ARTISTIC HYDRO II (PVT) LTD.

Registered office : Plot 3/A, M.A.C.H.S Shahrah-e-Faisal, Karachi-75350 Pakistan
Phone : 92-21-38704711-14 Fax : 92-21-34321940 Email :energy@artisticmilliners.com

7005-L-AH2-NEPRA-00020A

January 18, 2021

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

Subject: **Application for a Generation License for 55.032 MW Hydro Power Plant to be located at Ushu River, Kalam in District Swat, Province of Khyber Pakhtunkhwa**

Dear Sir,

I, Rafique Khanani, CFO/Company Secretary, being the duly authorized representative of Artistic Hydro II (Pvt) Ltd. by virtue of board resolution dated November 20, 2020, hereby apply to the National Electric Power Regulatory Authority for the grant of a Generation License to Artistic Hydro II (Pvt) Ltd 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 Electric 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 Cheque No. 13098908 dated 03 December 2020 of Bank AL Habib Limited amounting to PKR 429,971/- (Pakistani Rupees Four Hundred Twenty Nine Thousand Nine Hundred Seventy One Only) (net of WHT 8%), being the nonrefundable license application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations 1999 is also attached herewith.

Yours faithfully,

For and on behalf of **Artistic Hydro II (Private) Limited**

Rafique Khanani
CFO/Company Secretary

ARTISTIC HYDRO II (PVT) LTD.

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Extract of resolutions passed unanimously by the board of directors of Artistic Hydro II (Private) Limited on November 20, 2020.

"RESOLVED THAT Artistic Hydro II (Pvt.) Ltd, a company incorporated under the laws of Pakistan with registration number 0126604 and having its registered office located at Plot 3/A, M.A.C.H.S., Main Shahra e Faisal, Gulshan Town, Karachi, (the **"Company"**) be and is hereby authorized to file Generation License Application (including any modification) for submission to the National Electric Power Regulatory Authority (**"NEPRA"**) in respect of its 55.032 MW Hydro Power Project to be located at River Ushu in Kalm, District Swat, Province of Khyber Pakhtunkhwa, Pakistan (the **"Project"**) and in relation thereto, enter into and execute all required documents, make all filings and pay all applicable fees, in each case, of any nature whatsoever, as required."

"**FURTHER RESOLVED THAT** in respect of filing a Generation License Application (including any modification) for submission to NEPRA, Mr. Rafique Khanani, CFO/Company Secretary be and is hereby empowered and authorized for and on behalf of the Company to:

(i) review, execute, submit, and deliver the Generation License Application (including any modification) and any related documentation required by NEPRA including but not limited to filing, signing, presenting, modifying, amending or withdrawing the application and other documents, and responding to any queries of any nature whatsoever in respect thereof;

(ii) represent the Company in all negotiations, representations, presentations, hearings, proceedings, 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) appoint or nominate any one or more officers of the Company or any other person or persons, singly or jointly, in his sole and absolute discretion to communicate with, make presentations to and attend NEPRA hearings and to appear before NEPRA or any other relevant regulatory or governmental authority in any proceedings, hearings or representations pertaining to the Company or the Project;

(iv) do all such acts, matters and things as may be necessary for carrying out the aforesaid purposes and to give full effect to each of the matters approved in the above resolutions."

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"**AND FURTHER RESOLVED THAT** Mr. Rafique Khanani, CFO/Company Secretary of the company, be and is hereby authorized to delegate all or any of the above powers in respect of the forgoing to any other officials of the Company he may deem appropriate.

Rafique Khanani
CFO/Company Secretary

IN WITNESS THEREOF, I hereunder set my hands as such Director and affixed the corporate seal of said company.

Yaqoob Ahmed
Director

T142278

100
Rupees

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روپیہ

MOHAMMAD UMER STAMP VENDOR
Lic # 14, Shop # 114, New Ruby Centre,
Talpur Road, Boulton S.No..............
Market Karachi Date..............
Issue to with Address..GHULAM HABIB (Advocate)..
Through with Address........KBA No: 63..........
Purpose..
Value Rs........100.....Attached...................
Stamp Vendor's Signature..........................
(NOT USE FOR FREE WILL & OWN PURPOSE)
Vendor Not Responsible for Fake Documents

84877

15 JAN 2021

(RUPEES ONE HUNDRED ONLY)

BEFORE THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY

AFFIDAVIT

AFFIDAVIT of Muhammad Rafique, CFO/Company Secretary of M/s Artistic Hydro II (Pvt.) Ltd, a company registered under the laws of Pakistan with registration number 0126604 and having its registered address at Plot 3/A, M.A.C.H.S., Main Shahra e Faisal, Gulshan Town, Karachi.

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

1. I am the authorized representative of M/s Artistic Hydro II (Pvt.) Ltd., having age of 60 years and holding CNIC no. 42101-1625029-7.

2. The contents of the accompanying Application for Generation License dated January 18, 2021 of the Company's 55.032 MW Hydro Power Plant at Ushu River, Kalam, District Swat, Khyber Pakhtunkhwa, Pakistan, including all 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 there from.

3. I also affirm that all further documentation and information to be provided by me in connection with the aforesaid Generation License Application shall be true and correct to the best of my knowledge and belief.

....
Deponent

VERIFICATION

It is hereby verified on solemn affirmation at Karachi, Pakistan on this 18th day of January 2021 that the contents of the above Affidavit are true and correct to the best of my knowledge and belief and that nothing material or relevant thereto has been concealed or withheld there from.

....
Deponent

BACKGROUND TO GENERATION LICENSE APPLICATION

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

a. Issuance of "Letter of Intent"

ARTISTIC HYDRO-II (PRIVATE) LIMITED (a company duly organized and existing under the laws of Pakistan, with its office located at Plot No. 3-A M.A.C.H.S Main Shahra e Faisal Karachi, Pakistan (the **Project Company**), was issued a LETTER OF INTENT by Pakhtunkhwa Energy Development Organization (PEDO), Govt. of Khyber Pakhtunkhwa (GOKP) on August 03, 2018 vide its letter No; 1871-79/PEDO/DRE/AM/LOI (the **LOI**) to develop an approximately 43.35 MW (now 55.032 MW) hydropower project to be located at Ushu River, Kalam, District Swat **(Project)**.

b. Submission of the Feasibility Study

Pursuant to the relevant provisions of the KP Hydropower Policy 2016 and the LOI, the Project Company completed the detailed technical feasibility study for the Project and the Project Company submitted the same to PEDO, GOKP on June 22, 2020. A copy of Project Feasibility Study is attached hereto as ANNEXURE 07 for NEPRA's perusal.

c. Submission of Environmental Impact Assessment

The Project Company hired consultants, Joint Venture of BAK Consulting Engineers Pakistan & DOLSAR Engineering inc.co. Turkey, who completed the Environmental Impact Assessment (EIA) for the Project (the **Environmental Impact Assessment Report**) and the Project Company submitted the same to the KP Environmental Protection Agency (the **KP EPA**) on October 04, 2019. The project company submitted the revised EIA report on February 27, 2020

d. Grid Interconnection Studies

Discussions and study has been made regarding switchyards and grid stations in nearby area for power evacuation. The possible option is to evacuate power of 55.032 MW of Artistic II HPP to the 84 MW Gorkin Matiltan HPP Switchyard located downstream.

The transmission line 8 km long is recommended to be of cross section area 516.86 mm^2 "Rail" Aluminum conductor steel reinforced (ACSR), at 132 KV Double Circuit to evacuate power of 55.032 MW from Artistic-II HPP to Gorkin Matiltan HPP Switchyard.

Grid Interconnection Study is approved by PESCO on Nov 02, 2020 and attached as Annexure 09.

e. Location of Project & Lease of Land

The Artistic-II Hydropower project is a run-of-the river project to be constructed on Ushu River in district Swat of Northern areas of Khyber Pakhtunkhwa province. The weir site is located 7 km upstream of diversion weir of 84 MW Matiltan HPP which is under construction at present and about 10 km downstream of Mahudand Lake tourist resort. The powerhouse of the project is located about 240 m upstream of diversion weir of 84 MW Matiltan HPP. The project site is accessible through jeepable Kalam-Mahudand road which at present is unpaved. Project coordinates are given below.

Location	Northing	Easting	Operating Water Level
Weir / Intake	35°37'49.79"	72°41'03.38"	2505 masl
Power House	35°34'15.89"	72°40'19.28"	2305 masl

The catchment of the Artistic-II HPP lies in the upper region of the Ushu River, a tributary / sub system of a Swat river basin and can be classified as a "high mountain catchment" in which there are several glaciers up to the power house site and a Bisni Nullah just downstream of the proposed Powerhouse location. Snowmelt is the principal source of water in the river. The highest mountain Peak of Ushu River reaches up to 5,917amsl and mean elevation is about 4,500 amsl while river bed elevation at weir site is 2,499 amsl and river bed elevation at Powerhouse site is at approximately 2,302 amsl. The Ushu River (left tributary) and the Gabral River (right tributary) joins at Kalam and forms the Swat River. The basin elevation gradually decreases from 4,500 amsl to 910 amsl below Kalam and the valley becomes broader up to Chakdara town. Length of the Ushu River up to the weir site is about 25 km. Average river bed slope ranges from 0.02 to 0.03. Catchment area of the Ushu River at weir location is estimated to be 454 sq.km and at powerhouse location is approximately 600 sq.km.

Land shall be acquired through Government of KPK once the project is approved. The detail of land to be acquired for the project is given in EIA report (Table 9-7 and Annexure 12)

f. Brief Technical Synopsis of the Project

The Project has an estimated installed capacity of 55.032 MW_e with 1 small (unit-3) and 2 large (unit-1 and unit-2) turbines of the following characteristics.

Unit No	Rated Discharge (m^3/s)	Rated Net Head (m)	Capacity (MW_e)	Capacity (MW[illegible])
Unit-1	14.15	185	22.9	23.9
Unit-2	14.15	185	22.9	23.9
Unit-3	5.70	184.93	9.2	9.6
Total	**34.00**	-	**55**	**57.4**

There shall be a substation of 132 KV, which shall dispatch electricity as per Interconnection Grid Study as approved by PESCO.

g. Tariff

Upon issuance of the Generation License and award of the Feasibility Stage tariff, the Project Company would finalise the EPC Contractor, apply for EPC Stage tariff, execute the Power Purchase Agreement with the Power Purchaser and aims to achieve Financial Close for the Project within 24 months of granting Letter of Support. The expected Commercial Operations Date of the Project is to be 48 month from the Financial Close.

Request for grant of a generation license

Based on the matters provided in Sections a, b, c, d, e, f and g above whereby the Project Company, on its part, has undertaken and completed all activities required for procurement of approvals of the relevant matters from various stakeholders, it is submitted that the requirements of the regulatory process for applying to NEPRA for grant of a generation license to the Project Company are complete.

PROSPECTUS

All stakeholders interested / effected persons and the general public are notified that the authority has admitted the application of Artistic Hydro II (Private) Limited for consideration of grant of generation license to finance, design, engineer, procure, construct, install, test, complete and commission a 55.032 MW hydropower generation facility to be located on Ushu River at Kalam, District Swat, Khyber Pakhtunkhwa. All stakeholders interested/ effected persons and the general public are invited to submit their comments for/or against the grant of license. The comments should be submitted to the registered office of National Electric Power Regulatory Authority within a period of 14 days from the date of this publication.

Brief of prospectus including salient features of Artistic Hydro II (Private) Limited is as under.

Applicant – Artistic Hydro II (Pvt.) Limited

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

The Project Company (following grant of a generation license and approval of the Project Company's reference generation tariff by NEPRA) proposes to design, engineer, construct, insure, commission, operate and maintain the Project constituting of a 55.032 MW power generation facility (the Facility) to be located on Ushu River at Kalam, District Swat, Province of Khyber Pakhtunkhwa, Pakistan (the Site).

Sponsor – Artistic Milliners (Pvt.) Limited

The primary sponsor financing the Project is Artistic Milliners (Private) Limited (which is one of the leading textile sector undertakings of Pakistan having a variety of business divisions e.g., spinning, weaving, denim, garments etc.).

Artistic Milliners group of companies was established in 1949, and is today one of Pakistan's leading business houses and one of the largest premium quality denim cloth and finished products mills in the country. The company is engaged in the manufacturing and trading of denim, garments and fabrics and has the distinct privilege of being one of the few mills that are completely export oriented.

The group has its roots in textile trading and has since expanded to become a complete vertically integrated textile set up with the aim of providing high-end customers with premium quality of denim fabrics and garments.

Today Artistic Milliners has total assets of over PKR 55 billion (US$ 344 million: 2019) with an annual turnover of over PKR 38 billion (US$ 237 million: 2019).

Renewable Power:

- Artistic Milliners has successfully commissioned a 49.3 MW Wind Power Project (Artistic Energy (Private) Limited) in Sindh while other 50 MW Wind Power Project (Artistic Wind Power (Private) Limited) is under construction.

- Artistic Milliners is developing a 50 MW Solar Park called Artistic Solar Energy (Private) Limited with Generation License awarded in April 2020.

- Artistic Milliners is also carrying out feasibility study of 62.606 MW Artistic-I Hydropower Project near Sahibabad.

Environmental Impact

As per the requirements of Section 12 of Pakistan Environmental Protection Act (PEPA), 1997, Project Company has completed the Environmental Impact Assessment (**"EIA"**) report for the Project. Hydropower Project is a green energy Project and, therefore, there is no major long lasting social or environment impact foreseen. The Project is not likely to have any significant adverse environmental impacts, which could be irreversible or could affect sensitive eco-system, requires significant resettlement (except few small houses), or has an unprecedented impact. The Project Area does not fall under any sensitive, protected area. No threatened / Near-Threatened species of wildlife was recorded in the Project Area. There are no significant settlements in the project boundaries. Noise impacts will be less than 75 DB (A) which is within the range as per National Environmental Quality Standards (NEQs) of Pakistan.

Social Impact

The Sponsors of Project Company always regard corporate social responsibility as an important force in building a harmonious society. They also believe in paying full attention to human factors, exercising environmental protections and conservation, increasing employment, and helping build the community. Every year they support numerous educational, sporting, and charity programs designed to help a wide range of people. Operations of the Plant will provide job opportunities especially to the local people. Poverty alleviation, though at minor scale, will be another benefit besides meeting power shortage in Pakistan.

Proposed Investment

The Total Project Cost of US$ 133,846,085 (United States Dollars One Hundred and Thirty-Three Million, Eight Hundred and Forty-Six Thousand, and Eighty Five) is to be financed in a debt to equity ratio of 80:20.

DEBT

With regards to debt financing for the Project, the Project Company will arrange 100% foreign financing form International DFIs etc.

EQUITY

Based on the Debt to Equity ratio of 80:20, the equity required to be injected by Artistic Milliners (the **Equity**), being the primary sponsor, amounts to USD 26.77 Million.

Salient Features of the Facility

Project Information

Since the issuance of the LOI, the Project Company conducted various studies to assess the feasibility of the Project. These studies *inter alia* included the Hydrology Study, geo technical investigation, topographic map, Environmental Impact Assessment and grid interconnection study. The complete feasibility study was submitted by the Project Company to Pakhtunkhwa Energy Development Organization (PEDO).

Project Site

The site proposed for the implementation of the Project has been selected by considering:

- Available discharge and gross head in the Ushu River;
- Ecological conditions at the Site;
- Topographic conditions;
- Site accessibility; and
- Location of the grid with reference to the Site for interconnection.

The Site is located at Kalam, District Swat, Khyber Pakhtunkhwa. The catchment of the Artistic-II HPP lies in the upper region of the Ushu River, a tributary / sub system of a Swat river basin and can be classified as a "high mountain catchment" in which there are several glaciers up to the power house site and a Bisni Nullah just downstream of the proposed Powerhouse location. Snowmelt is the principal source of water in the river. The highest mountain Peak of Ushu River reaches up to 5,917amsl and mean elevation is about 4,500 amsl while river bed elevation at weir site is 2,499 amsl and river bed elevation at Powerhouse site is at approximately 2,302 amsl. The Ushu River (left tributary) and the Gabral River (right tributary) joins at Kalam and forms the Swat River. The basin elevation gradually decreases from 4,500 amsl to 910 amsl below Kalam and the valley becomes broader up to Chakdara town. Length of the Ushu River up to the weir site is about 25 km. Average river bed slope ranges from 0.02 to 0.03.

Catchment area of the Ushu River at weir location is estimated to be 454 sq.km and at powerhouse location is approximately 600 sq.km.

Land Description of the Project Site:

Location	Northing	Easting	Operating Water Level
Weir / Intake	35°37'49.79"	72°41'03.38"	2505 masl
Power House	35°34'15.89"	72°40'19.28"	2305 masl

Climate of Project Area

The climate in winter is extremely cold with heavy snowfall and pleasant in summer. July is the hottest month of the year with an average temperature of 24.1 °C. The coldest month January has an average temperature of 1.5 °C and minimum low temperature of -2.2 °C. The snowfall normally starts in November / December and stays on the ground until late March.

Topographical and Geological Conditions at Project Site

Topographical conditions:

Swat lies in the lap of mountainous ranges, which are the offshoots of Hindukush, so the larger part of Swat is covered with high mountains and hills, the crest of which are hidden by everlasting snow. Though these gigantic ranges run irregularly: some to the west while the others to the east, but the general direction is North-South. The area comprises gently rolling topography in its eastern and southern parts, high ridges, cliffs and rugged hills in the west and north-western part.

Topography of the site area is mountainous with altitude varying between 2200 m to 4000 m above mean sea level (amsl) and has steep slopes and some densely forested areas.

There are three settlements/villages from the weir site to the powerhouse site up to Maee Bannal. These three settlements are on the right and left bank of the river. All these settlements are a cluster of houses at different places along the river. In all these settlements few houses are at a high altitude while clusters are closer to the river.

Geological conditions:

The field studies have revealed that the Project area is occupied by both the unconsolidated overburden materials and the rock formations.

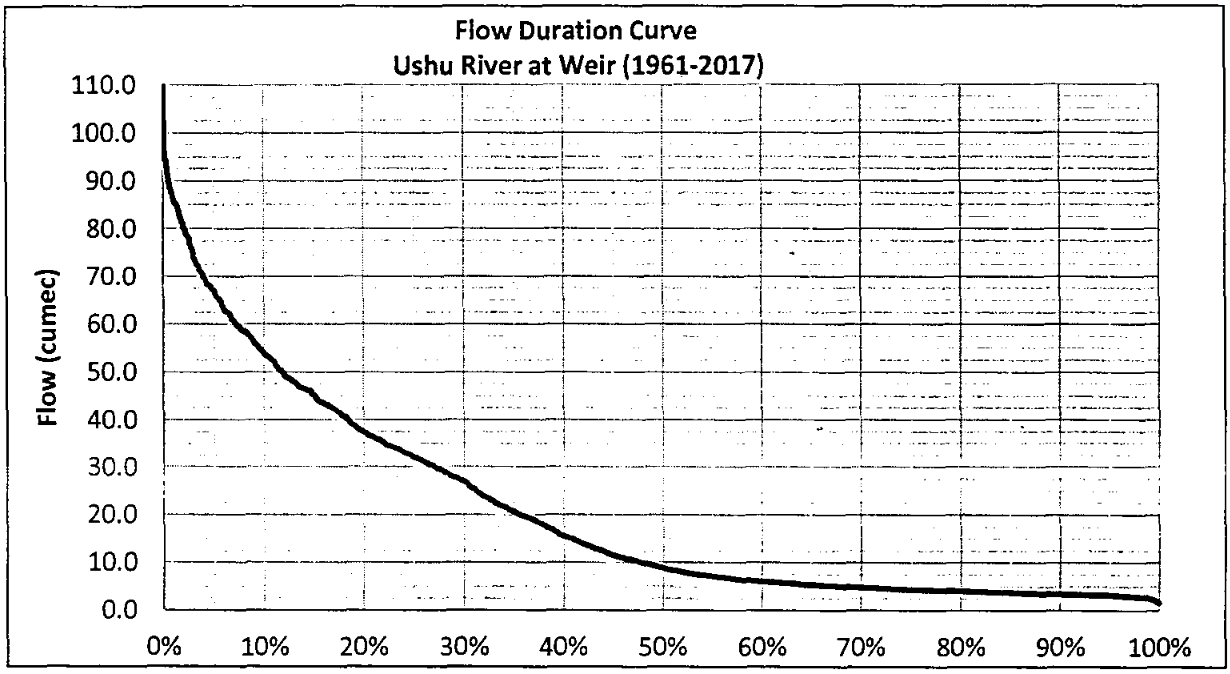
The bed rock is overlain by unconsolidated material of different nature throughout the project area. Valley of Ushu River at the project area is 200-300m wide. The river bed material consists of the gray, loose, sandy gravels, cobble with boulders generally of rounded to sub rounded and strong to very strong nature.

Glacio-fluvial terraces basically developed at the mouth of steep gradient stream draining to Ushu River. These deposits have been developed by the overlapping episodes of both alluvial and glacial activity. Along the river from weir site to powerhouse site, significant part of the Ushu valley is covered by these glacio-fluvial terraces. Besides the fan deposits, terraces comprised mainly of slope wash materials. These are materials deposited at the toes of hill slopes along the river. Moreover, Scree material is situated on the hill slopes as loose angular rock fragments detached from the upslope hill faces and generally accumulated on slope faces or at the toe of the hill faces.

The rock units exposed in the project area belong to mainly Utror Volcanics that comprise of andesite, dacite, rhyolite with tuffs of Late Eocene and Matiltan Granite that comprises of granite, granodiorite, amphibolite and diorite of Miocene age. The Granite/ Granodiorite are exposed at the powerhouse site near the tunnel outlet, part of penstock area, and along the most of the headrace tunnel. However, tunnel intake and initial small part of headrace tunnel will pass through rhyolite/ andesite that belong to Utror Volcanic.

Hydrology:

Availability of flows at the proposed weir/intake site was checked using detailed flow duration curve analysis. A flow duration curve (FDC) shows relationship between magnitude and frequency of stream flows for a particular river basin at a particular location. FDC provides estimation of cumulative percentage of time that a given quantity of flow is equaled to or exceeded which helps in planning and capacity sizing of a power plant. Flow series generated from Swat at Kalam , Ushu at Jildat and Matiltan data have been used for estimation of flow availability for exceeding probabilities as summarized and shown in figure below.



Site Accessibility

Karachi seaport is expected to be used for loading and unloading of heavy equipment. It is connected to Peshawar through two existing major north-south links i.e. National Highway 55 called N-55 on the western bank of the Indus River and National Highway 5 called N-5 on the eastern bank. N-45 branches from N-5 in Nowshera located 30 km east from Peshawar and goes through Mardan to Chakdara. At Chakdara, N-95 branches from N-45 that leads to District Swat and the project location. The road network from Karachi to project location is shown in figure below.

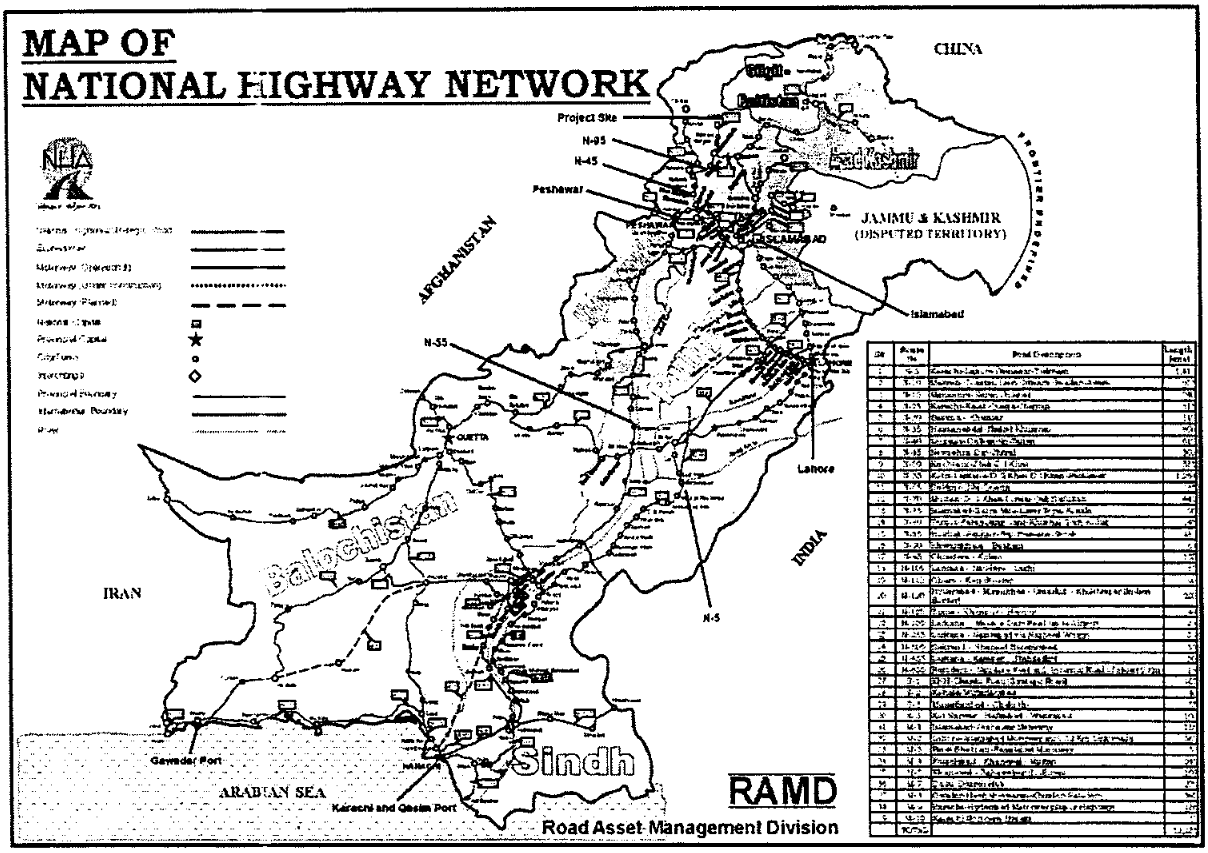


Figure 1 Map of National Highway Network

Availability of Semi-Skilled and Skilled Labor

There is a dearth of hydropower project specific skilled labor in the area, however unskilled and semi-skilled labor is available in the area and the Project will be a source of employment for these individuals. Training will be provided to the workers.

General Information

(i).	Name of Applicant/Company	Artistic Hydro II (Pvt.) Limited
(ii).	Registered/Business Office	Plot No. 3-A M.A.C.H.S Main Shahra e Faisal Karachi, Pakistan
(iii).	Plant Location	Ushu River, Kalam, District Swat, Khyber Pakhtunkhwa
(iv).	Type of Generation Facility	Hydropower

Hydropower Capacity & Configuration

(i).	Hydropower Turbine Type	Vertical Axis Francis
(ii).	Installed Electrical Capacity of Project (MW_e)	55.032 MW_e
(iii).	Installed Mechanical Capacity of Project (MW_m)	57.4 MW_m
(iii).	Number of Turbine Units/Size of each Unit (MW_e)	i. 1 x 22.9 MW_e (Unit-1) ii. 1 x 22.9 MW_e (Unit-2) iii. 1 x 9.2 MW_e (Unit-3)
(iv).	Plant Factor	43.67 %
(v).	Debt to Equity Ratio	80:20
(vi).	Dispatch / Power Purchaser	Central Power Purchasing Agency (Guarantee) Limited

Francis Turbine Details

Description	Large Units (Unit-1 & Unit -2)	Small Unit (Unit-3)
Types of turbine	Vertical Axis Francis	Vertical Axis Francis
Number of Units	2 Nos.	1 No.
Mechanical Output at Rated Head & Discharge	23.9 MW_m	9.6 MW_m

Rated Net Head	185.00 m	184.93 m
Rated Discharge	14.15 m^3/sec	5.7 m^3/sec
Rotational Speed	500 rpm or as proposed by vendor	600 rpm or as proposed by vendor
Runaway Speed at Maximum Head	862 rpm and 873 rpm or as proposed by vendor	1008 rpm or as proposed by vendor
Turbine Efficiency	93 %	
Direction of Rotation	Clockwise	

Proposed Investment:

The total project cost is estimated at USD 133.846 million at 2.43 million USD per MW.

Expected Date of Financial Close:
Within 24 months of granting of LOS
Expected COD:
48 months from the Financial Close

A046911

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

COMPANY REGISTRATION OFFICE, KARACHI

CERTIFICATE OF INCORPORATION

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

Corporate Universal Identification No. **0126604**

I hereby certify that **ARTISTIC HYDRO II (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 **Karachi** this **Twenty Third** day of **November, Two Thousand** and **Eighteen**

Incorporation fee Rs. **1,000/=**

(Muhammad Naeem Khan)
Additional Registrar/Incharge CRO

27/11/18

Certified True Copy
Artistic Hydro II (Pvt) Ltd.
Company Secretary

The Companies Act, 2017
Private Company Limited by Shares

ARTICLES OF ASSOCIATION
OF

ARTISTIC HYDRO II (PRIVATE) LIMITED

DEFINITIONS AND INTERPRETATIONS

1. In these Articles: unless there be something in the subject or context inconsistent therewith, words signifying the singular number only, shall include the plural and vice versa and words signifying males only shall extend to and include females and words signifying persons, shall apply mutatis mutandis to bodies corporate.

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

   (b) "Articles" means the Articles of Association as originally framed or as altered from time to time.

   (c) "Capital" shall mean the capital of the Company for the time being raised or authorised to be raised for the purpose of the Company.

   (d) "Company" means "ARTISTIC HYDRO II (PRIVATE) LIMITED"

   (e) "Dividend" includes bonus shares.

   (f) "Member" means the member of the Company within the meaning of the provisions of the Act.

   (g) "Month and year" shall mean the English calendar month and English calendar year respectively.

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

   (i) "Register" means the register of members to be kept pursuant to the provisions of the Act.

   (j) "Section" means Section of the Act.

   (k) "Seal" in relation to a Company means the Common Seal or official seal of the Company.

   (l) "Shares" shall mean the shares in the capital of the Company.

2. Unless the context otherwise requires, words or expressions contained in these Articles shall have the same meaning as in this Act; and words importing the singular shall include the plural, and vice versa, and words importing the masculine gender shall include feminine, and words importing persons shall include bodies corporate.

PRIVATE COMPANY

3. The company is a Private Limited Company within the meaning of Clause (49) of Sub-section (1) of Section 2 and accordingly:

   (a) The right to transfer of shares in the company is restricted in the manner and to the extent provided herein.

(b) The number of the members of the company (exclusive of the persons in the employment of the company) shall be limited to fifty, provided that for the purposes of this provision, where two or more persons hold one or more shares jointly in the company, they shall be treated as a single member.

(c) No invitation shall be issued to the public to subscribe for any shares, or debentures or redeemable capital of the company:

CAPITAL

4. The authorized share capital of the company is Rs. 100,000/- (Rupees One hundred thousand only) divided into 10,000 (ten thousand) Ordinary shares of Rs. 10/- (Rupees Ten only) each.

SHARES

5. In case of shares in the physical form, every person whose name is entered as a member in the register of members shall, without payment, be entitled to receive, within thirty days after allotment or within fifteen days of the application for registration of transfer, a certificate under the seal specifying the share or shares held by him and the amount paid up thereon:

Provided that if the shares are in book entry form or in case of conversion of physical shares and other transferable securities into book-entry form, the company shall, within ten days after an application is made for the registration of the transfer of any shares or other securities to a central depository, register such transfer in the name of the central depository.

6. The company shall not be bound to issue more than one certificate in respect of a share or shares in the physical form, held jointly by several persons and delivery of a certificate for a share to one of several joint holders shall be sufficient delivery to all.

7. If a share certificate in physical form is defaced, lost or destroyed, it may be renewed on payment of such fee, if any, not exceeding one hundred rupees, and on such terms, if any, as to evidence and indemnity and payment of expenses incurred by the company in investigating title as the directors think fit.

8. Except to the extent and in the manner allowed by section 86, 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.

TRANSFER AND TRANSMISSION OF SHARES

9. The instrument of transfer of any share in physical form in the company shall be executed both by the transferor and transferee, and the transferor shall be deemed to remain holder of the share until the name of the transferee is entered in the register of members in respect thereof.

10. Shares in physical form in the company shall be transferred in the form prescribed by Table A in the First Schedule to the Act, or in any usual or common form which the directors shall approve.

TRANSMISSION OF SHARES

11. The executors, administrators, heirs, or nominees, as the case may be, of a deceased sole holder of a share shall be the only persons recognised by the company to deal with the share in accordance with the law. In the case of a share registered in the names of two or more holders, the survivors or survivor, or the executors or administrators of the deceased survivor, shall be the only persons recognised by the company to deal with the share in accordance with the law.

12. The shares or other securities of a deceased member shall be transferred on application duly supported by succession certificate or by lawful award, as the case may be, in favour of the successors to the extent of their interests and their names shall be entered to the register of members.

13. A person may on acquiring interest in a company as member, represented by shares, at any time after acquisition of such interest deposit with the company a nomination conferring on a person, being the relatives of the member, namely, a spouse, father, mother, brother, sister and son or daughter, the right to protect the interest of the legal heirs in the shares of the deceased in the event of his death, as a trustee and to facilitate the transfer of shares to the legal heirs of the deceased subject to succession to be determined under the Islamic law of inheritance and in case of non-Muslim members, as per their respective law.

14. The person nominated under these Articles shall, after the death of the member, be deemed as a member of company till the shares are transferred to the legal heirs and if the deceased was a director of the company, not being a listed company, the nominee shall also act as director of the company to protect the interest of the legal heirs.

15. A person to be deemed as a member under these Articles to a share by reason of the death or insolvency of the holder shall be entitled to the same dividends and other advantages to which he would be entitled if he were the registered holder of the share and exercise any right conferred by membership in relation to meetings of the company.

ALTERATION OF CAPITAL

16. The company may, by special resolution:

    (a) increase its authorised capital by such amount as it thinks expedient;

    (b) consolidate and divide the whole or any part of its share capital into shares of larger amount than its existing shares;

    (c) sub-divide its shares, or any of them, into shares of smaller amount than is fixed by the memorandum;

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

17. Subject to the provisions of the Act, all new shares shall at the first instance be offered to such persons as at the date of the offer are entitled to such issue 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 letter of offer specifying the number of shares offered, and limiting a time within which the offer, if not accepted, will deem 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 this regulation.

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

19. The company may, by special 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 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.

20. The company may, by special resolution, reduce its share capital in any manner and with, and subject to confirmation by the Court and any incident authorised and consent required, by law.

GENERAL MEETINGS

21. A general meeting, to be called annual general meeting, shall be held, in accordance with the provisions of section 132, within sixteen months from the date of incorporation of the company and thereafter once at least in every year within a period of one hundred and twenty days following the close of its financial year.

22. All general meetings of a company other than the statutory meeting or an annual general meeting mentioned in sections 131 and 132 respectively shall be called extraordinary general meetings.

23. The directors may, whenever they think fit, call an extraordinary general meeting, and extraordinary general meetings shall also be called on such requisition, or in default, may be called by such requisitionists, as provided by section 133. If at any time there are not within Pakistan sufficient directors capable of acting to form a quorum, any director of the company may call an extraordinary general meeting in the same manner as nearly as possible as that in which meetings may be called by the directors.

24. The company may provide video-link facility to its members for attending general meeting at places other than the town in which general meeting is taking place after considering the geographical dispersal of its members:

NOTICE AND PROCEEDINGS OF GENERAL MEETINGS

25. Twenty-one days' notice at the least (exclusive of the day on which the notice is served or deemed to be served, but inclusive of the day for which notice is given) specifying the place, the day and the hour of meeting and, in case of special business, the general nature of that business, shall be given in manner provided by the Act for the general meeting, to such persons as are, under the Act or these Articles of the company, entitled to receive such notice from the company; but the accidental omission to give notice to, or the non-receipt of notice by, any member shall not invalidate the proceedings at any general meeting.

26. All the business transacted at a general meeting shall be deemed special other than the business stated in sub-section (2) of section 134 namely; the consideration of financial statements and the reports of the board and auditors, the declaration of any dividend, the election and appointment of directors in place of those retiring, and the appointment of the auditors and fixing of their remuneration.

27. No business shall be transacted at any general meeting unless a quorum of members is present at that time when the meeting proceeds to business. The quorum of the general meeting shall be governed as per the provisions of the Act and applicable to this company.

28. If within half an hour from the time appointed for the meeting a quorum is not present, the meeting, if called upon the requisition of members, shall be dissolved; in any other case, it shall stand adjourned to the same day in the next week at the same time and place, and, if at the adjourned meeting a quorum is not present within half an hour from the time appointed for the meeting, the members present, being not less than two, shall be a quorum.

29. The chairman of the board of directors, if any, shall preside as chairman at every general meeting of the company, but if there is no such chairman, or if at any meeting he is not present within fifteen minutes after the time appointed for the meeting, or is unwilling to act as chairman, any one of the directors present may be elected to be chairman, and if none of the directors is present, or willing to act as chairman, the members present shall choose one of their number to be chairman.

30. The chairman may, with the consent of any meeting at which a quorum is present (and shall if so directed by the meeting), adjourn the meeting from time to time 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. When a meeting is adjourned for fifteen days or more, notice of the adjourned meeting shall be given as in the case of an original meeting. Save as aforesaid, it shall not be necessary to give any notice of an adjournment or of the business to be transacted at an adjourned meeting.

31. (1) At any general meeting a resolution put to the vote of the meeting shall be decided on a show of hands unless a poll is (before or on the declaration of the result of the show of hands) demanded. Unless a poll is so demanded, a declaration by the chairman that a resolution has, on a show of hands, been carried, or carried unanimously, or by a particular majority, or lost, and an entry to that effect in the book of the proceedings of the company shall be conclusive evidence of the fact, without proof of the number or proportion of the votes recorded in favour of, or against, that resolution.

(2) At any general meeting, the company shall transact such businesses as may be notified by the Commission, only through postal ballot.

32. A poll may be demanded only in accordance with the provisions of section 143.

33. If a poll is duly demanded, it shall be taken in accordance with the manner laid down in sections 144 and 145 and the result of the poll shall be deemed to be the resolution of the meeting at which the poll was demanded.

34. A poll demanded on the election of chairman or on a question of adjournment shall be taken at once.

35. In the case of an equality of votes, whether on a show of hands or on a poll, the chairman of the meeting at which the show of hands takes place, or at which the poll is demanded, shall have and exercise a second or casting vote.

36. Except for the businesses specified under sub-section (2) of section 134 to be conducted in the annual general meeting, the members may pass a resolution (ordinary or special) by circulation signed by all the members for the time being entitled to receive notice of a meeting. The resolution by circulation shall be deemed to be passed on the date of signing by the last of the signatory member to such resolution.

VOTES OF MEMBERS

37. Subject to any rights or restrictions for the time being attached to any class or classes of sshares, on a show of hands every member present in person shall have one vote except for election of directors in which case the provisions of section 159 shall apply. On a poll every member shall have voting rights as laid down in section 134.

38. In case of joint-holders, the vote of the senior who tenders a vote, whether in person or by proxy or through video-link shall be accepted to the exclusion of the votes of the other joint-holders; and for this purpose seniority shall be determined by the order in which the names stand in the register of members.

39. A member of unsound mind, or in respect of whom an order has been made by any court having jurisdiction in lunacy, may vote, whether on show of hands or on a poll or through video link, by his committee or other legal guardian, and any such committee or guardian may, on a poll, vote by proxy.

40. On a poll votes may be given either personally or through video-link, by proxy or through postal ballot:

Provided that nobody corporate shall vote by proxy as long as a resolution of its directors in accordance with the provisions of section 138 is in force.

41. (1) The instrument appointing a proxy shall be in writing under the hand of the appointer or of his attorney duly authorised in writing.

(2) The instrument appointing a proxy and the power-of-attorney or other authority (if any) under which it is signed, or a notarially certified copy of that power 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 shall not be treated as valid.

42. An instrument appointing a proxy may be in the form as per the provisions of the Act, or a form as near thereto as may be.

43. A vote given in accordance with the terms of an instrument of proxy shall be valid notwithstanding the previous death or insanity of the principal or revocation of the proxy or of the authority under which the proxy was executed, or the transfer of the share in respect of which the proxy is given, provided that no intimation in writing of such death, insanity, revocation or transfer as aforesaid shall have been received by the company at the office before the commencement of the meeting or adjourned meeting at which the proxy is used.

DIRECTORS

44. The following subscribers of the memorandum of association shall be the first directors of the company, so, however, that the number of directors shall not in any case be less than that specified in section 154 and they shall hold office until the election of directors in the first annual general meeting:

    (a) Yaqoob Ahmed
    (b) Muhammad Omer Ahmed
    (c) Muhammad Murtaza Ahmed

45. The remuneration of the directors shall from time to time be determined by the company in general meeting subject to the provisions of the Act.

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

POWERS AND DUTIES OF DIRECTORS

47. The business of the company shall be managed by the directors, who may pay all expenses incurred in promoting and registering the company, and may exercise all such powers of the company as are not by the Act or any statutory modification thereof for the time being in force, or by these Articles, required to be exercised by the company in general meeting, subject nevertheless to the provisions of the Act or to any regulations in these Articles, and such regulation being not inconsistent with the aforesaid provisions, as may be prescribed by the company in general meeting but no regulation made by the company in general meeting shall invalidate any prior act of the directors which would have been valid if that regulation had not been made.

48. The directors shall appoint a chief executive in accordance with the provisions of sections 186 and 187.

49. The amount for the time being remaining undischarged of moneys borrowed or raised by the directors for the purposes of the company (otherwise than by the issue of share capital) shall not at any time, without the sanction of the company in general meeting, exceed the issued share capital of the company.

50. The directors shall duly comply with the provisions of the Act, or any statutory modification thereof for the time being in force, and in particular with the provisions in regard to the registration of the particulars of mortgages, charges and pledge affecting the property of the company or created by it, to the keeping of a register of the directors and to the sending to the registrar of an annual list of members, and a summary of particulars relating thereto and notice of any consolidation or increase of share capital, or sub-division of shares, and copies of special resolutions and a copy of the register of directors and notifications of any changes therein.

MINUTE BOOKS

51. The directors shall cause records to be kept and minutes to be made in book or books with regard to:

    (a) all resolutions and proceedings of general meeting(s) and the meeting(s) of directors and Committee(s) of directors, and every member present at any general meeting and every director present at any meeting of directors or Committee of directors shall put his signature in a book to be kept for that purpose;

(b) recording the names of the persons present at each meeting of the directors and of any committee of the directors, and the general meeting; and

(c) all orders made by the directors and Committee(s) of directors:

Provided that all records related to proceedings through video-link shall be maintained in accordance with the relevant regulations specified by the Commission which shall be appropriately rendered into writing as part of the minute books according to the said regulations.

THE SEAL

52. The directors shall provide for the safe custody of the seal and the seal shall not be affixed to any instrument except by the authority of a resolution of the board of directors or by a committee of directors authorized in that behalf by the directors and in the presence of at least two directors and of the secretary or such other person as the directors may appoint for the purpose; and those two directors and secretary or other person as aforesaid shall sign every instrument to which the seal of the company is so affixed in their presence.

DISQUALIFICATION OF DIRECTORS

53. No person shall become the director of a company if he suffers from any of the disabilities or disqualifications mentioned in section 153 or disqualified or debarred from holding such office under any of the provisions of the Act as the case may be and, if already a director, shall cease to hold such office from the date he so becomes disqualified or disabled:

Provided, however, that no director shall vacate his office by reason only of his being a member of any company which has entered into contracts with, or done any work for, the company of which he is director, but such director shall not vote in respect of any such contract or work, and if he does so vote, his vote shall not be counted.

PROCEEDINGS OF DIRECTORS

54. The directors may meet together for the dispatch of business, adjourn and otherwise regulate their meetings, as they think fit. A director may, and the secretary on the requisition of a director shall, at any time, summon a meeting of directors. Notice sent to a director through email whether such director is in Pakistan or outside Pakistan shall be a valid notice.

55. The directors may elect a chairman of their meetings and determine the period for which he is to hold office; but, if no such chairman is elected, or if at any meeting the chairman is not present within ten minutes after the time appointed for holding the same or is unwilling to act as chairman, the directors present may choose one of their number to be chairman of the meeting.

56. At least one-third (1/3rd) of the total number of directors or two (2) directors whichever is higher, for the time being of the company, present personally or through video-link, shall constitute a quorum.

57. Save as otherwise expressly provided in the Act, every question at meetings of the board shall be determined by a majority of votes of the directors present in person or through video-link, each director having one vote. In case of an equality of votes or tie, the chairman shall have a casting vote in addition to his original vote as a director.

58. The directors may delegate any of their powers not required to be exercised in their meeting to committees consisting of such member or members of their body as they think fit; any committee so formed shall, in the exercise of the powers so delegated, conform to any restrictions that may be imposed on them by the directors.

59. (1) A committee may elect a chairman of its meetings; but, if no such chairman is elected, or if at any meeting the chairman is not present within ten minutes after the time appointed for holding the same or is unwilling to act as chairman, the members present may choose one of their number to be chairman of the meeting.

(2) A committee may meet and adjourn as it thinks proper. Questions arising at any meeting shall be determined by a majority of votes of the members present. In case of an equality of votes, the chairman shall have and exercise a second or casting vote.

60. All acts done by any meeting of the directors or of a committee of directors, or by any person acting as a director, shall, notwithstanding that it be afterwards discovered that there was some defect in the appointment of any such directors or persons acting as aforesaid, or that they or any of them were disqualified, be as valid as if every such person had been duly appointed and was qualified to be a director.

61. A copy of the draft minutes of meeting of the board of directors shall be furnished to every director within seven working days of the date of meeting.

62. A resolution in writing signed by all the directors for the time being entitled to receive notice of a meeting of the directors shall be as valid and effectual as if it had been passed at a meeting of the directors duly convened and held.

FILLING OF VACANCIES

63. At the first annual general meeting of the company, all the directors shall stand retired from office, and directors shall be elected in their place in accordance with section 159 for a term of three years.

64. A retiring director shall be eligible for re-election.

65. The directors shall comply with the provisions of sections 154 to 159 and sections 161, 162 and 167 relating to the election of directors and matters ancillary thereto.

66. Any casual vacancy occurring on the board of directors may be filled up by the directors, but the person so chosen shall be subject to retirement at the same time as if he had become a director on the day on which the director in whose place he is chosen was last elected as director.

67. The company may remove a director but only in accordance with the provisions of the Act.

DIVIDENDS AND RESERVE

68. The company in general meeting may declare dividends but no dividend shall exceed the amount recommended by the directors.

69. The directors may from time to time pay to the members such interim dividends as appear to the directors to be justified by the profits of the company.

70. Any dividend may be paid by a company either in cash or in kind only out of its profits. The payment of dividend in kind shall only be in the shape of shares of listed company held by the distributing company.

71. Dividend shall not be paid out of unrealized gain on investment property credited to profit and loss account.

72. Subject to the rights of persons (if any) entitled to shares with special rights as to dividends, all dividends shall be declared and paid according to the amounts paid on the shares.

73. (1) The directors may, before recommending any dividend, set aside out of the profits of the company such sums as they think proper as a reserve or reserves which shall, at the discretion of the directors, be applicable for meeting contingencies, or for equalizing dividends, or for any other purpose to which the profits of the company may be properly applied, and pending such application may, at the like discretion, either be employed in the business of company or be invested in such investments (other than shares of the company) as the directors may, subject to the provisions of the Act, from time to time think fit.

(2) The directors may carry forward any profits which they may think prudent not to distribute, without setting them aside as a reserve.

74. If several persons are registered as joint-holders of any share, any one of them may give effectual receipt for any dividend payable on the share.

75. (1) Notice of any dividend that may have been declared shall be given in manner hereinafter mentioned to the persons entitled to share therein.

(2) Any dividend declared by the company shall be paid to its registered shareholders or to their order. The dividend payable in cash may be paid by cheque or warrant or in any electronic mode to the shareholders entitled to the payment of the dividend, as per their direction.

76. The dividend shall be paid within the period laid down under the Act.

ACCOUNTS

77. The directors shall cause to be kept proper books of account as required under section 220.

78. 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 and shall be open to inspection by the directors during business hours.

79. The directors shall from time to time determine whether and to what extent and at what time and places and under what conditions or regulations the accounts and books or papers of the company or any of them shall be open to the inspection of members not being directors, and no member (not being a director) shall have any right of inspecting any account and book or papers of the company except as conferred by law or authorised by the directors or by the company in general meeting.

80. The directors shall as required by sections 223 and 226 cause to be prepared and to be laid before the company in general meeting the financial statements duly audited and reports as are referred to in those sections.

81. The financial statements and other reports referred to in these Articles shall be made out in every year and laid before the company in the annual general meeting in accordance with sections 132 and 223.

82. A copy of the financial statements and reports of directors and auditors shall, at least twenty-one days preceding the meeting, be sent to the persons entitled to receive notices of general meetings in the manner in which notices are to be given hereunder.

83. The directors shall in all respect comply with the provisions of sections 220 to 227.

84. Auditors shall be appointed and their duties regulated in accordance with sections 246 to 249.

NOTICES

85. (1) A notice may be given by the company to any member to his registered address or if he has no registered address in Pakistan to the address, if any, supplied by him to the company for the giving of notices to him against an acknowledgement or by post or courier service or through electronic means or in any other manner as may be specified by the Commission.

(2) Where a notice is sent by post, service of the notice shall be deemed to be effected by properly addressing, prepaying and posting a letter containing the notice and, unless the contrary is proved, to have been effected at the time at which the letter will be delivered in the ordinary course of post.

86. A notice may be given by the company to the joint-holders of a share by giving the notice to the joint-holder named first in the register in respect of the share.

87. A notice may be given by the company to the person entitled to a share in consequence of the death or insolvency of a member in the manner provided under the above regulations addressed to them by name, or by the title or representatives of the deceased, or assignees of the insolvent, or by any like description, at the address, supplied for the purpose by the person claiming to be so entitled.

88. Notice of every general meeting shall be given in the manner hereinbefore authorised to (a) every member of the company and also to (b) every person entitled to a share in consequence of the death or insolvency of a member, who but for his death or insolvency would be entitled to receive notice of the meeting, and (c) to the auditors of the company for the time being and every person who is entitled to receive notice of general meetings.

WINDING UP

89. (1) In the case of members' voluntary winding up, with the sanction of a special resolution of the company, and, in the case of creditors' voluntary winding up, of a meeting of the creditors, the liquidator shall exercise any of the powers given by sub-section (1) of section 337 of the Act to a liquidator in a winding up by the Court including inter-alia divide amongst the members, in specie or kind, the whole or any part of the assets of the company, whether they consist of property of the same kind or not.

(2) For the purpose aforesaid, the liquidator may set such value as he deems fair upon any property to be divided as aforesaid and may determine how such division shall be carried out as between the members or different classes of members.

(3) The liquidator may, with the like sanction, vest the whole or any part of such assets in trustees upon such trusts for the benefit of the contributories as the liquidator, with the like sanction, thinks fit, but so that no member shall be compelled to accept any shares or other securities whereon there is any liability.

INDEMNITY

90. Every officer or agent for the time being of the company may be indemnified out of the assets of the company against any liability incurred by him in defending any proceedings, whether civil or criminal, arising out of his dealings in relation to the affairs of the company, except those brought by the company against him, in which judgment is given in his favour or in which he is acquitted, or in connection with any application under section 492 in which relief is granted to him by the Court.

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

Name and surname (Present and former) in full (In block letters) / Fathers Name / Nationality / NIC #	Occupation	Residential Address in Full	Number of shares taken by each subscriber	Signature
MR. YAQOOB AHMED S/O. AHMED OMER PAKISTANI CNIC # 42201-4651073-5	BUSINESS	HOUSE NO. 35, STREET # 10, KHAYABAN-E-MUHAFIZ, PHASE VI, DHA, KARACHI	= 100 = (One hundred shares)	
MR. MUHAMMAD OMER AHMED S/O. YAQOOB AHMED PAKISTANI CNIC # 42201-4652023-5	BUSINESS	HOUSE NO. 35, STREET # 10, KHAYABAN-E-MUHAFIZ, PHASE VI, DHA, KARACHI	= 100 = (One hundred shares)	
MR. MUHAMMAD MURTAZA AHMED S/O. YAQOOB AHMED PAKISTANI CNIC # 42201-8075257-7	BUSINESS	HOUSE NO. 35, STREET # 10, KHAYABAN-E-MUHAFIZ, PHASE VI, DHA, KARACHI	= 100 = (One hundred shares)	
		TOTAL	= 300 = (Three hundred shares)	

Dated this 17th day of November, 2018

Certified to be True Copy

Deputy Registrar of Companies

27/11/18

Securities and Exchange Commission of Pakistan

ANNEXURE 06: MEMORANDUM OF ASSOCIATION

THE COMPANIES ACT, 2017

(PRIVATE COMPANY LIMITED BY SHARES)

MEMORANDUM

AND

ARTICLES OF ASSOCIATION

Of

ARTISTIC HYDRO II (PRIVATE) LIMITED

LIMITED LIABILITY OF MEMBERS

IV. The liability of the members is limited.

CAPITAL

V. The authorized capital of the Company is Rs. 100,000/- (Rupees One hundred thousand only) divided into 10,000 (Ten thousand) ordinary shares of Rs. 10/- (Rupees Ten only) each with powers to increase and reduce the capital of the Company and to divide the shares in the capital for the time being into several classes in accordance with the provisions of the Companies Act, 2017.

THE COMPANIES ACT, 2017
THE COMPANIES (GENERAL PROVISIONS AND FORMS) REGULATIONS, 2018
[Section 197 and Regulations 4 and 20]
PARTICULARS OF DIRECTORS AND OFFICERS, INCLUDING THE CHIEF EXECUTIVE, SECRETARY, CHIEF FINANCIAL OFFICER, AUDITORS AND LEGAL ADVISER OR OF ANY CHANGE THEREIN

FORM 29

PART-I

1.1 CUIN (Incorporation Number) 0126604

1.2 Name of Company ARTISTIC HYDRO II (PRIVATE) LIMITED

1.3 Fee Payment Details

1.3.1 Challan Number E-2020-214612 1.3.2 Amount 250.0

PART-II

2. Particulars*:

2.1. New Appointment/Election

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation*** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)	Nature of directorship (nominee/independent/additional/other) (j)
EY FORD RHONES, CHARTERED ACCOUNTANTS			PROGRESSIVE PLAZA, BEAUMONT ROAD, P.O. BOX 15541, KARACHI 75530	Auditor	Pakistan	PRACTICING CHARTERED ACCOUNTA	27/10/2020	Re-Appointment	

2.2. Ceasing of Officer/Retirement/Resignation

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation*** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)	Nature of directorship (nominee/independent/additional/other) (j)

2.3. Any other change in particulars relating to columns (a) to (g) above

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation*** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)	Nature of directorship (nominee/independent/additional/other)

* In the case of a firm, the full name, address and above mentioned particulars of each partner, and the date on which each became a partner.
** In case the nationality is not the nationality of origin, provide the nationality of origin as well.
*** Also provide particulars of other directorships or offices held, if any.".
**** In case of resignation of a director, the resignation letter and in case of removal of a director, member's resolution be attached

PART-III

3.1 Declaration:

I do hereby solemnly, and sincerely declare that the information provided in the form is:
(i) true and correct to the best of my knowledge, in consonance with the record as maintained by the Company and nothing has been concealed and
(ii) hereby reported after complying with and fulfilling all requirements under the relevant provisions of law, rules, regulations, directives, circulars and notifications whichever is applicable.

3.2 Name of Authorized Officer with designation/ Authorized Intermediary YAQOOB AHMED Director

3.3 Signature Electronically signed by YAQOOB AHMED

3.4 Registration No of Authorized Intermediary, if applicable

3.5 Date (DD/MM/YYYY) 01/11/2020

Company Registration Office ★ Securities and Exchange Commission of Pakistan ★ Karachi

Certified to be True Copy
07/01/21
Assistant Registrar of Companies

Form A
THE COMPANIES ACT, 2017
THE COMPANIES (GENERAL PROVISIONS AND FORMS) REGULATIONS, 2018
[Section 130(1) and Regulation 4]
ANNUAL RETURN OF COMPANY HAVING SHARE CAPITAL

PART-I

(Please complete in typescript or in bold block capitals)

1.1 CUIN (Registration Number) 0126604

1.2 Name of the Company ARTISTIC HYDRO II (PRIVATE) LIMITED

1.3 Fee payment details 1.3.1 Challan No 1.3.2. Amount 250.0

dd mm yyyy

1.4 Form A made upto 27/10/2020

1.5 Date of AGM 27/10/2020

PART - II

Section A

2.1 Registered Office Address PLOT 3/A,, M.A.C.H.S., MAIN SHAHRAH-E-FAISAL, Gulshan Town Sindh

2.2 Email Address saleem@lecnet.com.pk

2.3 Office Tel. No. 34321937

2.4 Office Fax No.

2.5 Principle line of business --HYDEL

2.6 Mobile No. of Authorized officer (Chief Executive/ Director/ Company Secretary/ Chief Financial Officer) 02134321937

2.7 Authorized Share Capital

Classes and kinds of Shares	No. of Shares	Amount	Face Value
Ordinary Shares		100,000.00	

2.8 Paid up Share Capital

Classes and kinds of Shares	No. of Shares	Amount	Face Value
Ordinary Shares		3,000.00	

2.9 Particulars of the holding /subsidiary company, if any

Name of Company	Holding/Subsidiary	% Shares Held

2.10 Chief Executive

Name MUHAMMAD MURTAZA AHMED

Address HOUSE NO. 35, STREET # 10, KHAYABAN-E-MUHAFIZ, PHASE VI, DHA, KARACHI

NIC No 42201-8075257-7

Next Page

Registration Office Karachi ★ Securities and Exchange Commission of Pakistan ★

Certified to be True Copy
Assistant Registrar of Companies

07 01 21

2.17 List of members & debenture holders on the date upto which this Form is made

S#	Folio#	Name	Address	Nationality	No of shares held/Debenture	NIC No(Passport if foreigner)
Members						
1	1	MR. YAQOOB AHMED	HOUSE NO 35, STREET # 10, KHAYANAN-	Pakistan	100	4220146510735
2	2	MUHAMMAD OMER AHMED	HOUSE NO 35, STREET # 10, KHAYANAN-	Pakistan	100	4220146520235
3	3	MUHAMMAD MURTAZA AHMED	HOUSE NO 35, STREET # 10, KHAYANAN-	Pakistan	100	4220180752577
Debenture Holders						

Previous Page Next Page

Company Registration Office Karachi Securities and Exchange Commission of Pakistan

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

PESHAWAR ELECTRIC SUPPLY COMPANY

PROJECT MANAGEMENT UNIT PESCO PESHAWAR

Phone # 091-9211757, Fax # 091-9213018

No: CE (Dev) 7300-7302

Dated 02 /11/2020

Chief Commercial Officer
PESCO Peshawar

Subject: **GRID INTERCONNECTION STUDIES OF APPROX. 56 MW ARTISTIC-II HYDROPOWER PROJECT BY ARTISTIC MILLINERS (Pvt) LTD, AT RIVER USHU, KALAM, DISTRICT SWAT, KHYBER PAKHTUNKHWA**

Reference: (1) M/s Artistic Milliners letter No. 7005-L-AH2-PESCP-00016 dated 15.10.2020.
(2) This office letter No. 6593-95 dated 05.10.2020.
(3) M/s Artistic Milliners letter No. Nil dated 25.09.2020.
(4) This office letter No. 6331-33 dated 23.09.2020.
(5) M/s Artistic Milliners letter No. 7005-L-AH2-PESCO-00014 dated 17.09.2020.
(6) M/s Artistic Milliners letter No. AH-II/OUT/CPPA/001-2019 dated 25.05.2019.
(7) This office letter No. 5596-99 dated 08.10.2019.

The revised Grid Interconnection Study Report / Cases of 56 MW Artistic-II Hydropower Project by M/s Artistic Milliners (Pvt) Ltd. Karachi at Ushu River, Matiltan Kalam, District Swat, KPK received vide letter at S.No.1 referred above. The technical feasibility study has been analyzed for Load Flow, Contingency, Short Circuit and Stability analysis carried out for summer 2026. The following proposed interconnection scheme recommended by consultant is found feasible and technically approved.

"7.2 km 132 kV Double Circuit Transmission Line with Rail conductor from 56 MW Artistic-II Hydropower Project switchyard to 84 MW Matiltan Hydro Power Project Kalam by PEDO"

However, technical approval of Grid Interconnection Study may not be considered as consent for purchase of Power. In case of any variation, change in scope of work or change in the proposed network the study may be revised and re-vetted from this office.

Chief Engineer (Development)
PMU PESCO Peshawar

Copy to:

1. CFO/Company Secretary Artistic Hydro-II (Pvt) Ltd Plot 3/A, M.A.C.H.S Shahrah -e-Faisal, Karachi.
2. M/s Power Planners International, 95-H/2, Wapda Town Lahore.

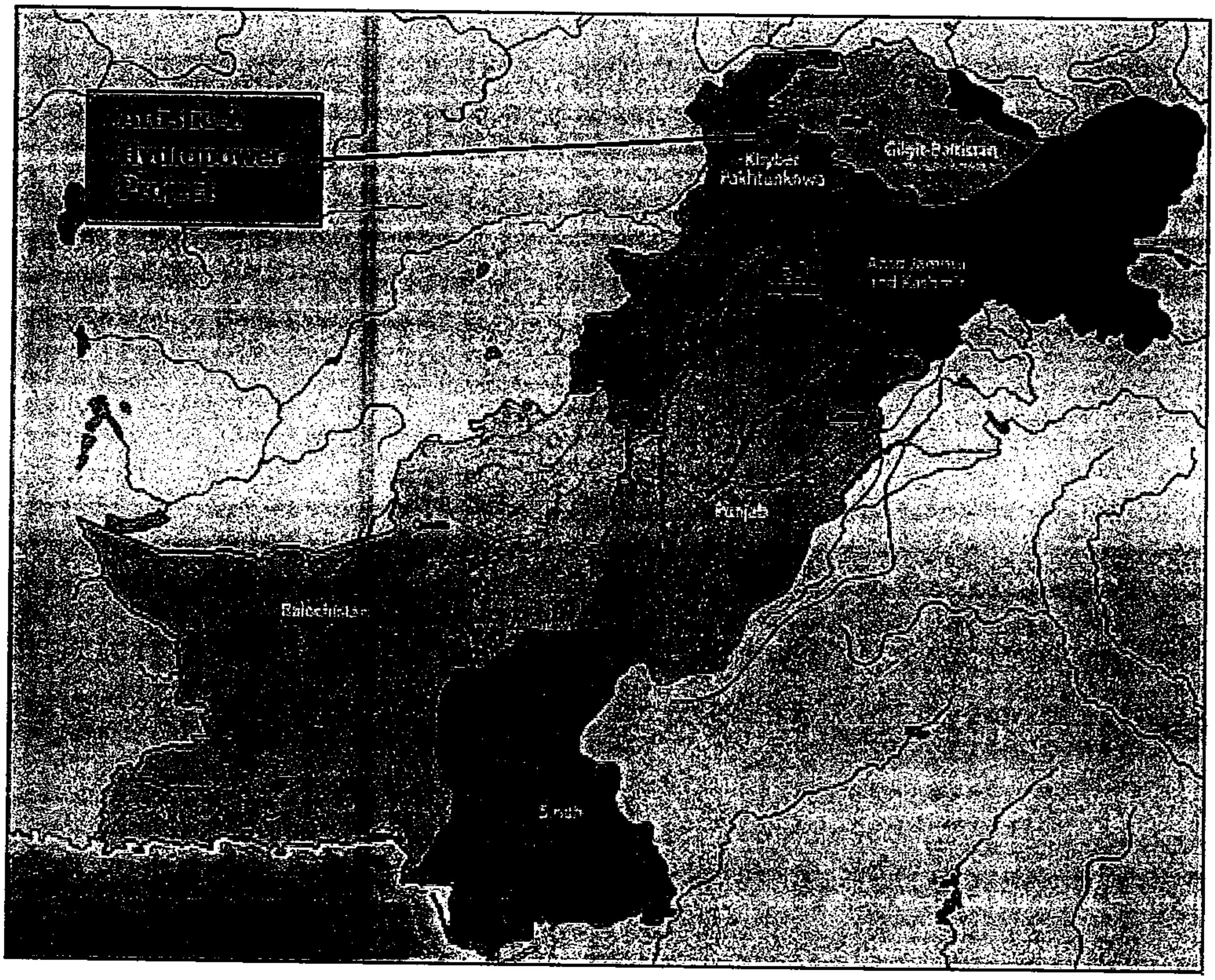
SCHEDULE-I

The Location, Size (i.e. Capacity in MW), Type of Technology, Interconnection Arrangements, Technical Limits, Technical/Functional Specifications and other details specific to the Generation Facilities of the Licensee are described in this Schedule.

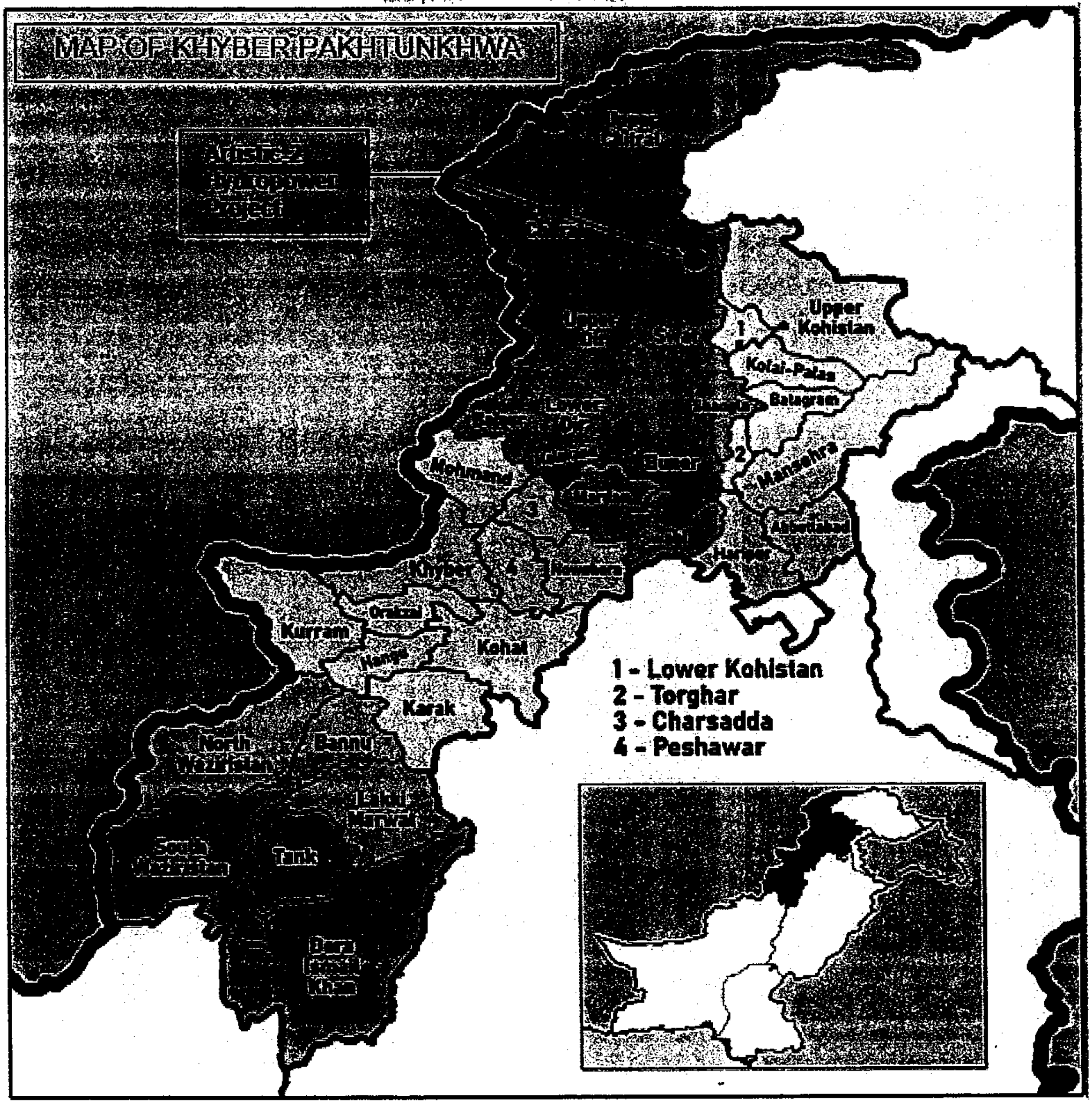
Location of the

Generation Facility/Hydel Power Plant

of the Licensee



Location of the Generation Facility/Hydel Power Plant of the Licensee



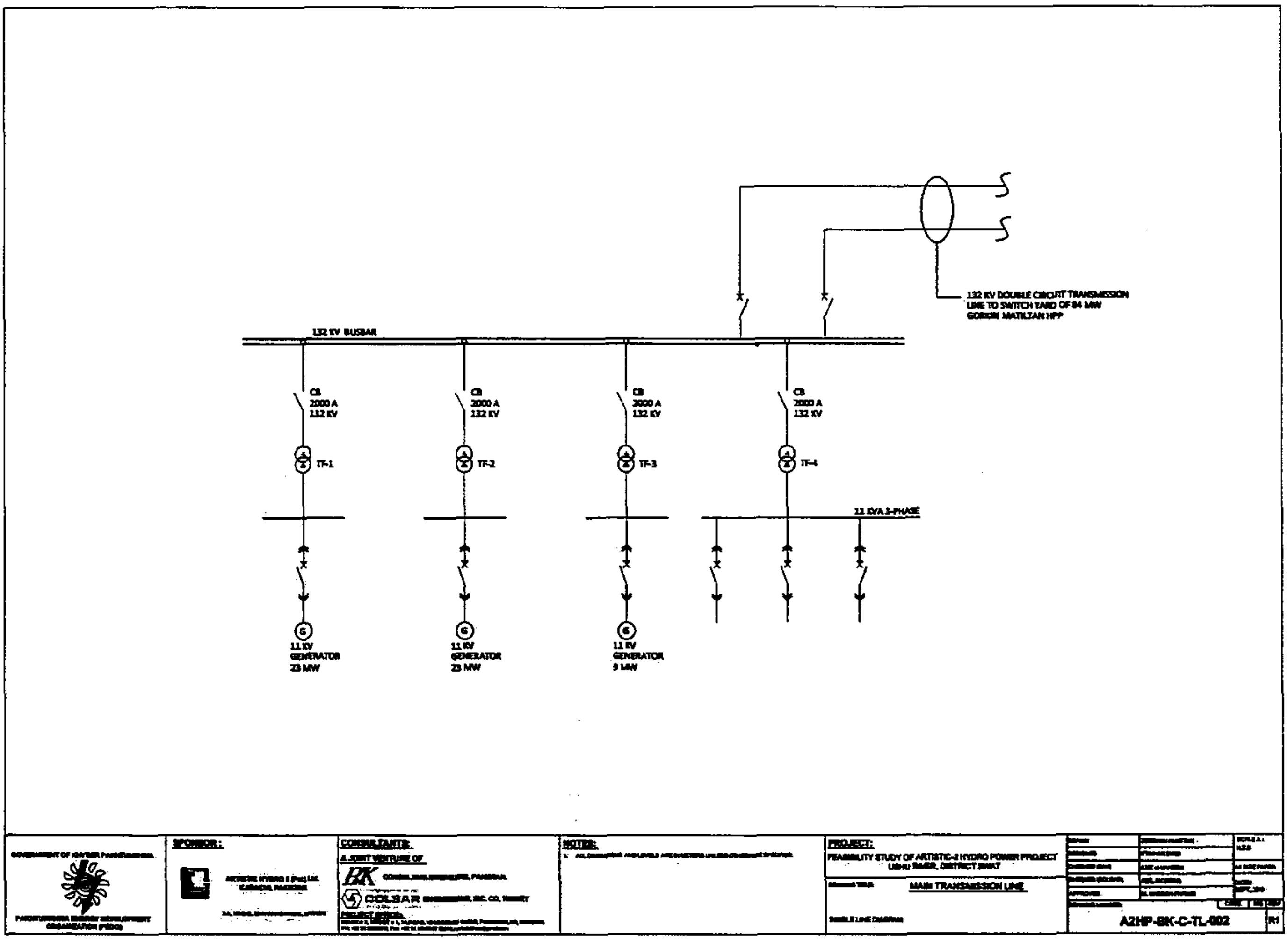
Location of the
Generation Facility/Hydel Power Plant
of the Licensee

Coordinates of

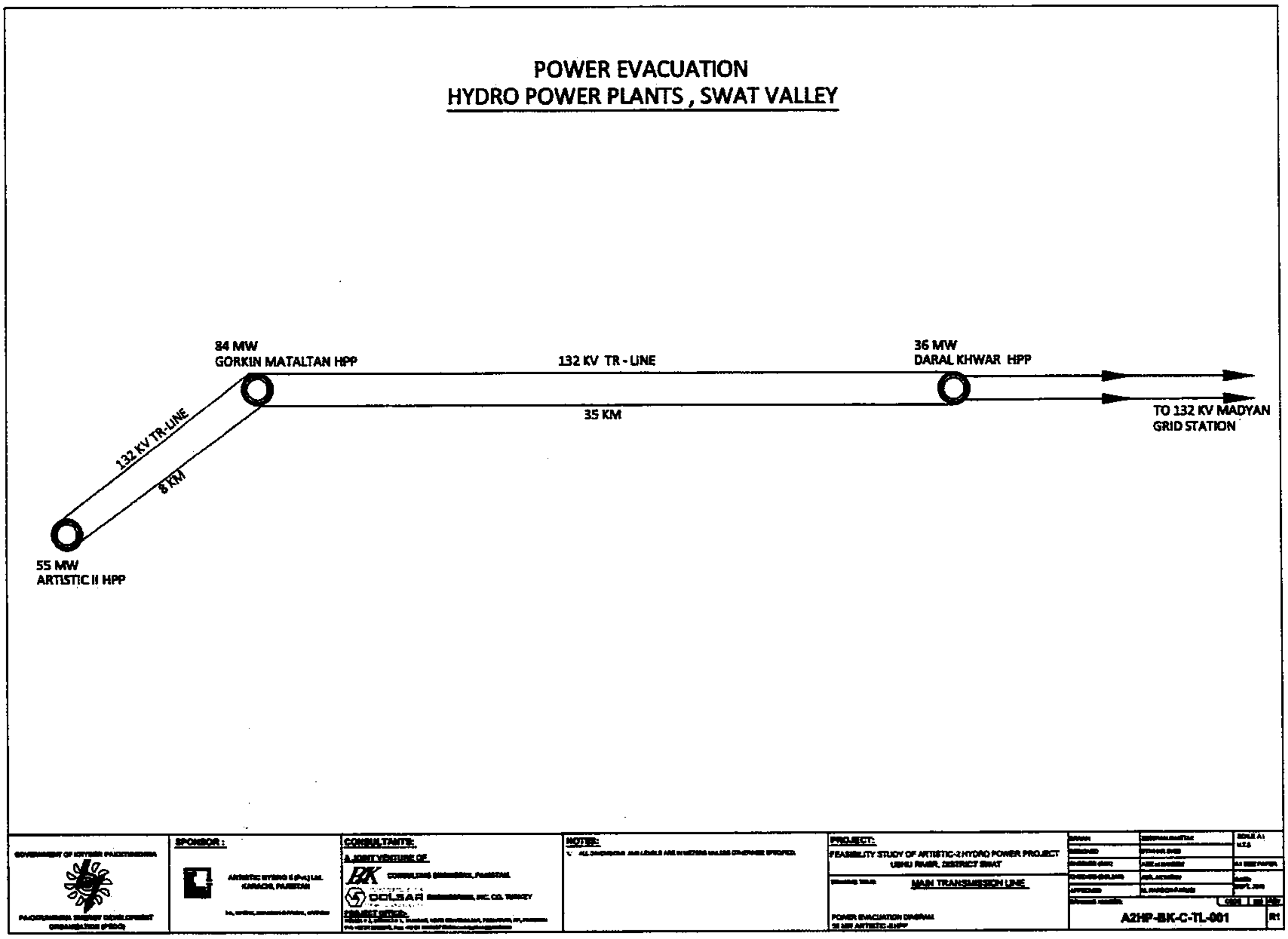
Start of the Intake and Powerhouse of the Generation Facility/Hydel Power Plant of the Licensee

Site	Latitude	Longitude
Weir / Intake	35°37'49.79"	72°41'03.38"
Power House	35°34'15.89"	72°40'19.28"

Single line Diagram
of the Generation Facility/Hydel Power Plant
of the Licensee



Schematic Diagram of the Interconnection Arrangement/Transmission Facility for Dispersal of Power from the Generation Facility/Hydel Power Plant of the Licensee



Interconnection Arrangement for Dispersal of Electric Energy/Power from the Generation Facility/Hydel Power Plant of the Licensee

The electric power generated from the generation facility/Hydel Power Plant/Artistic-II Project of the Licensee shall be dispersed to the load center of PESCO.

(2). The proposed Interconnection Arrangements/Transmission Facilities for dispersal of power from generation facility/Hydel Power Plant of the Licensee will consist of the following: -

> **(a).**8Km 132 kV Double CircuitTransmission Line with Rail Conductor from 55 MW Artistic – II Hydropower Project switchyard to 84 MW Gorkin Matiltan HPP Kalam by PEDO.

(3). Any change in the above Interconnection Arrangement/Transmission Facility duly agreed by Licensee and PESCO, shall be communicated to the Authority in due course of time.

Detail of
Generation Facility/Hydel Power Plant
of the Licensee

(A). General/Business Information

(i).	Name of the Entity/ Licensee	Artistic Hydro II (Pvt.) Ltd. Karachi, Pakistan
(ii).	Registered/Business Office of Entity/License	Plot 3/A, M.A.C.H.SShahrah-e-Faisal, Karachi-75350 Pakistan

(B). Location & Type of Facility

(i).	Location	Ushu River, Kalam in District Swat, Khyber Pakhtunkhwa, Pakistan
(ii).	UTM coordinates of weir	43 S, Easting=290301.2848m, Northing=3945435.9659 m
(iii).	Hydropower type	Run-of-the-river
(iv).	River Name	Ushu River

(C). Hydrology

(i).	Catchment Area	454 sq.km
(ii).	Normal Reservoir Level	2505 masl
(iii).	Design Discharge for Power	34 m^3/s
(iv).	Selected Design Flood for Weir	511 m^3/s
(v).	Flood Discharge 100yr	369 m^3/s
(vi).	Flood Discharge 1000 yr	511 m^3/s

(D). Diversion Weir

(i).	Type of Weir	Overflow ogee
(ii).	Crest level of ogee weir	2,505 masl
(iii).	Height of weir	6 m
(iv).	Total Length of spillway	36 m
(v).	Design flood	1000 year frequency

(vi).	Flood discharge	511 m^3/s
(vii).	Surcharge due to design flood	3.74 m
(viii).	Stilling basin	USBR Type III
(ix).	Size of basin	36m x 21.89m
(x).	Number of sluiceways	2 Nos.
(xi).	Size of sluice gates	3.5 m x 3.5 m
(xii).	Number of intake gates	3 Nos.
(xiii).	Size of intake gates	3m x 3.8m (WxH)

(E). <u>Sand Trap</u>

(i).	Type of Sand Trap	3 chambers
(ii).	Width of each chamber	6 m
(iii).	Limit Particle Size	0.30 mm
(iv).	Average Velocity in Chambers	0.276 m/s
(v).	Length of sand trap	90 m
(vi).	Bottom slope of sand trap	0.02
(vii).	Water depth at the beginning	5.4 m
(viii).	Water depth at the end	7.2 m
(ix).	Length of Upstream Transition	16 m
(x).	Length of Downstream Transition	16 m
(xi).	Free board (between crest of spillway and water level in sandtrap)	0.07 m
(xii).	Size of chambers at start	Width= 6m, Height = 6.07m
(xiii).	Size of chambers at end	Width= 6m, Height= 7.87m
(xiv).	Inlet service gates	3 Nos. (W=3 m, H= 3.8 m)
(xv).	Outlet service gates	3 Nos. (W=3 m, H= 3.8 m)
(xvi).	Flushing Arrangement	3 steel flushing pipes.
(xvii).	Diameter of flushing pipes	1 m
(xviii)	Flushing Discharge	19.5 cumecs
(xix).	Spillway Section	Sharp crested weir
(xx).	Crest Level of Spill Section	2504.90 masl
(xxi).	Total Length of Spill Section	50 m

(xxii).	Net length of spill section	48 m
(xxiii)	Surcharge due to overflow	0.54 m
(xxiv)	Total headloss in the sand trap	0.16 m
(xxv).	Design discharge of spill section	34 cumecs

(F). Box Channel

(i).	Type of Channel	Single-barreled, Rectangular, Reinforced concrete
(ii).	Discharge capacity	34 cumecs
(iii).	Invert level	2500.75 masl
(iv).	Water level at start	2504.67 masl
(v).	Dimensions	Width = 5.20 m, Height= 4.5 m
(vi).	Freeboard	0.58 m
(vii).	Total Length	1519 m
(viii).	Flow depth	3.92 m
(ix).	Velocity of water at full capacity	1.67 m/s
(x).	Bottom slope	0.0003

(G). Inlet Pond

(i).	Invert elevation at Start	2500 masl
(ii).	Invert elevation at tunnel inlet	2492 masl
(iii).	Normal Water level in inlet pond	2504.30 masl
(iv).	Length of inlet pond	60 m
(v).	Width of inlet pond	13 m
(vi).	Minimum submergence provided	3.56 m
(vii).	Spillway section	sharp crested weir
(viii).	Length of spillway section	60 m
(ix).	Discharge capacity of spillway section	34 cumecs

(H). Power Tunnel

(i).	Type of Power Tunnel	Horseshoe, reinforced concrete
(ii).	Length of power tunnel	4857 m

(iii).	Diameter of internal cross section	3.90 m
(iv).	Invert elevation of Tunnel	2492 masl
(v).	Normal water level at inlet pond	2504.30 masl
(vi).	Flow area	12.61m^2
(vii).	Bottom slope of tunnel	0.0085
(viii).	Flow velocity	2.70 m/s
(ix).	Length of tunnel upto surge shaft	4,773.49 m
(x).	Bed level of tunnel at surge shaft	2451.40 masl
(xi).	Friction loss in tunnel (concrete lining)	9.094 m
(xii).	Friction loss in tunnel (concrete + steel lining)	0.039 m
(xiii).	Design Discharge	34 cumecs

(I). Surge Shaft

(i).	Type of surge shaft	Circular shaft, reinforced concrete
(ii).	Maximum surge level	2,538.94 masl
(iii).	Maximum rise	34.64 m
(iv).	Minimum surge level	2,464.46 masl
(v).	Maximum Drop	39.84 m
(vi).	Diameter of surge shaft	6.1 m
(vii).	Height of surge shaft	94.65 m
(viii).	Bottom Elevation of Surge Shaft	2,455.34 masl

(J). Penstock

(i).	Type of Penstock	Steel
(ii).	Design discharge	34 cumecs
(iii).	Design velocity	5.52 m/s
(iv).	Invert level of penstock	2,451.26 masl
(v).	Length (until trifurcation)	340.79 m
(vi).	Diameter of penstock	2.8 m
(vii).	Thickness of penstock	14 mm ~ 18 mm
(viii).	Invert level of penstock at powerhouse	2,301.09 masl

(ix).	Diameter of Penstock (To Large Units)	1.8 m
(x).	Diameter of Penstock (To Small Unit)	1.20 m
(xi).	Friction loss in transition (from tunnel to penstock)	0.014 m
(xii).	Friction loss in penstock	2.407 m
(xiii).	Minor losses until trifurcation	0.68 m
(xiv).	Total loss until trifurcation	12.234

(K). Power Facilities

(i).	Type of powerhouse	Surface powerhouse
(ii).	Size of powerhouse	22.30 m x 30.80 m
(iii).	Turbines	3 Nos. (2 large and 1 small)
(iv).	Type of turbines	Vertical Axis Francis
(v).	Total installed capacity	55MW
(vi).	Capacity of large unit-1	22.9 MW
(vii).	Capacity of large unit-2	22.9 MW
(viii).	Capacity of small unit-3	9.2 MW
(ix).	Design discharge of large units	14.15m^3/s
(x).	Design discharge of small unit	5.70m^3/s
(xi).	Generator capacity of large unit-1	30 MVA
(xii).	Generator capacity of large unit-2	30 MVA
(xiii).	Generator capacity of small unit-3	12 MVA
(xiv).	Gross Head	200 m
(xv).	Net head for large unit-1	185.00 m
(xvi).	Net head for large unit-2	185.00 m
(xvii).	Net head for small unit-3	184.93 m
(xviii)	Average annual energy	211.745 GWh
(xix).	Plant factor	43.67%

(L). Tailrace Channel

(i).	Type of tailrace channel	Rectangular, Reinforced concrete
(ii).	Tail water level at design discharge	2,305.00 masl

	(Q = 34 m^3/s)	
(iii).	Type of end sill	Trapezoidal broad crested weir
(iv).	Width of tailrace channel	25.50 m
(v).	Slope of tailrace channel	2.50H:1V
(vi).	Length of tailrace channel (until end of end sill)	21.35 m
(vii).	Elevation of end sill	2304.17 masl
(viii).	Flow depth just upstream of broad-crested sill at design discharge (Q = 34 m^3/s)	0.83 m
(ix).	Free board (between TWL and top elevation of tailrace side walls)	5 m

(M). <u>Other Information</u>

(i).	COD of the generation facility/Hydel Power Plant	December 2027 (Expected)
(ii).	Expected minimum useful life of the generation facility from COD	60 years

SCHEDULE-II

The Total Installed Gross ISO Capacity (MW), De-Rated Capacity At Reference Site Conditions (MW), Auxiliary Consumption (MW) and the Net Capacity At Reference Site Conditions (MW) of the Generation Facility/Hydro Power Plant of Licensee is given in this Schedule

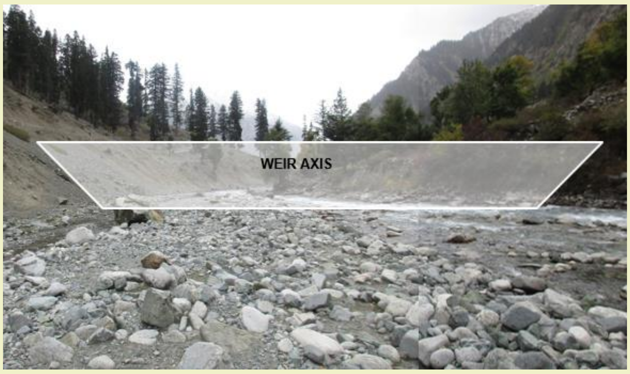
SCHEDULE-II

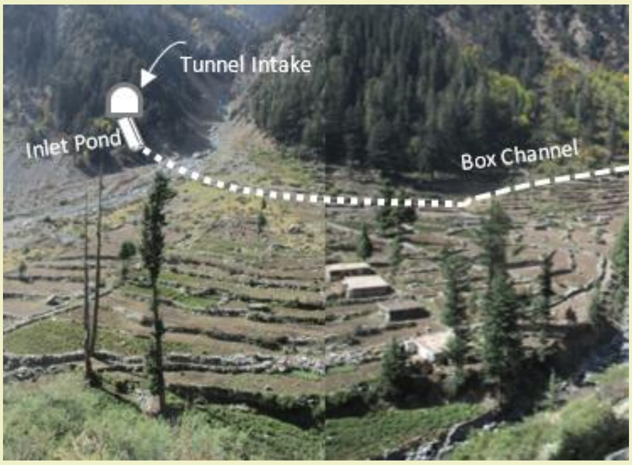
(1).	Total Installed Gross Capacity of the Generation Facility/Hydel Power Plant (23.9+23.9+9.6) MW_m	57.4MW_m
(2).	Total De-Rated Capacity of the GenerationFacility/Hydel Power Plant at Mean SiteConditions (23.9+23.9+9.6) MW_m	57.4MW_m
(3).	Total De-Rated Capacity (Electrical) of theGeneration Facility/Hydel Power Plant at MeanSite Conditions (22.9+22.9+9.2)MW_e	55MW_e
(4).	Auxiliary Consumption of the GenerationFacility/Hydel Power Plant	0.413 MW
(5).	Net Capacity of the Generation Facility/HydelPower Plant at Mean Site Conditions Condition	54.6 MW

Note

All the above figures are indicative as provided by the Licensee. The Net Delivered Energy available to Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement (EPA) or the Applicable Document(s).

ARTISTIC HYDRO II (Pvt.) Ltd.
KARACHI, PAKISTAN





ARTISTIC-II
HYDROPOWER PROJECT

DRAFT

FEASIBILITY STUDY

VOLUME - I (MAIN REPORT)

JUNE 2020

ARTISTIC-II HYDROPOWER PROJECT CONSULTANTS

A Joint Venture of

BAK CONSULTING ENGINEERS, PAKISTAN & DOLSAR ENGINEERING TURKEY

Project Office:
House # 2, Street 1, Tajabad, Near Board Bazar, Peshawar, KPK
Tel: +92 91 5703862, Fax: +92 91 5840807, Email: artistic2hpc@gmail.com

EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

1. INTRODUCTION

Hydropower potential in Khyber Pakhtunkhwa (KP) Provence especially in northern areas are very high and Pakhtunkhwa Energy Development Organization (PEDO) has been working on this dimension of development for the last three decades to achieve the self-sufficiency in the power sector, the organization is also encouraging public-private partnership and private investors. This effort has gained momentum in recent years. The present study is also an outcome of this effort of the PEDO.

Khyber Pakhtunkhwa has an estimated power potential of generating nearly 30,000 MW. The need for development of these immense hydropower potential in the province cannot be over-emphasized. 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 and Public Private Partnership sectors.

Raw hydropower sites identified by Pakhtunkhwa Energy Development Organization (PEDO) in Khyber Pakhtunkhwa Province need to be explored in detail. In this regard, PEDO under Government of Pakistan (GOP) policy, is encouraging the private investors, to develop infrastructure and hydropower projects in the province.

In view of the above, PEDO has entered into an agreement with M/s Artistic Milliners (Pvt) Ltd, Karachi to develop Artistic-II HPP Raw Site at Ushu River, Kalam in District Swat of northern part of Khyber Pakhtunkhwa Province, Pakistan.

2. TOPOGRAPHIC SURVEY

The Electronic Total Station (ETS) and DGPS were used for the for carrying out survey work for Artistic-II HPP. Survey control points for the project has been established by using latest survey equipment's and two survey control points of PEDO GM-28 and GM-29 of under constructed 84 MW Gorkin Matiltan Hydropower Project.

The coordinates of GM-28 & GM-29 are given in **Table 1;**

Table 1 : Coordinates of GM-28 & GM-29

S.NO	EASTING (m)	NORTHING (m)	LEVEL (m)	Remarks
GM-28	288929.035	3938248.282	2345.844	Gorkin Matiltan HPP Weir Site
GM-29	288941.205	3938331.434	2335.261	

Traverse was carried out in a closed loop to established control in the area of interest starting from the survey control concrete monuments GM-28, GM-29. The traverse distances were measured in two directions (forward & backward) and mean was accordingly adopted. The vertical control was established with the help of auto level Nikon AS-2. The traverse was closed with double run.

The topographic survey of the project has been carried out for alignment/layout of the structures by using modern and sophisticated Total Stations. GPS has been used to establish the control points at suitable locations. These controls points have been used for observing cross sections.

Topographic survey of Artistic-II HPP located in district Swat on Ushu River has been carried out for alignment/layout of structures as per TOR. The Consultants carryout the surveys with the most modern and sophisticated total stations and computer software “Eagle Point” has been used for plotting the surveys. GPS has been used to establish the control points at suitable locations. These controls points have been used for observing cross sections.

The topographic survey has been carried out and mapped for the main structrues such as intake area, box channel alignment, sandtrap headrace tunnel, surge tank, penstock, powerhouse and access roads. The survey data was then processed through computer softwares to develop survey drawings with contour interval of 1 m which were then used for planning and developing of different structures.

3. HYDROLOGY AND SEDIMENTATION

The hydrological studies for Artistic-II Hydropower Project have been carried out. The daily flow record of Ushu River at Matiltan Gauge Station is available on the records of Pakhtunkhwa Energy Develepement Organiztion (PEDO) for only 07 years (2011-2017) while for the same river at Jildat gauge station records for the period of 17 years (1993-2015) are available on the record of surface water hydrology (SWHP), WAPDA. However, daily flow records of Swat River at Kalam gauge station for the period of 1961 to 2010 are available on the records of Surface Water Hydrology (SWHP), WAPDA which has been used for the hydrological estimations for Artistic-II Hydropower Project. Derivation of flow pattern for Artsistic-II weir site is done by using

Kalam station historical stream flow data which is professionally acceptable option available to base one’s judgment upon. Comparison of stream flow for a concurrent period of Swat River at Kalam with Ushu River at Jildat is made by developing a correlation to generate flows for Ushu River at Jildat and then reduced the same for weir site by catchment area ratio method.

Flow series generated from Swat at Kalam, Ushu at Jildat and Matiltan data as explained above are used for estimation of flow availability for exceeding probabilities. Flow avaialbility against different exceeding probabilities generated from correlation model of Swat at Kalam and Ushu at Jildat including observed flow data at Matiltan are recommended.

Peak flood data of the River possessing similar hydro-meteorological conditions have been collected and frequency analysis through Gumbel extreme value distribution for each station have been carried out. Envelop curves of different return periods are drawn. Calculations of flood on the basis of envelop curves are also carried out. The regional river flood analysis includes flood peak data of July, 2010 in most of the gauging stations of surrounding Rivers, while Swat at Kalam was not included in July, 2010. Design flood estimated through regional River analysis are recommended for further design use.

For sedimentation study of the Artistic-II HPP, correlation was developed between the rate of flow and sediment load. For this purpose, the suspended data available for Ushu River at Ushu Bridge and Ushu Rive at Jildat are used to to develop correlation. The review of the suspended sediments indicates that small amount of suspended sediments is noticed during the low flow season that occurs in winter. During spring, the suspended sediment increases with discharge. The historical data reveals that the maximum suspended concentration is in the months of July and August. Origin of the sediments in the Swat catchment up to Chakdara is mainly originated during the rainfall period, while, in the northern part of the Swat Catchment (Gabral and Ushu) and increasing amount of sediment is originated from the melting of the glaciers.

Regional analysis has also been carried out to check the consistency and range of the average annual sediments at weir site of Artistic-II HPP. For the purpose, average annual runoff and sediment data for Swat River at Kalam, Chakdara and Munda stations is obtained from the Sediment Appraisal of Pakistan, 2008 published by the Surface Water Hydrology Project, WAPDA.

The mean annual suspended sediment load estimation by regional method (0.03 million metric Tons annually) is in fare agreement with the suspended sediment load estimation by using the gauge data of Swat river at Kalam. In the absence of bed load record, as there is no bed load measurement in Ushu River, as per standard practice to assume bed load 5 % to 20 % of suspended sediment load can be used. To be on more conservative side, 20 % of suspended sediment load has been taken as un-measured sediment load. Therefore, the annual bed load at Artistic-II HPP weir site is estimated to be 7,812 tons annually.

4. GEOLOGY AND GEOTECHNICAL STUDY

The geological and tectonic setting of the project area has been conceived based on the available geological literature (GSP 1999) and supplemented by latest geological, structural and stratigraphic information recorded during field studies. At the important project components, engineering geological mapping was undertaken on base maps prepared by superimposing topographic data on free available satellite images. Geological contacts among soil and rock units were marked on the base maps together with the recording of information about the geological structures. The field geological maps have been finalized in GIS and/ or AutoCAD environment which have been used for onward geotechnical evaluation and design activities. Similarly, at important project locations, subsurface geological sections have been prepared based on the surface geological information and recorded structural geological features.

It has been assessed in the field that the reservoir area is situated in overburden materials and it is likely that left bank scree and slope wash material may not be very good material for water tightness, and may require some treatment. However, right periphery may be more impervious and may not require any treatment.

The weir foundation will be lying mostly on river bed material while the the abutment will be on slope wash which overlying old river bed material. The river bed material at weir site is dominantly of sandy gravel. The sand mixed with gravels with minor amount of fine i.e. silt and clay. Sand is light brown to dark brown, fine to medium grain size mixed with gravels ranges from cobbles and boulders of igneous and metamorphic origin with sandy matrix. The gravels are mostly rounded to sub rounded shape while few of elephtical shape. The river bed material is loose at the top and relative density increases depth wise. The left abutment comprises of scree and slope wash terrace consisting of gravel to boulder size embedded in silty sandy matrix, which are assessed to be lying on old river bed material. The right abutment also comprises unconsolidated materials of slope wash, scree and glaciofluvial deposits with vegetation.

The box channel connecting de-sander to inlet pond is likely to be placed on unconsolidated deposits of different origins, that is, slope wash and scree; angular rock fragments of overlying andesite that vary in size from gravels to cobbles with occasional boulders. The scree is overlying on the slope wash material and glacio-fluvial deposits that has silty matrix with angular to subangular rock fragments.

The tunnel route corridor nearly 200-300 m wide, has been geologically mapped picking up various lithological and structural features. The sub surface conditions determined through geological mapping and 4 discontinuity surveys conducted as part of present geological studies. The interpreted geological information shows that the following rock types shall be expected along the tunnel route.

- Utror Volcanic; The Headrace Tunnel aligment is passing mostly from Matiltian granite and Utror Volcanic. The Utror volcanic rock is mostly exposed near to Inlet pond, Intake and it surrounding area. From RD 0+000 to RD 700m of the headrace tunnel is approximately 15 percent of total excavation will be in Utor volcanic which is is dominantly Andesite with subordinate intrusions of granite/ granodiorite, tuff, agglomerates, etc. The rock is light green to dark green, medium grain, blocky to very blocky having foliation trend in northeast-southwest direction dipping both in northwest and southeast at very steep angles. As per discontinuity surveys, the discontinuities are generally extremely close to moderately spaced, very low to very high persistent with tight to wide apertures and generally smooth to rough having planar to undulating surfaces. The rock quality as per ISRM, is interpreted from medium strong to strong. This rock unit present from tunnel intake to about 800m along the tunnel alignment where it makes its contact with the granite/ granodiorite of Matiltan Granite. This rock unit is present about 13% of the total tunnel length.

- Granodiorite/ Granite: approximately 4157m of Tunnel aligment is passing from Granodiorite /Granite of Matiltian Formation This rock unit is exposed on the surface along the headrace tunnel starting from RD 700m to upto the end RD. 4857m along the tunnel route and about 85% of the total excavation quantity It is light gray to whitish gray in colour ,medium to coarse ,slightly to moderatlely weathered, moderately jointed and fracture ,strong to very strong, very blocky to massive having joint trend in northeast-southwest direction dipping northwest at steep to very steep angle, with localized dip direction in southeast. As per discontinuity surveys, the discontinuities are extremely close to widely spaced, low to very high persistent with tight to wide apertures and generally have rough and undulating rock surfaces. The rock quality as per ISRM guidelines for intact rock classification is to be medium strong to very strong. This rock makes about 87% of the total rock mass along the tunnel.

The total length of Adit Tunnel is approximately 355m passing from Granite /Granodiorite parts Matiltian formation.The portal of the access adit will be,in rock comprising granodiorite/ granite is likely to be present, which in this area is assumed to be dipping toward valley (i.e. in southeast direction) with trend in northeast direction providing a fair ground conditions for the excavation. Rock mass condition has been assessed based on the discontinuity survey that indicates well developed foliation with three joint sets. The joints are extremely close to moderately spaced, low to very high persistent with tight to wide apertures and having generally rough and undulating surfaces. The rock is assessed to be medium strong to very strong.

The surge shaft and tunnel outlet area are located in the granite/ granodiorite of Matiltan Granite. The rock is generally exposed in the area or under thin cover of overburden and/ or vegetation. Rock mass condition has been perceived based on the discontinuity survey. This rock is again dipping steeply towards southeast with trend in northeast direction. The rock is assessed to be medium to very strong as per ISRM's guidelines for intact rock strength classification. The rock is dipping towards the valley at the tunnel outlet area posing a fair condition for tunnel excavation.

The entire valley floor of the powerhouse and tailrace site is occupied by the unconsolidated deposits, slope wash materials making valley slopes and river bed alluvium making valley bed. The rock present on higher elevations and is assessed to be at deeper depth (>60m) in the valley where powerhouse has been proposed. On both banks' slopes the thickness of the slope wash material is almost the same. Generally, these deposits are heterogeneous and comprise angular to subangular rock fractions in silty sandy matrix.

5. SEISMIC HAZARD ASSESSMENT

Seismic Hazard Evaluation of the Artistic-II Hydropower Project has been carried out by studying of the 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, identification and characterization of potential seismic sources in the project region and evaluation of seismic hazard in accordance with the current practices.

The Artistic-II Hydropower Project is located in the Kohistan Island Arc physiographic province, a tectonically active region which is sandwiched between the converging Indian and the Eurasian tectonic plates. The project region has been subjected to damaging earthquakes in the past. The major faults of the project region include, from north to south, the Main Karakoram Thrust (MKT), Kohistan Fault, Main Mantle Thrust (MMT), Panjal-Khairabad Thrust, Main Boundary Thrust (MBT) and Salt Range Thrust. The general trend of these faults is predominantly east-west with change in trend due to syntaxial bends.

The epicenters of three well-studied earthquakes of magnitude 5.9 or above have been recorded in Kohistan island arc east of the project area (Ambraseys, et al., 1975; Jackson &

Yielding, 1983). These earthquakes are:

- Patan earthquake (28 December 1974); magnitude (Mb) 5.9; 90 km south of the site; close to the surface expression of MMT;
- Hamran earthquake (3 September 1972); magnitude (Mb) 6.3; 55 km northeast of the site; within the Kohistan Island Arc; and
- Darel earthquake (12 September 1981); magnitude (Mb) 6.1; 20 km northeast of the site; within the Kohistan Island Arc.

The conclusions and recommendations regarding study of seismotectonic setting of Artistic-II Hydropower Project and the resulting seismic design parameters are as follows:

a) The project is located in the Kohistan Island Arc which is sandwiched between Indian and the Eurasian tectonic plates and very active seismically.

b) A number of moderate sized earthquakes have been recorded in Kohistan Island Arc during the last 100 years.

c) A number of active faults are present around the project site.

d) The main seismotectonic features considered critical for the seismic hazard for the project are as follows:

   - Main Karakoram Thrust (MKT),
   - Kohistan Fault,
   - Main Mantle Thrust (MMT), and
   - Shandur Thrust

e) Both probabilistic and deterministic seismic hazard evaluations were made to determine the expected ground motions at the project site.

f) The recommended horizontal Peak Ground Acceleration (PGA) associated with Operating Basis Earthquake (OBE) is 0.22g.

g) The recommended horizontal Peak Ground Acceleration (PGA) associated with Maximum Design Earthquake (MDE) is 0.39 g for all critical water retaining structures.

h) The recommended horizontal Peak Ground Acceleration associated with MDE for all appurtenant structures and powerhouse is 0.32g.

i) Uniform hazard spectra for OBE and MDEs given for use in the seismic resistant design of the project structures.

j) It is recommended that in-situ shear wave velocity profile of the subsoils at weir and powerhouse sites may be obtained for authenticating the assumption of Vs30.

6. PROJECT LAYOUT ALTERNATIVE & DESIGN OPTIMIZATION STUDIES

Layout alternative and design optimization studies have been carried out by the consultants to determine the best layout of the project as well as to optimize the dimensions of the structures belonging to this layout. Since Artistic-II HPP is a run-off-river type project, water conveyance system between weir and powerhouse can be constructed both at the right or left bank of the river. On the other hand, since the project is at a raw site, alternative locations for weir and powerhouse can be studied according to topographical, environmental, social and in-situ geological conditions as well as to utilize the maximum head potential, considering the rights of other projects which are located upstream of Artistic-II Weir and downstream of Artistic-II HPP. Therefore, the Consultants developed technically possible layout alternatives, studied advantages and disadvantages of them to make comparisons, thus to present the best one to be studied further in detail. Selection of best layout was achieved by taking the same design discharge into account for all layout alternatives.

Following the determination of best layout, the dimensions and capacities of the structures comprised by this layout is optimized. The optimization procedure involves first to assume a range of possible design discharges on the basis on hydrological studies. Special consideration is given to compensation flows and lowest natural flows. Comparative costs and energy benefits were estimated and economic analyses were then conducted for each design discharge within the context of this study. The design discharge which has the annual maximum net benefit (difference of annual benefit and annual cost) was selected as the optimum one among others. As different diameter options for power tunnel, penstock and surge shaft were taken into account together with the design discharge alternatives, the optimization study also resulted in with the best dimensions of those structures. Furthermore, the optimum installed capacity has also been revealed which is the main aim of project sizing.

Four possible layout alternatives have been studied by the consultants. Alternative 1, 2 & 3 are considered at the right bank of the river while alternative 4 is considered at the left bank of the river. For alternative 1, the weir site is considered which was provided by the client which is denoted as W1. The consultants studied different engineering aspects for the location of weir and concluded that the weir site (W1) as per coordinates provided by the Client (Alternative-1), is not safe from geological point of view due to huge glociofluvial fan at right bank. Shifting the axis ~220 m upstream, to the middle part of the glociofluvial fan, where right bank geological materials is more stable, is more appropriate which is considered for Alternate 2, 3 & 4. On the other hand, since W1 site is narrower, the side walls of the weir structure will be higher to spill the design flood discharge safely, in comparison to W2 site.

Shifting the weir axis by 220 m upstream have the following advantages:

1. The river becomes wider as we go upstream from W1 to W2 site and as a result the diversion arrangements during the construction will be easier. The part of the river will be plugged with the embankment at the end of the construction.
2. Additional head of about 5 m.
3. The levels of the Sand Trap will increase and flushing flows can be easily discharged in the river.
4. The level of the Tunnel Inlet portal will increase which will reduce the excavation near the tunnel inlet portal.

Two different locations for powerhouse have been considered for alternative layout studies. The powerhouse location (Alternative 1 & 2) as per coordinates provided by the Client is about 940 m upstream from the 84 MW Matiltan Weir. The consultant shifted the location of power house downstream by about 700 m (Alternative 3) i.e about 240 m u/s of Gorkin Matiltan Weir to get benefit of additional 28 m head. It is pertinent to mention that the location of Artistic-II powerhouse has been selected in such a way that the tailwater level when all units are in operation with full capacity, will be above or equal to the Matiltan Weir maximum (flood) water level.

The Consultants after detailed discussions, analysis and comparison of all project layout alternatives, come to the conclusion that right bank Alternative 3 would be more practical and beneficial from structural point of view, and geological & geotechnical aspects. Although Alternative 4 would offer maximum power potential, annual energy and consequently annual revenue, Alternative 3 deserves to be the optimum selection due to minimum environmental and social issues.

For the optimization of the selected layout alternative the consultants selected considered the design dishcharge of 20% to 30% exceedance of flow duration curve because the design discharge of similar previous projects in Pakistan generally falls between 20% - 30% exceedance of flow duration curve. Reviewing the flow duration curve at Artistic-II Weir site, eight discharges, namely Q = 30, 31, 32, 33, 34, 35, 36 and 37 cumecs, which corresponds to 20% - 30% exceedance were selected to be included in the optimization study.

For each design discharge different tunnel diameters and six different penstock diameters were planned to be optimized. Similary for different design discharges the box channel was dimensioned. As mentioned above, 8 different design discharges together with 3 different power tunnel diameters and 6 different penstock diameters decided for each discharge; result in 8 x 3 x 6 = **144 alternatives** that are included in the optimization study for Artistic-II HPP.

Table 2: Best Options for Design Discharge Alternatives

Q_d (m^3/s)	Diameter of Power Tunnel (m)	Diameter of Penstock (m)	Diameter of Surge Shaft (m)	Box Channel Width (m)	Box Channel Height (m)	Installed Capacity (MWe)	Average Energy Generation (GWh/year)	Net Benefit (PKR/year)
30	3,65	2,65	5,80	4,95	4,30	48,336	201,745	766.581.592
31	3,70	2,70	5,90	5,05	4,30	49,992	205,381	774.891.345
32	3,80	2,70	5,90	5,10	4,40	51,770	208,857	774.387.263
33	3,85	2,65	5,90	5,15	4,40	53,268	212,252	780.564.523
34	3,90	2,80	6,10	5,20	4,50	55,112	216,595	791.508.830
35	3,95	2,85	6,15	5,25	4,50	56,789	220,455	771.165.815
36	4,00	2,75	6,30	5,30	4,60	58,221	223,645	778.839.729
37	4,05	2,80	6,40	5,35	4,60	59,913	226,525	780.368.023

As can be seen from **Table 2**, by this detailed study, the design discharge, diameters of power tunnel, penstock and surge shaft, dimensions of box channel and consequently the installed capacity of the power plant, have been optimized at once.

7. DESIGN CONSIDERATIONS AND POWER POTENTIAL

From upstream to downstream, the Artistic-II project comprises of hydraulic structures such as weir, intake, sand trap, box channel, forebay, pressurized tunnel, surge tank, valve chamber, penstock and powerhouse. Following the determination of best layout, the dimensions and capacities of the structures comprised by this layout is optimized. The design discharge which has the annual maximum net benefit was selected as the optimum one among others. As different diameter options for power tunnel, penstock and surge shaft were taken into account together with the design discharge alternatives, the optimization study also resulted in with the best dimensions of those structures. Furthermore, the optimum installed capacity has also been revealed which is the main aim of project sizing.

The proposed characteristics due optimization study and further detail feasibility studies for final dimensioning are as follows

Box Channel:

Type of cross section	Rectangular, reinforced concrete
Flow regime	Open channel, subcritical
Capacity	34 m^3/s
Bottom Slope	0.0003
Manning’s “n” for concrete	0.014

Width	5.20 m
Water depth at full capacity	3.92 m
Freeboard	0.58 m
Height	4.50 m
Velocity of water at full capacity	1.67 m/s
Length of channel	1,519.8 m

Power Tunnel:

Type of internal cross section	Horseshoe, reinforced concrete
Type of excavation cross section	D-shaped
Diameter of internal cross section	3.9 m
Diameter of excavation cross section	4.6 m
Bottom slope of tunnel	0.0085
Length of tunnel	4.857 m
Steel lining	Last 32 m of tunnel

Surge Tank:

Type of internal cross section	Circular, reinforced concrete
Type of excavation cross section	Circular
Diameter of internal cross section	6.1 m
Diameter of excavation cross section	7.1 m
Height of surge shaft	94.7 m (above tunnel crown)

Penstock:

Diameter	2.8 m
Pipe wall thickness	14 mm ~ 18 mm
Length of penstock until trifurcation	341 m (including valve chamber)
Diameter of big unit branch pipe	1.80 m - 1.25 m
Diameter of big unit branch pipe	1.20 m - 0.90 m

Power House:

Tailwater level (All units are in operation)	2,305.00 masl
Turbines	3 Nos. (2 Big + 1 Small)
Type of turbines	Vertical Axis Francis
Design discharge	34 m^3/s (2x14.15 + 1x5.70) m^3/s
Assumed rated efficiencies	0.93 x 0.97 x 0.99 (Trbn, Gen, Tr.)
Gross head from Artistic-II Weir	200.00 m

Net head (All units are in operation)

For Unit-1 (large)	184.42 m
For Unit-2 (large)	185.00 m
For Unit-3 (small)	184.93 m

Power Generation (All units are in operation)	55.032 MWe
Average Annual Energy Generation	211.745 GWh

The river bed elevation at weir axis is 2.499,00 masl while the height of ogee has been selected as 6 m thus NWL of the project becomes 2.305,00 masl. The overflow ogee section has been designed for passing 1 in 1.000 year return flood discharge. To remove sediments two under sluices have also been designed between ogee and intake structure at right bank. A bridge was designed above ogee spillway to access right bank of river. The flood discharges at weir site with respect to different return periods were taken from Hydrology and Sedimentation Report, and given below:

Q_2 = 108 m^3/s	Q_{10} = 224 m^3/s	Q_{50} = 326 m^3/s
Q_{100} = 369 m^3/s	Q_{200} = 411 m^3/s	Q_{1000} = 511 m^3/s

The intake structure is envisaged at the right bank. The deflection angle between the longitudinal axes of intake and weir has been selected as 20º to minimize the excavation of sandtrap located just downstream of intake.

The flows from intake directly enter the sand trap in order to clean the water at the beginning of the conveyance system, thus to prevent the formation of settled sediments within the following box channel. Sandtrap has three chambers and 90 m in length. The width of each chamber and the bottom slope of the structure has been selected as 6 m and 2%, respectively. The top of the structure was covered with a concrete slab to prevent the water from freezing in winters. To evacuate the excess flows entering into the sand trap in case of emergency, a side spillway of 2 m width is provided at the left bank of structure.

Box channel connects the sand trap to forebay. The dimensions of the channel were determined through optimization studies and its salient features are given above in the same section. The design discharge is carried with water depth of 3.92 m. The freeboard above this depth has been taken as 0.58 m, thus, the internal height is 4.5 m. The cross-section of this free flow channel has been selected as rectangular box to prevent the formation of ice lenses at the flowing surface in winters. The box section is structurally more stable and protects the water from the entrance of debris material or slopewash which may show possible downward movements from top hills.

Forebay is provided just upstream of tunnel in order to avoid air entrance into the tunnel. The width of forebay has been taken same as the width of power intake (13 m) and the length is determined as 60 m. To evacuate the flows coming from box channel in case of emergency shut downs at powerhouse, a side spillway of 4 m width is provided at the left bank of forebay.

The power tunnel is designed as a horseshoe conduit of 3.9 m finished diameter. It is 4,857 m long and has a slope of 0.0085. The tunnel is envisaged to be reinforced cement concrete while steel lining is also provided at the last 32 m.

Surge shaft has been provided at the end of concrete lined tunnel. Based on the hydraulics considerations, the cicular surge shaft has been designed to have an internal diameter equaling 6.1 m and to have a 94.7 m height above the tunnel crown.

Valve chamber has been provided at the end of the tunnel after the surge shaft which provide room for butterfly valves which will be installed at the start of penstock. The diameter of penstock is 2.8 m and the length upto trifurcation is 341 m (including valve chamber).

Powerhouse is envisaged to be equipped with 3 vertical francis turbines. Two big turbines units will have design discharge of 14.15 cumecs while one small turbine unit will have design discharge of 5.70 cumecs.

The total head loss in the power system including all the components involving flow would be 14.73 m for unit-1 (large unit), 14.15 m for unit-2 (large unit) and 14.22 m for unit-3 (small unit) at full discharge.

8. MECHANICAL EQUIPMENT STUDIES

For the optimal use of the available hydropower potential, study was made of the hydrological data and other related parameters, the output of which was used to establish the type of turbine and number of units, for optimum output and trouble-free operation of the project.

The selection of turbine, along with its associated parts, and miscellaneous mechanical auxiliary systems, has been made for its optimum output with minimum losses. Two (2) units of 23.808 MW_m and 23.883 $MW_m$and One (1) unit 9.617 MW_m capacities (mechanical output of individual turbine at rated head and discharge) of vertical axis francis turbines will be installed in the powerhouse. The generating units have been designed to work at 10 % overload mechanically during the maximum flow season without developing any fatigue stresses in any moving part of the machine. It is pertinent to mention here that the installed capacity of the power plant is 55.032 MW_e, which is the maximum electrical power that can be generated when all units are in operation at the same time with their design discharges.

All mechanical equipment of the power plant, different auxiliary systems, and their operating mechanism, are made at feasibility level of proven design. Emphasis may be laid on reliability, easy operation and maintenance, and procedure for dismantling and assembly of parts of the machine.

The material and design of the underwater parts of the turbines are selected such that it should work without exceeding permissible stresses under rated unit discharges of 2 x 14.15 m^3/s (23.808 MW_m and 23.883 MW_m), 5.7 m^3/s (9.617 MW_m), and net rated heads of 184.42 m, 185.00 m m, and 184,93 m at runaway speeds (862 rpm for 23.808 MW_m, 873 rpm for 23,883 $MW_m$and 1008 rpm for 9.617 MW_m) of the machineries.

All the possible parameters are taken into accounts to minimize corrosion and sand abrasion to the possible extent on underwater parts of the turbine.

9. ELECTRICAL EQUIPMENT STUDIES

This section deals with the electrical equipment of Artistic-II Hydropower Project (55 MW). The feasibility level design aspects of the project including plant size, power plant equipment, generators, transformers, EHV, HV, MV and LV switchgear, power auxiliaries, batteries, control and monitoring, SCADA and Telecom System, have been developed and presented. The electrical equipment arrangement has been planned and laid out. It is proposed that all electrical equipment shall be designed, tested and supplied according to WAPDA/NTDC standards and specifications. Where WAPDA/NTDC standards and specifications are not available, International Standards such as IEC, BS, VDE, IEEE, ASTM, NFPA, ANSI etc. may be followed. Protective relays, PLC Communication System, Remote Satellite Communication with NPCC Islamabad and SCADA system manufactured and supplied from companies of West European origin which are proven to be reliable and compatible with NTDC/PESCO System are recommended.

The plant and electrical equipment proposed are listed below.

- Two 23 MW, 0.85 lagging power factor, 50 Hz, 11 kV, vertical shaft, synchronous generators complete with control, monitoring, protection and auxiliary systems.
- One 9 MW, 0.85 lagging power factor, 50 Hz, 11 kV, vertical shaft, synchronous generator completes with control, monitoring, protection and auxiliary systems.
- Three static excitation systems with Automatic Voltage Regulators (AVR).
- Three non-segregated phases 11 kV Busduct (NSPB) systems between generators and neutral cubicles, generators and phase cubicles, phase cubicles and generator step-up transformers.

- Three sets of 11 kV Generator Circuit Breakers (GCB) complete with all accessories.
- Three sets of generator phase cubicles complete with all accessories.
- Three sets of generator neutral earthing cubicle.
- Two 24/30 MVA (11/132 kV), 3 Phase, ONAN/ONAF, Transformers.
- One 10/12 MVA, (11/132 kV) 3 Phase, ONAN/ONAF, Transformer.
- Two 800 kVA 11/0.4 kV Station Service Transformers.
- One 4X200 kVA 11/0.4 kV Transformer for Housing Colony.
- One 50 kVA 0.4/11 kV and one 50 kVA 11/0.4 kV Transformer for Intake/Weir Site.
- 11 kV (MV) Switchgears.
- HV (132 kV) SF6 Gas Insulated Switchgear (GIS) and cable connection between step-up transformers and GIS.
- LV AC auxiliary supply systems for the Powerhouse, GIS and Weir Site;
- Two emergency diesel generating units, one 500 kVA at the Powerhouse, One 50 kVA Generator at the Intake/Weir Site.
- 110 V DC supply battery with charger and UPS systems for the Powerhouse and GIS.
- 48 V DC supply with charger for GIS.
- Protection Relays systems for the Powerhouse and Switchyard and auxiliary equipment;
- Supervisory Control and Data Acquisition (SCADA) system.
- Local Control System for weir site.
- Power and control cable systems;
- Earthing and Lightning Protection Systems;
- Power and Control cable systems;
- Lighting and small power installations;
- 11 kV overhead transmission line from Power Plant to Weir Intake.
- Electrical workshop.
- Communication and Security systems.
- Power Line Carrier Communication (PLCC) system.
- Independent metering system.

10. POWER EVACUATION & TRANSMISSION LINE

Discussions and study has been made regarding switchyards and grid stations in nearby area for power evacuation. The possible option is to connect to the downstream Gorkin Matiltan HPP Switchyard.

The transmission line 8 km long is recommended to be of cross section area 516.86 mm^2 "Rail" Aluminum conductor steel reinforced (ACSR), at 132 KV Double Circuit to evacuate power of 55 MW from Artistic-II HPP to Gorkin Matiltan HPP Switchyard.

The scope of work to include design, construction, supply and Erection of Towers, Tower Foundation, Conductors, Insulators/Hardware assemblies with all others required accessories with required equipment as per WAPDA/NTDC specifications.

The towers are recommended to be WAPDA/NTDC standardized towers (type ZM-1 to ZM-60 etc.). Standard ground clearance, tolerances, construction methodology, testing/commissioning are recommended to be followed as per international practice and WAPDA/NTDC standards.

All the accessories i.e. danger signs, number plates, phase plates, anti-climbing devices and step bolt etc. are recommended to be provided as per WAPDA/NTDC standards.

11. ENVIRONMENTAL IMPACT ASSESSMENT

The estimated power potential of Artistic-II Hydropower Project is 55.032 MW which falls in schedule "A "of IEE/EIA Regulations 2000. Thus, the Environmental Impact Assessments (EIA) has been carried out keeping in view the instructions contained in the Khyber Pakhtunkhwa (KP) Environmental Protection Act 2014, IEE/EIA Regulations 2000 and Technical guidelines prepared Pak EPA for Hydropower projects. These studies have identified alternative actions, mitigation activities, monitoring programme and other necessary aspects related to the social and environmental components of the project. They will be effectively incorporated into the Detailed Design and implementation process, which will help controlling environmental and social impacts to an acceptable level.

The proposed project is socio-environmentally friendly and sustainable. People agree with the proposed project but have the following reservations:

The electricity generated locally must be supplied to local population which has very little requirements, rest of the electricity may be utilized according to Government Policy. They agreed to provide their lands and property but needed full justice in entitlement matrix and demanded that compensation rates should be calculated on the existing market rates and payments should be made to the legitimate owners before commencement of project activities. They added that malpractices of all kinds must be checked and controlled by the responsible authorities and the process of estimation and payment should be transparent. Local population must be given preference in employment. They pointed out that they have ownership of the mountains in which tunnels will be excavated and constructed, for which compensation for muck should also be paid to them.

They also indicated that these mountains have vast grazing land which they lease out during summer seasons to shepherds of Buner area who pay rupee six lakh to the community. They stated that this important issue must be kept in the mind of the proponent so that they are not suffered economically.

They stated that the forest trees, land, river and their tributaries are under the sole ownership of the community on which litigation is going on with forest department. They further informed that the district administration is not implementing the decision of High court due to which they have stopped construction work on Matiltan HPP. They said that they will not sell out their land without receiving its compensation properly and in advance of starting construction work.

These studies have identified alternative actions, mitigation activities, monitoring programme and other necessary aspects related to the social and environmental components of the project. They will be effectively incorporated into the Detailed Design and implementation process, which will help controlling environmental and social impacts to an acceptable level.

12. TRANSPORTATION AND ACCESS ROADS

The Ushu River is not a navigable river for shipment and the province has no port where large ships can be moored. Therefore, the heavy equipment such as turbines and generators needed for the Project will be transported to the project site using inland transportation i.e. road network or railway track. Karachi or Qasim Ports are expected for the unloading seaport of the heavy equipment such as turbines and generators due to the port facilities and the connection for the road network, etc. National Highway 5 and 45 (N-5 and N-45) to the Project site are expected for the transportation route of the heavy equipment. The summary of the inland transportation is as follows.

National highway 5 (N-5) connected from Karachi and Qasim port to Peshawar passes through the western bank of the Indus River via the capital Islamabad and the main city such as Rawalpindi, Lahore and Hyderabad. It is the main route for the inland transportation of the whole country which has the longest highway having 1,756 km length. The bulk of the commercial and industrial activity is concentrated along the N-5 corridor and 60 % of entire traffic of the country is carried. N-5 has sufficient width and grade to get heavy transportation vehicles through, except the road maintenance partly. At present, N-5 will be utilized for transportation.

National highway 55 (N-55) connected from Hyderabad to Peshawar passes through the eastern bank of the Indus River via Ratodero, Shikarpur, Dera Ismail Khan. N-55 is also available for the inland transportation from Karachi and Qasim Port to Peshawar. However, the road condition is poor compared with N-5. In addition, for the transportation from Gwadar port to Peshawar, the federal government has planed the construction of Motorway 8 (M-8) between Gwadar Port and Ratodero that is connected to N-55, which is 90% completed (FWO). After completion of the construction of M-8, the transportation of the heavy equipment from Gwadar Port would be available to pass through M-8 and N-55 to Peshawar. While, N-45 leads from Nowshera to Chakdara from where N-95 branches leads to District Swat and the project location.

The roads within the project area (starting from Gorkin Matiltan HPP to Weir site almost 12 km) are narrow and unpaved. In some places, there are sharp bends and steep grades. These roads will need surfacing and some other necessary improvements also, e.g. widening, improving of radius of curvatures and moderating the steep grades. There are, however four major accesses which are as follows:

i. access to the power house
ii. access to the outlet tunnel portal
iii. access to the sand-trap and
iv. access to the right bank of the river in the general area of the conveyance system and Headworks.

At the left bank of the Ushu river, there is existing unpaved road through which headwork could be accessed. Over the weir, a permanent bridge will be constructed which will provide access to Intake structure, sandtrap and generally to the right bank of the river up to tunnel inlet portal. The road will be built on or to the side of box channel (running parallel to the box channel) starting from intake structure to tunnel inlet portal.

For construction of Adit tunnel, tunnel Inlet portal and sand trap, a temporary arrangement of access will be made during the low flow season at narrow section of the river. A new road that is about 735 m in length needs to be constructed.

One permanent bridge will be constructed for access of powerhouse. Including this bridge, the length of this new road is about 190 m. After this bridge there is another new road in 2 sections reaching the tunnel outlet portal and valve chamber and surge shaft. These roads have lengths of 1535 m and 1090 m, respectively.

13. CONSTRUCTION PLANNING & COST ESTIMATE

In order to complete the project in the shortest possible time, the construction schedule has been prepared so that the work can be taken up simultaneously on various activities independently at sites. The civil works will be taking about 36 months and erection of electromechanical works will take about 30.5 months. These works will start by the 4th month and 21st month respectively of the beginning of 2nd year. Accordingly, the first unit will be available for wet testing and commissioning at the end of 42nd month of the beginning of 2nd year as per construction schedule.

It is anticipated that, the construction of the entire project will be completed in about 48 months period. The sequence, in which the construction of various components of the project will be taken up, has been shown in Figure-14.1(Annexure 14B) at the end of chapter – 14.

The construction cost estimate of the Artistic-II Hydropower Project has been estimated and presented in this section. The total project construction cost of civil works has been estimated based on rates from recently completed hydropower projects of similar nature in the northern areas of Khyber Pakhtunkhwa.

In the case of cost of E&M equipment, due considerations have been given to the rates from on-going similar projects, engineering judgment to review the prevailing local market rates of different items of works and Current International market trends. Equipment which can be manufactured in Pakistan has also been priced accordingly.

The summary of cost estimate of the Artistic-II HPP is presented in **Table 3**.

Table 3: Summary of Cost Estimate of the Artistic-II HPP

ARTISTIC-2 HYDROPOWER PROJECT						
SUMMARY OF COST ESTIMATE						
S. No.	Description	Local Currency (PKR)	Foreign Currency, (US$ = 160 PKR as on May 15, 2020)		Total Cost of Each Item (US$)	Total Cost of Each Item (PKR)
		Civil Works (PKR)	Hydraulic Steel (HS) Works (US$)	Electro-mechanical (E&M) (US$)		
1	Preliminary Works	773,331,612			4,833,323	773,331,612
2	Diversion Works	18,551,618			115,948	18,551,618
3	Weir	713,996,672	693,484		5,155,964	824,954,190
4	Fish Ladder	13,254,246			82,839	13,254,246
5	Intake	97,713,993	822,032		1,432,745	229,239,146
6	Sandtrap	763,576,073	894,821		5,667,171	906,747,386
7	Box Channel	1,031,524,236			6,447,026	1,031,524,236
8	Forebay	501,741,258	735,109		3,870,992	619,358,704
9	Tunnel	5,035,781,532			31,473,635	5,035,781,532
10	Surge Shaft	411,817,274			2,573,858	411,817,274
11	Valve Chamber	200,892,679	15,813		1,271,392	203,422,679
12	Penstock	450,139,578	1,881,626		4,694,998	751,199,682
13	Powerhouse and Tailrace	826,140,276	181,235	17,714,565	23,059,177	3,689,468,326
14	Access Roads and Bridges	631,491,608			3,946,823	631,491,608
18	Dumping Site Protection	220,000,000			1,375,000	220,000,000
Sub total		**11,689,952,654**	**5,224,120**	**17,714,565**	**96,000,889**	**15,360,142,239**

		(US$)	(PKR)
A	Total Civil Works Cost	73,062,204	11,689,952,654
B	Total HS and E&M Works Cost	22,938,685	3,670,189,585
C	**Total Works Cost (A+B)**	**96,000,889**	**15,360,142,239**
D	Total Contingencies @ 3% on C	2,880,027	460,804,267
E	Transportation and Erection Charges of E&M Equipment @ 3% of B	688,161	110,105,688
F	**Total EPC Cost (C+D+E)**	**99,569,076**	**15,931,052,194**
G	Engineering Supervision of Civil and E&M Works @ 5% of F	4,978,454	796,552,610
H	Project Development Cost @ 5% of F	4,978,454	796,552,610
J	Environment & Resettlement Costs	5,193,076	830,892,160
K	Lenders Fees	1,921,973	307,515,680
L	Insurance during Construction @ 1.5% of F	1,493,536	238,965,783
M	Legal Costs @ 2.5% of F	2,500,000	400,000,045
N	Custom Duty @ 6.15% on E&M equipment (Bx1.06)	1,410,729	225,716,640
O	**Total Non EPC Cost (G+H+J+K+L+M+N)**	**22,476,222**	**3,596,195,527**
	Project Base Cost	**122,045,298**	**19,527,247,721**
P	Interest during Construction (IDC)	11,800,787	1,888,125,920
Q	**Total Project Cost (F+G+H+J+K+L+M+N+P)**	**133,846,085**	**21,415,373,641**

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1

INTRODUCTION

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INTRODUCTION

1.1 GENERAL

Electrical energy produced from the water resources is a green power as it is non-polluting and renewable in nature. Hydropower development is necessary for countries like Pakistan, where the peaking shortages, both seasonal and daily in power generation are very high, which can only be met with hydropower projects developed for diurnal peaking in a run-of-the river or reservoir scheme.

The total installed capacity of the hydropower stations in the country is about 6700 MW, out of which 3850 MW is in Khyber Pakhtunkhwa Province, 1699 MW in Punjab, 1039 MW in Azad Jammu & Kashmir (AJK) and 117 MW in the Gilgit Baltistan.

Khyber Pakhtunkhwa has an estimated power potential of generating nearly 30,000 MW. The need for development of these immense hydropower potential in the province cannot be over-emphasized. 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 and Public Private Partnership sectors.

In view of the above, the Government of KP has decided to announce a new hydro power policy which offers enhanced incentives and simplified processing mechanism for setting up of power generation plants to bridge the demand supply gap in the minimum time through generation of affordable electricity. This Hydro Power Policy 2016 offers profitable business opportunity, modern engineering and technical processes, lower costs of doing business so that local and international investors may fully participate as partners in the development of hydro power projects.

Hydropower potential in Khyber Pakhtunkhwa (KP) Provence especially in northern areas are very high and Pakhtunkhwa Energy Development Organization (PEDO) has been working on this dimension of development for the last three decades to achieve the self-sufficiency in the power sector, the organization is also encouraging public-private partnership and private investors. This effort has gained momentum in recent years. The present study is also an outcome of this effort of the PEDO.

1.2 CONSULTANCY SERVICES

Raw hydropower sites identified by Pakhtunkhwa Energy Development Organization (PEDO) in Khyber Pakhtunkhwa Province need to be explored in detail. In this regard, PEDO under Government of Pakistan (GOP) policy, is encouraging the private investors, to develop infrastructure and hydropower projects in the province.

In view of the above, PEDO has entered into an agreement with M/s Artistic Milliners (Pvt) Ltd, Karachi to develop Artistic-II HPP Raw Site at Ushu River, Kalam in District Swat of northern part of Khyber Pakhtunkhwa Province, Pakistan.

M/s Artistic Milliners (Pvt) Ltd., Karachi has entered into an agreement with JV of M/s BAK Consulting Engineers, Peshawar and M/s DOLSAR Engineering Inc. Co. Turkey to provide consultancy services for carrying out Feasibility Study of Artistic-II HPP.

1.3 PREVIOUS STUDY

The Artistic-II Hydropower Project site is a raw site and therefore, no previous reports / data exist at present. However, informations were obtained from previous studies of projects done in areas located adjacent or some distance from this raw site from the concerned departments i.e. PEDO, WAPDA etc. to be helpful for this study.

The data regarding the site have been collected and reviewed by a team of professionals and experts for its practicability and implementation and the requirement of topographic surveys and other field investigations required were determined.

Efforts has been initiated to collect reports/ literature regarding regional geological and tectonic maps and other reports on seismological aspects prepared by Geological Survey of Pakistan (GSP) and other relevant publications by the Department of Geology, University of Peshawar, Surface Water Hydrology Project WAPDA etc. The Consultants have also collected information and data from various departments relating to environmental and social parameters of the project areas.

1.4 PROJECT ACCESSIBILITY AND LOCATION

Artistic Hydro II (Pvt) Ltd. carried out the feasibility study of the 55 megawatt (MW) Artistic II Hydropower Project which is a run-of-river project and will be constructed on Ushu river in district Swat of Northern areas of Khyber Pakhtunkhwa province. The project proposed weir site is located 7 km upstream of diversion weir of 84 MW Gorkin-Matiltan HPP which is under construction at present and about 10 km downstream of Mahudand Lake tourist resort. The proposed powerhouse of the project is located about 240 m upstream of diversion weir of 84 MW Matiltan HPP. The project site is accessible through jeepable Kalam-Mahudand road which at present is unmettled. Coordinates of proposed weir and power house location are given in **Table** 1-1.

Table 1-1: Project Location Details

Location	Northing	Easting	River Bed Elevation
Weir / Intake	35°37'42.09"	72°41'5.68"	2499 masl
Power House	35°34'14.14"	72°40'19.23"	2302 masl

The location of the Artistic-II Hydropower Project is shown in **Figure 1-1.**

Figure 1-1 Project Location Map

1.5 PROJECT DESCRIPTION

Artistic II Hydropower Project (55 MW) is a run-of-river project and will be constructed on Ushu River in district Swat of Northern areas of Khyber Pakhtunkhwa province. From upstream to downstream it comprises of the following structures;

- Weir, Undersluice and Intake
- Sandtrap
- Box Channel
- Forebay
- Power Tunnel
- Adit Tunnel
- Surge Tank
- Valve Chamber
- Penstock
- Powerhouse
- Tailrace Canal
- Switchyard and Transmission Line
- Residential Colony
- Access Roads and Bridges
- Protection Works

The gross power to be generated at design discharge is estimated as 55.032 MW. The average annual energy generation of the project is estimated as 211.745 GWh.

1.6 PRESENT FEASIBILITY REPORT

Different Studies have been performed which are essential for the completion of Detailed Feasibility Report and are given below;

i.) Topographic survey of the whole project area with emphasis on details of the different project components such as access roads, main weir, box channel, sandtrap, headrace tunnel, tunnel portals, surge tank, penstock and powerhouse has been carried out. Important features of the site such as existing roads electric and telephone poles, houses, water courses, cultivated land and tress etc. were marked. The density of the observing points was considered for preparing a contour interval of 1m.

ii.) Hydrological studies have been performed to calculate the design flood and optimization of discharge for Artistic-II Hydropower Project. At the project location, instantaneous flow data or precipitation data is not available for 30 years, therefore, flows were generated from the data available for 49 years of Swat River at Kalam gauging station.

iii.) Historic suspended sediment and discharge observations are used to develop a sediment rating curve for the estimation of annual sediment inflow to the Artistic-II HPP weir site. In addition, regional analysis was also employed for comparison of sediment load estimated using sediment rating curve.

iv.) Geological and geotechnical investigations along with the engineering geological mapping of the project area with performance of discontinuity surveys for rock mass classification and characterization has been performed to develop geological / geotechnical models which are used for evaluation and design activities.

v.) Seismic Hazard Evaluation of the Artistic-II Hydropower Project has been carried out by studying of the 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, identification and characterization of potential seismic sources in the project region and evaluation of seismic hazard in accordance with the current practices.

vi.) Different possible layout alternatives have been studied by the consultants. The advantages and disadvantages of all the layout alternatives were compared in order to select the best alternative for further studies. The comparative costs and energy benefits were estimated and economic analyses were then conducted for different design discharges. The design discharge which has the annual maximum net benefit (difference of annual benefit and annual cost) was selected as the optimum one among others.

vii.) Mechanical equipment study has been performed based on the hydrological data and other related parameters, to establish the type of turbine and number of units, for optimum output and trouble-free operation of the project. The selection of turbine, along with its associated parts, and miscellaneous mechanical auxiliary systems, has been made for its optimum output with minimum losses. Two (2) units of 22.9 MW and One (1) unit 9.2 MW capacities (electrical output of turbine-generator-transformer at rated head and discharge) will be installed in the powerhouse.

viii.) The electrical equipment study has been performed for Artistic-II HPP based on a variety of factors, including economic, technical, environmental and operational consideration. The feasibility level design aspects of the project including plant size, power plant equipment, generators, transformers, EHV, HV, MV and LV switchgear, power auxiliaries, batteries, control and monitoring, SCADA and Telecom System, have been developed and presented.

ix.) Power evacuation and transmission line study has been carried out considering switchyards and grid stations in nearby area. The study revealed that the possible option is to connect the downstream Gorkin Matiltan HPP Switchyard. The transmission line 8 km long is recommended to be of cross section area 516.86 mm^2 "Rail" Aluminum conductor steel reinforced (ACSR), at 132 KV Double Circuit to evacuate power of 55 MW from Artistic-II HPP to Gorkin Matiltan HPP Switchyard.

x.) The estimated power potential of Artistic-II Hydropower Project is 55.032 MW which falls in schedule "A "of IEE/EIA Regulations 2000. Thus, the Environmental Impact Assessments (EIA) has been carried out keeping in view the instructions contained in the Khyber Pakhtunkhwa (KP) Environmental Protection Act 2014, IEE/EIA Regulations 2000 and Technical guidelines prepared Pak EPA for Hydropower projects. These studies have identified alternative actions, mitigation activities, monitoring programme and other necessary aspects related to the social and environmental components of the project. They will be effectively incorporated into the Detailed Design and implementation process, which will help controlling environmental and social impacts to an acceptable level.

xi.) Cost estimate and economic and financial analyses have been performed for the project in order to assess the project feasibility on the basis of EIRR and FIRR.

CHAPTER

2

POWER MARKET

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POWER MARKET

2.1 COUNTRY PROFILE

Located in South Asia, Pakistan, officially the Islamic Republic of Pakistan (Urdu: Islami Jumhuriyah Pakistan), shares an Eastern border with India (2,912km), a North-Eastern border with the People's Republic of China (523km), a South Western border with Iran (909km) and a Western and Northern edge with Afghanistan (2,530km). The Arabian Sea is Pakistan’s southern boundary with 1,064 km of coastline.

The name "Pakistan" means "Land of the Pure" in Sindhi, Urdu and Persian. It was coined in 1933 by Choudhary Rahmat Ali, who published it in the pamphlet “Now or Never”. The name was coined from the names of five territories that were proposed as constituents of a separate country for the Muslims of British India. Officially, the nation was founded as the “Dominion of Pakistan” in 1947, and was renamed as the Islamic Republic of Pakistan in 1956.

The country has a total area of 796,096 km² and is nearly four times the size of the United Kingdom. From Gwadar Bay in south-eastern corner, the country extends more than 1,800 km to the Khunjerab Pass on China’s border.

2.2 PAKISTAN ENERGY MARKET

2.2.1 INTRODUCTION

Electricity is the basic requirement of life and economy and most vital instrument of socioeconomic development of a country. Electricity has pivotal role in running machinery in factories and industrial units, for lighting our cities and powering our vehicles. Provision of electricity to all sectors of economy is a challenge for the government.

There has been an enormous increase in the demand of electricity as a result of industrial development and population growth, in comparison to enhancement in electricity production. Supply of electricity is, therefore, far less than the demand, resultantly crisis has emerged and load shedding has become a routine of the day.

2.2.2 HISTORY OF POWER DEVELOPMENT IN PAKISTAN

At the time of independence in 1947, Pakistan inherited about 60 MW of power generation capability for a population of 31.5 million, yielding 4.5 units per capita consumption. These were private sector owned power plants. However, the Government of Pakistan in 1952 by acquiring majority shareholding took control of the Karachi Electric Supply Company (KESC) engaged in generation, transmission and distribution of electric energy to the industrial, commercial, agricultural and residential consumers of the metropolitan city of Karachi and its suburbs.

In 1958, Water and Power Development Authority (WAPDA) was created as a semi-autonomous body for the purpose of coordinating and giving a unified direction to the development of in water and power sectors, which were previously being dealt with by the respective electricity and irrigation department of the provinces. In 1959, the generation capacity had increased to 119 MW and by that time the country had entered the phase of development, which required a dependable infrastructure, electricity being its most significant part. The task of power development was undertaken by WAPDA by executing a number of hydel and thermal generation projects, a transmission network and a distribution system, which could sustain the load of the rapid economic development.

After the first five years of its operation by 1964-65, the electricity generation capability rose to 636 MW. The task of accelerating the pace of power development picked up speed and by the year 1970, the generating capability rose from 636 MW to 1331 MW with installation of a number of thermal and hydropower units. In the year 1980 the system capacity touched 3,000 MW which rapidly rose to over 7,000 MW in 1990-91.

The rapid progress witnessed a new life to the social, technical and economic structures of the country. Mechanized agriculture started, industrialization picked up and general living standards improved. Due to fast economic development, the government could not keep momentum of development of power sector due to resource constraint. The government resources were limited and were not able to invest the required amount to power sector as it had responsibility for social sector as well more investment was needed. This resulted in heavy load shedding in 1990s.

2.2.3 INDUCTION OF PRIVATE SECTOR IN POWER GENERATION

In order to give enough impetus to the power sector, the government in 1985 declared the power sector as an industry and consequently power sector also became eligible for getting all the incentives that was available to industrial sector.

This did not prove successful and no private sector came forward for investment. In 1994 the government issued an investor friendly power policy that was very well received by national and international investors and more than the required amount of additional power generation capacity was committed by the government that caused power surplus situation.

The over commitment of additional power generation capacity was based on the presumption that economic growth will keep its momentum. But actually, it did not happen and economic growth slowed down that proved detrimental to the economy as the government had to pay capacity charges to the investors as per power policy and the agreement signed with the investors.

2.2.4 POWER POLICY

In order to eliminate power shortage/load shedding in the minimum possible time, the Government constituted an Energy Task Force in 1993 to devise a consolidated and comprehensive policy for revamping the energy sector. On the recommendations of the Energy Task Force, the Government announced a "Policy Framework and Package of Incentives for Private Sector Power Generation Projects" in March 1994 for a large-scale induction of private sector in power development and the terms for Independent Power Producer (IPPs) were standardized.

Under this policy, the government offered a fix levelized tariff of USD 0.0557/kWh to the prospective investors (USD 0.061/kWh average for 1-10 years) and a number of other incentives to attract foreign investment in the power sector.

The Power Policy 1994 helped in overcoming load shedding in the country. Rather, it resulted in surplus power as the actual load growth was much less than that projected and the projects were contracted beyond requirement. Moreover, the Policy attracted only thermal projects resulting in reversal of the hydro/thermal generation mix.

In order to provide one window facility to new investors in the power sector the Government of Pakistan (GoP) created a new organization, the Private Power and Infrastructure Board (PPIB), to negotiate agreements with sponsors and provide assistance in obtaining necessary government consents through a 'single window'. This power policy resulted in an enthusiastic response from the international investor community. The bulk supply tariff offered to the IPPs became a controversial issue as consumer tariffs had to be increased to meet the substantial financial commitments made for the IPP construction projects.

The 1994 power policy was only for a limited period and in 2002, the government issued a new policy (the 2002 Power Policy), which basically has the same structure and set of incentives as the 1994 policy but is broader in terms of its applicability.

The government's new power policy (2002) encourages solicited and unsolicited proposals for the establishment of new power plants. Unsolicited proposals allow investors to install a power plant at a location of their choice while solicited proposals give the government the opportunity to locate proposed power plants as it desires, generally, close to a load center. However, the 2002 power policy could not bring same result due to one reason or the other.

2.2.5 RESTRUCTURING/ UNBUNDLING OF POWER WING OF WAPDA

In the past there were two vertically integrated power supply companies operating in Pakistan, i.e. Water and Power Development Authority (WAPDA) and Karachi Electric Supply Corporation (KESC). WAPDA was responsible for supplying electricity to various sectors of the economy across the country apart from the greater metropolis of Karachi which is supplied by the KESC. However, with the passage time and unprecedented expansion of WAPDA was witnessed thereby losing control of the government which resulted in en-efficiencies and governance issues. Therefore, the government decided to restructure the power wing of WAPDA. Under the restructuring plan all the power generation, transmission and distribution formations were made separate corporate entities leading to privatization. Accordingly, the power wing of WAPDA has been unbundled into ten Distribution and four Generation companies and one Transmission and Dispatch Company known as the National Transmission and Dispatch Company (NTDC).

These fourteen (14) corporate entities are:

→ **Ten (10) Distribution Companies (DISCOs) as under:**

- Lahore Electric Supply Company (LESCO)
- Gujranwala Electric Power Company (GEPCO)
- Faisalabad Electric Supply Company (FESCO)
- Islamabad Electric Supply Company (IESCO)
- Multan Electric Power Company (MEPCO)
- Peshawar Electric Power Company (PESCO)
- Hyderabad Electric Supply Company (HESCO)
- Quetta Electric Supply Company (QESCO)
- Tribal Electric Supply Company (TESCO)
- Sukkar Electric Power Company (SEPCO)

→ **Four (4) Thermal Power Generation Companies (GENCOs)**

- Southern Generation Power Company Limited (GENCO-1) head quarter at Jamshoro district Dadu near Hyderabad Sindh.
- Central Power Generation Company Limited (GENCO-2) head quarter at Guddu district Jacobabad Sindh.

- Northern Power Generation Company Limited (GENCO-3) headquarters at TPS Muzaffargarh district Muzaffargarh Punjab.
- Lakhra Power Generation Company Limited (GENCO-4) Headquarter at WAPDA House Lahore.

→ **One (1) National Transmission & Power Dispatch Company (NTDC).**

These un-bundled companies are being controlled by another newly created company called Pakistan Electric Power Company (PEPCO) working under the Ministry of Water & Power. The water wing of WAPDA was not touched and it remained responsible for controlling dams and hydro generation installed in the country in public and private sector.

The function of NTDC is to control national transmission & grid network and economical dispatch of hydro & thermal power generation by various companies connected through the national grid system. It is also responsible for development, operation and maintenance of National Grid system of the country (i.e. primary grid system).

2.2.6 GENERATION CAPACITY AND ENERGY MIX

Oil, Gas, Hydropower and Nuclear Power are the sources of energy generation in Pakistan. While Hydro and Nuclear are used only for electricity generation with reference to energy, Oil and Gas are used to supply other areas also. Although Pakistan has one of the largest coal reserves in the world which remain under-utilized and their share in energy supply is insignificant at the moment.

Production of crude oil per day has increased to 86,533 barrels during 2013-14 from 76,277 barrels per day during the same period last year, showing an increase of 13.5 percent. During the same period the transport sector consumed 48.8% of the petroleum products, followed by power sector (42.7%), domestic (0.5%), industrial (6.1%), other government (1.7%), and agriculture (0.20%). The increase went on the next year (2014-15) to 94,493 barrels per day in the same rate as that of the previous year. The annual production of the crude oil has decreased during year 2015-16 to 31,652,000 barrels as compared to the previous year 2014-15 which was 34490000 barrels. While in the year 2016-17 an increased has been observed from 31,652,000 barrels to 32,269,000 barrels annually.

The average production of natural gas per day stood at 4,092 million cubic feet during July to March 2013-14, as compared to 4,126 million cubic feet over the same period last year, showing a decrease of 3.4%. The overall production of gas has decreased to 1,493,508 million cubic feet during July to March 2013-14 as compared to 1,505,841 million cubic feet daily in the same period in 2012-13, showing decrease of 0.8%. The daily production of natural gas has increased in the year 2015-16 as compared to 2014-15 from 4016 million cubic feet (mcf) to 4059 (mcf) respectively which was again decreased to 4032 (mcf) in the next year 2016-17.

Pakistan has large indigenous coal reserves estimated at over 186 billion tons which are sufficient to meet the energy requirements of the country on long-term basis. Apart from indigenous coal resources, there has been significant increase in import of coal as well due to commissioning of new power plants based on imported coal at Sahiwal and Port Qasim. However, domestic production of coal is expected to increase in the coming years with projects on Thar coal. During the period of 2016-17 the daily coal production was 10,883 tons as compared to 10,272 tons in the year 2015-16 showing an increase of about 5.46 percent.

Hydropower plants are considered one of the most capital-intensive projects and for a country like Pakistan, it is not possible to undertake such big projects without the financial support of international development agencies - a fact which brings in its own share of peculiarities and challenges.

During July - March FY2019, installed capacity of electricity reached 34,282 MW, which was 33,433 MW in corresponding period last year, thus, posting a growth of 2.5 percent. Although electricity generation varies due to availability of inputs and other constraints, the generation increased from 82,011 GWh to 84,680 GWh, posting a growth of 2.1 percent during July - March FY2019. Figure 2-1 gives the comparison of installed capacity (MW) and generation (GWh).

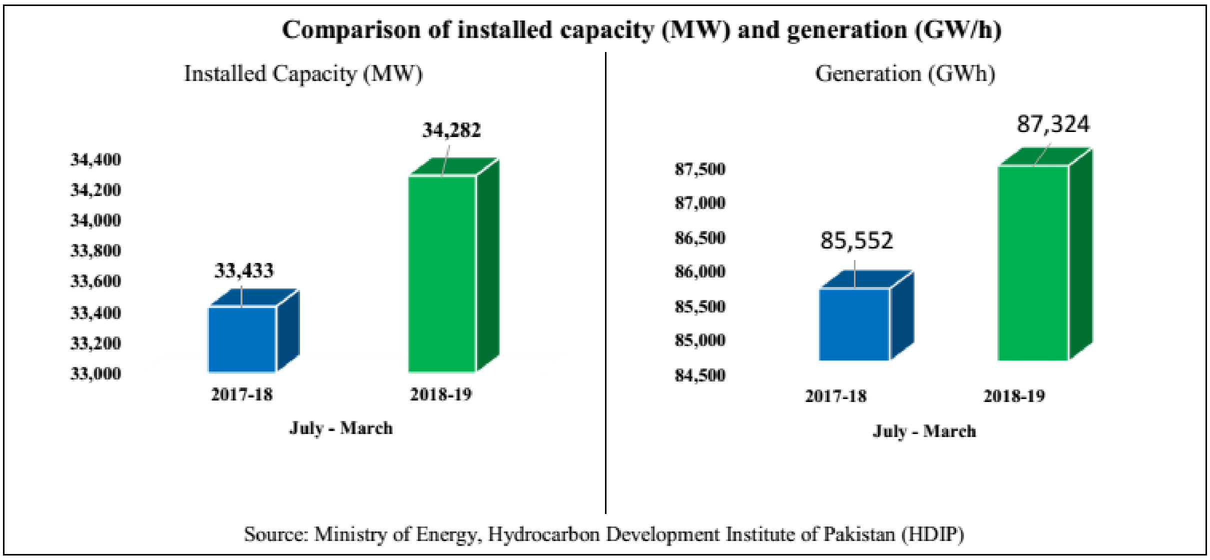


Figure 2-1 Comparison of Installed Capacity (MW) and Generation (GWh)

2.2.7 SHARE IN ELECTRICITY GENERATION

As far as the share of different sources of electricity generation is concerned, it can be observed that the share of hydro in electricity generation has decreased over the last few decades. Availability of water is also one of the main reason for reduced generation from hydel power plants. Currently, thermal has the largest share in electricity generation. Gas and Regasified Liquefied Natural Gas (RLNG) are other cheaper sources. RLNG tremendous growth in energy mix has helped supply the demand to various power plants (Bhikki, Haveli Bahadur Shah, Balloki, Halmore, Orient, Rousch, KAPCO, Saif and Sapphire) while, the remaining was supplied to fertilizer plants, industrial and transport sector.

As an alternate, the government showed commitment for electricity generation capacity through renewable energy sources. During July-March FY2019, there was an increase of 1 percent in share of renewables in electricity generation, and it is expected that the share will increase in coming yearsas well. The comparison of share of different sources of electricity generation is given in Figure **2-2**.

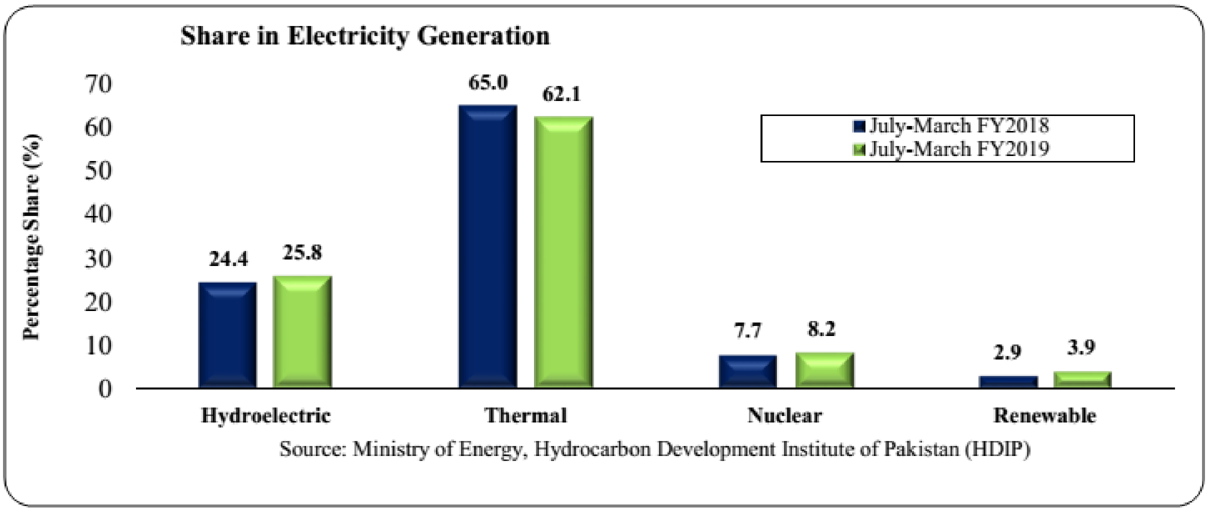
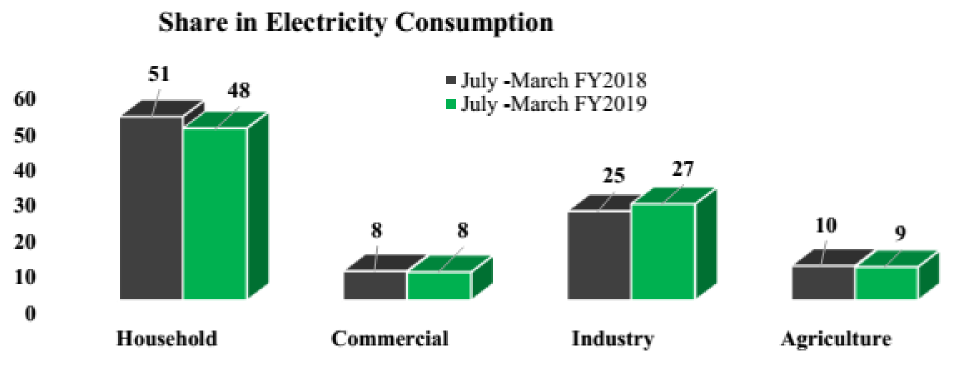


Figure 2-2 Share in Electricity Generation

2.2.8 ELECTRICITY CONSUMPTION

Regarding consumption pattern, there is no significant change in the consumption pattern of electricity. However, during July - March FY2019, the share of household and agriculture in electricity consumption has been decreasing which is indicating that people are trying to rationalize the usage due to increase in its tariff. The increase in the share of industry in electricity consumption is a positive sign showing revival of industry which was suffering earlier due to load shedding. The comparison between consumption patterns of electricity during July-March FY2019 with corresponding period last year is shown below in Figure 2-3.



Source: Ministry of Energy, Hydrocarbon Development Insititute of Pakistan (HDIP)

Figure 2-3 Share in the electricity consumption

2.2.9 POWER CRISIS

An increase in industrialization is accompanied by an increase in electricity demand. The nonavailability of natural resources for expansion of the power sector has widened the gap between demand and supply, which has resulted in excessive and frequent load shedding. The shortfall in supply could be the major cause for stunned growth in the industrial sector in Pakistan. At the moment industrial units are facing a dichotomous situation where market forces demand increased production, especially of consumer products, while the utility infrastructure fails to keep pace with this requirement. This dilemma is typical for organizations which see the potential for enhancing the market share of their products but are facing constraints in the reliability and supply of electricity.

The demand for electricity has continued to increase by out pacing the growth rate of the economy. A power shortage was likely to appear in 2006 which did and forced the utilities to go for load-shedding. Currently as per the “State of Industry Report 2018, NEPRA“ the shortfall has reduced to 374 MW for peak hours which has inturn reduced the load shedding throughout the country to a large extent. The same report predicts that by the end of June 2020, this shortfall will be overcomed and a surplus of 737 MW will be achieved.

The installed capacity does not fully contribute to energy production due to various factors like auxiliary consumption, impact of site reference conditions and seasonality effects on the renewables and large hydropower plants. After accounting for above factors, the capacity; known as the Generation Capability, is effectively used for meeting the electricity demand. The data about generation capability and future demand as reported by NTDC is shown in Table 2-1. It may be noted that in the years 2019 and 2020, the generation capability would just be close to the demand, whereas in subsequent years the capability would be more than the demand.

Table 2-1 Surplus/Deficit in Demand and Supply NTDC’s System

Year ending 30th June	Installed Capacity (NTDC System) (MW)	Planned Generation Capability as per NTDC (MW)	NTDC's Projected Demand Growth Rate (%)	NTDC's Projected Demand during Peak Hours (MW)*	Surplus/ Deficit (MW)
2019	35,870	26,887	3.90	27,261	-374
2020	37,834	28,892	4.10	28,155	737
2021	42,078	31,184	3.80	29,325	1,859
2022	50,852	35,883	3.90	30,921	4,962
2023	54,532	37,786	3.90	31,953	5,833
2024	58,318	39,196	3.80	33,696	5,500
2025	60,183	37,935	3.90	35,422	2,513

* *NTDC develops the Demand Projections of Peak Demand only.*
- *Electricity Demand Forecast based on Regression Report (Period 2018-2040)*
- *Summary of Power Balance based on latest IGCEP 29 October, 2018*

Source: NTDC

2.2.10 STATUS OF THE HYDRO GENERATION

Hydropower makes a significant contribution to electricity generation in Pakistan, representing around 25% of capacity and 21% of generation. In 2017-18, hydro power capacity had a utilisation rate of 44% although this ranges widely during the year due to the seasonal nature of Pakistan's water resources.

The nation's hydro capacity has remained fairly constant over the last five years but is currently in focus as Pakistan makes major efforts to increase capacity.

"The NEPRA 2017 State of Industry Report" notes there is 13.6 GW of hydro capacity additions planned out to 2025. However, Pakistan's hydro plans extend much further than this. WAPDA's current hydro development pipeline lists 6.3 GW of projects under construction, 13.6 GW ready for construction, and a further 6.8 GW identified as projects 'for the future'. In addition, there are 6.1 GW of IPP hydro projects on the Private Power and Infrastructure Board's (PPIB) development list (Source: PPIB, Upcoming IPPs, August 2018).

The installed capacity of WAPDA Hydropower increased to 8,341 MW in FY 2017-18 as compared to 6,902 MW, recorded in FY 2016-17 owing to addition of 969 MW Neelum Jhelum HPP and one unit of Tarbela 4th Extension having capacity of 470 MW, whereas the 26,951 GWh generated in FY2017-18 shows a decrease of 4,140 GWh from the last year due to several reasons.With regards to the Hydel IPPs, they contributed 130 GWh more energy in the system during FY 2017-18 as compared to FY 2016-17 owing to addition of 147 MW Patrind HPP and 8 MW Marala HPP. The hydropower production pattern over the year shows a downward trend as compared to the historical trendsowing to seasonal variations and water flows. The availability and overall performance of major hydropower plants including Tarbela and Mangla remained satisfactory during the year FY 2017-18 (Source: The NEPRA 2018 State of Industry Report).

Installed power generation capacity of Pakistan as of June 30, 2018 stands at 36,010 MW, of which 33,126 MW is connected with NTDC system whereas 2,884 MW is connected with K-Electric Limited (KEL) system. Source wise installed capacity for the years 2016-17 and 2017-18 is shown in Table 2-2. It may be noted that close to 5,000 MW of thermal capacity was added in the PEPCO system during the period; an increase of 27% over the last year. About 1,600 MW of hydro-based capacity was also added in the system during the same period.

Table 2-2 Source Wise Installed Capacity by Type (MW)

As on 30th June	2017	2018	Variation	
			Capacity	%
A. PEPCO/NTDC SYSTEM				
A.1 HYDEL				
WAPDA Hydel	6,902	8,341	1,439	20.85
IPPs Hydel	214	372	158	73.83
TOTAL HYDEL	**7,116**	**8,713**	**1,597**	**22.44**
A.2 THERMAL				
GENCOs with PEPCO	5,897	5,637	-260	-4.41
IPPs	10,566	15,297	4,731	44.78
SPPs/CPPs	340	340	--	--
CHASNUPP (I, II, III & IV)	1,005	1,330	325	32.34
TOTAL THERMAL including Nuclear	**17,808**	**22,604**	**4,796**	**26.93**
A.3 RENEWABLE ENERGY (WIND, SOLAR AND BAGASSE)				
RE Power Plants connected with PEPCO	1,465	1,809	344	23.48
TOTAL PEPCO/NTDC	**26,389**	**33,126**	**6,737**	**25.53**
B. K-ELECTRIC SYSTEM				
KEL Own	1,874	2,294	420	22.41
IPPs Connected with KEL	252	366	114	45.24
SPPs/CPPs connected with KEL	87	87	0	0
KANUPP	137	137	0	0
TOTAL KEL	**2,350**	**2,884**	**534**	**22.72**
Total Installed Capacity of the Country	**28,739**	**36,010**	**7,271**	**25.30**

Source: NTDC/KEL

For future generation additions, the plans provided by NTDC last year, projected capacity additions of around 30,000 MW in NTDC system over next seven years, so that more than 62,000 MW of installed capacity would be expected by the year 2025. As reported in NEPRA State of Industry Report 2017, no renewable energy plants based on wind and solar were foreseen after 2021, which was contrary to the stated policy of the Federal Government (Source: The NEPRA 2018 State of Industry Report).

2.3 WHY TO INVEST IN POWER SECTOR IN PAKISTAN

Pakistan currently has 36.01 GW of installed capacity for electricity generation. Conventional thermal plants (oil, natural gas, coal) account for 66.71% of Pakistan's capacity, with hydroelectricity making up 24.20%, whereas nuclear and renewable (wind, solar and bagasse) make up the remaining 4.07% and 5.02%, respectively. The current supply, however, is unable to satisfy the electricity demand of the local market during peak hours resulting in an acute shortage of 374 MW. The NTDC estimates that by 2019, Pakistan's demand for electricity during peak hours will reach 27,261 MW and the country will have to increase its generating capacity to meet the increasing demand.

Major reasons for the energy crises include:

i. Lack of investment in power sector.
ii. Depleting gas reserves.
iii. Increasing reliance on foreign fuel based power generation sources.

In light of the prevailing circumstances, hydropower generation appears to be a viable and environmental friendly alternative for meeting Pakistan's growing electricity demands over the long-run. The development of hydropower generation projects could reduce dependence on oil based thermal power generation, increase diversity in Pakistan's electricity generation mix, and reduce greenhouse gas (GHG) emissions, all of which will contribute towards projecting a positive image of Pakistan within the international community. Also, the per kWh tariff for hydro power projects are comparatively lower than that of furnace oil projects.

Government of Pakistan is cognizant of the fact that they need to develop indigenous sources of energy to overcome the current energy crises to achieve sustainable development. Ministry of Water and Power, PPIB and AEDB and state energy departments are putting lot of efforts in progressing hydro energy in the country. The Government of Pakistan also acknowledges the above stated facts and Policy for Development of Renewable Energy 2006 offers many incentives for IPP developers because alternatives to further fuel imports for electricity generation are the use of domestic coal, or generation from hydro-electric or other renewable sources, such as wind, solar and hydropower; further supplemented by HPP policies issued under state energy departments. These options will assist in reducing Pakistan's reliance on imported oil, and resulting vulnerability to changes in global oil prices, and will in turn also have a positive effect on the current trade deficit and inflating import bill.

As with gas, securing future supplies of domestic coal would require significant spending on infrastructure. While Pakistan has domestic reserves of coal, it currently makes up a very small proportion of the country's total power generation. This is due, in part, to the fact that most of the reserves are located in the remote Thar Desert region. Exploiting the coal reserves would require significant upfront investment in local infrastructure (including provision of water supplies), development of mines, housing and related infrastructure, and investment in transmission lines, as a pre-requisite to any power plant development. Hydroelectric power already supplies almost 30% of the domestic electricity that is generated, and numerous sites for future investment exist and are solicited by federal and provincial agencies.

So, the GOP has identified hydro as one of the feasible renewable energy resources for power generation in the short and long term. The technology is already present in abundance in Pakistan, it has a globally proven track record, recognized commercial viability and an installed base of over 1055 GW around the globe (over 323 GW of which is installed in China and India alone), making the case for further development of hydro energy in Pakistan very strong.

The hydropower sector has been a crucial and core component of the energy mix since the inception of Pakistan. The total installed capacity of Pakistan's hydropower stations up till 2014 is about 6795 MW. Out of this total installed hydel generation capacity, the largest share is of KPK, with a total of 3767 MW. Moreover, there are 1698 MW in Punjab, and 1036 MW in Azad Kashmir. It is to be noted that the KPK has an even greater potential, Malakand-III is a project on Swat River with an 81 MW (WAPDA, 2013). Thus this potential needs to be tapped on urgent basis.

Pursuant to the "Khyber Pakhtunkhwa Hydro Power Policy - 2016" the Pakhtunkhwa Energy Development Organization (PEDO) has entered into an agreement with M/s Artistic Milliners (Pvt) Ltd, Karachi to develop Artsitic-II HPP at Ushu River, Kalam in district Swat.

The license for the said project was issued by Pakhtunkhwa Energy Development Organization (PEDO) in August 03, 2018. The project is an Independent Power Producer (IPP) project which is going to be constructed in district Swat and is going to supply electricity to proposed 220 KV Double Circuit common transmission line from 84 MW Gorkin Matiltan HPP towards 88 MW Gabral Kalam HPP and onward to 220 KV Chakdara Grid Station.

M/s Artistic Milliners (Pvt) Ltd., Karachi has entered into an agreement with JV of M/s BAK Consulting Engineers, Peshawar and M/s Dolsar Engineering Inc.Co. of Turkey to provide consultancy services for conducting Feasibility Study of Artistic-II 43.35 MW Raw Site at Ushu River, Kalam in district Swat. In this regard, an agreement was signed between M/s Artistic Milliners (Pvt) Ltd., Karachi and JV of M/s BAK Consulting Engineers, Peshawar and M/s Dolsar Engineering Inc. of Turkey on October 4, 2018 to carry out Feasibility Study of above site.

2.4 GLOBAL HYDRO ENERGY INDUSTRY

2.4.1 HYDRO ENERGY FUNDAMENTALS

Hydroelectric schemes are the largest contributor of electricity from renewable sources worldwide and it is estimated that 20% of the world's electricity is generated from such schemes. Hydro schemes may be classified as either 'impoundment' or 'run of river'.

The majority of large hydro stations are based around the use of a dam and impoundment reservoir. Impoundment schemes have an advantage over other renewable energy technologies in that using a dam or weir to store water in a reservoir means it can be used when it is needed most. Run of River schemes normally divert water from a river by the building of a diversionary weir which diverts water from a river into an intake which then passes through a generator and the water is returned some distance down the river.

Small run-of-the-river hydropower systems consist of these basic components:

- Water conveyance - channel or Tunnel, pipeline, or pressurized pipeline (penstock) that delivers the water.
- Turbine or waterwheel - transforms the energy of flowing water into rotational energy.
- Alternator or generator - transforms the rotational energy into electricity.
- Regulator - controls the generator.
- Wiring - delivers the electricity.

Hydro power is produced by simply using a body of moving water to turn a turbine. This is normally achieved by passing the water down a closed pipeline or through a closed culvert which then turns the turbine and the revolutions of the turbine convert mechanical energy through the generator into electricity.

Generation potential of a site is dependent on three overriding factors - the head, the flow of water available and the rainfall characteristics of the site. The head of water refers to the vertical distance from the intake at the top of the scheme and the floor level of the turbine at the bottom of the scheme.

Hydroelectric schemes can be divided into three basic categories:

- low head schemes, which could be built using a head of between 5 - 25 metres
- medium head schemes, which would be in the region of 25 - 50 metres
- high head schemes, which would be 50 metres and over and have been built up to heads of 300m and more.

The flow of water is normally expressed in cubic metres per second or litres per second and refers to the quantity of water used by the scheme to turn the turbine. Water availability must be accurately measured before calculations regarding cost, compensation water availability and the energy generation potential of a scheme can be calculated. High head schemes would normally be associated with an impoundment reservoir, impoundment can also be used for low head schemes. Hydro technology has been used for some 70 years for both large and small schemes and it is a credit to early turbine designers that even the most modern machinery has only increased in efficiency by a maximum of 3%. The machinery is therefore well understood and proven technology for generating electricity wherever there is sufficient flow in a river or burn. The type of scheme will determine the need to build a diversionary weir or a dam and reservoir.

2.4.2 DESCRIPTION OF HYDRO TURBINES

The waterwheel is the oldest hydropower system component. Waterwheels are still available, but they aren't very practical for generating electricity because of their slow speed and bulky structure. Turbines are more commonly used today to power small hydropower systems. The moving water strikes the turbine blades, much like a waterwheel, to spin a shaft. But turbines are more compact in relation to their energy output than waterwheels. They also have fewer gears and require less material for construction.

There are two general classes of turbines: impulse and reaction. Impulse turbines, which have the least complex design, are most commonly used for high head small hydro systems. They rely on the velocity of water to move the turbine wheel, which is called the runner. The most common types of impulse turbines include the Pelton wheel and the Turgo wheel.

The Pelton wheel uses the concept of jet force to create energy. Water is funneled into a pressurized pipeline with a narrow nozzle at one end. The water sprays out of the nozzle in a jet, striking the cupped buckets attached to the wheel. The impact of the jet spray on the curved buckets creates a force that rotates the wheel at high efficiency rates of 70 to 90 percent. Pelton wheel turbines are available in various sizes and operate best under low-flow and high-head conditions.

The Turgo impulse wheel is an upgraded version of the Pelton. It uses the same jet spray concept, but the Turgo jet, which is half the size of the Pelton, is angled so that the spray hits three buckets at once. As a result, the Turgo wheel moves twice as fast. It's also less bulky, needs few or no gears, and has a good reputation for trouble-free operations. The Turgo can operate under low-flow conditions but requires a medium or high head.

Reaction turbines, which are highly efficient, depend on pressure rather than velocity to produce energy. All blades of the reaction turbine maintain constant contact with the water. These turbines are often used in large-scale hydropower sites. Reaction turbines exploit the oncoming flow of water to generate hydrodynamic lift forces to propel the runner blades. They are distinguished from the impulse type by having a runner that always functions within a completely water-filled casing. Because of their complexity and high cost, they aren't usually used for micro hydro projects. An exception is the propeller turbine, which comes in many different designs and works much like a boat's propeller.

Propeller turbines have three to six usually fixed blades set at different angles aligned on the runner. The bulb, tubular, and Kaplan tubular are variations of the propeller turbine. The Kaplan turbine, which is a highly adaptable propeller system, can be used for micro hydro sites.

The Spiral Case Francis turbine is essentially a modified form of propeller turbine in which water flows radially inwards into the runner and is turned to emerge axially. For medium-head schemes, the runner is most commonly mounted in a spiral casing with internal adjustable guide and stay vanes.

2.4.3 GROWTH TRENDS OF HYDRO INDUSTRY[1]

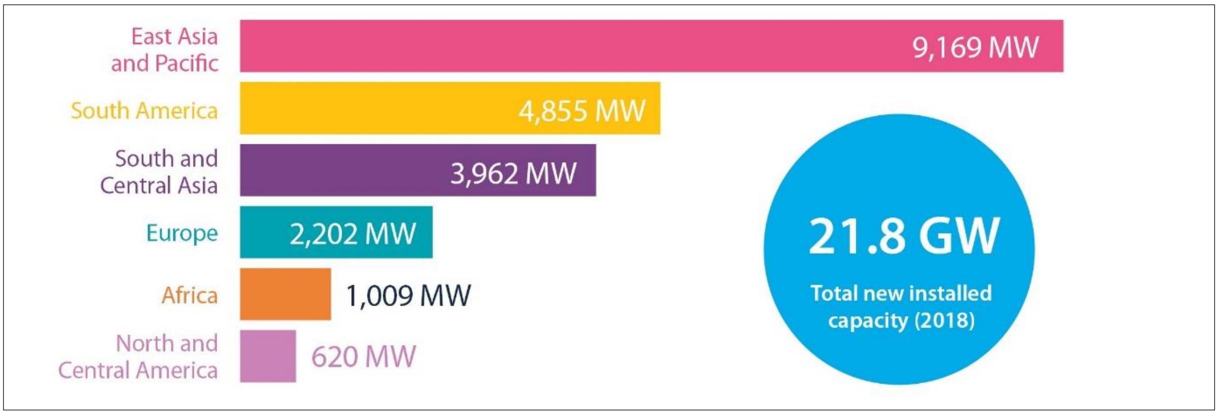
In 2018, electricity generation from hydropower reached an estimated 4,200 terawatt hours (TWh), setting the highest ever contribution from a renewable energy source.

An estimated 21.8 gigawatts (GW) of hydropower capacity was put into operation last year, including nearly 2 GW of pumped storage, bringing the world's total installed capacity to 1,292 gigawatts (GW).

The East Asia and Pacific region once again held its position as the fastest growing last year, with 9.2 GW of hydropower installed capacity added. It was followed by South America (4.9 GW), South and Central Asia (4.0 GW), Europe (2.2 GW), Africa (1.0 GW) and North and Central America (0.6 GW).

Forty-eight countries added hydropower capacity in 2018. The countries with the highest individual increases in installed capacity were China (8.5 GW) and Brazil (3.7 GW). Among the top five were Pakistan (2.5 GW), Turkey (1.1 GW) and Angola (0.7 GW).

With Brazil reaching 104 GW in installed capacity, the South American nation has now overtaken the United States (103 GW) as the second largest country by hydropower capacity. The new installed capacity by region in given in Figure **2-4** and by country is given in the Figure 2-5.



[1] International Hydropower Association – 2019 Key Trends in Hydropower.

Figure 2-4 New Installed Capacity by Region in the year 2018.

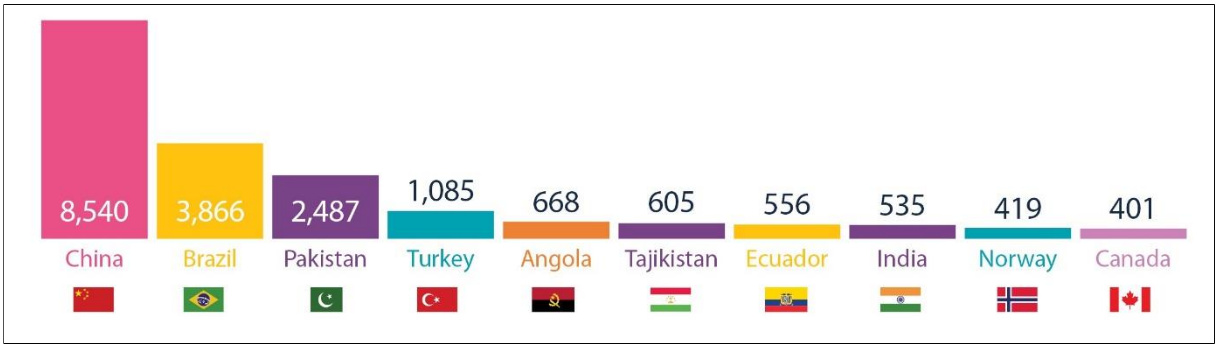


Figure 2-5 New Installed Capacity by Country in the year 2018.

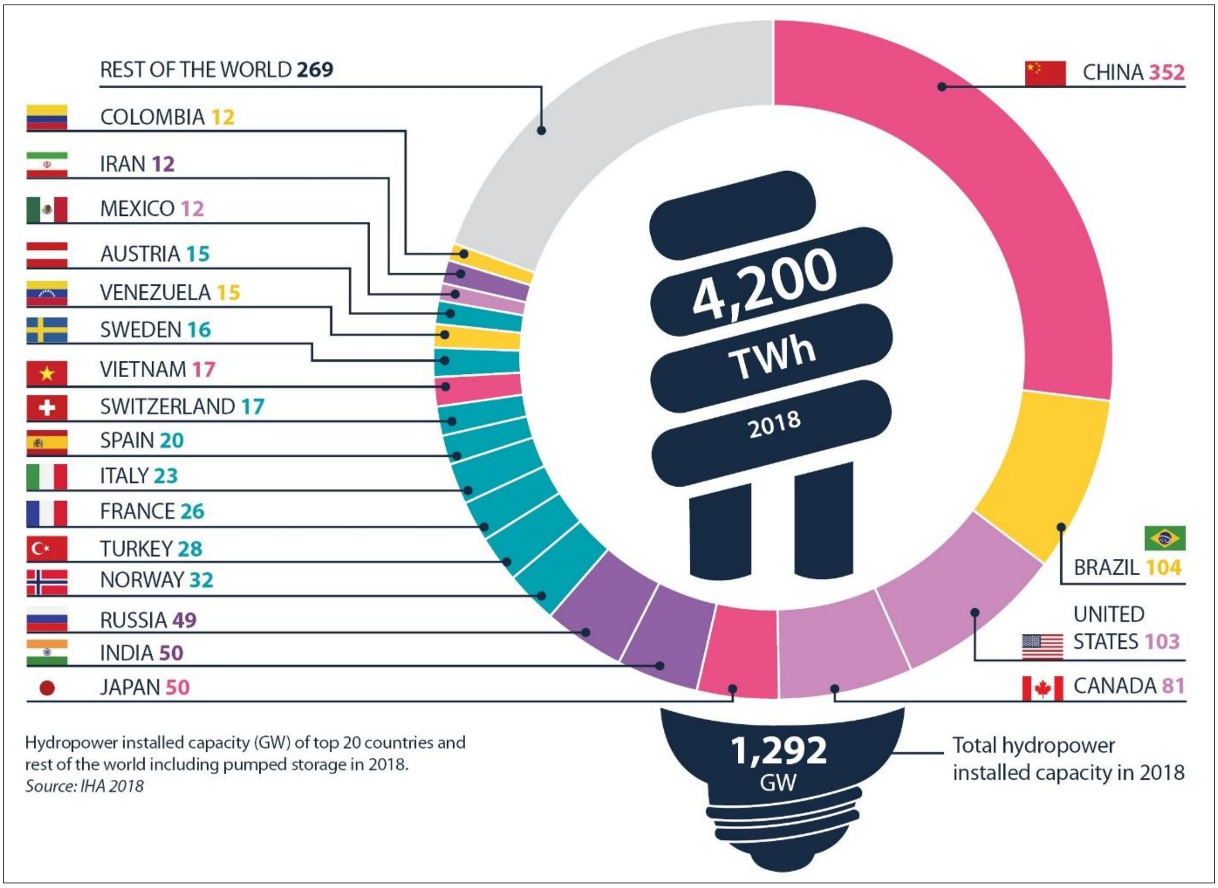


Figure 2-6 Distribution of Hydropower Generation Across the Globe (2018)

Globally, drivers for hydropower's strong showing include a general increase in demand not just for electricity, but also for particular qualities such as reliable, local, clean and affordable power. Looking forward, there remains significant undeveloped potential across all world regions, particularly in Asia, Africa and Latin America. Demand for electricity and other related reservoir services is also high in these areas, forming a strong foundation for continued growth in hydropower.

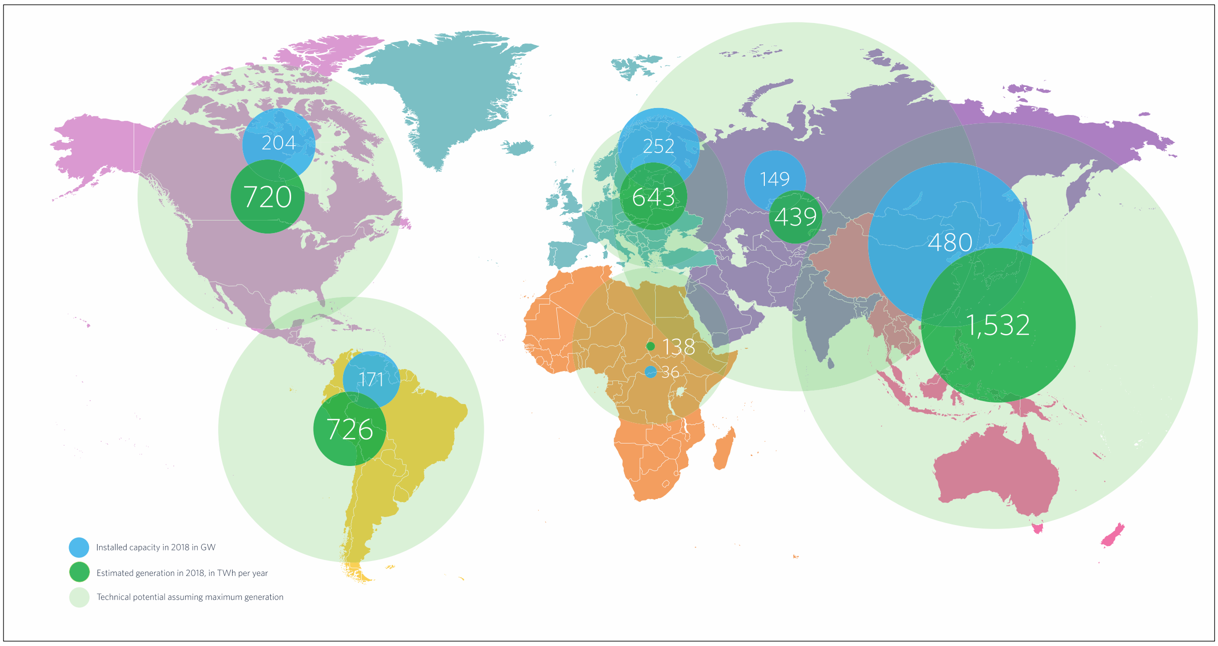


Figure 2-7 Comparison of Power Generation & Hydropower Potential Across the Globe

2.4.4 REGIONAL TRENDS IN BRIEF

2.4.4.1 NORTH AND CENTRAL AMERICA

Hydropower remains the dominant electricity source across North and Central America, although year-on-year growth in hydropower installed capacity is the lowest on a global scale. In 2018, 575 MW of conventional hydropower capacity was added in Canada, while the United States and Central America added a further 80 MW in 2018. Canada has four major hydropower projects under construction, which will add another 2,900 MW of capacity over the next five years.

2.4.4.2 SOUTH AMERICA

South America was the second fastest growing region, adding 4,855 MW in installed hydropower capacity in 2018. Brazil contributed 80 per cent of the region’s added hydropower capacity and is the second fastest growing country in the world after China. Brazil has now overtaken the USA as the world’s second largest country by installed hydropower capacity. Climate variability has increased the need for regional interconnections to import electricity from countries with growing surpluses like Bolivia, and diversify renewable energy sources in countries such as Argentina and Chile.

2.4.4.3 AFRICA

Africa has the highest percentage of untapped technical hydropower potential in the world. 1,009 MW was added in 2018, bringing total installed capacity to 36.3 GW. In 2018, Angola commissioned two more power generating units for the 2,070 MW Laúca hydropower station. Once fully operational in 2019, it will provide over 25 per cent of thecountry's electric installed capacity. Several modernisation projects were completed in 2018, including the 300 MW Kariba South Bank expansion project in Zimbabwe, the 32 MW Mwadingusha plant in the Democratic Republic of Congo and the 36 MW Nkula project in Malawi.

2.4.4.4 EUROPE

As variable renewables continue their rapid growth, hydropower is increasingly recognised in Europe for its flexible services to maintain secure, affordable and sustainable energy supply. Europe added an estimated 2.2 GW in 2018, including 384 MW of pumped storage, of installed capacity in 2018, bringing the total to 252 GW, including 57.4 GW pumped storage.Turkey led the region in new installed capacity additions, adding over 1 GW at greenfield sites. Austria added significant new and innovative pumped storage capacity to support wind and solar and overall system efficiency, including the 360 MW Obervermuntwerk-II project. Norway completed the 370 MW Lysebotn II project, which replaced its 210 MW predecessor. Iceland added 100 MW at the Búrfell II project, utilising existing infrastructure from Búrfell I.

2.4.4.5 SOUTH AND CENTRAL ASIA

Installed hydropower capacity in South and Central Asia grew by almost 4 GW in 2018, continuing the growth trajectory from 2017. India categorised large hydropower projects as renewable energy, which along with supporting measures, signifies a major step forward in national policy. Pakistan's installed hydropower capacity grew by over 25 per cent in 2018 alone, as large-scale projects came online boosting grid supply capacity. Tajikistan passed an important milestone with the construction of the Rogun hydropower project, as the first 600 MW unit entered into operation. Across Central Asia, there is growing interest in regional interconnections and power markets for hydropower development, including bilateral agreements signed between BBIN countries (Bhutan-Bangladesh-India-Nepal) in South Asia, and construction of the CASA 1000 cross-border transmission project. Modernisation programmes at large, older stations continued across Russia, Georgia and other Central Asian countries, with some rehabilitated units coming back into service in 2018.

2.4.4.6 EAST ASIA AND PACIFIC

East Asia and the Pacific again saw the highest annual increase in hydropower installed capacity in 2018. 9.2 GW was added last year, bringing total installed capacity across the region to over 480 GW. The region also accounted for over a third of the world's total hydropower generation. Over 90 per cent of the addedcapacity came from China, including 1.5 GW from pumped storage, which increased its total installed capacity to 352 GW. Significant activity took place in Myanmar where, after some delay, the government issued a notice to proceed for both the 1,050 MW Shweli 3 and the 60 MW Deeoke projects. Cambodia took an important step forward in achieving its energy goals with the commissioning of the 400 MW Lower Sesan II project, the country's largest hydropower project. Australia continued to progress with the development of several pumped storage projects, with Snowy Hydro's 2,000 MW 'Snowy 2.0' project receiving the green light to proceed in early 2019.Across the Pacific, in Fiji, the Solomon Islands and Samoa, a number of small hydropower projects are under active development.

2.5 HYDRO INDUSTRY IN PAKISTAN

2.5.1 CURRENT STATUS OF HPPs IN PAKISTAN[2]

The hydropower sector has been a crucial and core component of the energy mix since the inception of Pakistan. The total installed capacity of Pakistan's hydropower stations up till 2014 is about 6795 MW. Out of this total installed hydel generation capacity, the largest share is of KPK, with a total of 3767 MW. Moreover, there are 1698 MW in Punjab, and 1036 MW in Azad Kashmir. It is to be noted that the KPK has an even greater potential, Malakand-III is a project on Swat River with an 81 MW (WAPDA, 2013). Thus this potential needs to be tapped on urgent basis.

Straddling the Indus Valley, Pakistan is endowed with considerable water resources. According to Pakistan's Water and Power Development Authority (WAPDA), there is 60,000 MW of hydropower potential in the country, of which only 7,320 MW has been developed.

Pakistan's untapped hydropower potential largely lies in the mountainous north along the Indus River in the provinces of Gilgit-Baltistan and Khyber Pakhtunkhwa, as well as the Jhelum River in the provinces of Punjab and Azad Jammu and Kashmir.

Pakistan is currently amid an energy crisis. Some 51 million Pakistanis lack access to electricity, while a further 90 million suffer from unreliable power supply and load-shedding on a daily basis, which is having a serious impact on the economy.

However, hydropower is poised for a resurgence and will play a significant role in addressing the power deficit, with some studies estimating the proportion of hydropower in the total electricity generation to increase to more than 40 per cent by 2030. A number of hydropower

[2] https://www.hydropower.org/country-profiles/pakistan

plants were completed or commissioned in 2016 including Ranolia (17 MW), Daral Khwar (37 MW) and Machai (2.6 MW), all located in the Khyber Pakhtunkhwa province.

Several micro hydropower projects were also installed as part of an initiative led by the government of Khyber Pakhtunkhwa, with the support of the Asian Development Bank, to install some 1,000 micro plants. Expected to have a total installed capacity of 100 MW, these micro projects are designed to support rural, off-grid communities by providing affordable and reliable electricity.

Numerous projects are currently under planning and construction in the private sector, overseen by the Private Power & Infrastructure Board, including Karot (720 MW), Suki (870 MW) and Kohala (1,124 MW). These projects are part of the China–Pakistan Economic Corridor (CPEC) – a collection of infrastructure projects supported by the Chinese Government to strengthen Pakistan's economy and enhance the economic connectivity between both countries. The regulatory regime for private sector investors includes substantial incentives such as generous return on equity, tax concessions and hydrological risk cover.

Recently completed public sector projects overseen by WAPDA include Golen Gol (106 MW), Neelum-Jhelum (969 MW), Dasu (4,320 MW) and the fourth extension of the Tarbela plant that has lifted its installed capacity to 4,888 MW. The Tarbela Dam is the largest earth-filled dam in the world. The World Bank and the Asian Infrastructure Investment Bank have also announced USD 720 million in co-financing to help fund the fifth extension to the plant, which will add a further 1,140 MW in capacity.

2.5.1.1 LAND ALLOCATION BY GOVERNMENT OF KPK AND PEDO

PEDO will provide support and facilitation to project sponsors in acquisition of land through local government of project area or PEDO may acquire land for the project concerned and lease to the project company on mutually agreed terms and conditions for the term of the project as per PEDO Hydropower Policy 2016.

2.5.2 TARIFF REGIME IN PAKISTAN

Due to their unique nature however, hydropower plants present a number of risks, which may be seen as hurdles by the prospective investors to invest in hydropower plants relative to investing in other forms of electricity generation. While recognizing cost uncertainty as a genuine problem, NEPRA in order to remove such ambiguities, has developed a mechanism ("Mechanism for Determination of Tariff for Hydropower Projects"), which provides for determination of tariff and subsequent adjustments at different stages of hydropower project development. In this respect three distinct stages have been identified when costs may differ. These costs are discussed below.

i. Feasibility Level Costs

Feasibility Study shall clearly include, among other relevant information, formulae based on which the Applicant have arrived at unit rates for various activities such as soil excavation, rock excavation, fill, underground excavation, reinforcement etc. Before determining a tariff, NEPRA will invite comments and consider recommendations of the respective province in which the proposed project is located, including comments on resettlement costs and where applicable land costs claimed by the Applicant for resettlement.

ii. EPC Level Costs

All the applicants possessing NEPRA's determined tariff on feasibility costs shall be required to file a tariff petition based on EPC Costs in terms of NEPRA Tariff Standards and Procedure Rules-1998, if they wish to seek revision in tariff on the basis of EPC. NEPRA will allow such adjustments, provided that the Project Company substantiates its costs to NEPRA's satisfaction preferably in the form of EPC contracts and/or in a form and manner as determined by NEPRA. While determining tariff; NEPRA may carry out detailed prudence of costs however, if the Applicant supports its petition by providing competitive bids from a number of reputable contractors, NEPRA may accept the lowest of bids without going in to detailed prudence exercise.

iii. Final Costs which shall be no later than the Commercial Operation Date (COD)

The COD stage determination is again subject to "Tariff Reopeners" such cost variation due to geology in the tunnel(s), civil works cost escalation, cost variation in hydraulic steel structure and M&E works, cost variation due to resettlement cost.

The Mechanism For Determination of Tariff for Hydropower Projects provides for NEPRA's tariff determination based on costs at feasibility study stage and then at EPC stage, adjustable at COD to reflect those changes which have been permitted in this mechanism.

2.5.2.1 NEGOTIATED TARIFF FOR HYDRO IPPS

The tariff regime for HPPs is split in two options; first being the 'Negotiated Tariff', which is applicable where the Project Company shall justify all expenses and financial position to NEPRA through a petition. NEPRA in return determines the project tariff on a "cost plus" basis.

2.5.2.2 UPFRONT TARIFF FOR HYDRO IPPS

NEPRA had announced the upfront tariff for Small HPPs which varies for low-head and high head projects; this tariff catered to Projects having capacity from 1 MW to 25 MW. However, this tariff expired in fall of 2016.

In this regime, the hydrological risk could be passed to the Power Purchaser if the Annual Plant Factor of 65% for low head projects and 50% by high head projects was met by Projects after allowing for auxiliary consumption at 1% on gross installed capacity.

In cases where hydrological risk is borne by the power purchaser, the company was to receive an assured minimum amount every month from the power purchaser to cover its fixed costs (fixed O&M, insurance, return on equity and debt servicing) in case the plant is available but sufficient water i.e. at least equal to the average historic hydrology for that particular month is not available to generate electricity. Payment on account of hydrological risk was to be made by the power purchaser, on the basis of benchmark monthly energy generation, based on the average historic hydrology for that particular month. Further, the tariff was to be limited to the extent of benchmark net annual energy generation of the project; while net annual energy generation supplied to the power purchaser in a year, in excess of the benchmark net annual energy generation was to be charged at 10% of the prevailing upfront tariff. The power purchaser before signing the Power Purchase Agreement was required to verify the month wise benchmark hydrology. Power producers opting to bear hydrology risk were allowed to sell all power at the prevailing upfront tariff.

In order to address the gap and the ever increasing power shortage, there is a need to develop hydroelectric and other renewable energy resources to meet the expected demand of electricity.

In continuation of the above a feasibility study of Artistic II Hydropower Project is being conducted to meet the demand of affordable Hydro Electric Energy.

CHAPTER

3

TOPOGRAPHIC SURVEY

CHAPTER - 3

TOPOGRAPHIC SURVEY

3.1 GENERAL

Artistic-II Hydropower Project area is located 7km upstream of diversion weir of 84 MW Matiltan HPP which is under construction at present and about 10 km downstream of Mahudand Lake tourist resort. The catchment area is estimated about 454 km^2.

A credible topographic survey is one of the basic requirements for quality planning/design of a project. The Consultants, immediately after getting approval from Client, embarked upon to carry out topographic survey of the area as given in the project ToR.

This chapter describes the detailed topographic survey works carried out at the feasibility stage of the proposed Artistic-II Ushu River Swat Hydropower Project.

In this chapter the methodology for carrying out Topographic Survey is presented. Topographic Survey is the foremost activity to start the feasibility study of any Hydropower Project. The project area was visited and survey requirements were assessed keeping in view the location of various components of the proposed schemes. The survey was carried out concentrating various options of project layout at appropriate scale, so that it would help in planning an optimum layout. This planning was essential because studies and investigations depend on the availability of accurate topographic maps of the area depicting all essential existing features. The consultants' survey activities are part of Feasibility level design and will serve as basis of drawings to be prepared afterwards.

3.2 PROJECT SITE

The project proposed weir site is located 7km upstream of diversion weir of 84 MW Matiltan HPP and about 10 km downstream of Mahudand Lake tourist resort. The proposed powerhouse of the project is located about 1 Km upstream of diversion weir of 84 MW Matiltan HPP. The project site is accessible through jeepable Kalam-Mahudand road which is at present is unpaved. Project Location map is attached as **Figure** 3-1**.**

The site coordinates of weir and powerhouse site are given as under:

Location	**Northing**	**Easting**	**Elevation**
Weir / Intake	35°37'42.09"	72°41'5.68"	2499 masl
Power House	35°34'14.14"	72°40'19.23"	2305 masl

The topography of the site area is mountainous with altitude varying between 2200 m to 4000 m above mean sea level (amsl) and has steep slopes and some densely forested areas. These conditions made access to the ravines and to the tunnel alignment difficult.

Figure 3-1 Project Location Map

The climate in winter is extremely cold with heavy snowfall and pleasant in summer. July is the hottest month of the year with an average temperature of 24.1 °C. The coldest month January has an average temperature of 1.5 °C and minimum low temperature of -2.2 °C. The snowfall normally starts in November / December and stays on the ground until late March.

Kalam and Artistic-II site are connected through a paved road running on right bank of the Ushu River up to Matiltan village. A shingle road provide access to the weir and powerhouse site however a temporary and/or permanent river crossing structure will be needed during and after completion of the project as project layout features are located on the right bank of Ushu river.

The main features of the project are:

- Weir, Undersluice and Intake
- Box Channel
- Sandtrap / Sediment Removal System
- Power Tunnel
- Adit Tunnel
- Surge Tank
- Penstock
- Powerhouse
- Tailrace
- Switchyard
- Residential Colony
- Access Roads
- Bridges (2 Nos.)
- Protection Works

3.3 MOBILIZATION

Soon after signing contract agreement with the Client, Consultants initiated the activities by establishment of office, desk studies and preliminary planning for carrying out topographic surveys.

Survey teams, headed by Chief Surveyor, were constituted and mobilized after getting approval from the Client without wasting a single day to complete this most essential field activity on war footing basis before onset of the intense harsh winter. For timely completion of the task given to team, four (04) Nos. survey teams were deployed in the project area. Prior to making their move to the site, survey teams got associated themselves with the Client's requirements and planned their activities with the help of Google maps and as per TOR of the project.

The survey boundaries as per project requirements, marked on the google map, were provided to the Chief Surveyor to carry out the detailed topographic survey of various features of the project alternative layouts.

3.4 SURVEY METHODOLOGY/CRITERIA

To prepare project layouts and the feasibility level design of the project, following main tasks have been included in the survey scope of work:

- Installation of Permanent survey control points located at agreed points with BM level;
- Processing of topographic survey digital data by using survey software
- Generation of topographic sheets by using CAD/CAM techniques;
- Production of topographic survey drawings for different structures as per scale and mentioned in TOR.
- Preparation of comprehensive survey report.

Reconnaissance visits of the whole project area were made and survey parties were mobilized to carry out the requisite works. The Consultant's identified the extent of the survey work. Survey work was carried out accordingly and was reviewed and supervised by the Consultant's design team.

The project site is situated at far distance from Kalam in district Swat which is at about 90 minutes' drive. Therefore, to save time, the survey parties stationed themselves at rented accommodation in Matiltan village which is in close vicinity of the project site. They were equipped with laptop computers to download and process the survey data then and there.

Latest technology/equipment were used and special care has been taken in establishment of survey control points for the project. Based on these established Bench Marks, additional survey control points have been established as per requirement of the area. The two survey control points of PEDO under constructed 84 MW Gorkin Matiltan Hydropower Project i.e. GM-28 and GM-29 were used to establish permanent control points of Artistic-II HPP.

The aim was to survey the whole project area with emphasis on details of the different project components such as access road, Main Weir, Box Channel, Sand Trap, Headrace Tunnel portals, Surge Tank and Pressure Shaft, Penstock and Power House etc.

Important features of the site such as existing road/tracks, electric and telephone poles, houses, water courses, trees, cultivated land etc. were coded and marked. The density of the observing points was kept such that a contour map with 1-meter interval was prepared.

Universal transverse Mercator (UTM) coordinate system has been adopted for the project. UTM was originally invented by Germans and then further developed by US Army Corps of Engineers. The Topographic Survey Maps and natural and man-made features can be easily transported to the latest Google Earth Software.

The various steps taken to complete detailed topographic survey of the project are as under;

i. Mobilization
ii. Field visits
iii. Establishment of Bench Marks / Control Points
iv. Traversing
v. Precise Leveling
vi. Detail Topographic Survey
vii. Preparation of Survey Drawing
viii. Computer Plotting
ix. Field Check
x. Preparation of Survey Report

The above-mentioned activities are briefly described as under:

3.5 SURVEY INSTRUMENTS

The Electronic Total Station (ETS) and DGPS were used for the survey. The specifications of the instruments used for the survey are as under;

3.5.1 ETS NIKON NIVO 2.M

Nikon's next generation total station is Nivo and it is available in to exciting lines. Nivo M Series are the absolute Leaders for go anywhere measurement tools. It is compact in size and lightweight; they are convenient to carry over long distances. All Nivo models are supported with legendary Nikon high clarity optics, allowing clearer bright images and reduce eye stress.

- ETS Nikon Nivo 2.M has following specification;
- High quality Nikon optics
- Intuitive powerful software
- Fast, accurate EDM
- Prism and reflector less measurements
- Easy-to-use keypad
- Hot swappable batteries
- Compact, rugged, and lightweight
- Cable-free Bluetooth
- Optional laser plummet

3.5.2 ETS TOPCON GTM 3000

Specifications

- Telescope Length 150 millimeters
- Objective lens diameter 45mm (EDM: 50mm)
- Magnification 30 xs
- Image Erect
- Resolve power 3”
- Min. Focus Distance 1.3 meters

Measurement Range

- Measuring Accuracy
- Prism Mode +(2mm + 2ppm x D) M.S.E. fine
- Measurement Time 1mm: 1.2sec. (Initial 4sec.) fine
- 0.2sec. (Initial 3sec.) coarse,

Angle Measurement

- Method Absolute reading
- Detection 2 horizontal, 1 vertical
- Minimum reading 5’’/1’’, 1/5 Megon
- Tilt correction
- Type Automatic vertical and horizontal compensator
- Method liquid surface reflective profile sensor

Reading type

- Compensating range +3’
- Correction Unit 1arc sec,
- Computer Unit

3.5.3 ETS SOKKIA 610 K

The instrument works on a unique pulse laser technology which allows measuring up to 450 m in reflector-less mode with complete safety and confidence.

Specifications

- IP66 Rating
- Ultra-Light 5.2kg Body
- Extra Wide Screen

- 1,600m Prism Range
- 6″ Angle Accuracy
- Comprehensive easy-to-use on-board system

3.5.4 DGPS TRIMBLE 5800

The Trimble 5800 GPS receiver provides reliability and simplicity for basic surveying tasks. You can trust that the proven design of the Trimble 5800 will perform under the toughest conditions.

Performance specifications

Measurements

- Advanced Trimble Maxwell™ Custom Survey GPS Chip
- High precision multiple correlator for L1 and L2 pseudo range measurements
- Unfiltered, unsmoothed pseudo range measurements data for low noise, low multipath error, low time domain correlation and high dynamic response
- Very low noise L1 and L2 carrier phase measurements with <1 mm Precision in a 1 Hz bandwidth
- L1 and L2 Signal-to-Noise ratios reported in dB-Hz
- Proven Trimble low elevation tracking technology
- 24 Channels L1 C/A Code, L1/L2 Full Cycle Carrier
- 2 additional channels for SBAS WAAS/EGNOS support

Electrical

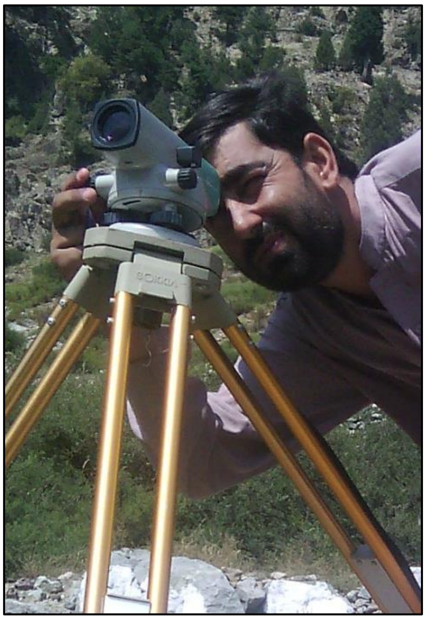
- Power 11 to 28 V DC external power input with over-voltage protection on Port 1 (7-pin Lemo)
- Rechargeable, removable 7.4 V, 2.4 Ah Lithium-Ion battery in internal battery compartment. Power consumption is <2.5 W, in RTK mode with internal radio.
- Operating times on internal battery: 5.5 hours with 450 MHz receive only
- (Varies with temperature)
- Certification Class B Part 15, 22, 24 FCC certification, Canadian FCC, CE
- Mark approval, and C-tick approval.

Communications and Data Storage

- 3-wire serial (7-pin Lemo) on Port 1. Full RS-232 serial on Port 2 (Dsub 9 pin)
- Fully Integrated, fully sealed internal 450 MHz receiver
- Fully integrated, fully sealed 2.4 GHz communications port (Bluetooth)

- External cell phone support for GSM/GPRS/CDPD modems for RTK and VRS operations
- Data storage on 2 MB internal memory: 55 hours of raw observables based on recording data from 6 satellites at 15 second intervals
- 1 Hz, 2 Hz, 5 Hz, and 10 Hz positioning
- CMR+, RTCM 2.1, RTCM 2.3, RTCM 3.0 Input and Output
- 16 NMEA outputs, GSOF and RT17 outputs

3.5.5 AUTOMATIC LEVEL NIKON AS-2



The automatic levels provide quick setup, easy sighting, and superior durability against vibration and shock, ensuring the increased productivity over an extra-long period of time.

Specification and Features:

- Precise measurements
- Waterproof
- High-power telescopes that help you make precise measurements even in the wettest conditions.
- Unique automatic air – dampened compensator to prevent magnetic Interference and an endless horizontal fine drive to ensure smooth, precise pointing and angular measurement.
- Auto levels are easy to set and easy to use.
- Can be attach to both flat and spherical head tripods.
- Mirror with a pent prism lets you view the circular bubble as an erect image during setup and sighting.

3.6 ESTABLISHMENT OF BENCHMARKS/ CONTROL POINTS

Establishment of control points is not only important for the survey work but also useful for the execution of the project at later stage. These control points should be on a firm ground and away from the places where it can be easily tampered. It is important to establish control points on permanent features i.e. existing structures, exposed rock, bridges, permanent protection bund etc. The monuments have been constructed of concrete and can be conveniently used during construction.

3.7 LEVEL CONTROL

3.7.1 MAIN BENCH MARK USED

Survey control points for the project has been established by using latest survey equipment's and two survey control points of PEDO GM-28 and GM-29 of under constructed 84 MW Gorkin Matiltan Hydropower Project.

The coordinates of GM-28 & GM-29 are as under;

S.NO	EASTING (m)	NORTHING (m)	LEVEL (m)	Remarks
GM-28	288929.035	3938248.282	2345.844	Gorkin Matiltan HPP Weir Site
GM-29	288941.205	3938331.434	2335.261	

Extra care has been taken in establishment of these permanent control points of Artistic-II HPP. The standard procedure, recommended for this kind of survey, was adopted. The Leveling was carried out in pleasant hours to avoid errors. Additional survey control points have also been established as per requirement of the TOR and as per requirement of the area. These survey control points are then used to conduct the topographic survey of reservoir area and other appurtenant structures. Before commencement of the detailed survey, all these control points were further refined by two-way leveling.

List of these control points with all the coordinates and levels are listed in the following table.

S.NO	EASTING (m)	NORTHING (m)	LEVEL (m)	Remarks
W1	290373.5	3945034	2509.952	Weir Site
W2	290425	3945043	2529.161	Weir Site
W3	290448.6	3944961	2534.547	Weir Site
P 1	289562	3939585	2380.729	Power House
P 2	289496.1	3939639	2370.408	Power House
P 3	289466.3	3939700	2372.199	Power House
A2-1	289503.3	3939648	2368.652	
A2-2	289543.1	3939601	2375.375	
A2-3	290255.9	3941531	2442.917	
A2-4	290263.1	3941561	2444.099	
A2-5	290433.8	3944957	2528.187	
A2-6	290442.6	3945005	2534.624	

3.7.2 TRAVERSE SURVEY

Traverse is a method in the field of surveying to establish control networks. Traverse networks involve placing survey stations along a line or path of travel, and then using the previously surveyed points as a base for observing the next point.

Traverse networks have many advantages, including:

- Less reconnaissance and organization needed

- In other systems, which may require the survey to be performed along a rigid polygon shape, the traverse can change to any shape and thus can accommodate a great deal of different terrains
- Only a few observations need to be taken at each station, whereas in other survey networks a great deal of angular and linear observations needs to be made and considered

Traverse was carried out in a closed loop to established control in the area of interest starting from the survey control concrete monuments GM-28, GM-29. The traverse distances were measured in two directions (forward & backward) and mean was accordingly adopted. A closed traverse (polygonal, or loop traverse) was employed, consisting of a series of linked traverse lines where the terminal point closed at the starting point.

The vertical control was established with the help of auto level Nikon AS-2. The traverse was closed with double run.

The horizontal angles were measured on two zeroes i.e. four angle measurements were taken from each side. The average of these was used in the traverse computation that provided the spread of angles which was not more than 20” of arc.

3.7.3 TRAVERSE POINTS

A network of control points was established along the road from Matiltan Powerhouse site to Weir site. Using Sokkia total station, bearing and distance observations were made two times on a single station from which mean value was calculated. The same process was repeated at every station. The mean value was converted to co-ordinate system. The vertical control observations were made with level Nikon AS-2. This traverse was also closed. The detailed observation and calculation of the vertical and horizontal control is being reproduced here. This error was distributed over the traverse points and the adjusted values were obtained. The closing error of vertical coordinate was 3 mm which was distributed among the traverse points to obtain the final value.

3.7.4 TRAVERSE ACCURACY

A closing horizontal error of 62 mm was observed in the northing which is equivalent of 4.39 mm per km. Similarly, a closing error of 85 mm was observed in the easting which is equivalent of 6.01 mm per km. The achieved accuracy is within the allowable limits of ± 10 mm per km.

The closing vertical error in the traverse was observed as 3 mm which is inside the allowable limits of ± 20 mm per km.

The error is distributed in proportion to the cumulative easting and northing from the first station of the respective traverse

3.7.5 HORIZONTAL CONTROL

A total of Twelve (12) survey control points have been established in the project area. The control points are concrete monuments with steel rods embedded in the center and flushed with the top surface. These steel pins are center punched with red paint. These control points are assigned the horizontal or position control values (Northing, Easting). All the control points have been established with the help of Total Stations (Sokia 610K, Nikon Nivo 2M and Topcon GTM3000). It may be noted that the closing error for angular measurement was 12 sec. This error was distributed over the traverse points and the adjusted values were obtained.

3.7.6 VERTICAL CONTROL

The Second Order, Class-II survey allows an error of ± 20mm in a kilometer distance. This accuracy can be described as an accuracy of 1 in 50,000. The accuracy of the surveys consultants carried out was more refined than the specified limit. The closing error of leveling was 0.003m or 3mm. The degree of accuracy of the surveys ± 20mm per kilometer was accepted for further use.

3.8 TOPOGRAPHIC SURVEY

A credible topographic survey is one of the basic requirements for quality planning/design of a project. To carry out the project layouts and the feasibility level engineering design of hydropower project sites, following main tasks have been included in the survey scope of work:

- Installation of Permanent survey control points established at appropriate locations with BM level.
- Processing of topographic survey digital data by using survey software.
- Generation of topographic sheets by using CAD/CAM techniques.
- Production of topographic survey drawings for different structures as per scale and mentioned in TORs.

Survey was carried out for marking the existing features, development of contour maps etc. Keeping in view the nature of diversity involved in the present survey requirements, the Consultants used a combination of Conventional and Latest Electronic / Digitizing Techniques to accomplish the assignment as desired.

Another desired output of the survey was the development of contour maps. Total station survey was done to collect data with feature codes through data loggers and memory cards loaded into the computer subsequently for processing and preparation of contour maps by computer aided drafting. Separate field sketches were drawn at site to depict existing features of the land and built up details.

Topographic survey was carried out by observing appropriate density of spot heights, marking existing feature above ground water edge, Drains, Protection works, Bridge, Houses, Roads and other features. The survey data was recorded for the accurate representation of the land surface in the interval and scale desired to give a true picture of the existing features.

3.9 STRUCTURAL SURVEY

Topographic survey of Artistic-II Ushu River HPP located in district Swat has been carried out for alignment/layout of structures as per TOR. The Consultants carryout the surveys with the most modern and sophisticated total stations and computer software “Eagle Point” has been be used for plotting the surveys. GPS has been used to establish the control points at suitable locations. These controls points have been used for observing cross sections.

The following topographic surveys in the area of the main structures has been carried out and mapped as per the detail given below.

3.9.1 INTAKE AREA:

Diversion weir with area of all appurtenant structures with contour interval of 1 m in a scale of 1:500 supported by sufficient number of Cross section and Long Sections as per site requirements.

3.9.2 BOX CHANNEL ALIGNMENT:

Connecting channel with 1 m contour interval at a scale of 1:500 supported by sufficient number of Cross section and Long Sections as per site conditions.

3.9.3 SAND-TRAP:

Sand-trap with 1 m contour interval at a scale of 1:500 supported by sufficient number of Cross section and Long Sections as per site conditions.

3.9.4 HEADRACE TUNNEL:

Survey of inlet and outlet portal of proposed tunnel alignment with contour interval of 1m in a scale of 1:500 supported by sufficient number of Cross sections and Long Section as per site conditions.

3.9.5 SURGE TANK AND PRESSURE SHAFT:

In location of surge chamber an alignment with contour interval of 1m in a scale of 1:500 supported by sufficient number of Cross sections and Long Section as per site conditions.

3.9.6 PENSTOCK:

Area with contour interval of 1m in a scale of 1:1000 supported by sufficient number of Cross sections and Long Section as per site requirements.

3.9.7 POWER HOUSE:

Area including tailrace canal with contour interval of 1m in a scale of 1:500 supported by sufficient number of Cross sections and Long Sections as per site requirements.

3.9.8 ACCESS ROADS:

To all structures including weir, Sand-trap, surge tank, Penstock and Powerhouse with contour interval of 5m at scale of 1:2000 supported by sufficient number of Cross sections and Long Sections as per requirement.

3.9.9 RIVER CROSS SECTIONS.

River cross sections 20 Nos. upstream of weir and 5 Nos. downstream of weir shall be taken at an interval of 100 meters. 5 Nos. of cross sections upstream of powerhouse and 5 Nos. downstream of powerhouse at an interval of 100 meters.

The topographical survey maps of all sites are presented in Annexure 3B.

3.10 PREPARATION OF SURVEY DRAWINGS

In general, latest survey instruments i.e. Total Stations were used for field survey. Later on, field data was computer processed and various maps/ plans, profiles and cross sections were prepared and plotted at recommended/ required scales on A3 size paper. Eagle Point and Civil 3D were used for processing of Survey data while AutoCAD for drawing and plotting purposes.

The drawings produced on the basis of the survey will be used for planning and developing weir, link canal alignment, sediment excluder, and other associated structures.

3.11 UNITS OF MEASUREMENT

All dimensions and elevations in topographic surveys are in metric units and the angular measurements are in degrees, minutes and seconds.

CHAPTER

4

HYDROLOGY AND SEDIMENTATION

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CHAPTER 4

HYDROLOGY & SEDIMENTATION

4.1 HYDROLOGICAL STUDIES

4.1.1 GENERAL

Artistic-II Hydropower project is a run-of-river project to be constructed on Ushu river in district Swat of Northern areas of Khyber Pakhtunkhwa province. The project proposed weir site is located 7 km upstream of diversion weir of 84 MW Matiltan HPP which is under construction at present and about 10 km downstream of Mahudand Lake tourist resort. The proposed powerhouse of the project is located about 240 m upstream of diversion weir of 84 MW Gorkin Matiltan HPP. The project site is accessible through jeepable Kalam-Mahudand road which at present is unpaved. Coordinates of proposed weir and power house location are given in **Table** 4-1**.**

Table 4-1: Project Location Details

Location	Northing	Easting	NWL/TWL
Weir / Intake	35°37’42.09”	72°41’5.68”	2505 m
Power House	35°34’14.14”	72°40’19.23”	2305 m

Hydrological studies presented in this Section have been carried out to ascertain;

a) The water availability and its seasonal variations.

b) Floods of different return periods.

c) Suspended sediment load/cocentration variation on monthly scale.

4.2 CATCHMENT AREA

The catchment of the Artistic-II HPP lies in the upper region of the Ushu River, a tributary / sub system of a Swat river basin and can be classified as a “high mountain catchment” in which there are several glaciers up to the power house site and a Bisni Nullah just downstream of the proposed Powerhouse location. Snowmelt is the principal source of water in the river.The highest mountain Peak of Ushu River reaches up to 5917amsl and mean elevation is about 4,500 amsl while river bed elevation at weir site is 2,495 amsl and river bed elevation at Powerhouse site is at approximately 2,302 amsl. The Ushu River (left tributary) and the Gabral River (right tributary) joins at Kalam and forms the Swat River. The basin elevation gradually decreases from 4,500 amsl to 910 amsl below Kalam and the valley becomes broader up to Chakdara town. Length of the Ushu River up to the weir site is about 25 km. Average river bed slope ranges from 0.02 to 0.03. Catchment area of the Ushu River at weir location is estimated to be 454 sq.km and at powerhouse location is approximately 600 sq.km. Catchment area map is shown in **Figure** 4-1.

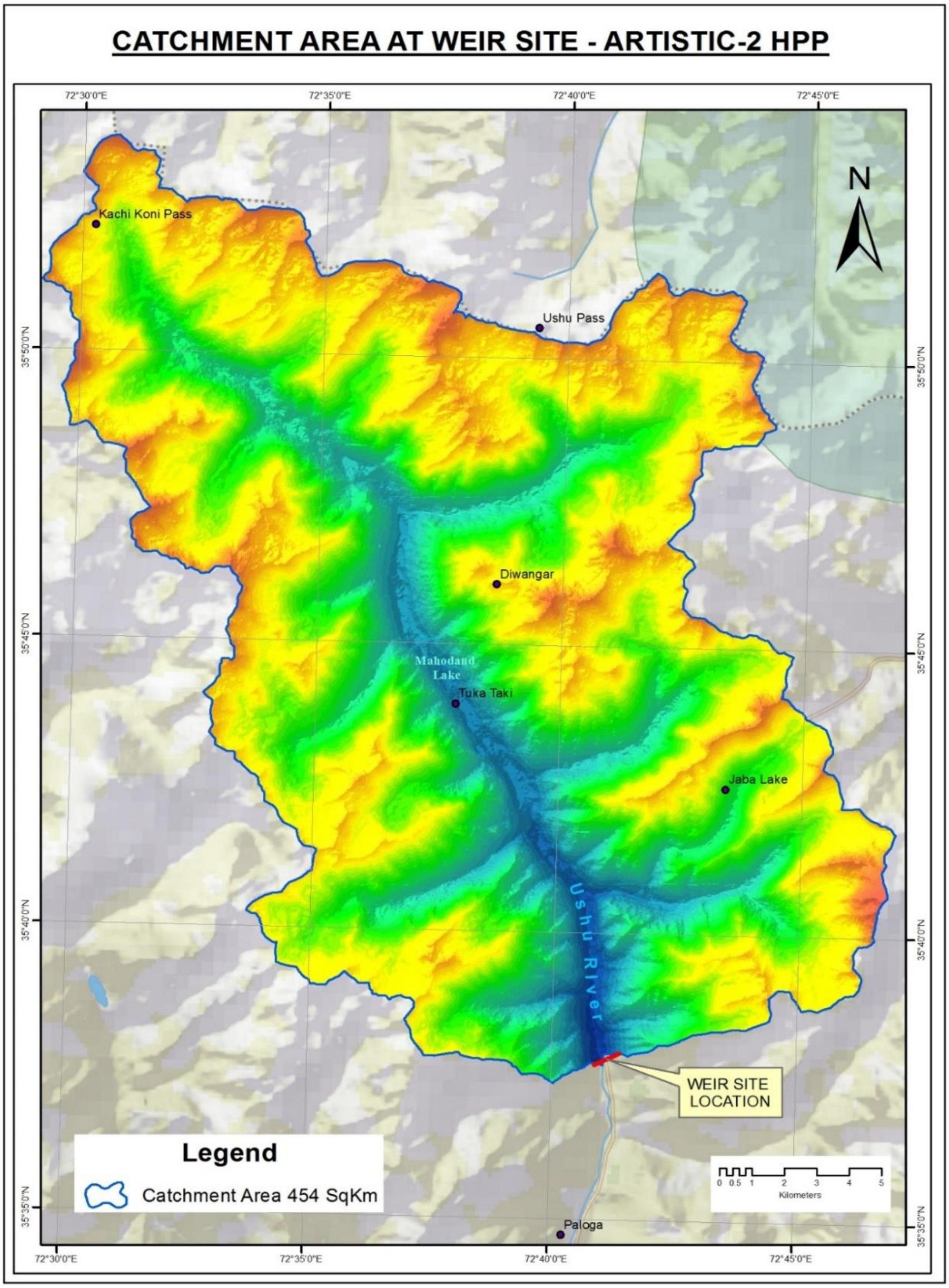

Figure 4-1: Catchment Area Map of Artistic-II HPP

Table 4-2 Catchment Area at Different Locations Near the Project Area

S.No	Station	Catchment Area (sq. km)
1	Ushu River at Artistic-II Weir Site	454
2	Ushu River at Artistic-II Powerhouse site	600
3	Ushu River at Matiltan HPP Weir site	615
4	Ushu River at Matiltan Gauge Station	656
5	Ushu River at Matiltan HPP Powerhouse site	715
6	Ushu River at Jildat	783
7	Swat River at Kalam	2020

4.3 COLLECTION OF HYDRO-METEOROLOGICAL DATA

4.3.1 CLIMATE DATA

Climate station do not exist within watershed of Ushu River. Location of climate and stream flow network are shown in **Figure** 4-2**.** Long term and reliable record of climate data exist at Kalam which is located just downstream of the confluence of Ushu and Gabral Rivers with Swat River. Detail climate data is given in "**Annexure-A1, Volume-V".**

Daily rainfall data of Kalam have been collected from SWHP, WAPDA for a period of 1963-2011, while from Pakistan Meteorological Department (PMD) daily rainfall record for period of 2004 to 2019 have been collected.

Available records indicate that precipitation in the project area and its vicinity occurs throughout the year with two peaks one is in spring and other in summer. Isoheytal map of the Pakistan (1981-2010) collected from PMD reveal that in project area annual rainfall range is in between 1000 mm to 1200 mm (**Figure** 4-3). Monthly and annual rainfall for different years are tabulated in **Table** 4-3 & **Table** 4-4. Graphically presentation of rainfall pattern through a year for different sources record are given in **Figure** 4-4 & **Figure** 4-5**.**

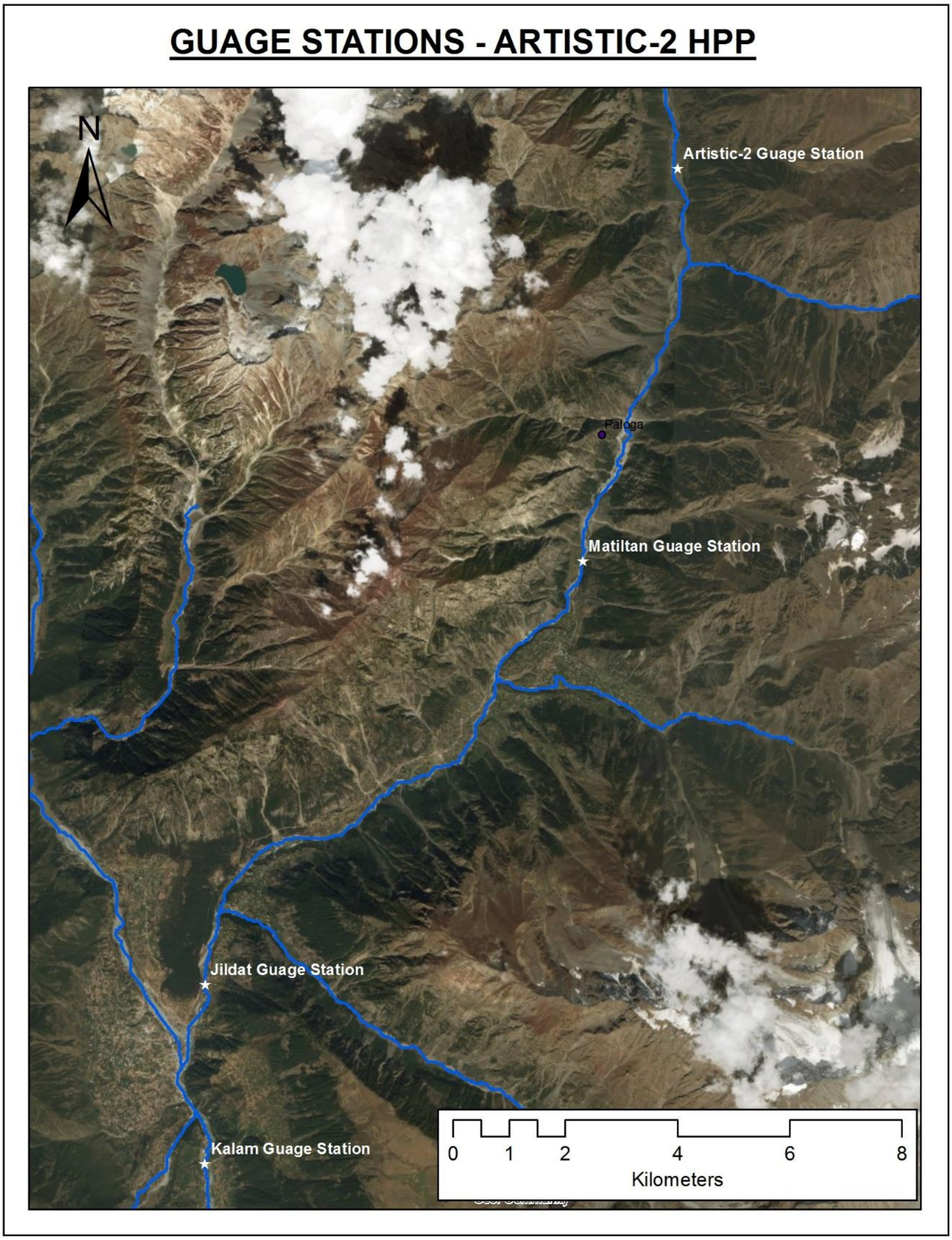

Figure 4-2: Stream Gauges Location near Artistic-II Hydropower Project

Table 4-3 Mean monthly Rainfall (mm) at Climate station Kalam (Source: SWHP, WAPDA)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
1963	--	70.2	308	204.9	169.9	5.2	38.2	31.3	20.6	18.7	60.5	48.7	976
1964	159.6	136.1	110.8	253.7	67.2	12.5	61.9	28.8	15.8	27.4	28.8	157.8	1060
1965	156.8	232.6	223.6	314.8	117.9	0.8	38.7	20.7	23.3	25.1	37.4	39.6	1231
1966	152.7	214.7	294.6	27.4	2.6	32	20.4	74.6	71.3	0	25.4	0	916
1967	50.8	192.6	125.2	210.7	122.7	16.5	11.9	22.4	40.6	64	5.3	104.9	968
1968	40.5	62.2	135.4	249.5	132.3	7.6	2.8	65.3	6.4	43.2	35.8	14.5	796
1969	80.2	175.6	210.8	213.1	80.1	27.7	16.1	31.5	43.4	89.7	21.4	7.9	998
1971	7.4	169.5	69.1	216.2	12.5	27	49.3	9	30	14.8	6.9	24.4	636
1972	131.6	150.8	105.9	231	144.2	31.1	22.1	76	82.3	44	32.5	121.6	1173
1973	125.5	179.6	191.5	157	57.5	1	35.2	38.4	57	33.3	8.1	21.8	906
1974	77.7	169	74.3	135.9	94.5	33.3	33.9	26.1	76.5	11.7	0	106.2	839
1975	56.9	154.6	217.1	253.9	195.1	1.5	48.5	113.3	28.5	49.8	35.8	60	1215
1976	86.3	205.2	191.4	136.9	61.7	27	29.3	67.8	43.1	30.5	24.1	31.1	934
1977	123.6	29.2	99.8	138.9	42.7	4.9	16.1	32.6	13.4	29.5	48.9	35.5	615
1978	73.2	45.9	148.7	123.3	62.3	20.9	129.7	19.1	34.4	12.6	112.2	10.1	792
1979	42.4	92.3	176.3	200.4	139.7	13.2	11.7	75.1	14.6	1.3	44.2	22.3	834
1980	114.8	36.3	4.9	104.7	89.3	31.5	43.7	25.4	32.1	87.9	84.1	26.7	681
1981	78.4	216.7	221.3	213.8	69.5	19.9	28.6	57.9	31.4	22.6	31.7	0	992
1982	56.7	185.2	167.5	63.5	49	11.7	27.8	12	25.6	32.2	123.3	0	755
1983	49.2	32.3	278.5	62.6	59.3	11	15.3	44.4	16.3	9.9	0	0	579
1984	37.1	159.9	176.9	145.6	90	10.7	23.6	22.5	45.8	6.6	83.2	76.7	879
1985	78.5	26.1	52.9	137.5	85.4	6.9	37.2	53.9	10.8	72.5	27.9	145	735
1986	27.2	147.3	363.2	178.1	52.7	19.7	27.4	97.1	12.4	9.7	182.9	39	1157
1987	0	82.2	323.7	234.9	101.8	79.9	26.9	3.3	18.5	206.6	0	63.5	1141
1988	58.5	96.1	193.5	91.3	52.2	50	38.6	40.9	7.9	3	0.5	133.2	766
1989	--	--	--	79	185.4	7.9	48.2	31.4	26.1	35.8	92.2	0.5	507
1990	--	--	--	53.7	14	27.5	15	23.3	9.9	--	--	--	143
1991	166.4	263.2	336.5	201.9	172.2	25.7	30.5	10.9	84.3	3.1	6.3	70.9	1372
1992	232.7	171.1	336.9	228.9	167.3	38.6	6.6	47.6	121.1	71.6	16	71.9	1510
1993	--	--	--	9.9	76.8	56.9	85.1	37.9	9.6	60.9	58.8	33.8	430
1994	164.4	149.3	181.5	248	73.5	25.1	23.1	24.8	61.5	78.2	30.8	105	1165
1995	9.2	101.2	226.9	231.2	93.8	104	53.7	12.3	29.5	110.3	27.9	59.5	1060
1996	66.8	148.4	323.3	207.5	128.3	46	28.8	28.3	8.7	75.7	19.8	21.6	1103
1997	25.4	31.5	284.8	168.7	84.2	16.5	6.6	47.3	26.5	15.5	18	8.2	733
1998	144.8	220.4	152.6	203.5	135.1	47.9	20	27.2	19	7.7	NA	NA	978
1999	116	197.5	336.4	191.4	59	27.9	45.9	37.2	49.7	5.9	139.3	0	1206
2000	87	47.5	218.2	31.5	15	30.7	30.8	14	39.5	64.1	69.4	86.4	734
2001	4.8	137.9	77.2	69	24.7	18.3	66.9	34.8	67.1	3.8	70.4	0	575
2002	53.1	176.5	228.1	187.6	26.4	57.2	18	57.3	23.1	0	33.3	121.1	982

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
2003	23.3	202.3	218.6	282.2	107.8	4.3	5.5	36.2	64.3	27.4	111.8	110.6	1194
2004	67	117.3	81.2	170.2	47.3	19.4	28.7	25.8	29.3	211.3	45.7	117.9	961
2005	75.8	347.1	245.4	230.2	124.3	16.3	20.8	35.8	9.2	92.6	82.3	5.1	1285
2006	180.2	218.9	81.5	109.2	35.6	21	35	53.4	23	2.3	168	169.4	1098
2007	9	54.7	257.5	77	84	36.8	18.3	31.7	19.1	5.6	1.3	25.5	621
2008	237.2	45.7	45.8	101.6	0	6.4	30.5	16.5	40.6	19.1	29.2	100.5	673
2009	156.2	115.6	188.1	234.4	87.9	50.9	78.8	58.4	63.5	84.2	92.7	109.3	1320
2011	58.4	213.3	113	64.7	44.6	20.4	30.6	59.9	29.2	30.5	59.8	24.2	749
Average	**87.1**	**141.4**	**190.9**	**163.4**	**83.8**	**25.7**	**33.2**	**39.2**	**35.2**	**42.4**	**49.6**	**56.3**	**914**

Table 4-4 Mean Monthly Rainfall (mm) at Kalam (Pakistan Met. Department)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2004	287	141	100	181	64.4	22	44	41.3	54	304.5	45	103.5	1388
2005	77	344.5	270	227	143.6	26.4	30.2	48	16	96.8	103	11	1394
2006	262	131.5	84	130.5	33	24.5	42	50.6	35	12.5	150.2	205	1161
2007	18	112.8	244.4	55	219.4	49.7	62.4	48.4	28.6	9	4.2	60.4	912
2008	284	62.8	124	165	47.5	6	39.9	22	31	20	28	159.5	990
2009	149	322	90	--	--	--	--	17	18	13	81	64	--
2010	63	474.6	53.5	107	123.7	42.1	182	85.9	79.9	1.9	0	2	1216
2011	40	306	167	137	50	12	17	34	32	103	64.5	1	964
2012	109	124	152	68	112	24.1	14	41	97	48	39	89	917
2013	39	234	177	137	45	46	12	96	17	28	31	17	879
2014	24	148	260	119	93	7.1	31	36	6.1	80.3	66	7	878
2015	55	224	179.5	184	71.8	26.1	47.4	60.4	74.6	102.5	90	50	1165
2016	76	23	234	268.3	89.5	47.5	35	55.8	20	11	14.8	25	900
2017	193	171	118	118.2	48	26.8	62	29.8	3.9	21	5	37	834
2018	35	79.5	153.5	201.5	107.4	14.8	37.4	14	22	60	109.6	21.2	856
2019	160	120	69.5	171.6	81	56.2	39.1	61.5					759
Average	**117**	**189**	**155**	**151**	**89**	**29**	**46**	**46**	**36**	**61**	**55**	**57**	**1014**

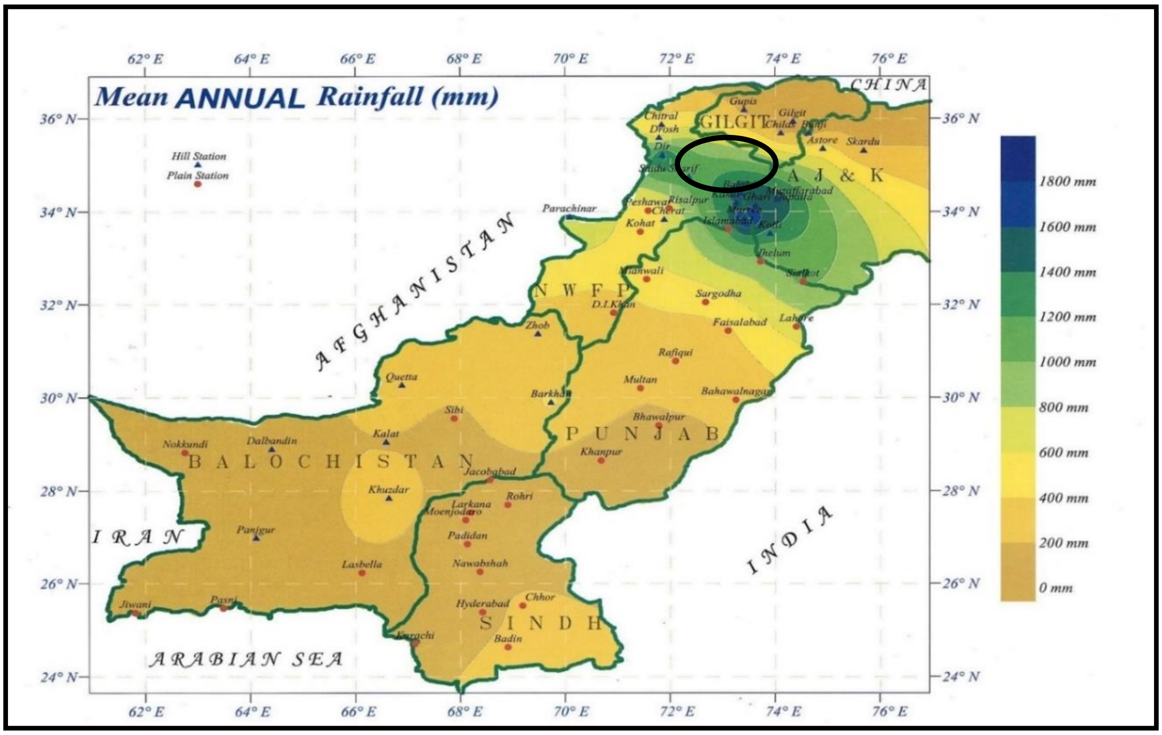

Figure 4-3 Isohyetal Map of Pakistan (1981-2010)

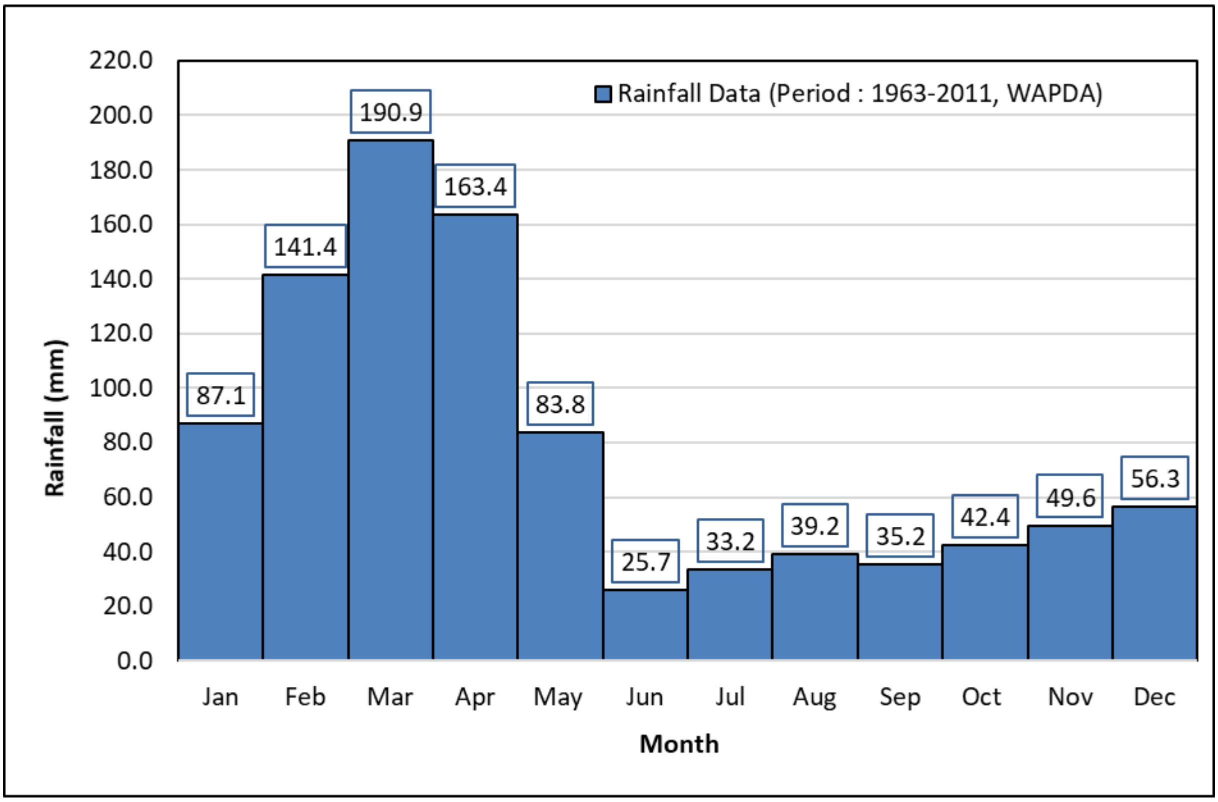

Figure 4-4 Mean monthly rainfall at Kalam (Source: SWHP,WAPDA)

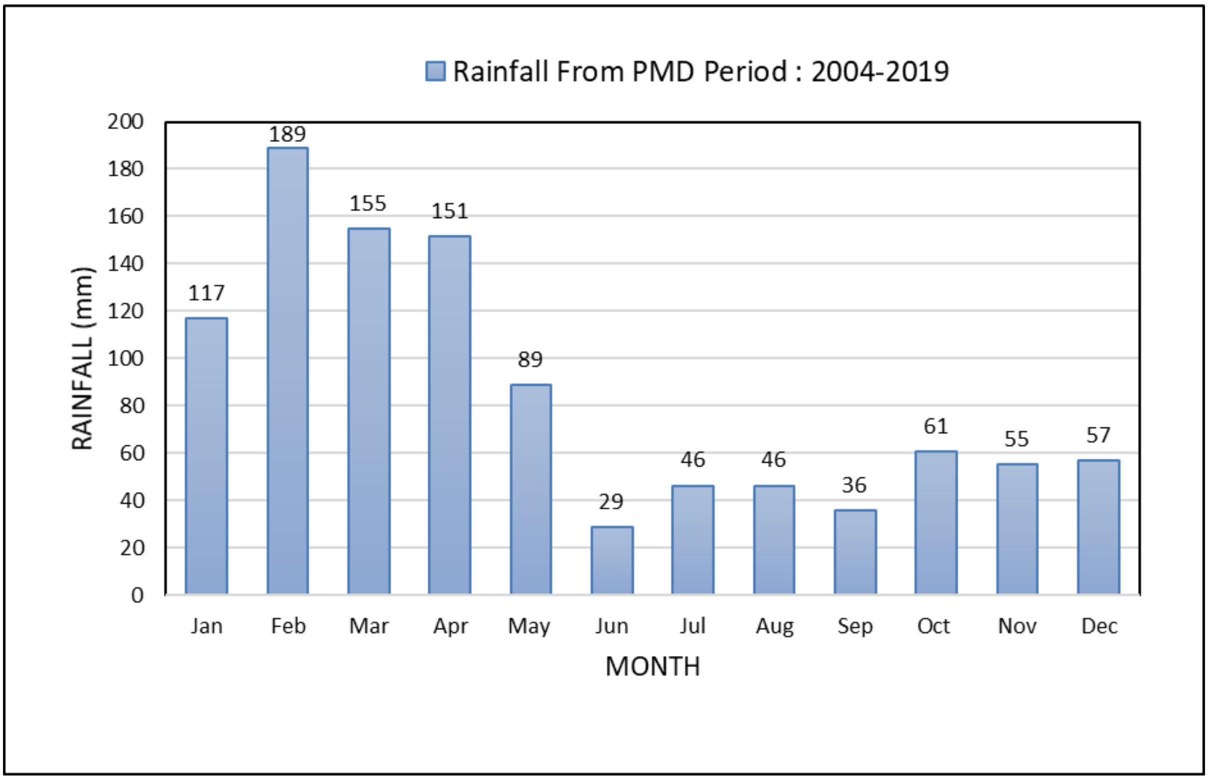

Figure 4-5 Mean monthly rainfall at Kalam (Source: Pakistan Meterological Department)

4.3.2 TEMPRATURE DATA

Temperature is an important parameter that helps to define the climate of the project area. As Artistic-II Hydropower Project is proposed on Ushu River in which flows are mostly generated due to snow and glacier melt. Therefore, monthly mean maximum and minimum temperatures at Kalam for the period of 1966 to 2015 are shown in **Figure** 4-6. The results depict that mean monthly maximum temperature ranges from 26.2°C in the month of June to 7.6°C in the month of January, whereas monthly mean minimum temperature varies between 14.9°C in July and -6.4°C in January.

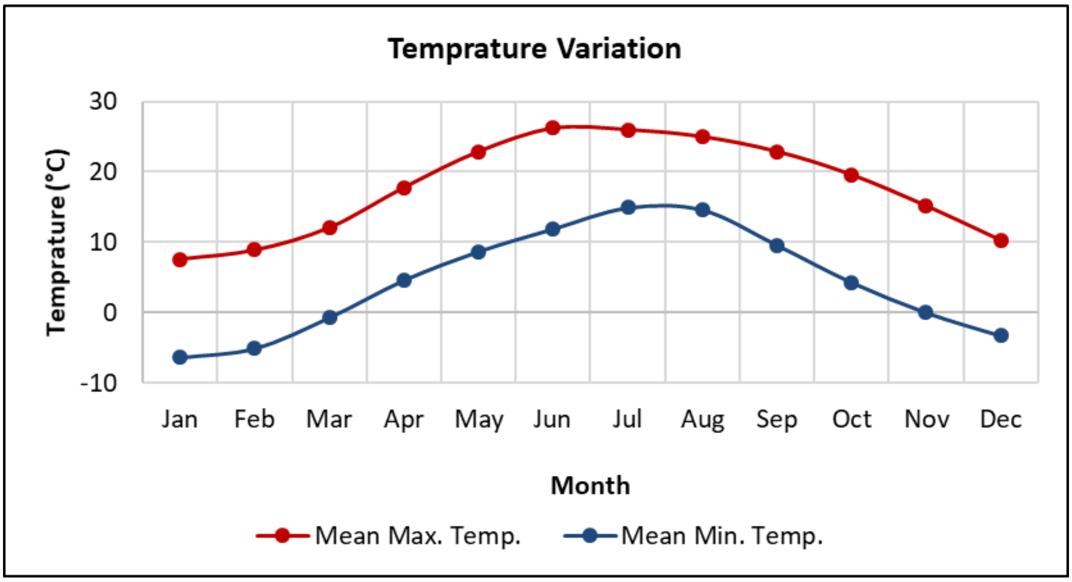

Figure 4-6 Monthly Mean Maximum and Minimum Temprature (°C) at Kalam Station

Table 4-5: Mean Monthly Max. Temperature (°C) at Kalam from 2016 to 2019 (Source: PMD)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	9.3	12.6	12.9	16.8	25.2	27.0	27.2	25.9	25.0	22.0	16.8	13.8
2017	6.1	10.2	11.5	19.2	24.7	27.0	27.0	27.2	26.1	22.5	17.1	11.5
2018	12.0	11.4	17.6	20.3	22.1	27.8	27.0	27.8	25.0	18.7	13.0	11.1
2019	4.5	5.5	13.0	18.8	22.1	24.7	27.2	25.9				
Average	**8**	**10**	**14**	**19**	**24**	**27**	**27**	**27**	**25**	**21**	**16**	**12**

Table 4-6: Mean Monthly Min. Temperature (°C) at Kalam from 2016 to 2019 (Source: PMD)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	-4.2	-3.8	0.5	3.8	9.0	11.7	14.3	12.1	9.4	4.4	0.8	-2.1
2017	-6.2	-8.1	-1.2	4.1	8.5	12.4	15.0	12.9	8.7	4.1	-0.6	-4.0
2018	-5.0	-3.4	-0.1	3.2	5.6	11.5	14.4	14.3	7.2	2.3	-0.6	-5.2
2019	-9.2	-8.2	-4.8	3.9	5.9	8.1	13.8	12.6				
Average	**-6**	**-6**	**-1**	**4**	**7**	**11**	**14**	**13**	**8**	**4**	**0**	**-4**

4.3.3 DISCHARGE DATA

There are three (03) gauge stations available near the project site maintain by various government organizations, as given in **Table** 4-7. stream flows of Ushu River and Swat River are being observed on daily basis. Location of these stations are shown in **Figure** 4-2.

Table 4-7 Stream Flow Gauging Stations

S.No	Station	River	Location		Catchment Area (Km^2)	Period of Record
			Latitude	Longitude		
1	Kalam	Swat	35°28'10"	72°35'40"	2020	1961-2009
2	Jildat	Ushu	35°29'15"	72°35'45"	783	1993-2015
3	Matiltan	Ushu	35°33'33"	72°40'05"	656	2011-2017

Kalam gauge station was located on Swat River 2.4 km (approx.) downstream of the junction of Ushu and Gabral rivers and have the longest records of river flow for around forty-nine (49) years.

Jildat gauge station is located on Ushu River 1.66 km (approx.) upstream of the junction of Kalam and Gabral Rivers. This station is maintained by SWHP, WAPDA and has the records of river flows for around ten (10) years (1993 to 2015).

Matiltan gauge station is located on Ushu River 1.32 km (approx.) downstream of the Gorkin Matiltan Hydropower project weir site, this gauge is maintained by PEDO and has record of river flow for around seven (07) years (2011-2017).

Daily & 10-Daily flow data of Swat at Kalam , Ushu at Matiltan and Jildat are given in **"Annexure-A2, Volume-V".** 10-Daily mean flow data are given below and presented in Figure 4-7 and Figure 4-8.

Table 4-8 10-Daily mean flow

Month	10-D	Swat at Kalam	Ushu at Matiltan	Ushu at Jildat
Catchment Area (sq.km)		**2020**	**656**	**783**
Period		**1961-2010**	**2010-2017**	**1993-2015**
JAN	I	15.57	5.47	7.80
	II	14.93	5.28	7.61
	III	14.29	5.08	7.27
FEB	I	13.79	4.85	7.12
	II	13.69	4.76	7.12
	III	13.61	4.80	7.04
MAR	I	14.03	5.15	7.10
	II	16.19	5.82	7.62
	III	20.41	6.98	9.30
APR	I	28.29	11.61	11.51
	II	44.17	12.92	17.33
	III	71.46	18.51	26.05

Month	10-D	Swat at Kalam	Ushu at Matiltan	Ushu at Jildat
Catchment Area (sq.km)		2020	656	783
Period		1961-2010	2010-2017	1993-2015
MAY	I	95.43	25.94	35.07
	II	129.42	33.86	44.81
	III	161.75	40.50	53.63
JUN	I	208.85	44.84	66.63
	II	243.02	51.12	78.32
	III	275.03	55.47	86.19
JUL	I	273.60	54.12	86.36
	II	256.72	52.07	77.94
	III	224.00	48.61	71.01
AUG	I	199.27	44.63	60.49
	II	167.26	39.75	51.51
	III	131.02	36.28	42.25
SEP	I	101.25	31.63	34.33
	II	77.78	26.05	26.45
	III	56.94	20.18	20.04
OCT	I	42.19	17.45	15.78
	II	34.19	14.59	13.53
	III	28.72	11.41	11.47
NOV	I	25.12	9.78	10.23
	II	22.46	8.98	9.53
	III	19.89	8.32	9.00
DEC	I	18.61	7.54	8.80
	II	17.43	6.82	8.48
	III	16.26	6.00	8.31
Source:		SWHP, WAPDA	PEDO	SWHP, WAPDA

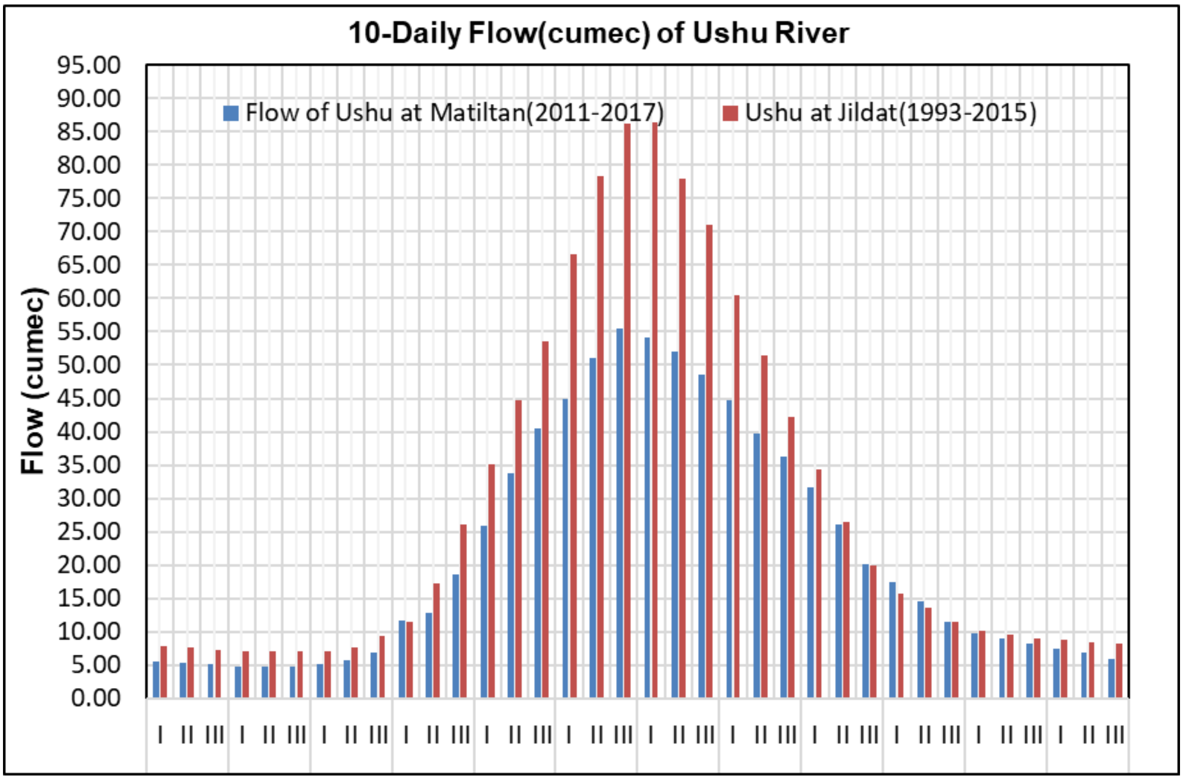

Figure 4-7 10-Daily Mean flow of Ushu River

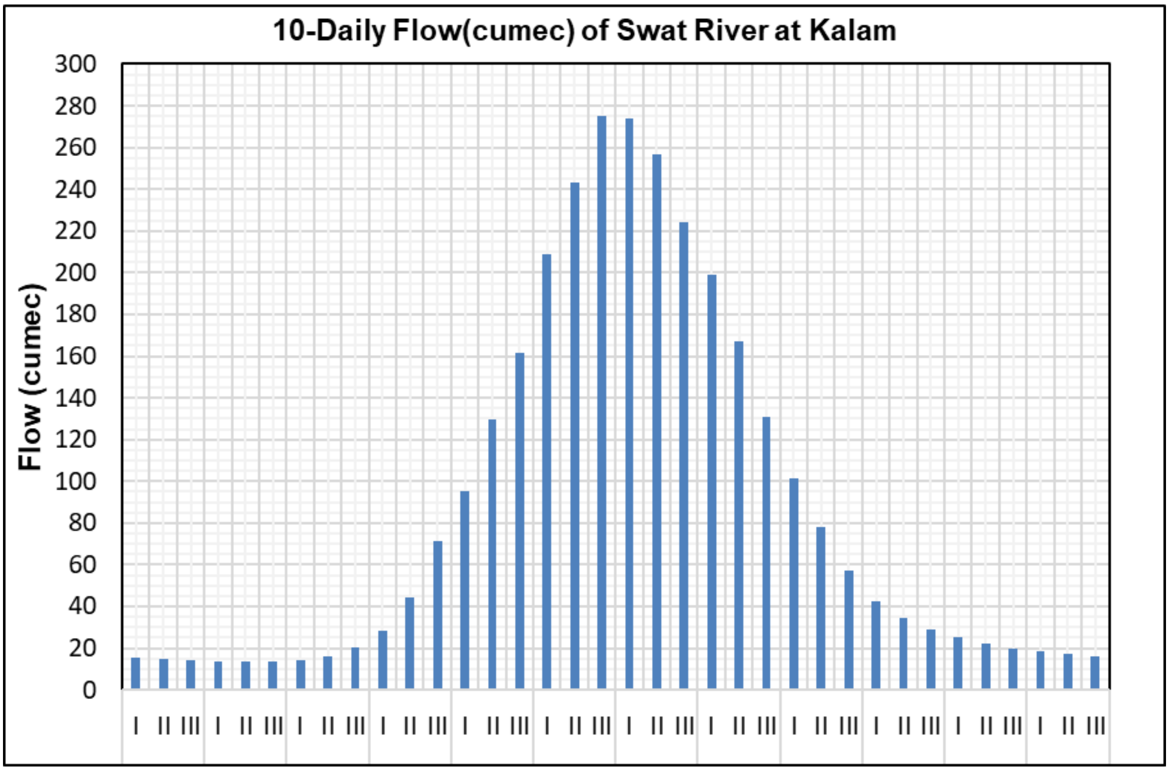

Figure 4-8 10-Daily Mean flow of Swat at Kalam

4.3.4 INSTALLATION OF GAUGE STATION AT PROJECT SITE

Installation of stream gauge is one of the tasks as mentioned in the terms of reference. Three Staged Stream gauge was installed on November 04, 2018 approximately 800m downstream of the proposed weir location on a right side of a foot bridge. The Google earth coordinates of the stream gauge location are 35° 37’ 19.55’’ N, 72° 41’ 04.94’’ E.

The Stream flow measurements were taken twice a month in the month of November as per USGS standards using AA-type (vertical axis Gurley Current meter of USGS specification). For the stage reading of the gauge a local is hired on monthly basis to record the stream gauge three times a day.

- Morning at 8:00 am
- Noon at 12:00 pm
- Evening at 4:00 pm

The estimated velocity obtained at site was applied to the stream width and water depth to estimate the quantity of the river flows.

Figure 4-9 Gauge installation at Artistic-II Site

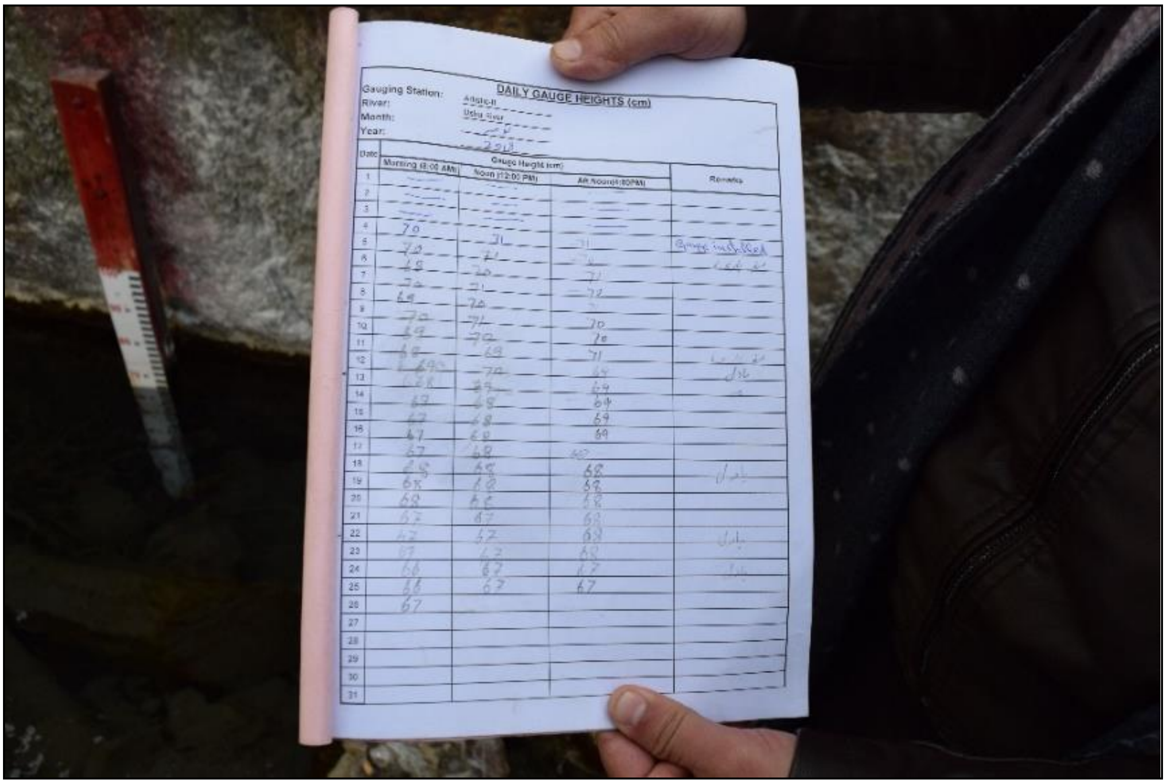

Figure 4-10 Reading of Daily Gauge Height

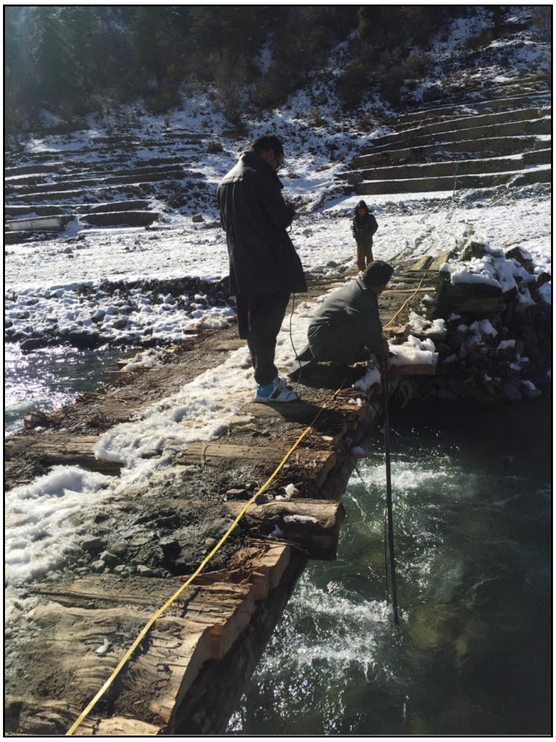

Figure 4-11 Discharge Measurements at Artistic-II Site

Apart from the stream flows, Suspended sediment samples are also collected using depth integrated suspended sediment sampler (D-49) and point sampler as per USGS standards.

These suspended sediment samples are collected twice a month which will be send to the laboratory for estimation of sediments contents. It is proposed that two samples (One in low flow and one during high flow season) will be sent to labortary for necessory testing/analysis.

Figure 4-12 Water Sampling at Artistic-II Site

Table 4-9 Summary of Current Meter Measurements till date

Date	Width		Area		Velocity		Gauge H (meter)	Discharge		Water Temp (°C)
	(feet)	(meter)	(feet^2)	(meter^2)	ft/sec	m/sec		ft^3/sec	m^3/sec	
4/11/2018	31.5	9.6	65.98	6.13	2.953	0.9	0.71	194.3	5.501	
20/11/2018	31.2	9.5	61.89	5.75	3.084	0.94	0.68	190.4	5.392	
5/12/2018	31	9.45	63.72	5.92	2.887	0.88	0.66	184	5.21	2
20/12/2018	30.7	9.35	61.89	5.75	2.756	0.84	0.62	171.3	4.851	2
5/1/2019	30.5	9.3	61.35	5.7	2.717	0.828	0.61	166.5	4.714	2
20/1/2019	30.3	9.25	60.06	5.58	2.707	0.825	0.6	162.6	4.604	-2
9/2/2019	30.2	9.2	57.91	5.38	2.69	0.82	0.57	155.5	4.404	0
27/2/2019	30.2	9.2	56.08	5.21	2.592	0.79	0.55	145	4.106	0.2

Date	Width		Area		Velocity		Gauge H	Discharge		Water Temp
	(feet)	(meter)	(feet^2)	(meter^2)	ft/sec	m/sec	(meter)	ft^3/sec	m^3/sec	(°C)
5/3/2019	30.2	9.2	49.73	4.62	3.215	0.98	0.58	159.2	4.508	0.2
26/3/2019	30.2	9.2	50.05	4.65	3.248	0.99	0.59	162.5	4.6	0.3
7/4/2019	33.3	10.14	81.0	7.52	6.04	1.84	0.8	488.3	13.824	0.6
21/4/2019	33.6	10.25	84.5	7.85	6.20	1.89	0.83	523.7	14.827	7
5/5/2019	33.8	10.3	89.5	8.31	6.40	1.95	0.91	570.1	16.141	8
22/5/2019	34.8	10.6	135.5	12.59	6.63	2.02	1.27	898.9	25.45	5
6/6/2019	35.4	10.8	140.6	13.06	6.71	2.05	1.3	943.8	26.722	6
24/6/2019	49.7	15.15	243.9	22.66	8.09	2.47	1.89	1974.0	55.89	7
6/7/2019	53.6	16.35	285.4	26.51	8.17	2.49	2.08	2330.5	65.982	7
24/7/2019	53.3	16.25	249.5	23.18	8.18	2.49	1.94	2041.4	57.797	8
7/8/2019	52.5	16	216.6	20.12	7.63	2.33	1.74	1652.5	46.788	7
25/8/2019	51.2	15.62	172.3	16.01	4.56	1.39	1.2	786.7	22.273	6
7/9/2019	51.2	15.6	155.1	14.41	4.98	1.52	1.19	772.7	21.876	5
22/9/2019	40.4	12.3	111.3	10.34	5.74	1.75	1.02	639.3	18.099	4
9/10/2019	33.3	10.16	90.6	8.42	5.18	1.58	0.78	469.26	13.288	5
26/10/2019	29.3	8.93	58.0	5.39	3.52	1.07	0.68	204.01	5.777	4
9/11/2019	28.9	8.82	57.4	5.33	3.20	0.98	0.65	183.74	5.203	2
26/11/2019	28.9	8.8	57.0	5.3	3.23	0.99	0.65	184.38	5.221	-3
7/12/2019	28.6	8.72	56.0	5.2	3.01	0.92	0.61	168.38	4.768	-2
24/12/2019	28.3	8.63	54.5	5.06	2.86	0.87	0.58	155.88	4.414	0
20/1/2020	28.4	8.65	55.5	5.16	2.92	0.89	0.59	161.95	4.586	0
30/1/2020	28.2	8.60	54.3	5.04	2.82	0.86	0.56	153.76	4.354	-2
10/2/2020	27.9	8.5	53.0	4.92	2.82	0.86	0.55	149.80	4.242	-2
22/2/2020	30.0	9.13	40.8	3.79	3.44	1.05	0.53	140.98	3.992	0
15/3/2020	30.3	9.24	43.3	4.02	3.44	1.05	0.54	148.36	4.201	2
29/3/2020	28.2	8.6	47.1	4.38	3.25	0.99	0.57	153.65	4.351	3
12/04/2020	28.9	8.82	53.8	5	3.48	1.06	0.65	187.34	5.305	2
22/04/2020	33.5	10.2	77.7	7.22	5.12	1.56	0.75	396.62	11.231	6
15/5/2020	37.5	11.43	109.8	10.2	6.43	1.96	1.12	707.35	20.03	8
28/5/2020	51.3	15.65	202.9	18.85	7.19	2.19	1.6	1480.64	41.927	6

4.4 ESTAMATION OF FLOWS AT WEIR SITE

To estimate the water availability a longer period of hydrological record must be available to rely upon. In case of Artistic-II Hydropower project, daily flow record of Ushu River at Matiltan Gauge station is available on the records of Pakhtunkhwa Energy Development Organization

(PEDO) for only 07 years (2011-2017), while for the same river at Jildat gauge station, records for the period of 17 years (1993-2015) are available on the record of Surface Water Hydrology (SWHP), WAPDA. However, daily flow records of Swat River at Kalam gauge station for the period of 1961 to 2010 are available on the records of Surface Water Hydrology (SWHP), WAPDA which can be used for the hydrological estimations for Artistic-II Hydropower Project. The Kalam gauge station was washed out during 2010 flood event and was not restored till to date, therefore, no data for this station is available after the flood event of 2010.

Derivation of flow pattern for Artsistic-II weir site is done by using Kalam station historical stream flow data which is professionally acceptable option available to base one's judgment upon. Comparison of stream flow for a concurrent period of Swat River at Kalam with Ushu River at Jildat by developing a correlation to generate flows for Ushu River at Jildat and then reducing the same for weir site by catchment area ratio method.

The following correlation with co-efficient of Determination as R^2= 0.98 has been developed between the 10-daily flows of Swat river observed at Kalam and Ushu river at Jildat for the concurrent period. Figure 4-13 & Figure 4-14 show the results of regression analysis between Swat river at Kalam and Ushu river at Jildat.

$$Q\ (\text{Jildat}) = 0.465 \times Q\ (\text{Kalam})^{0.99}$$

Where,

Q (Jildat) = Discharges at Jildat gauge station (m^3/sec)

Q (Kalam) = Discharges at Kalam gauge station (m^3/sec)

Using above correlation, Swat at Kalam flow was shifted to Jildat for the year 1961-2005. The estimated data at Jildat from the year 1961-2005, the observed data at Jildat for the year 2006 -2009 and the observed data at Matiltan for the year 2011 to 2017 was then transposed to the proposed Artistic-II weir site using the catchment area ratio (Table 4-10). Mean 10 Daily flow of Ushu River mentioned in Table 4-10 have been derived from Gabral at Gulshanabad, Swat at Kalam and above mentioned regression analysis. Finally recommended flow series have been derived from Swat at Kalam versus Ushu at Jildat from 1960 to 2005 including observed flow data of Ushu at Jildat for 2006-09 and Matiltan from 2011 to 2017.

10-Daily generated flow of Ushu River at weir is given **"Annexure-A2, Volume-V".**

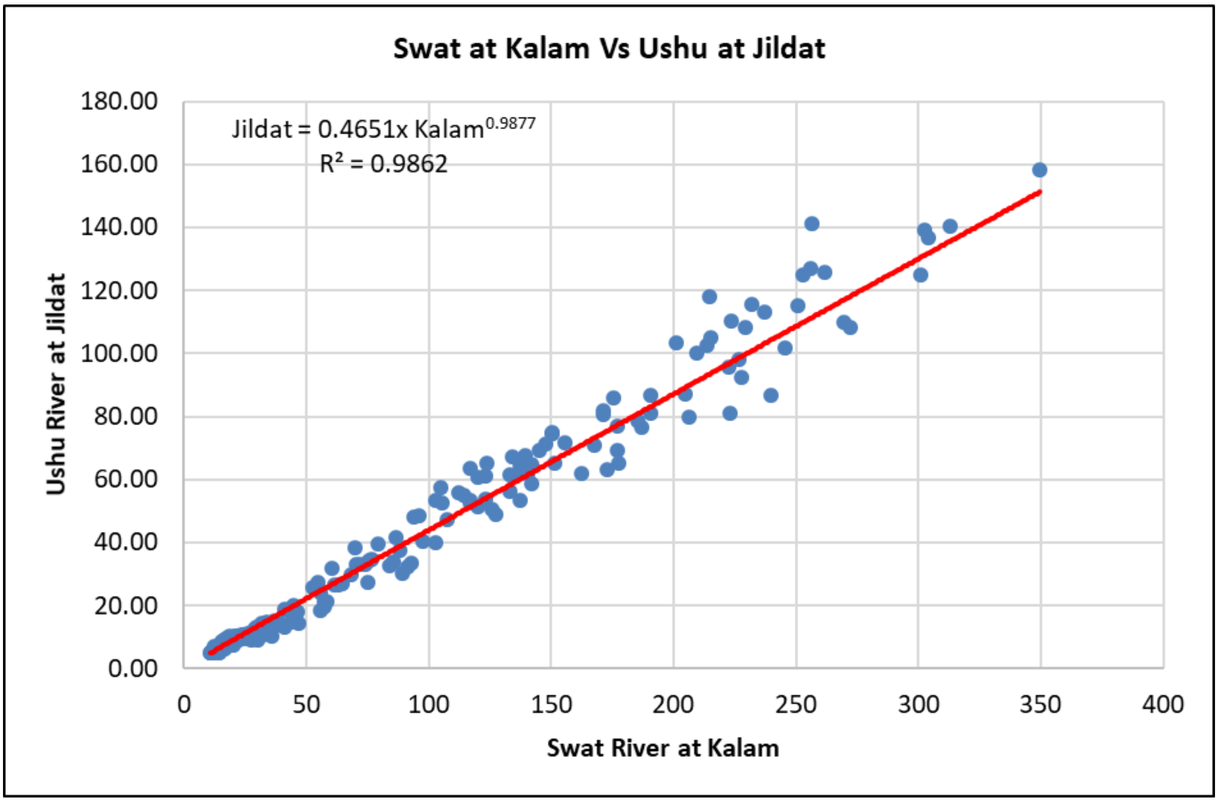

Figure 4-13 Regression Analysis of Jildat & Kalam stations flow data

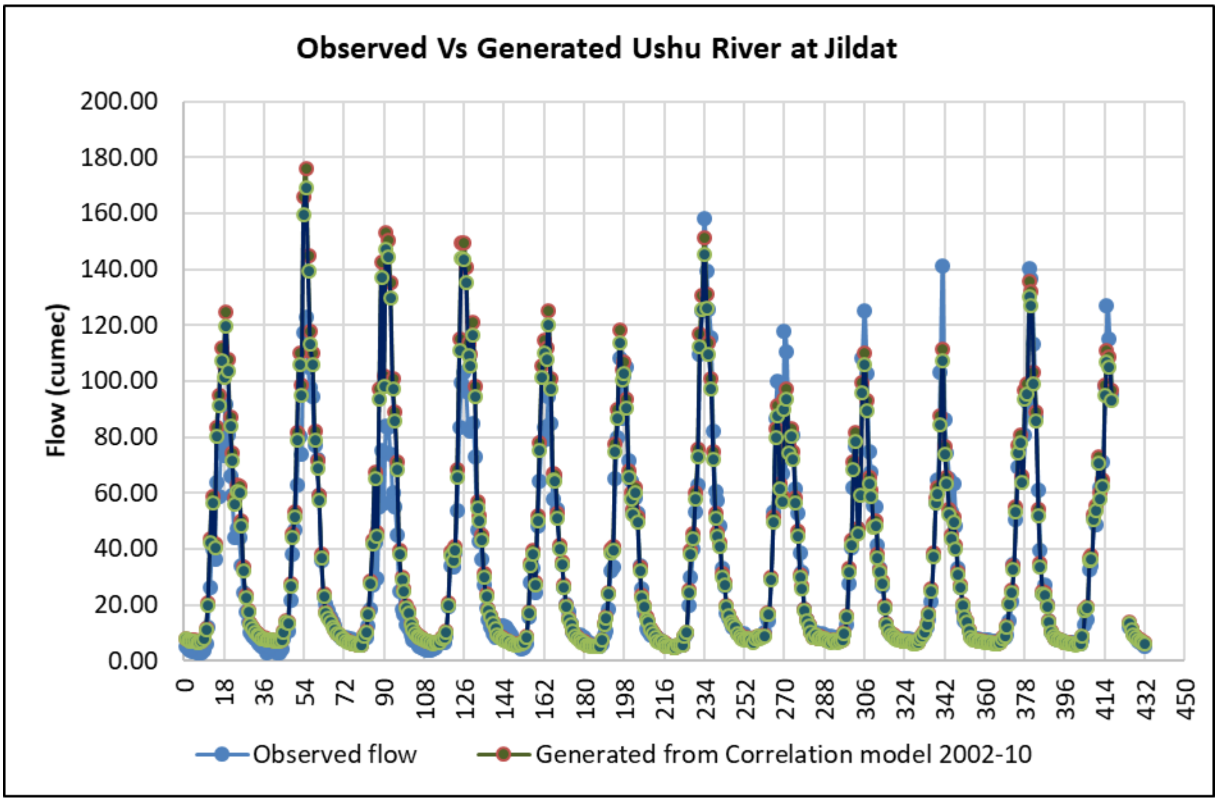

Figure 4-14 Comparison of Observed Vs Generated 10-Daily Flow at Jildat guaging station

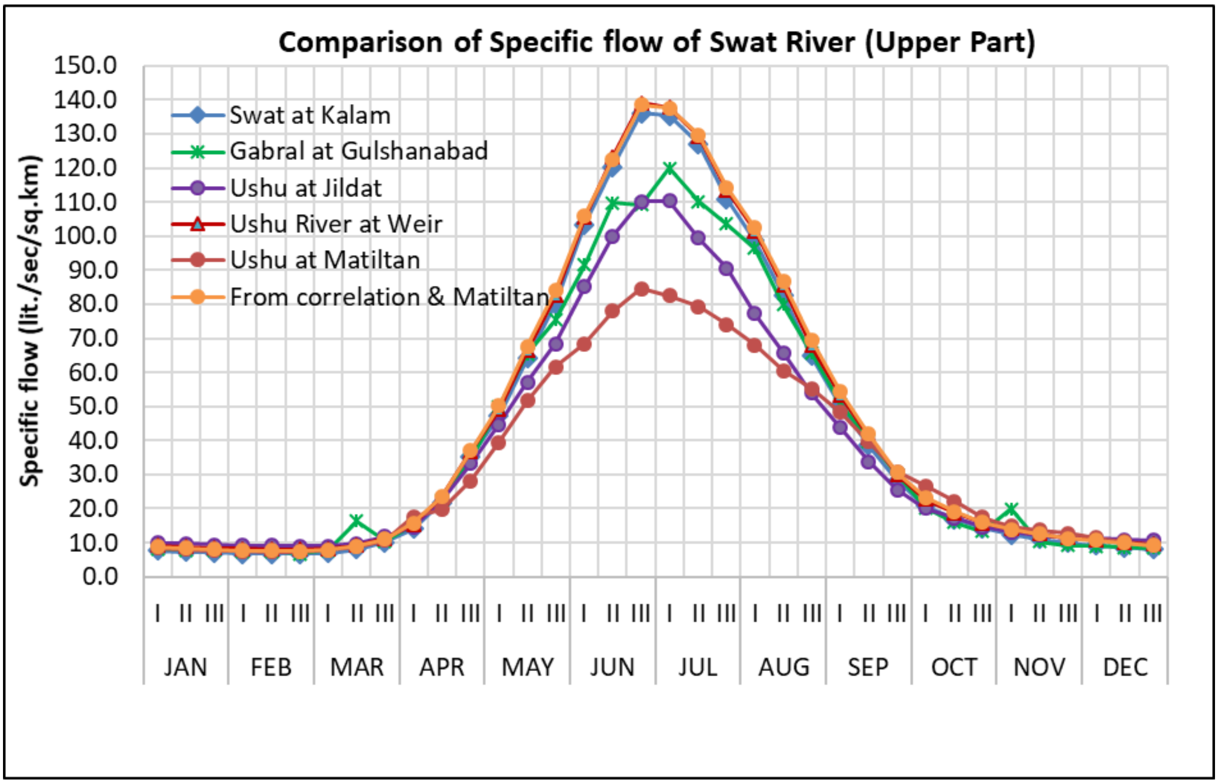

Figure 4-15 Comparison of Specific flow

Table 4-10 10-Daily water availability of Ushu River at weir

10 Daily		Based on Swat at Kalam	Gabral River at Gulshanabad data	Ushu at Jildat Correlation basis	Ushu at Jildat correlation basis including Matiltan 2011-2017
Jan	I	3.50	3.71	4.16	3.98
	II	3.36	3.61	4.00	3.81
	III	3.21	3.57	3.83	3.64
Feb	I	3.10	3.44	3.70	3.51
	II	3.08	3.36	3.68	3.47
	III	3.06	3.04	3.63	3.42
Mar	I	3.15	3.58	3.72	3.54
	II	3.64	7.41	4.20	4.05
	III	4.59	4.76	5.14	5.03
April	I	6.36	6.87	6.96	7.12
	II	9.93	10.19	10.54	10.64
	III	16.06	15.53	16.73	16.82
May	I	21.45	22.67	22.29	22.74
	II	29.09	29.69	30.16	30.72

10 Daily		Based on Swat at Kalam	Gabral River at Gulshanabad data	Ushu at Jildat Correlation basis	Ushu at Jildat correlation basis including Matiltan 2011-2017
	III	36.35	34.23	37.50	38.12
June	I	46.94	41.54	47.90	48.12
	II	54.62	49.82	55.96	55.68
	III	61.81	49.61	63.18	62.93
July	I	61.49	54.44	62.61	62.46
	II	57.70	50.04	58.72	58.89
	III	50.34	47.04	51.59	51.92
Aug	I	44.79	43.81	46.08	46.54
	II	37.59	36.29	38.79	39.34
	III	29.45	29.90	30.85	31.58
Sep	I	22.76	23.05	24.14	24.67
	II	17.48	18.09	18.59	18.99
	III	12.80	13.63	13.64	13.94
Oct	I	9.48	9.22	10.29	10.55
	II	7.68	7.23	8.49	8.65
	III	6.46	6.05	7.20	7.23
Nov	I	5.65	9.08	6.35	6.34
	II	5.05	4.71	5.73	5.71
	III	4.47	4.21	5.18	5.14
Dec	I	4.18	4.09	4.90	4.83
	II	3.92	3.95	4.63	4.52
	III	3.66	3.82	4.38	4.20
Period:		1961-2010 from catchment area ratio	1993-2015	1961-2015 including observed at Jildat reduced by catchment area ratio	1961-2010 & 2011-2017 Matiltan reduced by catchment area ratio

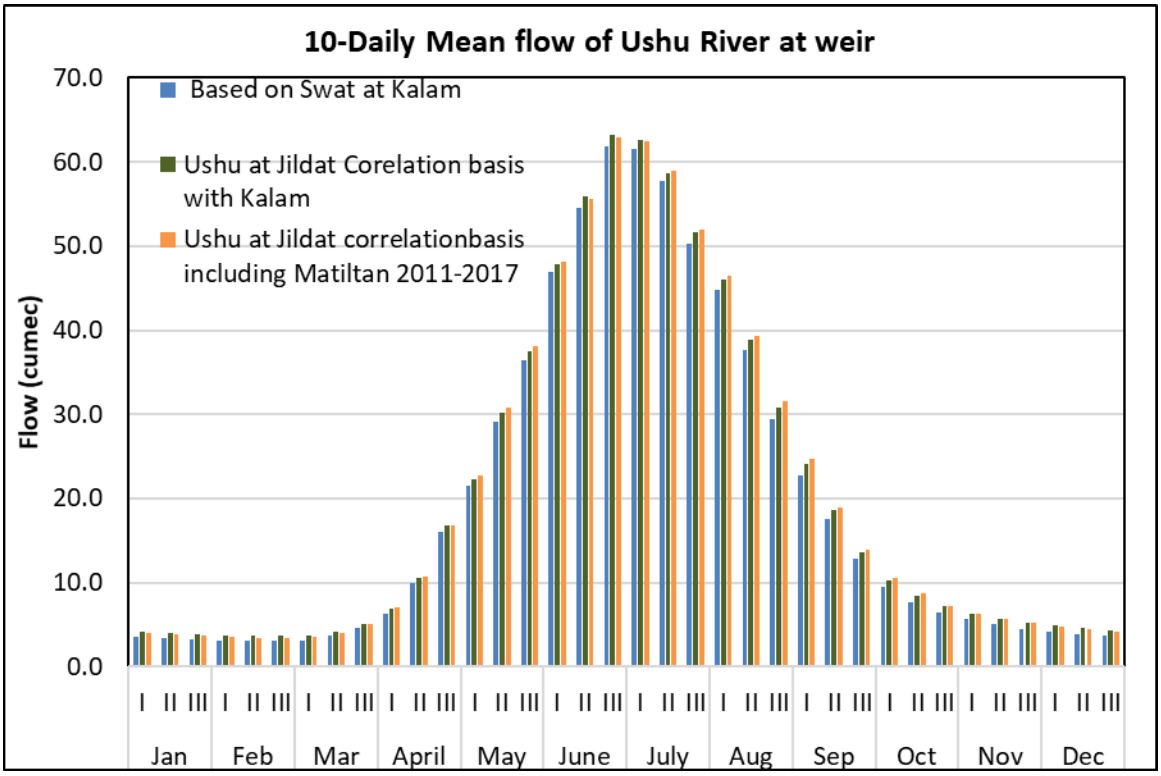

Figure 4-16 Generated Mean 10-Daily Flow at Artistic-II HPP Weir Site (1961-2017)

Table 4-11 10-Daily mean flow of Ushu River at weir

10 Daily		1961-2017	1961-80	1981-2000	2001-17
Jan	I	3.98	3.83	4.01	4.13
	II	3.81	3.62	3.85	3.98
	III	3.64	3.44	3.70	3.79
Feb	I	3.51	3.29	3.56	3.69
	II	3.47	3.24	3.49	3.70
	III	3.42	3.20	3.40	3.71
Mar	I	3.54	3.28	3.47	3.93
	II	4.05	3.82	3.78	4.65
	III	5.03	4.79	4.56	5.85
April	I	7.12	6.75	6.21	8.62
	II	10.64	10.41	10.14	11.51
	III	16.82	16.12	17.78	16.53
May	I	22.74	21.59	23.45	23.26
	II	30.72	28.63	31.45	32.34

10 Daily		1961-2017	1961-80	1981-2000	2001-17
	III	38.12	38.38	39.60	36.06
June	I	48.12	53.67	47.78	41.98
	II	55.68	64.65	53.36	47.86
	III	62.93	71.54	62.20	53.68
July	I	62.46	70.64	63.19	52.00
	II	58.89	67.33	59.96	47.69
	III	51.92	57.27	54.00	43.18
Aug	I	46.54	52.54	47.86	37.40
	II	39.34	44.60	39.95	32.03
	III	31.58	34.97	32.32	26.42
Sep	I	24.67	26.84	25.33	21.12
	II	18.99	20.45	19.30	16.79
	III	13.94	14.76	14.44	12.40
Oct	I	10.55	10.95	10.67	9.95
	II	8.65	8.69	8.82	8.41
	III	7.23	7.25	7.41	7.01
Nov	I	6.34	6.35	6.44	6.22
	II	5.71	5.61	5.78	5.75
	III	5.14	4.98	5.18	5.28
Dec	I	4.83	4.66	4.88	4.96
	II	4.52	4.34	4.59	4.66
	III	4.20	4.02	4.29	4.29

4.5 FLOW DURATION CURVE ANALYSIS

Availability of flows at the proposed weir/intake site was checked using detailed flow duration curve analysis. A flow duration curve (FDC) shows relationship between magnitude and frequency of stream flows for a particular river basin at a particular location. FDC provides estimation of cumulative percentage of time that a given quantity of flow is equaled to or exceeded which helps in planning and capacity sizing of a power plant.

Flow series generated from Swat at Kalam , Ushu at Jildat and Matiltan data as explained above are used for estimation of flow availability for exceeding probabilities. Summary of results are given below and finally adopted flow duration curve is given in Figure 4-17**.**

Flow avaialbility against different exceeding probabilities generated from correlation model of Swat at Kalam and Ushu at Jildat including observed flow data at Matiltan are recommended for further used.

Table 4-12 Summary of flow availability for different exceeding probabilities

%	Based on Swat at Kalam	Based on Gabral at Gulshanabad	Ushu at Jildat Correlation basis with Kalam	Ushu at Jildat Correlation basis with Kalam including Matiltan 2011-2017
20.0%	38.21	35.88	38.00	37.50
22.5%	34.16	33.65	34.40	34.50
25.0%	30.79	32.07	31.50	32.00
27.5%	28.09	29.21	28.75	29.50
30.0%	25.40	26.35	25.00	26.70
32.5%	21.80	24.13	21.75	23.50
35.0%	19.33	20.64	19.60	20.50
37.5%	16.86	18.10	17.30	18.25
40.0%	14.16	15.87	14.75	15.50
45.0%	10.34	11.75	11.00	11.60
50.0%	8.09	8.45	8.75	8.75
55.0%	6.52	6.48	7.20	7.20
60.0%	5.39	5.52	6.40	6.10
65.0%	4.70	4.95	5.65	5.30
70.0%	4.18	4.38	5.00	4.85
75.0%	3.80	3.94	4.55	4.40
80.0%	3.57	3.56	4.20	4.00
85.0%	3.32	3.24	3.80	3.70
90.0%	3.09	2.98	3.50	3.40
95.0%	2.87	2.60	3.25	3.20

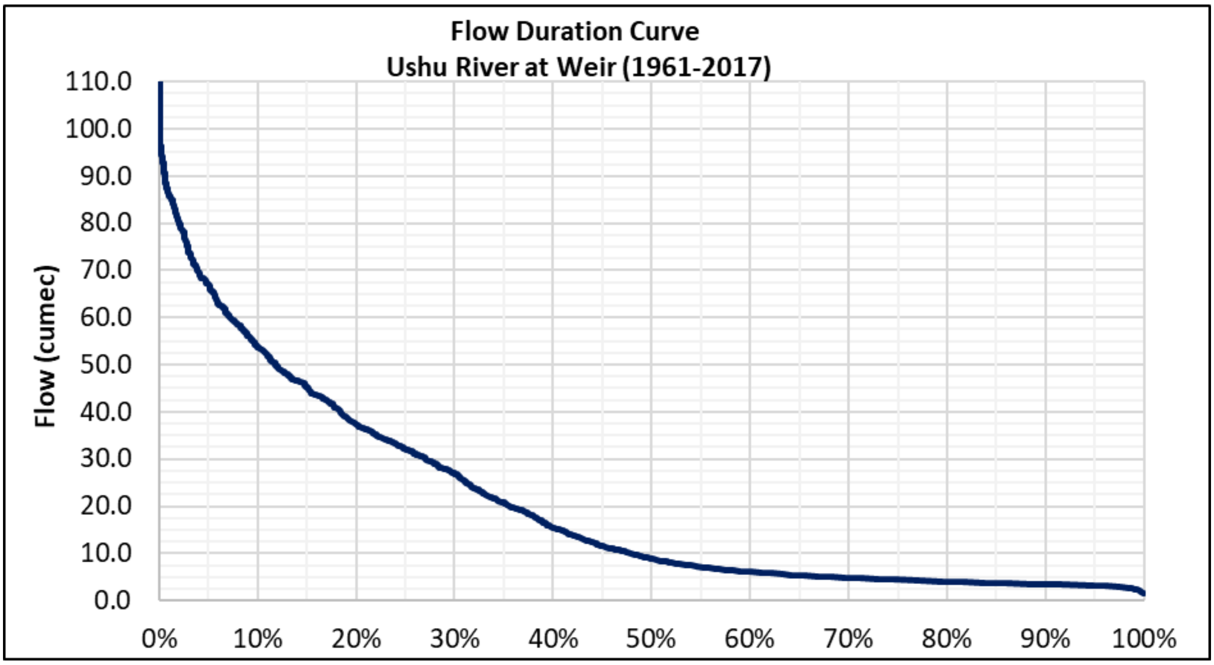

Figure 4-17 Flow Duration Curves of Artistic -2 HPP at Weir Site

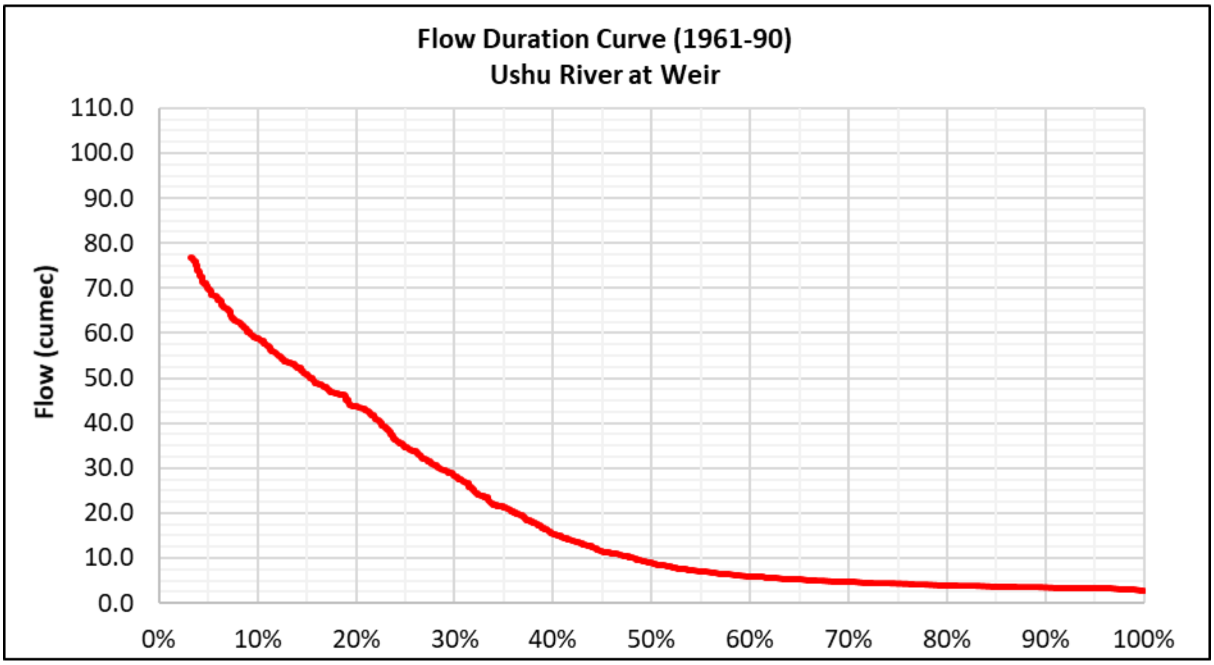

Figure 4-18 Flow Duration Curves of Artistic -2 HPP at Weir Site (1961-1990)

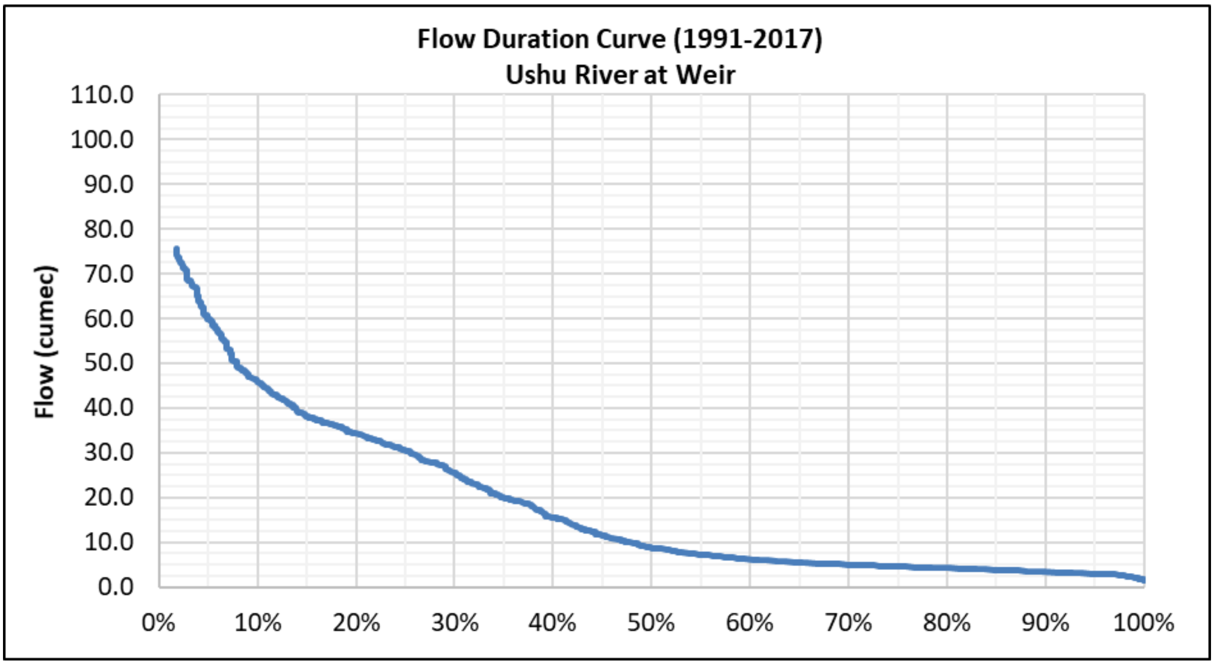

Figure 4-19 Flow Duration Curves of Artistic -2 HPP at Weir Site (1961-1990)

4.6 DESIGN FLOOD

Flood studies are carried out for planning and design as well as for checking the safety of hydraulic structures. To estimate the design flood at least thirty years of instantaneous flow data or precipitation data is normally required at the project location. In case of Artistic-II Hydropower Project both does not exists. Therefore, recourse has to be made to the instantaneous flow records of the swat river at Kalam gauging station (Nearest to Artistic-II Hydropower Project) which is available for 49 years i.e; (1961 to mid of 2010) maintained by the Surface water Hydrology (SWHP), WAPDA (Table 4-13 & Figure 4-20)**.** Maximum observed flood of Swat at Kalam was 597cumec in 1978. As per locals maximum flood was July, 2010 but value of flood is not known as all gauges of Upper Swat were washed out including Swat at Kalam.

Estimation of design flood was undertaken considering that floods in the northern areas of Pakistan can be generated by two different processes, snowmelt and precipitation. Recorded floods are normally from snowmelt origin. When large and powerful events (Monsoon and Western disturbances) develop over the area, intense rainfall can originate floods that can be as much large like July, 2010.

➢ Flood frequency analysis have been carried out on available peak flood data of Swat River at Kalam and specific flood per square kilometer worked out. With appropriate factor varies from 1.3 to 2.0 specific flood have been transformed at weir and powerhouse sites.

➢ Derivation of flood flows for different return periods on the basis of observed flood series of similar catchments in the region having longer historic records. Peak flood data of the River possessing similar hydro-meteorological conditions have been collected as mentioned in Table 4-14 and frequency analysis through Gumbel extreme value distribution for each station have been carried out. The results of frequency analysis are given in Table 4-14. Envelop curves of different return periods are drawn as shown in Figure 4-21 to Figure 4-23**.** Calculations of flood on the basis of envelop curves are also carried out (Table 4-14 & Table 4-15)**.** The regional river flood analysis includes flood peak data of July, 2010 in most of the gauging stations of surrounding Rivers, while Swat at Kalam was not included in July, 2010. Design flood estimated through regional River analysis are recommended for further design use.

Table 4-13 Instantaneous & Peak Mean Daily Flows at Kalam

S.No	Year	Peak Mean Daily Flows (m^3/s)	Peak Instantaneous Flows (m^3/s)	S.No	Year	Peak Mean Daily Flows (m^3/s)	Peak Instantaneous Flows (m^3/s)
1	1961	297.3	314.3	26	1986	430.4	518.2
2	1962	373.8	404.9	27	1987	342.6	379.4
3	1963	376.6	470.1	28	1988	376.6	390.8
4	1964	424.8	521.0	29	1989	328.6	333.8
5	1965	419.1	464.4	30	1990	421.9	534.0
6	1966	404.9	424.7	31	1991	485.5	549.8
7	1967	390.8	421.9	32	1992	430.1	468.8
8	1968	419.1	438.9	33	1993	341.2	403.1
9	1969	427.6	455.9	34	1994	445.4	489.3
10	1970	328.5	370.9	35	1995	433.8	487.8
11	1971	328.5	351.1	36	1996	452.6	533.7
12	1972	424.8	472.9	37	1997	310.3	344.7
13	1973	368.1	387.9	38	1998	416.3	494.7
14	1974	280.6	337.0	39	1999	321.7	373.6
15	1975	455.9	464.4	40	2000	221.1	236.9
16	1976	376.6	393.6	41	2001	183.8	196.5
17	1977	320.0	342.6	42	2002	317.5	347.5
18	1978	461.6	597.5	43	2003	381.8	393.1

S.No	Year	Peak Mean Daily Flows (m^3/s)	Peak Instantaneous Flows (m^3/s)	S.No	Year	Peak Mean Daily Flows (m^3/s)	Peak Instantaneous Flows (m^3/s)
19	1979	396.4	470.1	44	2004	313.4	327.7
20	1980	351.1	393.6	45	2005	485.9	505.6
21	1981	376.6	407.8	46	2006	253.5	270.5
22	1982	211.8	233.0	47	2007	304.1	319.1
23	1983	351.1	368.1	48	2008	289.6	298.2
24	1984	342.6	413.4	49	2009	353.3	364.7
25	1985	264.8	308.7				

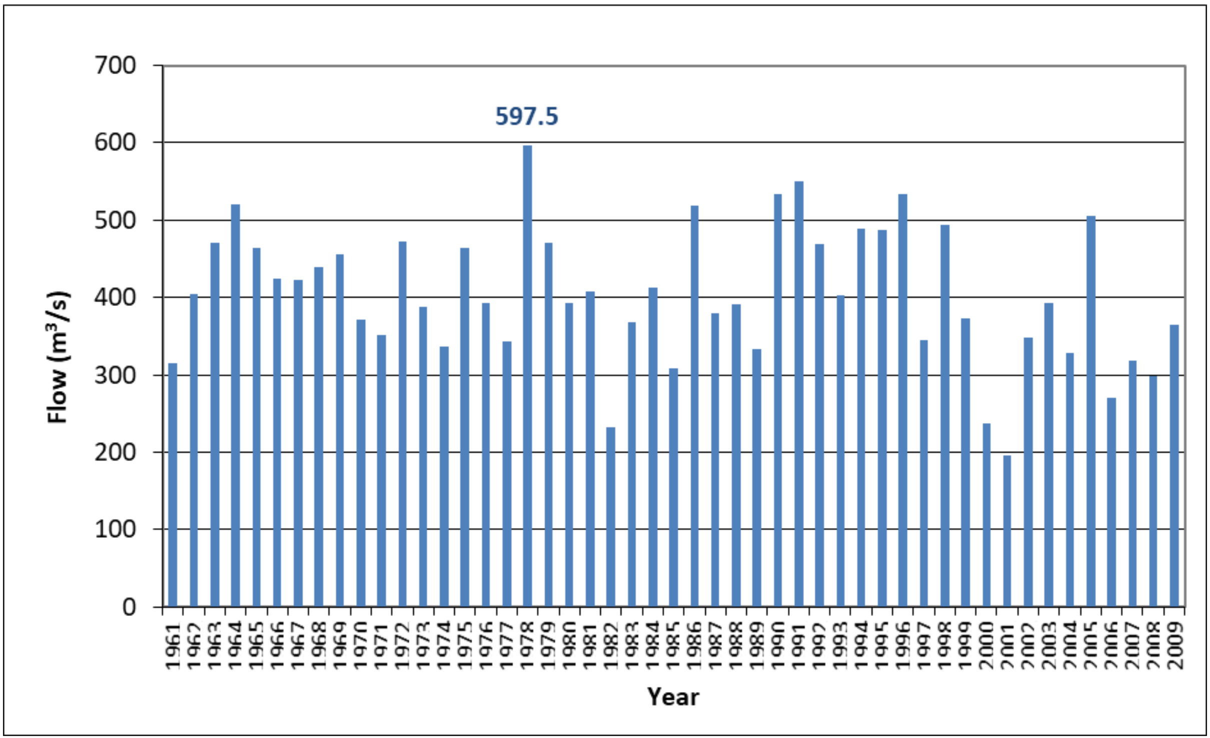

Figure 4-20 Instantaneous Flow Data at Kalam

Table 4-14: Regional Flood Peaks (cumecs)

River	Gauging station	years of Record	Period	Catchment Area sq.km	Return Period (yr.) 2	10	50	100	200	1000
Neelum	Muzaffarabad	54	1963-2014	7228	1444	2649	3706	4152	4597	5628
Jhelum	Domel	34	1976-2010	14504	1260	2782	4117	4681	5243	6545
	Chinari/Hattian Bala	33	1977-2010	13598	954	1668	2294	2559	2822	3433
Siran	Phulra	43	1969-2012	1057	572	1127	1614	1820	2025	2500
Kunhar	Naran	54	1960-2014	1036	235	405	554	617	680	826
Astore	Doyian	37	1974-2010	4040	656	1021	1341	1476	1611	1923
Kunhar	Garhi HB	50	1960-2010	2383	577	1160	1672	1888	2103	2602
Ghorband	Korora	29	1975-2010	635	316	887	1387	1598	1809	2297
Swat	Chackdara	54	1961-2014	5770	881	2261	3471	3982	4492	5672
	Kalam	49	1961-2009	2020	390	533	658	711	764	886
Ushu River	**Weir Site**	**With Swat at Kalam adjusted factor**		**454**	**123**	**168**	**207**	**224**	**240**	**279**
	Power House			**600**	**162**	**222**	**274**	**296**	**318**	**368**
	Jildat			**783**	**212**	**289**	**357**	**386**	**414**	**481**
Ushu River	**Weir Site**	**From fitted curve equations**		**454**				**466**	**492**	**644**
	Power House			**600**				**558**	**591**	**762**
	Jildat			**783**				**663**	**705**	**896**
Ushu River	**Weir Site**	**From average specific flood (Recommend for design purpose)**		**454**	**108**	**224**	**326**	**369**	**411**	**511**
	Power House			**600**	**142**	**296**	**430**	**487**	**544**	**675**
	Jildat			**783**	**186**	**386**	**562**	**636**	**710**	**881**

Table 4-15 Specific Discharge (cumecs /sq.km)

River	Gauging station	years of Record		Catchment Area	Return Period (yr.)					
				sq.km	2	10	50	100	200	1000
Neelum	Muzaffarabad	54	1963-2014	7228	0.200	0.367	0.513	0.574	0.636	0.779
Jhelum	Domel	34	1976-2010	14504	0.087	0.192	0.284	0.323	0.361	0.451
	Chinari/Hattian Bala	33	1977-2010	13598	0.070	0.123	0.169	0.188	0.208	0.252
Siran	Phulra	43	1969-2012	1057	0.541	1.067	1.527	1.722	1.916	2.365
Kunhar	Naran	54	1960-2014	1036	0.227	0.391	0.535	0.596	0.656	0.797
Astore	Doyian	37	1974-2010	4040	0.162	0.253	0.332	0.365	0.399	0.476
Kunhar	Garhi HB	50	1960-2010	2383	0.242	0.487	0.701	0.792	0.883	1.092
Ghorband	Korora	29	1975-2010	635	0.498	1.396	2.184	2.517	2.848	3.617
Swat	Chackdara	54	1961-2014	5770	0.153	0.392	0.601	0.690	0.778	0.983
	Kalam	**49**	**1961-2009**	**2020**	**0.193**	**0.264**	**0.326**	**0.352**	**0.378**	**0.438**
Average Specific flood (cumecs per sq.km)					**0.24**	**0.49**	**0.72**	**0.81**	**0.91**	**1.13**

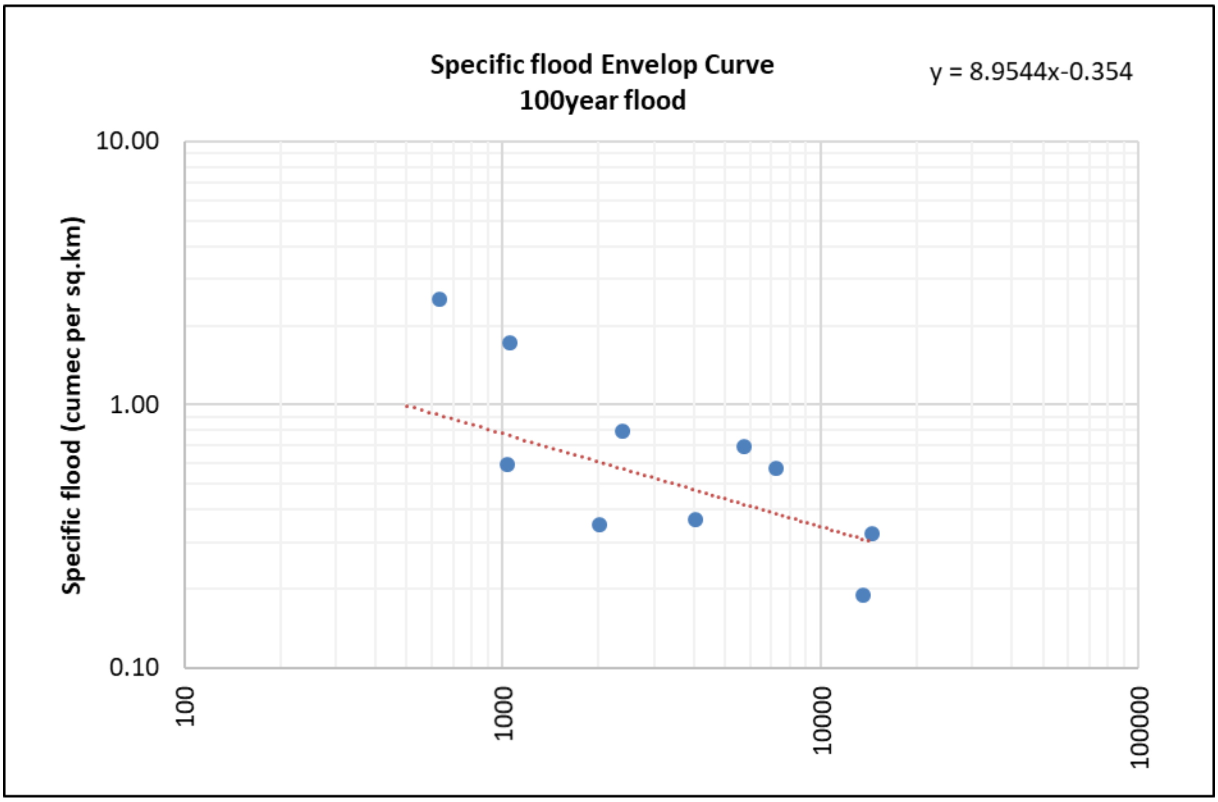

Figure 4-21 Envelop curve for 100year return period Specific flood

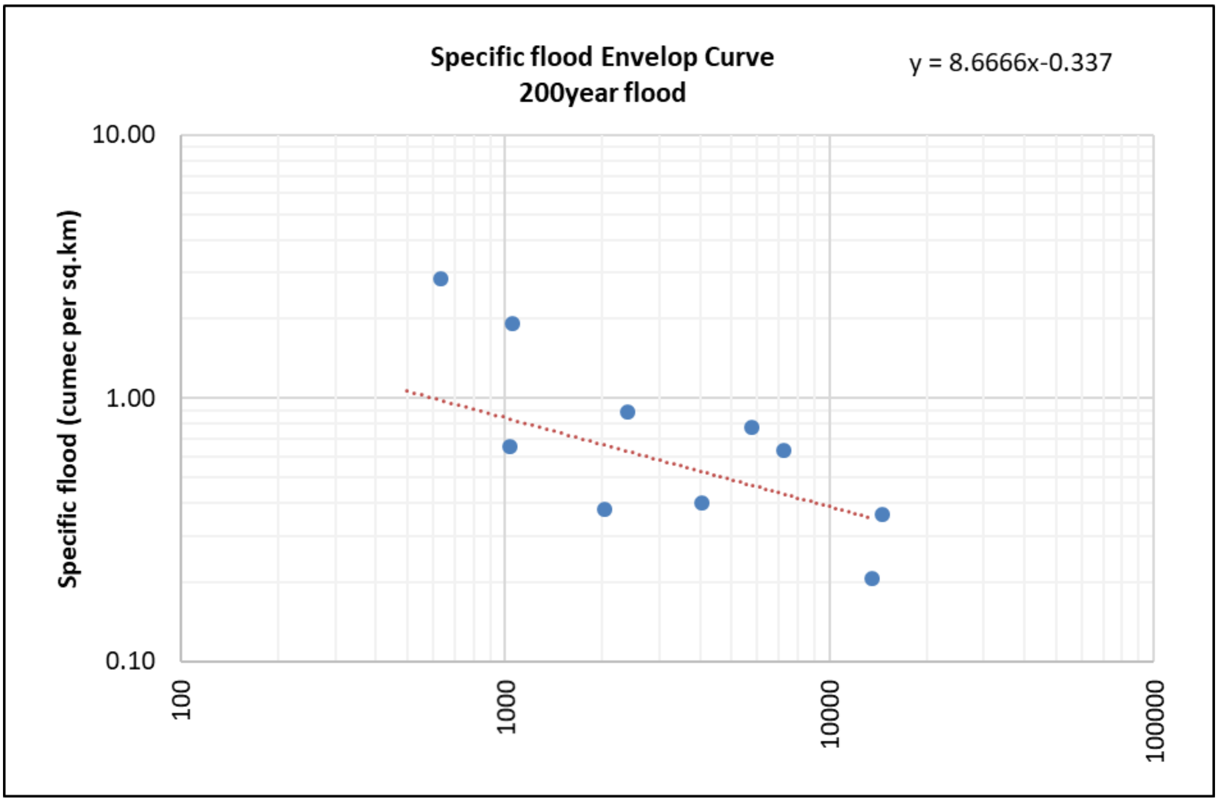

Figure 4-22 Envelop curve for 200year return period Specific flood

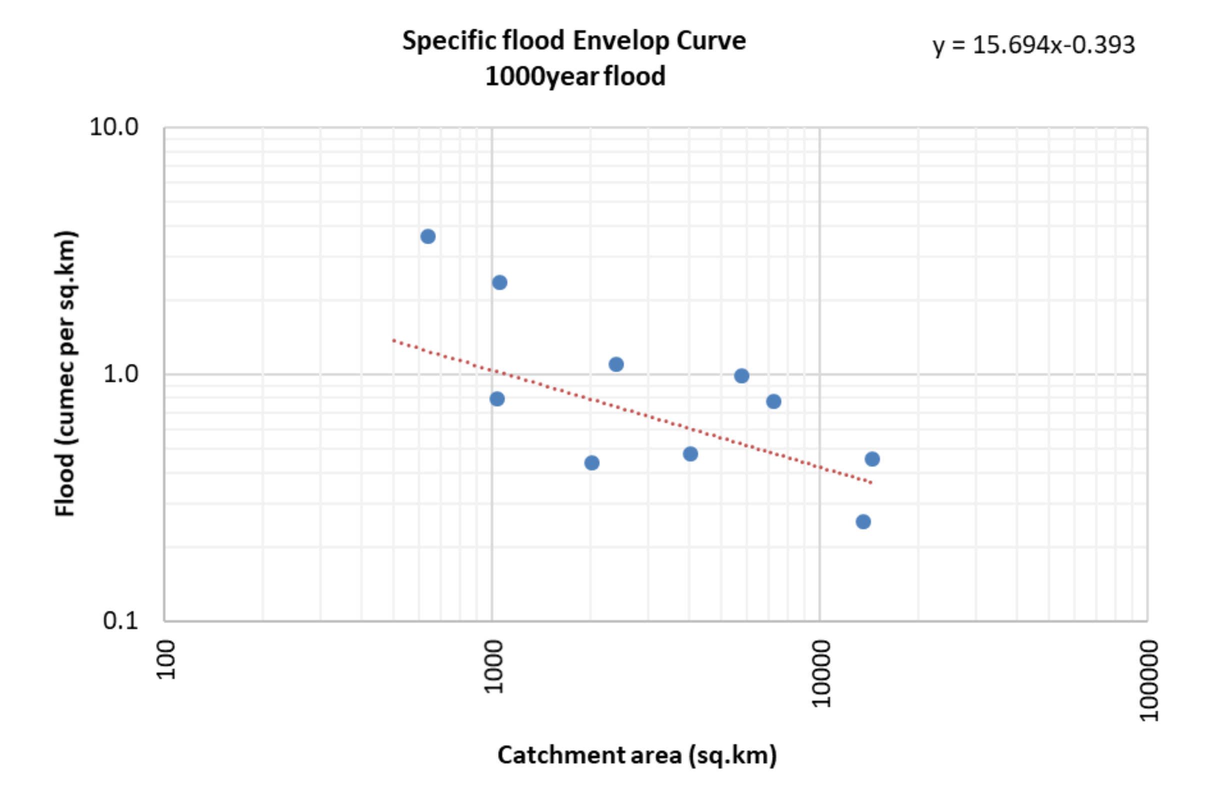

Figure 4-23 Envelop curve for 1000year return period Specıfıc flood

4.7 SEDIMENTATION STUDIES

Normally sedimentation studies are essential for the storage projects to assess the depletion rate and life of reservoir. The heavy sediment loads generally pose serious operational problems to the storage reservoir and can fastly deplete its storage capacity. Artistic-II Hydropower project is a run of the river project with no storage reservoir. The proposed project layout is decorated with a sophisticated mechanism of flushing out of the gravels through a gravel trap and the rest of the finer particles up to 0.3 mm size through a sand trap.

In general, historic suspended sediment and discharge observations are used to develop a sediment rating curve for the estimation of annual sediment inflow to the Artistic-II HPP weir site. In addition, regional analysis was also employed for comparison of sediment load estimated using sediment rating curve.

4.7.1 SEDIMENT DATA

Details of gauge stations available near the project area which can be used for the hydrological and sedimentation estimations is discussed earlier, namely Kalam Gauge Station, Jildat Gauge Station and Matiltan Gauge Station. The following sediment data has been collected which is further used for the sedimentation studies.

4.7.2 USHU RIVER AT USHU BRIDGE:

In the year 1995 SWHP-WAPDA collect the discharge and sediment concentration in parts per million(ppm) at Ushu bridge, which is located upstream to the junction of Ushu River and Babar Gol Nullah, for the Feasibility study of Gorkin Matiltan Hydropower Project. Approximately 46 samples were collected and is tabulated in **"Annexure-A3, Volume-V"**.

4.7.3 USHU RIVER AT JILDAT:

Surface Water Hydrology WAPDA (SWHP) has the stream gauge on Ushu river at Jildat, sediment concentration data of Jildat station for the year 2002 to 2016 (15 years) has been collected for this station and is tabulated in **"Annexure-A3, Volume-V"**.

4.7.4 SWAT RIVER AT KALAM:

Surface Water Hydrology WAPDA (SWHP) has the stream gauge on Swat river near Kalam which has the longest stream of data (40 years) available Therefore, this data, from the years 1970 to 2010, will be based for the Sedimentation estimation at Artistic-II HPP weir site, and is tabulated in **"Annexure-A3, Volume-V".** Suspended sediment rate per year of Swat at Kalam were worked out by SWHP,WAPDA. Summary of sediment load of Swat River at Kalam is given below.

Table 4-16 Summary of Suspended sediment load of Swat at Kalam

Year	Jan to Dec	May to Sept	Monsoon
	m.s.t.	m.s.t.	Whole Year %
1961	0.34		
1962	0.21		
1963	0.28	0.28	100
1964	0.34	0.31	91
1965	0.43	0.41	95
1966	0.24	0.23	96
1967	0.3	0.29	97
1968	0.24	0.23	96
1969	0.35	0.33	94
1970	0.22	0.2	91
1971	0.2	0.18	90
1972	0.21	0.2	95
1973	0.25	0.23	92
1974	0.13	0.12	92
1975	0.28	0.25	89
1976	0.24	0.23	95

Year	Jan to Dec	May to Sept	Monsoon
	m.s.t.	m.s.t.	Whole Year %
1977	0.17	0.15	86
1978	0.6	0.54	91
1979	0.25	0.24	96
1980	0.34	0.33	95
1981	0.444	0.41	92
1982	0.162	0.15	93
1983	0.303	0.279	92
1984	0.444	0.358	81
1985	0.256	0.252	98
1986	0.443	0.425	96
1987	0.448	0.406	91
1988	0.459	0.435	95
1989	0.442	0.329	74
1990	0.446	0.41	92
1991	0.659	0.634	96
1992	0.43	0.39	91
1993	0.32	0.285	89
1994	0.479	0.464	97
1995	0.435	0.41	94
1996	0.473	0.441	93
1997	0.311	0.282	91
1998	0.354	0.311	88
1999	0.245	0.216	88
2000	0.104	0.087	84
2001	0.082	0.071	87
2002	0.119	0.104	87
2003	0.155	0.139	90
2004	0.133	0.113	85
2005	0.539	0.517	96
Average:	**0.318**	**0.295**	**92%**
Weir Site	**0.071**	**0.066**	**93%**

The average sediment concentration is 0.01 % (by weight) or 100 ppm. The average annual sediment yield is about **0.314 Ac.ft. per sq. mile** of drainage area. The results of particle size analysis are not sufficient to denote the average drainage of suspended sediment is approximately **24% sand, 45% silt and 31% clay at high stages**. The computed maximum concentration is 947 ppm and the observed maximum concentration is 3,460 ppm. The minimum observed concentration is 3 ppm. Particularly whole of the suspended sediment is carried by the river during the five months from May to September. Unit weight of fresh deposits of this sediment is taken 60.9 lbs per c.ft (Source: Sediment Appraisal of Pakistani Rivers (1960-2005).

4.7.5 SEDIMENT RATING CURVE

In order to develop correlation between the rate of flow and sediment load, suspended sediment concentration data is required. This relationship is termed as Sediment Rating Curve. Two sets of suspended sediment data are available through which a correlation can be developed, these are:

i. Ushu River at Ushu Bridge

ii. Ushu River at Jildat

Suspended samples consist of the concentration of suspended sediments in Parts per Million (PPM) taken during flow measurements. In order to obtain the concentration by weight (Metric tons) the concentration of sediments in PPM estimated by SWHP was processed.

The review of the suspended sediments indicates that small amount of suspended sediments is noticed during the low flow season that occurs in winter. During spring, the suspended sediment increases with discharge. The historical data reveals that the maximum suspended concentration is in the months of July and August. Origin of the sediments in the Swat catchment up to Chakdara is mainly originated during the rainfall period, while, in the northern part of the Swat Catchment (Gabral and Ushu) and increasing amount of sediment is originated from the melting of the glaciers.

4.7.6 USHU RIVER AT USHU BRIDGE

Sediment rating curve of Ushu river at Ushu bridge is developed for the available data for the year 1995. Total of 46 samples are available which is mostly obtained during high flow season (May-September). The sediment rating curve is developed by plotting the discharges in cumecs and sediments in metric tons/day. A regression analysis was developed, shown in Figure 4-24, which gives the following relationship:

$$\mathbf{Q_s = 0.5772 \times Q_w^{\ 1.7021}}$$

Where,
Qs = suspended sediment load in metric tons per day.
Qw = discharge in cumecs.

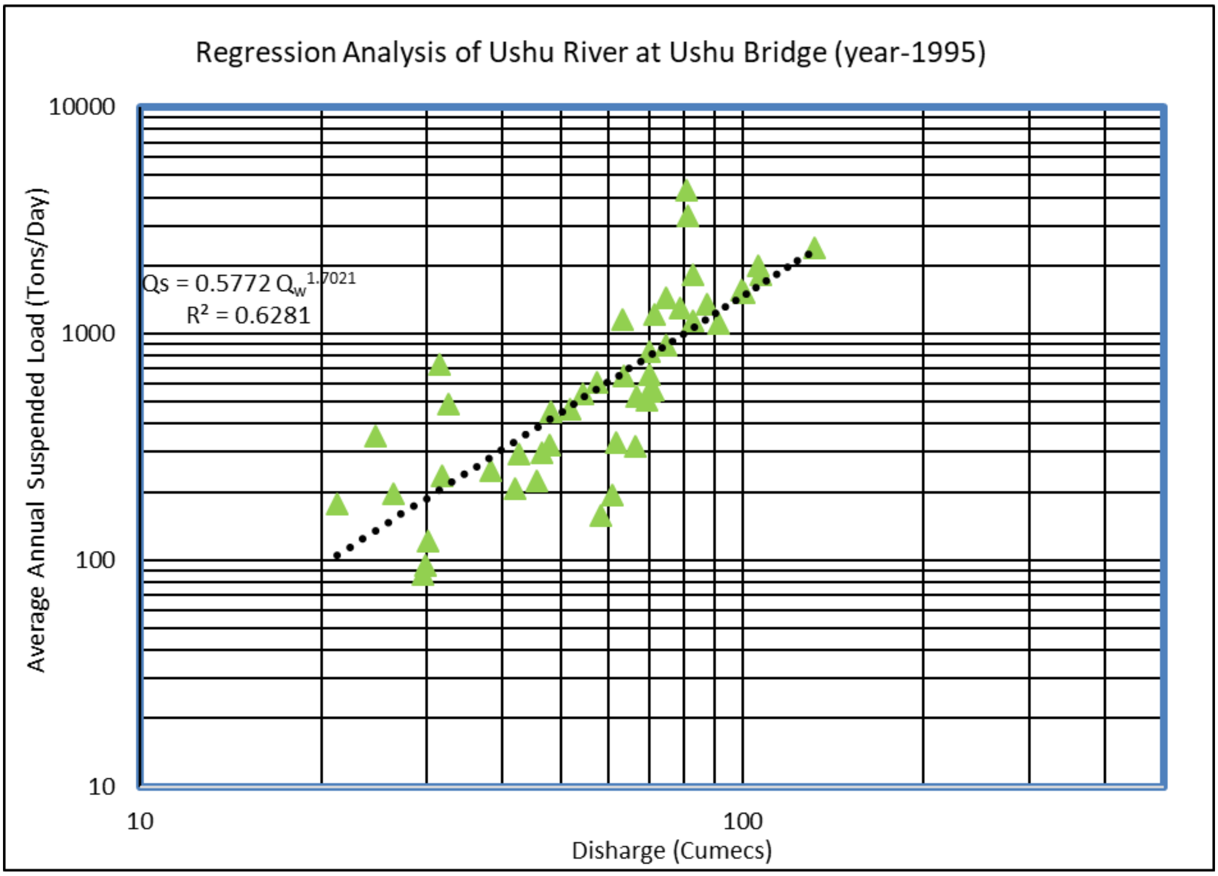

Figure 4-24 Regression Analysis of Ushu River at Ushu Bridge

The average annual suspended sediment, estimated by sediment rating curve (Figure 4-26) and flow duration curve is presented in Table 4-17, which shows that Ushu river at weir site may bring 0.066 million metric tons annually.

Table 4-17 Estimation of Annual Sediment Load Using Ushu Bridge Data Relation

% Limits	% Interval	% Mid Value	qw cumecs	qs metrict/day	Qw cumecs	Qs metrict/day
0-1	1	0.5	97.5	1402	0.98	14.02
2-Jan	1	1.5	92.5	1282	0.93	12.82
4-Feb	2	3	82	1044	1.64	20.89
6-Apr	2	5	73	857	1.46	17.14
8-Jun	2	7	67	740	1.34	14.81
10-Aug	2	9	62	649	1.24	12.98
15-Oct	5	12.5	53	497	2.65	24.84
15-20	5	17.5	44	362	2.2	18.1
20-25	5	22.5	36	257	1.8	12.86
25-30	5	27.5	30	189	1.5	9.43
30-40	10	35	23	120	2.3	12
40-50	10	45	13	45	1.3	4.54
50-60	10	55	7.5	18	0.75	1.78
60-70	10	65	5.5	11	0.55	1.05
70-80	10	75	4.8	8	0.48	0.83
80-90	10	85	4.5	7	0.45	0.75
90-100	10	95	4	6	0.4	0.61
Total	100				21.96	179.45
Average Suspended Sediments (Metric t/day)						179.45
Annual Suspended Sediments Load Million Metric Tons						0.066
qw = Flow at Mid Value						
qs = Sediment Load at Mid Value						
Qw = Flow in each interval						
Qs = Sediment Load at each interval						

4.7.7 USHU RIVER AT JILDAT

Sediment rating curve of Swat river at Jildat is developed from the available data from the year 2002-2016. The sediment rating curve is developed by plotting sediment load in terms of tons per day and are plotted with flows shown in Figure 4-25. A regression analysis is developed which gives the following relationship.

$$\mathbf{Qs = 4.1686 \times Qw^{1.1177}}$$

Where,

Qs = suspended sediment load in metric tons per day.

Qw = discharge in cumecs.

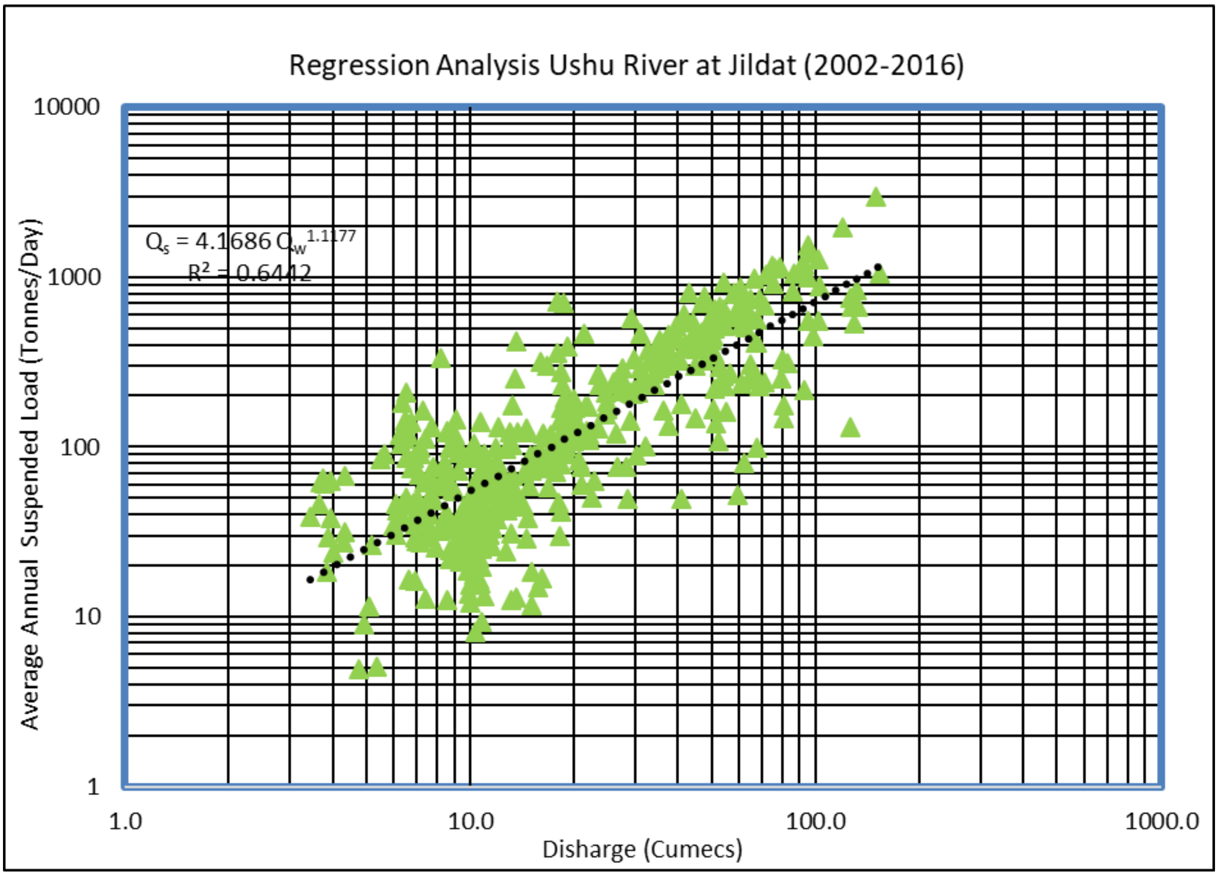

Figure 4-25 Regression Analysis Ushu River at Jildat (2002-2016)

In order to compute mean annual suspended sediment load at Artistic-II Hydropower Project weir site, sediment rating curve was applied to the long-term derived flow time series of Artistic-II Hydropower Project weir site (1961–2017) as presented in Figure 4-26. Table 4-18 shows the details for estimation of annual sediment load at weir location which depicts that Ushu river at weir section may bring 51,084.22 metric tons annually.

Table 4-18 Estimation of Annual Sediment Load Using Jildat Data Relation

% Limits	% Interval	% Mid Value	qw cumecs	qs metric t/day	Qw cumecs	Qs metric t/day
0-1	1	0.5	97.5	697	0.98	6.97
2-Jan	1	1.5	92.5	657	0.93	6.57
4-Feb	2	3	82	574	1.64	11.48
6-Apr	2	5	73	504	1.46	10.08
8-Jun	2	7	67	458	1.34	9.16

% Limits	% Interval	% Mid Value	qw cumecs	qs metric t/day	Qw cumecs	Qs metric t/day
10-Aug	2	9	62	420	1.24	8.4
15-Oct	5	12.5	53	353	2.65	17.63
15-20	5	17.5	44	286	2.2	14.32
20-25	5	22.5	36	229	1.8	11.44
25-30	5	27.5	30	187	1.5	9.33
30-40	10	35	23	139	2.3	13.87
40-50	10	45	13	73	1.3	7.33
50-60	10	55	7.5	40	0.75	3.96
60-70	10	65	5.5	28	0.55	2.8
70-80	10	75	4.8	24	0.48	2.41
80-90	10	85	4.5	22	0.45	2.24
90-100	10	95	4	20	0.4	1.96
Total	100				21.96	139.96
Average Suspended Sediments (Metric t/day)						139.96
Annual Suspended Sediments Load Million Metric Tons						0.051
qw = Flow at Mid Value						
qs = Sediment Load at Mid Value						
Qw = Flow in each interval						
Qs = Sediment Load at each interval						

4.7.8 REGIONAL ANALYSIS

In addition to the estimation of the suspended sediments at weir site described above, regional analysis has also been carried out to check the consistency and range of the average annual sediments at weir site of Artistic-II Hydropower Project. For the purpose, average annual runoff and sediment data for the following stations is obtained from the Sediment Appraisal of Pakistan, 2008 published by the Surface Water Hydrology Project, WAPDA. The mean annual values are tabulated in Table 4-19 below;

Table 4-19 Mean Annual Discharges and Suspended Sediments Load Used for Regional Analysis

Station	River	Catchment Area (Km^2)	Annual Flow (Cumecs)	Average suspended Sediments Load (Tons
Near Kalam	Swat River	2020	88.6	788
Chakdara	Swat River	5776	178.3	5915
Munda	Swat River	13649	233.5	15907

A power regression analysis is evolved between the catchment area and mean annual suspended sediment load of Swat River at Kalam, Chakdara and Munda stations which depicts a better correlation with coefficient of Determination as $R^2 = 0.9813$, and is shown in Figure 4-26 below and the fitted equation is

$$\mathbf{Qs = 0.0051\ (A)^{1.5854}}$$

Where "Qs" is metric tons per day and "A" is the catchment area in sq.km. Using this equation, the mean annual sediment load estimation for weir site of Artistic-II Hydropower Project is estimated to be;

$$Qs = 0.0051 * (454)^{1.5854} = 0.03 \text{million metric Tons annually}$$

Above results depict that the mean annual suspended sediment load estimation by regional method is in fare agreement with the suspended sediment load estimation by using the gauge data of Swat river at Kalam.

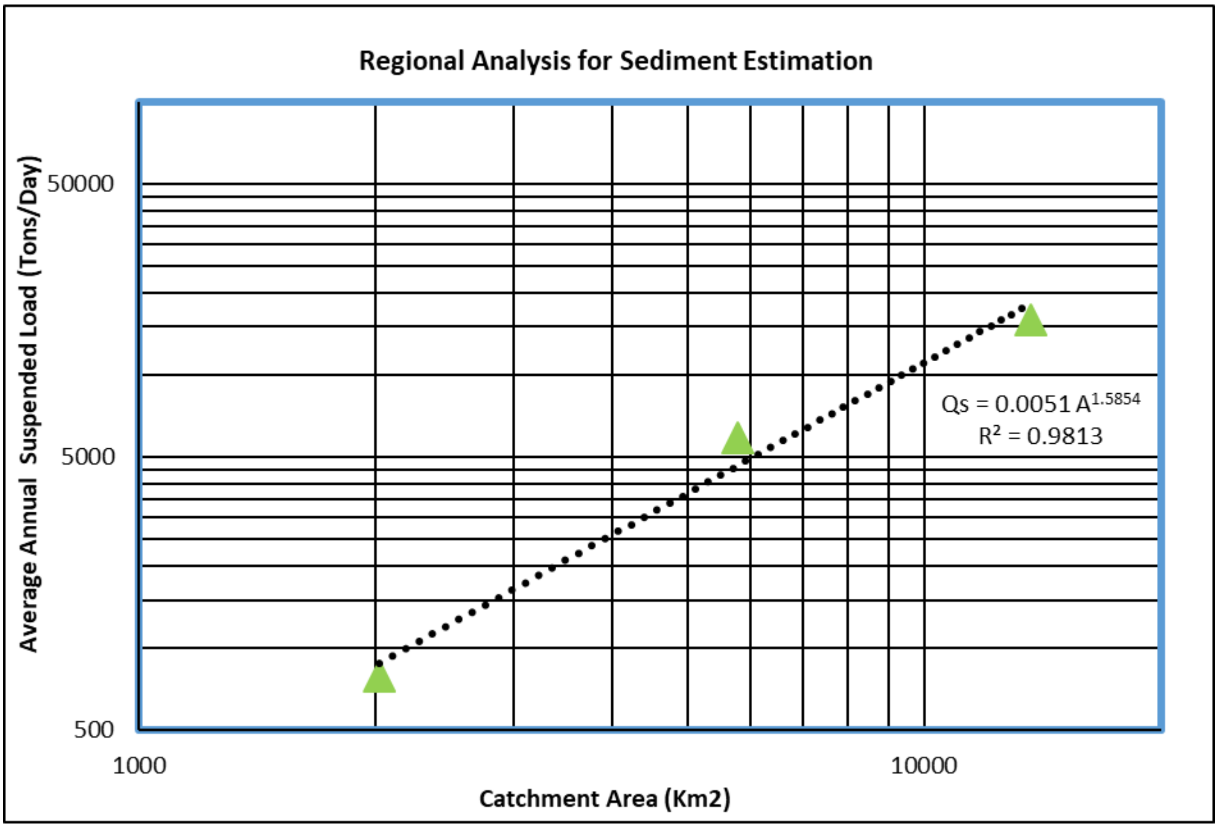

Figure 4-26 Regional Analysis for Sediment Estimation

4.7.9 SEDIMENT BED LOAD ESTIMATION

Methods developed to measure bed load are only applicable in laboratory or for small streams. It is not possible to measure bed load in river like Ushu, where the flows are normally very deep in high flow season, and are very turbulent and fast because of very steep gradient in river. In the absence of bed load record, as there is no bed load measurement in Ushu River, as per standard practice to assume bed load 5 % to 20 % of suspended sediment load can be used.

To be on more conservative side, 20 % of suspended sediment load has been taken as un-measured sediment load. Therefore, the annual bed load at Artistic-II HPP weir site is estimated to be **7,812 tons annually**.

Table 4-20 Total Annual Sediment Load

S.No	Description	Sediment Load (Metric Tons)
1	Mean Annual Suspended Sediment Load	39,060
2	Unmeasured Annual bed Load (20% of S.No1)	7,812
3	Total Annual Load	46,872 (0.047Mmton)

4.7.10 PARTICLE SIZE DISTRIBUTION

Reference to Sediment Appraisal of Pakistan Rivers by WAPDA published in April, 2008 the results of Particle Size Analysis, as reported are approximately 31% clay, 45% silt and 24% sand at high stages. The Weighted Mean Size of suspended sediment comes out to be 0.0295mm as tabulated below:

Table 4-21 Particle Size Distribution of Suspended Sediment of Swat River at Kalam

Sediment Type	Size (mm)	Mean Dia (mm)	Content (%)	Weighted Mean Dia (mm)
Clay	0.000 – 0.0055	0.001	31	0.0003
Silt	0.0055 – 0.062	0.018	45	0.0081
Sand	0.062 – 0.125	0.088	24	0.0211
Weighted Mean Sediment Size				0.0295

CHAPTER

5

GEOLOGY & GEOTECHNICAL INVESTIGATIONS AND CONSTRUCTION MATERIALS

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CHAPTER 5

GEOLOGY & GEOTECHNICAL INVESTIGATIONS AND CONSTRUCTION MATERIALS

5.1 INTRODUCTION

This section presents the geological and geotechnical studies conducted as part of the feasibility study of the Artistic-II Hydropower Project. The studies comprise regional geological and tectonic frame work of the project area, detailed geological/ engineering geological studies, geotechnical & geophysical investigations and evaluation of the geotechnical parameters and assessment of the geotechnical conditions at important structures' locations together with the assessment of rock conditions along the tunnel and adit alignments. Also a brief description of the construction materials has been given at the end of this section.

5.1.1 PROJECT INFORMATION

Artistic-II Hydropower Project (A2HP) site is located in the upper reach of the Ushu River somewhere among the Ushu village and Mahodand Lake. The Ushu River is one of the main tributaries of the Swat River. The Project area is north of Kalam (drawing no. A2HP-FS-GE-GNL-DWG-200), which is recognized as the last major tourist point in the upper Swat. The site of the Power House is about 10 Km by road from Kalam while the weir and intake sites are about 15 Km further upstream. Both the weir and powerhouse sites are accessible by an earthen jeepable track that leads to Mahodand Lake and other upstream villages.

5.1.2 PREVIOUS STUDIES

No geological mapping of the proposed scheme was undertaken in the past. Only available studies are regarding the downstream scheme named Gorkin-Matiltan Hydropower Project. As part of the feasibility and detail design of the project, geological studies have been undertaken by the EPC contractor "a joint venture of CMC & GRC". Since this scheme is downstream of the proposed Artistic-II Hydropower Project (A2HP), the available information is of no or little use. However, geological maps produced by the Geological Survey of Pakistan (GSP) were found helpful in perceiving regional geological setting.

Likewise, no geotechnical investigations including field investigations and laboratory testing were undertaken previously providing a basis for the detailed geotechnical investigations as part of the feasibility study.

5.1.3 PRESENT STUDIES

The present studies were aimed at preparing a detailed Feasibility Report of Artistic-II Hydropower Project (A2HP), based on sufficient surface and subsurface studies and investigations, comprise the followings;

5.1.3.1 GEOLOGICAL STUDIES

Regional geological studies based on the literature and field verification, detailed geological and engineering geological mapping, recording of structural information and characteristics, and execution of discontinuity Surveys (DS) for rock characterization with necessary sampling at representative location for the identification of various rock units.

Geological studies were planned as part of the feasibility study of A2HP, in which, regional as well as engineering geological mapping was considered mandatory together with picking up rock structures' information through discontinuity surveys. These studies were to be used for onward rock characterization and classification for the design of various surface and underground structures. Engineering geological mapping at 1:2000 scale was conducted for weir, power channel and Intake structure for power tunnel, and for surge, tunnel outlet, penstock and powerhouse areas. Along the tunnel route, the mapping was conducted at scale 1:2500 and 1:4000. Besides geological mapping, 14 discontinuity surveys were conducted along with necessary geological sampling for the petrographic analyses to identify the rock units. The summaries of all the discontinuity surveys are attached as Annexure B1 in Volume V of the Feasibility Report and the locations of the discontinuity surveys are marked on the respective geological maps. The field data have been provided location wise in in Volume V as Annexure B2. The discontinuity surveys' data was plotted for stereographic projection using computer code DIPS (Rocscience) for the identification of the pronounced discontinuity sets. As part of geological mapping, petrographic analyses were undertaken in University of the Peshawar to identify the rock types. These rock types were used to finalize the geological units in the mapping. The results of the petrographic analyses are attached as Annexure B3 in Volume V.

5.1.3.2 GEOTECHNICAL INVESTIGATIONS

Geotechnical investigations consisted of drilling of thirteen (13) boreholes together with necessary in-situ testing and sampling, excavation of eighteen (18) test pits for foundation design parameters and construction material evaluation. Necessary sampling and in-situ testing were conducted in all test pits. Laboratory testing programs were prepared, and laboratory testing was conducted on the selective and representative samples of soil and rock from boreholes and test pits and rock outcrops. Geotechnical investigations (field part) have been carried out by M/s Sarwar & Co. Islamabad. However, due to weather constraints nine boreholes (BH-01 to BH-07, BH-09 & BH-13) were completed, while remaining boreholes are intended to be drilled as part of the next stage studies and investigations.

As part of the geotechnical investigations, geophysical investigations comprising seismic refraction surveys were also carried out at locations of important project components. The geophysical investigations were carried out by M/s Sarwar & Co. Islamabad.

All the geotechnical and geophysical data have been provided in the Annexures B4-B8 in Volume V of the Feasibility Report while details and interpretation of the field investigations and laboratory testing have been discussed in this report.

5.1.3.3 CONSTRUCTION MATERIAL STUDIES

The construction materials studies were aimed at to have assessment of the construction materials both available in the vicinity of the project area and those that have to be transported from other areas. These studies included the reconnaissance of the project area and adjoining areas together with geological mapping and excavation of test pits for the estimation of the available materials.

All the field geological and geotechnical investigations for Artistic-2 Hydropower Project have been completed from October 2018 through to December 2019. The details of the studies and investigations are discussed in the following sections.

5.2 GEOLOGICAL MAPPING OF THE PROJECT AREA

The geological and tectonic setting of the project area has been conceived based on the available geological literature (GSP 1999) and supplemented by latest geological, structural and stratigraphic information recorded during field studies. At the important project components, engineering geological mapping was undertaken on base maps prepared by superimposing topographic data on free available satellite images. Geological contacts among soil and rock units were marked on the base maps together with the recording of information about the geological structures. The field geological maps have been finalized in GIS and/ or AutoCAD environment to be used for onward geotechnical evaluation and design activities. Similarly, at important project locations, subsurface geological sections have been prepared based on the surface geological information and recorded structural geological features. The details of drawings, prepared based on the geological mapping and interpretation, are provided below. It should be noted that these drawings have also been updated on the basis of outcome of geotechnical and geophysical investigations. All the locations of investigations points and lines have also been provided on selective drawings.

Drawing No.	Title
A2HP-FS-GE-GNL-DWG-200	Project Layout Plan
A2HP-FS-GE-GNL-DWG-201	Regional Geological Map
A2HP-FS-GE-GNL-DWG-202	Physiographic Map of the Project Area
A2HP-FS-GE-GNL-DWG-203	Geological Map of the Project Area
A2HP-FS-GE-WR-DWG-204	Geological Plan of Weir, Sand Trap and Box Channel
A2HP-FS-GE-WR-DWG-205	Geological Section at Weir and Sand Trap
A2HP-FS-GE-CNL-DWG-206	Geological Plan of Box Channel
A2HP-FS-GE-CNL-DWG-207	Geological Section at Box Channel (RD 0+300, 0+700, 1+000, 1+400)
A2HP-FS-GE-FB-DWG-208	Geological Plan of Box Channel, Forebay and Tunnel Inlet
A2HP-FS-GE-FB-DWG-209	Geological section along box channel (RD= 1+680) To Headrace Tunnel (RD= 1+880 and Cross Section of Fore Bay
A2HP-FS-GE-TNL-DWG-210	Geological Plan and Profile of Headrace Tunnel (Sheet 01 of 03)
A2HP-FS-GE-TNL-DWG-211	Geological Plan and Profile of Headrace Tunnel (Sheet 02 of 03)
A2HP-FS-GE-TNL-DWG-212	Geological Plan and Profile of Headrace Tunnel (Sheet 03 of 03)
A2HP-FS-GE-TNL-DWG-213	Geological plan and Profile of Adit Tunnel
A2HP-FS-GE-PH-DWG-214	Geological plan of tunnel outlet and Powerhouse area
A2HP-FS-GE-PH-DWG-215	Geological section along tunnel outlet, penstock and Powerhouse

5.2.1 REGIONAL GEOLOGY AND TECTONICS AROUND PROJECT AREA

The tectonic setting of Northern Pakistan is characterized by the collision of Eurasian Plate in the North and Indian Plate in the South. This collision started in Late Eocene (50 Ma) and is still continuing in the region. The continuous subduction of the Indian plate under the Eurasian plate has given rise to the mega features such as Main Karakoram Thrust/ Fault (MKT/ MKF) in the North and Main Mantle Thrust (MMT) or Indian Suture in the South. The Kohistan Island Arc (KIA) occupies the area between these two mega features. The Himalayan orogeny in the form of northward movement and subduction of the Indian Plate has given rise to numerous other tectonic features like Hazara Thrust Fault System, Main Boundary Thrust (MBT), Main Frontal Thrust (MFT) / Riasi Thrust and the Kashmir Thrust.

The project area lies in the upper part of the Swat valley i.e. Swat Kohistan, which is a part of the "Kohistan arc": This arc covers an area of about 36000 km^2 and is bounded by the geological units of Hazara, Diamir, Gilgit and Chitral. Evidence of the outpouring of lavas on a great scale can be seen by the presence of volcanic rocks forming two parallel arcs; one running along the northern margin of Kohistan and the other forming a bold and continuous outcrop in the vicinity of Kalam and extending south-westward towards Bajaur in Dir.

Geomorphologically, Kohistan is characterized by rugged terrain and very high relief; the mountains have a general east - west trend.

According to the regional geological map after Jagoutz & Schmidt 2012 (Figure 1), the Kohistan arc is bordered by the Hindukush-Karakoram belt in the north.

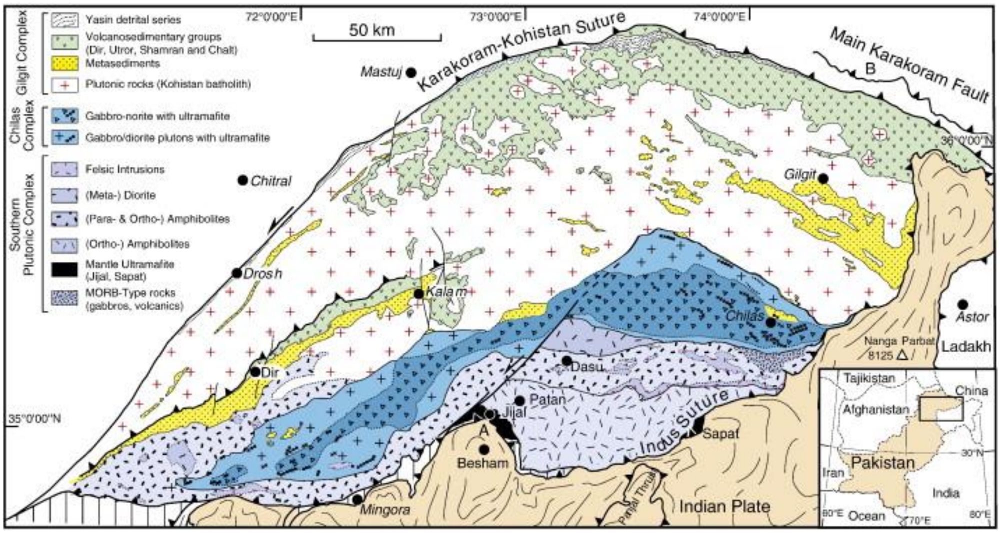

Figure 5.1: Geological map of the Kohistan arc (after Jagoutz & Schmidt 2012)

In this belt, the rocks are of Jurassic to Paleozoic age and consist of the Darkot-Karakoram metamorphic complex. In the east is the Nanga Parbat and on the south and south- east lies the Peshawar - Kashmir zone. The rocks bordering the Kohistan arc in this area belong mainly to the Pre-Cambrian Indian basement complex. The geology and rocks which are exposed in the Kohistan arc and the adjoining area can be briefly described as follows:

- Meta-sedimentary rocks of Mesozoic to Paleozoic age which lie in the eastern part.
- Kamila amphibolites and Mafic and ultramafic complex. These are Jurassic rocks which are located in the southern region.
- Chalt volcanics and the Yasin group in the northen part and Chilas complex in the southern part. These are Cretaceous to Jurassic rocks.
- Dir metasediments of Paleocene to late Cretaceous age which are found in the south-western part.
- Kohistan - Ladakh batholith and associated plutons of Miocene to Cretaceous age. These also contain smaller bodies of mafic Intrusive rocks with felsic associates of a much younger Tertiary age.
- Utror Volcanics are early Eocene to Paleocene rocks which are found in the western portion of the arc.

- Matiltan Granite of Miocene age rocks, shown in the map as plutonic rocks block, are present in the western portion of the arc.

5.2.1.1 STRATIGRAPHY AND LITHOLOGY

The regional geological setting around project area has been interpreted based on the geological map of Mahodand Quadrangle after Afridi et al. (1999) published by Geological Survey of Pakistan (GSP). An extract of this map has been reproduced at scale 1:50,000 and attached as drawing no. A2HP-FS-GE-GNL-DWG-201. The stratigraphy around the project area is summarized in the following table and is briefly described in the following sections. The distribution of these formations is shown on regional geological map attached as drawing no. A2HP-FS-GE-GNL-DWG-201.

Quaternary	Alluvial deposits (Qa)	
	Stream Deposits (Qs)	
Miocene	Matiltan Granite (Tmg)	
Late Eocene	Utror Volcanics (Tuv)	
Paleocene to Early Eocene	Dir Group	Barawal Banda Quartzite (Tbq)
		Barawal Banda Slates/ Phyllites/ Schists (Tbp)
Middle to Late Cretaceous	Deshai Diorite (Kdd)	
	Kalam Quartz Diorite (Associated with meta sediments) (Kkd)	

5.2.1.1.1 QUATERNARY DEPOSITS

- **Stream Deposits**

Stream deposits comprise gravels, cobbles and boulders with fine to coarse sand. The deposition is on-going process with the perennial and non-perennial streams. These cover the stream and river beds of active channels.

- **Alluvial deposits**

These are old river or stream deposits making terraces along the valley slopes. These deposits comprise gravels, cobbles and boulders embedded in silty sandy matrix. Most of the settlements are situated on these deposits. The top layer of these deposits comprises fine materials and therefore is being used for cultivation.

5.2.1.1.2 MATILTAN GRANITE (TMG)

Matiltan granite comprises white to light grey, medium to coarse grained and porphyritic granite and granodiorite composed of orthoclase, plagioclase, quartz, hornblende and biotite, with xenoliths of quartzite, amphibolite and diorite.

5.2.1.1.3 UTROR VOLCANICS (TUV)

Utror Volcanics comprise grey, green, maroon red and at places white, fine to medium grained, identified as andesite, dacite, rhyolite with tuffs, agglomerate and pyroclasts.

5.2.1.1.4 BARAWAL BANDA QUARTZITE (TBQ)

Barawal Banda Quartzite comprises light to dark grey on fresh surface and brownish grey on weathered surface, thin to thick bedded, fine grained quartz which is cherty at places.

5.2.1.1.5 BARAWAL BANDA SLATES/ PHYLLITES/ SCHISTS (TBP)

These rock units in this formation comprise grey, green and maroon in color, thin bedded, fine to very fine textured, occasionally silty phyllites, schists and slates. Occasional beds of light grey thinly bedded limestone are also present at places.

5.2.1.1.6 DESHAI DIORITE (KDD)

Deshai Diorite comprises grey, greenish grey, medium to coarse grained diorite composed of plagioclase, hornblende, biotite with subordinate quartz, hornblended pegmatites and quartz veins.

5.2.1.1.7 KALAM QUARTZ DIORITE (ASSOCIATED WITH META SEDIMENTS) (KKD)

It comprises grey, greenish grey, medium to coarse grained quartz diorite composed of plagioclase (andesites), hornblende and biotite. Quartz feldspathic veins and xenoliths of Kalam meta-sediments are present in places.

5.2.1.2 REGIONAL STRUCTURES AROUND PROJECT AREA

In and around project area, exposed rock units have generally northeast-southwest trend dipping into northwest. In the vicinity of the project area, a regional fault named as Shandur Thrust is present about 2km in the north of the project area (drawing no. A2HP-FS-GE-GNL-DWG-201). This thrust fault has been marked by the Utror Volcanics group of rocks in southeast while by Kalam Quartz Diorite associated with meta sediments (Kkd) in the northwest. The fault is dipping towards the northwest and is directed northeast-southwest ward.

About 4km downstream of the powerhouse site, a pronounced regional feature is overturned anticline having trend in northeast-southwest and both limbs dipping towards northwest. Phyllites, schists and slates of Dir Group (Tbp) make the core materials in the anticline which is underlain by the quartzite (Tbq) of the same group on both limbs of the anticline. Dir group rocks are underlain by the Matiltan Granite (Tmg) on the northern limb which is underlain by the Utror Volcanics (Tuv) in further north and northeastward.

Generally, foliation is well-developed throughout the project area from powerhouse to weir site. Mostly rock units have trend northeast-southwest dipping in the northwest at steep to very steep angles with localized variations in the dip directions. Two to four joint sets with random joints have been identified during recent field studies.

5.2.2 PROJECT AREA GEOLOGY

5.2.2.1 PROJECT AREA PHYSIOGRAPHY

Project area is situated amongst high relief mountains of the Lesser Himalayas. The mountain chains are almost directed northeast-southwest ward through which almost all the major rivers flow in generally south ward. Ushu River originates northern peaks near Shandur Plains. Ushu River flows almost southward to join Gabral River that flows from the southwestern hills. Near Ushuran, upstream of Kalam town Gabral and Ushu Rivers make Swat River that flows southward passing through Bahrain and Charbagh to Mingora further southward.

The relief of the surrounding mountains around project area is quite high (drawing no. A2HP-FS-GE-GNL-DWG-202), particularly on the left bank of Ushu River. The hills along right bank of Ushu River have relatively lower elevations through which the headrace tunnel shall pass. Various steep gradient nullahs join the Ushu River both on right and left banks. Because of these nullahs, numerous fan deposits have been formed along the both banks of the Ushu River. The high and steep slopes along both banks have thick cover of overburden of glaciofluvial and colluvial origin. Settlements are generally situated on these terraces. The cultivation is being carried out on these terraces where fine soils are present at top of the terraces. A road has been constructed along the left bank of the river generally on terraces and high rising terrain with high road cuts in rocky strata. The metaled road is present only up to Ushu town that converts to earthen jeepable track further northward.

5.2.2.2 STRATIGRAPHY AND LITHOLOGY

The composite geological map of the Project area is presented in drawing no. A2HP-FS-GE-GNL-DWG-203. The field studies have revealed that the Project area is occupied by both the unconsolidated overburden materials and the rock formations. These consist of the following;

5.2.2.2.1 OVERBURDEN

The bed rock is overlain by unconsolidated material of different nature throughout the project area. During engineering geological mapping, this overburden material has been mapped and named according to its origin and composition. The overburden found at various locations is of following types;

- **River bed alluvium**

The Valley of Ushu River at the project area is 200-300m wide. At the weir and powerhouse sites, it is around 200m wide, however, in the middle where left or right bank tributaries join the Ushu River, it is generally 300m wide. At places, the valley slopes with unconsolidated materials have narrowed the valley and the river flow. The river bed material consists of the gray, loose, sandy gravels, cobble with boulders generally of rounded to sub rounded and strong to very strong nature (**Figure 5.2**). This material is of metamorphic and igneous origin. The sand present as matrix is fine to coarse grained and is micaceous in nature. The similar material is present in the entire length of the river in project area. However, proportions of the sand, gravels, cobbles, and boulders vary along the river.

- **Glacio-Fluvial Deposits (Fan Deposits)**

The glacio-fluvial terraces basically developed at the mouth of steep gradient stream draining to Ushu River. These deposits have been developed by the overlapping episodes of both alluvial and glacial activity. Along the river from weir site to powerhouse site, significant part of the Ushu valley is covered by these glacio-fluvial terraces (**Figure 5.3**). The composition of the terraces is controlled by the transporting agents, that is, these are more of moronic nature where when deposited by the glaciers and more of fluvial nature when deposited by the running streams. Moraine is material transported by a glacier and then deposited. Moraines are accumulations of fine soils and gravelly materials that have fallen onto the glacier surface or have been pushed along by the glacier as it moves. This material can range in size from silt to large rocks and boulders. In the project area, moraines have been deposited along the steep gradient stream on fan deposits as interlayering with fluvial deposits, and at the toe of valley slopes as interlayering with colluvium/ slope wash material.

The gravelly material in moraines is highly heterogeneous and may have angular to rounded rock blocks varying from gravels to boulders.

On the other hand, the fans are deposited by the steep gradient streams entering to main river valley and depositing their debris at the mouth of streams. The debris/ rock fragments vary in size from gravels to boulders that are generally rounded to sub rounded. The matrix is more sandy, fine to coarse grained. The percentage of coarse fractions are function of the stream gradient or in turn water velocity. Owing to various episodes of the sedimentation, vertical section of these deposits will show layers of variable thicknesses with same to difference composition. Regardless of the origin, the top layer of glacio-fluvial deposits comprises of silty sandy material. In the Ushu valley, mostly settlements are on these deposits and are also being used for cultivation.

- **Slope Wash Materials**

Besides the fan deposits, terraces comprised mainly of slope wash materials. These are materials deposited at the toes of hill slopes along the river. These materials have colluvial, fluvial and glacial origin based on the mechanism of downslope transportation and deposition. These are basically derived from the rock exposures present at higher elevation.

Generally, these deposits are heterogeneous and comprise angular to subangular rock fractions in silty sandy matrix where origin is colluvial or glacial (**Figure 5.4** & **Figure 5.5**). However, these comprise rounded to subrounded rock fragments embedded in sandy matrix where their origin is alluvial. These normally possess thin to thick cover of silty/ clayey material and are under agriculture use. These materials are light gray to yellowish brown, firm to stiff, silty clay / clayey silt, overlying the material of varying size from gravel to boulders and occasionally of rock blocks.

These materials extend to fan deposits towards the tributaries of the Ushu River and towards the old terraces of river bed material forming colluvial cover.

- **Scree**

This material is situated on the hill slopes as loose angular rock fragments detached from the upslope hill faces and generally accumulated on slope faces or at the toe of the hill faces (**Figure 5.6**). Often these extend towards the old terraces of river bed material forming colluvial cover. This material also occupies the stream/ river beds extending into the main river valley. These materials are very loose to lose but having high degree of interlocking because of angularity. In the older scree deposits, the rock fragments have been stuffed with fines coming from upslopes and transformed to soil, that is currently covered by vegetation.

5.2.2.2.2 Rock Units

The rock units exposed in the project area belong to mainly Utror Volcanics that comprise of andesite, dacite, rhyolite with tuffs of Late Eocene and Matiltan Granite that comprises of granite, granodiorite, amphibolite and diorite of Miocene age. The Granite/ Granodiorite are exposed at the powerhouse site near the tunnel outlet, part of penstock area, and along the most of the headrace tunnel. However, tunnel intake and initial small part of headrace tunnel will pass through rhyolite/ andesite that belong to Utror Volcanic. In the volcanic lithologies, it is likely to have intrusions of Matiltan Granite (**Figure 5.9**). During geological mapping, 14 rock samples were collected for petrographic analyses for the identification of the rocks. These samples were collected from the locations of the discontinuity surveys. The results of the petrographic analyses are provided in the Appendix D while identified rock types are presented in Table 5-1. The characteristics of the rock units identified during field work and marked on the geological map (drawing no. A2HP-FS-GE-GNL-DWG-203) are described below.

- **Granodiorite/ Granite**

Granodiorite/ Granite belong to Matiltan Granite which is white to light grey, medium to coarse grained and porphyritic composed of orthoclase, plagioclase, quartz, hornblende and biotite, with xenoliths of quartzite, amphibolite and diorite. It is generally massive to thickly bedded, strong to very strong, moderately to highly weathered (**Figure 5.7**). Its mineral composition comprises mainly quartz, plagioclase feldspar, amphibole, epidote and potassium feldspar.

- **Rhyolite/ Andesites**

Rhyolite/ Andesite belong to Utror Volcanic which is grey, green, maroon red at places white, fine to medium grained, with tuffs, agglomerate and pyroclasts. These rock units are medium strong to strong and at places very strong. It is generally found with smooth and rough surfaces, deformed and highly fractured at places (**Figure 5.8**). Blocky to massive and Quartz veins are also present at places.

Figure 5.2: View of Ushu River bed material in weir axis and reservoir area.

Figure 5.3: Alluvial fan deposit near the inlet pond and tunnel intake area.

Figure 5.4: Mixture of slope wash & scree deposits at right bank immediate d/s of weir axis.

Figure 5.5: Glacio-fluvial (moraines) deposits at the right bank near the weir axis.

Figure 5.6: Scree slope in the project area, downstream of weir axis.

Figure 5.7: Granite/ granodiorite outcrop near surge shaft and tunnel outlet area.

Figure 5.8: Andesite outcrop near tunnel intake.

Figure 5.9: Contact between rhyolite (Tuv) and granodiorite (Tmg).

5.2.2.3 PROJECT AREA GEOLOGICAL STRUCTURES

The tectonic and structural features have been studied and picked up in the field. The orientation (strike and dip) of the individual beds have been picked-up and recorded to determine the overall structural trend of the rock units. The major joint sets and the discontinuity data have been picked up through window sampling technique. The orientation is observed to be same throughout the project area, trending in northeast-southwest and dipping in northwest ward. However, at some places along the tunnel alignment and powerhouse area, localized disturbance has induced the variation of dip direction from northwest to southeast.

The rock units at certain places have been observed as crushed and fractured which may represent the presence of certain features like fault and shear zones. However, no direct evidence of faulting could be observed in the field. For the completeness of the study, some faults and shears have been assumed along the deep nallahs near the box channel, tunnel intake and intersecting the headrace tunnel route.

5.2.2.4 DISCONTINUITY SURVEYS

The tectonic features and the joint system in the project area have been picked up through discontinuity surveys. The field data has been processed and interpreted to be used for rock characterization. The discontinuity parameters measured include;

- Orientation
- Spacing
- Persistence

- Aperture
- Roughness (Surface roughness, waviness & JRC- Joint roughness Coefficient)
- Joint Wall Strength/ Joint Compressive Strength (JCS) by Schmidt Rebound Hammer in terms of rebound values (Rn)
- Infilling materials
- Seepage, evidence of water flow
- Length of rock column above discontinuity

The major joint sets and the discontinuity data at various components of the Project (box channel, tunnel intake, along the headrace tunnel route and tunnel outlet areas) has been collected in the field through discontinuity surveys. A total of fourteen (14) discontinuity surveys have been conducted together with recording spot readings in the project area. The locations of the discontinuity surveys have been marked on prepared geological map (drawing no. A2HP-FS-GE-GNL-DWG-203) and the details are summarized in Table 5-1. The data has been summarized in Annexure B2. The summaries of the discontinuity data are provided in Annexure B1 of Volume V of the Feasibility Report. showing stereo-net plots, photograph of rock outcrop, representative orientations of joint sets and their average spacing, persistence, aperture and other characteristics.

Table 5-1: Summary of Conducted Discontinuity Surveys

Discontinuity Survey No.	Coordinates		Location & Sample No.	Identified Rock Type (Petrographic Analyses)	Bulk density (gram/cm^3)
DS-1	288681	3938894	RB-01	Granite	1.95
DS-2	290477	3945496	LB-01	Andesite	2.38
DS-3	290791	3944719	LB-02	Rhyolite	2.63
DS-4	290619	3943887	LB-03	Granodiorite	2.58
DS-5	290580	3943689	LB-04	Andesite	2.25
DS-6	290034	3940799	LB-05	Granodiorite	2.51
DS-7	290111	3943874	RB-02	Rhyolite	2.38
DS-8	289904	3943688	RB-03	Granodiorite	2.45
DS-9	290135	3943822	RB-04	Rhyolite	2.45
DS-10	289991	3939979	LB-06	Granodiorite	2.29
DS-11	289568	3939564	LB-07	Granite	2.28
DS-12	289350	3939974	RB-05	Granodiorite	2.38
DS-13	289305	3940013	RB-06	Granodiorite	2.14
DS-14	289267	3940070	RB-07	Granodiorite	2.48
RB-Right Bank, LB-Left Bank					

Also, the details of the discontinuity parameters are provided in Table 5-2 comprising number and type of discontinuities, representative orientation and mean values of the spacing, persistence, aperture, roughness and Schmidt hammer rebound values, corresponding to each discontinuity survey.

Table 5-2: Details of Discontinuity Parameters

DS NO.	Sr. No.	Discontinuity Type	Representative Orientation		Average Spacing (cm)	Average Persistence (m)	Average Aperture (mm)	Average Rebound No (Rn)	Joint Roughness Coefficient (JRC)
			Dip Direction	Dip					
DS-1	1	Foliation	165	66	28.87	2.27	1.32	35	2.93
	2	Joint Set 1	237	67	9.03	1.81	1.33	33	2.81
	3	Joint Set 2	75	40	26.34	1.86	5.13	35	3.47
DS-2	1	Foliation	311	66	10.80	1.60	0.89	36	3.33
	2	Joint Set 1	124	68	6.04	0.28	0.22	24	3.92
	3	Joint Set 2	56	88	10.31	4.38	0.35	34	2.50
DS-3	1	Foliation	297	45	9.75	1.83	1.07	36	3.33
	2	Joint Set 1	42	44	13.13	2.78	1.02	46	3.31
	3	Joint Set 2	155	59	15.43	13.43	1.18	36	3.30
	4	Joint Set 3	203	40	7.21	0.69	0.68	41	3.00
DS-4	1	Foliation	297	73	17.28	9.61	0.74	34	1.83
	2	Joint Set 1	44	83	6.63	5.71	0.14	41	2.35
	3	Joint Set 2	208	22	29.52	8.29	6.12	25	2.62
DS-5	1	Foliation	289	66	28.70	6.91	4.15	44	3.70
	2	Joint Set 1	230	37	10.96	11.42	2.04	39	3.75
	3	Joint Set 2	125	45	5.57	7.29	2.29	34	2.29
DS-6	1	Foliation	296	72	33.32	16.04	1.18	40	2.84
	2	Joint Set 1	244	74	21.96	5.61	2.01	40	2.70
DS-7	1	Foliation	302	50	11.38	19.79	1.49	37	3.75
	2	Joint Set 1	151	70	10.13	28.67	1.67	38	2.00
	3	Joint Set 2	56	62	15.86	22.64	2.59	26	4.00
DS-8	1	Foliation	115	79	18.95	16.05	3.00	35	2.42
	2	Joint Set 1	29	65	16.06	1.95	1.08	36	2.59
	3	Joint Set 2	230	22	16.78	6.17	3.26	34	2.26
DS-9	1	Foliation	298	67	29.77	19.55	27.50	31	3.77
	2	Joint Set 1	41	29	42.89	3.47	2.28	22	3.68
	3	Joint Set 2	118	23	37.88	1.40	1.66	22	3.72
	4	Joint Set 3	222	68	17.50	0.48	0.63	34	3.50
DS-10	1	Foliation	339	49	17.15	3.73	2.21	34	3.10
	2	Joint Set 1	69	67	23.73	3.54	1.44	37	3.55
	3	Joint Set 2	158	70	23.38	4.32	0.94	35	2.88
DS-11	1	Foliation	332	66	24.30	2.70	0.27	37	3.78
	2	Joint Set 1	49	54	30.06	2.44	0.26	38	3.31
	3	Joint Set 2	216	50	18.31	1.75	0.18	37	3.75
	4	Joint Set 3	150	60	15.20	2.40	0.18	35	3.80

DS NO.	Sr. No.	Discontinuity Type	Representative Orientation		Average Spacing (cm)	Average Persistence (m)	Average Aperture (mm)	Average Rebound No (Rn)	Joint Roughness Coefficient (JRC)
			Dip Direction	Dip					
DS-12	1	Foliation	108	69	21.79	24.79	1.37	35	3.79
	2	Joint Set 1	26	57	16.52	16.72	1.25	31	3.76
	3	Joint Set 2	157	72	45.33	6.72	0.75	40	3.39
DS-13	1	Foliation	331	64	10.77	9.58	1.19	40	3.23
	2	Joint Set 1	66	60	7.24	11.41	2.18	32	3.12
	3	Joint Set 2	248	36	6.70	2.83	0.88	35	3.22
	4	Joint Set 3	128	44	6.71	6.50	0.96	28	3.29
DS-14	1	Foliation	136	79	31.39	13.39	1.31	41	3.50
	2	Joint Set 1	224	81	23.90	4.14	1.39	42	3.71
	3	Joint Set 2	46	78	24.39	4.87	5.73	37	3.61
	4	Joint Set 3	122	24	29.78	4.39	0.68	34	3.61

5.3 GEOTECHNICAL INVESTIGATIONS

The Artistic-II Hydropower Project site has been investigated through various means to the level of Feasibility stage. These mainly include exploratory drilling, geophysical seismic profiling and the excavation of test pits. Besides, construction material investigations have also been carried out in the Project area and outside for the identification of potential sources of various construction Materials. The locations of the investigations points are provided on the respective drawings and referred in each section. A brief of the completed works is given below;

5.3.1 EXPLORATORY DRILLING & INSITU TESTING

The Contractor M/s Sarwar & Co. Islamabad was engaged to undertake subsurface investigations comprising exploratory drilling, excavation of test pits, in-situ testing and sampling. A total of thirteen (13) boreholes were proposed of cumulative lengths of about 427m. The contractor completed the drilling of nine boreholes up to the maximum depth of 50m together with necessary sampling and in-situ testing at Artistic-II weir, tunnel intake, adit, powerhouse and bridge sites. Cumulatively 277m drilling was completed in which mostly drilling (174.5m) was in overburden material that took too long. Resultantly, the contractor stopped working because of heavy snow fall in the mid of December 2019 leaving behind about 150m drilling. It is proposed that the remaining boreholes will be drilled in the next stage of studies i.e. design and construction (Table 5.3). Among the drilled holes; borehole A2-BH-7 of the depth of 50m was drilled at adit-tunnel location. Two holes A2-BH-9 and A2-BH-13 were drilled at powerhouse area, and the right abutment of the proposed bridge near the powerhouse respectively. All the six holes at weir site, four (A2-BH-1 at left abutment, A2-BH-2 at weir location river center, A2-BH-3 at right abutment and A2-BH-4 at sand trap location) at components of weir and two holes A2-BH-5 and A2-BH-6 at tunnel intake were drilled vertically. Also, the holes A2-BH-9 at powerhouse site and A2-BH-7 at adit tunnel location were drilled vertically up to the target depths. The locations of the boreholes are shown in drawing A2HP-FS-GE-WR-DWG-204 for weir site and sand trap area, and in drawing A2HP-FS-GE-FB-DWG-208 forebay and intake area. The locations of the investigations points along headrace tunnel and at adit are shown in drawings A2HP-FS-GE-TNL-DWG-210 to 13, and in A2HP-FS-GE-PH-DWG-214 for surge shaft, tunnel outlet and powerhouse area. The details of all boreholes are summarized in Table 5.3. In all holes, field permeability tests in overburden and water pressure tests in rock were conducted to have an assessment of permeability characteristics of the soil and rock units. Standard penetration tests (SPTs) were undertaken in the overburden soils to have estimation of relative density.

The field logs of all boreholes were prepared by an experienced geologist covering all aspects of geotechnical logging. These logs were checked and verified by principal engineering geologist/ geotechnical engineer. Core photographs of all core boxes of a hole were taken for record with the demarcation of picked samples for the laboratory testing. The field logs were later finalized in view of the results of the in-situ testing and laboratory testing on selective soil and rock samples. The borehole logs, core photographs and results of in-situ tests are attached as Annexure B4 of the Volume V of the feasibility report.

Table 5.3: Details of Borehole on Artistic-II Hydropower Project

BH NO.	LOCATION	COORDINATES			DEPTH (m)
A2-BH-01	Weir site, left bank	3945477	290354.3	2507	45
A2-BH-02	Weir site, riverbed	3945422	290324	2499	30
A2-BH-03	Weir site, right bank	3945416	290264.2	2518	29
A2-BH-04	Weir site, sand trap (right bank)	2945348	290282.6	2514	20
A2-BH-05	Inlet portal headrace tunnel	3943687	290209.6	2542	30
A2-BH-06	Inlet portal headrace tunnel	3943744	290222.4	2515	32
A2-BH-07	Adit tunnel	3941544	289701.5	2618	50
A2-BH-08	Surge Shaft and tunnel outlet	To be drilled in next phase study			50
A2-BH-09	Powerhouse	3938892	289027.9	2331	19
A2-BH-10	Powerhouse	To be drilled in next phase study			40
A2-BH-11	Powerhouse				30
A2-BH-12	Bridge Right Abutment				30
A2-BH-13	Powerhouse bridge left bank/ (riverbed)	3938879	289193	2308	22

5.3.2 TEST PITS EXCAVATION

The test pits were excavated both for the purpose of foundation material evaluation and for the construction material studies. Eighteen test pits were excavated up to a maximum depth of 3m; four at weir site, five at box channel, one at inlet pond, two at adit tunnel, two at pressure tunnel and three at powerhouse and penstock site. The locations of the test pits are shown in respective drawings and details are summarized in Table 5.4. Test pits' logs were prepared by an experienced geologist in view of the encountered subsurface materials. Small samples from the test pits were taken for moisture content determination in the laboratory for calculation of dry densities. Disturbed soil samples were also taken for other classification testing in the Laboratory. The test pit logs were finalized in view of the laboratory tests results. Test pit logs and photographs are attached as Annexure B5.

Table 5.4: Details of Test Pits excavated at Artistic-II Hydropower Project

TP NO.	LOCATION	COORDINATES			EXCAVATION DEPTH (m)
A2-TP-01	Weir site left bank	3945578	290279.1	2512	2.3
A2-TP-02	Weir site (Riverbed)	3945478	290291.3	2501	1.5
A2-TP-03	Weir site (Riverbed)	3945449	290305.4	2500	1.4
A2-TP-04	Weir site (Riverbed)	3945416	290335.3	2499	1.5
A2-TP-05	Box Chanel	3945181	290307.8	2504	3
A2-TP-06	Box Chanel	3944893	290199.1	2505	3
A2-TP-07	Box Chanel	3944551	290186.6	2505	2.13
A2-TP-08	Box Channel	3944254	290192.6	2504	3
A2-TP-09	Box Channel	3943936	290276.5	2506	3
A2-TP-10	Inlet pond	3943793	290257.9	2504	3
A2-TP-11	Adit tunnel	3941525	289776.9	2576	1.21
A2-TP-12	Adit tunnel	3941403	290015.2	2572	2.43
A2-TP-14	Pressure Tunnel	3939050	288912	2411	3
A2-TP-15	Pressure Tunnel	3938968	288975.2	2368	3
A2-TP-16	Powerhouse	3938881	289045.8	2326	3
A2-TP-17	Powerhouse	3938844	289030.9	2313	2.44
A2-TP-18	Powerhouse	3938865	289079.2	2313	1.5

5.3.3 GEOPHYSICAL INVESTIGATIONS

M/s Sarwar & Co. with association of Geo-Horizon International were entrusted to undertake geophysical Investigations comprising seismic refraction surveys at Artistic-II Hydropower Project site. The locations of the profiles were marked and handed over to contractor before initiating the survey. The main objective was to explore the subsurface exploration, that is, the thickness of overburden or the depth to bed rock, at important project structures' locations. A total of 2645m length was explored comprising thirteen (13) seismic refraction profiles; three (3) at weir site, five (5) at box channel and inlet pond, two (2) at adit tunnel location, and three (3) at penstock and powerhouse site. The location of the seismic profiles A2-SP-1 to A2-SP-10, are shown in respective drawings.

The details of the conducted seismic profiles are summarized in the following Table **5.5** and interpreted subsurface sections are attached as Annexure B6.

Table 5.5: Details of Seismic Profiles conducted at Artistic-II Hydropower Project.

Sr. No	Profile Names	Profile Lengths	Structure
1	A2-SP-1	60m	Weir, De-Sander & Box Channel
2	A2-SP-2	200m	Weir, De-Sander & Box Channel
3	A2-SP-3	200m	Weir, De-Sander & Box Channel
4	A2-SP-4	300m	Box Channel and Inlet Pound Area
5	A2-SP-5	200m	Box Channel and Inlet Pound Area
6	A2-SP-5A	120m	Box Channel and Inlet Pound Area
7	A2-SP-5B	120m	Box Channel and Inlet Pound Area
8	A2-SP-5C	120m	Box Channel and Inlet Pound Area
9	A2-SP-6	350m	Adit Tunnel
10	A2-SP-7	350m	Adit Tunnel
11	A2-SP-8	200m	Penstock & Powerhouse
12	A2-SP-9	200m	Penstock & Powerhouse
13	A2-SP-10	225m	Penstock & Powerhouse

5.3.4 LABORATORY TESTING

Laboratory testing program for Artistic-II Hydropower Project was prepared and selected sampled were sent to Department of Civil Engineering and Department of Mining Engineering of University of Engineering and Technology, Peshawar, and Department of Geology, University of Peshawar soon after completion of field investigations. The undertaken testing for rock samples comprises bulk and dry densities, uniaxial compressive strength (UCS), Poisson ratio & modulus on rock samples, Triaxial tests on rocks, Point Load Test (PLT), natural moisture content (NMC), water absorption and petrographic analysis for the samples of boreholes while gradation, Atterberg's limits, natural moisture content, modified proctor, California bearing ratio (CBR) and shear box testing for samples from test pits. Since the explored overburden is generally sandy and gravelly, no cohesive soil strength testing was undertaken. Likewise, chemical testing was undertaken on the water sampled collected from boreholes and Ushu River. A summary of all the laboratory test results is attached as Table **5.6** for boreholes, Table **5.7** for test pit samples and Table **5.8** for water samples. The test data sheets are attached as Annexure B7 for boreholes' and Annexure B8 for test pits' laboratory test results of Volume V of the Feasibility Report.

Table 5.6 :Summary of Laboratory Test Results of Boreholes' Samples

Borehole No.	Sample No.	Location	Depth (m)	NMC*	Bulk Density	Dry Density	Water Absorption	Point Load Index (Is 50)	Uniaxial Compression Test			Petrographic Analysis (Rock Identification)
									UCS**	Modulus	Poisson Ratio	
				(%)	(g/cc)	(g/cc)	(%)	(MPa)	(MPa)	(GPa)		
A2BH-1	R1	Weir site LA	20.46-20.56	-	2.58	-	0.30	0.80	-	-	-	-
	R2		21.00-21.45	-	2.56	-	-	1.03	-	-	-	-
	R3		28.38-28.50	-	2.50	-	0.21	0.62	-	-	-	-
	R4		34.19-34.53	0.20	2.61	2.60	-	2.21	53.06	-	-	Rhyolite
A2BH-6	R1	Tunnel Intake	29.28-29.42	-	2.47	-	-	1.89	-	-	-	-
	R2		29.58-29.84	0.11	2.55	2.54	-	2.30	55.24	0.25	3.36	-
	R3		31.37-31.61	-	2.26	-	-	2.39	57.43	-	-	Rhyolite
A2BH-2	R1	Weir site, valley centre	25.50-25.60	-	2.53	-	0.56	2.96	71.10	2.73	0.24	-
	R2		27.80-28.00	0.21	2.68	2.55	-	2.58	-	-	-	-
	R3		29.10-29.37	-	2.28	-	0.80	1.78	-	-	-	-
A2BH-5	R1	Inlet Pond	12.18-12.42	0.15	2.32	2.26	0.33	3.12	74.93	-	-	-
	R2		15.60-15.76	-	2.55	-	-	2.39	-	-	-	-
	R3		17.37-17.49	-	2.56	-	-	2.96	-	-	-	-
	R4		20.26-20.68	0.19	2.30	2.29	-	2.62	62.90	2.93	0.23	-
	R5		23.46-23.68	-	2.47	-	-	2.05	49.23	-	-	-

**NMC – Natural Moisture Content, **UCS – Uniaxial Compressive Strength*

Table 5.7 : Summary of Laboratory Test Results of Test Pits' Samples

TP No.	Sample No.	Depth	Particle Size Analysis (% passing)				Atterberg's Limits			NMC*	Modified Proctor		California Bearing ratio		Direct Shear Box	
			Sieve Analysis		Hydrometer test		Liquid Limit	Plastic Limit	Plasticity Index		MDD**	OMC***	Compaction at		Cohesion	Angle of Internal Friction
		(m)	Gravel	Sand	Silt	Clay	(%)	(%)		(%)	(lb/ft3)	(%)	95%	100%	(PSF)	(Degrees)
A2-TP-01	CS-1	0-2.3	90.3	7.9	-	-	-	-	-	15.41	-	-	-	-	0.0	42.2
A2-TP-02	CS-1	0-1.5	76.5	22.2	-	-	-	-	-	8.86	-	-	-	-	684.0	43.4
A2-TP-03	CS-1	0-1.4	69.4	29.0	-	-	-	-	-	9.47	-	-	-	-	557.0	44.4
A2-TP-04	CS-1	0-1.5	75.3	23.5	1.15	0.05	Non-Plastic			2.00	136.9	4.9	24.6	51.4	652.0	41.6
A2-TP-05	CS-1	0-3	60.4	27.0	12.36	0.24	23	19	4	9.76	-	-	-	-	225.0	42.4
A2-TP-06	CS-1	0-3	68.0	21.8	9.68	0.52	24	18	6	9.33	137.4	5.6	41.2	63.7	310.0	44.4
A2-TP-07	CS-1	0-2.13	67.7	22.3	9.91	0.19	23	17	6	10.07	-	-	-	-	534.0	43.6
A2-TP-08	CS-1	0-3	54.4	32.0	12.95	0.65	24	18	6	7.69	137.3	4.8	37.0	59.2	659.0	40.1
A2-TP-09	CS-1	0-3	49.0	44.1	6.62	0.28	21	18	3	11.03	-	-	-	-	408.0	43.3
A2-TP-10	CS-1	0-3	51.0	40.8	6.17	2.03	24	18	6	9.63	135.4	4.8	42.3	64.6	645.0	39.8
A2-TP-11	CS-1	0-1.21	69.2	18.9	11.22	0.68	22	17	5	27.51	-	-	-	-	206.0	38.6
A2-TP-12	CS-1	0-2.43	59.4	31.2	9.31	0.09	24	19	5	7.80	-	-	-	-	1191.0	39.2
A2-TP-14	CS-1	0-3	69.7	21.7	7.57	1.03	24	18	6	5.34	134.8	4.8	47.8	77.1	71.0	39.0
A2-TP-15	CS-1	0-3	74.3	19.0	6.70	0.00	21	18	3	6.89	-	-	-	-	926.0	39.2
A2-TP-16	CS-1	0-3	57.9	38.7	3.43	0.07	22	18	4	1.36	-	-	-	-	948.0	41.6
A2-TP-17	CS-1	0-2.44	60.5	33.9	5.44	0.16	Non-Plastic			2.72	136.0	5.2	47.0	78.3	1108.0	38.5
A2-TP-18	CS-1	0-1.5	49.6	42.3	8.10	0.00	Non-Plastic			2.42	-	-	-	-	436.0	36.0

**NMC – Natural Moisture Content, **MDD – Maximum Dry Density, ***OMC – Optimum Moisture Content*

Table 5.8 : Summary of Laboratory Test Results of Water Samples

Borehole	Sample No.	Chemical Test of water			
		Sulphate content (ppm)	Chlorite content (ppm)	TDS (ppm)	PH Value
A2-BH-01	A2-W-01	BDL*	6	80	6.7
A2-BH-02	A2-W-02	BDL	5	60	7.4
A2-BH-13	A2-W-03	BDL	16	270	10.1

***BDL - Below detection limit which is 25 ppm for sulphate.*

5.4 GEOTECHNICAL INTERPRETATION AND DESIGN

5.4.1 GENERAL

This section presents the geotechnical interpretation and assessment of the subsurface materials based on the geological, geophysical and geotechnical investigations. Rock characterization was undertaken on the discontinuity data and borehole data to get the rock classification and accordingly geotechnical parameters to be used in the foundation design and in estimation of support requirement for underground structures. Soil parameters were derived keeping in view of the in-situ and laboratory testing, and engineering judgment.

5.4.2 SOIL AND ROCK PARAMETERS

Soil and rock parameters were derived based on the laboratory test results (Table **5.6** & annexure B7 & B8), field studies and testing, engineering judgment and recent literature. Intact rock mechanical properties were determined mainly by analyzing the laboratory test data.

Schmidt Rebound Hammer values (Rn) recorded on joint surfaces during discontinuity surveys were plotted on Schmidt Rebound Hammer Rebound Values (Rn) Chart (After ISRM 1981) corresponding to adopted unit weight for granite/ granodiorite and Rhyolite/ Andesite (**Figure 5.10**). The UCS values as produced from this correlation are summarised in **Table 5.9**. It is to note that in discontinuity surveys (DS-1, 4, 6, 8 & 10-14) in granite/ granodiorite, the UCS value estimated as 55MPa corresponding to average values of 34.2 and 23.7 kN/m^3 as Rn and unit weight respectively. Likewise, UCS of 58 MPa was estimated corresponding to average values of 35.8 and 22.93 kN/m^3 as Rn and unit weight respectively.

Table 5.9 : Summary of Rn, unit weight and estimated UCS

Rock Unit and considered discontinuity surveys		Schmidt Rebound Number (Rn)	Unit Weight kN/m^3	Estimated UCS (MPa)
Rhyolite/ Andesite (Tuv) (DS-2, 3, 5, 7 & 9)	Mean	34.20	23.70	58*
	Minimum	27.25	22.05	
	Maximum	39.75	25.77	
Granite/ Granodiorite (Tmg) DS-1, 4, 6, 8 & 10-14	Mean	35.81	22.93	56*
	Minimum	33.33	19.11	
	Maximum	40.00	25.28	

*Estimated against mean values of Rn and unit weights

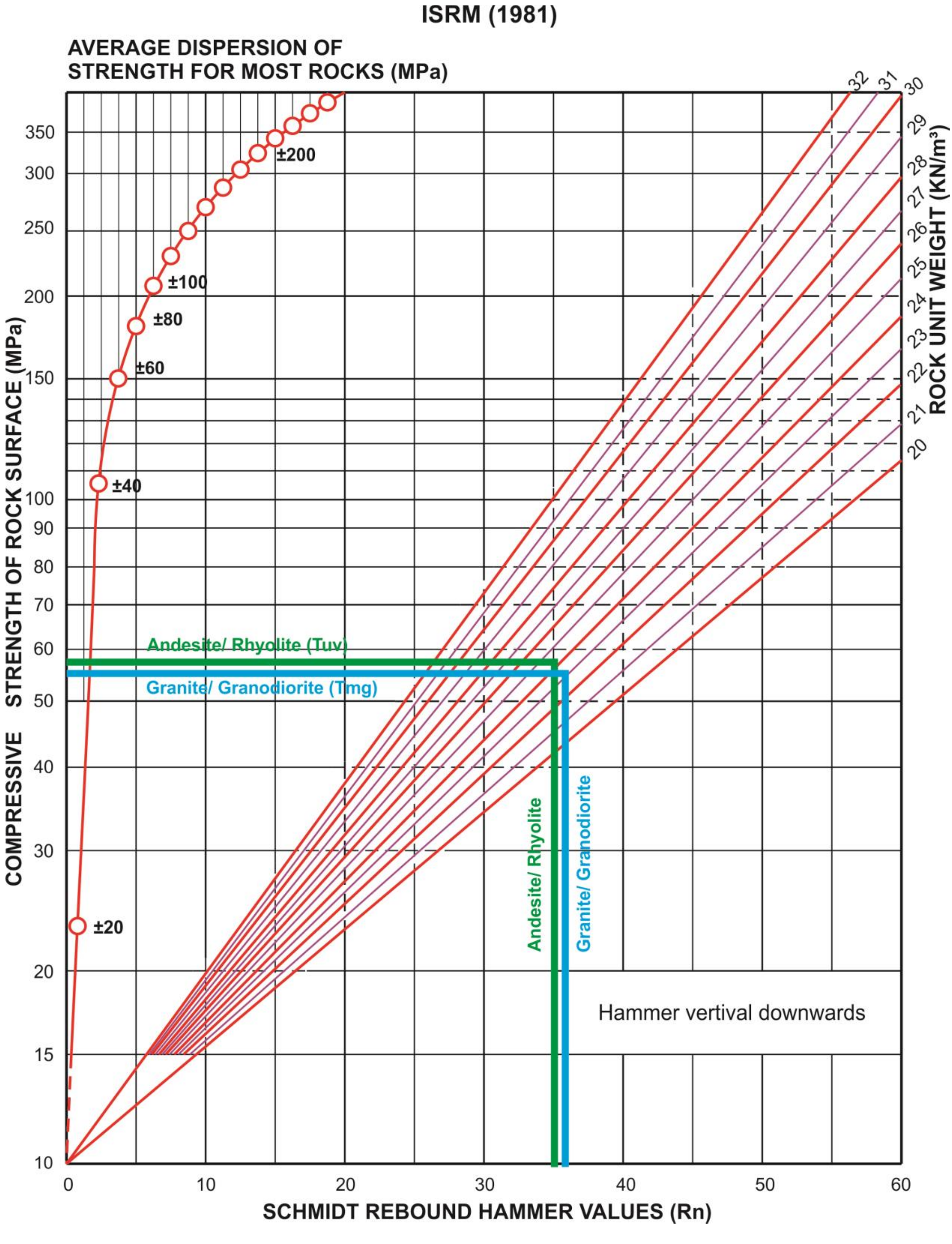

Figure 5.10: Plot showing correlation of correlation of Rn and UCS for granite/ granodiorite and rhyolite/ andesite.

The uniaxial compressive strength (UCS) and Point Load Strength Index (Is50) was measured in the laboratory of two rock units; Tuv (Rhyolite or andesite of Utror Volcanic) and Tmg (Granite or granodiorite of Matiltan Granite). In analysis, the results of UCS and Is50 were correlated (Figure **5.11**) to derive relation between both parameters and to estimate the UCS of rest of the similar rock units having done point load testing only. The UCS based on the UCS testing and estimation based on point load test range from 36.6 to 74.93 with mean of 51.53 for rhyolite/ andesite. Based on the outcome of this analysis and that of from Schmidt rebound hammer test, a value of 55MPa has been adopted. Likewise, the UCS based on the UCS testing and estimation based on point load test range from 24.52 to 79.01 with mean of 48.9 for granite/ granodiorite. Based on the outcome of this analysis and that of from Schmidt rebound hammer test, a value of 50MPa has been adopted. The Elastic moduli for both rock units determined in the laboratory testing were found on very lower side, e.g. 2-4GPa in comparison to 20-22.5GPa found by using Roclab (Rocscience). In considering both analyses output, values of 16.5GPa and 15 GPa was adopted for rhyolite/ andesite and granite/ granodiorite respectively (Table **5.10**). A summary of other intact rock parameters including point load strength index, Poisson's ratio, unit weight and water absorption are also provided in Table **5.10**.

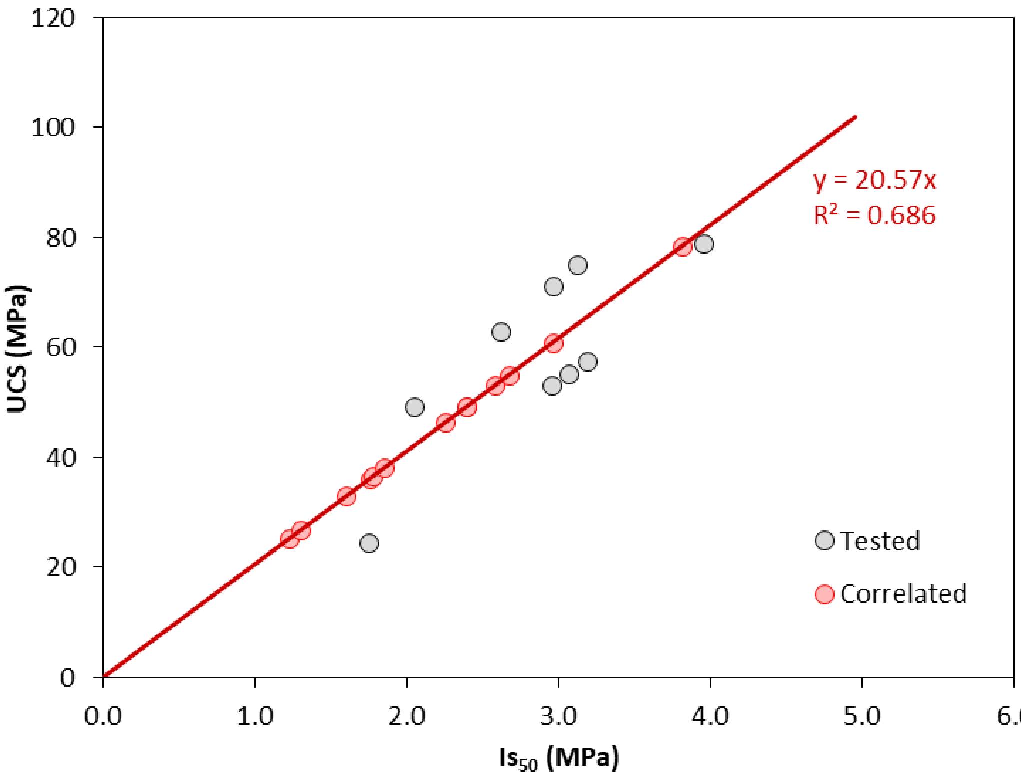

Figure 5.11: Plot showing correlation of point load index (Is_{50}) and UCS for rock units.

Table 5.10: Summary of Intact Rock Parameters

Rock Unit		Point Load Index (Is_{50}) MPa	UCS (MPa)	E (GPa)	Poisson's Ratio	Unit Weight kN/m³	Water Absorption (%)
Rhyolite/ Andesite (Tuv)	Adopted	2.45	55	16.5	0.24	24.32	0.44
	Mean	2.46	51.53		0.24	24.32	0.44
	Minimum	1.23	36.61		0.23	22.15	0.21
	Maximum	3.19	74.93		0.25	26.26	0.80
Granite/ Granodiorite (Tmg)	Adopted	2.40	50	15	0.27	25.33	0.35
	Mean	2.47	48.90		0.27	25.33	0.35
	Minimum	1.30	24.52		0.27	24.30	0.00
	Maximum	3.95	79.01		0.27	26.26	0.82

Similarly, the soil parameters were also adopted (Table **5.11**) based on the laboratory and field test data, and engineering judgment.

Table 5.11: Summary of Soil Parameters

Soil Unit		Atterberg's Limits			Bulk Unit Weight	NMC	Cohesion	Angle of Friction
		LL	PL	PI	(kN/m³)	(%)	(KPa)	(°)
River bed material (Sandy Gravels)	Adopted	Non Plastic			17.0	5.0	0	40
	Mean	Non Plastic			N/A	5.09	32.91	40.78
	Minimum	Non Plastic			N/A	2.00	20.88	36.00
	Maximum	Non Plastic			N/A	9.47	53.05	44.40
Slope Wash Material/ Glaciofluvial Deposits (Silty sandy Gravels)	Adopted	22.91	18.00	4.91	15.5	10.0	25	40
	Mean	22.91	18.00	4.91	N/A	10.15	24.43	41.12
	Minimum	21.00	17.00	3.00	N/A	1.36	0.00	38.60
	Maximum	24.00	19.00	6.00	N/A	27.51	57.03	44.40

5.4.3 ROCK CHARACTERIZATION

At rock exposures and borehole cores, characterization of rock mass was undertaken to have an assessment of rock mass classification along the proposed tunnel route and at location of important project components. During discontinuity surveys, all important parameters of discontinuities (orientation, persistence, spacing, aperture, surface roughness and undulation, infilling, and estimation of joint wall strength through Schmidt hardness), were recorded and standard empirical rock classification systems, that is, Rock Mass Rating (RMR) after Bieniawski (1989) and Tunneling Quality Index (Q) system after Barton (1974, 1993) were used for rock mass classification. Likewise, the borehole logs were also prepared estimating these parameters for rock characterization and classification. Later, based on the rock classification, rock mass parameters for foundation and support design were derived.

5.4.3.1 ROCK MASS CLASSIFICATION

RMR and Q systems were used to classify the rock mass along the tunnel route and at important project site. The RMR system is based on the evaluation of following six parameters:

1. Uniaxial Compressive Strength of rock mass
2. Rock Quality Designation “RQD”
3. Spacing of the joints / discontinuities
4. Condition of joints / discontinuities
5. Ground water conditions
6. Orientation of joints / discontinuities

These parameters have been given appropriate weightage and accordingly rating as per their characteristics. The sum of all rating (1-100) will designate specific rock class together with the estimation of rock mass mechanical parameters and correspondingly guideline for support assessment for surface and subsurface excavation. RMR gives weightage to the orientation of rock mass discontinuities and adjust the RMR values according to its application, that is, in underground excavation, slopes, foundation, etc.

The Q system is a function of three major parameters given below:

1. Block size (RQD/Jn) representing the structure of the rock mass and a measure of particle size.

2. Inter-block shear strength (Jr/Ja) represents the roughness and friction characteristics of the joint walls or filling material.

3. Active stresses (Jw/SRF) represent the stress field within and outside the rock mass in tunnels.

The numerical value of the Q is defined by the following equation

$$Q = (RQD/Jn)\ (Jr/Ja)\ (Jw/SRF)$$

The determined Q values classify the rock into various categories and provide support design for each category. The Q value is plotted against equivalent dimension of excavation

(De) which is span of tunnel or height of tunnel walls divided by excavation support ratio (ESR). ESR is generally taken as 1.6 for long term excavations.

Both RMR and Q systems have been applied on the project rock units. The values of RMR and Q were determined based on discontinuity data, borehole data and visual assessment (where discontinuity or borehole data is not available) of required parameters. The calculated values of RMR were adjusted for the orientation of discontinuities to classify the rock for foundation and underground excavations. However, the Q values were used only for the rock mass classification and estimation of support of headrace tunnel and adit.

The rock mass classification of all project rock units based on RMR and Q are summarized in Table **5.12** and detailed sheets are provided in Annexure B9. The rock mass quality is fair as per RMR and Q in andesite/ rhyolite. Likewise, it is fair as per RMR in granite/ granodiorite that becomes fair to poor with the adjustment of the discontinuity orientations. However, the rock mass quality mostly is poor as per Q in granite/ granodiorite with the variation of fair to very poor as well.

Table 5.12: Rock Classification based on Q and RMR values

Rock Unit	Data Used	Q Values	Rock Class based on Q	RMR	Rock Class based on RMR	RMR for Foundation	RMR for Tunnel
Andesite/ Rhyolite (Tuv)	Discontinuity Surveys	4.95-6.19	Fair	54	Fair	Not Applicable (NA)	42 Fair (Strike parallel to tunnel axis)
	Borehole data	-	-	42-53	Fair	(NA)	-
Granite/ Granodiorite (Tmg)	Discontinuity Surveys	5.14	Fair	43-55	Fair Rock	(NA)	38-50 Fair - Poor (Drive against dip)
		3.08-3.91	Poor				
		0.56-0.70	V. Poor				
	Borehole data	-	-	39	Poor	(NA)	-

5.4.3.2 Rock Mass Parameters

Rock mass parameters for each lithic units were obtained from Hoek & Brown Criteria (Hoek & Brown 2000) using computer program Roclab from Rocscience. Hoek- Brown criteria uses Geological Strength Index (GSI), material constant (mi), intact rock strength (UCS) and modulus (E), Excavation induced disturbance factor (D) and derive rock mass parameters. The input parameters (UCS and E of intact rock taken from Table **5.10** for) and derived rock mass parameters are summarized in Table **5.13**.

Table 5.13: Summary of Rock Mass Parameters

Rock Unit	UCS (MPa)	Intact Rock Modulus (GPa)	RMR Adopted (Range)	GSI (RMR-5)	Material Constant $(m_i)/(m_b)$	Disturbance Factor (D)	Rock Mass Global/UCS (MPa)	Rock Mass Modulus of Deformation (GPa)
Andesite/ Rhyolite	55	16.5	48 (42-54)	43	25/2.60	0.2	11.52/1.74	2.40
Ganite/ granodiorite	50	15.0	47 (39-55)	42	30/3.0	0.2	11.23/1.48	12.30

5.4.4 GEOTECHNICAL CONDITIONS AND DESIGN CONSIDERATIONS AT PROJECT STRUCTURE LOCATIONS

5.4.4.1 RESERVOIR AREA

The Artistic-II Hydropower scheme shall operate on run–off-river basis, therefore the reservoir created by the weir shall be shallow and of limited area. The area up stream of the weir is similar and 200-300m wide and with relatively gentle lower slopes in mostly overburdens materials (**Figure 5.12**). The upstream left periphery consists of loose angular rock fragments detached from the upslope hill faces screes along with colluvial, fluvial and glacial origin slope wash materials (**Figure 5.14**). The right bank of the reservoir comprises slope wash materials, scree with glaciofluvial deposits at places. The river bed materials comprise cobbles and boulders of igneous and metamorphic origin with sandy matrix (**Figure 5.2**).

Figure 5.12: A broad looking upstream view of the reservoir area from the proposed weir axis.

It has been assessed in the field that the reservoir area is situated in overburden materials and it is likely that left bank scree and slope wash material may not be very good material for water tightness, and may require some treatment. However, right periphery may be more impervious and may not require any treatment. Slopes in the reservoir area are gentle and again in overburden. The slopes may not require substantial treatment for the stability. However, minor treatment such as provision of rip rap (stone pitching) may help to stabilize the slopes at the problematic locations in case of ponding.

5.4.4.2 WEIR

The Ushu River at the weir site is flowing from NW to SW and the width of riverbed at the weir axis is about 60-90m. However, the valley is about 200m wide. At the weir site, the subsurface conditions have been investigated through engineering geological mapping, discontinuity surveys, exploratory boreholes, test pits and seismic profiling. The locations of all investigations points at weir site are shown in drawing no. A2HP-FS-GE-WR-DWG-204 and details are given in Table 5.3 (boreholes), Table 5.4 (test pits) and Table **5.5** (seismic refraction profiles). A downstream view of the Artistic-II Weir site is shown in **Figure 5.13**

The weir site geological map (drawing no. A2HP-FS-GE-WR-DWG-204) shows that the area is occupied by the slope wash material, scree and glacio-fluvial deposits. The river bed material is dominantly of cobbles and boulders of igneous and metamorphic origin with sandy matrix (Figure **5.13**). The riverbed material is loose at the top and relative density increases depth wise.

The left abutment comprises of scree and slope wash terrace consisting of gravel to boulder size embedded in silty sandy matrix, which are assessed to be lying on old river bed material (drawing no. A2HP-FS-GE-WR-DWG-204 & Figure **5.14**). The top layer of the terrace comprises clayey silty material. The left abutment slope is not very high and is not supposed to be an instability threat for the weir. Minor stability measures in form of protection by rip-rap (stone pitching) can be considered in design.

The right abutment also comprises unconsolidated materials of slope wash, scree and glaciofluvial deposits with vegetation (**Figure 5.15**). The top surface at bit higher elevations has scree accumulations on the pre-existing slope wash deposits. These deposits are believed to by lying on the underlying glaciofluvial fan, which is assumed to be on the valley floor of the river bed material. This material comprises gravels to boulders and occasional rock blocks embedded in sandy silty matrix. The gravelly material is angular to subangular having igneous origin. This slope wash material is mixed with scree and fan deposits of glacial and fluvial origin.

The upslopes on both left and right abutments are of andesite/ rhyolite of Utror Volcanics which is generally massive to blocky, light grey to grey, medium strong to very strong, moderately to highly weathered. The rock has trend almost across the river (N30-50E) with dip in upstream (i.e. 60-75NW) direction. Two joint sets J1 and J2 were also observed with some random joints during discontinuity survey (DS-2) at weir site (Table 5-2 & drawing no. A2HP-FS-GE-GNL-DWG-203). The discontinuity summaries with stereo-net plots are provided in the Annexure B1 & B2 of the Volume V of the Feasibility Report. The output of kinematic analysis on DS-2 data does not highlight any modes of slope movement in existing scenario. Since no rock cutting is involved in the placement of the weir, no disturbance/ excavation induced failures are likely.

Figure 5.13: A broad downstream looking view of the proposed weir axis area.

Figure 5.14: View of the left abutment where scree and slope wash deposit are present.

Figure 5.15: A view of right abutment area covered with slope wash material, scree and glaciofluvial deposits with vegetation.

The slope wash materials lying at the toe of the valley slopes are derived from the upslopes. However, presence of thick vegetation at the overburden slopes also leads to infer that the slopes are stable and there would not be any major slope movements in rock slopes.

Three boreholes; A2-BH-1, 2 & 3 were drilled along the weir axis up to a maximum depth of 45m to explore the subsurface. Similarly, four (4) test pits and three (3) seismic profiles were also conducted to estimate the depth to bed rock in this area (drawing no. A2HP-FS-GE-WR-DWG-204 & Figure **5.14**). The subsurface conditions as explored by the boreholes and relevant in-situ tests are given below together with the Rock Quality Designation (RQD), core recovery, permeability (in terms of Lugeon) and water table in Figure **5.16** for A2-BH-1 & 2, and in Figure **5.17** for A2-BH-3. The exploratory drilling has revealed that the bed rock is present at depth from 19.5m to 25.5m along the proposed left abutment of weir and center of the river weir axis respectively (drawing no. A2HP-FS-GE-WR-DWG-205). Along the right abutment, the lower limit of overburden was not determined. At the valley center, the depth to bed rock is 25.5m (A2-BH-2) at an elevation of 2473.5m.

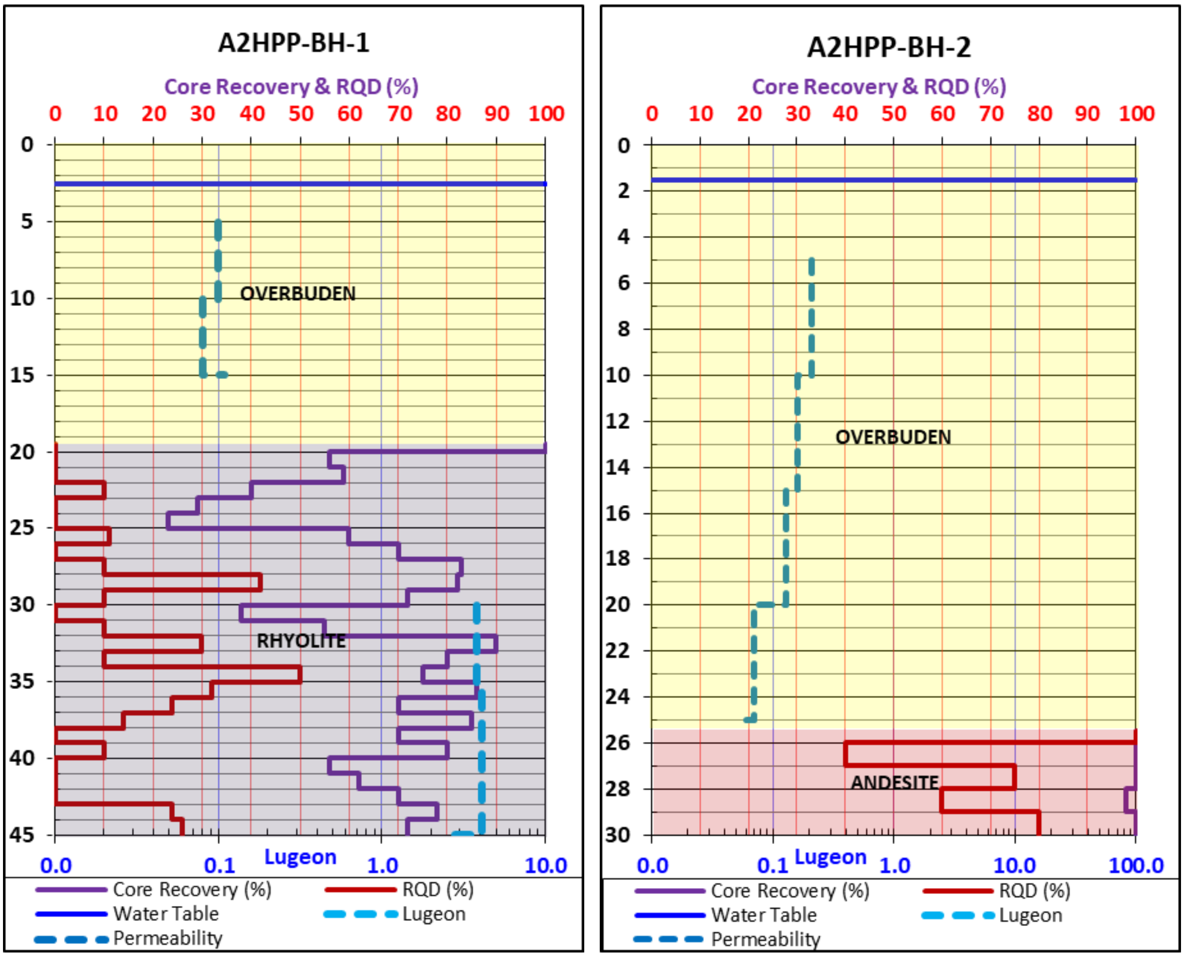

Figure 5.16: Plots showing subsurface profile as explored by the A2-BH-1 & 2.

The water table recorded during field investigations is at depth of 2.5m (A2-BH-1) at left abutment, at 1.5m (A2-BH-2) at valley center and 22.5m (A2-BH-3) at right abutment below natural surface level.

The laboratory testing on selective core samples of A2-BH-1,2 & 3 have revealed that the bed rock comprising rhyolite and andesite of Utror Volcanic is medium strong to strong as per ISRM intact rock classification; (Please refer Table **5.6** for summary of Laboratory test results). The laboratory tests have shown that bulk density of core samples varies from 2.28 to 2.68 g/cm^3 and dry density from 2.55 to 2.60 g/cm^3.

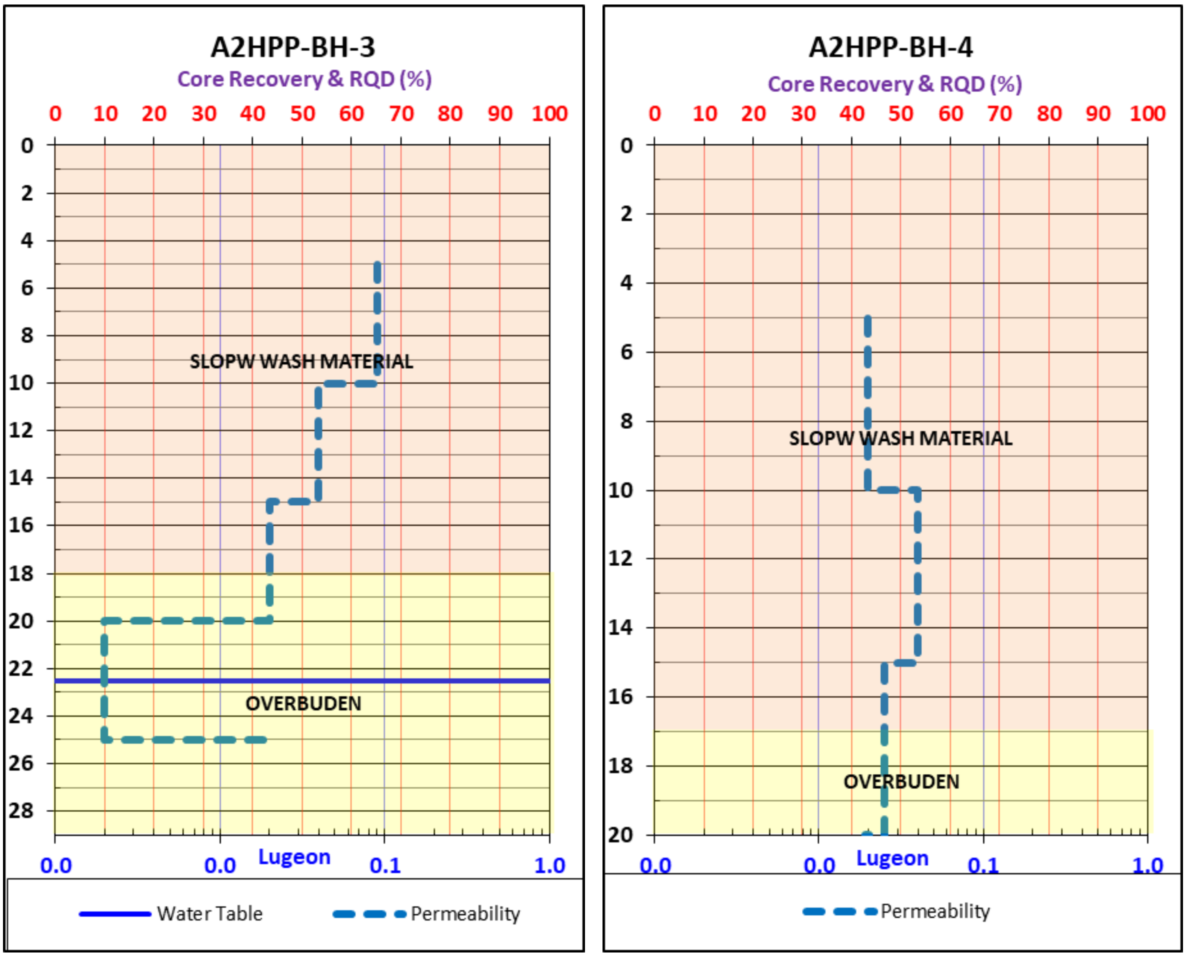

Figure 5.17: Plots showing subsurface profile as explored by the A2-BH-3 & 4.

Generally rock mass quality as determined from borehole and discontinuity data falls in fair class at weir site as per RMR (Table **5.12**). However, the foundation of the weir will be placed on the river bed material which is about 19.5m thick in the valley. As per the US Army Corps of Engineers, Bearing Capacity of Soils Manual (EM 1110-1-1905), a nominal allowable bearing capacity of 1.5-2.0kg/cm^2 is proposed to be used for slope wash materials and glaciofluvial deposits comprising angular to rounded gravels, cobbles and boulders embedded in silty sandy matrix. Similarly, according to same reference, bearing capacity values of 2.0 Kg/cm^2 can be used for the structures to be founded on the river bed material comprising loose to medium compacted rounded to subrounded gravels, cobbles and boulders embedded in sandy matrix. This allowable bearing pressures will require the removal of any encountered loose material and filling with granular fill compacted to 95% of its maximum dry density.

The values of permeability of overburden material is given in **Table 5.14** varies from 2.21E-03 to 2.09E-01 cm/sec. The bed rock has shown relatively low range of permeabilities in most of the in-situ water pressure tests (Table **5.15**). In view of the fact that this is not a storage type project, the uplift analyses show no problem under normal operating conditions. This lead to suggest that there is no need to provide cut-off wall or grout curtain for the structural stability of the weir.

Table 5.14: Summary of permeability test results at weir site.

Borehole No.	Test No.	Test Depth [m]	Permeability (cm/sec)
A-2 BH-1	1	5	1.03E-01
	2	10	8.37E-02
	3	15	1.06E-01
A-2 BH-2	1	5	2.09E-01
	2	10	1.58E-01
	3	15	1.25E-01
	4	20	6.84E-02
	5	25	6.05E-02
A-2 BH-3	1	5	9.20E-02
	2	10	4.37E-02
	3	15	2.16E-02
	4	20	2.21E-03
	5	25	1.94E-02

Table 5.15: Summary of Water Pressure Test Results at Weir Site.

Borehole No.	Test No.	Test Section [m]	Lugeon Value	Interpreted Flow Type
A-2 BH-1	1	25-30	3.8	Turbulent
	2	30-35	4.1	Turbulent
	3	35-40	4.1	Turbulent
	4	40-45	2.4	Turbulent
A-2 BH-2	1	27-30	11.5	Dilation

The weir structure would require cutting of slope wash and glacio-fluvial material at the both abutments as the thickness of overburden is in access of 19.5m. The excavation with 1H:1V cut slope angle for the permanent slopes along weir abutment is proposed as per the conducted limit-equilibrium analysis (**Figure 5.18**) using parameters provided in **Table 5.11** and based on the local experience in these types of materials. However, the temporary slopes can be cut at an angle of 1H:1.5-2V.

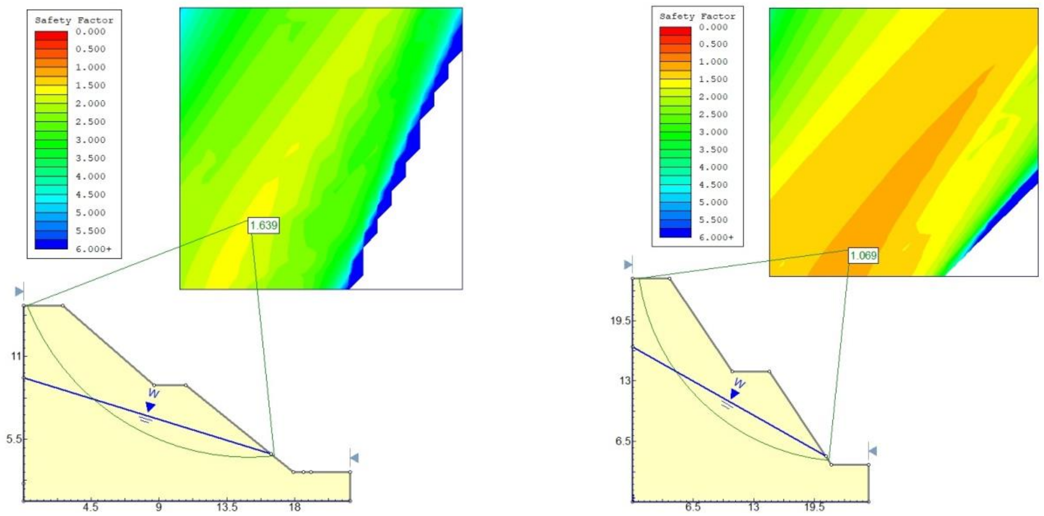

Figure 5.18: Plots showing outcome of limit equilibrium analysis at extreme condition i.e. with water table and earthquake loading (0.2g); for a overburden slope dressed at angle a) 1H:1V, b) 1H:1.5V.

5.4.4.3 SAND TRAP AND BOX CHANNEL

The sand trap has been proposed immediately after the intake structure. The box channel connecting sand trap with forebay will be mostly on the unconsolidated material comprising slope washes, scree and glacio-fluvial deposits along the right bank of Ushu River (drawing no. A2HP-FS-GE-WR-DWG-204 to 207). As part of geotechnical investigation, one bore hole A2-BH-04 with the depth of 20m along the location of sand trap, five (5) test pits; A2-TP-05 to A2-TP-09 and three seismic reflection profile line; A2-SP-01 to A2-SP-03 were conducted for the subsurface geology. The area for the sand trap and box channel comprises a thick cover of slope wash material/glacio-fluvial deposits with screes and vegetation cover. The borehole and test pits logs, interpreted section along seismic profiles and laboratory results of borehole and test pits' samples are attached in respective annexures.

The geological section (drawing no. A2HP-FS-GE-WR-DWG-205) shows that the sand trap will be constructed on the overburden material comprising slope wash material and glacio-fluvial deposits of mix origin. The analysis of the hole A2-BH-04 in terms of permeability is shown in **Figure 5.17** and values of permeability tests are given in Table **5.16**. The permeability values vary between 1.90E-02 to 3.66E-02 cm/sec. Similarly, the geological sections at box channel (RD 0+300, 0+700, 1+000 & 1+400) are given in drawing no. A2HP-

FS-GE-CNL-DWG-207 showing that the same material is present along box channel alignment.

The geotechnical investigations have revealed that these unconsolidated materials are comprised of gravels, cobbles and boulders embedded in silty sandy matrix of mix origin. The proportion of granular materials varies both vertically and horizontally along the channel route and rock comprising Andesite of Utror Volcanics interpreted to be present at depth greater than 40m.

Table 5.16: Summary of Permeability Test Results at Sand Trap Location.

Borehole No.	Test No.	Test Depth [m]	Permeability (cm/sec)
A-2 BH-4	1	5	2.20E-02
	2	10	3.66E-02
	3	15	2.50E-02
	4	20	1.90E-02

The structure of sand trap and box channel will have slope wash and glaciofluvial deposits as foundation material. As per the US Army Corps of Engineers, Bearing Capacity of Soils Manual (EM 1110-1-1905), a nominal allowable bearing capacity of 1.5-2.0kg/cm^2 is proposed to be used for slope wash materials and glaciofluvial deposits comprising angular to rounded gravels, cobbles and boulders embedded in silty sandy matrix. This allowable bearing pressures will require the removal of any encountered loose material and filling with granular fill compacted to 95% of its maximum dry density.

The placement of the sand trap and box channel will involve the cutting of slope wash and glacio-fluvial deposits. The weir structure would require cutting of slope wash and glacio-fluvial material at the both abutments as the thickness of overburden is in access of 19.5m. The excavation with 1H:1V cut slope angle for the permanent slopes along sand trap and box channel is proposed as per the conducted limit-equilibrium analysis (**Figure 5.18**) using parameters provided in Table **5.11** and based on the local experience in these types of materials. However, the temporary slopes can be cut at an angle of 1H:1.5-2V.

5.4.4.4 POWER FACILITIES

The power facilities are designed on the right bank of Ushu River shall stretch from tunnel intake to tunnel outlet near Basin Lilmal Village where powerhouse is proposed. An adit tunnel has been proposed near the mid of the headrace tunnel. The power facilities include the intake pond and intake portal, headrace tunnel, adit tunnel, penstock, and powerhouse. The geological, geotechnical and geophysical information has been collected in the field and each component has been evaluation based on the surface and interpreted subsurface geological conditions. The related geological maps and sections are attached as drawings A2HP-FS-GE-FB-DWG-208 to A2HP-FS-GE-PH-DWG-215.

5.4.4.4.1 FOREBAY, INTAKE POND, AND TUNNEL INTAKE

The box channel connecting sand trap to inlet pond is likely to be placed on unconsolidated deposits of different origins (A2HP-FS-GE-FB-DWG-208), that is, slope wash and scree; angular rock fragments of overlying andesite/ rhyolite that vary in size from gravels to cobbles with occasional boulders (**Figure 5.21**). The scree is overlying on the slope wash material and glacio-fluvial deposits that has silty matrix with angular to subangular rock fragments. As part of geotechnical investigations, two bore holes; A2-BH-05 (30m) and A2-BH-06 (32m), two test pits; A2-TP-09 & 10, and four seismic refraction profiles; A2-SP-5, A2-SP-5A, A2-SP-5B and A2-SP-5C of cumulative length of 560m were conducted along the intake pond, box channel and tunnel intake. The broad view of box channel, inlet pond and tunnel intake in shown in **Figure 5.19**.

The box channel connects the power conduit that links the tunnel intake through intake pond (drawing no. A2HP-FS-GE-FB-DWG-209 & Figure **5.19**). These structures have been planned at glacio-fluvial material where rock will be at greater depth (drawing no. A2HP-FS-GE-FB-DWG-209). Towards underground intake, the rock comprising andesite/ rhyolite of Utror Volcanics is exposed above scree (Figure A8, **Figure 5.20** & **Figure 5.30**) with some intrusions of Matiltan Granite. One discontinuity survey; DS-9 has been conducted at this location (Table 5-1). The discontinuity survey has revealed that rock is generally blocky to massive have foliation trend in northeast direction dipping in northwest ward at very steep angle (i.e. 70-80 degrees). In addition to foliation, three joint sets have been identified and recorded during field investigations with some random joints (Table 5-2). Intact rock is medium strong to very strong on fresh surfaces, as per ISRM guidelines for intact rock classification, with slight to moderate weathering profile from inward to surface. The discontinuities are generally extremely close to moderately spaced, very low to very high persistent with tight to wide apertures and generally smooth to rough and planar to undulating surfaces. The rock mass has been categorized as “fair” as per RMR and Q systems of rock mass classification and characterization. The orientations of the discontinuities have been plotted in drawing no. A2HP-FS-GE-GNL-DWG-203 and data has been provided in Annexures B1 and B2 of Volume V.

Two vertical boreholes; A2-BH-05 & 6 (**Table** 5.3) were drilled along the inlet pond and headrace tunnel up to the maximum depth of 32m. In borehole A2-BH-05, the rock comprising of rhyolite encountered at 10m depth at 2532m elevation, while in A2-BH-06, same rock was found at the depth of 29m at 2486m elevation. The subsurface conditions as explored by the boreholes and relevant in-situ tests are given below together with the Rock Quality Designation (RQD), core recovery, permeability (in terms of Lugeon) and water table in **Figure 5.22**.

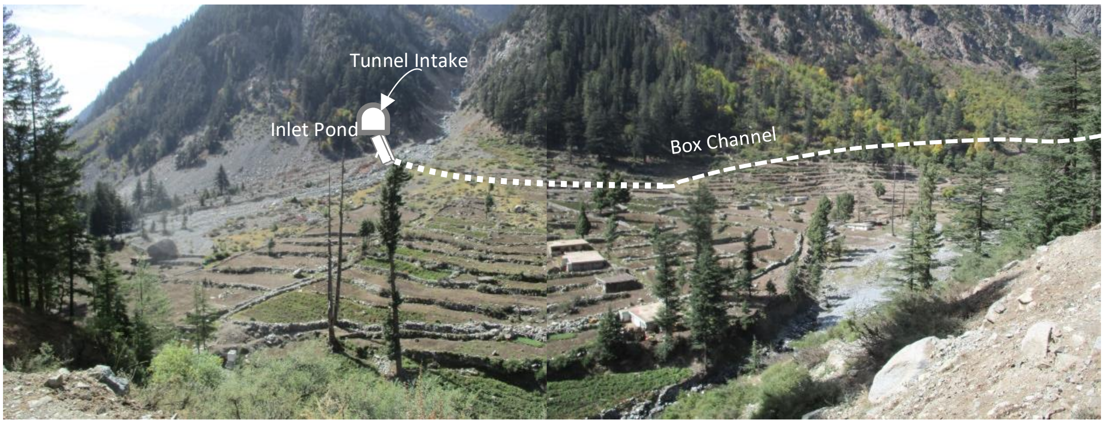

Figure 5.19: A broad view of the Box Channel, Inlet Pond and Tunnel Intake area.

In borehole A2-BH-05, core recovery and RQD was found to vary from 61-100% and 10-87% with mean of 91% and 54% respectively. These values indicate fair quality of rock. Also lower values of permeabilities in in-situ water pressure tests (Table **5.17** & **Figure 5.22**) appears to support this conclusion.

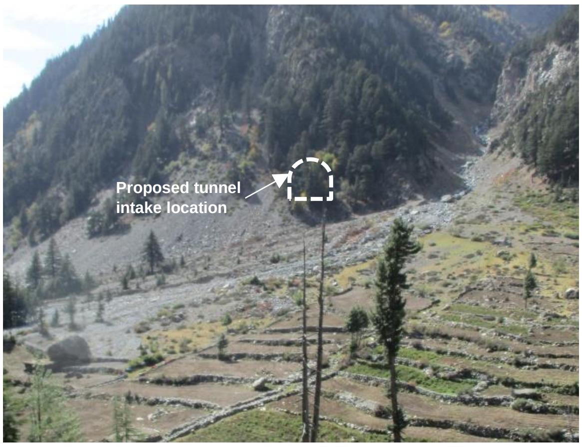

Figure 5.20: A close view of the approximate location of the intake portal of the proposed headrace tunnel.

Figure 5.21: A broad view of the andesite rock outcrop at the intake location.

The overburden material explored by borehole A2-BH-6 is dense to very dense as per the values of the SPT tests. The variation of permeability in slope wash/ glaciofluvial deposits is shown in **Figure 5.22** and values of permeability tests are given in **Table 5.18**. The permeability values were found to vary from 1.45E-03 to 9.91E-02 cm/sec.

Table 5.17: Summary of water pressure test results at tunnel intake.

Borehole No.	Test No.	Test Section [m]		Lugeon Value	Interpreted Flow Type
		From	To		
A-2 BH-5	1	15	20	2.0	Dilation
	2	20	25	1.8	Dilation
	3	25	30	1.0	Void Filling

Table 5.18: Summary of permeability test results at tunnel intake.

Borehole No.	Test No.	Depth [m]	Permeability (cm/sec)
A-2 BH-6	1	5	9.91E-02
	2	10	4.60E-02
	3	15	2.36E-02
	4	20	1.33E-02
	5	25	1.45E-03

Forebay and intake structure have to be placed in the overburden material by excavating slope wash material and glaciofluvial deposits. As per the US Army Corps of Engineers, Bearing Capacity of Soils Manual (EM 1110-1-1905), a nominal allowable bearing capacity of 1.5-2.0kg/cm^2 is proposed to be used for slope wash materials and glaciofluvial deposits comprising angular to rounded gravels, cobbles and boulders embedded in silty sandy matrix. This allowable bearing pressures will require the removal of any encountered loose material and filling with granular fill compacted to 95% of its maximum dry density.

The placement of the forebay and intake structure will involve the cutting of slope wash and glacio-fluvial deposits. The excavation with 1H:1V cut slope angle for the permanent slopes along the intake is proposed as per the conducted limit-equilibrium analysis (**Figure 5.18**) using parameters provided in Table **5.11** and based on the local experience in these types of materials. However, the temporary slopes can be cut at an angle of 1H:1.5-2V. In view of the foliation and joint sets, rock can be cut at it can be suggested to cut the face at an angle of 1H:4-6V with the provision of 4m benches after 10m depth/ height interval.

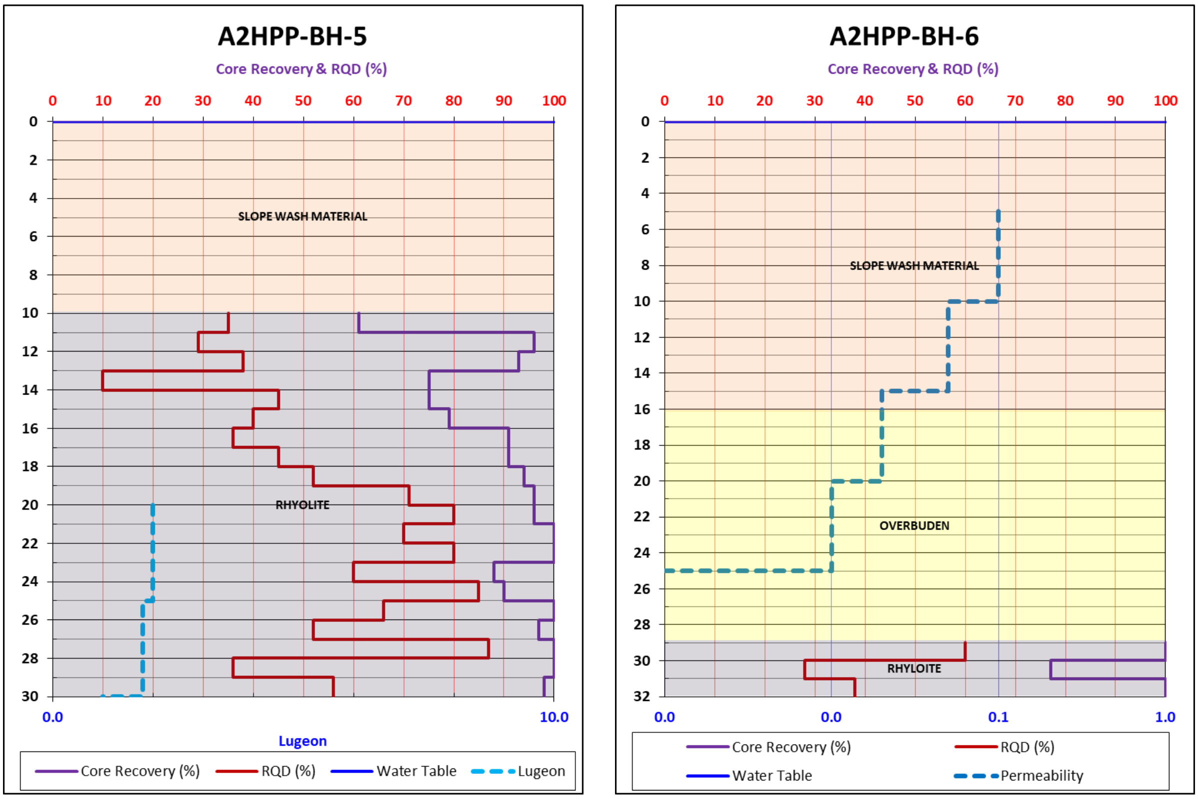

Figure 5.22: Plots showing subsurface profile as explored by the A2-BH-5 & 6.

5.4.4.4.2 The Headrace Tunnel

The headrace tunnel shall off take from the intake in almost south-southeast direction for a distance of about 2.25km (near access adit-tunnel junction) then it takes a bend towards west and is aligned in southwest direction up to further about 1.5km where it takes a smooth bend towards south and southward to surge shaft and tunnel outlet. The tunnel shall be horseshoe in shape with 4.9m of excavation diameter. The adit is about 460m long.

The tunnel route corridor nearly 200-300 m wide, has been geologically mapped picking up various lithological and structural features. The geological map of the headrace tunnel with its interpreted section is given in drawing no. A2HP-FS-GE-TNL-DWG-210 to A2HP-FS-GE-TNL-DWG-212, and geological plan & section of adit-tunnel is given in A2HP-FS-GE-TNL-DWG-213. The surface and sub-surface conditions along the headrace tunnel alignment are determined through geological mapping, geotechnical and geophysical investigations. Six discontinuity surveys (DS-09, DS-08, DS-14, DS-13, DS-12 and DS-01) were conducted as part of present studies. The interpreted geological information shows that the following rock types shall be expected along the tunnel route.

- Dominantly Andesite and rhyolite with subordinate intrusions of granite/ granodiorite, tuff, agglomerates, etc. This rock unit is present at the intake location and initial segment of the tunnel. The rock is blocky to very blocky having foliation trend in northeast-southwest direction dipping both in northwest and southeast at very steep angles. As per discontinuity surveys, the discontinuities are generally extremely close to moderately spaced, very low to very high persistent with tight to wide apertures and generally smooth to rough having planar to undulating surfaces. The intact rock quality as per ISRM, is interpreted from medium strong to strong. As per topography and climate conditions of the project area, water table is likely to be present above the proposed stretch of the tunnel in this rock unit suggesting that high water flows may be likely through the discontinuities intersecting the tunnel alignment. This rock unit is present from tunnel intake to about 625m along the tunnel alignment where it makes its contact with the granite/ granodiorite of Matiltan Granite. This rock unit is present about 13% of the total tunnel length.

- Granodiorite/ Granite: This rock unit is present from 625m along the tunnel route and extends up to the end of the tunnel. This rock is very blocky to massive having foliation trend in northeast-southwest direction dipping northwest at steep to very steep angle, with localized dip direction in southeast. As per discontinuity surveys, the discontinuities are extremely close to widely spaced, low to very high persistent with tight to wide apertures and generally have rough and undulating rock surfaces. The rock quality as per ISRM guidelines for intact rock classification is to be medium strong to strong. As per topography and climate conditions of the project area, water table is likely to be present above the proposed stretch of the tunnel in this rock unit. This in turn suggests that high water flows may be likely through the discontinuities intersecting the tunnel alignment. This rock makes about 87% of the total rock mass along the tunnel.

The lithological detail of these rock types is given in Section 5.2.2.2.2

The rock mass classes along the entire tunnel alignment were assessed using rock mass classification system; RMR after Bieniawski (1989) and Q after Barton et al. (1974 & 2002). A summary of the rock mass classes according to these systems are provided in **Table 5.19**, and detailed calculation sheets are provided in Annexure B9 of Volume V. Additionally, ground conditions in terms of tunnel stability and problems such as squeezing, spalling and bursting were also evaluated utilizing empirical schemes of Singh et al. (1992), Goel et al. (1994), Hoek and Marinos (2000), Hoek and Brown (1980) and Barton et al. (1974 & 2002). The details of tunnel segments, anticipated rock cover and corresponding ground conditions, exposed rock units and their characteristic and rock classification along whole tunnel route have been summarized in **Table 5.19**.

The chainage wise variation of RMR, Q and GSI of the total length of tunnel along with the graphical percentages of each class is given in Figure **5.23**. According to the RMR classification, the tunnel length of 4021m (83%) will pass through fair rock, and 850m (17%) will through poor rock. However, the characterization of rock masses through Q system concluded that the 1175m (24%), 2846m (58%) and 850m (17%) will pass through fair, poor and very poor rock mass classes respectively. This assessment of rock classes is based on surface conditions and rock parameters gathered during the discontinuity surveys as no borehole is drilled along the tunnel alignment due to high and inaccessible ridges.

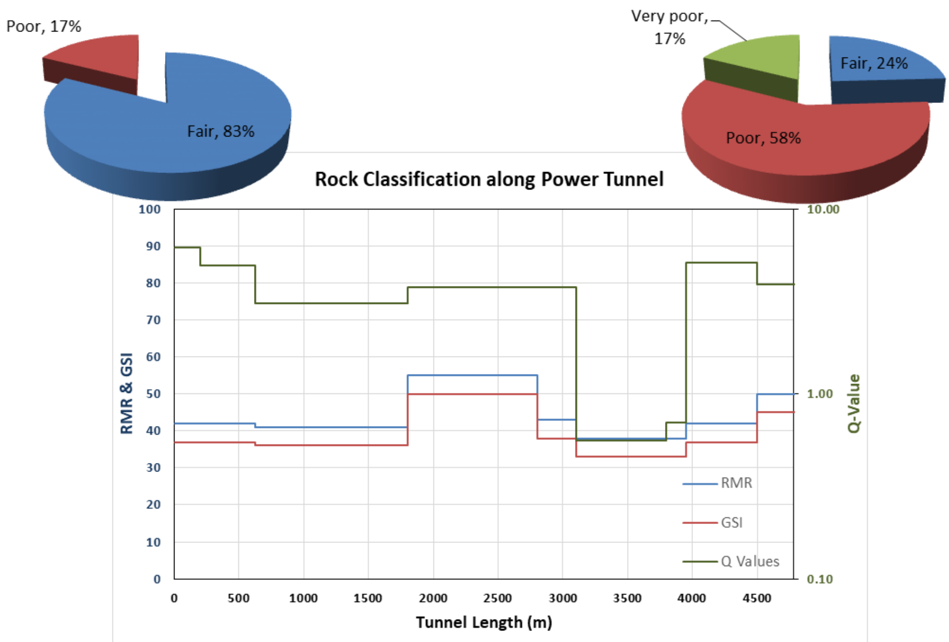

Figure 5.23: Variation of RMR, Q and GSI along the tunnel alignment.

The proposed tunnel alignment will pass through the minimum rock cover of 13m, and a maximum of 440m (**Table 5.19**). In order to evaluate the ground conditions along the tunnel alignment, empirically proposed schemes and criteria were used. Initially, two empirical classification systems of Singh et al. (1992) and Goel et al. (1994) are utilized as a starting point of the assessment. Singh et al. approach uses the value of Q assuming the stress reduction factor (SRF) of 2.5, implying that if the values of overburden are greater 350 times of cube root of Q-value, the squeezing ground condition will be encountered. The approach concluded that all the rock masses will not induce any squeezing potential. The graphical representations of results on the log-log graph of Singh et al. approach is given in **Figure 5.24**.

Table 5.19: Details of the rock profile and rock classification along Tunnel Route

<table>
<tr><th rowspan="2">Sr. No.</th><th colspan="2">Tunnel Chainage</th><th>Length</th><th rowspan="2">Rock Unit</th><th rowspan="2">Rock Cover Thickness (m)</th><th colspan="2">Rock Class</th><th colspan="4">Ground Condition Assessment</th></tr>
<tr><th>From</th><th>To</th><th>(m)</th><th>RMR</th><th>Q</th><th>Hoek & Brown (1980)</th><th>Singh et al. (1992)</th><th>Goel et al (1994)</th><th>Barton et al (2002)</th></tr>
<tr><td>1</td><td>0+000</td><td>0+200</td><td>200</td><td rowspan="3">Andesite/ Rhyolite (Tuv)</td><td>20-145</td><td rowspan="8">Fair</td><td rowspan="3">Fair</td><td rowspan="2">Stable</td><td rowspan="18">Non-Squeezing</td><td rowspan="7">Non-Squeezing</td><td rowspan="2">Medium Stress</td></tr>
<tr><td>2</td><td>0+200</td><td>0+400</td><td>200</td><td>145-265</td></tr>
<tr><td>3</td><td>0+400</td><td>0+625</td><td>225</td><td>265-280</td><td rowspan="9">Minor (Sidewall) spalling</td><td rowspan="9">High Stress</td></tr>
<tr><td>4</td><td>0+625</td><td>1+150</td><td>525</td><td rowspan="15">Granodiorite/ Granite (Tmg)</td><td>280-310</td><td rowspan="5">Poor</td></tr>
<tr><td>5</td><td>1+150</td><td>1+800</td><td>650</td><td>207-280</td></tr>
<tr><td>6</td><td>1+800</td><td>2+600</td><td>800</td><td>215-290</td></tr>
<tr><td>7</td><td>2+600</td><td>2+800</td><td>200</td><td>290-440</td></tr>
<tr><td>8</td><td>2+800</td><td>3+100</td><td>300</td><td>400-440</td><td>Minor Squeezing</td></tr>
<tr><td>9</td><td>3+100</td><td>3+500</td><td>400</td><td>345-430</td><td rowspan="4">Poor</td><td rowspan="4">Very poor</td><td rowspan="2">Severe Squeezing</td></tr>
<tr><td>10</td><td>3+500</td><td>3+650</td><td>150</td><td>298-360</td></tr>
<tr><td>11</td><td>3+650</td><td>3+800</td><td>150</td><td>220-298</td><td rowspan="2">Minor Squeezing</td></tr>
<tr><td>12</td><td>3+800</td><td>3+950</td><td>150</td><td>116-220</td><td rowspan="2">Stable</td><td rowspan="2">Medium Stress</td></tr>
<tr><td>13</td><td>3+950</td><td>4+050</td><td>100</td><td>78-220</td><td rowspan="6">Fair</td><td rowspan="4">Fair</td><td rowspan="6">Non-Squeezing</td></tr>
<tr><td>14</td><td>4+050</td><td>4+150</td><td>100</td><td>2230-303</td><td rowspan="3">Minor (Sidewall) spalling</td><td rowspan="3">High Stress</td></tr>
<tr><td>15</td><td>4+150</td><td>4+300</td><td>150</td><td>298-338</td></tr>
<tr><td>16</td><td>4+300</td><td>4+500</td><td>200</td><td>188-298</td></tr>
<tr><td>17</td><td>4+500</td><td>4+700</td><td>200</td><td>118-188</td><td rowspan="2">Poor</td><td rowspan="2">Stable</td><td rowspan="2">Medium Stress</td></tr>
<tr><td>18</td><td>4+700</td><td>4+871</td><td>171</td><td>13-118</td></tr>
</table>

Goel et al. approach uses the rock mass number (N-value), overburden and diameter/ width of the tunnel to evaluate the ground conditions along tunnel, this criteria ends up that the tunnel chainage from 2800m to 3100m and 3650m to 3950m (total 600m, 12%) will have minor squeezing potential, and from 3100m to 3650m (total 550m, 11%), will have severe squeezing potential. The results along the tunnel alignment on the log-log graph of Goel et al. criterion are presented in Figure **5.25**. The detail assessment of ground condition along tunnel alignment is presented in Table **5.19**.

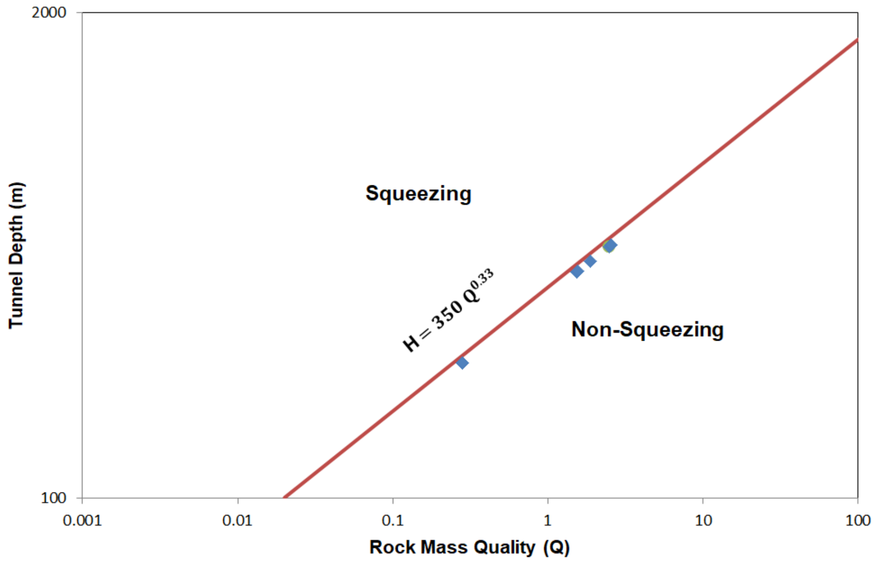

Figure 5.24: The ground conditions along tunnel alignment based on Singh et al (1992) approach.

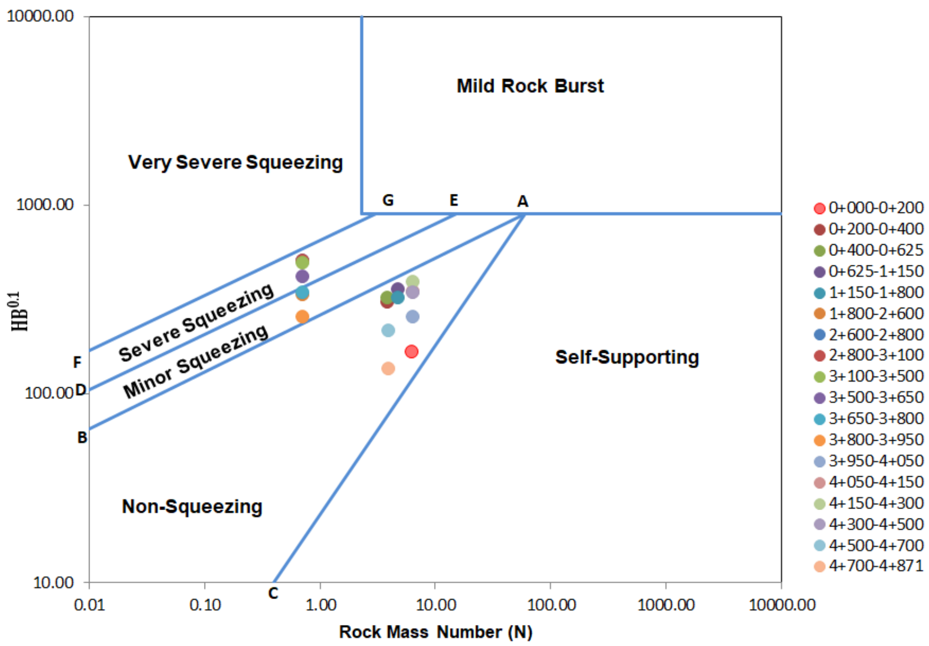

Figure 5.25: The ground conditions along tunnel alignment based on Goel et al. (1994) approach.

Similarly, two others empirical approaches of Hoek and Brown (1980) and Barton et al. (2002) were utilized for ground conditions and field stress assessments, and results are presented in **Table 5.19**. Hoek and Brown approach uses the ratio of intact rock strength and sigma theta giving the stability conditions in the form of stable, minor spalling, severe spalling and rock burst, while in Barton et al. scheme, the ratio of intact rock strength to the maximum principle stress is used for ground stress assessment in the form of low, medium, high, mild and heavy rock burst conditions. The results of these approaches are similar that the ground conditions for rock masses will be stable for 20% of the total length of tunnel having medium stress condition while in remaining, minor spalling along sidewalls will be induced having high stress conditions.

In order to cater the squeezing potential and strain potential assessment, Hoek and Marinos (2000) methodology was also examined that uses the ratio of rock mass strength and in-situ stress along abscissa and strain potential percentage along ordinate. The in-situ stress in terms of unit weight and overburden was determined. The strain percentage (tunnel closure/ tunnel diameter*100) was evaluated considering the diameter of 4.5m. The in-situ stresses in the present scenario are in moderate range so this approach concluded that the squeezing is not likely along the tunnel alignment. The graph of Hoek and Marinos is given in **Figure 5.26**.

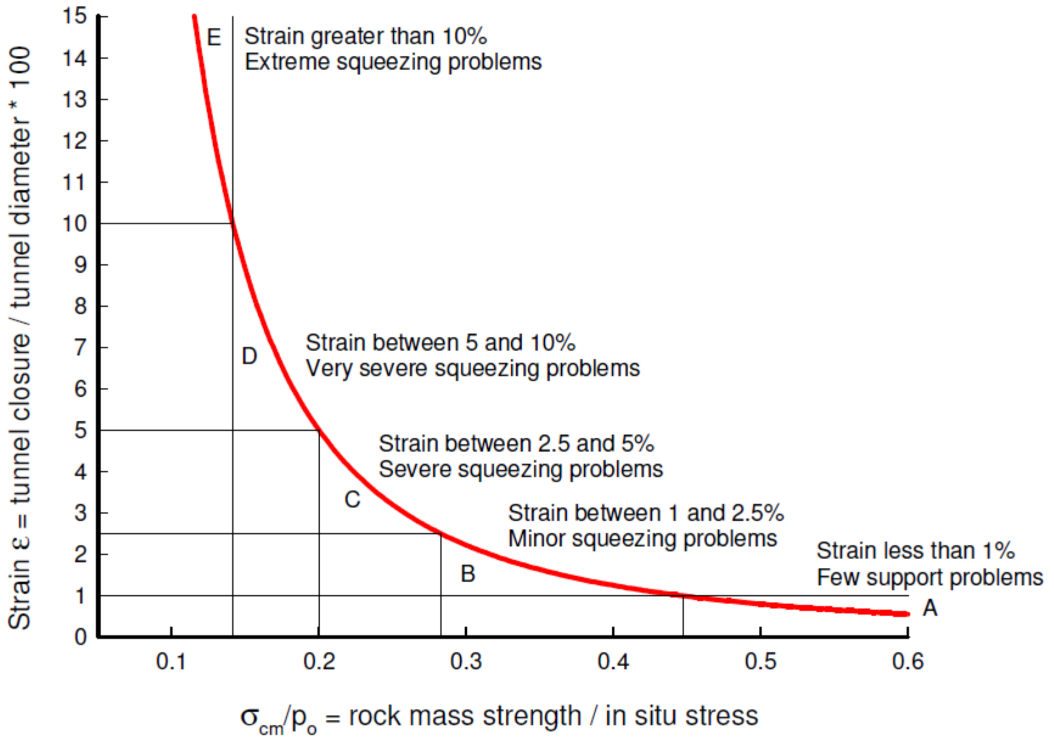

Figure 5.26: Relation between the rock mass strength/ insitu stress and percent radial strain of the tunnel (i.e. tunnel closure*100/ tunnel diameter), after Hoek & Marinos (2000).

5.4.4.4.2.1 Tunnel Support

Tunnel support is considered to be a function of mechanical response of rock mass. Empirical methods RMR and Q give guidelines for support design corresponding to rock classes. Along the tunnel, an assessment of rock mass quality has been made and both RMR and Q classification have been undertaken (Section 5.4.3.1). Rock classes based on RMR and Q systems of rock mass classification are given in **Table 5.19**.

Considering the rock mass quality as per RMR, the support estimation has been made in **Table 5.20** for fair and poor rock. This table gives an assessment of excavation method, estimation of rock reinforcement; length and spacing of rock bolts and thickness of shotcrete, and application of steel ribs subject to squeezing conditions.

Table 5.20: Support estimation based on RMR

Rock Category	RMR	Excavation	Rock bolts (20 mm dia fully grouted)	Shotcrete	Steel Sets
Fair	41-60	Full face	Systematic bolts 4 m long, spaced 1.5 – 2.0 m in crown and walls with wire mesh in crown.	50 – 100 mm in crown and 30 mm in walls.	None
Poor	<40	Full face	Systematic bolts 4-5 m long, spaced 1.0 – 1.5 m in crown and walls with wire mesh in crown only.	100 – 150 mm in crown and 100 mm in walls.	Light to medium ribs spaced 1.5 m where required.

Likewise, support assessment based on the Q system was also made corresponding to rock classes fair to very poor. In this regard, Q values are plotted against ratio of Equivalent Dimension (De) of an excavation to Excavation Support Ratio (ESR) i.e. span/ ESR. De is the ratio of height of wall or span of the tunnel to the ESR, span in our case is 4.5m. ESR for permanent excavation is 1.6 which yields span/ ESR ratio of 2.813. Q values of fair to very poor were plotted against 2.813 on Q-chart of support categories. The SRF values corresponding to medium to high stresses are used. The length of bolts and unsupported span are calculated by the equations proposed by Barton et al. The bolt length is a function of tunnel excavation span and ESR, while maximum unsupported span is equal to the product of twice the ESR and 0.4 power of Q.

The plot given in **Figure 5.27** shows that the rocks that fall in fair to poor quality rock which indicates support of category 1 (**Figure 5.27**); unsupported rock conditions with no need of rock reinforcement. However, spot bolting may be applied at places where rock blocks or wedges are prone to instability. The very poor rocks fall in category 4 & 5 where the shotcrete of 40-90mm is recommended. The typical support categories as per Q system are provided in drawing no. A2HP-FS-GEO_DWG-0600.

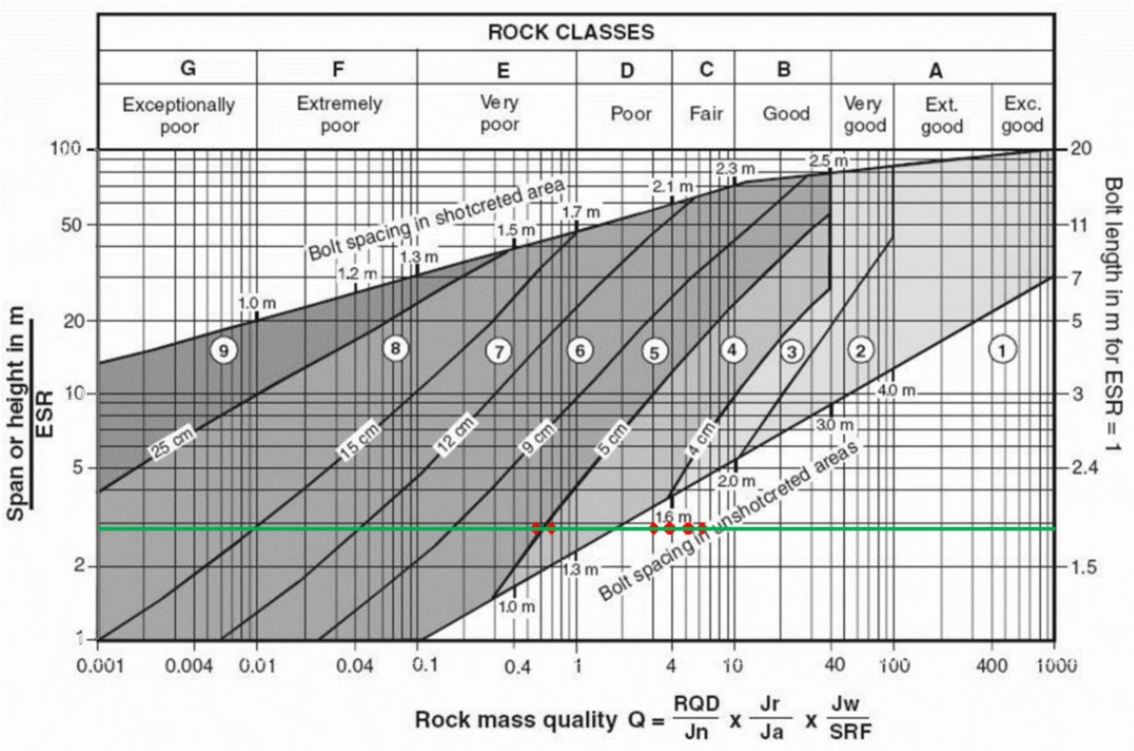

Figure 5.27: Estimated support corresponding to rock mass categories based on tunneling quality index Q- system.

Table 5.21: Support estimation based on Q- System

Rock Category	Q values	Support Type	Rock bolts	Shotcrete	Unsupported Span (m)
Fair	4-10	1*	Unsupported or spot bolts with length 2.4m	None/on the crown, if required.	6-6.5
Poor	1-4	1*	Unsupported or spot bolts with length 2.4m	None/on the crown, if required.	5-5.4
Very Poor	0.1-1	2**	Systematic bolts 2.4 m long, spaced 1.5 – 1.7 m	40 – 90 mm thick fiber reinforced or shotcrete with wire mesh	2.5-2.7

*Support category-1 as per Q-Chart for tunnel support
** Support category-4 & 5 as per Q-Chart for tunnel support

5.4.4.4.3 Access Adit

The access adit has been proposed almost in the middle of the headrace tunnel to facilitate/ speed up tunnel excavation. The adit is about 350m long. The investigations conducted at this area comprise engineering geological mapping, drilling of one borehole (A2-BH-7), excavation of two test pits (A2-TP-11 & A2TP-12) and two seismic refraction profiles (A2-SP-6 & A2-SP-7) each of 350m length along and across the adit alignment. The geological map and section of adit along with the locations of investigation points/ lines are provided in drawing no. A2HP-FS-GE-TNL-DWG-213.

As per the outcome of the investigations, the portal will be placed in the rock which is about 130m in to the slope and is covered by the slope wash material comprising gravel, cobbles and boulders embedded in heterogeneous matrix of the silty sand. This material is basically derived from the upslope and gathered along the toe of slope. The rock profile is deep varying from half meter to excess of 35m along the adit as per the investigations' results (A2-SP-6 & A2-SP-7). At some points above the slope wash materials, scree, angular loose rock fragments are present that vary in grain size from cobble to boulder. After the unconsolidated material, rock comprising granodiorite/ granite is likely to be present, which in this area is assumed to be dipping toward valley (i.e. in southeast direction) with trend in northeast direction providing a fair ground conditions for the excavation. Rock mass condition has been assessed based on the discontinuity survey DS-14 that indicates well developed foliation with three joint sets. The joints are extremely close to moderately spaced, low to very high persistent with tight to wide apertures and having generally rough and undulating surfaces. The intact rock is assessed to be medium strong to strong.

A vertical boreholes; A2-BH-07 (**Table** 5.3) was drilled along the adit tunnel up to the maximum depth of 50m. In borehole, the rock comprising of granite/ granodiorite encountered at 0.5m depth at 2617.5m elevation. The subsurface conditions as explored by the borehole and relevant in-situ tests are given below together with the Rock Quality Designation (RQD), core recovery, permeability (in terms of Lugeon) and water table in **Figure 5.28**. Core recovery and RQD was found to vary from 63-100% and 0-53% with mean of 91.5% and 23.78% respectively. These values indicate mostly poor rock quality as per RMR and Q systems of rock mass characterization and classification. Also relatively higher values of permeabilities in some horizons in in-situ water pressure tests (**Table 5.22** & **Figure 5.28**) appear to support this conclusion. In view of the laboratory test results, intact rock is found to be medium strong to strong. In consideration of fractured zones and high values of the permeabilities, ingress of water is much likely in rock part during adit excavation that need to be taken care of.

Table 5.22: Summary of water pressure test results at adit tunnel.

Borehole No.	Test No.	Test Section [m]		Lugeon Value	Interpreted Flow Type
		From	To		
A-2 BH-7	1	5	10	4.8	Dilation
	2	10	15	4.6	Laminar
	3	15	20	4.7	Laminar

Borehole No.	Test No.	Test Section [m]		Lugeon Value	Interpreted Flow Type
		From	To		
	4	20	25	7.6	Turbulent
	5	25	30	6.5	Turbulent
	6	30	35	14.9	Turbulent
	7	35	40	10.6	Void Filling
	8	40	45	6.4	Dilation
	9	45	50	4.0	Dilation

As it is evident (drawing no. A2HP-FS-GE-TNL-DWG-213) that the portal will be 130m in to the slope which is comprised of slope wash material, the excavation and slope stabilization in the slope wash material will be required.. As a guideline, the excavation with 1H:1V cut slope angle for the permanent slopes along the adit in overburden is proposed as per the conducted limit-equilibrium analysis (**Figure 5.18**) using parameters provided in Table **5.11** and based on the local experience in these types of materials. However, the temporary slopes can be cut at an angle of 1H:1.5-2V. The proposed slope cut design in overburden is quite reasonable for long term stability.

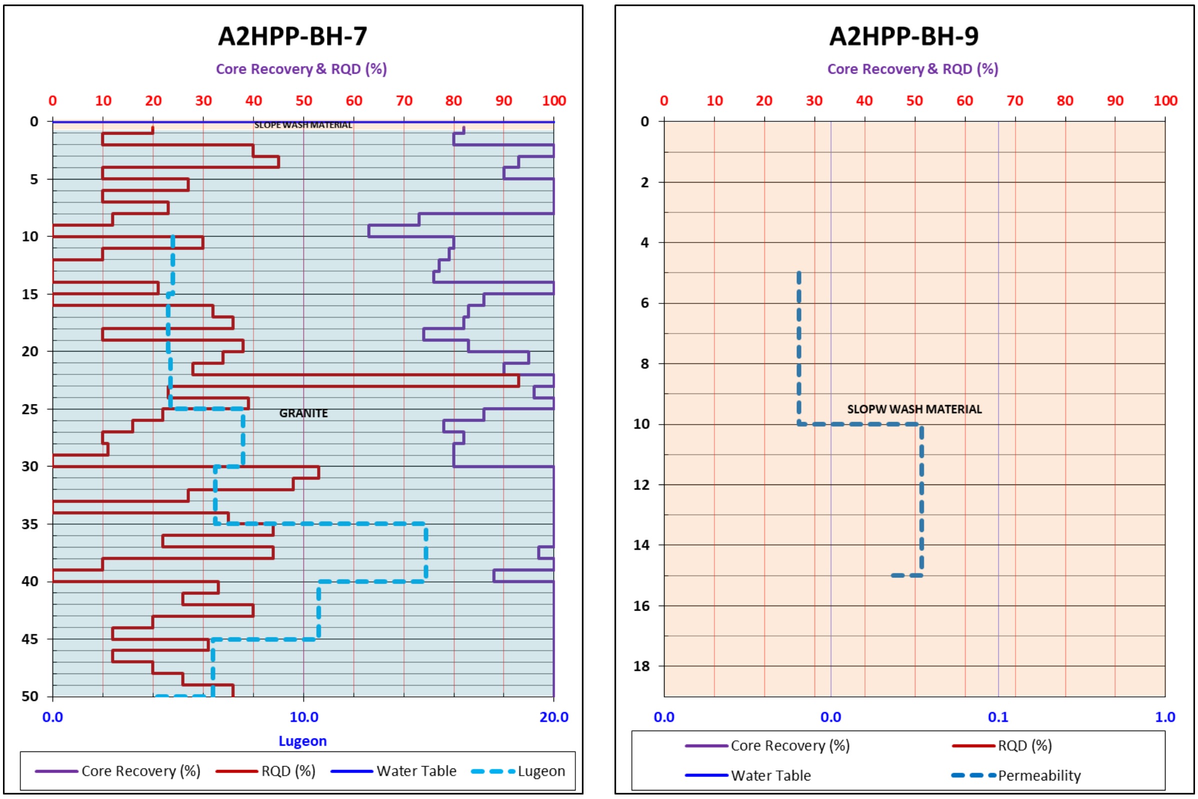

Figure 5.28: Plots showing subsurface profile as explored by the A2-BH-7 & 9.

5.4.4.4.3.1 Adit support

The rock mass quality determined using Q system was found to be poor based on DS-14 and A2-BH-7. Detailed calculation sheets are provided in Annexure B9 of Volume V. Using same diameter (4.5m) as that of headrace tunnel and plotting on the Q-chart of support (Figure **5.27**), support category 1 is concluded that defines unsupported rock mass (Figure **5.27**) along the adit. However, in addition to this rock mass class, limited stretches of very poor rock are also anticipated in view of shear zones. The adit is also likely to intersect water inflows through intersecting discontinuities given the climatic conditions. The typical support categories as per Q system are provided in drawing no. A2HP-FS-GEO_DWG-0600.

5.4.4.4.4 SURGE SHAFT/ VALVE CHAMBER AND TUNNEL OUTLET PORTAL AREA

The surge shaft and tunnel outlet area shall be located in the granite/ granodiorite of Matiltan Granite (**Figure 5.29** & **Figure 5.30**). The rock is generally exposed in the area or under thin cover of overburden and/or vegetation (drawing no. A2HP-FS-GE-PH-DWG-214). A borehole A2-BH-8 was proposed at the location of valve chamber/tunnel outlet. Due to extreme weather conditions this hole was not drilled during current drilling campaign. However, this has been proposed to be drilled in the next phase studies.

Rock mass condition has been perceived based on the discontinuity survey DS-12. This rock is again dipping steeply towards southeast with trend in northeast direction. Foliation is well developed with two joint sets. The joints are extremely close to moderately spaced, very low to very high persistent, with tight to very wide apertures, and having smooth to rough and planar to undulating surfaces. The rock is assessed to be medium to very strong as per ISRM's guidelines for intact rock strength classification. The rock is dipping towards the valley at the tunnel outlet area posing a fair condition for tunnel excavation. However, the foliation dipping in the southeast direction in conjunction with the dominant joint sets may pose problems in the form of rock falls and wedge failures for the portal slope. The rock may be cut at an angle 1H:3-4V along with supporting the rock blocks prone to instability induced by the foliation.

The surge shaft will be lined and shaft excavation is likely to be from top to bottom down to the tunnel crown. Generally, the support to the surge shaft wall depends on the size of unstable wedges. The rock quality as per the Q is poor that requires spot bolting in general in response to unstable wedges and specifically pattern bolting on the walls. Since the lining of the shaft is likely to be provided after the completion of the excavation, medium to heavy steel ribs shall be provided at one meter interval along with shotcrete (120-150mm) to cater gravitational falling of rock wedges during excavation and construction. The steel ribs and shotcrete will be buried afterward in the concrete lining to provide additional support. The layout and section of the shaft and valve chambers are provided in drawing no. A2HP-FS-

GE-PH-DWG-214 and shaft support is provided in drawing no. A2HP-FS-GEO-SS-DWG-0700.

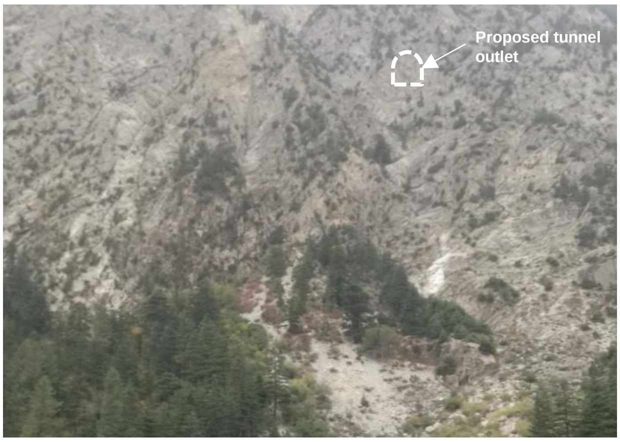

Figure 5.29: Approximate location of tunnel outlet. Rock comprising schist is outcropping in vegetation cover.

Figure 5.30: Close view of the granite at the tunnel outlet location.

5.4.4.4.5 PENSTOCK

The penstock starts right after the headrace tunnel outlet which is in mostly granite (drawing no. A2HP-FS-GE-PH-DWG-214 & **Figure 5.31**), a medium strong to very strong, foliated and blocky to massive rock.

Along the penstock alignment, four test pits (A2-TP-13 to 16) were excavated and two seismic refraction profiles (A2-SP-8 & 9) were conducted. Towards the lower end of the penstock near bivalve section, a borehole A2-BH-9 was drilled to maximum depth of 19m. The subsurface conditions interpreted based on the geological mapping and conducted investigations indicate the presence of the overburden material along the entire length of the penstock (drawing no. A2HP-FS-GE-PH-DWG-214 & 15). The overburden is slope wash material and scree that comprises cobbles and boulders embedded in sandy silty matrix. The rock fragments are subangular to angular embedded in silty matrix. The fractions of rock fragments vary both horizontally and vertically. The thickness of the slope wash material is interpreted to be increasing downslope. The alignment of the penstock will require some stability assessment/ remediation for the foundation bed and anchor blocks in the overburden material in next study stage. However, a bearing capacity of 1.5kg/cm^2 can be adopted on for anchor blocks to be placed on slope wash material.

Figure 5.31: Approximate location of penstock and powerhouse.

5.4.4.4.6 POWER HOUSE AREA

The surface powerhouse shall be placed in slope wash material on the right bank of the river at the slope toe (drawing no. A2HP-FS-GE-PH-DWG-214 & 215 & **Figure 5.31**). Currently no direct access is present as the road is on the left bank. The proposed location of the powerhouse is about 250 m upstream of the weir of Gorkin-Matiltan Hydropower Project.

The proposed powerhouse site has been explored by engineering geological mapping, one borehole (A2-BH-9), three test pits (A2-TP-16 to 18) and two seismic refraction profiles (A2-SP-9 & 10) having cumulative length of 425m. Initially three boreholes were proposed, but due to extreme weather conditions only drilling of one borehole was completed. Drilling of remaining boreholes is intended to be completed in the next stage studies. The subsurface conditions as explored by the borehole and relevant in-situ tests are given in **Figure 5.28**.

The outcome of the investigations indicate that at the powerhouse site, the entire valley floor is occupied by the unconsolidated deposits, slope wash materials making valley slopes and river bed alluvium making valley bed. The relative density of the slope wash deposits in terms of SPT (N) blows was found to vary from 18 to 60 and refusal at one point, indicating medium dense to very dense compaction. The vales of field permeabilities were found to vary from 6.44E-03 to 3.47E-02 (**Table 5.23**). The rock is present on higher elevations and is assessed to be at deeper depth (>30m) in the valley where powerhouse has been proposed

(A2HP-FS-GE-PH-DWG-215). The rock is likely to be granite dipping towards the slope (i.e. in southeast). On both banks' slopes the thickness of the slope wash material is almost the same. Generally, these deposits are heterogeneous and comprise angular to subangular rock fractions in silty sandy matrix.

Table 5.23: Summary of permeability test results at powerhouse location.

Borehole No.	Test No.	Depth [m]	Permeability (cm/sec)
A-2 BH-9	1	5	6.44E-03
	2	10	3.47E-02
	3	15	2.21E-02

The structure of powerhouse will have slope wash and river bed material as foundation material. As per the US Army Corps of Engineers, Bearing Capacity of Soils Manual (EM 1110-1-1905), a nominal allowable bearing capacity of 1.5-2.0kg/cm^2 is proposed to be used for slope wash materials comprising angular to subangular gravels, cobbles and boulders embedded in silty sandy matrix, and 2.0-2.5kg/cm^2 for river bed material comprising subrounded to rounded gravels, cobbles and boulders embedded in sandy matrix. This allowable bearing pressures will require the removal of any encountered loose material and filling with granular fill compacted to 95% of its maximum dry density.

Deep excavation may be required in slope wash material to place the foundation at some desired level. The excavation with 1H:1V cut slope angle for the permanent slopes at powerhouse site is proposed as per the conducted limit-equilibrium analysis (**Figure 5.18**) using parameters provided in Table **5.11** and based on the local experience in these types of materials. However, the temporary slopes can be cut at an angle of 1H:1.5-2V.

5.4.4.5 GEOTECHNICAL CONDITIONS ALONG THE PROPOSED ACCESS ROAD TO TUNNEL OUTLET

The alignment of the road leading towards the surge shaft is traversed mostly in the overburden material overlying the rock up to Valve Chamber from where it is mostly traversed through the rock up to top of surge shaft (drawing no. A2HP-FS-GE-PH-DWG-214.) Given the geology and rock conditions explored by the discontinuity surveys show a fair quality of rock having strike almost parallel slope face and moderately steep to steep dip into the face and towards the valley. The orientation of the foliation leads towards favorable conditions and no major slope failures are anticipated. However, minor rock falls as a result of intersection of foliation and other joint sets may induce localized rock falls that need to be addressed. Most of the road alignment will pass in the slope wash material that has reasonable strength in terms of CBR (**Table 5.7**) to act as subgrade material. However, the cut slopes in overburden material will be stabilized at 1H:1V~1.5V, while banked slopes at an angle of 1H:0.5V~0.75V. Retaining structures (Breast wall/toe wall, etc.) can be provided if overburden slope are to cut at angles steeper than 1H:1V~1.5V. The rock slopes can be cut steeply, that is, at angle 1H: 3-4V.

5.5 CONSTRUCTION MATERIAL

5.5.1 GENERAL

The Artistic-2 Hydropower Project shall to be constructed on Ushu River in District Kalam. It involves construction of a Weir, intake, sand trap, box channel, headrace tunnel, penstock, surge shaft headrace channel, forebay, powerhouse and tailrace channel. Almost all components of this project shall be constructed with concrete, requiring about 108,023 cubic meters of conventional concrete. Beside cement, steel and water, coarse and fine aggregates both shall also be required for manufacturing concrete. The different sources have been identified. The following material shall be required for the construction.

I. Coarse Aggregates for Concrete.
II. Fine Aggregate (Sand) for concrete
III. Rip Rap Material
IV. Cement
V. Steel
VI. Water

The coarse and fine aggregate should be obtained from nullah bed, tunnel excavation or suitable quarry area. The test pits were proposed and excavated at different locations of the project area to determine the soil parameter for foundation of structure and also to determine the properties of soil material for using this material as coarse and fine aggregate and for purpose of back fill material. For this purpose eighteen (18 Nos.) test pits were excavated at different locations of the project area (Table 5.4), samples were transported to UET Peshawar and necessary test were conducted on soil samples collecting from test pits and summarized in **Table 5.7**.

- The coarse and fine aggregate for construction can be obtained from nullah bed of Ushu River, rock quarry or from nearby crush plant. The petrographic and ASR potential studies were also carried out on Ushu river soil samples at feasibility stage.

- Furthermore most of the project area is covered by Matiltan Granite and Granodiorite and also most of the tunnel excavation is within granite and Granodiorite rock .The sufficient quantity of coarse and fine aggregate used in concrete construction of structure could be obtained by crushing the excavated material to required grade for used in concrete .During field studies rock samples were collected from different locations of project for petrographic ASR Potential studies for identification of rock types and their suitability for concrete aggregate. The petrographic test results summaries in **Table 5.26**.

5.5.2 COARSE AGGREGATE

The construction material studies have revealed that suitable coarse aggregate are available in close vicinity of the project area. Coarse aggregate required for manufacturing of concrete shall be obtained from river bed, suitable quarry area or tunnel excavation material. The nullah bed mainly comprises of sub-rounded to rounded boulders and gravel with sand and minor amount of fines (RBGM). These boulders and gravel include Granite, granitic gneiss, Granodiorite Rhyolite, and andesite. The materials are dense, hard and durable aggregate which are deposited by Ushu River.

The major rock exposed along tunnel alignment are Granite and Granodiorite rock therefore sufficient quantity of concrete aggregates for the construction of the structures could also be obtained by crushing the granite and granodiorite from the tunnel excavation .The excavated material should be crush up to required grade and should be used for manufacturing of concrete. The petrographic test results also reveal the granite and granodiorite are hard, compact and no ASR reactive which can be used as an aggregate for concrete with Ordinary Portland Cement

This is for information that deposited bed material of Ushu River is also currently approved source for under construction Gorkin-Matiltan Hydropower Project for both fine and coarse aggregate (sand) for manufacturing concrete. The location is shown in **Table 5.24**.

Table 5.24: The location of source area for both fine and coarse aggregate

S. No	Source Area	Coordinate	
		Northing	Easting
1	Borrow area-1	353623.285	72418.521
2	Borrow area-2	353619.012	72416.282
3	Borrow area-3 (Source area of under construction Gorkin- Matiltan HPP)	353516.357	724049.288

5.5.3 SAND

Fine aggregate (sand) of good quality shall be required for the manufacture of concrete. The good quality of fine material is also available in ample quantity in bed of Ushu River which will be used after necessary process for manufacturing of concrete. Some of the locations for borrow area were identified which are shown in **Table 5.25**

Table 5.25: Summary of laboratory test results conducted on soil Collected from Ushu River

S. No	Test Pit No.	Depth (m)	Gravel %	Sand %	Fines %	Classification	OMC %	Unit weight	Direct shear	
									C	Phi
1	TP-1	3	90.3	7.9	1.3	Sandy Gravel	15.4	111	0	42
2	TP-2	3	57.5	22.3	1.3	Sandy Gravel	8.86	134	684	43
3	TP-3	3	69.3	29.0	1.7	Sandy Gravel	9.47	130	557	44

The following conclusions were drawn from tests performed on soil and aggregate samples obtained from exploratory test pits.

- The soil encountered in all the test pits was gravely in nature. The percentage of gravel ranges from 57.5% to 90.3% while sand remained ranges from 7.9% to 29.0%
- The petrographic test results revealed the deposited material in nullah bed are different types of rock like granite Granodiorite and Utror volcanic origin. The granodiorite are hard, compact and no ASR while the Utror volcanic rock are ASR should not be used with ordinary Portland cement

The Tunnel alignment mainly consist Granite an Granodiorite rock of Matiltan formation the rock is hard and compact and present in the sufficient amount to be used for concrete aggregates and for stone pitching and for riprap material.

Petrographic analysis on samples indicated that some rocks i.e. Rhyolite, Andesite, alter granodiorites and alter granites are ASR which can be used either with low Alkali Cements or with volcanic ash/ puzzolanic materials

Other rocks i.e. Granites and Granodiorites exposed most of the project area are hard, compact and non ASR which can be used with Ordinary Portland Cement.

The rock samples were taken during field studies from different location of the project for petrographic and ASR test for deification of rock types and it potential used as aggregate for concrete .For this purpose fourteen (14) rock samples were collected and send to Geology department university Peshawar to determine the rock types and its suitability of rock to be used as aggregate during construction. The test results are shown in **Table 5.26**.

Table 5.26: Labortery test of rock samples and it used for Aggegate

S. No	Sample No	Location	Discontinuities survey Location	Rock Types	Recommendation
1	LB-01	Left Bank	DS-02	Andesite	The rock is ASR and should not be used as sole aggregate for concrete with ordinary portable cement
2	LB-02	Left Bank	DS-3	Rhyolite	The rock is ASR and should not be used as sole aggregate for concrete with ordinary portable cement
3	LB-03	Left Bank	DS-04	Granodiorite	The rock is hard and compact and having no effect of ASR can be used as aggregate
4	LB-04	Left Bank	DS-05	Andesite	The rock is ASR and should not be used as sole aggregate for concrete with ordinary portable cement
5	LB-05	Left Bank	DS-06	Granodiorite	The rock is hard and compact and having no effect of ASR can be used as aggregate
6	LB-06	Left Bank	DS-10	Altered and stained granodiorite representation from shear zone	Reactive silica in the foam of recrystallization and strain quartz vein observed which can potential cause of ASR if used as aggregate in concrete therefore the sample is not recommended as sole aggregate for concrete
7	LB-07	Left Bank	DS-11	Altered and stained granite	Reactive silica in the foam of recrystallization and strain quartz vein observed which can potential cause of ASR if used as aggregate in concrete therefore the sample is not recommended as sole aggregate for concrete
8	RB-01	Right Bank	DS-01	Granite	The rock is hard and compact and having no effect of ASRand can be used as sole aggregate for concrete
9	RB-02	Right Bank	DS-07	Rhyolite	The rock is ASR and should not be used as sole aggregate for concrete with ordinary portable cement
10	RB-03	Right Bank	DS-08	Altered and stained granodiorite representation from shear zone	Reactive silica in the foam of recrystallization and strain quartz vein observed which can potential cause of ASR if used as aggregate in concrete therefore the sample is not recommended as sole aggregate for concrete
11	RB-04	Right Bank	DS-09	Rhyolite	The rock is ASR and should not be used as sole aggregate for concrete with ordinary portable cement
12	RB-05	Right Bank	DS-12	Granodiorite	The rock is hard and compact and having no effect of ASR can be used as aggregate
13	RB-06	Right Bank	DS-13	Altered and stained granodiorite representation from shear zone	Reactive silica in the foam of recrystallization and strain quartz vein observed which can potential cause of ASR if used as aggregate in concrete therefore the sample is not recommended as sole aggregate for concrete
14	RB-07	Right Bank	DS-14	Granodiorite	The rock is hard and compact and having no effect of ASR can be used as aggregate

5.5.4 RIPRAP AND STONE MASONRY

Rock Granite and granitic gneiss and Granodiorite which are hard, compact and durable covered most of project in ample quantity and can be used for masonry works, riprapping within the project area.

The riprap / Stone pitching material will be required for protection works. Gabion wall structure will be required to prevent erosion material at face by wave action. The project area mainly composed of Granite, Granitic Gneiss and Utror volcanic rock. The good quality area are available in the surrounding vicinity of project area .The Granite ,Granitic Gneiss and Granodiorite rock exposed in in the project area should excavated for use as stone pitching /Riprap material.

- Riprap /Stone Pitching durability affects the ability of the source to provide a consistent shape, size and gradation and the ability to resist weathering and other environmental influences.
- Durability is typically determined by laboratory tests; but durability can be assessed by observing surface exposures, talus and waste piles or by examining rip-rap applications already using the potential source or similar source materials.
- Cracking, spalling, delaminating, splitting, dissolving and disintegrating are common forms of rock feature that affect the rock properties.
- Durability is a function of the rock's mineralogy, porosity, weathering, discontinuities and site conditions.
- In the close vicinity of the project area a good quality of rock is available. Samples shall be collected/ tested for its suitability as rip-rap material at construction stages

5.5.5 CEMENT

Cement will be procured from cement factories of Pakistan producing Ordinary Portland Cement (OPC). The OPC being produced by Pakistani Factories conform to BS-12 (1989) standard. There is no cement factory located in the close vicinity of the project area. The local market Mingora and Peshawar has been explored for obtaining initial information about the procurement of the cement (OPC) for local construction industry. It is found that the cement in the market is being procured from the nearest cement factories mentioned below.

- Cherat Cement Factory – Nowshera,
- Askari Cement Factory Nizampure– Nowshera,
- Best way Cement Factory – Islamabad,

- Wah Cement Factory – Hasanabdal
- Dewan Cement Factory – Hattar Taxila

5.5.6 STEEL

The quality of steel shall be ensured to meet accepted range of standard test from UET, Peshawar/CMTL Lahore or equivalent from elsewhere. While Steel, like cement, is not locally available in close vicinity of the project area and shall have to be procured from nearest local markets i.e. Peshawar, or the required supplies of steel shall be made from ISO certified steel re-rolling mills, such as from Rawalpindi/ Islamabad and Punjab. It is found that the Reinforcement steel in the market is being procured from the nearest steel factories mentioned below.

- Ittehad Steel- Islamabad, about 357 km from Kalam city
- Fazal Steel Ltd - Islamabad about 357 km from Kalam city
- Pak Steel Re-Rolling Mills- Islamabad, about 350 km from Kalam city
- Pakistan Steel Mills Corporation (pvt) Ltd-Lahore, Punjab about 645 km from Kalam city
- Fareed Steel Mills-Haripur, Punjab, Pakistan about 340 km from Kalam city.

5.5.7 WATER

Stream water of Ushu River can be used for construction. The test results of water samples are summarized in Table 5.27.

Table 5.27: **Table No 4 Test Result of Water sample collecting from Ushu River**

S. No	Sample Types	Ushu River water Samples Test Results			
		Sample-1	Sample-2	Ssampl-3	Recommended value
1	Sulphate	7.49	8.4	8.0	Max 400
2	Chlorite	13.97	12.5	10.0	Max 500
3	Sodium	4.97	4.37	3.1	Max 200
4	PH Value	6.72	6.96	6.1	Max 10000
5	TDS	55.33	47.33	102	6.50-8.50

5.5.8 LABORATORY TESTING FOR SOIL SAMPLES

All the test pits were properly logged, sampled and photographed. Test pit logs are given in Annexure-B of the Geo-Technical Investigation report, the selected samples were sent to UET Laboratory, Peshawar for testing. The results of laboratory tests on aggregate samples (course & fine) from test pits are briefly described and discussed here under are also summarized in **Table 5.7**.

The purpose of excavating test pits was to procure samples and to check .the suitability of material as aggregate and for back filling and for foundation design For the determination of engineering characteristics of aggregate around 70kg bulk samples were collected at every 3 meter depth or at change of strata, from each test pit. Disturbed samples collected from both test pits were tested to Lab testing laboratory Peshawar or for performing the following tests:-

1. Sieve Analysis
2. Hydrometer Analysis
3. Specific Gravity and Water Absorption
4. Proctor
5. Unit Weight
6. CBR
7. Plasticity index
8. Alkali Silica Reaction (ASR) Potential

CHAPTER

6

SEISMIC HAZARD ASSESSMENT

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CHAPTER 6

SEISMIC HAZARD ASSESSMENT

6.1 INTRODUCTION

Artistic-II Hydropower Project site is located in the upper reach of the Ushu River between Ushu village and Mahodand lake. The proposed Artistic-II Hydropower Project will utilize the flows of the Ushu River which is a tributary of Swat River in upper Swat. The Project area is in north of Kalam, which is recognized as the last major tourist point in the upper Swat. The site of the powerhouse is about 10 km by road from Kalam while the weir and intake sites are about 7 km further upstream. Access by road to the powerhouse and weir site is easy, as there is an asphalted jeepable road that leads to Mahodand Lake and other upstream villages.

The height of weir is 6 m. The reservoir capacity of weir will be very small as the river slope is very steep and potential downstream damage in case of weir break will also be negligible due to absence of significant reservoir capacity. The location coordinates of weir and powerhouse of Artistic-II Hydropower Project are given below:

Weir	Latitude 35° 37´ 42.09˝N	Longitude 72° 41´ 05.68˝E
Powerhouse	Latitude 35° 34´ 14.14˝N	Longitude 72° 40´ 19.23˝E

As the maximum height of weir is less than 10 meters, 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 building codes or concrete hydraulic structures.

The Artistic-II Hydropower Project is located in the Kohistan Island Arc physiographic province, a tectonically active region which is sandwiched between the converging Indian and the Eurasian tectonic plates. The project region has been subjected to damaging earthquakes in the past and therefore it is imperative that a study of tectonic and earthquake history of the region be conducted to determine the seismic hazard to which the proposed project may be exposed to and to evaluate realistic seismic design parameters for the safe design of the project components.

As the project is located in the collision zone of the Indian and Eurasian plates, therefore the Artistic-II Hydropower Project could face a severe earthquake hazard potential. The Geological Survey of Pakistan has placed the Project area in the “Serious Seismic Danger Zone”. In Building Code of Pakistan, Seismic Provisions (2007), the project area falls in Zone-3. Moreover, within the scenario of the October 08, 2005 earthquake of Pakistan it becomes important to be very cautious regarding the seismic hazard assessment for such an important project.

- For the seismic hazard evaluation of Artistic-II 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
  – EM 1110-2-6050 – Response Spectra and Seismic Analysis for Concrete Hydraulic structures
  – Building Code of Pakistan Seismic Provisions (2007)

6.2 GEOLOGY OF THE REGION

6.2.1 GENERAL

The geology and geodynamics of the Karakorum-Himalayan region in northern Pakistan are characterized by the interactions of three principal tectonic units:

- The Eurasian Plate;
- The Kohistan Sequence; and
- The Indian Plate.

These units have distinctly different lithology and structural settings and are separated by two major branches of the Indus suture (Tahirkheli, et al., 1979; Treloar, et al., 1990; Khan, et al., 1997). Both sutures are marked by the occurrence of a mélange including ultramafic rocks, the southern one also having a wedge of garnet granulites considered to have recrystallized at a depth of more than 40 km.

The rocks making up the Kohistan sequence, between the two sutures, are predominantly calc-alkaline plutonics and volcanics with subsidiary volcano sedimentary and sedimentary rocks. Tahirkheli, et al., (1979) have suggested that the Kohistan sequence represents the crust and uppermost mantle of an extended island arc turned on end during the collision of the Indian-Asian Landmasses. Later studies have shown that the structure of the area is too complex for such a simple interpretation and requires a detailed analysis before final conclusions can be reached about its nature (Coward, et al., 1986).

6.2.2 THE EURASIAN PLATE

In the Karakorum area, Gansser (1964) distinguished three tectonic zones:

- A Karakorum Tethyan zone
- A central metamorphic zone with plutonic rocks – Karakorum Batholith; and
- A southern volcanic schist zone.

Of these, the last one is now considered to be a part of the Kohistan sequence occurring to the south of the Main Karakoram Thrust (MKT or the Northern Suture), whilst the first two occur to the north of the MKT.

6.2.3 THE NORTHERN SUTURE

In the section from Hunza to Chalt, there is an almost chaotic arrangement of large lenses, each several kilometres long and several tens of meters wide, of limestone, sandstone, conglomerate and mafic and ultramafic rocks in a matrix of chloritoid slates. The basic rocks with prominent volcanic breccias and greenschists are rich in epidote, chlorite and actinolite. The ultra-basics consist of serpentine, talc-chlorite schists, talc-carbonate schist, calcite-chlorite schists, chromite-chlorite schists, and minor relict harzburgite. Ultra-basic masses are apparently more abundant to the west of Chalt. There are large lenses of quartzite which may have formed in situ or which may be tectonic blocks and limestone intermixed with other sediments. The whole assemblage has the appearance of a major mélange with no simple repetitions, as expected in an imbricate zone. The structures in the high-grade metamorphic rocks contrast with those in the main mélange up-dip as seen from mineral lineation and folds with curvilinear hinges.

This tectonic zone is considered to mark the suture between the Kohistan sequence and the Eurasian Plate to the north. There is no evidence of blue-schists, of abducted high-pressure granulites or of an ophiolite, but instead large tectonic lenses of a mélange.

6.2.4 THE KOHISTAN ISLAND ARC

The principal rock units of the Kohistan Island Arc include, from south to north:

- Jijal Complex; granulite, mafics, and ultra mafics;
- Kamila Amphibolite Complex; mostly norites;

- Chilas Complex; mafic and ultra-mafic layered complex of gabbros, norites, and dunite intersected by dikes and seams of anorthosite and chromitite;
- Kohistan Batholith; various calc-alkaline intrusives; and
- Kohistan Arc Sequence; various meta-sedimentary units and volcanic units typical of an island arc and fore-arc setting.

It is important to point out that geologic mapping has shown that the contacts of the major lithologic units in the Kohistan Island Arc area are faulted (e.g. Ghanzafar, et al., 1991), including the southern and northern boundaries of the Chilas Complex. The Kamila Complex is also dissected by numerous shear zones and is bounded to the north by a major shear zone (Kamila Shear Zone).

The Kohistan Island Arc was formed in the mid-Cretaceous and sutured to Asia around 100-85 million years ago. India later collided with the arc after continued subduction beneath the arc complex, now accreted to the active continental margin. After full collision, the arc was tilted, uplifted and dissected, enabling examination of the crustal structure of an immature island arc. Suturing to the Asian active continental margin meant that the arc itself became an active continental margin, and the attendant crustal thickening produce an evolution in magmatism from basaltic to calc-alkaline. This is best observed in the phases of plutonism observed in the gabbro-norite plutons of the Chilas Complex and in the Kohistan Batholith, and also in the surrounding (meta-) volcanics into which these granitic sheets are intruded.

The Indus river gorge section through the Kohistan Island Arc reveals an informative section through an island arc from the Main Mantle Thrust (MMT) to which the arc forms the hanging wall, in the south to its footwall position against the Northern Suture. The arc itself is exposed for over 200 km north to south and about 300 km from east to west. The strike of the various tectonic units is approximately east-west; therefore, the deepest crustal regions are represented in the southern portions.

6.2.4.1 JIJAL GROUP

A complex of layered mafic and ultramafic intrusions occurs between Patan and Jijal, an area of about 200 km². In the north are garnet-clinopyroxene-plagioclase rocks containing relics of norite, and so it is likely that these are high-pressure metamorphic equivalents of the Chilas complex. The grain size is similar to that of the norite but garnets continued to grow after the deformation and locally grew to cover 8 cm especially in leucocratic veins. Hornblendites may contain hornblende-garnet, garnetite and garnet plagioclase. The overall composition is a high-pressure metamorphic assemblage and the rocks are equivalent to eclogite facies, thus representing the lower parts of the crust.

Towards the southern boundary of the complex there is an increase in proportion of clinopyroxenes and hornblendites, until the main ultramafic body is reached, which consists of clinopyroxenites, and dunites which have lenses of layered chromitite up to 5 m thick. It has been concluded that both the granulites and the dunites suffered granulite grade metamorphism at 600 – 700°C and 12 – 14 kb and at 800 – 850°C and 8 – 12 kb respectively (Jan & Howie, 1981). The Jijal Complex is possibly a tectonic fragment of the Chilas Complex that was subducted or downthrusted to a substantial depth against the MMT.

6.2.4.2 KAMILA AMPHIBOLITE BELT

This is composed primarily of norites; mostly at amphibolite facies (therefore pyroxenes have retrograded to hornblendes). Amphibolite metamorphism is assumed to have occurred during suturing to Asia. The belt also includes banded amphibolites with or without garnet, hornblendites, schists, garnet gabbros, and anorthosites, diorites, tonalities and granites and thin garnet quartzites and calc-silicate lenses. The proportion of amphibolite is commonly low. The belt is distinctive in that most intrusive rocks are concordant and parallel to the regional trend and have been intensely deformed, many of the coarser leucocratic types becoming augen gneisses. Ghazanfar, et al. (1991) is of the view that these are the oldest exposed unit of the Kohistan sequence and show ophiolitic character.

The Kamila belt is dissected by a number of small shear zones and is bounded to the north (adjacent to the Chilas Complex) by a major shear zone, the 'Kamila Shear Zone'. The belt represents the mid crustal regions of the primitive arc.

6.2.4.3 CHILAS COMPLEX

The Chilas Complex is a vast stratiform cumulate body over 300 km long and 8 km thick, dominated by intrusions of calc-alkaline gabbro-norites, which locally show layering (Ghazanfar, et al. 1991). It contains an upward sequence of hypersthene gabbro, major chromite-layered dunite, norite, gabbro, minor troctolite, harzburgite and dunite, and at the top, norite. Particularly impressive are rhythmically-alternating phase-graded cumulate layers up to 0.1 m thick, slump folds, syn-sedimentation faults, and sedimentary breccias. Some layers up to about 0.3 m thick are of almost pure anorthosite. Dykes of pyroxene-hornblende anorthosite cut both homogeneous and layered rocks. The lower dunites are up to 1 km thick and contain 3-m-thick compact chromitite seams. All these rocks show evidence of several phases of deformation. Isoclinal folds in norites have hypersthenes orientated in axial planar fabrics and the penetrative mineral fabric in the norites is parallel to the axial planes of folded pyroxene amphibolite dykes. These relationships suggested a tectonic origin for the main mineral fabrics in the complex.

Ghazanfar et al. (1991) have shown both contacts of norite as fault which has led to the formation of norite mylonite in an otherwise very tough dark coloured rock with streaks of white or pale-white colour.

6.2.4.4 JAGLOT GROUP

Occurring north of the Chilas Complex, the Jaglot Group comprises schists intercalated with material of volcanic origin. To the south, the Jaglot schists are intruded by the Chilas gabbro-norites, while to the north the Kohistan Batholith intrudes them. This confusion and overprinting from magmatism mean that the Jaglot Group has only recently been defined as a unit (Treloar, et al., 1990). The main lithologies are greenschist facies metabasites, pillows and some volcaniclastic material inter-bedded with pelitic, psammitic and calc-silicate schists, representing clastic and carbonate sedimentary protoliths.

6.2.4.5 KOHISTAN BATHOLITH

This consists of a zone of plutonism associated with active continental margin volcanism (i.e. Andean type magmatism). This is a principal unit of the Kohistan magmatic arc and constitutes a 300 km long and up to 60 km broad belt to the west of Nanga Parbat. The Kohistan Batholith is composite and consists of numerous large to small plutons, plugs, dykes and sheets emplaced over a time span of some 75 million years (Kazmi & Jan, 1997). A wide range of rocks has been reported to constitute the batholith: gabbros, hornblendite, diorites, quartz diorite, adamellite, granodiorite, granite, tonalite, pegmatite etc.

6.2.4.6 NORTHERN KOHISTAN ARC SEQUENCE

This is comprised of various volcanic and metasedimentary Groups – Dir and Chalt Groups. These include Eocene calc-alkaline basaltic-andesitic-rhyolitic lavas and pyroclastic deposits associated with the active continental margin stage of the arc complex.

There is a tectonic break between rocks of the northern suture and the volcanic and sediments belonging to the Chalt Group to the south, which make up the northern part of the arc. This group contains meta-greywackes and slates, epidotic grits and tuffs, hornblende-bearing tuffs, chlorite schists, schistose amphibolites, amygdaloidal pillow-bearing basalts and fragments basic volcanics. Further south near Gilgit and Raikhot there are graded psammites and pelites and locally thick piles of deformed pillow lavas, but these occur as screens betweens large plutons of diorite and tonalite.

The total thickness of deformed and weakly metamorphosed sediments and volcanics reaches several kilometers but this may involve repetitions by folding and thrusting. The rocks are folded by large upright, tight to isoclinal anticlines and synclines, which plunge east or west.

They are cut by thin granitic dykes and by muscovite pegmatites, which are discordant to both cleavage and bedding.

6.2.5 INDIAN PLATE

The bedrock suites south of the Kohistan Island Arc and southern suture zone include those forming the pre-collisional stratigraphy of the Indian Plate plus the syn-and post-tectonic material eroded from the mountain ranges of the Himalayas, Karakoram, Hindukush, and Pamirs.

6.2.5.1 SALT RANGE

The Salt Range defines the Frontal thrust of the Himalayas, a thin-skinned structure riding on an evaporite decollement. The topographic relief of the Salt Range is produced by blind thrusts and ramp anticlines.

6.2.5.2 MOLASSE

Molasse sequences of detrital sediments form the Margalla Hills and the Punjab Plains. All tectonism is thin skinned with numerous southward-propagating thrusts that have produced numerous imbricate zones.

6.2.5.3 HAZARA SEDIMENTS

The Hazara metasedimentary belt is largely composed of Precambrian to Early Mesozoic sediments. The Precambrian sequence is composed of quartz schist, graphitic schist, marble and gneiss overlain by thick sequence of slate, phyllite and greywacke sandstone. The Precambrian sequence is unconformably overlain by quartzite and argillite.

6.2.5.4 MANSEHRA BATHOLITH

Imbricated slices of this granitic batholith, intruded into the metamorphic cover, are exposed in the Hazara Syntaxis. It is Cambrian in age.

6.2.5.5 METAMORPHIC COVER

This consists of late Precambrian – early Cambrian met sediments that have undergone a Palaeozoic low-grade metamorphism, and which are overlain by pre-collisional Mesozoic sediments. These were further metamorphosed and thrusted in the foothill of the MMT synchronous with full collision.

6.2.5.6 NANGA PARBAT GROUP

Rocks of the Nanga Parbat Group represent units belonging to the cratonic Gondwana basement, exposed in the Nanga Parbat – Haramosh Massif syntaxis. The Proterozoic gneisses of the Indian Plate have their northernmost exposure in the Nanga Parbat Syntaxis and represent the lowest structural levels of the Indian Plate observed. They have been mapped and subdivided into three lithostratigraphic groups (Madin et al., 1989).

6.2.6 LOCAL GEOLOGICAL SETTING

The local geological setting around project area has been interpreted based on the geological map of Mahodand Quadrangle after Afridi et al. (1999) published by Geological Survey of Pakistan (GSP).

6.2.6.1 QUATERNARY DEPOSITS

6.2.6.1.1 STREAM DEPOSITS

Stream deposits comprise gravels, cobbles and boulders with fine to coarse sand. The deposition is on-going process with the perennial and non-perennial streams. These cover the stream and river beds of active channels.

6.2.6.1.2 ALLUVIAL DEPOSITS

These are old river or stream deposits and slope wash material making terraces along the valley slopes. These deposits comprise gravels, cobbles and boulders embedded in silty sandy matrix. Most of the settlements are situated on these deposits. The top layer of these deposits comprises fine materials and therefore are being used for cultivation.

6.2.6.2 ROCK UNITS

6.2.6.2.1 MATILTAN GRANITE

Matiltan granite comprises white to light grey, medium to coarse grained and porphyritic granite and granodiorite composed of orthoclase, plagioclase, quartz, hornblende and biotite, with xenoliths of quartzite, amphibolite and diorite.

6.2.6.2.2 UTROR VOLCANICS

Utror Volcanics comprise grey, green, maroon red and at places white, fine to medium grained, identified as andesite, dacite, rhyolite with tuffs, agglomerate and pyroclasts.

6.2.6.2.3 BARAWAL BANDA QUARTZITE

Barawal Banda Quartzite comprises light to dark grey on fresh surface and brownish grey on weathered surface, thin to thick bedded, fine grained quartz which is cherty at places.

6.2.6.2.4 Barawal Banda Slates/ Phyllites/ Schists

This rock units in this formation comprise grey, green and maroon in color, thin bedded, fine to very fine textured, occasionally silty phyllites, schists and slates. Occasional beds of light grey thinly bedded limestone are also present at places.

6.2.6.2.5 Deshai Diorite

Deshai Diorite comprises grey, greenish grey, medium to coarse grained diorite composed of plagioclase, hornblende, biotite with subordinate quartz, hornblended pegmatites and quartz veins.

6.2.6.2.6 Kalam Quartz Diorite (Associated with meta sediments)

It comprises grey, greenish grey, medium to coarse grained quartz diorite composed of plagioclase (andesites), hornblende and biotite. Quartz feldspathic veins and xenoliths of Kalam meta-sediments are present in places

6.3 REGIONAL TECTONIC FRAMEWORK

The geodynamic framework 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 the Kohistan island arc in the 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 the 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) the locations of which are shown in Figure 6-1.

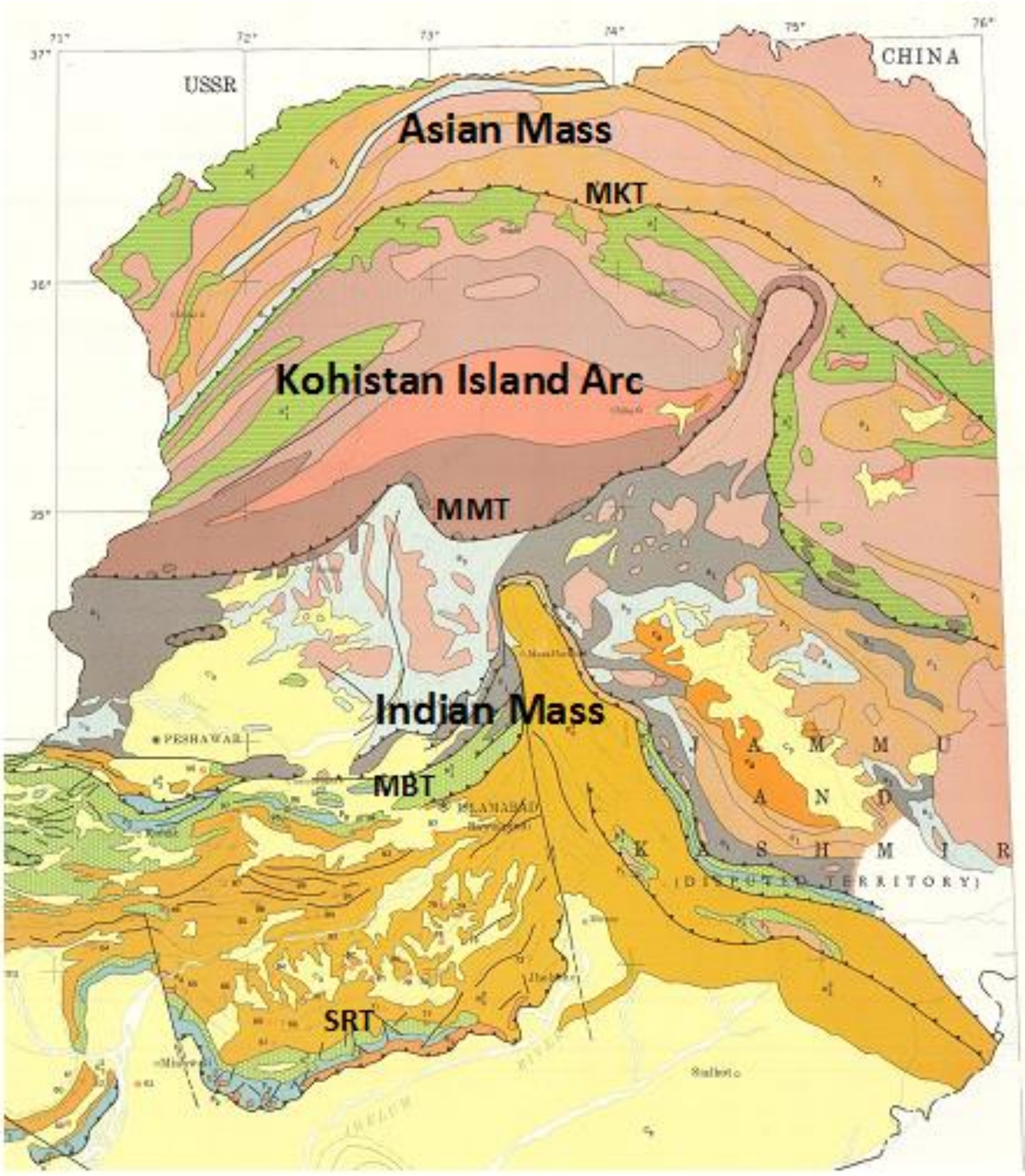

Figure 6-1: Generalized Tectonic Map – Northern Pakistan; by GSP

6.3.1 Regional Tectonics

The geology of northern Pakistan is a superb example of continental collision tectonics. In this area, the three of the world's greatest mountain ranges converge, 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. 1993). It is widely accepted that the northward movement of India was concurrent with the accretion to Asia of an intra-oceanic arc system, the Kohistan arc that collided with Asia along the Shyok Suture or MKT. The southern margin of Asia, including the Kohistan arc, then became an Andean type convergent margin, until India collided with Asia. 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 detailed description of the salient features of the Kohistan magmatic arc and the adjoining Northwestern Himalayan Fold-and-Thrust Belt of the Indian plate is given below.

6.3.1.1 KOHISTAN MAGMATIC ARC

Kohistan is an intra-oceanic island arc bounded by the Main Mantle Thrust (MMT) to the south and the 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. 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 (Figure 6-2). 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; Miller et al., 1991).

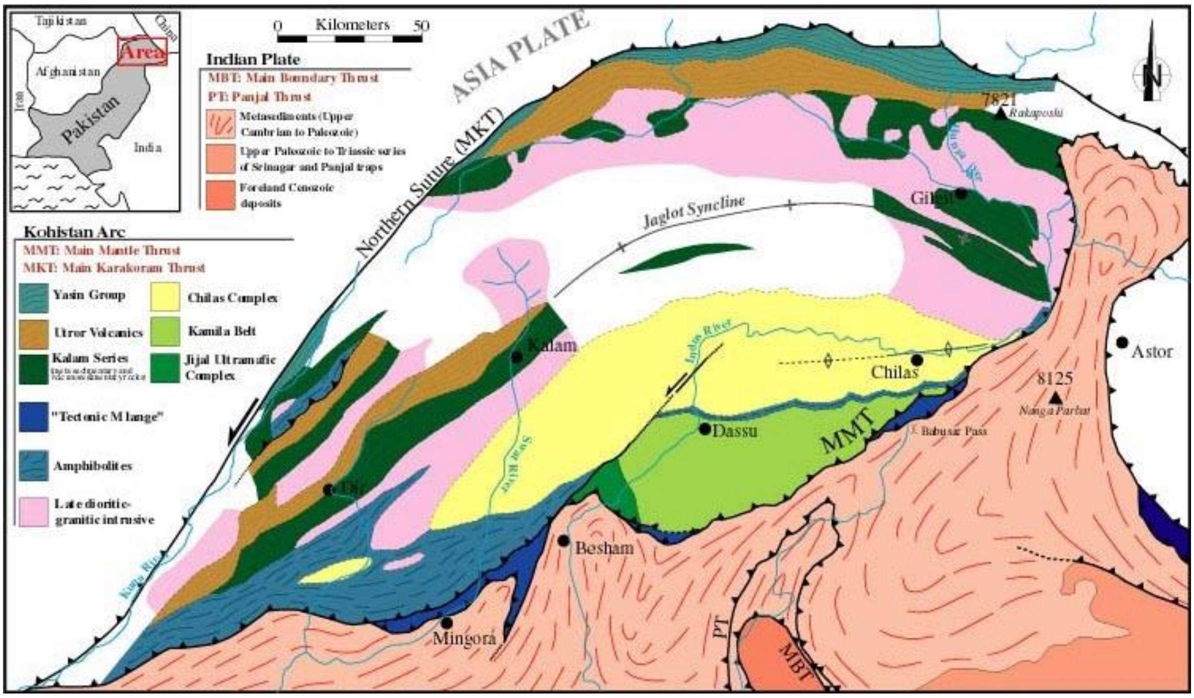

Figure 6-2: Simplified Geological Map of the Kohistan Arc; modified from Bard et al (1983)

6.3.1.2 NORTHWEST HIMALAYAN FOLD-AND-THRUST BELT

The Northwest Himalayan fold-and-thrust belt occupies a 250 km wide and about 560 km long irregularly shaped mountainous region stretching from the Afghan border near Parachinar up to the Kashmir Basin. The Hazara-Kashmir and Nanga Parbat Syntaxes form its eastern margin. It covers all the terrain between the Main Mantle Thrust (MMT) in the north and Salt Range Thrust in the south. This region comprises the mountain ranges of Nanga Parbat, Hazara, Southern Kohistan, Swat, Margalla, Kalachitta, Kohat, Potwar and Salt Range.

A major thrust fault, the Panjal-Khairabad Fault divides the NW Himalayan sequence into a deformed southern zone, often referred to as the external or foreland zone and a deformed and metamorphosed northern zone, also known as the hinterland zone (Pivnik & Wells, 1996). The foreland zone comprises the Hazara-Kashmir Syntaxis, Salt Range and Kohat-Potwar fold belt and the Kurram-Cherat-Margalla thrust belt, whereas the hinterland zone comprises the Himalayan crystalline nappe-and-thrust belt.

6.3.2 MAJOR TECTONIC FEATURES

The project site is located in the Kohistan island arc which is sandwiched between the Indian and the Eurasian plates. The major faults of the project region include, from north to south, the Main Karakoram Thrust (MKT), Kohistan Fault, Main Mantle Thrust (MMT), Panjal-Khairabad Thrust, Main Boundary Thrust (MBT) and Salt Range Thrust. The general trend of these faults is predominantly east-west with change in trend due to syntaxial bends. The general description of these major faults is as follows.

6.3.2.1 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. In the Chitral and Gilgit area, the rocks of Karakoram Batholith are thrusted over the rocks of Kohistan Batholith along MKT.

6.3.2.2 KOHISTAN FAULT

On the Geological Map of NWFP (2006) published by the Geological Survey of Pakistan (Figure 6-3), the contact between the Kamila amphibolies and the Satpat ultamafics to the south of Dasu are shown as the Kohistan fault. Along this fault, the rocks of the Kamila complex are thrust over the Satpat complex rocks. This fault runs almost parallel to MMT.

6.3.2.3 MAIN MANTLE THRUST (MMT)

Main Mantle Thrust (MMT) is a northward dipping regional thrust, which separate the Indian Plate from the Kohistan Island Arc. It extends from Khar (Bajaur Agency) in the west to the north of Naran (Kaghan Valley) in the east where it takes a northeast ward bend towards the east of Bunji and gets truncated by Raikot Fault.

The thrust inclines steeply near the surface; however, this inclination is believed to decrease considerably with depth likewise as interpreted for other local thrust faults of the region.

Structurally the Main Mantle Thrust is characterized by a number of northwest dipping high angle imbricate thrusts, which converge together in the east and being terminated as Raikot fault. A number of other sub-parallel shears associated with MMT and distributed near Chilas and Bunji merge together and join Raikot fault.

MMT is almost aligned sub-parallel to the Main Karakoram Thrust in the north and Main Boundary Thrust in the south except the Hazara-Kashmir Syntaxial area, where MMT remains unaffected and continues its journey in the northeast direction to join the Raikot fault. In the east it is abruptly juxtaposed against the Nanga-Parbat-Haramosh Massif, while in the west it meets the Main Karakoram Thrust in Afghanistan. Before joining the Main Karakoram Thrust, it is offset by northwest and northeast trending strike slip faults near Khwaza Khela and Besham. The Patan earthquake of December 28, 1974, having magnitude 6.2, was associated with MMT.

The Raikot fault zone and associated structures exhibit remarkable neotectonic features including fault scarps and exposures where Nanga Parbat gneisses overlie Pleistocene tillites. The earthquakes of November 2002 and January 2003 in Astore valley have been attributed to movement in this zone.

On the basis of the recorded seismicity and observed neotectonic features both the Main Mantle Thrust and Raikot fault are considered seismically active.

6.3.2.4 PANJAL-KHAIRABAD THRUST

The Panjal-Khairabad Thrust is an important active tectonic feature of regional significance. It runs northwards and parallel to the Main Boundary Thrust (MBT) on the eastern side of Hazara- Kashmir Syntaxis where it is normally called Main Central Thrust (MCT). These faults gradually converge and eventually join about 5 km north of Balakot (Calkin et al. 1975, Bossart et al. 1984 and Greco 1991). In the area west of Hazara-Kashmir Syntaxis, this fault is commonly called Panjal Thrust.

A left lateral strike slip fault cuts across both the Panjal Thrust and MBT approximately 6 km south of Balakot, from where onwards the Panjal Thrust continues its independent journey southwards. It is traceable up to Garhi Habibullah from where onward it is concealed beneath Quaternary deposits. The thrust comprises several segments having an aggregate length of about 130 km.

To the west this fault passes through the Gandghar range near Haripur and joins the Khairabad fault located on the northern side of the Attock-Cherat range, hence it is sometimes referred as the Panjal-Khairabad fault.

The geologic positioning and seismicity associated with the Panjal-Khairabad fault renders it as an active regional tectonic feature capable of generating large earthquakes.

6.3.2.5 MAIN BOUNDARY THRUST (MBT)

The most significant and active tectonic feature of regional extent is the Main Boundary Thrust (MBT). It is the main frontal thrust of the Himalayan Range, which runs along the Himalayan arc for almost 2500 km from Assam in the east to Kashmir and Parachinar in the west. The MBT along with other associated thrusts forms the sharp conspicuous Hazara-Kashmir Syntaxis. This syntaxial bend is the most dominant tectonic feature of the area as all local major fault systems and geologic structures follow its trend. On the west side of this feature, the MBT initially follows a rather southwest trend and then extends westward reaching Parachinar.

Near its surface trace, the MBT dips northward at a steep angle, which becomes sub-horizontal with depth. Islamabad-Rawalpindi area is located at a close distance south of the western limb of the MBT.

A number of large to major earthquakes have occurred along the Himalayan Arc east of the Hazara-Kashmir syntaxis during the last two centuries, which places it amongst the most active regions of the world. Much of the seismicity recorded during the last century is attributed to surface and subsurface extensions of the MBT and other associated thrusts. Based on this data, Seeber et al. (1981) have shown that great earthquakes occurring along Himalayan Arc are probably related to slips taking place along this quasi-horizontal detachment surface.

Based on the above, the MBT is considered active having seismic potential sufficient enough to generate large to major earthquakes.

6.3.2.6 SALT RANGE THRUST

The Salt Range Thrust runs along the southern extremity of the Salt Range between the Jhelum and Indus Rivers. It is marked by thrusting of highly deformed older rocks of the Salt Range over the relatively less deformed Tertiary Sequence of Jhelum Plains (Punjab Plains). Irregular escarpments rise explicitly from the Punjab Plains; however, on the northern side gently dipping strata merge into the Potwar Plateau.

The Salt Range Thrust is about 300 km long, having a general trend in an east-northeast direction. It is extensively segmented by northeast and southeast trending minor transverse faults. The fault segments exhibit considerable off-sets at various locations. A significant part of Salt Range Thrust is covered by fanglomerates, while at places near Jalalabad and Kalabagh the thrust trace is clearly visible where Paleozoic rocks overlie the Neogene strata.

The Salt Range Thrust terminates in the west against the Kalabagh fault, which is a seismically active tectonic feature of the area. Its eastern termination is near the right bank of the Jhelum River, where it bifurcates and takes a northeast wards bend. In contrast to other parts of the frontal zones in Pakistan, the Salt Range Thrust is marked by a low level of seismic activity which is mainly attributed to the aseismic nature of underlying Cambrian Salt deposits. It has no history of known rupture in moderate to large magnitude earthquakes. However, the entire Salt Range is considered active as indicated by micro-seismic studies and observation of Quaternary deformations in western and central portions of the fault.

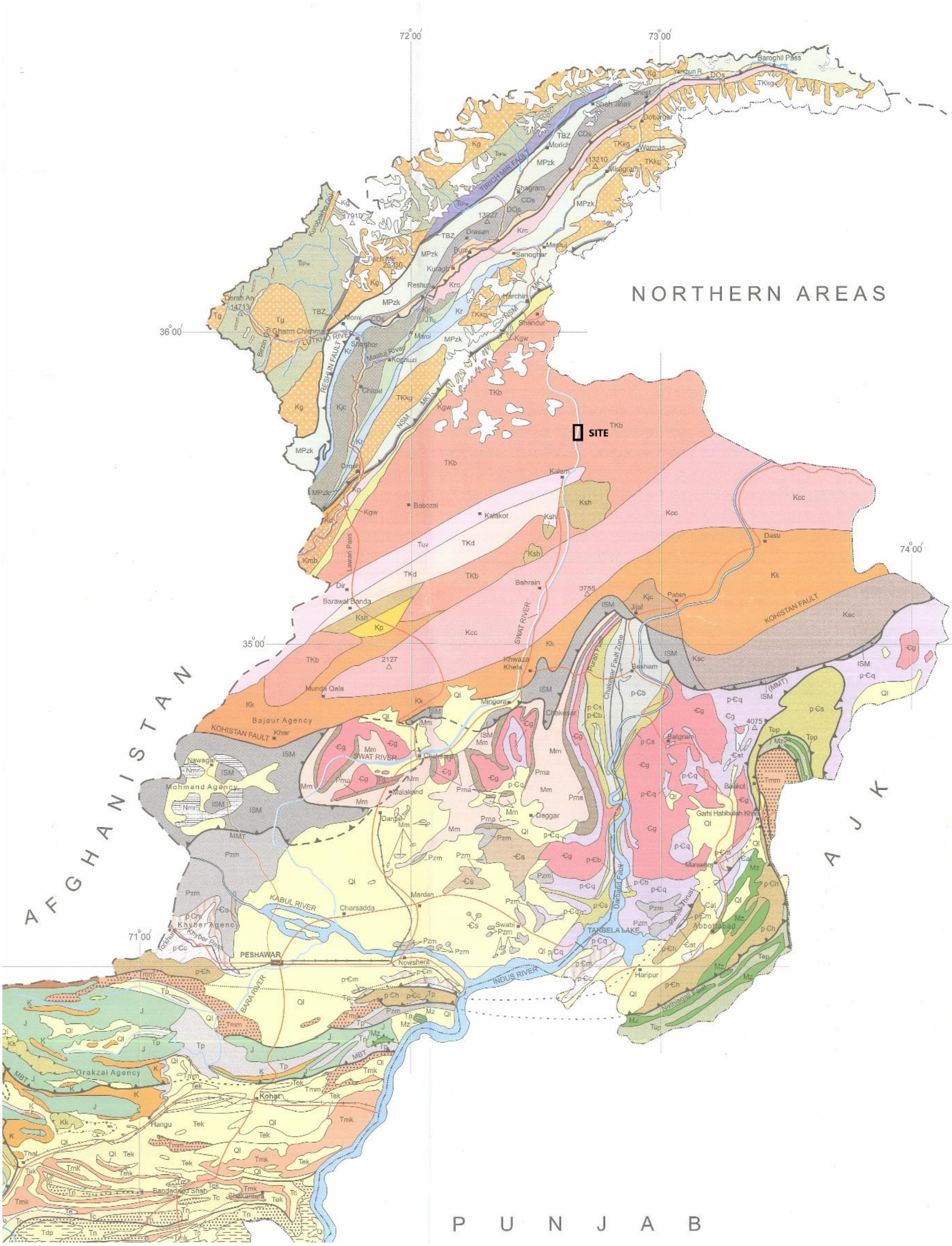

Figure 6-3a/3b: Geological Map of NWFP; by GSP (2006)

LEGEND

Ql **Quaternary Alluvium:** Unconsolidated deposit of gravel, sand, silt and clay.

Qbf **Quaternary Boulder Fan Deposit:** Mostly sandstone and limestone boulders and cobbles unconsolidated / poorly cemented.

CHITRAL AREA (Asian Plate)

Tg **Post-Collision Granite**: Include **Hot Spring granite** which is two mica granite with garnet and tourmaline. It is leucogranite, U-Pb ages indicate 24Ma. The Pluton is surrounded by granitic gneisses which are very similar to Hot Spring granite in composition. **Dorah An granite** is identical to the Hot Spring Pluton and has been intruded into Staurolite-schist and sillimanite K-feldspar migmatites. Age late Tertiary.

TKkg **Karakoram Batholith & Associated Rocks**: Include **Buni Zom granodiorite** which consist of undeformed non-porphyritic biotite hornblende granite. It hosts the magnetite mineralization. **Kesu Koghuzi granite** is highly complex and has foliated dioritic rocks with minor acidic intrusions. **Gamu Bar pluton** (Dobargar and Zagar Umalsit) is the hornblende-biotite granodiorite to granite. Slightly porphyritic and yields K-Ar ages of 56 & 40 Ma.

MESOZOIC

Kg **Pre-collision Intrusive Rocks**: Include **Tirich Mir pluton** which comprises hornblende-biotite granodiorite and has large (3-4cm) plagioclase phenocrysts. Rb-Sr biotite age of this pluton is 115± 4Ma. **Kafiristan granodiorite** is virtually similar to that of the Tirich Mir pluton. **Gazikistan granodiorite** which is a lenticular body and also identical to that of the Tirich Mir granodiorite pluton.

Krc / Kr **Reshun Conglomerate(Krc) and Reshun Marble(Kr)**: Two separate units are marked of marble, calcareous phyllite, red phyllite, conglomeratic phyllite and brownish gray conglomerate. Two thick marble/limestone outcrops follow the general strike direction throughout the Chitral District. The two carbonate outcrops surrounding the Chitral Slate form an anticlinal structure. It has been assigned Cretaceous age on the basis of Orbitolina fossils.

KJc **Chitral Slate:** It comprises fine grained black slate and thinly laminated dark gray phyllite. At some places, the phyllite contains thin beds of impure gray marble. It is about 5000m thick and forms an anticlinal structure in the Chitral area. Age Jurassic to Cretaceous.

JTRg **Koghuzi Greenschist and Calcareous Phyllite:** The **Koghuzi Greenschist** is pale green, fine grained containing sodic plagioclase, chlorite, actinolite, epidote and quartz. The **Calcareous Phyllite** is exposed between the Koghuzi Greenschist and the Chital Slate. It consists of calcareous phyllite with some marble. It is about 100m thick. Age Triassic to Jurassic.

TRPw **Wakhan formation, Atark Unit and Tirich Boundary Zone:** The **Wakhan formation** in the Hindukush range to the north of Tirich Fault consists of amphibolite and greenschist facies paragneisses, slate, phyllite, and pelites with marble and cal-silicate quartzite. The **Atark Unit** consists of carbonate rocks, having a Permian section with megalodonts and possible rudists. Age Permain to Triassic. The **Tirich boundary zone** (TBZ) is associated with Tirich fault and consists of peridotite, and metagabbro, amphibolite and gneisses.

MPzk **Karakoram metamorphic complex:** The Karakoram metamorphic complex in Chitral area between Tirich fault and northern suture consists of slate, greenschist facies phyllite, quartzite and limestone. It include Shah Jinali phyllites, and sediments and metasediments of Karakoram range.

PALEOZOIC

CDs **Sarikol Shale and Tash Kupruk Unit undivided:** The **Sarikol Shale** consists of black shale, micaceous phyllite, brown dolomite and gray sandstone. On the basis of fossil Devonian to Early Carboniferous age has been assigned. The **Tash Kupruk Unit** consists of Late Devonian to early Carboniferous basaltic lava flows, volcani-clasts and carbonates. The lavas preserve phenocrysts of clinopyroxene in a groundmass of plagioclase, magnetite and phyritic material.

DOs **Charun Quartzite and Shogram formation undivided:** The **Charun Quartzite** is white, medium grained and about 100m thick in Reshun area. It lies below the Shogram formation. The **Shogram formation** consists of a massive, medium bedded dolomite, gray, fossiliferous limestone and the upper part consists of fine to medium grained quartzite. The total thickness is about 800m and it is of Late Devonian (Frasnian) age.

NSM **Northern Suture Melange (Shyok Suture):** Deformed and chaotic assemblages of volcanic rocks, limestone, red shales, quartzite and serpentinite.

KOHISTAN ISLAND ARC

TERTIARY

Tuv **Utror Volcanics:** Andesite, rhyolite, dacite and tuffs interbedded with metasediments in the Western Kohistan arc. Age ^{40}Ar / ^{39}Ar Honblende 55± 2 Ma or Eocene to Paleocene.

Tkb **Kohistan Batholith:** Granites, granodiorites, quartz diorites with dykes and sheets of hornblende gabbros and leucogranits. Searle et al (1996) has reported Rb/Sr. Wr-110-90 Ma age. Miocene to Cretaceous.

Tkd **Dir Metasediments:** Sandstone, siltstone and turbidites with rare intercalated marine limestone containing late Paleocene faunas (60-54Ma).

CRETACEOUS

Kp **Purit formation:** Red shales with subordinate sandstone and conglomerate of continental fluvial origin and is correlative to the Reshun formation of Chitral area. Age Cretaceous.

Kmb **Mirkhani Batholithe:** Quartz diorite to granodiorite in composition. Large porphyritic bodies of feldspar are seen with in the body. Age Cretaceous.

Kcc **Chilas Complex:** Mafic-ultramafic stratiform plutonic complex, dominantly composed of gabbro-norite, pyroxene diorite-tonalite and olivine gabbro with minor ultramafic (chromite-layered dunite, peridotite, pyroxenite, hornblendite) and anorthosite associations. Age Cretaceous.

Ksc **Sapat Complex:** Ultramafic-mafic stratiform complex. The basal part is completely serpentinized, dunite, peridotite, pyroxinite and rare chromitite at the base, anorthosite and pyroxenite in the middle and isotropic gabbros at the top. Age Cretaceous.

Kjc **Jijal Complex:** High-pressure garnet granulite, layered gabbro at the top and layered ultramafic cumulates (peridotite, dunite, diopsidite, chromitite) at the base. Age Cretaceous.

Kd **Drosh formation:** Drosh formation to the south of Main Karakoram Thrust (MKT) in Shishi valley ; thickly bedded porphyritic andesite with phenocrysts of plagioclase, pyroxene and hornblende; thin interbeds of red shale are common within the volcanics. Age cretaceous.

Kgw **Gawuch formation:** Gawuch formation in the south of Main Karakoram Thrust (MKT) in the western Kohistan Arc in Chitral area; green color calcareous phyllite, with occasional bands of schist in the lower part followed by brown limestone.

Kp **Peshmal Schist**: In the western Kohistan arc; green schist facies, slate, phyllite and psammnites with an early Cretaceous turbidite protolith (with strong volcano - clastic component). Age Cretaceous.

Ksh **Shao formation**: In the southern Kohistan near Kalam, consists slate, limestone, and quartzite sequence. Age Cretaceous.

Kk **Kamila Amphibolites:** Upper amphibolite-facies and calc-alkaline metabasalts intruded by subduction-related gabbroic plutons; all strongly sheared. Trondhjemites, as partial-melting products, common near contact with the Chilas complex. Common intrusions of diorites, granodiorites and granites. Age Cretaceous.

Nmr ISM **Indus Suture Melange**: Includes, Shangla blueschist, Charbagh greenschist, Mingora ophiolites, Nawagai melange & Nawagai marble (Nmr), and Dargai ophiolites: Chaotic assemblage of serpenitinite, talc-Schist, greenschist, metabasalt and greenstone along the hanging wall of the Main Mantle Thrust.

Figure 6-4: Geological Map of Northern Pakistan and Adjacent Areas (Searle & Asif, 1995)

6.3.3 LOCAL TECTONIC FEATURES

The project is located in the western part of the Kohistan island arc close to the boundary between the Kohistan Batholith and Utror Volcanics. In the Geological Map of NWFP (2006) published by the Geological Survey of Pakistan (Figure 6-3), the contact between the Kohistan Batholith and Utror Volcanics is shown to be a normal contact but some researchers believe that this contact is faulted (Ghazanfar et al, 1991). In the Geological Map of Northern Pakistan edited by Searle & Asif (1995) presented in Figure 6-4, this contact is shown to be a faulted one.

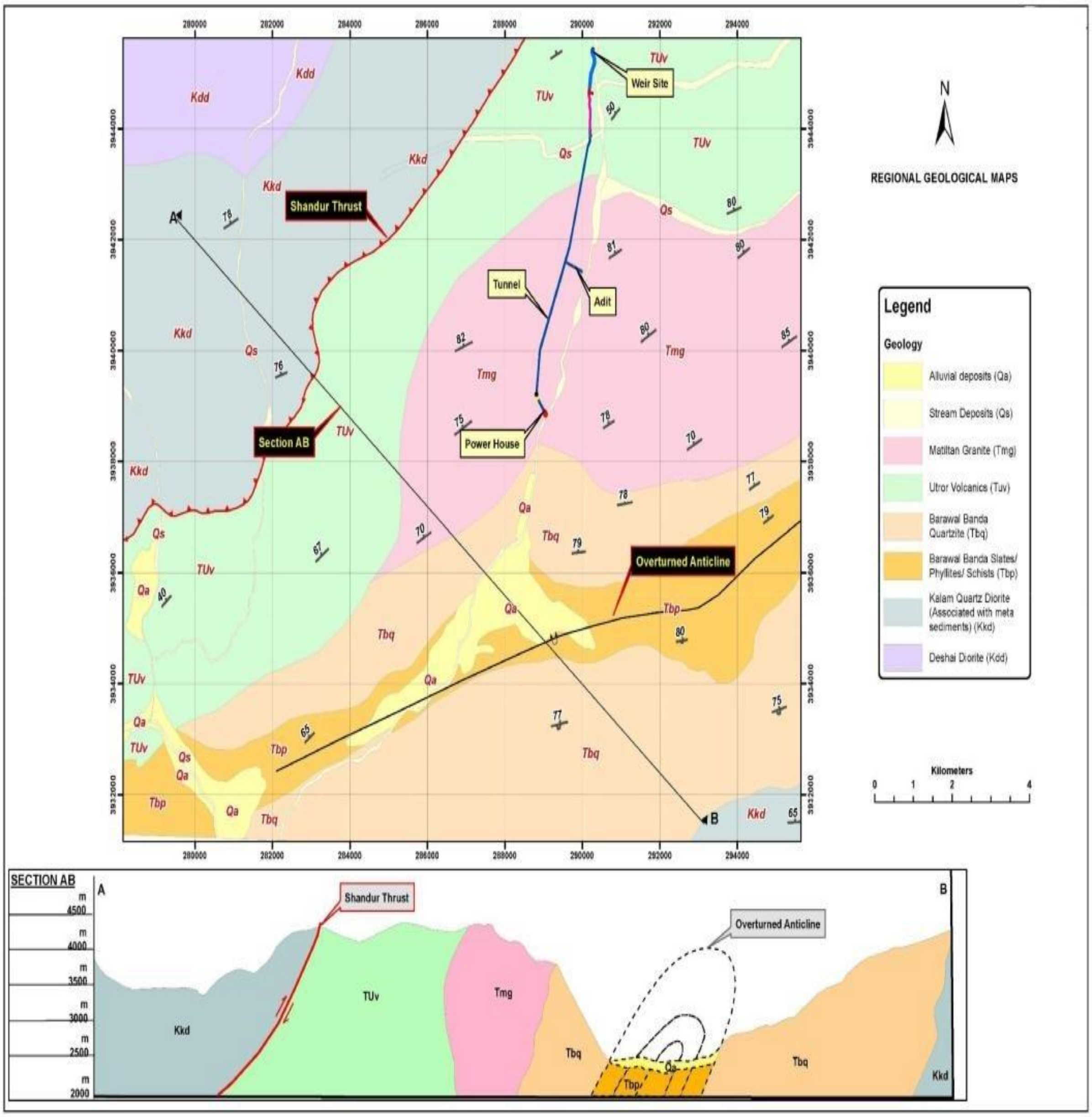

Figure 6-5: Geological Map of Mahodand Quadrangle, Swat; by Afridi et al., GSP (1999)

A regional fault named as Shandur Thrust is marked on GSP Geological Map of Mahodand Quadrangle (Scale 1:50,000) prepared by Afridi et al. (1999) and given in Figure 6-5 which shows this fault is passing at closest distance of about 2 km in the northwest of the weir site area. This thrust fault has been marked by the Utror Volcanics group of rocks in southeast while by Kalam Quartz Diorite associated with meta sediments in the northwest. The fault is dipping towards the northwest and is directed northeast-southwest ward. It appears that this fault may coincide with the contact between Kohistan Batholith and Utror Volcanic shown in above referred regional geological maps.

6.4 EARTHQUAKE RECORD

6.4.1 GENERAL

Study of the earthquake record involved several activities:

- Investigation of the pre-instrumental or historical seismicity
- Examination of instrumentally recorded earthquake record
- Interpretative description of the Kashmir earthquake of October 8, 2005
- Analysis of the earthquake record
- Description of interpreted focal mechanisms

6.4.2 PRE-INSTRUMENTAL (HISTORICAL) SEISMICITY

Before the establishment of seismological observatories, which began at the beginning of 20th century, intensity data collected from the historical records was the only source of earthquake information. Historical Earthquake data is a general account of damage/ loss to life (human & animal) and property. The historical pre-instrument earthquake data has been collected from the description of the earthquakes given in the memoirs or records of travellers, 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 and presented in **Annexure C1, Volume-VI**. The historical earthquake data reflects that northern Pakistan as a whole has remained a house of prominent earthquakes. Taxila (25 A.D.) event is probably the most conspicuous one that changed style of building-construction out rightly. An important value of intensity data is that it establishes some understanding of the level of the damage that can be expected to occur in a given region.

The catalogue of historical earthquakes for this region is rather sparse and probably highly incomplete. Since the 1700's, the historical earthquake data for the northern areas of Pakistan are few and mainly concentrated on the centres of colonial administration. The important tremors for which damage data is available are as follows:

- Aristobulus of Cassandreia described that the first known historical account of seismicity of northern part of Pakistan in the fourth century B.C. He accompanied Alexander on his expedition to India, who pointed out that the country above the river Jhelum was subjected to earthquakes, which caused the ground to open up so much, that even the river beds were changed (Ambraseys et al., 1975).

- An important historical earthquake occurring in northern Pakistan was the destructive earthquake of 25 A.D., which ruined the city of Taxila, to which the intensity of IX-X has been assigned (Ambraseys et al., 1975). The effect of this earthquake still can be seen in the excavated remains of Jandial, Sirkap, and Dharmarajika. The building methods after this earthquake changed, including reduction in the height of buildings, improvements in masonry bracing density, and making the foundations more secure.
- On March 25, 1869, a large earthquake occurred in the Hindukush region, strongly felt at Kohat, Peshawar, Lahore, and at Khodjend and Tashkent, the shaking lasting 20 seconds;
- On May 22, 1871, a damaging shock was recorded at Gilgit with many aftershocks. This earthquake was strong enough to be felt as far as Meerut and Agra in India;
- On January 20, 1902, a large earthquake caused damage in the Chitral area and was felt widely in the Punjab and up to Simla;
- On July 7, 1909 a strong earthquake in Hindukush region caused destruction in the region of Mankial and Kalam in the Swat valley where Lady Minot's Hospital was damaged and many houses collapsed, killing 10 people and cattle. Damage area extends to Dir, Karori and Alipurai and was felt in Gilgit, Besham, and to the north up to Tashkent; and
- The epicentral intensity of all these earthquakes is estimated to be not greater than VIII on the Modified Mercalli (MM) intensity scale.

6.4.3 INSTRUMENTAL SEISMICITY

The instrumental recording of earthquakes started in 1904 but very few seismic stations were established in the South Asian region until the 1960's. However, with the installation of high-quality seismographs under the World Wide Standard Seismograph Network (WWSSN) established by the U.S. Coast and Geodetic Survey in 1960, the quality of earthquake recording in this region improved and resulted in a better understanding of the seismicity of Pakistan.

In Pakistan and most other parts of the world, the seismic record is too short and incomplete to develop a complete sample that is truly representative of the spatial and temporal distribution of shocks over a large period. Nevertheless, all the available information has been gathered for the period covering the last century, which was used to develop a satisfactory and safe assessment of seismic hazard for the project.

For this study, the instrumental record of earthquakes within about 300-km radius of the project was searched from available earthquake listing obtained mainly from:

- International Seismological Centre (ISC) England;
- National Earthquake Information Centre (NEIC) of the U.S. Geological Survey
- Pakistan Meteorological Department;
- PAEC Microseismic Network; and
- Tarbela Microseismic Network, WAPDA.

A composite catalogue of instrumentally recorded earthquakes was prepared by combining these earthquake listings. This is presented in chronological order showing:

- Origin time;
- Epicentral location;
- Depth of focus;
- Magnitude; and
- Data source.

In preparing this composite catalogue, more weight was given to the data listed in the ISC catalogue because data within this catalogue tends to be more accurate, being calculated with more data than is used in the other listings, and less likely to contain duplicates. Where available, body wave (m_b), surface wave (Ms) or local (M_L) magnitudes are also indicated. The source catalogues overlap considerably and both automatic and manual procedures that incorporate judgment about source catalogue reliability and priority were used to help eliminate duplicate entries from the combined listing.

During the present study, a composite list of seismic events that occurred in the project region and adjoining areas has been prepared. This composite list includes events within an area between latitudes: 33.5^0 to 37.5^0 and longitudes: 70^0 to 75^0. This composite earthquake catalogue of project region is presented in **Annexure C2, Volume-VI**.

This catalogue comprises 19238 events of magnitude 3 and above covering a period up to December, 2018. The reporting agencies have given a variety of magnitudes viz: Body-wave magnitude (m_b), Surface-wave magnitude (M_S), Richter/Local magnitude (M_L) or Duration-magnitude (M_D) etc. Since attenuation relationships are based on magnitude of given type, a single type must be selected. For data to be used in seismic hazard analysis, all the magnitudes were therefore converted to moment magnitude (M_W) by the following equations.

Conversion from M_S and m_b to M_W was achieved through latest equation suggested by Scordilis (2006):

$M_W = 0.67\ M_S + 2.07$ for $3.0 \leq M_S \leq 6.1$

$M_W = 0.99\ M_S + 0.08$ for $6.2 \leq M_S \leq 8.2$

$M_W = 0.85\ m_b + 1.03$ for $3.5 \leq m_b \leq 6.2$

For M_L up to 5.7, the value of M_L was taken equal to M_W as suggested by Idriss (1985) and supported by operators of local networks in Pakistan. Conversion of M_L to M_W beyond magnitude 5.7 was done by using the following equations suggested by Ambraseys and Bommer (1990) and Ambraseys and Bilham (2003):

$0.82\ (M_L) - 0.58\ (M_S) = 1.20$

$\text{Log Mo} = 19.09 + M_S$ for $M_S < 6.2$

$\text{Log Mo} = 15.94 + 1.5\ M_S$ for $M_S > 6.2$

$M_W = (2/3)\ \text{Log (Mo)} - 10.73$

Where m_b is body–wave magnitude, M_S is surface-wave magnitude, M_L is local magnitude, M_W is moment magnitude and Mo is seismic moment.

All available types of magnitudes in the catalogue were converted into a uniform magnitude-scale i.e. M_W (Moment magnitude) and given in **Annexure C2, Volume-VI**. M_W represents area source rather than a point source and the same type of magnitude is mostly being used in the seismic hazard analysis.

6.4.4 KASHMIR EARTHQUAKE OF OCTOBER 08, 2005

A powerful earthquake with a magnitude of M_W =7.6 struck the northern part of Pakistan on October 08, 2005 and caused widespread damage in Azad Kashmir and adjoining areas of KPK. The epicentre of this earthquake was located northeast of Muzaffarabad. This earthquake was felt for several minutes in Pakistan, northern India, and Afghanistan. The heaviest damage was recorded in the towns of Balakot, Batal, and Batagram in KPK and Muzaffarabad, Bagh and Rawalakot in Azad Kashmir where the entire population was effected. Building collapse was also reported in Mansehra, Abbottabad, and Islamabad. Severe cracks were observed in many high-rise buildings in Islamabad. The death toll due to this earthquake exceeded 80,000 people and millions were rendered homeless due to collapse of houses. The earthquake was followed by a series of more than thousand aftershocks, hundreds of them exceeding magnitude 4.

This earthquake was caused by the movement due to rupture along a thrust fault named the “Balakot-Muzaffarabad-Bagh fault” which is a northern most branch of the Main Boundary Thrust (MBT) like Riasi Thrust, a main branch of the MBT in Kashmir. Ground ruptures and fresh landslides have been observed along this fault at many places near Muzaffarabad and

Balakot. Teleseismic aftershock data and distribution of damage indicates that more than 120 km of this fault between Batagram and Bagh districts ruptured during the major earthquake.

The fault plane solution for the main shock given by Harvard Moment Tensor Solution shows a predominant thrust motion and its strike is compatible with the strike of the HFT.

6.4.5 ANALYSIS OF SEISMICITY

The spatial distribution of seismic events recorded in the project region and given in **Annexure C2, Volume-VI** is plotted on Figure 6-6.

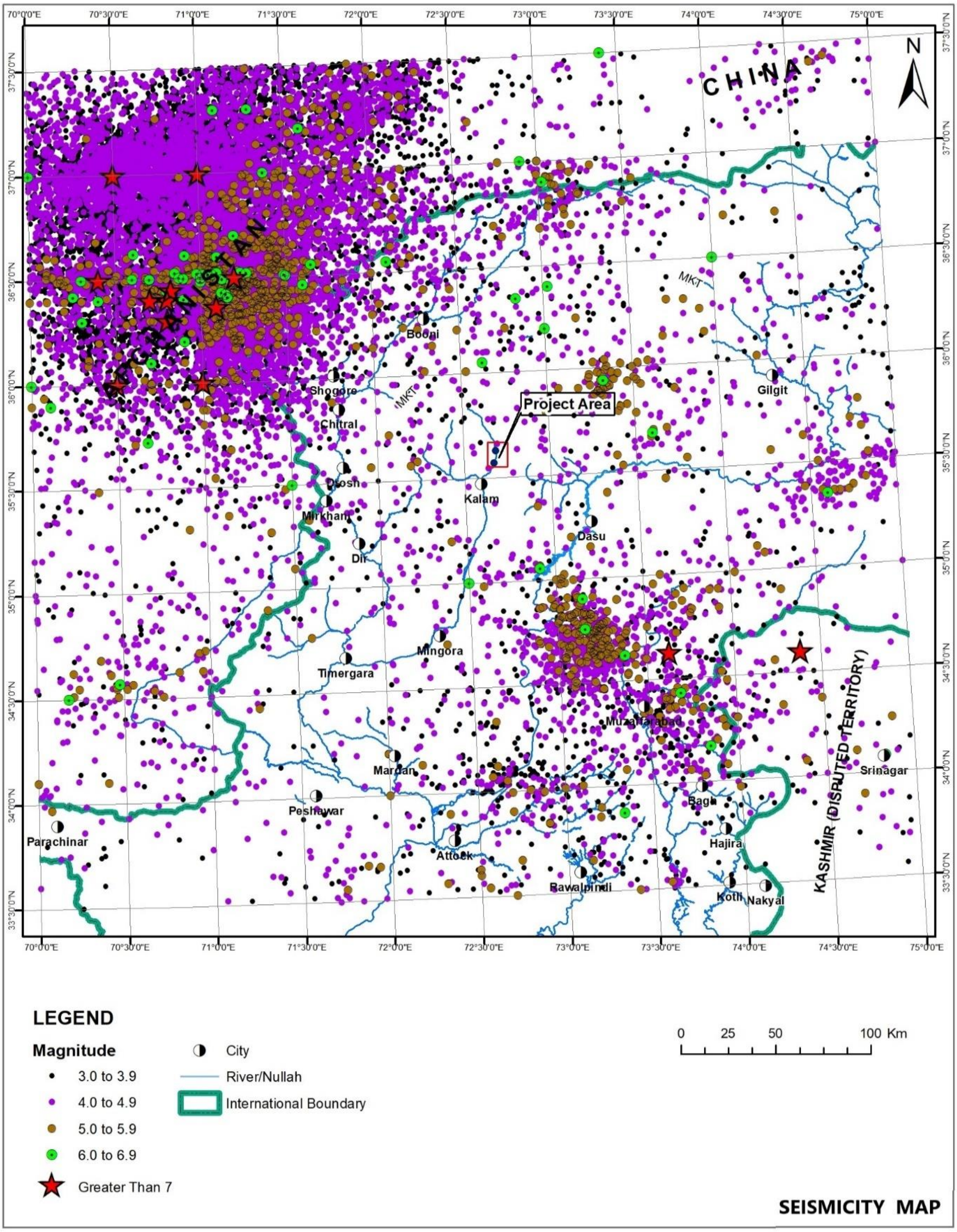

Figure 6-6: Seismicity Map of the Project Region.

The distribution of observed seismicity on the seismicity map clearly shows that the project is located in a region of high seismicity. The concentration of seismicity in the northwest of the project area is from very highly active Hindukush seismic zone where intermediate to deep earthquakes are more predominant. More than 80 % of total earthquakes listed in composite catalogue falls in this zone. Another concentration of earthquakes south of the project is related to seismically active Indus-Kohistan seismic zone and the Hazara-Kashmir Syntaxis where Kashmir earthquake of October 2005 occurred. The Nanga Parbat-Haramosh syntaxis east of the project area also shows high seismicity. The Jaglot Syncline area northeast of the project area, where Hamran and Darel earthquakes occurred, also shows concentration of seismic activity. A number of small to moderated earthquakes are located around the project area indicating that project area is also seismically active.

The epicenters of three well-studied earthquakes of magnitude 5.9 or above have been recorded in Kohistan island arc east of the project area (Ambraseys, et al., 1975; Jackson & Yielding, 1983). These earthquakes are:

- Patan earthquake (28 December 1974); magnitude (Mb) 5.9; 90 km south of the site; close to the surface expression of MMT;
- Hamran earthquake (3 September 1972); magnitude (Mb) 6.3; 55 km northeast of the site; within the Kohistan Island Arc; and
- Darel earthquake (12 September 1981); magnitude (Mb) 6.1; 20 km northeast of the site; within the Kohistan Island Arc.

The locations of these events are shown in Figure 6-7. While the Patan earthquake (28.12.1974) is located close to the surface expression of the MMT, the Hamran earthquake of 3.9.1972 and Darel earthquake of 12.9.1981 occurred within the Kohistan Island Arc, east of the project site. This shows that active tectonic features are present within or below the Kohistan island arc where the project site is located.

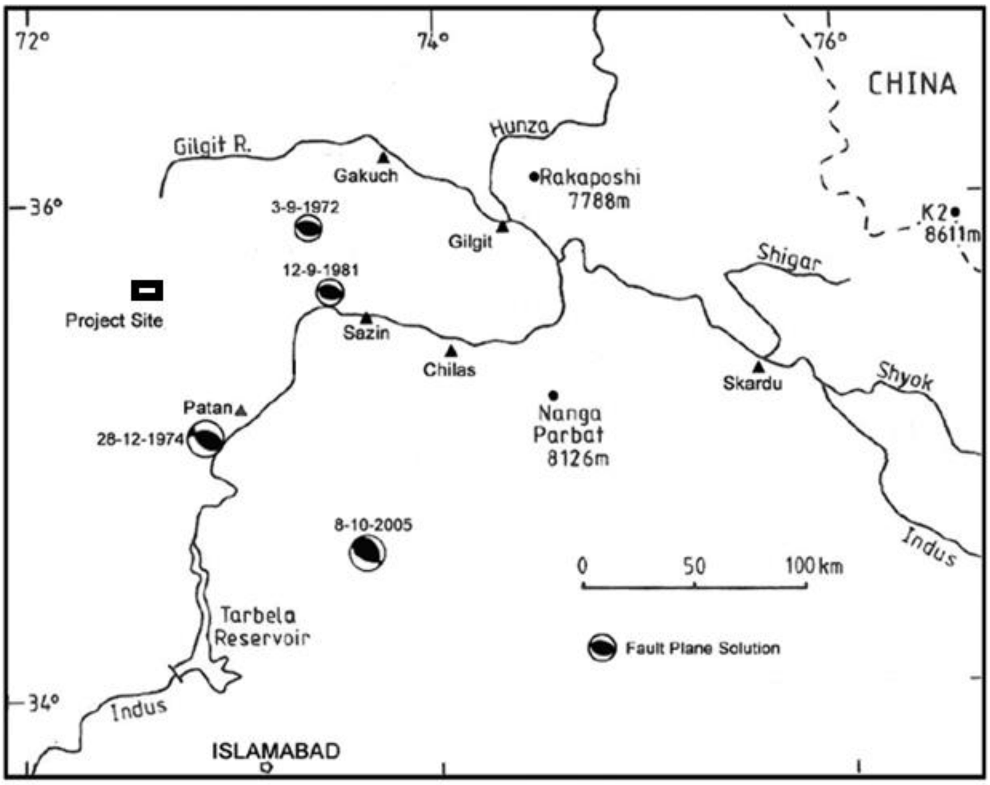

Figure 6-7: Fault Plane Solutions of Significant Events of Kohistan Region

Both spatial and temporal clustering or concentrations of seismic activity have been observed in the project region and is distributed over a large area and has not yet been associated with any known tectonic structure in the area. Previously, the cluster of seismicity north of Darel valley has been associated with the Jaglot syncline but recent geological maps have not shown this syncline as fault associated. Importantly, however, the results of new mapping have shown that the boundaries or contacts of the main lithologic units in Kohistan are faulted. In this respect, it is pointed out that the Darel earthquake occurred close to the northern boundary of the Chilas Complex.

6.4.6 FOCAL DEPTH AND MECHANISM

The reported focal depths of earthquakes included in the composite list range from 0 to more than 300 km. In general, the deeper events are related to Hindukush seismic zone whereas other areas have focal depths less than 100 km. In the Kohistan Island Arc, the depths of most of the earthquakes are generally shallower than 70 km and nominal depth of 33 km is mentioned for majority of these events in all the earthquake catalogues, due to the low-resolution in-depth calculation in the absence of a proper recording network in this region.

It is important to note that majority of the earthquakes in Kohistan island arc area having magnitude 5 to 6 are located up to about 60 km depth while majority of the events with magnitude greater than 6 remained concentrated in the focal depth less than 50 km. The October 08, 2005 earthquake (M=7.6) had focal depth less than 26 km.

The available fault plane solutions of earthquakes in this region show predominantly thrust mechanism. Jackson and Yielding (1983) have reanalyzed the phase data of three prominent earthquakes described above. Fault plane solutions for these earthquakes are presented in **Figure** 6-7. The fault plane solution of Kashmir earthquake of October 08, 2005 is also shown on **Figure** 6-7. Fault plane solutions for these earthquakes show a thrust source mechanism in keeping with the tectonic model described above involving subduction and under thrusting of the Indian Plate beneath the Eurasian Plate. The northeast to north-northeast dipping planes of these fault plane solutions are possibly representing the causative rupture which is in conformity with the observed northward dips of the major thrusts of the region.

6.5 SEISMOTECTONIC ANALYSIS

From the available tectonic and seismic data of the project region, an understanding about the seismotectonic set up of the project can be developed. A seismotectonic map of the Project region showing active faults and recorded seismicity is shown in **Figure** 6-8.

6.5.1 IDENTIFICATION AND DESCRIPTION OF SEISMIC SOURCES

The available seismic and tectonic data provides several evidences of the seismic activity along the major faults i.e. Main Mantle Thrust (MMT) and Kohistan Fault passing south of the site and Main Karakoram Thrust (MKT) passing northwest of the project.

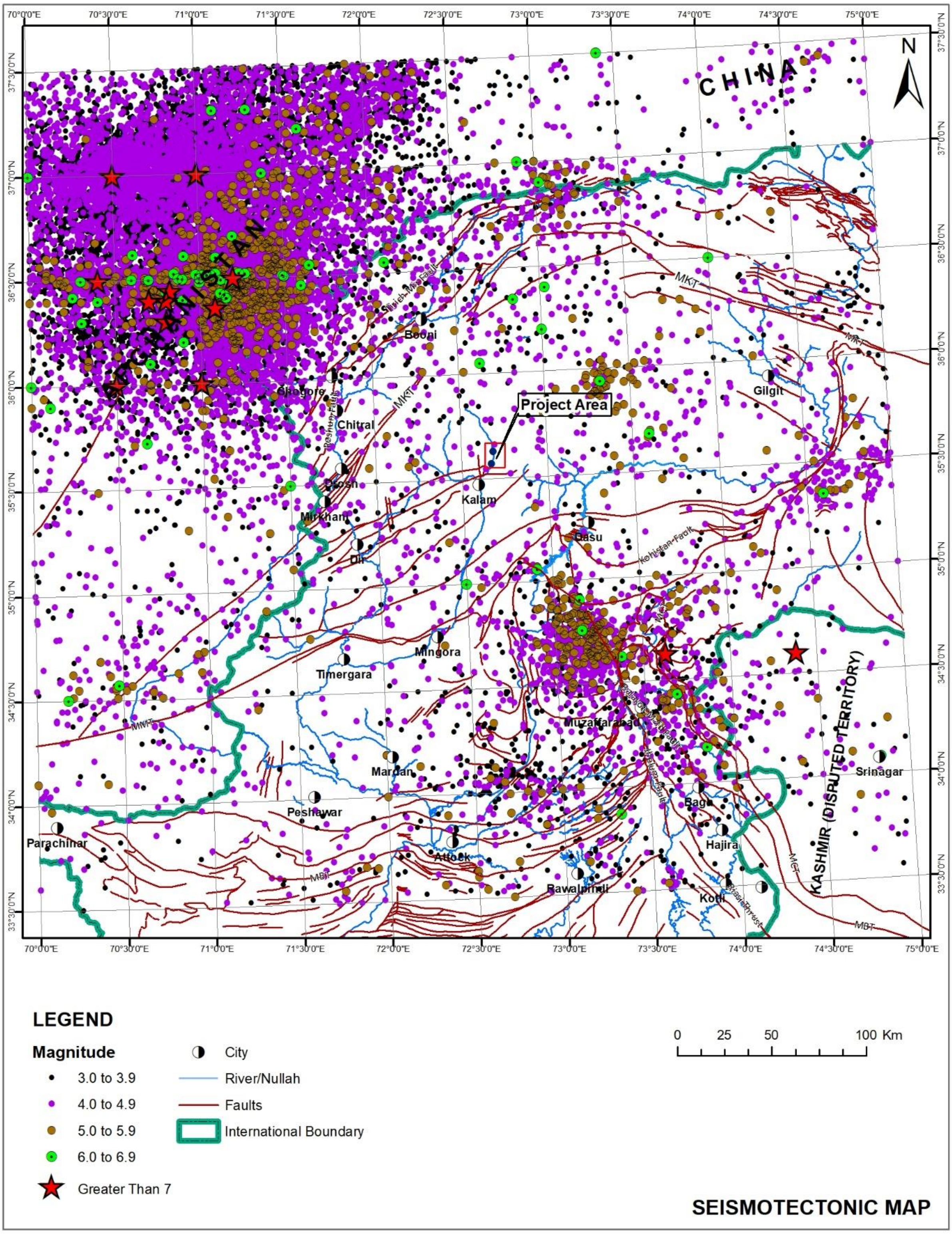

Figure 6-8: Seismotectonic Map of Project Region.

Based on this understanding of the seismotectonic setting and faults of the area, the seismogenic features which may significantly influence the seismic hazard for Artistic-II Hydropower Project are:

- Main Karakoram Thrust (MKT),
- Kohistan Fault,
- Main Mantle Thrust (MMT), and
- Shandur Thrust

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 terminates at its junction with Karakoram fault. In the Chitral and Gilgit area, the rocks of Karakoram Batholith are thrusted over the rocks of Kohistan Batholith along MKT.

Kohistan Fault: On the Geological Map of NWFP (2006) published by the Geological Survey of Pakistan, the contact between the Kamila amphibolies and the Satpat ultamafics to the south of Dasu are shown as the Kohistan fault. Along this fault, the rocks of the Kamila complex are thrust over the Satpat complex rocks.

Main Mantle Thrust: Main Mantle Thrust (MMT) is a northward dipping regional thrust, which separates the Indian Plate from the Kohistan Island Arc. It extends from Khar (Bajaur Agency) in the west to the north of Naran (Kaghan Valley) in the east where it takes a northeast ward bend towards the east of Bunji and gets truncated by the Raikot Fault. The thrust inclines steeply near the surface; however, this inclination is believed to decrease considerably with depth likewise as interpreted for other local thrust faults of the region.

The MMT is almost aligned sub-parallel to the Main Karakoram Thrust in the north and to the Main Boundary Thrust in the south except in the Hazara-Kashmir Syntaxial area, where the MMT remains unaffected and continues its journey in a northeast direction to join the Raikot fault. In the east it is abruptly juxtaposed against the Nanga-Parbat-Haramosh Massif, while in the west it meets the Main Karakoram Thrust in Afghanistan. Before joining the Main Karakoram Thrust, it is offset by northwest and northeast trending strike slip faults near Khwaza Khela and Besham. The Patan earthquake of December 28, 1974, having magnitude 6.2, is thought to have been associated with movement on the MMT.

The Raikot fault zone and associated structures exhibit remarkable neotectonic features including fault scarps and exposures where Nanga Parbat gneisses overlie Pleistocene tillites. The recent earthquakes of November 2002 and January 2003 have been attributed to movement on this tectonic feature.

On the basis of the recorded seismicity and observed neotectonic features both the Main Mantle Thrust and Raikot fault are considered seismically active.

Shandur Thrust: Shandur Thrust is marked on GSP Geological Map of Mahodand Quadrangle prepared by Afridi et al. (1999) which shows this fault passing at closest distance of about 2 km in the northwest of the weir site (Figure 6-5). This thrust fault has been marked by the Utror Volcanics group of rocks in southeast while by Kalam Quartz Diorite associated with meta sediments in the northwest. The fault is dipping towards the northwest away from project site and is directed northeast-southwest ward. It is assumed that this fault may coincide with the contact between Kohistan Batholith and Utror Volcanic shown in regional geological maps (Figure 6-3 and Figure 6-4). The inclusion of this fault in the hazard analysis would cover the hazard associated with near-site faults, as lot of observed seismicity in this area may be associated with these faults. Towards the east of the site, Hamran and Darel earthquakes also occurred on undefined faults. Based on observed seismicity around the project area, this fault is considered active.

6.6 SEISMIC HAZARD ANALYSIS

For seismic hazard evaluation, both probabilistic and deterministic methods were applied.

6.6.1 PROBABILISTIC PROCEDURE

6.6.1.1 PSHA METHODOLOGY

In probabilistic seismic hazard assessment (PSHA), 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 principle of the analysis, first developed by Cornell (1968) and later refined by various researchers, is to evaluate at the site of interest the probability of exceedance of a ground motion parameter (e.g. acceleration) due to the occurrence of a strong event around the site. This approach combines the probability of exceedance of the earthquake size (recurrence relationship), and probability on the distance from the epicentre to the site.

Each seismic source zone is split into elementary zones at a certain distance from the site. Integration is carried out within each zone by summing the effects of the various elementary source zones taking into account the attenuation effect with distance. Total hazard is finally obtained by adding the influence of various sources. The results are expressed in terms of a ground motion parameter associated with return period (return period is the inverse of the annual frequency of exceedance of a given level of ground motion).

The seismic hazard model used in the present analysis was developed based on findings of the seismotectonic synthesis. The seismic hazard model relies upon the concept of seismotectonic zones and does not include linear or discrete fault sources. Each seismic source zone is defined as a zone with homogenous seismic and tectonic features, inferred from geological, tectonic and seismic data. These zones are first defined, and then a maximum earthquake and an earthquake recurrence equation are elaborated for each of these seismic source zones.

The seismic parameters attached to the various seismic source zones are: a recurrence relationship relating the number of events for a specific period of time to the magnitude; the maximum earthquake giving an upper bound of potential magnitude in the zone; and an attenuation relationship representing the decrease of acceleration with distance.

The probabilistic seismic hazard evaluation requires a detailed analysis of distribution of observed seismic data to the seismic sources, determination of b-value and activity rate of each seismic source and assigning maximum magnitude potential to each seismic source.

6.6.1.2 SOURCE MODELING – AREA SOURCES

For the definition of seismic sources, either line (i.e. fault) or area sources can be used for source modeling. Because of uncertainty in the epicenters location, it is not possible to relate the recorded earthquakes to the fault sources and to develop recurrence relationship for each fault and use them as exponential model. The project region was therefore divided into five seismic area source zones (area sources) based on their homogeneous tectonic and seismic characteristics, keeping in view the geology, tectonics, seismicity and fault plane solutions of each area source zone. These seismic area source zones in the northern part of Pakistan are shown in Figure 6-9.

Each of these area sources was assigned a maximum magnitude based on recorded seismicity and potential of the faults within the zone and a minimum magnitude based on threshold magnitude observed in the magnitude-frequency curve for the zone. As the shallow earthquakes are of more concern to seismic hazard, the minimum depth of the earthquakes is taken as 5 km for all area sources except for deep Hindukush zone where minimum depth was taken as 80 km. The source zone parameters used in probabilistic hazard analysis are given in Table 6-1.

6.6.1.3 EARTHQUAKE RECURRENCE MODEL

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.

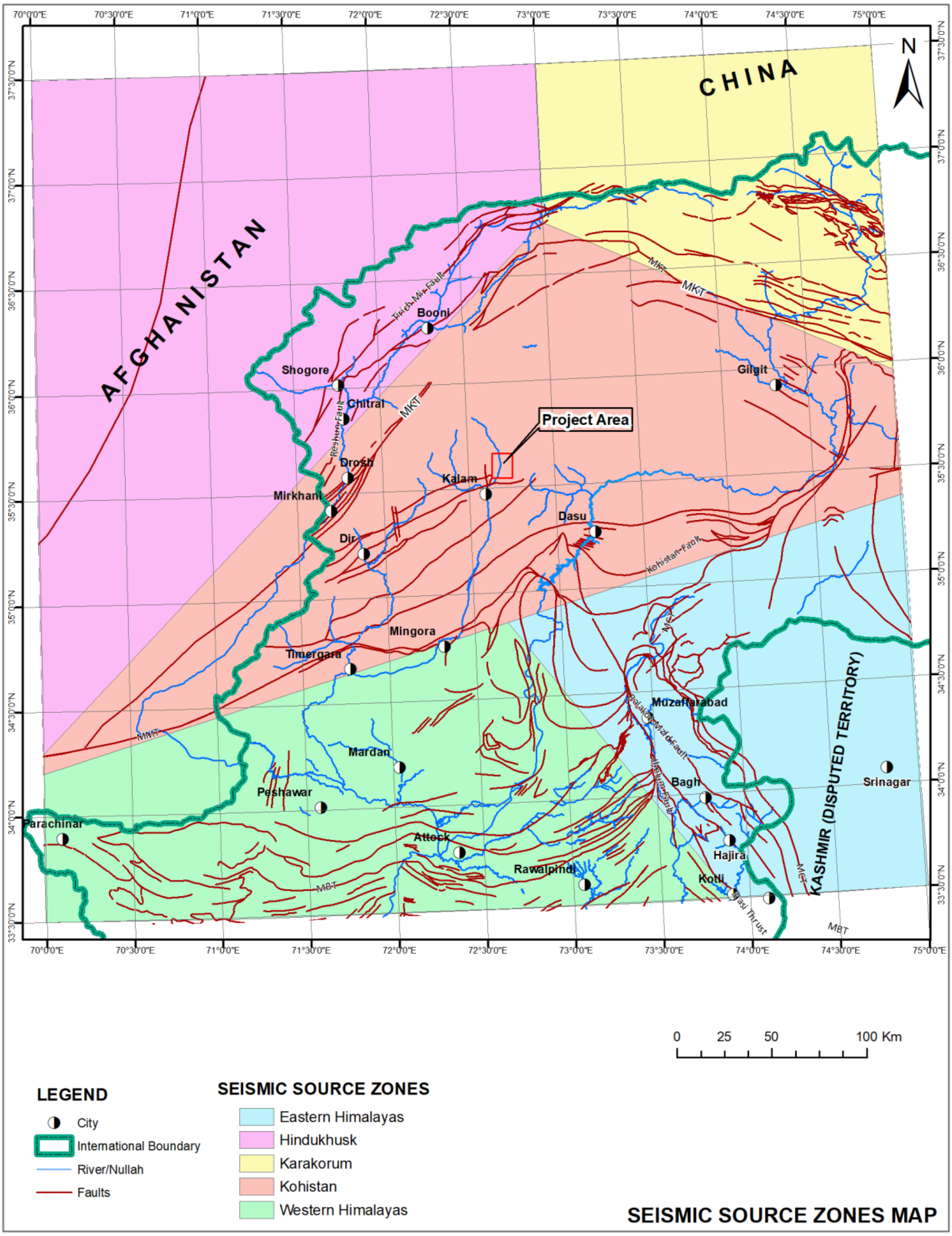

Figure 6-9: Seismic Area Source Zones used for Probabilistic Analysis

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 catalogue of earthquakes prepared for the Project region provided the necessary database for the computation of b-value for each seismic area source zone.

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 manually, as there are insufficient data to apply rigorous procedures such as that of Gardner and Knop off (1974) to eliminate foreshocks and aftershocks from the composite earthquake catalogue.

The completeness analysis of the overall data for the region showed that earthquake data above magnitude M_w=4.0 is complete after 1960. The converted moment magnitude for the period between 1961 and 2018 was therefore used in the PSHA after excluding the aftershocks. A separate list of earthquakes occurring in each area source zone was prepared through GIS software and magnitude-frequency curves were made for each seismic area source. The b-value for each seismic area source zone was calculated using linear regression through least square method. 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).

The b–values, minimum magnitude and the activity rates for the five seismic area source zones used in the probabilistic analysis are shown in Table 6-1.

Table 6-1: Seismic Area Source Zones Parameters for Probabilistic Analysis

Zone No.	Seismic Area Source Zone	No. of Earthquakes above Min. Magnitude	Minimum Magnitude Mw	Activity Rate /Year	b-Value	Maximum Magnitude Mw
1	Hindukush	8612	4.0	148.48	1.06	8.0
2	Karakoram	232	4.0	3.655	1.03	7.5
3	Kohistan	594	4.2	10.24	1.08	7.5
4	Eastern Himalayas	431	4.0	7.431	1.13	7.8
5	Western Himalayas	373	4.0	6.431	1.28	7.0

6.6.1.4 MAXIMUM MAGNITUDE

To each seismic area source zone, a maximum magnitude potential was assigned based on determining the maximum magnitude of the longest active fault in the area using Well & Coppersmith equation (1994). The maximum potential magnitude used for each seismic area source zone is given in Table 6-1.

6.6.1.5 ATTENUATION RELATIONSHIPS

Because of lack of sufficient strong–motion data covering a larger range of magnitudes and distances, attenuation relationships for the South Asian Region cannot be developed. A number of attenuation equations have been developed from strong motion data collected in other parts of the world. As shallow earthquakes are of more concern for hazard analysis of the Artistic-II hydropower project, attenuation equations developed for such conditions were considered for use in the hazard analysis for all seismic area sources except deep Hindukush seismic source. For probabilistic hazard analysis, available NGA equations developed under Pacific Earthquake Engineering Research (PEER) Centre, USA by Abrahamson & Silva (2008), Boore & Atkinson (2008) and Campbell & Bozorgnia (2008) were used as these equations are valid for tectonically active regions with shallow crustal faulting worldwide. For Hindukush area source, Youngs et al. (1997) attenuation equation applicable for subduction zone was used. As per geological mapping of the project area, the site foundation condition at both weir and powerhouse sites is predominantly slope wash material so dense soil foundation condition with V_{s30}=600 m/sec is assumed as in-situ shear wave velocity profile of the site is not available.

6.6.1.6 RESULTS OF PSHA

The probabilistic seismic hazard analysis was carried out using window-based EZ-FRISK software developed by Fugro Engineering Consultants, USA. All the parameters defined in Table 6-1 were incorporated in the model. The mean total hazard curve was obtained by giving equal weightage to all the attenuation equations used. The total hazard curves obtained for both weir and powerhouse sites are same and therefore only one hazard curve applicable for both sites is shown in Figure 6-10. This curve shows the annual frequency of exceedance (inverse of return period) of the peak horizontal ground acceleration expected in the project area. The major contribution to the total hazard is from Kohistan and Hindukush seismic area sources. The results of PSHA are summarized in Table 6-2.

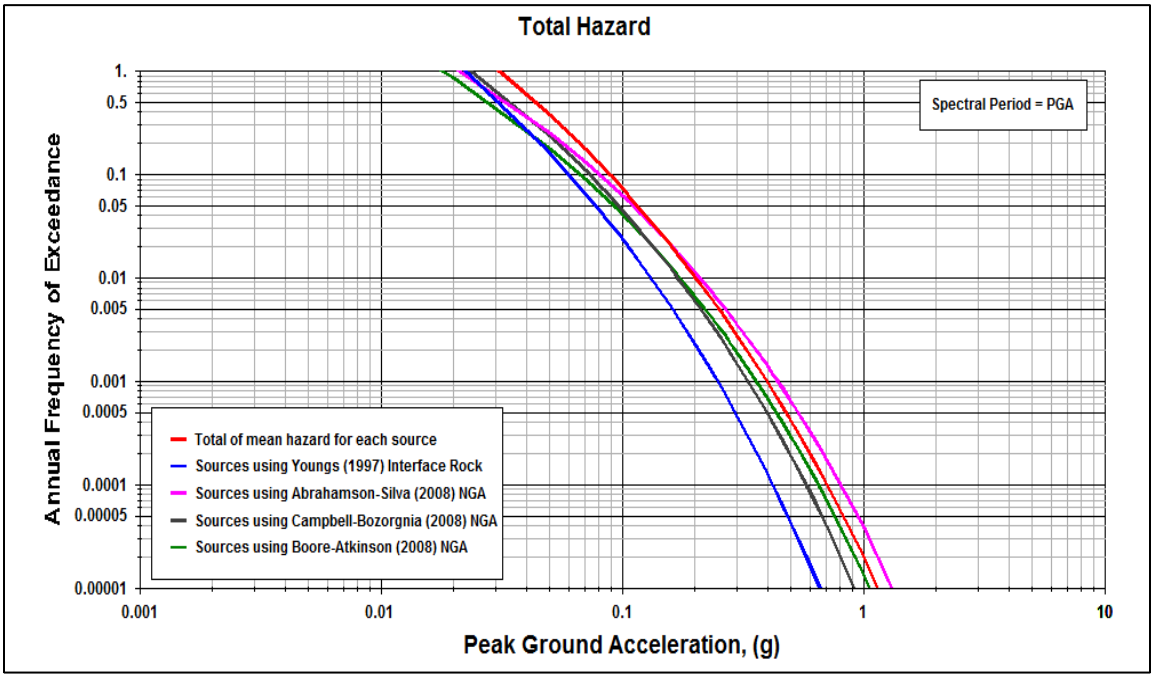

Figure 6-10: Total Seismic Hazard Curve for the Project

Table 6-2: Peak Ground Acceleration for Different Return Periods obtained through PSHA

Annual Frequency of Exceedance	Return Period (years)	Peak Ground Acceleration (g)*
0.007	145	0.22
0.002	475	0.32
0.001	975	0.39
0.00033	3000	0.53
0.0001	10000	0.70

* PGA for very dense soil condition (V_{S30}=600 m/sec)

6.6.2 DETERMINISTIC PROCEDURE

In the deterministic procedure, critical seismogenic sources (active or potentially active faults) that represent a threat to the project are identified and a maximum magnitude is assigned to each of these faults.

The capability of the faults is ascertained through observation of historical and instrumental seismic data and geological criteria such as rupture length – magnitude relationship or fault movement – magnitude relationship.

The maximum seismic design parameter is then obtained by considering the most severe combination of maximum magnitude and minimum distance to the project site, independently of the return period.

The main tectonic features around the project site which could be controlling the maximum earthquake hazard are as follows:

- Main Karakoram Thrust (MKT),
- Kohistan Fault,
- Main Mantle Thrust (MMT), and
- Shandur Thrust

Empirical correlations have been developed between maximum potential of a fault and key fault parameters like rupture length, fault area, fault displacement and slip rate. Out of these fault parameters, only fault lengths are known with sufficient accuracy. For the faults around the site, the half rupture length of the faults has been taken for determination of maximum magnitude potential. The maximum earthquake magnitude (in moment magnitude M_W) of each of the fault was calculated using Wells & Coppersmith (1994), Nowroozi (1985) and Slemmons et al. (1982) relationships between fault rupture length and magnitude and is given in Table 6-3 below.

Table 6-3: Critical Faults and Their Maximum Earthquake Potential

Tectonic Feature	Total Fault Length (Km)	Maximum Magnitude Potential (M_W)			Selected Maximum magnitude M_W
		Wells & Coppersmith (1994)	Nowroozi (1985)	Slemmons et al. (1982)	
Main Karakoram Thrust (MKT)	200	7.5	7.5	7.6	7.5
Kohistan Fault	150	7.3	7.3	7.4	7.3
Main Mantle Thrust (MMT)	200	7.5	7.5	7.6	7.5
Shandur Thrust	90	7.0	6.9	7.0	7.0

The peak horizontal ground acceleration at the site caused by the earthquake of maximum magnitude occurring at the closest distance to fault was then calculated by using the latest attenuation relationships developed by various researchers from strong motion data from USA and worldwide. As shallow crustal earthquakes are more important for the assessment of seismic hazard to the project, therefore equations applicable for shallow crustal earthquakes were employed. For the deterministic analysis, the same three NGA equations used for probabilistic analysis were used. The 50-percentile (median) values of the peak horizontal ground acceleration (PGA) were obtained by three attenuation relationships developed for tectonically similar environments are given in Table 6-4. The NGA equations are preferable for the evaluation of seismic hazard in the near field as these are based on a broad spectrum of data recorded in the near field. For all the seismic sources, thrust rupture mechanism have been assumed. While MKT and Shandur Thrust are dipping away from the site, Kohistan Fault and MMT are dipping towards the site. The site foundation condition was assumed as dense gravelly soil with shear wave velocity of V_{s30}=600 m/sec.

Table 6-4: Peak Horizontal Ground Acceleration (PGA)

Tectonic Feature	Maxi-mum Magni-tude (M_W)	Closest Distance to Fault (Km)	Median Peak Horizontal Acceleration (g)			
			Abrahamson & Silva (2008)	Boore & Atkinson (2008)	Campbell & Bozorgnia (2008)	Idriss (2008)
Main Karakoram Thrust (MKT)	7.5	45	0.10	0.12	0.11	0.11
Kohistan Fault	7.3	55	0.10	0.13	0.12	0.12
Main Mantle Thrust (MMT)	7.5	60	0.10	0.13	0.11	0.11
Shandur Thrust	7.0	2	0.47	0.44	0.56	0.49

6.7 SELECTION OF SEISMIC DESIGN PARAMETERS

6.7.1 DEFINITIONS

According to the ER 1110-2-1806 - Earthquake Design and Evaluation for Civil Works Projects, the definitions of design earthquakes are as follows.

6.7.1.1 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.

6.7.1.2 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 C2, Volume-VI**, Table B-1. 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.

6.7.1.3 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.

6.7.2 SEISMIC DESIGN PARAMETERS

Design seismic parameters are selected on the basis of the results provided by probabilistic and deterministic approaches, and in compliance with the recommendations of ER 1110-2-1806 - Earthquake Design and Evaluation for Civil Works Projects.

6.7.2.1 MAXIMUM DESIGN EARTHQUAKE (MDE) ACCELERATIONS

As the height of the weir is only 6 meters with very low reservoir capacity, therefore, as per ER 1110-2-1806 - Earthquake Design and Evaluation for Civil Works Projects, Hazard Potential Classification for Civil Works Projects in **Annexure C2, Volume-VI**, Table B-1, the project falls in Low Hazard Potential class. As failure of the project would not present a great 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 - Earthquake Design and Evaluation for Civil Works Projects recommends to adopt 975 year or less return period ground motion for Low Hazard Potential Hydraulic structures. As Artistic-II Hydropower

Project is categorized as Low Hazard Potential Hydraulic structure, therefore for all water retaining structures of the project, the recommended ground motion for MDE is 0.39g (corresponding to a return period of 975 year). For all other appurtenant structures including powerhouse, the recommended ground motion for MDE is 0.32g (corresponding to a return period of 475 year).

6.7.2.2 OPERATING BASIS EARTHQUAKE (OBE) ACCELERATIONS

The OBE accelerations are selected from the results of the probabilistic analysis which is presented in Figure 6-10 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.

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 0.22g.

6.7.2.3 UNIFORM RESPONSE SPECTRA

Uniform hazard spectra generated by EZ-FRISK for OBE (145-year return period) and MDE (975 year return period and 475 year return period) are shown in Figure 6-11.

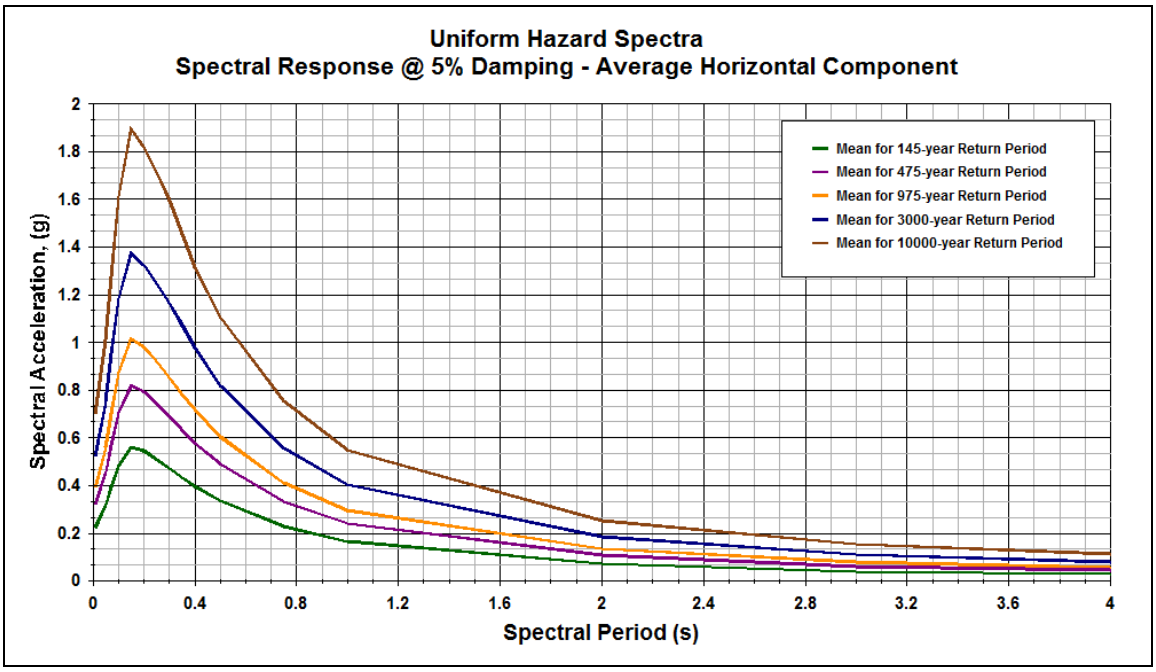

Figure 6-11: Uniform Hazard Spectra obtained through Probabilistic Analysis

6.8 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations regarding study of seismotectonic setting of Artistic-II Hydropower Project and the resulting seismic design parameters are as follows:

a) The project is located in the Kohistan Island Arc which is sandwiched between Indian and the Eurasian tectonic plates and very active seismically.
b) A number of moderate sized earthquakes have been recorded in Kohistan Island Arc during the last 100 years.
c) A number of active faults are present around the project site.
d) The main seismotectonic features considered critical for the seismic hazard for the project are as follows:

- Main Karakoram Thrust (MKT),
- Kohistan Fault,
- Main Mantle Thrust (MMT), and
- Shandur Thrust

e) Both probabilistic and deterministic seismic hazard evaluations were made to determine the expected ground motions at the project site.
f) The recommended horizontal Peak Ground Acceleration (PGA) associated with Operating Basis Earthquake (OBE) is 0.22g.
g) The recommended horizontal Peak Ground Acceleration (PGA) associated with Maximum Design Earthquake (MDE) is 0.39 g for all critical water retaining structures.
h) The recommended horizontal Peak Ground Acceleration associated with MDE for all appurtenant structures and powerhouse is 0.32g.
i) Uniform hazard spectra for OBE and MDEs given for use in the seismic resistant design of the project structures.
j) It is recommended that in-situ shear wave velocity profile of the subsoils at weir and powerhouse sites may be obtained for authenticating the assumption of Vs30.

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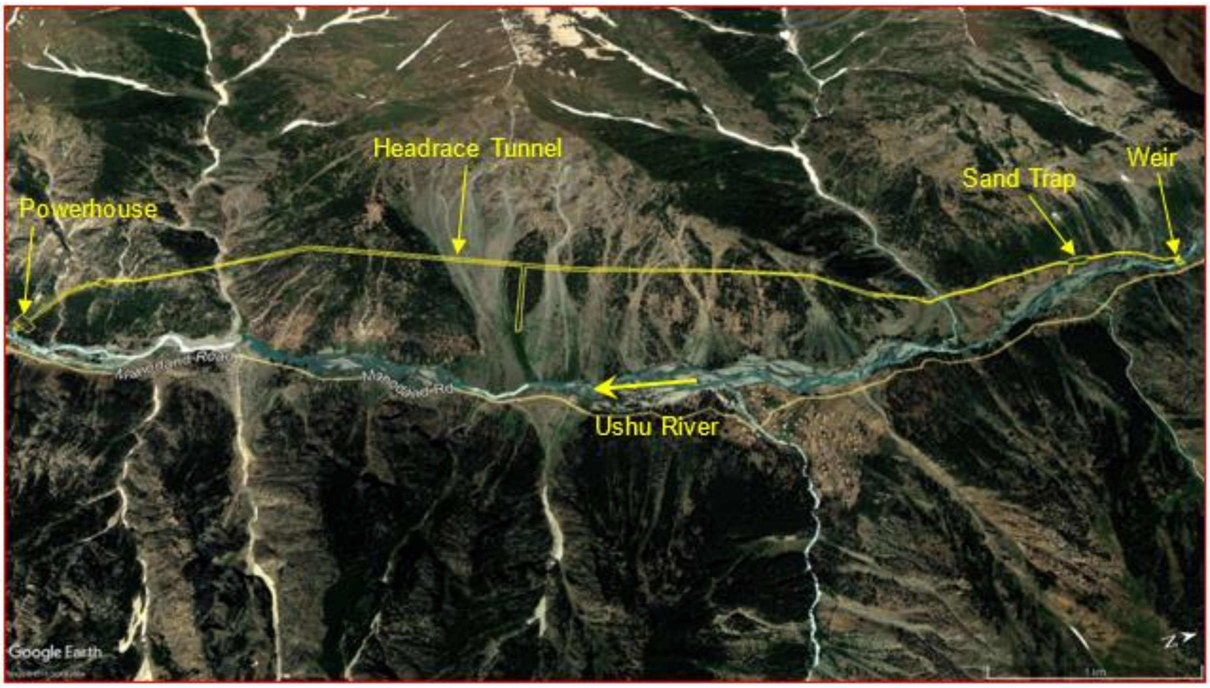
ARTISTIC HYDRO II (Pvt.) Ltd. Karachi

Feasibility Study of Artistic-II Hydropower Project

Ushu River, District Swat



ENVIRONMENTAL IMPACT ASSESSMENT REPORT

June 2020

Artistic-II Hydropower Project Consultants

A Joint Venture of

BAK Consulting Engineers, Pakistan & DOLSAR ENGINEERING*, Turkey*

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ENVIRONMENTAL IMPACT ASSESSMENT (EIA) REPORT

Executive summary

Government of Khyber Pakhtunkhwa is continuously putting immense effort through PEDO in implementing economically sound and environment friendly hydropower projects throughout the province. PEDO is also encouraging public-private partnership and private investors. This effort has gained momentum in recent years. The present study is also an outcome of this hectic effort of the PEDO.

The proposed Artistic-II Hydropower Project is a run-of-river project on Ushu River which is situated on Kalam-Mahodand road. This is one of the potential raw sites identified by Artistic Hydro II, (Pvt) Ltd, Karachi.

The Environmental Impact Assessments (EIA) are being carried out keeping in view the instructions contained in the Khyber Pakhtunkhwa (KP) Environmental Protection Act 2014, IEE/EIA Regulations 2000 and Technical guidelines prepared Pak EPA for Hydropower projects. The estimated power potential of Artistic-II Hydropower Project is 55 MW which falls in schedule “A “of IEE/EIA Regulations 2000.

Objective and Functions of EIA

The overall purpose of the EIA to identify the potential environmental and social impact of the proposed project and evaluate them following the process, which is acceptable to regulatory authorities in Pakistan and the project lenders. In this process, the EIA seeks to identify measures to minimize any anticipated adverse impact of the proposed Project, at least to the level that it meets the national and good international industry practice (GIIP) criteria for evaluation of environmental and social impacts.

The scope of the EIA includes the environmental and social impacts of all activities required in the immediate vicinity of the proposed Project Site.

Study Area

The spatial boundaries of the Study Area for the EIA is selected to cover all areas where any measurable change to any component of the environment is likely to take place, directly or indirectly, due to any activity directly associated with the proposed Project. The selection of the study area takes into account the environmentally sensitive receptors that are most likely to be impacted by the Project’s development activities. It also takes into account the different stages of the project specifically construction and operation. The study area is selected to be large enough to allow the assessment of the Valued Ecosystem Components (VECs) that maybe affected by the Project activities.

Policy and Legal Framework

The EIA process of the Project will be governed by various instruments, namely the policies of the Government of Pakistan, the laws of the Government of Khyber Pakhtunkhwa Province, international environmental agreements to which Pakistan is a party.

Project Description

The Artistic-II is a run of the river hydropower project to be constructed on the Ushu River in district Swat of Khyber Pakhtunkhwa Province. The catchment area of Ushu River at the proposed Weir Site is 454 square kilometre (km^2).

The coordinates of Artistic-II weir are (35º37'42.09" N, 72º41'5.68" E) and of Powerhouse are (35º34'14.14" N, 72º40'19.23""E). The Project is situated on Kalam-Mahodand road. The Weir site is located in village Eshegal and Powerhouse is located upstream of the under construction 84 MW Gorkin Matiltan Hydropower Project near Mai Banda village as shown in **Figure 1-1**. The total land required for the project is approximately 381618.6 sq.m or 94.3 acres.

Alternatives

Project site alternatives were given due consideration keeping in view environmental, social and economic aspects. The present site was found most appropriate and practical.

Anticipated Impacts

Impact on land:

Some cultivated and barren land in Kichgil village, some walk paths and a portion of mountain where box channel and tunnel will be constructed are likely to be affected. The legitimate owners of these properties will be properly compensated in time as per their demand and regulatory provisions.

Impact on socio-economic conditions:

No significant impact is observed on human life during pre-construction period. It is observed that the project is environment friendly which will help improve the socio-economic conditions of the area by providing them employment opportunities, improvement of existing civic infrastructure i.e. roads and bridges and health services.

Impact during Construction Stage:

Disturbance and change in landscape, land use, drainage etc, due to disposal of material obtained from excavation from borrow pits, blasting of rocks, erosion, change in stream regime, likelihood of ambient air quality and noise deterioration, degradation due to construction activities, vehicular movement, labour camp problems, pollution of stream during construction, effects on lower riparian, aquatic life, disturbance to livestock herds and migratory birds are some of the negative impacts which were identified during scoping sessions, however, environmental management plan will be able to mitigate these negative impacts.

Biological Impacts:

Due to construction activities, forest trees and crops may face limited risk of significant biological impacts which may be mitigated with the help of the concerned Divisional Forest Officer and land owners. Disturbance and threat to wildlife and species of flora in the project area seem to be insignificant. However, seasonal movement of common wildlife, disturbance of natural habitat of fish movement and seasonal migration of wildlife due to construction works possibly impacts somewhat on weir site. These impacts will be mitigated through Environmental Management Plan (EMP).

Socio-Economic and Cultural Impacts:

Baseline Socio-Economic situation was studied to ascertain possible impacts on demography of the project area; possible impact on social cultural and religious practices; impacts on social/cultural norms, values and rituals; impact on gender; possible impact on existing civic amenities of people and domestic animals during and after implementation of the project; possible displacement of households, infrastructure, lands and public roads and civic paths, social security, conflicts etc. No indigenous people were found in the project area. No religious and historical monuments are available near the project area which might be affected.

Poverty and Vulnerability aspects of the project population were given due consideration during EIA Studies. It was found that the minimum income of per house hold was Rs. 8,000 to 10,000 per month which exceeded in some cases even more than Rs. 30,000 per month. These income figures relate to the project affected persons only.

Environmental Management Plan:

The Environmental Management Plan (EMP) provides the organizational requirements, management and monitoring plans to ensure that the necessary measures are taken by Consultant/Contractor to avoid potentially adverse effects and maximize potential benefits of the Project as identified in preceding Section of the EIA and to operate in conformance with applicable laws and regulations of KP and Pakistan. The EMP is a standalone document.

Environmental Management System

The Environmental Management System (EMS) ensures that the measures introduced in the EMP are implemented. The framework for the EMS is provided. The EMS that will be developed for the Project will be developed in line with the policies, plans and procedures described by the Khyber Pakhtunkhwa EPA.

Mitigation measures are clear and concise descriptions of the actions that must be executed to mitigate the impacts of the project. Where relevant, targets, indicators, trigger points are incorporated into the management measure. Implementing and monitoring responsibilities are also identified in the mitigation and monitoring plan.

Institutional Implementation

Effective implementation and functioning of the EMP depends on adequate human and financial resources, clearly defined responsibilities for environmental management, appropriate training and good communication.

The following are commitments, which will be achieved:

A) Putting environmental matters high on the agenda of meetings;

B) Highlighting the importance of environmental issues in relation to the HSE considerations in business decisions and communication with stakeholders;

C) Evaluating environmental aspects, before final decisions are reached;

D) Being fully aware of the main environmental hazards associated with the Contractor and Sub Contractor activities and the systems, procedures and field practices in place to manage these hazards;

E) Immediately and visibly responding and being involved in investigating incidents or other abnormal events related to environmental and HS issues;

F) Seeking internal and external views on environmental issues; and recognizing their achievement.

Public Consultation:

As part of the EIA process, consultations are undertaken with communities and institutions that may have interest in the proposed project or may be affected by it. The consultation process was designed to be consistent with the relevant national and provincial legislation. Consultations with the Project stakeholders were undertaken in Oct 2018. Separate meetings with institutional stakeholders were arranged in Bahrain, Madyan and Mingora/Saidu Sharif.

Conclusion:

The proposed project is socio-environmentally friendly and sustainable. People agree with the proposed project but have the following reservations:

The electricity generated locally must be supplied to local population which has very little requirements, rest of the electricity may be utilized according to Government Policy. They agreed to provide their lands and property but needed full justice in entitlement matrix and demanded that compensation rates should be calculated on the existing market rates and payments should be made to the legitimate owners before commencement of project activities. They added that malpractices of all kinds must be checked and controlled by the responsible authorities and the process of estimation and payment should be transparent. Local population must be given preference in employment. They pointed out that they have ownership of the mountains in which tunnels will be excavated and constructed, for which compensation for muck should also be paid to them.

They also indicated that these mountains have vast grazing land which they lease out during summer seasons to shepherds of Buner area who pay rupee six lakh to the community. They stated that this important issue must be kept in the mind of the proponent so that they are not suffered economically.

They stated that the forest trees, land, river and their tributaries are under the sole ownership of the community on which litigation is going on with forest department. They further informed that the district administration is not implementing the decision of High court due to which they have stopped construction work on Gorkin Matiltan HPP. They said that they will not sell out their land without receiving its compensation properly and in advance of starting construction work.

Some participants at Palogah meeting demanded royalty in income from the electricity generated form the Gorkin Matiltan HPP. They were informed that all the issues will be handled in accordance with the Government policy in practice.

These studies have identified alternative actions, mitigation activities, monitoring programme and other necessary aspects related to the social and environmental components of the project. They will be effectively incorporated into the Detailed Design and implementation process, which will help controlling environmental and social impacts to an acceptable level.

1. INTRODUCTION

1.1 GENERAL

Electrical energy produced from the water resources is considered to be a green power as it is non-polluting and renewable in nature. The generation of electrical energy from thermal and nuclear resources always poses many challenges on the environmental front, owing to emission of green-house gases and susceptibility of nuclear plants to harmful nuclear radiations due to technical and human errors. From economic considerations, production of hydropower is cost effective, as the water is a renewable resource and has very little cost in comparison to the fossil fuels required to operate thermal and nuclear power plants. In addition, the power production scenario from other renewable resources such as wind, solar power, bio-gas, etc. is also not very favourable as the technological cost for power generation in above cases is much higher and at the same time, in order to meet the demand of industry, requires a huge infrastructure development.

Hydropower development is the more necessary for countries like Pakistan, where the peaking shortages, both seasonal and daily in power generation are very high, which can only be met with hydropower projects developed for diurnal peaking in a run-of-the river or reservoir scheme. Another very significant benefit of hydropower, in contrast to thermal or nuclear power is the inherent ability of hydropower plants for quick start and stoppage and almost instantaneous load acceptance and rejection. These characteristics of hydropower plants make them an ideal choice for meeting the peak power demands. However, hydropower development does involve concerns of large inundations, disposal of muck/waste material, biodiversity losses, environmental degradation and problems related to resettlement and rehabilitation. The environmental and resettlement concerns of hydropower development can, however, be resolved with the help of scientific and technological knowledge base and prevailing socioeconomic framework provided in the Policies/Acts.

Hydropower potential in Khyber Pakhtunkhwa (KP) Provence especially in northern areas are very high and Pakhtunkhwa Energy Development Organization (PEDO) has been working on this dimension of development for the last three decades to achieve the self-sufficiency in the power sector, the organization is also encouraging public-private partnership and private investors. This effort has gained momentum in recent years. The present study is also an outcome of this hectic effort of the PEDO.

Artistic Hydro II (Pvt) Ltd. plans to develop the 55 megawatt (MW) Artistic-II Hydropower Project which is situated on Kalam-Mahodand road in District Swat, Khyber Pakhtunkhwa

Province (KP). **Figure 1-1** shows the location of the Artistic-II Hydropower Project.

1.2 PROJECT BACKGROUND

The Artistic-II Hydropower project is run of the river project to be constructed on Ushu River in district Swat of Northern areas of Khyber Pakhtunkhwa province. The Weir site is located near village Eshegal and Powerhouse is located upstream of the under construction 84 MW Gorkin Matiltan Hydropower Project near Mai Banda village. The project sites are approachable from Kalam, district Swat. It is connected through under construction road from Bahrain to Kalam. The catchment of the Artistic-II HPP lies in the upper region of the Ushu River, a tributary / sub system of a Swat river basin and can be classified as a “high mountain catchment”. Snowmelt is the principal source of water in the river. Catchment area of the Ushu River at weir location is estimated to be 454 sq.km and at Powerhouse location is approximately 600 sq.km. The total installed capacity of the Artistic-II hydropower project will be 55 MW.

Artistic-II HPP conveyance system is designed for discharge of 34 cumecs. Artistic-II weir is proposed at location which offers relatively better geology and ease in river diversion during construction, as river becomes wider. The normal operating level of the weir is 2505.00 masl. The ogee type overflow spillway body, undersluices and crest elevation of upstream walls were designed according to Q_{1000} flood discharge (511 m^3/s). Since, the valley is relatively wide at this location, the river will be diverted to left bank, during the construction of concrete weir structure at right bank. The estimated flow data at Artistic-II weir site shows that the average maximum monthly flow ranges from 57.76 m^3/s in July to 3.47 m^3/s in February. Availability of flows at the proposed weir/intake site was checked using detailed flow duration curve analysis.

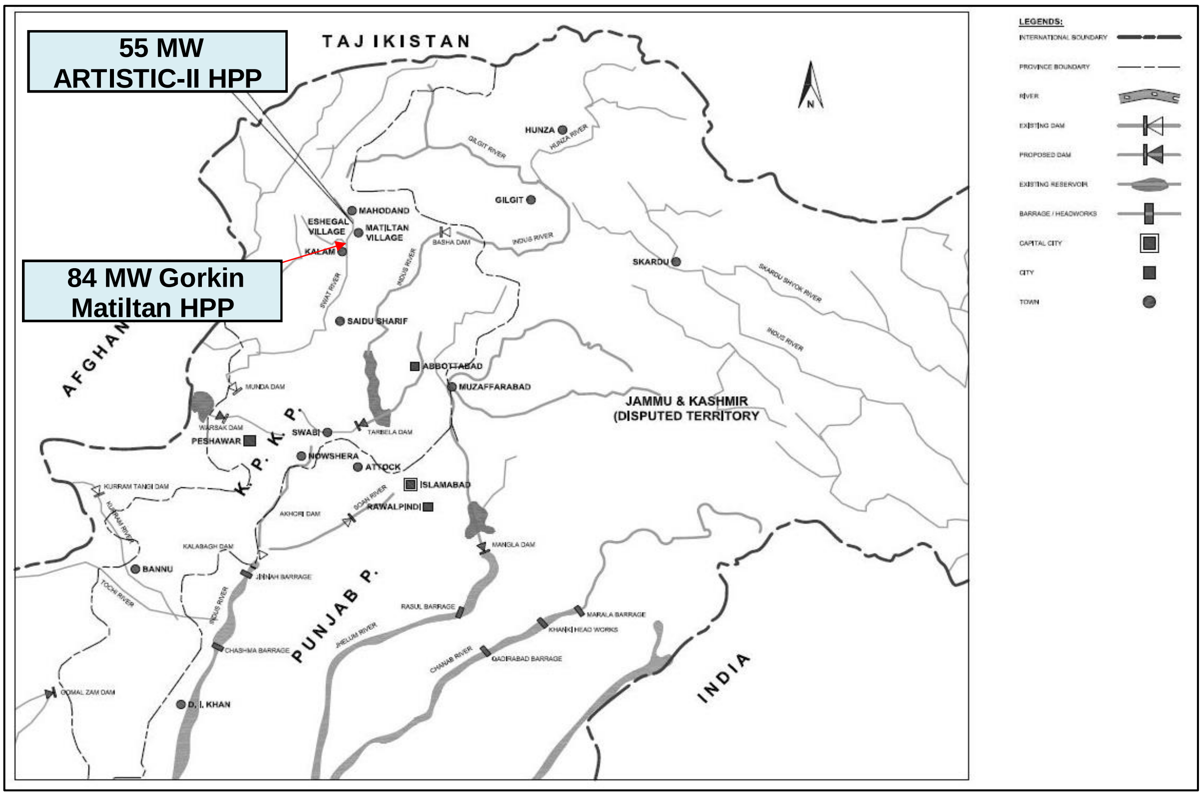


Figure 1-1: Artistic-II HPP and Gorkin Matiltan HPP Location Map

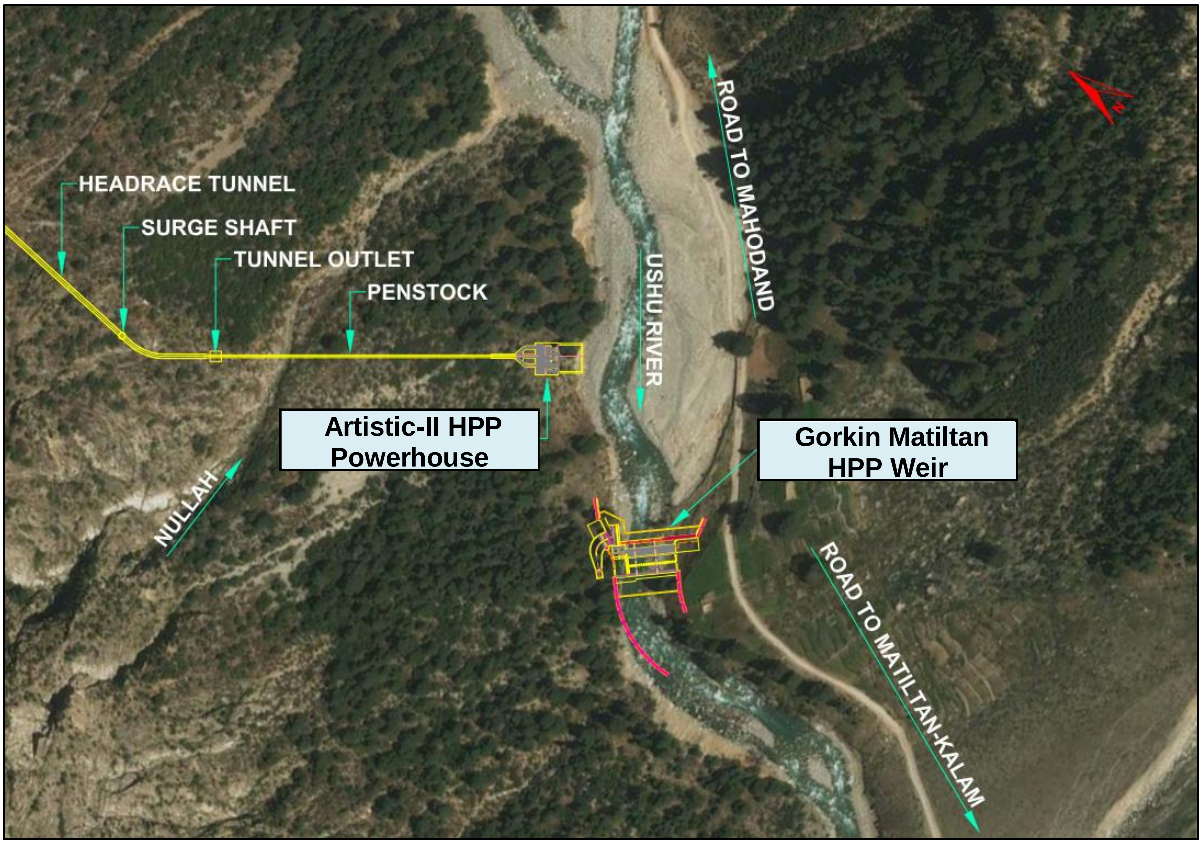


Figure 1-2 Layout of Artistic-II HPP Powerhouse and Gorkin Matiltan HPP Weir

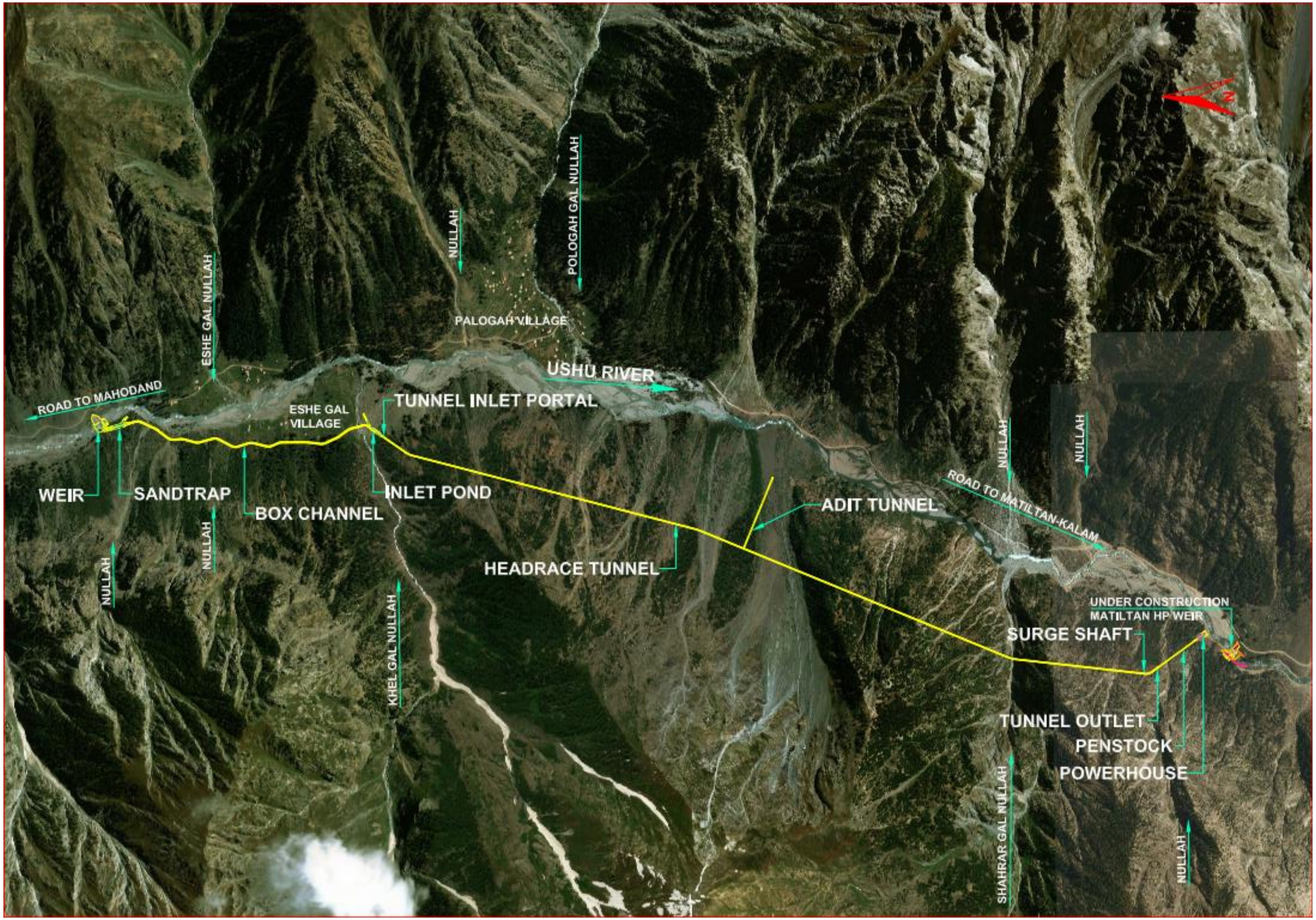


Figure 1-3: Artisitc-II Hydropower Project Layout Plan

Table 1-1Salient Features of the Artistic-II Hydropower System

GENERAL	
Project Layout	Right Bank of Ushu River
Weir Location	Eshegal village, Kalam Valley
Catchment Area	454 sq.km at weir site, 600 sq.km at Powerhouse
Powerhouse location	Mai Banda, Matiltan
Design Discharge	34 cumecs
Gross Head	200 m
Net Head	185 m
Installed Capacity	55 MW
Total Annual Energy	211.745 GWh
Plant Factor	43.67%
Normal Water Level at Weir	2505 masl
Tail water level	2305 masl
WEIR STRUCTURE	
Design Flood (Q_{1000})	511 cumecs
River Bed Elevation at Weir Axis	2499 masl
Weir Type	Overflow Ogee
Weir Height	6 m
Length of Spillway	36 m
Max. Water Level (Q_{1000})	2508.74 masl
SANDTRAP	
Chambers	3 nos
Length of Sandtrap	90 m
Net Width of Sandtrap	18 m
Bottom Slope	2%
Flushing Pipes	3 Nos (steel)
BOX CHANNEL	
Cross-Section	Rectangular Box, Reinforced Concrete
Height of Channel	4.5 m
Freeboard	0.58 m
Width of Channel	5.2 m
Slope	0.0003 (1 in 3333)
Length of Channel	1520 m
HEADRACE TUNNEL	
Cross-Section (inner)	Horseshoe, Reinforced Concrete
Length	4857 m
Diameter (inner)	3.90 m

SURGE SHAFT	
Cross-Section	Circular, Reinforced Concrete
Diameter (inner)	6.1 m
Wall Thickness	0.5 m
Height	94.7 m (above tunnel crown)
VALVE CHAMBER	
Valve Type	Butterfly
Diameter	2.8 m
PENSTOCK	
Type	Buried Steel
Number	1
Length	341 m (including valve chamber)
Diameter	2.8 m
Pipe wall thickness	14 mm ~ 18 mm
POWERHOUSE	
Type	Surface
Turbines	3 Nos. (2 large & 1 small)
Turbines Type	Vertical Axis Francis

1.3 CONCEPT OF THE EIA STUDIES

Environmental Impact Assessment (EIA) is a systematic process for evaluating the environmental consequences of any proposed Policy, Plan or Program initiative in order to ensure that the various concerns are fully identified and appropriately addressed at the earliest stage of decision-making at par with economic and social considerations. The economic, social, and environmental change is inherent to development. Whilst, development aims to bring about positive change, it can lead to conflicts. In the past, the promotion of economic growth, as the moto for increased well-being, was the main development thrust with little sensitivity towards adverse social or environmental impacts. The need to avoid adverse impacts and to ensure long term benefits led to the concept of sustainability. This has become accepted as an essential feature of the development if the aim of increased well-being and greater equity in fulfilling basic needs is to be met for the present and future generations.

EIA thus, has three main functions:

i. To predict positive and adverse impacts.
ii. To find ways to minimize/manage adverse impacts.
iii. To enhance positive effects.

The third function is of particular importance. The EIA provides a unique opportunity to demonstrate ways in which the environment may be improved as part of the development process. The EIA also predicts the conflicts and constraints between the proposed project, program or sectoral plan and its environment. It provides an opportunity for mitigation measures to be incorporated to minimize the problems. It enables monitoring programs to be established to assess future impacts and provide data on which managers can take informed decisions to avoid environmental damage. EIA includes the study of various baseline parameters viz. air, land, water, flora, fauna and social aspects. The principal phenomenon or pathways of impacts are land/soil impacts, air pollution impacts, noise and health effects, ecology impacts including endangered species assessment, geological hazards assessment, water pollution and aquatic impacts, etc. whereas related analysis of social impacts is achieved through social impact assessment wherever necessary.

Integration of these parameters gives an overall perception of both positive and adverse impacts due to any project construction.

With reference to hydropower development in our country, it is pertinent to point out that EIA is now a mandatory requirement and has to be carried out according to the Terms of Reference (ToR) defined by the Government of Pakistan. International financial institutions have also laid down stringent environmental guidelines for developmental projects and financial assistance is possible only after the borrowing agency has fully committed itself to adopt adequate provisions for environmental conservation, management and impact minimization/ mitigation.

Since the Stockholm Conference in 1972, there is a co-evolutionary race between the thrust of development on the one hand and the stringency of newer concerns in Environmental Impact Assessment (EIA) on the other. It has many positive fall outs, notwithstanding some acrimonious debates on many occasions that have racked up between environmentalists and developers.

The positive outcome includes acceptance of internalization of environmental concerns by industry/ institutions connected with development, evolution of policy planning frameworks and technological innovations, which minimize negative/adverse impacts of the developmental activities on environmental resources. The ‘clean technologies’, ‘green rating ‘and ISO 14000 certification are some of the important outcomes that have followed the environment development debate.

The complexity of EIA varies greatly from project to project and depends vastly on the magnitude of operations involved in the developmental activity of the projects to be undertaken in that particular area. Further, EIA studies have to be conducted within several intrinsic and external constraints, which call for the focused expertise of individuals, who are involved in EIA and also for the prior firming up of the detailed project reports (DPR) by the development authorities and decision-makers.

It is well known that in the process of impact assessment and prediction, one must bear in mind the irreversibility and reversibility of the impact(s) of development on the various environmental aspects and resources. There are some project activities which create impacts that are temporary in nature. Noise and air pollution, for example, constitute a temporary impact by a developmental activity on a dam construction site. These impacts are reversible because they are likely to cease and normal environmental quality will be restored once the construction activity is completed. Similarly, adverse impact on water quality (physio-chemical characteristics) of a river receiving effluents from an industry is likely to be brought back to normal levels after installation of effluent treatment plant or relocation of the industry, etc. However, there are other impacts which are irreversible and even with the best of technology in place, nothing can be done to reverse the process and bring such environmental resources back.

EIA report is based on analysis and findings of collected data and field observations. It contains baseline information on the present environment of the project area and Environmental Impact Assessment for different components of the proposed project. The mitigation plan has been devised to overcome the adverse impacts in the project area.

1.4 OBJECTIVE AND SCOPE OF EIA

The overall purpose of the EIA to identify the potential environmental and social impact of the proposed project and evaluate them following the process which is acceptable to regulatory authorities in Pakistan and the project lenders. In this process, the EIA seeks to identify measures to minimize any anticipated adverse impact of the proposed Project, at least to the level that it meets the national and Good International Industry Practice (GIIP) criteria for evaluation of environmental and social impacts.

The specific objectives of this EIA were to:

i. Assess the existing environmental conditions in the project area, including the identification of environmentally sensitive areas.

ii. Assess the proposed activities to identify their potential impacts, evaluate the impacts, and determine their significance.

iii. Assess effects on aquatic ecology.

iv. Propose appropriate mitigation and monitoring measures that can be incorporated into the design of the proposed activities to minimize any damaging effects or any lasting negative consequences identified by the assessment.

v. Assess the proposed activities and determine whether they comply with the relevant environmental regulations in Pakistan and Khyber Pakhtunkhwa (KP) and the requirements of project lenders.

vi. Prepare an EIA report for submittal to the Khyber Pakhtunkhwa Environmental Protection Agency (KP-EPA) and the lenders.

The scope of the EIA includes the environmental and social impacts of all activities of the proposed project in the immediate vicinity of the proposed project site during construction and operation phases of the project.

To evacuate power from the proposed project, transmission line to be constructed by National Transmission and Dispatch Company (NTDC) falls in the category of associated project. It is essential that NTDC undertake the EIA of the transmission line and develop a sound EMP consistent with the national legal environmental requirements. The scope of this EIA does not include the design, construction, and operation of the transmission line for evacuation of the power produced by this project.

1.5 APPROACHES TO THE PROJECT AREA.

The proposed project is located on Ushu River in District Swat of Khyber Pakhtunkhwa Province. Ushu River is a tributary / sub system of a Swat river basin and can be classified as a “high mountain catchment”.

The project area is a part of tehsil Bahrain that is approachable from Peshawar and Islamabad through a metalled road up to Bahrain and also up to Kalam which is under construction. Swat district will also be connected with M1 Motorway, the construction work is going on rapidly which will save time and resources.

1.6 METHODOLOGY

In this study, standard methods were followed for Environmental Impact Assessment. All the methods were structured for collection and organization of environmental baseline data and identification of environmental impacts using different survey tools and discussions with different stakeholders. The information, thus gathered, has been analysed and presented in the form of a number of visual formats for easy interpretation and decision-making.

1.7 STUDY AREA

The study area related to EIA of the project comprised the following features / aspects:

a) Catchment area of the project
b) Influence zone area that is the area in the region within 5 km radius from the project site and the reservoir margins, where the impacts can possibly visualize, excluding the upstream areas of higher elevation as there would be no adverse impacts.
c) The project study area is spread over the following components:

   i. Catchment area of the project.
   ii. Weir Site area
   iii. Powerhouse area
   iv. Proposed Labour camps / contractor's offices area
   v. Downstream settlements along both sides of the river from the weir site to the powerhouse site
   vi. Proposed staff residential colony/offices area

A reconnaissance survey was carried out in the Kalam valley during the year 2018. Thereafter, several visits were made to understand the terrain and vegetation of the study area as well as catchment area of the project.

During these visits, the preliminary interpreted data were tested and necessary corrections made after knowing proper ground truths. The physiographic features on satellite imagery appearing in different tones and textures were used to correlate image elements and ground features for accurate identification. During the field visit, emphasis was laid on ground verification for refinement of the land use/ land cover classification scheme.

a) Different forest classes identified and the degraded areas and scrubs delineated for erosion mapping. The high altitude grasslands/alpine pastures and agricultural areas also identified and delineated.
b) Fauna of the study area was identified and lists of various classes were compiled.
c) Rare and endangered species were identified referring to the Red Data Book of Pakistan (2003) and other available literature.
d) Socioeconomic and cultural resources of the study area were also assessed.

1.8 SURVEYS

Preliminary and then detailed environmental surveys were conducted, in the study area, in October 2018 to collect data related to geology, flora, fauna, forest types and ecological parameters including soil types. During these surveys, data and information were collected on physical and biological attributes of the study area. In addition, detailed surveys and studies were also conducted for understanding aquatic ecology and fish life of Ushu River and its tributaries. A comprehensive socioeconomic survey of the project affected villages and families was also conducted. The detailed questionnaires used for the collection of data on villages and individual households. Detailed environmental surveys were also conducted in the reservoir area. For this purpose, the prepared land use and land cover map was checked with respect to various attributes such as land features, rivers, forests and vegetation types on the ground in the reservoir, project and other parts of the study area.

Spatial database on the physiographic features was prepared based on the various data sources including Survey of Pakistan (SoP), topographic sheets, and satellite images data. These data were extracted and presented in accordance with the standard EIA methodology used for such studies.

The section on climatology has been taken from the detailed report of the project. This section contains the source of database and detailed methodology adopted for deriving water discharge series at the weir site, design flood and sedimentation rate, etc.

The regional geology and seismotectonic of the region are discussed based on various data sources. Particularly, the discussion on project geology has been based on the data available in the project report and field observations in selective pockets of different project affected sites. The landslides and geomorphology have been discussed based upon field observations at particular locations. Land use and land cover mapping was carried out by standard methods of analysis of remotely sensed data followed by ground truth, which included use of image elements like tone, texture, shape, location, association, pattern, etc. and were adopted for vegetation mapping and ancillary information like elevation and land forms.

Different forest classes were identified and the degraded areas and scrubs were delineated for the purpose of erosion mapping. The high-altitude grasslands/ alpine pastures and agricultural areas were also identified and delineated. The non-forest land cover in the form of rocky land, moraines, glaciers, lakes, etc. were also delineated for the calculation and classification of erosion intensity.

Soil resource mapping of the proposed project area was prepared from the basic data/map of soil classification contained in Soil Survey of Pakistan.

Forest types and plant species were recorded during the field visits and the floristic data for the catchment were sourced from the published literature. Rare and endangered species were identified referring to the Red Data Book of IUCN Pakistan (2003) and other available literature.

In order to collect the information on the fauna (mammals, avifauna, herpetofauna, and butterflies) in the catchment area of Ushu River, primary as well as secondary sources were utilized.

The Forest Working Plans of the Forest Divisions falling in the project area were referred for secondary information on the wildlife of the catchment area.

Interviews of the local villagers for the presence of various animal species within each locality were also taken to have first-hand information.

1.9 IMPACT PREDICTION

Prediction of impacts has been based on a broad matrix group ‘ecosystem’ constituted by physical and biological components. The vulnerability of an ecosystem to various impacts resulting from an activity or multiple activities were identified and accordingly impacts predicted. The main theme of the ecosystem approach in visualizing impacts on various sets of environmental data revolves around the idea that natural processes and patterns are likely to be affected under impacts of a developmental activity. In natural ecosystems, the impacts would surely change the existing state of equilibrium. In managed ecosystems and human societies, impacts could be of positive as well as adverse consequence. Similarly, in case of natural ecosystems, likelihood of adverse impacts could be seen in terms of temporary or permanent impacts. In the absence of long-term data availability on various environmental variables and the paucity of studies on their likely responses to changes under developmental activities, it is difficult to predict impacts with a high degree of exactness and certainty. For example, it will not be possible to predict impacts of such a developmental activity on the behavioural patterns of animal and bird populations except for the fact that their habitats may come under stress. In that sense these predictive impacts could be said to have a limitation.

The quantification of various parameters like agricultural lands / residential area, commercial area, reservoir area and built up area was done.

The mitigation measures and environmental monitoring have been worked out in the light of environmental impacts assessed. The resettlement issues have been taken care of and for this purpose estimates of the affected population were made according to the census of 2017 and physical survey of the study area. Potential resettlement areas have been identified and visited for further evaluation.

Interviews, field visits/surveys, scoping sessions with officials/notables and concerned stakeholders were also made for the accomplishment of the study.

2. REGULATORY LAWS AND THE INSTITUTIONAL FRAMEWORK

2.1 GENERAL

This section provides an overview of the current national and international legislation, policies and guidelines, which will have a bearing and relevance to the planning, design, implementation and operation of the project. It is mandatory to comply with all appropriate national legislation relating to the environment in Pakistan and to obtain all regulatory clearances required. Letters of no objection to the project have to be issued by the relevant national and provincial environmental regulatory authorities. The project will also be required to conform to the World Bank Operational Manual (Policy) and Asian Development Guidelines.

2.2 POLICY REQUIREMENTS

The main Federal Government policy documents that are directly applicable to the proposed project are the National Conservation Strategy, Provincial Conservation Strategy, the Resettlement Policy and the Pakistan Power Policy of 2002. The Ministry of Environment is responsible at the Federal level for policy, planning and implementation in respect of environmental aspects in Pakistan. The Pakistan Environmental Protection Council (PEPC) headed by the Chief Executive of Pakistan is the highest inter-ministerial and multi-stakeholder decision making body for such matters. The various Federal Government policy documents on environment have also been made applicable to all the provinces of Pakistan. Accordingly, the Ministry of Environment of KP is responsible for the compliance/implementation of all the environmental regulations in the Khyber Pakhtunkhwa Province.

2.3 THE PAKISTAN NATIONAL CONSERVATION STRATEGY (PNCS)

The Pakistan National Conservation Strategy (PNCS) is the principal policy document for environmental issues in the country and was developed and approved by the Government of Pakistan on March 1, 1992. The PNCS works on a ten-year planning and implementation cycle, and deals with 14 core areas, which are: a) maintaining soils in cropland b) increasing irrigation efficiency c) protecting watersheds d) supporting forestry and plantations e) restoring rangelands and improving livestock f) protecting water bodies and sustaining fisheries g) conserving biodiversity h) increasing energy efficiency i) developing and deploying material for renewable energy j) preventing/abating pollution k) managing urban wastes supporting institutions for common resources m) integrating population and environmental programs, and n) Preserving the cultural heritage.

2.4 SARHAD PROVINCIAL CONSERVATION STRATEGY (SPCS)

United Nations Environment Programme, the World Wildlife Fund and International Union for Conservation of Nature (IUCN), and the World Conservation Union (WCU) proposed and then funded the development of a global strategy for the rational development and conservation of natural resources, called the World Conservation Strategy (WCS) - Living Resource Conservation for Sustainable Development. It was launched in 1980. After the completion of National Conservation Strategy of Pakistan, the KP Government approved the preparation of Sarhad Provincial Conservation Strategy (SPCS), 1992. The SPCS used a two-track approach during the two years of strategy finalization activities i.e. preparation of an environmental profile, institution strengthening and awareness raising were implemented in parallel. The SPCS is the principal plan for implementing the National Conservation Strategy in KP. Its specific objectives are: a. Treatment of the fundamental social problems that are the underlying cause of environmental degradation. b. Conservation, rehabilitation, and sustainable development of natural resources such as forests, water, soil and wildlife. c. Protection of living environment from air, water and soil pollution. d. Development of high-quality environmental protection mechanism, including appropriate legislation, development planning mechanism, environmental quality standards and participatory and regulatory institutional arrangements. e. Improvement of institutional and financial capacity to achieve sustainable development of the province s' natural resources. f. Protection and conservation of the cultural heritage of the KP. g. Rising of public awareness and understanding of conservation and sustainable development.

2.5 KHYBER PAKHTUNKHWA COMPREHENSIVE DEVELOPMENT STRATEGY 2010-2017 (SECTION 29; ENVIRONMENT)

Khyber Pakhtunkhwa, historically, has established a high profile in the environmental arena in Pakistan. The province was the first to begin the implementation of Pakistan's National Conservation Strategy, and formulated the first-ever Sarhad Provincial Conservation Strategy in 1992. The provincial Environment Department (ED) oversees the affairs of the Environmental Protection Agency (EPA), which is the key agency dealing, with the environmental agenda in the province. The ED also oversees the affairs concerning fisheries, forests and wildlife, and transport sub-sectors. Amongst the most pressing environmental problems in KP are a high population growth rate and population density; a narrow rural economic base; an exodus to urban centres; congestion and pollution; the brunt of Afghan refugees; waterborne diseases; lack of awareness, education and research; and inadequate institutional infrastructure. Almost all Comprehensive Development Strategy (CDS) proposed priority measures will be required to be environmentally assessed to ensure their compliance with the environmental regulations. These assessment measures include the modification of the PC-I to include environmental impact, and the use of the PC-II for financing the Environmental Investigation Agency. There are also a large number of measures, proposed under the various sectors in the CDS which, once implemented, will directly contribute to the environmental improvements in the province. Key measures are: a) Improvement of the spatial planning and management of urban land; b) Improvement in planning for urban transportation systems; c) Updating of the urban development plans; d) Bringing of cultivable wasteland into farming, through the provision of irrigation and land development with the help of bulldozers and tractors; e) Provision of new access to safe drinking water, with appropriate supervision of quality, especially in un-served or underserved areas, and improved maintenance and reliability of the existing supplies; f) For the irrigation and drinking water supply strategy (DWSS), promotion of water saving measures and local water harvesting schemes, reducing unaccounted for water, promoting metering and so on; g) Promotion of new arrangements for collaboration with communities and for public private partnership in water supply; h) Preparation of the provincial DWSS; i) Refining and finalizing the Provincial Sanitation Strategy and preparing for its implementation, including a programme of incentives, giving 20% match funding to the national programme; j) For the irrigation and DWSS, establishing a management information system to ensure evidence based municipal planning; k) Promotion of alternative energy resources; l) Implementation of the Third Flood Sector Project and 10-Year Comprehensive Flood Protection Plan; m) Implementation of small dams, rainwater harvesting ponds and actions to harness hill torrents; n) Rehabilitation and improvements to existing irrigation schemes; for the irrigation and DWSS, establishment of water quality management and monitoring; o) Upgrading of capacity in integrated water resources management and production of a master plan; p) Expansion of large and medium-scale water storage capacity for the irrigation and DWSS, a feasibility study on groundwater potential and regulatory mechanisms and preparation of a plan for the financial sustainability of irrigation and drainage; q) Together with these measures, however, the Environmental Protection Agency (EPA) of the Environment Department will require resources to continue strengthening its capacity in the areas of environmental awareness raising, environmental monitoring and compliance, and strengthening of review processes (e.g. IEE and EIA) in the province.

2.6 POLICY FRAMEWORK

Based on the NCS, policies are being framed for institutional strengthening and human resource development for environmental protection, especially at the local and provincial level. The NCS is a policy document that deals with the core environmental issues in Pakistan at the macro level and recommends an action plan to address these issues. As a signatory to the

Convention on Biological Diversity in 1992, it was also mandatory for Pakistan to develop a national strategy for the conservation of biodiversity. The Biodiversity Action Plan (BAP) recognizes that at the project level Environmental Impact Assessment is used as a tool to identify the environmental impacts of any proposed project and suggests ways for reducing adverse impacts.

2.7 RESETTLEMENT POLICY OF PAKISTAN, 2002

An important aspect of EIA is consideration of the displacement and relocation of the project affected population. A new resettlement policy has yet to be approved by Government but amendments to the Land Acquisition Act of 1894 have been made from time to time. The Resettlement Policy of Pakistan (2002) is currently in a draft form with the Pakistan Environmental Protection Agency. The policy has been formulated to ensure an equitable and uniform treatment of the resettlement issues throughout Pakistan. This policy will apply to all development projects involving adverse social impacts, including land acquisition, loss of assets, loss of income, loss of business and other possible losses. The draft Resettlement Policy addresses those areas, which are not taken care of in the Land Acquisition Act of 1894 (LAA), and will be applicable wherever any public sector or private development project affects people, families or communities, even when there is no displacement of population. The legal procedures for land acquisition have the objective of providing adequate compensation for the loss of income to those who suffer loss of individual or communal property, including common assets, productive assets, structures, other fixed assets, income and employment, loss of community networks and services, pastures, water rights, public infrastructure like mosques, shrines, schools, graveyards and any consequential losses.

2.8 THE PAKISTAN POWER GENERATION POLICY 2002

The Power Generation Policy of the Government of Pakistan (GoP) aims to reform the power sector through restructuring and deregulation. The aim is to help the country to meet its future power needs. WAPDA and Karachi Electric Supply Company (KESC) are the two main producers and distributors of electricity in Pakistan. KESC has already been privatized, while WAPDA is still a public organization. WAPDA owns 54% of national electricity generation and distribution and serves about 88% of the electrical customers in Pakistan. WAPDA has prepared a Hydropower Development Plan- “Vision 2025”to meet the deficit of electricity through proposed provision of additional generation capacity. The objectives of the power policy are to: a. Provide sufficient capacity of power generation at the least cost to avoid capacity shortfall. b. To encourage and ensure exploitation of indigenous resources, human resources, participation of local engineering and manufacturing capabilities. c. To ensure that all stakeholders are looked after in the process. d. To safeguard the environment, the requirements of the Pakistan Environmental Protection Act (PEPA), 1997 relating to environmental protection, environmental impact and social soundness assessment shall have to be met.

2.8.1 FEDERAL STATUTORY FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT AND ASSESSMENT

The key items of the existing regulatory framework at the Federal level that have implications for the proposed project are identified and discussed below. These include Ordinances, Acts, Laws, Regulations, Rules and Guidelines.

2.8.2 THE PAKISTAN ENVIRONMENTAL PROTECTION ORDINANCE 1983

The Pakistan Environmental Protection Ordinance, 1983 (PEPO 1983) was the first legislation designed specifically for the protection of the environment in the country. The Pakistan Environmental Protection Agency was established in 1984. This is the primary government institution dealing with environmental issues. Significant work on developing environmental policy was carried out by the late 1980s, which culminated in drafting of the Pakistan National Conservation Strategy. Provincial Environmental Protection Agencies were also established at about the same time. The National Environmental Quality Standards were established in 1993 and then revised in 2000. The enactment of PEPA No XXXIV of 1997, conferred broad- based enforcement powers to the Environmental Protection Agencies. The publication of the Pakistan Environmental Protection Agency Review of IEE and EIA Regulations (IEE- EIA Regulations), 2000, provided the necessary details on the preparation, submission, and review of Initial Environmental Examinations (IEE) and Environmental Impact Assessments (EIA). In addition to the PEPA of 1997, Pakistan’s statute books contain a number of other laws that have clauses concerning the regulation and protection of the environment. A summary of the laws and regulations relevant to the proposed Artistic-II project in the context of environmental assessment and management of the project are given in **Table 2-1**.

Table 2-1 Major Sectors of Pakistan Environmental Legislation

Sr. No	SECTOR	LEGISLATION
1	Environmental Protection	The Pakistan Penal Code (1860) Pakistan Environmental Protection Act, No. XXXIV of 1997
2	Land Use	The Pakistan Penal Code (1860) The Canal and Drainage Act (1873) The Baluchistan, Khyber Pakhtunkhwa, Punjab and Sindh Local Government Ordinance(s) (1979/80) On farm Water Management and Water Users' Associations Ordinance (1981)
3	Water Quality and Resources	The Pakistan Penal Code (1860) The Motor Vehicles Ordinance (1965) and Rules (1969)
4	Air Quality	The Motor Vehicles Ordinance (1965) and Rules (1969)
5	Noise	The Motor Vehicles Ordinance (1965) and Rules (1969)
6	Toxic or Hazardous Substances	- The Pakistan Penal Code (1860) - The Explosives Act (1884) - The Agricultural Pesticides Ordinance (1971) and Rules (1973)
7	Solid Waste and Effluents	- The Baluchistan, Khyber Pakhtunkhwa, Punjab and Sindh Local Government Ordinance(s) (1979/80) - Pakistan Environmental Protection Act, No. XXXIV of 1997
8	Marine and Fisheries	- The West Pakistan Fisheries Ordinance (1961) - The Khyber Pakhtunkhwa Fisheries Rules (1976)
9	Forest Conservation	- The Forests Act (1927). - The Khyber Pakhtunkhwa Hazara Forest Act (1936) - The West Pakistan Firewood and Charcoal (Restrictions) Act 1964 - The Cutting of Trees (Prohibition) Act (1975) - The Khyber Pakhtunkhwa Management of Protected Forests Rules (1975) - The Khyber Pakhtunkhwa (Conservation and Exploitation of Certain Forests) - The Khyber Pakhtunkhwa Forest Development Corporation Ordinance (1980) - The Protection of Trees and Brushwood Act of 1949

Sr. No	SECTOR	LEGISLATION
10	Parks and Wildlife Conservation Protection	- The West Pakistan Ordinance (1959) - The Khyber Pakhtunkhwa Wildlife (Protection, Preservation, Conservation and Management) Act (1975) and Rules (1976) - Northern Areas Wildlife Preservation Act (1975) - The Pakistan Plant Quarantine Act (1976) - The Khyber Pakhtunkhwa Local Government Ordinance - Export and Control Order (1982)
11	Mineral Development	The Regulation of Mines and Oil-Fields and Mineral Development (Government Control) Act (1948)
12	Cultural Environment	- The Antiquities Act (1975)
13	Livestock	- West Pakistan Goats (Restriction) Ordinance (1959) - The Grazing of Cattle in Protected Forests (Range Lands) Rules (1978) - Pakistan Animal Quarantine (Import and Export of Animals and Animal Products) Ordinance (1979/80) - The Khyber Pakhtunkhwa Local Government Ordinance.
14	Resettlement	- Land Acquisition Act 1894 - Project Implementation and Resettlement Ordinance - Draft Resettlement Policy of Pakistan,2002 - The Telegraphy Act (1910) - The West Pakistan Water & Power Act (1958) - The Electricity Act IX (1910)
15	Public Health and Safety	- The Pakistan Penal Code (1860) - The Public Health (Emergency Provisions) Ordinance (1944) - The Khyber Pakhtunkhwa Local Government Ordinance. - The West Pakistan Epidemic Diseases Act (1979/80)

Source: Pakistan Environmental Assessment Procedures, Pakistan EPA, Islamabad.

2.8.3 THE PAKISTAN ENVIRONMENTAL PROTECTION ACT (PEPA) NO. XXXIV OF 1997

This comprehensive piece of legislation has evolved over time to provide the legal framework for the preparation and implementation of national environmental policies. It is entitled “The Pakistan Environmental Protection Act, 1997 (PEPA 1997)”. The PEPA was enacted in 1997, repealing the PEPO of1983. The PEPA 1997 provides the framework for implementation of the National Conservation Strategy, including the protection and conservation of species, wildlife, habitats and biodiversity, along with the conservation of renewable resources. The PEPA also establishes the standards for the quality of the ambient air, water and land, along with the establishment of Environmental Tribunals and appointment of Environmental Magistrates. The need and nature of Initial Environmental Examinations (IEE) and Environmental Impact Assessments (EIA) are given along with the need for promotion of public education and awareness of environmental issues through the mass media. The PEPA of 1997 is the basic legislative tool empowering the government to frame regulations for the protection of the environment. This enabling Act is applicable to a broad range of issues and extends to air, water, soil, marine, and noise pollution, as well as to the handling of hazardous wastes. Penalties have been prescribed for those contravening the provisions of the Act. The key features of the Act that have a direct bearing on the Artistic-II Hydropower Project are the following:

Section 11(1) states that “Subject to the provisions of this Act and the rules and regulations made thereunder, no person shall discharge or emit, or allow the discharge or emission of, any effluent or waste or air pollutant or noise in an amount, concentration or level, which is in excess of the National Environmental Quality Standards.” The Pakistan Environmental Protection Agency (Pak-EPA), the body mainly responsible for enforcing the PEPA of 1997, has published National Environmental Quality Standards (NEQS), which are applicable to all the projects. These are given as **ANNEXURE 1**. Drinking water quality standards of Pakistan and Section 12(1) requires that “No proponent of a project shall commence construction or operation unless he has filed with the Federal Agency an Initial Environmental Examination [IEE] or, where the project is likely to cause an adverse environmental effect, then an Environmental Impact Assessment [EIA], and has obtained from the Federal Agency approval in respect thereof. “Section 12(2) the Federal Agency shall review the Environmental Impact Assessment report and accord its approval subject to such conditions as it may deem fit to impose, or require that the Environmental Impact Assessment be resubmitted after such modifications as may be stipulated, or reject the project as being contrary to environmental objectives. Section 14 requires 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 or Provincial 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 Pakistan Federal or Provincial EPA to issue regulations regarding Licensing procedures and to define ‘hazardous substance’.

2.9 THE PROJECT IMPLEMENTATION AND RESETTLEMENT ORDINANCE OF 2001

The Government has proclaimed an ordinance entitled “Project Implementation and Resettlement of the Affected Persons Ordinance 2001", later referred to as the “Resettlement Ordinance". This ordinance will be used to safeguard the interests of the persons/groups, who have to be involuntarily resettled due to land acquisition caused by a proposed project. This Ordinance establishes that the resettlement of the involuntarily displaced persons is done as a matter of right and not by way of charity or any such sentiment. In addition, the Affected Persons (APs) shall be accepted as special groups, who in the supreme interest of the country has accepted/undergone involuntary displacement. The proposed Ordinance shall be supplementary to the Land Acquisition Act of 1894, as well as other Laws of Pakistan, and, wherever such items are included in the Draft Resettlement Policy.

2.9.1 THE LAND ACQUISITION ACT, 1894 (INCLUDING LATER AMENDMENTS)

The Land Acquisition Act of 1894 sets out the rules and procedures for acquiring land and immovable assets needed for development. The Act sets out the methodology for compensating the owners of affected land and assets. The Act comprises 55 Sections dealing with area notifications, surveys, acquisition, compensation, apportionment awards, dispute resolution, penalties and exemptions. However, it does not cover the aspect of resettlement of the affected population. In this respect, the GoP is in the process of formulating appropriate laws and policies with the assistance of the ADB. It should be noted that there have been frequent revisions to the Land Acquisition Act and that the latest revisions will apply.

2.9.2 THE ANTIQUITIES ACT, 1975

The Antiquities Act of 1975 ensures the protection of cultural resources in Pakistan. The act is designed to protect defined “antiquities “from destruction, theft, negligence, unlawful excavation, trade and export. Antiquities have been defined in the Act as ancient products of human activity, historical sites, or sites of anthropological or cultural interest and national monuments. The law prohibits new construction in the proximity of a protected antiquity and empowers the Government of Pakistan to prohibit excavation in any area, which may contain articles of archaeological significance. The guideline procedure for Environment Assessment recommended by the Pakistan EPA reads as follows:

“If the proponent or the consultant identifies an archaeological site that appears to be of importance but the site is not listed, they should discuss the site with the relevant conservation authority”. “The relevant conservation authority should inform the Responsible Authority of their assessment of the significance of the likely impact of the proposed development early in the process, for the Responsible Authority to determine the level of documentation required. The EPA will then be in apposition to review the level of reporting required in the light of advice from the Archaeology Department". The Federal Department of Archaeology and Museum, Government of Pakistan, is the sole custodian of all articles of archaeological finds and historical heritage. The above powers have now been given to the provinces after the devolution of Federal Authority.

2.9.3 THE TELEGRAPHY ACT, 1910

The Telegraphy Act of 1910 was promulgated for installation of telegraph poles and stringing. The Act allows provision for installing poles and towers without the need to acquire any land. However, there is provision for temporary acquisition of land during the construction period of such infrastructure. In such circumstances, compensation is made just for the loss of crop for a specific period of temporary occupation for construction.

2.9.4 THE WAPDA ACT NO. XXXI OF 1958

WAPDA Act No XXXI of 1958 provides for the unified and coordinated development of the water and power resources of Pakistan (then West Pakistan). This Act authorizes WAPDA to construct and operate electrical transmission lines, entrusting powers and obligations to them as a licensee under the Telegraphy Act of 1910. The WAPDA Act also establishes policy for land acquisition and compensation, as well as the degree of liability of WAPDA for damages sustained by landowners and other parties.

2.9.5 THE ELECTRICITY ACT, NO IX OF 1910 WITH ELECTRICITY RULES OF 1937

The Electricity Act of 1910 and Electricity Rules of 1937 relate to the supply and use of electrical energy in Pakistan. This Act applies together with supplementary rules that have been issued from time to time.

2.9.6 THE FOREST ACT OF 1927, AND LATER AMENDMENTS

The Forest Act of 1927 establishes the right of the Government to designate areas for reserved forest, village forest and protected forest, and they may acquire such areas in order to prohibit or restrict the public use of such resources or other activities within them.

2.9.6.1 THE PROTECTION OF TREES AND BRUSHWOOD ACT OF 1949

The Protection of Trees and Brushwood Act of 1949 prohibits the cutting or lopping of trees and brushwood without the permission of the Forest Department.

2.9.7 THE LOCAL GOVERNMENT ORDINANCE OF 1979

Section 93 of the Local Government Ordinance of 1979 pertains to environmental pollution. Under this Ordinance, the local councils are authorized to restrict activities causing pollution to air, water or land. They may also initiate schemes for improving the environment.

2.9.8 THE NORTH-WEST FRONTIER PROVINCE WILDLIFE (PROTECTION, PRESERVATION, CONSERVATION AND MANAGEMENT) ACT, 1975.

Nothing hereinafter provided shall be deemed to authorize any person to hunt in the reserved or protected forests or protected waste land as constituted and declared under the provisions of the Forest Act, 1927 (Act XVI of 1927), or the Hazara Forest Act, 1936 (N.W.F.P. Act VI of 1937), or on any person's private property without permission. According to this Act, no person shall:

a) Hunt any wild animal by means of a gun, drop spear, deadfall, gun trap, explosive projectile, bomb, grenade, baited hook, net, snare or any other trap, an automatic weapon, or a weapon of a caliber used by the Pakistan Army or Police Force or by means of a projectile containing any drug or chemical substance likely to anaesthetize, paralyze, stupefy or render incapable an animal whether partly or totally;

b) Hunt any protected animal;

c) Hunt any game animal except under a permit and in accordance with the provisions of this Act or the rules;

d) Provided that no person shall hunt any game animal other than birds or hares with a shot-gun or with non-magnum rifle of 22 calibre or less use, or have in his possession any net, snare, bhagwa, poison or like injurious substance for the purpose of hunting a game animal, use vehicle of any type to pursue any game animal, or to drive or stampede game animal for any purpose;

e) Shoot any game animal from any conveyance or from within two hundred yards of the conveyance.

2.9.8.1 THE WEST PAKISTAN FISHERIES ORDINANCE, 1961(ORD. XXX OF 1961).

This Ordinance may be called the West Pakistan Fisheries Ordinance, 1961.This Act pertains to different regulatory and control measures relating to Fisheries. The relevant important provision of this are reproduced below.

1	**Section 6:** No person shall use 1[any dynamite, electric shock or other explosive substance] in any water with intent thereby to catch or destroy any of the fish that may be therein.	Destruction of fish by explosive
2	**Section 8:** No person shall kill, capture, or possess any species of fish specified in the second column of the First Schedule, of a size less than that specified in the third column of the said Schedule against such species.	Fish that shall not be taken
3	**Section 9:** (1) No person shall use or employ for the capture of any species of fish, in any water other than private water, any net, cage, trap or other contrivance for taking fish or fixed engine, except during the period permitted. [Provided that in the case of trout, only such gear and in such number shall be used or employed as may be specified in the license or permit, (2) Licenses shall be issued by authorities, on payment of fees and on conditions as may be prescribed.	Net, fixed engine trap, etc. shall not be employed without a permit or license.
4	**Section 10:** Every person in possession of any fishing license or permit shall produce his license or permit, as the case may be, on a demand made by the Inspector of Fisheries or any other person authorized in this behalf by the Director of Fisheries.	Duty to produce license or permit on demand made by employees of Fisheries Department
5	**Section 11:** (1) Not withstanding anything contained in this Ordinance, Government may, by notification, declare any water to be a sanctuary for fish mentioned in the First Schedule for a period, which may be specified, and during such period, no person shall kill, capture or possess such fish without a special permit issued under this Ordinance by the Director of Fisheries.	Power to declare any water to be a sanctuary for fish

2.9.9 THE EXPLOSIVES ACT, 1884 (IV OF 1884)

This Act may be called the Explosives Act, 1884; and it extends to the whole of Pakistan. This deals with the manufacture, possession, transportation, possessing, storage, using, selling or importation of dangerous explosives.

2.9.10 PAKISTAN PENAL CODE, 1860

The provisions of the Pakistan Penal Code of 1860 fix the penalties for violation of statutory instruments in the country. These include pollution of air, waterbodies and land. The Penal Code 1860 provides for and deals with a wide spectrum of offences and related punishments under the law.

2.9.11 PROVINCIAL GOVERNMENT STATUTORY FRAMEWORK

The proposed Artistic-II HPP is to be located in the KP Province. The following KP laws are likely to be relevant and must be taken into consideration.

a. Forest

i. NWFP (KP) Forest Ordinance 2002

ii. NWFP (KP) Forestry Commission Act 1999

iii. NWFP (KP) Management of Protected Forests Rules 1975

iv. NWFP (KP) River Rules 1952

v. NWFP (KP) Protection of Trees and Bush wood Act 1949

b. Fisheries

i. NWFP (KP) Fisheries Rules 1976

c. Wildlife/Fauna/Non-Timber Flora

i. NWFP (KP) Wildlife (Protection, Preservation and Management) Act 1975

ii. NWFP (KP) Wildlife (Protection, Preservation, Conservation and Management) Act1975

d. Protected Areas

i. NWFP (KP) Wildlife (Protection, Preservation and Management Act 1975-National

ii. Sanctuaries, Game Reserves, Private Game Reserves)

e. Freshwater

i. NWFP (KP) River Protection Ordinance 2002
ii. NWFP (KP) Local Government Ordinance 2001 (Clause 4.3.2.1)

2.10 INSTITUTIONAL FRAMEWORK RELEVANT FOR EIA IN PAKISTAN

The success of environmental assessment as a means of ensuring that development projects are environmentally sound and sustainable depends in a large measure on the capability of regulatory institutions to operate in an effective manner to achieve the objective. The institutional framework for decision making and policy formulation on environmental and conservation issues are briefly described below.

2.10.1 FEDERAL GOVERNMENT INSTITUTIONS

Headed by a Federal Minister, the Ministry of Environment, Local Government and Rural Development, is the main government organization responsible for the protection of environment and resource conservation. The Ministry works with the Pakistan Environmental Protection Council (PEPC) and the Federal and Provincial Environmental Protection Agencies and was established under the provisions of the PEPA of 1997.

Two organizations, the Pakistan Environmental Protection Council (PEPC) and the Pakistan EPA, are primarily responsible for administering the provisions of the PEPA of 1997. The EPC oversees the functioning of the Pakistan EPA.The Federal Government has formed the PEPC. Its members include the President of Pakistan (or someone appointed by the President), as the Chairperson; the Minister of the Ministry of Environment as the Vice-Chairperson; Governors of the Provinces; Ministers in charge of the subject of environment in the Provinces; the Secretary to the Federal Government in charge of the Ministry of Environment, Local Government and Rural Development; the Director General of the Federal EPA; Heads of Federal and Provincial Environmental Protection Departments; environmentalists and community representatives, including scientists. The functions and powers of the Council include formulation of national environmental policy, enforcement of the PEPA of 1997, approval of the NEQS, incorporation of environmental considerations into national development plans and policies and to provide guidelines for the protection and conservation of biodiversity in general and for the conservation of renewable and non-renewable resources. The Federal Government has also formed the Federal EPA, which is headed by a Director General and has wide ranging functions given in the PEPA of 1997.

These include preparation and co-ordination of national environmental policy for approval by PEPC, administering and implementing the PEPA of 1997 and preparation, revision or establishment of NEQS. The Federal EPA has overall jurisdictions over EIA/IEE issues. Federal jurisdiction is applicable to the projects which are:

a. On federal land

b. Military projects

c. Involving trans-national impacts and

d. Having trans-province impacts

For all other cases, the concerned provincial Responsible Authority shall have jurisdiction over EIA and IEE issues. The Federal EPA reserves the rights to review any Environmental Report at any time and to suspend the powers it has delegated to any Responsible Authority if it believes those powers have not been properly used.

2.10.2 Provincial Government Institutions

Each provincial government has its own environmental protection institution responsible for pollution control. The provincial EPAs and the Environmental Protection Departments (EPDs) are the provincial counterparts of the Federal EPA, which is authorized to delegate powers to its provincial counterparts. The Provincial Environmental Protection Agencies are formed by the respective Provincial Governments. A Director General who exercises powers delegated to him by the concerned Provincial Government heads the Provincial EPA. The reports covering IEEs and EIAs are submitted to the concerned Provincial EPAs for approval. For public works, responsibility for IEE management, review and granting or refusing of environmental approval, will be vested in the Planning and Development Departments (referred as P&Ds) responsible for economic and development planning at federal and provincial levels. At the provincial level, the KP holds all the required administrative powers regarding land acquisition, resettlement and rehabilitation of displaced people of any development project. For this project, various government departments at Federal, Provincial and District level will interact and collaborate for implementation of the project. One of the prerequisites which will require immediate action relates to the handling of environmental issues. For construction of the project, reservoir area upstream of the weir, land required for the Box Channel, Inlet pond and Powerhouse area will need to be acquired. The project area is covered within the administrative jurisdiction of District Administration of District Swat. The Land Acquisition Act of 1894 with its amendments will need to be applied for acquisition of the land. Other land-based assets will be acquired according to the rules and regulations applicable for acquiring such assets.

2.10.3 International and National Non-Governmental Organizations (NGOs)

International environmental and conservation organizations, such as the International Union for the Conservation of Nature (IUCN) and the World Wildlife Fund for Nature (WWF), have been active in Pakistan for some time. Both these organizations have worked closely with the Government and have played an advisory role regarding the formulation of environmental and conservation policies. Ever since the Rio Summit, a number of national environmental non-governmental organizations (NGOs) have also been formed, and are engaged in advocacy and, in some cases, research. The most prominent national environmental NGOs, such as the Sustainable Development Policy Institute (SDPI) and Shirkatgah, are members of the Pakistan National Committee of IUCN. The International Fund for Agricultural Development (IFAD) has also been active for some time. Much of the Government's environmental and conservation policy has been formulated in consultation with leading NGOs, who have also been involved in drafting new legislation on conservation.

2.11 SPECIFIC EIA REQUIREMENTS FOR ARTISTIC-II HYDROPOWER PROJECT

2.11.1 BASIS FOR THE ENVIRONMENTAL STUDY

The Pak-EPA under the powers conferred upon it by the PEPA of 1997 provides the necessary details for the preparation, submission, and review of the Initial Environmental Examination (IEE) and the Environmental Impact Assessment (EIA) for the proposed developments. Categorization of projects for IEE and EIA is one of the main topics of the IEE-EIA Regulations of 2000. Projects have been classified based on expected degree and magnitude of environmental impacts and are included in different schedules contained in the IEE-EIA Regulations of 2000. The projects listed in Schedule-B include those where the range of environmental issues is comparatively narrow and the issues can be understood and managed through less extensive analysis. Schedule-B projects require an IEE to be conducted, rather than a full-fledged EIA, provided that the project is not located in an environmentally sensitive area. The projects listed in Schedule-A are generally major projects and have the potential to affect a large number of people. Projects in environmentally sensitive areas are also included in Schedule-A. The impact of such projects may be irreversible, and could lead to significant changes in land use and the social, physical and biological environment. Dams and reservoirs with a maximum storage volume greater than 50 million cubic meters or a surface area greater than 8 square kilometres fall under the Schedule-A category of the IEE-EIA Regulations of 2000. This project therefore falls in Category A and requires a full EIA. The details of the classification criteria for Schedule-A and Schedule-B are given in **Table 2-2**. The major international Conventions and Treaties signed by Pakistan are presented in **Table 2-3.**

2.12 EIA REQUIREMENTS OF POTENTIAL FINANCING INSTITUTIONS

2.12.1 THE WORLD BANK

Potential financing and managing institutions for the proposed project include the World Bank. The environmental assessment requirements of the World Bank are clearly laid out in its safeguard policies and procedures and considered to constitute International Best Practice. The crucial documents are the Bank's Operational Policies (OP) and Bank Procedures (BP). Operational Policy 4.01and Bank Procedure 4.01 (amended in March 2007 and revised in Feb.2011) clearly outline the requirements for Environmental Assessment for World Bank managed development projects and programmes. These two documents are supported by a Guidance Note on Environmental Assessment. All three of these documents are publicly available on the website of the World Bank, along with the Environmental Assessment Sourcebook and toolkits. The sourcebook has a section specifically dealing with dams and electricity transmission lines. The way that the World Bank makes sure that these environmental safeguards are incorporated into the Bank's lending policy is clearly set out in OP/BP 4:00 on the use of borrower systems to address environmental and social safeguards.

The basic philosophy that underpins the World Bank approach to environmental assessment is that all development should be environmentally sound and sustainable in the broadest sense, covering both the natural and human/social aspects of development. No person is to be made worse off as a result of any intervention. Any potential adverse impacts are to be avoided by appropriate changes in intervention design. Where this is not possible, the potential adverse impacts are to be fully mitigated by appropriate interventions and the costs of these are to be included in the economic appraisal of the proposed intervention. In addition, the aim of the World Bank's environmental assessment process is to ensure proposed interventions maximize their environmental benefits, often adopting suitable design elements to enhance positive impacts. The World Bank Guidance Note on Environmental Assessment has a categorization of projects according to their type, size and likely degree of impact and outlines the different procedures needed for each category. The proposed project falls into World Bank Category A under both Section (a) being a dam and reservoir, and Section (l) being a hydropower development. The World Bank has an Operational Policy specifically for Water Resources Management (OP4.07 dated February 2000), which is of direct relevance to the proposed project. There is also a Bank Procedure for projects on International Waterways (BP 7.50, dated October 1994), which is of the utmost importance to the proposed project. BP 7.50 outlines the Bank's requirements for dealing with trans-boundary water projects, of which the Indus Water Treaty of 1960 is critical in addressing this issue. Other relevant World Bank policies and guidelines include OP/BP 4.02 on

Environmental Action Plans (EAPs), which outline the need for and nature of an EAP. An EAP is required for all Categories A projects, and also if there are significant adverse impacts that cannot be avoided by changes in the design of the proposed intervention. The EAP is to include targeted mitigation programmes, with cost estimates and an implementation programme. An EAP also includes an environmental management and monitoring framework with recommendations for appropriate institutional arrangements for its implementation. Biodiversity considerations form an intrinsic part of the environmental assessment process. The World Bank has a guideline for showing how biodiversity issues are to be mainstreamed into the development process. This is available on the Bank's website. Similarly, public consultation is to be an intrinsic part of the environmental assessment process. The requirements for pubic consultation are clearly stated in Update No 26 of the Environmental Sourcebook, dated May 1999.

2.12.2 THE ASIAN DEVELOPMENT BANK

The Asian Development Bank (ADB) could be another potential funding institution for the proposed project. The environmental assessment requirements of the ADB are clearly laid out in their Environmental Assessment Guidelines of 2003 and available on the ADB website. Under the ADB classification system, any dam or reservoir is classified as a Category A, as is any project requiring relocation of people. Category A requires a full EIA to be carried out and the formats for reporting are clearly given in Appendix 2 of the 2003 ADB Guidelines. The section headings for an EIA report are given and for a Summary EIA report maximum page length for each section are prescribed. The ADB have also produced sector guidelines for environmental assessment and rapid environmental assessment checklists, including one for hydropower.

2.12.3 OTHER INTERNATIONAL PROCEDURES FOR ENVIRONMENTAL ASSESSMENT OF DAMS

There are also other international institutions dealing with questions concerning the environmental assessment of dams. These include the World Commission on Dams, which carried out a major review of the environmental consequences of dam construction, and the International Commission on Large Dams (ICOLD). In addition, the Equator Principles, which are a set of guiding environmental principles for both public and private concerns are starting to be used as a framework for environmental management, particularly in the mining and power sectors.

2.13 IMPLICATIONS FOR THE PROPOSED PROJECT

Under the national regulatory framework, the project proponent is the Pakhtunkhwa Energy Development Organization (PEDO) and they are legally bound to follow the national requirements for environmental assessment. The regulatory authority for environmental assessment is the Khyber Pakhtunkhwa Environmental Protection Agency. The proposed Hydro Power Project is a Schedule A project under the Pakistan national classification system and requires a full EIA. Under both the World Bank and Asian Development Bank classifications, the proposed project falls under Category A and requires a full EIA. This EIA report has been structured to satisfy not only the national EA requirements but also at the same time those of the World Bank and the Asian Development Bank.

Table 2-2: Details of the classification criteria for Schedule-A and Schedule-B

SCHEDULE A	**LIST OF PROJECTS REQUIRING AN EIA** The Projects in Schedule A are generally major projects and have the potential to affect a large number of people. They also include projects in environmentally sensitive areas. The impact of such projects may be irreversible and could lead to significant changes in land use and the social, physical and biological environment. **Agriculture and Livestock** No EIA's required unless a specific proposal is designated by the Responsible Authority, which could be the result of significant impacts being discovered at the IEE stage. **Energy** Thermal Power Generation over 200 MW Hydroelectric Power Generation over 50 MW Petroleum Refineries Major Power transmission lines (above 11kV) including Grid Stations Nuclear Power Plants **Manufacturing and Processing** Major manufacturing of chemicals, pesticides or fertilizer Petrochemical complexes Major tanning and leather finishing Man-made fibers and resin projects greater than 10 crore (100 million) rupees in value Industrial Estates (including export processing zones) Large scale food processing such as sugar mills, refineries, breweries, distilleries, soft drinks, milk and dairy products greater than 10 crore rupees in value Large scale industrial plants such as: synthetic resins, plastics and manmade fibers, paper and paperboard containers and boxes, plastic products, textiles except apparel, printing and publishing, paints and dyes, oils and fats greater than 1 crore rupees in value Cement plants **Mining and Mineral Processing** Major mineral development including; mining and processing of coal, gold, copper, iron, and precious stones Major smelting plants Major non-ferrous metals, iron and steel rolling

	Transport Major Ports and Harbours development Major Airports Federal or Provincial Highways or major roads greater than 5 crore rupees in value Maintenance (rebuilding or reconstruction of existing roads is excluded from the requirement of an EIA). Major railway works **Water Management; Dams, Irrigation and Flood Protection** Dams and reservoirs with a maximum storage volume greater than 50 million cubic meters or a surface area greater than 8 square kilometres Irrigation and drainage serving more than 15,000 hectares **Water Supply and Treatment** Major urban water supply infrastructure, including major head works and treatment plants **Waste Disposal** Waste disposal and/or storage of hazardous or toxic wastes (including landfill sites, incineration of hospital toxic waste) Waste disposal facilities for domestic or industrial wastes, where more than 10,000 cubic meters of waste will handled annually **Urban Development and Tourism** Land use studies and urban plans (large cities) Large scale tourism developments **Environmentally Sensitive Areas** Any project, which will be situated in an environmentally sensitive or critical area, should be carefully investigated, and the results communicated to the Responsible Authority, who will advise whether an EIA is necessary (see "Guidelines for sensitive and critical areas").
SCHEDULE B	**LIST OF PROJECTS REQUIRING AN IEE** These projects include those where the range of environmental issues are comparatively narrow and the issues can be understood and managed through less extensive analysis These are projects not generally located in environmentally sensitive areas or smaller proposals in sensitive areas. **Agricultural and Livestock** Agro-industrial installation: large poultry farms and beef cattle lots

	Repacking, formulation or warehousing of agricultural produce **Energy** Thermal Power Generation less than 200 MW Hydroelectric power generation less than 50 MW Electrical transmission lines (11kV or smaller), and large distribution projects Major waste to energy generation projects Oil and gas transmission systems Oil and gas extraction including exploration, production, gathering systems, separation and storage **Manufacturing and Processing** Man-made fibers and resin projects less than 10 crore (100 million) rupees in value Food processing such as sugar mills, refineries, breweries, distilleries, soft drinks, milk and dairy products less than 10 crore rupees in value Sizable ceramics and glass manufacturing Sizable apparel manufacturing including dying and printing Manufacturing wood products on a sizable scale **Mining and Mineral Processing** Commercial extraction of sand, gravel, limestone, clay and other minerals not included in Schedule A Crushing, grinding and separating processes Minor smelting Plants **Transport** Ports and Harbours Development for ships less than 500 gross tons Federal or Provincial Highways (except maintenance, rebuilding or reconstruction of existing paved roads) less than 5 crore rupees in value. **Water Management; Dams, Irrigation and Flood Protection** Dams and Reservoirs with a storage volume less than 50 million cubic meters or a surface area less than 8 square kilometre Irrigation and Drainage serving less than 15,000 hectares Small-scale irrigation systems **Water Supply and Treatment** Minor head works and small systems **Waste Disposal**

	Waste disposal facility for domestic or industrial wastes, where less than 10,000 cubic meters of waste will be handled annually **Urban Development and Tourism** Urban development projects, including large rural hotels, schools and universities Public facilities which have significant off-site impacts (i.e. hospital wastes) Housing Estates Any other projects that the EPA may require
SCHEDULE C	**LIST OF PROJECTS NOT REQUIRING IEE OR EIA** Essentially Schedule ‘C" combines everything not in Schedules ‘A ‘and ‘B’. As is the case for ‘A’ and ‘B’ projects, Schedule ‘C’ projects are also subject to review if they are situated in an environmentally sensitive or critical area. No attempt is made here to detail these projects, however some illustrative examples are provided below: a. Construction of homes, offices and small commercial buildings, subject to compliance with existing zoning laws; b. Reconstruction/rehabilitation of roads including sealing; c. On-farm dams; d. Projects promoting energy efficiency; and e. Lining of existing canals and/or watercourses.

Source: Government of Pakistan, Pakistan Environmental Protection Agency, “Policy and procedures for the filing, review and approval of environmental assessments”.

Table 2-3: Major International Conventions and Treaties Signed by Pakistan

Sr.No.	Treaties/ Convention	Brief Description
1	The Convention on Biological Diversity	Pakistan signed this convention in 1992. The objective of this convention is conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including those by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies and by appropriate funding
2	The Convention on Conservation of Migratory Species of Wild Animals – 1979	The Convention on the Conservation of Migratory Species of Wild Animals (CMS), 1979, requires countries to take action to avoid endangering migratory species. The term "migratory species" refers to the species of wild animals, a significant proportion of whose members cyclically and Predictably cross one or more national jurisdictional boundaries. The parties are also required to promote or cooperate with other countries in matters of research on migratory species.
3	The Convention on Wetlands of International Importance, Ramsar 1971	Pakistan is a signatory to the said Convention. The principal obligations of contracting parties to the Convention are: a) To designate wetlands for the List of Wetlands of International Importance; b) To formulate and implement planning to promote wise use of wetlands, to carry out EIA before transformations of wetlands, and to make national wetland inventories. c) To establish nature reserves on wetlands and provide adequately for their wardening and through management to increase waterfowl populations on appropriate wetlands;

Sr.No.	Treaties/ Convention	Brief Description
		d) To train personnel competent in wetland research, management and wardening; e) To promote conservation of wetlands by combining farsighted national policies with coordinated international action, to consult with other contracting parties about implementing obligations arising from the Convention, especially about shared wetlands and water system. f) To promote wetland conservation concerns with development aid agencies. g) To encourage research and exchange of data for 9 sites in Pakistan that have been declared as wetlands of International Importance or Ramsar Sites (WWF – Pak 2000). None of these wetlands is located within or in close vicinity of the project area.
4	Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) –1973	This convention came into effect in March 1973 at Washington. In all 130 countries are signatory to this convention with Pakistan signing the convention in 1976. The convention requires the signatories to impose strict regulation (including penalization, confiscation of the specimen, etc.) regarding trade of all species threatened with extinction or that may become so, in order not to endanger further their survival.
5	IUCN Red List 2000	The red list is published by IUCN and includes those species that are under potential threat of extinction. These species have been categorized as: a) Endangered: species that are seen to be facing a very high risk of extinction in the wild in the near future, reduction of 50% or more either in the last 10 years or over the last three generations, survive only in small numbers, or have very small populations. b) Vulnerable in Decline: species that are seen to be facing a risk of extinction in the wild, having apparent

Sr.No.	Treaties/ Convention	Brief Description
		reductions of 20% or more in the last 10 years or three generations. c) Vulnerable: species that are seen to be facing a high risk of extinction in the wild, but not necessarily experiencing recent reductions in population size. d) Lower Risk: species that are seen to be facing a risk of extinction that is lesser in extent that for any of the above categories e) Data Deficient: species that may be at risk of extinction in the wild but at present there is insufficient information available to make a firm decision about its status

3. PROJECT DESCRIPTION

The Artistic-II HPP is a diversion-type hydropower project which will be constructed on the Ushu River in KP. The Ushu River is fed by melting glaciers and it rushes down to Kalam where it joins the Utror River and eventually becomes the River Swat. This is probably over 3200 meters above sea level. The area is surrounded by Chitral District on the north, Swat District on east and south and Upper Dir district on the west. The project area is located at distance of 123 km from Saidu Sharif in the village of Eshegal & Mai Banda, of Kalam valley. The Project is situated on Kalam-Mahodand road. The coordinates of the Artistic-II HPP weir site are (35°37’42.09” N, 72°41’5.68” E) and Powerhouse are (35°34’14.14” N, 72°40’19.23” E). The total land required for the project is approximately 381618. 6sq.m or 94.3 acres.

Artistic-II HPP conveyance system is designed for discharge of 34 cumecs. Artistic-II HPP weir is proposed at location which offers relatively better geology and ease in river diversion during construction, as river becomes wider. The normal operating level of the weir is 2505 masl. The ogee type overflow spillway body, undersluices and crest elevation of upstream walls were designed according to Q_{1000} flood discharge (511 m^3/s). Since the valley is relatively wide at this location, the river will be diverted to left bank, during the construction of concrete weir structure at right bank. The diversion channel is composed of an embankment at right bank, which will also serve as upstream and downstream cofferdams. The left bank of the channel is designed as mix section, i.e., by excavation where the topography is narrow and by engineered fill where the topography is wide. Left bank fill is preferred in order to prevent the disturbance effect of flowing water on the slope stability of the existing road. Diversion system is designed according to Q_{10} flood discharge (224 m^3/s). After completion of construction of right bank concrete structures, the left bank will be plugged by a clay core earth fill embankment, which will be a part of Artistic-II Weir.

Just at right bank of undersluices, three span intake and sand trap has been designed. The selected location for these structures offers the minimum excavation work. By this arrangement, water, entering the conveyance system is de-silted at the beginning, thus formation of settled sediments within the box channel is prevented, which is advantageous from operation & maintenance point of view. The flushing canals are composed of 1 m diameter steel pipes, emerging from the bottom of the sand trap towards downstream, where the riverbed elevation is 2.495,00 masl, which is a lower elevation than the bottom elevation of the control gates. Sandtrap dimensions were designed according to the method described by Emil Mosonyi, in “High Head Power Plants, Volume 2/A”.

Following the sandtrap, box channel starts. Its dimensions were selected by using Manning's equation. Checks for flow regime and velocity are satisfied. Channel alignment was designed principally by following 2505.00 m contour. In order to minimize local losses, the minimum radii of horizontal curves were calculated hydraulically and applied. Moreover, minimum distance criterion between counter-curves was followed. The alignment of channel offers minimum excavation.

At the end of box channel, is the forebay structure. For the determination of operating water levels of the forebay, design discharge of small turbine was taken as Q = 5.7 m^3/s, whereas design discharge of big units was taken as Q = 14.15 m^3/s. By selecting these discharges, the Francis type turbines will not lose any amount of water due to cavitation, i.e., will be able to utilize all discharges between 2.34 m^3/s and 34 m^3/s, entering from the conveyance system. In order to determine the dimensions of the forebay, the diameter of power tunnel (horseshoe cross-section) was selected first, as 3.9 m, according to the optimization study. The velocity of water is 2.7 m/s while design discharge is passing in this tunnel. Then the height of the inlet of tunnel intake structure and the vortex height that should be left above the inlet were calculated, to fix the depth of the structure, under minimum operation water level. This depth helps the determination of height of the rack. In order to maintain a stable system both structurally and hydraulically, two trash racks separated by a middle pier is designed. Thus, the width of the tunnel intake and forebay was fixed. Thereafter, the length of the forebay was calculated regarding to safe evacuation of the design discharge by a side spillway.

The base slope of the power tunnel was determined, both taking into account the height of clear cover above the tunnel, under Shahrar Gal Nullah and the height required for surge tank. Surge shaft diameter and height above the tunnel were selected according to hydraulic calculations carried out by Pressel's Method. For down surge calculations, the duration of turbine opening was assumed as 30 seconds, whereas for upsurge calculations, the duration of turbine closing was assumed as 6 seconds. The portion of tunnel, between surge tank and the exit, will be lined both with concrete and steel.

Following the exit of power tunnel, a transition from tunnel cross-section to penstock cross-section is designed. Penstock diameter was chosen as 2.8 m, as per optimization study, resulting in a 5.52 m/s water velocity at design discharge. Penstock alignment was determined according to the powerhouse location. At the beginning of penstock alignment, is a valve chamber to control the system.

The powerhouse location is shifted towards downstream and located near to the reservoir of Gorkin-Matiltan Weir, in order to utilize ~30 m additional head, which is a national wealth of the country. Since the maximum flood level of Gorkin-Matiltan Weir is 2304,385 m, the tailwater level of the powerhouse is selected as 2305.00 m. Artistic-II power plant is located according to this tailwater level and embedded according to the suction head requirement for the turbines.

The characteristics of the structures according to design are summarized as follows:

Artistic-II Weir:

Figure 3-1 Site for Weir

Design flood discharge (Q_{1000})	: 511 m^3/s
Spillway type	: Ogee, overflow
Spillway apex elevation	: 2505.00 m (Also normal operation level)
River Bed elevation	: 2499.00 m
Foundation bottom elevation	: 2493.80 m
Height of ogee body from river bed	: 6 m
Height of ogee body from foundation	: 11.2 m
Energy dissipating basin type	: USBR Type III

Energy dissipating basin elevation	: 2495.30 masl
Energy dissipating basin length	: 21.89 m
Width of spillway	: 36 m
Discharge from ogee spillway at Max. WL	: 511 m^3/s
Discharge from undersluices at Max. WL	: 179.4 m^3/s
Total discharge at Max. WL	: 690 m^3/s
Maximum water level (Q_{1000})	: 2508.74 masl
Weir crest level	: 2505.00 masl
Undersluices	: 2 Nos.
Dimensions of undersluice gates	: 3.5 m x 3.5 m (Height x Width)

Diversion System:

Design flood discharge (Q_{10})	: 224 m^3/s
Type of diversion channel	: Trapezoidal
Side slopes of channel	: 1 V / 2H
Bottom width of channel	: 6.00 m
Water depth at Q_{10}	: 2.78 m
Bottom slope of channel	: 0.0181
Height of channel	: 3 m
Channel coating material	: Dry Rubble or Rip-Rap
Manning's "n" for rip-rap	: 0.028

Intake:

Service gates and racks	: 3 Nos.
Size of inlet gates	: 3.0 m x 3.8 m (w x h)
Inlet sill height	: 1.5 m
Base elevation of intake structure	: 2501.00 masl
Middle piers	: 2 Nos.

Thickness of middle piers : 1 m

Sandtrap:

Number of chambers : 3 Nos.

Width of each chamber : 6.0 m

Width of middle piers : 0.5 m

Length of sandtrap : 90 m

Bottom slope of sandtrap : 2 %

Minimum particle size to be settled : 0.3 mm (for Francis type turbines)

Avg. Velocity of water : 0.276 m/s

Water level within the settling basin : 2504.83 masl

Flushing pipes : 3 Nos.

Starting base elevation of flushing pipes : 2495.63 masl

Diameter of flushing pipes : 1 m

Total flushing discharge : 19.5 m^3/s

Velocity of water in flushing pipes : 8.28 m/s

Box Channel:

Type of cross section : Rectangular, reinforced concrete

Flow regime : Open channel, subcritical

Capacity : 34 m^3/s

Bottom Slope : 0.0003

Manning’s “n” for concrete : 0.014

Width : 5.2 m

Water depth at full capacity : 3.92 m

Freeboard : 0.58 m

Height : 4.5 m

Velocity of water at full capacity : 1.67 m/s

Length of channel	: 1520 m

Forebay:

Normal water level	: 2504.30 masl
Minimum water level	: 2500.96 masl
Width of forebay	: 13 m
Length of forebay	: 60 m
Crest elevation of forebay	: 2505.00 masl
Side spillway width	: 4.00 m
Side spillway capacity	: 34 m^3/s
Apex elevation of side spillway	: 2504.35 m
Bottom slope of side spillway	: 2 %
Length of transition	: 12.4 m (From side spillway to chute)
Length of chute	: 72.21 m
Base elevation at the beginning of chute	: 2501.00 masl
Base elevation at the end of chute	: 2485.00 masl
Type of energy dissipating basin	: USBR Type III
Length of energy dissipating basin	: 12.7 m

Tunnel Intake Structure:

Figure 3-2 Site for Tunnel Intake

Inlet sill height	: 1.65 m
Base elevation of the structure	: 2492.00 masl
Crest elevation of the structure	: 2505.00 masl
Racks	: 2 Nos.
Width of racks	: 4.5 m
Service gate	: 1 No.
Width of gate	: 3.9 m
Height of gate	: 5.4 m
Diameter of air vent pipe	: 0.7 m

Power Tunnel:

Type of internal cross section	: Horseshoe, reinforced concrete
Type of excavation cross section	: D-shaped
Diameter of internal cross section	: 3.90 m

Diameter of excavation cross section	: 4.6 m
Bottom slope of tunnel	: 0.0085
Length of tunnel	: 4857 m

Surge Tank:

Type of internal cross section	: Circular, reinforced concrete
Type of excavation cross section	: Circular
Diameter of internal cross section	: 6.1 m
Diameter of excavation cross section	: 7.1 m
Maximum downsurge	: 39.84 m
Maximum upsurge	: 34.64 m
Top elevation of surge tank	: 2550 masl
Bottom elevation of surge tank	: 2455.34 masl
Height of surge shaft	: 94.65 m (above tunnel crown)

Penstock:

Length	: 341 m (including valve chamber)
Diameter	: 2.8 m
At the end	: Trifurcation

Powerhouse:

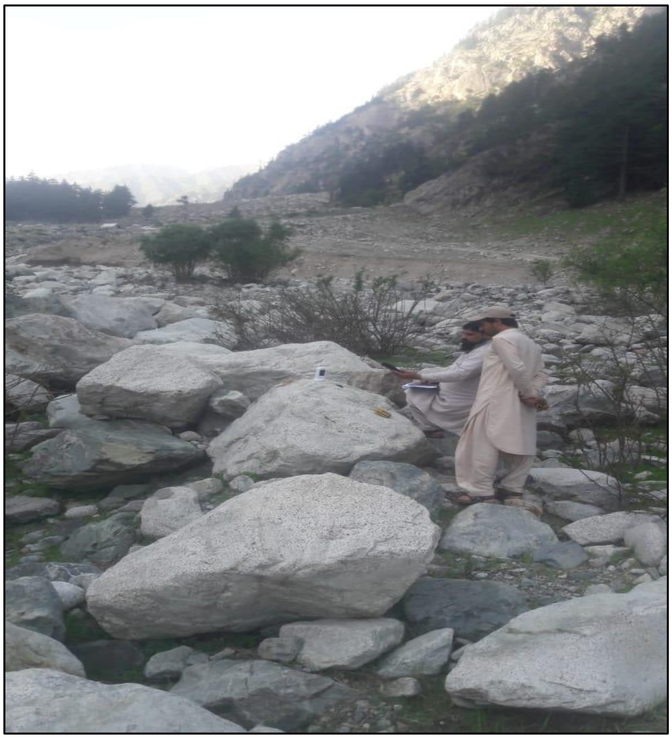


Figure 3-3 Site view of Artistic-II HPP Powerhouse

Tailwater level	: 2305.00 masl
Gross head from Artistic-II Weir	: 200.00 m
Net head (at design discharge)	: 185 m
Turbines	: 3 Nos. (2 Big & 1 Small)
Design discharge	: 34 m^3/s (2 x 14.15 + 1 x 5.70) m^3/s
Type of turbines	: Vertical Axis Francis
Assumed rated efficiencies	
Turbine	: 93%
Generators	: 97%
Transformers	: 99%
Installed Capacity	: 55 MW
Width of tailwater canal	: 25.5 m

4. BASELINE CONDITIONS

The baseline conditions covering the existing physical, biological and socioeconomic environment of the project as well as study area; have been derived from the field surveys, desk studies, visits to the Government departments and other relevant agencies, discussions with the affected people and notables of the area.

4.1 STUDY AREA

The project study area mainly includes areas where the weir, staff residential colonies/offices, tunnel route, powerhouse, contractor camps/Labour camps, etc. will be constructed. In addition, it also includes the surrounding areas where the influence of the project implementation will occur.

4.2 BASELINE STUDY PURPOSE

The purpose of baseline study is to fulfil the following objectives:

a) To get the data about the physical, biological and socio-economic environment of the project area

b) To understand the current situation of the area comprehensively

c) To rationalize the decisions according to the ground realities

The main environmental conditions, likely to be affected due to project execution are:

i. Physical Environment

ii. Biological Environment

iii. Socioeconomic Environment

4.2.1 PHYSICAL ENVIRONMENT

Physical environment includes topography, geology and soils, land use, climatology, atmosphere and water resources.

4.2.2 GEOGRAPHY

The district Swat lies between from 34^0, 34' to 35^0,55' north latitude and 72^0,08' to 72^0,50' east longitude. Total area covered by the district is 5337 km^2. It is bounded on the north by Chitral district and Ghizer district of northern areas. On the east by Kohistan and Shangla district on the south by Buner district and Malakand and on the west by Lower and upper Dir districts. The total area of the district is 5337 square kilometres.

The Ushu valley is situated in beautiful district of KP, Swat. Its west northern boundary is marked by district Dir. The area comprises gently rolling topography in its eastern and southern parts, high ridges, cliffs and rugged hills in the west and northwestern part. Relief of the area is moderate to high. Highest point in the area is Falak Sar having an altitude of 5918 m above sea level.

The beautiful valley of Ushu is bounded by lofty mountains from all the sides. It lies 123 km from Saidu Sharif in the Hindu Raj Ranges (Southern Hindu Kush). The area is linked with Saidu Sharif by a metallic road via Khwaza Khela Town. Administratively it comes under Sub Division Bahrain of District Swat. The valley bound Bahrain Tehsil with Osherai Dara (Dir) in the west, and Dir Kohistan in the north. There are several mountain peaks ranging from 4500 to over 6000 meters above sea level. These mountains are the western extremities of Great Himalaya range. Its highest mountain Falak Sar. Swat is divided into two physiographic regions:

a) Mountainous Ranges

As mentioned above, Swat lies in the lap of mountainous ranges, which are the offshoots of Hindukush, so the larger part of Swat is covered with high mountains and hills, the crest of which are hidden by everlasting snow. Though these gigantic ranges run irregularly: some to the west while the others to the east, but the general direction is North-South.

b) Plains

The length of the valley from Landakay to Gabral 151.6 km (91 miles). Two narrow strips of plains along the banks of Swat River from Landakay to Madyan. Beyond Madyan in Kohistan-e-Swat, the plain is too little to be mentioned. So far as the width concerns, it is not similar, it varies from place to place with the average width of 8.33 kilometre (5 miles). The widest portion of the valley is between Barikot and Khwaza Khela. The widest viewpoint and the charming sight where a major portion of the valley is seen at Gulibagh on the main road, which leads to Madyan.

4.2.3 ROCKS

The rocks are mainly granites, quartzites, siliceous schists, silt stones, shales, lime stones and hornblende felspar. Soil is fairly deep on the moderately steep slopes of the Southern exposures. Overall the soil is capable of supporting a vigorous and good coniferous crop. In addition, the group also contains more basic rocks such as Norites and peridotites.

4.2.4 CLIMATE

Climate station do not exist within watershed of Ushu River. Long term and reliable record of climate data exist at Kalam which is located just downstream of the confluence of Ushu and Gabral Rivers with Swat River

Daily rainfall data of Kalam have been collected from SWHP, WAPDA for a period of 1963-2011, while from Pakistan Meteorological Department (PMD) daily rainfall record for period of 2004 to 2015 have been collected.

Available records indicate that precipitation in the project area and its vicinity occurs throughout the year with two peaks one is in spring and other in summer. Isoheytal map of the Pakistan (1981-2010) collected from PMD reveal that in project area annual rainfall range is in between 1000 mm to 1200 mm (**Figure 4-1**)

Table 4-1: Mean monthly Rainfall (mm) at Climate station Kalam (Source: SWHP, WAPDA)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
1963	--	70.2	308	204.9	169.9	5.2	38.2	31.3	20.6	18.7	60.5	48.7	976
1964	159.6	136.1	110.8	253.7	67.2	12.5	61.9	28.8	15.8	27.4	28.8	157.8	1060
1965	156.8	232.6	223.6	314.8	117.9	0.8	38.7	20.7	23.3	25.1	37.4	39.6	1231
1966	152.7	214.7	294.6	27.4	2.6	32	20.4	74.6	71.3	0	25.4	0	916
1967	50.8	192.6	125.2	210.7	122.7	16.5	11.9	22.4	40.6	64	5.3	104.9	968
1968	40.5	62.2	135.4	249.5	132.3	7.6	2.8	65.3	6.4	43.2	35.8	14.5	796
1969	80.2	175.6	210.8	213.1	80.1	27.7	16.1	31.5	43.4	89.7	21.4	7.9	998
1971	7.4	169.5	69.1	216.2	12.5	27	49.3	9	30	14.8	6.9	24.4	636
1972	131.6	150.8	105.9	231	144.2	31.1	22.1	76	82.3	44	32.5	121.6	1173
1973	125.5	179.6	191.5	157	57.5	1	35.2	38.4	57	33.3	8.1	21.8	906
1974	77.7	169	74.3	135.9	94.5	33.3	33.9	26.1	76.5	11.7	0	106.2	839
1975	56.9	154.6	217.1	253.9	195.1	1.5	48.5	113.3	28.5	49.8	35.8	60	1215
1976	86.3	205.2	191.4	136.9	61.7	27	29.3	67.8	43.1	30.5	24.1	31.1	934
1977	123.6	29.2	99.8	138.9	42.7	4.9	16.1	32.6	13.4	29.5	48.9	35.5	615
1978	73.2	45.9	148.7	123.3	62.3	20.9	129.7	19.1	34.4	12.6	112.2	10.1	792
1979	42.4	92.3	176.3	200.4	139.7	13.2	11.7	75.1	14.6	1.3	44.2	22.3	834
1980	114.8	36.3	4.9	104.7	89.3	31.5	43.7	25.4	32.1	87.9	84.1	26.7	681
1981	78.4	216.7	221.3	213.8	69.5	19.9	28.6	57.9	31.4	22.6	31.7	0	992
1982	56.7	185.2	167.5	63.5	49	11.7	27.8	12	25.6	32.2	123.3	0	755
1983	49.2	32.3	278.5	62.6	59.3	11	15.3	44.4	16.3	9.9	0	0	579

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
1984	37.1	159.9	176.9	145.6	90	10.7	23.6	22.5	45.8	6.6	83.2	76.7	879
1985	78.5	26.1	52.9	137.5	85.4	6.9	37.2	53.9	10.8	72.5	27.9	145	735
1986	27.2	147.3	363.2	178.1	52.7	19.7	27.4	97.1	12.4	9.7	182.9	39	1157
1987	0	82.2	323.7	234.9	101.8	79.9	26.9	3.3	18.5	206.6	0	63.5	1141
1988	58.5	96.1	193.5	91.3	52.2	50	38.6	40.9	7.9	3	0.5	133.2	766
1989	--	--	--	79	185.4	7.9	48.2	31.4	26.1	35.8	92.2	0.5	507
1990	--	--	--	53.7	14	27.5	15	23.3	9.9	--	--	--	143
1991	166.4	263.2	336.5	201.9	172.2	25.7	30.5	10.9	84.3	3.1	6.3	70.9	1372
1992	232.7	171.1	336.9	228.9	167.3	38.6	6.6	47.6	121.1	71.6	16	71.9	1510
1993	--	--	--	9.9	76.8	56.9	85.1	37.9	9.6	60.9	58.8	33.8	430
1994	164.4	149.3	181.5	248	73.5	25.1	23.1	24.8	61.5	78.2	30.8	105	1165
1995	9.2	101.2	226.9	231.2	93.8	104	53.7	12.3	29.5	110.3	27.9	59.5	1060
1996	66.8	148.4	323.3	207.5	128.3	46	28.8	28.3	8.7	75.7	19.8	21.6	1103
1997	25.4	31.5	284.8	168.7	84.2	16.5	6.6	47.3	26.5	15.5	18	8.2	733
1998	144.8	220.4	152.6	203.5	135.1	47.9	20	27.2	19	7.7	NA	NA	978
1999	116	197.5	336.4	191.4	59	27.9	45.9	37.2	49.7	5.9	139.3	0	1206
2000	87	47.5	218.2	31.5	15	30.7	30.8	14	39.5	64.1	69.4	86.4	734
2001	4.8	137.9	77.2	69	24.7	18.3	66.9	34.8	67.1	3.8	70.4	0	575
2002	53.1	176.5	228.1	187.6	26.4	57.2	18	57.3	23.1	0	33.3	121.1	982
2003	23.3	202.3	218.6	282.2	107.8	4.3	5.5	36.2	64.3	27.4	111.8	110.6	1194
2004	67	117.3	81.2	170.2	47.3	19.4	28.7	25.8	29.3	211.3	45.7	117.9	961
2005	75.8	347.1	245.4	230.2	124.3	16.3	20.8	35.8	9.2	92.6	82.3	5.1	1285
2006	180.2	218.9	81.5	109.2	35.6	21	35	53.4	23	2.3	168	169.4	1098
2007	9	54.7	257.5	77	84	36.8	18.3	31.7	19.1	5.6	1.3	25.5	621
2008	237.2	45.7	45.8	101.6	0	6.4	30.5	16.5	40.6	19.1	29.2	100.5	673
2009	156.2	115.6	188.1	234.4	87.9	50.9	78.8	58.4	63.5	84.2	92.7	109.3	1320
2011	58.4	213.3	113	64.7	44.6	20.4	30.6	59.9	29.2	30.5	59.8	24.2	749
Average	**87.1**	**141.4**	**190.9**	**163.4**	**83.8**	**25.7**	**33.2**	**39.2**	**35.2**	**42.4**	**49.6**	**56.3**	**914**

Table 4-2: Mean Monthly Rainfall (mm) at Kalam (Source: Pakistan Meteorological Department)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2004	287	141	100	181	64.4	22	44	41.3	54	304.5	45	103.5	1388
2005	77	344.5	270	227	143.6	26.4	30.2	48	16	96.8	103	11	1394
2006	262	131.5	84	130.5	33	24.5	42	50.6	35	12.5	150.2	205	1161
2007	18	112.8	244.4	55	219.4	49.7	62.4	48.4	28.6	9	4.2	60.4	912
2008	284	62.8	124	165	47.5	6	39.9	22	31	20	28	159.5	990
2009	149	322	90	--	--	--	--	17	18	13	81	64	--
2010	63	474.6	53.5	107	123.7	42.1	182	85.9	79.9	1.9	0	2	1216
2011	40	306	167	137	50	12	17	34	32	103	64.5	1	964
2012	109	124	152	68	112	24.1	14	41	97	48	39	89	917
2013	39	234	177	137	45	46	12	96	17	28	31	17	879
2014	24	148	260	119	93	7.1	31	36	6.1	80.3	66	7	878
2015	55	224	179.5	184	71.8	26.1	47.4	60.4	74.6	102.5	90	50	1165
2016	76	23	234	268.3	89.5	47.5	35	55.8	20	11	14.8	25	900
2017	193	171	118	118.2	48	26.8	62	29.8	3.9	21	5	37	834
2018	35	79.5	153.5	201.5	107.4	14.8	37.4	14	22	60	109.6	21.2	856
2019	160	120	69.5	171.6	81	56.2	39.1	61.5					759
Avg	**117**	**189**	**155**	**151**	**89**	**29**	**46**	**46**	**36**	**61**	**55**	**57**	**1014**

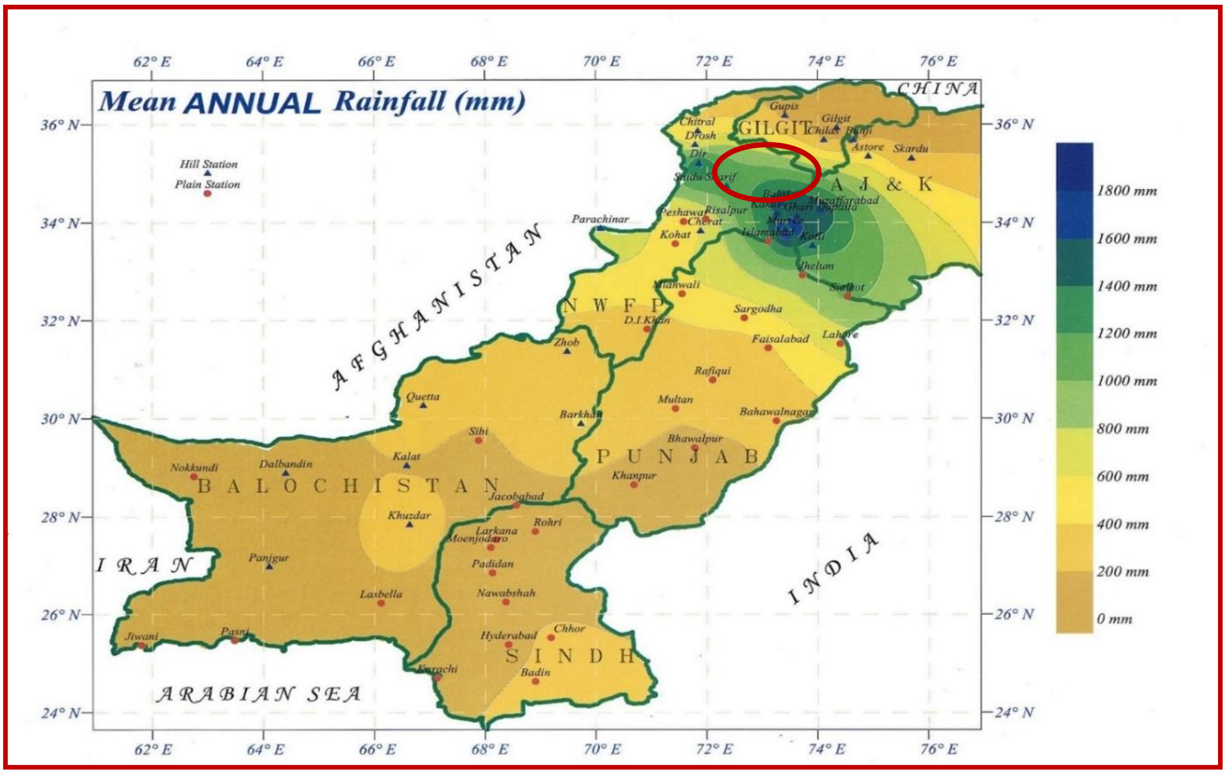


Figure 4-1: Isohyetal Map of Pakistan (1981-2010)

4.2.5 TEMPERATURE

Temperature is an important parameter that helps to define the climate of the project area. As Artistic-II Hydropower project is proposed on Ushu River in which flows are mostly generated due to snow and glacier melt. Therefore, Monthly mean maximum and minimum temperatures at Kalam for the period of 1966 to 2011 are shown in **Figure 4-2**. The results depict that mean monthly maximum temperature ranges from 26.2°C in the month of June to 7.6°C in the month of January, whereas monthly mean minimum temperature varies between 14.9°C in July and -6.4°C in January.

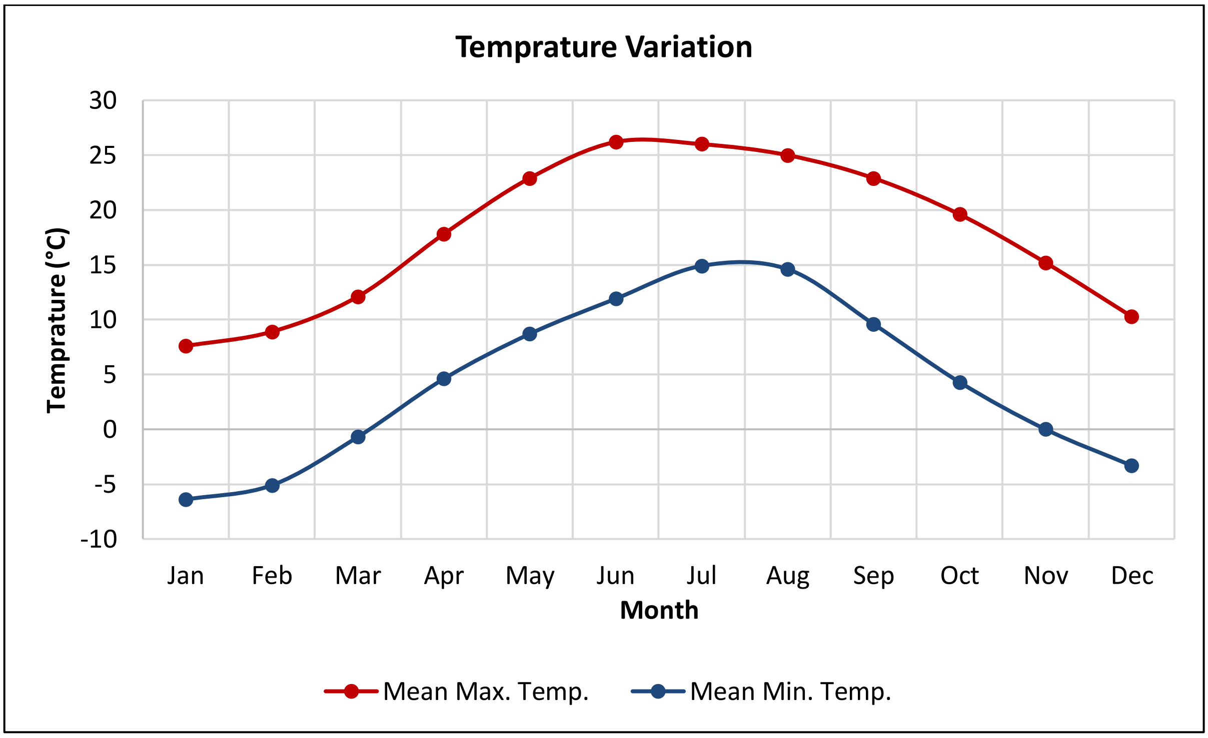


Figure 4-2 Monthly Mean Max. and Min. Temperatures at Kalam (1966 to 2015)

Monthly mean maximum and min temperature at Kalam for a period of 2016 to 2019 has been collected from Pakistan Meteorological Department which is shown in the following **Table 4-3** and

Table 4-4.

Table 4-3 Monthly Mean Max Temperature at Kalam (2016 to 2019) (Source: PMD)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	9.3	12.6	12.9	16.8	25.2	27.0	27.2	25.9	25.0	22.0	16.8	13.8
2017	6.1	10.2	11.5	19.2	24.7	27.0	27.0	27.2	26.1	22.5	17.1	11.5
2018	12.0	11.4	17.6	20.3	22.1	27.8	27.0	27.8	25.0	18.7	13.0	11.1
2019	4.5	5.5	13.0	18.8	22.1	24.7	27.2	25.9				

Average	**8**	**10**	**14**	**19**	**24**	**27**	**27**	**27**	**25**	**21**	**16**	**12**

Table 4-4 Monthly Mean Min Temperature at Kalam (2016 to 2019) (Source: PMD)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	-4.2	-3.8	0.5	3.8	9.0	11.7	14.3	12.1	9.4	4.4	0.8	-2.1
2017	-6.2	-8.1	-1.2	4.1	8.5	12.4	15.0	12.9	8.7	4.1	-0.6	-4.0
2018	-5.0	-3.4	-0.1	3.2	5.6	11.5	14.4	14.3	7.2	2.3	-0.6	-5.2
2019	-9.2	-8.2	-4.8	3.9	5.9	8.1	13.8	12.6				
Average	**-6**	**-6**	**-1**	**4**	**7**	**11**	**14**	**13**	**8**	**4**	**0**	**-4**

4.2.6 RELATIVE HUMIDITY

The average monthly humidity percentage collected at Kalam station for the period mention in the **Table 4-5.**

Table 4-5: Monthly Humidity of Kalam

Monthly Mean Humidity (%) At 0800 AM												
Year	**Jan**	**Feb**	**March**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2004	82	77	69	68	52	66	69	62	63	64	54	81
2005	84	86	76	60	65	48	67	66	62	58	65	65
2006	85	73	69	49	47	53	66	73	64	58	70	77
2007	75	75	69	40	59	54	67	67	67	59	49	73
2008	85	83	60	62	53	61	67	71	59	56	63	82
2009	87	91	76	-	-	-	-	64	61	60	78	84
2010	66	92	78	64	72	57	57	72	65	58	66	70
2011	88	95	72	63	43	45	63	67	71	65	68	69

Source: Pakistan Metrological Department (NATIONAL AGROMET CENTRE)

4.2.7 HYDROLOGICAL STUDIES

Artistic-II Hydropower Project is a run of river project to be constructed on Ushu River in district Swat of Northern areas of Khyber Pakhtunkhwa province.

Hydrological studies presented in this section have been carried out to ascertain the water availability and its seasonal variations and floods of different return periods.

a) Catchment Area

The catchment of the Artistic II HPP lies in the upper region of the Ushu River, a tributary / sub system of a Swat river basin and can be classified as a "high mountain catchment". Snowmelt is the principal source of water in the river. Catchment area of the Ushu River at weir location is estimated to be 454 sq.km and at Powerhouse location is approximately 600 sq.km.

b) Discharge data

There are three (03) gauge stations available near the project site maintain by various government organizations, as given in **Table 4-6.**

Table 4-6: Stream Flow Gauging Stations

S.No	Station	River	Location		Catchment Area (km^2)	Period of Record
			Latitude	Longitude		
1	Kalam	Swat	35°28'10"	72°35'40"	2020	1961-2009
2	Jildat	Ushu	35°29'15"	72°35'45"	783	2006-2015
3	Matiltan	Ushu	35°33'33"	72°40'05"	656	2011-2017

c) Estimation of Flows at Weir Site

To estimate the water availability at Artistic-II Hydropower project daily flow record of Matiltan, Jildat and Kalam Gauge stations were used.

Comparison of stream flow for a concurrent period of Swat River at Kalam with Ushu River at Jildat was carried out to develop a correlation which was then used to transpose Kalam data to Jildat for the year 1961-2005. The estimated data at Jildat from the year 1961-2005, observed data at Jildat for the year 2006 -2009 and observed data at Matiltan for the year 2011 to 2017 was then transposed to the proposed Artistic-II HPP weir site using the catchment area ratios.

The estimated flow data at Artistic-II HPP weir site shows that the average maximum monthly flow ranges from 57.76 m^3/s in July to 3.47 m^3/s in February.

d) Flow Duration Curve Analysis

Availability of flows at the proposed weir/intake site was checked using detailed flow duration curve analysis. For the purpose of this study, the estimated daily stream flow data of Artistic-II site has been analysed and FDC has been generated. The developed FDC is presented in **Figure 4-3** which shows that the 34 cumecs of water will be equal or exceed 23.2% of the times.

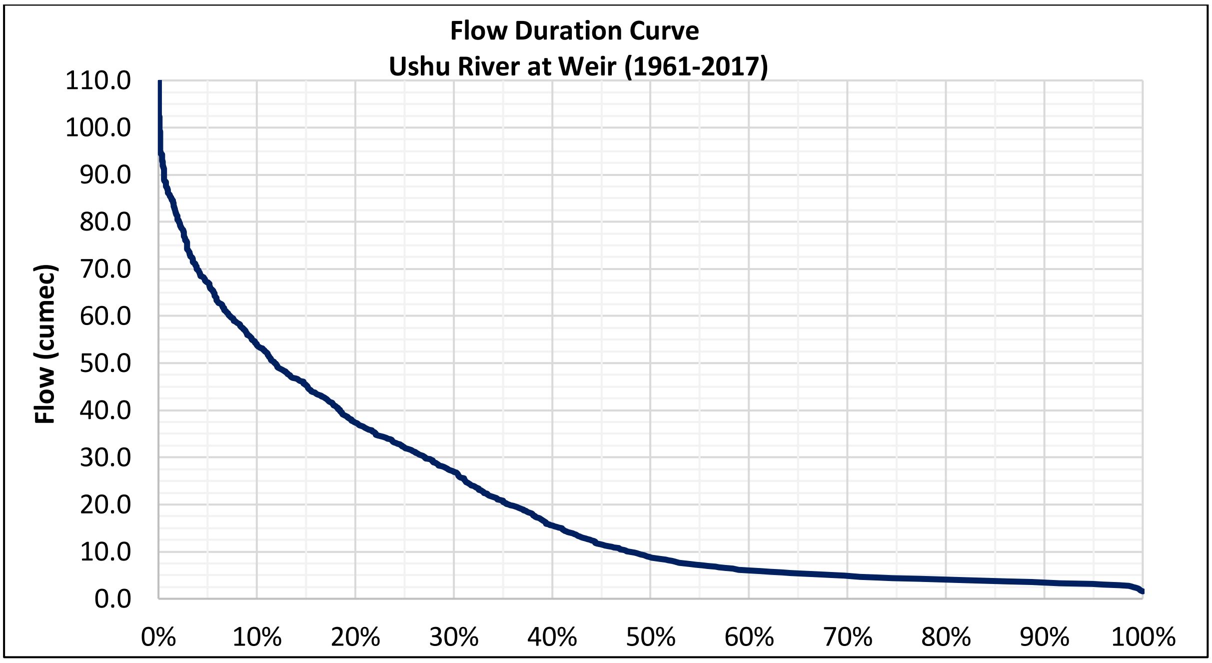


Figure 4-3: Flow Duration Curves of Artistic-II HPP at Weir Site

4.2.8 FLOOD ANALYSIS

Flood studies are carried out for planning and design as well as for checking the safety of hydraulic structures. To estimate the design flood at least thirty years of instantaneous flow data or precipitation data is normally required at the project location. In case of Artistic-II Hydropower Project both does not exists. Therefore, recourse has to be made to the instantaneous flow records of the swat river at Kalam gauging station (Nearest to Artistic-II Hydropower Project) which is available for 49 years i.e.; (1961 to mid of 2010) maintained by the Surface water Hydrology (SWHP), WAPDA. Maximum observed flood of Swat at Kalam was 597cumec in 1978. As per locals maximum flood was July, 2010 but value of flood is not known as all gauges of Upper Swat were washed out including Swat at Kalam.

Estimation of design flood was undertaken considering that floods in the northern areas of Pakistan can be generated by two different processes, snowmelt and precipitation. Recorded floods are normally from snowmelt origin. When large and powerful events (Monsoon and Western disturbances) develop over the area, intense rainfall can originate floods that can be as larger like July, 2010.

- Flood frequency analysis have been carried out on available peak flood data of Swat River at Kalam and specific flood per square kilometre worked out. With appropriate factor varies from 1.3 to 2.0 specific flood have been transformed at weir and powerhouse sites.

- Derivation of flood flows for different return periods on the basis of observed flood series of similar catchments in the region having longer historic records. Peak flood data of the River possessing similar hydro-meteorological conditions have been collected as mentioned in **Table 4-7** and frequency analysis through Gumbel extreme value distribution for each station have been carried out. The results of frequency analysis are given in **Table 4-7**. Calculations of flood on the basis of envelop curves are also carried out **(Table 4-7&Table 4-8**). The regional river flood analysis include flood peak data of July,2010 in most of the gauging stations of surrounding Rivers, while Swat at Kalam was not included in July,2010. Design flood estimated through regional River analysis are recommended for further design use.

Table 4-7: Regional Flood Peaks (cumecs)

River	Gauging station	years of Record	Period	Catchment Area	Return Period (yr)					
				sq.km	2	10	50	100	200	1000
Neelum	Muzafarabad	54	1963-2014	7228	1444	2649	3706	4152	4597	5628
Jhelum	Domel	34	1976-2010	14504	1260	2782	4117	4681	5243	6545
	Chinari/Hattian Bala	33	1977-2010	13598	954	1668	2294	2559	2822	3433
Siran	Phulra	43	1969-2012	1057	572	1127	1614	1820	2025	2500
Kunhar	Naran	54	1960-2014	1036	235	405	554	617	680	826
Astore	Doyian	37	1974-2010	4040	656	1021	1341	1476	1611	1923
Kunhar	Garhi HB	50	1960-2010	2383	577	1160	1672	1888	2103	2602
Ghorband	Korora	29	1975-2010	635	316	887	1387	1598	1809	2297
Swat	Chackdara	54	1961-2014	5770	881	2261	3471	3982	4492	5672
	Kalam	49	1961-2009	2020	390	533	658	711	764	886
Ushu River	**Weir Site**	**With Swat at Kalam adjusted factor**		**454**	**123**	**168**	**207**	**224**	**240**	**279**
	Power House			**600**	**162**	**222**	**274**	**296**	**318**	**368**
	Jildat			**783**	**212**	**289**	**357**	**386**	**414**	**481**
Ushu River	**Weir Site**	**From fitted curve equations**		**454**				**466**	**492**	**644**
	Power House			**600**				**558**	**591**	**762**
	Jildat			**783**				**663**	**705**	**896**
Ushu River	**Weir Site**	**From average specific flood (Recommend for design purpose)**		**454**	**108**	**224**	**326**	**369**	**411**	**511**
	Power House			**600**	**142**	**296**	**430**	**487**	**544**	**675**
	Jildat			**783**	**186**	**386**	**562**	**636**	**710**	**881**

Table 4-8 Specific Discharge (cumec /sq.km)

River	Gauging station	years of Record		Catchment Area	Return Period (yr)					
				sq.km	2	10	50	100	200	1000
Neelum	Muzafarabad	54	1963-2014	7228	0.200	0.367	0.513	0.574	0.636	0.779
Jhelum	Domel	34	1976-2010	14504	0.087	0.192	0.284	0.323	0.361	0.451
	Chinari/Hattian Bala	33	1977-2010	13598	0.070	0.123	0.169	0.188	0.208	0.252
Siran	Phulra	43	1969-2012	1057	0.541	1.067	1.527	1.722	1.916	2.365
Kunhar	Naran	54	1960-2014	1036	0.227	0.391	0.535	0.596	0.656	0.797
Astore	Doyian	37	1974-2010	4040	0.162	0.253	0.332	0.365	0.399	0.476
Kunhar	Garhi HB	50	1960-2010	2383	0.242	0.487	0.701	0.792	0.883	1.092
Ghorband	Korora	29	1975-2010	635	0.498	1.396	2.184	2.517	2.848	3.617
Swat	Chackdara	54	1961-2014	5770	0.153	0.392	0.601	0.690	0.778	0.983
	Kalam	**49**	**1961-2009**	**2020**	**0.193**	**0.264**	**0.326**	**0.352**	**0.378**	**0.438**
Average Specific flood (cumec per sq.km)					**0.24**	**0.49**	**0.72**	**0.81**	**0.91**	**1.13**

4.2.9 SEDIMENTATION STUDIES

Origin of the sediments in the northern part of the Swat Catchment (Gabral and Ushu) is melting of the glaciers. Historic suspended sediment and discharge observations are used to develop a sediment rating curve for the estimation of annual sediment inflow to the Artistic-II HPP weir site. In addition, regional analysis was also employed for comparison of sediment load estimated using sediment rating curve.

4.2.9.1 SEDIMENT RATING CURVE USING AVAILABLE DATA

Sediment rating curves of Ushu River at Ushu Bridge and Jildat Gauge Station were developed for the available data by plotting the discharges in cumecs and sediments in metric tons/day. Regression analysis were carried out and the derived relationships were applied to the long-term derived flow time series (FDC) of Artistic-II Hydropower Project weir site to estimate the annual sediment concentration.

Table 4-9: Estimated Annual Suspended Sediments Load

Station	Annual Suspended Sediment Load (Million Metric Tons)
Ushu Bridge	0.066
Jildat Gauge Station	0.051

4.2.9.2 REGIONAL ANALYSIS

In addition to the estimation of the suspended sediments at weir site described above, regional analysis has also been carried out to check the consistency and range of the average annual sediments at weir site of Artistic-II Hydropower Project. For the purpose, average annual runoff and sediment data for the following stations (**Table 4-10**) is obtained from the Sediment Appraisal of Pakistan, 2008 published by the Surface Water Hydrology Project, WAPDA. The mean annual values are tabulated in **Table 4-10**.

Table 4-10: Mean Annual Discharges and Suspended Sediments Load Used for Regional Analysis

Station	River	Catchment Area (km^2)	Annual Flow (cumecs)	Average suspended Sediments Load (Tons per day)
Near Kalam	Swat River	2020	88.6	788
Chakdara	Swat River	5776	178.3	5915
Munda	Swat River	13649	233.5	15907

A power regression analysis is evolved between the catchment area and mean annual suspended sediment load of Swat River at Kalam, Chakdara and Munda stations which depicts a better correlation with coefficient of Determination as $R^2 = 0.9813$, the relation obtained is as follows;

$$Qs = 0.0051 (A)^{1.5854}$$

Where "Qs" is metric tons per day and "A" is the catchment area in sq.km. Using this equation, the mean annual sediment load estimation for weir site of Artistic-II Hydropower Project is estimated to be;

$$Qs = 0.0051 * (454)^{1.5854} = 0.03 \text{ million metric Tons annually}$$

Above results depict that the mean annual suspended sediment load estimation by regional method is in fare agreement with the suspended sediment load estimation by using the gauge data of Swat river at Kalam.

4.2.9.3 SEDIMENT BED LOAD ESTIMATION

Methods developed to measure bed load are only applicable in laboratory or for small streams. It is not possible to measure bed load in river like Ushu, where the flows are normally very deep in high flow season, and are very turbulent and fast because of very steep gradient in river. In the absence of bed load record, as there is no bed load measurement in Ushu River, as per standard practice to assume bed load 5 % to 20 % of suspended sediment load can be used.

To be on more conservative side, 20 % of suspended sediment load has been taken as un-measured sediment load. Therefore, the annual bed load at Artistic-II HPP weir site is estimated to be **7,812 tons annually**.

Table 4-11: Total Annual Sediment Load

S.No	Description	Sediment Load (Metric Tons)
1	Mean Annual Suspended Sediment Load	39,060
2	Unmeasured Annual bed Load (20% of S.No 1)	7,812
3	Total Annual Load	46,872 (0.047Mmton)

4.2.10 WATER RESOURCES AND DRAINAGE

Precipitation is the major source of water supply which is received in the form of rains and snow. The snow is the most important source of water supply which is ultimately gives rise to springs and perennial streams. Water from the streams and spring is supplies through water channels and gravitational flow pipe lines to the nearby population both for irrigation and drinking purposes. Other source of water is the high-altitude lakes, the lake Mahodand have great attraction for the tourists. The area is drained by Swat River.

The flow in the streams increases with the snow melting during hot season generally by the end of June and gradually subsides by the first week of July. The water of these streams is used for irrigation and drinking. As the winter and summer rains are generally of long durations, plenty of springs and streams flow throughout the district. Water of springs, streamlets and rains, coming from the upper areas join Swat River at Kalam. The main tributaries of Swat River are Ushu and Utror rivers which rise from Shandur or Mashabar range bordering Swat district with Chitral in the north and flows south and south-west.

4.2.11 LAND USE-STATISTICS

Land use in the area is linked with physiography, soils and water availability. Population pressure also plays a pivotal role in land usage patterns. According to KPK Agricultural Statistics 2017, the land utilization in Swat District for the year 2015-16 was as under:

Reported Area	:	506500 ha
Total Cultivated Area	:	97281 ha
Total Cropped area	:	181974 ha
Total Un-Cultivated Area	:	409219 ha

The break of un-cultivatable area is as under:

Cultivable waste	:	129025 ha
Forest	:	138282 ha
Not available for cultivation	:	141912 ha

4.2.12 AMBIENT AIR QUALITY

Though no formal record is available for quality of atmospheric air in the Project area however, it is evident that the ambient air quality of the project area on both Weir and Powerhouse proposed sites is free of pollution at present and within the acceptable limits. During implementation of the project construction activity will generate an accountable noise and dust in the atmosphere of the project area. Although there are no noise levels specified for construction in the National Environmental Quality Standards (NEQS), a noise level of 86 dB for day time and 35 dB for night time has been specified for vehicular noise pollution. During construction it is expected that these levels will be violated. Dust level consisting of Particulate matters and Smoke have also not been specified in the NEQS for ambient air, but emission limits from stationary sources should not exceed 40% or 2 (Ringleman Scale) for smoke. Particulate matter should not exceed 200-500 milligram/Nm^3 depending upon energy source.

4.2.13 WATER POLLUTION

Water from the tunnel used in drilling activity or originating from groundwater inflow will be silt laden. This water cannot be directly discharged in the Ushu River and will have to be cleared/settled before disposal. In this context, the natural surface water run-off will also get polluted as it may collect fine material from dump areas close to the construction activity as it trickles down the slopes.

4.2.14 GEOLOGY

According to a survey, which was carried out by the Geological Department, University of Peshawar, the major geological formations in the area are the Swat granites, Kalam volcanic and hornblendes. The rocks are mainly granites, quartzite, siliceous schists, silt stone, shales, lime stone and hornblende feldspar. Soils is fairly deep on the moderately steep slopes of the southern exposures and are capable of supporting vigorous and good conifers. The details of geology may be referred in the chapter of geology.

4.2.14.1 RESERVOIR AREA

The area up stream of the weir is 200-300m wide and with relatively gentle lower slopes in mostly overburden materials. The upstream left periphery consists of loose angular rock fragments detached from the upslope hill faces screes along with colluvial, fluvial and glacial origin slope wash materials. The right bank of the reservoir comprises slope wash materials, scree with glaciofluvial deposits at places. The river bed materials comprise cobbles and boulders of igneous and metamorphic origin with sandy matrix.

4.2.14.2 WEIR AXIS

Based on weir site geological map, the weir site area is occupied by the slope wash material, scree and glacio-fluvial deposits and rock is likely to be at greater depth (i.e. >40m). The river bed material is dominantly of cobbles and boulders of igneous and metamorphic origin with sandy matrix. The river bed material is loose at the top and relative density increases depth wise. The left abutment comprises of scree and slope wash terrace consisting of gravel to boulder size embedded in silty sandy matrix, which are assessed to be lying on old river bed material. The right abutment also comprises unconsolidated materials of slope wash, scree and glaciofluvial deposits with vegetation.

4.2.14.3 SANDTRAP AND BOX CHANNEL

The box channel connecting weir intake structure along with sandtrap will be mostly on the unconsolidated material comprising slope washes, scree and glacio-fluvial deposits along the right bank of Ushu River. These unconsolidated materials comprise cobbles and boulders embedded in silty sandy matrix of mix origin

4.2.14.4 HEADRACE TUNNEL

The interpreted geological information shows that the following rock types shall be expected along the tunnel route.

- Dominantly Andesite with subordinate intrusions of granite/ granodiorite, tuff, agglomerates, etc. This rock unit is present along the box channel, de-sander, inlet pond and tunnel intake, and is blocky to very blocky having foliation trend in northeast-southwest direction dipping both in northwest and southeast at very steep angles. As per discontinuity surveys, the discontinuities are generally extremely close to moderately spaced, very low to very high persistent with tight to wide apertures and generally smooth to rough having planar to undulating surfaces. The rock quality as per ISRM, is interpreted from medium strong to strong. This rock unit present from tunnel intake to about 800m along the tunnel alignment where it makes its contact with the granite/ granodiorite of Matiltan Granite. This rock unit is present about 13% of the total tunnel length.

- Granodiorite/ Granite: This rock unit is present from 800m along the tunnel route and extends up to the end of the tunnel. This rock is very blocky to massive having foliation trend in northeast-southwest direction dipping northwest at steep to very steep angle, with localized dip direction in southeast. As per discontinuity surveys, the discontinuities are extremely close to widely spaced, low to very high persistent with tight to wide apertures and generally have rough and undulating rock surfaces. The rock quality as per ISRM guidelines for intact rock classification is to be medium strong to very strong. This rock makes about 87% of the total rock mass along the tunnel.

4.2.14.5 PENSTOCK

The penstock starts right after the headrace tunnel outlet which is in mostly granite, a medium strong to very strong, foliated and blocky to massive rock. However, the entire length of the penstock will be laid in the overburden material. The overburden is slope wash material and scree that comprises cobbles and boulders embedded in sandy silty matrix. The rock fragments are sub angular to angular embedded in silty matrix.

4.2.14.6 POWERHOUSE AREA

The surface powerhouse shall be placed in slope wash material on the right bank of the river at the slope toe. The rock present on higher elevations and is assessed to be at deeper depth (>60m) in the valley where powerhouse has been proposed. The rock is likely to be granite dipping towards the slope (i.e. in southeast). On both banks' slopes, the thickness of the slope wash material is almost the same. Generally, these deposits are heterogeneous and comprise angular to sub angular rock fractions in silty sandy matrix.

4.2.15 SEISMIC HAZARD ASSESSMENT STUDIES

The project is located in the Kohistan Island Arc which is sandwiched between Indian and the Eurasian tectonic plates. Number of moderate sized earthquakes have been recorded in Kohistan Island Arc during the last 100 years. The main seismo-tectonic features considered critical for the seismic hazard for the project are as follows:

- Main Karakoram Thrust (MKT)
- Kohistan Fault
- Main Mantle Thrust (MMT)
- Shandur Thrust

Both probabilistic and deterministic seismic hazard evaluations were made to determine the expected ground motions at the project site. The results of probabilistic seismic hazard assessment (PSHA) are summarized in the **Table 4-12**.

Table 4-12: Peak Ground Acceleration for Different Return Periods Obtained through Probabilistic Seismic Hazard Assessment (PSHA)

Peak Ground Acceleration for Different Return Periods Obtained Through(PSHA)		
Annual Frequency of Exceedance	**Return Period (years)**	**Peak Ground Acceleration (g)**
0.007	145	0.22
0.002	475	0.32
0.001	975	0.39
0.00033	3000	0.53
0.0001	10000	0.70

The maximum earthquake magnitude (in moment magnitude Mw) of each of the fault was calculated using Wells & Coppersmith (1994), Nowroozi (1985) and Slemmons et al. (1982) relationships between fault rupture length and magnitude and is given in the **Table 4-13** below.

Table 4-13: Critical Faults and Their Maximum Earthquake Potential

Tectonic Feature	Total Fault Length (km)	Maximum Magnitude Potential (M_W)			Selected Maximum magnitude M_W
		Wells & Coppersmith (1994)	Nowroozi (1985)	Slemmons et al. (1982)	
Main Karakoram Thrust (MKT)	200	7.5	7.5	7.6	7.5
Kohistan Fault	150	7.3	7.3	7.4	7.3
Main Mantle Thrust (MMT)	200	7.5	7.5	7.6	7.5
Shandur Thrust	90	7.0	6.9	7.0	7.0

4.2.15.1 RECOMMENDATIONS

- Recommended horizontal peak ground acceleration (PGA) associated with operating basis earthquake (OBE) is 0.22g.

- Recommended horizontal PGA associated with maximum design earthquake (MDE) is 0.39 g for all critical water retaining structures.

- Recommended horizontal PGA associated with MDE for all appurtenant structures and powerhouse is 0.32g.

4.2.16 SOILS

The cultivated soils of the project area have developed from alluvial material transported by Ushu River from the catchment area. The soils are shallow having a silty-loam texture. These are used either for dry or irrigated farming. The land holdings are generally very small varying between some kanals to 1 acre only, mainly potato and maize are grown along with seasonal vegetables. Due to fertile nature of these soils, crops are successful and fetch high prices as off-season crops in the plains. On the steep of hills, contour farming is usually under threat of floods of the streams and glacier sliding.

The cloud-burst of monsoon 2010 played a havoc in many parts of the country. The project area, though in the upper reaches was also affected. The hill torrents washed away a large portion of land situated on the left bank of Ushu River. The melting of glaciers also added land sliding in the area. The washed away land had no soil cover and big boulders, stones and gravels are left rendering the soil uncultivable for agricultural crops. It is hoped that muck material received from the excavation of the tunnel may be deposited on these barren pieces of land, which will help in reclamation.

4.2.17 SURFACE WATER AND ITS QUALITY

Swat district and particularly the project sites are devoid of groundwater resources. The rocky physiography of the area and steep slopes of mountains provide spring in abundance. Spring water is used for drinking, domestic, agricultural and construction purpose as well. This surface water is not safe for drinking.

The watersheds of the project area lie in the upper region of Ushu River. This is a high mountain catchment having several glaciers. The area receives more than 50 mm rainfall but snowfall is the most important source of water in the area. Ushu River is perennial. For practicing agriculture people use water from the river, streams and a few springs.

4.3 BIOLOGICAL RESOURCES

4.3.1 FOREST TYPES OF THE VALLEY

Phytogeographically the area comes under the Sino Japanese Region, enjoying a plentiful precipitation in the form of rain in the summer monsoon and heavy snowfall in winter. The area has established "the west Himalayan Moist Temperate type of forests" with the sub-alpine and alpine vegetation in the northern high altitudes. Depending upon the altitude, temperature variation, topography, soil and moisture, vegetation of Ushu valley is classified into six major types. These types are:

a. Low lying oak forest	b. Blue pine forest
c. Fir and Spruce forests	d. Tree line oak forest
d. Alpine scrub	e. Alpine pastures

4.3.2 FLORA

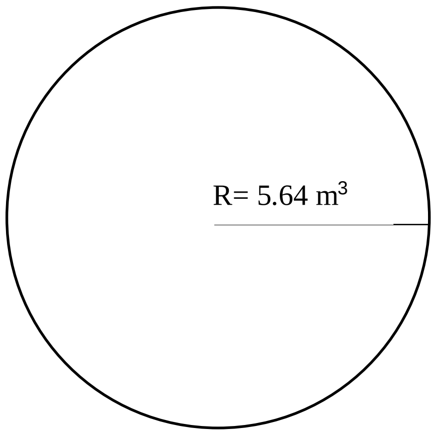
The Forests of Kalam and Bahrain valley have characteristics of the dry sub-tropical broadleaves, moist temperate, Himalaya dry temperate and sub alpine temperate regions. According to the species composition these can be divided into the following forest types.

a. Scrub Forests,
b. Dry Oak (Quercus Baloot) Forests;
c. Dry Zone Deodar (Cedrus deodara) Forests;
d Mixed silver Fir (Abies Pindrow) ·Spruce (Picea Smithiana), Kail (Pinus Wallichiana) and Deodar Forests.
e Sub-Alpine Scrub.
f. Alpine Pastures.

Figure 4-4: Flora of Project area

4.3.2.1 FLORAL SURVEY METHODOLOGY

The sampling design for field Inventory was developed keeping accuracy, limitations and available resources under consideration. The basic principle: a collection of accurate data with available resources in terms of financial, time and technical capacities has been followed. Based on ground conditions, Line transact method was used for the collection of field data, sample plot of fixed radius 5.64 m^3 or 100 $m^2$for trees, 10m^2 for shrubs and 1m^2 for herbs within the fixed radius plot were designed to collect data. Random sampling was adopted to collect data, ten plots on each transect were taken for trees, herbs and shrubs.



Following are the results of survey method adopted, which are given in the **Table 4-14**.

Table 4-14: Major Floral species of the area

Family	Botanical Name	Vernacular Name	Local Name	IUCN Status
Coniferae	Abies pindrow	Parthal	Achar	Least Concern
	Cedrus Deodara	Diar	Ranzrna	Least Concern
	Juniperus squamata	Parthal	Kachar	Least Concern
	Picea smithiana			Least Concern
	Pinus geradiana	Chilgoza	Chilgoza	Near Threathen
	Pinus willichiana	Biar	Pewuch	Least Concern
	Taxus baccata	Barmi	Banrya	Least Concern
Cupilifereae	Alnus nitida	Shrol	Girey	Least Concern
	Betula u tilis	Bhurj	Bruj	Data Defficient

Family	Botanical Name	Vernacular Name	Local Name	IUCN Status
	Quercus dilatata	Barungi	Tor Banj	Endangered
	Quercus incana	R him	Spin Banj	Least Concern
	Quercus ilex			Least Concern
	Quercus semicarpifolia	Banchar	Kanar	Least Concern
Ebenaceae	Diosporus lotus	Amlook		NA
Euphobiaceae	Euphorbia royleans	Thordana		Endangered
Filicineae	Adiantum capius veneris		Sumbal	Least Concern
	Male Ferrr		Kunji	NA
Gnetacea	Ephedra spp	Usmani Booti		Least Concern
Hamomeli dacea	Parroti jacquomantina	Pasher	Beranj	Least Concern
Juglandaceace	Juglans regia	Akhroot	Ghuz	Least Concern
Labiateae	Mentha Salvestris	Podina		Least Concern
	Plectranthus ragous	Bui	Sperkai	NA
Leguminoseae	Indigofera gerardiana	Kianthi	Ghoreja	Vulnerable
	Indigofera weightii	Kianthi	Ghoreja	NA
	Mimosa spp			Least Concern
	Sophora spp			Mimosa spp
	Trifolium repense			Least Concern
Lythraceae	Punica granatus			Least Concern
Meliaceae	Melia azedrach	Bakian	Bakiana	Least Concern
Moraceae	Ficus glomerata	Gular	Injir	Least Concern
	Ficus religiosa	Pipal	Pipal	Least Concern
	Morus alba	Tut	Tut	Least Concern

Family	Botanical Name	Vernacular Name	Local Name	IUCN Status
	Morus serrata	Tut	Tut	Least Concern
Oleacea	Olea cuspidate	Kau	Khuna	Nearly Threathen
Platanceae	Platinus orientalis	Chinar	Chinar	Data Defficient
Ranunculaceae	Peoina emodi	Mamekh		Least Concern
Rhamnaceae	Zizyphus nummuleria	Beri	Markhanria	NA
	Zizyphus sativa	Beri		Least Concern
Rosaceae	Cotoneaster spp		Shin Lakhta	NA
	Fragaria indica		Sehra-tut	Least Concern
	Potentetilla ambigua			Least Concern
	Potentetilla parviflora			Vulnearble
	Prunus armenica	Hori		Data Defficient
	Prunus cornuta	Kalakat	Bareet	Least Concern
	Prunus eubernea	JangliBadam		Least Concern
	Prunus padus	Kalakat	Bareet	Least Concern
	Pyrus pashia	Batangi		Least Concern
	Rosa mosehata	Pulwari	Kirrai	Least Concern
	Rubus spp		Corach	NA
	Spiraea spp		Jijrai	NA
	Sorbus tomentosa			Extint in the wild
Rutaceae	Skimmia laureole	Ner	Nazar Panra	NA
	Xanthoxylum alatum	Timber	Dambara	Endanger
Acanthacea	Adhatode vesical	Bhekar		Nearto Therathen
	Strobilanthus attenuates			NA

Family	Botanical Name	Vernacular Name	Local Name	IUCN Status
	Strobilentus glutonousus			NA
Ampelidaceae	Vitis Lanta		Parwathis	NA
	VItis himalayana			NA
Anacardiceae	Pistacia integsima	Kangar		Least Concern
	Rhus continus	Ban		Vulnerable
	Rhus semialata	Titar		Least Concern
Apocynaceae	Nerium odorum	Kaner	Gandiral	Least Concern
Berberidaceae	Berberis lyciumx	Simbul	Kurai	Endanger
	Podophyllum emodi	Bankari	Kankora	Least Concern
Caprifoliaceae	Lonicera quinquelocularis	Phut		NA
	Vibernium continifolium			Least Concern
	Vibernum stellulatum			Least Concern
Compositeae	Artemisia spp	Tarkha		Least Concern
	Saussurea lappa	Kut	Lassora	NA
	Saussurea cardicans			NA
Saliceae	Populas alba	Sofeda	Sapedar	Least Concern
	Populas ciliate	Palach		Least Concern
	Popolus nigra	Sofeda		Data Deficient
	Salix tetrasperma		Kharwala	NA
	Salix spp		Wala	NA
Sapindaceae	Asculus indica	Bankor	Jawza	Vulnerable
	Acer caesium		Tharkanh	Data Deficient
Urticaceae	Ficus palmate			Least Concern

Family	Botanical Name	Vernacular Name	Local Name	IUCN Status
Umbeliferea	Carum spp	Zera	Zankai	NA
	Cannabis satwa	Bhang	Bhang	NA
Valeriancaeae	Valeriana pyrolaefolia	Mushk Bala	Mushk Bala	NA
Verbinaceae	Vitex spp	Marwan		NA
Violaceae	Viola serpens	Banafsha		NA

The above-mentioned Species are endemic to Kalam tehsil of District Swat. These species are locally found in wide spread range in the mountains of Kalam. *TaxusBacccata* which belongs to the family Coniferae and is locally known as “Banrya” is found in the area which is an endangered tree species both locally and internationally. The specie is also listed in the IUCN red list as Endangered. Across most of its range through the Himalayas,*TaxusBaccata* has been heavily exploited for its leaves and bark which are used to produce the anti-cancer drug.

Saussurealappa belonging to the family Compositeae locally known as “Lassora” is a well identified medicinal plant is found in the area, due to its medicinal values commonly this is used in numerous indigenous systems of medicine all over the world. Due to high consumption of medicinal plants their population size has been decreased day by day. Among them *Saussurealappa* is most on the edge of extinction due to high rate of exploitation by local people. They usually do inappropriate carrying, handling and collection due to which they loss a major quantity of medicinal plants.

According to IUCN *Saussurealappa* protection status is critically endangered. *Saussurealappa* is a tremendously endangered species because of its high medicinal importance. Decrease in the population number of the natural plant species is due to some major ecological causes, such as deforestation, loss of habitat, invasive and high consumption. Due to of limited geographical ranges and precise territories endemic and erratic taxa of the area are at risk. The plant communities in the study area have been largely exploited due to some of these reasons like, excess intake of medicinal resources to cure the diseases, deforestation for fuel, increased tourism, population explosion and lack of sentience.

Figure 4-5: Floral survey

4.3.3 FUELWOOD

Like other part of the mountain region, the project area is mainly dependent on forest for fuelwood. Fuelwood is used more intensively in winter than in summer i.e. 100 kg/day/household in winter and 50 kg/day/household in summer. An average of 75 kg/day/household is consumed. Therefore, the average annual demand of average households for fuelwood is about 27375 kg. The preference of fuelwood increases in order of *Pinus wallichiana*, *Abies*, *Picea*, *Taxus*, *Parotiopsis*, *Ulmus*, *Prunus*, *Aesculus* and *Quercus*.

4.3.4 TIMBER

People of the Ushu valley are totally dependent on forest for timber. Mostly after 25 years a single family needs to construct a new house. For construction of a new house with furniture, they required an average of 8 trees of 0.6 m dbh and 20 m height. There are 1600 households in the project area therefore they required about 12800 trees in 25 years or 512 trees annually. The most common trees used as timber are *Juglans regia*, *Platinus orientalis*, *Pinus wallichiana*, *Aesculus indica*, *Abies pindrow* and *Picea smithiana*.

4.3.5 WILD VEGETABLES

For vegetables, they mostly dependent on their agricultural land. In rare cases and very few people are collecting wild vegetables. Mostly they collect *Allium sepa*, *caltha alba, Dryopteris remosa*, *Urtica dioica, Pteris aquilina, Rumex dentatus and Rumex alpinus.*

4.3.6 MEDICINAL PLANTS AND OTHER NON-TIMBER FOREST PRODUCTS (NTFPS)

Among the NTFPs some medicinal plants Zira (Carum species), honey, edible mushroom and Walnut fruit are exported on a very low scale. Most of the medicinal herbs found in the area are either used locally in medicines or are eaten by cattle, sheep and goats of the locals and nomad Gujars. Since the area falls in dry temperate zone hence, the ground flora is low in diversity and density. In spite of all natural and man induced traumas to the land there is vivid scope for persuasion, culture and commercial exploitation of high valued medicinal herbs and other available NTFPs through organized communities following the innovative concept of Participatory integrated Natural Resource Management and actualizing the Village Plans. This will support the livelihood at the household level and ultimately reduce the pressure on the tree crops.

Like wild vegetation, most of the people are unaware about the medicinal plants. Mainly they are dependent on the allopathic medicine and rarely using medicinal plants. Knowledge of traditional medicine practices has not yet sufficiently transferred from the elders to the young generation. Only 35% of the people know the names of few medicinal plant species like *Aconitum violaceum, Acorus calamus, Adiantum venustum, Arisaema flavum, Berbirus lycium, Foeniculum vulgare, Hypericum perforatum, Podophyllum hexandrum, Polygonatum verticilatum, Polygontum aviculare, Valeriana jetamansai, Viola biflora* and *Zanthoxylum alatum*.

4.3.7 FAUNA

The valley is quite rich in mammalian and avian Wildlife species, of which the following species are worth mention:

Snow leopard, Markhor and Leopard; Monal, Koklas and Tragopan Pheasants, Himalayan snow cook and snow partridge. The Wildlife of the area is ruthlessly destroyed by the locals since times. Pheasants are shot or trapped for their beautiful skins.

The whole Plan area falls in the management jurisdiction of Divisional Forest Officer, Swat stationed at Mingora. Khyber Pakhtunkhwa Wildlife (protection, preservation and management) Act 1975 does extend in the area, yet in actual practice locals have all the liberty to kill as many animals and birds as they can afford to do. This practice must be checked through implementation of Wildlife Act 1975 in true spirit, and giving incentives to locals. It is a well-established fact that underdeveloped and deprived areas throughout the country, province and region must now be placed at top priority for special development programs. The development of Wildlife resources available in the area and commercializing these for the livelihood support through organized communities in the need of time. This can better be achieved through village plan based on Participatory Integrated Natural Resources Management Framework.

4.3.8 WILD ANIMALS

The Ushu valley is highly mountainous and the elevation rises from 1800 to 4100 m. Apart from great variation in altitude, the valley has a considerable variation in temperature and precipitation. As a result, it supports a variety of vegetation from moist temperate forests to the alpine pastures. The forest comprises of various species of trees like blue pine, deodar, fir, spruce, bird cherry, walnut, acer and birch etc. The valley is a home to a great diversity of wildlife. It supports some of the endangered mammals. **Table 4-15** including those mammals and their present status in Ushu Valley.

Table 4-15: Mammals and their status in Ushu Valley

S.No	Mammal	Status	Reason	IUCN Status
1	*Rhesus monkey (Macaca mulatta)*	*Rare*	*Due to shooting and trapping because of their fondness for ripening maize crop.*	*Least Concern*
2	Wolf (*Canis lupus*)	Vary rare	Due to degraded habitat and Persecuted by people because of its depredation on domestic flocks of goats and sheep	*Least Concern*
3	Jackal (*Canis aureus*)	Common but reducing gradually	Because of diseases (rabies) and raiding orchard crop but useful in controlling rodent's population	*Least Concern*
4	Brown bear (*Ursus arctos*)	Extremely rare	Due to hunting and destruction of their habitat	*Least Concern*
5	Black bear (*Selenarctos tibetanus*)	Disappear (listed in the I.U.C.N. Red Data Book)	Due to deforestation and hunted because of its depredations to crop	*Least Concern*
6	Marten (*Martes foina*)	Common	It has ability to adapt to a wide variety of habitat	*Least Concern*
7	Otter (*Lutra lutra*)	Rare	Due to great commercial value of its skin	*Least Concern*

S.No	Mammal	Status	Reason	IUCN Status
8	Leopard cat (*Felis bengalensis*)	Extremely rare	Due to unavailability of prey animals and commercial value of its fur	*Least Concern*
9	Common *leopard (Panthers pardus*)	Extremely rare	Due to high hunting pressure and its habitat is continuous to decline because of increased human settlement	Endangered
10	Squirrel (*Petaurista petaurista*)	Common but reducing	Due to increasing grazing pressure and grass cutting	*Least Concern*
11	Porcupine (*Hystrix indica*)	Common	Due to increase in human population and gradual destruction of wilderness area	*Least Concern*
12	Bat (*Rbinolophus ferrumeqinum*)	Common but reducing	Required very humid and sheltered dark roosting place but due to deforestation and overgrazing its habitat is declining	*Least Concern*

According to local survey and consultation with WWF-Pakistan the above-mentioned species are endemic to the area and are found according to the status mentioned in the above list. Among the list *Panthers pardus* (Common leopard) is found in the area is Vulnerable globally and according to WWF-Pakistan the specie is endangered in context of Pakistan. The Specie is declining due to posed threats like shrinkage of habitat, deforestation and retaliatory killing.

4.3.9 AVI-FAUNA

Birds are valued for more than their beauty. They protect the environment by consuming insect pest in agricultural fields and forests, and help pollination and disperse seeds of many economically important plant species. During the last 5 decades' birds' population is reducing rapidly in Ushu valley. Deforestation, overgrazing, soil erosion, rampant hunting, and agricultural practices pose more specific threats to birds. **Table 4-16** including those birds and their present status in Ushu Valley.

Table 4-16: Birds and their status in Ushu Valley

S.No #	Birds	Status	S.No #	Birds	IUCN Status
1	Paddy Bird (*Ardeola grayii*)	Common	20	Black partridge (*Francolinus francolinus*)	Least Concern
2	Little egret (*Egretta garzetta*)	Frequent	21	Gray partridge (*Francolinus pondicerianus*)	Least Concern
3	Heron (*Ardea cinerea*)	Common	22	Quail (*Coturnix coturnix*)	Least Concern
4	Black shouldered kite (*Elanus caeruleus*)	Frequent	23	Koklass pheasant (*Pucrasia macroopha*)	Least Concern
5	Black kite (*Milvus migrans*)	Common	24	Kalij pheasant (*Lophura leucomelana hamiltonii*)	Least Concern
6	Bearded vulture (*Gyoaetus barbatus*)	Rare	25	Wood cock (S*colopax rusticola*)	Least Concern
7	Scavenger vulture (*Neophron perconpterus*)	Common	26	Tit (*Parus major*)	Least Concern
8	Sparrow hawk (*Accipiter badius*)	Rare	27	Tree creeper (*Certhia himalayana*)	Least Concern
9	Rock dove (*Columba livia*)	Common	28	Crow (*Dicrurus macricerus*)	Least Concern
10	Little brown dove (*Sterptopelia senegalensis*)	Abundant	29	House sparrow (*Passer domesticus*)	Least Concern
11	Rose-ringed parakeet (*Psitacula krameri*)	Common	30	Kingfisher (*Nalcyon smyrnensis*)	Least Concern
12	Eurasia cuckoo (*Cuculus conorus*)	Common	31	Roller (*Coracias benghalensis*)	Least Concern
13	Koel (*Eudynamys scolopacea*)	Common	32	Woodpecker (*Dendrocopos assimilis*)	Least Concern
14	Owl, (*Otus bakkamoena*)	Common	33	Myna (*Acridotheres tristis*)	Least Concern

S.No #	Birds	Status	S.No #	Birds	IUCN Status
15	Eagle owl (*Bubo bubo*)	Rare	34	Jay (*Garrulus lanceolatus*)	Vulnerable
16	Nightjar (*Caprimulgus europaeus*)	Frequent	35	Pipit (*Anthus sylvanus*)	Endangered
17	Swift (*Apus affinis*)	Common	36	Hoopoe (*Upupa epops*)	Least Concern
18	Buzzard eagle (*Butastus teesa*)	Rare	37	Dipper (*Cinclus pallasii*)	Least Concern
19	Botted eagle (*Hieraaetus pennatus*)	Frequent	38	Robin (*Sanicoloides fulicata*)	Least Concern

4.3.10 FISH/AQUATIC FAUNA

The Ushu River is a healthy habitat for local fish and famous among the fishermen and visitors for fishing both local and trout fish. Ushu River is rich in brown (*Salmo Trutta*) and rainbow (*Onchorhyncus*) type of trout fish which flourishes in cold water, and native camloop fish (*Schizothorax plagiostomus*) species called Swati more popularly known as the snow trout. At present trout is being bred in the Madyan Hatchery in regularly stocked in Ushu and Swat River. Rainbow trout has a tolerance for high temperature but brown trout does not flourish above 22˚ C. Private Hotels and some houses have developed running water ponds where trout is raised for commercial purpose. The present rates were reported between Rs.1000-1500 per kg fish catching of trout is strictly prohibited by the government. Local fish species are given in **Table 4-17.**

Table 4-17: Local fish species found in Ushu River

Scientific name	English name	Local name
Triplophysa choprai	Singhat Machli	Braithai
Glyptosternum riticulatum	Chakaar Machli	Chakia Mahay
Salmo Trutta	Brown trout	Trout
Onchorhyncus	Rainbow trout	Trout
Xinentodon Cancila	Crow fish	Ka Machli
Channa gachua	Daoly Machlee	Katay Mahee
Schizothorax plagiostomus	Galali	Swati
Racoma labiata	Chunr	Churn

Figure 4-6: Aquatic Fauna of the Project site

4.3.11 Aquatic Flora

Water bodies are complex ecosystems composed of distinct habitats influenced by biological, physical and chemical processes. Aquatic plants are a major part of this complex and are actively growing continuously or periodically depending upon seasonal variations, the availability of required amount of water and other ecological factors. They occur submerged below or floating on the surface or growing up through the water surface. These plants play an important role in the structure and function of the aquatic ecosystem. The aquatic plants are of various types, some are rooted in hydro-soil some are emergent; often found on the bank or shoreline while others are submerged and live below the water surface for most of the time. Still others are free floating, and some are rooted on the bank of the impoundments, adopting semi aquatic habitat. Some of the plants have a profuse growth pattern, propagate with such rapidity, and infestation is so high that unless timely action is taken it is extremely difficult to keep them under control.

4.3.12 Major threats to the wildlife

High population growth in the valley and demands for increased standards of living, which may force the poor to depend heavily on natural resources. Hunting has deep roots in our culture. Wild animals and birds have been hunted to extinction from hunting pressure. A greater threat to wildlife than hunting, however, is probably the disappearance of habitat or the competition with domestic grazing animals. The closed canopy forest in the valley is shrinking gradually. Arrival of thousands of Afghan refugees with their livestock most of the beautiful pastures in the valley were utilize more than it carrying capacity and with it has been badly affected the availability of food for life and wildlife. Use of pesticides in agricultural fields also play active role in decreasing the population of wild birds in the valley. Despite ban on cutting trees in Pakistan the timber mafia, which became more active as it was easier to cut more forests and degrading the wildlife habitat in Ushu valley.

4.3.13 Endangered Species of the area

The catchment area of Artistic-II HPP is also home to important endangered species of the area, including Snow leopard and otter in fauna. Similarly, in flora the most important specie is *Taxus wallichiana* (Yew). *Taxus wallichiana* the tree is native to the Himalaya is endangered according to IUCN red list and has medicinal use in Ayurveda and Tibetan medicine and is also a source of the anticancer drug, paclitaxel. *Geranium wallichianum* and *Saussurea lappa* are other two important medicinal herbs of the area are now endangered.

4.4 SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

4.4.1 GENERAL

This section provides the information on socioeconomic and cultural environment of the project area including political and administrative setup, settlement pattern, demographic characteristics, availability of social amenities, occurrence of religious and cultural sites, indigenous people and gender issues. To ascertain the information regarding socioeconomic and cultural environment of the project area, detailed field survey of the project area was conducted by the Consultants' environmental and social team. During this survey, project affected persons, individuals and relevant departments were consulted as well as secondary resources of information were also depended upon to establish socioeconomic environment of the project area**.** During socioeconomic survey, all houses/households were selected. The visit schedule was circulated before visiting the area for the collection of required data/information.

4.4.2 ADMINISTRATIVE AND POLITICAL SETUP

The proposed project falls within the administrative jurisdiction of Swat district. The district consists of seven tehsils Barikot, Babozai, Charbagh, Kabal, Khwaza khela, Matta and Bahrain. Selected Hydropower plant project falls in Tehsil Bahrain.

The Deputy Commissioner is the Administrative head of the district stationed at Saidu Sharif. He supervises the activities of all the departments situated in the district with the help of Assistant Commissioners of different tehsils named above. All the important Nation Building Departments are available in the district including Judiciary, Police, Education, Health, Communication and Works, Agriculture, Livestock, Environmental Protection Agency, Forestry, Wildlife, Fisheries, Industry, Food Department, Tourism Department, WAPDA and Telecommunication. The land settlement was carried out in Swat District during 1976-80. However, some area of the Project site still remains for land settlement record.

4.4.3 PATTERN

The weir site of the project is located in village Esheghal and Powerhouse is located upstream of the under construction Gorkin Matiltan Hydropower Project near Mai Banda village. The total land required for the project is approximately 381618.6 sq.m or 94.3 acres. The entire area is lush green and some people are settled on both banks of the river, which is characterized by high mountains all along the way. The settlements of the villages along the project corridor is generally scattered. The people normally construct their houses near the lands which they cultivate.

4.4.4 Housing Characteristics and Nature of Construction

In the project area, most of the houses are small and katcha and semi pacca type. Based on the field survey, 02 households are going to be affected due to the construction. These houses /households are located on right bank of the river. On an average, the houses are generally composed of two rooms and a separate room for animals.

4.4.5 People

The tract is inhabited by various clans of Kohistanis and Pathans. They are descendants of the ancient Indo-Aryan race. The Gorai tribe of Dir Kohistan is also of the same or allied stock. In early days Kohistanis were pushed into higher and inaccessible valleys by the Scythian tribes who invaded the area from time to time. The Kohistanis were lastly pushed by the Yousaf Zai Pathans who came from Ghazni via Kabul. The Madyan area and parts of lower Bahrain are inhabited by various clans of Yousaf Zai, Pathans. They have occupied the better arable land once own by Kohistani. The Kohistanis in turn subjugated the docile Gujars of the valley whose were already settle there when Kohistanis arrived.

The Gujar are of two types those permanently settled and those migratory. They keep large herds of cattle and stay in alpine pasture in summer and migrated to the lower area valley during the winter while the migratory Gujars move down to the plain of Pakistan in September and October. They always move about in search of better grazing ground and pay a fee called Kalang to the Maliks of local landowner for securing grazing rights in the alpine pasture. Both Kohistanis and Gujars are extremely poor and backward. Poverty illiteracy, ill health, unemployment and malnutrition are some of the social maladies which they have inherited from their forefathers. The local language spoken over the entire area is Torwali (Kohistani) and Pashto. However, the majority of the population can understand and speak Urdu. Some Torwali Maliks can also communicate in Urdu but they feel comfortable with Pashto. Amongst themselves the Gujars speak their typical Gaujri Language, which resembles Punjabi.

The women are confined to domestic life and sometimes they work in their fields when needed. They are not exposed to external society. Even if some female outsiders belonging to NGOs or other social organization want to meet them, they are hardly allowed to speak to women.

The people of Bahrain are divided into the following clans, which have been given in the order of their number, which are mentioned below in the tribes. The data have been collected through personal efforts from interviews with locals; therefore, the absolute authenticity is not claimed.

4.4.6 TRIBES

According to Kalam working plan forest department, the people in Bahrain Tehsil belong to different tribes in which the main tribes are;

Torwali speaking	Torwalis
Pakhtu speaking	Akhund Khel, Syeds, Mulla Khel and Katanis
Gujari speaking	Gujars
Kohistani speaking	Akar Khel
Other	Chitralis and Kashmiri

4.4.7 RELIGIOUS AND CUSTOMS

Swatis are almost 100% Sunni Muslims. They are very religious people that is why Maulanas are usually elected from the area for the legislative Assemblies. Most of the Swatti wear caps, keep beard and pray five times a day. Amazingly many locals can act as Paish Imams all over Bahrain and other valleys. In almost all mosques of major villages young kids are taught preliminary Islamic books by Paish Imams and young boys are sent outside their homes to Islamic institutions in Swat, Buner, Akora Khattak, Peshawar, Rawalpindi, Lahore and Karachi. Besides asking the Paish Imam of the local mauzha, Swatis specially invite Paish Imams of other mauzhs having large number of pupils to attend funerals of their relatives because it is considered being auspicious. The dead bodies are usually buried as soon as possible Purdah is very strictly observed throughout the valley and cases of adultery coming to surface are severely penalized.

4.4.8 OCCUPATIONS AND AVERAGE FAMILY INCOME

Major occupation of the residents of project area is agriculture farming and major crops are Maize, Potato and Peas. Small-scale businesses, government and private services and Labour are other professions in the project area. These include tourism related activities in the summer season, which contribute substantially to the income of the local residents. The average household income ranges between PKR 8,000 to 10,000 and in some cases the amount raises to 30,000 in the area.

4.4.9 Household Expenditure Pattern

Detailed information was gathered during the baseline survey about the household expenditure patterns. It was concluded that on the overall basis, the respondents spent major part of their total expenses to meet food costs and non-food expenditures come second. The household expenditure pattern in respect of the sample population is shown in **Table 4-18**.

Table 4-18: Average Annual Family Expenditure (PKR)

Item	Food Items	Non Food Items	Education	Health	Social Activities	Other	Total
Expense	46440	21600	7560	10800	11880	9720	108000
%age of Total	43	20	7	10	11	9	100

4.4.10 Educational Facilities and Education Level in Project Area

Education is one of the basic factors that contributes towards the foundation of a society. The literacy rate is the outcome of the education facilities in an economy that reflects the socio-economic behaviour of the communities. The educational facilities in the project area include one primary school at Eshegal, one primary school at Matiltan and one high school at Ushu. For higher secondary education and above students get admission in Bahrain, Madyan, Matta and Mingora/Saidu Sharif. A large number of middles, high and higher secondary schools are available in Swat which are within the reach of local population. The students are also enrolled in private schools and institutions which are scattered throughout the district. Number of Government schools and colleges available in Swat district is given in **Table 4-19**.

Table 4-19: Government Educational Institutions in Swat District 2015-16

S.No #	Institutions	Male	Female	Total
1	Government Primary Schools	796	503	1299
2	Middle Schools	84	45	129
3	Government High Schools	81	38	119
4	Higher Secondary	18	5	23

S.No #	Institutions	Male	Female	Total
5	Masjid/Maktab/Schools	631	-	631
6	Degree Colleges	3	4	7
7	Govt Post Graduate Colleges			3
8	Govt Colleges of Management Sciences			1
9	Govt Colleges of Technologies and Polytechnic Institutes			1
10	Govt Technical and Vocational Centres			28
11	Universities			1
12	Private Primary School			109
13	Private/Middle/High and Higher Secondary schools			256
14	Computer training centres	These are spread all over the district. No numerical data is available.		

Source: KPK Development Statistics 2017

4.4.11 LANGUAGES OF PROJECT AREA

Language is the human capacity for acquiring and using complex systems of communication, language is one specific example of such a system. The major language of the project area is Kohastani, while Pashto is also used.

4.4.12 AVAILABLE SOCIAL/PUBLIC AMENITIES

1. Road Network

In the project area, the unpaved road is situated along the bank of River Ushu connecting all the villages with each other. Besides this, katcha tracks are available inside the villages.

2. Telecommunication

Telecommunication services and Mobile networks are not available in any of the villages. However, mobile network is available in Kalam and it stops working at the distance of about 10 km from Kalam town.

3. Electricity Supply

In the project area WAPDA electricity is available. Besides, people have installed electric turbines on nullahs and electricity is generated for lighting purposes at least, while in Kalam town, the fuel power generators are also used.

4. Health Facilities

Basic Health facilities are available at Matiltan and Kalam areas which are within easy reach of the project area. For a specialized treatment people of the project area visit Khwaza Khela, Saidu Sharif or Peshawar where sufficient medical cover is available. The available hospital facilities in Swat district are given in **Table 4-20**.

Table 4-20: Health Institutions in Swat District 2015-16

S. No.	Medical Centers	No.
1	Hospitals	10
2	Dispensaries	18
3	T.B Clinics	01
4	Mother Care Health Center	03
5	Basic Health Units (BHUs)	41
6	Leprosy Centers	03

Source: KPK Development Statistics 2017

A few Private Hospitals and Clinics are also available in the District from where people get medical treatment.

5. Drinking Water Availability

Based on the socio-economic survey, it was observed that in the project area there is no municipal water supply connections available. The people using spring or Nullah’s water for domestic use and animal needs. The spring water is considered to be of good quality water for drinking.

6. Solid Waste

Solid waste disposal is another key problem faced by the population in the project area, as no proper system of solid waste collection and disposal is available in the villages. Majority of the people throw the solid waste of their houses in the open land, nullahs and the river.

7. Industry, Trade and Commerce

In the project area, no significant industry exists. The crops produce and livestock are generally marketed in Kalam. However, at powerhouse site even no small commercial market exists.

8. Sewerage

Sewerage is yet another key problem that is being faced by the population in the project area. The sanitation condition is very poor; no proper sewage system is available.

9. Indigenous People

No indigenous groups and vulnerable persons affected due to the implementation of the project found in the project corridor. However, a few women headed households reported in the project area and most of them are widows.

10. Cultural, Religious, Archaeological and Historical Sites

Cultural sites include mosques, shrines and graveyards. These are socially sensitive areas to deal with. The survey has revealed that the people of the project area are strongly attached to their religion and culture. Shrines and graveyards are regarded as sacred heritage and receive devoted attention from the people. No archaeological and historical sites were observed in the vicinity of the project area.

11. Migration

In the project area, people usually migrate from the month of October to the downside lower elevations of the country, due to extreme low temperature and snowfall. They, generally, start going back to the project area residences from the months of April and May when temperature starts rising. This migration badly affects the education of the children and socio-economic activities of the people.

12. Land Holdings

Due to sub-division of land under the law of inheritance, the land holdings are very small mostly in Kanals in the project area. Large holdings if available are about 2-3 acres which are commonly managed by the family but have individual titles of grandfathers. In most cases where elders of the families have full commanding hold, farming is done on joint basis.

13. Agriculture

Project area land is more or less steep in the form of small terraces. It is moderately fertile and capable of producing many crops. The fertility of the land differs from place to place. The land holding is generally small and majority of the population comprises of small and holders.

14. Crops Patterns

In the northern part of Bahrain Tehsil single crop is produced while in the southern part double crops are produced annually. The single cropped area includes the villages of Arianai, Peshmal, Laikot, Mankial, Balakot, Gurni and upper villages of Ushu valley. The main crops in this area are potato, maize, tomato and some vegetables such as sumchal, pumpkins and beans. The double cropped area includes Gham gari, Torwal, Darolai, Bahrain proper, Statal Gan, Ayeen, Shagram tirat, Madyan, Chel and Beshigram. The summer crops in these villages are maize tomato, potato and rice while the winter crops are wheat, onion, peas, turnips, radish, barseen and barley.

Cropping patterns and cropping intensities are followed on semi-commercial and subsistence basis where water availability is no problem. Potato of the project area is well reputed in potato products. Some farmers are compelled to seek off farm and alternate sources of income rather to depend on agriculture. Out migration for livelihood earnings in these areas has been reported which is increasing substantially.

Cropping practices and agricultural implements are primitive and knowledge of improved crop production is very poor. There is a lack of seed of improved varieties and other planting materials. Vegetables and pulses are grown on very small scale and fruit trees are hardly cultivated despite considerable potential. Agricultural support services are almost non-existent and poor access and rugged terrain makes the import of agricultural inputs costly and difficult. There are no formal rural credit systems, and informal systems are generally exploitative.

15. Fruit Plants

A variety of fruits are produced at different places in Bahrain Tehsil. The main fruit Plants found in the area are apple, walnut, Apricot, plums, Amlook (Persimon), pears. Peaches and grapes. Many of the fruit plants like peach, grapes, amlook and walnut grow naturally along the streams even inside the forest. There is a general trend among the farmers to plants fruit trees on the hill slope adjoining the agriculture fields and also courtyard of their houses.

16. Food situation

The total arable land in Bahrain Tehsil is 5500 ha which 5% of the total area. This shows that the land available for agriculture is very small which is not sufficient to produce enough food within the area. The main crops are potato, maize and some vegetable. The average yield is

1224 kg per hectare for maize and 14.4 ton per hectare for all kinds of vegetable. (Agriculture statist reported 1990-91). The local food does not meet the local demand of 89680 population therefore the required food is imported from the other area.

17. Livestock and fodder

There is no reliable data available regarding the livestock. The people keep herds of domestic animals like cows, goats, donkeys, buffalos and chicken etc. for the domestic use and in few cases for the commercial purpose. Cows and goats are majority in the upper part of the valley while buffalos are in the lower part especially in the Triat and Madyan. Mankiali bulls are famous all over in the Swat valley. There is no proper facility available in the area for the preventive measure and treatment of the animals.

18. Livestock and marketing

There has been no adequate marketing system for livestock. Animals are sold in the area when cash is needed on urgent basis. Normally the animal are in their best health after grazing in alpine pastures but due to absence of proper marketing system at Bahrain and Madyan, surplus and old animals are sold in downside areas during winter months. However, in the process of walking long distances in down- country areas, the animals loose fat, become weak and do not fetch good prices.

19. Fodder

People mostly rent their high-altitude pastures to Gujar nomads while people in the north go with their herds of cattle and a part of their family to their respective pasture during summer for 3-4 months. Generally, fodder crops are not grown in the fields but grazing lands close to the villages and even forests near the population are used for grazing animals. In the valley bottom fodder is insufficient due to small land holdings, lack of irrigation and technical know-how.

20. Forestry

Forests are of vital importance for subsistence of the local economy. People meet their day-to-day requirements from forests in respect of timber, firewood, fodder, grazing, grass medicinal plants, wild vegetable, mushrooms honey fruit etc. Most important is the function of forest in maintaining the ecosystem which support and maintain other means of livelihood such as agriculture and livestock rearing. The common forest product sold out are timber, firewood, medicinal plants, honey and mushrooms. Oak firewood though on a small scale is also cut for sale in the lower area. Timber harvesting is under control of Forest Department Corporation while NTFPs are collected by local people without any restriction and are either use inside the valley or are sold out to the private dealers.

The population depends largely on Forests for grass, grazing fodder and timber. There are no restrictions on grass cutting, grazing and lopping for fodder. The people can collect or cut dry trees and branches for firewood. They can even lop or cut green trees for fuel wood, agricultural implements and constructional purposes without the permission of local authorities if they reside at least 1.6 km (1mile) inside the valley from Main Kalam road. Hundred percent of the people use fuel wood for cooking and heating. About 15% of the households use kerosene for light and the rest use other sources. The demand on timber for constructional purposes is high because each household uses large quantities of timber. The demand of timber for agricultural purposes is not large and is met from the broadleaf trees. The sheep and goats are fed entirely on Oak leaves and hay except during summer months when the herds are taken to pastures in alpine zone.

Forestry is one of the main sources of income, beside royalty, the people get a lot of benefits like timber of house constructions, firewood, edible plants, fodder and mushrooms, fruits, nuts, medicinal plants and forest manure.

4.5 ECOLOGICAL WATER DEMAND AND DOWNSTREAM WATER USAGE

4.5.1 CATCHMENT AREA

The catchment of the Artistic-II HPP lies in the upper region of the Ushu River, a tributary / sub system of a Swat river basin and can be classified as a “high mountain catchment”. Snowmelt is the principal source of water in the river. Catchment area of the Ushu River at weir location is estimated to be 454 sq. km and at Powerhouse location is approximately 600 sq.km.

4.5.2 DISCHARGE DATA

There are three (03) gauge stations available near the project site maintain by various government organizations, as given in **Table 4-21**.

Table 4-21: Stream Flow Gauging Stations

S.No	Station	River	Location		Catchment Area (km^2)	Period of Record
			Latitude	Longitude		
1	Kalam	Swat	35°28’10”	72°35’40”	2020	1961-2009
2	Jildat	Ushu	35°29’15”	72°35’45”	783	2006-2015
3	Matiltan	Ushu	35°33’33”	72°40’05”	656	2011-2017

4.5.3 ESTIMATION OF FLOWS AT WEIR SITE

To estimate the water availability at Artistic-II Hydropower project daily flow record of Matiltan, Jildat and Kalam Gauge stations were used.

Comparison of stream flow for a concurrent period of Swat River at Kalam with Ushu River at Jildat was carried out to develop a correlation which was then used to transpose Kalam data to Jildat for the year 1961-2005. The estimated data at Jildat from the year 1961-2005, observed data at Jildat for the year 2006 -2009 and observed data at Matiltan for the year 2011 to 2017 was then transposed to the proposed Artistic-II weir site using the catchment area ratios.

The estimated flow data at Artistic-II weir site shows that the average maximum monthly flow ranges from 57.76 m^3/s in July to 3.47 m^3/s in February.

4.5.4 DRY, AVERAGE AND WET YEARS ANALYSIS

Estimated mean annual discharge data of Artistic-II site (1961 – 2017) was used for analysis of dry, average and wet years using the criteria of 0–30%, 31–70% and 71–100% probability of exceedance for wet, average and dry years respectively, 15 years out of 55 years fall in dry year category, while 17 years fall in wet year category and 23 years in average category.

4.5.5 RIVER TRIBUTARIES

The main source of Ushu River is Mahodand and Saifullah Lake, nearly 30 km from Kalam town. Glaciers, waterfalls of Ushu valley, Eshegal nullah, Khel Gal nullah, Palogah Nullah feed the river. The Ushu River flows through the entire Valley via Eshegal, Palogah, Matiltan, Ushu and joins the Gabral River in Kalam town. The other streams/ nullahs present in the area also contribute towards increasing the water quantity in the river.

4.5.6 DOWNSTREAM DEGRADATION

The release of clear water either through the outlets or power plant, will upset the regime of the natural channel on the downstream side of the powerhouse, in the form of degradation of the channel bed and banks. The degradation process progressively moves downstream, until it reaches a point where the quantities of the sediment being transported result in a stable channel, or equilibrium. The one exception to a clear water release would be a reservoir that has planned sluicing with low-level outlets, having a capacity equal to the high river discharges for moving large amounts of sediments into the downstream channel.

4.5.7 LOWER RIPARIAN WATER USE STUDY

The environmental water requirements, downstream of the weir are the water needed to sustain the ecology of the downstream reach of the river. The ecology of the downstream reach consists of plant life, wildlife, and aquatic life including of fisheries. It should also include the river bed losses and the bank charges, which are likely to affect the groundwater table along the river banks. The depression of the groundwater recharge to the banks, is nominal due to steep mountains on the sides and the rocky strata that hardly allow infiltration. Water use study survey of the river was conducted downstream of the weir site, just at the start of Eshegal village and up to Maee Bannal at a distance of about 10 km, where the river flow will considerably be reduced after the project construction.

Water use studies determine the consumptive and non-consumptive water use of communities along the river. It was essential to identify the concerns of the communities due to flow reduction there in the river in their villages/ localities.

4.5.8 STUDY AREA

The Ushu River from the Weir site to the Powerhouse site is confined within narrow steep sided valley. The river has a steep to very steep gradient and is contained within a single swiftly flowing channel that carries almost clean or little volumes of suspended and bed load material. Due to the nature of precipitation, the terrain and the inhospitable river environment, comparatively a few settlements have developed closer to the River. Discharge is highly seasonal with lowest flow in winter and the high flow occurring in summer with the onset of snow melt and monsoon rains. The river is extremely swift and dangerous, some sections above the rock bars have slower water, where local population and livestock can safely access the river from the rock edges. The inhabitants' activities are generally during the summer season, from April to November, while in winter season, there is no activity due to extreme weather, i.e. snowfall and low temperature. Water temperature is very low in winter and rises during the summer. The area is sparsely settled in a few places at both sides and the open valleys at higher elevation. The terraced lands are used for dry (rain fed) farming or irrigated cereal crops cultivation. Settlements are normally not dependent on the river and depend mostly on the nullahs/ tributaries joining the river with respect to water consumption for livelihood and other utilities. The smaller village settlements may consist of mostly clusters of houses that extend both vertically and laterally along the river depending on land and water availability. Spring water is plentiful in the area for domestic consumption. Thus, most of the communities that have settled on the valley floor are present but have poor communication and road access but are native to the valleys. For these communities, the importance of river is secondary. The water for drinking purpose and small farm irrigation in these areas is almost wholly rain fed or somewhere from small nullahs.

4.5.9 SETTLEMENTS

There are three settlements/villages from the weir site to the powerhouse site up to Maee Bannal. These three settlements are on the right and left bank of the river. All these settlements are a cluster of houses at different places along the river. In all these settlements few houses are at a high altitude while clusters are closer to the river.

Figure 4-7: Settlements of Project site

4.5.10 DRINKING WATER SUPPLY

The source of obtaining drinking water in all the villages is almost through spring water. All of the community's favour spring water, which they perceive as good and river water being of inferior quality due to its turbidity and possible contamination from upstream users.

4.5.11 SAND AND GRAVEL EXTRACTION

Substantial quantities of sand and gravel get accumulated closer to the river banks during the summer season. This accumulated sand and gravel are lifted up from the river banks and stored along the sides. This is marketed to the end users in construction works. Persons involved in the sand and gravel collection and its marketing business have apprehensions that their business will be adversely affected, which needs some mitigation measures. They can be provided with the employment opportunities in the Project construction works during the project implementation stage on priority.

4.5.12 FLOATING TIMBER WOOD

Floating wood is collected from the rivers occasionally in the area and logs have particularly a good market value. This is though a dangerous practice as logs are mainly washed down during the flood season and lives have been lost when trying to retrieve logs from the river. A negative concern has been expressed by the communities about the loss of floating timber wood due to the project construction.

4.5.13 WASHING

Washing is also one of the water uses for the settlements along the river/stream, this use is in the summer season only.

4.5.14 FISHING

Fish catching reported in the area is rare and at some places in limited quantity. The catching of fish is mostly as a hobby and for their own use and no one is dependent for their livelihood on this business. They catch fish during the summer season only. Summer is the best season for fishing, as the larger summer flows are recognized as being more productive in terms of fish catch. Fish catching are being done with fish nets and fishing rods. Fish is not included in the regular diet nor is it considered prestigious to be served on special occasions.

4.5.15 COMPENSATION WATER REQUIREMENT

Compensation water releases from the Weir do not consist of only environmental water requirement but also include riparian rights of water users in the downstream reach of the river. The riparian rights consist of water supply for the domestic and commercial use, established irrigation use and water needed for dilution of the sewage entering the river from various sources. The environmental water requirement downstream of the proposed Weir is the water needed to sustain the ecology of the downstream reach of the river. The ecology of the downstream reach consists of plant life, wildlife, and aquatic life including fisheries. It should also include the river bed losses and bank charges, which are likely to affect the groundwater table along the river banks. The depression of the groundwater table may affect the riverine forests. The groundwater recharge to the banks is nominal due to steep mountains on the sides and rocky strata that hardly allow infiltration.

4.5.16 ENVIRONMENTAL WATER RELEASE FROM THE WEIR SITE

The proposed project is a run-of-the stream project involving diversion of water from Eshegal village through a headrace tunnel, leading to a penstock, which in turn will feed the powerhouse. The combined flow from the powerhouse i.e. tailrace discharge will be released back into the Ushu River near Maee Bannal. The diversion of water for the project may have adverse impacts on the downstream users of the streams, thereby requiring adequate management and mitigation measures among others to be put in place well in advance. Currently, three small villages are dependent on this segment (between weir site and powerhouse) of the Ushu River for their domestic needs and other water requirements. Although all these settlements, depend mostly upon streams flowing in the river from the surrounding areas, the drinking water needs are met through spring waters. The water use study conducted indicates that the general water use in the area consists of water required for cattle, tourists and water requirement for ecological sustenance. Construction of Artistic-II HPP will result in reducing the flow downstream in about 10km stretch of the river from the weir site to the powerhouse site. This may have some adverse impacts on the aquatic life, fowl life, downstream people and other environmental elements in this reach.

4.5.17 ENVIRONMENTAL FLOWS

The river is the only ecosystem that connects other ecosystems, carries water, transports dissolved minerals, sediments and nutrients to maximum places before emptying into its natural outlet. How much water would flow through a river channel? The sediment and nutrient load carried by a river is decided by the nature of the catchment and the rainfall or snow fall pattern. Flowing rivers connect different ecosystems like glaciers, forests, riparian zones, flood plains, mangroves etc. on their way. Flowing rivers also create flood plains, sand deposits, deltas, etc. Rivers while draining the land carry out groundwater recharge by percolating into deeper aquifers. All rivers do not necessarily flow directly to the seas or open oceans. High flows of different frequency are important for channel maintenance, bird breeding, algae control, wetland flooding and maintenance of riparian vegetation. Moderate flows may be critical for cycling of organic matter from river banks and for fish migration, while low flows of different magnitudes are necessary for fish spawning, water quality maintenance, the use of the river by local people, etc.

It is hence imperative to understand the inextricable linkages between flowing rivers and dependencies of communities, which is at the core of the ‘environmental flows’ concept. Considering this reality, devising ways for mainstreaming community concerns and efforts in water management within a river basin in general and e-flows in particular is a challenging task. The term environmental flow refers to the quantity, quality, and timing of water flow needed to sustain ecosystems and the services they provide to humans (Dyson et al. 2003; Poff et al. 2010).

A distinction should be made between the natural flow regime of a river that would maintain ecosystems in a pristine state and an environmental flow. An environmental flow has the goal of allocating sufficient water to ecosystems to maintain. Since the concept emerged in the mid-20th century, more than 200 methods for estimating environmental flows have been developed globally. These methods can be classified into four approaches (23.1; Tharme 2003). Hydrology-based methodologies use historical discharge records to make environmental flow recommendations, usually expressed as a fixed proportion of flow intended to sustain river health (e.g. 10% of average annual discharge). Hydraulic-rating methodologies rely on basic hydraulic parameters (e.g. depth, wetted perimeter) that relate to habitat for aquatic biota; environmental flow recommendations are made by plotting acceptable levels of reduction in these parameters against discharge. Hydraulic rating methodologies preceded more sophisticated habitat simulation methodologies that employ hydrological, hydraulic and biological response data to quantify suitable instream physical habitat available to target species, usually fish, under different flow regimes. Habitat-discharge curves depicting the range of habitat for biota as a function of flow are then used to determine environmental flow recommendations.

Holistic methodologies aim to approximate the natural flow regime and often employ some of the tools of hydrology-based, hydraulic rating and habitat-simulation approaches.

Reference: A Primer on Environmental Flows LathaAnantha&ParineetaDandekar, 2012

In the absence of a specific guideline or recommendations in Pakistan for the amount of water (residual water) to be retained in a water reach as an environmental flow when water is diverted for hydropower purposes, the following method was considered to evaluate ecological flow:

4.5.18 CEMAGREF MODEL

For the determination of ecological flow, a formula representing a function of the available mean monthly discharges and the mean annual discharges, was used as presented below,

Qe= {(0.0651 X Qm+ 2) /100} x Qa

Where Qe= Mean monthly ecological flow (m^3/s)

Qm= Mean monthly flow (m^3/s)

Qa= Mean annual flow (m^3/s)

The formula was also used for feasibility study for Madian HPP, Koto HPP feasibility and feasibility study of the Gabral-Kalam HPP and was developed by CEMAGREF which is an Agricultural and Environmental Engineering Research Organization of (Antony) France. The model is also recommended by the International Association of Small Hydropower.

The CEMAGREF Model is used as a reference to calculate the mean monthly ecological or residual flows in Koto hydropower project feasibility study. The results are given in **Table 4-22** Environmental flows calculated by CEMAGREF Model in low flow seasons are less than calculated as 15% by USA method. So, nearly 0.7635 m^3/s as by USA method is considered to be appropriate as environmental flow from October to March and 5.34 m^3/s from April to September in this river reach. The water released continuously from the weir site along with the water augmented through the streams and nullahs will be sufficient /adequate to meet the ecological and environmental requirements of the downstream area between the weir and powerhouse sites during the operational stage of the project. Walk-through survey indicated that agriculture field blocks along river sides are located near weir site but it is mainly irrigated not from the Ushu river water but the people use the tributaries nullahs for irrigation purposes. However, as agriculture practices are carried out during the summer season only. Thus, at the time there is enough water to irrigate the agriculture lands of the village. So, overall, there will be no significant effect on the agriculture lands of the area due to construction of this hydropower project. So, environmental flow of the above-mentioned quantity is recommended for downstream requirements and to maintain ecological flows in between weir and powerhouse for this river reach.

Table 4-22 Mean Monthly Flow and Ecological Flows calculation

Month	Mean Monthly flows (cumec)	Ecological Flows Calculated by CEMAGREF Model (cumec)	15% as Calculated by USA (Montana Method) (cumec)
January	3.810	0.457	0.5715
February	3.467	0.453	0.5200
March	4.207	0.463	0.6310
April	11.527	0.560	1.7290
May	30.527	0.811	4.5790
June	55.577	1.143	8.3365
July	57.757	1.172	8.6635
August	39.153	0.926	5.8730
September	19.200	0.661	2.8800
October	8.810	0.524	1.3215
November	5.730	0.483	0.8595
December	4.517	0.467	0.6775

5. PROJECT ALTERNATIVES

The Project alternatives are considered for analysing the most feasible option keeping in view technical and economic factors as well as acceptability from environment and social aspects.

In case of this HPP, the present alignment (Alternative-3) has been found the most suitable for generating 55 MW electricity. The layout alternatives were studied in detail during site visits by the design experts and the environmentalist/sociologist of the project.

The Consultants made desk studies based on satellite imagery available from google earth and mark various layout alternatives on the image to be studied during site visit of experts.

The following alternatives for project development were considered from the perspective of economic and environmental considerations:

1. No project options
2. Project Layout Alternatives

5.1 NO PROJECT OPTION

KP and Pakistan are going through an acute power shortage. The gap between supply and demand has crossed 5,000 MW. The proposed Project will supply some needed power to reduce the current gap. Environmentally, this Project will contribute towards improving the air quality as in the long run it will displace fossil fuels used in power generation.

For years, the matter of balancing Pakistan's supply against the demand for electricity has remained a largely unresolved matter. Pakistan faces a significant challenge in revamping its network responsible for the supply of electricity. Pakistan’s electricity producers are now seeking parity in returns for both domestic and foreign investors, which makes it as one of the key unresolved disuse in overseeing a surge in electricity generation when the country faces growing shortages.

As of 2013, massive long duration electricity shortages continued with continuous failure to provide reliable service, and rampant corruption being met by public protests, unauthorized connections, and refusal by consumers to pay for intermittent service. Electricity generation in Pakistan has shrunk by up to 50% in recent years due to an over-reliance on fossil fuels. In 2008, availability of power in Pakistan fell short of the population's needs by 15%. Pakistan was hit by its worst power crisis in 2007, when production fell by 6000 MW and massive blackouts followed. Load shedding and power blackouts have become more severe in Pakistan in recent years.

Measures have already been taken to restrict demand by using an inverse tariff by which well to do customers using larger amounts of electricity pay a high erratum per unit.

The situation is causing serious economic losses to the country as well as being politically and socially divisive and could gradually lead to a risk of social unrest. The current situation with insufficient installed power generation capacity is very serious and untenable. Therefore, there is imperative need to construct new power projects at the earliest.

5.2 PROJECT LAYOUT ALTERNATIVES

The Consultants made desk studies based on satellite imagery available from google earth and mark various layout alternatives on the image to be studied during site visit of experts. The project layout alternatives are presented in **Figure 5-1**.

The layout alternatives were studied and discussed in detail during various visits to the site and the observations of design experts are elaborated below.

The Consultants, before carrying out detailed topographical survey, have included additional areas under survey boundaries in advance to study various project alternatives in detail as access to the project site during winter season (Dec-March) would not be possible.

The layout alternatives and their merits and demerits are discussed in detail.

Consultants identified alternate project site for weir W2 (Alternative 2, 3 & 4) about 220 m upstream of weir site W1 (Alternative 1 provided by the Client) resulting in additional head of about 5 m.

Consultants also identified alternate project site for powerhouse P2 / P3 (Alternative 3 / 4) which is 700 m downstream of powerhouse site P1 (Alternative 1 provided by the Client) offering additional head of about 28 m. The powerhouse site P2 / P3 is about 240 m upstream of 84 MW Gorkin Matiltan HPP.

It is pertinent to mention that the location of Artistic-II powerhouse P2 / P3 has been selected in such a way that its tail water level when all units are in operation with full capacity, will be above or equal to the Gorkin Matiltan Weir maximum (flood) water level.

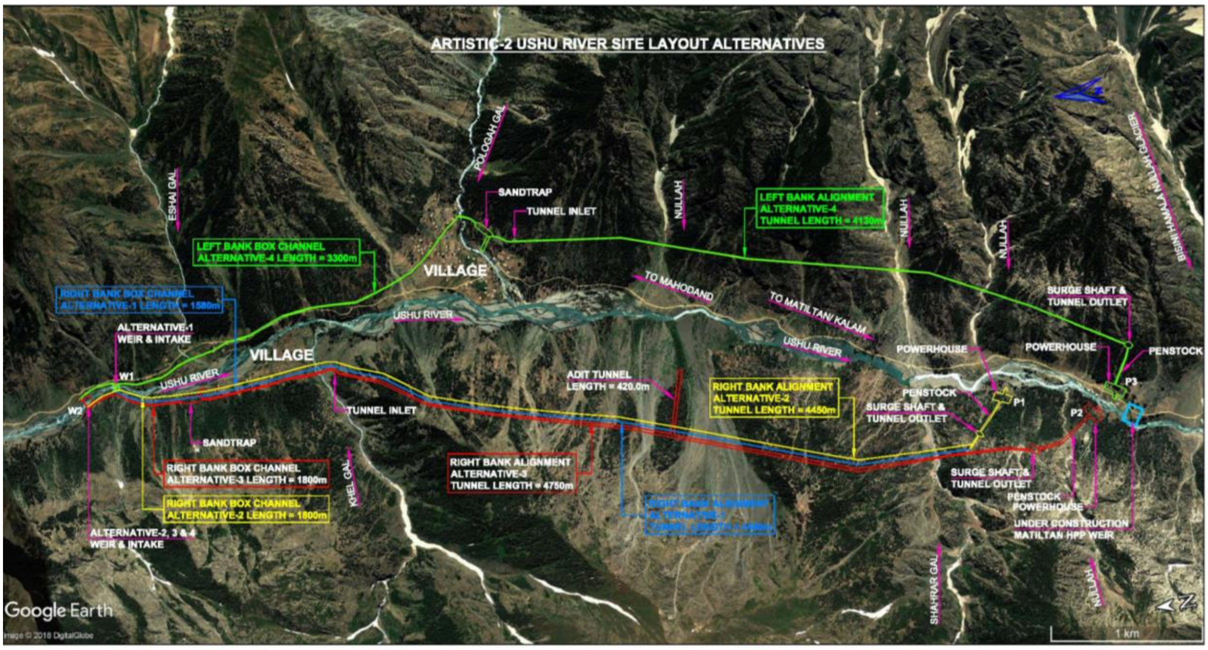


Figure 5-1: The project layout Alternatives

5.2.1 ALTERNATIVE-1, 2 & 3 (RIGHT BANK LAYOUTS)

Weir

The weir site (W1) as per coordinates provided by the Client (Alternative-1), is not safe from geological point of view due to huge glociofluvial fan at right bank. Shifting the axis ~220 m upstream, to the middle part of the glociofluvial fan, where right bank geological materials is more stable, will be more appropriate (Alternate 2, 3 & 4). On the other hand, since W1 site is narrower, the side walls of the weir structure will be higher to spill the design flood discharge safely, in comparison to W2 site.

Shifting the weir axis by 220 m upstream will have following advantages:

1. The river becomes wider as we go upstream from W1 to W2 site and as a result the diversion arrangements during the construction will be easier. The part of the river will be plugged with the embankment at the end of the construction.

2. Additional head of about 5 m.

3. The levels of the Sand Trap will increase and flushing flows can be easily discharged in the river.

4. The level of the Tunnel Inlet portal will increase which will reduce the excavation near the tunnel inlet portal.

The rain water / flows from melting snow emerging from the top and downstream side of glaciofluvial fan, will be captured by providing drainage ditch to guide the flows safely to the Ushu River.

The upstream side walls of the weir will be extended enough, towards reservoir, in order to protect the toes of the right and left bank geologies.

The height of the weir shall be 6 m for safely diverting design flows from reservoir.

Implementation of a radial gated (serving both for sluiceway and spillway) barrage type weir is not recommended, due to operational difficulties that will be encountered in this part of the region. Therefore, a traditional Ogee type weir with under sluices and lateral intake would be able to serve the purpose.

Right Bank Conveyance Box Channel

The canal alignment will pass through the toe of glociofluvial fan approximately. Although similar terrace materials stand at a right angle surprisingly at some neighbouring locations, it will be useful to determine geotechnical parameters of this material during geological investigations.

Right Bank Sandtrap

The structure is placed at weir site, just after the intake, in order to clean the water at the beginning of the conveyance system, thus to prevent the formation of settled sediments within the box channel.

Right Bank Tunnel Inlet

The alignment of box channel, before tunnel inlet, passes Khel Gal tributary route at an approximately right angle. In order to protect box channel from the flows of this tributary, it will be crossed as super passage over the box channel.

The tunnel inlet would be located where rock is exposed at the right bank of the tributary at some distance away where the contours are high. Location of tunnel inlet, just after the sand trap, does not seem suitable due to absence of exposed rock surface.

Shahrar Gal Passage of Right Bank Tunnel u/s of Tunnel Outlet:

Sufficient rock cover above the tunnel section must be ensured, which will pass beneath the tributary. Therefore, the depth of alluvium under tributary must be determined during the geotechnical investigations.

Right Bank Surge Tank, Penstock Alignment and Powerhouse Location:

According to Thoma criteria, for a preliminary decision, if the pressurized conduit length is greater than 4~8 times of the gross head than principally a surge tank is needed.

The exit (outlet) location of tunnel was fixed according to the location and approximate dimensions of powerhouse as well as the route of penstock and height of surge tank.

The powerhouse location (Alternative 1 & 2) as per coordinates provided by the Client is about 940 m upstream from the 84 MW Matiltan Weir. It is possible to shift the location of power house downstream by about 700 m (Alternative 3) i.e. about 240 m u/s of Gorkin Matiltan Weir to get benefit of additional 28 m head. It is pertinent to mention that the location of Artistic-II powerhouse must be selected in such a way that the tailwater level, when all units are in operation with full capacity, will be above or equal to the Matiltan Weir maximum (flood) water level.

Provision of Road Bridges:

The right bank layout alternatives alignment would require construction of two vehicular bridges i.e. one each at weir and power house, respectively for loadings as per project's requirement for access during and after construction.

5.2.2 ALTERNATIVE-4 (LEFT BANK LAYOUT)

Box Channel Alignment:

The box channel alignment will be carried through under the main Kalam-Mahodund road at the beginning of the alignment and runs parallel to the road up to Palogah village at higher elevation from the middle reach till end of the channel. Excessive deep cut excavation and cutting of forest trees would be involved at the beginning of the reach. Diversion arrangement of traffic will be required where box channel crosses the road. Since, the road remains open to traffic throughout the year except from December to March and remain stable, therefore it is expected that box channel may also remain stable along this alignment. At the end of the alignment the box channel will be on a higher level than the road on the left bank, and will pass through Palogah Village. At Palogah village, some serious social issues may arise and needs to be addressed as the alignment goes through some houses, cultivated lands etc.

Left Bank Sandtrap:

It was initially envisaged that to carry design flows via box channel through the Palogah Village and after crossing Palogah Gal, sand trap could be suitably located including tapping flows from Palogah Gal. However, after visiting the site it seems that it would involve serious social issues including number of houses, displacement of people and cutting of forest trees and fragments of arable land would be utilized.

Left Bank Powerhouse:

The location of powerhouse (P3) is proposed as opposite to location envisaged for Alternative 3 (P2), i.e. to a shifted location about 240 m u/s of Gorkin Matiltan Weir to get benefit of additional 30 m head. The other details are same as that of Alternative 3 discussed above.

Salient features of layout alternatives are given in **Table 5-1.**

Table 5-1: Salient features of layout alternatives

Description	Alternative 1 (W1P1) (Right Bank)	Alternative 2 (W2P1) (Right Bank)	Alternative 3 (W2P2) (Right Bank)	Alternative 4 (W2P3) (Left Bank)
Deep Cut / Excavation	No	No	No	Yes
Slope Stability Issues at Weir Location	(W1) Relatively higher than W2 Alternative	(W2) Small	(W2) Small	(W2) Small
River Diversion during Construction	Stage Construction require Longer Construction	Easier & Time Saving during Construction	Easier & Time Saving during Construction	Easier & Time Saving during Construction
Sand Trap Location	Excellent	Excellent	Excellent	Difficult / Not suitable
Tunnel inlet / Outlet Portal	Reasonable	Reasonable	Reasonable	Difficult
Power House	Suitable	Suitable	Suitable	Suitable
Environmental & Social issues	Minimum	Minimum	Minimum	Severe
Access Bridges at Weir & Power House	2 Nos.	2 Nos.	2 Nos.	Not Required

Description	Alternative 1 (W1P1) (Right Bank)	Alternative 2 (W2P1) (Right Bank)	Alternative 3 (W2P2) (Right Bank)	Alternative 4 (W2P3) (Left Bank)
Multi span culvert / Bridge for at Weir & Tailrace crossing Kalam-Mahudand Road	Not Required	Not Required	Not Required	2 Nos.
Box Channel Length	1580m	1800m	1800m	3300m
Tunnel Length	4450m	4450m	4750m	4130m
Penstock Length	250 m	250 m	400m	300 m
Total Length (Box Channel + Tunnel + Penstock)	6280m	6500 m	6950m	7730m
Gross Head	164m	170m	199m	199m
Design Discharge	34 m^3/s	34 m^3/s	34 m^3/s	34 m^3/s
No. of Turbine Units	3 (2 large & 1 small)	3 (2 large & 1 small)	3 (2 large & 1 small)	3 (2 large & 1 small)
Combined Efficiency (Assumed for Comparison)	87%	87%	87%	87%
Power Potential (Tentative for Comparison)	43.35 MW	45.10 MW	53.52 MW	53.81 MW
Annual Energy (Tentative for Comparison)	175.95 GWh	179.71 GWh	212.42 GWh	213.55 GWh

The Consultants after detailed discussions, analysis and comparison of all project layout alternatives, come to the conclusion that right bank Alternative 3 would be more practical and beneficial from structural point of view, and geological & geotechnical aspects. Although, Alternative 4 would offer maximum power potential, Alternative 3 deserves to be the optimum selection due to minimum environmental and social issues. Alternate 4 (Left Bank) has severe environmental and social issues, involving deep excavation for box channel and other structures and due to absence of suitable/favourable sand trap location, therefore it is considered as the least preferable option to be studied further.

Alternative 3 has been further refined by carrying out project sizing and optimization studies.

6. STAKEHOLDERS CONSULTATION

As part of the Environmental Impact Assessment (EIA) process, consultations were undertaken with communities and institutions that may have interest in the proposed project or may be affected by it. This Section documents the consultation process for the EIA of the proposed Project and summarizes its results. The Environmental Protection Act (PEPA 1997) makes the participation of the local communities mandatory in the planning and design of a development project. Scoping session is a process that ensures participation of the affected people, communities, notables, elite and other stakeholders of the project area.

6.1 OBJECTIVE

The core objective of such consultation and participation of the affected stakeholders is 'to inform stakeholders about the proposed project, to provide an opportunity for those otherwise unrepresented to present their views and values, providing better transparency and accountability in decision making, creating a sense of ownership with the stakeholders'.

Stakeholders refer 'People, who may be directly or indirectly affected by a project, will clearly be the focus of public involvement. Those who are directly affected may be project beneficiaries, those likely to be adversely affected, or other stakeholders. The identification of those indirectly affected is more difficult, and to some extent it will be a subjective judgment. For this reason, good practice to have a very wide definition of who should be involved and to include any person or group thinks that they have an interest. Sometimes it may be necessary to consult with a representative from a particular interest group. In such cases the choice of representative should be left to the group itself. Consultation should include not only those likely to be affected, positively or negatively, by the outcome of a proposal, but should also include those who can affect the outcome of a proposal'.

The main objectives of stakeholder consultation are following

- Providing key project information to the stakeholders and to record their views on the project and its potential or perceived impacts.
- Developing and maintaining communication links between the Consultants, Project Authorities and Stakeholders.
- Ensuring that views and concerns of the stakeholders are incorporated into the project design and implementation with the objectives of reducing or off-setting negative impacts and enhancing benefits of the proposed Project.

6.2 IDENTIFICATION AND CONSULTATION WITH STAKEHOLDER

The main project stakeholders identified are project affected persons (PAPs), who reside or own businesses or land subject to expropriation as a result of the planned hydropower project. Other stakeholders identified included local Government representatives, village elite, and Government officials of the relevant department's i.e. Revenue, Forest, Agriculture, etc., CBO/NGOs and general public. All those stakeholders have different types of stakes according to their professions and involvements in various aspects of the project. The Consultant contacted all the stakeholders and shared their views and concerns with the implementation of the project and also interacted with the community-based organizations that can support the community during the execution of the project.

As a first step, potential affectees/local population as well as other stakeholders was identified. As a result, the following people/community and Departments were considered as the project stakeholders:

6.2.1 PERSONS / DEPARTMENT CONTACTED

Local People:

- **i.** Individuals
- **ii.** Owners/farmers of the land and houses, whose property is directly affected by the proposed project.
- **iii.** People (other than owners/farmers) who could be affected by the project operations
- **iv.** Women of the affected households
- **v.** Communities/villages
- **vi.** Traditional authorities e.g. village leaders, notables
- **vii.** Local influential people, leaders, political figures and public representatives

NGOs:

- **i.** Local communities, CBOs /NGOs
- **ii.** Those which are active in the local area or have interest in the natural resources/social welfare.
- **iii.** Interested parties in the country of any external financing agency.

Voluntary Organizations:

- **i.** Local community
- **ii.** Development or users' groups
- **iii.** Recreational groups
- **iv.** Neighbourhood associations
- **v.** Gender groups
- **vi.** Ethnic organizations

Private Sector

- **i.** Business interest groups
- **ii.** Trade associations
- **iii.** Professional societies, etc.

National/Local Governments

- **i.** Local, Tehsil and District Government Administration Offices
- **ii.** Provincial Departments (Agriculture, Mining, Irrigation, Soil Conservation, Forest, Wildlife, Fisheries, Health, Revenue, Education, Building and Works and Environmental Protection Agency, etc.)
- **iii.** Those with responsibilities for management of the natural resources along with people welfare and those likely to be affected by the development project.

Scientist/Experts

Those who focus on the technical aspects of the project, such as

- **i.** Land use planning
- **ii.** Natural resource management
- **iii.** Social infrastructure, etc.
- **iv.** Think tanks and academia

Others

This group includes any other person contacted not specially following in one of the other categories.

Forums Consulted

The following forums were used to carry out the public consultation process.

- **i.** Consultative meetings held with the general stakeholders

ii. Scoping sessions held with the local communities

iii. Focused group discussions held with the people directly affected by the project.

iv. Consultative meetings held with the officials of different Govt. Departments

6.3 METHODOLOGY

i. The consultation sessions/ meetings were held in October, 2018 with the concerned stakeholders. On the basis of these sessions and meetings Environmental Management and Monitoring Plan were prepared for the communities of the proposed project.

ii. Some specific consultation tools that are used for conducting consultations include; focus group discussions (FGDs), needs assessment, semi-structured interviews; village meetings and workshops.

iii. The communities were informed one day before the meeting and asked to assemble on the common places. The meetings were held in an open and encouraging atmosphere where the local population expressed their concern and views frankly.

6.4 PARTICIPANTS OF THE CONSULTATIONS / SCOPING SESSIONS

The Consultants' EIA team comprising Sociologist, Ecologist and Environmental Scientists conducted these sessions. The major stakeholders include land affectees, local residents, local government representatives and local CBO/NGO working in the project area. Efforts were made to discuss all the major issues In addition, formal sessions were also held with the relevant stakeholders included land and property owners, Departments of Agriculture, Forest, Wild Life, Fisheries, Environmental Protection Agency and Tehsil Administration situated at Bahrain, Madyan and Mingora/Saidu Sharif.

Figure 6-1: Public consultation at Palogah and Eshegal Village

Figure 6-2: Public consultation at Eshegal village near proposed weir site

6.5 ORGANIZATION OF MEETINGS

The Consultants organized the consultative meetings in almost all the villages affected either directly or indirectly by the project. The meetings were publicized with the help of the local administration, personal contacts and through announcements in the local mosques very few participants were aware of the Proposed Project. They received first-hand information from the project professionals and welcomed it, however, they were well informed about the ongoing Gorkin Matiltan HPP. They have some issues of land with forest department for which they are waiting decision from the concerned quarters. The Sociologist apprised the audience with the technical and social aspects of the project in detail. All the participants were of the view that there is a dire need of power projects in the country, due to the shortage of electricity and serious load shedding. The concerns were discussed with all the participants in general, followed by a question-answer session.

6.6 POINTS DISCUSSED

Following points were discussed during the public consultations:

- **i.** Project components, its activities and impacts.
- **ii.** Needs, priorities and reactions of the affected people regarding the proposed project.
- **iii.** Downstream environmental water requirements.
- **iv.** Ensuring the participation of the PAPs in the resettlement planning
- **v.** Grievances redress procedures.
- **vi.** Entitlement Matrix development for the affectees of the project.
- **vii.** Evaluation criteria of the buildings.
- **viii.** Basis for determining the rates of the land, houses, and other infrastructure.
- **ix.** Compensation framework for the project affectees.
- **x.** Compensation criteria to be followed for the payment to the affectees.
- **xi.** Role of the affectees in implementation of the project.
- **xii.** Social Issues.

6.7 VIEWS OF LOCAL COMMUNITY ABOUT THE PROJECT

They appreciated the efforts of the government and involving them in the planning process. They agreed for the construction of proposed Project in their area but they wanted to give us full justice during assessment and preparing compensation matrix. They said that before the implementation of the Project full payment should be made to the legitimate owners. They also referred to the pending case of Gorkin Matiltan hydropower project for which they gave their property. They also requested that houses and infrastructure available in the Project area should be saved as much as possible. They requested that appropriate electricity should be given to local population and surplus should be utilized as per policy of the Government. Some participants wanted that Government should give us subsidy on electricity.

They added that the mountain slopes and tops in the project area were used as pastures for grazing their animal herds. The residents pointed out that pastures were the great source of income to them. They not only use them for their animals but also rent out in summer for shepherd coming from plain areas especially Buner. They demanded protection of these rights by the project management.

6.8 CONSULTATIONS DURING IMPLEMENTATION STAGE OF RESETTLEMENT ACTION PLAN

Resettlement Action Plan (RAP) will be implemented with due consultation and consent of the PAPs. The representative of the implementing agency together with Social and Resettlement Experts will publish brochures, posters, leaflets, etc. explaining the impacts of the proposed project, compensation policies for PAPs, resettlement options/strategies for households, and tentative implementation schedule of the project. Furthermore, steps will be taken to keep the affected people informed about land acquisition plan, compensation policies and payments, resettlement plans and strategies and to ensure that the PAPs and other stakeholders will be involved in making decisions concerning their relocation and implementation of the RAP. PAPs will also be involved in the grievance redressal committees (GRC) to review and resolve, “out of court,” any dispute concerning compensation and other resettlement benefits.

This consultation will be very important and a continuous process to develop a better understanding and participation of the stakeholders especially at the implementation stage. In each section of the project being constructed, an interaction with the affectees will ensure its uninterrupted continuity and give a sense of ownership of the entire project developmental work. This information sharing will cover the following aspects:

- **a.** Entitlement package applicable to the various types of affectees having their land and land-based assets
- **b.** Tenants and Labours working at the farms, and cultivators having contractual arrangements under the lease agreements either formal or informal.
- **c.** Difficulties being experienced by the affectees in the processing of their compensation cases.
- **d.** Type of arrangements made towards rehabilitation and restoration of their livelihood.
- **e.** Health, safety and environmental issues related with the project implementation stage.
- **f.** Application submission procedure for affected land and assets.
- **g.** Kind of compensation for affectees.
- **h.** Compensation to be paid to the family head or his representative.
- **i.** One window operation for the purpose of early payment / resettlement.
- **j.** Rented houses / shops, etc. and payment procedure.

Holding of regular meetings on given dates and places will ensure their availability and sharing the information, and to arrive at some conclusions in taking further steps to facilitate the project implementation, and address the concerns of the affectees in a mutually acceptable way. These meetings will facilitate two-way communications i.e. from the project authorities to affectees and vice versa. During this consultation, any problem as and when raised by the affectees, will be evaluated on its merit and some mitigation measures will be devised to either solve the issue or reduce its impacts to minimize the nature and extent of the problem. All such findings and solutions of the emerging situation in the project area will be discussed, as required, to facilitate the implementation of the project.

These meetings and interactions will also ensure the involvement and employment of the affectees in the project work by the contractors, against the opportunities available in accordance with the capability of the affectees, as feasible.

Table 6-1: List of Consultation with Government departments' officials

DATE	NAME & DESIGNATION	NAME OF INSTITUTION AND ADDRESS	TELEPHONE #.
29-10-2018	**Mr. Abid Khan Mohmand** Assistant Commissioner	**Tehsil administration Bahrain, District Swat**	0946-780135
	Mr. Afzal Khan Tehsildar	**Tehsil administration Bahrain, District Swat**	
	Mr. Arsalan Tariq DFO Kalam Forest Division	**Forest Department Madyan, District Swat**	0342-9092020
	Mr. Muhammad Saeed Fisheries Inspector	**Government Trout Fish Hatchery, Madyan**	0344-5961701
30-10-2018	**Mr. Fazal Rahman** Superintendent	**Agricultural Department, Mingora District Swat**	0946-9240248
	Mr. Ali Khan Superintendent	**Fisheries Department Mingora, District Swat**	
	Mr. Muhammad Riaz Monitoring Inspector	**Environmental Protection Agency, Mingora, District Swat**	0346-9240098
04-12-2018	**Dr. Muhammad Bashir** Director General	**Environmental Protection Agency, KPK**	091-9210263

DATE	NAME & DESIGNATION	NAME OF INSTITUTION AND ADDRESS	TELEPHONE #.
20-12-2018	**Ameer Hamza** Deputy Director	**Fisheries Department, KPK**	0345-2211555
	Muhammad Niaz DFO	**Wildlife Department, KPK**	091-5243198
11-11-2019	**Asad Zia** Assistant Director	**Mineral Development Department**	03459829465
	Nazir Khan SDO Matta,Swat	**Irrigation Department**	03449454444
12-11-2019	**Nazir Ahmad** Director Swat	**Soil Conservation Department**	03339474130
	M. Wajid Deputy Director	**EPA Swat**	03339292135
19-11-2019	**Jan Sher Khan** Deputy Director Swat	**Fisheries Department**	03028532800
	Abdul Ghafoor DFO Swat	**Wildlife Department**	03459452441

Visits have been conducted along with the above Government officers for site visits and their written comments along with visits pictures are given below.

Consultation with Soil Conservation Department

On 12th of November 2019, a meeting was held with Mr. Nazir Ahmad, the District Director Soil Conservation Swat. The consultants presented the project in detail in reference with soil conservation concern. Mr. Nazir Ahmad was of the view that there is no such concern of Soil Conservation in the project related activities. However, he suggested that during the excavation process of the project, if there is a chance of soil erosion of the existing landscape and that of Muck materials, Artistic Hydro-II will bound the contractor to take directions from the Soil Conservation Department regarding provision of some Bio Engineering Structure in order to avoid soil erosion in the project area. NOC from soil and water conservation department has been received on November 19, 2019 and is attached as **Annexure 13.**

Figure 6-3 Meeting With District Director Soil Conservation Swat

Consultation with Irrigation Department

On 11th of November 2019, a meeting was visit with Mr. Nazir Khan, SDO Irrigation Matta Sub Division, Swat as the project fall in the jurisdiction of Matta Sub Division. The consultants presented the project in detail particularly in reference with irrigation.The consultant informed that there is very small piece of agricultural land in the area which is irrigated by the small Nullahs of Eshegal, Khel Gal and Palogah Gal so there is no threat to the agricultural land due to project implementation. SDO Irrigation Matta Sub Division confirmed that there is no exsisting or proposed irrigation scheme in the project vicinity.

Figure 6-4 Meeting with Irrigation SDO Matta

Consultation with Fisheries Department

On 19th of November 2019, a meeting was held with Mr. Jan Sher, the Deputy Director Fisheries Swat at his office located at Government Trout Fish Hatchery Chail Road Madyan. The Deputy Director Fisheries was consulted in detail about the project. Being an important line department, he informed that the project area is a pure habitat of Brown Trout therefore he suggested that a proper Fish ladder should be designed for the project. Moreover, he emphasised that during construction stage the contractor will regularly consult the Fisheries department staff to avoid disturbance of the Fish breeding spots. NOC from Fisheries Department has been received on March 5, 2020 and is attached as **Annexure 13.**

Figure 6-5 Meeting with Deputy Director Fisheries Swat

Consultation with Wildlife Department

On 19th of November 2019, a visit was made with Mr. Abdul Ghafoor, the Divisional Wildlife Officer, Swat Wildlife Division to the project site. Divisional Wildlife Officer was informed in detail about the project. He suggested that the Client shall ensure training for labours as well as local community regarding wildlife and habitat. He further stated that precautionary measures should be taken in order to avoid the habitat of wildlife. He also informed that there is no any threatened species in project area. NOC from Wildlife Department has been received on February 10, 2020 and is attached as **Aenxure 13**.

Figure 6-6 Site Visit with the Divisional Wildlife Officer, Swat Wildlife Division

Consultation with Mineral Department

On 11th of November, 2019, a meeting was held with Mr. Asad Zia, the Assistant director Mineral Development, at his office. The Assistant director was consulted in detail about the proposed project. Mr. Asad Zia stated that he will send the case to Director General Mines and Mineral Development KP, Peshawar. However, Mr. Asad Zia was of the view that they have no objection after the prior approval of Director General Mines and Mineral Development Khyber Pakhtunkhwa.

Figure 6-7 Meeting with Assistant Director Mineral Development Swat

Figure 6-8: Meeting with DFO Madyan

Figure 6-9: Meeting with AC Bahrain

Figure 6-10: Meeting with Tehsildar Bahrain

Figure 6-11: Meeting with EPA Monitoring Inspector, District Swat

Figure 6-12: Meeting with Agriculture Department

Figure 6-13: Meeting with fisheries officials at Govt. Fish Hatchery, Madyan

Figure 6-14: Meeting with fisheries department official at fisheries department office Mingora, swat

7. PROJECT IMPACT AND MITIGATION MEASURES

During the scoping stage of the EIA process, several potential environmental and social impacts of the project were identified. The baseline surveys were conducted keeping in consideration the potential impacts. In this chapter, the potential environmental and social impacts are evaluated. The impacts have been identified based on consideration of the information presented in previous chapters.

The environmental consequences of hydropower project construction are numerous and varied, and include direct impacts on the biological, chemical and physical properties of the rivers and riparian (or "stream-side") environment. The construction of hydropower project, in general, has both beneficial and adverse impacts on different physical, biological socio-economic and cultural parameters in relation to water and land, and the existing ecosystem balance. Although the construction industry is generally considered as a whole, different potential hazards are at the forefront in each work field, as the areas of operation differ from each other. When it is considered from the point of view of construction activities, the following dangers are noteworthy. First of all, in weir construction, rock blasting and tunnel works exist different from other construction works. Weir constructions, especially tunnel works, contain underground activities similar to mines. The construction of Artistic-II HPP will also have some impacts on such parameters, which need to be identified. For this purpose, a checklist has been prepared. This checklist provides the significance of different parameters due to environmental impacts/issues of the project. The various environmental components likely to have impacts are analysed and evaluated. The adverse impacts/issues are especially addressed for mitigation measures.

Thus, all foreseeable socio-environmental impacts of the project construction are to be identified and evaluated for dealing with the significant adverse impacts. Resettlement is often a major problem and has short- and long-term effects, and therefore, there is need to assess the extent of significant resettlement issues.

7.1 ADOPTED ASSESSMENT PROCEDURE

To assess the environmental impacts of the project in accordance with EPA guidelines, the protocol used for the assessment of impacts is given in **Table 7-1**. The adverse and positive impacts on various parameters were assessed by considering the following environmental impact scaling factors:

1. Magnitude and degree of impact

2. Extent or proportion of the impacts and the area affected by the impact
3. Time or duration and frequency of the impact
4. Probability or likelihood of the impact
5. Importance or sensibility of the impacts
6. Risk or possibility of environmental catastrophe of the impact

Table 7-1: Checklist of Environmental Issues Relating to Hydropower Projects (Based on EPA Guidelines)

Environmental Component	Environmental Issue	Impacts Scaling Factors					
		A	B	C	D	E	F
1. PHYSICAL							
Water	Water Availability	Low	Medium	Project life/seasonal	Low	Significant	Low
	Water Quality	Low	Small	-do-	Low	Small	Insignificant
	Erosion	Very Low	Small	-do-	Insignificant	Insignificant	Nil
	Sedimentation	Medium	Small	-do-	Medium	Insignificant	Nil
	Floods	Medium	Small	-do-	Low	Significant	Low
	River bed Morphology	Low	Small	-do-	Low	Insignificant	Nil
Land	Land Submergence	Low	Small	-do-	Low	Insignificant	Nil
	Geology/ Seismology	Low	Large	-do-	Low	Significant	Low
	Land Severance due to Reservoir	Very Low	Small	-do-	Very Low	Insignificant	Nil
Climate	Climate Change	Very Low	Small	-do-	Low	Insignificant	Nil
	Microclimate	Low	Small	-do-	Low	Insignificant	Nil
Atmosphere	Dust	Small	Small	During Project Construction	Low	Insignificant	Nil
	Noise	Low	Small	-do-	Low	Insignificant	Nil
	Air Quality	Low	Small	-do-	Low	Insignificant	Nil

2. HUMAN							
Social	Population	Low	Small	Project Life	Medium	Significant	Nil
	Demography	Insignificant	Very Small	-do-	Very Low	Insignificant	Nil
Environmental Component	**Environmental Issue**	**Impacts Scaling Factors**					
		A	**B**	**C**	**D**	**E**	**F**
	Land Ownership	Low	Medium	-do-	Medium	Insignificant	Nil
	Social Cohesion	Low	Small	-do-	Low	Insignificant	Nil
	Social Attitude	Low	Small	-do-	Low	Insignificant	Nil
	Gender and Age	Medium	Small	-do-	Low	Low	Nil
	Health	Low	Small	-do-	Very Low	Insignificant	Nil
	Safety	Low	Small	-do-	Low	Significant	Nil
Economics	Income	High	Medium	-do-	High	Significant	Positive
	Employment	High	Medium	-do-	High	Significant	Positive
	Land Value	High	Medium	-do-	High	Significant	Positive
	Resettlement	Medium	Small	-do-	Medium	Insignificant	Negative
Economics	Livestock	Low	Small	-do-	Low	Low	Nil
	Fisheries	Medium	Small	-do-	Low	Medium	Nil
	Cultivation	Medium	Small	-do-	Low	Low	Nil
	Transport/ Communication	Medium	Small	Short Period	Medium	Medium	Nil
	Recreation	Low	Small	Project Life	Low	Low	Nil
Cultural	Lifestyle	Very small	Nil	Project Duration	Low	Very Low	Nil

	Historical /Archaeological Sites	Very small	Nil	-do-	Low	Insignificant	Nil
	Aesthetics	Small	Very small	-do-	Low	Insignificant	Nil
3. BIOLOGICAL							
Fauna	Wildlife communities /Habitat	Small	Small	Project Duration	Low	Insignificant	Nil
	Fish Communities /Habitat	Small	Medium	-do-	Medium	Very low	Negative
Environmental Component	**Environmental Issue**	**Impacts Scaling Factors**					
		A	**B**	**C**	**D**	**E**	**F**
							Reservoir
	Reptile Communities/Habitat	Insignificant	Small	-do-	Very Low	Insignificant	Nil
Flora	Forest Trees	Low	Medium	-do-	Low	Insignificant	Nil
	Terrestrial Vegetation	Small	Low	-do-	Low	Insignificant	Nil
	Aquatic Vegetation	Small	Low	Project Duration	Medium	Low	Nil

A. Magnitude and degree of impacts

B. Extentor proportion of the impact and area affected by the impact

C. Time or duration and frequency of the impact

D. Probability or likelihood of the impact

E. Importance or sensibility of the impact

F. Risk or Possibility of environmental catastrophe of the impact

Project Impact Area

The area of direct influence of the project starts from the upper limits of the catchment of the reservoir and extends to the downstream of the weir axis. It, therefore, includes the watershed and river valley below the weir.

The construction and commissioning activity also have the potential to cause a number of environmental impacts. The potential environmental impacts include the location and management of working camp. Impacts relating to dust, noise vibration, and procurement of construction materials, liquid and oil discharges, water pollution, waste collection& muck excavation, disposal and storage. The principal construction and commissioning impacts and mitigation measures are described below.

7.2 CONSTRUCTION STAGE IMPACTS

1. Permanent and Temporary Land Acquisition

Construction of infrastructure usually will result in permanent loss of land. Temporary losses of land and habitats may also occur during the construction phase. But being a run-of-river type and small project, a small piece of land is expected to be lost for the project structures.

Mitigation Measures

All the land required for different project components is community owned barren land, no land base infrastructure will be affected during construction as well as operational phases of the project. The permanent land for project components such as weir, powerhouse, offices, etc. will be purchased while temporary land will be taken on lease. The cost of land purchase and lease cost are added in Environmental Management Cost.

2. Workers' Camp

A construction camp of suitable area will be required by the contractor for accommodating the workers, storing equipment and materials, fuels and serving vehicles etc.

Mitigation Measures

The camp site will be established near the project site and at least 500 m away from local population with prior approval of Resident Engineer (RE). The camp will have proper dormitory and toilets with proper sanitation system. The contractor should build septic tanks for environment friendly discharge of the sewage effluent. The contractor will be bound to comply with rules and procedures defined for this respect and from time to time with the emerging situation with the approval of the Resident Engineer as described in the tender documents.

3. Generation of Waste

A lot of solid waste will be generated in the Labour camps and residential areas. The uneducated Labour is used to scatter solid waste in the open spaces.

The solid wastes generated during the construction phase will consist primarily of excess concrete and cement, rejected components and materials, packing and domestic garbage, etc. Such wastes can contaminate the soil, groundwater, surface water and air quality. Moderate adverse impact will be expected with medium intensity and duration, which needs to be effectively controlled to minimize these adverse impacts associated with the generation of the waste.

Mitigation Measures

Activities at the camp need to be conducted in a manner to ensure that waste generation of any kind may be restricted to a minimum level by managing efficiently and properly. Solid waste collection points should be established in the Labour camps. A system of collection, storage and transportation should be in place to transfer the solid wastes to a temporary waste site. The solid wastes so deposited in the land fill should be covered with earth after each filling.

The best possible way to handle the waste is to keep waste to its lowest possible level at site. For this the contractor will arrange environmental awareness /education sessions with the workers for reducing waste at site. The Contactor will also outline guidelines for waste management by involving them for keeping their waste minimum at source during work to avoid any environmental threat.

4. Solid Waste

Solid waste during the construction phase will consist primarily of excess concrete and cement, rejected components and materials, packing and other garbage. Such wastes can contaminate the soil, groundwater, surface water and air quality

Mitigation Measures

The muck excavated from the tunnel may be utilized as soil layers on the barren land situated on the left bank of Ushu River. It would be helpful in some reclamation of this land which is presently consist of boulders and stones.

Construction places, storage houses and workers camp will be kept clean, and wastes will be deposited in temporary waste sites. The sites will be opened with the approved diagrams by the Engineers as outlined in the tender documents.

Concrete and cement excess and left over and usable will be broken down in small pieces and deposited in proper waste disposal sites. Packages made of biodegradable such as papers, cardboard and wood will be deposited in proper bins. A team will be responsible to maintain the working site clean, collecting all solid waste produced by the workers involved in the project. All workers shall receive training and guidelines with respect to waste management.

Solid Waste Management Plan

Background:

Artistic Hydro-II (Pvt.) Ltd. Karachi is going to establish a hydropower project on Ushu River in District Swat. The current camp accommodations will be located near Weir and Powerhouse Sites. Around 250 labours will be resident of the labour camps during the construction phase of project. The aim of this plan will be the safe disposal of solid waste that will be produced in the camps. This waste management plan incorporates the basic principles of waste management, source reduction, reuse, recycle/recover, treatment and disposal. Artistic Hydro-II (Pvt.) Ltd. Karachi is committed to conduct operations within the acceptable environmental standards of KP-EPA. These methods are important in reducing the environmental footprint of operations.

- Source reduction is the elimination or decrease of the volume or toxicity of waste by adopting practical methods such as using alternative materials or processes. This can be achieved by material elimination, inventory control and management, material substitution, process modification and improved housekeeping, maintenance and training.
- Reuse is achieved by using a product more than once for the same application or for different purposes.
- Recycling of products that typically have one use is an excellent method of reducing the volume of waste generated at a worksite. Sorting the products so that they can be managed in bulk eliminates the need for additional handling and allows for different products to be managed by efficient recycling processes.
- Waste treatment is used to reduce the volume, mass and/or toxicity of the material prior to disposal due to contaminants contained within the waste. There are a number of treatment options including thermal, chemical, biological and physical processing which may be used separately or combined to be the most effective and efficient.

- Disposal of waste is the final option for waste management. When disposing of waste, the type of waste, volume, location and final containment must be considered. The waste disposal options available to the municipal solid waste generated in the camp include composting, control dumping and use as protective material from harsh environment.

Purpose of the Plan:

This Camp Operations Waste Management Plan (WMP) will detail how waste generated will be safely managed. The management of camp wastes are stringently regulated and require planning and implementation of those plans to handle waste in a complaint manner. The ultimate goal of waste management is to safely manage waste streams in at the source of generation and disposed of in an environmental friendly way.

This Waste Management Plan will cover:

- Waste types including characterization of waste and waste management methods
- Segregation at the spot of generation
- Reduce, reuse and recycle the waste as much as possible.
- Appropriate disposal of solid waste

Solid Waste Generation at Construction Camp

The total number of labours that will work on the camp site will be around 250 during the construction phase. The amount of total waste generated is given in **Table 7-2**. According to various research finding the average waste generation in the developing countries is around 0.4-0.8 kg/capita/day. At the construction site generated solid waste may consist of biodegradable waste (food waste and wood debris), plastic (PET bottles and PE bags), paper (newspaper and white papers), cardboard, cans of drinks and so on.

Table 7-2 Solid Waste Generation at Camp Site

S.No	Labours	Waste (kg) per capita/day	Per day Solid Waste (kg)	Per Month (kg)	Per Year (kg)
1	250	0.4	100	3,000	36,000
2	250	0.8	200	6,000	72,000

Solid Waste Collection:

Solid waste collection will be carried out at the camp site. Dustbin will be installed on the camp site. Dustbins with different colours i.e. blue, grey and green will be installed for different types of waste such as recyclable, non-recyclable and biodegradable waste. On spot segregation will be carried out to avoid the mixing of solid waste. Workers will be aware about the different types of dustbins that which waste will be dumped in which colour of bin. Furthermore, throughout the whole camp various types of banners and poster will be hanged to aware the workers regarding the proper solid waste management.

Figure 7-1 Various Colours of Dustbins for Different Types of Waste

Waste Disposal

Solid waste disposal will be the last option that will be used for the solid waste management at the camp site. Reduce, reuse, recycle and recover universal phenomena should be adopted at the camp site. To manage the biodegradable waste, compost pits will be established at the camp site. As major portion of generated solid waste at camp will be consist of biodegradable waste, thus, a number of compost pits (around 10) will be constructed at the camp site. The size of the compost will be 5 m^3 for each compost. According to recent study in Peshawar, around 21% of produced solid waste consist of biodegradable. So, by following the outcomes of the present study, around 630 kg biodegradable waste will be generated in the camp per month. The produced compost will be used as a fertilizers for the plantation which will be carried out in the surroundings of the camp. However, combustible waste such as wood, grasses, debris and so on will be segregated from the wood waste and will be used as source of fuel wood. The compost pit will be concreted to avoid the chances of ground water contamination.

Figure 7-2 Compost Pit for Conversion of Biodegradable Waste into Compost

Figure 7-3 Use of Plastic Bottles for Plantation and for Electric Bulb

Plastic waste generated at the camp site most probably consists of pet bottles and PE bags. However, Government of KP is going to imposed ban on the use of PE bags from December, 2019 onward. So, the generation of PE bags at camp site will be zero. Regardless of that, if PE bags are produced at the camp site even though due to strict policies of KP-EPA, only biodegradable PE will be available in KP. These biodegradable PE can be degraded through natural process. Thus, a separate pit will be constructed to dump these PE bags. PET bottles will be reused for several purposes such as for drinking water, as holder for electric bulb to avoid from rain water and so on. Furthermore, it can be used for plantation of flowers and other ornamental plants.

Combustible waste which may contain papers, cardboard and so on will be used for several purposes. Cardboard can be used for ceiling of labours camp as the winter is very harsh and prolonged in the project area. It will help to get some relief for the workers from the harsh environment. However, it can be used as a source of fuel via incineration or it can be used as bulky materials for the compost, which will enhance the quality of produced compost.

At the end, if there is some solid waste left, it will be dumped in control dumping site which will be constructed at labour camp sites. The dumping sites will be established away from river bank to avoid the chances of water contamination. Furthermore, leachate collection pipe will be installed if any leachate is produced, it will be collected and treated before it comes to open environment.

5. Hazardous/Semi-Hazardous Wastes

The presence and operation of heavy machinery in close proximity to the village Eshegal and Kichgil, during construction will increase the chance for use of chemicals and fuels etc., this can result in localized contamination and a decrease will occur in water quality. This phenomenon will create negative impacts on the biota of the stream and its immediate environment, as well as to downstream. Therefore, improper disposal of oils filters and other materials from vehicles and machinery maintenance can also cause water pollution.

Mitigation Measures

Measures will be taken to ensure all activities involving the transfer, storage and potential for such contamination. These will be confined to appropriately bounded areas. All such storage areas, including those for fuels and other chemicals, should be situated away from the river as for as possible and should be properly sign posted.

All workers involved in the use of such materials will receive proper training to manage them and shall use protection equipment such as gloves, masks, uniforms, etc. for safety purposes.

All danger sites will be communicated properly with tailor-made sign boards depicting like dangerous etc. both in English and in Urdu languages. In designing such boards, standard communication principles and guidelines will be followed for workers and public safety.

In machinery maintenance activities cover the soil under the machinery with plastic sheet to collect any spell. Avoid any spills of oils or fuels to the soil or river. If the soil is contaminated, it shall be immediately removed and treated in the main camp.

Used oil will be stored in sealable drums and should not be mixed with other substances such as petrol and other solvents. Used oils may be returned to the appropriate agencies for disposal and further usage if any.

6. Impact of taking borrow material from earth borrow site

There is likelihood for obtaining the earth fill material. Excavation and cutting activities could cause adverse environmental impacts including sliding, soil erosion and drainage on the surrounding areas.

Mitigation Measures

- No private land will be acquired for the borrow areas.
- The Contractor will ensure that selected borrow areas are clearly demarcated and approved by the RE including the allowed depth of the excavation before starting excavation.
- The borrow areas will be levelled. The Contractor will not leave the borrow pits in such a condition that they are unsuitably filled with rain water and cause the problem for the community.
- If the borrow area is near to the settlements, then it should be fenced completely.
- If agriculture land needs to be used as borrowing area, then the Contractor will adopt the following methods during the digging process.
    - Fix the location of excavation.
    - Remove thirty centimetres of the top soil and keep it on reserved site for re-spreading in the field.
    - Excavate up to one-meter depth.
    - Maintain the slope as far as possible.
    - Place the top soil back during the restoration process.
    - Pay compensation for any damages/ crop losses.

Following the above criteria, after identification and approval by the Engineers, the Contractor will mark borrow areas location.

7. Water Pollution

Maintenance of river water quality will be the most important concern during construction activities. During construction concerns also relate to the potential for chemicals or fuel spills.

Mitigation Measures

Appropriate control measures will be taken to avoid degradation of water quality.

The presence, storage and use of chemicals and fuels near river can result in localized contamination and decrease in water quality. Improper disposal of oil contaminated materials from vehicles and machinery can cause pollution. Proper sanitation and waste disposal procedures will help to reduce the contamination of water resources. Every effort will be made by the contractor to prevent such pollution wherever, possible and minimize these effects.

All residual waters from domestic uses in the camps will be treated in septic tanks, conveniently dimensioned in accordance with the number of workers involved in the project, before releasing to the surrounding environment.

8. Air Quality

The air quality of the project area and its vicinity is generally fresh and clear under normal conditions. There is no industry in the area. Frequent traffic flow in the project vicinity up to Mahodand may cause a little air pollution.

Construction activities may generate emission of fugitive dust caused by a combination of on-site excavation and transport of building materials. A secondary source of emissions may include exhaust from diesel engines of earth moving equipment, as well as from open burning of solid waste on-site.

The construction workers and the operation of heavy machinery will increase pollution in the levels of dust and noise, leading to respiratory diseases to the workers and local community (colony residents).

Mitigation Measures

Techniques to consider for the reduction and control of air emissions from construction and commissioning sites include the daily use of water-browsers, near colony areas to wet dirt roads, in order to keep the emission of dust minimum level. Minimizing dust from open area sources, including storage piles, by using control measures such as installing enclosures and covers, and increasing the moisture content.

Contractor's contractual obligation to keep the dust and smoke low by using machinery which is well maintained and is almost noise less and all Katcha roads and paths are sprinkled with water after regular intervals.

The contractor must avoid/ control the dust and smoke by carefully storing and distributing the construction material so as to cause minimum dust. During transportation, covering of vehicle with sheet will be done. Unloading of vehicles will be done on designated sites.

9. Noise and Vibration

During construction activities, noise and vibration may be caused by the operation of pile drivers, earth moving and excavation equipment, concrete mixers, cranes and the transportation of materials etc.

The increase of noise and vibration levels would be site specific and short term. There is a chance to increase the noise level which may disturb the surroundings.

Mitigation Measures

Noise level would be localized and can be prevented by taking preventive measures like use of mufflers and silencers.

The workers operating machinery and vehicles must be conscious of speed limits. Avoid unnecessary horns. It is required to take necessary measure to avoid generation of unnecessary noise.

Contractor's contractual obligation to use new, well maintained and low noise machinery preferably during day time. The drivers, operators and workers working on or near the heavy machinery must be provided ear plugs.

The contractor will ensure use of newer, well maintained machinery that creates minimum noise and emissions, as per National Environmental Quality Standards (NEQS 2000). Environment Specialist will ensure that this clause is added into the bids and contracts. Night time construction activities will be strictly discouraged, and only be carried out in exceptional cases, with prior permission of Resident Engineer. Noise monitoring will be carried out near sensitive receptors on a monthly basis. The NEQS for noise in residential areas is 55 dB (A) in the day time and 45 dB (A) at night. It is recommended that noise levels close to sensitive receptors do not exceed 55 dB (A) during the day time as required by the NEQS.

Table 7-3: Noise Levels and their Effects

Noise Level dB(A)	Situation
194	Lung damage
180	Ear drum rupture
150	Absolute limit with ears protected
150	Maximum of instantaneous noise
135	Absolute maximum with ears unprotected
100	Prolonged noise causing permanent damage
90	Factory work for an 8-hours/day. 5 day a week
85	Ear protection should be worn
80	Noise on building or construction sites
70	Road traffic near residential areas

Table 7-4: Damage Risk Criteria for Hearing Loss

S.No	Maximum allowable duration per day in hrs.	Noise level in dB(A)
1	8	90
2	6	92
3	4	95
4	3	97
5	2	100
6	1.5	102
7	1.0	105
8	0.5	110
9	0.25 or less	115 (Max.)

10. Traffic Accidents

Swat-Mahodand Road passes nearby. The alternate temporary road will have to be constructed for the Project staff movement. During the construction phase, increase in heavy movement of vehicles will occur, presenting the risk for traffic accidents which may be prevented by following traffic regulations strictly.

Mitigation Measures

Warning signboards should be displayed properly at appropriate locations during construction period to avoid accidents.

11. Social Conflicts and Diseases out break

Since, the subprojects are being constructed at a remote site, safety of labour will be of prime concern. In addition, adequate measures related to Health, Safety and Environment (HSE) will have to be provided for the labour employed.

During the construction phase, a large number of workers will concentrate around the construction site. Although there are least chances of interacting of workers with the local residents, so creating the potential risk for social conflicts and diseases is minimum. However, within the worker community the chances of such outbreak risk cannot be overlooked. Risks of different diseases outbreak is always there when an interaction of outsiders is expected. It is possible, there may be an increase in communicable diseases like, throat infections, scabies, skin diseases, eye soaring etc.

Mitigation Measures

Social cohesion and brotherhood campaigns shall be launched within the workers and in communities for better relationship and to avoid conflicts. Worker shall be asked to take care and protect the local traditions and ethics.

The contractor will ensure that proper HSE protocols are in place, including protective gear, drinking water, sanitation, energy supply and overall safety for the labour. Evacuation plans in case of fire or any other accidents will also be prepared, and drills carried out to ensure the labour is aware of responding to such a situation.

7.3 ECOLOGICAL IMPACTS

1. Temporary Loss of Habitats

Construction of infrastructure usually will result in loss of some natural habitat. Temporary losses of habitats may also occur during the construction phase. But being a small project, a small piece of land is expected to be lost for the project structures. A barren land is available for temporary camping and hauling of material; it is unlikely to have any significant habitat loss.

However, care will have to be taken in choosing construction camp work sites other than this to cause as little interference as possible to habitats. Camp sites, office sites and storage yards will be constructed in areas that minimize the potential for ecological impacts. Some loss of breeding and nursery grounds for fishes and invertebrates may occur. These prolonged disturbances may cause stress to the aquatic life.

Mitigation Measures

Land used temporally should be restored to its original condition. All structure erected by the contractor will be dismantled and removed. Any rubble generated from the dismantling of campsite will be dumped at an approved disposal site. Once the area has been cleared of all materials, the ground will be prepared for rehabilitation. The area shall then be left to rehabilitate through the process of natural succession. Systematic search, capture and safe release of species inhabiting the right of way (for the weir structure).

The contractor is liable to comply with all relevant laws and regulations in Pakistan and KPK concerning water pollution, sanitation, and wastewater discharge and solid waste disposal as defined in tender documents.

2. Trees and Agricultural crops

As box channel, tunnel and penstock will cover a portion of mountain on the right side of Ushu River, a sizeable number of deodar and other trees of different ages and stature will have to be cut by the forest department after providing them the layout plan and exact location.

Mitigation Measures

The NOC will be issued by the government in the light of explaining actual position of the trees to be cut and preparing estimates by the Kalam forest division, Madyan. Payments will be paid by the proponent as prescribe by the forest department according to their related policy. The policy of the forest department will be followed which has already been worked out for the nearest ongoing HPP i.e. Gorkin Matiltan. The agricultural crops sown in the area are generally maize, potato and vegetables for which agriculture department of the area will be requested to prepare estimates for compensation.

During scoping visits the site was visited for calculating approximate number of trees which are expected to be affected. They are approximately 698 in number. It is expected that living and working areas will be established at places which are free of forest trees.

Plantation Plan

In order to compensate the trees to be cut in project implementation, a plantation plan is prepared with the consultation of Kalam Forest Division which is given below.

Loss of Fruit Trees

During the implementation of the project, no fruit trees will be affected by the project.

Loss of Non-Fruit or Forest Trees

As provided in the below table, during the implementation of the project 698 forest trees will be affected by the project and will be compensated.

Table 7-5 Loss of Non-Fruit or Forest Trees

Trees	Small	Medium	Large	Total
Deodar	386	-	256	**642**
Kail	-	-	44	**44**
Fir	-	-	12	**12**
Total	**386**	**-**	**312**	**698**

Total 698 trees would be cut for project activities. The valuation of compensation for trees is based on their market values. For wood trees, unit prices are obtained from Forest Departments, Swat District, who assess the prices every year based on market rates. The cost of the non-fruit or Forest trees along with unit rates adopted are calculated at the village level. The types and volume measurements in case of forest trees while present and productive age in case of fruit trees are considered. Summary of the cost of trees is given in **Table 7-6**.

Afforestation Plan

The marginal lands constituting the catchment area of the proposed Artistic-II HPP are either private ownership or communally held. Therefore, the Forest Department / Client shall execute agreements with the concerned communities explaining the terms of partnership (TOP) with mutual understanding.

Total 698 trees will be cut due to project activities. As for 1:10 ratio, total 6980 trees will be planted in projects area. Spacing for new planted species is normally 10×10 feet or 1075 plants per hectare. Afforestation over 6.49 hectares is planned to be done.

Planting

Slope and aspect, being some of the determining factors for selection of appropriate plant species for afforestation, shall be recognized. Planting of suitable tree species, like Deodar (Cedrus deodara) and other native species, shall be carried out over 6.5 ha at 10×10 feet spacing on gentle to moderate slopes (10-40%).

Afforestation shall be carried out twice a year in spring and Monsoon seasons with major reliance on natural precipitation except for limited water supply in the foothills. Afforestation activities are tightly time-bound therefore; all out efforts shall be made to capture the most conducive seasons to get maximal utility of the winter and summer rain.

Preference shall be given to the local species for its easier and better acclimatization with the locality factors like soil, precipitation, temperature, humidity and frost etc. Choice of the people for quick growing species to ensure early return to the community, in view of its adaptability with the local climatic and edaphic dynamics, shall also be respected. Biodiversity shall be imperatively considered for all intents and purposes to help develop and ensure proper habitat for compatible life forms.

Table 7-6 Plantation Schedule and Cost

Species	Time of plantation	Number of plants	Unit Cost of Plant (PKR)	Plantation and Transportation cost (PKR)	Total Cost (PKR)
Deodar	As suggested by Forest Department	6420	40	130,500	387,300
Kail	As suggested by Forest Department	440	45	14,400	34,200
Fir	As suggested by Forest Department	120	50	4,100	10,100
Grand Total					**431,600**

3. Excavation and Blasting

Being in a hilly terrain, the projects will require excavation for alignment of abutments and may likely blasting especially tunnel works, contain underground activities similar to mines. As a result, workers may be exposed to dangers such as collapses, cave-ins, toxic or suffocating gas emissions, gas explosions, dust explosions, component falls, and floods. In addition, hiding, storing, transporting and exploiting explosives such as dynamite, which are used in work such as rock blasting and tunnelling, potentially dangerous. Big bursts are inevitable in the unauthorized storage and usage processes.

Such physical work has the propensity to alter the landscape, due to cutting of trees and/or levelling mounds and hills, and also create dust pollution. Moreover, use of dynamite also poses risks to the safety of the workers as well as general public as a whole.

Any excavation work during the construction activities, whether permanent or temporary, may lead to loss of soil. Erosion of soil can also occur from removal of vegetation cover, runoff from unprotected excavated areas, etc. Excavations on slopes would also decrease its stability. It is expected that minor level of short-term risk is associated with the type of construction activities that are likely to take place. The current land formation is fairly stable therefore no major impact is associated with regards to slope stability. The duration of the risk is expected to be short and the spatial scale of risk is small because the excavation effects are not likely to affect areas further than 200 meters from the project facilities.

Mitigation Measures

The best place for disposal of excavated material seems to be both right and left bank of Ushu River from where top soil has been washed out as a result of successive seasonal floods and particularly severe flood of 2010. This material will cover boulders and gravels up to some extent and help in restoration of the affected lands.

Vegetation loss will be avoided as much as possible and limited to demarcated construction area. Slope stabilization measures will be adopted such as adequate vertical and horizontal drains, cross drainage etc. Slope movements will be monitored around excavation work areas. Top six inches' soil should be protected before excavation and should be placed back after completion of construction work.

It is very important to plan before starting work in order to avoid trench cave-ins. In addition, to reduce the possibility of accidents, it is necessary to take proper precautions according to the soil type, to build suitable ramps for safe access to the excavation site, to carry out the inspections of excavation work machines and to work with competent drivers and operators. Blasting may be done where it is absolutely necessary, use safety measures in handling explosives, prepare blasting schedules along with warning sirens, and ensure minimum damage to the landscape.

In compliance to the GoP guideline, the Contractor will be strictly advised for controlled blasting like use of explosives for relatively hard rock in order to shatter and break the rock.

These blasting activities are for a short time period and anticipated temporary impacts are disturbing the ambient air level in particular the emissions of NO_2, CO, and NO are generated during the explosions. However; the Contractor will be strictly advised to implement the following pollution prevention and control techniques:

- Alternatives to blasting, such as hydraulic hammers or other mechanical methods will be preferred wherever applicable;
- The correct burning of the explosive,
- A consistent blasting schedule by Contractor, minimizing blast-time changes; specific warning to alert all workers and third parties in the surrounding areas (e.g. local communities).
- Trained personnel shall be handling explosives and safety management has been considered;
- Blasting-permit procedures shall be followed; and,
- Blasting sites should be checked post-blast by qualified personnel of Contractor for malfunctions and unexploded blasting agents, prior to resumption of work.

Controlled Blasting Mechanism

Controlled blasting methods will be used to control blast induced effects in tunnel such as, over-break, fractures within remaining rock walls and ground vibrations etc.

Adopting various techniques of controlled blasting such as line drilling, trim (cushion) blasting, smooth (contour or perimeter) blasting, pre-splitting etc,; selecting and employing various parameters of blast design; using modern technology such as precise timing delays, varied density of explosives product by using bulk explosives; muffle blasting at a very critical and congested areas normally employed for mitigation of adverse impact of blasting.

The drilled holes in control blasting usually have a tighter spacing than production holes, are lightly loaded and are fired simultaneously before the production holes.

Drilling and blasting currently utilizes many different varieties of explosives with different compositions and performance properties. Higher velocity explosives are used for relatively hard rock in order to shatter and break the rock, while low velocity explosives are used in soft rocks to generate more gas pressure and a greater heaving effect.

As the name suggests, drilling and blasting works as follows:

- A number of holes are drilled into the rock, which are then filled with explosives.
- Detonating the explosive causes the rock to collapse.
- Rubble is removed and the new tunnel surface is reinforced.
- Repeating these steps until desired excavation is complete.

The positions and depths of the holes (and the amount of explosive each hole receives) are determined by a carefully constructed pattern, which, together with the correct timing of the individual explosions, will guarantee that the tunnel will have an approximately required cross-section.

During operation, blasting mats may be used to contain the blast, suppress dust and noise, for fly rock prevention.

As a tunnel or excavation progresses the roof and side walls need to be supported to stop the rock falling into the excavation. The philosophy and methods for rock support vary widely but typical rock support systems will include:

- Rock bolts or rock dowels
- Shotcrete
- Ribs or mining arches and lagging
- Cable bolts
- In-situ concrete

Typically a rock support system would include a number of these support methods, each intended to undertake a specific role in the rock support such as the combination of rock bolting and shotcrete.

4. Soil erosion and land sliding:

Any excavation work during the construction activities, whether permanent or temporary, may lead to loss of soil. Erosion of soil can also occur from removal of vegetation cover, runoff from unprotected excavated areas, etc. Excavations on slopes would also decrease their stability.

Mitigation Measures

Good engineering design will protect erosion and land sliding in the project area. Effective mitigation measures and sound environmental management practices will be specified in the contracts to ensure minimum soil erosion and land sliding.

5. Water turbidity

During construction of intake and weir the removal of bank/ in stream soil and vegetation clearing will cause sedimentation affecting fish and aquatic invertebrates sensitive to changes in the water quality parameters such as, increased turbidity, changes in temperature etc.

Fresh water fish and some other aquatic organisms are unlikely to live and breed well in such modified areas. In addition, sediment eroded from stream banks may be carried further downstream where it is deposited, smothering eggs and invertebrates. Moreover, extreme (too high) flow variations will increase sediment load from the subprojects site, which inhibits percolation and lowers available oxygen. Sediment in the flow scours spawning beds for breeding species.

Fish species that rely on vision to obtain food would be adversely affected as a result of sedimentation. Poor visibility due to sedimentation of stream water (by construction activities).

Mitigation Measures

Monitor water flow during construction and maintain the minimum ecological requirement for all rivers to ensure water is available downstream all the time.

Maintain the desired hydrological connectivity in the system (upstream-downstream and maintain low water temperature necessary for survival of the moderately flow-sensitive species found at this site;

Ensure riverine protection through observing the 6-30m away from the river banks and planting of indigenous riparian trees to reduce sedimentation.

Provide compensation and sediment channels in the weir as well as physical removal of sediment.

6. Impact on Aquatic Life

During construction diversion weir and water tunnel may create temporary barriers to highly mobile aquatic fauna unfamiliar with new surrounding until they adapt navigating across them.

Long distant migratory fish may experience delays due to blocked passages, which depletes energy reserves and increases stress.

Proper care is required that the workers should not be involved in fishing activity in Ushu river. The government has put a ban on this activity.

Mitigation Measures

For avoiding any disturbance and threat to the fish population, construction of proper fish ladder will have to be considered on priority basis while developing detailed design.

Minimize activities to areas of construction and initiate habitat restoration immediately after construction works are through; and

Restore disturbed areas to near-to-nature to blend with the immediate environment.

It is proposed that fish seeding should be introduced. Fish breeding and commercial exploitation should be monitored regularly. Similarly, protection will be provided at the intake tunnel.

7. Impacts on Wildlife

A hydropower is a clean and green source of energy. However, it has some negative environmental impacts. One of them is Impacts on wildlife. Artistic II HPP is maximum underground, however the weir and power house sites are open and it may disturb the easy movement of local wildlife species. It is clear that the proposed project area doesn't contain any endangered species according to IUCN Red list. During and after construction, the routine pathways of local wildlife species may be disturbed, and similarly during tunnelling, the blasting sound may disturb the wildlife of the area.

Mitigation measures

To manage the routine and easy movement of local wildlife species, connectivity corridors will be made for free movement of wildlife. As the Box Channel will be totally covered, so, it will not hinder the wildlife movement. Similarly, there will be controlled blasting in the tunnel in order to reduce the disturbance of wildlife species.

Trainings will be arranged for labors as well as for the community regarding the sensitivity of wildlife in the project area.

7.4 SOCIAL IMPACTS

1. Public Safety and Convenience

The contractors will be required to implement safety measures to avoid accidents and protect workers. Health precautions need to be undertaken to minimize health risks to construction workers and nearby communities. The construction of the proposed project will involve heavy machinery and vehicular movement in the project area. There is possibility of physical injuries, communicable diseases, encroachment of wildlife including snakes etc. and other incidents for which proper precautionary and preventive measures will be required which must be embedded in the contract agreements. Public security and convenience are related with the workers and local residents.

Mitigation Measures

- prevention of site
- public access to resources
- protection from injuries and diseases
- control of dust fume and noise and
- increase in road hazards

2. Population influx

The Project may lead to minor in-migration from other parts of KP and other provinces to provide services to construction workers. The project is likely to provide a general uplift in the infrastructure of the area and to increase economic activity. However, there is a general trend of out-migration to larger towns and cities so in-migration may not be a serious problem. During the detailed design stage, the Client/Contractor will consult with the local administration to ensure adverse impacts of population in-migration are minimized.

Although, the Project will not have significant adverse social impacts, the Client/Contractor would like to contribute to community development in collaboration with the concerned local agencies as and when needed.

3. Impact on Civic Infrastructure

This will cause additional wear and tear of roads and cross drainage. Such situation can arise through carelessness of the heavy machinery drivers / operators. A considerable damage to paths, roads and drainages may occur if the drivers/operators are not made aware, trained and bound to be careful. It is a concern of slight significance but can be mitigated through care and regulation.

Mitigation Measures

Contractor's contractual obligations to impose strict control over operators and drivers of all types of vehicles/machinery. Awareness may be given to them. The position of infrastructure and underground installation should be precisely located to avoid any damage. Should the damage take place, the contractor must be bound to carry out repair immediately.

Ensure existing road access is maintained & provide bridge access across the river at appropriate place.

4. Temporary and permanent job creation

During construction stage of the project it will create number job opportunities for the local community. Construction of project is a temporary activity, despite its temporary nature, employment creation for local communities has significant positive impact. However, number of people will be employed for operation stage as well. An injection of capital within the household economy through payments of wages will create opportunities to raise their life style.

Mitigation Measures

The project should incorporate and maximize the use of local labour force. Despite the low level of formal education, there are several activities within the project for non-qualified labour. There may also exist, locally, semi-qualified labour force, such as carpenters, drivers, bricklayers, masons etc. would get the employment opportunity.

7.5 IMPACTS DURING OPERATION

The flows after weir site will likely to be reduced up to some extent which may lead to lower riparian issues.

Mitigation Measures

The weir will be designed in such a way that appropriate water flows are allowed to meet essential needs of local population. This aspect will be given special consideration during detailed designing.

To ensure that the Project is in harmony with the environment, the Contractor will employ sound environmental management practices, including:

i. waste management at residential complexes and offices, particularly sewage treatment to the required standard and reuse of treated effluents for irrigation

ii. waste management at warehouses, workshops and motor pools

iii. landscaping and plantations

iv. Environmentally responsible conduct of personnel, covering such practices as hunting, tree cutting, noise and other public nuisance abatement.

The above practices will be institutionalized in the environmental management system of the Contractor's company.

7.6 CUMULATIVE IMPACT ASSESSMENT

7.6.1 INTRODUCTION:

The Artistic Hydro II (Pvt.) Ltd. Plans to develop the feasibility study of 55 MW Artistic II HPP in Kalam, Swat, KP. The Government of Pakistan (GoP) awarded Artistic-II HPP at Kalam, District Swat to the Artistic Milliners (Pvt) Ltd. Karachi, an investment company that acquires, develops, constructs, owns and operates renewable power generation projects. M/S BAK Consulting Engineers in joint venture with M/s Dolsar Engineering Inc. Co. Turkey prepared an Environmental and Social Impact Assessment (ESIA) and developed the Resettlement Action Plan (RAP) for the Project in conformance with a) the national requirements including that of the Khyber Pakhtunkhwa Environmental Protection Agency (KP-EPA); and b) International Finance Corporation's (IFC) Environmental and Social Performance Standards (PS).

7.6.2 RATIONALE FOR CUMULATIVE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT:

Environmental and social impact assessment (ESIA) is now an established tool, and a mandatory requirement in almost all the countries in the world for assessing the environmental and social impacts of development projects. The emphasis of ESIA is on the environmental and social impact of a single project. Even if all the projects in a geographical location are studied through their respective ESIA studies, how the projects will collectively change the environment is not captured in the studies. This assertion is based on the understanding that environment and ecosystems are non–linear systems. The cumulative impact of a number of projects will not be equal to the sum of incremental impacts of individual projects—it is likely to be more. Therefore, considering the limitations of ESIA studies, the countries and organizations, understanding the importance of environment and a possible change in it as the key factor to impact its biophysical integrity, now emphasize and direct the project proponents and donors to conduct assessment of cumulative environmental and social impacts of the projects.

Cumulative impacts are those that result from the incremental impact of a project or developments when assessed in combination with other existing and reasonably foreseeable future developments in a rationally set geographical and temporal scale. Cumulative impacts of a project are limited to those impacts only which are generally recognized as important on the basis of scientific concerns and concerns of the local communities located around the project area which can be affected by the project development and other developments in their vicinity.

Cumulative Impact Assessment (CIA) signifies a systematic impediment in environmental and social impact assessment (ESIA) because the spatial horizon of impact assessment is expanded and multifaceted as compared to ESIA and the interactions between human activities and Valued Environmental and Social Components (VECs) increase in number and intricacy. The overall objectives of a cumulative environmental assessment studies are:

- Safeguard the subject and future development's cumulative social and environmental impacts and risks to not exceed a threshold that could compromise the sustainability of Valued Environmental and Social Components (VECs);
- Ensure that the subject and future development's value and feasibility are not limited by cumulative social and environmental impacts and risks; and
- Support development of regional governance structures for decision making and managing cumulative impacts.

7.6.3 METHODOLOGY FOR CUMULATIVE IMPACTS ASSESSMENT.

There are a number of guidelines for conducting cumulative environmental and social impact assessments. The methodology used in this Study has been adapted from the guidelines of International Finance Corporation. The key steps of the Study are shown in **Figure 7-4.**

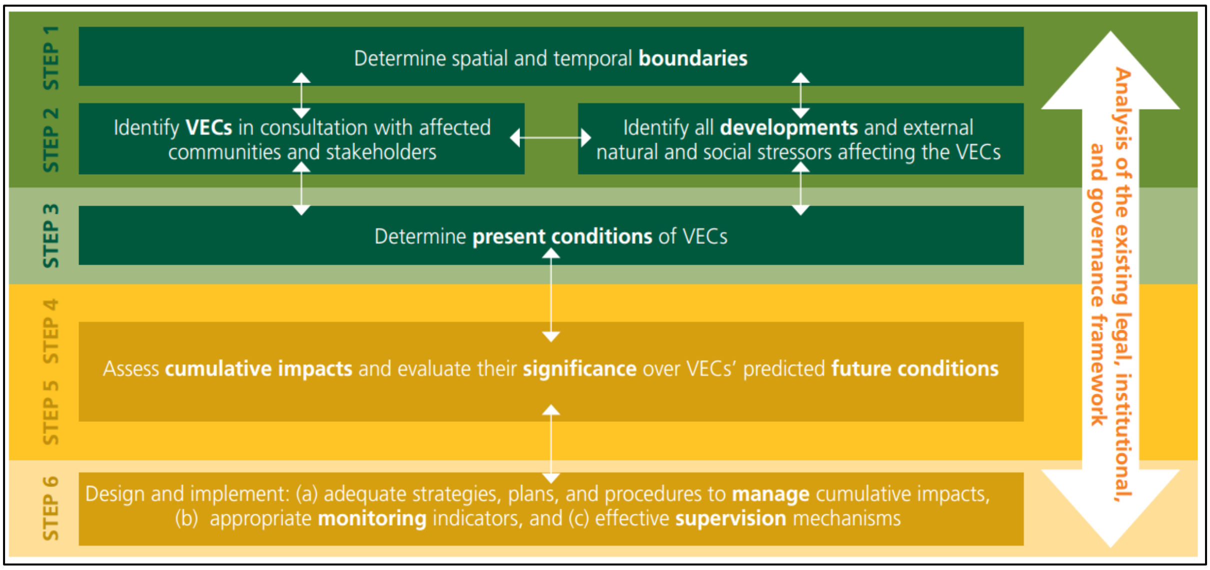


Figure 7-4: Key Steps of the Study

Source: International Finance Corporation. Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. 2014

7.6.4 Spatial and Temporal Boundaries

The spatial and temporal boundaries for the CIA are defined in this section together with justification for their selection.

7.6.5 Spatial Boundaries:

The Study Area selected for the CIA (CIA Study Area) includes the Swat River from Eshegal village to Kalam town. It also includes segment of the Gabrial River, which meet with the Swat River in Kalam town. Significant tributaries which are important breeding areas for fish and recharge the rivers with water included Eshegal Nullah, Palogah Village Nullah and Ushu village Nullah. All the aforementioned Nullah are also included in the CIA Study Area as the tributaries and the main river constitute an integrated and interdependent ecosystem. Matiltan Hydropower Project is also located on the same river at downstream area of Artistic-II HPP.

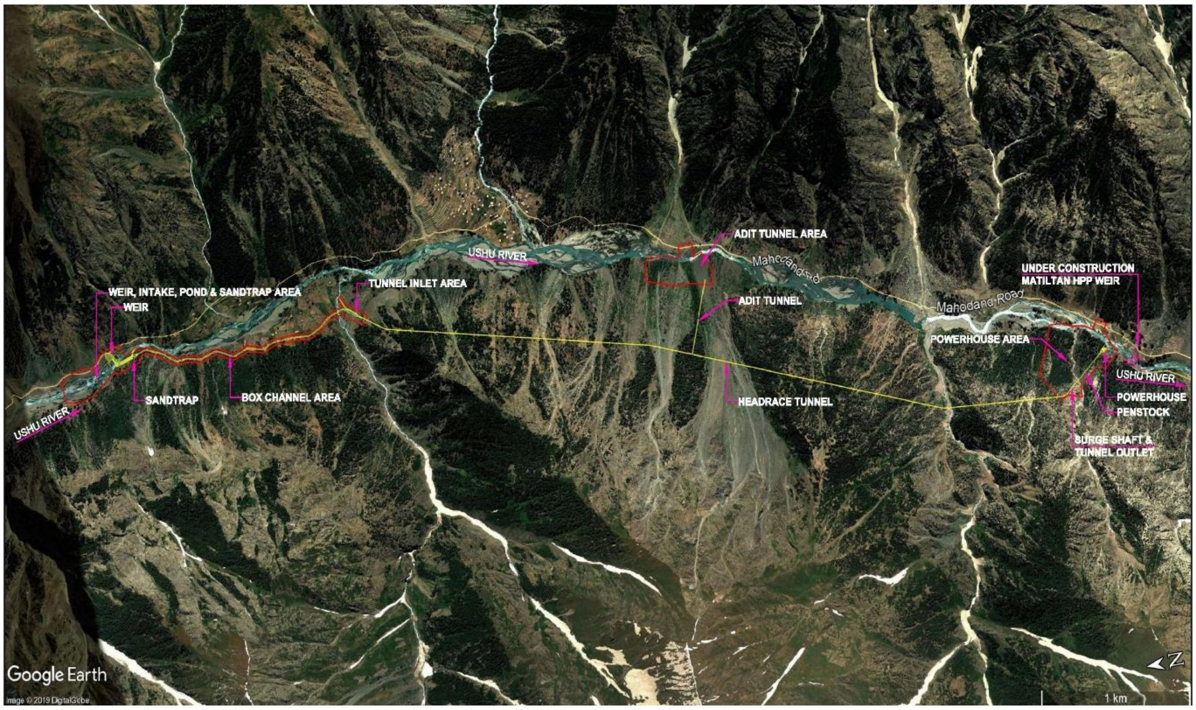


Figure 7-5 Spatial Boundaries Map

7.6.6 TEMPORAL BOUNDARIES:

The temporal scope of the CIA spans a period of 50 years up till the year 2050. This includes the first 5 years of construction (1 year pre-construction and 4 years construction period) of the Artistic-II HPP and a further 45 years of its operation.

7.6.7 HYDROPOWER PROJECTS DEVELOPMENT PLAN

Pakistan is going through an acute power shortage. The gap between supply and demand has crossed 5,000 MW. Over the last decade, the development of hydropower resources in Pakistan has become a priority for the governments. This shortfall has resulted in prolonged power cuts of about 8 hours a day across both states and has adversely affected economic growth and development; thus, becoming one of the top challenges facing the political leadership.

7.6.8 MAJOR EXISTING, PLANNED AND UNDER CONSTRUCTION HYDROPOWER PROJECT ON SWAT RIVER

According to the latest information available, the major hydropower projects on Ushu River are listed in **Table 7-7.** Information about their installed capacity, executing agency and progress status (existing, under construction or planned) is also provided.

Table 7-7: List of the Major Hydropower Projects on River Ushu in Various Stages of Development by Different Agencies

S.No	Project	Installed Capacity (MW)	Executing Agency	Project Status	Reservoir Length (km)
1	Artistic-II HPP	55	Artistic Hydro-II (Pvt.) Ltd.	Feasibility Study	Run of River
2	Gorkin Matiltan HPP	84	PEDO	Under Construction	Run of River

Ecosystem Services Review

Ecosystem Services, as defined by the World Resources Institute (WRI), are the benefits that people get from nature. Examples include fresh water, timber, climate regulation, recreation and aesthetic values. Ecosystem services are an important class of Valued Environmental and Social Components as the livelihoods of the communities depend on them, and are therefore discussed separately in this section.

The Ecosystem Services Review is an initiative to view the environment as an integrated system. The framework that is being used in this study has been developed by World Resources Institute (WRI, 2011). This new framework systematically addresses impacts on ecosystem services, defined by WRI (2011) as “the many benefits—large and small, direct and indirect—that ecosystems provide to people”, and thereby links people and their environment. The benefits humans obtain from ecosystems are generally divided into four categories:

i. Provisioning services are the goods or products obtained from ecosystems, such as food, timber, medicines, fiber, and freshwater;
ii. Regulating services are the benefits obtained from an ecosystem’s control of natural processes, such as climate, disease, erosion, water flows, and pollination, as well as protection from natural hazards;
iii. Cultural services are the nonmaterial benefits obtained from ecosystems, such as recreation, spiritual values, and aesthetic enjoyment; and
iv. Supporting services are the natural processes that maintain the other ecosystem services, such as nutrient cycling and primary production.

7.6.9 Identification of Ecosystem Services Associated with the River

Identification of ecosystem services was carried out through a review of the Socioeconomic Baseline of the ESIA of Artistic-II HPP. Ecosystem services in the categories of regulating and supporting services are not of significance in the CIA Study Area. The following provisioning ecosystem services were identified:

7.6.9.1 Provisioning Services

- Fishing
- Sand Mining
- Driftwood Use as a Fuel
- Land irrigation
- Domestic Uses of River Water
- Pumping of River Water by River–side Restaurants

7.6.9.2 Cultural Services

- Tourism and Recreation

7.6.10 Determination of Priority Ecosystem Services

Priority ecosystem services were determined based on two criteria including significance of community dependence on the ecosystem service and whether or not the Project will impact the ecosystem service. These ecosystem services are described below, along with information and analyses to assess their priority. Prioritization of ecosystem services is summarized at the end of this section.

7.6.10.1 Fishing

Fish hunting was carried out along the project area mainly for the sake of food and recreation, however at very small level it was used for business purposes as well. The fish intensity is higher in the above stream area of the proposed project, while it decreases as we move in the downstream. The fish season was prolonged almost throughout the whole year due to extreme cold weather. Seasonal permits for fishing using rods and cast nets are issued by the KP Fisheries and Wildlife Department, but most of the fish caught is without permits as enforcement is weak. The most common fish species caught include Singhat Machli

(*Triplophysa choprai*), Chakaar Machli (*Glyptosternum riticulatum*), Brown trout (*Salmo Trutta*), Rainbow trout (*Onchorhyncus*), Crow fish (*Xinentodon Cancila*), Daoly Machlee (*Channa gachua*), Galali (*Schizothorax plagiostomus*) and Chunr (*Racoma labiata*). It is reported that most of the fish is self–consumed whereas the some of it is sold commercially as well. Commercially fish was sold to the local hotel especially for the tourists, however some fish was sold to the middle man for the export to the other cities. It may be noted that a large part of the fishing activity is illegal, i.e., is undertaken without license from the Fish Department. The fishermen are, therefore, reluctant to share information on the fishing activities and its volume. Fishing will be affected by the proposed project. The creation of the barrier and diversion of water to the tunnel will decrease the volume of water in the river and decrease the habitat, thereby, impacting fish populations in the proposed project area of Swat River. But as the dependence on fish of the local community as a livelihood was low, thus overall impact is not significance. Furthermore, maximum fish population is found in the area which lies above the project area. However, presence of some endangered fish species such as trout increase the significance of that impact. With the construction of these project may lead to decrease the population of trout fish which is already endangered species in the area.

7.6.10.2 SAND MINING

Sand mining is carried out along the whole proposed project area and it's downstream as well especially at those places where there are population or any commercial activities such as hotel are under construction. The mineable sand resource is being extracted to meet small–scale construction demand, involving construction and maintenance of local residential and commercial buildings. The mining techniques are crude, involving use of labour for sand dredging. No mechanical extraction was observed anywhere in the CIA Study Area. The sand is mined using shovels and spades and is loaded onto animals or vehicles, by means of which it is transported to the roadside. The extraction is carried out in areas where the flow of the river is gentle, the width is wide or where due to meandering of the river sand bars area created. The operation continues throughout the year except in the flood season. However, as sand mining is carried out to meet the local requirement for the construction of their own houses. Thus, the demand is very low and only a small amount of sand mining was carried out.

The construction of this project will have positive impacts on the overall economy of the area. As it was already practiced in the area during the construction phase of Gorkin Matiltan Hydropower Project, the local land owner was paid for the sand mining. Furthermore, job opportunities were also provided to the local people. Thus, overall it increases the economic conditions of the area. However, during the construction phase sand mining may affect the aquatic life in the area. Use of heavy machinery may lead to the degradation of the natural habitat of the aquatic life. Especially it will badly affect the endangered trout species. Furthermore, the extraction of sand and stone may lead to cause turbidity which will affect the quality of the water by increasing the load of dissolved and suspended particles. However, these aforementioned effects will be only associated with the construction phase. Thus, there impact will be not as significant.

7.6.10.3 DRIFTWOOD USED AS FUEL

Fuel wood is the main source of energy for domestic cooking and heating. Respondents, interviewed as part of the ESIA of Artistic-II HPP reported that fuel wood is collected from the farm lands and dead–fallen trees in the forests. Driftwood use as a fuel is likely to be affected by the project especially at the box channel site. At the point of box channel, a small village of Eshegal is located and along the both bank of River Ushu a cluster of houses are located. These peoples use driftwood as a source of fuel. With the construction of box channel, it may alter the path for the local community to transport their fuel wood.

7.6.10.4 LAND IRRIGATION

The local community in the propose project area is highly reliable on the livestock and agriculture practices in the area. However due to extreme climate conditions only one crop is grown throughout the year. The main crop is potato, which is very famous all over the Pakistan. The demand of Kalam potato is very high in the country. A little area which under the box channel is mainly agriculture lands. Construction of box channel will lead to degrade the agriculture land of the Eshegal village. Thus, it is a significant impact of proposed project in the area. During the demographic survey the respondent were very concerned about their agriculture lands. They demand high compensation for their lands. Agriculture land in Palogah Village is mainly irrigated not from the Ushu river water but the people use the tributaries nullahs for irrigation purposes. However, as agriculture practices are carried out during the summer season only. Thus, at the time there is enough water to irrigate the agriculture lands of the village. So overall there will be no significant effect on the agriculture lands of the area due to construction of this hydropower project.

7.6.10.5 RIVER WATER USAGE FOR HOTEL AND DOMESTIC PURPOSES

The Ushu River starts from Mahodand Lake and meets to Swat River at Kalam crossing from various villages. Though the population of these villages were not too much populated but still cluster of houses were found along both ends of the river. In addition, few hotels and restaurants were also constructed along the left bank of the river especially in the village of Palogah, Matiltan and Ushu village. The habitant of all these areas using the water of the river for their domestic purposes. The establishment of this project will lead to decrease the flow of water along the tunnel side especially during the winter season when the river water volume will already decrease due to extreme climate conditions. However, during the winter season majority of the habitant of the areas moves to other cities of the Pakistan. Thus, overall impact in this regard will be not significant. Furthermore, addition of Palogah Nullah and Eshegal Nullah near Palogah and Eshegal village will recharge the river and overall increase the volume of the water.

7.6.10.6 TOURISM AND RECREATION

Recreational dependence on the river was reportedly high in the proposed project area, based on the ESIA of Artistic-II HPP. Mahodand Lake, Palogah Village and Ushu village are the major sites of recreation and tourism in the area. Mahodand Lake is located above the proposed project site; thus, it has no impact due to the construction of this hydropower project. Palogah village lies in the middle of the proposed project area on river left bank side, while Ushu village life downstream area of the proposed project. The tourism activities in the aforementioned sites are fishing, boating and picnic point. However, boating is only limited to Mahodand lake. Most of the respondent stated that river–based activities, primarily fish supplied from river to hotel, and the river view are important for the tourist from other areas and any reduction in river flows could adversely affect the hotel business from the tourist. However, the share of business coming from fish is reportedly small compared to the total volume of business. The river view in the summer which is the primary season for the visitors will not be affected by the Project as there will be enough water volume in the river during this period. The river is not the main source of fish purchased by the hotels, the fish caught from the river is illegal, and fish produced in the farms downstream is commonly available and consumed. The dependence of local community on income from fishing was very limited as well.

The impact of the Project on tourism will not be significant. Furthermore, local communities do not rely on the river for recreation to any significant extent, therefore, it was not considered significant in terms of community dependence.

7.6.10.7 FOREST DEGRADATION

The proposed project site is dominated with the pine species which take hundreds of years to get mature. The construction of the project will lead to degradation of the forest in the project area. Around 698 Trees will fell down to make the area clear for the construction of the Artistic-II hydropower project. The similar number of trees were already fell down along the Ushu River for the construction of Gorkin Matiltan Hydropower Project which is already under construction phase. Cutting of such huge number of trees will lead to effect the ecology of the area.

Furthermore, it may enhance the soil erosion especially during the construction phase. The impact of project on forest will be highly significant.

7.6.11 Results of Prioritization

Significant community dependence was signified by Yes (Y) as was Project impact. Insignificant community dependence and the absence of impact by the Project were signified by No (N). The significance for both the parameters has to be Y for an ecosystem to qualify as a priority ecosystem service (**Table 7-8**).

Table 7-8: Prioritization of Ecosystem Services

Ecosystem Service	Significant Community Dependence	Impacted by Project	Priority Ecosystem Service
Fishing	N	Y	N
Sand Mining	N	N	N
Driftwood Use as a Fuel	Y	Y	Y
Agriculture	Y	Y	Y
Forest	Y	Y	Y
Tourism and Recreation	N	N	N
Domestic Use of River Water	N	N	N
Pumping of River Water by River–side Restaurants	N	N	N

Kalam, an area which is very famous for its natural beauty and hub of tourism and recreation in the whole country. Every year thousands of people visit to the area. Ushu River that started from Mahodand Lake and join the Swat River in Kalam city. On the Ushu River, hydropower projects were proposed among which one is under construction i.e. Gorkin Matiltan HPP, while feasibility study of Artistic-II HPP is in progress. The construction of these projects on Ushu river have positive and negative impacts which may include job opportunities, forest degradation, agriculture land degradation and so on. However, there are only few negative impacts which have some significant impact due to construction of this project. Nevertheless, these impacts can be managed by adopting the proper mitigation measures or by paying proper compensation.

8. ENVIRONMENTAL MANAGEMENT & MONITORING PLAN

8.1 CONSTRUCTION PHASE

The project Environmental Management Plan (EMP) includes an organizational structure, roles and responsibilities of the various entities, an impact mitigation plan, an environmental monitoring plan, communication and documentation, and environmental training.

The Contractor will assume overall responsibility for compliance with environmental and social management requirements of the government of KP and the lenders. The Engineering, Procurement and Construction (EPC) contractor will assume overall responsibility for the environmental performance of all the subcontractors, i.e., it will ensure that they effectively implement all environmental management measures stipulated in the EMP and in the contracts.

The contractor company's project manager will discharge the company's environmental and social responsibility as part of project implementation management. The company will appoint an environmental and social inspector to assist the project manager and provide policy support on all environmental and social matters. The company will coordinate with relevant government departments (e.g., the KP Environmental Protection Agency) and other stakeholders through the environmental and social inspector. Each subcontractor will appoint an environmental and social officer to help its resident engineer to implement the EMP and provisions specific to its contract.

8.2 OPERATIONAL PHASE

Considering the nature of the Project, environmental and social management during the operational phase of the powerhouse will be minimal and routine matter. Management of wastes from residential quarters and offices will be the main task. The management of the powerhouse will induct one environmental and social officer.

8.3 ENVIRONMENTAL MITIGATION PLAN (EMP)

A detailed mitigation plan for the construction phase has been prepared for engineering designing. In essence, the mitigation plan contains:

i. A comprehensive listing of mitigation actions
ii. The persons responsible for ensuring full implementation of the action
iii. The persons responsible for monitoring the action

iv. A timescale for the implementation of the action to ensure that the objectives of mitigation are fully met.

The mitigation measures will be translated into environmental requirements and specifications for detailed design and construction, with legally binding effect.

8.4 MONITORING PLAN

Two types of monitoring will be conducted: compliance monitoring and impact or effect monitoring. Compliance monitoring will be the responsibility of consultants and client to monitor the field activities. The PEDO will also shoulder the responsibility of monitoring as their official obligation during construction and thereafter. The environmental and social inspectors of client, consultants and EPC contractor will carry it out.

The effects monitoring will be carried out in line with the requirements in the mitigation plan focusing on soil erosion, water quality (covering suspended solids, turbidity, biological oxygen demand, and dissolved oxygen), air quality (covering suspended particulate matters), noise (to be measured at selected sensitive receivers during construction creating noise), and socio-economic aspects (covering complaints and employment created by the proponents of the project). A detailed monitoring plan will be developed during the design phase of the project, when specific information on field activities is known. The monitoring schedule will be linked to the construction schedule.

8.4.1 OWNER-SPONSOR RESPONSIBILITIES

The owner of the project shall ensure the implementation of the following:

a. That the contractor abides by all requirements of EPA (KP), other rules and regulations of Federal or Provincial Government notified from time to time, all the relevant laws of Pakistan as included in the EIA and all the international conventions/ treaties signed by Pakistan.
b. Ensure that all the mitigation measures for the adverse impacts have been implemented properly and timely.
c. Assist the contractor on social conflicts at the work site.
d. Ensure that all the utility services affected by the construction works are relocated.
e. Ensure that all the health and safety measures are fully followed by the contractors.

8.4.2 CONSTRUCTION SUPERVISION CONSULTANTS

The construction supervision consultants will supervise the implementation of the EMMP by the contractor and assist the owner (sponsor) of the project to monitor the implementation. The consultant will also assist the sponsor and the contractor in training the site staff. The responsibilities of the consultants are:

a. Supervise the implementation works of the EMMP by the contractor.

b. Ensure that all the works carried out are in accordance with EPA, PEPA Act 1997/2000 rules and regulations, and NEQS.
c. Ensure that health and safety measures are addressed on worksite and in Labour camps.
d. Impart training to the contractor and other persons related to environmental control.

8.4.3 PROJECT CONTRACTOR RESPONSIBILITIES

a. The contractor is required to implement the mitigation measure as included in the EMMP and the contract documents. The contractor shall carry out the following environmental works in addition to the good engineering practices.
b. The contractor will prepare a site-specific environmental plan in the light of EIA and EMMP as required under the specifications of the contract documents.
c. Ensure that all the mitigation measures are carried out according to the specifications of the Client. Ensure that EPA rules, regulations, PEPA Act 1997 and other prevailing rules and regulations of Pakistan and international conventions signed by Pakistan are complied with carrying out of the works.
d. Coordinate various government agencies to resolve the issues hindering the project works.
e. Ensure that first aid facilities are provided on site.
f. Submit monthly and quarterly reports of implementation works carried out on the instructions of the Client or any other agency indicated by the Client.
g. Submit a report on the major accidents on site to the Client and relevant government agencies immediately on occurrence of such accidents.
h. The contractor will prepare a Health and Safety Plan in the light of EIA and EMMP as required under the specifications of the contract documents.

8.5 MITIGATION MEASURES DURING CONSTRUCTION PHASE

8.5.1 GENERAL

Various adverse impacts occur due to the construction activities. The operation of equipment and plant produces noise and causes dust pollution. The Labour camps should be managed to avoid health risk to the workers. Some of the materials used for construction are toxic and others may be explosive in nature. Discarded construction waste requires proper disposal. The main issues addressed in the EMMP are elaborated hereunder. A complete EMMP matrix is given in **Table 8-1**.

During construction, the air quality of the adjoining areas gets deteriorated due to excavation, disposal of the excavated material, fugitive dust and emissions from the construction machinery and haulage of automobiles on unpaved roads at the construction sites. Care should be taken that the respirable and suspended particulate matter levels do not exceed the allowable limit. Similarly, emission of exhaust gases should also be contained below the permissible limits prescribed in the National Environmental Quality Standards (NEQS).

8.5.2 Noise and Vibration

Noise and vibration will be produced due to blasting operation and the movement of construction machinery and other construction related activities. This should be alleviated by avoiding old machinery, using noise control techniques such as silencers and sound insulation materials. In no case the noise level should be 75 dBA. No worker should be exposed to more than 8 hours to a noise level of 75 dBA or above. Earmuffs and plugs should be provided to the operators of the machinery.

8.5.3 Drinking Water

Drinking water should be supplied to the workers and other staff members after proper treatment according to the National Standards for Drinking Water Quality (NSDWQ)/World Health Organization (WHO) standards fixed for drinking water.

8.5.4 Sewage Effluent

Arrangement should be made for the proper treatment and disposal of the sewage effluent according to the EPA surface discharge standards. Pollution of the river from untreated sewage water should be safeguarded.

8.5.5 Solid Waste

Proper arrangements should be made for the collection of solid waste and its disposal to a designated landfill site/area.

8.5.6 Explosive Material

The explosive material should be stored in a safe place away from the work and residential area and its storage, handling and use must comply with the Explosive Act of the Ministry of Mines. Rock blasting must be strictly controlled and carried out with all necessary safety measures.

8.5.7 HAZARDOUS AND TOXIC MATERIALS

In transportation, storage, handling and use of hazardous and toxic materials, proper care must be taken to avoid soil and water contamination. The persons handling such materials must be provided with protection equipment/gadgets. The containers of the chemicals and other toxic materials should be disposed of properly so that it may not be re-used by anybody under any circumstance.

8.5.8 FLORA AND FAUNA

The project activities may affect the flora and fauna of the area. Care should be taken to avoid damage to the flora and fauna of the area due to the operation of machines, equipment, transport, and any human intervention.

8.5.9 EXCAVATED MATERIAL

During construction a large quantity of excavated material will be produced. It should be properly disposed of, outside the excavation area at appropriate site(s). This will reduce the load of sediments to the surface water, resulting in better water quality. After disposing of this material, the site should be rehabilitated properly and timely.

Appropriate sites for the dumping of muck material has been marked at four locations i.e. near tunnel inlet, box channel, adit tunnel and tunnel outlet. Details about the quantity of muck material produced and the area allocated for the dumping of the excavated material is presented in the following **Table 8-2** & **Table 8-3**.

Table 8-2 Details of Dumping Sites Allocated for Excavated Material

S.No	ID	Dumping Site Location	Area (acres)	Total Muck Material Capacity (Approx.) (cubic meter)
1	D1	Box Channel	6.55	274,347
2	D2	Tunnel Inlet	4.8	201,048
3	D3	Adit Tunnel	8.64	361,886
4	D4	Tunnel Outlet/ Powerhouse	12.2	510,997
Total				**1,348,277**

Table 8-3 Details of Muck Material Produced during Construction Phase

S.No	Structure	Total Muck Material (m^3)	Dumping Site
1	Weir	18,813	D1
2	Diversion Works	3,533	D1
3	Fish Ladder	369	D1
4	Intake	12,471	D1
5	Sandtrap	108,473	D1
6	Box Channel	81,703	D1,D2
7	Forebay	76,578	D2
8	Tunnel	605,604	D2,D3,D4
9	Surge Shaft	14,221	D4
10	Valve Chamber	69,986	D4
11	Penstock	99,419	D4
12	Powerhouse and Tailrace	120,643	D4
13	Access Roads and Bridges	132,877	D1,D2,D3,D4
Total		**1,344,691**	

Layout and coordinates of the marked sites for the dumping of the excavated material has been attached as **ANNEXURE 11**.

8.5.10 WEATHER RECORDING INSTRUMENT

In the project area there is every possibility of weather generated hazards during the execution. It should be ensured that weather recording instruments are installed, which are working properly and alert the contractors/workers of any expected weather hazard like excessive rain or wind storm in the project area, well in advance for taking necessary precautionary measures.

8.5.11 BLASTING AND QUARRYING OPERATION

The blasting and quarrying operation may cause some damage to the men working in the project area. It is essential, that during the blasting and quarrying operation, compliance with the safety regulations is done and safety precautions are adopted. It is also imperative that blasting and quarry waste is disposed of with proper care at the proper site. The site should be rehabilitated properly after disposal of the waste material.

8.5.12 HEALTH AND SAFETY REQUIREMENT

The Contractor will be responsible for the security, safety, health and Group Life Insurance of his employees. The Contractor will provide the Employer with a Security, Safety and Health Manual within one month of Notice to Proceed, covering all aspects mentioned in the relevant clauses of the Contract, Laws and Regulations of Government of Pakistan and Government of KP, relevant International Standards (ISO 18000:2000 procedures for safety), traditions and customs of KP. He will provide and maintain at his own cost all lights, guards, fencing, warning signs and security, when and where necessary or required by the Employer or by any duly constituted authority, for the protection of works or for the safety and convenience of the public or others. He will also take all reasonable steps to protect the environment on and off the site and to avoid damage or nuisance to persons or to property of the public or others resulting from pollution, noise or other causes arising as a consequence of his method of operation. The Contractor shall comply with all legal duties and obligations regarding the protection of the environment as laid down, Laws and Regulations of Governments of Pakistan and KP, like water quality, waste management, borrow and disposal material, etc.

8.5.13 TRAFFIC MANAGEMENT

During construction and transportation of the heavy machinery, it should be ensured that the traffic is controlled and managed properly to avoid any adverse impact on the movement of local traffic and inconvenience to the local population of the area. If it is necessary diversion road should be provided to avoid any disturbance to the local people.

The Kalam to Mahodund road is on the left bank of the river, whereas, the proposed Artistic-II Hydropower Project is located on the right bank of the Ushu River, therefore, most of the construction activities will be on the right bank of the river with minimum disturbance to the existing traffic.

However, amount of PKR. 250 million is kept for the improvement and maintenance of existing road to keep the road in excellent working condition throughout the construction period.

8.5.14 FLOOD PROTECTION PLAN

The diversion weir of Gorkin Matiltan HPP is under construction at present and is located about 200 m downstream of the proposed Artistic-II HPP Powerhouse. The diversion weir of Gorkin Matiltan HPP has been designed for 1000 cumecs discharge which is of the order of about 1 in 10,000 year return flood. The protection works at the Artisitc-II HPP Powerhouse will also be, therefore, designed for the same discharge of 1000 cumecs.

8.6 MONITORING OF THE EMMP AT OPERATIONAL LEVEL

8.6.1 WATER QUALITY MONITORING

It is an important component of the post project monitoring. The environmental monitoring cell should collect and analyse the water samples from the stream entering the weir to assess the water quality. Water pollutants entering the weir should be monitored at definite intervals.

8.6.2 AMBIENT AIR QUALITY MONITORING

During the construction and operational phases of the project, environmental protection measures need to be carried out strictly and timely. It is envisaged that, there will be some adverse impact on the environment of the area, which needs to be monitored regularly during the above phases. Environment monitoring is not only necessary for periodically knowing the environmental conditions in the project area, but it also provides valuable data for comparing and analysing the changes in the environment due to the execution and operation of the project. Furthermore, it is a tool to confirm that the adverse impacts have not exceeded the stipulated environmental quality objectives for the project.

8.6.3 REPLACEMENT OF PLANTS / PLANTATION FOR SOIL CONSERVATION MEASURES

Plants are very important for maintaining a healthy environment. During the project construction, some plants will be cut/ damaged. So, in order to maintain a friendly environment, it is proposed that these cut/damaged plants will be replaced with 10 times the number of these affected plants/trees. Environmental Monitoring Cell should monitor the planting, survival rate and after-care of these plants. Moreover, for the stabilization of the banks of the weir and tunnel, different soil conservation measures will be adopted. The plantation at the banks of the weir and tunnel will be one of the most important components.

8.7 COMMUNICATION, DOCUMENTATION AND COMPLAINTS

An effective mechanism for communicating environmental information will be established. The data and information will be systematically filed and stored in a central location. Periodic meetings will be held involving the client, consultant, contractor, environmental and social officers to review the implementation of the EMP and monitoring results, and to resolve any problems. The contractor’s environmental and social supervisor will produce periodic monitoring and evaluation reports. At the end of the construction phase, the contractor will prepare a final monitoring and evaluation report which will be part of a project completion report.

In addition, at the project site the contractor will establish a social complaint register to document all complaints received from local the community. The register will also record the measures taken to mitigate these concerns. All complaints will be sent to the Contractor's company environmental and social inspector and project manager for their information and further action and if not resolved at these levels then grievances redress committee will look into these problems.

8.8 ENVIRONMENTAL TRAINING

The contractor's environmental and social supervisor will train subcontractors, and other staff engaged for the project. Training will cover the requirements of the EIA and the EMP and will emphasize sensitizing project staff to environmental and social aspects. A training program will be prepared during the detailed design phase.

9. ENVIRONMENTAL COST ESTIMATES

9.1 GENERAL

The social and resettlement aspects of the project are important components of environmental and social impact assessment. These cover the areas of Weir, Box Channel, Headrace Tunnel, Adit Tunnel, powerhouse, residential colonies, etc. together with the rehabilitation/resettlement of the affectees being impacted by the project.

Keeping in view the sacrifices to be made by the affectees, it is their right that they must be compensated properly and timely. Furthermore, their assets should be evaluated, keeping in view the market rates, and their post-project situation must be better or at least maintained to their previous standards. If the affectees of the project are satisfied with the resettlement policy, this could serve as an encouraging/facilitating example for other similar types of projects being planned in the area.

The Chapter has been prepared for undertaking the resettlement and rehabilitation of affected persons and includes, identification of categories of impact, number of affected persons with inventory of affected assets and other losses, entitlement of compensation, and other mitigation and rehabilitation assistance measures, resettlement strategy, entitlement for compensation and assistance to restore their livelihood and budgetary allocation, etc.

The RAP will deal with the various issues related to the affectees of the project area, which are discussed in the following subsections:

9.2 OBJECTIVES

The RAP of Artistic-II HPP has been prepared under the general policy guidelines and procedures developed by the Government of Pakistan for projects involving involuntary resettlement. The objectives of the RAP of this project are:

a) To avoid or minimize involuntary resettlement wherever feasible, exploring all viable alternative project designs.

b) Where involuntary resettlement is unavoidable, resettlement plans should be conceived, developed and executed as development programmes, wherein re-settlers are provided with sufficient investment resources and opportunities to share their project benefits.

c) Persons to be displaced should have their former living standards and income earning capacity improved, or at least restored, and should be provided with adequate support during the transition period.

d) Community participation should be encouraged during the planning and implementation of resettlement.

e) All the project affectees should be provided due compensation for their land and land-based assets, addition to houses and shops, such as trees, infrastructure, community buildings etc.

f) Housing/building structure compensation should be provided to the adversely affected population. In this specific situation, only houses/building structures are planned to be compensated.

g) Ensure that the compensation process will be fully transparent; and

h) Considering the growing requirements and complexity of resettlement in this development project, it is better to gear up the concerned government agencies and departments to upgrade their institutional capacity to design and implement RAP.

9.3 SOCIAL IMPACT ASSESSMENT

With the construction of the project, there will be some significant impacts on the physical, biological and socioeconomic parameters including resettlement issues of this project. To evaluate the impacts before the project execution, a socioeconomic study for the project was carried out with the objective to ascertain the overall socio-economic conditions as a part of the social impact assessment.

July, 2010 flood affected many aspects of socio-economic life of the people as well as some physical infrastructure of the area. The area has suffered a significant loss of livelihood due to the flood that has caused damage to the land, crops, livestock and infrastructure.

Under such circumstance, it is of primary importance to gauge the current socioeconomic conditions of the population residing in the project area that is once again likely to suffer due to the implementation of the project.

The main idea was to assess the overall impact of the project on the local population. The impact was studied through the socio-economic baseline survey and public consultation process for project sustainability under pre and post project conditions. The specific social assessment aims were:

a) Define the demographic, sociological and economic characteristics of the project area

b) Incorporation of interest of vulnerable population; including ethnic minorities

c) Define the gender issues and incorporate the interest of women

d) Level of acceptance of the project by the local community

e) Identification of project potential adverse effects, i.e., resettlement issues and spelling out remedial measures as per national laws/policy, local culture and traditions

f) Conduct public consultation sessions to assess the locals' need, demands and possible options for the sustainability of the proposed project

9.4 METHODOLOGY FOR SOCIAL AND RESETTLEMENT PLANNING

Under this specific phase of the study, methodology adopted for the resettlement planning are preparation of inventories of affected land and land-based assets including houses/buildings and the affectees. The ultimate objective was to enable those displaced by the project to improve their living standards. Affected houses/buildings and the population, and impacts were identified through a series of following steps:

a) Surveys and preparation of maps that identify such features as population settlements, agricultural land, infrastructure, natural vegetation areas.

b) A focus census that enumerates the affected people.

c) An inventory of affected land and land-based assets including houses/building structures at the household, enterprise and community level.

d) Socioeconomic surveys and studies of representative number of the affected people as necessary. The survey conducted included the following major components;

    i. Demographic characteristics
    ii. Education and literacy levels
    iii. Nature of occupations and sources of income
    iv. Income levels
    v. Household expenditure patterns
    vi. Housing characteristics and amenities

vii. Access to social amenities

viii. Situation analysis of women

ix. Perceptions and protective measures suggested about the project

e) Analysis of the surveys and studies to establish compensation parameters, to design appropriate income restoration and sustainable development initiatives and to identify the baseline monitoring indicators.

f) Consultation with affected populations regarding mitigation of effects and development opportunities.

g) All the above-mentioned studies generated the required information for the appropriate resettlement planning of the affectees.

9.5 LEGAL AND POLICY FRAMEWORK

The review of legal, administrative and regulatory framework governing acquisition of property for development purposes, and resettlement of affected population in Pakistan, is presented in this section. It also discusses the relevant legislation, regulation and reviews of legal procedures.

9.5.1 LAND ACQUISITION ACT

9.5.1.1 GENERAL

The present general law for acquisition of land for public purposes such as urban development, new roads, railway lines and canals, etc. was introduced in the year 1894 as the Land Acquisition Act, 1894 (LAA). This Act remains the primary law governing land acquisition in Pakistan today and is the principal general statute laying down the framework for the exercise of the right of eminent domain of the State.

In addition to the provisions of the Act, regulations setting out the procedure for land acquisition have been provided in the Punjab Land Acquisition Rules, 1983; published in the Gazette of the Punjab Extraordinary, dated February 22, 1983. These rules are applicable in the Punjab but also used as guideline in other provinces. There is another body of general regulations called the Standing Order No. 28, which is followed by the KP and Punjab. For the acquisition of land, the above-mentioned Act, rules and regulations are followed by all Government Agencies / Departments.

The LAA lays down definite procedures for acquiring private land for projects and payment of compensation. The rights of people whose land is to be acquired are fully safeguarded. Even for entering private land or carrying out surveys and investigations, specified formalities have to be observed and notifications have to be issued. Damage to the crops during survey and investigations has to be compensated. The affected persons, if not satisfied, can go to the Court of Law to contest the compensation award of the Land Acquisition Collector (LAC).

9.5.1.2 BRIEF REVIEW OF IMPORTANT FEATURES OF LAA

In accordance with the Act, the legal process is initiated by an application from the Government agency that requires the land as it is the Requiring Body (RB). As land is a provincial subject according to the Constitution of Pakistan, the next step is for the Provincial Government to deem it necessary to acquire land, and it then takes the following actions.

Under Section 4, it causes the publication of preliminary notification notifying that the land is needed for a public purpose. This permits entry, survey and investigations of the land in question by an authorized Government servant. He shall pay compensation for any damage caused by such entry. The purpose of a notification under Section 4 is to enable the authorities to carry out preliminary investigations for deciding whether the land intended to be acquired is suitable for the purpose for which it is needed. The process of acquisition must start with a notification under Section 4. It is a condition precedent to the exercise of any further powers under the Act.

Notification date of Section – 4 is considered as cut-off date.

Under Section 5, a formal notification is issued that the particular land is needed for a public purpose. This notification is published in the official Gazette and the Collector is required to cause public notice to be given of the substance of the notification. Issuance of Section 5 has to take place not later than one year after notification of Section 4.

Any person interested in any land which has been notified under Section 5 may, within thirty days after the issuance of the notification, object to the acquisition of the land under Section 5-A. The Collector shall hear the objection, make necessary inquiries and submit a report within 90 days to the appropriate Government authority. This authority must announce its decision, which shall be final, within 90 days, otherwise the objection shall be deemed to have been admitted and the acquisition proceedings will come to an end.

When the Provincial Government is satisfied, after considering the report, if any, made under Section 5-A that any particular land is required for public purpose, a declaration to that effect shall be made by an authorized officer of the Provincial Government under Section 6. This should follow within six months of the publication of the Section 5 notification.

After the declaration under Section 6, the Commissioner Land Acquisition shall direct the Collector to take order for the acquisition of land under Section 7. The Collector then notifies Section 8 to cause the land to be marked out, measured and planned (if this was not done after Section 4). Under Section 9, the Collector gives notice to all the interested people that the Government intends to take possession of the land and if they have any claims for compensation then those be made to him at an appointed time. Section 10 delegates powers to the Collector to record statements of persons possessing any interest in the land or any part thereof as co-proprietor, sub proprietor, mortgage and tenant or otherwise.

The most important section of the Act is Section 11; it enables the Collector to make inquiry into measurements, value and claim, and issue the final award. Included in the award is the lands' true area, his view of what compensation is warranted, and the apportionment of that compensation to all interested people. Though this section is the one that contains the final award, there are two other sections i.e. Section 23 and Section 24, which actually precede Section 11. This is because these two sections pertain to compensation and the criteria to be followed (Section 23) or not to be followed i.e. Section 24 in arriving at appropriate compensation. Under Section 23 are included such items as the market value of the land at the time of notification of Section 6, and various damages that have been sustained at the time possession was taken.

Matters to be neglected in awarding compensation i.e. Section 24 includes such items as the degree of urgency which led to the acquisition, any disinclination of the person interested in the land to part with it, any expected increase in value of the land from its future use, etc. When the Collector has made an award under Section 11, he will then take possession under Section 16 and the land shall thereupon vest absolutely with the Government, free from all encumbrances.

Another section of note is Section 18, which pertains to persons still dissatisfied with the award who may request the Collector to refer the case to the court for determination and decision. This does not affect the taking possession of the land by the Government.

In cases of emergency, where the Board of Revenue considers it expedient to take possession of any land at any time before an award under Section 11 has been made, it shall notify this act in writing to the Collector intimating in addition the date by which the land is required by it. Under Section 17, the Collector can, after causing a notice to this effect to be served on the person or persons interested in the land, take possession of the land subject to the liability to pay any amount, which may be incurred on account of acquisition. This specific section will not be applicable in this project as the acquisition of land is being done through normal applicable procedures.

From operational point of view, the LAA is a provincial law and each province has its own version and interpretation of this law, mostly procedural in nature. These differences lead to different dispensations in compensation and resettlement packages for the affectees of projects. Provincial governments have also evolved mechanisms for calculation and payment of compensation, suited to their specific needs and socio-cultural contexts. The procedures so far adopted for compensation, grievance redress, appeal periods, interest rate calculations, etc. do not aggregate to the resettlement policy. Recourse is often taken to adhoc arrangements, agreements and understandings for resettlement in difficult situations.

9.5.2 POLICY FRAMEWORK

9.5.2.1 BACKGROUND

The experience of development during the last century that led to massive human sufferings and dislocation in the name of development has confirmed that people have to be at the center of all development processes. To achieve long term social benefits in development projects, the people must be consulted, compensated for their losses and assisted in rebuilding their lost assets and livelihoods to enjoy at least the same standard of living, which they have before the project. Very often affected people are poor and vulnerable and therefore, unable to absorb the adverse impacts on their lives. They need significant help to restart their normal lives and re-establish their livelihoods. Mere payment of cash compensation under the LAA is not enough to restore livelihood and living standards.

9.5.2.2 NATIONAL RESETTLEMENT POLICY (MARCH 2002)

National Resettlement Policy has been formulated (which is still in draft shape) to not only cover the affected persons (APs) in the existing systems but also to ensure an equitable and uniform treatment of the resettlement issues all over Pakistan. This Policy will apply to all the development projects involving adverse social impacts, including land acquisition, loss of assets, income, business, etc. It has addressed those areas, which are not looked after in LAA (1894) and will be applicable wherever the people, families or communities are affected by any public sector or private development project, even when there is no displacement. The Policy also aims to compensate for the loss of income to those who suffer due to loss of communal property including common assets, productive assets, structures, other fixed assets, income and employment, loss of community networks and services, pastures, water rights, public infrastructure like mosques, shrines, schools, graveyards etc.

9.5.2.3 POLICY OBJECTIVES

The Policy objectives are relevant to other policies and laws of the Government of Pakistan, including the following:

a. Avoid or minimize adverse social impacts in a project wherever possible and where adverse impacts cannot be avoided, the mitigation measures and resettlement activities should be conceived and executed as development programs and the affected persons be provided opportunity to share the project benefits.

b. Project affected persons (PAPs) be provided with sufficient compensation and assistance for lost assets that will assist them to improve or at least restore their living standards, income earning or production capacity to the pre-project levels.

c. Provide a development opportunity to all the vulnerable groups (including poverty groups, women headed households, refugees and those without security of tenure /usufruct rights, etc.). The vulnerable population should receive special assistance to bring them at least to a minimum living standard at par with the pre-project level.

d. All population adversely affected by the project, should be eligible for sharing the social and economic benefits, envisaged after completion of the project.

9.5.2.4 PRINCIPLES OF THE POLICY

The Policy is based on the following principles, whereas the Guidelines will explain all the resettlement issues at operational and procedural levels.

a) To minimize involuntary resettlement, the proponents should consider alternative planning and design standards, and finalize an option with the minimum adverse impacts.

b) Involuntary resettlement should be conceived and executed as a part of the project and full cost of resettlement and compensation be included in the project costs and benefits.

c) Key stakeholders (including affected communities and APs) are fully consulted regarding the projects' design, implementation and operation, and all activities are carried out through a participatory process.

d) All APs residing in, working, doing business, or cultivating land, or having rights over resources within the project area as on the date of the census surveys are entitled to compensation for their lost assets, incomes, jobs and businesses at replacement cost, on the cut-off-date notified in the Official Gazette.

e) APs losing their incomes, jobs and employment, should get additional development assistance that enables them to improve their incomes to restore their standard of living to pre-project level.

f) APs losing all of their productive assets (farm land, house or business), or in case of partial loss when the remaining assets are not viable for continued use, will be entitled for full compensation for the entire affected assets at replacement cost.

g) APs affected by partial impact on their assets i.e. suffering partial loss of land or structures while the remaining assets remain viable for continued use, and where the livelihood is not land-based, the compensation for affected assets would be paid in cash.

h) Affected population should be informed fully and consulted in a timely manner, in order to enable them to make the informed decisions on resettlement and compensation options.

i) Existing social and cultural institutions of the affected communities and their host communities should be supported and integrated.

j) Absence of a formal legal title to land by some affected person should not be a bar to qualify for compensation of his/her lost assets (structure, houses, trees, etc.), business and incomes, including rehabilitation assistance measures.

k) Special provisions should be made for the vulnerable groups in a project, over and above their entitlements for compensation and other assistance to improve their living standards to minimum socially acceptable level.

l) Where in a project the cultural minorities or indigenous peoples (tribal communities) are affected, the social and economic benefits they receive be in harmony with their cultural preferences and be decided in consultation with the affected communities.

m) Any acquisition of, or restriction on access to resources owned or managed by the APs as a common property will be mitigated by arrangements ensuring access of those APs to equivalent resources on a continuing basis.

n) Project proponents shall resolve maximum possible claims and unresolved issues related to the tenure status and ownership of land and other assets, prior to initiating any land acquisition activity. However, just for this reason, the scheduled commencement of the project work should not be delayed.

o) The usufruct rights of the APs shall be protected.

p) Resettlement programs will have adequate institutional set-ups to ensure effective design, planning, consultation and implementation of compensation, resettlement and rehabilitation measures, supervision and monitoring of the resettlement and rehabilitation measures.

q) A clear mechanism of grievance redress should form part of the resettlement and rehabilitation process.

r) Resettlement transition period be minimized and the acquisition of assets, compensation, resettlement and rehabilitation activities (except where long-term rehabilitation measures such as vocational training are recommended) be completed prior to the initiation of construction work.

s) In resettlement and compensation, the gender biases should not deny to the women their due entitlements. Affected women will have equal access to all income restoration programs. In addition to receiving the compensation, the women should be eligible for financial credit for starting their own businesses, etc. and to restore their income and livelihoods.

9.5.2.5 IMPACTS COVERED

This policy covers direct social and economic impacts that are caused by;

a. The involuntary taking over of land resulting in:

   i. Relocation or loss of shelter;
   ii. Loss of assets or access to assets; or
   iii. Loss of income sources or means of livelihood, whether or not the affected persons must move to another location; or

b. The involuntary restriction of access to legally designated parks and protected areas resulting in adverse impacts on the livelihoods of the displaced persons.

c. Where necessary to achieve the objectives of the Policy, the Resettlement Plan or Resettlement Policy Framework also includes measures to ensure that displaced persons are;

   i. Offered support after displacement, for a transition period, based on a reasonable estimate of the time likely to be needed to restore their livelihood and standards of living; and

   ii. Provided with development assistance in addition to compensation measures such as land preparation, credit facilities, training, or job opportunities.

9.5.2.6 Criteria for Eligibility

Displaced persons may be classified in one of the following three groups:

a. Those who have formal legal rights to land (including customary and traditional rights recognized under the laws of the country)

b. Those who do not have formal legal rights to land at the time the census begins but have a claim to such land or assets provided that such claims are recognized under the laws of the country or become recognized through a process identified in the resettlement plan

c. Those who have no recognizable legal right or claim to the land but they are occupying the land.

Persons who encroach the project area after the cut-off date established by the borrower are not entitled to compensation or any other form of resettlement assistance.

9.5.2.7 Projects Resettlement Principles and Objectives

The development projects that displace people involuntarily can generally give rise to economic, social and environmental problems. Involuntary resettlement may cause severe long-term hardship, impoverishment, and environmental damage without the application of appropriate measures to mitigate these impacts. The RAP provides details regarding the likely impacts resulting from this intervention and the mitigation measures that will be adopted to address these adverse impacts.

The main objectives of the RAP are to:

a. Present a strategy for achieving the objectives of the National Resettlement

Policy;

b. Provide a framework for implementation of the stated strategies to ensure timely acquisition of assets, payment of compensation and delivery of other benefits to PAPs.
c. Provide details on the policies governing land expropriation, the range of adverse impacts and entitlements, and implementation of the project facilitating the PAPs' efforts to improve their living standards, income earning capacity and production levels or, at least restore them to pre-project levels;
d. Provide details on the public information, consultation and participation, and grievance redress mechanism in the project planning, design and implementation;
e. Identify and provide an estimate of required resources for implementation of recommended strategies; and
f. Provide a framework for supervision, monitoring and evaluation of resettlement implementation.
g. Given the growing requirements and complexity of resettlement in development projects, the government agencies and departments should upgrade the institutional capacity to design and implement RAPs.

9.5.2.8 ENTITLEMENT AND COMPENSATION MATRIX

In the light of review of LAA, 1894 and Policy Framework (World Bank OP 4.12), and consultations with the affected people, the following Entitlement and Compensation Matrix (ECM) as summarized in **Table 9-1** is prepared for the project keeping in view the nature of losses, entitlements and implementation issues. The said ECM will be applied for determining the compensation of the affectees.

The answers to some of the frequently asked questions related to compensation are given below in accordance with the guiding principles laid out for such purposes;

a) What will be the entitlements for different categories of affectees (based on the severity of impacts)?

   This has been precisely identified and given in the ECM **(Table 9-1),** which covers all types of affectees and their entitlements. This ECM is based on the National Resettlement Policy.

b) What will be the status of title and non-title holders? Who are eligible for what?

   In case of title holders

   i. One-time cash compensation grant for facilitating alternative housing/ land

ii. Shifting charges to resettle somewhere else

iii. Transition period allowance

iv. Trainings of the affectees for their capacity building to restore their livelihoods

In case of non-title holders

i Compensation for the lost structure (if owner) as per assessed values/price by District Officer Revenue (DOR), provided it is certified by the land owner.

ii The owners' income is below the poverty line.

iii Cash compensation for shifting of the house from proposed RoW.

iv Trainings of the affectees for their capacity building to restore their livelihoods.

c) How will the prices for different affected assets / infrastructure / livelihood / community property, etc., be determined?

The construction rates of various types of structures are adopted after consulting the Building Department and receiving their rates notified each quarter regularly. These rates reflect current replacement costs, without depreciation. These structures are divided into three main categories;

i. pacca houses with concrete roof / corrugated sheet roofing,
ii. semi-pacca houses with blocks / stones / masonry, mud mortar and T-iron-girder
iii. Katcha structures / houses with stone walls / mud mortar, sirky or tree wood batten roof. All the three types of structures were assessed at the following rates for their damages as follows:
Pacca building @ Rs.2000/ sq. ft, Semi-pacca building @ Rs.1500/sq. ft and Katcha building @ Rs.1000/ sq. ft.

d) What prices will be used? (More mention of market prices is not sufficient); how will those prices be collected?

Compensation framework (Section–5, sub-section 5.3) covers all these prices in detail for each type of affected land, private and commercial building structures and other immoveable land-based assets. These prices are based on the current market prices ascertained through the field investigations and consultation with the affectees, relevant government departments, local real estate dealers and transactions made in the project area within the last one year. These prices have been collected, computed accordingly as given in the Resettlement Budget and Financing chapter.

e) The affected community will be paid cash compensation for the structures through the Management Committee along with the shifting assistance.

Community facilities/common property resources will be reconstructed/ improved/rehabilitated at project cost

9.6 POTENTIAL RESETTLEMENT IMPACTS OF THE PROJECT

9.6.1 GENERAL

The proposed Artistic-II HPP is run-of-river type hydropower project, with a planned capacity of 55 MW. The main resettlement impacts are related with the construction of the project components. The project components consist of weir, box channel, headrace tunnel, adit tunnel penstock, powerhouse etc. with staff residential colony and offices.

For construction of all these components, a total 94.3 acres of land will be required. Among this 02 No. of houses, 04 acre agriculture land, 33.25 acre forest land and 57.05 acre barren land will be affected. The detail of the affected land is provided in **Table 9-2.**

Table 9-2: Land Required for the Project Area

Project Component		Land Required (Acres) / Affected			
		Forest Land	Irrigated/ Cultivated	Barren/ Rocky	Total
1	Weir Structure and Box Channel	0	04	33.46	37.46
2	Headrace Tunnel	0.25	0	0	0.25
3	Adit Tunnel and Its Material Dumping Site	0	0	15.07	15.07
4	Staff Colony	02	0	0	02
5	Powerhouse/Switch Yard, Access Roads, etc.	31	0	8.52	39.52
Total		33.25	04	57.05	94.3
	Labour Camps, Contractor Offices, etc. (Temporary on Lease)	Will be provided on contractor demand and most probably barren land will be selected for this purpose.			

9.6.2 IMPACTS OF PROJECT COMPONENTS

The Artistic-II HPP will be constructed on Ushu River in district Swat of Northern areas of Khyber Pakhtunkhwa province. The Weir site is located near village Eshegal and Powerhouse is located upstream of the under construction Gorkin Matiltan Hydropower Project near Mai Banda village. The project sites are approachable from Kalam, district Swat. It is connected through under construction road from Bahrain to Kalam. The catchment of the Artistic-II HPP lies in the upper region of the Ushu River, a tributary / sub system of a Swat river basin and can be classified as a “high mountain catchment”. About 02 acre will be acquired for the construction of the Staff Colony for Artistic-II HPP.

An additional 05acre private land will be acquired temporarily on lease, for a period of four years, for the construction of contractor camp, contractor labour colony and contractor office at weir site. While, 02 acre private land will be acquired temporarily on lease, for a period of four years, for the construction of contractor camp, labour colony etc. at powerhouse site.

9.6.3 Affected Land and Infrastructure

It will be the responsibility of the contractor to protect and/or restore the affected infrastructure during the course of construction works, to their original condition and to the complete satisfaction of the affected persons or community, as the case may be. The access road needs to be improved before the start of the project implementation.

9.6.4 Compensation Parameters

All the PAPs due to the construction of the different components will be fully compensated for their respective losses. The compensation for different parameters will be as under;

The agricultural land will be compensated, based on DC/ current market/ replacement value to the land owners, plus 15% involuntary land acquisition charges, as provided in Land Acquisition Act (LAA).

The crops compensation will be based on the market value of mature crops. If sown or standing crops are damaged or uprooted, the eligible persons will be compensated in cash for the loss of un-harvested crops, at the mature crop value to be assessed on the basis of current market prices, regardless of the title or tenurial status.

Compensation for the loss of fruit trees will be based on the value of fruit up to 10 years, to be assessed at the rate of current market prices, regardless of the title or tenurial status.

Compensation for the loss of different types of houses, building structures will be based on the cost estimates of the Building Department. The affected persons will also be provided shifting allowance (one time) and livelihood allowance (for three months).

9.6.5 Land Acquisition

Overall, for the execution of the project total 94.30 acre land will be affected. This land consists of 33.25 acres, 04 acres, 57.05 acres forest, agriculture and barren land respectively. The details are provided in **Table 9-3**.

The affected lands replacement values were computed on the basis of the most recent sale price in the project affected villages and in the adjacent valleys. The land acquisition maps are attached as **ANNEXURE 12**

9.6.6 Temporary Land Acquisition

The temporarily acquired land will be used for the storage of construction material, parking of machinery, storage of equipment, Labour camps, and contractor offices during the execution of the work. However, additional temporary land will be needed at both the powerhouse and weir sites. Total area for temporary acquisition is estimated as 7 acre. This land will be taken on lease for a period of about four years. According to the local rates, the total rent for this land is shown in **Table 9-4**.

Table 9-3: Showing the Cost of Permanent Land Acquisition

Sr. No	Description	Unit	Quantity	Rate/unit (million PKR)	Total Cost(million PKR)
A	**Permanent Land Acquisition**				
i.	**Weir Site Area and Box Channel**				
1	Agricultural Land	acre	4	8.696	34.784
2	Forest Land	acre	0	8.696	0
3	Barren Land	acre	33.46	4	133.84
	Total	acre	**37.46**		**168.624**
ii.	**Headrace Tunnel**				
1	Agricultural Land	acre	0	8.696	0
2	Forest Land	acre	0.25	8.696	2.174
3	Barren Land	acre	0	4	0
	Total	acres	**0.25**		**2.174**
iii.	**Adit Tunnel and its material dumping site**				
1	Agricultural Land	acre	0	8.696	0
2	Forest Land	acre	0	8.696	0
3	Barren Land	acre	15.07	4	60.28
	Total	acres	**15.07**		**60.28**
iv.	**Powerhouse Area (including Residential colony)**				
1	Agricultural Land	acre	0	8.696	0
2	Forest Land	acre	33	8.696	286.968
3	Barren Land	acre	8.52	4	34.08
	Total	acre	**41.52**		**321.048**
	Total (A)		**94.3**		**552.126**
B	**TEMPORARY LAND ACQUISITION**				
1	Contractor Camp, Contractor Labour Colony, Contractor Office for Weir Site	acre	5	1/yr/acre	20
2	Contractor Camp / Labour Colony for Powerhouse, Power house Colony, etc.	acre	2	0.5/yr/acre	4
Total (B)					**24**
Total (A+B)					**576.126**

Table 9-4: Showing the Cost of Temporary Land Acquisition

Sr.No	Description	Unit	Quantity	Rate/unit (million PKR)	Total Cost (million PKR)
1	Contractor Camp, Contractor Labour Colony, Contractor Office for weir site (Cultivated Land)	acre	5	1/yr/acre	20.0
2	Contractor Camp/ Labour Colony for Powerhouse (Barren Land)	acre	2	0.5/yr/acre	4.0
Total					**24.0**

9.6.7 Affected Trees

Approximately, 698 trees will have to be cut/ removed for clearing the proposed alignments/sites during the execution of different components of project. The plant species of forest trees is mainly Deodar (*Cedrusdeodara*), however some other species like Willow, Wild Almond and few trees of *Pinus Wallichiana* and Fir are also coming in the alignment of the project. **Table 9-5** provides details of the types of the affected trees, and their estimated costs, assessed on the basis of current market values of the trees. The detail of trees given below is approximate and the same will be processed after the actual estimation of Forest Department after their visit and demarcation.

Table 9-5: Approximate No. of Trees Falling in Total Project Area

Sr. No.	Species	Volume (ft^3)	Qty	Total Volume (ft^3)	Rate (PKR)	Amount (PKR)
1	Deodar (*Cedrusdeodara*)	187	256	47872	4200/f^3	201,062,400
2	Deodar (*Cedrusdeodara*)	Under Size	386	-	-	-
3	*Pinus Wallichiana*	150	44	6600	2300/ft^3	15,180,000

Sr. No.	Species	Volume (ft^3)	Qty	Total Volume (ft^3)	Rate (PKR)	Amount (PKR)
4	Fir	150	12	1800	1500/ft^3	2,700,000
5	Willow	Negligible				
6	Wild Almond	Negligible				
Total			**698**			**218,942,400**

9.6.8 Residential Buildings

A total of 02 houses of various categories are falling in the Box Channel area on right sides of the river. These houses consist of katcha houses. The details are provided in **Table 9-6**.

Table 9-6: Details of Residential Structures Falling in the Box Channel

Sr. No.	Construction Category	Location	Quantity	Area ft^2	Cost (PKR)
1	Katcha	Right Bank of the River	2	2152	2,152,000
2	Semi Pacca		0		
3	Pacca		0		
	Sub-Total		**2**	**2152**	**2,152,000**
4	Katcha	Left Bank of the River	0	0	0
5	Semi Pacca		0	0	0
6	Pacca		0	0	0
	Sub-Total		**0**	**0**	**0**
GRAND TOTAL			**2**	**2152**	**2,152,000**

* Construction cost is Rs.1000/square ft, Rs.1500/square ft and Rs.2000/square ft for Katcha, Semi-Pacca and Pacca type of houses respectively

9.7 INSTITUTIONAL FRAMEWORK

9.7.1 General

Client/ Government will be responsible for the implementation of the RAP through its Project Director and the field offices, with the collaboration of district government departments. Project Director will make necessary arrangements for the implementation of tasks about environment, afforestation, land and social aspects (EALSA) and to coordinate and monitor the resettlement activities. The concerned government departments will assess the prices; undertake the process of land acquisition, compensation and livelihood rehabilitation. Grievance redress mechanism, internal and external monitoring mechanism will be established to ensure proper implementation of the RAP in an accountable and transparent manner.

9.7.2 Implementation Arrangements

Client/ Government has overall responsibility for the program implementation and financing of all RAP development tasks and cross-agency coordination. The department will exercise its functions as under:

There will be a *Program Management Unit (PMU*); The PMU shall be adequately staffed with competent professionals. The staff will be headed by a Project Manager, and include an Environment Specialist, a Resettlement Specialist, a Contract Administration Specialist and a Financial Management Specialist. The PMU will be responsible for the overall planning, management and monitoring of the environment and resettlement program.

Environment and Resettlement Specialists: The Environment Specialist and Resettlement Expert/Specialist will provide technical guidance and support to the PMU and field offices on environmental and social issues during implementation. They will supervise the implementation of the RAP. Specific responsibilities will be as under:

Coordination for all land management related issues with the Project Director and ensure economic utilization of funds earmarked for land acquisition.

Liaison with the field office on land management and project matters on permanent basis.

Maintain complete record/data of land management and social issues including follow-up of land acquisition disputes and response to petitions/complaints received from general public regarding payment of compensation and other related issues.

Assist the Legal section in court cases concerning land acquisition disputes.

Monitoring and reporting of social and environmental issues, compliance during the implementation of the project.

Coordination with all relevant donor missions visiting various components of the project for social / environmental impact review and analysis.

Field Implementation Unit; Two Field Implementation Units (FIUs) shall be set up headed by an Environment and Resettlement Specialist. The units will be overall responsible for the implementation of all ESIA and RAP development tasks and cross-agency coordination, and tasked with day-to-day related activities. The Specialists shall be assisted by a Social Safeguards, Health and Safety Supervisor and Dispenser. A Land Acquisition Collector (LAC) – one assigned to the project area– shall acquire land.

Specifically, the Unit will be responsible for Synchronization of resettlement activities with the project construction schedule;

Ensure that all eligible APs are identified, provided with their respective entitlements according to the resettlement policy and are relocated/ compensated as per the implementation schedule and with minimum hardships;

Liaison with the Revenue Offices regarding timely acquisition of land required for the project and payment of compensation, and to ensure that these activities are completed as per schedule;

- **a.** Negotiate with contractors for arranging employment for APs in the construction works.
- **b.** Ensure all the environment related issues in the field during the construction works.
- **c.** Ensure health and safety related issues in the field during the construction works.
- **d.** Monitor the Labour camps, machinery, quarry sites and borrow areas.

9.7.3 District and Provincial Governments

District-based agencies have the jurisdiction for land administration and compensation and for the compensation/rehabilitation of other affected assets. DOR and several other staff members of the Revenue Department, most notably the Tehsildar, Patwari, and record keeper carry out specific roles such as title identification and verification of the ownership. The compensation rates will require approving by and in turn confirming by the Board of Revenue Office at state level.

Deputy Commissioner has a key role in the implementation process. He/she has the legal responsibility of acquiring land and paying compensation directly to the APs as per Land Acquisition Act. To facilitate Client/ Government as well as the APs in the project area, there will be a Land Evaluation Committee under the chairmanship of Deputy Commissioner. The other members of the committee are Project Director, Resettlement Specialist, District/Tehsil Council Chairman and at least three representatives of affectees. The Office of the District Council Chairman (the elected district head) is expected to play a coordinating role and will represent the rights of the local citizens. The affectees, representatives in each area will also be associated in implementation and monitoring of the RAP along with the government departments involved in the RAP development and implementation.

9.7.4 Contractors

The construction contractors will also nominate one liaison officer to coordinate with the project implementation unit (PIU) and other relevant offices on matters related to possible impacts occurring during the project implementation, and to coordinate on employment opportunities for the APs in the construction works. His key roles and responsibilities are to collaborate with the PIU and the Implementation Consultants in the following activities:

- **a.** Verify the loss of infrastructures and other assets of APs due to project implementation and ensure their compensation;
- **b.** Determine/review the replacement cost for all kinds of loss occurred;
- **c.** Hold consultation meetings with the affected people.

9.7.5 Grievance Redressal Mechanism

A Grievance Redressal Committee (GRC) will be constituted, which will look into all the grievance cases. This GRC will be composed of the representatives of (i) District Revenue Officer; (ii) PEDO (iii) Management Consultants (iv) Contractor and the (v) Affectees' Representatives. The main objective of the grievance redressal mechanism shall be to investigate charges of irregularities and complaints received from the affectees and provide an early, transparent and fair resolution. The Environment and Resettlement specialist will be assigned to maintain a community complaints-management register to record grievances brought forward by the affected person/communities, and ensure that these are appropriately addressed. Main objective of the grievance redress procedure will be to provide a mechanism to mediate conflicts and cut down on lengthy litigation, which are often observed to be sources of delays of such projects. It will also provide a forum of people who might have objections or concerns about their assistance and address these issues adequately.

9.7.6 Complaints and Grievances

A grievance redress mechanism (GRM) will be available to allow an AP appealing any disagreeable decision, practice or activity arising from land or other assets assessment, acquisition, compensation and other environment issues. APs will be fully informed of their rights and of the procedures for addressing complaints whether verbally or in writing during the consultation, assessment survey, at the time of compensation and during the construction phase. Care will always be taken to prevent grievances rather than going through a redress process. This can be obtained through careful Land Acquisition Resettlement (LAR) design and implementation, by ensuring full participation and consultation with the APs, and by establishing extensive communication and coordination between the community, the Project Management, the LAC and local governments in general.

Table 9-7: Environmental Cost Estimate

Sr. No	Description	Quantity	Rate per unit (PKR)	Total cost (PKR)	Remarks
Compensation Cost					
A	**Permanent Land acquisition**				
a	**Weir and channel area**				
1	Forest land	-	-	-	
2	Barren land	33.46 Acre	4.0 million	133.84 million	
3	Agriculture land	4 Acre	8.696 million	34.784 million	
b	**Head Race Tunnel**				
	Forest Land	0.25 Acre	8.696 million	2.174 million	
c	**Adit Tunnel and its Material Dumping Site**				
	Barren Land	15.07 Acre	4.0 million	60.28 million	
d	**Power House**				
	Power House and access road etc.(Barren Land)	8.52 Acre	4.0 million	34.08 million	
	Forest Land	31 Acre	8.696 million	269.58 million	
	Staff colony and offices (Forest Land)	2 Acre	8.696 million	17.39 million	
	Total			**552.126 million**	
B	**Residential Building compensation**				
1	Katcha houses	2152 sq. ft	1000	2,152,000	
2	Pakka houses	-	-	-	
3	semi-pakka	-	-	-	
	Total			**2,152,000**	

Sr. No	Description	Quantity	Rate per unit (PKR)	Total cost (PKR)	Remarks
C	**Tree compensation**				
1	Deodar	47872 cft	4200	201,062,400	
2	Pinus Wallichiana	6600 cft	2300	15,180,000	
3	Fir	1800 cft	1500	2,700,000	
	Total			**218,942,400**	
D	**Others**				
1	Crops compensation		LS	500,000	
2	Shifting charges		LS	500,000	
3	Rehabilitation of Houses	No			
4	Others				
	Total			**1,000,000**	
E	**Environmental Management**				
1	Capacity Building trainings	Trainings will be arranged for Labours as well as community regarding social and Environmental aspects			
2	Replanting against cut trees (1:10)	Plantation Plan is attached as **Table 7-6**			
3	Soil conservation				
	Total				
F	**Temporary Land acquisition**				
1	Contractor Camp, Contractor Labour Colony, Contractor Office for weir, channel and tunnel	5 Acre	1 million/yr/acre	20.0 million	Lease
2	Contractor Camp, Contractor Labour Colony, Contractor Office for Powerhouse	2 Acre	0.5 million/yr/acre	4.0 million	Lease

Sr. No	Description	Quantity	Rate per unit (PKR)	Total cost (PKR)	Remarks
G	**Corporate Social Responsibility (CSR)**				
1	Medical Staff	4 years	1,200,000	4,800,000	Medical staff salary
2	Medicines	4 years	800,000	3,200,000	
	Total			**8,000,000**	
H	**Plantation**				
1	Plantation	L.S	431,600	**431,600**	Replanting against cut trees (1:10)
I	**Total**			**806.65 million**	
J	**Contingencies**			**24.24 million**	3% of the total cost
K	**Grand Total**			**830.89 million**	

10. CONCLUSION & RECOMMENDATIONS

The proposed design and construction activities were assessed considering the laws of KP and the GoP policies. Mitigation and management measures were recommended and made part of the project design.

This study found that the Project, being a run-of-the-river hydropower project, is unlikely to cause any significant, lasting environmental and social impacts. Environmental disturbances, normally associated with construction activities will be minimized through an EMP, which is available in this report along with a mitigation plan that defines mitigation actions, specifies persons responsible for ensuring implementation and for monitoring actions.

The detailed design will show the time frame for activities. The essentials of an environmental monitoring plan can be used effectively which are available in the EMP section. Communication and documentation requirements, and training needs should be given due consideration.

Sound environmental management practices and effective mitigation measures will have to be included in detailed design and contract agreements for construction. This EIA has considered adequate environmental and social justification for the Project and there seem no other main issues that required further investigation. The following points should also be followed for effective implementation of the project.

- All environmental concerns will be documented in a very comprehensive way in the tender documents.
- An EMP will be included as Contractors obligation in the award of contract and approved by the proponent’s engineers.
- The contractor shall take special care for equipment, its proper and safe handling during construction and transportation. Special care will also be taken by him to ensure minimize risk of any damage or spillage during temporary storage, packaging, uploading and transporting and unloading of such equipment to its destination for ultimate disposal.
- Environmental Mitigation guidelines will be followed strictly during construction.

Corporate Social Responsibility (CSR):

In the current project under the CSR umbrella, Artistic Hydro-II will provide medical facilities to the local community. The Artistic Hydro-II will establish a medical dispensary in the project area for their workers. In the same medical dispensary, medical service will be provided to the local community. However, for local community, these facility will be available for five (5) days per week i.e. from Monday to Friday. While, for labors, 24 hours and 7 days a week (24/7) medical facility will be provided. Each year, a budget of two (2) million Pakistani Rupees will be provided in the head of CSR. This budget will include the medicine and salary of the Medical staff as well. For the medicines, PKR 0.8 million will be provided every year, while PKR 1.2 million will be given to the Medical staff as salary which is tabulated in the following **Table 10-1**.

Table 10-1 Budget Allocated for the Medical Facility

Particulars	Amount (PKR)/year	Justification
Medicines	800,000	Life Saving & General Medicine
Medical Staff	1,200,000	Medical Staff Salary

Power Planners International

Artistic-II Hydropower Project by Artistic Milliners Pvt. Limited at Ushu River Kalam, District Swat, KPK

Report No. PPI-384.2-Final/20

www.powerplannersint.com

Executive Summary

- The Final Report of Artistic-II Hydro Power Project by Artistic Milliners Pvt. Ltd. at District Swat, Khyber Pakhtunkhwa, referred to as Artistic-II HPP in the remainder of the report, is submitted herewith after incorporating all the comments received vide PESCO letter no. **CE(Dev)/6593-95 dated 05-10-2020**.
- Artistic Milliners is planning to develop hydro power plant at Ushu River, Kalam in District Swat of KPK. The installed capacity of plant comprises of three units generating 55.032 MWe due to limitations as mentioned in plant data received from Client, attached in Exhibit A.
- The study objective, approach and methodology have been described and the plant's data received from the Client is validated.
- In view of planned COD of Artistic-II HPP in 2026, the proposed interconnection scheme has been assessed for steady state conditions through detailed load flow studies for summer 2026 as Hydel generations will be at peak.
- The proposed interconnection scheme for Artistic-II HPP is by looping in-out one of the double circuit from Matiltan to Daral Khwar-II HPP. The looping of the circuit will be done just outside the boundary wall of Matiltan sub-station so as to evade the requirement of additional line bays at Matiltan switchyard. The circuit of around 7.2 km will be on Rail conductor.
- Steady state analysis by load flow reveals that the proposed scheme is adequate to evacuate the power plant under normal conditions and no constraints are caused by the interconnection of Artistic-II HPP in the 132 kV network of PESCO in the load flow scenarios of summer 2026.
- The short circuit levels of the Artistic-II HPP 132 kV are 6.56 kA and 6.74 kA for 3-phase and 1-phase faults, respectively, in the year 2026. Therefore, industry standard switchgear of a short circuit rating of 40 kA would be sufficient for installation at 132 kV switchyard of Artistic-II HPP, as the maximum short circuit levels for the year 2026 were also found to be well within this range, taking care of any future generation additions and system reinforcements in its electrical vicinity and also fulfilling the NEPRA Grid Code requirements specified for 132 kV switchgears. There are no violations of the power rating of the equipment in the vicinity of Artistic-II HPP in the event of fault conditions.

- The dynamic stability analysis of proposed schemes of interconnection has been carried out. The stability has been tested for the worst cases, i.e. three phase fault right on the 132 kV bus bar of Artistic-II HPP substation followed by trip of a 132 kV single circuit from Artistic-II HPP has been performed for fault clearing of 5 cycles (100 ms), as understood to be the normal fault clearing time of 132 kV protection system. The extreme worst case of stuck breaker (breaker failure) has been studied where the fault clearing time is assumed 9 cycles i.e. 180 ms for single phase fault. The stability of the system for far end faults of 3-phase occurring at Artistic-II HPP 132 kV bus bar has also been checked. The system is stable for all the tested fault conditions.
- The proposed scheme of interconnection has been subjected to Load Flow, Short Circuit and Dynamic Stability Analysis and found to be feasible for interconnection of Artistic-II HPP with the PESCO network.
- Although, the capacity of Rail conductor used for interconnection is sufficient for the network up till the commissioning of Artistic-II HPP, yet the conductor may require up-gradation to twin bundle rail if and when new hydropower generations come into the system owing to the fact that the study area is excessively rich in hydropower potential.

TABLE OF CONTENTS

1. Introduction

1.1. Background

Khyber Pakhtunkhwa has a rich potential of small and big hydropower projects in the province. A lot of private investors are coming in to tap this huge natural resource. Artistic Pvt. Ltd. is one such investor which plans to develop a hydropower plant at Ushu River, Kalam, Swat. The net output planned to be generated from the site is about 53.032 MW of electrical power. The electricity generated from this project and other nearby projects would be supplied to the 132 kV grid of PESCO available in the vicinity of this project. Artistic-II HPP is expected to start commercial operation by 2026. The approximate location of Artistic-II HPP can be seen in the map attached in Appendix – B and the neighboring network is evident from Sketch-2 attached in Appendix - B.

1.2. Objectives

The overall objective of the Study is to evolve an interconnection scheme between Artistic-II HPP and PESCO network, for stable and reliable evacuation of electrical power generated from this plant, fulfilling the N-1 reliability criteria. The specific objectives of this report are:

- To develop scheme of interconnections at 132 kV for which right of way (ROW) and space at the terminal substations would be available.
- To determine the performance of interconnection scheme during steady state conditions of system, normal and N-1 contingency, through load-flow analysis.
- To check if the contribution of fault current from the plant unit increases the fault levels at the adjoining substations at 132 kV voltage levels to be within the rating of equipment of these substations, and also determine the short circuit ratings of the proposed equipment of the substation at Artistic-II HPP.
- To check if the interconnection withstands dynamic stability criteria of post fault recovery with good damping.

1.3. Planning Criteria

The planning criteria required to be fulfilled by the proposed interconnection is as follows:

Steady State:

Voltage	± 5 %, Normal Operating Condition
	± 10 %, Contingency Conditions
Frequency	50 Hz Nominal
	49.8 Hz to 50.2 Hz variation in steady state
	49.4 - 50.5 Hz, Min/Max Contingency Freq. Band
Power Factor	0.80 Lagging; 0.85 Leading

Short Circuit:

132 kV Substation Equipment Rating of 40 kA

Dynamic/Transient:

The system should revert to normal condition after transients die out with good damping, without losing synchronism. The system is tested under the following fault conditions:

a) Permanent three-phase fault on any primary transmission element; including: transmission circuit, substation bus section, transformer or circuit breaker. It is assumed that such a fault shall be cleared by the associated circuit breaker action in 5 cycles.

b) Failure of a circuit breaker to clear a fault ("Stuck Breaker" condition) in 9 cycles after fault initiation.

2. Assumptions of Data

As per the data provided by the client following data has been modeled:

2.1. Artistic-II HPP Data

No. of Units	= 3
Gross Capacity of Power Project	= 61.227 MW [(25.483×2) + (10.261×1)]
Net Capacity of the Power Project	= 55.032 MW [(22.483×2) + (9.235×1)]
Lump sum MVA capacity	= 72 MVA
Generating Voltage	= 11 KV

The difference between the installed capacity (Maximum Output) and net capacity (Actual Output) of plants can be explained through the following argument:

$$\mathbf{P = 9.81 \times \eta_{Tu.} \times \eta_G \times \eta_{Tr.} \times Q \times H_{net}}$$

Where:

P : Power generation (kWe, "e": electrical power)

$\eta_{Tu.}$: Turbine efficiency (Accepted as 0.93)

η_G : Generator efficiency (Accepted as 0.97)

$\eta_{Tr.}$: Transformer efficiency (Accepted as 0.99)

Q : Design discharge (m^3/s)

H_{net} : Net head with respect to Q (m)

In Artistic-II HPP project, the design discharges of large units and small unit were selected as 14.15 m^3/s and 5.7 m^3/s, respectively. Hence

Units	Discharge (m^3/s)	Hnet (m)	Power (MWe)
Large Unit (Unit-1)	14.15	184.42	22.863
Large Unit (Unit-2)	14.15	185.00	22.934
Small Unit	5.70	184.93	9.235
TOTAL	**34.00**	**-**	**55.032**

The detailed parameters, which have been used in this study, for all the machines are attached in Appendix – B.

2.2. Network Data

The 132 kV network in the area near Artistic-II HPP, is shown in Sketches in Appendix-B. The latest Generation Expansion Plan and Load Forecast of NTDC, as available, and latest network data and load forecast of PESCO.

3. Study Approach and Methodology

3.1. Understanding the Problem

Artistic Milliners Pvt. Limited is developing a hydropower project in the Kalam on Ushu River. The site of proposed project is located at a distance of about 7 km from the proposed 132 kV Matiltan Grid Station. The proposed Artistic-II Hydropower Project is going to be embedded in the transmission network of PESCO through this nearest available 132 kV network.

The adequacy of PESCO network of 132 kV in and around the proposed site of Artistic-II HPP has been investigated in this study for absorbing and transmitting this power fulfilling the reliability criteria.

3.2. Approach to the Problem

The following approach has been applied to the problem:

- The scenario of summer 2026 has been selected for the study of Artistic-II HPP. Thus, lines in the vicinity of this plant will be loaded to the maximum extent, allowing us to judge the complete impact of the plant on the transmission system in its vicinity.
- The scenario of summer 2026 has also been completely analyzed for the system, considering maximum hydel dispatches and the maximum power demand in the system.
- An interconnection scheme without any physical constraints, such as right of way or availability of space in the terminal substations, have been identified.
- Technical system studies have been conducted for peak load conditions, to confirm technical feasibility of the interconnection. The schemes will be subjected to standard analyses such as load flow, short circuit, and transient stability to gauge the strength of the machines and the proposed interconnection under disturbed conditions.

4. Development of Interconnection Scheme

4.1. The Existing Network and the Proposed Scheme of Interconnection

The existing 132 kV network available around the proposed location of Artistic-II HPP is shown in Sketch-1 in Appendix-B. The nearest grid station around the proposed site of Artistic-II is proposed grid station of Matiltan 132 kV. The network around the proposed sites comprises of Rail double circuit. The power form this plant and other nearby plants will be feed to the network of PESCO from the planned Kabal grid station.

The Existing transformers at Chakdara and Matta are insufficient to feed the increasing load demand, so to overcome these overloading following Extension/Augmentation have been proposed:

- Augmentation of 26 MVA transformer at Chakdara to 40 MVA
- Extension of 26 MVA transformer at Matta

4.2. The Interconnection Scheme of Artistic-II HPP

Considering the location of Artistic-II the proposed interconnection scheme for Artistic-II HPP is by looping in-out one of the double circuit from Matiltan to Daral Khwar-II HPP. The looping of the circuit will be done just outside the boundary wall of Matiltan sub-station so as to evade the requirement of additional line bays at Matiltan switchyard. The circuit of around 7.2 km will be on Rail conductor.

This scheme will be put to test using load flow analysis, short circuit analysis and dynamic stability analysis in the upcoming chapters.

5. Detailed Load Flow Studies

The base cases have been developed for the peak conditions of summer 2026 using the network data of NTDC available with PPI and the updated transmission plan and load forecast of PESCO. Detailed load flow studies have been carried out for summer 2026. The plant has been modelled in detail according to the client provided information mentioned in Chapter- 2 and attached in Appendix - B.

5.1. Peak Load Flow Case Summer 2026

5.1.1. Peak Load Flow Case Summer 2026 – Without Artistic-II HPP

The results of load flow for this base case are plotted in Exhibit 0.0 of Appendix-C. The system plotted in this Exhibit shows 132 kV network in the vicinity of Artistic-II HPP.

The load flow results show that the power flows on all circuits are within their specified normal current carrying rating. The voltages are also within the permissible limits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit-0.1 Matiltan to Daral Khwar – II 132 kV Single Circuit

Exhibit-0.2 Daral Khwar – II to Madyan 132 kV Single Circuit

Exhibit-0.3 Daral Khwar – II to Kabal 132 kV Single Circuit Out

Exhibit-0.4 Madyan to Kabal 132 kV Single Circuit

Exhibit-0.5 Kabal to Chakdara-New 132 kV Single Circuit

5.1.2. Peak Load Flow Case Summer 2026 – With Artistic-II HPP

The results of load flow for the base case with Artistic-II HPP interconnected are shown in Exhibit 1.0 of Appendix-C. The power flows on the circuits under normal conditions are seen well within the rated capacities. Also, the voltages on the bus bars are within the permissible operating range of ± 5 % off the nominal

We find no capacity constraints on the 132 kV circuits under normal conditions i.e. without any outages of circuits as shown in Exhibit 1.0 in Appendix - C

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit-1.1 Artistic-II to Matiltan 132 kV Single Circuit

Exhibit-1.2 Artistic-II to Daral Khwar – II 132 kV Single Circuit Out

Exhibit-1.3 Matiltan to Daral Khwar – II 132 kV Single Circuit Out

Exhibit-1.4 Daral Khwar – II to Madyan 132 kV Single Circuit Out

Exhibit-1.5 Daral Khwar – II to Kabal 132 kV Single Circuit Out

Exhibit-1.6 Madyan to Kabal 132 kV Single Circuit Out

Exhibit-1.7 Kabal To Chakdara New 132 kV Single Circuit Out

We find that power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 10 % off the nominal for contingency conditions' criteria. We find no capacity constraints on 132 kV circuits under normal and contingency conditions.

5.2. Off- Peak Load Flow Case Summer 2026

An off-peak case has been developed from the peak 2026 case considering 80% loads. The normal case for this analysis is shown in Exhibit – 2.0 in Appendix – C.

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % off the nominal.

We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits, as shown in Exhibit 2.0 in Appendix - C.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit-2.1 Artistic-II to Matiltan 132 kV Single Circuit

Exhibit-2.2 Artistic-II to Daral Khwar – II 132 kV Single Circuit Out

Exhibit-2.3 Matiltan to Daral Khwar – II 132 kV Single Circuit Out

Exhibit-2.4 Daral Khwar – II to Madyan 132 kV Single Circuit Out

Exhibit-2.5 Daral Khwar – II to Kabal 132 kV Single Circuit Out

Exhibit-2.6 Madyan to Kabal 132 kV Single Circuit Out

Exhibit-2.7 Kabal to Chakdara New 132 kV Single Circuit Out

The power flows on the circuits are seen well within the rated capacities and the voltages on bus bars are also within the permissible operating range of ± 10 % off the nominal for contingency conditions' criteria.

We find that there are no capacity constraints in the proposed connectivity scheme even in the off-peak scenario.

5.3. Conclusion of Load Flow Analysis

From the analysis discussed above, we conclude that the proposed connection of Artistic-II HPP with PESCO network according to proposed scheme is adequate to evacuate its power under normal as well as contingency conditions. Hence, there are no constraints in connecting Artistic-II HPP as per proposed scheme for the evacuation of power.

6. Short Circuit Analysis

6.1.1. Methodology and Assumptions

The methodology of IEC 909 has been applied in all short circuit analyses in this report for which provision is available in the PSS/E software used for these studies.

The maximum fault currents have been calculated with the following assumptions under IEC 909:

- Set tap ratios to unity
- Set line charging to zero
- Set shunts to zero in positive sequence
- Desired voltage magnitude at bus bars set equal to 1.10 P.U. i.e. 10 % higher than nominal, which is the maximum permissible voltage under contingency condition.

For evaluation of maximum short circuit levels we have assumed contribution in the fault currents from all the installed generation capacity of hydel, thermal and nuclear plants in the system in the years 2026 i.e. all the generating units have been assumed on-bar in fault calculation's simulations.

The assumptions about the generator and the transformers data are the same as mentioned in Chapter.2 of this report.

6.1.2. Fault Current Calculations Year 2026 - without Artistic-I I HPP

In order to assess the short circuit strength of the 132 kV network without Artistic-II HPP, three-phase and single-phase fault currents have been calculated for PESCO in the vicinity of the site of the Plant near Kabal. The results are attached in Appendix – D.

The short circuit levels have been calculated and plotted on the bus bars of 132 kV of substations lying in the electrical vicinity of our area of interest and are shown plotted in the Exhibit 3.0 attached in Appendix-D. Both 3-phase and 1-phase fault currents are indicated in the Exhibit 3.0 which are given in polar coordinates i.e. the magnitude and the angle of the current. The total fault currents are shown below the bus bar.

The tabular output of the short circuit calculations is also attached in Appendix-D for the 132 kV and 11 kV bus bars of our interest. The total maximum fault currents for 3-phase and 1-phase short circuit at these substations are summarized in Table 6.1. We see that the maximum fault currents do not exceed the short circuit ratings of the equipment at these 132 kV substations which normally are 31.5 kA for older substations and 40 kA for new substations.

Table-6.1
Maximum Short Circuit Levels without Artistic-II HPP – Year 2026

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Matiltan 132 kV	5.67	5.64
Daral Khwar – II 132 kV	8.33	7.37
Madyan 132 kV	9.28	7.51
Kabal 132 kV	12.48	9.68
Swat 132 kV	11.55	8.64
Barikot 132 kV	9.72	6.84
Timergara 132 kV	11.07	9.50
Chakdara New 132 kV	20.10	17.04

6.1.3. Fault Current Calculations Year 2026 - with Artistic-II HPP

Fault currents have been calculated for the electrical interconnection of proposed scheme. Fault types applied are three phase and single-phase at the 132 kV bus bar of Artistic-II HPP itself and other bus bars of the 132 kV substations in the electrical vicinity of Artistic-II HPP. The graphic results are shown in Exhibit 3.1.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV bus bars of the network in the electrical vicinity of Artistic-II HPP and the 132 kV bus bars of Artistic-II HPP itself are placed in Appendix-D. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.2.

Table-6.2
Maximum Short Circuit Levels with Artistic-II HPP – Year 2026

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Artistic-II 132 kV	6.56	6.74
Matiltan 132 kV	6.59	6.85
Daral Khwar – II 132 kV	9.29	8.06
Madyan 132 kV	10.00	7.92
Kabal 132 kV	13.08	9.97

Swat 132 kV	11.95	8.81
Barikot 132 kV	9.93	6.91
Timergara 132 kV	11.13	9.53
Chakdara New 132 kV	20.53	17.26

Comparison of Tables 6.1 and 6.2 shows an increase in short circuit levels for three-phase and single-phase faults due to connection of Artistic-II HPP on the 132 kV bus bars in its vicinity. We find that even after some increase, these fault levels are much below the rated short circuit values of the equipment installed on these substations.

6.1.4. Conclusion of Short Circuit Analysis

The short circuit analysis results show that for the proposed scheme of interconnection of Artistic-II HPP, we don't find any violations of short circuit ratings of the already installed equipment on the 132 kV bus bars in the vicinity of the plant due to fault current contributions from Artistic-II HPP. Therefore industry standard switchgear of the short circuit rating of 40 kA would serve the purpose as per NTDC requirement taking care of any future generation additions and system reinforcements in its electrical vicinity.

7. Dynamic Stability Analysis

7.1. Assumptions and Methodology

7.1.1. Dynamic Models Assumptions

The assumptions about the generator and its parameters are the same as mentioned in Chapter 2 of this report.

We have employed the generic dynamic models available in the PSS/E model library for dynamic modeling of the generator, exciter and the governor as follows;

Generator	GENSAL
Excitation System	EXST1
Speed Governing System	HYGOV

7.1.2. Dynamic Models Assumptions

The scenario of summer 2026 has been selected for the study because it represents the peak load season after the COD of Artistic-II HPP and thus the loading on the lines in the vicinity of Artistic-II HPP will be maximum, allowing us to judge the full impact of the plant.

The proposed Artistic-II HPP has been modeled in the dynamic simulation as per data provided by client. All the power plants of WAPDA/NTDC from Tarbela to Hub have been dynamically represented in the simulation model.

7.1.3. Presentation of Results

The plotted results of the simulations runs are placed in Appendix-E. Each simulation is run for its first one second for the steady state conditions of the system prior to fault or disturbance. This is to establish the pre fault/disturbance conditions of the network under study were smooth and steady. Post fault recovery has been monitored for ten seconds. Usually all the transients due to non-linearity die out within a few seconds after disturbance is cleared in the system.

7.1.4. Worst Fault Cases

Four phase faults are considered as the worst disturbance in the system. We have considered 3-phase fault in the closest vicinity of Artistic-II HPP i.e. right at the 132 kV bus bar of Artistic-II HPP substation, cleared in 5 cycles, as normal clearing time for 132 kV i.e. 100 ms, followed by a permanent trip of a 132 kV single circuit from Artistic-II HPP to Matiltan. Also to fulfil the Grid Code criteria case of stuck breaker (breaker failure) single phase fault has also been studied where the fault clearing time is assumed 9 cycles i.e. 180 ms.

7.2. Dynamic Stability Simulations Results

The detailed parameters used for the Stability Analysis have been tabulated in Appendix – E.

a) Fault at 132 kV Artistic-II HPP

Fault Type: 3-Phase			
Fault Location: Artistic-II 132 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: Artistic-II to Daral Khwar HPP 132 kV single circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Artistic-II 132 kV 2. Matiltan 132 kV 3. Daral Khwar 132 kV 4. Madyan 132 kV 5. Kabal 132 kV 6. K.Khela 132 kV	The voltages of all the bus bars recover after fault clearance	1.1
Frequency	Artistic-II 132 kV	Recovers after fault clearance	1.2
MW/MVAR Output of the Plant	Artistic-II unit-1 11 kV	Recovers after damping down oscillations	1.3
Speed and $P_{mechanical}$ of the Plant	Artistic-II unit-1 11 kV	Recovers after damping down oscillations	1.4
Line Flows (MW/MVAR)	Artistic-II to Matiltan 132 kV intact single circuit	Attains steady state value after damping of oscillations	1.5
Rotor Angles	1. Artistic-II 11 kV 2. Matiltan 132 kV 3. Daral Khwar 132 kV 4. Shigokas 132 kV 5. Golengol 132 kV 6. Guddu-New 500 kV (reference angle)	Damps down quickly and attain a steady state value	1.6

b) Fault at 132 kV Artistic-II HPP (Stuck Breaker)

Fault Type: 1-Phase			
Fault Location: Artistic-II 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Artistic-II to Daral Khwar – II 132 kV single circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Artistic-II 132 kV 2. Matiltan 132 kV 3. Daral Khwar 132 kV 4. Madyan 132 kV 5. Kabal 132 kV 6. K.Khela 132 kV	The voltages of all the bus bars recover after fault clearance	2.1
Frequency	Artistic-II 132 kV	Recovers after fault clearance	2.2
MW/MVAR Output of the Plant	Artistic-II unit-1 11 kV	Recovers after damping down oscillations	2.3
Speed and $P_{mechanical}$ of the Plant	Artistic-II unit-1 11 kV	Recovers after damping down oscillations	2.4
Line Flows (MW/MVAR)	Artistic-II to Matiltan 132 kV intact single circuit	Attains steady state value after damping of oscillations	2.5
Rotor Angles	1. Artistic-II 11 kV 2. Matiltan 132 kV 3. Daral Khwar 132 kV 4. Shigokas 132 kV 5. Golengol 132 kV 6. Guddu-New 500 kV (reference angle)	Damps down quickly and attain a steady state value	2.6

c) Fault at 132 kV Artistic-II

Fault Type: 3-Phase			
Fault Location: Artistic-II 132 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: Artistic-II to Matiltan 132 kV single circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Artistic-II132 kV 2. Matiltan 132 kV 3. Daral Khwar 132 kV 4. Madyan 132 kV 5. Kabal 132 kV 6. K.Khela 132 kV	The voltages of all the bus bars recover after fault clearance	3.1
Frequency	Artistic-II 132 kV	Recovers after fault clearance	3.2
MW/MVAR Output of the Plant	Artistic-II unit-1 11 kV	Recovers after damping down oscillations	3.3
Speed and $P_{mechanical}$ of the Plant	Artistic-II unit-1 11 kV	Recovers after damping down oscillations	3.4
Line Flows (MW/MVAR)	Artistic-II to Daral Khwar 132 kV intact single circuit	Attains steady state value after damping of oscillations	3.5
Rotor Angles	1. Artistic-II 11 kV 2. Matiltan 132 kV 3. Daral Khwar 132 kV 4. Shigokas 132 kV 5. Golengol 132 kV 6. Guddu-New 500 kV (reference angle)	Damps down quickly and attain a steady state value	3.6

d) Fault at 132 kV Madyan

Fault Type: 3-Phase			
Fault Location: Madyan 132 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: Madyan to Kabal 132 kV single circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Madyan 132 kV 2. Kabal 132 kV 3. Artistic-II132 kV 4. Matiltan 132 kV 5. Chakdara-New 132 kV 6. K.Khela 132 kV	The voltages of all the bus bars recover after fault clearance	4.1
Frequency	Artistic-II 132 kV	Recovers after fault clearance	4.2
MW/MVAR Output of the Plant	Artistic-II unit-1 11 kV	Recovers after damping down oscillations	4.3
Speed and $P_{mechanical}$ of the Plant	Artistic-II unit-1 11 kV	Recovers after damping down oscillations	4.4
Line Flows (MW/MVAR)	Daral Khwar to Madyan 132 kV intact single circuit	Attains steady state value after damping of oscillations	4.5
Rotor Angles	1. Artistic-II 11 kV 2. Matiltan 132 kV 3. Daral Khwar 132 kV 4. Shigokas 132 kV 5. Golengol 132 kV 6. Guddu-New 500 kV (reference angle)	Damps down quickly and attain a steady state value	4.6

e) Fault at 132 kV Kabal

Fault Type: 3-Phase			
Fault Location: Kabal 132 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: Kabal to Swat 132 kV single circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Kabal 132 kV 2. Madyan 132 kV 3. Artistic-II132 kV 4. Matiltan 132 kV 5. Chakdara-New 132 kV 6. K.Khela 132 kV	The voltages of all the bus bars recover after fault clearance	5.1
Frequency	Artistic-II 132 kV	Recovers after fault clearance	5.2
MW/MVAR Output of the Plant	Artistic-II unit-1 11 kV	Recovers after damping down oscillations	5.3
Speed and $P_{mechanical}$ of the Plant	Artistic-II unit-1 11 kV	Recovers after damping down oscillations	5.4
Line Flows (MW/MVAR)	Daral Khwar to Kabal 132 kV intact single circuit	Attains steady state value after damping of oscillations	5.5
Rotor Angles	1. Artistic-II 11 kV 2. Matiltan 132 kV 3. Daral Khwar 132 kV 4. Shigokas 132 kV 5. Golengol 132 kV 6. Guddu-New 500 kV (reference angle)	Damps down quickly and attain a steady state value	5.6

7.3. Conclusion of Dynamic Stability Analysis

The results of dynamic stability carried out for summer 2026 show that the system is very strong and stable for the proposed scheme for the severest possible faults of 132 kV systems near to and far from Artistic-II HPP under all events of disturbances. There is no problem of dynamic stability for interconnection of Artistic-II HPP; it fulfills all the criteria of dynamic stability.

8. Conclusions

- Artistic Milliners is planning to develop hydro power plant at Ushu River, Kalam in District Swat of KPK. The installed capacity of plant comprises of three units generating 55.032 MWe due to limitations as mentioned in plant data received from Client, attached in Exhibit A.
- The proposed interconnection scheme for Artistic-II HPP is by looping in-out one of the double circuit from Matiltan to Daral Khwar-II HPP. The looping of the circuit will be done just outside the boundary wall of Matiltan sub-station so as to evade the requirement of additional line bays at Matiltan switchyard. The circuit of around 7.2 km will be on Rail conductor.
- In view of planned COD of Artistic-II HPP in 2026, the proposed interconnection scheme has been assessed for steady state conditions through detailed load flow studies for summer 2026 as Hydel generations will be at peak.
- The short circuit levels of the Artistic-IIHPP 132 kV are 6.56 kA and 6.74 kA for 3-phase and 1-phase faults, respectively, in the year 2026. Therefore, industry standard switchgear of a short circuit rating of 40 kA would be sufficient for installation at 132 kV switchyard of Artistic-II HPP.
- The dynamic stability analysis of proposed schemes of interconnection has been carried out. The stability has been tested for the worst cases, i.e. three phase fault right on the 132 kV bus bar of Artistic-II HPP substation followed by trip of a 132 kV single circuit from Artistic-II HPP has been performed for fault clearing of 5 cycles (100 ms), as understood to be the normal fault clearing time of 132 kV protection system. The extreme worst case of stuck breaker (breaker failure) has been studied where the fault clearing time is assumed 9 cycles i.e. 180 ms for single phase fault. The stability of the system for far end faults of 3-phase occurring at Artistic-II HPP 132 kV bus bar has also been checked. The system is stable for all the tested fault conditions.
- The proposed scheme of interconnection has been subjected to Load Flow, Short Circuit and Dynamic Stability Analysis and found to be feasible for interconnection of Artistic-II HPP with the PESCO network.
- Although, the capacity of Rail conductor used for interconnection is sufficient for the network up till the commissioning of Artistic-II HPP, yet the conductor may require up-gradation to twin bundle rail if and when new hydropower generations come into the system owing to the fact that the study area is excessively rich in hydropower potential.