for handling smaller equipment and for normal maintenance work such as runner removal, etc. The proposed capacity of the crane shall be reviewed during the bidding stage when the suppliers confirm the actual weight of the generator rotor corresponding to generator inertia preliminary calculated as $392tm^2$.

13.7 Balance of Plant

13.7.1 Ventilation and Air Conditioning

The air conditioning and ventilation system will provide sufficient flow of air to all areas of the power station to control temperature and humidity so that equipment can operate as reliably as possible and at the same time, a safe working environment is provided for people working there.

The air conditioning and ventilation system must function as an integral part of the overall fire protection and evacuation plan for the power station complex.

The central control room will be air-conditioned by means of equipment which should be installed in the roof of the control block. In the control room the minimum temperature should not be less than 18°C and the maximum temperature should not exceed 28°C, with a maximum relative humidity of 50%.

13.7.2 Fire Fighting System

The fire fighting equipment shall comprise the following components and sub-systems:

- Fire hydrant system for the power station.
- Automatic high velocity water spray system for the generator transformers.
- Raw water distribution network
- Microprocessor based fire detection and alarm system.
- Portable and mobile type chemical fire extinguishers.

13.7.2.1 Oil Treatment Plant

The facilities will include a mobile oil filtration plant for purifying the transformer oil system. The mobile high vacuum oil treatment plant will be equipped with evacuation pumps, vacuum pumps, degasifying, heaters, filters, connecting rubber hoses etc. and any other items required for conditioning of the oil to maintain its dielectric properties. Further one mobile transformer oil tank of sufficient capacity is included to store oil of one main single phase transformer, with lifting lugs for lifting the tank completely filled with oil.

A separate bearing and governor oil purifying system is foreseen. Both oil treatment plants will be capable of the following functions:

- Filtration, dehydration and degassing of oil supplied in drums or in a tanker before filling into transformers, respectively into the bearing or governing systems;
- Processing of oil after long periods of use;
- Regeneration of oil after long periods of use to restore loss factor, surface tension, saponification, acidity factor etc. to values approaching those of new oil;
- Addition of inhibitor.

13.7.2.2 Workshop

The powerhouse is located in a remote area with low infrastructure nearby. Therefore the maintenance and repair work to be performed will include basic machining like turning, milling, drilling, grinding, welding, etc.

A suitable mechanical workshop shall be fully equipped with machine tools, equipment and tools necessary for normal maintenance and small repair of the turbines, generators and auxiliary equipment installed in the power station, switchyard, de-sander and at the power intake.

13.7.2.3 Service Air System / Low Pressure

The service air system will supply pressurized air at working pressure of 8 bar to various consumers in the power station, e.g. such as inflatable standstill and maintenance seals on the turbine shaft and main inlet valves, generator brakes and service air take-off points located throughout the power station structure for air supply to pneumatic tools and other equipment used during maintenance.

The low pressure compressed air will mainly consist of two motor driven screw type compressors, one as stand-by. The compressors will deliver the air to a main air receiver with app. 6 m^3 capacity. The compressors and the main receiver will be installed at the level of the erection bay floor elevation. From the main receiver the air will be distributed to various consumption points in the power station via a network of steel pipes.

The low pressure compressed air system shall be designed for automatic operation with the possibility of local manual control of the individual compressors from the local control panel.

The air receiver and the pressure accumulators shall be designed for normal working pressure of 10 bar in compliance with ASME Boiler and Pressure Vessel Code, Section VIII; Division 1 or equivalent.

13.7.2.4 Compressed Air System / High Pressure

The high pressure compressed air system will supply pressurized air for the hydraulic governing and other consumers in the power station, if so required. Its main purpose will be to supply sufficient high compressed air volume to close the nozzles servomotors and the main inlet valve under emergency conditions. The working pressure has to be defined together with the hydraulic pressure unit of the turbine governor.

The high pressure compressed air will consist of two motor driven screw type compressors per unit, with one compressor in stand-by. The compressors will deliver the air to a main air/oil receiver of sufficient capacity for emergency closing. The compressors and the main receiver will be installed at the level of the hydraulic governor.

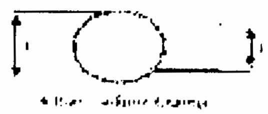
The compressed air system shall be designed for automatic operation with the possibility of local manual control. The air receiver and the pressure accumulators shall be designed in compliance with ASME Boiler and Pressure Vessel Code, Section VIII; Division 1 or equivalent.

13.7.3 Powerhouse Layout

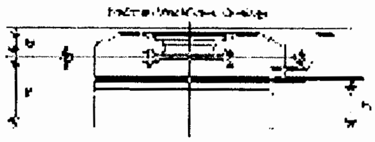
A conventional approach shall be applied to size the Pelton turbine's based surface powerhouse, calculating the sizes of turbine components, generator, and allocating adequate space for systems equipment. Preliminary the turbine and generator sizes as worked out for available hydraulic conditions and the nearest synchronous speed of 500 rpm to the trial speed are provided as under:

Pelton Turbine

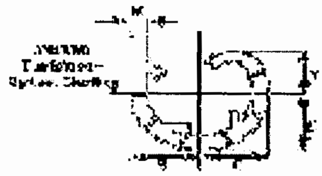
Dj	0.16

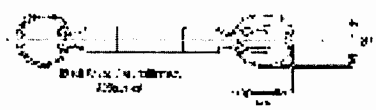


D2	1.74
D3	2.25
H1	0.54
H2	0.48

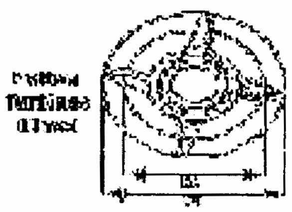


F	4.94
G	1.04
H	3.40
HS	3.09
I	3.29
M	5.42
N	4.69



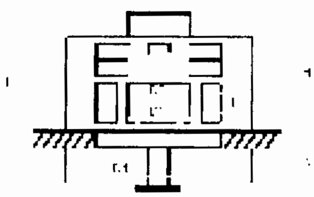


A	1.24
B	4.36
C	4.05
D	3.57
E	4.22



Generator Dimensions (500rpm)

H	5.32
J	3.70
K	2.02
L	1.21
D1	3.30
D3	4.82
D4	6.64



13.8 Hydraulic Steel Structure Equipment

13.8.1 General

The feasibility layout and design for the Turtonas-Uzghor Hydro-electric power Project comprises of the following main components, which include hydraulic steel structure equipment:

- Concrete diversion weir structure with flushing gates of fixed wheel type
- Power intake with coarse trash rack
- Sand trap with gates at inlet and outlet

- Fine trash rack
- Power waterways
- Tailrace outlet structure

Diversion Weir

The diversion weir equipment includes:

- Two vertical fixed wheel gates (5.2 m x 4.6 m) with rope hoisting electrical/manual drive
- Two upstream and downstream maintenance stop logs (5.0 m x 4.6 m)
- Gantry crane with capacity 50/10 t;

Power Intake

The power intake facilities include:

- Two trash racks (10m x 4.0m)
- Two intake fixed wheel gate (W x H = 4.10 m x 4.10 m)
- One set of downstream maintenance stop log (4.10 m x 4.10 m)

Sand Trap

Three chambers sand trap are equipped with:

- One upstream stop log (3.58 m x 5.70 m)
- One downstream stop log (7.70 m x 5.75 m)
- Six flushing gates (1.0 m x 1.75 m)
- One fine trash rack

Power Waterway

The power waterways will include these HSS equipment:

- Pressure shaft steel (2.5m dia.) lining starting from the top bend below the surge tank
- Pressure tunnel steel (2.5m dia.) up to Wye Bifurcation
- One Wye Bifurcation

Tailrace Outlet Structure

The outlet structure at the end of the tailrace will be equipped with a stop log (W x H = 4.60 m x 4.20 m).

13.8.2 Design Criteria

For the feasibility design, the following hydraulic and civil design criteria have been established in coordination with the Project Sponsor:

13.8.2.1 General Design Criteria

The properties of water in the Golen Gol River were determined in the period 2006 to 2007 at Babuka gauging station by the Consultant

According to the elevation of the project area between 2582 m at the weir structure and 2087.9 m at the powerhouse the gravity acceleration is applied as follows:

- at mean sea level 9.810 m/s²
- at weir site (2582) 9.771 m/s²
- at powerhouse site (2087.9) 9.775 m/s²

Particular attention shall be given to the potential impact of bed load and the expected rate of sediment transport during the flood season in the feasibility study.

This will also be achieved by an appropriate and proven wear resistant corrosion protection system, which is applied to all steel components exposed to water and not made of stainless steel. This system has to comply with ISO 12 944 and ISO 4628.

The hydraulic steel structure equipment described here below refers to state-of the art design and international recognized standards are applied to the design.

The design of all gates, stop-logs and other equipment with the appurtenant drives has to fulfil the requirements according to the standards for hydraulic steel structures DIN 19704 (Criteria for design and calculation) and DIN 19705 (Recommendations for the design, construction and erection of hydraulic steel structural equipment) or equivalent British, American Japanese and Chinese standards.

13.8.2.2 Gates of Undersluice

The undersluice/flushing structure is located right side of the weir in extension of the power intake structure. The two fixed wheel gates shall be operated intermittently to flush the sand and gravel which may deposit in front of the power intake into the tailrace when required. In view of the expected high sediment load during the high flow season, particular attention has to be given to a rigid and wear resistant design.

The gates shall have upstream seals (off seat arrangement) and shall close the gate opening through gravity closure against flow with adequate factors of safety against hydraulic forces and friction including a load resulting from 2 m high sediment deposition. The gates shall operate without failure or vibration under the most adverse combination of hydraulic flow and mechanical resistance due to friction, debris or other causes. The gate is designed to be opened safely under downstream water levels.

Control shall be by a rope hoisting system operating at deck. Maintenance platforms, handling equipment and dogging devices will be provided to facilitate raising and removal of the gate. All gate controls and motors shall be housed in a control building at the intake deck level. Emergency closure of the intake gate will be possible by remote control from the powerhouse and by an emergency closure control button at the intake.

Gates shall be designed, fabricated and erected in accordance with BS 5950 and DIN 19704 as applicable and equivalent standards. Design data of flushing gate is in **Table: 13.4**:

Table: 13.4 Basic Data and Design Criteria Of The Fixed Gates

Type	Fixed wheel Gate
Number of gates	2
Clear width of opening	5.0 m
Clear height of opening	3.88 m
Sill elevation	2576.0 m asl
Max surcharge Level	2582.5 m asl
Weir crest level	2582.0 m asl
Operation	Open against maximum differential head and Close at max. flow
Max. operation load:	All dead weights and friction loads
Seal position:	upstream
Maximum allowable leakage	0.1 l/m of seal/sec
Operating mechanism:	Rope Hoist

13.8.2.3 Coarse Trash-rack at Power Intake

The coarse trash rack screen consists of 2 identical elements covering the inlet area with a clear width of 10 m and a clear height of 4.0 m each (total area of 2 x 40 m^2) each split in two segments. The frames and screen segments shall be fabricated from structural steel plates and sections which shall comply with EN 10025 or other approved and equivalent standards dealing with structural steelwork. The trash rack panels shall be supported by means of a steel beam of fish belly shape.

The design has to provide vibration-free performance and minimal head loss. A clear spacing between screen bars of 150 mm has been selected and will be re-confirmed in the detailed design in co-operation with the turbine manufacturer. The screens have vertical screen bars. The edges of the bars should be designed to prevent or suppress flow induced vibration in flow direction. The trash rack shall be designed to withstand a differential head of not less than 3 m.

Suitable differential pressure sensors will be installed to register pressure differentials across screens to waterways. The sensors shall activate an alarm, when the differential pressure reaches 0.5 m. If the differential pressure continues to rise and reaches 2 m, the sensor shall operate the fixed wheel gate closure or act otherwise to stop the flow. Further, the control will set signal for operation of trash-rack cleaning.

13.8.2.4 Power Intake Fixed Wheel Gate

The intake gates located downstream of the trash rack serve as emergency closure devices in case of failures or damages of downstream structures in the sand trap or waterways, extraordinary pressure difference at the trash rack, etc.

Table: 13.5 Basic Data and Design Criteria of Fixed Wheel Gates at Power Intake

Type	Fixed Wheel Gate
Number of gates	2
Clear width of opening	3.60 m
Clear height of opening	3.88 m
Sill elevation	2574.46 m asl
Max Reservoir Level	2582.5 m asl
Crest of the piers	2590.0 m asl
Operation	Open against maximum differential head and Close at max. flow
Max. operation load:	All dead weights and friction loads
Seal position:	upstream
Maximum allowable leakage	0.1 l/m of seal/sec
Operating mechanism:	Hydraulic Hoist

The gates shall seal upstream water passage and close through gravity against flow with adequate factors of safety against hydraulic forces and friction. The gates shall operate without failure or vibration under the most adverse combination of hydraulic flow and mechanical resistance due to friction, debris or other causes. Operation of the gates shall be by motorised rope hoisting system positioned at deck level. Temporary maintenance platforms, handling equipment and dogging devices will be provided to facilitate raising and removal of the gate. Filling of the headrace tunnel (e.g. after inspection) will be performed by opening the gates slightly.

All gate controls shall be housed in a control building at the intake deck level. Emergency closure of the intake gate will be possible by remote control from the powerhouse and by an emergency closure control button at the intake. Gates will be designed, fabricated and erected in accordance with BS 5950 and DIN 19704 as applicable. Design data of roller gate is given in **Table: 13.5**:

13.8.2.5 Power Intake Stop-logs

To dewater the individual bays of the intake structure for maintenance of the trash-rack and the intake fixed wheel gate, stop-logs can be installed upstream of the trash-rack and immediately downstream of the fixed wheel roller gates. These stop-logs will be stored at deck level. Setting of these two stop-logs permits maintenance/inspection at one gate or trash-rack while flow and power plant operation may proceed via the remaining inflow sections. All stop-log elements shall have the same shape and dimensions. The stop-log elements will be installed by means of a mobile crane. Design data of stop-log after the fixed wheel gate **Table: 13.6**:

Table: 13.6 Basic Data and Design Criteria of Power Intake Stop-log

Clear width of the culvert	3.2 m
Number of stoplog elements	1
Height of one stoplog element	4.0 m
Sill elevation of stoplog	2573.70 m asl
Max Reservoir Level	2582.50 m asl
Crest of the piers	2582.00 m asl
Placing stoplogs	Balanced water head conditions
Max. operation load:	All dead weights and friction loads
Sealing:	At upstream side total circumference
Lifting device:	Mobile crane and lifting beam

Balanced water level conditions between stop-logs and roller gate will be achieved by slightly lifting the upper stop-log element.

13.8.2.6 Main Intake Downstream Stop-log

To have access to the downstream sedimentation basin and flushing gates for maintenance purposes under any operating conditions, a stop-log will be installed. The stoplog will be stored at deck level. The stoplog elements shall have the same shape and dimension and shall be designed to withstand the pressure generated of sediment deposition of up to 2 m height. The stoplog elements will be installed by means of a mobile crane. Design data of stoplog elements of flushing gate in **Table: 13.7**:

Table: 13.7 Basic Data and Design Criteria of Stop-Log

Type	Stop-log
Number of elements	2
Clear width of opening	3.60 m
Clear height of opening	4.10 m
Sill elevation	2578.0 m asl
Max Reservoir Level	2582.5 m asl
Crest of the piers	2590.5 m asl
Operation	Open/close at balanced water level
Max. operation load:	All dead weights and friction loads
Seal position:	to waterside
Maximum allowable leakage	0.1 l/m of seal/sec
Lifting device:	Mobile crane and lifting beam

13.8.2.7 Sedimentation Basin Upstream and Downstream Stop-logs

The civil design provides a single headrace tunnel and a sandtrap comprising of three chambers. For inspection and maintenance of each chamber stoplogs are provided upstream and downstream of the sandtrap. This concept ensures inspection and maintenance of a single chamber without suspending power plant operation and emptying the entire pressure tunnel.

Two stoplogs one each on upstream and downstream of the sandtrap shall be provided to isolate the sandtrap and the flushing gates for inspection and maintenance.

The flushing gates shall have upstream bronze seals and close under balanced water conditions with adequate factors of safety against hydraulic forces and friction. They have to close without failure or vibration under the most adverse combination of mechanical resistance due to friction or other causes. The gate with motorised hoist will be installed in a hermetically sealed housing to prevent the chamber from flooding.

All gate controls and motors will be located on the deck. Closure of the outlet gate will be only possible by remote control from the powerhouse and by a closure control button in the gate chamber.

Gates will be designed, fabricated and erected in accordance with BS 5950 and DIN 19704 as applicable. Design data of flushing gate is **Table: 13.8**:

Table: 13.8 Basic Data and Design Criteria of Sliding Gates

Type	Sliding Gate with housing
Number of gates	6
Clear width of opening	1.0 m
Clear height of opening	1.75 m
Sill elevation	2570.66 m asl
Max Reservoir Level	2582.27 m asl
Operation	Open against maximum differential head and Close at max. flow
Max. operation load:	All dead weights and friction loads
Seal position:	downstream
Maximum allowable leakage	0.1 l/m of seal/sec
Operating mechanism:	Motorised Stem Hoist

13.8.2.8 Fine Trash-rack at Sedimentation Basin

The fine trash rack screen consisting of 3 identical elements covering the inlet area with a clear width of 7.5 m and a clear height of 7.13 m each (total area of 3 x 53.475 m^2) each split in three segments shall be provided. The frames and screen segments shall be fabricated from structural steel plates and sections which shall comply with EN 10025 or other approved and equivalent standards dealing with structural steelwork. The trash rack panels shall be supported by means of a steel beam of fish belly shape if required.

The design has to provide vibration-free performance and minimal head loss. A clear spacing between screen bars of 60 mm has been selected and will be re-confirmed in the detailed design in co-operation with the turbine manufacturer. The screens have vertical screen bars. The edges of the bars should be designed to prevent or suppress flow induced vibration in flow direction. The trash rack shall be designed to withstand a differential head of not less than 3 m.

13.8.2.9 Pressure Shaft Steel Liner and Wye-Bifurcation

The whole pressure shaft and the pressure tunnel shall be steel lined with an internal diameter of 2.5 m starting from the bend below the surge tank and finished at Wye bifurcation.

The bifurcation will have an optimized shape to minimize head losses and an internal reinforcing structure. The splitting of bifurcation for site installation will be made depending on the size of construction and tunnel excavation. Two branches each of 1.24 m internal diameter will be site-erected and installed including the required bends to the upstream pipe of the spherical valves with nominal internal diameter of 1.24 m. The design pressure will be 57 bar. The external leakage and grout pressure shall be verified during the detailed tender design taking into consideration the latest available data at that stage.

The design method of "E. Amstutz, Schweizerische Bauzeitung No. 28, 1969" or "Buckling of circular rings and cylindrical tubes under external pressure, S. Jacobsen" will be applied. Stiffeners or anchors will be included at Tender Design stage to guarantee the required safety against buckling. The following standards may become applicable for the design of the steel liner and the wye bifurcation:

- European Standards
- DIN Standards
- American Codes, ASME, AWS, ASCE
- CECT (Recommendations for the Design, Manufacture and Erection of Steel Penstocks of Welded Construction for Hydroelectric Installations, published by the European Committee for Boiler Making and Kindred Structures)

The steel plates (stiffeners, steel liner a. s. o.) shall comply with the EN 10028-3, P355N or equivalent. Once erected the steel liner will be pressure tested with a factor of 1.5 of maximum operating pressure. A corrosion allowance of 1 mm and adequate anti-corrosion protection shall be defined in the present feasibility design.

13.8.2.10 Tailrace Outlet Bulkhead Gate

The bulkhead gate located at the outlet of the tailrace, where the flow is returned to Golen River, will close the tailrace in case of an outage of the powerhouse or any maintenance works in the tailrace tunnel. For this purpose a bulkhead gate of sliding gates type is foreseen including all accessories and control cubicles, which are located in the control building integrated in the gate structure. The gate will seal to the riverside and close under gravity under balanced water conditions with adequate factors of safety against hydraulic forces and friction. Closure and opening of the gate will be possible by a mobile crane.

Provisions are to be made to re-suspended sediments that may have settled immediately downstream of the gate during the time of closure, such as e.g. a pipe with a number of ejectors embedded in the bottom slab downstream of the gate through which air may be injected under high pressure by means of a mobile compressor. Design data of outlet gate in **Table: 13.9**:

Table: 13.9 Basic Data and Design Criteria of Maintenance Gate at Surge Tank

Type	Sliding Bulkhead Gate
Number of gates	1
Clear width of opening	6.1 m
Clear height of opening	7.3 m
Operation	at balanced condition
Max. operation load:	All dead weights and friction loads
Seal position:	downstream / to riverside

The gate may be slightly lifted (by a mobile crane) and a single turbine unit may be operated under partial load so that the flow is removing flushing the sediments towards the riverbed. The bulkhead gate will be designed, fabricated and erected in accordance with BS 5950 and DIN 19704 as applicable.

Summary of All Hydraulic Steel Structures (Steel Gates)

Description	Type of Gate	Qty. (Nos./Set)	Embedded Parts (Set)	Opening Size (WxH) (mxm)	Gate Size (WxH)	Sill Elevation (m)	Full Supply Level (m)	Head on Sill (m)	Type of Construction	Type of Hoist
DIVERSION WEIR										
Main flushing upstream stoplog	Slide	1	2	5 x 4.6	5.2 x 4.6	2574.70	2582.5	7.80	Welded	Mobile crane and lifting beam for lowering and lifting of the stoplog
Main flushing gate	Fixed wheel	2	2	5 x 4.6	5.2 x 4.6	2576.00	2582.5	6.5	Welded	Motorized hoist with wire rope drum
Main flushing downstream stoplog	Slide	1	2	5 x 4.6	5.2 x 4.6	2576.00	2582.5	6.5	Welded	Mobile crane and lifting beam for lowering and lifting of the stoplog
LETERAL INTAKE AND MAIN INTAKE										
Coarse trashrack	Flat bar vertical side	2	2	9.6 x 4	10 x 4	2578	2582.5	4.5	Welded	Mobile crane and lifting beam for

										lowering and lifting of the stoplog
Main intake gate	Fixed wheel	2	2	3.6 x 3.88	3.8 x 3.88	2574.46	2582.5	8.04	Welded	Motorized hoist with wire rope drum
Main intake downstream stoplog	Slide	1	2	3.6 x 4.10	4.10 x 4.10	2573.7	2582.5	8.8	Welded	Mobile crane and lifting beam for lowering and lifting of the stoplog
SANDTRAP										
Sandtrap upstream stoplog	Slide	1	3	3.18 x 5.7	3.58 x 5.7	2577.77	2582.27	4.5	Welded	Mobile crane and lifting beam for lowering and lifting of the stoplog
Sandtrap downstream stoplog	Slide	1	3	7.7 x 5.75	8.1 x 5.75	2578.61	2582.27	3.66	Welded	Mobile crane and lifting beam for lowering and lifting

										of the stoplog
Sandtrap flushing gate	Fixed wheel	6	6	1.0 x 1.75	1.2 x 1.75	2570.66	2582.19	11.53	Welded	Motorized hoist with wire rope drum
Fine trashrack	Flat bar inclined slide	3	3	7.5 x 7.13	7.9 x 7.13	2577.84	2582.19	4.35	Welded	Mobile crane and lifting beam for lowering and lifting of the stoplog

Miscellaneous Metal Works

Description	**Qty. (Nos./Set)**	**Size (WxH) (mxm)**	**Design Pressure**
Air vent pipes	2	Φ600mm	
Screen for access tunnel to surge chamber	1	1.2 x 2.1	
Pressure door for access to headrace tunnel	1	1.2 x 2.1	4 bar
Screen door for aeration tunnel	1	1.2 x 2.1	
Pressure tunnel access door	1	Φ600mm	50 bar

CHAPTER - 14

PROJECT SELECTED LAYOUT - ELECTRICAL

Chapter: 14

PROJECCT SELECTED LAYOUT - ELECTRICAL EQUIPMENT

14.1 General

This chapter describes the feasibility design of the electrical equipment of Turtonas-Uzghor HEPP to be installed at the powerhouse and other structures. The design concept is based on the assumption to connect the 132kV transmission line of Turtonas-Uzghor HEPP at the 132kV switchyard of Golen Gol (in operation) HPP switchyard, however, the scheme of power dispersal shall be finalised following the completion of interconnection study presently underway.

Despite availability of secondary 11kV source from the Golen Gol powerhouse, arrangements for black start and independent emergency power supply shall be made at powerhouse and weir/ power intake site.

The dimensions and layouts of the equipment have been developed to a detail sufficient to form the basis for a reliable cost estimate. In the present document the concepts of the electrical equipment are described. Scope of the main electrical equipment of the power station will comprise the following:

- Two (2) 50 MVA generators complete with closed circuit cooling system, monitoring systems, safety devices and fire protection system
- Two (2) static excitation systems with automatic voltage regulators
- Two (2) generator bus duct systems.
- Two (2) generator voltage switchgear assemblies
- Two (2) unit auxiliary Transformers (2x500KVA, 11/0.4KV)
- Two (2) main transformers (2x50/67MVA, ONAN/ONAF, 11/132KV)
- One (1) step-down transformer (5/6.7MVA, ONAN/ONAF, 132/11KV) for the common services of powerhouse, switchyard, dam area and supply to local village
- One station service transformers (500KVA, 11/0.4 kV)
- LV AC 3-ø 4-wire auxiliary supply system for the powerhouse, service building/switchyard and weir area
- Two (2) emergency diesel generating units for powerhouse/switchyard (500KVA, 0.4kV) minimum and weir area (150KVA, 0.4kV) minimum.
- 110V DC systems for the powerhouse, service building/switchyard and dam area
- UPS systems for the power house, service building/switchyard
- Protection/Control systems for the powerhouse and switchyard equipment Computerized Control System (CCS)
- Communication System with SDH/DVM/MDF & also interfacing with existing system of two remote ends.
- Earthing (40kA for 3 sec) with copper material with minimum size of Cu 240mm² conductor and lightning protection system.

- Power cables, shielded control cables, shielded instrument cables and fiber optic cables systems and its terminations.
- Lighting and small power installations.
- One 11kV feeder with OPGW from Power House to intake weir along with 11kV Switchgear and 2x200kVA Transformers.
- One underground XLPE Cu cable 11kV feeder for residential colony. Connection of 11kV feeder with distribution transformers through SF6 Ring Main Units.
- Three distribution Transformers (3x200 kVA) for colony.
- CCTV system at Power House/Switchyard/intake weir and colony etc.
- Separate independent Automatic Meter Reading System panels including revenue meters for Energy measurements.
- Fire Alarm and protection system for power house and grid station yard.
- 11kV Switchgear from step down Transformer.
- Neutral earthing with Transformers/Resistors.
- Surge Arresters with leakage current and surge counter for 132kV and 11kV System.
- 132kV SF6 CBs, 132kV Disconnect Switches and Earthing Switches.
- CTs and PTs for 132/11kV Systems
- Modification at both remote ends and additional equipments for both remote ends as per 132kV Transmission Lines layouts.
- OPGW up to both remote ends as per 132kV Transmission lines layouts.
- Protection relay system for mitigation of arc flash for Human Safety.
- Erection, Testing and commissioning of Electrical Equipments.

14.2 Standards and Regulations

The layout and design of all equipment and installations will comply with the latest edition of the relevant IEC/WAPDA/NTDC Standards. Also Contractor should follow all engineering practices of WAPDA/NTDC. All powerhouse/grid station equipment's/accessories shall be according to the approved manufacturer list of WAPDA/NTDC.

14.3 Electrical System Parameters

The following system parameters have been considered in the design:

132kV System

- Nominal voltage 132kV
- Highest system voltage 145kV
- Phases and frequency 3-phase, 50Hz
- Insulation level BIL, 650kV x factor as per IEC for height more than 1000 meter from sea level.
- Fault level 3-phase, 3 s 40kA minimum.

- Neutral earthing Solid through Disconnect Switch.
- Ambient Temperature 40°C

11kV System

- Nominal voltage 11kV
- Highest system voltage 12kV
- Phases and frequency 3-phase, 50Hz
- Insulation level BIL, 95kV x factor as per IEC for height more than 1000 meter from sea level
- Fault level 3-phase, 3 s 25kA
- Neutral earthing i) Generator neutral via resistor loaded earthing transformer.
  ii) System neutrals solid.

14.4 Single Line Diagram

The Single line diagram (SLD) mainly comprises electrical generators, main transformers, switchyard and auxiliary power supply system. Each generator (41MW, 11kV) is connected to a unit step-up transformer (50/67MVA, ONAN/ONAF, 11/132KV) via air insulated bus duct system and generator circuit breaker (11KV). The main transformers are arranged outside the powerhouse building. The high voltage side of the transformers is connected to the bays in the 132kV switchyard by means of bare Aluminum Conductor steel reinforced (ACSR). HV and MV Surge Arresters shall be installed on step up transformers.

The 11kV distribution switchgear will be supplied from the grid station's step-down transformer (5/6.7MVA, ONAN/ONAF,132/11KV).The powerhouse, switchyard, weir area and the local consumers will be supplied by the 11kV distribution switchgear. The weir area will be supplied by 11kV feeder routed together with a one fiber optic ground wire (OPGW) along the access road to the weir area. One fiber optic shall be routed through tunnel for redundancy.

The 400V 3-ø 4-wire, 4 poles CBs main distribution board in the powerhouse will be supplied from one station service transformer (1x500KVA, 11/0.4kV) and one DG set (500KVA). The unit auxiliary power supply will be branched off between the generator voltage switchgears and step-up power transformers for both the Units via two 500 KVA, 11/0.4kV unit auxiliary transformers, each rated for 100% auxiliary load. Back-up power supply for both the units will also be provided by the 0.4kV 3-ø 4-wire distribution switchgear of station auxiliary.

The powerhouse, switchyard and weir area redundant DC supply system will comprise 110V installations consisting of lead acid batteries, battery chargers, DC main and sub-distribution boards. Two redundant uninterrupted power supply systems will be required for power house and switchyard for supplying the supervisory and control systems, SCADA and the relevant peripheral installations.

Notwithstanding, 132kV switchyard single line diagram (SLD) of Turtonas Uzghor HPP as aforementioned, either based on one and half breaker scheme or double bus single breaker or single bus single breaker with bus section shall be finalised following completion of the interconnection study and NEPRA recommendation. However, the proposed SLD is shown in **Drawing No. TUHPP-380**, duly supported by **Drawing No. TUHPP-380-A** through

Drawing No. TUHPP-380-C for 11kV & 0.4kV power supply at power house and intake weir area respectively.

14.5 Electrical Equipment

14.5.1. Main Generating Equipment

14.5.1.1. Characteristics of Generator

The power and speed of the generators are dictated by the turbine, with its calculated output at the shaft coupling at design heads and design flow. The rated generation voltage as selected will be 11 kV, which is a typical standard voltage and suitable for generators of this size. Considering the respective turbine power output, a typical generator efficiency of approx. 97% and a power factor of 0.85 (which allows the generation of the necessary reactive power for voltage regulation at the 132 kV grid), the respective generator design data (**Table: 14.1**) is as follows:

Table: 14.1 Generator Design parameters

Turbine generator parameters		
Number of units	2	
Design according to	IEC 60034	
P_{rated}	MW	41.125
Generation voltage	KV	11
Power factor	-	0.85
Nominal speed	rpm	500
Rated frequency	Hz	50
GD^2	tm^2	392
Generator efficiency	%	97.0
$P_{S\text{-}rated}$	MVA	50

All windings of stator and rotor will be provided with a class "F" insulation system. As the long-term performance of the insulation system is affected by the maximum operating temperature of the windings, the rated output of the generators will be related to a temperature rise corresponding to class "B" insulation. As per IEC 60034 the permitted temperatures respectively temperature rises are:

Table: 14.2 Insulation Classes for Generators

Generator Part	Class B Insulation	Class F Insulation
Stator windings maximum temperature rise (measured by embedded temperature detectors ETD)	85 K	110 K
Rotor windings maximum temperature rise (measured by winding resistance)	90 K	110 K
Maximum air-inlet temperature	40 °C	40 °C

K = degree Kelvin (used for temperature differences)

The closed-cycle air-cooled generators will be equipped with air-water heat exchangers, connected to the plant cooling water system. For all load conditions maximum air temperature will be limited to 40°C.

The W41 generator bearing arrangement is suitable for vertical-shaft generators of above mentioned rated output. The combined thrust- and guide-bearing will be arranged on the upper bracket, the lower guide bearing of the generator beneath the rotor. The thrust bearing will be provided with an automatic high-pressure oil-injection, to reduce wear on the Babbitt-metal coated segments during start-up and shut-down of the unit.

To reduce the run-out time of the unit an air-pressure braking system will be provided. The air-brake system will be combined with an oil-pressure jacking system, to allow the jacking up of the rotor for maintenance purposes. For the dimensioning of the civil layout the following generator dimensions were estimated:

- Rotor diameter approx. 3300 mm
- Outer stator diameter approx. 4820 mm
- Weight of complete rotor approx. 95 tons

Due to the limitations of transport dimensions and weights, the stator housings will be divided and delivered in sections and the winding at the joints will be completed on site. The rotor will be assembled completely at site, including stacking of the rotor rim and fixing of the poles.

14.5.1.2. Neutral Grounding

In the case of earth-fault current flowing through the generator stator winding will have to be limited to a value which will not damage the winding before the protection operates.

The generator neutral will be grounded via a dry-type single-phase power transformer. The secondary winding of this transformer shall be loaded with a resistor. Detailed design of the neutral grounding will be subject to the detail designs stage of the Project.

14.5.1.3. Excitation System

According to the state-of-art the excitation system will be of the fully static-type (**Drawing No. TUHPP-392**) including digital type programmable automatic voltage regulator, thyristor rectifiers and field-suppression equipment.

The automatic voltage-regulator will be equipped with automatic and manual channels with follower allowing bump-less change-over from automatic to manual control in case of fault in the automatic regulation. It will further be furnished with the necessary protection and limitation devices and with a reactive power regulator.

The excitation energy will be branched-off the generator main bus ducts through a dry-type excitation transformer (500kVA, 11/0.4kV). For the initial excitation during start-up, a field-flashing equipment fed from the 400 V station supply and a back-up field-flashing from the DC system will be provided. Provision for coping with power swing in the system will be made (power system stabilizer PSS).

14.5.1.4. Generator Bus Ducts

For the connections between the generators and step-up transformers, standardized single-phase air-insulated bus ducts (Isolated Phase Bus ducts) with space heaters will be required. This type of bus duct offers the advantage of elimination short-circuits risks and guarantees for high grade of personnel safety, since all live conductors remain inaccessible and the touchable enclosures are grounded.

Table: 14.3 Design Parameter for Generator Bus Ducts

Number of bus bar systems	2
Number of phases of each system	3
Rated voltage (between conductors)	11 kV
Maximum system voltage (design) Space haters	17.5 kV Yes
Frequency	49.5 to 50.5 Hz
One minute power frequency withstand test voltage (minimum)	38 kV (rms) x factor as per IEC for height more than 1000 meter from sea level
Impulse withstand test voltage	95 kV (peak) x factor as per IEC for height more than 1000 meter from sea level
Rated current for main bus ducts	4000 A
Rated current for bus duct tap connections	100 A
Rated short-circuit current	50kA for 3sec minimum

The bus duct system will incorporate the required current transformers for protection and metering. The voltage transformers as well as the protective capacitors and surge arresters will be arranged in a separate fully enclosed cubicle, directly connected by tap connections to the main bus ducts. Excitation transformer and unit auxiliary transformer (at unit No. 1 and 2) will also be installed in metal-enclosed cubicles with isolated tap connections to the main bus ducts.

Enclosures will be Aluminium and conductors of the bus ducts will be of Copper. For the connection to the equipment suitable flexible connections will be provided. Considering the distance between generator and step-up transformers expansion joints will be considered.

Taking into account the generator voltage of 11 kV and the expected voltage regulation range of ± 5%, the characteristics of the proposed bus duct system will be in **Table: 14.3**.

14.5.1.5. Generator Circuit-Breakers

Main data of generator circuit-breaker is presented in **Table: 14.4**:

Table: 14.4 Design Parameters for Generator Circuit Breakers

Number of circuit-breakers	2
Number of phases of each system	3
Nominal operating voltage	11 kV
Highest system voltage	17.5 kV
Frequency	50 Hz + 3 %
One minute power frequency withstand test voltage (minimum)	38 kV (rms)x factor as per IEC for height more than 1000 meter from sea level
Impulse withstand test voltage	95 kV (peak)x factor as per IEC for height more than 1000 meter from sea level
Rated continuous current	4000 A
Rated symmetrical interrupting capability (minimum)	50 kA (rms)
Type of circuit-breaker	vacuum
Type of cooling	Air natural cooling up to 3150Amerpe, between 3150 and 4000 Ampere air forced cooling.
Ratings of disconnecting and grounding switches	consistent with circuit-breaker ratings

14.5.1.6. Fire Protection

A water-spray fire protection system will be provided for the generators, for which provision will be made for locating the pressurized water-tank and air-compressor and the generator pit should be provided with a suitable drainage system. As an alternative, conventional carbon dioxide gas system was considered. However, this system does not commensurate with the modern practice and is, therefore, not recommended.

14.5.2. Unit Auxiliary Transformers

Two three-phase transformers will be provided for unit auxiliary power supply each from the generator bus ducts of unit No. 1 and 2. The 11 kV terminals will be suitable for the connection to the tap-off from the generator bus ducts. The rating of each transformer will be 500 kVA, where each transformer will be suitable to feed the total auxiliary power demand of turbine generator units. The voltage ratio will be 11 / 0.40 kV. Each transformer will be provided with an off-load tap changer having a regulating range from -5% to +5%, in steps of 2.5%. The cooling type of the transformers will be AN.

The three-phase unit auxiliary transformers will be installed in metal-clad protection housings. To facilitate the movement of the transformer during installation, swivel type wheels will be provided.

14.5.3. Step-Up Main Transformers

14.5.3.1. General

The rating of each oil-immersed step up power transformer will be 50/67 MVA, ONAN/ONAF 132 ± 4x2.5 % / 11kV. The transformer LV terminals will be suitable for connection to the air insulated generator bus duct system. The HV side of the transformers will be connected to the outdoor switchyard by means of bare Aluminum Conductor steel reinforced. The main transformers will be equipped with no-load tap changers having a voltage range of ± 5%, adjustable in 8 steps. The range and the number of steps will be confirmed during the detailed design. Due to the transportation weight restrictions, the transformers shall be supplied disassembled without the oil and other accessories. Wheels shall be provided for Transformers.

14.5.3.2. Characteristics of Main Transformer

The design parameter of three phase main step-up transformer is presented in **Table: 14.5**:

Table 14.5: Design Parameters of three Phase main Transformers

Number of three-phase transformers	2
Type	Three-phase, oil immersed, outdoor
Rated power output of 3 phase transformers	50/67 MVA,
Frequency	50 Hz
Type of cooling	ONAN/ONAF
Rated voltage:	
High voltage winding	132 kV
Low voltage winding	11 kV
Vector group On line gas Analyser	YNd 11 Yes

14.5.3.3. Fire Protection

An automatically operated firefighting water-deluge system will be provided for all step up transformers. However, transformer are placed over the tailrace and concrete separation walls are provided to control the fire.

14.5.4. 132 kV Switchyard

The 132 kV switchyard shall be of the outdoor type with SF_6 gas Circuit Breakers. The switchgear scheme shall either be one and half breaker or double bus single breaker system or single bus single breaker with bus section to ensure reliability and flexibility during normal and also during exceptional operating conditions. For the sake of comparison, three schemes of the switchyard have been considered, briefly described as under:

Option A - One and half breaker scheme

This scheme consists of two bus bars with bays, each comprising three breakers to control two circuits. In schematic single line diagram (reference **Drawing No. TUHPP-380-A**) this scheme involves eight (8) 132 kV circuit breakers along with associated disconnecting switches, control, protection and measuring instruments etc. Merits/demerits of the scheme are as under:

- The scheme is most reliable as there are two bus bars. Each circuit is controlled by two breakers which have the ability to connect the generator or transmission line to one of the two bus bars.
- However, this scheme involves more circuit breakers and allied electrical equipment such as disconnection switches, current transformer and protective devices, leading to higher cost.

Option B - Double bus, single breaker Scheme

The scheme consists of two bus bars connecting one generator/transformer or transmission line through single breaker using two isolators/disconnecting switches. In schematic single line diagram (reference **Drawing No. TUHPP-380-B**), the switchyard consists of five (5) 132kV circuit breakers along with allied devices. Merits/demerits are as under:

- The scheme is reliable as there are two bus bars. Each circuit is controlled by one breaker which have the ability to connect the generator or transmission line to one of the two bus bars.
- The scheme involves less circuit breakers and allied electrical equipment. Cost of the switchyard is comparatively less.

Option C - Single bus, Single breaker Scheme

The scheme comprises single bus bar with bus section connected with all the circuits of generators and transmission lines. The scheme is less reliable. In case a fault develops at the bus bar, it will trip one generator and one transmission line circuit breakers, thereby leading to a 50% shutdown of the hydropower plant (**reference Drawing No. TUHPP-380-C**). Merits/demerits are as under:

- The scheme is equally reliable as compared to two other options mentioned above.

- The scheme is the least cost as it involves less electrical equipment in switchyard.

From the brief description of three options for the type of switchyard scheme of the HPP, it has been observed that option A and B are comparatively more reliable, yet, option C is equally good from technical requirement view point and is recommended for its implementation due to its economic advantages.

14.5.5. Power Supply for station Auxiliaries and Common services

To provide power for the station auxiliaries and common services, the station service board will receive power via the 132 kV network, step-down transformer (5/6.7MVA, ONAN/ONAF, 132/11kV) with on load tap changer and station auxiliary transformer (1x500KVA, 11/0.4kV). In case of a complete power failure, one 500 kVA emergency diesel generating set will provide the required power.

400V 3-ø 4-wire auxiliary power requirements of each unit will be provided through one unit auxiliary board fed from both the Generators as well as from 0.4kV bus 3-ø 4-wire of station service supply as per attached SLD (Ref. **Drawing No: TUHPP-380**). Detail of the power supply scheme will be analysed and specified in the tender design of the project.

14.5.5.1. Two UPS Systems

Two redundant UPS systems will comprise 400 V safe AC-systems and two 100% redundant 110 VDC-, 24 VDC-, 48 VDC-, Systems with one emergency diesel generator system as follows:

14.5.5.2. Two 110 V DC Systems

The 110 V DC system, which will provide power for the electrical protection systems, the station main DCS control equipment and for the switchgear control, will comprise the following components (the final capacities of which will be developed during final design (Ref. **Drawing: TUHPP-386**).

- Two rectifiers of 110 V DC each 100%
- Two lead-acid type batteries sealed type each 100%
- A main distribution board with two incoming breakers and one bus-tie breaker with ATS including 30% spare outgoing breakers and sub-distribution boards as necessary. Each circuit breaker shall have auxiliary contact for alarms.

14.5.5.3. 24 V DC Systems

The 24 V DC power supply for the station main DCS will be provided using suitable number of redundant DC/DC converters connected to the 110 V DC distribution boards.

14.5.5.4. 48 V DC Systems (if required)

The 48 V DC power supply, mainly used for the communication systems, fibre-optical type communication and telephone system, will be provided using suitable number of redundant DC/DC converters connected to the 110 V DC distribution boards.

14.5.5.5. 400 V Safe AC Supply

The 400/230 V 3-ø 4-wire safe AC supply will provide safe power to the control room equipment of the DCS control system (PC´s, monitors, printers, etc.) and for the emergency lighting system. It will comprise the following components:

- Two inverters 110 V DC/400 V AC each 100%, connected to the 110 V DC main distribution and static by-pass switches connected via isolating transformers to the 400 V station service board (normal voltage)
- One main distribution board and sub-distribution boards with 30% spare CBs as necessary

The capacity of the inverters will be determined during final design at tender phase.

14.5.5.6. Diesel Generator Set

The 400 V emergency diesel-generator set will be required to provide the necessary emergency and black-start power supply. The emergency energy generating system will include principally:

- One 4 stroke diesel engine / three-phase AC synchronous generator set, mounted on common base complete with flywheel, air cleaners, vibration damper, forced lubricating system, fuel supply system, radiator type cooling water system.
- Woodward hydraulic governor or electronic governor system including exhaust manifold, silencer and piping.
- 24V DC electric starter.
- The DG set Generator will have nominal voltage of 400 V, 500 kVA and 0.85 power factor.
- Brushless excitation system with rotating diodes.

The unit will start and build-up voltage automatically within 15 seconds. Shut-down of the diesel engines will be by means of fuel shut-off solenoid. As a result from preliminary estimations of the essential loads to be supplied by the diesel generator set, a rated output of 500 kVA will be sufficient. The definite rating of the diesel generator set will be determined during the tender phase of the project.

14.5.6. Electrical Protection Systems

All electrical protection systems will be of the digital (numerical) type and will comprise the following sub-systems: In addition to, Main Protection as well as Back-up protection shall be provided with separate DC Source, CTs Cores and PTs Cores. All relays shall be according to approved relays list of WAPDA/NTDC. All auxiliary relays shall be separate/independent.

14.5.6.1. Generator Protection System

The following list indicates the required protection functions/devices. Also additional protection (**Drawing No. TUHPP-390**) required as per recommendation of Generator manufacturer:

- 21/51 G Minimum impedance protection/over current relay

- 46 Negative phase sequence protection
- Thermal winding monitoring
- 49 S Stator thermal overload protection
- 32 Reverse power protection
- Over- and under-frequency protection
- Over- and under-voltage protection
- Voltage Transformer Failure (60)
- 40 Field failure protection
- 64 S (and 59N) Stator ground-fault protection 95% and 100%
- 87 G Generator differential protection
- 87 GT Generator-transformer and unit aux. transformer differential protection
- Bearing protection device
- Vibration monitoring
- 59 G Generator Neutral Overvoltage.
- Over excitation Protection.
- 50 Instantaneous over current relay
- 78 loss of synchronization.
- 64F Field Ground Protection/Rotor Ground Protection
- 50/51G Generator neutral over current protection
- 27TN - 3rd Harmonic Neutral Under voltage
- Over flux relay.
- 11 kV Connections Earth Fault Protection (64C)
- Generator Circuit-breaker Fail Protection (50 BF/62)
- Generator Inter-turn Protection (60 IT)
- Mechanical and Thermal Protection

14.5.6.2. Step-Up Power Transformer Protection

In addition to the generator protection, each step-up unit transformer will be protected by a Buchholz relay and the following protection devices:

- 51 TN Transformer neutral over-current protection
- 50/51 Inverse-time over current protection
- Transformer pressure-rise and gas detection device
- Transformer oil-level device (71 oil low protection).
- 87T Transformer differential Protection
- Restricted Earth Fault Protection (87 REF)

- Back-up Earth Fault Protection (51N)
- Online gas Analyser, oil and winding temperature devices and tap changer fault detection protection devices, etc.

14.5.6.3. Station Service Transformer Protection

The station service step down transformer will be protected by the following protection devices:

- 50/51 Inverse-time over current protection
- Thermal overload protection
- Buchholz relay
- 50/51 Inverse-time over current protection
- Transformer pressure-rise and gas detection device
- Transformer oil-level device (71 oil low protection).
- 87T Transformer differential Protection
- Restricted Earth Fault Protection (87 REF)
- Back-up Earth Fault Protection (51N)
- Online gas Analyser, oil and winding temperature devices and tap changer fault detection protection devices, etc.

14.5.6.4. 132kV Switchgear Protection

The protection of the 132 kV switchgear includes protection devices for the outgoing lines, the incoming feeders, bus section, Step down Transformer and bus bars briefly described as under (Ref. **Drawing No. TUHPP-388**):

Line Bays

The transmission line bays will be equipped with distance protection relays with at least three stages, over-voltage relays, disturbance recorders and distance fault locators. Inter-tripping and blocking will be carried out via a PLC (Power Line Carrier) link as well as through OPGW. Additionally, they will be equipped with three-phase auto re-closing devices suitable for 3-phase auto re-closing operation. Back-up protection will be provided by a directional earth-fault relay and an inverse-time over-current relay with definite-time earth-fault protection. The protection scheme will be closely co-ordinated with WAPDA/NTDC.

Transformer Feeder Bays

The Step up/step down transformer bays will be equipped with back-up over-current and earth-fault protection and with transformer voltage regulation and supervision.

Bus Section bay.

One three-phase over-current and one earth-fault protection will be provided to detect inter-phase and phase-to-ground faults.

Bus bars

A bus bar differential protection scheme with phase-segregated measurement will be provided for the 132 kV bus bars.

14.5.6.5. 11 kV Switchgear

Protection comprises 3-phase over-current- and earth-fault relays in the incoming feeders. The over-current relay will be of the inverse-time type with instantaneous tripping set at a high level. The relays will be installed in the relay compartment of the 11 kV panels.

14.5.6.6. 400 V 3-ø 4-wire Switchgear

Protection of the 400 V 3-ø 4-wire system will be provided by magnetic thermal trip units mounted on the circuit-breakers. Under-voltage relays on each busbar will supply the criteria for the automatic change-over device for the different supply sources.

14.5.7. Fire Detection and Fighting System

A decentralised fire alarm system with detection and release function will be provided for the entire power station and the corresponding galleries. The system will consist of one central unit (main fire alarm panel) supervising the sub-units located in the different areas of the cavern.

Fire-fighting systems for areas such as oil tanks, cable ways, cable spreading room, step up transformers, step down transformers and the main control room will be required.

14.5.8. Electrical Workshop and Laboratory

A suitably equipped workshop and laboratory for maintenance and repair of the electric and electronic equipment will be located in the power house.

14.5.9. Control and Monitoring System

14.5.9.1. General

For reliable, efficient and safe operation of the power station a monitoring and control system will be provided suitable for supervisory, control, status and monitoring of each individual unit as well as common equipment in the powerhouse, weir and power intake.

Due account shall be taken of the requirement for high system availability by implementing a functionally distributed and hierarchical structure, resulting in the following concept:

- The automation technology shall be distributed with decentralized systems and equipment. In this way, the impact of faults in one unit or in a component will be as small as possible.
- The availability structure of the I & C system must be matched to the power station structure. For example, control and signal loops for one unit shall be allocated to separate cubicles or equipment racks.
- Functionally hierarchical structure: In the event of failure of a supervisory level, it shall be possible for the operator, to intervene in the lower level(s) from the control room and also from the local operator panel. Individual open- and closed-loop functions

shall be implemented on the lowest automation level. These consist of software modules, which may be controlled optionally from the higher automation level and manually.

The control system will contain all functions needed for operating the entire hydropower plant, such as:

- Data acquisition and signal processing
- Plant control, unit control, group control, automatic equipment control
- Monitoring, annunciation
- Control and monitoring via VDUs
- Data archiving
- Communication bus
- Time synchronization with GPS-clock
- Diagnosis
- Engineering tools
- Complete system documentation.

The control system will be connected to the Process Stations using redundant serial automation busses (redundant data highway). For remote monitoring of the weir site and intake, an adequate communication link, using fibre-optics, e.g. ADSS cable (All-Dielectric Self-Supporting Aerial), between remote equipment and the power house will be used.

14.5.9.2. Operating and Monitoring Facilities

The station shall be operated from a Central Control Room (CCR) located in the powerhouse. Within the CCR, two operator's workstations with two monitors will be foreseen, from which the operator will supervise, operate and monitor the units. Also a further workstation will be provided with one monitor for engineering works at the system. The engineering workstation also will provide backup, in case of an operator workstation malfunctions. For hard copies printers (monochrome and colour) will be connected to the system. Printouts are output as required.

14.5.9.3. Local Control

In addition to the normal operation and monitoring from the CCR, operating panels (HMI – human-machine-interface) are also foreseen at each process station. These will be equipped with monitors, so permitting full operation and monitoring of the relevant unit or related components.

Local HMI will be provided for each of the following areas:

- 2 for the unit control systems (unit 1 to unit 2)
- 1 common
- common electrical systems
- common mechanical equipment

- emergency diesel set
- 132 kV, 11kV and 0.4KV switchgear
- 1 for the weir site installations (including power intake)

14.5.9.4. Process Stations

Individual PLC (Programmable Logic Controller) based control system will be used for each unit, for common systems and also for the weir site. Each PLC will contain all functions required for automatic operation of the assigned tasks, e. g.

- Signal processing (I/O level)
- Open- and closed-loop control
- Supervision
- Control and monitoring via local HMI
- Diagnosis
- Engineering tools
- Complete system documentation.

Complete manual control of all control system will be made possible from the local control cubicles (located next to the respective equipment) in case of failure of the control computer or for test and maintenance purposes. The system shall be able to perform all functions through standardized hardware and software modules. It shall be scalable to match the plant complexity.

The hardware shall be made up of a small number of different hardware modules, with these being replaceable during plant operation. The system shall be provided with interfaces to commonly used field bus and remote I/O systems.

14.5.10. Metering Panels

For the monitoring of the power generation and power transmission a metering system using fully static energy meters and energy recorders will be provided. For the metering and billing of each of the outgoing lines, one main and one back-up energy meter with accuracy of 0.1 will be foreseen.

14.5.11. Telecommunication System

The entire power station will be equipped with a telephone system consisting of a main exchange. This system will take over the internal and external telephone traffic of the power station area. The system will enable the telephone communication for at least 40 internal subscribes and 5 external lines via OPGW.

An OPGW (optical ground wire) via the transmission line will be installed for a communication link with a grid dispatch centre, remote ends grid stations and for the transmission line protection and for DCS control communication with the process stations at dam site and de-sander cavern. The system will be used for data transmission as SCADA system. The system will allow telecommunication from the telephone extension via the telephone system and to the dispatch centre and the telephone network and vice versa.

14.5.12. Electrical Equipment for power supply at weir site

14.5.12.1. General

The power supply at the weir site, including the weir control building and the power intake, will be made through 11 kV Feeder on Osprey Conductor with OPGW wire from the TUHPP 11kV bus bar as shown in **Drawing No. TUHPP-382**.

The following equipment will be foreseen at weir site:

- One 11 kV incoming panel with one spare panel
- One 11kV Panel for 2MW HPP
- One 11kV outgoing panel to Turtonas village
- Two transformers 11/0.4 kV, 200 kVA minimum.
- One synchronous 400 V emergency diesel generator set 150 kVA minimum.
- One redundant 100% UPS systems, battery backed-up (mainly for local DCS control)
- One DCS (connected via fibre-optic cable to the TUHPP main DCS).
- Communication/Telephone system via OPGW.
- One 400V 3-ø 4-wire Switchgear.
- Small power and lighting.
- Lightning protection.
- Grounding mesh and equipment Grounding.

14.5.12.2. 11 kV Switchgear

The 11 kV switchgear will be located within weir control building. The 11 kV indoor switchgear will be of the steel enclosed type and will comply with the requirements of latest edition of IEC. The switchgear will be complete with vacuum circuit-breakers, dry-type instrument transformers, earthing arrangements, instruments and protective relays.

The technical characteristics of the 11 kV switchgear will be as follows:

Maximum operation voltage	12 kV
Rated power frequency withstand voltage	28 kV (rms value) x factor as per IEC for height more than 1000 meter from sea level
Rated lighting impulse withstand voltage	95 kV (peak) x factor as per IEC for height more than 1000 meter from sea level
Rated short-circuit breaking current	25 kA for 1 second
Rated current for bus bars and feeders	1250 A
Space heater	Yes

14.5.12.3.11/0.4 kV Transformers

Two three-phase transformers will be provided for the weir site auxiliary supply. The rating of each transformer will be 200 kVA, which will be suitable to feed weir site power demand. The voltage ratio will be 11 / 0.4 kV. The transformer will be provided with an off-load tap-selector having a range from -5% to +5%, in steps of 2.5%. The cooling type of the transformer will be ONAN. The 11kV terminals will be suitable for the connection of 11 kV XLPE cable. To facilitate the movement of the transformer during installation, swivel type wheels will be provided.

14.5.13. Power Evacuation Scheme

The volume of power generated by the plant shall be in the range of 80-85MW, Net power to be transferred to the nearest connection point has been considered equal to 80MW at 132kV voltage level. The nearest 132kV switchyard is at 108MW Golan Gol HPP which is about 5 km and second nearest 132kV grid station is Jutilash which is about 30-35 km from Turtonas-Uzghor HEPP. Keeping in view the difference in length of transmission line and associated cost along with other disadvantages, it is decided that 132kV TL (D/C) shall be connected at Golan Gol HPP switchyard or to its outgoing 132kV TL through In/Out connections. The physical route of the TL has been shown in **Drawing No.TUHPP-385**.

Double circuit TL either with Lynx or Rail conductor is considered the most suitable solution for power evacuation to account for n-1 contingency. In case of a fault on one circuit, other single circuit with rail conductor having 800 A capacity shall have enough margin in thermal loading (MVA). On the other hand, if Lynx conductor is used it may pose sag problem in case of power flow through single circuit while second circuit is not available due to fault on it.

OPGW shall be provided up to both remote ends grid stations. Cores of OPGW shall be 48 minimum. Fiber Optic Terminal Equipment (FOTE) and connections with equipment shall be provided at local and also at both remote ends. Testing of OPGW shall be required after installation and splicing.

14.5.14. Interconnection Options

After deciding the interconnection of the power plant with the existing power network of Golan Gol HPP, evacuation of power through 132 kV TL (D/C) on rail conductor with various options shown in **Drawing No. TUHPP-384** is briefly described as under:

Option 1:

In/Out arrangement of one circuit of outgoing TL (D/C) from Golan GOL HPP is the best option due to its merits. The option is most economical as it involves no circuit breakers and allied electrical equipment at Golan GOL HPP.

Option 2:

Connection of both the outgoing circuits of TUHEPP at Golan Gol HPP existing switchyard by its extension is also the preferable choice from technical point of view. However, it involves more capital cost as it needs extension of the existing 132kV switchyard.

Option 3:

In/out of both the circuits of Golan Gol HPP at 82MW TUHEPP is 3rd option which is technically viable but involves more capital cost and power losses.

Based on the option 1, a complete scheme of TL delivering the power to Chitral, Dir and Chakdara 132kV Grid stations has been developed and shown in **Drawing No. TUHPP-383 & 385**. The existing 132kV (D/C) TL on Rail conductor shall be capable for evacuation of power if it is interconnected at various towns as shown in the said drawing.

CHAPTER - 15

HYDROPOWER GENERATION AND SIMULATION STUDIES

CHAPTER: 15

HYDROPOWER GENERATION AND SIMULATION STUDIES

15.1. Introduction

Real benefits of a Hydro Electric Power Project would come from the sale of energy generated by it, in addition to other benefits such as employment generation, domestic resource development, strategic, renewable, environment friendly, etc. Therefore, estimation of energy and power potential was the main task in this chapter and being elaborated in details, considering all possible options available to choose the economical best head, discharge and by selecting most suitable turbine /gear/generator option. The modelling has been undertaken using the standard methodology adopted for other hydropower plants. The power and energy generation and reliability studies have been undertaken using an in-house computer based energy model.

Power and energy calculations have been carried out by using the following formulae:

POWER

$$P = Q \times H \times g \times h / 1000$$

Where

P	=	Power (MW)
Q	=	Discharge (m^3/s)
H	=	Available net head (m)
g	=	Acceleration due to gravity (9.81 m/sec^2)
h	=	Efficiency coefficient (%) (Turbine, Generator and Transformer)

ENERGY

$$E = P \times T$$

Where

E	=	Energy (GWh)
P	=	Power (MW)
T	=	Time (hour)

15.2. Methodology and Basic Parameters

Layout and design of the project has been based on the following parameters:

• Normal Operation Level	=	2582.0	m.a.s.l
• Turbine centreline Level	=	2087.90	m.a.s.l
• Powerhouse Design Discharge	=	20	m^3/s
• Gross Head H max	=	494.1	m
• Net Head	=	477.1	m

Simulation of hydropower plant operation and the corresponding energy calculations were based on daily flow data of the available records of 52 years of Chitral gauging station which were extrapolated at Turtonas-Uzghor HEPP diversion weir site by catchment area correlation method.

The calculation of the available gross head for power generation takes into account the head pond level at diversion weir site and the turbine centreline level at the powerhouse outlet. The net head was determined deducting the head losses of the power waterway system from the gross head applying the head loss characteristics. The available power and energy generation were simulated applying the efficiency of the turbine units, generator and transformer.

Moreover, the calculation has been carried out by considering the project as a run-of-the-river scheme.

15.3. Analysis of Hydrological Data Base

15.3.1. Hydrographic Analysis

A detailed analysis of the hydrological data base was carried out and established a series of daily river flows at the diversion weir site (**Chapter: 6 and for details Appendix: C**). Minimum River flows occur in the period from November to March while river flow normally exceeds the design discharge (20 m^3/s) from May to October.

The mean annual flow for 51 years has been estimated as 14.7 m^3/s. The maximum mean annual flow was available in year 2015 as 21.3 m^3/sec and the minimum mean annual flow has been observed in year 2001 as 10.2 m^3/sec.

The mean annual flows at the Project weir site are presented below (**Figure: 15.1**).

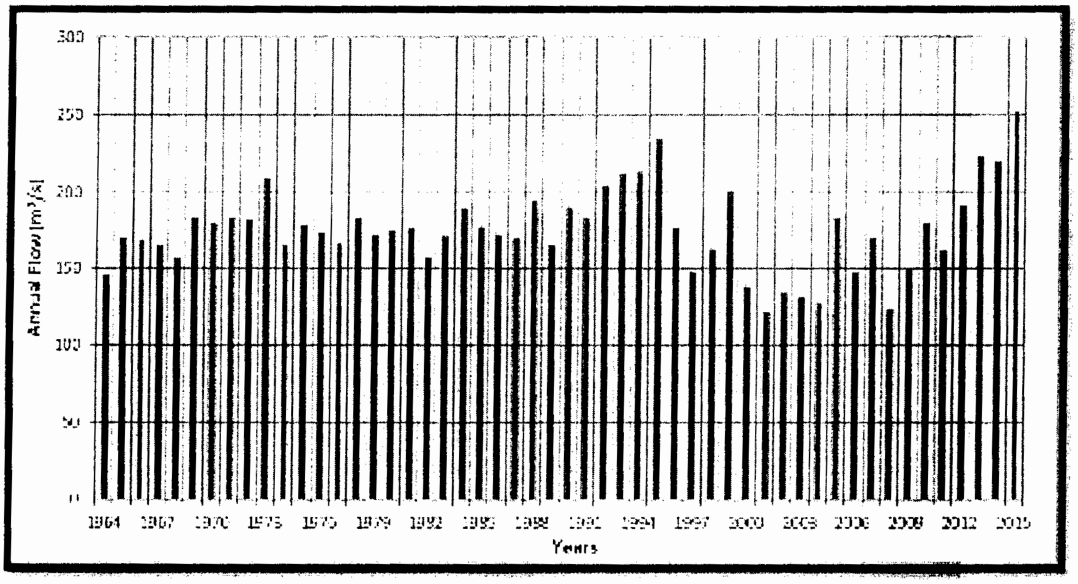


Figure: 15.1 Annual water availability at the Turtonas-Uzghor project site

The mean monthly flows range from 6.9 m^3/s to 32 m^3/s in **Figure: 15.2** which shows seasonality in the flow from October to March in dry period and April to September in Wet Period.

The mean monthly flows at the Project weir site are presented below (**Figure: 15.2**):

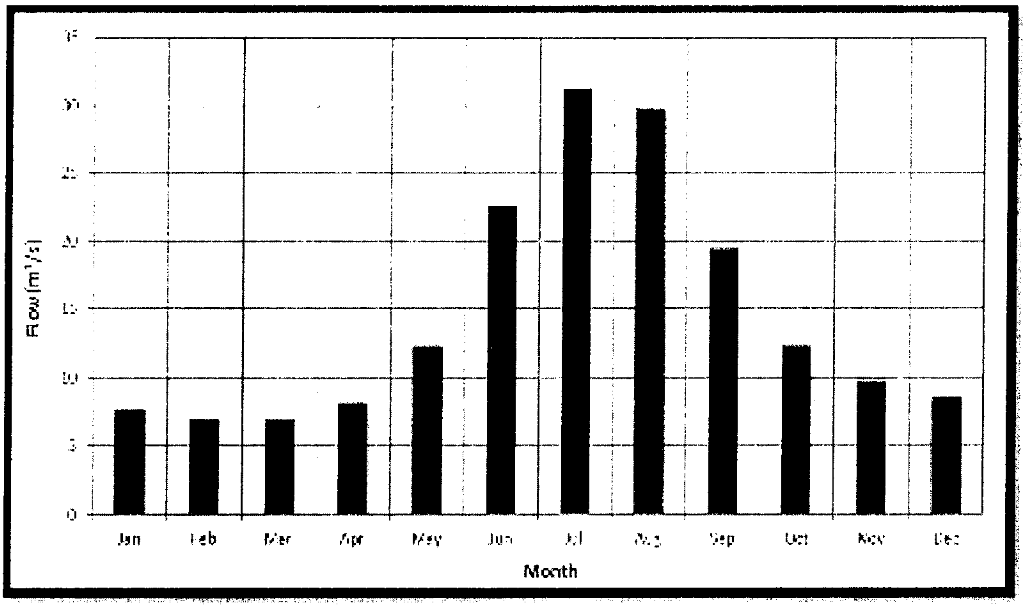


Figure: 15.2 Mean Monthly Flows at Turtonas-Uzghor Weir Site (1964 – 2015)

15.3.2. Flow Duration Curve

A flow-duration curve (FDC) represents the relationship between the magnitude and frequency of daily, weekly, monthly (or some other time interval of) stream flow for a particular river basin, providing an estimate of the percentage of time a given stream flow was equaled or exceeded over a historical period. The flow duration curve is calculated using the daily flows available at the project site continuously for the whole period (1964-2015). The flow duration curves for the year (1964-2015) and the wet year (2015) have also been plotted and shown in below **Figure: 15.3.**

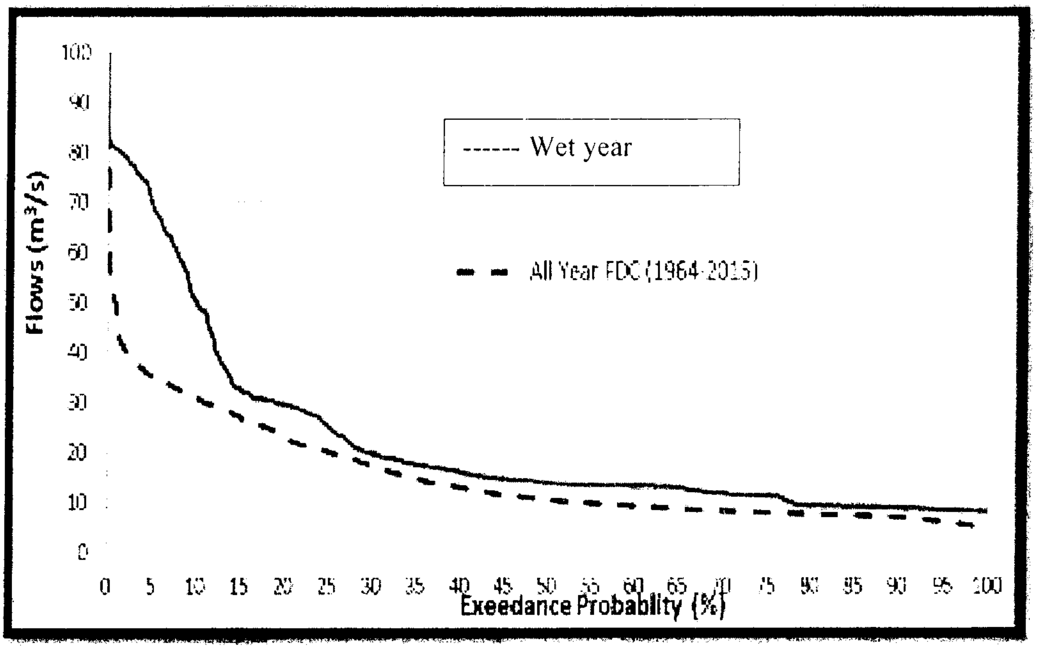


Figure: 15.3 Flow Duration Curve at Turtonas-Uzghor Weir Site (1964 – 2015)

15.3.3. Environmental Flow

A certain part of river flow may not be used for energy generation. An ecological minimum flow need to remain in the river bed downstream of the diversion weir. A fixed minimum ecological flow of 2.5 m^3/sec shall be released during period when discharge in the river are less than design discharge of the plant and they were taken into account in calculation of the potential energy generation.

The ecologically minimum flows in Golen Gol River constitute the releases at the diversion weir site, the inflows of the right bank tributary and the left bank tributary located downstream of diversion weir and before tailrace of proposed powerhouse. This ecological flow will meet the operational requirement of Birmogh Small Hydropower Project and also minimum flow downstream of diversion weir of Birmogh SHPP.

15.3.4. Tail Water Rating Curve

The tail water rating curve developed at the weir and powerhouse site is presented below in **Figure: 15.4** and **Figure: 15.5, 4** respectively. These rating curve were developed by use computer and river cross section measured during hydrographic survey at weir and powerhouse site. About 15 river cross-section were observed at weir site while ten cross section at powerhouse site. The bed level of Golen Gol at confluence of tailrace is 2070 masl.

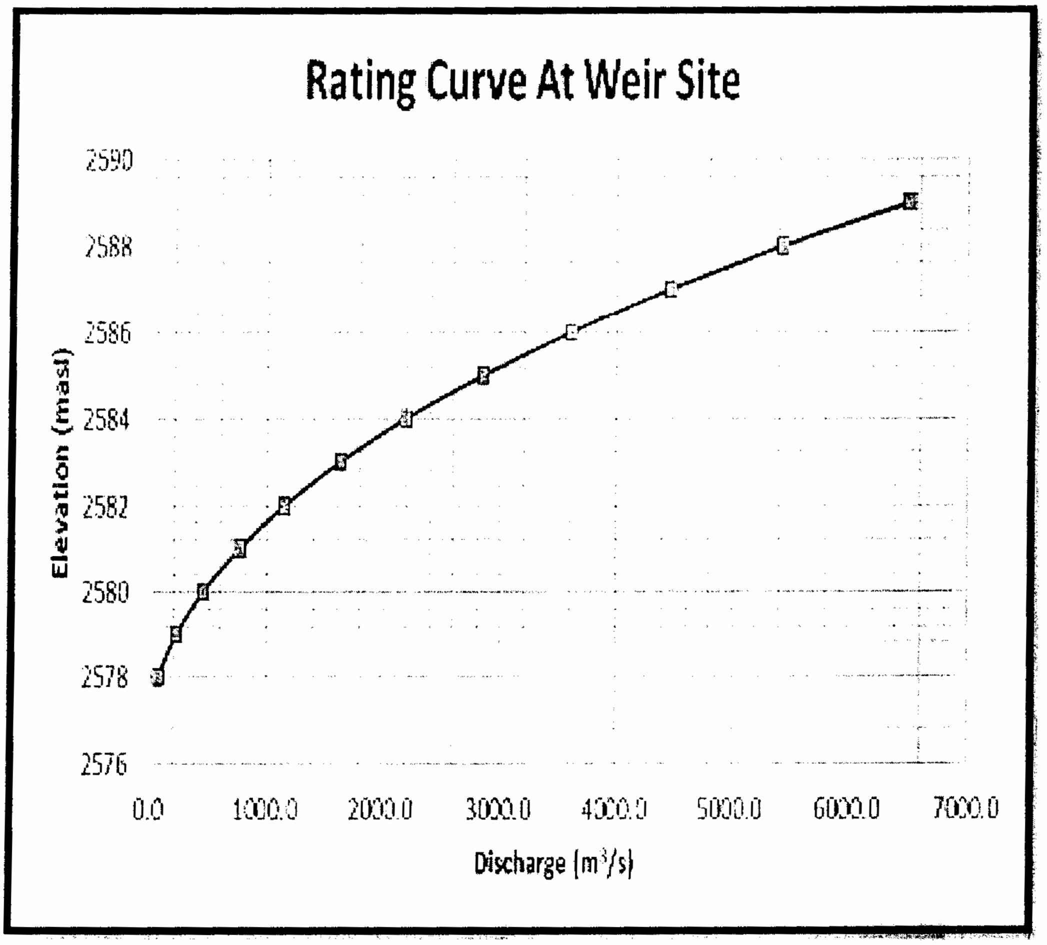


Figure: 15.4 Tail Water Rating Curve at Weir Site

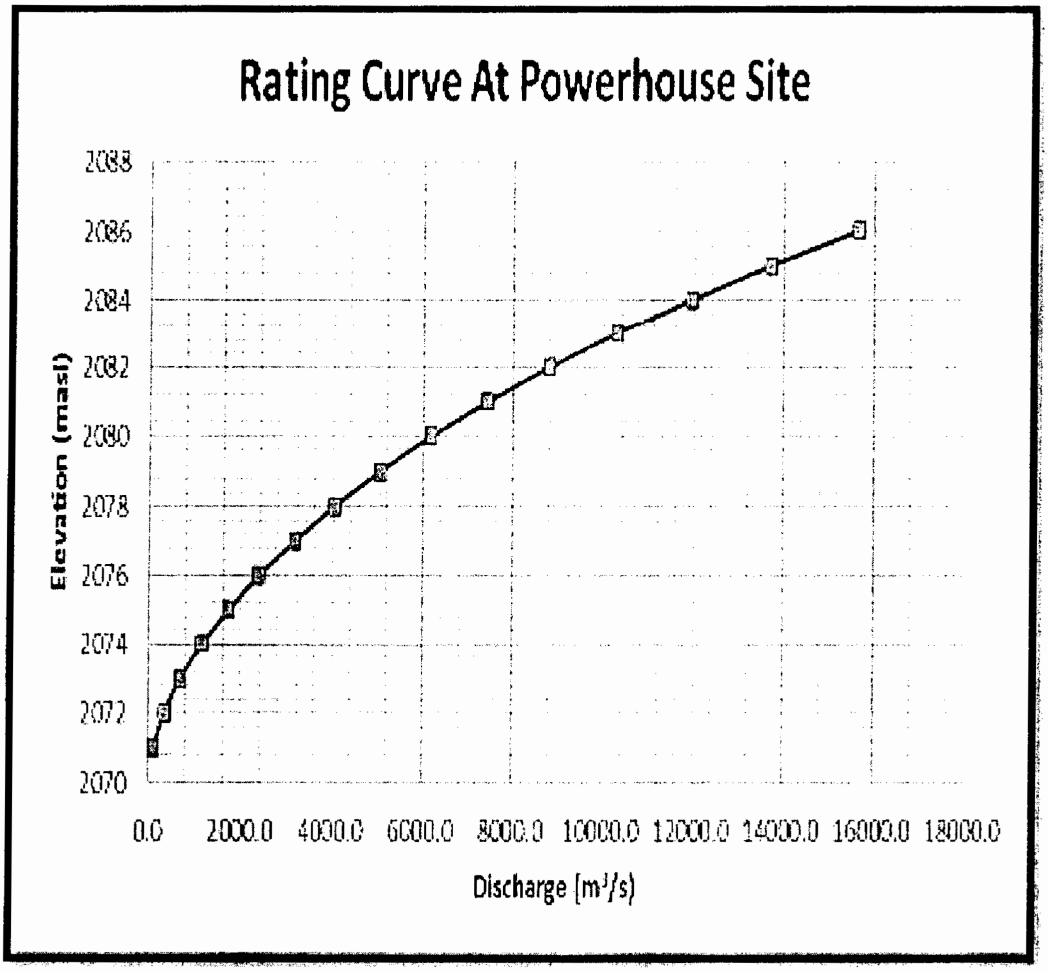


Figure: 15.5 Tail Water Rating Curve at Powerhouse Site

15.3.5. Head Loss Calculation

The non- recoverable losses through the system at full generating output will comprise minor losses resulting from the various flow transitions that will occur at key features and major losses are friction losses in the headrace tunnel and steel penstock. The frictional loss in the headrace tunnel and steel penstock has been calculated using Darcy-Weisbach approach by assuming the absolute roughness values 0.6 mm.

The following form of losses considered in the power waterways:

- Trash screens
- Intake entrance
- Contraction
- Gate slot
- Dividing flow
- Bends
- Valve, etc.

The total non-recoverable head loss through the power system at full output will be in the order of:

Table: 15.1 Head Loss in Waterways

#	Head Losses in Structure	Head Loss (m)
1	Connecting Channels	0.4
2	Sedimentation Basin	0.004
3	Headrace Tunnel	6.6
4	Pressure Tunnel /Penstock	6.56
5	Penstock - Manifolds	3.45
	Total	**17.014**

For the power waterway system, a maximum head loss of 17.01 m was determined at turbine design discharge of two units at design head. Head loss for discharges smaller than the design discharge was consequently reduced. The detailed head loss calculations are provided in **Annexure: 15.1**.

15.4. Arrangement of Turbine Units

Based on the analysis of the hydrological data base, two (2) identical Pelton units (2x10 m^3/s) have been selected. Therefore, corresponding electro-mechanical design of the following key parameters were considered in the simulation of hydropower plant operation and the corresponding estimation of annual energy generation. The optimum powerhouse design discharge for the Turtonas-Uzghor Hydro Electric Power Project (the "Project") is determined as 20 m^3/s.

E&M key parameters:

- Design Discharge = 20 m^3/s
- Unit Design Discharge = 10 m^3/s
- Design Net Head = 477.1 m
- Installed Power Capacity = 82.25 MW
- Unit Capacity = 41.125 MW
- Turbine efficiency for energy calculation = 91.5 %
- Minimum Turbine Flow = 15 % of Rated Discharge
- Turbine centreline Level = 2087.90 m.a.s. l

Constant generator and transformer efficiencies of 97 % and 99 % were assumed and used correspondingly.

15.5. Energy Model

An in-house computer-based energy model has been used for the power and energy studies. The model has been used to undertake the power and energy studies for the full period of record using the available data.

- Inflow data - 51 years (1964-2015) daily & monthly flow record.

- Tailwater rating curve at Powerhouse Site
- Hydraulic characteristics of the power waterways i.e. head loss.
- Minimum environmental release / compensation flow.
- Characteristics of generating units i.e. unit's capacity at rated head, efficiency, maximum unit output, etc.
- Water level in the surge tank
- Minimum turbine flow
- Turbine centreline elevation

The modelling tool creates a wide range of results which are presented as a time series of:

- Inflow (m^3/s).
- Net generating head (m).
- Discharge of the powerhouse / turbine flow (m^3/s).
- Spill (m^3/s).
- Generated power (MW).
- Energy production (GWh).
- Plant factor (%)

15.6. Annual Energy Generation

The annual energy generation each year for design discharge of 20 m^3/s for the period 1964-2015 is presented graphically in **Figure: 15.6.**

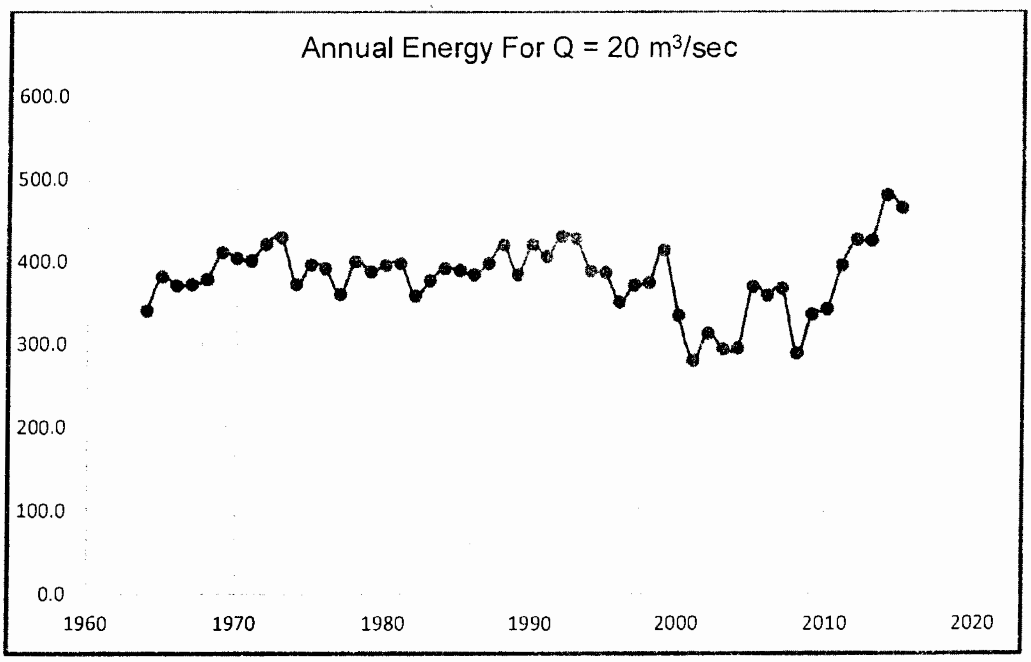


Figure: 15.6 Annual Average Energy for Q = 20 m^3/sec

The annual energy generation varies between 349.03 GWh and 395.41 GWh. The mean energy generation shall be 382.33 GWh for plant has design discharge of 20 m^3/s.

The minimum, maximum and average monthly energy generations have been presented in **Table: 15.2** and graphically in **Figure: 15.7**.

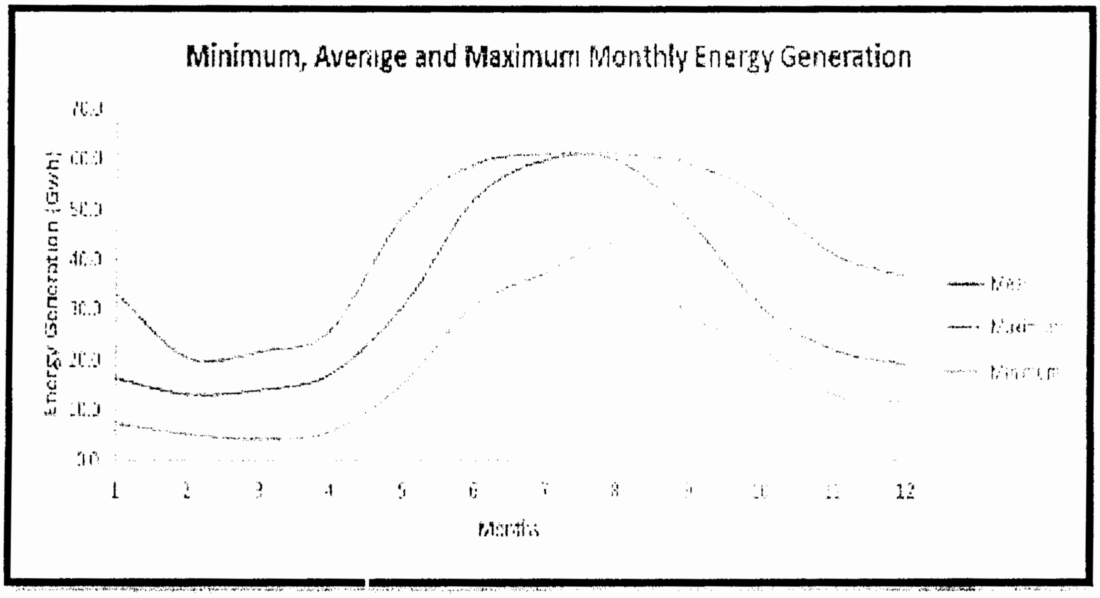


Figure: 15.7 Minimum, Average and Maximum Monthly Energy Generation

Table: 15.2 Minimum, Average and Maximum Monthly Energy Generation

Month	Mean	Maximum	Minimum
January	16.3	33.2	7.2
February	13.1	20.4	5.1
March	13.9	21.7	4.1
April	17.1	26.0	5.7
May	30.6	48.8	15.0
June	52.4	59.2	30.9
July	60.0	61.2	37.4
Aug	59.33	61.2	43.2
September	48.0	59.2	29.1
October	30.6	52.6	22.0
November	22.0	41.1	13.1
December	19.0	36.7	11.3
Total	**382.33**	**521.2**	**224.0**

The monthly average, minimum and maximum power generation for the design discharge of 20.0 m^3/s for the period 1964-2015 is presented graphically in **Figure: 15.8.**

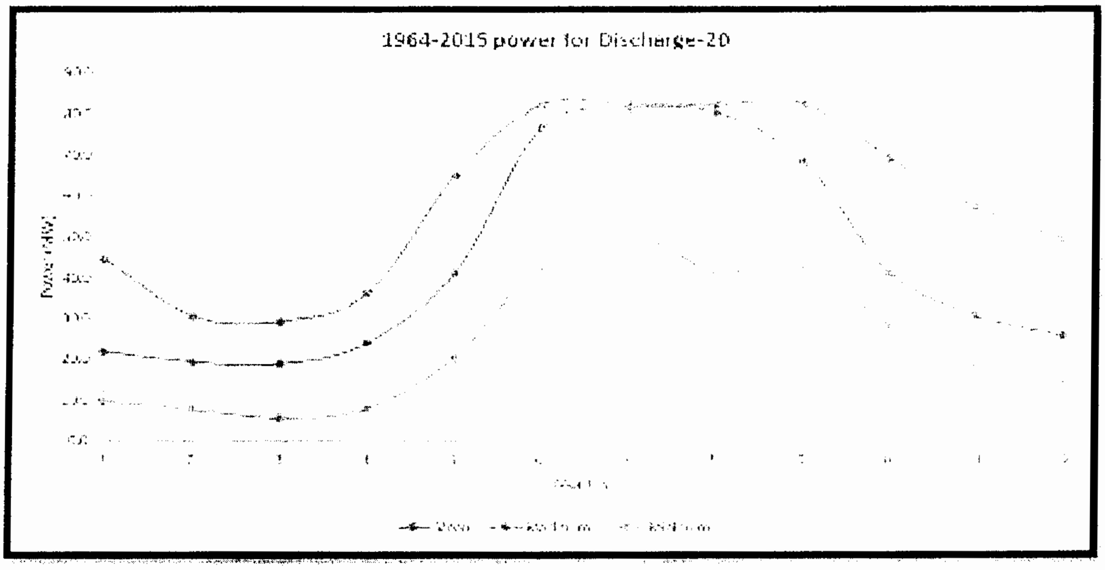


Figure: 15.8 Minimum, Average and Maximum Monthly Power Generation

The exceedance curve for the net generating head is also prepared after processing the 50 years monthly energy simulation results and shown in **Figure: 15.9**. The below figure shows that there will be minimum net head of approximately 477.1 m which is available about 32% of the time in a year while remaining 68% of time in a year varies between 477.1 to 491.5 m.

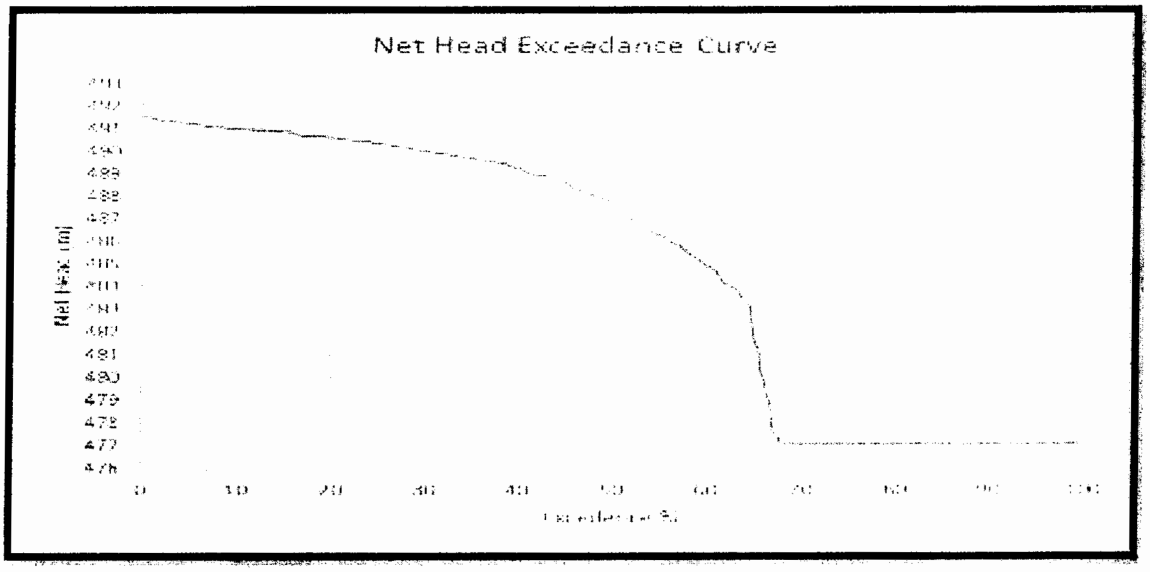


Figure: 15.9 Net Head Exceedance Curve

15.7. Interpretation of Results and Recommendation

The power output varies with the plant discharge. A power output of 82.25 MW shall be generated for design discharge of 20 m^3/s and mean annual energy generation will be 382.33 GWh. This will be available at net head of 477.1 m and 491.5 m. Total head loss at maximum discharge is 17.01 m. The efficiency of turbine, generator and transformer are 91.5%, 97%, 99%, respectively.

Annexure: 15.1 Detailed Head Loss Calculations

A	**Connecting Channels**			
	i	Bed level at U/S End	2578.000	m
	ii	Water level at U/S End	2582.000	m
	iii	Length	400.000	m
	iv	Slope	1 in 1000	
	v	Losses		
		a Friction Head Losses	0.400	m
		c Total Head Loss	0.400	m
	vi	Bed Level at D/S End	2577.600	m
	vii	Water level at D/S End	2581.600	m
B	**Sedimentation Basin**			
	i	Water level at U/S End	2581.600	m
	ii	Losses		
		a Friction Head Losses	0.0002	m
		b Transition Losses	0.004	m
		c Total Head loss	0.0045	m
	iii	Water level at D/S End	2581.595	m
C	**Headrace Tunnel**			
	i	Water level at U/S End with Q=8.0 Cumecs	2581.595	m
	ii	Length	4837.060	m
	iv	**Losses**		
		a Friction Head Losses	6.552	m
		b Bends Losses (03 Bends)	0.040	m
		c Entrance Losses	0.020	m
		d Gate Slot Losses	0.001	m
		e Trash Rack Losses	0.001	m
		d Total Head Loss	6.614	m
	v	Water level at D/S End (Hyd. Grade Line)	2574.981	m
D	**Surge Shaft**			
	i	Max. Surge Level	1022.735	m
	ii	Min Surge Level	996.863	m
	iii	Tunnel Length	4837.060	m
	iv	Total Head Loss in Tunnel	6.614	m
E	**Pressure Tunnel/Penstock**			
	i	Water level at U/S End (Hyd. Grade Line)	2574.981	m
	ii	Length	791.280	m
	iii	Losses		
		a Frction Head Losses	5.988	m
		b Bends Losses	0.198	m
		c Contraction Losses	0.251	m
		d Intrance Losses	0.132	m
		e Total Head Loss	6.570	m
	iv	Water level at D/S End (Hyd. Grade Line)	2568.411	m
F	**Penstock-Manifold (Bifurcation)**			
	i	Water level at U/S End (Hyd. Grade Line)	2568.411	m
	ii	Length	25.000	m
	iii	Losses		
		a Frction Head Losses	0.678	m
		b Entrance Losses	0.255	m
		c Bends Losses	0.485	m
		d Contraction Losses	0.893	m
		e Valve Losses	0.638	m
		f Manifold Losses	0.510	m
		g Total Head Loss	3.458	m
	iv	Water level at D/S End (Hyd. Grade Line)	2564.953	m
Summary				
G	**Total Head Losses**		17.0	m

CHAPTER - 16

PROJECT COSTING AND BUDGETING

Chapter: 16

PROJECT COSTING AND BUDGETING

16.1. Introduction

The cost for Civil works as well as procurement of Electro-mechanical equipment, Transportation, Erection, Testing and Commissioning have to be estimated. Cost of temporary facilities during construction, their running and maintenance, land acquisition & resettlement have also to be worked out. The cost related to engineering, administration, financial and legal for preparation of project during financial close and project construction have to be assessed properly. Similarly, the Interest during construction (IDC), Taxes & duties, Physical (if any) and Price Contingencies (Escalation) have to be estimated to arrive at a realist total project cost.

A number of cost estimation methods are available in the market which are very effective provided all required information are available. For example, the "unit price" basis is excellent, provided that unit prices of all items are analyzed properly.

Very important method of cost estimation is to use competitive bid prices from Consultant's data bank of the similar projects. However, it is not always possible to directly use these prices due to several reasons such as the different locations, sizes and type of projects and the time, the competitive bids are received. A combination of the above methods supplemented by engineering judgment and proper rate analysis is the only choice that would result in a realistic cost estimate.

Estimation of cost is one of the challenging job amongst the other studies required at the feasibility stage. The difficulties stem from numerous factors, some of which are unpredictable such as the rapidly changing market prices of various materials, equipment, inflation, foreign exchange rates, price escalation, etc. Therefore, estimation of quantities and cost have undertaken with due care.

16.2. Project Structures

Turtonas-Uzghor Hydro Electric Power Project (the "Project") is located on Golen Gol Nullah, a left bank tributary of Mastuj River in District Chitral, Khyber Pakhtunkhwa (KPK) Province. The project shall have a provisional capacity of 82.25 MW and will generate about 382.33 GWh of energy annually. The project is run-of-river and its layout is along right bank of Golen Gol with associated facilities/structure are:

- Diversion Weir Structure near Turtonas village
- Lateral Intake Structure along Right Bank of Diversion Weir
- Connecting Canal between Sand Trap and Lateral Intake along with spilling section and canal
- Sand trap and Flushing and Spilling Canal
- Connecting canal between Tunnel Portal and San Trap
- Headrace tunnels
- Surge Tank
- Pressure Shaft
- Pressure Tunnel
- Open Powerhouse

- Tailrace as Open Channel
- Access roads and Bridges required for construction and operation of the Project
- Residential camps for Operation and Maintenance Staff

The project makes use of Golen Gol River flow which falls in an established river system. It will not change the water flow characteristics and hydrological regime of the area.

16.3. Basis of Cost Estimation

All costs presented are from July 2018 without allowances for subsequent cost escalation. The civil works quantities such as Concrete, Excavation of Soil and Rock, Reinforcement, Drilling and Grouting, Rock Support, Roads, Pavement, etc. have been estimated based on engineering design drawings consisting of plans and sections of all structures of the project, based on the topographic survey and data from the geo-technical investigation.

The cost estimates for Turtonas-Uzghor Hydro Electric Power Project are based on the following suppositions:

- An EPC Contractor will be responsible for project completion including engineering design, environmental and resettlement consideration, procurement of civil works material & civil works construction, procurement of E&M equipment, transportation, insurance, erection, testing, commissioning and leading to commercial operation.
- Prior to tendering and contracting, Sponsor shall complete i) feasibility approval, ii) EPA approval, iii) Interconnection approval, iv) tariff approval, v) consents, vi) land acquisition, vii) environmental compensations, viii) financial commitments, ix) detailed engineering design and bidding documents. Completion of all of the above are necessary to reduce cost risks which may be included by bidders in the bid prices.
- The FIDIC contract conditions of "Engineering, Procurement & Construction/ Commissioning" on Turnkey Basis (EPC/T) will be used by SINOHYDRO-SACHAL CONSORTIUM for construction of Turtornas-Uzghor Hydro Electric Power Project. The EPC/Turnkey contract under FIDIC has its own implications with respect to obligations and risks of each party. The rate analysis and project cost has been estimated keeping in view the implications of the EPC/Turnkey contract conditions under FIDIC.

16.3.1. Elaboration of Unit Rate

Unit rates have been elaborated for all major work items, including cost of labor, operational cost of construction equipment, cost of materials (concrete, wood, fuel, etc.), cost of contractor overhead and contractor profit cost. Unit rates are selected from the latest bided project (e.g., DASU HPP, Suki Kinari HPP, etc.) of the same nature and further cost is escalated up to 10 % for future cushion as a contingency plan considering rapidly growing inflation.

Similarly, the quantities have been calculated for all major work items by using Drawing prepared during Draft Feasibility Study Report and quantities of minor items have been estimated by using an allowance ranging from 5 to 10% depending upon the degree of take-off details which will help to compensate the cost of several unforeseen minor items.

16.3.2. Indirect Expenses

The indirect expenses include expenses of the guarantees, contractor's taxes on civil works (7%), and contractor's home office over heads, profits and contingencies. All of these indirect costs have been taken into account, for rate analysis. However, no tax including withholding tax and duties have been assumed on the import of plant equipment, machinery and hydraulic steel structures of the project.

16.3.3. Construction Schedule

A realistic construction schedule indicating the milestones of the project has been prepared to define the "time related" indirect costs. It is also important to decide the methodology for execution and rates of production of the principal items of the works against the allocated time to the tasks.

16.3.4. Bid Factor

"Bid Factor" has been assessed to convert the "direct cost unit rates" into "unit prices" for estimation. In the projects of complex nature like hydroelectric projects, it may vary 15% to 60% depending upon the indirect costs. The indirect costs, other than the usual components, also depend upon many factors such as location of the project and geo-political situation of the area, contract conditions and associated risks, the cost for mobilization and administrative personnel, the cost of contractors interest during construction, the type of financing and duration of the project, etc.

16.3.5. Currency Break-Down

Currency Break-down has also been made to assess the local and foreign currency costs requirement so that FEC could be arranged, to assess the price escalation in both the currencies and overall impact on completion costs of the project due to price adjustments. The 85% cost of civil work of the total is local currency remaining 15% is foreign currency, cost of M&E equipment is 80% of the total is Foreign currency and remaining 20% is local currency and 70% cost of Hydraulic steel works is foreign currency and remaining 30% is local currency. It is mentioned that at Feasibility level foreign currency is taken in US$. However, during tendering and contracting stage, a decision about which foreign currency be mentioned in the bidding document is must.

16.4. Estimation of the Direct Project Cost

The direct costs of a hydropower project are estimated separated for the following major components based on the major items/elements.

a) Civil works;
b) Electro-Mechanical Equipment
c) Mechanical and hydraulic steel
d) Preliminary Works (Mobilization/De-mobilization)
e) Environment/Social and Mitigation
f) Transportation and Erection Charges
g) EPC Engineering Cost
h) Client Cost

Detail of Cost Estimation of each component is attached in **Table: 16.2** while summary is attached as **Table: 16.1.**

16.4.1. Estimation of Civil Works

Quantities of each civil work were prepared on the basis of drawings in the form of plan, sections and cross-sections which were prepared on the basis of hydraulic, geo-technical and structural design and placed in **Volume: VII (Appendix:F)**. A detailed cost estimates for the civil works have been prepared on the basis of rate analysis and detailed quantities. The quantities and costs have been estimated for Diversion Weir, sediment basin, waterway, Powerhouse and other structures and associated works, which include:

- Diversion Weir
- Lateral Intake
- Under sluice
- Sediment Basin
- Connecting Canals
- Headrace Tunnel
- Pressure Tunnel/Shaft
- Surge Tank
- Powerhouse and Tailrace
- Preliminary Works (contractor camps, construction yard & Mobilization)
- O&M Staff Residential Colony
- Environment/Social & Mitigation Costs

The quantities of excavation, backfilling and compaction, concrete including formwork, reinforcement and stone pitching and gabion, dewatering, etc, based on engineering design made for this feasibility study have been estimated. The unit rates were established as defined above, were used for preparation of cost estimate. Residences and offices will be constructed and for cost estimation 7530 ft^2 is considered as covered area. PKR 6106 per ft^2 has been considered for construction and furnishing.

16.4.2. Electro-mechanical Equipment Cost

List along with quantity of electro-mechanical equipment's required on the basis of design has been prepared. It is understood that the Electro-mechanical equipments have several sub components and devices, the cost of major assemblies is only determined which is deemed to include, the costs of all related components, devices and sub-systems, although the same are not mentioned explicitly. However, in several cases, the costs of individual components were taken and then the cost of the complete assembly was determined taking into account the installation, wiring and construction details, as applicable.

16.4.3. Hydraulic Steel Structure Equipment Cost

Equipment costs were estimated based on the cost of material which will be prepared internationally and assemblling/ fabrication will be done at site. Similarly, Cost will be changed corresponding. As per General Engineering Practice 70% of the total cost will be considered material manufacturing cost and remaining 30% will be assembling/ fabrication Cost.

16.4.4. Preliminary works (Mobilization /De-Mobilization)

After the award of EPC-contract, as per general engineering practice, 10% of the civil works cost mobiliaztion charges will be paid to EPC-Contractor, which helps contractor to transport construction equipemnte, to construct the contractor's camp, temperary access road, purchasing of equipment, intsallation of plants, etc:

16.4.5. Environment/ Social Impact and Mitigation

Land acquisition, environmental and social impact and its mitigation cost plays a vital role in project cost. Cost of Land acqisition for permanent structures and lease out cost for temporary structures is determined through a detailed survey of project area. Cost of social impact mitigation is also determined.

16.4.6. Transportation/ Shipment and Erection Charges

Transportation/Shipment and installation charges includes cost of inland transportation, insurance, erection, testing and commissioning. A suitable 9% of the net cost of the electro-mechanical, electrical equipment and hydraulic steel structure has been taken.

16.4.7. Engineering Cost of EPC

The engineering cost for EPC has been estimated 4 % of the cost of civil works, E&M works, preliminary and environment has been taken into account of engineering works.

16.5. Estimation of the Indirect-Direct Project Cost

16.5.1. Client and Engineering and Supervision

Engineering and supervision cost has been included at rate of 3% of cost of civil works, E&M works, preliminary and environment as the Engineering, Procurement & Construction (EPC) works cost. This includes costs for foreign and local consultants to do further site investigations, the tender design and preparation of tender documents and supervision of the construction work. The contract administration and quality control including checking of design prepared by the EPC Contractor would be the responsibility of the Project Consultants. This cost also include cost of the Client office.

16.5.2. Independent Engineer

The cost of Client required for hiring an independent engineer is considered, a suitable rate 0.5% of cost of Engineering, Procurement & Construction (EPC) Works is included in the project. This Engineering firm will help in handing over the project and its equipment to the Client from EPC Contractor.

16.5.3. Legal Advisor Fee

As defined in pre-construction phase, preparation of security document (power purchase agreement, implementation agreement and water use agreement) and their negotiation is more legal than engineering. Therefore, to cover the cost of the legal 1 % of cost of EPC works has been taken into consideration.

16.5.4. Financial Advisor Fees

As defined in pre-construction phase arrangement of financing, documentation and their negotiation is the responsibility of a financing advisor. Therefore, to cover the cost of the financing advisor 1 % of Engineering, Procurement & Construction (EPC) Works cost has been taken into consideration.

16.5.5. Pre-construction Expenses

The Client costs and expenditure incurred during the pre-construction phase was estimated to count for expenses during issuance of LOI, feasibility study, LOS, financial closing, etc. 14 % of Engineering, Procurement & Construction (EPC works is estimated and included in the project base cost. However, at time of tariff petition submission the actual expenditure would be made part of the base cost.

16.5.6. Import and Other Charges

Customs duty at the rate of 5% on the import of plant and equipment not manufactured locally has been taken as per policy. The cost is taken as local cost.

16.5.7. Lenders Financial Fees and Charges

Debt equity ratio of the project is 80:20. Lenders Financial fees and charges are taken at the rate of 2.5% of the debt cost.

16.6. Disbursement of Costs – Cash Flow

Based on its experience, the Consultant elaborated a Project cash flow for the construction period to achieve an adequate disbursement of costs and the corresponding estimation of interest during construction shown in **Table 16.3**.

As a conservative estimate an advance payment of 10% is assumed for the civil contractor. Further payments are nearly constant since major part of construction activities are underground works with rather constant production rates which are not affected by climatic conditions. A certain variation of the progress of work and the corresponding cash flow is considered with a slightly higher percentage for the summer period compared to the winter period when concrete work, drilling etc. may be affected by climatic conditions.

TABLE 16.1

TURTONAS - UZGHOR HYDRO ELECTRIC POWER PROJECT
SINOHYDRO – SACHAL CONSORTIUM
SUMMARY OF THE COST ESTIMATES

Code	Description	Total Amount (PKR)	Local Currency (PKR)	Foreign Currency (PKR)	Remarks
A	**PRILIMINARY WORKS**				
A1	Mobilization and De-Mobilization	894,576,560	715,661,248	178,915,312	
A2	TEMPORARY AND PERMANENT RESIDENCE	45,972,204	45,972,204		
	SUB TOTAL OF PRILIMINARY WORKS	**940,548,764**	**761,633,452**	**178,915,312**	
B	**CIVIL WORKS**				
B1	WEIR	402,599,470	322,079,576	80,519,894	
B2	FISH LADDER	75,813,762	60,651,009	15,162,752	
B3	UNDER SLUICE	53,119,887	42,495,910	10,623,977	
B4	LATERAL INTAKE	158,779,779	127,023,823	31,755,956	
B5	OVER FLOW SECTION	21,363,126	17,090,501	4,272,625	
B6	SANDTRAP	538,290,118	430,632,094	107,658,024	
B7	HEADRACE TUNNEL	1,686,399,435	1,349,119,548	337,279,887	
B8	SURGE TANK	113,207,720	90,566,176	22,641,544	
B9	PRESSURE TUNNEL/SHAFT	1,211,615,600	969,292,480	242,323,120	
B10	POWERHOUSE AND TAILRACE	1,319,748,796	1,055,799,037	263,949,759	
B11	ACCESS ROAD AND BRIDGES	3,344,827,907	2,675,862,326	668,965,581	
B12	SURVEY AND INVESTIGATION	20,000,000	16,000,000	4,000,000	
	SUB TOTAL OF CIVIL WORKS	**8,945,765,600**	**7,156,612,480**	**1,789,153,120**	
C	**ELECTRO-MECHANICAL EQUIPMENT**				
	ELECTRO-MECHANICAL EQUIPMENT	4,951,855,929	990,371,186	3,961,484,744	
	SUB TOTAL OF ELECTRO-MECHANICAL WORKS	**4,951,855,929**	**990,371,186**	**3,961,484,744**	
D	**HYDRAULIC STEEL EQUIPMENT**				
	HYDRAULIC STEEL EQUIPMENT	2,216,340,000	664,902,000	1,551,438,000	
	SUB TOTAL OF HYDRAULIC STEEL WORKS	**2,216,340,000**	**664,902,000**	**1,551,438,000**	
E	**TRANSPORTATION AND E/M ERECTION CHARGES**				
1	Transportation & Erection charges of E&M Equipments	445,667,034	89,133,407	356,533,627	
2	Transportation charges of Hydraulic Steel Equipments	199,470,600	59,841,180	139,629,420	
	SUB TOTAL OF TRANPORTATION CHARGES	**645,137,634**	**148,974,587**	**496,163,047**	
F	**SUB TOTAL (ITEM A~F)**	**17,699,647,927**	**9,722,493,704**	**7,977,154,222**	
G	**ENGINEERING COST OF EPC**				
	Engineering Cost of EPC (4% of G)	707,985,917	141,597,183	566,388,734	
	Contingencies @0%	0	0	0	
H	**Total EPC Cost (Feasibility Stage)**	**18,407,633,844**	**9,864,090,888**	**8,543,542,956**	
I	ESIA Monoitoring & Implementation	133,070,602	133,070,602	0	
J	Land Acquisition & Rent Cost	272,756,030	272,756,030	0	
K	Client Engineering & Supervision (3.5% of H)	644,267,185	386,560,311	257,706,874	
L	Independent Engineer (0.5% of H)	92,038,169	49,320,454	42,717,715	
M	Development Cost (9.7% of H)	1,795,848,758	1,436,679,006	359,169,752	
N	SUB TOTAL (ITEM H~N)	21,345,614,587	12,142,477,291	9,203,137,296	
O	Contingencies @0% of O	0	0	0	
P	BASE COST (A~P)	21,345,614,587	12,142,477,291	9,203,137,296	
Q	Custom Duties	275,646,137	275,646,137	0	
R	Insurance During Construction (2% of H)	368,152,677	368,152,677	0	
S	Lenders Financial Fees & Charges (2.5%)	439,788,268	65,968,240	373,820,028	
T	Interest During Construction	2,859,656,444	302,527,933	2,557,128,511	
U	**TOTAL PROJECT COST**	**25,288,858,114**	**13,154,772,278**	**12,134,085,835**	

TABLE 16.2					
TURTONAS - UZGHOR HYDRO ELECTRIC POWER PROJECT SINOHYDRO – SACHAL CONSORTIUM, COST ESTIMATE FOR MAIN COMPONENTS					
Sr No.	**Description**	**Unit**	**Qty**	**Rate (PKR)**	**Total Amount (Pak. Rs.)**
A	**PRILIMINARY WORKS**				
A1	**MOBILIZATON AND DEMOBILIZATION**				
1	Mobilization and De-mobilization including temporary facilities	10%	1	894,576,560	894,576,559.98
A2	**TEMPORARY AND PERMANENT RESIDENCE**				
1	O&M Residence	sq-ft	7530	6,105	45,972,204
	Sub Total -A				**940,548,764**
B	**CIVIL WORKS**				
B1	**WEIR**				
(i)	**Excavation and Backfilling**				
1	weir	m³	40,128	804	32,262,936
(ii)	**Concrete works**				
1	Lean Concrete	m³	484	11,900	5,759,600
2	Mass Concrete (Backfill)	m³	5,913	11,900	70,360,416
3	Structural Concrete (Raft)	m³	3,851	13,950	53,724,240
4	Structural Concrete (Retaining Wall)	m³	4,609	16,206	74,691,890
5	Stone Apron	m³	10,627	2,600	27,629,381
6	Reinforcement (Grade-60)	Ton	592	176,400	104,465,358
(iii)	**Diversion works**				
1	1st Stage coffer Dam	m³	8,000	494	3,952,000
2	2nd Stage Coffer Dam	m³	5,070	494	2,504,580
3	Dewatenng	L.S	1	27,249,069	27,249,069
	Sub Total - B1				**402,599,470**
B2	**FISH LADDER**				
(i)	**Excavation and Backfilling**				
1	Excavation	m³	6,713	804	5,397,574
(ii)	**Concrete Works**				
1	Lean Concrete	m³	51	11,900	604,639
2	Structural Concrete (Raft)	m³	500	13,950	6,981,836
3	Structural Concrete (walls)	m³	8	16,206	135,482
4	Structural concrete (Retaining Wall) above ground	m³	1,516	16,206	24,563,596
5	Structural Concrete (Pier/slab)	m³	450	16,206	7,291,533
6	Reinforcement (Grade-60)	Ton	173	176,400	30,554,978
(iii)	**Stone Fill**				
1	Stone Fill	m³	237	1,200	284,124
	Sub Total - B2				**75,813,762**
B3	**UNDERSLUICE**				
(i)	**Excavation and Backfilling**				
1	Excavation	m³	21,275	804	17,104,939
(ii)	**Concrete Works**				
1	Structural Concrete (Raft)	m³	163	13,950	2272455
2	Structural concrete walls and Slab	m³	1,111	16,206	18009128
4	Reinforcement (Grade 60)	Ton	89	176,400	15733366

TABLE 16.2					
TURTONAS - UZGHOR HYDRO ELECTRIC POWER PROJECT SINOHYDRO – SACHAL CONSORTIUM, COST ESTIMATE FOR MAIN COMPONENTS					
Sr No.	**Description**	**Unit**	**Qty**	**Rate (PKR)**	**Total Amount (Pak. Rs.)**
	Sub Total - B3				**53,119,887**
B4	LATERAL INTAKE				
(i)	**Excavation and Backfilling**				
1	Excavation	m³	5,341	804	4,294,175
2	Backfilling	m³	2,141	429	918,403
(ii)	**Concrete Works**				
1	Lean Concrete	m³	106	11,900	1,262,352
2	Structural Concrete (Raft)	m³	1,574	13,950	21,952,836
3	Structural Concrete (Other than Raft)	m³	3,885	16,206	62,953,455
4	Steel Reinforcement (Grade 60)	Ton	382	176,400	67,398,557
	Sub Total - B4				**158,779,779**
B5	OVERFLOW SECTION				
(i)	**Excavation and Backfilling**				
1	Excavation	m³	8,368	804	6,727,711
(ii)	**Gabion Box**				
1	Overflow Section	m³	1,000	9,344	9,343,626
2	Reinforcement (Grade 60)	Ton	30.00	176,400	5,291,788
	Sub Total - B5				**21,363,126**
B6	SANDTRAP				
(i)	**Excavation and Backfilling**				
1	Connecting canal excavation (U/s & D/s)	m³	43,634	804	35,082,137
2	sandtrap excavation	m³	69,522	804	55,895,543
3	Backfilling	m³	4,900	490	2,401,000
(ii)	**Concrete Works**				
1	Lean Concrete	m³	452	11,900	5,380,371
2	Structural Concrete (raft)	m³	12,237	13,950	170,701,212
3	Structural Concrete (Other than raft)	m³	2,639	16,206	42,760,678
4	Reinforcement (Grade-60)	Ton	1,041	176,400	183,679,177
5	Flushing Pipe	m	600	70,650	42,390,000
	Sub Total - B6				**538,290,118**
B7	HEADRACE TUNNEL				
(I)	**Excavation and Mucking**				
1	Tunnel Excavation (All types of Rock)	m³	94,951	4,740	450,067,740
(ii)	**Concrete Works**				
1	Invert Concrete	m³	4,339	16,206	70,315,286
2	Reinforcement (Grade 60)	Ton	304	176,400	53,576,031
(ii)	**Rock Support**				
1	Shotcrete for slope stablization	m³	225	55,679	12,527,775
2	Shotcrete (For Good rock)	m³	1,923	58,650	112,783,950
3	Shotcrete (For Fair rock)	m³	3,632	58,770	213,452,640
4	Shotcrete (For Poor rock)	m³	1,152	58,770	67,703,040
5	Grouted Rock Bolts 32mm (for Good Rock)	m	11,100	2,136	23,709,600
6	Grouted Rock Bolts 32 mm (for fair Rock)	m	53,332	2,136	113,917,152
7	Grouted Rock Bolts 25 mm (for Poor Rock)	m	41,438	1,445	59,877,188
8	Steel Ribs (For Poor Rock)	Ton	625	249,890	156,181,250

TABLE 16.2

TURTONAS - UZGHOR HYDRO ELECTRIC POWER PROJECT
SINOHYDRO – SACHAL CONSORTIUM,
COST ESTIMATE FOR MAIN COMPONENTS

Sr No.	Description	Unit	Qty	Rate (PKR)	Total Amount (Pak. Rs.)
(ii)	**Drilling and Grouting**				
1	Drilling Drain holes and Weep holes (3m-upward and lateral)	m	2,000	7,841	15,682,000
2	Drilling Drain holes and Weep holes (3m horizontal and downword)	m	1,500	7,141	10,711,500
3	Drilling holes for Consolidation Grouting	m	4,500	6,763	30,433,500
4	Consolidation Grouting	m³	1,654	113,907	188,402,178
(iii)	**Dewatering and Ventilation**				
1	Handling and Caring of Water	L.S	1	35,907,000	35,907,000
2	Ventilation of Tunnel	L.S	1	71,151,605	71,151,605
	Sub Total - B7				**1,686,399,435**
B8	SURGE TANK				
(i)	**Excavation and Mucking**				
1	Chamber Excavation	m³	7,686	4,740	36,430,929
(ii)	**Concrete Works**				
1	Structural Concrete	m³	1,015	16,206	16,449,090
2	Reinforcement (Grade 60)	Ton	71	176,400	12,533,220
(iii)	**Rock Support**				
1	Shotcrete (For all type of rock)	m³	216	55,679	12,026,664
2	Rock Bolting (for Good Rock)	m	4,300	2,136	9,184,800
(iv)	**Drilling and Grouting**				
1	Drilling Drain holes and Weep holes (3m horizontal)	m	54	7,841	423,414
2	Drilling holes for Consolidation Grouting	m	170	7,141	1,213,970
3	Consilidation Grouting	m³	219	113,907	24,945,633
	Sub Total - B8				**113,207,720**
B9	PRESSURE SHAFT/ PRESSURE TUNNEL				
(i)	**Excavation and Mucking**				
1	Pressure Shaft	m³	4,291	4,740	20,339,340
2	Pressure Tunnel	m³	7,587	4,740	35,962,380
(ii)	**Rock Support**				
1	Shotcrete (for Good rock)	m³	922	55,679	51,336,038
2	Rock Bolts 32mm (for Good rock)	m	32,316	2,136	69,026,976
(iii)	**Concrete Works**				
1	Concrete Backfilling	m³	6,150	16,206	99,666,900

TABLE 16.2					
TURTONAS - UZGHOR HYDRO ELECTRIC POWER PROJECT SINOHYDRO – SACHAL CONSORTIUM, COST ESTIMATE FOR MAIN COMPONENTS					
Sr No.	**Description**	**Unit**	**Qty**	**Rate (PKR)**	**Total Amount (Pak. Rs.)**
(iv)	**Drilling and Grouting**				
1	Drilling Drain holes and Weep holes (3m horizontal)	m	613	7,841	4,806,533
2	Drilling holes for Consolidation Grouting	m	613	7,141	4,377,433
3	Consiidation Grouting	m³	5,250	176,400	926,100,000
	Sub Total -B9				**1,211,615,600**
B10	**POWERHOUSE AND TAILRACE**				
(i)	**Excavation**				
1	Open powerhouse and tailrace excavation	m³	76,636	804	61,615,344
2	Slope Excavation	m³	2,203	4,266	9,397,998
3	Backfilling	m³	36,670	493	18,078,310
(ii)	**Concrete Works**				
1	Lean Concrete	m³	93	11,900	1,109,299
2	Structural Concrete	m³	4,849	16,206	78,583,721
3	2nd Stage concrete	m³	1,614	16,206	26,156,160
4	Tailrace Concrete	m³	1,490	16,206	24,146,940
5	Reinforcement (Grade-60)	Ton	104	176,400	18,398,520
(iii)	**Rock Support**				
1	Shotcrete (for Good rock)	m³	333	55,679	18,541,107
2	Rock Bolts 32mm (for Good rock)	m	270	2,136	576,720
3	Rock Bolts 32mm (for Fair rock)	m	1,000	2,136	2,136,000
(iv)	**Drill and Grouting**				
1	Drilling Drain holes and Weep holes (3m horizontal)	m	260	7,841	2,038,660
2	Drilling holes for Consolidation Grouting	m	260	4,141	1,076,660
3	Consolidation Grouting	m³	9,085	113,907	1,034,845,095
(v)	**Dewatering**				
1	Powerhouse and Tailrace	L.S	1	23,048,263	23,048,263
	Sub Total - B10				**1,319,748,796**
B11	**ACCESS ROAD, BRIDGES AND ACCESS TUNNELS**				
(i)	**Access Road to Weir Site**				
1	Filling	m³	1,669,934	736	1,229,071,748
2	Cutting	m³	450,250	736	331,383,750
3	Base Couse	m³	175,343	4,890	857,427,838
4	Sub Base Course	m³	167,882	2,750	461,674,694
5	Asphaltic wearing Course	m³	3,012	28,618	86,190,548

TABLE 16.2					
TURTONAS - UZGHOR HYDRO ELECTRIC POWER PROJECT SINOHYDRO – SACHAL CONSORTIUM, COST ESTIMATE FOR MAIN COMPONENTS					
Sr No.	**Description**	**Unit**	**Qty**	**Rate (PKR)**	**Total Amount (Pak. Rs.)**
(ii)	**Access Road to Power House**				
1	Filling	m^3	43,074	736	31,702,427
2	Cutting	m^3	26,155	736	19,250,374
3	Base Couse	m^3	4,523	4,890	22,116,343
4	Sub Base Course	m^3	4,523	2,750	12,437,616
5	Asphaltic wearing Course	m^3	205	28,618	5,872,414
(iii)	**Access Road Power house to Headrace Tunnel and upper Surge Chamber**				
1	Filling	m^3	76,000	736	55,936,000
2	Cutting	m^3	114,000	736	83,904,000
3	Base Course	m^3	5,913	4,890	28,913,592
4	Sub base Course	m^3	5,913	2,750	16,260,200
5	Asphaltic Waring Course	m^3	1,489	28,618	42,602,186
(iv)	**Road Bridges/Culverts**				
1	Pile (Boring)	m	250	11,000	2,750,000
2	Pile (Concrete)	m^3	250	16,206	4,051,500
3	Abutments (Concrete)	m^3	352	16,206	5,704,512
4	Grder (Concrete)	m^3	672	16,206	10,890,432
5	Girder (Launching)	Ton	269	1,719	461,960
6	Slabs	m^3	113	16,206	1,831,278
7	Reinforcement (Grade-60)	Ton	97	176,400	17,126,676
(iv)	**Access Tunnel**				
1	Access Tunnel to Headrace Tunnel	m^3	1,987	4,740	9,418,380
2	Access Tunnel to surge chamber	m^3	1,656	4,740	7,849,440
	Sub Total - B11				**3,344,827,907**
B12	**SURVEY AND INVESTIGATION**				
1	Survey and Investigation	L.S	1	20,000,000	20,000,000
	Sub Total - B12				**20,000,000**
	SUB TOTAL OF CIVIL WORKS				**8,945,765,600**
C	**ELECTRO-MECHANICAL EQUIPMENTS**				
C1	**Electro-Mechanical Equipments**				
1	TURBINES,GOVERNORS	L.S	2	443,720,817	745,450,971.80
2	ANCILLARY EQUIPMENT	L.S	1	228,432,360	191,883,182.74
3	INLET VALVES	L.S	2	79,319,557	133,256,855.93
4	GENERATORS & EXCITER	L.S	2	670,785,634	1,126,919,865.20
5	CONTROL & TELECOM SYS	L.S	1	511,161,663	429,375,796.58
6	DIESEL GENERATORS	L.S	1	52,419,233	44,032,155.30
7	ELEVATOR	L.S	1	42,710,737	35,877,018.83
	Sub Total - C1				**2,706,795,846**

TABLE 16.2					
TURTONAS - UZGHOR HYDRO ELECTRIC POWER PROJECT SINOHYDRO – SACHAL CONSORTIUM, COST ESTIMATE FOR MAIN COMPONENTS					
Sr No.	**Description**	**Unit**	**Qty**	**Rate (PKR)**	**Total Amount (Pak. Rs.)**
C2	**Protection System**				
1	FIRE FIGHTING	L.S	1	98,092,877	89,264,518.43
2	HVAC	L.S	1	128,787,078	117,196,240.80
3	WORKSHOP EQUIPMENT	L.S	1	83,554,109	76,034,238.83
4	MISCELLANEOUS EQUIPMENT	L.S	1	88,181,873	80,245,504.25
5	MV SWITCHGEAR	L.S	1	161,679,180	147,128,053.98
6	LV SWITCHGEAR	L.S	1	67,128,990	61,087,380.72
7	DC SYSTEM	L.S	1	77,335,117	70,374,956.38
8	CABLES	L.S	1	120,275,502	109,450,706.37
9	STATION WATER SERVICES SYSTEM	L.S	1	36,950,067	33,624,561.15
10	OIL HANDLING EQUIPMENT	L.S	1	32,580,064	29,647,857.88
11	STATION COMPRESSED AIR SYSTEM	L.S	1	32,234,314	29,333,225.65
12	CRANES	L.S	1	120,763,397	109,894,691.09
13	TRANSFORMERS	L.S	1	391,220,714	356,010,850.10
14	SWITCHGEAR / SWITCHYARD	L.S	1	1,028,315,712	935,767,297.47
	Sub Total - C2				**2,245,060,083**
	SUB-TOTAL OF ELECTRO-MECANICAL WORKS - C				**4,951,855,929**
D	**HYDRAULIC STEEL**				
1	Gates/ Trashrack	Sq-m	480	225,000	108,000,000
2	Penstock	T	2,652	795,000	2,108,340,000
	SUB TOTAL OF HYDRAULIC STEEL- D				**2,216,340,000**
E	TRANSPORTATION AND ERECTION CHARGES				
1	**TRANSPOTATION CHARGES INCLUDING ERECTION OF MACHINERY**				**645,137,634**
	Sub Total - F				**645,137,634**
	TOTAL SUB-BASE COST (Sub Total-A to Sub Total-F)				**17,699,647,927**
F	EPC ENGINEERING COST				
	EPC Engineering Cost (4% of Sub total A~F)				707,985,917
	0% Contigency				0
G	TOTAL EPC COST				**18,407,633,844**
NON-EPC COST					
H	**ESIA Implementation & Mitigation**				133,070,602
I	**Land Acquisition & Rent Cost**				272,756,030
J	**Engineering, Supervision & IE Cost (4% of G)**				736,305,354
K	**Development & Management Expenses (9.75% OF G)**				1,795,848,758
L	**SUB TOTAL (ITEM I~N)**				**21,345,614,587**
M	**Custom Duties (5% OF C&D)**				275,646,137
N	**Insurance During Construction (2% of G)**				368,152,677
O	**Financing Fees & Charges (2.5%)**				439,788,268
	TOTAL PROJECT COST EXCLUDING IDC				**22,429,201,669**

TABLE - 16.3

TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT

SUMMARY OF COST ESTIMATE (YEARWISE BREAK UP)

(Amount in Million Rupees)

Item	Description	Total Project Cost			Year 1			Year 2			Year 3			Year 4		
		Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
A	PRELIMINARY WORKS	761.634	178.916	940.550	96.728	50.096	146.824	108.914	55.464	164.378	281.805	51.886	333.690	274.188	21.470	295.658
B	CIVIL WORKS	7156.613	1789.153	8945.766	908.890	500.963	1409.853	1023.396	554.637	1578.033	2647.947	518.854	3166.801	2576.381	214.698	2791.079
C	ELECTRO-MECHANICAL EQUIPMENT	990.371	3961.485	4951.856	125.777	1109.216	1234.993	141.623	1228.060	1369.683	366.437	1148.831	1515.268	356.534	475.378	831.912
D	HYDRAULIC STEEL EQUIPMENT	664.902	1551.438	2216.340	84.443	434.403	518.845	95.081	480.946	576.027	246.014	449.917	695.931	239.365	186.173	425.537
E	TRANSPORTATION & ERECTION CHARGES	148.975	496.163	645.138	18.920	138.926	157.845	21.303	153.811	175.114	55.121	143.887	199.008	53.631	59.540	113.170
F	SUB TOTAL (ITEM A TO E)	9722.495	7977.155	17699.650	1234.757	2233.603	3468.360	1390.317	2472.918	3863.235	3597.323	2313.375	5910.698	3500.098	957.259	4457.357
G	ENGINEERING COST OF EPC (4% OF F, Local 20% & Foreign 80%)	141.597	566.389	707.986	35.399	141.597	176.997	35.399	141.597	176.997	35.399	141.597	176.997	35.399	141.597	176.997
H	TOTAL EPC COST	9864.092	8543.544	18407.636	1270.156	2375.201	3645.357	1425.716	2614.515	4040.231	3632.722	2454.972	6087.694	3535.497	1098.856	4634.353
I	ESIA MONITORING & IMPLEMENTATION	133.070	0.000	133.070	46.575	0.000	46.575	46.575	0.000	46.575	19.961	0.000	19.961	19.961	0.000	19.961
J	LAND ACQUISITION & RENT COST	272.756	0.000	272.756	272.756	0.000	272.756	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K	CLIENT ENG. AND SUPERVISION (3.5% OF H)	386.560	257.707	644.267	96.640	64.427	161.067	96.640	64.427	161.067	96.640	64.427	161.067	96.640	64.427	161.067
L	INDEPENDENT ENGINEER (0.5% OF H)	49.320	42.718	92.038	6.351	11.876	18.227	7.129	13.073	20.201	18.164	12.275	30.438	17.677	5.494	23.172
M	Development Cost	1436.679	359.170	1795.849	235.095	213.868	448.962	235.095	213.868	448.962	235.095	213.868	448.962	235.095	213.868	448.962
N	SUB TOTAL (ITEM H TO N)	12142.477	9203.139	21345.616	1927.572	2665.371	4592.943	1811.154	2905.882	4717.036	4002.581	2745.541	6748.122	3904.870	1382.644	5287.514
O	CONTINGENCIES (0% OF O)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
P	BASE COST (ITEM A TO P)	12142.477	9203.139	21345.616	1927.572	2665.371	4592.943	1811.154	2905.882	4717.036	4002.581	2745.541	6748.122	3904.870	1382.644	5287.514
Q	CUSTOM DUTIES (5% OF FOREIGN OF C & D)	275.646	0.000	275.646	35.007	0.000	35.007	39.417	0.000	39.417	101.989	0.000	101.989	99.233	0.000	99.233
R	INSURANCE DURING CONSTRUCTION (2% of H)	368.152	0.000	368.152	92.038	0.000	92.038	92.038	0.000	92.038	92.038	0.000	92.038	92.038	0.000	92.038
S	LENDER'S FINANCIAL FEES AND CHARGES (2.5%)	65.968	373.820	439.788	14.160	80.240	94.400	14.545	82.424	96.970	20.826	118.017	138.843	16.436	93.139	109.576
T	INTEREST DURING CONSTRUCTION	302.527	2557.129	2859.656	13.182	169.235	182.417	39.181	499.802	538.983	90.148	833.623	923.771	160.015	1054.466	1214.481
	PROJECT COST	13154.771	12134.088	25288.858	2081.959	2914.846	4996.805	1996.336	3488.109	5484.444	4307.583	3697.181	8004.763	4272.592	2530.250	6802.842

CHAPTER - 17

PROJECT IMPLEMENTATION PLANNING AND PROCUREMENT PACKAGING

Chapter: 17

PROJECT IMPLEMENTATION PLANNING AND CONSTRUCTION METHODOLOGY

17.1. Introduction

The construction planning and scheduling required for implementation of Turtonas-Uzghor Hydro Electric Power Project is described in this Chapter. Considering specified construction material & quantities derived from design drawing presented in **Volume: 9 Project Drawings** and discussed in **Chapter: 12** to **14** of this feasibility report, type and kind of construction equipment needed for this type of project, sequence of construction, procurement & erection/commissioning activities and their dependence on the discharges in Golen Gol River, a 84 months implementation schedule consisting of 48 months for construction & procurement and 36 months is proposed for preparation of construction such as approval of feasibility, tariff determination by NEPRA, engineering design & tender document, issuance of Letter of Support and financial close to start the construction & procurement of project. If this schedule would be followed, the first unit would be commissioned on October 1st, 2024 while 2nd unit would be on line by January 1st, 2025.

An implementation schedule starting from approval of feasibility study, determination of Tariff by NEPRA, engineering design & tender documents, tendering and contracting, signing of concession agreements, issuance of Letter of Support leading to financial close and start of construction till plant will be put into commercial operation is presented in **Figure: 17.1**. This schedule comprises of duration and sequence of each activities, keeping in view time allocated in Private Power and Infrastructure Board (PPIB) guideline policy.

Implementation schedule was prepared with the assumption that approval of activities belong to PPIB and NEPRA would be provided within allocated time in Power Generation Policy .The Project will be awarded to a qualified constructor on EPC/Turnkey basis having similar experience in the construction of major hydraulic structures , hydro Electric powerhouses, tunnels and with the experience in the design, manufacture or procurement, transportation, erection, testing and commissioning of hydropower generating equipment.

17.2. Activities under Letter of Interest (LOI)

The following activities have to be completed under the Letter of Interest issued by PPIB and the latest Power Policy of the Government of the Pakistan revised in 2015. All these activities along with their duration and sequence are given in **Figure. 17.1**.

17.2.1. Approval of Feasibility Study

Preparation of feasibility study and its presentation to Panel of Experts for quality control is the responsibility of the Sponsor and their Consultants. The Final Feasibility Study Report has been prepared as per schedule given along with LOI. Till to-date seven reports and draft feasibility study report have been submitted to PPIB. Four Panel of Experts (POE) meetings have been held. Panel of Experts meetings were held on Inception Report, project preliminary Location and layout Alternatives, interim and draft feasibility. The POE agreed with the conclusion made by the Consultants and offered some comments. After incorporating comments received from PPIB upon Draft Feasibility Study Report, this Final Feasibility Study Report is submitted to PPIB for approval by the Panel of Experts (POE).

17.2.2. Generation License

Parallel to finalization and submission of Final Feasibility Study Report after incorporating the comments and observation of Panel of Experts appointed by PPIB, the Sponsor with the consent of the PPIB apply for generation license. It is well-known that generation License is mandatory for tariff petition to NEPRA for any projects.

17.2.3. Tariff Negotiations and Approval

After completion of feasibility study and approval by Private Power Infrastructure Board, the Sponsor will submit tariff petition to NEPRA. Time given in NEPRA Tariff guidelines for Power Generation Policy is 180 days. But examples show that it never achieved. The tariff will be two part tariff, energy sale price and capacity purchase price. The tariff normally based on the total project cost, loan terms and reasonable rate of return on equity. NEPRA has a minimum time of 09 months for decision-making and generation licencing.

17.2.4. Issuance of Letter of Support (LOS)

Once the proposed levelled tariff will be determined by NEPRA and approved by PPIB Board, the Private Power and Infrastructure Board (PPDB) will require the Sponsor for furnishing of bank guarantee as per the Power Policy of the Government of Pakistan. Upon furnishing the required bank guarantee, PPIB would issue LOS within 30 days. The time limit for LOS is 24 months, however, Sponsors are allowed to get LOS for 18 months in first hand and then if required, extension will be granted for balance period.

17.2.5. Environmental Impact Assessment Approval

Being the Project of Category B, full Environment Impact Assessment was prepared and presented in **Chapter: 9** and **Volume: 6 Appendix: E Environment and Social Impact Assessment** to this Final Feasibility Study Report and is intend for use in meeting the GOP, Financiers and EPA-KPK requirements in connection with environmental study clearances. The Sponsor has submitted the IEE to EPA-KP. The review and approval process is required 09 months but should be completed before financial close. A meeting was held in EPA office wherein report was presented to EPA. As a result of this meeting, public hearing at site was conducted by EPA to seek the consent of affecttees. The project is high head and run-off-river and has low impact which would be mitigated by providing fish ladder, releasing ecological flow downstream of the river and plantation of 10 trees against loss of one tree of desired spices. Public hearing concluded that Turtonas-Uzghor Project be implemented, however locals will be given priority in employment. Consultants are ready to attend any query or comments from EPA and its relevant department in respect of approval to move forward.

17.3. Activities under Letter of Support (LOS)

17.3.1. Appointment of Owner Engineer

Smooth implementation of project could only be possible if appointment of the Owner Engineer (Implementation Consultant) will be achieved timely. It is proposed that parallel to approval of feasibility study and tariff by NEPRA, the Owner Engineer should be appointed. This Owner Engineer will be responsible for preparation of detailed Engineering Design, pre-qualification document and tender documents. Pre-qualification and tender documents would be drafted by using EPC format of International Financing Institution. Tendering and contracting leading to bids clarification, receipt of bids, bids evaluation, negotiation of bids and award of contract.

It is highly required that Owner Engineer should supervise the Project during construction, because changing Owner Engineer during construction supervision means opening of such design and contract clauses which have been already part of the Contract Document ending with delay in project and huge claims. During construction quality control, contract administration & management, processing of Interim Payment certificates and progress monitoring shall be their responsibility.

The construction design will not be the responsibility of the Owner Engineer, because, the Contract is EPC wherein the Contractor is the designer for civil as well as E&M equipment. However, construction design of EPC will be reviewed by the Owner Engineer in light of Employer Requirement.

17.3.2. Appointment of Financial Advisor

Arrangement of financing is the key activity in project implementation. Sponsor can perform this activity, however, it is proposed that Sponsor will appoint financial advisor well in time. Financial advisor will be responsible and assist Sponsor for tariff negotiation and financial close. The minimum duration for financial closing after issuance of LOS is 18 months.

17.3.3. Appointment of Legal Consultants

Four to five different types of concession agreement and financial agreement has to be signed with different department, Government of KPK, Government of Pakistan and International & National Financing Institutions (IFI). These agreements are more legal than technical/financial; therefore, it is proposed that the services of legal consultants be acquired for drafting and negotiation of these agreements. At-least, before start of negotiation of concession documents legal consultants must have been appointed

17.3.4. Engineering Design, Tender Document and Tendering

This activity is very important and reduce construction risks which otherwise force the Contractor to bid on the higher side. The Owner Engineer will prepare engineering design, performance specifications and tender documents required for the project delivery contractor. Engineering design may require additional topographic survey and sub-soil investigation. Therefore parallel to engineering design and preparation of tender document, these investigation would be completed. The intent would be to have tender documents complete and ready for issuance once preliminary financial commitments are obtained. The time requirements are as follows

Tender Design and Document	6 months
Bidding Period	3 months
Evaluation of Proposal	2 months
Contract Negotiation and Award	3 months
Total	**14 months**

The selection of EPC shall be based on pre-qualification process. The pre-qualification document be such that EPC shall be a Joint Venture of Engineering Firms, Construction Contractor for Civil Work, design, Fabrication, installation and testing by E&M Contractor. Three entities will work under the Control of Construction Contractor, however, their presence and responsibility at site/office shall be independent from each other's and shall be liable to the Employers independently.

17.3.5. Power Purchase Agreement

The legal consultants will study and draft the Power Purchase Agreement (PPA). This document will be based on model/standard agreement provided for this purpose by PPIB. Parallel to the tariff negotiations, preparation of the PPA can be started. The PPA has to be negotiated between Power Purchaser in this case Central Power Purchase Agency Guarantee and the sponsor after determination of tariff by NEPRA.

17.3.6. Water Use License (WUL) and Implementation Agreement (IA)

The legal consultants will draft water use license and implementation agreement parallel to the finalization of PPA. The legal consultants will support the sponsor during negotiation and sign the water use license and Implementation agreement with Government of KP and PPIB. The Implementation agreement will cover the GOP and GoKP Guarantees; therefore, two-implementation agreement has to sign, one with PPIB and the Sponsor and second with Government of KPK.

17.3.7. Land Acquisition

It is concluded that land required on permanent or temporary basis belongs to Land and Revenue Department of KPK. The land belongs to Land and Revenue Department would be purchased and leased out for concession period be equity participation in the project. As envisaged that the land to be acquired permanently for this project is for the O&M colony, weir, lateral intake, sediment basin, connecting canals, O&M camp, access roads, tailrace and powerhouse, it is proposed that the Sponsor may approach to Land and Revenue Department after approval of feasibility study, to find out modality for land acquisition. This process need an agreement between both parties (Sponsor and GoKP) therefore should be initiated on priority, because government procedures takes time to move.

17.3.8. Consents

After approval of feasibility study, SINOHYDRO-SACHAL CONSORTIUM approaches various department and agencies, including the State Bank of Pakistan, Ministry of Commerce, Ministry of Finance, the Securities and Exchange Commission, Electricity Inspector, NEPRA, Ministry of Water and Power, PPIB, Ministry of Mineral, etc. to obtain their consents and approval. This is a huge activity and requires constant attention. The Sponsor shall establish a dedicated team of qualified officer and official along with furnished office.

17.3.9. Award of (EPC/TURNKEY) Contract

Award of the Contract will be based on single package which include all civil works related to project, access roads, staff colony and E&M works necessary for robust operation of the project.

The FIDIC Contract conditions of "Engineering, Procurement and Construction" on Turnkey (EPC/T) is a worldwide preferred option for construction of Hydro Electric Projects. Tariff adjustment by NEPRA is also based on EPC/T bids. The processing of bidding and selection of the project delivery contractor shall be concluded prior to Financial Close. The selection of the contractor shall be on responsive and lowest evaluated bid price however, the selection must be transparent to satisfy PPIB and Power Purchaser requirement. It is important to mention that contractor qualification, specifications and contract documents must meet tender requirement. Mobilization of the contractor has been planned a critical task within 07 days after the Financial Close.

17.3.10. Financial Close

Upon initialling of concession documents, Sponsor would formally apply for loans to different financial institutions. It is proposed that Sponsor should start consultation with potential lenders to identify interested and eligible entities just from the approval of feasibility study. The interested lenders would review the Project and project documents, carrying out their own due diligence and offer loan terms.

The agreed terms sheets for loans will be submitted to PPIB for approval at least one month advance of the scheduled financial close. Upon signing of loan agreement and project delivery contract and after obtaining all consents, the documents will be submitted to PPIB for review and final approval. PPIB will take 45 days to review and confirm the achievement of financial close and will provide the Government guarantee as per the format in the Implementation Agreement.

The minimum time from issuance of LOS to financial close is 18 months.

17.4. Project Construction Methodology

17.4.1. Mobilization and Demobilization

After receiving letter of award, advance payment and possession of site, the Contractor will start mobilization of its manpower and construction equipment. Side by side preparation of construction camps will be initiated. Initial activities will include set-up of construction camps and housing facilities for contractor labour and O&M Staff of the Sponsor. The majority of the work force will be local, with site labours and semi-skilled labour available from the project area and skilled labour also coming from the region as well as from other parts of Pakistan. Foreign labour and experts will be employed for special tasks, especially that associated with installation and testing of major E&M equipment. Foreign labour and experts may also needed for tunnel construction.

The Contractor will start construction of two bridges along Golen Gol and widening / grading of access road to weir site side by side mobilization and construction of camps. After project is completed and handed over to the Sponsor, the Contractor will demobilized its machinery and equipment. The Sponsor has the right to take over any facilities constructed by the Contractor free of cost. The Contractor has to demolish the camps/facilities not required by the Sponsor and level the ground in original form for handing over to land owners.

17.4.2. Construction Methodology

Concrete works will be stopped during cold months, however, excavation works especially tunnel excavation will remain continue round the year, except due to heavy rain or snow. Construction of headrace tunnel and E&M works are considered critical to meet the schedule, however, concrete works are not at critical path.

Conventional construction methods are expected to be applied such as:

- Open excavations and backfilling require conventional earth moving equipment such as excavators, graders, loaders, dumpers, scrapers, dozers, roller, compacters, etc. This methodology will be used at diversion weir, connecting canal, sedimentation basin, powerhouse and tailrace. Dewatering from excavation pits be done if any by collecting seepage water in pits and then pumping out back in to Golen Gol River. Diversion weir will be constructed in two stages. In first stage, excavation and construction of divide wall including fish leader, right abutment, power intake and undersluice will be completed. In second stage river will be diverted through undersluice by constructing upstream and downstream coffer dam. After completion of diversion and excavation, concreting of fixed weir along with left abutment will be completed. Concreting at powerhouse and sedimentation basin will be started after completion of excavation as per design drawings.

- Concrete works requires common or two sets of (one at powerhouse site and second near diversion weir) batching plants, trans-mixtures, pumps, and vibrators etc. which are available in local market. Good quality of concrete also require quality form works which will be fabricator from steel or plywood with proper supports. Concrete from batching plants will be transported by trans-mixtures and shifted to structures by concrete pumps. Concrete work at powerhouse, diversion weir and sedimentation basin shall start simultaneously.

- Headrace excavation will be done by drill and blast method by using drilling jumbos. Road headers can also be used. Mucking of excavated material will be done by vehicle by loading and unloading. Rock supports will be installed immediately after blast, however, shotcrete lining will be applied after proper scaling, finishing, etc. Headrace tunnel will be excavated from both sides. After access to weir site is available, headrace construction will be started after preparation of tunnel intake portal. Concrete in the bottom of headrace will be carried out after full excavation of headrace tunnel. Excavation of headrace will be started from downstream side after completion of access roads at top and bottom of surge chamber. Mucking will be transported and piled on left bank of Golen near and upstream of Uzghor village and near to river course.

- Pressure tunnel will be excavated by drill and blast method and will be steel lined. However, pressure shaft will be excavated by raise boring technique. Surge tank will be excavated from top to bottom by using drill and blast method. After rock support the surface will be lined with shotcrete. However, raising boring technique will also be used for excavation of surge tank.

- It is concluded that at least three teams are required for tunnel excavation and one each at powerhouse and diversion weir site. Excavation of headrace tunnel from both side, pressure tunnel from downstream and pressure tunnel to surge tank will be started simultaneously. After completion of pressure tunnel and chamber for raising boring for excavation of pilot hole from surge tank or from headrace tunnel will be started. After completion of pilot hole, excavation will be completed. Steel lining will be started from bottom of pressure shaft toward its top and toward powerhouse and completed side by side.

17.4.3. Detailed Engineering Design and Construction Supervision by EPC

This is an EPC Contract; therefore, construction designs, drawings and related investigations are the responsibility of EPC/T contractor under the FIDIC conditions. Construction design may require additional investigation, which has to be done by EPC Contractor. The Contractor has to work out the plant size and final layout for review and approval by the sponsor as per Employer requirement for Level -1 Design. After review and vetting of level-1 design, the Contractor will prepare Level-2 Design for review of the Sponsor.

Physical model study may be required for diversion weir. Therefore, after approval of Level-I design, the Contractor should approach the Irrigation Research Institute for budgeting and construction and operation of model. This activity is very important and time consuming and may lead to delay in project completion if not handled properly.

The construction supervision is the responsibility of the EPC Engineer who prepared the construction design. Quality control cannot be rest with construction contractor and also Owners Engineer. Therefore, the Engineer of EPC shall develop complete quality control system and established its site office for supervision accordingly. Any defect/incident/loss to the project due to poor design shall be the EPC Engineer responsibility.

Design and fabrication of E&M equipment is the next critical task. The Contractor should take this activity independent from Civil Engineering design, otherwise delivery of embedded parts may be delayed. Level-2 design will remain side by side construction of project structure. The Contractor design team would be responsible for preparation of as build drawings and operation manuals for civil and E&M works.

17.5. Project Construction

17.5.1. Site Facilities

Temporary roads are required to the disposal area, as well as temporary and permanent camps. Aggregate processing and concrete batching facilities are to be erected and operated by the contractor at very first near powerhouse site along left bank of Golen Gol. The Contractor will have to construct camps, offices, permanent roads to all permanent facilities with proper drainage, paving and shoulders. Road along right bank should be constructed for access to powerhouse site for the construction of powerhouse, switchyard, pressure tunnel/shaft, surge tank, and headrace tunnel and on left bank to the weir site for construction of diversion weir, lateral intake, sediment basin, coffer dam for diversion of river and headrace tunnel.

Construction of Camps will be started with the mobilization of the EPC contractor, parallel to construction of bridges over Golen Gol one near powerhouse and second near weir and widening of road to weir site. Levelling, grading, widening and finishing will be completed in a six-month period for an easy access to project area. First construction camp will be along left bank of Golen Gol near the powerhouse site. This is barren land and will acquire on temporary or permanent basis.

17.5.2. Diversion weir

Diversion weir will be constructed in two stages. In first stages, the Contractor would start excavation in the area of right abutment, power intake, divide wall, fish leader and under-sluices. This part of the weir will be placed over dry area and will be enclosed by upstream and downstream coffer dam to protect entering of flood and rain water. After completion of this part river water will be diverted toward under sluice by constructing upstream and downstream coffer dam for enclosing the area under fixed weir. Upon completion of coffer dam, excavation, concreting, pitching, placing of concrete block, and backfill for main fixed weir and left abutment will be completed and river will be diverted toward fixed weir.

Dewatering from excavation pit if any will be done by collecting seepage water in pits constructed for this purpose. Collected water will be pumped out in Golen Gol River.

17.5.3. Sediment Basin

The contractor will start the excavation of sediment basin parallel to the construction to diversion weir. Sediment basin is consisted of three chambers, on right bank of the Golen Gol River. Sediment basin will be linked with upstream and downstream connecting canals.

Later on, structure will be backfilled with granular material for the stability of the structure. Sedimentation basin will be completed in 18 months.

17.5.4. Connecting Canals.

Upon completion of sedimentation basin and first stage of diversion weir, upstream connecting canal will be constructed along with side spill weir and spill channel. This spill weir and spill channel is provided to pass the surplus flows back in to Golen Gol on downstream of diversion weir.

Downstream connecting canal will be constructed after completion of sedimentation basin. However, joint between connecting canal and headrace tunnel would be completed when headrace tunnel is cleaned for filling and ready for wet testing.

Downstream connecting canal will be completed within period of 6 months. A road bridge will be provided toward downstream part of the connecting canal for road leading to Ustor village and Golen Gol valley. However, connecting canals are kept covered from top.

17.5.5. Headrace Tunnel

Construction of Headrace Tunnel is a critical activity, which will take 46 months for completion. The headrace tunnel will be constructed from both ends means from intake portal and surge tank. Major length will be constructed from intake portal, because access road and access tunnel to start excavation of headrace tunnel from surge tank need 6 to 9 months being in the difficult terrain.

Tunnel will be excavated by conventional drill and blast method or by using road header. The mucking will be carried by vehicles. Mucking material will be stored at place where it will be reused in concrete after processing.

Before start of mucking, rock support system will be installed. Headrace tunnel would be lined with shotcrete which will be applied after scaling, finishing and grouting of fishers and over excavated area. Bottom of tunnel would be concreted after completion of full headrace. Tunnel will be cleaned with water before filling for wet testing. Construction duration of the headrace is given in **Figure: 17.1**

17.5.6. Pressure Tunnel/shaft and Surge Tank

Construction of Pressure tunnel/shaft is also an important activity in completion of waterway. Excavation will be started from the powerhouse area downstream to upstream till lower bend. It will be excavated by routine drill and blast method. Raise boring will be applied for construction of surge tank and pressure shaft. A pilot hole will be drilled from top and then reamed from down toward up though raise boring method.

Mucking of excavated material from surge tank and pressure shaft will be down from pressure tunnel and stored near to construction camps for powerhouse. This material will be reused in concrete after processing.

Pressure tunnel and shaft is totally steel lined. Steel lining will start from lower part of pressure shaft toward up and pressure tunnel from bend of pressure shaft toward powerhouse. It will remain continue parallel to construction of Headrace tunnel and powerhouse as shown in **Figure: 17.1**

17.5.7. Powerhouse/Tailrace

The construction of powerhouse will be started after levelling the Access Road and construction of bridge on Golen Gol River near Uzghor for river crossing. Recent on the location of Powerhouse there is a huge scree deposit, which will be removed up to required depth and removed material will be used for the levelling and raising of the platform for the construction of Camps.

Benching and rock support will be provided for the rock slope stabilization behind the powerhouse building. A stone wall will be provided between toe of slope and powerhouse wall. This wall will act as barrier in front of rolling stone (if any) from slope and stone will not hit the powerhouse wall and therefore no damage to powerhouse building. Excavation in the powerhouse foundation will be started after completion of coffer-dam around the powerhouse higher than the maximum flood level.

Construction of powerhouse is a time dense activity program which start from excavation, installation of dewatering system, grouting and foundation treatment. On completion of excavation and foundation treatment, the construction of concrete reinforced sub-structure will be started and subsequent concrete works will be completed leaving spaces for second stage concreting. The second stage concrete will be placed while installation of embedded part for turbine, Governor, Generator, manifolds, Main Inlet Valve (MIV) etc.

After completion of substructure construction of super-structure would be taken up immediately and will be completed before start of second stage concreting. The powerhouse roof will be constructed along with the installation of powerhouse crane system, which will be used for installation of embedded parts for turbines, generators, etc. and installation of other E & M equipment. Backfilling around powerhouse will be done upon completion of bifurcation and tailrace structure and retaining walls in parallel of powerhouse construction. The powerhouse substructure and superstructure does not require unusual construction techniques or methods for reinforced concrete construction.

Parallel to erection of the turbine and generator, all auxiliaries' electromechanical equipment and controls will be installed. Before put in to operation under load, dry testing and wet testing would be completed with due care. Finally, testing and commissioning will be achieved before start of commercial operation. The other architectural work, parking and fencing leading to installation of gates for security are completed parallel to testing and commissioning of the plants.

17.5.8. Supply of Turbine and Generator Equipment

The EPC contractor is responsible for fabrication, supply, scheduling and transport of the major equipment. Turbine manufacturing require special design and testing, therefore, fabrication of equipment be started immediately after signing of contract or mobilization, so that supply of turbines and other equipment be done in timely manner.

The process of design, fabrication and transportation of hydropower turbines and generators of this size takes about 36 months. However, about 10 months are kept for erection of the above equipment including testing and commissioning. Keeping in view time constraint effort could be made to reduce the time required for fabrication and transportation so that powerhouse could be put in to testing after 46 months.

17.5.9. Supply of Switch Yard Equipment

The switchyard is proposed to place right side of proposed powerhouse location on right bank of the Golen Gol River. The civil works would be completed in parallel of concreting of powerhouse and ancillaries structures. Procurement and supply of switchyard equipment be done in parallel of E&M equipment for powerhouse procurement and supply. As per NEPRA and grid code the transmission line and switchyard equipment should be ready 6 months before, commissioning of power plant.

The installation of switchyard equipment is not a critical task. The size of equipment can easily be procured from the local market.

17.5.10. Supply of Hydraulic Gates and Stop logs

Installation of hydraulic gates has to be done during construction and after completion of civil structures. One set of stop logs for Lateral Intake, sand trap, under sluice for each would be procured which may be used during any problem upon gates. Gates and stop logs can be procured from local market being cheap and to avoid sea transportation and witnessing effort and cost by Employer at manufacturer premises.

17.5.11. Testing and Commissioning

Erection, testing and commissioning includes final inspection of construction and equipment, testing of all equipment and facilities, operational tests of electromechanical equipment under different load conditions (both dry and wet condition) and safety tests. The activities require about 3 months after finalization of erection of the E&M equipment. Testing and commissioning not only for E&M, it shall be civil and hydraulic works also.

17.6. Conclusions

Keeping in view project scope, construction quantities, procurement of E&M equipment, sequence of activities and their dependence on access, the total implementation period includes:

Activities under LOI	=	09 months after submission of Feasibility
Activities under LOS	=	18 months
Construction phase:	=	48 months

Total construction time is 74 months.

Critical paths are as under:

SEQUENCE OF CRITICAL PATH

1. Preparation of feasibility study
2. Clearance of feasibility report by PPIB
3. Generation Licence
4. Tariff determination by NEPRA
5. Issuance of LOS
6. Financial Close.
7. Land Acquisition and Possession of Land
8. Award of EPC Contract and mobilization
9. Detail design for civil works, plant size and final layout and Construction of Colony and construction camps

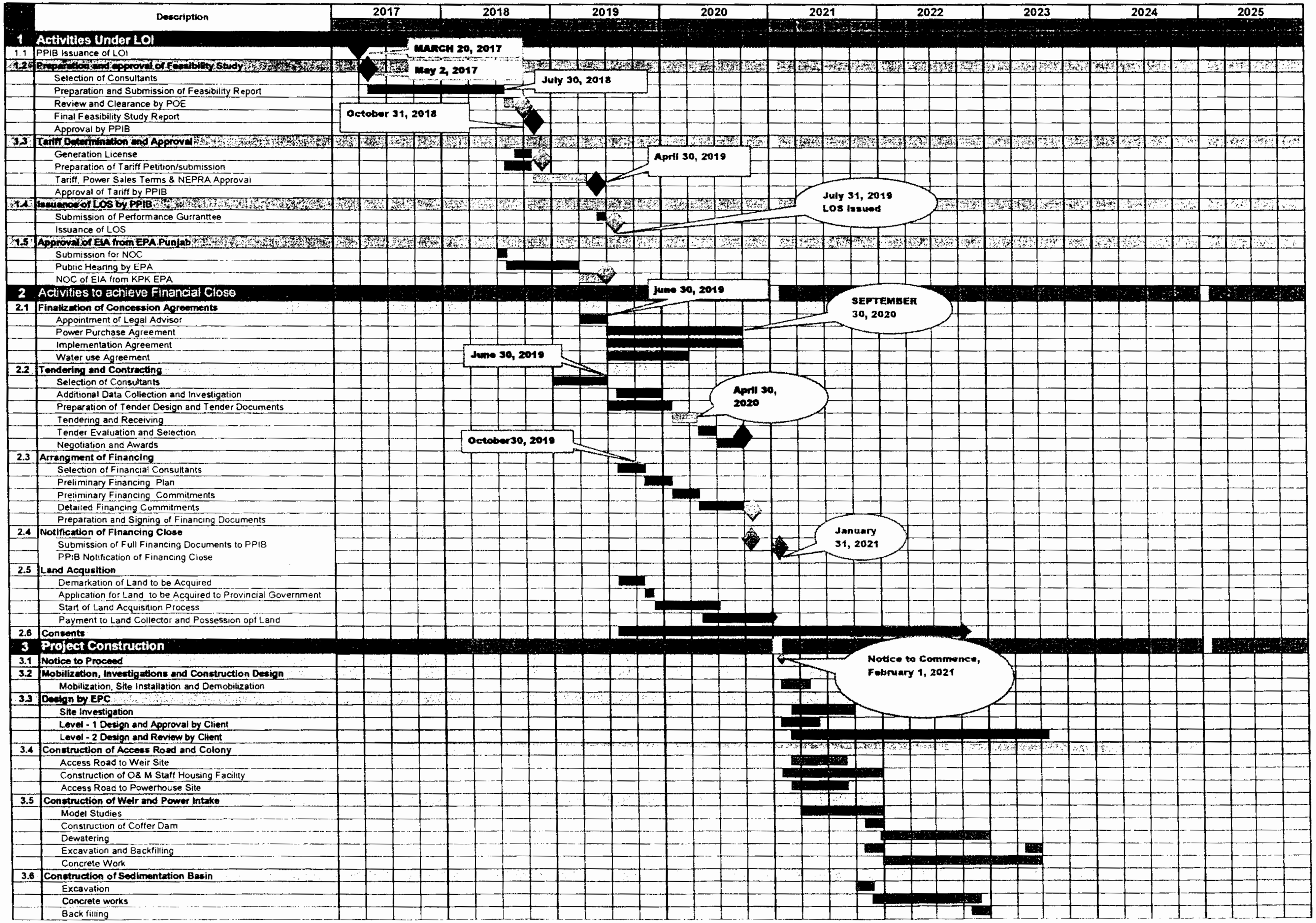
10. Manufacturing and Transportation of E & M equipment
11. Construction Civil Works
12. Erection / installation of E & M equipment
13. Testing and Commissioning
14. Handing and Taking Over

Special consideration should be given to the critical tasks and schedule transportation of the E & M equipment to the site.

FIGURE 17.1

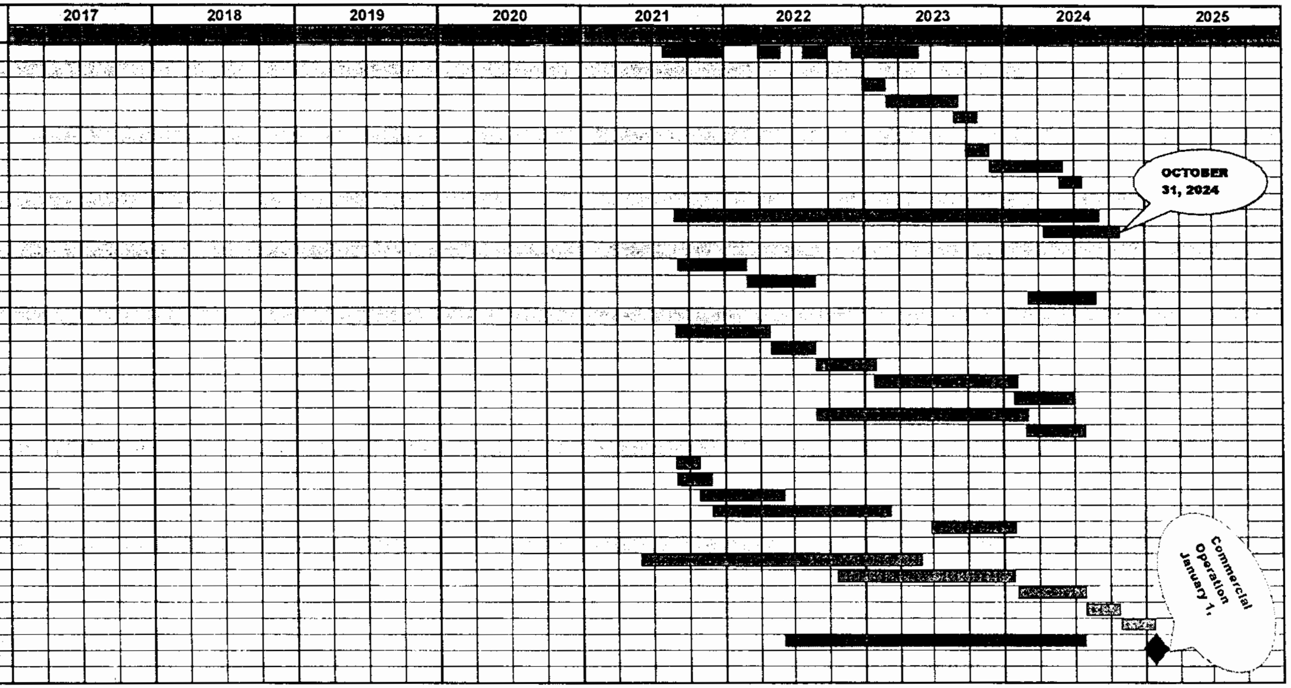
TURTONAS UZGHOR HYDRO ELECTRIC POWER PROJECT

IMPLEMENTATION SCHEDULE



TURTONAS UZGHOR HYDRO ELECTRIC POWER PROJECT
IMPLEMENTATION SCHEDULE

	Description
	Hydraulic Steel Gates / Equipments
3.7	**Construction of Connecting Canal - Upstream**
	Excavation
	Concreting
	Back filling
3.8	**Construction of Connecting Canal - Downstream**
	Excavation
	Concreting
	Back filling
3.9	**Headrace Tunnel**
	Construction of headrace Tunnel
	Concrete Linning in Bottom
3.10	**Pressure Tunnel**
	Stabilization of Slope -Excavation and Rock support
	Construction of Pressure Tunnel
	Steel Linning
3.11	**Surge Tank and Pressure Shaft**
	Construction of Access Road to Surge Tank
	Construction of Access Road to Headrace Tunnel
	Raising Boring
	Construction of Surge Tank and Pressure Shaft
	Steel Linning in Pressure Shaft
	Construction of headrace Tunnel
	Concrete Linning in Bottom
3.12	**Construction of Powerhouse**
	Coffer Dam arround Construction Pit
	Excavation
	Dewatering
	First Stage Concrete
	Second Stage Concrete
3.13	**E&M Works**
	Design and Fabrication
	Installation of Emmbeded Parts
	Erection of E&M Equipment
	Dry Testing
	Wet Testing
3.14	**Swicthyard and Transmission Line**
3.15	**Start of Commercial Operation**



CHAPTER - 18

ECONOMIC ANALYSIS

Chapter: 18

ECONOMIC ANALYSIS

18.1. Introduction

Feasibility study attempts to assess the practicability of an idea and suggestions of a project. In economic term practicability of an idea of a project can be assessed through analysis by juxtaposing returns (usually referred as benefits) from its operation against costs to be incurred over its useful life.

In case of hydropower projects, useful life of the civil engineering work has been assumed to be 60 to 80 years and that of electrical and mechanical equipment 30 years. Analysis has therefore been done over a period of 30 years.

18.2. Economic Analysis

Economic analysis is a systematic and scientific approach to determine the program of action by comparing the ex-ante performance with ex-post achievements which essentially entails major socio-economic developments in the area of influence. Economic analysis seeks to ascertain the reward for investment and provides guidelines to establish the feasibility of the project. It is necessary that gains generated should exceed the cost of the goods and services used in its construction and operation. At least these gains must match or yield higher returns from an alternative investment. The primary objective of undertaking economic analysis is thus to determine whether the contribution of a particular project in the shape of added value benefits is adequate enough to justify use of scarce resources needed in the form of project investment costs. The economic justification of investment in a capital-intensive project depends on three factors: firstly, there is a need for the project, secondly, where technological options are available, the project represents the most economic choice of option; and thirdly, that investment in the project will produce an acceptable return to the national economy. This process involves the assessment of project benefits and identification of project costs over the economic life of the project.

The economic evaluation of this project has been carried out on the basis of providing an equivalent quantum of generation from the steam plant using furnace oil.

It is further assumed that proposed plant will run in integrated mode with the National Grid.

18.3. Shadow Pricing

The economic analysis of the project requires that all costs and benefits must be evaluated at prices within the economy which reflect their real worth. Major inputs into the scheme of economic analysis do not necessarily reflect their true opportunity cost to the economy because of distortions in market prices. Like many other developing countries, the prices of goods and services are distorted by subsidies and taxes in Pakistan too. The rate of foreign exchange has differed from its true opportunity cost. Due to disguised under-employment in agriculture and implications of minimum wage legislation in the industrial sector, the price of labor has generally been higher than its true opportunity cost. Shadow pricing has, therefore, been used to find out true opportunity cost of capital as well as other inputs to determine the economic cost of this project to the national economy.

18.4. Cost of Capital

Shadow price of capital is defined as the opportunity cost of funds withdrawn from other uses and is considered equal to marginal cost of capital in the economy of Pakistan. The World Bank has used 10% discount rate for rural electrification projects and 12% by Planning Commission of Pakistan for economic evaluation of public sector projects followed by a study of Havard Advisory Group on opportunity cost of capital. Accordingly, costs and benefits have been discounted @ 12% for the assessment of economic feasibility of the project.

18.5. Cost of Labour

In cases where there is significant unemployment and under-employment in a local economy shadow wage rates for labor should be used which are considerably lower than actual wages paid. The objective in economic analysis is to use the opportunity cost as an alternative application. In Pakistan, the situation is one of under-employment for unskilled labor rather than full employment since there is labor shortages in rural areas in sowing and harvesting seasons. There is no employment problem for skilled labor as there are sufficient opportunities locally and in nearby oil producing countries.

The project is located in District Chitral of the Khyber Pakhtunkhwa province, where during harvesting period of crops, the labor supply is found to be scarce for construction or other economic activities. On the other hand, the skilled labor force is not sufficient to meet the local needs of the area as observed in the district and surrounding settlements. Therefore, shadow wage rates of 1.00 and 0.78 for skilled and unskilled labor respectively, have been used for deriving the economic cost (refer Mangla Raising Project, WAPDA).

The economic cost of labor has been determined by applying shadow wage factors to the total labor cost which is equivalent to 38% of the local cost of the project with 40% & 60% as skilled and unskilled labor components, respectively.

18.6. Cost of Material

Most of the material inputs for the project, i.e., steel, cement etc, are transported to the project site involving high freight expenditures. It is, therefore, assumed that shadow rate for material may be used as 0.92.

The results of shadow conversion factors have been applied to various components of project costs to derive adjusted economic costs.

18.7. Exchange Rate

Since 1982, the value of the Pakistani Rupee has been worked out with the help of a "managed float" linking it to a basket of currencies. It is recognized that conversion factors are sometimes used even when a currency is floating especially if restrictions exist on currency exchange. Based on the facts it is concluded that conversion factor should not be applied to the exchange rate. Prevailing interbank exchange rate of 1US$ = Rs123.60 (As on 20.08.2018) has therefore been applied.

18.8. Economic Cost

The economic costs are derived by converting financial cost with adjustments for direct transfer payments like taxes, subsidies and interest (transfer payments) during construction, besides adjustments for distortions in the market prices of traded and untraded goods used in the project works. For this study, also economic costs of the project have been derived by removing transfer payments in addition to adjustment of cost of labor and material with appropriate shadow conversion factors. The economic costs of the project thus derived have been used in economic evaluation and given in **Table 18.1**.

18.9. Derivation of Thermal Equivalence

The project feasibility has been assessed on the assumption that in the absence of hydel generation, an equivalent thermal generation plant would be required to produce equivalent amount of energy per annum. A comparative study has, therefore, been made and costs calculated on the basis of providing an equivalent quantum of generation from the steam plant using furnace oil described as economic benefits.

18.10. Operation and Maintenance Cost

The annual operation and maintenance cost excluding establishment cost of a steam electric plant has been assumed as 4% of the estimated capital cost.

18.11. Economic Benefits

Economic benefits have been computed based on the equivalent thermal generation costs that would be avoided if the Hydro Electric Power Project is installed. Thus, the savings for not installing thermal plant, fuel and operating costs would be benefits, attributable to the project.

Description		
Energy	GWh	382.33
Plant Factor	%	84
Cost per KW*	US$	1200
O & M Cost	%	4
Fuel Cost (Financial)/KWh**	Rs.	8.82

* Based on latest capacity cost of thermal power projects.

** Electricity Marketing Data (Power System Statistics – 42nd Issue).

Planning Power Department (NTDC), WAPDA.

The economic feasibility of the project is shown in Table18.1for the proposed hydropower project. The internal economic rate of return (IERR) of the project comes to 17.85% with B.C Ratio of 1.34.

18.12. Sensitivity Analysis

Although the project has shown economic viability with higher rates of return than the opportunity cost of capital even then the project is susceptible to different kind of adverse circumstances like cost over-run, delay in construction and decrease in benefits. The economic feasibility of the project has, therefore, been assessed against 10% decrease in benefits, 20% cost overrun, as well as combined impact of both the variations to see if the project remains economically viable. The results show that the project yields viable rates of return as shown in **Table 18.2** and summarized:

Description	Base Case	10% decrease in benefits	20% cost over-run	Combined impact
IRR	17.85%	15.51%	13.99%	12.12%

18.13. Justification of the Project

The project is economically justifiable in view of supplying low cost hydel power to the local area. The electricity will act as a catalyst for development of basic industry, creation of employment opportunities and uplift of socio-economic conditions, etc. The project has shown economic viability in the form of positive rate of return and also qualifies the sensitivity analysis criteria.

TABLE - 18.1
TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT
ECONOMIC ANALYSIS

MILL.Rs

YEAR	COSTS			EQUIVALENT THERMAL BENEFITS				NET BENEFITS
	CAPITAL	O & M	TOTAL	CAPITAL	O & M	FUEL	TOTAL	
1	6542.43		6542.43	1156.00			1156.00	-5386.43
2	4215.76		4215.76	2312.01			2312.01	-1903.75
3	6008.79		6008.79	2697.35			2697.35	-3311.44
4	4578.63		4578.63	1541.34			1541.34	-3037.29
5		341.24	341.24		308.27	3034.94	3343.21	3001.97
6		341.24	341.24		308.27	3034.94	3343.21	3001.97
7		341.24	341.24		308.27	3034.94	3343.21	3001.97
8		341.24	341.24		308.27	3034.94	3343.21	3001.97
9		341.24	341.24		308.27	3034.94	3343.21	3001.97
10		341.24	341.24		308.27	3034.94	3343.21	3001.97
11		341.24	341.24		308.27	3034.94	3343.21	3001.97
12		341.24	341.24		308.27	3034.94	3343.21	3001.97
13		341.24	341.24		308.27	3034.94	3343.21	3001.97
14		341.24	341.24		308.27	3034.94	3343.21	3001.97
15		341.24	341.24		308.27	3034.94	3343.21	3001.97
16		341.24	341.24		308.27	3034.94	3343.21	3001.97
17		341.24	341.24		308.27	3034.94	3343.21	3001.97
18		341.24	341.24		308.27	3034.94	3343.21	3001.97
19		341.24	341.24		308.27	3034.94	3343.21	3001.97
20		341.24	341.24		308.27	3034.94	3343.21	3001.97
21		341.24	341.24		308.27	3034.94	3343.21	3001.97
22		341.24	341.24		308.27	3034.94	3343.21	3001.97
23		341.24	341.24		308.27	3034.94	3343.21	3001.97
24		341.24	341.24		308.27	3034.94	3343.21	3001.97
25		341.24	341.24		308.27	3034.94	3343.21	3001.97
26		341.24	341.24		308.27	3034.94	3343.21	3001.97
27		341.24	341.24		308.27	3034.94	3343.21	3001.97
28		341.24	341.24		308.27	3034.94	3343.21	3001.97
29		341.24	341.24		308.27	3034.94	3343.21	3001.97
30		341.24	341.24		308.27	3034.94	3343.21	3001.97
31		341.24	341.24		308.27	3034.94	3343.21	3001.97
32		341.24	341.24		308.27	3034.94	3343.21	3001.97
33		341.24	341.24		308.27	3034.94	3343.21	3001.97
34	-1705.45	341.24	-1364.21		308.27	3034.94	3343.21	4707.42
TOTAL	21345.61	10237.32	29877.48	7706.70	9248.10	91048.20	108003.00	78125.52

PW OF BENEFITS @ 12%; MILL.Rs	=	22889.34
PW OF COSTS @ 12%; MILL.Rs	=	18099.70
NET PRESENT WORTH; MILL.Rs	=	4789.64
BENEFIT COST RATIO	=	1.26
I . E . R . R	=	16.52%

TABLE - 18.2
TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT
SENSITIVITY ANALYSIS

MILL.Rs

YEAR	TOTAL COST	BENEFITS	NET BENEFITS	10% LESS BENEFITS	NET BENEFITS	20% COST OVER-RUN	NET BENEFITS	COMBINED IMPACT
1	6542.43	1156.00	-5386.43	1040.40	-5502.03	7850.92	-6694.92	-6810.52
2	4215.76	2312.01	-1903.75	2080.81	-2134.95	5058.91	-2746.90	-2978.10
3	6008.79	2697.35	-3311.44	2427.62	-3581.18	7210.55	-4513.20	-4782.93
4	4578.63	1541.34	-3037.29	1387.21	-3191.43	5494.36	-3953.02	-4107.16
5	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
6	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
7	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
8	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
9	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
10	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
11	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
12	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
13	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
14	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
15	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
16	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
17	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
18	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
19	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
20	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
21	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
22	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
23	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
24	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
25	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
26	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
27	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
28	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
29	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
30	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
31	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
32	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
33	341.24	3343.21	3001.97	3008.89	2667.65	409.49	2933.72	2599.40
34	-1364.21	3343.21	4707.42	3008.89	4373.10	-1637.05	4980.26	4645.94
TOTAL	29877.48	108003.00	78125.52	97202.70	67325.22	35852.98	72150.02	61349.72

INTERNAL RATE OF RETURN = 16.52% 14.34% 12.91% 11.13%

CHAPTER - 19

FINANCIAL ANALYSIS

Chapter: 19

FINANCIAL ANALYSIS

19.1. Introduction

The Financial analysis is undertaken to ascertain the expected returns on investment and assess the financial viability of the project. For a project to be financially viable, it is necessary that gains generated (expected returns) exceed the cost of goods and services used in the form of project investment. At least, these gains must match or yield higher returns as compared to an alternative investment plan.

19.2. Financial Analysis

The primary objective of undertaking this kind of analysis is to determine whether the contribution of a particular project in the shape of added value of benefits is adequate enough to justify the use of already scarce resources needed for construction and operation of the project in the form of project investment cost. As financial analysis is basically carried out from the view point of project owner rather than the economy as a whole, it specifically aims to:

- determine the costs and returns of the project under reasonable financing plan
- establish a framework demonstrating the financial viability of the project during financial negotiations for project financing and capital investment
- assess repayment capability of the project

19.3. Project Base Cost

The project base cost is a mix of local and foreign currency components. The local currency cost is required for payment of land compensation, construction, tools and supplies, inland transportation, etc. which, in this case, amounts to about 56.47% of the total base cost. The foreign cost is required for import of electro-mechanical equipment like generators, turbines, auxiliaries, etc. which, in this case, amounts to about 43.53% of the total base cost. The year-wise phasing (during construction) of the project base cost and its break-up into local and foreign components is presented in Chapter-16 (Project Costing and Budgeting).

19.4. Financial Cost

The financial cost of the project includes interest during construction (IDC) and custom duties. The power projects are exempted from import duties but are subjected to custom duties @ 5% on import of plant and equipment not manufactured locally (Refer hydel policy 2002). The IDC has been charged at the rate of 10.68 % (KIBOR+275bps) on local currency and 6.9096% (LIBOR+460bps) on foreign currency components for the purpose of financial analysis. The financial cost of the project is estimated as Rs 26166.740 million.

19.4.1 Unit Costs

Unit cost refers to cost per unit of energy generated or cost per unit of installed capacity. It is a useful parameter as it indicates project financial efficiency at a glance. Cost of generation and installation per unit as per today has been worked out for the project as per

WAPDA's practice. The project generation cost per kWh and per MW of installed capacity are shown in **Table 19.1(attached)** and summarized:

Description	Generation Cost / kWh		Installed Cost / MW	
	Rs	US Cents	M.Rs	M.US$
	4.76	3.85	318.14	2.57

19.4.2 Operation and Maintenance Cost

The operation and maintenance costs of the project have been assessed @ 1.5% per annum of the base cost, which amounts to Rs 337.157 million per annum during its 30 years of useful life.

19.5. Financial Benefits Analysis

The project will yield both direct and indirect financial benefits. The direct benefits include annual power revenue obtained from sale of electricity generated by the project over its useful life. The indirect benefits will come in the form of savings of foreign exchange for importing an equivalent steam power plant, its annual maintenance cost and cost of fuel to be used for operating the plant. Only the direct benefits of the scheme via power revenues have been used to assess the financial viability of the project.

The proposed project may supply 82.25 MW of power and generate 382.33 GWh per annum at its generation bus-bar but shall be able to deliver about 376.568 GWh of energy annually at NTDC grid. The expected financial benefits throughout the life of the project are estimated as Rs 6788.11 million per annum.

Energy from the project is assumed to be available at a constant rate throughout the life of the project. The power benefits from this project will thus be available from sale of power subject to the prevailing demand. Power benefits have been estimated by assuming likely constant sale price of energy and O&M costs. The likely sale price for estimation of power revenues has been obtained by escalating the average energy sale price of Rs 12.20 per kWh in 2016-17 @ 5% per annum to Rs 18.025 per kWh in the year 2024-25.

To determine the financial viability of the project 98.5% of gross power benefits have been attributed to generation facility and only 1.5% auxiliary losses have been assumed. The results of financial analysis are given in **Table19.2** (**attached**) which show that the project yields financial rate of returns of 20.24% which is greater than the prevailing interest rate and hence makes the project viable.

19.6. Non-Quantifiable Benefits

The importance of availability of electricity from the local hydropower plant needs no emphasis. Locally available hydroelectricity would accelerate pace of development through village electrification. This would encourage local development of local industries. The people would also get employment through setting up of industries. The project would also increase the business activity in the area, thereby providing increased employment and investment opportunities and provide incentive to the work force to live near their homes. Availability of reliable electric supply would also provide cleaner and better living conditions to the local residents.

Furthermore, it will help to achieve improvement in health facilities and general standard of living of the local people of the project area and also usher in an era of continuous prosperity as well as economic emancipation through utilization of indigenous resources of land, labour and capital.

19.7. Conclusion

The project is socially, economically and financially viable, hence recommended for implementation.

TABLE - 19.1
TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT
COST PER kWh AND MW

	DESCRIPTION	MILLION Rs.
1	BASE COST	21345.616
	a) LOCAL	12142.477
	b) F.E.C	9203.139
3	CUSTOM DUTIES	275.646
4	INSURANCE DURING CONSTRUCTION	368.152
	LENDER'S FINANCIAL FEES AND CHARGES	439.788
6	INTEREST DURING CONSTRUCTION	2859.656
	a) LOCAL	302.527
	b) F.E.C	2557.129
5	PROJECT COSTS	25288.858
	* a) LOCAL	13154.771
	b) F.E.C	12134.088
6	AMORTIZATION FOR 12 YEARS AND LEVELIZED OVER 30 YEARS OF:	
	a) LOCAL FINANCIAL COST @ 10.68%	302.527
	b) FOREIGN FINANCIAL @ 6.9096%	2557.129
7	OPER.& MAINT, COST @ 1.5% OF PROJECT COST	379.160
8	ANNUAL RECURRING COST (Debt Pmt., O&M, INS. & WUC)	3269.017
9	ANNUAL ENERGY (GWh)	382.30
10	ANNUAL COST PER kWh - Rs	8.55
	US Cents	6.92
11	INSTALLED CAPACITY (MW)	82.25
12	INSTALLED COST PER MW - Million Rs	307.46
	Million US$	2.49

* Inclusive of total Interest during construction.

TABLE - 19.2
TURTONAS-UZGHOR HYDRO ELECTRIC POWER PROJECT
FINANCIAL ANALYSIS

MILL.Rs

YEAR	PROJECT COST	Cost	TOTAL COST	ENERGY GWh	ENERGY BENEFITS	NET BENEFITS
1	4996.80		4996.80			-4996.80
2	5484.44		5484.44			-5484.44
3	8004.76		8004.76			-8004.76
4	6802.84		6802.84			-6802.84
5		3269.02	3269.02	382.30	7065.76	3796.74
6		3269.02	3269.02	382.30	7065.76	3796.74
7		3269.02	3269.02	382.30	7065.76	3796.74
8		3269.02	3269.02	382.30	7065.76	3796.74
9		3269.02	3269.02	382.30	7065.76	3796.74
10		3269.02	3269.02	382.30	7065.76	3796.74
11		3269.02	3269.02	382.30	7065.76	3796.74
12		3269.02	3269.02	382.30	7065.76	3796.74
13		3269.02	3269.02	382.30	7065.76	3796.74
14		3269.02	3269.02	382.30	7065.76	3796.74
15		3269.02	3269.02	382.30	7065.76	3796.74
16		3269.02	3269.02	382.30	7065.76	3796.74
17		723.28	723.28	382.30	7065.76	6342.48
18		723.28	723.28	382.30	7065.76	6342.48
19		723.28	723.28	382.30	7065.76	6342.48
20		723.28	723.28	382.30	7065.76	6342.48
21		723.28	723.28	382.30	7065.76	6342.48
22		723.28	723.28	382.30	7065.76	6342.48
23		723.28	723.28	382.30	7065.76	6342.48
24		723.28	723.28	382.30	7065.76	6342.48
25		723.28	723.28	382.30	7065.76	6342.48
26		723.28	723.28	382.30	7065.76	6342.48
27		723.28	723.28	382.30	7065.76	6342.48
28		723.28	723.28	382.30	7065.76	6342.48
29		723.28	723.28	382.30	7065.76	6342.48
30		723.28	723.28	382.30	7065.76	6342.48
31		723.28	723.28	382.30	7065.76	6342.48
32		723.28	723.28	382.30	7065.76	6342.48
33		723.28	723.28	382.30	7065.76	6342.48
34	-110.54	723.28	612.74	382.30	7065.76	6453.02
TOTAL	**25288.85**	**52247.21**	**77425.52**	**11469.00**	**211972.68**	**134547.16**

INTERNAL RATE OF RETURN = 13.83%

NOTE:

1. Auxiliary losses taken as 1.5%.
2. Revenue attributed to the project @ 98.5%.
3. Sale price of Rs 18.025 taken for the year 2024- 2025.

CHAPTER - 20

TARIFF

Chapter: 20

PROJECT TARIFF

20.1. Capital Cost

The capital cost of the project is the total installation cost including direct cost of all project components (such as civil works, hydraulic works, electro-mechanical equipment and other direct cost), indirect costs, land, environment mitigation, insurance, government approvals, administration and management costs etc. required to commission the project.
The Project feasibility level cost is briefly mentioned in the below table:

No.	Description	Amount (US$ Mil)
	EPC COST	
1	Civil Works	79.986
2	E&M Works	45.283
3	Hydraulic Works	17.933
4	Engineering & Survey Cost	5.728
	Total (A)	148.93
	NON-EPC COSTS	
1	Engineering & Supervision	5.957
2	Project Development Cost	14.529
3	Land Acquisition, Resettlement & Env. Mitigation	3.283
4	Custom Duties & Taxes	2.230
	Total (B)	25.999
	CAPITAL COST (A+B)	174.929
	Interest During Construction	23.136
	Financial Charges	3.558
	Insurance During Construction	2.978
	PROJECT COST (US$)	204.602

The cost estimates used in the Feasibility study are prepared based on price levels prevalent in August 2018. The nominal exchange rate in August 2018 has been taken as 1 USD = PKR123.60.

EPC COST:
The Feasibility stage EPC cost estimates are prepared from (a) Bill of Quantities for the preparatory and permanent civil works (b) Costs of E&M equipment (including engineering/design, cost of procurement, transportation, erection and commissioning) and

(c) Survey & Investigation etc. The cost estimates are further subdivided into local and foreign cost components and are benchmarked with similar on-going projects in international and domestic power markets.

NON-EPC COST:

The Feasibility Stage Non-EPC cost estimates are prepared mainly on the precedents and cost benchmarks allowed by NEPRA to similar hydropower projects. In case of land acquisition, the cost is based on standards prevailing in Golen Gol area through the investigation by the Consultant.

Sound project development is key to the success of any project, and is absolutely critical for such project as the Project development activities and will take several man months of time and efforts of various professionals and staff. Due to nature of project development, the cost will continue all the way to COD (at least seven years from the approval of feasibility study by NEPRA) and throughout the term of the PPA. The Project Sponsors shall be able to hire and retain both Pakistani as well as foreign top professionals to manage this large infrastructure project. The development cost mainly includes salaries and wages, utilities, travelling and conveyance, office supplies and administration cost, rent rates and taxes, medical and insurance, fees and subscription, vehicles running and maintenance, repair and maintenance, printing stationary and periodical, miscellaneous and other expenses. The services of international and domestic legal and financial advisors are essentially required for the project. Given long implementation period of the Hydro projects, the services of legal and financial advisors will be required throughout the development and construction period to assist in connection with the negotiation and execution of the project documents. The Project Development Cost also includes the costs pertaining to Project Company legal, technical & financial advisors, lenders legal & technical advisors cost, feasibility study cost etc.

The Engineering and Supervision costs expected to be incurred by the Company comprise of Owners Engineer, Independent Engineer, Reopener Verifier under Power Purchase Agreement (PPA), Project Company's other engineering consultants, and Company's own supervision cost during the construction of the Project. Proper Engineering and effective Supervision is the essence for effective and timely execution of the Project. The Engineering and Supervision costs of 3.5% of EPC cost is assumed and will cover the cost of Independent Engineer, Owner Engineer, Re-Opener Verifier and for other engineering consultants.

Custom Duty @ 5.00% (Five Percent) has been assumed on the hydro electrical and mechanical equipment and machinery, and materials for the Project, in accordance with the GOP Power Policy.

The Interest during Construction (IDC) has been calculated at USD 23.136 Million based on the following assumptions:

- LIBOR : 2.31% (Aug. 20, 2018)
- SPREAD : 4.60%
- Interest Rate (Foreign) : 6.91%
- KIBOR : 7.93% (Aug. 20, 2018)
- SPREAD : 2.75%
- Interest Rate (Local) : 10.68%

The Financial Fee & Charges include costs related to debt financing of the project i.e. Mandate / Working Fee, Upfront fee, commitment fee and other financing fees cost and charges as may be required by the Lenders. The financial charges computed are based on feasibility stage project cost and debt requirements. NEPRA has set a benchmark of Financial Fees & Charges (2.5%) of Debt excluding IDC and financial charges.

Insurance during construction which is 2% of the EPC cost. Insurance during Construction cost covers the insurance cost of the Project's assets during the construction period.

20.2. Tariff Structure

The proposed Reference Tariff is a typical two parts tariff comprising an Energy Purchase Price (EPP) for the energy generated and delivered to the power purchaser and a Capacity Purchase Price (CPP) based on the installed plant capacity. The tariff is based on 17% Return on Equity (IRR Based), as it is considered reasonable for the investor. The cash flows of revenues have been derived from multiplying each element of the capacity tariff by the guaranteed capacity, and each element of the energy tariff by the amount of energy sold over the useful life of the project. The cash flow of cost comprises the equity component of the investment, the repayment of principal as well as interest on loans in local and foreign currencies, variable and fixed operation and maintenance costs, insurance cost, Return on Equity (ROE), Return on Equity during Construction (ROEDC) and water use charges.

20.3. Energy Purchase Price

Energy Purchase Price consists of three components i.e., Variable O&M local, foreign component and Water Use Charges.

a) Variable O&M Cost

Variable O&M cost caters for the cost of the services of the O&M operators for day to day management of the power plant. It includes the cost of lubricants and other chemicals etc. It also covers cost of maintenance of the plant including replacement of parts as and when required. It has been taken as 25% of O&M Cost which amounts to Rs 0.2517/kWh annually comprises on local (65%) and foreign (35%) components respectively.

b) Water Use Charges (WUC)

Water Use Charges will be paid @ 0.425/kWh by the private sector hydropower projects to Khyber Pakhtunkhwa province (Refer Power Generation Policy, 2015 GOP). Water Use Charges have been added in the tariff stream amounting to Rs 0.425/kWh annually.

20.4. Capacity Purchase Price

Capacity Purchase Price (CPP) is a fixed monthly payment per kW of the capacity available at the plant to meet the fixed cost of the project, provided that plant is available for dispatch as per the standards defined in Power Purchase Agreement (PPA). The CPP comprises of fixed local & foreign O&M cost, insurance, return on equity, return on equity during construction, principal repayment and interest.

a) Fixed O&M local & foreign

Fixed O&M cost component reflects the fixed cost of all the O&M staff including the remuneration to staff and other administrative costs including rent, utilities, environmental monitoring, local taxes and duties, etc. It also includes the management fee and cost of

O&M contractor's management to be engaged for operation and maintenance of the plant. It has been worked out @ 75% of O&M Cost which amounts to Rs 292.5034/kW/Month on local (35%) and foreign (65%) components respectively.

b) Insurance

The insurance cost (during project operations) is required for insurance policies to maintain the plant as defined in PPA and as required by the lender. The risks to be covered through insurance during operation include machinery breakdown, natural calamities (like earth quake, etc.) and business interruption. It has been taken @ 1% of EPC Cost and its tariff is about Rs 189.3410/kW/Month.

c) Return on Equity (ROE)

Return on equity is meant to provide benefit to the project sponsor on the amount of equity. A hydropower plant carries a higher risk as compared to an equivalent thermal plant due to being capital intensive, longer gestation period, susceptibility to political instability, security problems and cost over-run, etc. The return on equity comes about Rs 884.4122/KW/Month which is calculated by assuming 17% ROE (IRR Based).

d) Return on Equity During Construction (ROEDC)

ROEDC is calculated @ 17% (IRR Based) on equity and capitalized over life of the project for the interest of the investor starting from the first year of tariff. It comes about Rs 298.7727/KW/Month.

e) Debt Services

The debt equity ratio of 80:20 has been assumed and applied in the tariff profile of the project. The lending terms assumed in the Feasibility Study are as follows:

Lending terms assumed for financing plan:

Financing	90% Foreign 10% Local
Debt Amount	USD 163.681 Million
Construction Period	4 Years
Repayment Period	12 Years from COD
LIBOR	2.30963%
Spread	4.60%
KIBOR	7.93%
Spread	2.75%
Exchange Rate (USD/PKR)	1USD = PKR123.60

The debt will be financed by assuming 10% local financing and 90% foreign financing. The repayment of principal loan is calculated on quarterly basis. The payment of loan starts immediately after commissioning of the project. Interest during construction (USD 23.136 million) is capitalized to estimate the installments of the repayment.

f) Hydrological Risk

Hydrological risk will be borne by the power purchaser in accordance with the Power Policy of the Government, 2015.

The assumptions of tariff are summarized in **Table 20.1**.

20.5. Reference Tariff

The levellized tariff has been computed over 30 years of useful life of the project, which comes to Rs 9.8206 per kWh, equivalent to US Cents 7.9454 per kWh at reference exchange rate of PKR 123.60 for 1 USD. Year-wise tariff profile of the project is presented in **Table-20.2**.

Table 20.1: Tariff Assumptions:

Description	Million USD
Installed Capacity	82.25MW
Plant Factor	53.06%
Total Project Cost	204.602
Construction Period	48 Months
Debt: Equity Ratio	80:20
Debt	163.68
Equity	40.92
Return on Equity	17% IRR Based
O&M Cost	1.50% of Project Cost
Insurance During Operations	1% of EPC Cost

Loan Currency	USD
Financing	90% Foreign; 10% Local
Foreign Debt Amount	147.31 Million
Local Debt Amount	16.36 Million
Construction Period	4 Years
Repayment Period	12 Years from COD
LIBOR	2.31%
Spread	4.60%
KIBOR	7.93%
Spread	2.75%
Repayment	Quarterly

Section Ref.	Description	Amount (US$ Mil)
7.2.1	EPC Cost	148.93
7.2.2	Engineering & Supervision	5.957
7.2.3	Project Development Cost	14.529
7.2.4	Land Acquisition, Resettlement & Env. Mitigation	3.283
7.2.5	Custom Duties & Taxes	2.230
7.2.6	Insurance During Construction	2.978
7.2.7	Financial Charges	3.558
7.2.8	Interest During Construction	23.136
	TOTAL PROJECT COST	204.602

Turtonas Uzghor Hydropower Project											
REFERENCE TARIFF TABLE											
Energy Purchase Price					Capacity Purchase Price						
Year	Variable O & M Local	Variable O & M Foreign	Water charge	Fixed O & M Local	Fixed O & M Foreign	Insurance	ROE	ROEDC	Principal Repayment	Interest	Total Tariff
	Rs/kWh	Rs/kWh	Rs/kWh	Rs/kW/M	Rs/kW/M	Rs/kW/M	Rs/kW/M	Rs/kW/M	Rs/kWh/M	Rs/kW/M	Rs/kWh
1	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	1132.3772	1486.1711	11.7357
2	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	1216.3328	1402.2155	11.7357
3	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	1306.6485	1311.8998	11.7357
4	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	1403.8205	1214.7278	11.7357
5	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	1508.3852	1110.1630	11.7357
6	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	1620.9228	997.6255	11.7357
7	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	1742.0605	876.4878	11.7357
8	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	1872.4772	746.0711	11.7357
9	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	2012.9074	605.6408	11.7357
10	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	2164.1464	454.4018	11.7357
11	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	2327.0552	291.4931	11.7357
12	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	2502.5663	19.6159	11.7357
13	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	1124.3018	298.7727	-	-	5.5947
14	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	1075.1678	298.7727	-	-	5.4678
15	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	1026.0338	298.7727	-	-	5.3410
16	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	976.8998	298.7727	-	-	5.2141
17	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	927.7658	298.7727	-	-	5.0873
18	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	878.6318	298.7727	-	-	4.9604
19	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	829.4978	298.7727	-	-	4.8336
20	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	780.3637	298.7727	-	-	4.7067
21	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	731.2297	298.7727	-	-	4.5799
22	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	682.0957	298.7727	-	-	4.4530
23	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	632.9617	298.7727	-	-	4.3262
24	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	583.8277	298.7727	-	-	4.1993
25	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	534.6937	298.7727	-	-	4.0725
26	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	485.5597	298.7727	-	-	3.9456
27	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	436.4257	298.7727	-	-	3.8188
28	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	387.2916	298.7727	-	-	3.6919
29	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	338.1576	298.7727	-	-	3.5651
30	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	289.0236	298.7727	-	-	3.4382
Levilized Tariff											
Average(1-12)	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	884.4122	298.7727	1,535.1036	1,083.4447	11.7357
Average (13-30)	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	732.0555	298.7727	333.0366	36.4529	5.5478
Levilized Tariff (Rs/kWh)	0.1636	0.0881	0.4250	102.3762	190.1272	189.3410	868.4736	298.7727	1,155.7641	733.6427	9.8206
Levelized Tariff (1-30 years) discounted at 10% per annum = US Cents 7.9454/kWh at reference exchange rate of 1US$=Rupees 123.60.											

Foreign Debt Loan Amortization Schedule (USD) Base					
Quarters	Opening Balance	Installment	Interest	Principal	Closing Balance
1	147,313,736	4,540,218	2,544,709	1,995,510	145,318,226
2	145,318,226	4,540,218	2,510,238	2,029,980	143,288,246
3	143,288,246	4,540,218	2,475,172	2,065,046	141,223,199
4	141,223,199	4,540,218	2,439,500	2,100,718	139,122,481
5	139,122,481	4,540,218	2,403,212	2,137,006	136,985,475
6	136,985,475	4,540,218	2,366,297	2,173,921	134,811,554
7	134,811,554	4,540,218	2,328,745	2,211,473	132,600,081
8	132,600,081	4,540,218	2,290,544	2,249,674	130,350,407
9	130,350,407	4,540,218	2,251,683	2,288,536	128,061,871
10	128,061,871	4,540,218	2,212,150	2,328,068	125,733,803
11	125,733,803	4,540,218	2,171,935	2,368,283	123,365,520
12	123,365,520	4,540,218	2,131,025	2,409,193	120,956,327
13	120,956,327	4,540,218	2,089,409	2,450,810	118,505,518
14	118,505,518	4,540,218	2,047,073	2,493,145	116,012,373
15	116,012,373	4,540,218	2,004,006	2,536,212	113,476,161
16	113,476,161	4,540,218	1,960,196	2,580,023	110,896,138
17	110,896,138	4,540,218	1,915,628	2,624,590	108,271,548
18	108,271,548	4,540,218	1,870,291	2,669,927	105,601,621
19	105,601,621	4,540,218	1,824,170	2,716,048	102,885,573
20	102,885,573	4,540,218	1,777,253	2,762,965	100,122,608
21	100,122,608	4,540,218	1,729,525	2,810,693	97,311,915
22	97,311,915	4,540,218	1,680,973	2,859,245	94,452,670
23	94,452,670	4,540,218	1,631,583	2,908,636	91,544,034
24	91,544,034	4,540,218	1,581,339	2,958,880	88,585,155
25	88,585,155	4,540,218	1,530,227	3,009,992	85,575,163
26	85,575,163	4,540,218	1,478,232	3,061,986	82,513,177
27	82,513,177	4,540,218	1,425,339	3,114,879	79,398,297
28	79,398,297	4,540,218	1,371,532	3,168,686	76,229,611
29	76,229,611	4,540,218	1,316,796	3,223,422	73,006,189
30	73,006,189	4,540,218	1,261,114	3,279,104	69,727,085
31	69,727,085	4,540,218	1,204,471	3,335,747	66,391,338
32	66,391,338	4,540,218	1,146,849	3,393,369	62,997,969
33	62,997,969	4,540,218	1,088,232	3,451,987	59,545,982
34	59,545,982	4,540,218	1,028,602	3,511,616	56,034,366
35	56,034,366	4,540,218	967,942	3,572,276	52,462,089
36	52,462,089	4,540,218	906,234	3,633,984	48,828,105
37	48,828,105	4,540,218	843,460	3,696,758	45,131,347
38	45,131,347	4,540,218	779,602	3,760,616	41,370,731
39	41,370,731	4,540,218	714,641	3,825,577	37,545,154
40	37,545,154	4,540,218	648,558	3,891,660	33,653,494
41	33,653,494	4,540,218	581,333	3,958,885	29,694,608
42	29,694,608	4,540,218	512,947	4,027,271	25,667,337
43	25,667,337	4,540,218	443,380	4,096,839	21,570,498
44	21,570,498	4,540,218	372,610	4,167,608	17,402,891
45	17,402,891	4,540,218	300,619	4,239,599	13,163,291
46	13,163,291	4,540,218	227,384	4,312,835	8,850,457
47	8,850,457	4,540,218	152,883	4,387,335	4,463,122
48	4,463,122	4,540,218	77,096	4,463,122	0

Local Debt Loan Amortization Schedule (USD) Base					
Quarters	Opening Balance	Installment	Interest	Principal	Closing Balance
1	16,368,193	608,931	437,031	171,901	16,196,292
2	16,196,292	608,931	432,441	176,490	16,019,802
3	16,019,802	608,931	427,729	181,203	15,838,599
4	15,838,599	608,931	422,891	186,041	15,652,559
5	15,652,559	608,931	417,923	191,008	15,461,551
6	15,461,551	608,931	412,823	196,108	15,265,443
7	15,265,443	608,931	407,587	201,344	15,064,099
8	15,064,099	608,931	402,211	206,720	14,857,379
9	14,857,379	608,931	396,692	212,239	14,645,139
10	14,645,139	608,931	391,025	217,906	14,427,233
11	14,427,233	608,931	385,207	223,724	14,203,509
12	14,203,509	608,931	379,234	229,698	13,973,811
13	13,973,811	608,931	373,101	235,831	13,737,981
14	13,737,981	608,931	366,804	242,127	13,495,854
15	13,495,854	608,931	360,339	248,592	13,247,262
16	13,247,262	608,931	353,702	255,229	12,992,032
17	12,992,032	608,931	346,887	262,044	12,729,988
18	12,729,988	608,931	339,891	269,041	12,460,947
19	12,460,947	608,931	332,707	276,224	12,184,723
20	12,184,723	608,931	325,332	283,599	11,901,124
21	11,901,124	608,931	317,760	291,171	11,609,953
22	11,609,953	608,931	309,986	298,946	11,311,007
23	11,311,007	608,931	302,004	306,927	11,004,080
24	11,004,080	608,931	293,809	315,122	10,688,958
25	10,688,958	608,931	285,395	323,536	10,365,421
26	10,365,421	608,931	276,757	332,175	10,033,247
27	10,033,247	608,931	267,888	341,044	9,692,203
28	9,692,203	608,931	258,782	350,150	9,342,054
29	9,342,054	608,931	249,433	359,498	8,982,555
30	8,982,555	608,931	239,834	369,097	8,613,458
31	8,613,458	608,931	229,979	378,952	8,234,506
32	8,234,506	608,931	219,861	389,070	7,845,436
33	7,845,436	608,931	209,473	399,458	7,445,978
34	7,445,978	608,931	198,808	410,124	7,035,854
35	7,035,854	608,931	187,857	421,074	6,614,780
36	6,614,780	608,931	176,615	432,317	6,182,463
37	6,182,463	608,931	165,072	443,860	5,738,604
38	5,738,604	608,931	153,221	455,711	5,282,893
39	5,282,893	608,931	141,053	467,878	4,815,015
40	4,815,015	608,931	128,561	480,370	4,334,645
41	4,334,645	608,931	115,735	493,196	3,841,448
42	3,841,448	608,931	102,567	506,365	3,335,084
43	3,335,084	608,931	89,047	519,885	2,815,199
44	2,815,199	608,931	75,166	533,766	2,281,434
45	2,281,434	608,931	60,914	548,017	1,733,417
46	1,733,417	608,931	46,282	562,649	1,170,768
47	1,170,768	608,931	31,259	577,672	593,096
48	593,096	608,931	15,836	593,096	0

Income Statement (US$)

Year	Income			Operating Expenses						Total Expenses	Operating Profit	Depreciation	Financial Expenses	Profit Before Tax
	Capacity Payments	Energy Payments	Total Income	Water Use Charge	Variable O&M-Local	Variable O&M-Foreign	Fixed O&M-Foreign	Fixed O&M-Local	Insurance					
1	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	11,689,710	11,393,333
2	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	11,029,344	12,053,699
3	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	10,318,951	12,764,091
4	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	9,554,630	13,528,412
5	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	8,732,160	14,350,883
6	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	7,846,978	15,236,064
7	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	6,894,151	16,188,892
8	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	5,868,338	17,214,705
9	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	4,763,762	18,319,281
10	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	3,574,168	19,508,874
11	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	2,292,784	20,790,258
12	33,693,145	2,061,744	35,754,889	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	29,903,122	6,820,080	912,274	22,170,769
13	14,983,436	2,061,744	17,045,180	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	11,193,413	6,820,080	-	4,373,333
14	14,596,965	2,061,744	16,658,708	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	10,806,942	6,820,080	-	3,986,862
15	14,210,493	2,061,744	16,272,237	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	10,420,471	6,820,080	-	3,600,391
16	13,824,022	2,061,744	15,885,766	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	10,034,000	6,820,080	-	3,213,920
17	13,437,551	2,061,744	15,499,295	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	9,647,528	6,820,080	-	2,827,448
18	13,051,080	2,061,744	15,112,823	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	9,261,057	6,820,080	-	2,440,977
19	12,664,608	2,061,744	14,726,352	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	8,874,586	6,820,080	-	2,054,506
20	12,278,137	2,061,744	14,339,881	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	8,488,115	6,820,080	-	1,668,035
21	11,891,666	2,061,744	13,953,410	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	8,101,644	6,820,080	-	1,281,564
22	11,505,195	2,061,744	13,566,939	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	7,715,172	6,820,080	-	895,092
23	11,118,724	2,061,744	13,180,467	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	7,328,701	6,820,080	-	508,621
24	10,732,252	2,061,744	12,793,996	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	6,942,230	6,820,080	-	122,150
25	10,345,781	2,061,744	12,407,525	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	6,555,759	6,820,080	-	(264,321)
26	9,959,310	2,061,744	12,021,054	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	6,169,287	6,820,080	-	(650,793)
27	9,572,839	2,061,744	11,634,583	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	5,782,816	6,820,080	-	(1,037,264)
28	9,186,367	2,061,744	11,248,111	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	5,396,345	6,820,080	-	(1,423,735)
29	8,799,896	2,061,744	10,861,640	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	5,009,874	6,820,080	-	(1,810,206)
30	8,413,425	2,061,744	10,475,169	1,294,834	498,492	268,419	1,495,475	805,256	1,489,291	5,851,766	4,623,403	6,820,080	-	(2,196,677)

Cash Flow Statement (US$)									
Years	Profit Before Tax	Depreciation	Interest Expense	**Operating Cash Flow**	Interest Payments	Principal Payments	Equity Redemption	**Cash Flow after Debt Service**	Available for Dividends
1	11,393,333	6,820,080	11,689,710	29,903,122	(11,689,710)	(8,906,889)	-	9,306,524	9,306,524
2	12,053,699	6,820,080	11,029,344	29,903,122	(11,029,344)	(9,567,254)	-	9,306,524	9,306,524
3	12,764,091	6,820,080	10,318,951	29,903,122	(10,318,951)	(10,277,647)	-	9,306,524	9,306,524
4	13,528,412	6,820,080	9,554,630	29,903,122	(9,554,630)	(11,041,968)	-	9,306,524	9,306,524
5	14,350,883	6,820,080	8,732,160	29,903,122	(8,732,160)	(11,864,438)	-	9,306,524	9,306,524
6	15,236,064	6,820,080	7,846,978	29,903,122	(7,846,978)	(12,749,620)	-	9,306,524	9,306,524
7	16,188,892	6,820,080	6,894,151	29,903,122	(6,894,151)	(13,702,447)	-	9,306,524	9,306,524
8	17,214,705	6,820,080	5,868,338	29,903,122	(5,868,338)	(14,728,260)	-	9,306,524	9,306,524
9	18,319,281	6,820,080	4,763,762	29,903,122	(4,763,762)	(15,832,836)	-	9,306,524	9,306,524
10	19,508,874	6,820,080	3,574,168	29,903,122	(3,574,168)	(17,022,430)	-	9,306,524	9,306,524
11	20,790,258	6,820,080	2,292,784	29,903,122	(2,292,784)	(18,303,814)	-	9,306,524	9,306,524
12	22,170,769	6,820,080	912,274	29,903,122	(912,274)	(19,684,324)	-	9,306,524	9,306,524
13	4,373,333	6,820,080	-	11,193,413	-	-	(2,273,360)	8,920,053	8,920,053
14	3,986,862	6,820,080	-	10,806,942	-	-	(2,273,360)	8,533,582	8,533,582
15	3,600,391	6,820,080	-	10,420,471	-	-	(2,273,360)	8,147,111	8,147,111
16	3,213,920	6,820,080	-	10,034,000	-	-	(2,273,360)	7,760,640	7,760,640
17	2,827,448	6,820,080	-	9,647,528	-	-	(2,273,360)	7,374,168	7,374,168
18	2,440,977	6,820,080	-	9,261,057	-	-	(2,273,360)	6,987,697	6,987,697
19	2,054,506	6,820,080	-	8,874,586	-	-	(2,273,360)	6,601,226	6,601,226
20	1,668,035	6,820,080	-	8,488,115	-	-	(2,273,360)	6,214,755	6,214,755
21	1,281,564	6,820,080	-	8,101,644	-	-	(2,273,360)	5,828,284	5,828,284
22	895,092	6,820,080	-	7,715,172	-	-	(2,273,360)	5,441,812	5,441,812
23	508,621	6,820,080	-	7,328,701	-	-	(2,273,360)	5,055,341	5,055,341
24	122,150	6,820,080	-	6,942,230	-	-	(2,273,360)	4,668,870	4,668,870
25	(264,321)	6,820,080	-	6,555,759	-	-	(2,273,360)	4,282,399	4,282,399
26	(650,793)	6,820,080	-	6,169,287	-	-	(2,273,360)	3,895,927	3,895,927
27	(1,037,264)	6,820,080	-	5,782,816	-	-	(2,273,360)	3,509,456	3,509,456
28	(1,423,735)	6,820,080	-	5,396,345	-	-	(2,273,360)	3,122,985	3,122,985
29	(1,810,206)	6,820,080	-	5,009,874	-	-	(2,273,360)	2,736,514	2,736,514
30	(2,196,677)	6,820,080	-	4,623,403	-	-	(2,273,360)	2,350,043	2,350,043

!

PRIVATE POWER AND INFRASTRUCTURE BOARD

Sinohydro – Sachal Consortium

TURTONAS UZGHOR HYDRO ELECTRIC POWER PROJECT

FEASIBILITY STUDY REPORT

VOLUME VI - APPENDIX E

ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

(March-2019)

Technical, Engineering and Management (TEAM) (Pvt.) Ltd. Pakistan

FICHTNER GmbH, Germany

TABLE OF CONTENTS

TABLE OF CONTENTS

EXECUTIVE SUMMARY

CHAPTER - 1
INTRODUCTION

CHAPTER - 2
ENVIRONMENTAL POLICY AND LEGAL FRAMEWORK

CHAPTER - 3

DESCRIPTION OF THE PROJECT

CHAPTER - 4

CONSIDERATION OF ALTERNATIVES

CHAPTER - 5
ENVIRONMENTAL BASELINE

CHAPTER - 6
MITIGATION MEASURES

CHAPTER - 7

ENVIRONMENTAL AND SOCIAL MANAGEMENT AND MONITORING PLAN

CHAPTER - 8

EMERGENCY PREPAREDNESS AND RESPONSE

CHAPTER - 9

STAKEHOLDER ENGAGEMENT

CHAPTER - 10

GRIEVANCE REDRESS MECHANISM

CHAPTER - 11

MONITORING AND REVIEW

CHAPTER - 12

CONCLUSIONS AND RECOMMENDATIONS

LIST OF ABBREVIATIONS

AKRSP	Agha Khan Rural Support program
CDM	Clean Development Mechanism
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CSC	Construction Supervision Consultants
EU	Environment Unit
ESIA	Environmental and Social Impact Assessment
EIA	Environmental Impact Assessment
ESMP	Environmental and Social Management Plan
EPA	Environmental Protection Agency
GR	Game Reserve
GRC	Grievance Redress Committee
GWh	Giga Watt hour
IEE	Initial Environmental Examination
IFC	International Finance Corporation
KPKP-EPA	Khyber Pakhtunkhwa-Environmental Protection Agency
KV	Kilo Volt
MP	Monitoring Plan
MW	Mega Watt
NCS	National Conservation Strategy
NEPRA	National Electric Power Regulatory Authority
NEQS	National Environmental Quality Standards
NOx	Oxides of Nitrogen
NTDC	National Transmission Dispatch Company
PAP	Project Affected Persons
PCU	Public Complaint Unit
PEPA	Pakistan Environmental Protection Act
PM	Particulate Matter
PPE	Personal Protective Equipment
PPAF	Pakistan Poverty Alleviation Fund
SO_2	Sulfur dioxide
SHYDO	Sarhad Hydel Development Organization

SRSP	Sarhad Rural Support Program
WS	Wildlife Sanctuaries

US$ 1.00 = Rs. 110.38 Currency Equivalents

WEIGHTS AND MEASURES

ac	acre
dB	decibel
ft	feet/foot
ft^3	cubic foot
ha	hectare
km	kilo meter
m	meter
mm	millimeter

REFERENCES

1. Sheikh, K. M., and S. Molur. 2006. "Status and Red List of Pakistan's Mammals: Based on the Conservation Assessment and Management Plan", pp. 20-312. IUCN Pakistan, Karachi.
2. Roberts TJ. 1997. Mammals of Pakistan. Oxford University Press, Karachi.
3. Shah, S. A. "Conservation of endangered species in Khyber Pakhtunkhwa." Journal of Animal and Plant Sciences 21, no. 2 (2011): 400-404.
4. Molur, Sanjay. "Status and Red List of Pakistan's Mammals." (2005).
5. Grimmett, Richard, Tom J. Roberts, Tim Inskipp, and Clive Byers. 2008. Birds of Pakistan. A&C Black.
6. Ahmad, D. (2012). Khyber Pakhtunkhwa State of the Environment. Peshawar: Environmental ProtectionAgency, Government of Khyber Pakhtunkhwa.
7. Shinwari, Muhammad Ibrar, and Maryum Ibrar Shinwari. "Botanical Diversity in Pakistan; Past Present and Future." *World Environment* 85 (2010).
8. *Sarhad Provincial Conservation Strategy*. IUCN Pakistan and Government of Pakistan, Karachi (1996).
9. http://www.wwfpak.org/species/Markhor.php
10. IUCN Red List of Threatened Species. Accessed on January 10, 2018. Available at http://www.iucnredlist.org/
11. Mertens, R. 1969. "Die Amphibians und Reptilians West Pakistan". Stutt. Beit. Naturkunde, 197, pp. 196.
12. Khan, M.S., 2006. Amphibians and reptiles of Pakistan. Krieger Publishing Company, Malabar, Florida.pp 311.
13. CITES. Checklist of CITES Species. Accessed on Jan 10, 2018. Available at http://checklist.cites.org/#/en
14. Akhtar, N. 1991. The Northern Areas (Pakistan). Fisheries profile, feasible sites for trout culture and overall sectoral development perspective. Report for Proj. PAK/91/008. Rome, FAO. 29p.

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

1. Title and Location of the Project

Turtonas-Uzghor Hydro Electric Power Project is located between the villages of Turtonas and Uzghor on Golen Gol Nullah, a tributary of Mastuj River in Chitral, Khyber Pakhtunkhwa (KPK) Province. The project would be having the provisional capacity of 82.25 MW and will generate about 382.33 GWh of energy annually.

The confluence of Golen Gol River with Mastuj River occurs about 22km northeast of Chitral town on Chitral-Buni Road. The project area extends over a 6 Km length of Golen Gol River starting from weir to the power house. The scheme is situated between an altitude of 1625m.a.s.l (Powerhouse, Latitude 35° 57' 11" N; Longitude 71° 57' 28" E) and 2050m.a.s.l (Weir, 35° 55' 20" N; Longitude 71° 59' 30" E).

2. Project Status and Proponent

The Turtonas-Uzghor Hydro Electric Power Project is being implemented/accomplished by a consortium of M/s Sinohydro Corporation Limited and M/s Sachal Engineering Works (Pvt.) Limited (the "Consortium") in accordance with Letter of Interest (LOI) issued by Private Power and Infrastructure Board (PPIB). The PPIB authorization for issuance of LOI is in accordance with the Power Generation Policy,2015 (Power Policy) to encourage private sector investment in developing power generation projects. The LOI provides the aforementioned consortium the legal right to develop the site, with diligently proceeding for feasibility investigations required for the completion of Feasibility Report. ESIA Study was conducted by a multidisciplinary team initially during the period September– November, 2017 as the part of feasibility study

3. Project Consultants

The Consultants M/s Technical, Engineering and Management (TEAM), Pakistan and FICHTNER GmbH, Germany were selected by the consortium to prepare a bankable Feasibility Report of Turtonas-Uzghor Hydro Electric Power Project. The expertise and technical resources of the TEAM and FICHTNER shall play a key role in completing the assignment.

4. Brief Outline of the Proposal

The proposed 82.25 MW HEPP project is a run of river scheme. The project layout is disposition along the right bank of the Golen Gol River. The difference of elevation between Weir and Powerhouse site was measured in the field with GPS, checked by Google Pro and counter verified with actual survey; which gave a gross head of 494.1m. The project components will consist of a weir near Turtonas village, a head pond behind the weir at conservation level of 2582 m above mean sea level, intake structure followed by sand trap, headrace tunnel, pressure shaft, surge chamber, penstocks, powerhouse, and tailrace. Coffer dams and a diversion tunnel may be built to keep the river bed in dry condition during construction of the weir. The diversion weir site is proposed some 250m upstream of Turtonas Wooden Bridge along right bank of Golen Gol River. The Diversion Weir will consist of fixed and gated parts. The power intake would be located along right bank of Golen Gol. Water from Power Intake will pass through the connecting canal before entering into sedimentation basin. Another connecting canal will lead water to headrace tunnel, surge chamber, pressure shaft and pressure tunnel. Water after generating power will pass through the tailrace channel and fall back into the Golen Gol River just upstream of Golen Gol HPP, Diversion Weir.

Environmental and social assessment is undertaken to meet the requirements of Pakistan Environmental Laws, National Environmental Quality Standards (NEQS), Land Acquisition Act 1894, NWFP Forest Ordinance 2002, Sarhad National Conservation Strategy 1992 and IFC's performance standards and guidelines. This type of project is classified as "category A" project according to IFC's Environmental and Social Review Procedures Manual (2016).The Project also falls into "category A" according to the schedule 11 (Regulation 4) of Pakistan Environmental Protection Agency (review of IEE and EIA) Regulations, 2000, making it therefore subject to an Environmental Impact Assessment (EIA). Similarly requirements laid down by the World Bank/ International Finance Corporation, Asian Development Bank. In particular, it is also prepared under the guidelines of IFC to seek loan funding from International Donor. Therefore, the present report constitutes an ESIA (Environmental and Social Impact Assessment), and not only an EIA.

Alternatives are essentially different ways through which the proponent can feasibly achieve sustainable development by carrying out a different type of actions, choosing design alternatives or adopting a different technology or design for the Project to create win-win scenario for all stakeholders. Various alternatives are studied to plan project sustainably, these alternatives are discussed in chapter 4 of this report.

5. Environmental and Social Impacts Assessment (ESIA)

The major environmental and social impacts identified are associated with construction activities. The likely impacts are increased traffic incidents, noise, vibration and dust and air pollution through blasting and construction traffic, loss of land for construction of camp and staff colony on permanent basis, possible social conflicts among labor force and community, loss of trees to clear land for construction of colony, loss of land and land acquisition impacts. **No resettlements impacts are associated with the project because no houses, shops or any other amenities are built on the land required for project. Most of this land is also uncultivated and is barren wasteland.**

6. Environmental and Social Mitigation and Management Plan(ESMP)

The mitigation and management measures are proposed to the impacts and risks identified in project screening. Mitigation cost has been also proposed for the replantation/ tree loss compensation. All mitigations measures identified are part of the detailed ESMP given in the report. Brief traffic management, solid management plans and emergency preparedness and response procedures also part of the management measures.

7. Stakeholder Engagement

Apart from collecting quantitative data through household survey of project area, consultation with local communities was carried out to share the information about the project and to record their concerns about the project. Different topics discussed with the stakeholders included employment and livelihood opportunities, land acquisition issues, social and environmental issues. The concerns or feedback of the stakeholders regarding the project are documented in detail and appropriate mitigation and management measures are proposed.

Grievance redress mechanism is defined in detail and a process is proposed to cater the grievances of the communities and project affected persons affectively. The role and responsibilities of public complaint unit and grievance redress committee are described in detail to support the process and to avoid social unrest in the project area.

8. Proposed Monitoring

A monitoring plan is the part of the report to monitor the contractor's work during project implementation in order to check contractual compliance with specified mitigation measures, and subsequently to monitor and assess the changes in environmental and social parameters of the project over the years following completion of the various project components.

9. Conclusions

The project will be highly beneficial for the local communities to raise their income and increase economic activity in the area. It will also have some negative environmental impacts mostly associated with construction activities and these can be successfully mitigated by implementing ESMP attached with ESIA. The ESIA, ESMP and Monitoring Plan are sufficient to ensure compliance with Government of Pakistan environmental policies and IFC's guidelines. M/S Sinohydro Corporation Limited and M/s Sachal Engineering Works (Pvt.) Limited, Supervisory Consultant, EPA Khyber Pakhtunkhwa are the key players who have to implement and monitor the measures during and after construction as given in the ESMP and MP.

CHAPTER - 1

INTRODUCTION

CHAPTER-1

INTRODUCTION

1.0 GENERAL OVERVIEW

Pakistan domestic energy resources are characterized by sizeable reserves of natural gas, substantial hydropower potential, coal and modest reserves of crude oil. The country also has a large base of traditional fuels such as fuel wood and agriculture and animal wastes that mainly meet the energy needs of rural consumers. However, the exploitation of these energy resources has been slow due to funding constraint and unsatisfactory performance of public sector entities.

Development and distribution of electricity was the responsibility of WAPDA and Distribution companies. However the gap between demand and supply of Electricity continued to increase due to budgetary constraints and unsatisfactory performance of both entities. Therefore reforms of the electricity sector through deregulation and restructuring and involvement of private sector was initiated.

Electricity generation plays a vital role in the socioeconomic development of the area community and the national growth of the country in term of the industrial and manpower sector achievements in the growing and competitive markets. In order to capture the due share of the world business markets, sustainable and uninterrupted support from the energy sector is the need of the hour. Government of Pakistan in this regard has focused and taken initiative to invest on several short and long terms non-renewable, renewable and alternative energy power projects to meet the requirements of the country with an ultimate objective to bring Pakistan back on track of development. The construction of these projects especially hydropower, will not only help address acute water challenge but also produce cheap and clean hydroelectricity and will bridge the gap in circular debt which is due to thermal generation projects.

Most of the Hydro Power Projects of Pakistan contributing with reliable and cost effective electricity into the national grid including the historical Tarbela and Warsak Dams are located in Khyber Pakhtunkhwa. Pakistan has a hydro potential of about 60,000 MW of which only 6,600 MW has been tapped so far with nearly half of it installed in this province. The Khyber Pakhtunkhwa has an estimated power potential of generating nearly 30,000 MW. While most of the hydro power projects under development are in public sector, the provincial government has embarked on a multi-pronged strategy for encouraging investment through Public, Private & Public Private Partnership sectors.

1.1. Purpose and Scope of Environmental Report

This environmental and social assessment is undertaken as part of the overall feasibility study of Turtonas-Uzghor Hydro Electric Power Project and is designed to meet the requirements of environmental assessment and social laws of Pakistan and the IFC. Project Company will submit this report for review and approval by the KPK Environmental Protection Agency as required by the Pakistan Environmental Protection Act, 1997.

The Turtonas-Uzghor Hydro Electric Power Project is a base load plant and will supply power to network around the clock. The provisional capacity of the project is estimated as 82.25 MW.

The Turtonas-Uzghor Hydro Electric Power Project falls in category A as specified by the IFC and Pak-EPA "Policy and Procedures for filing, Review and Approval of Environmental Assessment", 2000, which deals with projects where the range of environmental issues is comparatively broad, and with those that could have adverse environmental impacts. Extensive analysis in the form of detailed Environmental Impact Assessment (EIA) is required for hydropower electric generation above 50 MW in form of an EIA report submission.

In order to comply with international requirements, the present report constitutes an ESIA (Environmental and Social Impact Assessment), and not only an EIA (Environmental Impact Assessment). The objectives of the ESIA are to:

- Assess the existing environmental and social conditions of the area where project is located including the identification and information of environmentally sensitive areas;
- Assess the proposed activities, identify and evaluate the potential impacts and determine their significance; and
- Propose appropriate mitigation measures that can be incorporated into the proposed activities to minimize any adverse impacts, ensure that impacts are acceptable and to propose appropriate monitoring requirements.

1.2. Identification of Project and Proponent

The Turtonas-Uzghor Hydropower Project was initially identified by GTZ/SHYDO and presented in their report "Identification of Hydropower Development Potential in Chitral Valley" in February 2001.The Project is being implemented/accomplished by a consortium of M/s Sinohydro Corporation Limited and M/s Sachal Engineering Works (Pvt.) Limited in accordance with Letter of Interest (LOI) issued by Private Power and Infrastructure Board (PPIB) in March, 2016. The PPIB authorization for issuance of LOI is in accordance with the Power Policy to encourage private sector investment in developing infrastructure projects. The LOI provides the aforementioned consortium the legal right to develop the site, with diligently proceeding for feasibility investigations required for the completion of this Feasibility Report.

1.3. Details of Consultants

The Consultants are selected to conduct the bankable Feasibility Report of Turtonas-Uzghor Hydro Electric Power Project. The Consultants are joint venture comprising of M/s Technical, Engineering and Management (TEAM) Consultants, Pakistan and FICHTNER GmbH, Germany. The expertise and technical resources of the TEAM and FICHTNER shall play a key role in completing the assignment.

Upon signing of the Contract Agreement with the Client, the Consultants immediately undertook the assignment and are rendering services in accordance with the TOR given in the Contract agreement.

Environmental assessment was conducted by the TEAM Consultants, as part of the overall Feasibility Report. The information and data required to file this report was collected through field surveys, secondary source of information and public consultation undertaken specifically for this project. A full list of those organizations contacted is given in Annex 1, written statements of these organizations were not collected being not needed.

1.4. Description of Nature, Size and Location of the Project

Turtonas-Uzghor Hydro Electric Power Project (the "Project") is located on Golen Gol Nullah, a tributary of Mastuj River in Chitral, Khyber Pakhtunkhwa (KPK) Province. The project shall have a provisional capacity of 82.25 MW and will generate about 382.33 GWh of energy annually. The project and its associated facilities which are part of the scope of ESIA are:

- Weir structure at Turtonas village
- Sand trap
- Reservoir and Connecting canals
- Powerhouse
- Construction camps
- Borrow and disposal areas
- Operation and maintenance colony
- Headrace and tailrace tunnels
- Access road up-gradation

Transmission line is not part of the scope of this ESIA as it has to establish by the NTDC as a separate project.

The project makes use of Golen Gol River flow and falls in an established river system. It will not change the water flow characteristics and hydrological regime of the area. This study presents environmental and social assessment regarding design, construction and operation of the proposed Hydro Electric Power Project. This Environmental and Social Impact Assessment (ESIA) has been carried out to ensure that the potential adverse environmental impacts are appropriately addressed in line with PEPA, 1997 and applicable IFC Performance Standards; Environmental, Health & Safety Guidelines and applicable World Bank Operational Policies.

1.5. Organization of the Report

The ESIA is structured in 12 chapters.

- ➢ Chapter 1 (Introduction) provides the information that put the project into context.
- ➢ Chapter 2 (Environmental and Social Policy and Legal Framework) describes the legal, policy, and regulatory requirements applicable to the ESIA process and the project design.
- ➢ Chapter 3 (Description of the Project) describes the Project facilities, its main components, project location and site layout and the technical design summary.

- Chapter 4 (Consideration of Alternatives) analyze various alternatives to project including 'no project' option, alternative source of power generation and alternative Project location/ layout design.
- Chapter 5 (Environmental Baseline) describes the current environmental condition of the study area in to further sub-section as:
  - Physical Environment describes the climatology, geology, soils erosion, air, and noise and water resources.
  - Ecological Resources describe the mammals, birds, reptiles, forest resource, trees and vegetation, fish resources.
  - Socio-Economical and Cultural Environment describes demography, language, religion, tribes, Indigenous People, land ownership, houses and households, education, employment, family income, agriculture & livestock, fish farm & fishing, infrastructure, health facility and sanitation, water supply, fuel sources and consumption, recreational areas, NGOs working in Area and influential of the area.
  - Environmental Flow Assessment

- Chapter 6 (Impacts and Mitigation Measures) assess the possible impacts of proposed project during design, construction and operational phase and proposed mitigation measures to reduces the severity of impacts.
- Chapter 7 (Environmental and Social Management and Monitoring Plan) provides details on management and mitigation measures to be carried out during the design, construction and operation phases of the Project. It also categorizes these measures based on the responsibilities of various members of the Project execution team and lays out the main aspects for monitoring of the implementation of management and mitigation measures.
- Chapter 8 (Emergency Preparedness and Response) provide measures and guidance for establishment and implementation of emergency preparedness plan.
- Chapter 9 (Stakeholder Engagement) describes the consultation process undertaken for the project and outcomes of consultation.
- Chapter 10 (Grievance Redress Mechanism) describes the procedures to handles and resolve the grievances of the affected persons or community and labor force.
- Chapter 11 (Monitoring and Review) describes the monitoring and review procedures to be carried out during construction and operational phases and roles and responsibilities of monitoring personals. This unit also describes the land acquisition cost and environmental costs.
- Chapter 12 (Conclusions and Recommendations) convey the key findings of the ESIA study and recommend measures if the project is to be executed.

CHAPTER - 2

ENVIRONMENTAL POLICY AND LEGAL FRAMEWORK

CHAPTER-2

ENVIRONMENTAL AND SOCIAL POLICY AND LEGAL FRAMEWORK

2.1 Policy Requirements

This chapter provides an overview of the legislative and statutory requirements for the environmental and social assessment process in Pakistan and requirements of institutions that may influence the environmental management of the proposed project. This also provides an overview of IFC's Performance Standards, the IFC Environmental, Health and Safety guidelines and related World Bank Operational Policies.

2.2 Laws and Regulations of Host Country

The development of statutory and other instruments for environmental protection and management has steadily gained priority in Pakistan since the late 1970s. The Pakistan Environmental Protection Ordinance 1983 was the first piece of legislation designed specifically for protection of the environment. The promulgation of this ordinance was followed in 1984 by the establishment of the Pakistan Environmental Protection Agency, the primary government institution dealing with environmental issues. Significant work on developing environmental policy was carried out in the late 1980s, which culminated in the drafting of the Pakistan National Conservation Strategy. Provincial environmental protection agencies were also established at about the same time. The National Environmental Quality Standards (NEQS) (**Annexure: E.2**) were established in 1993. The enactment of the Pakistan Environmental Protection Act 1997 (PEPA 1997) conferred broad-based enforcement powers to the environmental protection agencies. Publication of the Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations 2000 (IEE-EIA Regulations 2000) provided the necessary details on the preparation, submission, and review of an IEE and EIA. In addition to the PEPA 1997, Pakistan's statute books contain a number of other laws that have clauses concerning regulation and protection of the environment.

2.2.1 Pakistan Environmental Act, 1997

The Pakistan Environmental Protection Act (PEPA) 1997 is the basic legislative tool empowering the government to frame regulations for the protection of the environment. Following sections of the Act directly cater the proposed project:

- **Section 11** (Prohibition of Certain Discharges or Emissions): states that "Subject to the provisions of this Act and the rules and regulations made there under, 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 NEQS".
- **Section 12-I** (IEE and EIA); 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 EIA report and accord its approval subject to such conditions as it may deem fit to impose, or require that the EIA be re-submitted after such modification as may be stipulated or rejected, the project as being contrary to environmental objectives.
- **Section 14** (Handling of Hazardous Substances); require that "Subject to the provisions of this Act, no person shall generate, collect, consign, transport, treat, dispose of, 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 the Motor Vehicles): subject to provisions of this clause of the Act and the rules and regulations made there under, 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 sub-section (1) of Section 6 of the Act.
- **Section 17** (Penalties): Whoever contravenes or fail 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.

2.2.2 Khyber Pakhtunkhwa Environmental Protection Act 2014

The KP Environmental Protection Act 2014 is applicable to a broad range of issues and extends to air, water, industrial liquid effluent, and noise pollution, as well as to the handling of hazardous wastes. The articles of KP Act 2014 that have a direct bearing on the proposed Project are listed below.

The details are discussed in the following sections:

- Article 11 that deals with the KP environmental quality standards (KPEQS) and its application.
- Article 12 that deals with discharges, emissions and waste disposal.
- Article 13 that deals with IEE and EIA with review and approval process.
- Article 14 that prohibits import of hazardous waste.
- Article 15 that provides rules on handling of hazardous substances.
- Article 16 that provides regulations on motor vehicles.
- Article 17 that prohibits various acts detrimental to the environment.

The ESIA is prepared under KPK-EPA 2014 directions.

2.2.3 Review of IEE and EIA Regulations, 2000

Pakistan Environmental Agency (Review of IEE and EIA) Regulations, 2000 provides necessary detail to prepare, submit, and review and approval of Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) reports. Projects are classified on the basis of the significance of environmental impacts under these regulations. Projects with less significant or limited environmental impacts require an IEE if they fall under Schedule I of these regulations. And the projects listed in Schedule II with highly significant environmental impacts require a full fledge EIA to be carried out. Projects with Hydro Electric power generation over 50MW fall under Schedule II. Turtonas-Uzghor Hydro Electric Power Project falls in Schedule II as per classification of EPA because the power generation would be 85MW, thus requires an EIA to be carried out. In order to comply with international requirements, the present report constitutes an ESIA (Environmental and Social Impact Assessment), and not only an EIA.

2.2.4 Pakistan Penal Code, 1860

This Act deals with the 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. This penal code also empowers local authorities to control noise, toxic emissions and disposal of effluents.

2.2.5 Pakistan Explosives Act, 1884

It provides regulations for handling, transportation and use of explosives. The contractors have to abide by the regulation during quarrying, blasting and for other purposes.

2.2.6 Forest Act, 1927

This Act deals with the matters concerning protection and conservation of natural vegetation and habitats and authorizes the concerned department to establish forest reserves and protect forests. In spite of the fact that it recognizes the right of people to the natural resources for their household use, it prohibits the unlawful cutting of trees and other vegetation. A prior permission is required from the concerned area forest department to clear the vegetation/ trees for construction or other purposes. As it was verified during the site visit undertaken during elaboration of this report, there is no forest in the vicinity of this particular project.

2.2.7 Protection of Trees Act, 1949

This Act particularly prohibits the cutting or damaging of trees along roads and canals planted by the Forest Department without permission of the Forest department.

2.2.8 Land Acquisition Act, 1894

This Act deals with the acquisition of land and immovable properties of public interest and set out the procedures and rules for acquisition and compensating the land owners including any damage caused to their properties, trees and crops by the project, however it lacks the mechanism to address complex issues of resettlement. The Act comprises of 55 sections dealing with area notification, surveys, acquisition, compensation, appointment awards, dispute resolution, penalties and exemptions.

2.2.9 Factories Act, 1934 (as amended in 1997)

The pertinent clauses of the Act are those that deal with health, safety and welfare of the workers, disposal of solid waste and effluents and damage to private and public property. It also deals with the regulations for handling and disposing of toxic and hazardous materials. As the construction activity has also been classified as 'industry', the regulations will be applicable to the Contractors.

2.2.10 Motor Vehicle Ordinance, 1965 and Rules, 1969

This ordinance has been extended with effect from March 05, 1978 to the whole of Pakistan. It deals with the licensing requirement for driving; powers of licensing authority, regional transport authority and those of court disqualification for license and registration requirements to control road transport; compensation for the death of or injury to a passenger of public carrier; Road Transport Corporation; traffic rules, power to limit speed, weight, use of vehicles; power to erect traffic signs; specific duties of drivers in case of accidents and powers of police officers to check and penalize traffic offenders. All the vehicles used for the project by the consultants and the contractors will be subject to this ordinance.

2.2.11 Antiquity Act, 1975

The Act ensures the protection, preservation and conservation of archeological/ historical sites and monuments. It prohibits construction activity within 200 meters of such sites unless prior permission is obtained from the Federal Department of archeology and museum. In spite of the fact that Provincial Archeological Departments exists, the pertinent authority for issuing clearance is the Federal Department.

2.2.12 The West Pakistan Firewood and Charcoal (Restriction) Act, 1964

This Act is to prohibit and regulate the burning of firewood and charcoal in the province. Use of firewood is still very common in the area and for this reason the act is applicable for the entire project area.

2.2.13 KPK Wildlife Protection, Preservation, Conservation and Management Act, 1975 (NWFP Act No. V of 1975)

This Act specifies restrictions on hunting and trade in animals, trophies or meat and enacted to protect the provincial wildlife. It classifies wildlife by degree of protection, i.e. animal that may be hunted on a permit or a special license especially for threatened species and species that are protected and cannot be hunted on any circumstances like the endangered species. The Act also defines various categories of wildlife protected areas i.e., National Parks, Wildlife Sanctuaries and Game Reserves. As observed during the site visit, there are no wildlife reserves in the vicinity of the Project area.

2.2.14 Fisheries W.P. Ordinance XXX of 1961 Amended Vide NWFP Fisheries (Amendment) Ordinance 1982

This ordinance provides protection to fish against 1) destruction of fish by explosives, 2) Destruction of fish by poisoning water. It also grants power to Director General (DG) Fisheries to issue permit to catch fish.

2.2.15 The Provincial Administered Tribal Areas (Conservation and Exploitation of certain Forests) Regulation 1980

The purpose of this regulation is to provide for conservation, better exploitation and prohibition of unlawful cutting of forest in certain Provincially Administered Tribal areas.

2.2.16 The NWFP(KPK) Power Crushers (Licensing) Ordinance, 1980

This ordinance deals with the licensing authority, registration fee of power crushers and with the penalties.

2.2.17 Labor Laws

Labor laws in Pakistan are governed by several legislative tools. However, the principal labor rights are provided by the constitution of Pakistan. Several Acts and Ordinances have been enforced for limiting working hours and establishing a minimum working age and conditions of employment.

2.2.18 Employment of Child Act, 1977

Constitution of Pakistan by Article 11(13) prohibits employment of children below age 14years in any mine, factory or hazardous place. The Employment of Child Act prohibits the child labor in the country in any occupation (transport sector, railways, construction and ports etc.).

2.2.19 Highway 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.

2.2.20 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. 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.

2.3 National Environmental Guidelines and Policies

2.3.1 National Climate Change Policy, 2012

Pakistan has prepared the National Climate Change Policy in order to ensure that climate change is mainstreamed in the economically and socially vulnerable sectors of the economy and to steer Pakistan towards climate resilient development. The Policy addresses the key issues relevant to the country including food security, water security, energy security, and extreme weather events. The Policy covers climate change adaptation with respect to water resources, agriculture and livestock, human health, forestry, biodiversity, disaster preparedness, poverty, and gender aspects, while it addresses energy, transportation, town planning, and industry with respect to climate change mitigation.

2.3.2 National Conservation Strategy (NCS) 1992

The Pakistan National Conservation Strategy (NCS) that was approved by the federal cabinet in March 1992 is the principal policy document on environmental issues in the country. The NCS outlines the country's primary approach towards encouraging sustainable development, conserving natural resources, and improving efficiency in the use and management of resources. The NCS has 68 specific programs in 14 core areas in which policy intervention is considered crucial for the preservation of Pakistan's natural and physical environment. The core areas that are relevant in the context of the proposed project are pollution prevention and abatement, restoration of rangelands, increasing energy efficiency, conserving biodiversity, supporting plantations, and the preservation of cultural heritage.

2.3.3 Chitral Conservation Strategy (CCS), 2004

The Chitral Conservation Strategy (CCS) takes stock of the area's resources and investigates ways in which to sustainably increase their productivity. Developed under a District Roundtable comprising local residents and government functionaries, the strategy formulation process was facilitated by the CCS Unit of IUCN–The World Conservation Union. Views of participants at district, tehsil and village consultations determined the content of this strategy. The Chitral Conservation Strategy (CCS) searches for ways in which to foster the sustainable development of Chitral's meager resource base. The strategy aims to identify the capacity of the people, and to increase their income by enhancing productivity and optimizing the use of natural resources. In the light of past experience, the CCS attempts to find new institutional arrangements through which local communities, supported by the government, can become the prime engine for development.

2.3.4 National Environment Policy

This policy was implemented in 2005 to provide an overarching framework for addressing the environmental issues facing Pakistan. It gives directions for addressing sectorial issues and provides means for promoting conservation and environmental protection in water, air and waste management, forestry, and transport. The policy aims to promote protection of the environment, the honoring of international obligations, sustainable management of resources and economic growth.

2.3.5 Clean Development Mechanism (CDM) Strategy 2006

Clean development mechanism strategy prepared to fulfill the requirements of establishing a designated national authority (DNA) and ensuring transparent, participatory and effective management of CDM process in the country. The strategy describes the functions and powers of DNA, the criteria for CDM projects and national approval process. Under the Policy, Pakistan allows unilateral, bilateral and multilateral CDM projects preferably in the areas of energy including renewable energy, energy efficiency, energy conservation and fossil-fueled cogeneration; land use, land use change and forestry (e.g. biodiversity protection, soil conservation, watershed maintenance and sustainable forest/rangeland management); agricultural and livestock practices; waste management (e.g. landfills, solid waste management, recycling animal/livestock wastes); transportation (e.g. alternative fuel vehicles, mass transit systems, cleaner engines, compressed natural gas; and Industrial processes.

2.3.6 Guidelines for the Preparation and Review of Environmental Reports, 1997

The guidelines on the preparation and review of environmental reports target the project proponents, and specify;

- The nature of the information to be included in environmental reports
- The minimum qualifications of the EIA team appointed.
- The need to incorporate suitable mitigation measures at 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 report must contain baseline data on the project area, detailed assessment thereof, and mitigation measures.

2.3.7 Guidelines for Public Consultation, 1997

These guidelines deal with possible approaches to public consultation and techniques for designing an effective program of consultation that reaches out to all major stakeholders and ensures that their concerns are incorporated in any impact assessment study.

2.3.8 Policy and Procedures for Filing, Review and Approval of Environmental Assessments, 2000

These policies and procedures define the policy context and the administrative procedures that govern the environmental assessment process, from the project prefeasibility stage to the approval of the environmental report.

2.3.9 Guidelines for sensitive and critical areas, 1997

These 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 within or near to such sites. Environmentally sensitive areas include, among others, archaeological sites, biosphere reserves and natural parks, and wildlife sanctuaries and preserves, none of which are relevant to the Project area.

2.3.10 National Environmental Quality Standards (NEQS)

The National Environmental Quality Standards (NEQs) specify the following standards:

- Maximum allowable contamination of pollutants (32 parameters) in emissions and liquid industrial effluents discharged to inland water.
- Maximum allowable concentration of pollutant (16 parameters) in gaseous emission from sources other than vehicles.
- Maximum allowable concentration of pollutants in gaseous emissions from vehicle exhaust and noise emission from vehicles.
- Maximum allowable noise level from vehicles.
- Ambient noise standards
- Ambient air quality standards.

These standards apply to gaseous emissions and liquid effluents discharged by batching plants, asphalt plants, camp sites, construction machinery, and vehicles. The standards for vehicle, noise, wastewater and drinking water will apply during the construction as well as operational phase of the project.

2.4 Environmental Regulatory Authorities

2.4.1. Pakistan Environmental Protection Council (PEPC)

The PEPC is the highest inter-ministerial statutory body in the country headed by the Prime Minister and is responsible for:

- Formulating national environmental policy;
- Enforcing PEPA 1997;
- Approval of the NEQS;
- Incorporation of environmental considerations into national development plans and policies; and
- Provision of guidelines for the protection and conservation of biodiversity in general as well as conservation of renewable and non-renewable resources.

2.4.2. Climate Change Division

The Climate Change Division, which falls directly under the Prime Minister Secretariat, is the focal point for National Policy, Legislation, Plans, Strategies and programs with regard to Disaster Management, Climate Change including Environmental Protection and preservation. The Division also deals with other countries, international agencies and forums for coordination, monitoring and implementation of environmental agreements.

2.4.3. Pakistan Environmental Protection Agency (PAK-EPA)

PAK-EPA is headed by a Director General and has wide ranging functions as set out 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 PAK-EPA has issued regulations regarding the environmental assessment procedures known as Review of Initial Environmental Examination (IEE) and EIA Regulations, 2000; these provide a firm legal status to the IEEs and EIAs.

2.4.4. Provincial/ Regional Environment Protection Agencies

The four provinces and the two regions (Azad Jammu and Kashmir - AJK and Gilgit-Baltistan) each have their own Environmental Protection Department (EPD) and/or EPAs, which are counterparts of the PAK-EPA at the provincial/regional level. The provincial/regional EPAs are established by the respective provincial/regional governments. They are headed by a Director General. The IEE and EIA reports pertaining to projects falling within the different provincial/regional boundaries are to be submitted to the relevant provincial/regional EPA for approval. For the proposed project, KPK-EPA is the relevant agency for the approval of the EIA.

2.5. Applicable International Laws and Regulations

2.5.1. Convention on Biological Diversity

Pakistan is a signatory to this convention since 5 June 1992 and ratified the convention on 26 July1994. The Convention on Biological Diversity (CBD) entered into force on 29 December 1993. It has three main objectives:

- The conservation of biological diversity,
- The sustainable use of the components of biological diversity and
- The fair and equitable sharing of the benefits arising out of the utilization of genetic resources

2.5.2. Convention on Wetlands (RAMSAR Convention)

Pakistan ratified the Ramsar Convention in 1975 and there are currently 19 Ramsar sites in Pakistan, covering an area of 1,343,627 hectares (3,320,170 acres). The convention requires protection of identified wetlands of international importance as identified under Ramsar convention. The Ramsar Convention (formally, the Convention on Wetlands of International Importance, especially as Waterfowl Habitat) is an international treaty for the conservation and sustainable utilization of wetlands. No Ramsar site will be affected by the project.

2.5.3. Convention on International Trade in Endangered Species (CITES)

Pakistan is a party to CITES, with the conventions implementation through "Pakistan Trade Control of Wild Fauna and Flora Act (2012)". CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

2.5.4. Kyoto Protocol

The Kyoto protocol was signed by Pakistan in 2005 and in February 2006 the national CDM operational strategy was approved. The convention pertains to the United Nations framework on Climate Change. The 3rd Conference of the Parties to the Framework Convention on Climate Change (FCCC) held in Kyoto in December 1997 introduced the Clean Development Mechanism (CDM) as a new concept for voluntary greenhouse-gas emission reduction agreements between industrialized and developing countries on the project level.

2.5.5. Montreal Protocol

Pakistan ratified its accession of the Montreal Protocol along with its London Amendment on 18 Dec 1992 and also ratified the Copenhagen, Montreal and Beijing Amendments of 2003. The Montreal Protocol on Substances that Deplete the Ozone Layer regulates many radioactively powerful greenhouse gases for the primary purpose of lowering stratospheric chlorine and bromine concentrations. These gases include the CFCs, HCFCs, chloro-carbons, bromocarbons and halons. This protocol prohibits excessive use of the substances in vehicle oils, refrigerants and cleaning solvents during project construction which emit greenhouse gases.

2.5.6. Convention on Conservation of Migratory Species of Wild Animals and Migratory Species

The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention) aims to conserve terrestrial, aquatic and avian migratory species throughout their range.

2.6. IFC Requirements

IFC applies the Performance Standards (2012) to manage social and environmental risks and impacts and to enhance development opportunities in its private sector financing in its member countries eligible for financing. The Performance Standards may also be applied by other financial institutions electing to apply them to projects in emerging markets. Together, the eight Performance Standards establish standards that the client is to meet throughout the life of an investment by IFC or other relevant financial institution:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labor and Working Conditions

- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Performance Standard 7: Indigenous Peoples
- Performance Standard 8: Cultural Heritage

2.6.1 IFC's Performance Standards on Social and Environmental Sustainability (2012)

International Finance Corporation applies the Performance Standards to manage social and environmental risks and impacts and to enhance development opportunities in its private sector financing in its member countries eligible for financing.

PS 1 Assessment and Management of Environmental and Social Risks and Impact: It establishes the importance of integrated assessment to identify the social and environmental impacts, risks, and opportunities in the project's area of influence. PS 1 requires Social and Environmental Assessment and Management Systems for managing social and environmental performance throughout the life cycle of this Project and runs through all subsequent PSs. The main elements of PS 1 include following elements: (i) Social and Environmental Assessment; (ii) Management program; (iii) organizational capacity; (iv)training; (v) community engagement; (vi) monitoring; and (vii) reporting.

This ESIA is based on the guidelines described in PS1.

PS 2 Labor and working conditions: requires that worker management relationship is established and maintained, compliance with national labor and employment laws and safe and healthy working conditions are ensured for the workers.

The Project will have to adhere to the regulations laid down in the standard for hiring workers during construction and operation, along with performing due diligence for workers in the supply chain for Project materials.

PS 3 Resource Efficiency and Pollution Prevention: outlines approach to pollution prevention and abatement in line with Internationally disseminated technologies and practices with objectives to a)avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from activities; and b) promote the reduction of emissions that contribute to climate change. It requires a project to avoid, minimize, or reduce adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.

This PS is applicable to the emissions and effluents resulting from Project activities.

PS 4 Community health, safety and security: concentrates on the responsibility that must be undertaken by the client to avoid or minimize the risks and impacts to the community's health, safety and security that may arise from project activities. This PS is applicable to the project.

PS 5 Land Acquisition and Involuntary Resettlement: This standard requires that project does not result in involuntary resettlement or at least if unavoidable it is minimized by exploring alternative project designs. Also the project will ensure that social and economic impacts from land acquisition or restrictions on affected persons' use of land are mitigated.

AS the project involves the land acquisition there associated land acquisition procedures will conform to the guidelines of PS 5. No resettlements impacts are associated with the project because no houses, shops or any other amenities are built on the land required for project.

PS 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources: aims at protecting and conserving biodiversity, the variety of life in all its forms, including genetic, species and ecosystem diversity and its ability to change and evolve, is fundamental to sustainable development.

This PS addresses how clients can avoid or mitigate threats to biodiversity arising from their operations as well as incorporate sustainable management of living natural resources. Few species of mammals and one birds species identified near the project area are of conservation importance as enlisted in IUCN red list and national conservation list and needs to follow the guidelines of PS 6.

PS 7 Indigenous Peoples: acknowledges the possibility of vulnerability of indigenous people owing to their culture, beliefs, institutions and living standards and that it may further get compromised by one or other project activity throughout the life cycle of the project. The PS underlines the requirement of minimizing adverse impacts an indigenous people in the project area, respecting the local culture and customs, fostering good relationship and ensuring that development benefits are provided to improve their standard of living and livelihoods.

The Project area is not used by Indigenous Peoples as defined by IFC PS 7.

PS 8 Cultural Heritage: aims to protect the irreplaceable cultural heritage and to guide clients on protecting cultural heritage in the course of their business operations.

PS 8 is not applicable to the project as there is no cultural heritage identified in the project area.

The applicability of these Performance Standards is established during the Social and Environmental Impact Assessment process. While implementation of the actions is necessary to meet the requirements of IFC, the Performance Standards are managed through the owner's Social and Environmental Management System. Performance standards 7 and 8 are not applicable to the project as there are no cultural heritage sites and indigenous people found in the project area.

2.6.2 IFC General Environmental, Health and Safety General Guidelines (2007)

The IFC General EHS Guidelines (2007) are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP).

The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The General EHS Guidelines consist of the following components:

Environmental: This guideline applies to facilities or projects that generate emissions to air, water, and soil at any stage of the project life-cycle. They look into aspects of energy conservation, wastewater and ambient water quality, water conservation, hazardous materials management, waste management, noise and contaminated land.

Occupational Health and Safety: This section provides guidance and examples of reasonable precautions to implement in managing principal risks to occupational health and safety. Although the focus is placed on the operational phase of projects, much of the guidance also applies to construction and decommissioning activities. This incorporates general facility design and operation, communication and training, physical hazards, chemical hazards, biological hazards, radioactive hazards, Personal Protective Equipment (PPE), special hazard environment and monitoring.

Community Health and Safety: This guidance complements the above two guidelines by specifically addressing aspects of project activities which fall outside the traditional project boundaries but which are related to the project operations as and when they occur.

Construction and Decommissioning: This section provides an additional and specific guidance to the prevention and control of community health and safety impacts that may occur during new project development, at the end of the project life-cycle or due to expansion or modification of existing project facilities.

2.6.3 IFC's Environment, Health and Safety Guidelines for Electric Power Transmission and Distribution (2007)

The IFCEHS Guidelines for Electric Power Transmission and Distribution include information relevant to power transmission between a generation facility and a substation located within an electricity grid, in addition to power distribution from a substation to consumers located in residential, commercial, and industrial areas. The various aspects comprising this guidance are industry specific impacts and management and performance indicators and monitoring. Transmission line will be established by NTDC as a separate project and will carry out the ESIA also. So transmission line is not the part of scope of this ESIA.

2.6.4 World Commission on Dams 2000

The World Commission on Dams (WCD) established the most comprehensive guidelines for dam building. It describes an innovative framework for planning water and energy projects that are intended to protect dam-affected people and the environment, and ensure that the benefits from dams are more equitably distributed. The WCD framework covers key areas for improved planning of dams, including the need to fully assess all available options for meeting water and energy needs;

addressing outstanding social issues from existing dams before building new ones, gaining public acceptance for key decisions, and the importance of protecting healthy rivers. The Project is being constructed in an area with natural resources. It is being financed by an international funding body, the WB and IFC therefore; international standards, guidelines and best practices need to be considered.

2.6.5 IFC Handbook for Preparing a Resettlement Action Plan (April 2002)

Involuntary resettlement may entail both the physical displacement of people and the disruption of their livelihoods. The purpose of the IFC Handbook for Preparing a RAP is to provide guidance in the planning and execution of involuntary resettlement associated with IFC investment projects. IFC's policy on involuntary resettlement applies to any project that may result in the loss of assets, the impairment of livelihood, or the physical relocation of an individual, household, or community.
As no resettlement impacts are associated with the land to acquire for the project so this RAP is not applicable to the project.

2.6.6 World Bank Operational Policy 4.01 on Environmental Assessment (January, 1999)

OP 4.01 provides the framework for World Bank environmental safeguard policies and describes project screening and categorization to determine the level of environmental assessment required. For category A and B projects the policy requires public consultation and disclosure to be undertaken as part of the Environmental Assessment process. Finally the policy sets out requirement to comply and report on implementation of any environmental management plans (i.e. mitigation measures, monitoring program etc.) The policy is triggered.

2.6.7 World Bank Operational Policy 4.12 on Involuntary Resettlement (December, 2001)

The World Bank aims to avoid involuntary resettlement where possible. Where necessary or acquisition of land or other assets is necessary, the policy sets out requirements for participation in resettlement planning, mandates compensation for assets at replacement cost, and expects the borrower to see that incomes and standards of living of affected persons are improved or at least restored to what they were prior to displacement. The document also identifies the need for a Resettlement Plan, an abbreviated Resettlement Plan or otherwise. Since no resettlement impacts identified under the project this OP will not be applicable.

WB OP 4.37 Safety of dams is not applicable to this project as no dam or check dam will be constructed. Only a weir structure along with the lateral intake will be constructed to divert the water power generation.

2.6.8 The World Bank Environmental and Social Framework 2017

This Framework comprises of a vision for 'Sustainable Development', which sets out the Bank's aspirations regarding environmental and social sustainability, the World Bank Environmental and Social Policy for investment project financing, which sets out the mandatory requirements that apply to the Bank and the Environmental and Social Standards which set out the mandatory requirements that apply to the Borrower and projects.

The Environmental and Social Standards set out the requirements for Borrowers relating to the identification and assessment of environmental and social risks and impacts associated with projects supported by the Bank through Investment Project Financing. The ten Environmental and Social Standards establish the standards that the Borrower and the project will meet through the project life cycle, as follows:

- Environmental and Social Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Environmental and Social Standard 2: Labor and Working Conditions
- Environmental and Social Standard 3: Resource Efficiency and Pollution Prevention and Management
- Environmental and Social Standard 4: Community Health and Safety
- Environmental and Social Standard 5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement
- Environmental and Social Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Environmental and Social Standard 7: Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities
- Environmental and Social Standard 8: Cultural Heritage
- Environmental and Social Standard 9: Financial Intermediaries and
- Environmental and Social Standard 10: Stakeholder Engagement and Information Disclosure.

CHAPTER - 3

DESCRIPTION OF THE PROJECT

CHAPTER-3

DESCRIPTION OF THE PROJECT

3.1. Type and Category of the Project

Due to its relatively large size (more than 50 MW), the project is classified as "Category A" Project of Schedule II in accordance with Pak-EPA regulations 2000. This implies that the proponent of the project has to file a detailed environmental impact assessment (EIA) to address potential adverse effects.

As part of the review of environmental and social risks and impacts of a proposed investment, IFC uses a process of environmental and social categorization to reflect the magnitude of risks and impacts. The resulting category also specifies IFC's institutional requirements for disclosure in accordance with IFC's Access to Information Policy.

These categories are (IFC, 2016):

- **Category A**: Projects with potential significant adverse social or environmental impacts that are diverse, irreversible, or unprecedented.
- **Category B**: Projects with potential limited adverse social or environmental impacts that are few in number, site-specific, largely reversible, and readily addressed through mitigation measures.
- **Category C**: Projects with minimal or no adverse social or environmental impacts.
- **Category FI**: Investments in a financial institution or other legal entity whose primary business activity is to provide loans, equity, guarantee products or other financing to third parties that may engage in activities that have potential

The Turtonas-Uzghor Hydro Electric Power Project can be classified as "category A" according to IFC's Environmental and Social Review Procedures Manual (2016), requiring therefore a detailed Environmental and Social Impact Assessment (ESIA).

3.2. Objectives of the Project

This project is designed to augment the power supply and distribution system in KPK through the national network and also will help to meet the overall national power needs. Another objective is to generate power under green energy program to avoid adverse impacts of the non-renewable resources.

3.3. Golen Gol

Golen Gol River is a typical steep mountainous gravel bed river. The river morphology and the alluvial deposits on the river banks in the proposed reservoir area give an indication of the capability of Golen Gol River to transport sediments. Golen Gol River is the natural drainage of glaciated areas in North-Pakistan, which are the source of sediments of different gradation. Approximately 11% of the catchment area of Turtonas-Uzghor HPP extends at elevations higher than 5200m.a.s.l. The average slope at weir site 40 % was computed with GIS and remote sensing tools. The Golen Gol River 3-D basin morphology is presented in Figure 40 below.

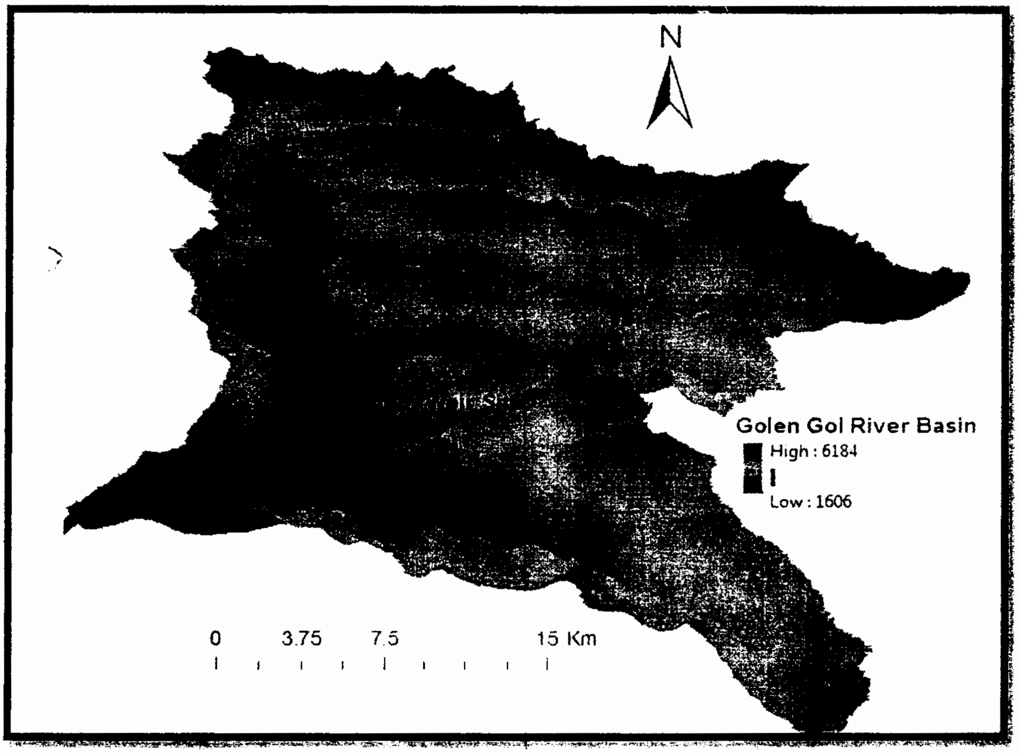


Figure E.1: Golen Gol River Basin Average Slope (%) and D-3 River basin Morphology

The Golen Gol River originates from a mountainous region (> 6000 m) and flows down for about, in the beginning towards south-west for about 25 km till it reaches the proposed weir site and then changes the direction towards Uzghor and Golain, where the proposed powerhouse site of the project is located.

The catchment area of the Golen Gol lies between latitude 35P0P, 48' to 36P0P, 30' and longitude 71P0P, 58' to 72P0P, 18'. The catchment area of the Golen Gol at its confluence with Mastuj River is 518 km^2. The area is enclosed with high mountains ranging from 4875 m to 5800 m.

Golen Gol Hydropower Project constructed by WAPDA is located at the downstream end of the GolenGol River. The diversion weir is located about 1 km upstream from Golain Village and about 1.5 km downstream from Uzghor village. The powerhouse of GolenGol is located along left bank of Golen Gol and Mastuj River at the confluence of both (**Drawing No. E2**). The headrace tunnel is along left bank.

The Turtonas-Uzghor HEPP is situated in the middle reach of the GolenGol River. The drainage area of the Uzghor weir site on the Golen Gol River is about 388 km^2 and the drainage area of the Powerhouse site on the Golen Gol River is about 412.5 km^2. The mean elevation of the catchments area at weir site is 4262m.a.s.l. and at Powerhouse site is 3552m.a.s.l. Most of the watershed remains covered with snow and glaciers in winter season. The flow in the river is mainly due to glacier and snow melting. A slight rainfall-runoff is also available in some summer months. There is moderate to little vegetation cover over the watershed.

The proposed powerhouse site and diversion weir of Turtonas-Uzghor Hydro Electric Power Project is about 500 to 600m and 6 km respectively from upstream of diversion weir of GolenGol Hydropower Project.

A small hydropower project with the name of Birmogh is situated in between diversion weir and powerhouse site of Turtonas-Uzghor HEPP. The weir and powerhouse of Birmogh is about 1.5 km and 3 km, respectively downstream of diversion weir of Turtonas-Uzghor HEPP. Birmogh has installed capacity of 2 MW while its design discharge is 4 m^3/s. During winter month plant will require 2 m^3/s only.

3.4. Project Location and Site Layout

Turtonas-Uzghor Hydroelectric Power Project is located in District Chitral of Khyber Pakhtunkhwa Province of Pakistan. Chitral is the largest district in Khyber Pakhtunkhwa province covering an area of 14,850 km^2. It is the northernmost district of Pakistan. It shares a border with Gilgit-Baltistan to the east, with Kunar, Badakhshan and Nuristan Provinces of Afghanistan to the north and west, and with the Khyber-Pakhtunkhwa districts of Swat and Dir to the south. A narrow strip of Wakhan Corridor separates Chitral from Tajikistan in the north **(Drawing No. E1)**.

Chitral is counted amongst the highest regions of the world, sweeping from 1,094m at Arandu to 7,726m at Tirich Mir, and packing over 40 peaks more than 6,100m in height. The terrain of Chitral is very mountainous and Tirich Mir (7,708 m) the highest peak of the Hindu Kush, rises in the north of the district. Around 4.8 percent of the land is covered by forest and 76 percent is mountains and glaciers.

The district has a population of about 447,362 according to the 2017 population census, and the average annual growth rate from 1998 to 2017 is 1.80%. The general population is mainly of the Koh people, who speak the Khowar, which is also spoken in parts of Yasin, Gilgit, Dir and Swat. Chitral is also home to the Kalash tribe, who live in Bumburet and two other remote valleys southwest of Chitral town.

The town of Chitral is the main town in the district and serves as its capital. It is situated on the west bank of the Chitral River (also known as the Kunar River in Afghanistan) at the foot of Tirich Mir which is the highest peak of the Hindu Kush.

The district of Chitral is divided into twenty-four union councils and two tehsils namely Chitral and Mastuj. The district elects by direct popular vote, one member of the National Assembly (MNA) and two members of the Provincial Assembly.

The project is located in the Union Council of Koh which lies in Chitral Tehsil. The project is located along GolenGol a left Bank Tributary of Mastuj River **(Drawing No. E2 & E3)**. The catchment of the GolenGol is 518 km^2.

The basic features of the project are; main weir structure which is proposed to be built in concrete in two sections. The overall weir length will comprise of an overflow and under-sluice section. The overall weir has been designed to pass a flood of 1125 cumecs which has a return period of 1000 years. The ogee shaped overflow section of weir is 40 m wide. The under-sluice section of weir has 2 no. vertical lift gates. The power intake consists of 2 No. gated inlets. Each inlet is equipped with vertical stop-logs and trash-rack inclined at an angle of 82° with the horizontal floor on intake. There is provision of stop logs at the downstream side of intake gates in order to carry out repairs of one gate while the other gate is still open and transferring flows to the connecting channel.

The flows will then be carried through a rectangular connecting channel to the sand trap. The sand trap structure has been proposed and will be a reinforced concrete structure. The total length of sand trap will be 161.78 m; including 27.64 m long transition from the channel end. The width of combined structure is 25.30 m while its depth varies between 8.55 m and 11.5 m. The flows will resume through a rectangular connecting channel to headrace tunnel. The headrace tunnel is designed as a horseshoe shaped free flow conduit of 4.0 m diameter. It is approx. 5 km long and has a slope of 1 in 1000.

There are two manifolds finishing at the inlet valves of Pelton turbines. The diameter of each manifold is 2.5 m. An open type powerhouse will be provided on the right bank of river. The powerhouse will be equipped with three Pelton turbine units having vertical axis. The concrete lined free flow tailrace will convey the discharge from the draft tube outlet gates up to the Golen Gol River. Salient Features of the Project are given in **table E.3.1**.

Table E.3.1: Salient Features of Main Civil Work Components

Hydrological Features at Weir Site:		
Catchment Area of Golen Gol	518	km^2
Mean Annual Flow	18.86	m^3/s
$HQ_{1,000}$	1,025	m^3/s
Weir Structure:		
Crest Level of Weir	2582	m SOP
Max. Weir Height	8.3	m above river bed
Length of Weir Crest	40.0	m
Invert of Flushing Outlet	2574.44	m SOP
Spillway:		
Level of Spillway Crest	2582	m SOP
Desander/Sedimentation Basin:		
Design Discharge	20.0	m^3/s
Design Particle Diameter	0.20	mm
Number of settling chambers	3	
Effective length of chamber	91.27	m w/o transition
Total Width of chamber	25.3	m
Average depth of chamber	8.5	m
Low-pressure Headrace Tunnel:		
Length	4.837	km

Net Diameter	4	m
Max. Flow velocity	2.7	m/s
Surge Tank:		
Diameter:	15.00	m
Pressure Shaft and High-Pressure Tunnel:		
Length of vertical shaft		m
Diameter	2.5	concrete lined
Diameter	2.5	steel lined
Steel lining	20 – 28	mm
Powerhouse:		
No. of units	2	Pelton
Capacity each unit	41.125	MW
Installed Capacity	2 x 41.125 = 82.25	MW
Max. Turbine Design Discharge	20	m^3/s
Cavern type		
Electro-mechanical Equipment:		
No of Transformers	2	
Type of GIS Switchyard	SF6	
Voltage	220	KV
Tailrace Tunnel:		
Total length (w/ manifold)	75	m
Additional Project Parameters:		
Mean Annual Energy		About 382.33GWh

3.5. Land Use on the Site

The land required for project implementation would be acquired on temporary and permanent basis. Land for dumping excavation earth material and contractor camps will be required on temporary basis and will be returned back to owner/owners after bringing into original condition. Requirement of land for temporary purpose is to place the temporary facilities mentioned earlier only during construction of project and not required during operational phase. Land for operation and maintenance staff residence colony, power house, weir, sand trap, connecting canal, reservoir and up-gradation and widening of road is required on permanent basis. The headrace, powerhouse and tailrace lies in the existing alignment. Requirements for land estimated by considering the project components to be built. The estimated land required will be about 66.5 acres which include 52.7 acres for permanent land use and 13.8 acres for temporary land use. Proposed location for the O & M staff colony and excavated material dumping site is shown in **Annex E.4**.

3.6. Access to Project Area and Site

The project site and area is accessible by air, good roads and railway networks. Chitral is connected to the rest of Pakistan through a number of other high passes, including Darkot Pass, Thoi Pass, and Zagaran Pass; provide access on foot to Chitral from Gilgit-Baltistan in Ghizer District.

Chitrai is well connected to Khyber Pakhtunkhwa Province via Motorway, National Highway and District Road. National Highway starts from Mardan Interchange over M1 Motorway and is double carriage till Dargai. From Dargai to Chakdara it passes the Malakand Hills with dual carriage which is of good quality. From Chakdara to Dir is a dual carriage road and can pass all kind of traffic. Dir till to mouth of Lowari Tunnel road is under construction. Lowari Tunnel is in operation and is a dual carriage. From Lowari to Chitral a dual carriage road is under construction and hope shall be completed much earlier before arrival consignments.

Project site is accessible from Chitral City via Chitral-Buni Road having width of 5.0 m. The road is in good condition. From Chitral-Buni Road Bridge along GolenGol, an asphalt road along the GolenGol has been constructed by GolenGol Contractor for access to GolenGol Hydropower Project diversion weir site. Road is newly constructed with three concrete bridges along GolenGol and two underpasses where road is being crossed by mud flowing non-perennial Nullah.

A jeep-able track is available along Golen Gol starting from Golen Gol HPP Diversion Weir site to Weir site of the Project. Road has to be upgraded for transportation of construction machinery and material. The up-gradation of this unpaved road implies construction of asphalt road along its enlargement and bridge at weir.

A number of national and international airports are operating in Pakistan. Bacha Khan International Airport, Peshawar and Benazir Bhutto International Airport, Islamabad are the two most nearest international airports to the site. One national airport that is Chitral Airport is located in Chitral city which is just 35 km from the project site via Chitral – Mastuj Road (N-45).PIA (Pakistan International Airport) runs two flights each from Islamabad and Peshawar to Chitral.

The nearest operational railway station from the project location site is Noshera Jn. Railway station. Loading and unloading of heavy equipment is possible through this Station. The Site from this railway station is further accessible by national highway (N-45).

3.7. Vegetation Features of the Site

The project area has sparse vegetation cover and few trees species along GolenGol River. Most popular plant species are Willow, Birch and Juniper. Fruit trees like Mulberry, Walnut, Apricot, Apple, Grapes are found in the orchards. Some cold resistant aromatic species like Buckthorn, Hawthorn, Low shrubs, Sage brush, Wormwood, Bulbous iris, low-lying cushion plants, meadows grasses, Artemisia, Cobra Asia, Clovers and Alfalfa are found in and around villages near project site.

3.8. Cost and Magnitude of Operation & Schedule of Implementation

The total cost of the project is PKR. 26166.73 millions. And it will be completed in 48 months after the approval from respective departments.

3.9. Description of Project

The diversion weir site is proposed some 250 m upstream of Turtonas Wooden Bridge along right bank of GolenGol River. The diversion weir will consist of fixed and gated parts. The power intake would be located along right bank. Water from power intake will pass through the connecting canal before entering into sedimentation basin. Another connecting canal will lead water to headrace tunnel, surge chamber, pressure shaft and pressure tunnel (**Drawing No. E4**). Water after generating power will join the Golen Gol River back through tailrace tunnel just upstream of Golen Gol HPP, Diversion Weir.

The location of Diversion Weir and Powerhouse are as follows:

Site	Latitude	Longitude
Diversion Weir	35° 56.398'	72° 3.168'
Powerhouse	35° 55' 13.74"	72° 00' 2.40"

The proposed project of 82.25 MW is a run of river scheme. The layout of the waterway is along the right bank of the GolenGol River. The difference of elevation between weir and Powerhouse site was measured in the field with GPS and Google pro counter verified through actual survey, which gave a gross head of 494.1m. The proposed layout has a headrace length of 4837m and an underground powerhouse on the right bank of river near Uzghor village and tailrace will discharge back into the GolenGol upstream of Diversion Weir of Golen Gol HPP.

The main features of the project are

- Diversion Weir with Lateral Intake
- Sedimentation Basin along right bank
- Connecting Canal along right bank
- Headrace Tunnel along right bank
- Surge Tank
- Vertical Pressure Shaft of 440.07 m height
- Pressure Tunnel 791.28m long
- Power House at an elevation of 2087.90m.a.s.l is proposed on right bank
- Tailrace of 75 m length
- Bridge at weir and Access road up-gradation
- Operation and Maintenance Staff colony

3.10. Restoration and Rehabilitation Plans

As the project construction will proceed it will involve the excavation of the material, dumping of material on pre-identified dumping sites and also clearing of the land from vegetation/plantation along the banks, camps and colony areas. So following restoration and rehabilitation measures will be taken on the completion of the project.

- Soil/aggregate dumping sites and temporary camps facilities will also be planted with endemic tree species to restore to its original condition and to avoid soil erosion.
- Trees will be planted along the banks of the river/canal after the completion of the project.

Details of tree planting program and cost of plantation is given in **Table E.6.4** and also discussed in the Environmental Management Plan along with other restoration and rehabilitation measures given at the end of the report.

3.11. Government Approval Requirements

The Government of Pakistan has almost the same Environmental Assessment requirements as IFC for Hydroelectric Projects of more than 50MW capacity. A full scale Environmental Impact Assessment (EIA) is mandatory for projects bigger than 50MW. This project falls under category A of schedule II (Regulation 4) of Pakistan Environmental Protection Agency (review of IEE and EIA) Regulations, 2000.An EIA is required to submit to KPK-EPA by the Client for approval prior to commence construction work. In order to comply with international requirements, the present report constitutes an ESIA (Environmental and Social Impact Assessment), and not only an EIA.

CHAPTER - 4

CONSIDERATION OF ALTERNATIVES

CHAPTER-4

CONSIDERATION OF ALTERNATIVES

4.1. Alternatives

Various alternatives were considered during the study and which provide their environmental and social benefits. Following alternatives have been considered:

- No Project Option
- Alternative source of power generation
- Alternative Project location/ layout

4.2. No project Option

Pakistan is suffering from worse power and energy crisis, which is primarily caused by the increasing gap between the supply and the demand of electricity. It is well known fact of the modern world that electricity plays a vital role in the growth of a nation's economy. Energy crisis is also considered a major development hurdle in Pakistan and which resulted in the energy policy formulation by the government. The additional power demand of Pakistan has been anticipated to be 39,217 MW by the year 2023-24 as mentioned in the **Table E4.1** as under:

Table E4.1: Electric Power Demand Forecast

Year	2017-18	2018-19	2019-20	2020-21	2023-24	Growth Rate (%)
[illegible]	29,399	30,919	32,422	34,009	39217	[illegible]

Source; General Manager Planning Power NTDC / PEPCO, WAPDA House, Lahore.

Development of the electricity sector is crucial to support continued growth of Pakistan's economy. Electricity demand in Pakistan is increasing at the rate of 5%–6% annually (Table 4.1). A number of efforts are being made to meet the alarming energy and power deficit at Federal and Provincial level.

Shortage of power has resulted in unpredictable long load shedding for households, commercial activities and industries. This load shedding has affected the quality of life and prolonged hours of load shedding up to 8 hours a day in summer caused social unrest. It has caused serious impacts on the commercial activities and industrial growth thereby resulting in fall of economy in the country.

No Project Option is unrealistic, rather country need to construct more power plants to fill in the demand and supply gap. Progressive power generation will minimize generation cost of fuel-based power plants and boost the economy.

4.3. Alternative Source of Power Generation

Different alternative energy sources include both renewable and non-renewable. Renewable energy sources include solar, wind and water while non-renewable energy sources are oil, gas and coal.

4.4. Alternate Hydro Power Projects:

Pakistan is endowed with a hydel potential of approximately 60,000 MW, most of which lies in the KPK Province, Northern Areas, Azad Jammu and Kashmir and Punjab. However, an abundant hydel potential is still untapped which needs to be harnessed. The total installed capacity of the hydropower stations in the country is about 6600 MW, out of which 3767 MW is in KPK, 1698 MW in Punjab, 1036 MW in AJK and 99 MW in the Northern Areas.

The Government of KPK has established a corporate body known as Pakhtunkhwa Energy Development Organization (PEDO) for carrying out hydro-power prospects, hydro-power development and to act as a utility company for isolated rural communities. With the assistance of WAPDA and GTZ, SHYDO prepared a Master Plan for the development of hydro-power potential in KPK. About 150 potential sites, with a total capacity of 18,698 MW were identified on the basis of high, medium and small head. Out of these, 17 projects are in operation, 6 sites are under implementation in the public sector, and 1 site has been offered to the private sector. Mainly, these are run-of-river sites, with some as daily storage projects. About 7 raw sites with a potential above 50MW are identified in Chitral.

Mostly difficult mountainous terrain and absence of high power transmission lines prohibit or discourage private investors. But developing this project has a positive edge because of already under construction Golen Gol project, whose grid will be at 5 to 6 km distance from this project; thus will be cost effective in terms of existing transmission line and road access.

4.5. Other sources of Renewable Energy:

Other renewable energy resources available in Pakistan are small scale wind and solar projects which also have positive impacts in avoiding environmental impacts of thermal or fossil fuel energy generation. These resources are under experimental stage and few projects are under implementation having lower efficiency and power potential and cannot be considered as a replacement of other power generation resources.

4.5.1. Nuclear

Currently two nuclear power plants designed for year-round base load are operating in Pakistan contributing with 3 % for the overall power generation in country. There could be more nuclear plants but major problem associated with them is the handling of their radioactive waste which is hazardous for human health and environment. The environmental and social impacts of hydro power plants can be at least partially mitigated but Pakistan has not yet found satisfactory measures to mitigate radioactive impacts of nuclear waste. Thus, nuclear power generation cannot be considered as successful alternative as compared to cleaner and green hydro power generation.

4.5.2. Thermal Power Resources:

Power can be generated from non-renewable resources like oil, gas and coal. Pakistan has limited gas resources and oil is also imported to meet the present needs. Hydropower can be compared with these thermal power sources in terms of cost and carbon dioxide emissions.

Hydropower is a clean and renewable source of energy than thermal power and its use reduce emission of pollutants such as carbon dioxide (CO_2), Sulphur dioxide (SO_2), particulate matter (PM), carbon monoxide (CO), oxides of nitrogen (NOx) and hydrocarbons. The following **Table E4.2** provides a comparative analysis of estimated emissions of CO_2 from a power station generating same amount of energy as Turtonas-Uzghour Hydro Electric Power Project over a 30-year period using oil, gas and coal as a fuel source. Between 3.4 to 4.7 million tons of carbon dioxide emissions are saved over the 30 years of the project by using hydropower rather than fossil fuels.

Table E4.2: Comparative Analysis of CO_2 Emission using Oil, Gas and Coal for Generation

Fuel source	Oil	Gas	Coal
Grams CO_2/kwh	297	232	410
Total Saving (Million Tons CO_2)	3.4	2.7	4.7

Note: Assume generation of 382.33 Gwh per year over a 30-year project life = 11,469.9 GWh

4.6. Alternative Project Location/ Layout

Five (5) alternative locations for diversion weir were identified and designated as W1, W2, W3, W4 and W5, while five (5) locations for powerhouse were identified and marked on GT Sheet. Two locations for powerhouse were on right bank of Golen Gol while three locations were along left bank of Golen Gol. All identified powerhouse locations envisage underground powerhouse, except one location along the left bank near Uzghor, which is open standalone. The following location and layout alternatives were marked and checked in the field.

1) Alternative-1 Lateral intake and Diversion Weir (W1) located upstream of Turtonas Wooden Bridge while underground powerhouse (P-R1) near Uzghor Village. The sediment basin and headrace tunnel, surge chamber will be located along right bank of river on open area.
2) Alternative-2 Lateral intake and Diversion Weir (W1) located upstream of Turtonas Wooden Bridge while underground powerhouse (P-R2) near UzghorVillage. The sediment basin and headrace tunnel,

surge chamber will be located along right bank of river on open area.

3) Alternative-3 Lateral intake and Diversion Weir (W2) located at or downstream of Turtonas Wooden Bridge while underground powerhouse (P-R2) near Uzghor Village. The sediment basin and headrace tunnel, surge chamber will be located along right bank of river on open area.

4) Alternative-4 Lateral intake and Diversion Weir (W3) located at power intake of under construction MHP downstream of wooden bridge along Golen Gol while underground powerhouse (P-R2) near Daman Dok Village. The sediment basin and headrace tunnel, surge chamber will be located along right bank of river and may be underground.

5) Alternative-5 Lateral intake and Diversion Weir (W1) located at upstream of Turtonas Wooden Bridge while underground powerhouse (P-L2) near Daman Dok Village. The sediment basin and headrace tunnel, surge chamber will be located along left bank of river on open area.

6) Alternative-6 Lateral intake and Diversion Weir (W1) located upstream of Turtonas Wooden Bridge while open powerhouse (P-L1) near Uzghor Village. The sediment basin and headrace tunnel, surge chamber will be located along left bank of river on open area.

7) Alternative-7 Lateral intake and Diversion Weir (W3) located at power intake of under construction MHP downstream of wooden bridge along Golen Gol while underground powerhouse (P-L3) near Daman Dok Village. The sediment basin and headrace tunnel, surge chamber will be located along left bank of river on open area.

8) Alternative-8 Lateral intake and Diversion Weir (W4) located upstream of Ustur Village while underground powerhouse (P-R1) near Uzghor Village. The sediment basin and headrace tunnel, surge chamber will be located along right bank of river on open area.

9) Alternative-9 Lateral intake and Diversion Weir (W5) located upstream of Ustur Village while underground powerhouse (P-R1) near Uzghor Village. The sediment basin and headrace tunnel, surge chamber will be located along right bank of river on open area.

Alternative 1 was considered the most favorable option, as it will generate high energy with less land use and low to minimal environmental and social impacts in comparison to other alternatives. A detail of alternative location and layout analysis is described in Vol. 2 (Appendix A) of main report.

CHAPTER - 5

ENVIRONMENTAL BASELINE

CHAPTER 5

ENVIRONMENTAL BASELINE

5.1. Description of The Environment

5.1.1. Provincial Context

Khyber Pakhtunkhwa province of Pakistan is enriched with biological diversity spreading throughout the province. It hosts wide varieties of wild animals and tree species, about 98 species of mammals, 456 species of birds and 48 species of reptiles are found in different national parks and wildlife sanctuaries in KPK. Various protected areas extending across the province are mentioned asunder:

- Ayubia National Park in Abbottabad District at a distance of 515 km from project site
- Chitral Gol National Park in Chitral District at a distance of 43.75 km from project site
- Brog Hill Valley National Park in Chitral District at a distance of 232 km from the project site
- Sheikh Buddin National Park in Dera Ismail Khan District (661 km from project site)
- Saif-Ul-Muluk National Park in Mansehra District (610 km from project site)
- Lulusar-DudipatsarNational Park in Mansehra District (530 km from project site)

Few protected wetlands identified in KPK are:

- Tanda Dam in Kohat District at a distance of 440 km from project site
- Thanedar Wala in Lakki Marwat, Bannu District at a distance 634 km from project site

Neither of these parks and wetlands is in vicinity of project and will not be affected from project activities.

5.1.2. Physical Environment

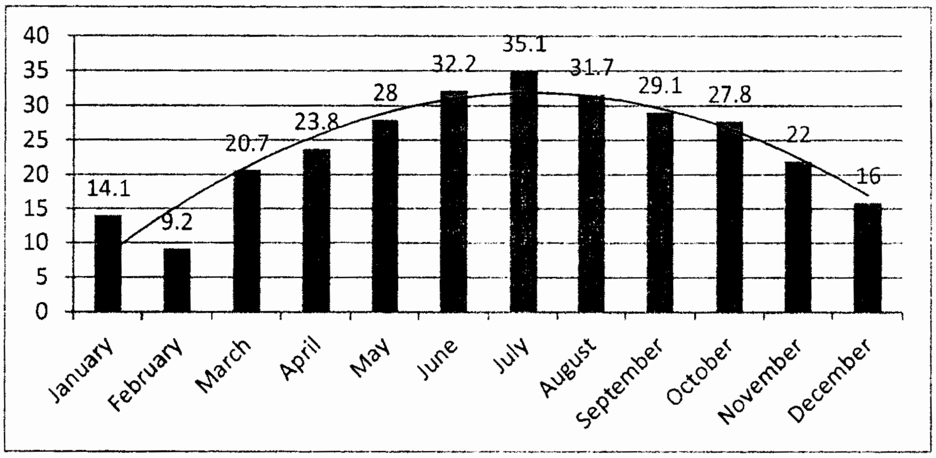
5.1.2.1. Climatology

District Chitral has continental climate with hot summers and chilly winters. Precipitation occurs mainly from spring thunderstorms brought about by western frontal system. Widespread snow fall occurs in winter. For Chiral town, the mean maximum temperature is 35° C in July and extreme minimum temperature is -3.8°C and 4.8°C for months of December and January respectively. The moon soon hardly penetrates into the project area and main mechanism for producing rain is western disturbances. Chitral like other areas in KPK receives only 476 mm precipitation per year, of which 75% occurs in winter and spring. Average monthly precipitation ranges from about 6mm in June and July to more than 100mm in March. Winter snow fall in the town can be quite heavy with an accumulation of up to two feet being quite common; at higher elevations snowfall can reach as high as 20 meters.

Table E5.1: Mean Monthly Temperature, Precipitation and Relative Humidity recorded at Chitral

Month	Chitral		
	Mean Temperature (^{0}C)		Total Rainfall (Millimeters)
	Maximum	Minimum	
January	14.10	-0.20	94.30
February	9.20	-1.00	151.80
March	20.70	6.00	48.70
April	23.80	8.80	76.90
May	28.00	11.70	78.80
June	32.20	14.30	31.20
July	35.10	18.00	63.20
August	31.70	17.50	33.00
September	29.10	12.60	28.20
October	27.80	6.90	3.50
November	22.00	0.70	0.00
December	16.00	-2.90	0.60

Graph E5.1: Monthly Maximum Temperature (Chitral)



Source: Pakistan Meteorological Center Lahore.

5.1.2.2. Geology

The project area lies in the southern part of Hindukush which is the western segment of greater Himalayan system. The region has undergone intensive deformations associated with the collision of Indian and Eurasian Plates resulting in complex geological features concerning geomorphology, stratigraphy, petrology and tectonics. In the project area, three important rock formations: Kaghozi Granite, Reshun Formation and Green Schist Unit as well as different types of Quaternary Deposits are present. The Kaghozi formation in the project area has three important rock units i.e., Kaghozi Granite, Reshun Formation and Green Schist Unit as well as different types of Quaternary deposits are present. The Kaghozi Granite is main rock unit exposed in the project area. This is grey, fine to medium grained, foliated, non-porphyritic and hard to very hard. Its lower contact with Reshun formation is faulted and is characterized by cataplastic texture. Rocks of Reshun formation are medium hard except at places where these have been affected by Ayun fault. Weir site is located where Golen Gol is wider in section and a spillway can be made on right bank. The foundation will be over the cobbles and gravel with little or no sand. The sand trap and the headrace canal are to be constructed through terrace deposits. Headrace tunnel will be excavated through three rock formations Kaghozi granite, Reshun formation and Green schist unit. Six types of rocks are expected to be encountered during tunneling. The excavation of surge structure will take place in rocks of Reshun formation. The power house is situated just downstream of GolenGol mouth over a terrace consisting of the slope deposits. Appropriate drainage arrangement shall be needed for the terrace and slope deposits underneath the power house and the lower part of the pressure shaft.

5.1.2.3. Soils

The soils found both on the valley bottoms and old river terraces are derived from the fluvial and glacio-fluvial deposits mainly brought by the hill torrents, avalanches and glaciers. These soils are the drift soils. Solis of various colors ranging from dark grey to brown and white are found in the project area. This is due to ground water and back water conditions as well as the development of thin layer of humus soils.

5.1.2.4. Erosion

Loss of land through erosion by rivers, landslides and flash floods is common throughout the district because of which considerable areas go out of use every year. The problem of erosion is most serious in Drosh, Ayun, Belach, Yarkhun valleys and landslides and land slips are common in Mulkhow, parts of Torikhow and Lotkhuh areas. Flash floods are experienced in all parts of districts.

5.1.2.5. Air

There is no monitoring of air quality in the area. According to sensorial observations, the air quality of the Project area is generally good and mostly free of pollutants. This is so because there is no major source of air pollution like industrial activity, or vehicular traffic. The vegetal cover in the area is thin. This results in a rise in suspended particulate matter (SPM) during high winds or major traffic movement which is of temporary nature.

During blasting, transportation of construction material and heavy equipment, dust levels are expected to rise in the project area. The large particles of dust will deposit in the adjoining areas and smaller particles will remain suspended in the air causing air pollution in the surrounding areas. The area is already prone to high dust levels due to thin vegetation cover and limited annual precipitation. Although the problem will be temporary, special measures should be taken to reduce this impact.

5.1.2.6. Noise

According to Golen Gol HPP report, noise level in the project area during high flow of river is fairly high ranging from 50 to 65 dB without traffic, mainly because flowing water collide with boulders and rocks against it. The traffic noise on the jeep-able track of Golen Gol valley is negligible.

5.1.2.7. Water

Golen Gol joins the Mastuj River from its left bank. It originates from glaciers namely Lohigol and Shachio koh. It flows through narrow gorges and joins Mastuj River about one km upstream of Kaghozi. The main tributaries of Golen Gol are Shachiokoh, Lohigol, Dok Gol, Birmogh Gol and Chitral Gol. All these are left bank tributaries. The height of the catchment varies from 1918 m to 629 m approximately. The mean elevation of the catchment is 3950 m.

The catchment area of the Golen Gol lies between latitude 35P0P, 48' to 36P0P, 30' and longitude 71P0P, 58' to 72P0P, 18'. The catchment area of the Golen Gol at its confluence with Mastuj River is 518 km^2. The area is enclosed with high mountains ranging from 4875 m to 5800.

Water is one of the most important natural resource of the project area. Most of the socio-economic activities of the area are connected with the availability of adequate quantity and good quality of water from various springs and nullahs. The quality of river water monitored with high pH value and sample reports are attached in **Annexure E.9**.

The rights for distribution of water for irrigation purposes are proportional to the land holding sizes. Irrigation canals have normally enough water to serve all the irrigated land.

Starting from weir up to powerhouse site, direct river flows are neither used for irrigated agriculture not for domestic water supplies; instead springs as well as nullah's joining the Golen Gol flows are used to serve both these purposes.

Golen Gol derives its flow from snowmelt and rainfall both of which do not contain any impurities. As the river flow proceeds over the drainage basin, water picks up sediment load, dissolved solids, toxic substances, and organic matter including bacteria from the surface of the earth. Domestic sewage though insignificant, may get into it. Sediment load is important with respect to the operation stage of the project. The suspended load of Golen Gol contains sand, silt and clay particles, their proportion varying in low and high flow seasons.

5.1.3. Ecological Resources

The information regarding ecological resources of the project area has been collected from exiting reports of Golen Gol HPP, research articles, site visits and respective government departments.

5.1.3.1. Wildlife of Project Area

Wildlife data was collected by visiting the project area, SDO's of wildlife department and from locals by social survey described in detail in the following sub-sections.

- **Mammals**

Pakistan is home to ten of 18 known mammalian orders.[1]The varied and interesting mammalian fauna found in Pakistan is largely due to the country being on the transitional zone between two of the world's six major zoogeographical regions, the Palearctic and Oriental.[2] Khyber Pakhtunkhwa (KP) has diverse physical and climatic conditions. In a short stretch of 700 km from south to north, the elevation range extends from 174m in Dera Ismail Khan to 7,690 m at Tirichmir Peak in Chitral. This has given rise to eleven major habitat types which support about 100 mammalian species.[3]

Chitral is highly regarded for its treasure of Fauna as well. Some endangered, near threatened and vulnerable species of the world and national conservation i.e., Snow Leopard (*Panthera uncial*), Gray Wolf (*Canis lupus*), Red Fox (*Vulpesvulpes*), Jackal (*Canisaureus*), Golden Marmot (*Marmotacaudataaurea*)and Markhor (Capra falconeri) Male and Female still live in these remote valleys of the Hindu Kush. Other common mammals of this mountain habitat are Cape Hare (*Lepuscapensis*), Rat (*Rattusrattus*), Brown Bear(*Ursusarctos*), Himalayan Lynx (*Lynx lynxisabellinus*), Common/river Otter (*Lutralutra*) and Himalayan Ibex (*Capra ibex sibirica*). A complete list of Mammals with their IUCN and National conservation status is given in **Table 1, Annexure E.5**.

According to the Wildlife department of the area and local peoples, most commonly found mammals near the project area are Ibex (*Capra ibex sibirica)*, Markhor (*Capra falconeri*), Red Fox (*Vulpesvulpes*), Gray Wolf (*Canis lupus*), Lynx (*Lynx lynxisabellinus*), RhesusMonkey (*Macacamulatta*), Asiatic Jackal (*Canisaureus*) and Cape Hare (*Lepuscapensis*). Neither of these is found in 1 km range of project. Among theseMarkhorand Gray wolf are endangered according to national conservation status and IUCN also enlisted Markhor as Near Threatened in its red list. Red Fox (*Vulpesvulpes*), Rhesus Monkey (*Macacamulatta*), Asiatic Jackal (*Canisaureus*)and Cape Hare (*Lepuscapensis*) are near threatened in national conservation list of mammals which are mostly killed for safety purpose. Decline in the number of wild animal has been witnessed over the year by the locals.

KPK Wildlife Department is trying harder to conserve these wild animals by banning shooting, trapping and catching/pouching. A trophy hunting programme for Markhor has been also started by the department to increase conservation efforts which allow a permit of PKR. 1,200,000 for one shoot per year only.A hunting permit of PKR 2-3 hundred thousand is required for one shoot per year to protect Ibex (*Capra ibex sibirica*) population.

Following biodiversity conservation projects by WWF were launched with a focus on Markhor Conservation[9]. These include:

- Protected Areas Management Project (Chitral Gol National Park)
- Markhor "Trophy hunting programme" in Kaigah valley –Kohistan
- Snow leopard conservation programme with focus on Markhor conservation as prey base
- Mountain Areas Conservancy Project

- **Birds**

Pakistan has a rich diversity of avian habitats, from the dry alpine and moist temperate forests of the western Himalayas to the deserts of Baluchistan and Sindh. These diverse habitats are of importance to some 669 recorded bird species.[5]Of these, 30% are long distance migratory birds, 43% are either Palearctic species visiting Pakistan only for breeding and 28% are regular winter visitors, which breed mainly in the northern trans-Himalayan regions.[5]

The topographic variety of KP makes the province diverse in avifauna and the Himalayan forests provide habitat for a number of bird species. Of 669 bird species reported from Pakistan, 456 bird species are found in KP.[6]

About 34 different bird species are reported near the project areas which are listed in **Table 2, Annexure E.5** with their IUCN status. Commonly found species of birds in the project area areYellow-crowned Wood pecker *(Dendrocoposmahrattensis)*, Common myna (*Acridotherestristis*),Chukar (*Alectorischukar*), Mallard (*Anasplatyrhynchos*), Golden Eagle(*Aquila chrysaetos*), Koklass Pheasant (*Pucrasiamacrolopha*), House Crow(*Corvussplendens*), Snow Partridge (*Lerwalerwa*), Red-collared dove (*Streptopeliatranquebarica*), Yellow-billed Blue Magpie (*Urocissaflavirostris*), House Sparrow (*Passer domesticus*), Russet sparrow*(Passer cinnamomeus*), Eurasian Sparrow hawk (*Accipiter nisus*), Great Tit (*Parus major*) and Eurasian Scops-owl (Otusscops). These all species are listed as Least Concern in IUCN red list.

Some migratory species of birds also reported from the area. These are Common teal (*Anascrecca*), Ferruginous Duck (*Aythyanyroca*), Marbled teal (*Marmaronettaangustirostris*), Common Goldeneye(*Bucephalaclangula*), Red-crested pochard (*Nettarufina*), Common pochard(*Aythyaferina*), White Wagtail(*Motacillaalba*) and Wigeon (*MarecaPenelope*). Among these species marbled teal (*Marmaronettaangustirostris*)and Wigeon (*MarecaPenelope*) are enlisted as vulnerable in IUCN red list.

The hunting of the Chukar (*Alectorischukar*),Koklass Pheasant (*Pucrasiamacrolopha*), and Golden Eagle(*Aquila chrysaetos*)is restricted and hunting permit of PKR 2000 per year is required.

- **Reptiles**

According to the Chitral Wildlife Department and Golen Gol HPP EIA reports Lizards were observed commonly during the field survey. Five species of snakes namely ColuberKarelini, *Lycodonstriatusbicolor, Ptayasmuscosus*, *Natrix tessellate* and *Agkistrodonhimalayanus* have been reported from Chitral valley. The last one is the only poisonous snake. *Natrix tessellate* stays close to water and feeds on fish and frogs.[11, 12]

Most of these reptile species are not evaluated by the ICUN red list. List of reptiles with their ICUN status is given in **Table 3 Annexure 5**.

5.1.3.2. Forest Resources

The coniferous forests occur from 1,000 m to 4,000 m altitudes in Chitral, Swat, Upper Dir, Lower Dir, Malakand, Mansehra and Abbottabaddistricts of Khyber Pakhtunkhwa. Ecologically the protected forest of Chitral are dry temperate where productive forests are confined to the valley of lower Chitral of ShihshiKoh, Beori, Ashraits, Arundu, Ursuu and Kalash valley.Main natural species are Deodar (*Cedrusdeodara*), Spruce (*Piceasmithiana*), Chir (*Pinusroxburghii*), Silver Fir (*Abiespindrow*), Juniper (*Juniperuscommunis*), Himalayan White Pine (Kail) (*Pinuswallichiana*)and other broadleaved species. Non-availability of gas fuel has increased deforestation here and more and more of wood is used for construction and heating of homes and hotels. Increasing population and illegal trading of timber for furniture also put pressure on the forest resources of district and reduce forested area. KPK Forest department has started "Billion Trees Tsunami Afforestation Project" in 2014 in all districts of KPK to conserve the forests.

5.1.3.3. Trees and Vegetation

Pakistan has great diversity of flowering plants due to its varied climatic and edaphic factors. Nearly 6,000 vascular plant species occur in Pakistan, and about 7.8% flora of over 400 species, are endemic to Pakistan.[7]Due to great physiographic diversity and climatic conditions, the province of KP hosts 11 major habitat types with over 4,000species of plants.[8]

The vegetation in the project area is mostly scrub vegetation which is least important of all vegetation type and not of appreciable extent. The area where project components have to be placed is rocky and barren having sparse vegetation and only few plants.

Natural flora in the Golen Gol valley consists of grasses, herbs, shrubs and trees. Grasses are conspicuously absent from flora types. Common herbal plants are *Astragalusspp*, *Polygonumspp*, *Saxifragaspp*, *Osytopisspp*, *Coorydalis spp*. The common bushes are *Biburnumcontinifolium*, *Lonicerspp.*, *Spiraealindleyana*, *Daphne oleoides*, *Prunusdulcis*(Chitrali-Kandu), *Salix spp*, *Sophoramollis* (Chitrali-beshu), and *Caraganadecorticans* (Chitali-Kagbeshu) Indigofera.

Trees are found in and around the Ustor, Turtonas, Uzghor, Birmogh and Golen Gol villages used for fruit, shade, timber and fuel wood. Most commonly grown fruit plants are Apple (*Pyrusmalus*), Peach (*Prunuspersica*), Pear (*Pyruscommunis*), apricot (*Prunusarmeniaca*), walnut (*Juglansregia*), black Mulberry (*Morusnigra*), White Mulberry (*Morusalba*),Cherry (*Prunusavium*), grapes (*Vitisvinifera*), Russian olives (*Elaeagnusangustifolia*), pigeon peas (local name is toor) (*Cajanus Cajan*) and Pomegranate (*Punicagranatum*).

Deodar (*Cedrusdeodara*), Spruce (*Piceasmithiana*), Chir (*Pinusroxburghii*), Silver Fir (*Abiespindrow*), Juniper (*Juniperuscommunis*), Sweet almond (*Prunusdulcis*), HimalayanBirch (*Betulautilis*),Himalayan White Pine (Kail) (*Pinuswallichiana*), Greek Juniper (Saroz) (*Juniperus excels*),Eucalyptus (*Eucalyptus camaldulensis*)and Sanober/cypress (*Cupressustorulosa*) are the tree species near the villages and at high altitude as documented by the Forest department.

A complete list of Trees and vegetation along their IUCN status is given in **Table 4, Annexure E.5**.

5.1.3.4. Fish Resources

Golen Gol is a cold / glacier melt river that is swift, turbid and has low primary fish productivity. As the river is not productive it is not fished on commercial scale. Apart from opportunistic fishing, fish does not form significant part of any of the local communities diets.

According to the fisheries department the commonly fish found in the GolenGol River is trout only for which fishing permit costing to Rupees 100 per 5 pieces is issued by the department. Locals have also created fish farms in the Uzghorvillage which are not in the vicinity of the project. Common species of trout found in the northern areas areBrown Trout (*Salmotrutta*), *Snow trout* (*Schizothoraxplagiostomus*) and Rainbow trout (*Oncorhyncusmykiss*) [14]. A list of these species with IUCN status is given in **Table 5, Annexure E.5.**

Ecological considerations downstream of the weir require that flow of water should remain available throughout the year. All definitions of reserved or minimum flow place emphasis on the protection of natural life in the river. From the point of view of environmental considerations certain flow is planned to be released from the headpond for ecological flow throughout the year, which will be enough to take care of stress on aquatic flora and fauna including any fisheries potential which is very limited in any case. Moreover, numerous small and one big hill torrents join the GolenGol stretch below the weir site; substantial flows have been observed during field visits hence minimizing the stress on aquatic flora and fauna during low flow season.

5.2. Socio-Economical and Cultural Environment

Socio-economic studies mainly focus on demography, education, housing, health, family income, basic amenities, land use, livestock, resettlement concerns, industry, archeology, tourism, land values, role of women etc. The nearby villages to the project area are Golen, Uzghor, Birmogh, Turtonas and Ustor. The data of these villages were collected by the social survey and processed to generate information regarding basic amenities. For this purpose participatory rural appraisal technique was used and scoping sessions were held during field survey September to November 2017. The aspect of acquisition of land in terms of land area requirement and infrastructure falling within the project area was also investigated. The field team consisting of environmentalists, sociologist, ecologist and local representative undertook the process of informing community representatives and affected households about the Project and its impacts. The consultation process was conducted during the social survey preparing the affected community regarding land acquisition, helping to counter the rumors, preventing unnecessary distress, and bringing clarity on issues that might be raised by the affected persons.

A sample Questionnaire is attached with **Annexure E.6** and pictures of the survey activities are given **in Annexure E.7.**

5.2.1. Demography

KPK is third largest province of Pakistan with respect to population as shown in Table 5.2. More population of Chitral district is residing in rural areas than urban (Table 5.3). The data of population is taken from Statistical Bureau of Pakistan, census 2017.

Table E5.4 representing the number of households and estimated population of villages near project site.

Table E5.2: Province wise population of Pakistan

Province Wise Population			
Administrative units	**Households**	**Population 2017**	**1998-2017 Average Annual Growth Rate**
Pakistan	32,205,111	207,774,520	2.4
KPK	**3,845,168**	**30,523,371**	**2.89**
FATA	558,379	5,001,676	2.41
Punjab	17,103,835	110,012,442	2.13
Sindh	8,585,610	47,886,051	2.41
Baluchistan	1,775,937	12,344,408	3.37
Islamabad	336,182	2,006,572	4.91

Table E5.3: Population of District Chitral

Population of District Chitral			
Administrative units	**Households**	**Population 2017**	**1998-2017 Average Annual Growth Rate**
CHITRAL DISTRICT	61,619	447,362	1.8
RURAL	54,556	397,568	1.71
URBAN	7,063	49,794	2.59

Source: Statistics Bureau of Pakistan, census 2017

Table E5.4: Estimated Population of villages near Project site

Village/Hamlet	Households	Estimated Population
Uzghor	12	170

Goleen	700	6000
Birmogh	50	350
Turtonas	4	35
Ustor	65	640

5.2.2. Language

Residents of all villagers in the vicinity of project speak Chitrali also known as Khowar, only few elders can speak Urdu. Majority of the young population can speak and write Urdu.

5.2.3. Religion

Religion followed by the locals is Islam with 100% Sunni sect.There are neither vulnerable or minority ethnic groups in project area nor are there any other groups which can be considered indigenous people.

5.2.4. Tribes

Inhabitants of the villages near the project area belong to Akhunzada, Musingy, Bashkar, Dushmane, Gujar and Madak tribes. All tribes are living in harmony and peacefully in the area and no one is superior from others. There will possibly be no tension among the tribes for job opportunities during construction.

5.2.5. Indigenous People

The IFC's Performance Standard 7 recognizes that "Indigenous Peoples (IP) are social groups with identities that are distinct from dominant groups in national societies and that they are often the most marginalized and vulnerable segments of the society. Their economic, social, and legal status limits their capacity to defend their rights to, and interests in, lands and natural and cultural resources, and may restrict their ability to participate in and benefit from development. Indigenous Peoples are particularly vulnerable if their lands and resources are transformed, encroached upon, or significantly degraded. Their languages, cultures, religions, spiritual beliefs, and institutions may also come under threat. As a consequence, IPs may be more vulnerable to the adverse impacts associated with project development than non-indigenous communities."

In IFC Performance Standard 7, the term "Indigenous Peoples" is usually used in a generic sense to refer to a distinct social and cultural group possessing the following characteristics in varying degrees:

- Self-identification as members of distinct indigenous cultural groups and recognition of this identity by others;
- Collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories;
- Customary cultural, economic, social or political institutions that are separate from those of the dominant society or culture; or

- An indigenous language, often different from official language of the country or region.

Keeping in view the above mentioned characteristics IPs are not residing in the Socio economic Study Areas.

5.2.6. Land ownership

Household's heads has ownership rights to their respective cultivable and residential land and has legal government stamp papers. All the land required for "the Project" and its facilities is privately owned and will be acquired following standards procedures of land acquisition by IFC and national laws.

5.2.7. Houses and Households

Uzghor village is very small village which consist of only 12 houses with an estimated population of 170 persons with an average household size of 8 persons. All are native people living since long. Neither of the household migrated out of the settlement since 20 years as reported by the inhabitants. The adobe and masonry houses proportion in the village is 50:50.

Golen village consist of 700 houses with an estimated population of 6,000 persons with an average household size of 6 persons. All are native people living since long. Neither of the household migrated out of the settlement since 20 years as reported by the indigenous people. The village is a compact village having masonry houses.

Birmogh is a village of 50 houses with 60% masonry structure and an estimated population of 350 persons. It shows an extended family system with an average household size of 7 persons. About 6-7 households move out of settlement to Chitral for better education and employment opportunities.

Turtonas a small hamlet with only 4 houses and 35 people; residing here since not less than 3 years. It also shows an extended family system with 8 persons per family.

The last village visited is the Ustor at higher altitude, above that no more village exist due to severe weather conditions in winters. This is a compact village comprises of 65-70 houses with an estimated population of 640 people. Almost 12 houses migrated in the village for fodder/ livestock feeding.

Mosques and graveyards exist in each of the above village except Turtonas; however there are no sites of archaeological and historical importance in the project area.

5.2.8. Education

Golen village is located about 3.5 km downwards from the project power house, has two government schools; one is primary school for girls with an enrollment of 150 students. Other is middle school for boys with an enrollment of 250 students. People have to move towards Chitral city and Peshawar to get higher education. The adult population is not well educated but child literacy rate is 70%.

Adult literacy rate of male in Uzghor is almost 61% with majority of middle school qualification while female literacy rate is only 1 %. But now trends are changing for female education, people are encouraging female education as well. Village has one government primary school for girls where 14 girls are enrolled. Mostly boys study in nearby Golen middle school up to 8th grade and then move to city Chitral for matric or higher education.

There is one primary school in Birmogh with an enrollment of 40 boys and 40 girls. Adult female literacy rate is 20% having education up to middle and adult male literacy rate is 30% educated up to higher degrees.

Turtonas residents including male and female are uneducated, only one person possess secondary education.

Ustor also has one government primary school with an enrollment of 35 girls and 35 boys. Child literacy rate is far higher than adult with 45% only. Elderly woman are uneducated but young girls are getting education up to10th grade in nearby schools.

Table E5.5: Education Facilities in the Surveyed Villages

Sr. No.	Village Name	Educational Facilities							
		Primary School		Middle School		High School		Madrassa / Masjid	
		Male	Female	Male	Female	Male	Female	Male	Female
1.	Uzghor	0	1	0	0	0	0	1	0
2.	Turtonas	0	0	0	0	0	0	0	0
3.	Ustor	1	1	0	0	0	0	1	0
4.	Golen	0	1	1	0	0	0	1	0
5.	Birmogh	1	1	0	0	0	0	1	0

5.2.9. Employment

Almost 50% of the male population of Golen are working as labor and others are government employers and self-employed. Mostly government employers are associated with police, army and drivers, cooks in other occupation. Only 10% of employers are designated at higher posts.

In Uzghor 75% of the population is employed in various government and private organizations and 25% are involved in farming. Among 45-50% of employed are government employees working in police department, army, clerical and engineering departments. Among the villagers 7% working in the private organizations and rest are associated with labor.

80% of the population is self-employed working on farms and livestock and only 20% are government or private employer in Birmogh village. In Turtonas only 1% is employed in government job, 50% with farming and rest are working as labor.

In Ustor, majority of the population is working as labor i.e. 80%, rest are associated with farming and some other employments. Women in all villages are confined to houses busy in regular house chores including tending the livestock, hand embroidery. Household without water may compel the women to go out for washing the cloths and to fetch drinking water from nearby streams and nullahs. The quality of water is good as reported by the locals. The project will not affect these streams and nullahs and also will not affect the provision of water to Ustor or any other village. Some women go out to collect fuel wood and grasses to store for winters. They also carry out apricot and mulberry drying.

5.2.10. Family income

Majority of the population has to depend on the varying degree of alternative sources of income. They work as labor in construction and in private and public organizations. Main source of income of Uzghor inhabitants is through permanent employment as 75% of population is employed in government or private organizations. About 50% of population of Golen is working as labor. Majority of the population of the Ustor, Turtonas and Birmogh are labor class earning almost Rupees 700 per day. Almost 2-3 household are generating income through small scale fish farming in Uzghor. They also have small cultivatable land and livestock for subsistence.

Women are housewives or busy in house chores and few help in farming as well. Their share in raising the income through poultry and livestock selling is limited.

5.2.11. Agriculture & Livestock

Most of the agricultural activities in the project area are carried out on the terraces prepared in the vicinity of villages. The measuring unit of land in the area used is Chakawaron which is 108*108 square feet. Villagers own land from 3 Chakawaron to a maximum of 80 Chakawaron for agriculture purpose which is below the minimum economic unit. Minimum economic unit is from 3 to 5 hectare. The villagers practice mixed cropping pattern with wheat, maize and potato. Majority people are small landowners growing crops for subsistence. About 9.04 Kanals (0.46 hactare) agricultural land will be affected by the project. This land currently was not cultivated as observed during site visit.

Besides farming villagers also rear livestock mostly for subsistence, only few are earning income by selling milk and meat. Every household has cows, sheep or goat and hen for milk and egg. About 100 Goats or sheep are reared to sell for meat by few households.

5.2.12. Fish Farm & Fishing

Uzghor inhabitants owned two Small scale fish farms to earn income. They were not sure about the area used for farm. These farms are located upstream of powerhouse and downstream of weir along river. They will be not affected by the project.

Residents in the project area are not actively involved in fishing from the river; only few are found of fishing. Commonly found fish is trout near Golen village.

5.2.13. Infrastructure

Golen Village is easily accessible through paved road and regular transport service. But road from Golen to other villages located above is unpaved, uneven and no regular transport is available. The unpaved road runs along left bank up to wooden bridge downstream of Ustor Village. Further up the road runs along right bank and runs in the center of Ustor Village. There are no local communication services, police station, police check-post, post office, hotel and banks in these villages. Out of various mobile phones network only Telenor network is reachable in all these villages except Turtonas and Ustor village.

Table 5.6: Number of Govt. Health Institutions and their Bed Strength in District Chitral

District/ Tehsil	Hospitals		Dispensaries		R.H.Cs		T.B Clinics		MCH Centres	Sub Health Centres	BHUs	Leprosy Clinics
	No.	Beds	No.	Beds	No.	Beds	No.	Beds				
Chitral Distt:	**4**	**184**	**40**	**0**	**4**	**59**	**1**	**10**	**3**	**0**	**21**	**3**
Chitral S/D	2	110	11	0	2	31	0	0	1	0	3	1
Drosh	1	40	7	0	0	0	1	10	1	0	6	1
Latkoh	0	0	0	0	0	0	0	0	0	0	0	0
Mastuj S/D	1	34	10	0	1	18	0	0	0	0	4	1
Arando	0	0	1	0	0	0	0	0	0	0	1	0
Malkoh	0	0	9	0	0	0	0	0	0	0	4	0
Tarkhow	0	0	2	0	1	10	0	0	1	0	3	0

Source: Statistics Bureau of Pakistan, census 2017

5.2.14. Health Facility and Sanitation

Although villagers are not suffering from any contagious and prevalent disease, only seasonal illness like cold, flue, diarrhea and eye diseases prevailed for not more than a week. There is no basic health unit (BHU) in these villages. Only small dispensary in Birmogh and one Rural Health Center (RHC) in Kaghozai village is available but Chitral city has all modern health facilities. The population living in these villages has proper sanitation system which is mostly pit type latrine connected to septic tank. None of the settlement has municipal sewage system and all the wastewater eventually runs off into river.

5.2.15. Water Supply

Both domestic and livestock water supply is directly from numerous springs located nearby of these villages and the river. The water quality slightly deteriorates during summers as reported by the villagers.

5.2.16. Fuel Sources and consumption

Project area has no dense forest; trees are found in and around the villages used for fruits, timber and fuel wood. The main fuel source for cooking and heating of houses during winters is fuel wood which is mostly purchased from other villages with a rate of rupees 650 per 40 kilogram and some are cut from their relevant land. There is no electricity supply to the villages by the government. Villagers on self-help basis installed a small powerhouse on running water stream near Turtonas to provide electricity for lighting only. Another commonly used fuel is LPG available for rupees 160 per kg to make tea and occasionally to cook food.

5.2.17. Recreational Areas

Area has potential for development of tourism but supporting tourism facilities are hardly available. There are no hotels/restaurants in the villages to accommodate the tourists. The recreational areas near the project site which can attract the tourist are Birmogh spring, safe heaven, fish farm in Uzghor and Chatodok Lake, Dakadoki, Dook lake at higher altitude in Ustor. Several locations along Chitral to Project site road provide the picturesque view of the Chitral, Mastuj and Golen Gol Rivers.

5.2.18. NGOs Working in Area

NGO's workings in the area are AKRSP (Agha Khan Rural Support program), PPAF (Pakistan Poverty Alleviation Fund), SRSP (Sarhad Rural Support Program) which are helping to raise awareness about gender equality, health and hygiene and livelihood enhancement and protection.

5.2.19. Influential of the Area

The influential in the area are head of families, Jirga and religious scholars which resolve conflicts among people. Matters related to property and natural resources of villages are also resolved by the Jirga and religious scholars.

5.3. Environmental Flow Assessment

Environmental flow (EFLOW) or ecological flow is the minimum flow of river required to sustain river ecology. E-Flows has to be released from the weir to meet the requirements of the aquatic ecosystem, is of concern in about 1.5 km stretch of the river downstream of the weir of Turtonas Hydro Electric Power Project where flow will be reduced due to diversion of flow into 2 MW mini Hydropower project with the name Birmogh Hydropower project with design discharge of 4 m^3/s. In winter months the plant will require 2 m^3/s only so it is proposed that the Turtonas-Uzghor project will discharge at least 2.5 m^3/s to maintain water requirement of mini plant and to sustain ecology of the river in 1.5 km stretch. Further downstream discharge of 2.5 m^3/s will be available.

CHAPTER - 6

MITIGATION MEASURES

CHAPTER-6

IMPACTS AND MITIGATION MEASURES

6.1. Introduction

This section discusses the potential environmental and social impacts of proposed project and identifies the mitigation measures to minimize the impacts in the design, construction and operation phases. The process of impact prediction is the core of environmental assessment process and it is critical that recommendations and mitigation measures are carried out during design, construction and operation of the project in accordance with IFC's and PEPA's environmental regulations.

6.2. Impact Assessment Methodology

Potential environmental and social impacts were identified on basis of environmental baseline study discussed in Chapter-5 and the focus group discussions as well as stakeholder consultation. The significance of potential impacts was assessed using the criteria and methodology given below.

6.2.1. Impact Magnitude

The potential impacts of the project have been categorized as major, moderate, minor or nominal based on consideration of the parameters such as:

- duration of the impact
- spatial extent of the impact
- reversibility
- likelihood
- legal standards and established professional criteria

6.2.2. Sensitivity of Receptor

The sensitivity of a receptor has been determined based on review of the population;

- (including proximity / numbers / vulnerability) and
- Presence of features on the site or the surrounding area.

6.2.3. Assigning Significance

Following the assessment of magnitude, the quality and sensitivity of the receiving environment or potential receptor has been determined and the significance of each potential impact established using the impact significance matrix.

A summary of the impacts and their significance are given in **Table E6.1**.

Table E6.1: Potential impacts and their significance

IMPACTS	Phase	Sensitivity	Magnitude	Significance Prior to Mitigation	Mitigation and Enhancement Measure	Residual Significance
Environmental and Social Impacts due to Project design						
Changes in physiographic and landform	All phases	Mild	Minor	low	Develop and Implement a landscape and plantation plan in the project areas	Minimal
Changes in Land use	Preconstruction, Construction	Mild	Minor	Low	Prepare and implement land acquisition process	Minimal
Loss of natural vegetation and trees	Preconstruction, Construction	Mild	Minor	Low	Planting of native trees near villages and along roads Promote the use of alternatives for fuel wood	Minimal
Impact of increased traffic and Transportation	All phases	Severe	Medium	High adverse	Traffic Management Plan, including awareness raising and safety measures	Low to moderate
Generation of sustainable employment	Construction and Operation	Severe	Medium	Moderate beneficial	Fixed quota for local workers and technicians Vocational training; Monitoring of labor rights, workforce composition, working and living conditions	Highly beneficial
Increased economic activity	All phases	Mild	Medium	Moderate beneficial	Establishment of new businesses and commercial enterprises; Local employment	Moderate beneficial

Environmental and Social Impacts During Construction:						
Impact on river habitat due to construction activities and drying of river section	Construction	Mild	Medium	Moderate adverse	Control of waste water and sediment releases to river Water quality management protocols in Contractor agreement Studies to improve aquatic baseline data	Low
Increased traffic on Local Access Roads	Construction	Severe	Medium	High adverse	Traffic Management Plan, including awareness raising and safety measures	Low adverse
Risk of pollution from solid waste and waste effluents	Construction	Mild	Medium	Moderate	Waste Management and Effluent Management Plan	Minimal
Potential risk of pollution of air, noise, soil and water resources by construction works	Construction	Medium	Medium	Moderate	Pollution Prevention Plans to be prepared by Contractor	Minimal
Loss of land in disposal areas	Construction	Low	Nominal	Minimal	Re-use plan for rock material Disposal Area Restoration Plan	Nominal
Impacts of noise and dust from construction and use of explosives	Construction	Severe	Medium	High adverse	No blasting during night time Awareness raising and grievance mechanism	Minimal
Public Health and Safety of Workers	Construction and Operation	Severe	Medium	High adverse	Safety and security actions and procedures to protect local community Safety training for workers Emergency Preparedness Plan; Contractor follows IFC Performance	Minimal

					Standards on Labor and Working Conditions;	
Risk of water pollution of storage tanks	Construction	Mild	Minor	Low adverse	Removal of oil tanks and other potential sources of pollution	Minimal
Shortages in local water supply and sanitation in residential areas	Construction	Mild	Medium	Moderate	Drinking Water Supply and Sanitation Plan to be prepared by Contractor independent from local domestic services	Minimal
Impacts from increased human activities on flora and fauna	All phases	Mild	Minor	Low	Use of non-wood fuel for cooking and heating; Improvements to community forestry management Code of conduct for workers and employees Awareness raising to workers and protection of flora and fauna	Minimal
Fish entrainment and mortality	Construction andOperation	Mild	Minor	Low adverse	Protection measures at inlets of tunnels to deter movement of fish	Low to minimal
Possible tension and conflicts between in-migrants and local communities	Construction and Operation	Mild	Medium	Moderate adverse	Awareness campaign Grievance mechanisms to address complaints	low to Minimal
Environmental and Social Impacts During Operation and Maintenance:						
Entrapment of fish at intake	Operation	Severe	Major	High adverse	installation of screen devices at the intake	Minimal

Barrier effect to fish migration	Operation	Mild	Medium	Moderate adverse	Provision of Fish ladder for fish movement	Minimal

6.3. Project Location and Design Impacts and Mitigation Measures

6.3.1. Positive Impacts

The proposed 82.25 MW Hydroelectric Power Project will be important for bridging the widening gap between demand and supply. The electricity generated through this project will be supplied to the national grid along, future hydropower projects in the region and the wider population of the district as well.

Availability of power would reduce consumption of fuel wood and other fossil fuels by villagers for cooking, heating and other domestic purposes thus will conserve the resources.

The project will provide jobs to the locals both in the skilled and unskilled categories during the construction phase of the project. This project will boost financial position of the locals who have to travel to various parts of the country for employment.

6.3.2. Change in Physiographic and Landform

The Physiographic and landform of Turtonas and Uzghor sites will change gradually during pre-construction and construction stage. During pre-construction changes will be moderate to minimum only. The activities in the project area shall increase with the start of up-gradation of roads, staff offices and colony. Preparations for establishing temporary labor camps, workshop and medical facility will continue until the main Contractor mobilizes. Once the main Contractor start excavation and construction work the landform character of the Turtonas and Uzghor will change and this will continue during construction.

6.3.3. Mitigation measures

To minimize these impacts, a landscape and plantation plan will be prepared and implemented by the Contractor. This will reduced the significance of the impacts to minimal level.

6.3.3.1. Loss of Land and Compensation

The total land area required for construction of project is calculated by considering areas required for each component of the project and is given in Table 6.2. Total land for project and its components is estimated as 66.5 acres which include 52.7 acres for permanent land use and 13.8 acres for temporary land use. Permanent land is required to construct the operation and maintenance staff colony and camps downstream of Uzghor village, weir, sand trap, connecting canals, powerhouse, road up-gradation and Reservoir Area. Temporary land will be required to dump excavated material from construction activities and after dumping this place will be used for establishment of construction camp and storage. It is proposed that during excavation process workers will stay at the colony area due to less leveled land availability near construction site. Two dumping sites have been identified for dumping of excavated material from powerhouse, pressure shaft, tunnel and weir. One dumping site of 7.8 acres identified at downstream of Turtonas village and other one of 6 acres at downstream of Birmogh village and upstream of Uzghor village. This land will be rented for during 4 year construction. The land is barren with no trees; only few bushes and shrubs are found.

The most of the area to be acquired for the project is uncultivated or natural wasteland and have no houses, civic amenities, and cultural resources **therefore no relocation and resettlement issues will arise from the project**. Whole land required for permanent and temporary use belongs to the villagers and will be acquired and rented according to land Acquisition Act 1894 and IFC's Performance Standard 5.

All the land near project site is communal land and possible compensation of land acquisition is by cash. Compensation amount for the land acquisition will be disbursed to land owners in an equitable and transparent manner by Revenue Department District Chitral, Khyber Pakhtunkhwa. The total cost for land acquisition kept in feasibility report is Rs. **272,756,080/-.** The land cost is worked on cost provided by Revenue Department Chitral plus escalation (**Table E11.3**).

Table E6.2 Land Required for Project

<table>
<tr><th>No.</th><th>Permanent Land Use</th><th>Land (Acres)</th><th>Temporary Land Use</th><th>Land (Acres)</th></tr>
<tr><td>1</td><td>Staff Colony part 1</td><td>6.3</td><td rowspan="3">Dumping site downstream of Turtonas village</td><td rowspan="3">7.8</td></tr>
<tr><td>2</td><td>Staff colony part 2</td><td>5</td></tr>
<tr><td>3</td><td>Area for weir, sand trap, and connecting canals</td><td>15.8</td></tr>
<tr><td>4</td><td>Area for powerhouse</td><td>10.2</td><td rowspan="3">Dumping site upstream of Uzghor village</td><td rowspan="3">6</td></tr>
<tr><td>5</td><td>Area along the road to be purchased (Total length of road to be constructed = 8500 m x 7m =59500 m^2)</td><td>14.7</td></tr>
<tr><td>6</td><td>Reservoir Area</td><td>0.7 acre
(<1 acre)</td></tr>
<tr><td></td><td>Total</td><td>52.7</td><td>Total</td><td>13.8</td></tr>
</table>

Details of land owners will be prepared by Revenue Department of Chitral District. After achieving financial close the Sponsor will approach Revenue Department for land assessment and acquisition. Assessed land cost will be deposited with Revenue Department which will be responsible for payment to land owners.

6.3.3.2. Loss of Natural Vegetation and Trees and Trees Planting Program

As described in Chapter 5 Baseline Conditions, the vegetation in the area is sparse and mostly scrubs vegetation which is least important of all vegetation type and not of appreciable extent. The area where project components have to be placed is mostly rocky and barren having sparse vegetation and only few plants. About 9.04 Kanals (1.13 acres) of agricultural land to be affected by the project which is currently is not under cultivation as observed during site visits. Only few small trees and bushes will be cut to clear the land for the construction of main facilities of the project. About 79 trees will be cut to clear the land for staff colony construction, which are endemic species of Pine (*Pinus roxburghii*) and Birch (*Betula utilis*, *Betula Chitralica Browicz*) listed as of least concern in IUCN status (Table 6.3). A tree planting program has been proposed at dumping sites and along the river banks for which cost estimates are prepared and provided in Table 6.4.

Loss of trees and natural vegetation will also have an effect on the collection of firewood as selling of firewood is an important business in the project area and common practice in winters for heating and cooking in the summer season. People harvested many fuel wood trees in and around their villages to maintain their needs for fuel wood. Local selling rate of fuel wood are higher in the area amounting rupees 650 per 40 kilogram. It is also expected that project will attract immigrants for construction work and will create high demand for firewood for cooking and heating. This will increase the pressure on forest at high altitude which is already under pressure from local communities.

The loss of trees and vegetation cover will be compensated by plantation of native tree species along river banks, near residential areas, dumping sites, staff colony and offices. Locals will be encouraged to cut and use the tree to be removed from the area. About 3 to 5 trees will be planted against one tree uprooted. The tree plantation estimation is given not only to conserve the existing situation but also to enhance the environment as required by then national environmental guidelines. The Contractor will also make sure to use the non-timber fuel like LPG for their construction staff for cooking and heating.

Out of total affected trees/plants, majority are birch plants, about 25-30 are nursery birch (*Betula utilis*, *Betula Chitralica Browicz Spp.*) with a height of 3 meter, 15-20 are 4-5m feathered plants and 10-15 are mature birch plants. Around 5-6 semi mature *Pinus roxburghii* were observed. Others are semi –mature kikar (*Acacia nilotica*) and eucalyptus.

Table E6.3 Number of Affected Trees & Plants

No.	Project Components	Affected Trees/Plants (No.)
1	Camps & Staff Colony 1	57
2	Camp and Colony 2	22
	Total	**79**

Table E6.4 Cost Estimates for Raising One Acre Tree Plantation

No.	Particulars	Work Days	Amount (Rs.)
1.	Digging of 435 pits, 10x10 ft. spacing, 1.5 ft. deep, & Planting of 435 saplings @ Rs. 800/day	4.4	3,520
2.	Procurement of 435 plants @ Rs. 50/plant	-	21,75o
	i. **Sub-Total**		**25,270**
3.	Beating up of 30% failure in the 2nd year, 131 plants		
a.	Re-opening of 131 pits, 1.5 ft deep, and planting of 131 saplings @ Rs. 800/day	1.3	1,040
b.	Procurement of 131 plants, @ Rs. 50/plant	-	6,550
	ii. **Sub-Total**		**7,590**
4.	Beating up of 15% failure in the 3rd year, 65 plants		
a.	Re-opening of 65 pits, 1.5 ft. deep, &planting of 65 saplings @ Rs. 400/day	1.3	520
b.	Procurement of 65 plants @ Rs. 50/plant		3,250
	iii. **Sub-Total**		**3,770**
	TOTAL		**36,630**
	TOTAL COST OF PLANTATION AT 11.3 ACRES		**413,919**
	With 10 % Contingency Cost		**455,310.90**

6.3.4. Employment Opportunities

Majority of the population near the project area is working as labor. About 25-30% is employed and mostly self-employed in farming and livestock rearing as described in Chapter-5 Baseline Study. This project will provide an opportunity to locals to apply for skilled and un-skilled employment. The contractor has to attract local residents for job on the basis of agreed quota. This quota could be based on the directly and indirectly affectless of project but priority should be given to directly affected persons from project. There will also be an employment opportunity for office staff, administrative and semi-skilled and unskilled works. This is major and significant positive impact of the project and highly beneficial to boost employment for locals and increase their social and economic status.

6.3.5. Increased Economic Activity

This project will help to increase the economic activity in the area by allowing influx of people in all stages of project, which will create new opportunities to local businessmen, shop keepers, suppliers, transportation sector and village level enterprises. This will considerably stimulate the local economy.

6.4. Construction Impacts and Mitigation

6.4.1. Materials

The project will require various materials for construction. The requirement of aggregate (fine, coarse, boulder) for construction of various project structures will be procured from suitable quarries within or near the project area. Excavated material will also be used as construction material where filling is required.

6.4.2. Construction Activities

Construction of the project involves the excavation and movement of materials for:

- Making of temporary cofferdams up and downstream of the proposed weir in the bed of the river and tailrace channel if required.
- Removal of cofferdams when the weir and tailrace construction is complete.

Excavation work including drill-blasting will result in spoil material. This will be used as fill material, as far as possible, for structure of weir, powerhouse and the stabilization of the head pond banks, embankment of access roads, coffer dams and for terracing of hill slopes. The excavation material will consist of broken stones, boulders and sand and only the surplus amount shall be dumped at a specified dumping site as defined in the drawing without affecting settlements, agricultural activities, etc.

Rate of erosion will be increased slightly due to removal of sparse vegetation on the slopes during construction. Construction activities like setting up of weir site, road extension, movement of trucks, clearing of land, setup of housing for the work force and storage for machinery, excavation, tunneling will contribute to increased surface fluvial erosion and will increase sediment load in the river. Vegetation and forestation are the most effective long term and economic measures to avoid soil erosion. The affected areas should be planted with grass cover, tiny bushes and trees after construction work completion. Contractor will be required to control waste water and sediment release to the river and implement water quality protocols.

6.4.3. Access and Traffic Management

There is only a single road to access the project site which is unpaved and irregular onward from the Golen Gol Weir. Before commencement of the work a road will be constructed to easily access the site and to carry the material. There is no local transport system existing in the area as described in Baseline Study; so the road is mostly clear off traffic. But the construction related traffic on road may disrupt existing traffic and may also create safety hazards for the villagers. Additional project vehicles will be used to transport heavy machinery and equipment such as turbines, generators, etc., which may cause traffic congestion and safety hazards. Managing traffic at a construction workplace is an important part of ensuring the workplace is without risk to health and safety. Vehicles moving in and around project site, reversing, loading and unloading are often linked with death and injuries to the workers and public. The most effective way to avoid these risks is through devising a traffic management plan, and by implementing through the Contractor. The main objective of the plan shall be to maximize the safety of the workforce and the travelling public. The second objective will be to keep traffic flowing as freely as possible. This infrastructure of access roads including bridges required during construction phase will remain an essential part of the project operation and maintenance.

Locals were informed about road construction during community consultation. They were further informed that during road widening few boundary walls may be shifted. The local appreciated construction of road and agreed to shift boundary walls voluntarily where required.

However, detailed consultation will be carried during engineering design and preparation of tender document parallel to financial close and EPA will be appraised accordingly.

6.4.4. Construction Site and Camp Impacts and Mitigation

6.4.4.1. Workforce Required During Construction

Project implementation will require the workforce for the construction of various components of the project. A large number of workers will be required from the initial startup (about 50 workers) to the peak construction time (200 workers). This construction labor will consist of skilled, semi-skilled and unskilled workers. The unskilled labor will preferably be hired from adjoining areas. Semi-skilled and unskilled labor will reside in the construction camp which is proposed to be spread over an area of 13.8 Acre near project site. During construction phase, areas for residential colonies for professional staff and labor as well as equipment storage sites would be needed. Due to the mountainous character of the region suitable land areas are rare. However, it is pointed out that most of the work force would daily commute between construction sites and nearby villages or towns, thus considerably reducing the requirement of housing needs at the sites of project construction.

6.4.4.2. Power Required During Construction

The electricity will be required during construction and operation of the project and to the residents of the colony and camps. As the project construction will require a continuous supply of power for the construction machinery; to augment/ensure an uninterrupted power supply a standby diesel generator set(s) of 100KV or more will be needed. The major problems with these generators are; the emissions of particulate matters, carbon monoxide and NO_2 which are highly dangerous for health and environment; and according NEQs generation of noise more than 65-75 dB during day time create noise problems (**Table 7, Annexure E.2**). To curb these emissions and noise, the generator must be properly tuned and be fitted with modern Clean Air Filters to reduce emissions and silencer to reduce noise level.

6.4.4.3. Construction of Tunnel

Tunnel will be excavated through Drill and blast method. Excavated material from tunnel will be first stocked for use in concrete. About 50 to 60 % of excavated material will used as concrete aggregate or stone for protection of slopes, etc. The remaining will be placed in proper terracing while using watering and compaction with machines. The terraces so formed will be stabilized by converting in to agriculture or planting trees.

Chemical and explosives will be transported and used as per country regulation and these will be made part of EPC Contract document.

Monitoring and evaluation of transportation and use chemicals and explosives will be the responsibility of the Consultant. Through provisions of bidding document, the Consultant will be empowered to take any kind of action against EPC Contractor. The Project will also be responsible for monitoring and evaluation of environment management of the whole project and will report on monthly basis to EPA Khyber Pakhtunkhwa.

6.4.4.4. Water supply, Sanitation and Solid Waste Management

To meet the demand of the drinking water supply and sanitation during construction period, it is recommended that proper water supply system should be provided at the site by connecting water system to spring or nullah.

Large construction works generate large amount of waste material from construction site such as steel cuttings, concrete, discarded materials etc., and from camps and colony such as garbage, food waste and debris. Hazardous waste will also generated from the maintenance activities such as oil filters, hydraulic oil, contaminated soils from leakage of constriction chemicals and other waste products. A large amount of waste produce from the camps and colony will be bio-degradable. It is important to dispose of this type of waste responsible to avoid adverse environmental, health and aesthetic impacts.

Mitigations: Environmental protection act 1997 and Environmental, Health and Safety Guidelines of IFC requires that all the municipal and industrial waste should be treated for surface discharge to any stream or open land should comply with NEQs and IFC standards. As described earlier in chapter 5, there is no municipal sewage system and landfills in the area. Contractors must prepare pollution prevention plan and with the help of district waste management authority, identify suitable sites for disposal of hazardous and non-hazardous wastes in properly planned landfills. For proper sanitation facilities, pour flush type latrines with septic tank are recommended. Also proper arrangements of solid waste management should be made in construction camps see Solid Waste Management Plan in Chapter 7).

6.4.4.5. Leakage and Exhaust Pollution During Construction

Many toxic and hazardous materials are used during construction like oils, fuel, paints, gases, cut pieces of plastic cable sheathings etc. Separate stores should be built to store toxic materials and strict regulations (**Annexure: E.3**) should be followed and utmost care must be taken to handle these materials.

Proper handling measure as given in IFC' s Hazardous Material Management and Land Contamination (**Annexure: E.3**) should be taken to transport the liquid materials such as fuel to avoid their leakage on the construction site, because most fuels are carcinogenic and they not only contaminate soil but also carried away in canal/river water with surface water flow. Thus it may cause damages to existing fauna and flora.

Gaseous emissions and dusty environment will result from movement of heavy vehicle for transportation of equipment and construction material. Similar effects could be caused by construction machinery so the contractors must control these emissions by construction management techniques as per NEQs and IFC guidelines.

Construction related activities would result in negative but short lived impacts in term of noise, dust and exhaust pollution on nearby settlements and labor working.

6.4.4.6. Dust impacts

Most of the construction work will generate dust during excavation. Among the variety of options to control dust emissions (particulate matter) from construction sites, most effective is the wet suppression. Spraying water on exposed surfaces and soil with adequate frequency to keep land moist at all times can reduce the total dust emission from the project by as much as 98% (**Annexure: E.3, Table 1.1.5**). The following mitigation measures will be implemented during construction to control emission of dust:

i. Water will be sprayed daily on all exposed surfaces sufficient to suppress emissions of dust. The frequency of spraying will be increased as necessary but controlled such that surface remains just moist at all times, particularly when air is blowing toward nearby village.
ii. Dust emission from soil and aggregate storage stockpiles used for construction will be reduced by appropriate measures. These will include:

- Covering the pile with thick plastic sheets when not in use at the end of working day.
- Keeping the material moist by spraying water at appropriate intervals to prevent emissions.

iii. The construction vehicles will maintain a speed limit of 20 km/h or less on all unpaved areas within the construction route. Speed limit signpost will be erected in highly visible positions along the access road and within the route and maintained for the duration of the construction. Speed bumps will be constructed near all sensitive receptors such as villages; where there is a risk that vehicle may exceed the speed limit.

iv. Construction materials will be transported to the route and around the route in trucks securely covered with tarpaulin to prevent dust emissions during transportation

6.4.4.7. Noise

Noise, gaseous emission and dusty atmosphere will result from movement of heavy vehicles for transportation of equipment and construction materials. Similar effects would be caused by drill-blasting for the tunnel, pressure shaft and caverns. The EPC contractor would be required to control noise and exhaust pollution by construction management techniques which are sensitive to these effects. Operation of construction machinery and vehicles can be nuisance for the nearby villages especially Uzghor (less than 1 km apart from powerhouse),Turtonas and Ustor (which are less than 1 km apart from the weir) and the site workers. Excessive noise level cause damage to eardrums, lungs and even effect the nervous system of the workers. The permissible noise level is 85dB in NEQs (**Table 5, Annexure E.2**). Noise can be minimized by

- Not undertaking construction work during night time
- Prevention of horn blowing by the vehicles except in emergencies
- Use of powered mechanical equipment that is acoustically insulated to reduce noise impacts
- Tuning and proper maintenance of construction equipment and vehicles.

Noise Pollution and blasting will affect the habitat of wild life which can be minimize by the EPC contractor and will be part of EPC contract. EPC will minimize noise by;

- Not undertaking construction work during night time
- Performing test blasting with various charges and monitor resultant noise and vibration level at various distance and chose optimum blast size to avoid any impacts to nearby receptors.
- Developing Blast and Explosive management plan with consultation of community.
- Local communities should be notified of the timing and frequency of blasts.
- Install and operate a siren of sufficient volume to be easily heard above the general site noise from all points within the radius of 1 km of surface blasts.
- Material stockpiles can also be used as acoustic shield around high noise generating equipment's and crushing plants and also along the boundaries of quarry areas.

- Prevention of horn blowing by the vehicles except in emergencies
- Use of powered mechanical equipment that is acoustically insulated to reduce noise impacts
- Tuning and proper maintenance of construction equipment and vehicles.

6.4.4.8. Public Health and Safety of Workers

The rough terrain and difficult work conditions in some parts of the area will need extra attention from Contactors and Project Management for the increased risk of accidents, unsafe working conditions and health problems. This is especially true for underground working tunnels, but also during excavation and construction work. The Contractors shall provide on-site safety induction training for their personnel upon starting of construction work such as;

- The Contractor shall provide personal protective equipment, including hard hats, protective gloves, mask, goggles, safety shoes etc. and such other equipment and shall take all measures and actions for safety and protection of personnel.
- Non-metallic hard hats shall be worn all times by the personnel at the site with the exception of those areas where engineer has indicated it not necessary to do so.
- Safety glasses if required shall meet international standards and be available for use and worn in specified worksite areas. As a minimum, safety glasses shall be worn for the following type of work: hammering, chipping, welding, grinding, use of electricity powered equipment, insulation handling, spray painting, working with solvents and other jobs where the potential of an eye injury exists.
- Personnel shall not be permitted to work whilst wearing personal clothing or footwear likely to be hazardous to themselves or others.
- Hearing protection, including ear muffs, plugs or combination thereof shall be provided for all personnel operating in areas where noise level exceeds 90dB.
- The contractor should encourage employees to wear substantial work gloves whenever it is necessary.
- Construction workers should be provided with necessary masks to protect them from any adverse health effects.

Public health and safety measures will also be undertaken such as barriers and warning signs at required places. All safety, health, environmental and other safety notices and signs shall be clearly displayed and written in Urdu, English and the native language of the Construction Contractor's personnel. Although majority of the elder near project speaks chitrali language but cannot read it as they are illiterate but the young can read and speak Urdu.

6.4.4.9. Impact on Water Quantity and Quality

The construction works are likely to affect the water quality temporarily by increasing the silt content in it. Golen Gol River is low flow river during few months of the year there is very little water in the river so construction of the project will be phased to ensure that the cofferdams are completed in the low flow time. This will minimize the need to work in the water and minimize impacts on water quality. However, the locals water supply needs will be fulfilled by the springs and Nullah or streams in the area.

Therefore, any significant impact on the water quality is not anticipated during construction period.

Another impact on water quality could be from the chemicals used for tunnel construction. Tunnels will be excavated through Drill and blast method. Chemicals from blasting may affect the quality of seepage water from tunnel. However, water coming from tunnel will be collected in pond and before discharging into Golen Gol it be treated for the level of drinking quality. This will be part of EPC Contract and EPC Contractor will be responsible.

6.4.4.10. Impacts on Flora and Fauna and Mitigation

Construction activities will increase large influx of workers, technicians, suppliers, businessmen, engineers and inspectors. This increasing population will exert pressure on the local environment by increasing noise, disturbances, hunting, poaching and trapping of wild fauna.

To avoid pressure on local environment, contractor will maintain liaison with the concerning Wildlife Protection Department and local community to protect the wildlife and forest in the area. Tree cutting, hunting, poaching/catching of wildlife by the workers will not be allowed and public education program and worker awareness program about wildlife protection and conservation will be devised and implemented.

6.4.4.11. Impacts on Fish and Mitigation Measures

Fish try to move downstream in water conduits such as diversion tunnels, powerhouse intake tunnels and spillways will potentially be subjected to high levels of mortality and injury. There is no significant fish population in the river as reported by the locals and fisheries department. But to protect this small population fish, inlets should be protected either by entrainment screens or by acoustic and or electric methods in order to prevent fish to be caught by the inflow and be killed in the turbines.

As the workforce during the implementation of the project could have an increasing demand for the fish so there must be some measures to consider controlling the overfishing and production of the fish in the river. One way to increase the fish production can be through increase supply of the fish.

No Dam and Check dam will be constructed for this project. Only a weir structure along with lateral Intake will be constructed to divert the water power generation.

A fish ladder is provided to help in movement of fish from downstream to upstream or vice versa in the river (see fish ladder design in **Vol.9 Drawings TUHPP-221 and TUHPP-225 to TUHPP 229**).

Environment flow 2.5 m^3/s is being released to meet the fish requirement during low flow season. However during high flow there will be not impact on flow pattern. Further during construction period fish sampling will be done to establish fish species available in the river. Sampling will be done all round the year and sampling remained continued during operation for first five year. The project is ready to mitigate any impact on fish if found during sampling and monitoring. These measures may include stocking, construction of fish pond for locals, etc.

6.4.4.12. Possible Tension and Conflicts between Immigrants and Local Communities

The project will bring large proportion of immigrants and different ethnic groups to the area. It will also engage local peoples who will make significant changes in their lives and livelihood. If improperly managed, this influx can create social tension and conflicts between various ethnic groups.

To avoid these conflicts, an awareness campaign regarding different social group and their ethnicity, cultural understanding and a proper grievance mechanism to address complaints of each group/ individual must be developed and will be implemented by the Project Management group.

6.4.4.13. Impacts and Mitigation During Operational Phase

a. Soil erosion, degradation and vegetation loss

Planting and subsequent maintenance of trees and vegetation cover over initial 3 years of the project operation will be undertaken along the renovated connecting canals and access roads to avoid soil erosion, degradation and vegetation loss

b. Impacts on Fish and Mitigation Measures

Major issue with the fish during operational phase is entrapment of fish at the water intake. Protection of fish should be made against entrapment and impingement by installing screen devices at the intake which will divert the fish from the water intake. A fish ladder is also suggested and designed to help in movement of fish from downstream to upstream of river see **Drawing Vol.9 TUHPP-221**.

CHAPTER - 7

ENVIRONMENTAL AND SOCIAL MANAGEMENT AND MONITORING PLAN

CHAPTER-7

ENVIRONMENTAL AND SOCIAL MANAGEMENT AND MONITORING PLAN

7.1. Introduction

This Chapter presents the environmental and social management plans (ESMP) for all the project components. It summarizes the organizational requirements, management and monitoring plans to ensure that the necessary measures are taken by respective departments to avoid potentially adverse impacts and maximize potential benefits of the Project as identified in previous section of the ESIA and to operate in conformance with the applicable laws and regulations of KPK, as well as the policies of international financial organizations such as IFC and World Bank.

The basic objective of the ESMP is to manage adverse impacts of project interventions in a way, which minimizes the adverse impact on the environment and people of the Project area. The specific objectives of the ESMP are to:

- Facilitate the implementation of the mitigation measures identified during the present ESIA.
- Maximize potential project benefits and control negative impacts;
- Draw responsibilities for project proponent, contractors, consultants, and other members of the Project team for the environmental and social management of the Project;
- Describe a monitoring mechanism and recognize monitoring parameters to ensure the complete implementation and effectiveness of all mitigation measures;
- Maintain and preserve biodiversity and where possible restoring degraded natural resources; and
- Assess environmental training requirements for different stakeholders at various levels.

The ESMP will be managed through a number of tasks and activities and site specific management plans. One purpose of the ESMP is to record the procedure and methodology for management of mitigation identified for each negative impacts of the Project. The management will clearly delineate the responsibility of various participants and stakeholders involved in planning, implementation and operation of the Project.

Client will ensure that conditions are included in project construction contract documents. It will also ensure that during construction phase, environmental mitigation measures as per the ESMP are effective and are implemented. The ESMP implementation will be coordinated with concerned Government Agencies.

7.2. Institutional Arrangements

The overall responsibility for the implementation of the project rests with the Client's Project Management Unit (PMU). Within the PMU there will be an Environment Unit responsible for implementing the ESMP. The responsibilities of Environment Unit are t o:

- Supervise, facilitate and coordinate to implement the environmental and social plans including in the ESMP
- Ensure implementation of ESMP, IFC guidelines, World Bank operational policies and KP-EPA regulations by the contractor.
- Identify the non-compliance issues and reporting to the relevant department
- Interact and consult stakeholders for their concerns about construction activities.

PMU will further employ different officers for environment, social, ecology and occupational health and safety (OHS). These officers will work in close cooperation with the respective field based office on the day-to-day activities of ESMP implementation.

7.3. Roles and Responsibilities

7.3.1. Environment Unit

Some specific responsibilities of the Environment unit (EU) will include:

- Connecting with the Construction Supervision Consultants (CSC) and EPC contractor to make sure that they perform their responsibilities effectively and adequately
- Communicating with relevant project bodies, national and international financial institutions and relevant stakeholders regarding environmental matters
- Resolving the disputes and conflicts with respect to environmental management
- Ensuring environmental complaints are investigated for effective resolution
- Coordinating the involvement of environmental expert as need arise through construction phase and finalizing TOR for hiring of consultant.
- Prepare monthly or quarterly reports on the status of implementation of ESMP for client and funding agencies.
- Ensure review of ESMP and update if needed.
- Overall planning, management and monitoring of the land acquisition activities, as well as implementation of other plans
- Establish Grievance Redress Committees (GRCs) and ensure its smooth functioning;
- Obtain approvals from KPK-EPA and then monitor the project and forward monitoring reports on a regular basis to the provincial EPA as per the requirements of the federal EPA regulations.

7.3.2. Construction Supervision Consultants

The Construction Supervision Consultants (CSC) will be responsible for supervising the contractors for the implementation of ESMP. For this purpose, the CSC will appoint dedicated environment and social staff to ensure the ESMP implementation during the project. They will also be responsible for implementing the mitigating measures and monitoring of effects of these measures.

The environment staff of CSC will closely supervise the construction team to ensure that all environmental commitments are incorporated into the construction activities and work processes. Specific responsibilities of CSC include:

- Supervising contractors to implement specific work plan and supporting in achieving their responsibilities as per ESMP
- Issuing notices to the contractors in case of non-compliance
- Making necessary arrangements to implement ESMP and granting approvals on specific work plans
- Reviewing and evaluating environmental risks regularly throughout the construction phase
- Identifying, preparing and conducting environmental trainings
- Assisting EU to address and resolve environment-related complaints and grievances
- Preparing and managing compliance reports quarterly for relevant departments
- Coordinating with EU and relevant departments for effective environmental and social management
- Reviewing ESMP if needed

7.3.3. Contractor

Specific responsibilities of the contractor are to;

- Implement the ESMP/ESIA during construction by all personnel
- Ensure the provision of resources to implement the ESMP and ESIA
- Prepare quarterly reports and undertake audits on regular basis
- Ensure compliance with all national and international legislations
- Coordinate with the client on all issues arising during construction

Contractor has to appoint adequate number of environmental and social officers to implement the ESMP at project site and be responsible for the training of their staff in relevant environmental and social aspects. Before the commencement of construction work, contractor has to develop various plans directed towards health and safety, social and environmental issues and get approval from CSC. The construction contract must have clauses to bind the contractor to meet all these obligations. Appropriate numbers of the following personnel are required in the contractor's environmental team:

- Environmental Specialists
- Occupational Health and Safety Specialists
- Environmental Technicians

7.4. Management and Mitigation Plan

The ESMP is developed in Table 7.1 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN. Supervision and implementation of ESMP will be undertaken by client in conjunction with a proposed implementation specialist, as well as by the Construction Contractor.

The environmental and social management plan consists of following parameters;

- Project phase; indicating the project phase when the management measure is applicable.
- Description of impacts; which describes the potential impacts arises during project activities and need mitigation measures
- Mitigation and management measures; clear, concise and preventive and corrective actions to be taken to avoid or reduce the significance of impacts
- Means of implementation; actions to be taken to implement measures
- Institutional responsibilities: roles and responsibilities to implement and supervise the planned measures

7.5. Traffic Management Plan

The key components of traffic management plan are:

- Hiring the qualified and trained drivers for construction work, managing the activities of visiting drivers and by training the drivers.
- Providing separate traffic routes for pedestrians and vehicles.
- Designating specific parking areas for workers and visitor's vehicles outside the construction area.
- Providing clearly signed and lit crossing points where walkways cross roadways, so drivers and pedestrians can see each other clearly.
- Scheduling work so vehicles, powered mobile plant and pedestrians are not in the same area at the same time.
- Minimizing vehicle movement around a workplace by providing loading and un-loading away from the work area.
- Where possible, avoid the need for vehicles to reverse as this is a major cause of fatal incidents.
- Ensuring a signal person wearing high visibility clothing assists the driver who cannot see clearly behind their vehicle.
- Ensuring workers and other people are familiar with reversing areas and these areas are clearly marked.

- Traffic routes should be clearly signed to indicate restricted parking, visitor parking, headroom, speed limits, vehicle movement, key site areas and other route hazards. Standard road signs should be used where possible and speed limits should be implemented and enforced.
- Assign duties to the people at site to control and manage the traffic.
- Train the staff to handle the traffic in case of emergency situations.
- Implement and monitor the effectiveness the traffic management plan.

7.6. Solid Waste Management Plan

Solid waste generated from the construction activities, worker camps and during operational phase from the power house and staff colony need to be properly managed and disposed of. Main steps involve in the waste management are

- Segregation of waste at the source
- Collection of waste
- Transportation of waste
- Proper disposal according to the standards

It is recommended to provide specified colored bins to segregate different type of waste like plastics, glass, paper and kitchen waste (also known as bio-degradable waste) at the source and then transported to a properly designed disposal site (a landfill and composting site). There is not landfill and composting sites near the project area and contractor has to establish the appropriate waste management sites with the help of concerned authority.

Train the workers about 3 R's to manage the solid waste properly. These 3 R's are

- Reduce; aware the workers to reduce their consumption of plastic bags and other resources as much as possible by producing less waste.
- Re-use the material such as glass bottles and plastic bag instead of throwing them away.
- Recycle the used items like compost the kitchen waste and yard waste to make fertilizers. Paper and broken glass can also be recycled so instead of throwing it away, provide to recycling facility.

TABLE E7.1: ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

Environmental Aspects & Potential Impacts	Remedial Measures	Means Of Implementation	Institutional Responsibility	
			Implementation	Supervision
Design / Pre-Construction Components				
Project Construction & Potential loss of property, agriculture and other land uses	1. Examination of alternative layouts and technology and choice of river alignment with least land take and minimum loss of existing land use 2. Design to maximize use of excavated material at various stages of construction process, i) to make embankments of the headrace ii) building upstream and downstream cofferdams iii) reuse material to fill in grooves near project area and renovate it with plantation 3. Complete land acquisition and Government land leasing process prior to work commencement	Proper planning measures to be added in relevant parts of contract documents.	Design consultants & client	Client
Excavation of construction materials, development of quarries & borrow areas causing loss of alternative land use	1. Maximize use of existing quarry & borrow areas already in operation for sand and aggregates	Proper planning measures to be added in relevant parts of contract documents.	Design consultants & client	Client
Disruption of roads and wooden bridge crossing at Turtonas by construction	2. Design for least disruption of road communications and existing wooden bridge crossing.	Proper planning measures to be added in relevant parts of contract documents.	Design consultants & client	Client
Construction stage				
Earth works for	1. Maximize re-use of material in different	Careful planning	Contractor's	CSC, EU,

construction of connecting canal and powerhouse causing loss of land use and trees.	construction phase and avoid or reduce the need to find areas for deposition of the excavated materials. 2. Tree planting Program on connecting canal banks and to renovate diversion canal.	and monitoring	Environment Engineer	KPk-EPA
Disruption of access for local people	1. Ensure the existing road access is maintained near the site	Proper planning, implementation and monitoring	Contractor's Environment Engineer	CSC, EU, KPk-EPA
Taking of quarry and borrow materials with loss and degradation of land	2. Quarry materials will be obtained from existing operating sites in the area with proper licenses & environmental clearances. 3. Renovation of any borrow land and quarrying areas in the immediate project area with plantation	Careful monitoring and include conditions in contracts	Contractor's Environment Engineer	CSC, EU, KPk-EPA
Operation of construction equipment and construction activities cause contamination of soil, loss of water quality and water pollution	1. Fuel storage & refueling will have adequate contaminant and should be away from river/Nullah. 2. Equipment will be properly maintained and any waste petroleum products will be collected, stored and disposed of at approved sites as per hazardous waste management act. 3. Planning of construction phases to minimize the limit of time to work in water to avoid loss of water quality and turbidity in river. Maximum efforts for building the cofferdams during dry period.	Careful planning and monitoring of conditions included in contracts	Contractor's Environment Engineer	CSC, EU, KPk-EPA
Construction activities causing disruption of existing river	1. No canal and irrigation channel is off-taking from the river.	Careful planning and monitoring of conditions included in the contract.	Contractor's Environment Engineer	CSC, EU, KPk-EPA

system and the supply of irrigation water				
Construction camp & residential colony. Social impacts and pollution from waste water & solid waste	1. The construction camp will be located away from settlements. There is adequate waste land available near the project site. 2. Construction camp and colony will have properly designed sewage system for effluents and solid waste collection.	Careful design and planning by design consultants and monitoring of conditions included in the Contract.	Contractor's Environment Engineer	CSC, EU, KPk-EPA
Emissions from construction vehicles and equipment causing air pollution	1. Emission levels of all construction vehicles and equipment will adapt to Pakistan and IFC's emission standards. 2. Pollution parameters will be monitored during construction. 3. Crushing & concrete plants will be at defined construction areas but away from the river.	Careful monitoring of condition included in the Contract.	Contractor's Environment Engineer	CSC, EU, KPk-EPA
Dust particulate causing health impacts for workers and villagers	1. All precautions should be taken to reduce dust level emissions from batching plants & crushers. 2. Regular water spraying at all mixing sites & temporary service roads will be undertaken. 3. All delivery vehicles will be covered with tarpaulin. Mixing equipment will be sealed & equipped as per standards. 4. Personal protective equipment will be provided to workers in highly dust environment.	Careful monitoring of condition included in the Contract.	Contractor's Environment Engineer	CSC, EU, KPk-EPA
Noise pollution from construction activity, vehicles, plant & equipment operation	1. All construction equipment & plants will be under permissible limits of NEQs noise standards. 2. All vehicles and equipment be fitted with noise abatement device. 3. Construction worker should be provided with	Careful monitoring of condition included in the Contract.	Contractor's Environment Engineer	CSC, EU, KPk-EPA

	earplugs/earmuffs in high noise places.			
Loss of vegetation and trees during construction	1. No tree will be removed without prior approval from relevant department. 2. Compensation for tree loss. 3. Tree plantation program at the dumping sites and on the wasteland around the project site. 4. Use of non-wood fuel for cooking and heating by construction workers 5. Indigenous tree species will be planted only. 6. Improvements to community forestry management	Careful monitoring of condition included in the Contract.	Contractor's Environment Engineer with forest department	CSC, EU, District Forest Dept., KPk-EPA
Impacts of increased Human activity and construction on Wild Fauna and fish	1. Awareness raising among workers about wild fauna and fish protection and preservation 2. Prohibit hunting of migratory birds and fauna without permits 3. Protection measures at inlet tunnel to deter movement of fish 4. Provision of fish ladder for upstream movement of fish	Careful monitoring of condition included in the Contract.	Contractor's Environment Engineer with Wildlife and fisheries department	EU, CSC, KPK-EPA
Construction activities and accidental risks	1. Safety signals will be installed on routes affected by construction work particularly during work from the existing road. 2. Workers will be provided with PPE (hamlets, masks & safety goggles and a readily available first aid unit with dressing materials etc.). 3. Educate vehicle drivers about road safety and ensure traffic management. 4. Information dissemination through banners & local announcement at mosque about project time frame, activities causing disruption & any temporary arrangements for public relief.	Inclusion of measures in contracts and follow up monitoring	Contractor's Environment Engineer	CSC, EU, KPk-EPA

Construction activities causing disruption to public utilities	1. Any public utilities impacted must be relocated to suitable places in consultation with local beneficiaries.	Careful monitoring of condition included in the Contract.	Contractor's Environment Engineer	CSC
Operational Stage				
Soil erosion, land degradation and vegetation loss	1. Planting and subsequent maintenance of trees and vegetation cover over initial 3 years of the project along the renovated connecting canal and access roads.	Sub-contractor	Client's Environment Engineer	EU
Entrapment of fish at intake and barriers to fish movement	1. Installation of screen devices at intake 2. Provision of fish ladder for fish movement	Sub-contractor	Client's Environment Engineer	EU

CHAPTER - 8

EMERGENCY PREPAREDNESS AND RESPONSE

CHAPTER-8

EMERGENCY PREPAREDNESS AND RESPONSE

8.1. Introduction

Emergency preparedness and response procedures provide measures and guidance for establishment and implementation of emergency preparedness plan. The aim of emergency response procedures is to:

- Ensure all personnel, visitors and communities to the project site are given maximum protection from unforeseen events.
- Ensure all personnel are aware of the importance of this procedure to protection of life and property.

Contractor will prepare and submit an Emergency Preparedness, Response and Recovery Plan (EPRRP). The EPRRP will be prepared in accordance with IFC Performance Standard 4 Community Health and Safety, which require that a plan is in place to effectively respond to emergencies associated with project hazards and that local communities are involved in the planning process.

Emergency preparedness and response planning should include following considerations;

- Identification of hazards or areas where accidents and emergency situation may occur
- Communities and individual that may be impacted
- Response procedures
- Provision of equipment and resources
- Designation of responsibilities
- Communication with potentially affected communities
- Periodic training to ensure effective response

8.2. Identification of Hazards or Potential Hazardous Areas

Following are the some hazards or emergencies which can occur at project site

- Construction accidents
- Hazardous material leakage or spills
- Road or traffic accidents
- Structure collapse or failure
- Fire
- Bomb threats
- Environmental pollution
- Loss of life
- Community accidents
- Natural calamities like floods, landslides or earthquake

8.3. Communities and Individuals that may be Impacted

Most commonly affected persons due to the hazards and emergencies identifies will be the workforce at the project site. In case of large scale hazards like floods, landslides, etc. surrounding communities near project site could be impacted.

8.4. Response procedures

An emergency can be reported from any source: a worker on site, an outside agency, or the public. Circumstances may change during the course of an emergency. The developed procedures must be able to respond to the ongoing situation. The following list covers basic actions to take in an emergency.

These steps apply to almost any emergency and should be followed in sequence.

- Stay calm
- Assess the situation
- Take command
- Provide protection
- Aid and manage
- Maintain contacts
- Guide emergency services

8.5. Communication of the Procedure

To be effective, an Emergency Response Procedure must be clearly communicated to all site personnel. The following activities should be considered:

- Review the procedure with new site subcontractors and new workers to ensure that it covers their activities adequately.
- Review the procedure with suppliers to ensure that it covers any hazards that the storage or delivery of their materials might create.
- Review new work areas in operating plants to ensure that new hazards are identified and covered in the procedure.
- Post the procedure in a conspicuous location.

8.6. Provision of Equipment and Resources

Emergency equipment and resources must be available at the project site to deal with the emergencies appropriately. Following resources must be provided

- Early warning system
- Firefighting equipment
- First aid kits
- ambulance
- Communication systems
- Four wheel drive, van or loader
- Emergency Power sources
- Emergency access routes

8.7. Designation of Responsibilities

An emergency response team must be designated to assist in emergency situation at the project site. This team will comprise of following key members.

- Emergency coordinator
- Site safety supervisor
- Security team
- Rescue and medical team
- General administration team
- Environment team
- Department heads
- Other staff and employs

Roles and responsibilities of these personnel will be herein:

8.7.1. Emergency Coordinator

- Serve as primary contact person responsible for coordination of all emergency actions.
- Emergency coordinator will support and advise the site safety supervision.
- Serve as public relation spoke person and delegate responsibilities to staff members.
- Assist on-site personnel in making timely and accurate decisions regarding warnings and evacuation.
- Facilitate exercise of the emergency preparedness and response plan to ensure its effectiveness and review and update the plan.

8.7.2. Site Safety Supervisor

- Overall responsibility for activating emergency plan and for terminating emergency actions.
- Disseminates warnings and information as required to ensure all people in the immediate area have been warned and evacuated either by alarms or by word of mouth.
- Supervise the actions of the Emergency Response Team to ensure all persons are safe from the danger.
- Notify outside authorities if assistance required.
- Ensure resources available to purchase needed emergency response equipment and supplies.
- Assures that all persons on the Emergency Response Team aware and fully understand their individual responsibilities for implementing and supporting the emergency plan.
- Establish the emergency drill schedule of all identified emergency scenarios, track the status and evaluate the emergency.
- The Emergency supervisor shall ensure that senior management personnel have been reported of the emergency as soon as practical after the event.

8.7.3. Security Team

- Ensure that the exit route is regularly tested and maintained in good working order.
- Maintain station at the security gate to secure the area during any emergency such that only authorized personnel and equipment may enter and prevent access to the site of unauthorized personnel.
- Assist with activation of services during an emergency.
- Ensure vehicles and obstructions are moved to give incoming emergency vehicles access to the emergency scene.

8.7.4. Rescue and Medical Team

- Protect the injured from further danger.
- Provide treatment to the victims to the best of their ability by first aid and then transfer to hospital.
- Be familiar with the rescue activities and rescue apparatus.
- Assist outside medical services personnel when they arrive

8.7.5. General Administration Team

- Respond to support any requested general facilities to assist Emergency Response Team in their work.

8.7.6. Environment Team

- In case of emergency related to the environmental pollution such as the chemical spill, oil spill into the ambient, the environment team will support the emergency response team to control and mitigate the pollution until it return to the normal situation.

8.7.7. Department Heads

- Call personnel into the safe location for life and property protection.
- Take immediate and appropriate action while Emergency Response Team is being mobilized.
- Provide and maintain emergency equipment of their responsible areas.

8.7.8. Other Staff and Employee

- All other staff and employees will remain at their workstations or assembly point unless directed otherwise from Emergency Response Team.
- Each supervisor will ensure that all members of his work group are accounted for and keep in touch with each of their Department Head.

8.7.9. Periodic Training to Ensure Effective Response

Periodic training and exercises are necessary to educate the personnel and thoroughly familiarize them with the emergency preparedness and response procedures and their individual roles and responsibilities. Exercises can include:

- Orientations
- Phone Drills
- Table Top Exercises
- Functional Exercises

CHAPTER - 9

STAKEHOLDER ENGAGEMENT

CHAPTER-9

STAKEHOLDER ENGAGEMENT

9.1. Introduction

Extensive consultations were carried out at an early stage during September and November 2017 primarily through community consultations and stakeholder meetings. Community consultations involved household level interviews/survey, community meetings and focus group discussions. This step is done to improve project design, planning and implementation and ensuring that the project is both environmentally and socially viable. The consultation process was carried out according to requirements of IFC and KPK Environmental Protection Agency. Objectives of consultation process are to:

- Disseminate the information about project to the community and all other stakeholders
- Analyze the local people's issues at an early stage and give consideration to resolve or mitigate the issues
- Encourage and promote participation of local community, different government stakeholders and elected representatives of local area to play their part, express their views and acquire suggestions to mitigate any anticipated impacts
- Socially prepare the community with confidence and capacity to deal with displacement, environmental and resettlement management.

9.2. Identification of Stakeholders

The crucial part of the stakeholder consultation process is identification of stakeholders who are generally categorized as:

- Primary stakeholders
- Secondary stakeholders

9.2.1. Primary Stakeholders

Primary stakeholders are the ones who face direct impact of the project such as affected persons, local community and others residing in the area.

9.2.2. Secondary Stakeholders

The secondary stakeholders are the representatives of Government Departments/Agencies involved in the planning, design, implementation and operation of the project, including various government departments such as District Administration, Revenue Department, Agriculture, Irrigation, Forest, Fisheries, Wildlife Education and other relevant departments.

9.3. Stakeholder Consultation Process

Stakeholder consultation was carried out at an early stage during scoping through meetings with local people, groups, relevant departments and organization which are linked with project. Both primary and secondary stakeholders were consulted and briefed about the project. Besides collecting quantitative data from social survey from the project area, consultation conducted with local community to inform about the project and how it may affect their lives/activities, and to record their concerns, whether real or perceived. A list of local people interviewed and photographs of consultation is given in **Annexure E.8.**

The following secondary stakeholders were consulted on different occasions to seek their inputs, feedback and opinion on the design and scope of the project. The offices and Individuals who were consulted are:

- Wildlife Division, Chitral
- Forest Department, Chitral
- Education Department, Chitral
- Health Department, Chitral
- Revenue Department, Chitral

During consultation community in the project area informed about:

i) The purpose, nature and scale of the project
ii) The duration of the proposed activities
iii) Any risk to and potential impacts on such communities and relevant mitigation measures
iv) The envisaged stakeholder engagement process
v) The grievance mechanism

Through the use of various tools (such as group discussion, in depth interview, dialogue and scenario building) the study team tried to involve the stakeholders in active decision-making.

9.4. Outcomes of the Consultations

- People have no serious concerns regarding project since they are well aware of the project outcomes due the development of Golen Gol HPP in the area.
- There is need of infrastructure development in the area like hospital, postal/courier service, transport etc.
- There should be employment opportunity for the local people in both skilled and unskilled employments as majority of population are daily wage earner working as labor.
- There is a need to upgrade the unpaved road along with its enlargement to access the site easily and to ease the community to travel.
- Electricity is needed in the project area to improve living.
- All actions associated with the project should be taken through proper consultations.

- Chances of some environmental effects like noise/ vibration and dust emissions to the nearby community.
- Vocational training needs to be provided to the community so they can support their families by supplementing the household income.
- No resettlement issues are associated with the project as no house, shop or any type of infrastructure is in the project site.
- No major effects are identified on crops or agricultural land because project's components have to construct on wasteland.
- People are willing to sell their land to project on cash compensation at market price.
- Overall project will have positive impacts on local community and their livelihood.

Due to mountainous character of the region, suitable land areas are rare and all land in project area is communal or private land which cannot fulfill the compensation requirements. So compensation in form of cash will be a favorable option for this project than in the form of land.

Both primary and secondary stakeholders supported the Turtonas-Uzghor Hydro Electric Project provided that environmental and social concerns are addressed through mitigation measures. Environmental and Social Management Plan is prepared to address the issues and mitigation measures are suggested to resolve the concerns.

CHAPTER - 10

GRIEVANCE REDRESS MECHANISM

CHAPTER-10

GRIEVANCE REDRESS MECHANISM

10.1. Introduction

People adversely affected (or about to be affected) by a development project will raise theirgrievances and dissatisfactions about actual or perceived impacts in order to find a satisfactorysolution. These grievances, influenced by their physical and/orsocial losses, can surface at different stages of the project cycle. Some grievances may ariseduring the project design and planning stage, while others may come up during project implementation. Not only should affected persons (APs) be able to raise their grievances and begiven an adequate hearing, but also satisfactory solutions should be found that mutually benefit both the APs and the project. It is equally important that APs have access to legitimate, reliable, transparent, and efficient institutional mechanisms that are responsive to their complaints.

Grievance Redress mechanisms (GRMs) are institutions, instruments, methods and processes by which a resolution to a grievance is sought and provided. A number of mechanisms areavailable to aggrieved parties to access redress. They can be complex and diverse. They may include institutions specific (internal) to a project and set up from its inception or others that have emerged over time in response to needs identified while the project evolved. Other institutions may be already established within a country's judicial, administrative, and/or political systems and exist outside a project. They include the government bureaucracy; judicial institutions; and political institutions such as Parliament, parliamentary select committees, and provincial councils. In addition, if a project is funded through external sources, the aid agency itself sometimes provides a forum for grievance redress. GRMs can include avenues for resolving conflicts between APs or other stakeholders, and can provide information sought by the public on the project.

Grievance Redress mechanism will be established to allow affected persons or communities appealing against any decision or activity arising out of survey, data collection, environmental and social impacts and land acquisition related grievances. Affected persons or communities will be fully informed of their rights and procedures for addressing complaints under grievance redress mechanism before project construction. Timely and effective grievance redress brings sustainability in the operation of the project.

10.2. External Communication

IFC requires that clients will implement and maintain a procedure for external communications that includes methods to

(i) receive and register external communications from the public;
(ii) screen and assess the issues raised and determine how to address them;
(iii) provide, track, and document responses, if any; and
(iv) Adjustthe management program.

In addition, clients are encouraged to make publicly available periodic reports on their environmental and social sustainability.

The project will establish;

- Public Complaint Unit (PCU) to receive, log and resolve complaints
- Grievance redress committee: The scope or mandate of GRC is to resolve any grievance or dispute issues related to policy and measures under ESMP. In addition affected people will be allowed to lodge any complaints against unanticipated impacts during project construction.
- Representatives of affected villages or Grievance focal points (GFPs), who will be the literate persons from affected persons and will help APs in drafting the grievances against the project.

10.2.1. Function and Structure of PCU

Project Management Unit (PMU) will establish a PCU to receive, lodge, screen and resolve the complaints at the community level. During the construction period when the issues are mainly expected to arise, two assistants, one male and one female will be responsible for coordinating correspondence and preparing documentation work and will assist the senior official.

10.2.2. Function and Structure of GRC

The GRC will function as an independent body that will regulate PCU and the grievance redress process. It will compose of:

- Project manager
- Manager of environment, social, health and safety
- Representatives of local government (District Collector, Assistant Commissioner)
- Representatives from the affected persons or communities

All GRC members will attend a training and orientation meeting prior to commencement of their work. The training should be provided by competent technical experts in social/resettlement and environmental management. The training will address the policy aspects, compliance requirements, expectations of the community, and need for rapport and communication with the affected communities, and finally need for independence and transparent views in dealing with grievances.

10.2.3. Grievance Focal Points

The GFPs will be literate people from each community that will facilitate their community members in reporting grievances from the Project. The GFPs will be provided training by the Project in facilitating grievance redress.

10.2.4. Grievance Redress Process

Grievance Redress Process explains the processes involve in GRC for example filling of complaints/ cases, review and hearing, records and documentation and notification of outcomes. Figure 1 represents a complete grievance redress process.

10.2.4.1. Filing and Lodging Complaints

For social/resettlement as well as environmental safeguards, the affected persons and/or communities will be able to file their grievances without any fear and intimidation. Where required, the GFPs will assist the APsin drafting the grievances.

All grievances will be recorded and lodged into project grievance database and comprises of following information

- Name and contact detail
- Detail of grievance and how and when it was submitted, acknowledged, responded to and closed out.

All grievances will be acknowledged within 2 working days.

10.2.4.2. Investigation or Screening for Standing

PCU will then investigate and screen the causes of grievance whether the complaint has standing or not. If the grievance has standing, then inform the grievant in writing within 5 working days and defines the solution through PCU resolution within one week. In case of invalid complaint, document the reason for invalidity in the grievance database and inform the complainant in one week.

10.2.4.3. Resolution through PCU

Once grievance categorized as standing, PCU will share the proposed course of action to resolve the complaint with the grievant. The PCU will

- Identify the parties involved
- Clarify the issues and concerns raised by the grievance through direct dialogue
- Classify the grievances in term of seriousness and appoint the staff to resolve it.
- Provide opportunity to the stakeholders to revert with their comments on the proposed plan of action;
- Keep the stakeholder informed of the progress in grievance resolution;
- Maintain confidentiality of the stakeholder, if requested so.

If the complainant considers the grievance has been satisfactory resolved, the PCU log the complaint as decision. In case the grievance remains unresolved, it is reassessed, and the PCU further discuss with the grievant to arrive at a mutually agreed resolution to the problem or grievance. If the PAP will not be satisfied with the solution then grievance will be deferred to Grievance redress committee.

10.2.4.4. Resolution through GRC

In case the PCU is unable to resolve the issue, the matter will be referred to GRC. All complaints that could not be resolved within four weeks will by default be referred to GRC.However, the complainant or the PCU can convene the GRC at any point in time, depending onthe nature and urgency of the issue.

For each complaint, the GRC will determine whether additional investigations are warranted. Ifso, the additional information will be collected before the GRC meeting with the PAPcomplainant and will be provided to the PAP before the meeting. The GRC will then inform thePAP about the date, time and place of its review meeting, and invites the PAP accordingly.

If the stakeholder or PAPs are still not satisfied with the GRC solution then they can further pursue to the local judicial proceedings.

10.2.4.5. Reporting to Communities

Affected communities and all other stakeholders will be informed about the PCU and GRC establishment through various awareness campaigns or methods. They will be inform of whole procedures of PCU and GRC functioning, responsibilities, accessibilities and registering and following a complaint.

The GR process will be documented, monitored and evaluated at regular time interval by the client and project manager to determine the quality of process and outcome of cases.

10.3. Internal Communication

IFC requires that clients will implement and maintain a procedure for internal communications that includes methods to

(v) receive and register internalcomplaints from the workers/labour
(vi) screen and assess the issues raised and determine how to address them;
(vii) provide, track, and document responses, if any; and
(viii) Adjustthe management program.

For the internal communication the project will establish;

- Project level Unit (PLU) to receive, log and resolve complaints of workers
- Project Level Grievance redress committee
- Labor union to help communicate between labor force and GRC

10.3.1. Grievance Redress Process for Workers

Grievance Redress Process for workers will also work in the same manner as described earlier for communities. The processes involve in GRCare filling of complaints/ cases, review and hearing, records and documentation and notification of outcomes.

10.3.1.1. Filing and Lodging Complaints

Workers will be able to file their grievances without any fear and intimidation through labor union. All grievances will be recorded and lodged into project grievance database and comprises of following information

- Name and contact detail
- Detail of grievance and how and when it was submitted, acknowledged, responded to and closed out.

10.3.1.2. Investigation or Screening for Standing

PLU will then investigate and screen the causes of grievance whether the complaint has standing or not. If the grievance has standing, then inform the grievant in writing within 2 working days and defines the solution through PLU resolution within one week. In case of invalid complaint, document the reason for invalidity in the grievance database and inform the complainant in one week.

10.3.1.3. Resolution through PLU

Once grievance categorized as standing, PLU will share the proposed course of action to resolve the complaint with the grievant.

If the affected worker considers the grievance has been satisfactory resolved, the PLU log the complaint as decision. In case the grievance remains unresolved, it is reassessed, and the PLU further discuss with the grievant to arrive at a mutually agreed resolution to the problem or grievance. If the worker will not be satisfied with the solution then grievance will be deferred to Grievance redress committee.

10.3.1.4. Resolution through Project level GRC

In case the PLU is unable to resolve the issue, the matter will be referred to GRC. All complaints that could not be resolved within2 weeks will by default be referred to GRC.However, the complainant or the PLU can convene the GRC at any point in time, depending onthe nature and urgency of the issue.If the workers or labor union are still not satisfied with the GRC solution then they can further pursue to the local judicial proceedings.

10.3.1.5. Reporting to Workers/ Labor union

Workers will be informed about the PLU and GRC establishment through various project manager, Construction contractor and labor union. They will be inform of whole procedures of PLU and GRC functioning, responsibilities, accessibilities and registering and following a complaint. The GR process will be documented, monitored and evaluated at regular time interval by the client and project manager to determine the quality of process and outcome of cases.

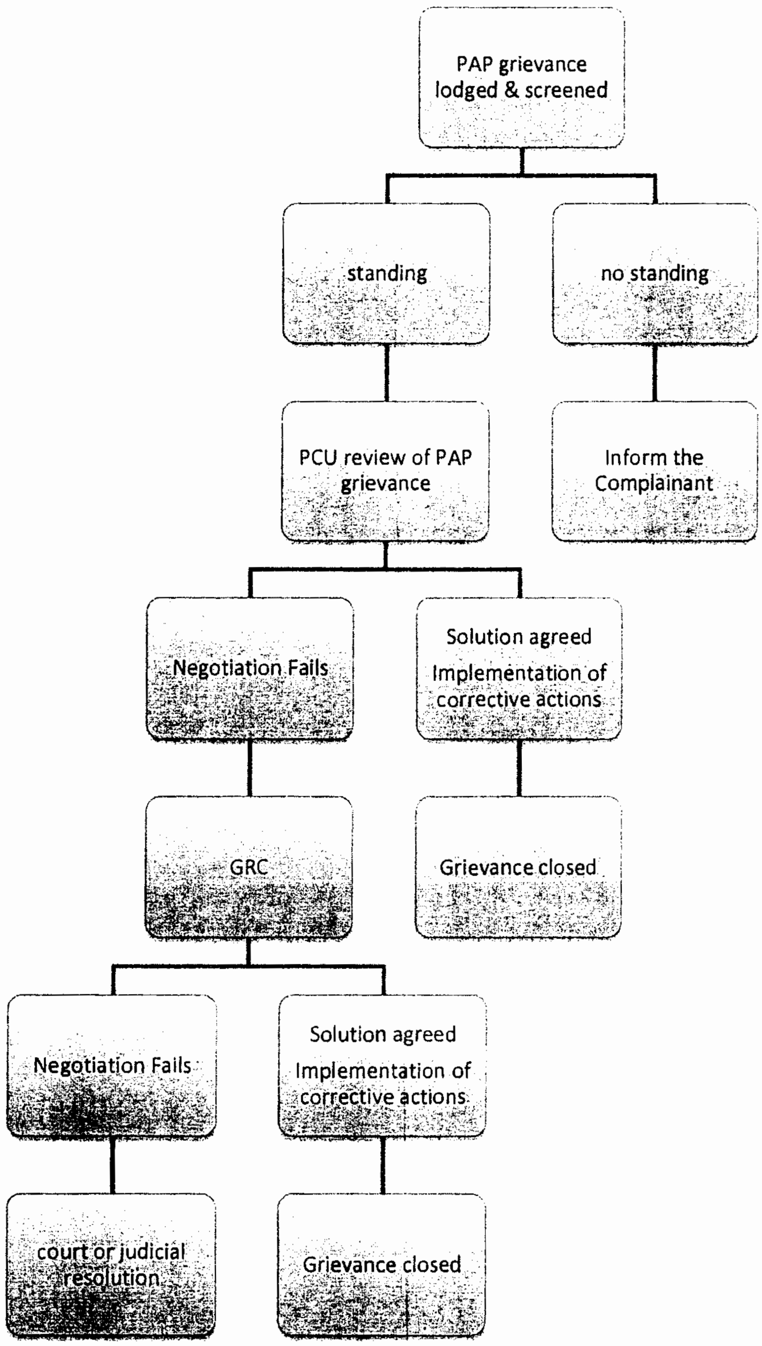


Fig E.10.1: Grievance Redress Process

CHAPTER - 11

MONITORING AND REVIEW

CHAPTER-11

MONITORING AND REVIEW

11.1 Monitoring Plan

The monitoring program has a dual purpose. It is designed

(i) to monitor the contractor's work during project implementation in order to check contractual compliance with specified mitigation measures, and subsequently

(ii) To monitor and assess the changes in environmental and social parameters of the project over the years following completion of the various project components.

Monitoring will be carried out by the construction consultants as described earlier in management programs and by the external organization or consultants having necessary experience in relevant field. Monitoring indicators and frequency are shown in **Table E11.1**.

11.2 Capacity Building and Training

The purpose of capacity building is to strengthen the project management unit in the field of environmental and social management. The members of TU designated for supervision of social and environmental mitigation measures will be trained in environmental management, environmental quality control, ecology, environmental awareness, occupational health and safety, participatory approach and social development. The contractor also trained its personnel to relevant training program or hire only trained personnel.

11.3 Site Inspection

Site inspection will be carried out regularly in the project area to check the compliance of ESMP. This will also create and increase awareness about ESMP among workers. In case of minor conformance, discussion with the staff to comply with relevant standards and guidelines will carried out and outcomes will be recorded as finding in the inspection report. But major non-conformance will be reported as incidents and results will be disclosed at management meetings.

11.4 Audits

Formal audits will be undertaken at planned intervals in accordance with the requirements of client and regulatory authorities. Internal environmental audits will be held with an objective to review the effectiveness of environmental and social management of the project. External audits on implementation of the ESMP will be carried out by a specialist consulting firm. These audits would be used to re-examine the continued appropriateness of the ESMP and to provide suggestion on any updates required. Usually environmental regulatory authorities require a quarterly audit report for large scale projects.

11.5 Corrective and Preventive Actions

Corrective and preventive actions will be identified and implemented in response to the non-conformances to relevant plans, guidelines and standards identified in the inspection and audits. These actions will address the root cause of the non-conformance and will reduce or prevent further and repeated non conformances.

Environmental Monitoring during construction will ensure the protection of air, soil and water pollution, community safety, wildlife and ecological resources preservation and cultural conflicts etc. During operational phase, air emissions, water, soil, noise, plantation would be the important parameters of monitoring programs.

11.6 Annual Review of ESMP

CSC under the supervision of PMU will carry out annual review of the appropriateness and adequacy of the ESMP in the light of its own monitoring and supervision as well as on the basis of the third party monitoring and audits discussed earlier. CSC will revise the ESMP in case of substantial shortcomings which are identified in these plans.

11.7 Documentation and Reporting

The information generated through monitoring and management programs will be documented, disseminated and responded in accordance with specific document management programs. Client will supervised, implement and maintain the procedures. They are also necessary rendering the environmental management system auditable with primary focus on pragmatic control of impacts.

Documentation and record keeping management must include;

- Relevant document and records with proper labeling, dated and protected from any damage
- Reviewing of documents by authorized experts at least annually
- Availability of relevant documents at operational sites for effective functioning
- Establishment of electron document version
- identification and segregation of confidential and privileged information

CSC will also prepare monthly, quarterly reports covering compliance, monitoring findings, capacity building and corrective and preventive actions.

Table E11.1: Monitoring Plan				
Parameters	**Means of Monitoring**	**Frequency**	**Responsible Agency**	
			Implementation	**Supervision**
During Construction				
Landslide	Visual Inspection on stability of landslide areas	Monthly	Contractor	CSC, EU
Erosion	Visual Inspection of erosion prevention measures and occurrence of measures	Monthly	Contractor	CSC, EU
Operation of quarry sites	visual inspection of quarry sites	Monthly	Contractor	CSC, EU
Surface water quality	Sampling and analysis of river water quality and waste water discharges for the parameters given in NEQS and IFC guidelines	Monthly & Annually	Contractor & External monitor	CSC, EU
Air Quality	Visual inspection to ensure the equipment quality and dust suppression	Weekly	Contractor	CSC, EU
	Measurements of CO_2 and oxygen in tunnel as defined in IFC guidelines and NEQs	Monthly	CSC	EU
Air Quality (Particulate matter (PM 2.5 &10),SO_2, NO, NO_2, CO)	Air quality monitoring for 24 hours for the parameters specified in NEQS (at/near construction sites, camp sites, offices, colony, communities, quarry area, transportation routes)	Quarterly, annually	Contractor, External Monitor	CSC, EU
Noise	24 hour noise monitoring (at/near constructionsites, camp sites, offices, colony,communities, quarry area, transportation routes)	Quarterly	Contractor	CSC, EU
During Operation				
Soil erosion and degradation	Visual inspection to ensure the plantation is growing well	Monthly, yearly	EU through District Forest Office	EU, External monitor
Fish	Surveys for fish (in theriver upstream and downstream of reservoir, weir) Monthly data on fish catchment	Half yearly, Monthly	EU through a external monitor	EU

11.8 Cost Estimates

For the implementation of SEIA and ESMP, it is proposed to hire implementation and monitoring specialist who will monitor the EPC contractor and CSC. The estimated cost of EMP implementation for project is given in Table E11.2.

Table E11.2- Estimated Cost of ESMP Implementation

No.	Description of Expense	Unit	Quantity	Avg. Rate (Rs.)	Total Amount	
					(Rs.)	(US$)
1	Environment and social Specialist (2)	Man-Months	48	500,000.00	48,000,000.00	388,000.00
2	Environment and social Monitoring Evaluation (3)	Man-Months	48	360,000.00	51,840,000.00	419,000.00
3	Environment Management & Implementation	Man-Months	48	450,000.00	21,600,000.00	174,000.00
Sub-Total Environmental Expertise:					**121,440,000.00**	**982,000.00**
4	Contingencies (10%)				12,144,000.00	98,200.00
	TOTAL ESTIMATED COSTS				**133,584,000.00**	**1,076,623.00**

Exchange Rate: US $ 1.00 =Rs. 123.60

Land Acquisition Cost

A total of 66.5 Acres (532 kanals) land has to acquire (for temporary and permanent land use) at different locations for various purposes. This land has been categorized as A, B, and C. The category A land include agricultural land, category B is covered with vegetation, bushes and few trees and category C is barren land. Land leasing/rental cost of temporary land use of 110.4 Kanals (1 hactare is equal to 19.77 Kanals) for dumping excavated material is also estimated. Table E11.3 is prepared to estimate land acquisition cost. The land rate are obtained from the revenue department of Chitral.

Table E11.3- Land Acquisition Cost ofTurtonasUzghorHPP

No.	Location	Type of Land	Total Unit (Kanal)	Unit Cost (Rs. Per Kanal)	Total Cost (Rs.)
1	Staff Colony and camp area	Category A	9.04	550,000.00	4,972,000.00
		Category B	8.136	550,000.00	4,474,800.00
		Category C	73.224	550,000.00	40,273,200.00
2	Area for weir, sand trap, and connecting canals	Category C	126.4	550,000.00	69,520,000.00
3	Power House Area	Category C	81.6	550,000.00	44,880,000.00
4	Area along the road	Category C	117.6	550,000.00	64,680,000.00
5	land for Reservoir	Category C	5.6	550,000.00	3,080,000.00
6	Proposed 4 year lease of Land for dumping excavated Material	Category C	110.4	12000/kanal/year	5,299,200.00
7	15% Compulsory Land Acquisition Surcharge on private land			15%	35,576,880.00
TOTAL			**532**		**272,756,080.00**

Total Environmental Cost

Project mitigation measures and costing for the project are indicated in Table E11.4 proposed mitigation cost.

Table-E11.4 Total Proposed Mitigation Costs

No.	Mitigation Measure	Total (Rs)	Total $US
1	Environment Management and Social Expertise	133,070,602.00	1,076,623.00
2	Land Acquisition Cost	272,756,080.00	2,206,764.00
3	**Total Estimated Costs**	**405,826,632.90**	**3,283,387.00**

Exchange Rate: US $ 1.00 =Rs. 123.60

CHAPTER – 12

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER-12

CONCLUSIONS AND RECOMMENDATIONS

12.1 Introduction

The Environmental and Social Impact Assessment (ESIA) study has been conducted in line with Pakistan Environmental Protection Act 1997 as well as the relevant guidelines of International Finance Company (IFC), Asian Development Bank (ADB), and World Bank (WB). The objective of the study is to identify and assess the potential environmental and social impacts of the Turtonas-Uzghor Hydro Electric power Project. The Report also includes Public Consultation with the communities in the project area in order to apprise them of the project activities and to obtain their views and concerns. This Chapter presents the conclusions/ key findings and recommendations for further actions.

12.2 Conclusions

The major conclusions of the ESIA are;

- During the Project implementation, environmental and social impacts are experienced primarily during the construction phase. The operation phase will have mostly insignificant impacts on the social, physical and biological environment of the area. This has been confirmed during field surveys for the environmental and social assessment as part of this report.
- The potential impacts during the construction phase of the project include land acquisition (resulting in loss of land and trees), soil erosion, water pollution, effect on ambient air quality caused by vehicle exhaust and kicked-up dust, noise pollution, safety hazards and public health concerns for the nearby communities.
- The key environmental issues during the operation phase of the project include downstream flow variations, waste disposal, safety hazards for the plant staff.
- All the recommended mitigation measures are contained in the Environmental and Social Management and Monitoring Plan (ESMMP), which will need to be made part of the EPC Contract. The plan provides for the requisite structure of the organization during the project implementation, defining roles and responsibilities of key players. The plan defines the mitigation actions, and monitoring agencies.
- There are no resettlements issues involve during the implementation of the Project.
- The proposed mitigation measures adequately address all the concerns raised by the stakeholders.
- The project is unlikely to cause any significant, lasting impact on the social, physical and biological environment of the area.
- The overall findings of the environmental impact assessment and resettlement plan shows that the project is environmentally and socially viable provided that the proposed activities are carried out as mentioned in this report, and the mitigation measures are completely and effectively implemented.

12.3 Recommendations

On the basis of the environmental and social impact assessment and the conclusions as discussed above it is recommended that:

- The Environmental and Social Management Plan should be made a part of the EPC Contract awarded by the Company for implementation of the project.
- The Company should ensure adherence to the environmental legislation and regulations.

Company and its contractor(s) should employ local labour as for as possible.