PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION
Government of Khyber Pakhtunkhwa

No.542-544 /PEDO/PD Balakot HPP
Dated Peshawar the 29 -07-2021

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

Subject: Application for Grant of Generation Licence

I, Wajid Nawaz Khan, Project Director 300MW Balakot Hydropower Project Pakhtunkhwa Energy Development Organization (PEDO) being the duly Authorised representative of PEDO by virtue of authority letter No.1890/CEO PEDO/Balakot HPP dated 25th February 2021,hereby apply to National Electric Power Regulatory Authority for the grant of a Generation Licence to PEDO for 300MW Balakot Hydropower Project, pursuant to the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

I hereby 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, Modification, Extension and Cancellation) Procedure Regulations, 2021, 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 no material omission has been made.

BANK DRAFTS in the sum of **Rupees 1,500,000/- (CDR No.01516378, and CDR No.01516823 amounting to Rs.934,720/- and 565,280/- respectively)** being the license application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application, Modification, Extension and Cancellation) Procedure Regulations, 2021, is also attached herewith.

Wajid

(Engr. Wajid Nawaz Khan)
Project Director Balakot HPP

Copy to:
1. Chief Executive Officer PEDO Peshawar.
2. Chief Engineer (O&C), PEDO Peshawar.

Project Director Balakot HPP

PEDO

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION
Government of Khyber Pakhtunkhwa

No./1890 /CEO PEDO/ Balakot HPP
Dated:25/ 02 / 2021

To

The Registrar,
National Electric Power Regulatory Authority (NEPRA),
NEPRA Tower,
G-5/2, Islamabad.

Subject: **<u>AUTHORITY LETTER FOR GENERATION LICENSE/TARIFF PETITION</u>**

Mr. Wajid Nawaz Khan S/O Muhammad Nawaz Khan, Director (P&F)/ Project Director (Balakot HPP) PEDO, bearing CNIC No. 17301-1333544-5 is hereby appointed as Authorized Representative of the Pakhtunkhwa Energy Development Organization (PEDO), for the purpose of filing an application for determination of Generation License/Tariff Petition for 300MW Balakot Hydropower Project. He is also authorized to attend any meeting(s) and discussions related to the determination of tariff and to provide any information & documents required in this regard.

For and on behalf of
Pakhtunkhwa Energy Development Organization (PEDO)

Chief Executive Officer
PEDO, Peshawar

PEDO

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

Government of Khyber Pakhtunkhwa

APPROVAL
OF THE
CHAIRMAN EXECUTIVE COMMITTEE
OF
PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION (PEDO)

RESOLUTION FOR FILING OF GENERATION LICENSE AND TARIFF PETITION APPLICATION FOR 300 MW (GROSS ISO) CAPACITY HYDROELECTRIC POWER PROJECT

It is hereby AUTHORISED THAT the Project Director 300MW Balakot HPP of Pakhtunkhwa Energy Development Organization (PEDO), is authorized to file an application for the issuance of Generation License for 300 MW high head project and also to file a Tariff Petition; on behalf of PEDO with NEPRA, for the determination of EPC stage Tariff for the 300 MW (Gross) Capacity, High Head, Balakot Hydroelectric Power Project.

FURTHER DECLARED THAT the Project Director 300MW Balakot HPP of PEDO, is hereby authorized to sign all documentation pay all NEPRA fees, appear before NEPRA and provide any information required by NEPRA with respect to the Project, and inter alia conduct all necessary business required for the processing of issuance of Generation License and award of tariff determination for the aforementioned Hydroelectric Power Project from NEPRA.

29/04/2021

Muhammad Naeem Khan
C.E.O. / Chairman, PEDO Executive Committee
Date: April 29, 2021

G921935

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Rupees

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BEFORE THE NATIONAL ELECTRIC POWER REGULATRY AUTHORITY

Affidavit

I, Wajid Nawaz Khan, S/o Muhammad Nawaz Khan, Project Director, Pakhtunkhwa Energy Development Organization (PEDO), being duly authorized representative/ attorney of 300 MW Balakot HPP, hereby solemnly affirm and declare that the contents of the accompanying Generation License application dated 5-05-2021, including all supporting document are true and correct to the best of my knowledge and belief that nothing has been concealed.

I also affirm that all further documentation and information to be provided by me in connection with the accompanying petition shall be true to the best of my knowledge and behalf.

Deponent
Project Director
Balakot HPP, PEDO

CHECK LIST FOR EXAMINATION OF LICENCE APPLICATION FOR NEW HYDEL POWER PROJECT

(Regulation 3 read with 3(4)(A) of AMECPR-2021)

Name of Company: Pakhtunkhwa Energy Development Organization (PEDO)

Installed Capacity: 300 MW

Regulation #	Information/Documents Required	Information/ Documents Submitted
3(1)	Application fee (including Indexation)	Attached
3(3)	Application submitted in triplicate	Draft Attached
3(4)(a)	Applicable documents-in-support and information set out in Schedule III of these regulations;	Complied
3(4)(b)	A prospectus	Provided
3(4)(c)(i)(a)	Certified copies of certificate of incorporation	PEDO is a public sector organization constituted under SHYDO Act 1993 and is Exempt under Section 24 of NEPRA Act and thus not required
3(4)(c)(i)(b)	Certified copies of memorandum and articles of association	PEDO is a public sector organization constituted under SHYDO Act 1993. Notification for renaming to be provided by PEDO.
3(4)(c)(i)(c)	Certified copies of annual reports of the company	Attached
3(4)(c)(ii)	The last annual return of the Company submitted in compliance of section 130 of the Companies Act or, in case of an applicant to whom section 130 of the Companies Act does not apply, a return comprising of all such information and particulars as required by the specified form under section 130 of the Companies Act, as the case may be;	PEDO is a public sector organization constituted under SHYDO Act 1993 and therefore, not required to submit annual Return Statement
3(4)(c)(iii)	The authorized, issued, subscribed and paid up share capital of the applicant	N/A
3(4)(c)(iv)	The shareholding pattern of the applicant including list of shareholders holding 5% or more shares, number of shares Held by each of them and percentage shares of the total paid-up capital	N/A
3(4)(d)(i)	Evidence of cash balances held in reserve by the applicant, along with bank certificates;	PEDO is a public sector organization constituted under SHYDO Act 1993 and therefore, it is not required
3(4)(d)(ii)	Details of charges or encumbrances attached to the applicant's assets, if any;	Attached
3(4)(d)(iii)	Latest audited financial statements of the applicant;	PEDO is a public sector organization constituted under SHYDO Act 1993 and therefore, not required to submit annual Return Statement

Regulation #	Information/Documents Required	Information/ Documents Submitted
3(4)(d)(iv)	Expressions of interest to provide credit or financing along with sources and details thereof;	Project is funded by Asian Development Bank (ADB).
3(4)(d)(v)	Documents describing the net worth and the equity and debt ratios of the applicant, as on the date of the audited balance sheet accompanying the application;	Attached
3(4)(d)(vi)	A reasonably detailed profile of the applicant and the applicant's senior management, technical and professional staff;	Attached
3(4)(d)(vii)	Employment records of engineering and technical staff of the applicant proposed to be employed;	Provided (CVs)
3(4)(d)(vii)	Profile of sub-contractors, if any, along with expressions of interest of such sub-contractors;	N/A
3(4)(d)(ix)	Verifiable references in respect of the experience of the applicant and its proposed sub-contractors;	EPC awarded under PEC rules after ICB and complete verification of contractors.
3(e)	Technical and financial proposals in reasonable detail for the operation, maintenance, planning and development of the facility or system in respect of which the license is being sought;	EPC Contract has been awarded to JV of CGGC and GRC whereas O&M will be done by PEDO through its own staff.
3(f)	Feasibility Study	Provided
3(g)	An affidavit stating whether the applicant has been granted any other license under the Act;	PEDO is Govt entity and GL has been granted for the following projects: 11.80 MW Karora HPP at Distt shangla KP. 36.60 MW Daral Khwar HPP Bahrain Distt Swat KP. 10.2 MW Jabori HPP Distt mansehra KP. 2.60 MW Machai HPC Distt Mardan KP. 18 MW pehur HPC Distt Swabi KP. 17 MW Ranolia HPP. 4.20 MW Reshun HPC Chitral. 1.875MW Shishi HPC Chitral 40.8MW Koto HPP Lower Dir.
3(h)	A duly authorised statement stating whether the applicant has been refused grant of license under the Act and, if so, the Particulars of the refused application, including date of making the application and decision on the application;	N/A
3(6)	Authorization from Board Resolution / Power of Attorney	Attached

Regulation #	Information/Documents Required	Information/ Documents Submitted
3(7)	An affidavit as to the correctness, authenticity and accuracy of the application,	Attached
3(8)	The applicant shall also furnish a bank guarantee equivalent to applicable annual license fee for two year	PEDO is a govt entity and once GL granted to 300MWBalakot HPP, annual Generation License fee will be regularly submitted.
Schedule III (Regulation 3(4)(a)(A)(a)		
1.	Environmental and Social Soundness Assessment Study/Report	Provided
2.	Interconnection Study	Provided
3.	System Studies (load flow, short circuit, stability, etc.)	Attached with the Application (Volume 2- Grid Interconnection Study)
4(i)	Location (location maps, site map, land)	District Mansehra
4(ii)	Plant Type (run of the river, storage, wier)	run of the river
4(iii)	Plant characteristics: generation voltage, power factor, frequency, automatic generation control, ramping rate, control metering and instrumentation	Generating Voltage – 18 KV Frequency -50 Hz Power Factor - Leading 0.90 & Lagging 0.85 Automatic Generation Control -No Ramping Rate -5 minutes Alternative Fuel -No Auxiliary Consumption 3 MW (1 % of installed capacity) Time required from starting/watering turbine to Synchronise -10 minutes
4(iv)	Head (minimum, maximum)	Maximum Net Head-218m Minimum Net Head-213m
4(v)	Technology (Frances, Pelton, etc.) size of the plant and number of units	Francis, 3x100 MW
4(vi)	Tunnel (if proposed): length, diameter	**Headrace** L-9137m Dia-8m **Tailrace** L-1515m Dia-8m
4(vii)	Resettlement Issues	For setting Resettlement Issues preparation of a detail Land Acquisition and Resettlement Plan (LARP) is in progress.
4(viii)	Necessary approvals have been sought from the concerned authorities of the Federal Government and Provincial Government	EIA NOC issued Environment Deptt Govt of KP (Attached)

Regulation #	**Information/Documents Required**	**Information/ Documents Submitted**
4 (ix)	Infrastructure Development	Included in EPC
4(x)	Project Schedule and expected life	Constperiod:60 months, Project expected life 30 years.
4(xi)	Peaking/base load	Peaking during low flow season.
4(xii)	Training and development	Details provided in the EPC Contract
4(xiii)	Efficiency Parameters	Turbine – 95 % and Generator – 98 %

Article - 1

Definitions

(1) **In this Licence**:

a. "Act" means the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 (XL of 1997);

b. "Authority" means the National Electric Power Regulatory Authority constituted under Section 3 of the Act.

c. "Licensee" means Paktunkhwa Energy Development Organization (PEDO) Balakot Hydropower Project

d. "Rules" mean the National Electric Power Regulatory Authority Licensing (Generation) Rules, 2000.

(2) Words and expressions used but not defined herein bear the meaning given thereto in the Act or in the Rules.

Article - 2

Application of Rules

This Licence is issued subject to the provisions of the Rules, as amended from time to time.

Article - 3

Generation Facilities

(1) The location, size, technology, interconnection arrangements technical limits, technical functional specifications and other details specific to the generation facilities of the licensee are set out in Schedule - I to this Licence.

(2) The net capacity of the generation facilities is set out in Schedule - II hereto.

(3) The Licensee shall provide the final arrangement, technical and financial specifications and other details specific to generation facilities before commissioning of the generation facilities.

Article - 4

Term

(1) The Licence is granted for a term of **thirty (30) years** after the commercial operation date.

(2) Unless revoked earlier, the licensee may, ***ninety (90) days*** prior to the expiry of the term of the licence, apply for renewal of the Licence under the Licensing (Application and Modification Procedure) Regulation, 1999.

Article - 5

Licence Fee

The Licensee shall pay to the Authority the Licence fee in the amount and manner and at the time specified in the National Electric Power Regulatory Authority (Fee) Rules, 2002.

Article - 6

Tariff

The Licensee shall charge from its consumers only such tariff which has been approved by the Authority.

Article - 7

Competitive Trading Arrangement

(1) The Licensee shall participate in such measures as may be directed by the Authority from time to time for development of the Competitive Trading Arrangement. The Licensee shall in good faith work towards implementation and operation of the aforesaid Competitive Trading Arrangement in the manner and time period specified by the Authority:

Provided that, any such participation shall be subject to any contract entered into between the Licensee and another party with the approval of the Authority.

(2) Any variation and modification in the above-mentioned contracts for allowing the parties thereto to participate wholly or partially in the Competitive Trading Arrangement shall be subject to mutual agreement of the parties thereto and such terms and conditions as may be approved by the Authority.

Article - 8

Maintenance of Records

For the purpose of sub-rule (1) of Rule 19 of the Rules, copies of records and data shall be retained in standard and electronic form and all such records and data shall, subject to just claims of confidentiality, be accessible by the authorized officials of the Authority.

Article - 9

Compliance with Performance Standards

The Licensee shall conform to the relevant NEPRA rules on Performance Standards as may be prescribed by the Authority from time to time.

Article - 10

Compliance with Environmental Standards

The Licensee shall conform to the environmental standards as may be prescribed by the relevant competent authority from time to time.

Article - 11

Provision of information

(1) The obligation of the licensee to provide information to the Authority shall be in accordance with Section 44 of the Act.

(2) The licensee shall be subject to such penalties as may be specified in the relevant rules made by the Authority for failure to furnish such information as may be required from time to time by the Authority and which is or ought to be or have been in the control or possession of the licensee.

Schedule – 1

It contains the following information / drawings / sketches relating to the Power Plant Equipment and related System which are attached here with:

Plant Details

- General Information
- Plant Configuration
- Fuel Details
- Emission Values
- Installed Capacity
- Derated Capacity
- Expected Life
- Operation Record
- Cooling System
- Plant Characteristics
- Other details specific to the generation facility of the licensee such as:
    - Technical Limits of the Plant
    - Site Plan of Balakot Power Plant
    - General Layout of entire Balakot Power Plant
    - Interconnection Arrangements with National Grid

Plant Details

1. General Information

- Name of Applicant: Paktunkhwa Energy Development Organization (PEDO), Balakot Hydropower Project.
- Address of the registered office: PEDO House,38-B2, Phase-5, Hayatabad, Peshawar
- Plant Location : Balakot, District Mansehra, Province of Khyber Pakhtunkhwa.
- Type of Facility: Run of River Hydropower Project.

2. Plant Configuration

- High Head Hydropower turbines
- Capacity of the Power Plant (Net Power Output)
- Type of Technology: High Head Hydropower
- Number of Units / Capacity -: Three units / 100 MW each
- Power Plant Make and Model –Francis turbine and vertical shaft Generators
- Commissioning Date ----13 Sep,2026

3. **Fuel Details**
   - Type of Fuel: Hydropower Project
   - Fuel (Imported / Indigenous) NA
   - Fuel Supplier NA
4. **Emission values**
   - SOx -- NA
   - NOx -- NA
   - CO -- NA
   - PM10 -- NA
5. **Installed Capacity -300 MW**
6. **Derated Capacity No Derating as compared to ISO**
7. **Expected Life of the Facility ---------------------------------- 30 years**
8. **Operation Record --- New Plant to be commissioned by Sep 2026.**
9. **Plant Characteristics**
   - Generating Voltage --------------------------------- 18 KV
   - Frequency --- 50 Hz
   - Power Factor -- Leading 0.90 & Lagging 0.85
   - Automatic Generation Control -------------------- No
   - Ramping Rate -------------------------------------- 5 minutes
   - Alternative Fuel --------------------------------------No
   - Auxiliary Consumption ------------------------------3 MW (1% of installed capacity)

   Time required to Synchronise ----------------------- 10 minutes

SCHEDULE - II

The Net Capacity of the Licensee's Generation Facility

- Gross Installed Capacity of the Plant (ISO) ----------- 300 MW
- De-rated Capacity of the Plant --------------------------- 297 MW
- Auxiliary Consumption of the Plant -------------------- 3 MW
- Net Capacity of the Plant -------------------------------- 297 MW
- Construction Period -------------------------------------- 60 months
- Expected date of Commercial Operation of the Plant – **Sep 2026**

Note: These are indicative figures provided by the Licensee.

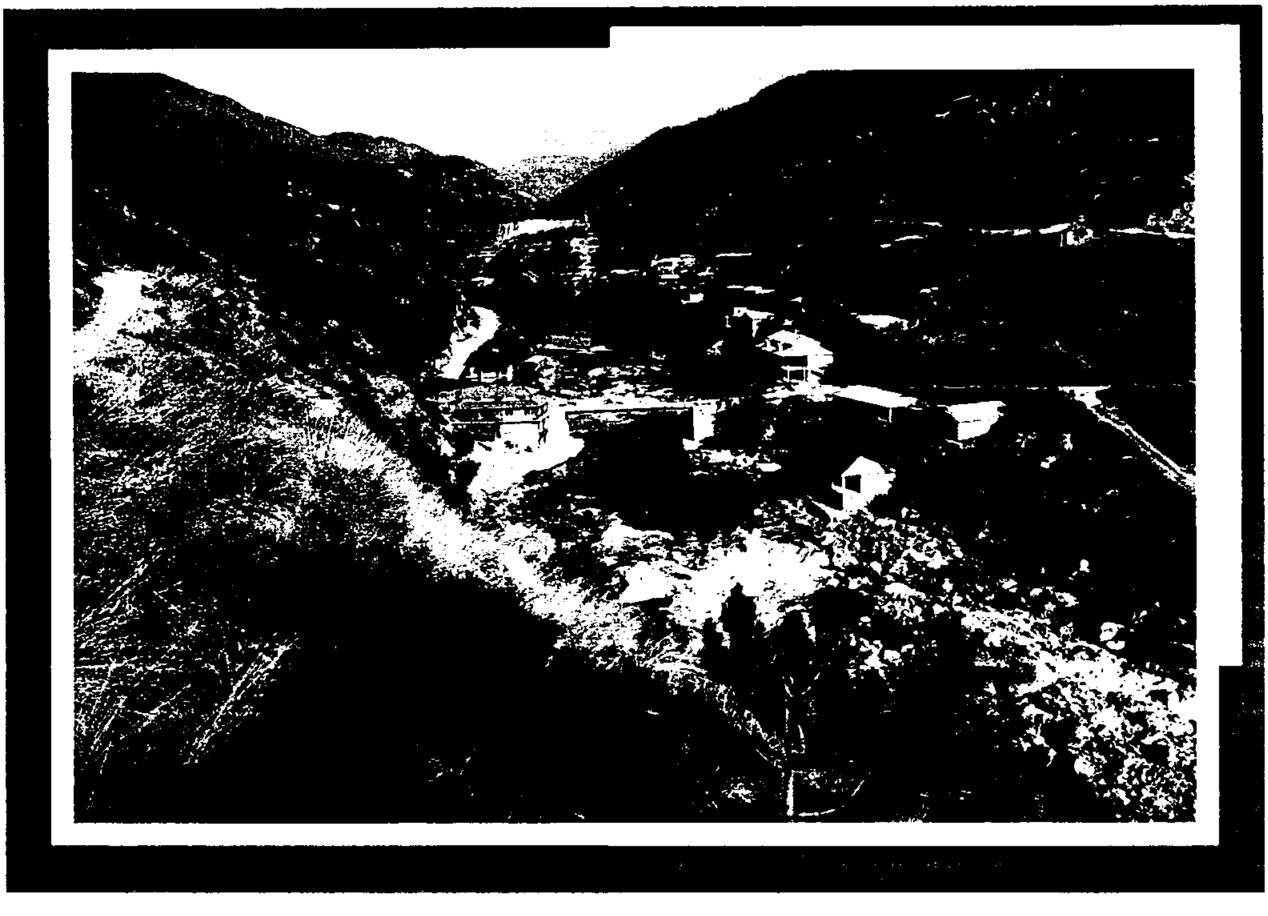
The Net Capacity of the Plant available for dispatch to Power Purchaser will be determined through procedures contained in the EPC Agreements or Grid Code

Interconnection Arrangement with National Grid for Power Dispersal of the Plant

The interconnection scheme for the Power dispersal from Balakot Hydro Power Plant would be through 132 kV transmission Line to PESCO, Grid station namely Balakot City Grid Station and Mansehra (NEW) Grid Station, and though 500 KV transmission line (as Loop-in and Loop-out arrangement) between Suki Kinari HPP and Switching Station at Maira.

PEDO
PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION
GOVERNMENT OF KHYBER PAKHTUNKHWA

PROSPECTUS



300 MW BALAKOT HYDROPOWER PROJECT

BALAKOT HYDROPOWER CONSULTANTS

A JOINT VENTURE OF:

OFFICE: House 1-A (11F). Railwav Road. Universitv Town. Peshawar. Khvber Pakhtunkhwa. Pakistan. Tel: +92 91 260 1188

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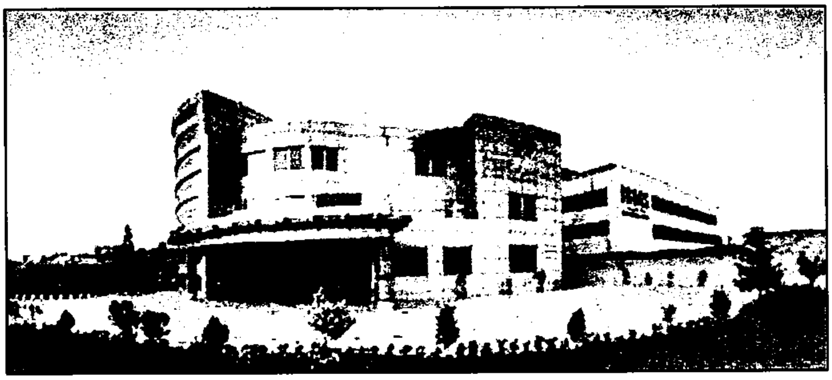
PROSPECTUS

1. PEDO Introduction

Khyber Pakhtunkhwa Province of Pakistan is blessed with huge hydropower potential. This potential remained focus of interest to private investors and international funding agencies. Most of the hydel projects of Pakistan including Tarbela and Warsak hydropower stations are located in KP.



Pakhtunkhwa Energy Development Organization (PEDO), since its inception in 1986, has been instrumental in identifying and exploiting hydel potential in Khyber Pakhtunkhwa. The organization is under the administrative control of Energy and Power Department of Provincial Government and is governed by the Board of Directors. PEDO has so far identified a number of promising hydel potential sites of more than 6000 MW capacity, which can be developed in a systematic manner either through Public sector or Private sector.

i. Objectives of the Organization

- Prepare comprehensive plan for development of the power and energy resources of the province.
- Frame schemes related to Generation, Transmission and Distribution of power, construction, maintenance and operation of powerhouses.
- Advisory body for the Government of KP in power sector matters regarding hydropower development.
- Conducting feasibility studies, surveys of hydel potential sites etc.
- Implementation of Provincial Hyde-l Power Policy to promote private sector investment in generation, transmission and distribution of power.

ii. Role of PEDO

The Provincial Government has entrusted a dynamic role to PEDO, which is mainly oriented towards private sponsors participation in power sector projects besides developing projects in public sector. PEDO has established a dedicated Directorate to provide one window facility to private sponsors.

iii. PEDO Organization

A Board of Directors under the chairmanship of the Chief Minister of Khyber Pakhtunkhwa governs the affairs of PEDO. The members include Additional Chief Secretary, Secretary Finance, Secretary Energy and Power and Chief Executive Officer PEDO. The head office of the Organization is Situated at Peshawar. A copy of the organogram of PEDO is given with this introduction.

1.1 Achievements by PEDO

PEDO, with the assistance of GTZ (German Agency for Technical Cooperation), has compiled a Master Plan for rural electrification in the Northern mountainous areas of KP with particular emphasis on those areas which were not connected to the National Grid System. The Master Plan entails a total potential of more than 6000 MW that has been identified for public and private sector development. The hydropower potential sites are mainly located in the Northern districts of K.P i.e. Chitral, Dir, Swat, Indus Kohistan and Mansehra.

i. Small Hydel Potential Sites

The Master Plan envisages small scale potential sites having total capacity of about 240 MW, comprising 53 hydel potential sites. These sites are suitable for regional supply to isolated communities in the mountainous areas of KP. The district wise breakup of sites is as follows:

Sr. No.	Region	Nos. of Sites	Power Potential (MW)
1	Upper Chitral	12	80
2	Lower Chitral	10	68
3	Kohistan	4	6
4	Swat	5	5
5	Mansehra \Vest	2	19
6	Kaghan Valley	3	13
7	Dir	17	50
TOTAL:		53	241

ii. Medium /Large Hydropower Systems

During field investigations, some very attractive sites of medium and large hydropower potential were also identified by PEDO.

Sr. No.	Name of Project I Location	Capacity (MW)	Remarks
1.	Kandiah System, Kohistan a. Karang Scheme, 454 MW b. Kaigah Scheme, 548 MW	1002	Private sector is developing these sites under Federal Power Policy
2.	Swat System, Swat a. Upper Scheme AI, 101 MW b. Middle Scheme BI, 410 MW c. Lower Scheme CI, 148 MW	659	-do-
3.	Spat-Gah, Kohistan a. Upper Scheme 200 MW b. Middle Scheme 550 MW c. Lower Scheme 500 MW	1250	WAPDA has undertaken the feasibility study through KfW, Germany
4.	Chor Nala System, Kohistan a. Scheme C-II, 700MW b. Scheme C-L 650 M\V c. Scheme K-II, 150MW	1500	-do-
5.	Kunhar River System, Mansehra a. Naran, 215 MW b. Suki Kinar, 840 NW	865	Private sector is developing these sites under Federal Power Policy

iii. Feasibility Studies Completed

Out of the identified sites, PEDO has completed feasibility studies of the following potential sites. These schemes are in various stages of implementation.

Sr. No.	Project / Location	Capacity (MW)	Remarks
1.	Daral Khwar HPP, Swat	36	Construction completed
2.	Ranolia HPP, Kohistan	17	-do-
3.	Pehur HPP, Swabi	18	-do-
4.	Summar Gah HPP, Kohistan	28	Suitable for private sector
5.	Batal Khwar HPP, Swat	8	Suitable for private sector
6.	Matiltan HPP, Swat	84	Under construction stage
7.	Khan Khwar HPP, Besham	72	Picked up by WAPDA for implementation
8.	Duber Khwar HPP, Kohistan	130	
9.	Allai Khwar HPP, Batagrarn	120	

1.2 Hydropower Projects Completed

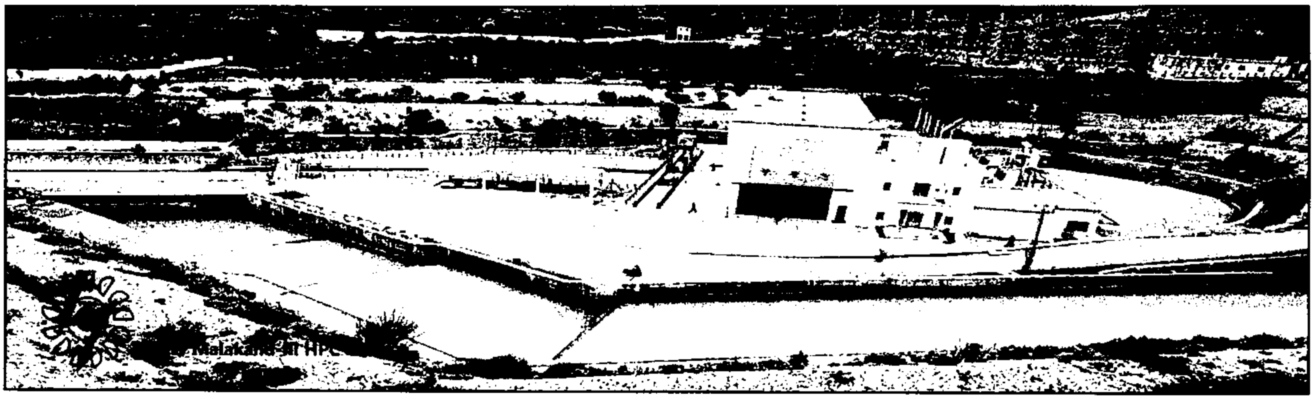
PEDO, after successful completion of following four small and medium size hydel projects with its own resources is planning to launch number of small, medium and large hydropower projects in view urgency for combating energy crises in the country.

Projects Completed by PEDO

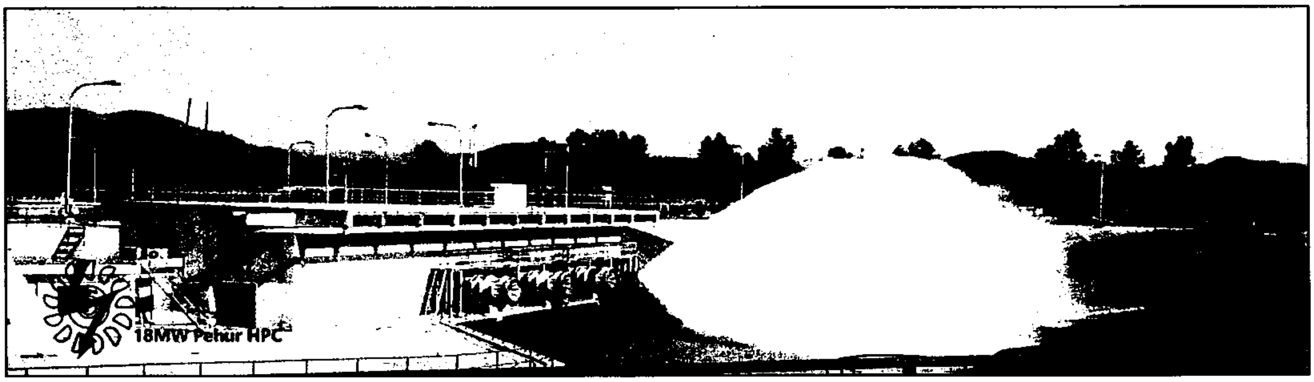
Sr. No.	Name of Scheme	Location	Capacity in MW
i	Malakand-III HPP	Malakand	81
ii	Pehur HPP	Swabi	18
iii	Shishi HPP	Chitral	1.8
iv	Reshun HPP	Chitral	4.2
v	Ranolia HPP	Kohistan	17
vi	Daral Khwar HPP	Bahrain, Swat	36.6
vii	Machai HPP	Mardan	2.6
		Total Installed Capacity	**161.2**

These projects are not only contributing towards the reduction in load shedding but also generating annual revenue of Rs. 2 to 3 billion for the province.

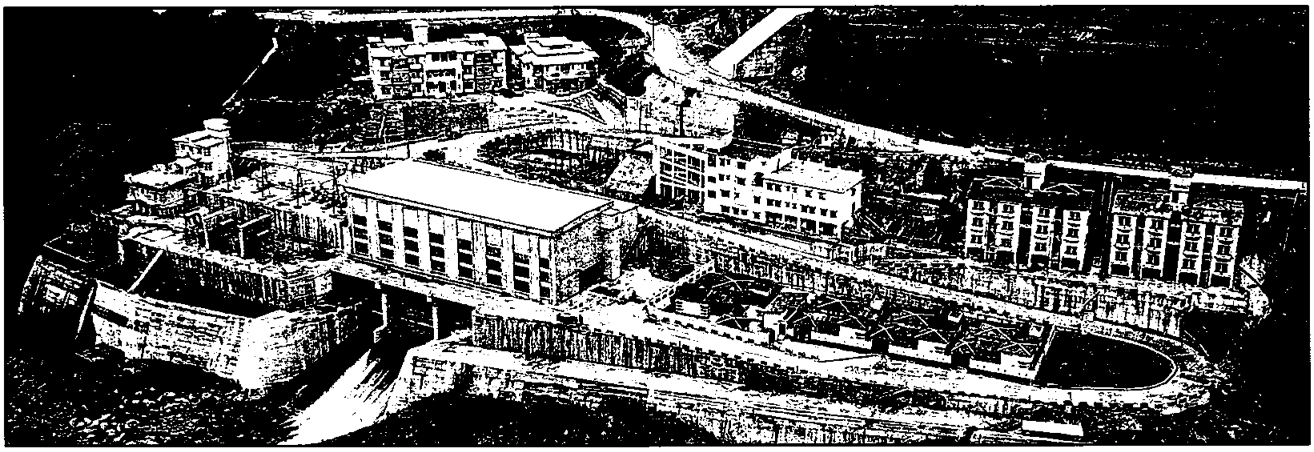
Besides the above completed Hydropower Projects, PEDO is implementing following projects with the assistance of Asian Development Bank (ADB) for the development of Hydropower Potential in Khyber Pakhtunkhwa Province which will be completed within three years;



Malakand-III HHP 81 MW



Pehur HPP 18 MW



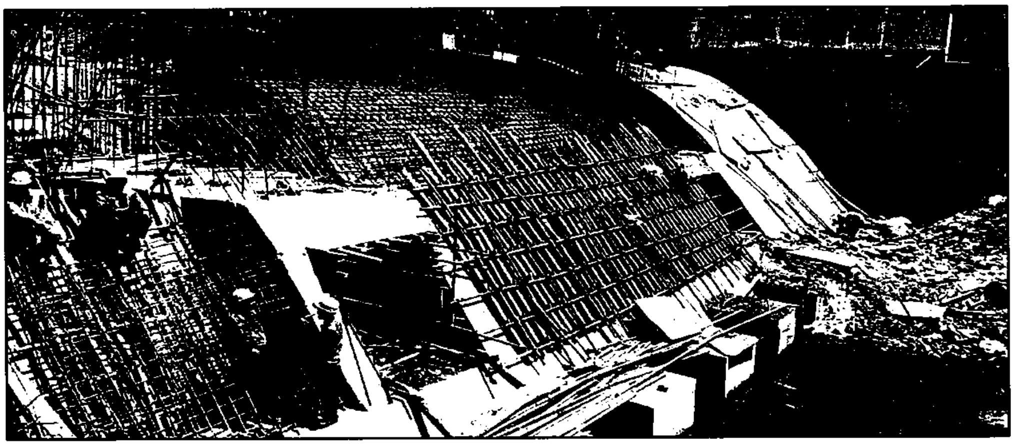
Daral Khwar HPP 36.6 MW

Machai HPP 2.6 MW

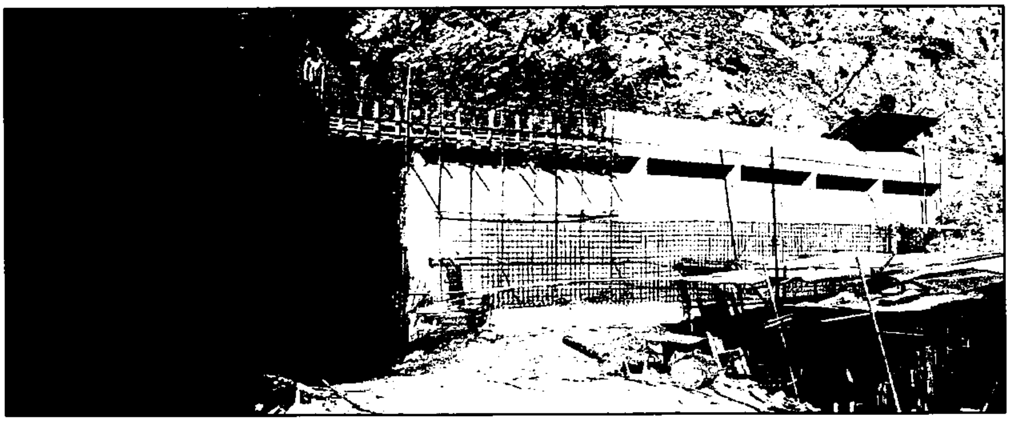
Projects under construction:

Sr.No	Name of Scheme	Location	Capacity in MW
i	Karora HPP	Shangla	11.80
ii	Jabori HPP	Mansehra	10.20
iii	Koto HPP	Dir (Lower)	40.8
iv	Matiltan HPP	Swat	84
v	Lawi HPP	Chitral	69
vi	Balakot HPP	Mansehra	300
		Total Capacity	**515.8**

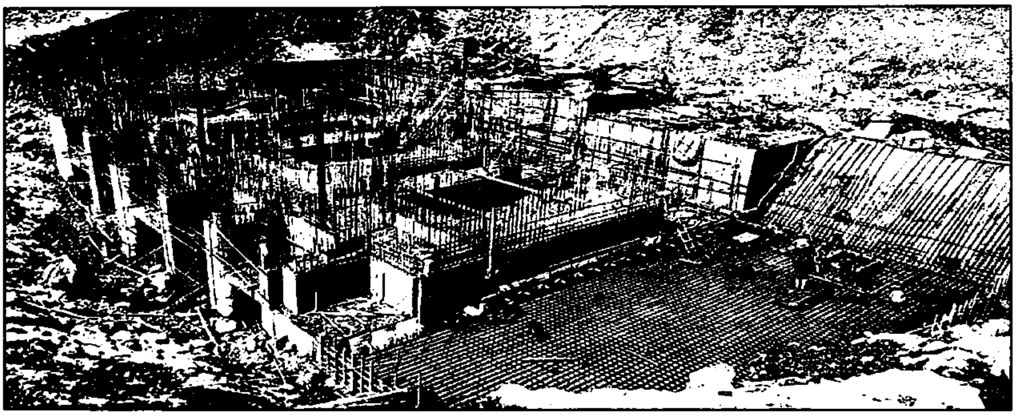
A view of Under Construction Projects as shown in below:



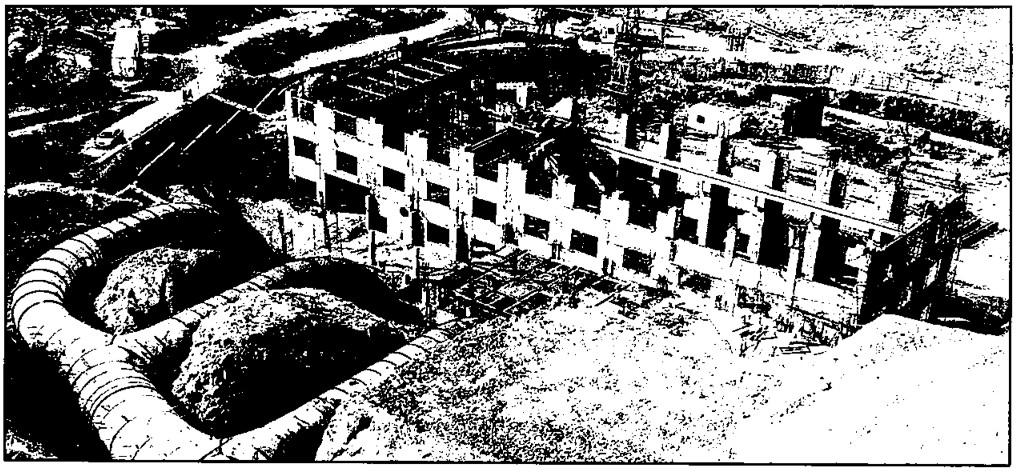
Karora HPP 11.80 MW



Jabori HPP 10.20 MW



Matiltan HPP 84 MW



Koto HPP 40.8 MW

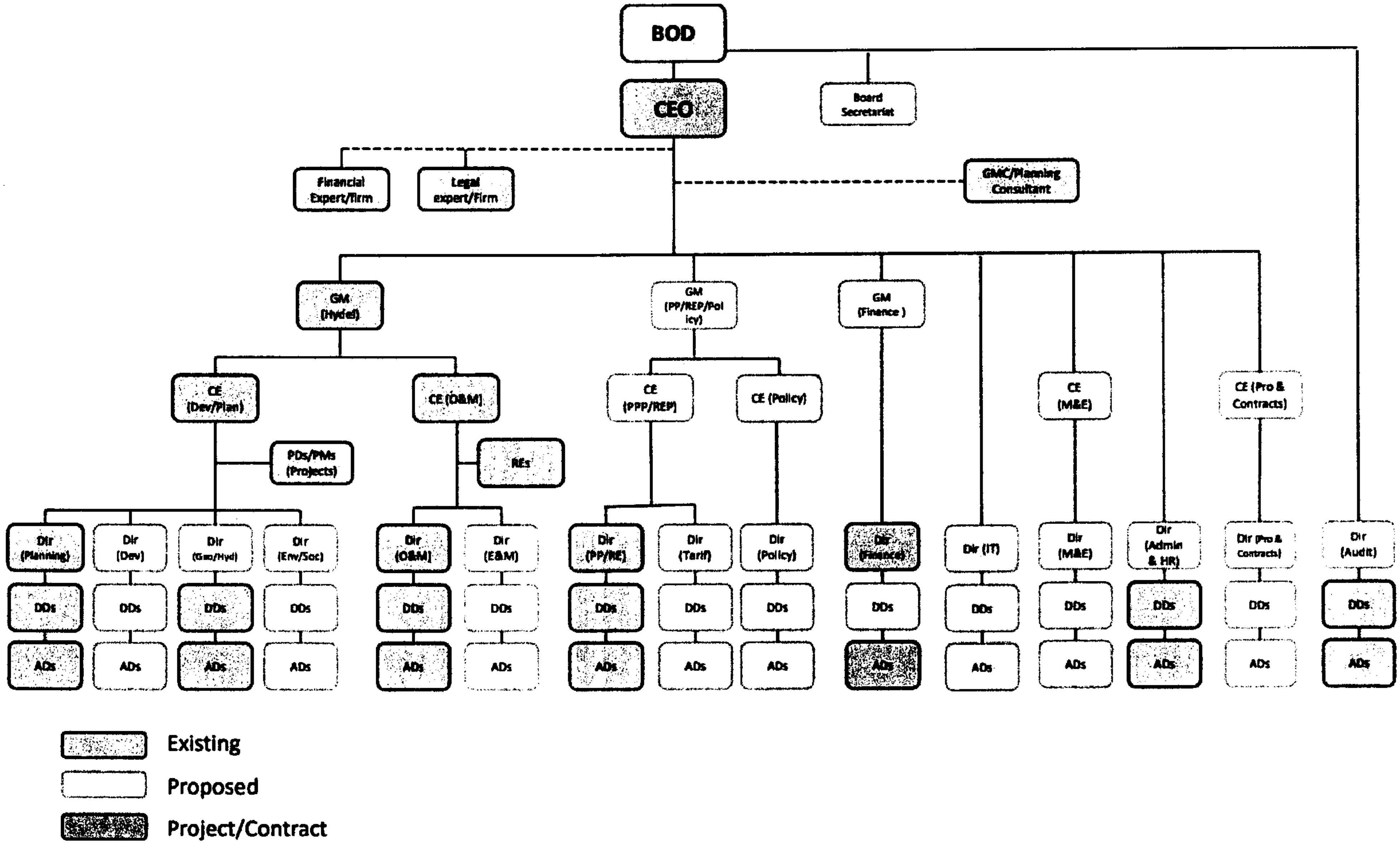
The Honorable Chief Minister has issued special directives for the implantation of hydel projects to address the acute energy crises in the country. In this regard, PEDO prepared all ACTION PLAN which has been **approved** by the Provincial Government of Khyber Pakhtunkhwa, under which following project are under construction/tendering stage.

In addition to construction projects, PEDO has also completed feasibility study of 13 Hydel Power Projects with potential of 1322 MW under the same ACTION PLAN. The construction of these projects will be achieved during the period 2011-2021.

Projects in Feasibility Studies Stage

Sr.No	Name of Scheme	Location	Capacity in MW
1	Gahrit-Swir Lasht HPP	Chitral	377
2	Jamshail-Toren More HPP	Chitral	260
3	Toren More – Kari HPP	Chitral	350
4	Laspur Marigram HPP	Chitral	230
5	Arkari Gol HPP	Chitral	99
6	Istaru-Buni HPP	Chitral	72
7	Mujigram Shogo HPP	Chitral	64.26
8	Barikot Patrak HPP	Dir	47
9	Patrak Shringal HPP	Dir	22
10	Shigo Kach HPP	Dir	102
11	Ghor Band HPP	Shangla	20.6
12	Nandihar IIPP	Batagram	12.3
13	Naram Dam HPP	Mansehra	188
14	Shushai-Zhendoli HPP	Chitral	144
15	Shogo Sin HPP	Chitral	132
16	Batakundi HPP	Mansehra	99
17	Gabral Kalam	Swat	88
18	Kari Mushkur HPP	Chitral	495
Total Installed Capacity			**2802.16**

In order to facilitate the private sector, PEDO has also conducting Pre-Feasibility study of 10 raw sites in various districts of Khyber Pakhtunkhwa province having capacity and these sites have been offered to private sector for development.


BOD
CEO
Board Secretariat
Financial Expert/firm
Legal expert/Firm
GMC/Planning Consultant
GM (Hydel)
GM (PP/REP/Policy)
GM (Finance)
CE (Dev/Plan)
CE (O&M)
CE (PPP/REP)
CE (Policy)
CE (M&E)
CE (Pro & Contracts)
PDs/PMs (Projects)
REs
Dir (Planning)
Dir (Dev)
Dir (Geo/Hyd)
Dir (Env/Soc)
Dir (O&M)
Dir (E&M)
Dir (PP/RE)
Dir (Tariff)
Dir (Policy)
Dir (Finance)
Dir (IT)
Dir (M&E)
Dir (Admin & HR)
Dir (Pro & Contracts)
Dir (Audit)
DDs
ADs
Existing
Proposed
Project/Contract

2 Salient features of the Balakot HPP are given below:

1. Hydrology and Design Flows	
River	Kunhar
Catchment area at dam site (km^2)	1939
Design Flood (m^3/s) T= 10 000 years	3500
Probable Maximum Flood (m^3/s)	5000
2. Reservoir	
Normal Operation Level (NOL)	1288.0
Minimum Operation Level (MOL)	1283.0
Surface area (at MOL) (km^2)	0.28
Length of Reservoir (at NOL) (km)	2.20
Gross storage capacity (at NOL) (x10^6 m^3)	3.56
Live storage (at NOL) (x10^6 m^3)	1.20
3. Dam Structure	
Type	Concrete Gravity Arch
Dam crest elevation (masl)	1292.0
Maximum height above river bed (m)	35.0
Maximum height above foundation (m)	58.0
Crest length (m)	130.0
4. Spillways and Low Level Outlets / Flushing Sluices	
Spillway type	Upper Gated Ogee Crest Spillway + low level Gated Spillway
Upper spillway crest elevation (masl)	1278.0
Low level spillway invert elevation (masl)	1258.0
5. Sediment Management	
Solution	Sediment Bypass Tunnel (SBT) + Flushing Outlets
SBT type	Gated Intake followed by Archway Tunnel
Tunnel length (m)	650
6. Headrace Tunnel	
Tunnel section	Circular concrete lined (8.0 m inner diameter)
Length up to surge tank (m)	9137
Tunnel slope (%)	0.56%
7. Upstream Surge Shaft	
Type	concrete lined circular surge shaft
Internal diameter (m)	14.5
Surge shaft height (m)	122
Surge shaft bottom elevation (masl)	1220.0

8. Pressure Tunnel/Shaft and Penstock	
Pressure tunnel/shaft main section type and size	Steel lined circular cross section (5.6 m internal diameter)
Pressure tunnel/shaft length (m)	152
Penstock length (m)	88
9. Powerhouse and Substation	
Powerhouse type	Conventional underground cavern
Main cavern general dimensions (LxWxH) (m)	71 x 20 x 34
Turbine type	Francis
No. of units	3
No. of generators	3
Transformer / Substation type	Underground cavern (adjacent to the main powerhouse cavern)
Transformer cavern general dimensions (LxWxH) (m)	88 x 14 x 20
10. Downstream Surge Shaft	
Type	concrete lined circular surge shaft
Internal diameter (m)	3
Surge shaft height (m)	244
Surge shaft bottom elevation (masl)	1055.0
11. Tailrace	
Type	Circular tunnel with transition to an archway section at the final length and Outlet portal
Tunnel section	Circular concrete lined (8.0 m diameter)
Length up to the final transition section (m)	1515
Length from transition to outlet (m)	50
12. Power and Energy	
Gross Head (m)	229.0
Design Net Head (m)	217.6
Installed plant capacity (MW)	300 (at the generator)
Mean annual energy (GWh)	1143 (average of 55 years)
13. Project Access Facilities	
Access road to dam and related structures (length)	550 m (from Sharan Road, connection to National Highway N-15 at the left side of Kunhar River, nearby Paras village)
Access road to sediment by-pass tunnel (length)	440 m (from dam bridge deck up to sediment by-pass tunnel intake)

3 Proposed Investment:

Balakot HPP will be financed by Asian Development Bank (ADB) and Asian Infrastructure Invest Bank (AIIB). Of the total financing amount of USD580 million, ADB will provide USD 300 million while AIIB will provide USD 280 million.

4 Social & Environmental impact

Study Area

The selection of the Study Area for the EIA considered environmentally sensitive receptors that are most likely to be impacted by the Project's development activities during construction and operation. For assessment of cumulative impacts, the Study Area was selected to be large enough to allow the assessment of the Valued Ecosystem Components (VECs) that may be affected by the Project activities.

Policy and Legal Framework

The EIA process and the environmental and social performance of the Project will be governed by the policies of the GoP, the laws of the Government of KP, and international environmental agreements to which Pakistan is a party. The Project is following ADB's guidelines as ADB is a lender.

Overview of the Physical Environment

1. Topography

The relief in the catchment of the dam varies from 629 m amsl to 5,199 m amsl. The dam site is at an elevation of 1,257 m amsl and the powerhouse site at an elevation of 1,316 m amsl.

2. Land Use and Cover

The land use distribution is demarcated as per the Socioeconomic Zones within the Socioeconomic Study Area. Pine and scrub forests cover the majority of the area (59% of the total zones combined) followed by agricultural intensity (26%). Density of built-up area is low about 8% and same is the percentage of water bodies in the Study Area.

3. Geology, Soils and Seismicity

i Tectonics

The Project lies along a major and active continental margin, at the confluence of Eurasian and Indian Plates that has resulted in the Himalayan orogeny. The Project area has been affected considerably by tectonics which has produced some prominent faults like the Main Boundary Thrust (MBT), the Panjal Thrust, and the Himalayan Frontal Thrust (HFT). MBT passes along the right bank of the Kunhar River, while the powerhouse area and headrace tunnel run parallel on the left bank. This fault is about 2.4 km west of Kunhar River at the dam site. The maximum distance of headrace tunnel from MBT is about 4.64 km. It continues in a southern direction through the rock formation some 2 km away from the powerhouse site.

ii Earthquakes and Seismicity

Earthquakes occur very frequently in the Project area, which is within a highly seismically active area. Several regional faults, which are some of the most active faults in the Himalayas, pass through the close vicinity of the Project site. The area is known for recent seismic events including 2004 Paras Earthquake of magnitude 5.2 and 2005 Earthquake of magnitude 7.6.

The peak ground acceleration (PGA) with 10% probability of exceedance in 50 years (475-year average return interval) is reported and is between 1.6 meter per second squared (m/s^2) and 2.4 m/s^2 at the Project site as per Global Seismic Hazard Assessment Project (GSHAP).

According to the revised Building code of Pakistan with Seismic Provision (PBC, 2007) the Project location is classified under seismic Zone 4 for which the Project is required to withstand a PGA greater than 0.32g (3.2 m/s^2).

iii Lithology

The Project is located in rocks belonging to Murree Formations. The Murree Formation is of early Miocene age, and consists of dark red to purple and greenish grey sandstone and siltstone, purple to reddish brown shale, mudstone and lenses of conglomerates. These rocks are exposed at the dam site and consist of alternate beds of sandstone and shale. Structurally, the formation shows a high degree of compression in the form of tight folding with repeated faulting and fracturing. At places, it shows open broad folds which have been weathered into steep ridges and valleys with a succession of cliffs and steep slopes.

The Murree Formation exposed in the Balakot area represent as last stages of Neo-Tethys and the beginning of Siwalick system in the area which is indicated by sandstone and shale deposits.

iv Soils

The soils of the Project area are composed of piedmont alluvial deposits, where upper layer of the plain/leveled land consists mostly of silty clay loam soils, rich in organic matter content. The subsurface strata are generally sandy loam with gravel. The soils of the hill slopes consist mostly of thin layered sandy loam soils, underlain by rocks or gravelly materials. The valley terraces in-between the mountains are very fertile and used for intensive cropping, while, the hill slopes are used for forest vegetative cover.

4. Climate

A regional climate overview was established using available data from Balakot weather station. This is the nearest Pakistan Meteorological Department (PMD) weather station to the Project. The climate analysis of Study Area was carried out based on climatic normal (1961 – 1990) developed by PMD and by classifying it into different seasons as follows:

i Summer (mid-March to mid-June)

Characterized by high temperatures, moderate rainfalls with moderate humidity and high speed-winds.

ii Summer Monsoon (mid-June to mid-September)

The summer monsoon, hereafter referred to as the Monsoon, is characterized by high temperatures (although milder than the summer), significantly high rainfalls with high humidity and moderate speed-winds, slightly lower than summers.

iii Post-Monsoon summer (mid-September to mid-November)

Characterized by moderate temperatures, low rainfalls with moderate humidity higher than summers, as the humidity again reduces after monsoon and low speed-winds.

iv Winter (mid-November to mid-March)

Characterized by very low temperatures, moderate rainfalls, with an increasing amount of rainfall at the end of the winter, with relative humidity greater than post-monsoon summer and moderate speed-winds.

Climatic normal data for the time period of 1961 – 1990 was compared with more recent data from 1991 – 2011 for temperature and precipitation. Climatic normal are based on 30-year period and developed by the PMD. The following conclusions can be drawn:

Temperature: There is slight variations in temperature observed in recent data as compared to climatic normal. The increase in mean temperatures in recent years is 0.2 °C. This shows that overall temperature is increased at the Project site.

Rainfall: The amount of rainfall only increased in the months of January, June and September by an amount of 1 mm, 3 mm and 29 mm, respectively. However, in the rest of the months the amount decreases. The decrease in annual amount of rainfall is 175 mm.

Possible reasons for the change in weather parameters may be because of climate change or urbanization, which can explain increased temperatures and decreased amount of rainfalls.

5. Water Resources

Water resources in the area consist of surface water including rivers and nullahs and groundwater including springs and boreholes.

i Regional Hydrology

The Dam and Powerhouse are located on the Kunhar River. The Kunhar River originates from the glaciers above Lulusar Lake in the Kaghan Valley of KP. Glaciers of Malka Parbat and Makra Peak and the waters of Saiful Muluk Lake feed the river. It passes through Jalkhand and meets Jhelum River at Rarra. The drainage area of the river is 2,535 km^2, with elevation ranging from 600 to 5,000 m. It is one of the biggest tributaries of the Jhelum River Basin and the only main tributary situated entirely in Pakistan's territory. Snowmelt from the Kunhar Basin contributes 65% of the total discharge of the Kunhar River and 20-40% of the Jhelum River at Mangla.

The Kunhar River has two temperature regimes; upstream of Kaghan the water is cooler with average summer temperatures of 8-10 °C and downstream of Kaghan temperatures are higher and near 12-13 °C. The Jhelum River at its confluence with the Kunhar has a temperature of 16-17 °C and the cooler waters of the Kunhar have a moderating influence on the Jhelum.

ii Dam Site Hydrology

The hydrology at the dam site is typical of Himalayan rivers, characterized by peak flows in the month of June associated with melting of snow at higher elevations in the catchment, followed by declining flows in the summer supported by monsoon rainfall and continuing snowmelt in the months of July and August. The dry or low flow winter season typically extends from October through February when the flows are reduced to the order of one sixth of peak in the month of June.

iii Community Water Supply Census

A census was carried out to map the community water resources for villages near Project facilities. A 500 m buffer around the underground headrace tunnel in the uphill direction and up till the Kunhar River in the downward direction was demarcated for the survey to account for the distance to which the impact of the tunnel on groundwater might possibly extend.

During survey, a total of 70 springs were identified and characterized within the hydro census area. Of the 70 springs, 1 went dry completely and did not used after the 2005 earthquake.

Based on the pH and electrical conductivity of the springs sampled the water is fresh and potable. The total number of households relying on the springs within the area covered by the hydro census is 1,905. The springs are the sole supply for the majority of households for potable water. 50% of active water sources are used to supply drinking water to livestock as well. This is in line with the socioeconomic surveys and discussions during the surveys across the Study Area, where it was reported the drinking water supply is largely, given some exceptions, from springs, and, given some exceptions, the livestock do not typically venture close to the river to drink river water, and are therefore, also reliant on spring water.

Small tanks are typically built around springs to store water, and act as constant head for water supply pipelines, or such that communities can manually draw water from the tank.

iv Demand for River Water for Other Uses

River water is not used for irrigation as the slopes on the river bank are steep, cost of pumping water to agricultural lands located at elevations above the river is high, and agriculture depends on rain and water available from streams flowing down the mountain slopes. There is no large or medium scale industry that depends on water, and level of industrialization is very low. River water is not suitable for drinking as it is contaminated by fecal coliform, and communities use water from springs for drinking purposes. Livestock is also mainly dependent on spring water and water from open mountain streams flowing down the slopes. River water can be turbid in seasons and use of river water by livestock is limited to a relatively small fraction of total households that are located close to the river. These uses are insignificant in comparison to the total flow of the river. Quantification of river water use was therefore not considered to be necessary. Identifications of community sources of drinking water, mainly springs, that could be potentially impacted by the project was carried out in detail and is described in the previous section.

v Water Quality

Water quality samples from Kunhar River and community springs were collected and analyzed for establishing baseline conditions for surface and groundwater.

Key observations on the basis of the results are as follows:

- All the water quality parameters (with the exception of microbiology) are within NEQS and WHO drinking water standards.
- All river and tributary water samples were found bacteriologically contaminated and unsatisfactory for drinking due to fecal contamination. Of the two springs tested, one contained bacteriological contamination while the other was satisfactory for drinking.
- Fifteen metals were analyzed for metal content and are found within permissible levels for drinking water NEQS. However, reported aluminum value at one location W4 (Talhatta gauging station, Kunhar River) is highest among all samples and is exceeding both the NEQS and WHO standards. This can be attributed due to higher colloidal particles in river water.
- No major differences were found within the water quality at all sampling locations.

6. Ambient Air Quality

The ambient air quality was measured for respirable particulate matter (PM), sulfur dioxide (SO_2) and oxides of nitrogen (NO_X). Air quality sampling was carried out at four different locations in the Study Area between March 19 and May 8, 2017.

Key observations on the basis of the results are as follows:

- The annual and 24-hour concentrations of SO_2, NO_x, NO_2 and NO comply with both the NEQS and IF-EHS limits.
- The 24-hour PM_{10} concentration comply with both the NEQS and IFC-EHS limits at all sampling locations. The 24-hour $PM_{2.5}$ concentration exceeds the NEQS at all sampling locations however, it complies with IFC-EHS interim target 1 at all locations except at A4 (Balakot town) where it exceeds both the NEQS and IFC-EHS limits.
- The concentration of all pollutants at A2 (near dam site) are lowest among all sampling locations.

7. Traffic

Traffic baseline is prepared to assess the current traffic conditions on the road route that will be used for the Project related transportation of services during construction and operation of the Project. The objectives of the traffic study are to document present traffic situation, identify existing road capacity, bottle necks (congestion points) and potential impacts due to the Project traffic during construction and operation.

Traffic counts were conducted at four locations. At the counting site, two people were stationed for daytime and two for nighttime to separately count the daily traffic in both directions. The traffic count was recorded over a 24-hour period on a weekday (May 4, 2017) and a weekend (May 7, 2017).

Key findings of the traffic count are presented below:

- There was an increase in traffic over the weekends for points T1 - Paras (about 25 to 30% more vehicles) and T2 - Sendori (50% increase in vehicles heading to Balakot town) as they are on the transit route to tourist locations.
- Although the morning peak (9 am) shows a significant drop over the weekends at T3 - Balakot market and T4 - Balakot (from 700-800 vehicles to 500-600 vehicles), the traffic volumes are still generally higher on the weekend with steady flows throughout the day.

8. Noise Levels

Noise measurements were taken at four locations considered representative of the nearby receptors of possible noise pollution from the Project.

Key findings of the noise measurements are presented below.

- **Small Town:** Noise levels in both the small towns of Paras (N1) and Sangar (N3) are well within NEQS noise limits and within IFC-EHS limits for most hours other than early morning hours in Paras where the nighttime limits are crossed.
- **Large Town:** The noise levels at N4, which was located within the market of Balakot Town were high and exceed both daytime and nighttime NEQS and IFC-EHS limits. Natural sources such as wind (of which the speed went up to 5.4 m/s during sampling) and river noise may also have contributed to the high noise levels.
- **Forests:** Noise levels at powerhouse site (N2) are steady throughout the day and night at around 50 dbA as there are no varying anthropogenic sources of noise in the area. Constant sources of noise include noise from the river and wind.

9. Overview of Biodiversity Values

i Aquatic Biodiversity

The main aspects of the aquatic biodiversity in the Aquatic Study Area include the fish fauna, macro-invertebrates, and riparian vegetation.

ii Overview of Fish Fauna in Jhelum River

The long-distance migratory species Alwan Snow Trout *Schizothorax richardsonii,* as well as the Himalayan Catfish *Glyptosternum reticulatum* and Kashmir Hillstream Loach *Triplopysa Kashmirensis* are widely distributed species and found in the Kunhar River upstream and downstream of proposed Project. The species Nalbant's Loach *Schistura nalbanti*, Stone Barb *Schistura alepidota*, Arif's Loach *Shistura arifi* and Flat Head Catfish *Glyptothorax pectinopterus* are mainly found in Kunhar River and tributaries downstream of the proposed Project dam but they are also recorded from few places upstream. The species Kunar Snow Trout *Schizothorax labiatus* is exclusively found in Kunhar River downstream of the proposed dam site. They tend to migrate in summers towards upper parts of the river. Two introduced species Brown Trout *Salmo trutta fario* and Rainbow Trout Oncorhynchus mykiss are found exclusively upstream of the proposed dam. These two are cold water species and of high food value. There is an extensive raceway culture of Rainbow Trout in the areas upstream and downstream of the proposed dam. Alwan Snow Trout (both upstream and downstream of the dam) and Kunar Snow Trout (mostly downstream of the dam) are two other species of food value. They are not cultured but are captured from the river.

A total of ten species have been reported from the Kunhar River based on the surveys carried out in February 2017 and May 2017 as a part of this study, in July 2016 as a part of the Biodiversity Strategy for Jhelum Poonch River basin – Preparatory Phase, and advice from Dr Muhammad Rafique, a fish expert with the Pakistan Museum of Natural History (PMNH). Out of these, one species is a long-distance migratory species and two are endemic to the Jhelum Basin.

iii Migratory Fish Species

Based on the surveys carried out in July 2016 and February and May 2017, the Aquatic Study Area contains one long distance migratory species, the Alwan Snow Trout *Schizothorax richardsonii*. The species is listed as Vulnerable on the IUCN Red List.

iv Endemic Fish Species

There are two fish species endemic to the Jhelum Basin, found in the Aquatic Study Area the Nalbant's Loach and the Kashmir Hillstream Loach. The ranges for these species are shown in Error! Reference source not found. and Error! Reference source not found.. The Nalbant's Loach prefers shallow water, mainly riffle habitat in tributaries. Damming will alter its habitat irreversibly causing drastic population declines. The Kashmir Hillstream Loach prefers shallow riffles and spawns in side channels. A Critical Habitat Assessment, carried out as part of the Ecology Baseline, determined that the Project is located in Critical Habitat based on the population of the endemic species in the Discrete Management Unit (DMU) defined for the Critical Habitat Assessment of the Project.

v Macro-invertebrates

Based on surveys carried out for the EIA the most abundant macro-invertebrate taxa reported include *Baetis sp.* followed by *Rhithrogena sp.*. Abundance was found to be highest upstream of Paras village. Species richness was found to be the same throughout the Aquatic Study Area.

vi Riparian Vegetation

The dominant species include *Parthenium* hysterophorus. *Conyza Canadensis* and *Rumex* dissectus. Vegetation cover was reported as ranging between 1.48% and 0.52%, average plant count was 27.5 and floral diversity was reported as 3.25 species per Sampling Location. One of the dominant plant species in the Riparian zone is the invasive species *Parthenium* hysterophorus.

vii Overview of Socioeconomic Environment

Rural settlement surveys were undertaken in selected settlements with river dependence or within 1 km of Project facilities. Detailed interviews were conducted with key informants to gather information on each settlement's social and economic setup, with focus on infrastructure and livelihoods.

A total of 31 settlements were surveyed during the field work, ranging in size from 3 households to 1,500 households. Both the right and left banks of the river are almost similar in terms of settlement distribution and size, and the average households per settlement in all zones is 128. The average household size in the Socioeconomic Study Area is 6.2 individuals, with a minimum of 3.5 and a maximum of 10.

People in the pastoral communities within the Socioeconomic Study Area have a trend of seasonal migration, with one home close to the river and one at higher elevations. These communities move their livestock herds to higher elevations in the mountains for grazing during the summer. Migration into and out of the Socioeconomic Study Area was found to be insignificant over the past 7 years.

People from 7 different casts are resident in the Socioeconomic Study Area, with Gujjar and Syed being the biggest groups. The predominant language is Hindko, however, Gojri is also widely spoken. Urdu, the language of communication is also understood everywhere especially amongst the youth.

School enrolment for both boys and girls was found to be comparable at all levels, in fact enrolment of girls is actually higher in many cases.

Most parts of the Socioeconomic Study Area have access to basic health facilities, such as pharmacies, lady health visitors/workers and dispensaries. No disease was reported as an epidemic, and as expected, the most common illness reported in the adult male and female populations was flu/fever. Other illnesses reported included dysentery, diabetes and jaundice.

The settlements situated on the left bank of Jhelum River in the Socioeconomic Study Area are well connected as there is a road running along the river for its entire length in the area. Communities residing on the right bank are not as well connected, however suspension bridges and unsealed roads do connect them to major roads.

Most surveyed settlements reported having access to a public potable water supply system consisting of a central water storage system, where water collects from a mountain spring and is supplied to the community via a pipeline up to a central point in the community. Almost all surveyed settlements also reported having access to spring water at relatively short distances.

None of the settlements surveyed in the Socioeconomic Study Area are connected to a municipal sewage system. Most human waste is disposed of in septic tanks and all other wastewater eventually runs off into the Jhelum River. Most settlements surveyed reported access to pit latrines of some type.

The three major fuel sources in the Socioeconomic Study Area include electricity, fuelwood and liquefied petroleum gas (LPG). Natural gas is not supplied in the area. None of the settlements are connected to the country's landline telephone network, however most of the area does receive a mobile phone signal.

The Socioeconomic Study Area and surroundings are generally peaceful, and there are no major law and order problems reported. Police check posts are only present on main Kaghan Highway. Police check posts monitor incoming traffic to tourist areas, to determine purpose of visitors to the valley.

Banks and markets are available mainly in Balakot city. Shops are present on main Kaghan Highway. The shops provide for the day to day needs of the local communities or to supply travelers and tourists. For major purchases all settlements in the survey area depends mainly on Balakot city, which is the hub of economic activity in the region.

55% of the total employable population is employed while 25% are unemployed. The remaining are students, retired and others such as labor and small business operators.

The major sources of income are private and government services and business while other significant livelihoods include wage labor, and work as skilled artisans. A significant portion of households in the Socioeconomic Study Area earn less than PKR 25,000 and can therefore be considered impoverished.

The average landholding in all settlements ranges from 4 to 7 kanals per household. The largest landholding size was reported as 7.67 kanals. The main winter crop in all zones is wheat and the main summer crop is maize. Most agricultural land is rain fed with almost no dependence on river water for irrigation. The agricultural economy is purely subsistence in nature.

Livestock commonly owned include bullocks/buffalos, cows and goats. Livestock owners often engage herders to rear goats, whereas poultry, cows and buffalo are reared at home.

River dependent socioeconomic activities in the Socioeconomic Study Area were found to be quite limited.

Sediment (sand, gravel and cobble) mining is carried out throughout the Study Area. The mineable sediment resource is being extracted to meet small-scale construction demand, involving construction and maintenance of local residential and commercial buildings as well as for roads. Miners in the Balakot area reported that the import of sediment varies from year-to-year depending on the status of construction industry.

The mining techniques are crude, involving use of labor for dredging. No mechanical extraction was observed anywhere in the Study Area except Jagir (Thanda Mor) where sand is extracted through an excavator. The sand and gravel is mined using shovels and spades and is loaded onto animals and vehicles, from where it is transported to the roadside.

Fishing for self-consumption was observed in the Study Area. Fishing as a business was not observed in any of the six zones except in Zone 5 at Balakot. Even here it was on a small scale to meet the local restaurant clientage. The fishing season lasts between six months through the year, depending on the fish species caught.

Fuel wood is the main source of energy for domestic cooking and heating. Respondents reported that fuel wood is collected from the farmlands and dead-fallen trees in the forests. There is limited dependence on driftwood collected from the riverbanks as source of fuel wood except in settlements at the peripheries of Balakot where the river flows through more plain areas creating room for such activities

Recreational dependence on the river was reportedly low in all the zones. During the survey the respondents did not cite riverside fishing, boating or picnics as a major recreational activity. However, the roadside hotel owners reported that riverside recreation was popular to certain extent among the tourists from other areas.

viii Project Impacts

A summary of Project impacts is presented in table below.

Summary of Significant Impacts

ID	Aspect	Impact	Phase	Stage	Magnitude	Timeframe	Spatial Scale	Consequence	Probability	Significance	+/-
1	Aquatic Ecology	Change in the Ecological Integrity through implementation of the BAP (see Volume 2C of the EIA)	C, O	Init	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	+
2	Aquatic Ecology	Loss of riverine ecosystem due to inundation by Project Reservoir	C, O	Init	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-
				Res	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-
3	Aquatic Ecology	Degradation of the river ecosystem in the low flow segment downstream of the Project dam	C, O	Init	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-
				Res	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-
4	Aquatic Ecology	Degradation of the River Ecosystem Downstream of the Tailrace	C, O	Init	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-
				Res	Moderate	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	+
7	Terrestrial Ecology	Project operation leading to animal disturbance, displacement and decline.	O	Init	Minor	[redacted]	Small	Medium	Possible	Medium	-
				Res	Minor	Medium	Small	Low	Possible	Low	-
8	Ambient Air Quality	Increase in ambient and ground level concentration of air pollutants from construction activities and vehicular movement may cause health impacts to the community.	C	Init	Moderate	Medium Term	Small	Medium	Possible	Medium	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
9	Blasting and Vibration	Vibration from blasting during the construction phase may disturb local communities	C	Init	Moderate	Medium Term	Intermediate	Medium	Possible	Medium	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
10	Blasting and Vibration	Blasting may pose a health hazard due to flying debris.	C	Init	Moderate	Short Term	Intermediate	High	Possible	Medium	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
11	Hydrology and Water Quality	Alterations of natural passage of springs due to blasting for tunnels may disrupt the water supply for mountain spring users.	C	Init	Moderate	[redacted]	Intermediate	[redacted]	Possible	[redacted]	-
				Res	Minor	Medium	Intermediate	Low	Possible	Low	-

ID	Aspect	Impact	Phase	Stage	Magnitude	Timeframe	Spatial Scale	Consequence	Probability	Significance	+/-
12	Hydrology and Water Quality	Use of local water resources for construction activities may reduce the water availability for local communities.	C	Init	Moderate	Short Term	Intermediate	Medium	Possible	Medium	-
				Res	Minor	Short Term	Small	Low	Unlikely	Low	-
15	Soil, Topography and Land Stability	Contamination of soil as a result of accidental release of solvents, oils and lubricants can degrades soil fertility and agricultural productivity.	C	Init	Moderate	Medium	Intermediate	Medium	Possible	Medium	-
				Res	Minor	Medium	Intermediate	Low	Unlikely	Low	-
17	Soil, Topography and Land Stability	Failure of spoil dumping sites resulting in increased erosion and sediment load entering river.	C	Init	Moderate	[redacted]	Intermediate	[redacted]	Possible	[redacted]	-
				Res	Moderate	Medium Term	Intermediate	Medium	Unlikely	Low	-
26	Livelihood and Well-being	Direct, indirect and induced employment at the local levels, resulting in increased prosperity and wellbeing due to higher and stable incomes of people.	C, O	Init	Minor	[redacted]	[redacted]	Medium	Possible	Medium	+
				Res	Moderate	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	+
27	Livelihood and Well-being	Increase in the stock of skilled human capital due to transfer of knowledge and skill under the Project resulting in enhanced productivity of the local labor.	C, O	Init	Minor	[redacted]	Intermediate	Medium	Possible	Medium	+
				Res	Moderate	[redacted]	[redacted]	[redacted]	Possible	[redacted]	+
28	Livelihood and Well-being	Increase in recreational and subsistence fishing due to increase in catch of fish following creation of favorable habitats for the fish in the Kunhar River	C, O	Init	Minor	[redacted]	[redacted]	Low	Possible	Low	+
				Res	Minor	[redacted]	[redacted]	Low	Possible	Low	+
29	Livelihood and Well-being	Loss of income from sediment mining due to change in pattern of sediment deposition following construction of the dam	O	Init	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	-
				Res	Minor	Medium	Small	Low	Possible	Low	-

ID	Aspect	Impact	Phase	Stage	Magnitude	Timeframe	Spatial Scale	Consequence	Probability	Significance	+/-
30	Livelihood and Well-being	Loss of assets and livelihood as a result of land acquired for the Project	D, C	Init	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	-
				Res	Minor	Medium	Small	Low	Possible	Low	-
31	Socio-Cultural Impacts	Increase in population due to in-migration of job seekers (in-migrants) leading to pressure on existing social infrastructure and services in the Study Area.	C	Init	Moderate	Medium	Intermediate	Medium	Possible	Medium	-
				Res	Minor	Medium	Intermediate	Low	Possible	Low	-
32	Socio-Cultural Impacts	Disputes over distribution of Project employment within and between Study Area inhabitants and the in-migrants resulting in social unrest	C	Init	Moderate	Medium	Intermediate	Medium	Possible	Medium	-
				Res	Minor	Short term	Intermediate	Low	Possible	Low	-
33	Socio-Cultural Impacts	Potential social unrest in the Study Area due to conflicting socio-cultural norms amongst the inhabitants and in-migrants.	C	Init	Minor	Short term	Small	Low	Possible	Low	-
34	Socio-Cultural Impacts	Submergence of the graveyards.	C	Init	Moderate	Medium	Intermediate	Medium	Possible	Medium	-
				Res	Minor	Short term	Intermediate	Low	Possible	Low	-

C: Construction (and pre-Construction); O: Operation; Init: Initial; Res: Residual; Duration: Short (less than four years), Long (beyond the life of the Project)

Frequency: High (more than 10 times a year), Low (less than once a year)

10. The Biodiversity Management Plan

A Critical Habitat Assessment deduced that the Project is located in a Critical Habitat due to the presence of valued aquatic biological resources, including the restricted range or endemic fish species Nalbant's Loach *Schistura Nalbanti* and Kashmir Hillstream Loach *Triplophysa kashmirensis*. In addition, the Kunhar River provides habitat for the Alwan Snow Trout *Schizothorax richardsonii* which is migratory fish and listed as Vulnerable in the IUCN Red List. According to the International Finance Corporation's Performance Standard 6 (IFC PS6), in Critical Habitats 'Net Gain' is required for those values for which Critical Habitat has been designated. This can be done through the development of a biodiversity offset and/or, through the implementation of programs that could be implemented in situ (on-the-ground) to enhance habitat, and protect and conserve biodiversity.' This Biodiversity Action Plan (BAP) has, therefore, been prepared to support the corporate commitments of the Pakhtunkhwa Energy Development Organization (PEDO) for conserving biodiversity as well as to meet the requirements of IFCs PS6 and ADB's Safeguard Policy Statement 2009 for the Project.

11. Spatial and Temporal Scope of the Biodiversity Management Plan

The selection of geographic scope of the BAP has been defined to incorporate an area where biodiversity will be directly impacted by the Project. This area is defined as the Area of Management, and includes an impact zone of about 45 km length of river. The Area of Management includes the reservoir of the Project, 4 km upstream of where the Project dam will be constructed, and extends to 5 km upstream of the Patrind dam but excluding the reservoir of Patrind HPP. The Area of Management also includes segments of the Barniali, Ghonul, Jalora, and Shisha Nullahs.

Protection of the terrestrial ecological resources in the Area of Management has not been included in the BAP. This is because Project construction and operation impacts on terrestrial flora and fauna are not likely to be significant. In addition, there are no Protected Areas near the Area of Management. Any potential impacts on the terrestrial biodiversity will be mitigated and managed through the implementation of the Environment Management Plan.

12. Proposed Conservation Measures

The strategy and approach used for protecting the biodiversity includes the following:

- Setting up an effective and efficient watch and ward system that will help to reduce the existing anthropogenic pressures in the Area of Management which is central to keeping the integrity of the Area of Management of the BAP intact. This will:
    - Curtail illegal fishing including non-selective fishing, fishing in breeding season of fish, fishing in river tributaries.
    - Regulate sediment mining to maintain it at sustainable levels and prevent sediment mining from ecologically sensitive locations.
- Promote environmental awareness among the local communities and engage them in protecting the ecological resources
- Institutional strengthening of custodian government departments

13. Control of Illegal Fishing

The following measures will be implemented by the Fisheries Department, KP and Wildlife Department, KP (referred to as Departments) with support from Project for conserving the fish populations of the Kunhar River.

- Non-selective fishing using fine mesh gill nets, poisons and dynamites will be completely controlled in the entire stretch of the Kunhar River.
- Fishing in the tributaries that are breeding grounds of fish will be banned.
- Fishing during the breeding season of the fish (May – August) will be banned.
- Fishing in habitats identified as sensitive particularly for the fish species of conservation importance will be restricted or banned, with special attention to sections of tributaries that are breeding grounds of fish.
- Commercial fishing will not be allowed either in the river and its tributaries or in the reservoir.
- The above rules and regulations will be strictly implemented with an efficient and effective watch and ward system.
- Subsistence fishing using rods and cast nets with limited weights will be allowed through a permitting system in the reservoir created upstream of the dam, and downstream of the dam when the KP Fisheries Department considers the fish populations to have recovered.
- Angling will be allowed to attract visitors and develop the educational and recreational value of the river when the KP Fisheries considers the fish populations to have recovered.

14. Regulation of Sand and Gravel Mining

Sediment mining will only be allowed in designated areas and banned from ecologically sensitive areas such as habitat of fish of conservation importance, and fish breeding locations in tributaries. An Outline for Sediment Mining Management Guidelines is provided in the BAP. The Sediment Mining Guidelines will ensure that a balance is achieved between meeting community needs for sand and gravel as well as the integrity of aquatic habitat in the Area of Management such that the habitat is not excessively damaged due to uncontrolled mining activities on the river bed.

15. Awareness among Local Communities

An Awareness and Education Program will be initiated to inform and educate the local communities about the importance of the biological resources of the area and actions required for their protection.

16. Human Resources for Management of Aquatic Biodiversity

As part of the BAP, PEDO will provide funds to support an improved watch and ward system within the Area of Management. This will include construction of field offices, hiring of additional staff members (watchers), and necessary equipment and facilities. Mining inspectors will be hired to prevent sand and gravel extraction from ecologically sensitive locations. Social mobilizers will be hired for education and awareness-raising of the local communities.

17. Establishment of an Institute for Research on River Ecology (IRRE)

The IRRE is proposed as a basin wide institution in which all the developers of HPPs in the Jhelum Poonch and Kunhar basin contribute to establishment and operation of the institute, and jointly benefit from the research outputs. The initiative is the outcome of the International Finance Corporation of the World Bank (IFC) initiative to set up a Hydropower Working Group for the basin, through which the project owners can cooperate and collaborate to collectively manage the basin in a sustainable manner. The proposed institute will help the project owners in maintaining ecological databases and research and analysis capabilities that will benefit them individually by lowering their environmental management costs. PEDO will contribute to the establishment and operation of an Institute for Research on River Ecology (IRRE), subject to approval of associated costs in the tariff by the National Electric Power Regulatory Authority (NEPRA).

18. Establishment of Watershed Management Program (WMP)

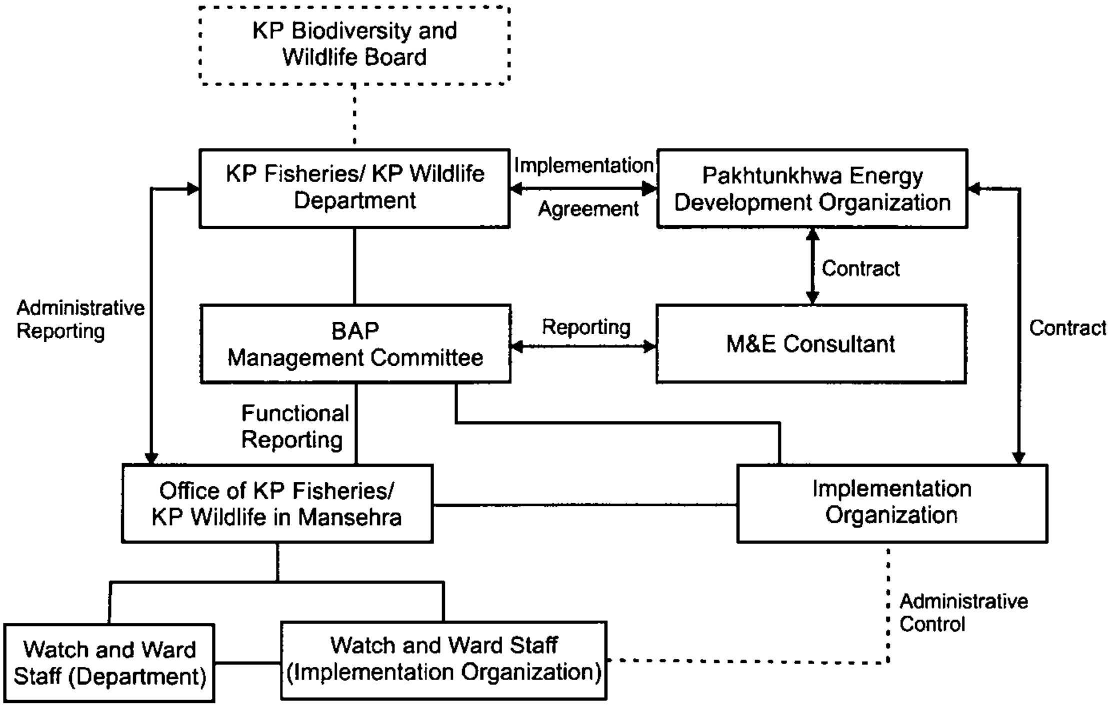
The Watershed Management Program (WMP) will primarily focus on improvement of water quality in the Kunhar basin that is critical for protection of biodiversity in the long term. The institutional and financial model for setting up watershed management institutions will be similar to that proposed for the IRRE but will be restricted to the Kunhar basin. The support provided by PEDO and project owners in this case, however, will be limited, as additional support and resources will be mobilized from the participating government departments which will include forests, wildlife, agriculture, and irrigation. Action areas may include, but not be limited to, land use management and reforestation to reduce erosion and risk of landslides and to meet community needs for fuel wood and timber, management of water use, and control of water quality. As in the case of the IRRE, PEDO will contribute to the establishment and operation of a WMP subject to approval of associated costs in the tariff by the NEPRA.

19. Institutional Arrangements for Implementation of BMP

In Khyber Pakhtunkhwa (KP), the responsibility for watch and ward of the terrestrial and aquatic ecological resources lies with the Wildlife Department, while the Fisheries Department regulates recreational fishing and is also responsible for management of water quality of the river. It is therefore not clear which department will take the lead in supporting implementation of the BAP. For the purpose of this Draft BAP, both organizations have been proposed and a decision can be taken by the KP Government about which department will finally be designated.

PEDO will support an Implementing Organization which will implement the actions outlined in the BAP with support from KP Fisheries/Wildlife Department. A BAP Management Committee in KP will be established, which will be responsible for reviewing the reports submitted by the Implementation Organization and the M&E Consultant, reporting to on an annual basis and coordination with a high level oversight body such as KP Wildlife Management Board, and providing directions to the staff of the Department, Implementation Organization, and the M&E Consultant for improving the effectiveness of the implementation of the BAP.

Institutional Arrangements for Implementation of BMP in KP



20. Monitoring and Evaluation Framework and Adaptive Management

A Pressure-State-Response (PSR) framework will be used for monitoring of effectiveness of implementation on the BAP. The type of indicators proposed for monitoring the pressures are:

1. The total amount of fish by species being harvested in a year, for subsistence and recreational purposes, through legal as well as illegal means.
2. Total amount of sand and gravel extracted from the river and tributaries, separately reported or estimated for extraction through legal means (with permits at designated mining sites) and through illegal means (without permits).

Indicators of state will include hydrology, water quality, catchment, and fish. The method of data collection, frequency and timing of collection as well as data analysis is included in a detailed Monitoring and Evaluation Plan prepared for the BAP. The methodologies will be adjusted and adapted over time where required to facilitate assessment.

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ZEERUK INTERNATIONAL (Pvt.) Ltd.

TA-9185 PAK: Hydro Power Development Investment Program
PPTA Consulting Firm (49055-001)

300 MW BALAKOT HYDROPOWER PROJECT PPTA

Final Report
UPDATED FEASIBILITY STUDY
VOLUME 1 - MAIN REPORT
(rev. 2)

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TA-9185 PAK: Hydropower Development Investment Program

PPTA 300 MW BALAKOT HYDROPOWER PROJECT

UPDATED FEASIBILITY STUDY

VOLUME 1 - MAIN REPORT

PROJECT INFORMATION:

Client: Asian Development Bank (ADB) / Pakhtunkhwa Energy Development Organization (PEDO)

Contract n.º: 130499-S52967 (ADB reference)

Designation: TA-9185 PAK: Hydro Power Development Investment Program - PPTA Consulting Firm (49055-001)

Authors: Aqualogus, Engenharia e Ambiente, Lda. (AQUA)
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Prepared by: AQUALOGUS, TEAM, ZEERUK

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1	203.01-D2.2B-1	31-05-2019	Revision as per ADB comments and geological information for the powerhouse and tailrace	FC	FC
2	203.01-D2.2B-2	03-07-2019	Revision as per DSP and PEDO comments	FC	FC

300 MW BALAKOT HYDROPOWER PROJECT PPTA

FINAL REPORT

UPDATED FEASIBILITY STUDY

VOLUME 1 – MAIN REPORT

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ABBREVIATIONS

ADB	Asian Development Bank
AC	Alternating Current
ADCP	Acoustic Doppler Current Profilers
AEP	Annual Exceedance Probability
AIS	Air Insulated Substation
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BD	Bidding Documents
BH	Borehole
BHP	Balakot Hydropower Project
BOQ	Bill of Quantities
CAPEX	Capital Expenditures
CB	Circuit Breaker
CCGT	Combined Cycle Gas Turbine
CN	Curve Number
COD	Commercial Operations Date
CPEC	China-Pakistan Economic Corridor
CT	Current Transformer
DBE	Design Basis Earthquake
DC	Direct Current
DEM	Digital Elevation Model
DSHA	Deterministic Seismic Hazard Analysis
DWT	Deadweight tonnage
E	Energy
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
EPC	Engineering, Procurement and Construction
GCB	Generator Circuit Breaker

GIL	Gas Insulated Line
GIS	Gas Insulated Substation
GIS	Geographic Information System
GLOF	Glacial Lake Outburst Floods
GOP	Government of Pakistan
GOKP	Government of Khyber Pakhtunkhwa
GPS	Global Positioning System
GWh	Giga Watt hour
HadCM3	Hadley GCM 3 model (HadCM3)
HEC-HMS	Hydrologic Engineering Centre - Hydrologic Modelling System
HEC-RAS	Hydrologic Engineering Centre - River Analysis System
HPP	Hydropower Project
HPU	Hydraulic Power Unit
HV	High Voltage
HWSD -	Harmonized World Soil Database
Hz	Hertz
ICOLD	International Commission on Large Dams
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IPD	Isolated Phase Bus
IPBD	Isolated Phase Bus Duct
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
ISO	International Organization for Standardization
JV	Joint Venture
Kg	Kilogram
km	Kilometre
kN	Kilo Newton
KP or KPK	Khyber Pakhtunkhwa
kV	kilo Volt
LAN	Local Area Network

LCU	Local Control Unit
LED	Light-Emitting Diode
LRMC	Long Run Marginal Cost
m	Meter
M	Million
m.a.s.l.	Meter Above Sea Level
m^3	Cubic Meter
m^3/s	Cubic Meter per second
MBT	Main Boundary Thrust
MCC	Motor Control Center
MCE	Maximum Credible Earthquake
MCL	Manual Control Level
MDE	Maximum Design Earthquake
MFL	Maximum Flood Level
MFT	Main Frontal Thrust
Min	Minute
MMI	Modified Mercalli Intensity
MSSP	Micro Seismic Studies Programme
MV	Medium Voltage
MVA	Mega Volt Ampere
MW	Megawatt
MWh	Megawatt-hour
NEPRA	National Electric Power Regulatory Authority
NOL	Normal operation level
NPCC	National Power Control Center
NPV	Net Present Value
NTDC	National Transmission and Despatch Company
NWFP	North West Frontier Province
OBE	Operating Basis Earthquake
OCGT	Open Cycle Gas Turbine
O&M	Operation and Maintenance

OPEX	Operational Expenditures
P	Power
PAEC	Pakistan Atomic Energy Commission
PCS	Plant Control System
PEDO	Pakhtunkhwa Energy Development Organization
PESCO	Peshawar Electric Supply Company
PGA	Peak Ground Acceleration
PSR	Phase Supervision Relay
PHYDO	Pakhtunkhwa Hydel Development Organization
PLC	Programmable Logic Controller
PMD	Pakistan Meteorological Department
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PMS	Probable Maximum Storm
PPIB	Private Power Infrastructure Board
ppm	Parts per Million
PPTA	Project Preparatory Technical Assistance
PSHA	Probabilistic Seismic Hazard Analysis
Q -	Discharge
RCC	Regional Control Centers
RMR	Rock Mass Rating
RQD	Rock Quality Designation
Rs	Pakistani Rupees
RTD	Resistance Temperature Detector
s	Seconds
SBT	Sediment By-pass Tunnel
SCADA	Supervisory Control and Data Acquisition
SCF	Safety Check Flood
SCS	Soil Conservation Service
SEE	Safety Evaluation Earthquake
SHYDO	Sarhad Hydel Development Organization

SOP	Survey of Pakistan
SPT	Standard Penetration Test
TBM	Tunnel Boring Machine
T_{max}	Maximum temperature
T_{min}	minimum temperature
TOR	Terms of Reference
TS	Technical Specifications
UPS	Uninterruptible Power Supply
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
USD	United State Dollars
V	Volt
VA	Volt Ampere
VT	Voltage Transformer
WACC	Weighted Average Cost of Capital
WAPDA	Water and Power Development Authority
XLPE	Cross-linked Polyethylene

EXECUTIVE SUMMARY

The present document is the *Updated Feasibility Study* ("the Report") of the 300 MW Balakot Hydropower Project. The Report has the main objective of developing and presenting, at a feasibility level, the proposed technical solution for the hydropower scheme.

The Report includes a revision of the Basic Studies carried out and included in the preceding reports, namely regarding hydrology, sediments, seismic and geology. It also provides a context of the current project development stage, as well of the previous work performed and that supports the envisaged technical solution.

The proposed project layout closely follows the recommended arrangement in the *D2.2A - Alternative Locations and Layout Analysis Study*. Key differences are the realignment of the tailrace, with a shorter length and an outlet portal at a higher elevation, which motivated a slight decrease in the scheme's gross head. An additional important element now considered is the downstream surge shaft that the results of the transients analysis motivated. The overall solution was developed with the existing topography survey from the 2013 Feasibility Study (FS2103) and a recently executed complement for the tailrace end area.

The hydrology and sediments are generally kept according to the prior D2.2A study. The proposed peak design discharge for the spillway, corresponding to a 10 000 year period, is 3 500 m^3/s. The proposed safety check flood, corresponding to the Probable Maximum Flood (PMF) peak, is 5 000 m^3/s. The modular flow at the intake section is 87 m^3/s. The flow regime is typical of high mountain areas, with higher flows during springtime. The average flow with 80% exceedance probability is 23 m^3/s. The proposed estimate for the mean annual sediment load at Balakot intake section, considering the effect of the upstream reservoir of Suki Kinari, is 420 kton.

The Report also includes a reservoir sedimentation and flushing analysis, based on a simulation model. The obtained results indicated a 77% trap efficiency of the reservoir. It was also possible to determine that only very small particles (0.0625 to 0.125 mm) are anticipated to enter the power circuit. However, it is expected that the significant capacity of the flushing arrangements will be able to maintain the reservoir operational throughout the project life, although requiring periodic mechanical interventions inside the reservoir to move sediments closer to the flushing intakes. Coordination with Suki Kinari flushing operations is also considered of the utmost importance.

From a neo-tectonic perspective, the project is located on the northern tip of the Hazara-Kashmir syntaxial bent, close to the boundary between the Indian plate and Kohistan Island arc, which is sandwiched between the Indian and Eurasian tectonic plates. It is, therefore, a

collisional zone of the plate boundaries, seismically very active. The seismic studies recommend a horizontal Peak Ground Acceleration (PGA) associated with the SEE of 0.90g (84-percentile). The recommended horizontal PGA associated with the OBE is 0.29g (with a return period of 475 years) for the design of the dam.

The geological studies included field investigation works in the proposed dam location, in the headrace tunnel alignment, in the powerhouse and in the tailrace alignment. Geological mapping of the dam and headrace areas was also carried out, as well as of the reservoir area. Per the site investigation data, no faults and shears were identified at the dam site. The analysis and interpretation of dam site boreholes rock mass data supported the definition of the foundation design parameters.

The geology of the reservoir area was also appraised, and historical landslide areas were identified, in particular the ones associated with the MBT. The presence of adverse material composition, the MBT as a major weak structural layer and the manifestation of the active sliding at the face of reservoir bank, indicates the potential of bank slope instability. Therefore, an analysis of the impact in the reservoir of a large-scale landslide was performed. It was assumed that an event with an earthquake of more than 7 magnitude and heavy rains for prolonged periods could lead to a total potential volume displacement of 300 000 m^3. The resulting induced wave in the reservoir and run-up at the dam were calculated for the referred scenario, with a resulting dam overtopping height of about 2 m. Subsequent stability calculations for the referred overtopping show that the dam remains stable under such conditions.

The scan line mapping along the Naran Road indicated the presence of faults and shear zones. Some of these features could potentially intersect the proposed headrace tunnel. The main shear and fault sets have dip and dip direction of 34/023, 26/250, 45/205 and 79/202. The analysis and interpretation of tunnel boreholes rock mass data supported the definition of the design parameters with disturbance factors of 1, 0.5 and 0. The presence of the weak rocks along the tunnel alignment, such as shale and claystone, indicates potential of squeezing. Based on the interpretation and analysis of tunnel boreholes data, the rock mass ratings of claystone range between 12-59, sandstone 7-56 and siltstone 38-54. Claystone and sandstone fall under very poor to fair rock quality and siltstone falls under poor to fair rock quality. The slake durability test results showed a high percentage of durability against slaking.

Phase III site investigations included drilling of boreholes at the powerhouse and tailrace tunnel. Borehole BH-301 was drilled at the powerhouse site and no faults and shears were identified. The obtained RMR and Barton Q ratings indicate a good quality rock mass. Boreholes BH-302 and BH-303 were executed along the tailrace alignment. For BH-302, RMR and Barton classification render the rock mass as fair to good quality. In the case of BH-303, the same criteria points to a fair to poor rock mass quality.

A hydropower scheme simulation model was used to determine energy generation. Such model was developed for a daily time step and considered the intraday regulating effect of the Suki Kinari scheme upstream. Average annual energy is approximately 1140 GWh, where about 380 GWh in peak hours, leading to a plant capacity factor of 43%. The average firm peak power, for a 90% exceedance probability, is about 160 MW (the firm average power is about 27 MW). Full power during peaking period is estimated to be achieved, on average, about 55% of the time. The decrease in production relative to the previous studies is due to the reduction in the gross head and, importantly, the increase in the ecological flow.

The energy simulation analysis was also performed for projected daily flow series under climate change scenarios. The obtained results indicate that the Balakot hydropower plant is expected to increase the overall annual energy production in about 8% for the future, while reducing its peaking ability in about 5%.

The capacity optimization analysis showed that the economic difference, measured by the NPV, for design flows in the approximate range of 120 to 170 m^3/s (roughly corresponding to 240 - 330 MW), would not be very significant. The benefits valuation was based on the LRMC proxy approach. A turbine design flow of 154 m^3/s was therefore selected, which corresponds to an installed capacity at the generators of 300 MW.

Hence, the proposed hydropower scheme in this Report has the following main components: 58 m high gravity concrete dam above foundation, 640 m long sediment by-pass/diversion tunnel, 9.1 km long concrete lined headrace tunnel with 8 m internal diameter, 122 m high surge shaft with 14.5 m inner diameter, 5.6 m diameter steel lined pressure shaft and penstock, cavern power house for 3 Francis groups with 300 MW installed capacity (for a 218 m reference net head and 154 m^3/s turbine flow), 244 m high downstream surge shaft with 3 m internal diameter, and 1.6 km long tailrace tunnel.

The dam structure is a concrete gravity, with a curved axis in plane and a radius of 187 m. The dam crest elevation is 1292.00 masl and the crest length is approximately 130 m. A crest width of 8.5 m is proposed to ensure adequate access for vehicles, cranes and other maintenance equipment. The dam will create a 2.2 km long reservoir, with a gross storage of 3.6 million m^3 at the normal operation level (NOL) 1288.00 m.a.s.l.

The proposed underground powerhouse is composed of two conventional cavern structures for three identical Francis units with vertical axis and for the power transformers and GIS equipment. The turbine axis is defined at elevation 1054.00 m, according to the estimated requirements to prevent cavitation of the turbines. The anticipated dimensions of the powerhouse main cavern (machine hall) are as follows: 20 m width, 71 m length and 34 m height. The single-phase transformers are arranged in a smaller cavern next to the main powerhouse cavern. The transformers' cavern is approximately 14 m wide, 15 m high and 88 m long. The caverns' cover depth is *circa* 230 m.

The concrete gravity dam stability was analysed following the linear pseudo-static (seismic coefficient) method for the most pertinent design scenarios. The safety evaluation was done by comparing the factors of safety (*i.e.* the ratio between the stabilizing forces/moments and the destabilizing forces/moments) obtained for two representative dam sections – spillway section and the highest generic section – with the adopted minimum allowable factors of safety for each design scenario. The results show that the proposed concrete gravity dam solution complies with the stability criteria for all scenarios, except for the sliding stability verification in the SEE scenario. However, a more suitable method of analysis was employed for such extreme conditions - the Permanent Displacement Method. The results obtained with this method point to a stable dam state. Therefore, the analysed concrete gravity dam solution was considered safe for all design scenarios.

The HEC-RAS 5.0.7 was used for the dam break study that included also the upstream Suki Kinari dam. The results of the model, with the dam break hydrographs, indicate a very severe flood wave that impacts the Kunhar River from the Suki Kinari dam and Balakot dam sites to the Patrind HPP. There is a relevant number of bridges, as well as many kilometres of roads along the flood path which would likely suffer damage in the dam break scenarios modelled. The population-at-risk (PAR) was estimated at 6150 in the reference scenario. The analysis indicates that the dam should be classified as 'High' potential impact category due to the significant PAR and the likely damage to infrastructure being major or catastrophic.

The Report includes a description of the hydromechanical, electromechanical and electrical equipment. The hydromechanical equipment mainly encompasses the racks, gates and stoplogs. The electromechanical equipment includes the turbines, cranes, lifting beams, turbidity/sediment measurement installations and the powerhouse auxiliary mechanical equipment. The group's generators are considered in the electrical equipment. The automation and remote control requirements are also presented, covering both local and remote control, as well as the integration with other plants in the Kunhar river cascade.

The grid interconnection study (GIS) of the Balakot Hydropower project is also included in the Report in its Draft version. The GIS considers the installed capacity of the plant with three generating units, where two will be at 500 kV and one unit will be at 132 kV to supply the local grid of the Balakot area. Steady state analysis by load flows, short circuit and stability criterion reveals that the proposed scheme is adequate to export 300 MW output from the plant under normal and contingency conditions. The dynamic stability analysis of the proposed scheme of interconnection has been carried out and the system is deemed stable for all the tested fault conditions.

The work quantities for the scheme construction were estimated. The dam and associated structures concrete volume is 194 000 m^3. The project overall excavation volume is estimated at 1.7 x 10^6 m^3, where about 60% correspond to underground excavation.

The estimate for the project investment is 635.5 MUSD, not including administration, legal and financing costs. The operational expenditures are estimated at 16 MUSD per year.

The project implementation schedule anticipates a 56 months period for completion of all components, including design during EPC stage, plus a 9 month period for testing and commissioning of the hydropower plant.

1 INTRODUCTION

The present document is the *Feasibility Study* Report (the "Report") of the Project Preparatory Technical Assistance (PPTA) for the 300 MW Balakot Hydropower Project.

This report is presented as part of the contract "*TA-9185 PAK: Hydro Power Development Investment Program - PPTA Consulting Firm (49055-001)*" entered between the companies Aqualogus, Engenharia e Ambiente, Lda. (AQUALOGUS) of Portugal, Technical, Engineering and Management Consultants Pakistan (TEAM) and Zeeruk International Pvt. Ltd., both from Pakistan, hereinafter AQUALOGUS/TEAM/ZEERUK or "the PPTA Consultant", and the Asian Development Bank (ADB).

The Report has the main objective of defining, at a feasibility level, the optimal technical solution for the Balakot hydropower scheme. The Report is organized as follows.

Chapter 2 briefly presents and discusses the antecedent studies carried out for the project, its conclusions and proposals, while Chapter 3 depicts the salient features of the technical solution envisaged for the hydropower scheme. Chapter 4 describes the topographical and hydrographic surveys that were used in the Report, where the most part came from precedent work.

Chapters 5, 6 and 7 refer to the basic studies, namely the revision of the available work in the areas of hydrology and sediments, neo-tectonic and seismic, and geology. Chapter 8 is devoted to the problem of the sedimentation in the reservoir, where the sediment inflow volumes are discussed, model for reservoir sedimentation and flushing is presented, and the general sediment management strategy is proposed. In Chapter 9 the energy generation profile of the plant is calculated with a simulation model for different operating regimes. The simulation also encompasses climate change scenarios.

Chapter 10 provides a detailed description of the proposed dam solution and related structures, where Chapter 11 summarizes the stability analysis of the proposed dam, also including the submerged weir of the sediment by-pass tunnel arrangement. Chapter 12 summarizes the dam break study. Chapter 13 describes the envisaged powerhouse and power circuit, including water intake, headrace tunnel, surge shafts, pressure shaft and penstock, cavern powerhouse and tailrace.

In Chapter 14, the hydromechanical and electromechanical equipment is described, also covering the main auxiliary mechanical equipment. Chapter 15 refers to the scheme electrical equipment, in particular of the powerhouse. Chapter 16 concerns the power evacuation and transport, based on a grid interconnection study that is included as annex. Chapter 17 deals with the plant automation and remote control systems.

The materials and equipment transportation, as well as the infrastructure planning with a view to construction is discussed in Chapter 18. The estimate of the work quantities required for the project's structures erection is presented in Chapter 19, which also includes the corresponding cost estimates. The costs estimates are based on current unit prices projections. Chapter 20 concerns the construction planning and envisaged implementation schedule of the Project.

Finally, based on the information and analysis provided along the report, Chapter 21 presents the Feasibility Study main conclusions, recommendations for the subsequent stages of design of the hydropower scheme and, importantly, particular requirements that must be observed in the EPC development stage.

The Report is organized in a Main report (Volume 1), the associated drawings (Volume 2) and the Annexes (Volume 3). The Main report is focused on key information, important results of the analysis performed, proposals and recommendations, whereas base information, studies, calculations and outputs are mostly depicted in the Annexes.

2 PREVIOUS STUDIES

The Balakot Hydropower scheme was object of different studies in the past, where the most developed and recent is the Feasibility Study that was the prepared by the consortium Mirza Associates Engineering Services (Pvt.) Ltd. (MAES) / ILF Beratende Ingeniere ZT GmbH (ILF) / Berkeley Associates (BA) in December 2013 (FS2013)[1].

According to the FS2013, the Balakot project was identified in 1995 under the study "Identification of Hydropower Potential in Kaghan Valley" by Sarhad Hydel Development Organization (SHYDO) with the technical collaboration of the German Agency for Technical Cooperation (GTZ). The project envisaged a 140 m high dam with a 4.5 km long intake tunnel and an underground powerhouse with 190 MW capacity. The dam axis was identified 9 km upstream of Balakot town, headrace tunnel on the left bank and the powerhouse near the confluence of the Sangarh nullah with the Kunhar River. The FS2013 indicates that the referred work relied only on desk studies, without any field reconnaissance.

The FS2013 Consultant identified a number of limitations in the scheme proposed in the GTZ study that led him to propose a diverse solution. These limitations where:

a. *Balakot scheme with 140 m high dam near a high seismic zone is highly risky. The dam ought to be located as far as possible from the fault zone. The shifting of dam axis a few kilometres upstream would not only reduce the seismic risk but also the dam height.*

b. *The identified dam site has weak geological conditions on both sides of the river; therefore, it cannot support the high dam in the shale dominant valley section. The dam height needs to be reduced.*

c. *River diversion and construction of coffer dams would be difficult.*

d. *The identified project would not fully utilize the river potential downstream of Suki Kinari scheme. By relocating the dam axis upstream, the reservoir level can be raised to improve the gross and net head for Balakot project by 60 m.*

e. *A discrepancy in the tailrace outlet of Suki Kinari has been observed. The reservoir level mentioned for Balakot project is at El.1250 m.a.s.l. in the GTZ Study whereas topographic survey carried out in the reservoir area indicates that the level at the outlet of Suki Kinari is El.1305 m.a.s.l. The gross head and corresponding capacity can be improved by utilizing the potential of Kunhar River from the tailrace outlet of Suki Kinari HPP to Sangarhnullah confluence.*

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[1] Mirza Associates Engineering Services (Pvt.) Ltd. (Lead Consultant), December 2013, Feasibility Study of Balakot Hydropower Project, Volume I Main Report for Pakhtunkhwa Hydel Development Organization.

f. *The structures of the identified layout were based on regional geological conditions on the reconnaissance observations only. In active seismic zone, preliminary field investigations are considered necessary for establishing technical feasibility of the identified layout.*

g. *The identified dam site would largely inundate the upstream Kunharvalley,i .e. lower portion of Ghanool and Kawai and Sangarnullahs in addition to the cultivated lands, therefore, shifting of the dam site would reduce the environmental impacts.*

The FS2013 proposed solution emerged from a screening process of 3 possible dam sites and 4 possible powerhouse sites. The dam sites are depicted in the following figure, where D3 corresponds to the site proposed by GTZ and, therefore, discarded as referred.

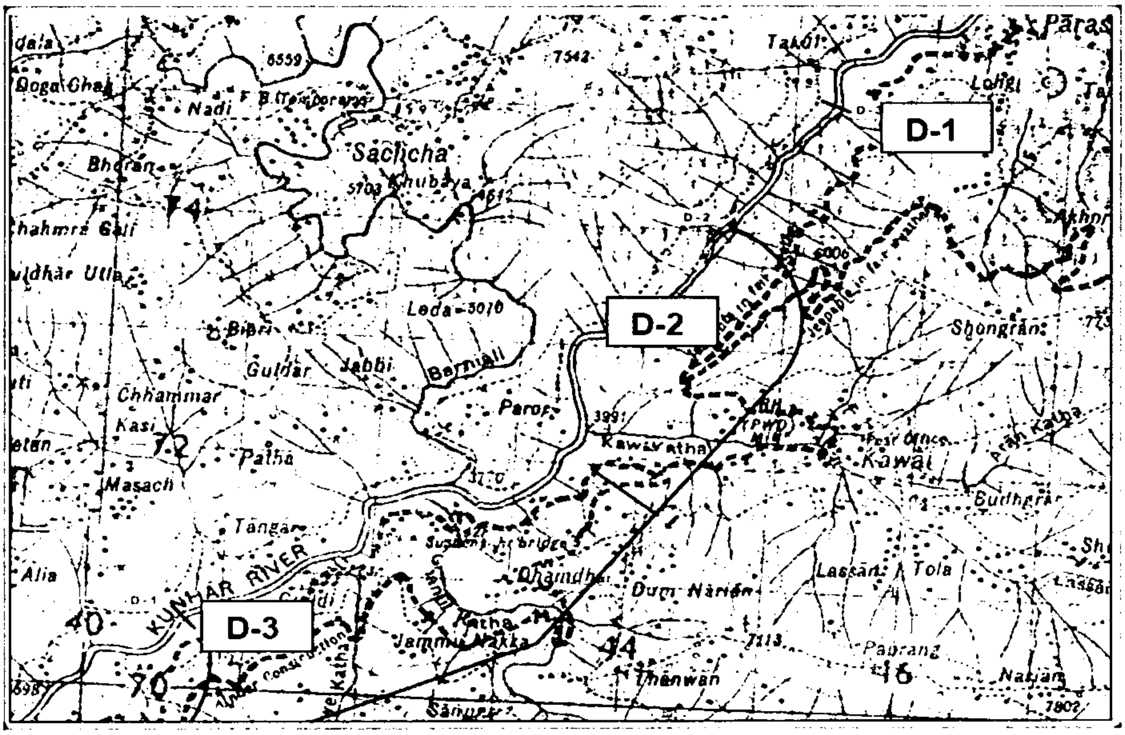

Figure 2.1 – Alternative dam sites (extracted from the FS2013)

The location D1, the most upstream one, is located approximately 1 km from D2. Both the dam sites D2 and D3 have been selected on the basis of geological conditions and narrow valley sections. The main features of dam site at D2 are presented in the following table.

Table 2.1 – Dam at D2 – Features (extracted from the FS2013)

A	Riverbed elevation	1215 m
B	Dam crest length	250 m
C	Dam Top Elevation	1293 m
D	Dam height above riverbed	78 m
E	Maximum Reservoir normal operating level	1288 m
F	Minimum Reservoir minimum operating level	1283 m
G	Gross storage	12.61 MCM
H	Dead storage	10.04 MCM
I	Live storage	2.566 MCM
J	Reservoir operating range	5 m

The four (4) powerhouse sites that have been identified and investigated in the FS2013 are depicted on the following figure. Three sites (P1A, P1B and P1C) are in close vicinity of each other, near Dheri village on the right bank of Sangarh Nullah. An underground powerhouse was proposed in the cases of P1A and P1B, and an exterior type was equated for P1C. Boreholes were drilled at the three locations and sound rock mass was not encountered at greater depths. Therefore, these sites were not recommended for further studies.

On the basis of surface geological conditions, it was concluded by the FS2013 Consultant that the geological formation improves while moving from Balakot upstream in the valley. The P2 location, about 2,5 km upstream from P1 site, was then selected for further investigation. Boreholes were drilled at surge shaft and powerhouse locations and concluded that sound rock was available at deeper depth, while rock in shallow depth is still fractured. Considering better rock conditions at deeper depth this site was selected.

The P2 proposed powerhouse layout includes a surge shaft, vertical pressure shaft, pressure tunnel, powerhouse main cavern, transformer cavern, tailrace gate chamber, access road tunnels at various levels and the tailrace tunnel.

The FS2013 was critically assessed in the scope of the PPTA initiated by ADB in 2017, where a due diligence process was one of the key activities. The revision and analysis of the basic studies in the FS2013 by the PPTA Consultant showed that some significant problems existed (*D2.1 – Technical Due Diligence Report*, 2017).

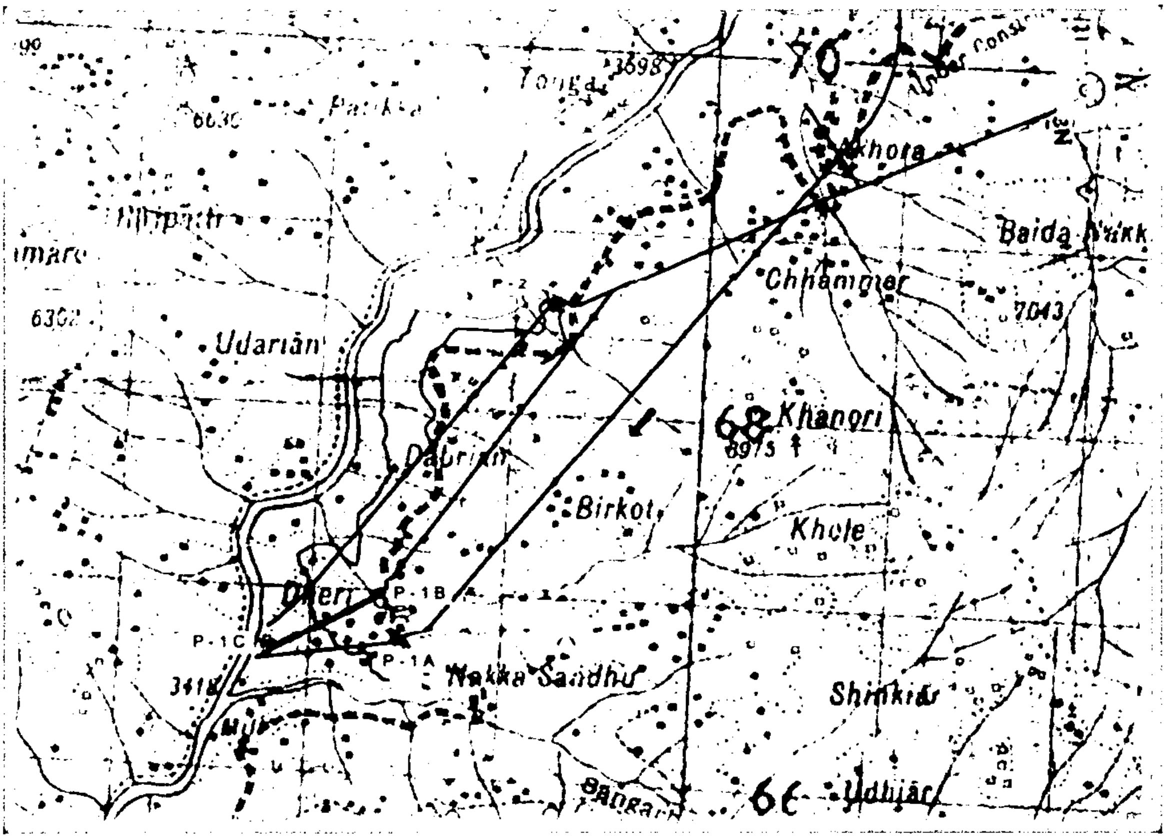

Figure 2.2 – Alternative powerhouse sites (extracted from the FS2013)

The surface hydrology analysis indicated that the flow regime at the Balakot scheme's intake seemed to be properly addressed, though the flood study presented some discrepancies among the obtained estimates that were not properly explained. The sedimentation studies, which are a critical element in the project, also seem to have not properly taken into account what is believed to be the major factor of sediment input. The FS2013 provided estimates based on measurements from the Kunhar River, which were not considered a proper basis for extrapolation.

Regarding the geological studies, the PPTA Consultant was of the opinion that they did not provide a realistic structural model to support the scheme design. Also, the collected geological information was deemed insufficient to support the design of key project structures such as the dam, tunnels and powerhouse.

The analysis of alternatives included in the FS2013 was also considered insufficient, as relevant factors seem to have not being accounted for. In relation to the scheme design of the FS2013, several aspects presented major problems and the PPTA Consultant recommended that other scheme alternatives were considered.

In the wake of the due diligence process and its conclusions, ADB and PEDO decided to carry out an assessment of possible scheme alternatives with the objective of identifying one of the best options available, considering all the relevant factors. To that purpose, new field reconnaissance visits were done, additional information was collected in the domains of hydrology and geology and the basic studies revised. The subsequent work of scheme technical alternatives definition, analysis and comparison is described in the *D2.2A - Alternative Locations and Layout Analysis Study* (the "Study"). This report compared two alternative locations for the dam (with two possible dam types in each location) and two powerhouse locations (one cavern and one exterior). The main conclusions of the Study were the following:

- *For each dam location (A and B), both upstream of the FS2013 dam location, concrete and rockfill types were explored. Concerning the powerhouse, the cavern solution and respective location of the FS2013 was retained as Base option, and an alternative open air solution was analysed. All the referred alternatives were deemed technically viable at a pre-feasibility level.*
- *The flood hydrology of the FS2013 was revised. The proposed design peak discharge for the spillway, corresponding to a 10 000 year period, is 3 500 m^3/s. The proposed safety check flood, corresponding to the Probable Maximum Flood (PMF) peak, is 5 000 m^3/s.*
- *The sedimentation study was reviewed, also to consider the effect of the upstream reservoir of Suki Kinari. The proposed estimate for the mean annual sediment load at Balakot intake section is 420 kton.*
- *The Study also included a reservoir sedimentation and flushing analysis. The results indicate a reservoir trap efficiency of about 70%. It was also possible to determine that only very small particles (0.0625 to 0.125 mm) were anticipated to enter the power circuit.*
- *The revision of the neo-tectonic and seismic studies, notwithstanding following similar approaches to the one in the FS2013, recommended an upward adjustment of the design parameters. Proposed PGA associated with the SEE and OBE are 0.90g and 0.29g, respectively.*
- *The geological studies included field investigation works in the proposed A and B dam locations and in the alternative powerhouse area (exterior). Geological mapping of this areas, as well of part of the headrace tunnel route and reservoir area was also carried out.*

- *The analysis showed that, from a geological/geotechnical perspective, both dam locations were feasible for the envisaged solutions (concrete gravity and rockfill). Regarding the alternative powerhouse area, a very significant depth of overburden material, as well as important faults on the rock mass were identified. Although such findings did not render the solution unfeasible, important geological risks were recognised.*
- *The mapping of the headrace tunnel indicated that there were some structural features which may intersect it, in particular highly tectonized zones of Murree formation that potentially would pose ground squeezing issues during the tunnel construction.*
- *The mapping of the reservoir area allowed the identification of the Main Boundary Trust (MBT) in a different alignment from the indication of the FS2013.*
- *Both reservoir alternatives showed similar energy outputs. Average annual energy is approximately 1250 GWh, where 420 GWh in peak hours.It was also shown that for volumes greater than 1 hour of generation at maximum capacity there would be almost no gain in peak power production.*
- *The analysis of the dam alternatives encompassed a cost and a technical suitability comparison to select the best type for each location. The gravity types were considered the more favourable options for both locations A and B. As a result, the alternatives under analysis included concrete dams at locations A and B, cavern and open air powerhouse alternatives, and respective power circuits. Four possible combinations were evaluated. Both power circuits had similar arrangements, including headrace tunnel, surge shaft and pressure shaft/penstock, although with different lengths and alignments.*
- *The preliminary estimates for the project investment of the different combinations varied from 605 MUSD to 619 MUSD, not including administration, legal and financing costs. The dam location B and the open-air powerhouse alternative presented the lowest cost, although almost identical to the cavern solution ones.*
- *The Study included an Economic analysis of the four alternatives, with calculation of NPV and LCOE at a 10% discount rate. The project benefits were based on the LRMC. The NPV varied between 4 and 13 mUSD, and the LCOE between 77.9 and 79.2 USD/MWh. Dam location B plus the alternative powerhouse showed the best indicators.*
- *An Environmental and Social impact analysis was also performed, that showed that the impacts were quite similar in all the considered alternatives. Only Dam location B*

seemed to have a slighter advantage, as it would require less land acquisition due to a smaller reservoir.

- *A preliminary risk assessment showed that, although some differences emerged, the risk profiles of the alternatives where fairly similar.*
- *Based on the Economic analysis, the Environmental and Social impact analysis and the preliminary Risk assessment results, a multi-criteria analysis was conducted in the Study. The outcome of the referred analysis pointed to Dam location B with the Cavern (base) powerhouse and respective power circuit being the most favourable alternative.*

Additionally to the previous conclusions, the Study also included the following recommendations for the subsequent stage of work:

- *That the hydropower scheme is further developed with a concrete type dam on location B and a cavern type powerhouse. In the case of the powerhouse, even if the precedent analysis did not indicate a clear preference for the cavern, the PPTA Consultant considers that the area topographically suitable for an open air (or well) type solution presents important geological risks that should be avoided. Even if presently there is uncertainty about the geological conditions for the proposed cavern location, it is probably easier to adjust the location of this solution type in a later stage of the design, if needed.*
- *That further and intensive geological reconnaissance work is carried out, including geological/geotechnical investigations and geological mapping. Such necessity is justified by the uncertainty that still exists about the geological conditions for the proposed underground structures, which was demonstrated by the latest investigation works. Particularly the area of the proposed powerhouse cavern and tailrace are of significant concern.*

Subsequently to the *D2.2A - Alternative Locations and Layout Analysis Study* completion and approval, the PPTA Consultant continued developing the scheme design and collecting information, namely in the geological area. A new site visit and geological mapping campaign was carried out, as well as a number of additional geological investigations focusing on the powerhouse and the tailrace tunnel.

In the wake of the referred visits and previous recommendations, it was decided to move the scheme outlet (restitution) section upstream. Such decision was mostly motivated by the anticipated poor geological conditions in the downstream area of the initially considered tailrace tunnel and supported on different hypothesis[2]. The most downstream option TL-4 was selected and the investigation program was defined for the correspondent layout. This layout implies a tailrace tunnel approximately 600 m shorter than previously considered and a reduction in gross head of about 12 m (5%).

The following figure summarizes the chronology of the more recent studies of the project, as well as related main activities and decisions.

Table 2.2 – Balakot project studies development (milestones)

1995	*2013*	*2017*	*2018*	*2019*
A	**B**	**C**	**D**	**E**
Potential study	**Feasibility Study**	**Due Diligence for ADB**	**Alternative Locations and Layout Analysis Study**	**Feasibility Study** (current)
GTZ	Mizra et al.	PPTA Consultant	PPTA Consultant	PPTA Consultant
140 m dam 4.5 km circuit 190 MW	100 m dam 10.8 km circuit 300 MW (cavern, 4 groups)	Important problems detected in the 2013 FS Questions if the best layout was selected	Alternative locations and dam types compared, two powerhouse locations an types compared Geological investigations at dam and alternative powerhouse site Proposed layout of: 45 m dam (location B) 11.5 km circuit 310 MW (cavern, 3 groups)	Additional geological investigations in reservoir, dam, headrace, powerhouse and tailrace 58 m dam (same location, foundation lowered) 10.9 km circuit (tailrace shortened) 300 MW (cavern 3 groups, head reduced) Downstream surge shaft included

Figure 2.3 depicts the main project locations considered in the Balakot project studies previously referred (letters as per the preceding table).

The FS2013 included in its volume 9 an ESIA report. A new ESIA has been developed in parallel with the PPTA work and its report is concluded[3]. The current ESIA includes an Environmental Flow Assessment which recommendations were considered in the present Report.

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[2] Four different sections were considered, designated TL-01 to TL-04, as discussed in the *Technical Memorandum (TM05 Powerhouse cavern and Tailrace geological investigations).*

[3] HaglerBailly Pakistan, August 8, 2017, Environmental Impact Assessment of Balakot Hydropower Project for the Asian Development Bank (ADB).

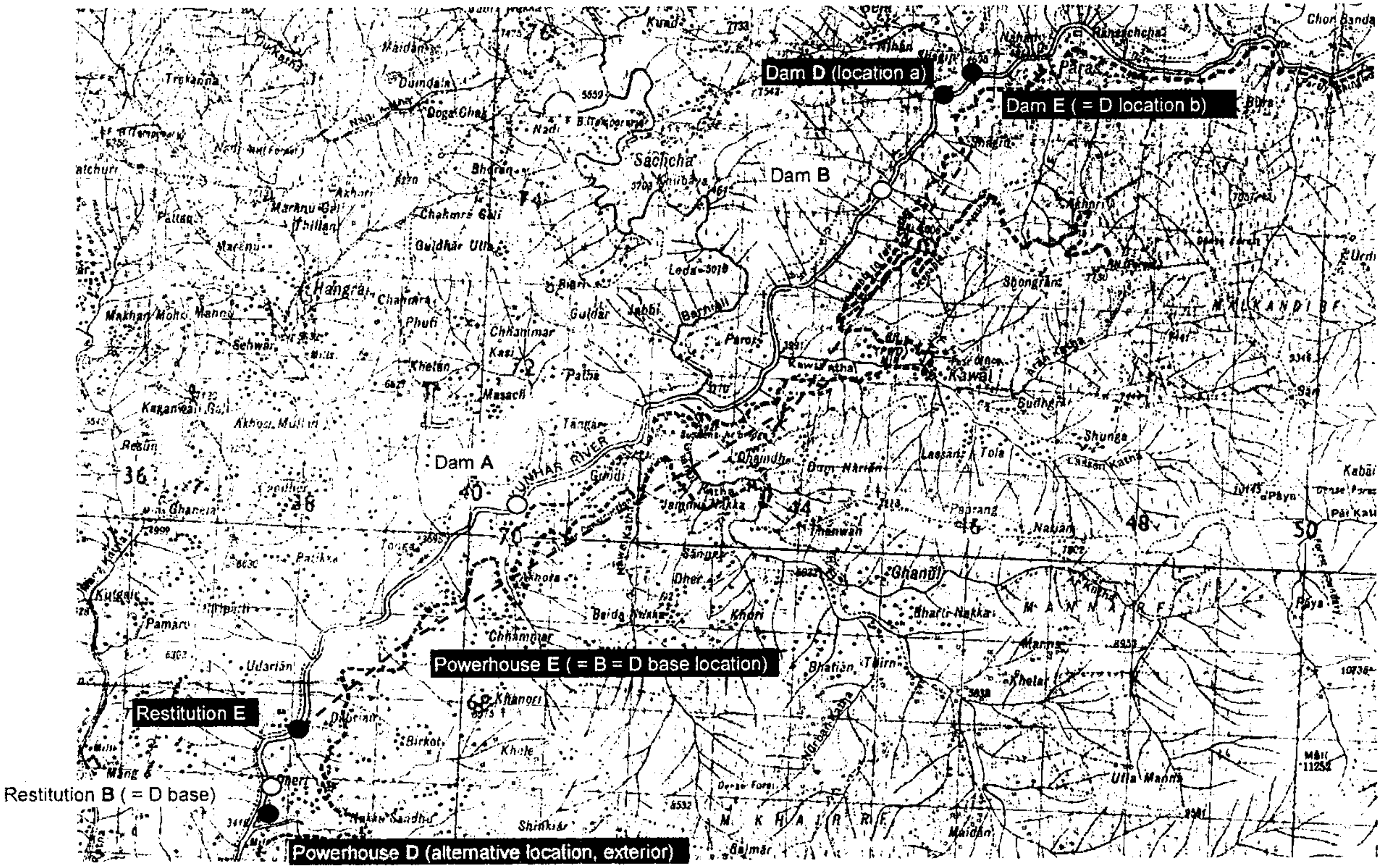


Figure 2.3 – Main project locations considered in the Balakot alternative's studies

3 PROJECT SALIENT FEATURES

The salient features of the Balakot HPP as per this Feasibility Study are summarised below.

Balakot Hydropower Project

Project Salient Features

1. Hydrology and Design Flows	
River	Kunhar
Catchment area at dam site (km^2)	1939
Modular flow at the intake (m^3/s)	87
Design Discharge (m^3/s)	154
Design Flood (m^3/s) T= 10 000 years	3500
Probable Maximum Flood (m^3/s)	5000
2. Reservoir	
Normal Operation Level (NOL)	1288.0
Minimum Operation Level (MinOL)	1283.0
Surface area (at NOL) (km^2)	0.28
Length of Reservoir (at NOL) (km)	2.2
Gross storage capacity (at NOL) (x10^6 m^3)	3.56
Live storage (at NOL) (x10^6 m^3)	1.20
3. Dam Structure	
Type	Concrete Gravity Arch
Dam crest elevation (masl)	1292.0
Maximum height above river bed (m)	35.0
Maximum height above foundation (m)	58.0
Crest length (m)	130.0
4. Spillways and low level outlets / flushing sluices	
Spillway type	Upper gated ogee crest spillway + low level gated spillway
Upper spillway crest elevation (masl)	1278.0
Upper spillway gates no. and type	3 (radial gates)
Upper spillway gates size (W x H) (m)	11 x 10
Low level spillway invert elevation (masl)	1258.0
Low level spillway gates no. and type	2 (sluice gates)
Low level spillway size (W x H) (m)	6 x 8

Balakot Hydropower Project
Project Salient Features

5. Sediment Management

Solution	Sediment Bypass Tunnel (SBT) + flushing outlets
SBT type	Gated intake followed by archway tunnel
Intake size (W x H) (m)	7.5 x 4.5
Inlet invert elevation (masl)	1261.0
Tunnel cross section (W x H) (m)	archway (7.5 x 8.0)
Tunnel length (m)	650
Tunnel slope (%)	1.5
Outlet invert elevation (masl)	1248.0
Submerged guiding structure crest elevation (masl)	1272.0
Submerged weir/guiding structure height (m)	21 (estimated maximum above foundation)

6. River Diversion

Construction Flood (m^3/s) (T= 20 years)	900
Diversion type	openings left in the dam body for the low-level spillway and a left bank diversion tunnel (which will be further converted to the sediment by-pass tunnel)
Upstream Coffer dam type	concrete gravity solution (which will be further converted to guiding structure)
Upstream Coffer dam crest elevation (masl)	1272.0
Downstream Coffer dam type	concrete gravity solution
Downstream Coffer dam crest elevation (masl)	1252.5
Diversion tunnel type	Archway (concrete lined)
Diversion tunnel no. (-)	1
Diversion tunnel size (W x H) (m)	archway (7.5 x 8.0)
Diversion tunnel length (m)	650
Diversion tunnel slope (%)	1.5
Diversion tunnel inlet invert El. (masl)	1261.0
Diversion tunnel outlet invert El. (masl)	1248.0

7. Power intake structure

Intake type	Horizontal intake
Trash rack no.	4
Trash rack size (W x H) (m)	8 x 10
Service gates no.	2
Service gates size (W x H)	4 x 8 m
Intake crest elevation (masl).	1271.0

Balakot Hydropower Project
Project Salient Features

8. Headrace tunnel	
Tunnel section	Circular concrete lined (8.0 m inner diameter)
Length up to surge tank (m)	9137
Tunnel slope (%)	0.56%
9. Upstream surge shaft	
Type	concrete lined circular surge shaft
Internal diameter (m)	14.5
Surge shaft height (m)	122
Surge shaft bottom elevation (masl)	1220.0
10. Pressure tunnel/shaft and penstock	
Pressure tunnel/shaft main section type and size	Steel lined circular cross section (5.6 m internal diameter)
Pressure tunnel/shaft length (m)	152
Penstock length (m)	88
Branch Section Type	Manifold (3 branches)
Size of each branch (m)	3.2 m internal diameter conduits
Max. Length of branch (m)	~30
Pressure tunnel/shaft main section type and size	Steel lined circular cross section (5.6 m internal diameter)
11. Powerhouse and substation	
Powerhouse type	conventional underground cavern
Main cavern general dimensions (LxWxH) (m)	71 x 20 x 34
Turbine type	Francis
No. of units	3
Turbine axis elevation (masl)	1054.0
No. of generators	3
Transformer / Substation type	Underground cavern (adjacent to the main powerhouse cavern)
Transformer cavern general dimensions (LxWxH) (m)	88 x 14 x 20
12. Downstream surge shaft	
Type	concrete lined circular surge shaft
Internal diameter (m)	3.0
Surge shaft height (m)	244
Surge shaft bottom elevation (masl)	1055.0

13. Tailrace	
Type	Circular tunnel with transition to an archway section at the final length and Outlet portal
Tunnel section	Circular concrete lined (8.0 m diameter)
Length up to the final transition section (m)	1515
Tunnel slope up to the transition section (%)	0.23% (ascending slope)
Tunnel final section	Archway concrete lined section (8.0 W x 8.0 H)
Length from transition to outlet (m)	50
Tunnel slope up to the outlet portal (%)	15% (ascending slope)
14. Power and Energy	
Gross Head (m)	229.0
Design Net Head (m)	217.6
Installed plant capacity (MW)	300 (at the generator)
Average annual energy (GWh)	1143 (average of 55 years)
15. Project access facilities	
Access road to dam and related structures (length)	550 m (from Sharan Road, connection to National Highway N–15 at the left side of Kunhar River, nearby Paras village)
Access road to sediment by-pass tunnel (length)	440 m (from the dam bridge deck up to the sediment by-pass tunnel intake)

4 TOPOGRAPHIC AND HYDROGRAPHIC SURVEYS

4.1 INTRODUCTION

Detailed topographic and hydrographic surveys were conducted during the Feasibility Study prepared in 2013 (FS2013) for the project area that were used for the alternative and final layout study by the FS2013 Consultant. However, in the area of the new tailrace outlet a fresh survey was conducted by the PPTA Consultant to meet the requirements of planning and designing of the tailrace alignment, outlet, and access road connections. The current FS uses, therefore, the surveys from 2013, complemented in a small area with a more recent survey.

4.2 PREVIOUS TOPOGRAPHIC AND HYDROGRAPHIC SURVEYS

4.2.1 Scope of the topographic and hydrographic surveys

The following topographic and hydrographic survey work was carried out during the FS2013:

a) Topographic survey for the dam, diversion works and the power intake at a scale 1:500 with contour interval of 1 m. The estimated area mapped is 335 acre.

b) Topographic survey of the headrace tunnel that includes the identification of the alignment and definition of both portal axes at a scale of 1:2000 with contour interval of 5 m.

c) Topographic survey for the surge tank to powerhouse area on the left bank of Kunhar River at a scale 1:1000 with contour interval of 2 m. The covered area is 650 acre.

d) Topographic survey for the reservoir at a scale 1:2000 with contour interval of 5 m. The area mapped is 380 acre.

e) Kunhar River cross sections (10) at an interval of 200 m, in the indicated 2 km area for the dam. The cross sections cover the elevation from the water level to 100 m above on either side of the valley.

f) Kunhar River cross sections (10) at an interval of 200 m, in 2 km area including 1 km area for the powerhouse and 1 km further downstream. The cross sections cover the elevation from the water level to 60 m above on either side of the valley.

g) Longitudinal section of Kunhar River from 2 km downstream of Sangarh nullah confluence to 3 km upstream of the suspension bridge at Paras village. The approximate length of the river covered is 20 km.

4.2.2 Instruments Used

The following instruments have reportedly been used by the survey teams to obtain field data in the digital form:

a) Three Digital Total Stations of Sokkia
  - Set 610K, Sr. No. 201948, Japan,
  - Set 610K, Sr. No. 208051, Japan,
  - Set 610K, Sr. No. 149661, Japan,

b) Total Station Sokkia Set 630R, Total Station D-21876 Sr. No. 137905, Japan.

c) Auto Level, Topcon Green Label AT G-4 5 W-0805, Japan.

d) Electronic Distomat (EDM).

4.3 METHODOLOGY

4.3.1 General

According to the FS2013, the detailed topographic survey has been carried out to cover all the main structures of each layout of the project. Detailed maps for the tunnel alignments and adit areas have been developed from high resolution satellite images where access for normal mapping was not possible.

4.3.2 Data Collection

The following steps were reportedly followed for collection of topographic data from the field (FS2013 information):

a) To link the topographic survey with Survey of Pakistan (SOP) bench mark system, Batrasi Bench Mark (3233468.220, 1137338.210, 1199.863) was nearest. Its coordination (x, y, z) was collected from the SOP office at Rawalpindi.

b) Three Bench Marks, two near powerhouse and one near dam were established by using total station and digital level and by traversing method starting from Batrasi SOP Bench Mark. Accuracy of these were also checked with GPS.

c) Fifty four (54) control points were established between powerhouse and dam and were used for data collection of the respective area.

d) For inaccessible areas of the tunnel alignments, where it was difficult to carry out ground survey, maps have been developed with the help of satellite images. High resolution DEMs have been used to prepare topography of the tunnel alignment areas. Terrestrial survey carried out for the dam and powerhouse areas has been used as a basis for improving the precision of DEM. Topography developed with DEM has been connected with the ground survey for the dam and powerhouse areas.

e) The following prominent physical features have been shown on the maps:

- Existing houses, settlements, powerhouses, businesses or other constructed buildings.
- Existing roads, passages, water courses/irrigation channels, drainage, electricity lines and poles, telephone lines and poles and retaining walls.
- Contact between overburden and rock exposed.
- Abrupt change in elevation marked differentially, and steep slopes.
- All control points/benchmarks established and used.
- Boulders bigger than 1 m.
- Dominant land use and land forms (trees, cultivated areas, scree, loose rocks)
- Ground control points
- Multiple interval contours

f) River Cross sections (11) in total in the area of dam, powerhouse and gauging station were recorded by using electric sounder and boat. The area under dry were surveyed with total station.

g) Longitudinal section (20 km) of the Kunhar River between the dam and the Sangarh nullah was also prepared with the help of boat and electric sounder.

4.3.3 Data Processing and Presentation

The field data collected through the digital Total Stations was downloaded on the computer for processing and preparation of survey maps. Data has been processed on specific software used for developing the topography into digital files. Eagle-Point software has been used for processing of field data and to transform the data into AutoCAD files. Various features have been stored in layers to present the details as required. AutoCAD software has been used for further presentation on maps to be used for engineering studies.

The following topographic survey sheet were prepared for the FS2013 (and also used in this Report):

a) Area of the dam and all the appurtenant structures with contour interval of 1 m at a scale of 1:500.

b) Identification of the headrace alignment and definition of both portal axes with contour interval of 5m at a scale of 1:2000.

c) Area of the surge tank with contour interval of 2 m at a scale of 1:1000.

d) Penstock / pressure tunnel area with contour interval of 2 m at a scale of 1:1000.

e) Powerhouse and tailrace area with contour interval of 2 m at a scale of 1:1000.

f) Access roads to all the structures including the dam, surge tank, powerhouse and residential colony with contour interval of 5 m at a scale of 1:2000.

g) Reservoir area with contour interval of 5 m at a scale of 1:2000 m.

h) Project map: scale of 1:25 000.

i) River cross sections and longitudinal section.

4.4 TOPOGRAPHIC SURVEY BY THE PPTA CONSULTANT

4.4.1 Objective

The PPTA Consultant hired the services of the Geomatics and Engineering Services Pvt. Ltd., from Lahore, for carrying out the supplementary survey in the area of powerhouse and tailrace due to the change in location of tailrace outlet on the basis of geological and geotechnical information. The following survey was requested.

- Establishment of survey control stations.
- Topographic survey of power house area.
- Topographic survey of tailrace area.
- River cross sections.

4.4.2 Scope of Work

The following was the scope of work for the topographic and hydrographic survey:

- Construct three (3) number permanent survey stations.
- Carryout levelling and check levelling through the survey stations.
- Carry out EDM traverse starting from known existing survey stations and connection to the new station through closed loop format.

- Carry out topographic survey of the power house and tailrace areas as specified in the scope of work.
- Mark and carry out river cross sections survey of the Kunhar river.
- Carry out computer aided mapping of the survey work done.
- Prepare the survey report on the work performed and results achieved.

4.4.3 Methodology / Approach

The work methodology encompassed the following main activities:

- Reconnaissance of the project site was carried out to select locations of new survey stations at safe and stable locations. New stations were sited such that they are easily and readily accessible for all present and future works.
- Three new survey stations were constructed. The survey station is made up of one meter ¾" diameter steel rod driven into ground, hole dug round it and 9" diameter PVC pile section placed on it, partially underground and around a foot above ground. It is filled with 1:2:4 ratio concrete. Complete details of their construction are available in pictorial format in the Survey Report (**Annex XV - Topographic survey**).
- Levelling and check levelling runs were carried out using automatic levelling instrument and compatible levelling staves – complete filed data and levelling calculations are available in the Survey Report.
- EDM traverse was carried out and complete data is available in the Survey Report.
- Topographic survey of the designated terrain was carried out using total station, survey data acquired in digital format and saved on board the instrument. All manmade and natural features as they existed at the time of the survey were marked. Large numbers of spot levels were surveyed such that accurate contouring fully representative of the terrain formation can be developed.
- Digital topo survey field data was downloaded to the computer and processed for computer aided mapping (CAM). Contours were generated using appropriate computer software at desired contour interval (1 m). A-3 size prints of the topographic survey are included in the Survey Report.
- River cross sections (bathymetric survey) - four cross sections were surveyed. Kunhar river at the site has steep and some inaccessible side slopes. Flow in the river was low and it was possible to wade across with rod and prism. The side slopes were generally surveyed using the reflectors facility available with the total station. Digital data was

computer processed and plotted. The cross sections data and plotting is available in the Survey Report.

- Photographic record – large number of digital photographs were taken at site during the various field activities and they are available in the Survey Report.

4.4.4 Submittals

The survey report, included in **Annex XV**, consists of the following

- Appendix A about survey control points existing or new established during the Survey;
- Appendix B contains data of Intermediate station of the EDM traverse;
- Appendix C contains levelling data;
- Appendix D contains EDM traverse data;
- Appendix E includes the topographic and hydrographic data.

5 HYDROLOGY AND SEDIMENTS

5.1 GENERAL CONSIDERATIONS

The hydrological study mostly aims at estimating the water availability at the proposed dam site and the design floods for the spillway and diversion works. Therefore, it covers climatology, characteristics of the drainage basin, historic hydro-meteorological data, assessment of stream gauging network, floods and generation of flows at the dam site.

The sediment study estimates the quantity of suspended and bed load sediment in the Kunhar River and the grading curves of this sediment. This information on the sediments is essential for analysing the sediment accumulation in the reservoir, simulating the flushing operations and analysing the long-term behaviour of the reservoir.

For the hydrological and sediment study of the watershed, reservoir, dam and powerhouse sites, large datasets were available and collected from existing sources, namely from the Pakistan Meteorological Department (PMD), the Surface Water Hydrology Project (SWHP), and the Hydrology and Research Department (H&RD) of WAPDA. Most of the referred data was collected in the scope of the FS2013 and is also used in this Report.

Parts of the text presented under the current chapter may have been collected from the FS2013 with due permission from PEDO, notwithstanding possible and necessary adjustments.

5.2 CATCHMENT CHARACTERIZATION

5.2.1 General Characterization

The Kunhar River constitutes a major right bank tributary of the Jhelum River, which is one of the major tributaries of the Indus. The Kunhar River total drainage basin (Kaghan Valley) has an area of around 2660 km^2 and is located along an elongated valley lying between latitude N 34°10' and 35°10' and longitude E 73°15' and 74°10'.

The total length of the Kunhar River is about 145 km and its average slope around 2 %. It flows mainly from northeast to southwest, passes through Balakot, and then flows to Garhi Habibullah after which it joins the Jhelum River.

The Kunhar catchment and its key locations are presented in **Figure 5.1**.

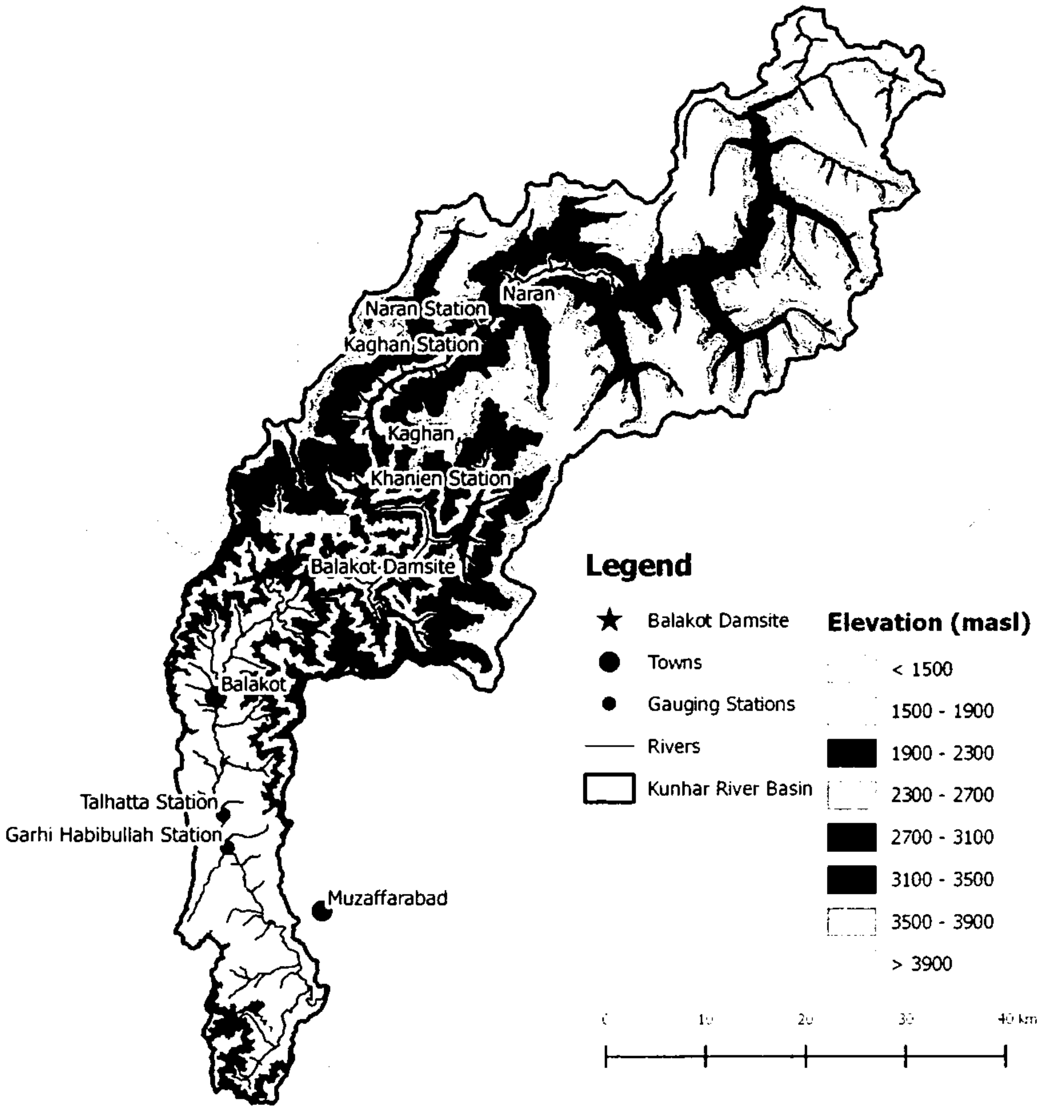


Figure 5.1 – Kunhar catchment and key locations

The valley is bounded by Diamer District and Baltistan on the north, Neelum Valley of Azad Kashmir on the east, Abbottabad District on the south and southwest and Manshera Distric and Kohistan District on the West. The main towns of the Kunhar River valley are Balakot, Kaghan and Naran.

As shown in **Figure 5.1**, the topography of the Kunhar valley is mainly mountainous with steep valley sides. The main geomorphic feature is reflected by an altitudinal difference of around 4400 m from its origin, nearby Lake Lulu Sar. Actually, the glacial lakes play an important role to the upper catchment of the valley, particularly the Lulu Sar Lake, covering an area of 0.8 km^2 and the Saif-Ul-Muluke Lake covering an area of 0.5 km^2.

The network of streams in Kunhar River basin is perenial in nature. The major tributaries of Kunhar River are listed in **Table 5.1**.

Table 5.1 – Major tributaries of the Kunhar River

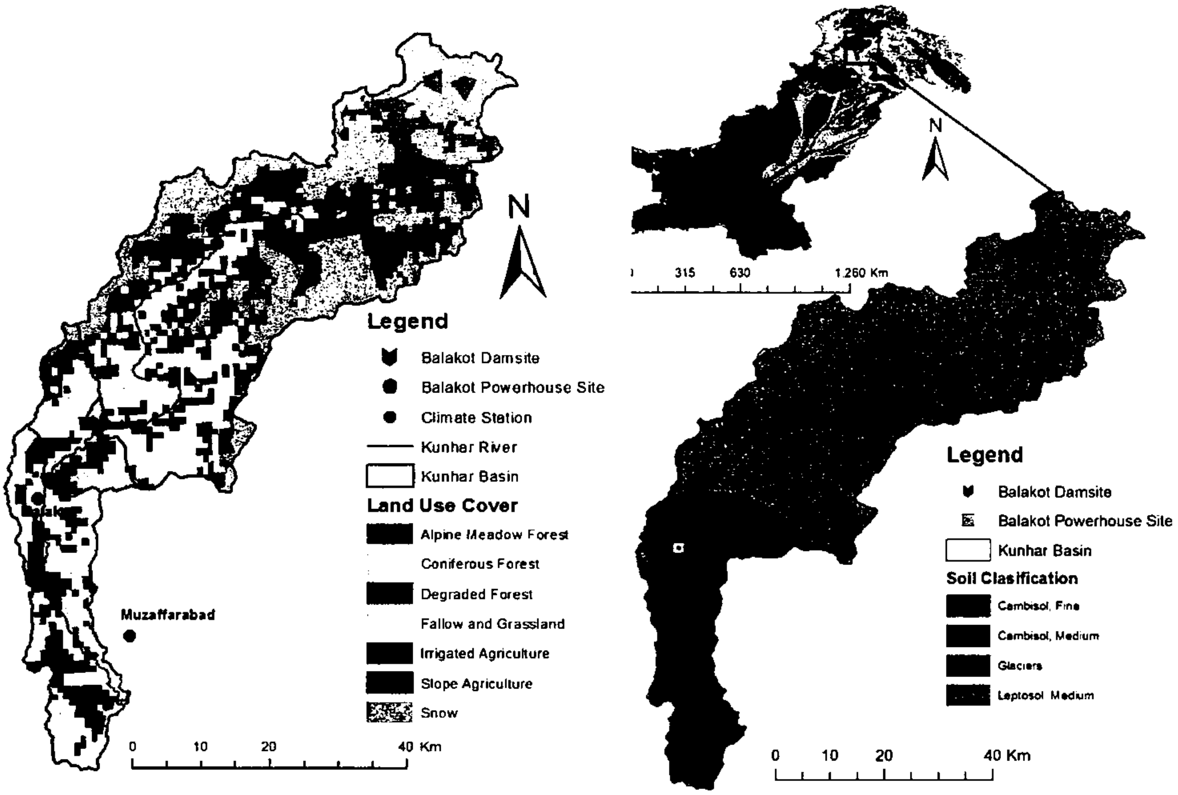
Kunhar River Tributaries	Catchment Area (km²)	Kunhar River Tributaries	Catchment Area (km²)
Aputha Nar	37	Barna Katha	17
Sadullah Nar	30	Jalora Katha	36
Purbi Nar	72	Chanual Katha	33
Jhalkad Nulla	103	Sangar Nala	13
Jora Nala	149	Jhnagri Katha	2
Bas Katha	32	Salol Nala	28
Dadar Nar	136	Serhan Katha	37
Spat Katha	64	Kanshian Nala	35
Kinari Da Katha	20	Khairbad Katha	28
Bharjali Da Nar	18	Sorida Kashkar	14
Safar Maluk Katha	57	Barniali	114
Bhimbal Katha	106	Bolo Katha	6
Manur Nala	192	Bheran Katha	5
Ochari Katha	110		

5.2.2 Land Cover and Soil

The Kunhar River basin has a great diversity of vegetation such as temperate coniferous forests, subtropical coniferous forests, alpine meadows, agricultural cover, and snow. The **Figure 5.2 a)** shows the land cover of Kunhar River basin developed by the Joint Research Center (JRC) of the European Commission.

As shown in **Figure 5.2 a)** and **Table 5.2**, forest, agriculture and snow are the most representative land cover in the Kunhar River basin.

The **Figure 5.2 b)** shows the soil characteristics of the Kunhar River basin drawn from the digital soil map of the world developed by the FAO geo-network. As suggested by **Figure 5.2 b)** and **Table 5.3**, the predominant soil type in Kunhar River basin is Leptosol, particularly at the upper part of the basin.



a) b)

Figure 5.2 – Land use (a) and soil characteristics (b) in Kunhar River catchment

Table 5.2 – Land use type of Kunhar River catchment (source: JRC)

Land Use Type	Area	
	(km^2)	(%)
Alpine Meadow Forest	754	28.7
Coniferous Forest	852	32.4
Degraded Forest	10	0.4
Fallow and Grassland	7	0.3
Irrigated Agriculture	3	0.1
Slope Agriculture	301	11.4
Snow	702	26.7
Total	**2629**	**100**

Table 5.3 – Soil classification and soil fraction of Kunhar River Catchment (source: FAO)

Soil Type	Area		Top Soil Fraction		
	(%)	(km^2)	Sand (%)	Silt (%)	Clay (%)
Cambisol, Fine	13	337	22	30	48
Cambisol, Medium	13	336	22	30	48
Leptosol, Medium	73	1908	43	34	23
Glacier	2	48	0	0	0
Total	**100**	**2629**	-	-	-

5.2.3 Climate

5.2.3.1 General characterization

In general, the climate of the Kunhar River is influenced by two wind systems. One is the monsoon, persisting spatially downstream of the Balakot dam site during the summer months of June to September - the Easterlies; and the second system is the Westerlies, which dominates in the winter months of November to March and has more influence upstream of the project area.

The northern area of Pakistan and Kashmir is surrounded by high Himalayas, Karakoram and Hindu Kush mountain ranges. Actually, the climatic condition of the project area is mainly determined by the high altitude of the surrounding mountains. It generates a tropical composite belt over central India, leading to advancing of the southeast air flow of the Bay of Bengal, and the two warm moist air masses encounter in north-eastern of Pakistan and Kashmir, which triggers storms and floods. In addition, strong tropical depressions formed over the Bay of Bengal move to India, Rajasthan, northern Pakistan and Kashmir. In winter, the Westerlies from the Caspian Sea and the Mediterranean Sea trigger precipitation that begins by the end of November in the forms of rainfall and snow.

As shown in **Figure 5.3**, in most winter seasons (generally from January to May) between 80 and 90% of the upstream part of the project area becomes snow-covered, although occasionally this percentage may fall to as low as 60%. Snow deposits have been witnessed till October and later in the valley bottom between Kaghan and Naran. Any runoff from winter rainfall over the low-lying areas of the basin is usually insignificant.

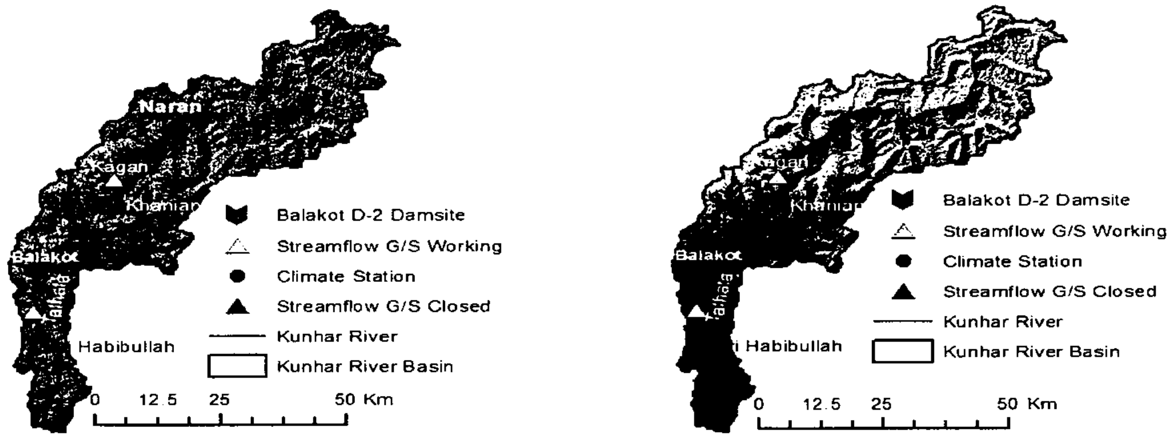


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Figure 5.3 – Snow cover in the Kunhar River catchment

There are a number of climatic stations in and around the project area, which are operated by the Pakistan Meteorological Department (PMD), the Surface Water Hydrology Project

(SWHP), and the Hydrology and Research Department (H&RD) of WAPDA. Climatic stations operated by PMD and SWHP are located in the valleys, while H&RD is operating weather stations at high altitudes. Only three weather stations (Naran, Balakot and Saif-ul-Muluk) are located in the vicinity of the project area. Muzaffarabad climate station is located near to the project area but outside the river basin. **Table 5.4** depicts the climatological stations in the catchment and the available period of records.

Table 5.4 – Climatological stations

Climate Station	Location[1]		Elevation (m)	Year of data				Source
	Latitude	Longitude		Precipitation (mm)	Air Temperature (°C)	Relative Humidity (%)	Evaporation (mm)	
Naran	34° 54'E	73° 39'N	2 363	1961-2011	1961-2011	1961-2011	1981-2007	SWHP
Saiful Muluk	34° 53'E	73° 42'N	3 210	1998-2011	1998-2011	1998-2013	-	H & RD
Balakot	34° 23'E	72° 21'N	980	1961-2011	1961-2011	1961-2011	-	PMD
Muzaffarabad	34° 22'E	73° 29'N	686	1971-2010	1971-2010	1971-2010	-	PMD

(1) Coordinate System WGS84

Naran and Balakot climatological stations were considered to evaluate the climatic conditions in the Kunhar River basin. The main parameters describing the climatic conditions of the project area, *i.e.* the precipitation, temperature, and evaporation are presented in the ensuing sections.

5.2.3.2 Precipitation

The precipitation distribution along the year depends largely on the topography of the area and the season. The precipitation regime in the project area is dominated by the occurrence of eastward moving extra tropical zones of low pressure, also known locally as Western Disturbances. During the summer season the frequency and intensity of the Western Disturbances normally decrease, and the monsoon precipitation on the upstream part of the project area also decreases. The intensity of monsoon summer precipitation is increased towards downstream of the catchment.

Precipitation data is one of the most important hydrologic parameters in the hydrological and flood study of the Balakot dam site at Kunhar River. Therefore, obtaining reliable data over time and space was an essential step before modelling the rainfall-runoff. Pakistan precipitation is being recorded at many places by the Pakistan Meteorological Department (PMD) and Surface Water Hydrology Project (SWHP), WAPDA.

The monthly average precipitations are shown in **Figure 5.4** below, observed at the Naran and Balakot climate stations, in the vicinity of the project area. According to statistical data of the

Naran climate Station upstream of the project, the annual average precipitation is 1575 mm, with uneven distribution during the year. The maximum precipitation (242 mm) is in March, and the minimum precipitation (57 mm) is in August. According to statistical data of the Balakot climate station, downstream of the project, the annual average precipitation is 1500 mm, with uneven distribution during the year. The maximum precipitation (355 mm) is in July, and the minimum precipitation (37 mm) is in November.

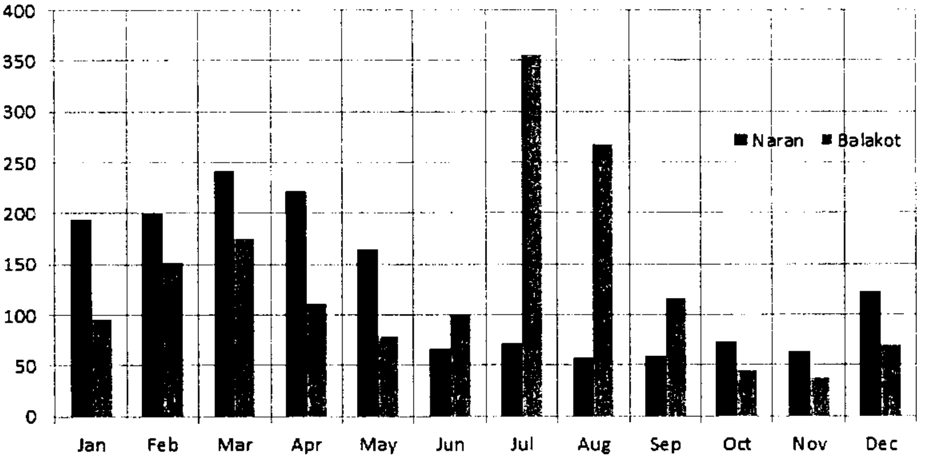


Figure 5.4 – Monthly average rainfall observed at the climate stations in the vicinity of the project area

5.2.3.3 Temperature Regime

The temperature regime follows the temperature pattern in the northern hemisphere. The temperature during the winter months from December to February falls below freezing point at most upper part of the catchment. On the other hand, during the summer months from June to August the temperature rises up to over 20 °C at most upper part of the catchment and over 30 °C in the lower part of the catchment. Moreover, the temperature daily variation is higher in the upper part of the Kunhar River basin.

Figure 5.5 and **Figure 5.6** show the variation of the average maximum, minimum and mean temperature during the year, as observed at Naran and Balakot climate stations respectively, located near the proposed hydropower site.

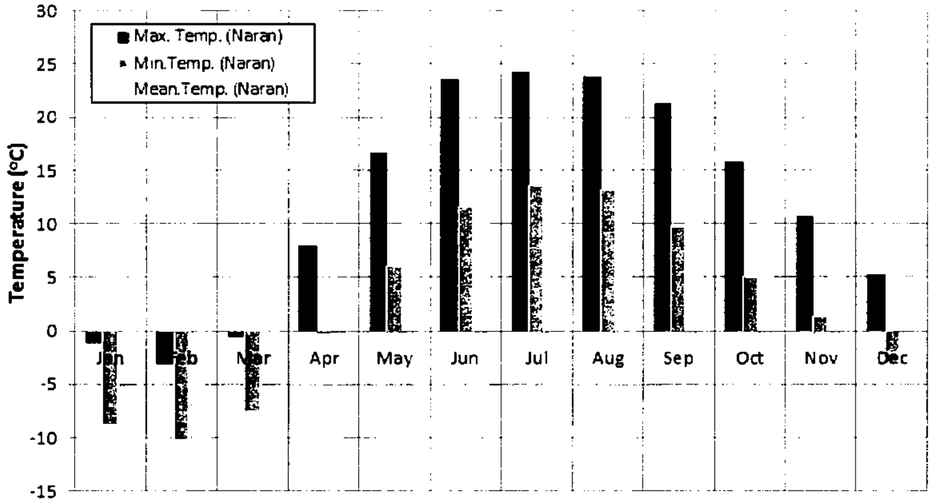


Figure 5.5 – Monthly average maximum and minimum temperature observed at the Naran station

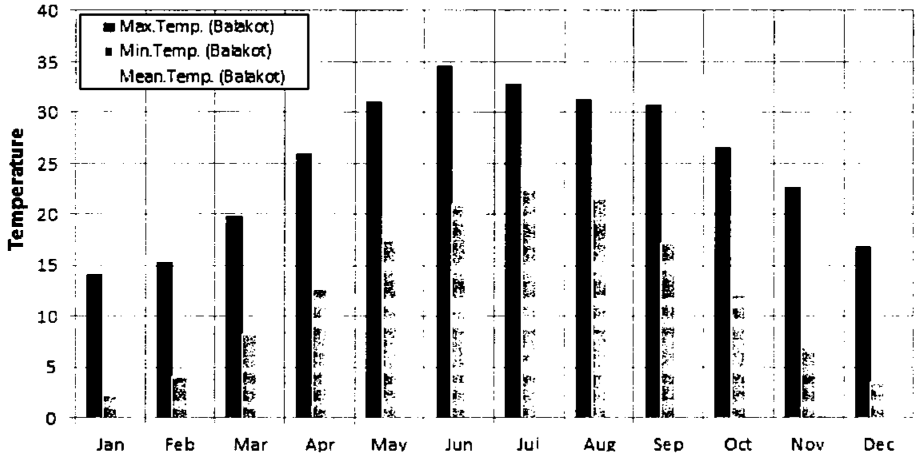


Figure 5.6 – Monthly average maximum and minimum temperature observed at the Balakot station

5.2.3.4 Evaporation

Evaporation data of Naran and Balakot climatological stations is collected and used for the evaporation analysis in the Kunhar River basin. The Naran station was installed and maintained by SWHP, WAPDA and the Balakot station was installed and maintained by Pakistan Meteorological Department (PMD). The mean monthly pan evaporation data is available at Naran gauging station for the period 1981 to 2007 and mean monthly pan evaporation data is available at Balakot gauging station for the period 1970 to 1979.

Mean monthly evaporation of Naran and Balakot are shown in **Figure 5.7**. During the months of December to March, evaporation data is not recorded at Naran, as the temperatures are much below the freezing point during this period. The results show that evaporation at Naran station is maximum in the month of July with a value of 156 mm and minimum in the month of November with a value of 29 mm. Whereas the evaporation at Balakot station is maximum in the month of June with a value of 294 mm and minimum in the month of December with a value of 49 mm.

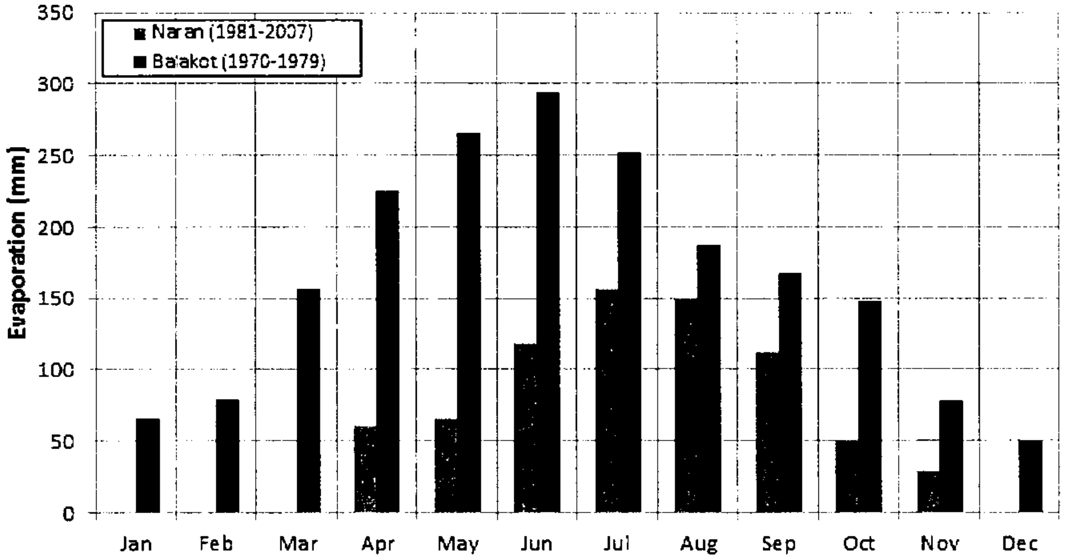


Figure 5.7 – Monthly average evaporation observed at Naran and Balakot stations

5.3 FLOW REGIME

The flow pattern in the Khunar river is mainly governed by snowmelt, with higher flows occurring generally between June and July. Currently, Kunhar River is being gauged at Kaghan and Talhatta, wherein hourly and daily gauge readings are continually recorded. Kaghan and Talhatta gauging stations represent around 42% and 88% of the Kunhar River basin area, and thus they provide a comprehensive overview of the flow regime of the Kunhar River.

The monthly average flows at Kaghan and Talhatta gauging stations are presented in **Figure 5.8**. As shown in **Figure 5.8**, the highest average monthly flows occur in June both at Kaghan and Talhatta stations.

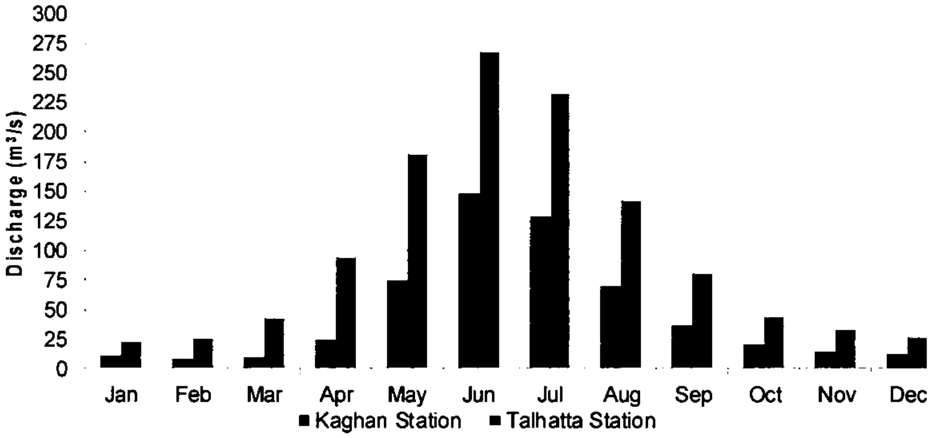


Figure 5.8 – Average monthly flows at Kaghan and Talhatta gauging stations (1960-2015)

Since there is no is no gauging/discharge measurement site on the Kunhar River at Balakot dam site, the availability of water was evaluated from the available daily flows records from 1960 to 2015 at Garghi Habibullah/Talhatta gauging stations. Actually, daily flow data is available in Garhi Habibullah stream gauging for the period of 1960 to 1992. In 1992, the Garhi Habibullah station was destroyed and then it was shifted to Talhatta (slightly upstream of Garhi Habibullah) in 1994.

In order to evaluate the flow regime at the Balakot dam site, the flow data was transposed from Garhi Habibullah/Talhatta stations with the relationship defined in the FS2013 as follows:

$$Q_{damsite} = 0.8539\ Q_{Garghi\ Habibullah} \qquad (1)$$

The long term (1960-2015) mean daily and monthly flows for Balakot dam site are presented in **Table 5.5.** As shown in **Table 5.5**, the mean maximum daily flow in Balakot dam site is 249.2 m^3/s, occurring in June. On the other hand, the mean lowest daily flow is 19.9 m^3/s, occurring in January. The average daily flow is 86.6 m^3/s. It should be noted that these values are very similar to the estimates presented in the Balakot FS2013 (87.3 m^3/s). Therefore, the PPTA Consultant considered the mean daily flow as previously estimated in precedent studies (87 m^3/s).

Table 5.5 – Long term mean daily and monthly flows at Balakot dam site (1960-2015)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	21.3	20.6	25.7	53.6	120.6	205.7	234.3	157.9	86.0	46.3	30.9	24.7
2	20.7	20.7	26.5	54.6	121.4	214.2	224.2	158.7	86.3	45.8	30.4	24.6
3	20.4	20.9	27.9	55.0	124.5	216.6	224.2	159.4	83.2	45.7	30.9	24.3
4	20.4	21.0	27.9	54.9	128.3	215.9	219.4	151.2	82.9	44.1	31.1	24.5
5	20.5	20.8	28.1	56.8	132.2	220.9	217.9	147.5	80.1	43.2	29.9	24.0
6	20.7	20.7	28.7	59.7	135.3	224.5	217.5	145.6	76.0	42.6	29.4	23.9
7	20.6	21.3	29.1	61.3	137.4	230.5	217.8	138.0	74.0	42.5	28.8	23.9
8	20.6	21.4	29.1	61.7	142.5	234.7	216.9	138.3	99.5	41.1	36.6	23.6
9	20.4	21.5	30.1	62.6	136.2	232.2	218.7	135.1	87.0	41.9	28.9	23.7
10	20.6	20.8	30.6	65.0	137.7	233.7	217.1	130.9	94.8	41.3	28.8	23.8
11	20.5	22.2	30.9	68.9	141.4	236.0	215.0	127.1	79.7	40.5	28.8	23.7
12	20.4	22.2	31.4	71.3	142.9	236.8	213.8	125.2	72.0	39.5	29.4	23.3
13	20.3	22.7	32.2	76.6	145.4	235.2	212.3	126.3	69.6	38.4	28.6	23.1
14	20.3	22.7	33.1	78.3	151.0	231.6	203.5	124.1	67.5	38.2	29.4	23.0
15	20.4	22.4	35.2	80.8	156.9	229.5	203.8	122.4	67.4	37.7	28.5	23.0
16	20.4	22.0	38.1	83.7	161.9	230.7	200.9	118.7	64.4	36.9	28.1	23.1
17	20.3	22.3	39.0	84.2	168.6	228.4	195.3	118.1	65.3	36.6	27.8	22.7
18	20.5	23.4	41.1	87.7	169.1	231.3	193.7	115.6	62.7	36.6	27.3	22.7
19	20.5	23.3	41.9	92.1	174.7	232.7	186.2	117.5	59.9	36.7	26.9	22.3
20	20.2	23.8	42.1	94.8	171.1	233.9	189.0	112.0	58.9	35.7	26.9	22.8
21	20.1	22.7	41.5	94.1	172.9	233.9	184.9	109.1	57.5	35.5	26.7	22.2
22	19.9	22.9	42.5	96.4	173.7	236.8	182.4	105.5	57.1	34.8	26.4	22.1
23	20.1	22.8	43.8	99.8	178.2	240.9	187.5	100.7	58.9	35.1	26.2	22.0
24	20.0	23.9	45.1	107.8	179.4	243.6	186.6	100.2	55.7	35.3	25.9	22.0
25	20.5	24.5	46.4	111.1	183.8	244.5	177.0	99.5	53.4	35.3	25.8	21.8
26	20.4	24.9	47.2	113.9	182.3	249.2	172.9	101.0	51.7	33.8	25.4	22.0
27	20.7	25.3	48.2	113.8	180.5	244.9	174.0	96.5	51.3	34.0	25.4	21.8
28	20.5	25.6	50.4	114.2	183.4	248.8	176.1	91.5	49.7	33.4	25.1	22.1
29	20.2	25.4	51.2	115.2	186.1	244.6	173.9	89.9	48.9	32.4	24.9	21.7
30	21.1		50.8	119.7	191.1	236.7	164.2	91.3	47.6	31.9	24.7	21.6
31	20.7		53.1		197.4		158.5	88.3		31.3		23.1
Monthly mean	**20.4**	**22.6**	**37.7**	**83.0**	**158.3**	**232.6**	**198.7**	**120.7**	**68.3**	**38.2**	**28.1**	**23.0**

The average annual flows at the Balakot dam site from 1960 to 2015 were also organized and are shown in **Figure 5.9**. The maximum average annual flow is 137.3 m^3/s and occurred in 1992. The minimum average flow is 46.3 m^3/s and occurred in 2001. The mean annual flow at the Balakot dam site from 1960 to 2015 is estimated as 86.6 m^3/s, as referred.

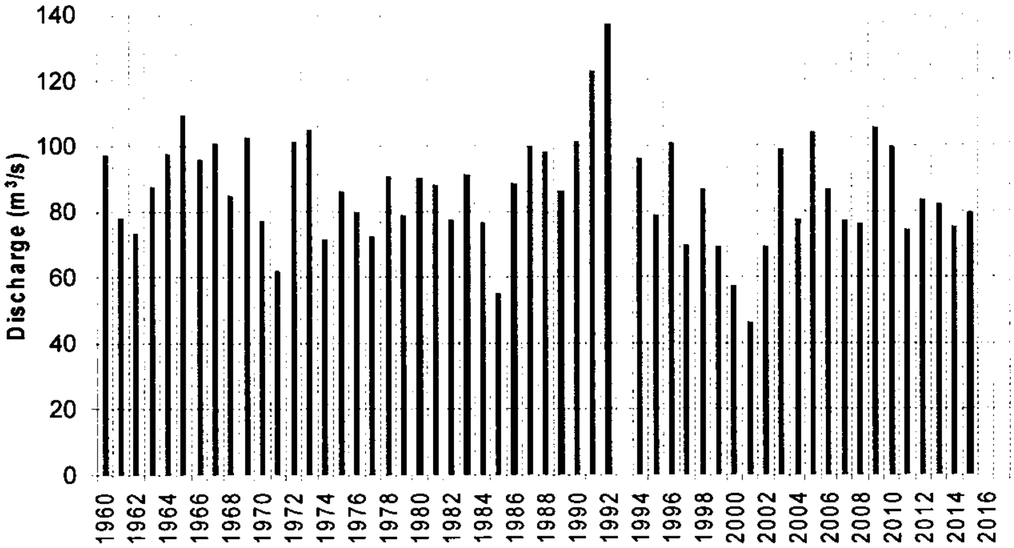


Figure 5.9 – Mean annual flows at Balakot dam site (1960-2015)

In order to evaluate the flow availability at the proposed Balakot dam site, the flow duration curve was computed and is presented in **Figure 5.10** and summarized in **Table 5.6**.

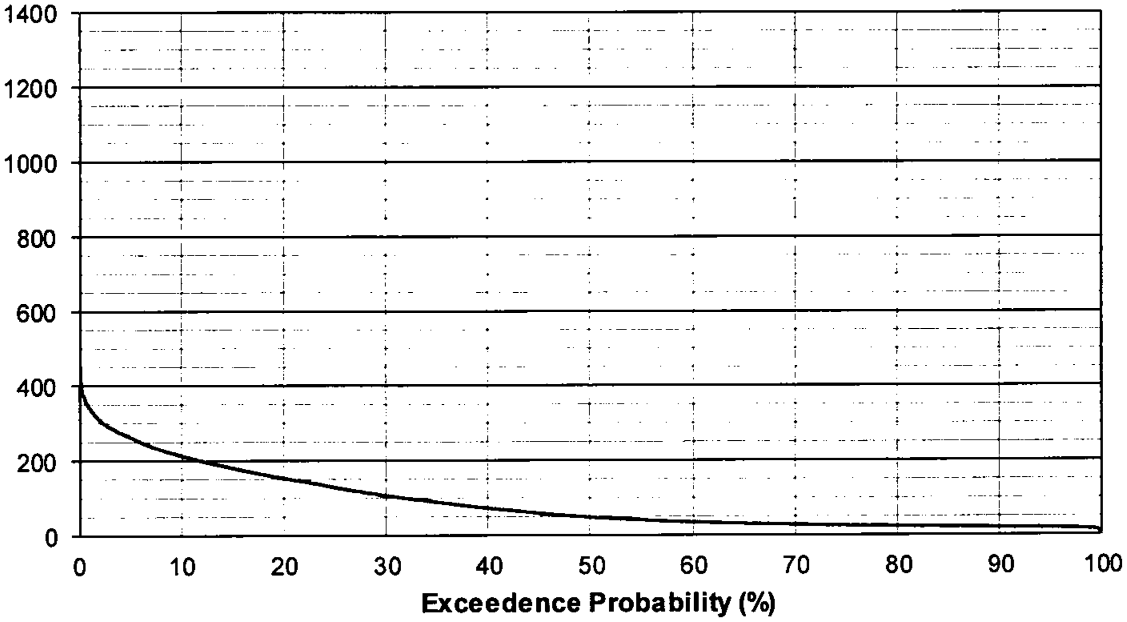


Figure 5.10 – Flow Duration Curve at Balakot dam site (1960-2015)

Table 5.6 – Flow Duration Curve at Balakot dam site (1960-2015)

Exceedance probability (%)	10	20	30	40	50	60	70	80	90
Flow (m^3/s)	213.3	152.8	106.6	72.4	47.6	34.1	27.2	22.9	19.3

As shown in **Figure 5.10** and **Table 5.6**, the flows available with 50 and 70% of probability of exceedance are 47.6 and 27.2 m^3/s, respectively. It should be noted that these values are very similar to the estimates presented in the FS2103.

5.4 FLOOD STUDY

The annual flood events in the Kunhar River are mostly caused by snowmelt, occurring following prolonged hot weather in the dry season of late May and June. Nevertheless, the major floods of the Kunhar are caused by heavy concentrated rainfall, which occasionally is increased by snowmelt flows, resulting in severe flood events during the monsoon season. Actually, intense rains and steep topography quickly generate high flows (flash floods) and high sediment yields in the streams.

Historically, a few relevant floods occurred in the Kunhar basin. The 1992 flood was considered as the largest flood in the upper Jhelum (including Kunhar River) since 1929.

Regarding the Kunhar River, the flood of September 1992 was the largest on record. According to the collected data, the peak flows in 1992 at Naran and Garghi Habibullah gauging stations were 967 and 2302 m^3/s (after revision).

The maximum instantaneous discharges at the gauging stations in the Kunhar River are presented in the **Figure 5.11**.

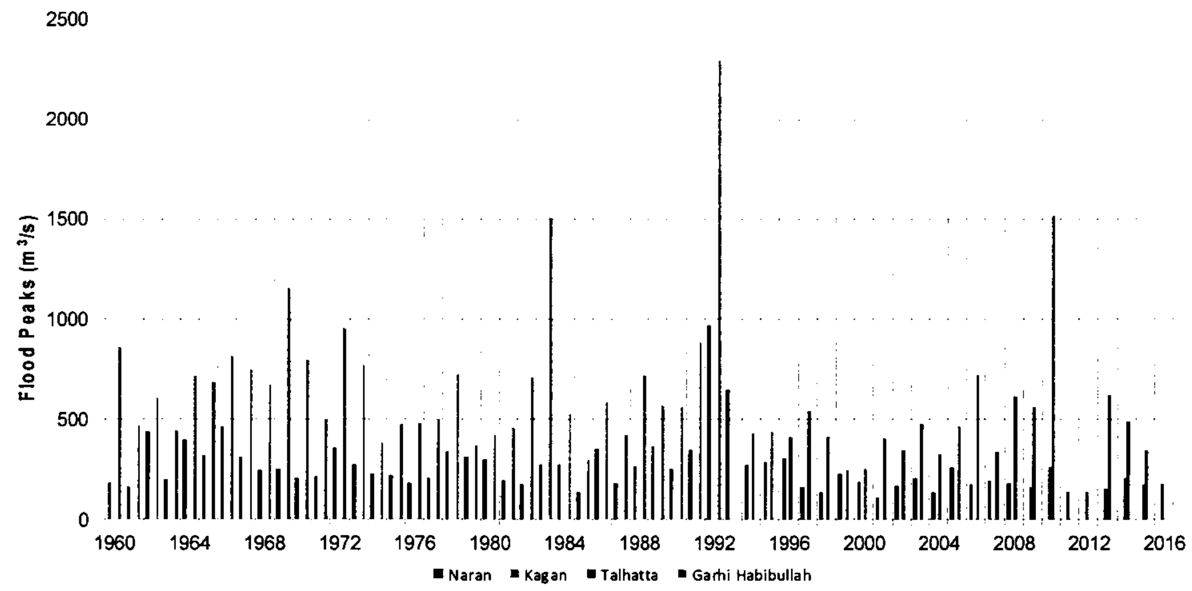


Figure 5.11 – Maximum instantaneous discharges at Naran, Kaghan, Garhi Habibullah and Talhatta gauging stations

In order to support the appropriate design of the Balakot HPP and related structures, the PPTA Consultant carried out a comprehensive technical investigation of flood behaviour, magnitude and statistical analysis in the Kunhar River basin, which is detailed in **Annex II – Flood Hydrology**.

As referred in **Annex II**, the approaches used in the flood analysis to establish design floods were the following:

- statistical flood frequency analyses based on observed data;
- rainfall-runoff models;
- empirical formulas.

Following these approaches, the design floods for the Balakot dam and powerhouse sites were estimated and are presented in **Table 5.7** and **Table 5.8**, respectively.

Table 5.7 – Design floods at Balakot dam site

Frequency / Return Period	0.01%	0.1%	0.2%	0.5%	1%	2%	4%	10%	20%	50%
	10000	1000	500	200	100	50	25	10	5	2
Flood Peak Discharge (m³/s)	3500	2300	2100	1700	1500	1200	1000	7500	600	400

Table 5.8 – Design floods at the Balakot powerhouse site

Frequency / Return Period	0.01%	0.1%	0.2%	0.5%	1%	2%	4%	10%	20%	50%
	10000	1000	500	200	100	50	25	10	5	2
Flood Peak Discharge (m^3/s)	3870	2540	2210	1770	1550	1330	1110	770	660	440

The probable maximum flood was also estimated based on hydrological modelling employing the HEC-HMS software, as described in **Annex II**. The meteorological parameters frequency storm (1 hour 68.8 mm, 2 hour 87.1 mm, 3 hour 99.5 mm, 6 hour 125.5 mm, 12 hour, 158.3 mm and 24 hour 199.5 mm) of the project area were computed with GIS spatial applications. The PMF peak discharge at the Balakot dam site is estimated to be 5043 m^3/s. The PMF hydrograph is shown in **Figure 5.12**.

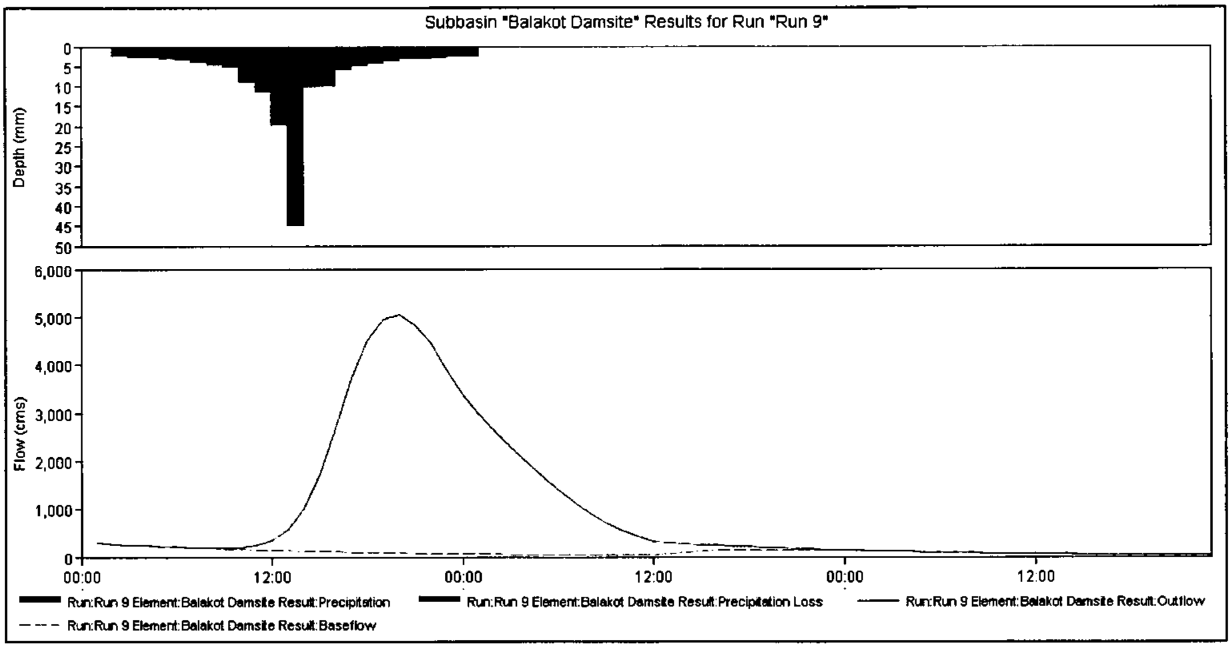


Figure 5.12 – Probable Maximum Flood (PMF) hydrograph for Balakot dam site

As detailed in **Annex VII**, and according to the size of the dam and related structures and also with the consequences of a potential failure, the following design floods are considered adequate as a conservative approach, in accordance with the adopted design standards:

- Design Flood: flood discharge of 10 000 years return period; $Q_{10\,000}$ = 3 500 m^3/s
- Safety Check Flood: probable maximum flood; Q_{PMF} = 5 000 m^3/s

Consequently, the spillway of the dam is designed to pass the design flood of 3500 m^3/s (T=10 000 years) without the reservoir level surpassing the NOL and checked for discharging the PMF (5000 m^3/s) without endangering the safety of the structure.

Due to the reduced storage capacity in relation to the flood volume, the Balakot reservoir flood routing is negligible and thus the natural inflow hydrograph peaks were considered for sizing and design of Balakot spillways and other hydraulic structures.

5.5 SEDIMENTS

This chapter presents the estimate of the mean annual sediment load inflow at Balakot dam site, taking into account the previous studies and the operation of the Suki Kinari hydropower project.

For a more detailed analysis *vide* **Annex III – Sediments**.

The previous Feasibility Study of the Balakot Hydropower Project (MIRZA *et al*, 2013), FS2013, estimated the mean annual sediment load at the Balakot dam site based on sediment discharge and sediment concentration measurements from the Kunhar River, Garhi Habibullah and Talhatta gauging stations. The sediment discharge data is available only on an occasional basis, especially during high flows, which results in long periods of data inexistence. Additionally, the fact that many measurements were only carried out during flood periods, and the lack of knowledge about occurrences of landslide events in the watershed upstream, which are frequent, may distort the data analysis.

Figure 5.13 shows the sediment concentration vs. flow for Garhi Habibullah and Talhatta gauging stations. It is possible to observe that, for similar discharges, suspended sediment concentration may vary extremely, without clear correlation between increasing or decreasing discharge rates. This behaviour may be mainly justified by the occurrence of landslides that, although possibly triggered by precipitation, cannot be correlated with its occurrence or intensity, since the time for them to occur will strongly depend on geological and geotechnical features, which are site specific conditions.

Taking into account the referred features, it is clear that the definition of a reasonably accurate relationship between the suspended sediment concentration and the flow measurements is not possible. Therefore, for the purpose of this Study, an annual rate of sediment yield was considered, based on White (2001), which presents the rates of sediment yield for different countries, based on case studies available. The range of values indicated for Pakistan is 50-100 / 250-500 $ton/km^2/year$. Based on this ranges of sediments yield, the adopted rate of sediment yield for the Balakot dam site is 450 $ton/km^2/year$. Considering this value, the mean annual sediment load value for the Balakot dam site is presented in **Table 5.9.**

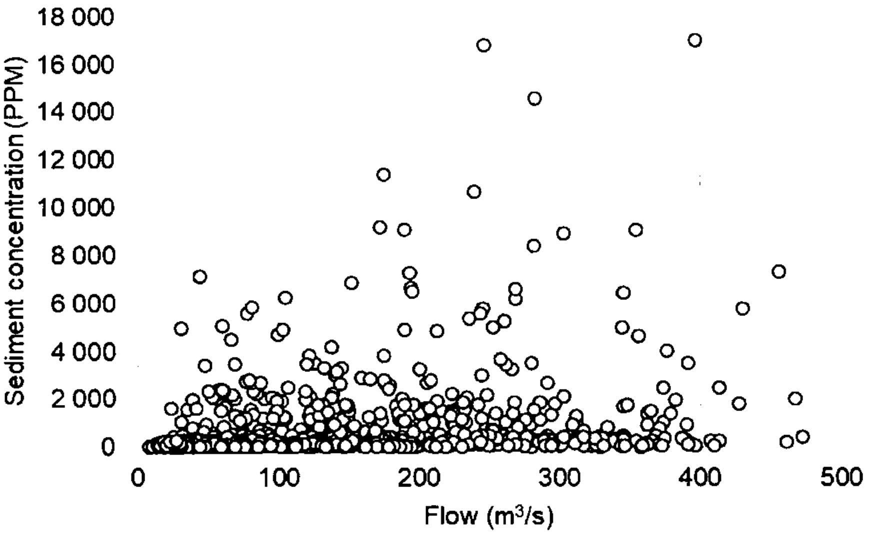


Figure 5.13 – Sediment concentration vs flow for Garhi Habibullah and Talhatta gauging stations

Based on the ranges of sediments yield for Pakistan presented by White (2001), the adopted rate of sediment yield for the Balakot dam site is 450 ton/km²/year. Considering this value, the mean annual sediment load value for the Balakot dam site is presented in **Table 5.9.** For the purpose of this study, the mean annual sediment load adopted is therefore 285 kton/year. This value only concerns the catchment area comprised between the Balakot and Suki Kinari dams.

Table 5.9 – Mean annual sediment load of Balakot catchment

Dam site	**Catchment area** (km²)	**Sediment yield rate** (ton/km²/year)	**Mean annual sediment load** (kton)
Balakot	627.7	450	282

Additionally, the FS2013 does not take into account the fact that there are several dams upstream of the Balakot reservoir at planning and execution stages. It is clear that most of the sediments, which would be deposited into Balakot reservoir, will be controlled by Suki Kinari's dam, already under construction. Considering the large uncertainty in the sediment production estimate, either in the Suki Kinari catchment or in the area situated between Suki Kinari and Balakot, the major outflow of sediments from Suki Kinari will be rather linked with future flushing operations of the Balakot dam. Therefore, a coherent analysis of the sediment inflow into the Balakot reservoir must necessarily incorporate the effect of the Suki Kinari dam and powerhouse.

Under normal conditions, it is suitable to consider that the sediments with smaller grain sizes will pass through the turbines of Suki Kinari's powerplant and eventually reach the Balakot reservoir. Therefore, when computing the total sediment inflow into Balakot during the period of normal operation of Suki Kinari power plant, which means that no flushing operations are performed at Suki Kinari dam, that amount of sediments should be accounted for.

According to **Figure 5.14**, it is possible to get an estimation of the mean annual sediment concentration passing the units, based on type and rated head of the turbines. Considering that Pelton turbines with a rated head of nearly 820 m will be installed at Suki Kinari (Mott MacDonald, 2008) and that the values in Area B are appropriate to the Suki Kinari hydropower scheme, according to **Figure 5.14**, the mean annual sediment concentration passing through the turbines will be within the range 50-100 g/m^3. For the purpose of the present Study an intermediate value of 70 g/m^3 is considered.

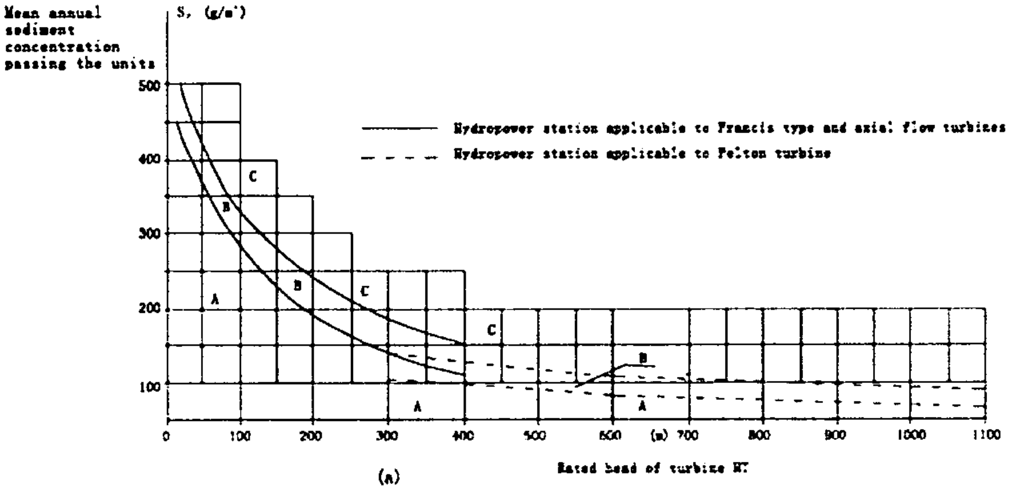


Figure 5.14 – Design Specification of Desilting basin in Hydraulic and Hydro-Power Engineering (DL/T 5107-199)

On the other hand, to obtain an estimate of the mean annual flow turbined in Suki Kinari (60 m^3/s), the mean monthly flows at the Suki Kinari dam site (Mott Macdonald, 2008) were used. With these values, the mean annual flow turbined in Suki Kinari and the mean annual weight of sediments passing through the turbines was estimated to be 135 kton. The mean annual sediment load at the Balakot dam site, considering the normal operation of the Suki Kinari dam, which means during the turbine operation periods, without any intermediate flushing operations, is estimated to be 420 kton (**Table 5.10**).

Table 5.10 – Mean annual sediment load at Balakot dam site

Mean annual sediment load (kton)	
Suki Kinari powerhouse	135
Balakot (sub-catchment area)	285
Total at Balakot dam site	**420**

6 NEO-TECTONIC AND SEISMIC

6.1 REGIONAL TECTONIC SETTING

6.1.1 Regional Tectonic Features

The project area is located in northern part of Pakistan at the apex of Hazara-Kashmir syntaxial bend near the collisional zone 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 Fault and Main Boundary Thrust (MBT). The general trend of these faults is predominantly east-west with change in trend at the syntaxial bends (**Figure 6.1** and **Figure 6.2**). Other important faults of the project region comprise the Balakot-Muzaffarabad-Bagh Fault, the Riasi Thrust (RT) and the Jhelum Fault (JF). For more details *vide* **Annex V – Seismic Hazard Evaluation**.

6.1.2 Local Tectonic Features

The project area is located at the northern tip of the Hazara-Kashmir syntaxial bend (HKS) where the regional tectonic features take a sharp bend and divide the Himalayan ranges into Eastern Himalayas and Western Himalayas. The eastern Himalayas extends from HKS to as far as Assam along the Himalayan mountain. The eastern Himalayas have experienced a large number of destructive earthquakes of magnitude 7-8 during the last century, the latest of which is the October 08, 2005 earthquake. The western Himalayas is seismically less active with few earthquakes of magnitude greater than 6 - the largest is the Taxila earthquake of 25 A.D.

The Project area falls in eastern (Kashmir) Himalayas, at the apex of HKS where the major tectonic features like Panjal fault and Main Boundary Thrust (MBT) takes sharp bend. On the northeastern limb of HKS, both faults dip towards northeast away from the project site (**Figure 6.3**). The Balakot-Muzaffarabad-Bagh Thrust also runs parallel to MBT, dips towards northeast and passes under the project site. Being close to project area, these active tectonic features are important for the seismic hazard evaluation of the project.

The other tectonic feature passing near the site is the Main Mantle Thrust (MMT), to the north of the project area. MMT is, however, dipping towards north, away from the project area (**Figure 6.3**).

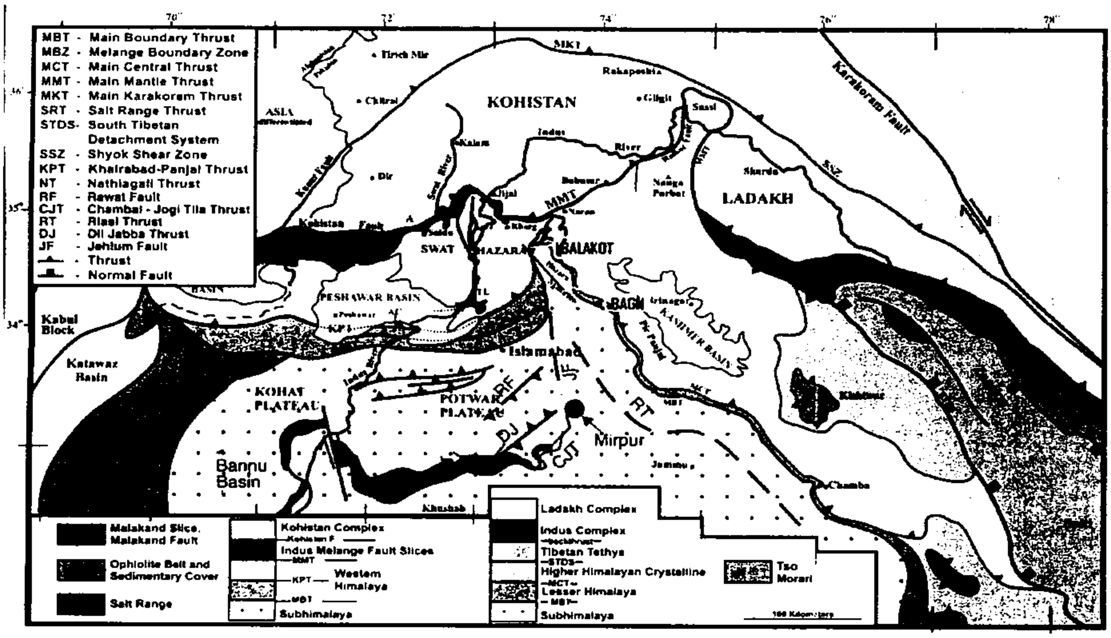
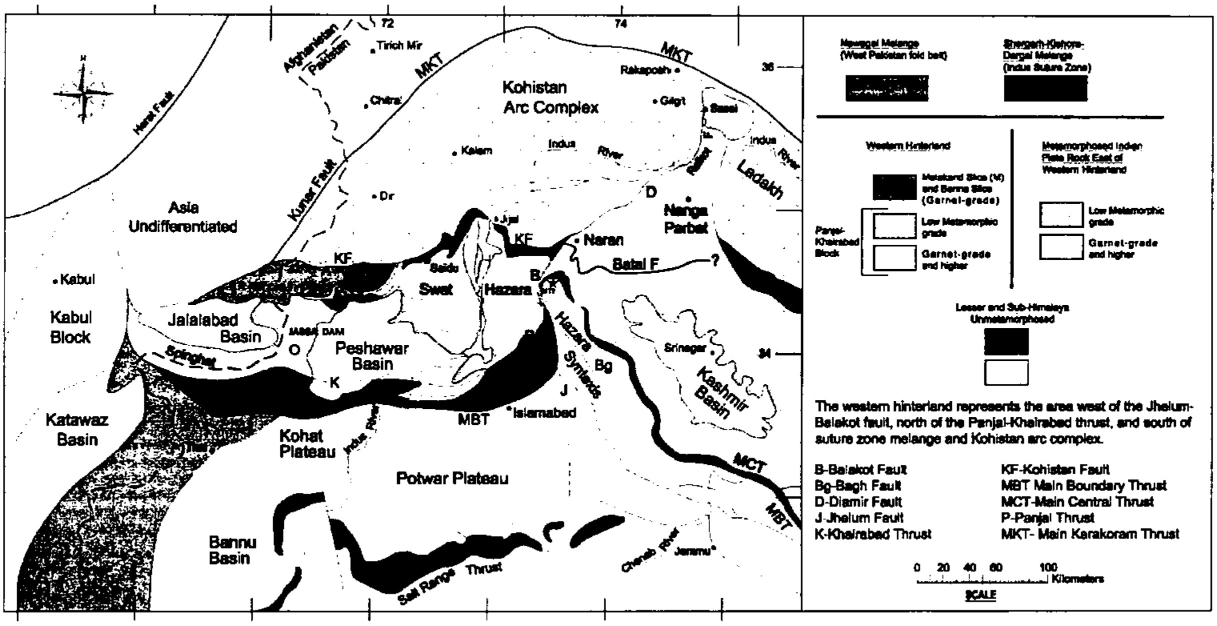


Figure 6.1 – Tectonic Map of Northern Pakistan showings major faults in Northern Part of Pakistan (after Ahmad Hussain *et al.*, 2004). Location of the Project site is shown by a red star



The western hinterland represents the area west of the Jhelum-Balakot fault, north of the Panjal-Khairabad thrust, and south of suture zone melange and Kohistan arc complex.

B-Balakot Fault
Bg-Bagh Fault
D-Diamir Fault
J-Jhelum Fault
K-Khairabad Thrust

KF-Kohistan Fault
MBT Main Boundary Thrust
MCT-Main Central Thrust
P-Panjal Thrust
MKT- Main Karakoram Thrust

Figure 6.2 – Tectonic Map of Northern Pakistan showings major faults in Northern Part of Pakistan (after DiPettero *et al.*, 2008). Location of Project site is shown by a red star

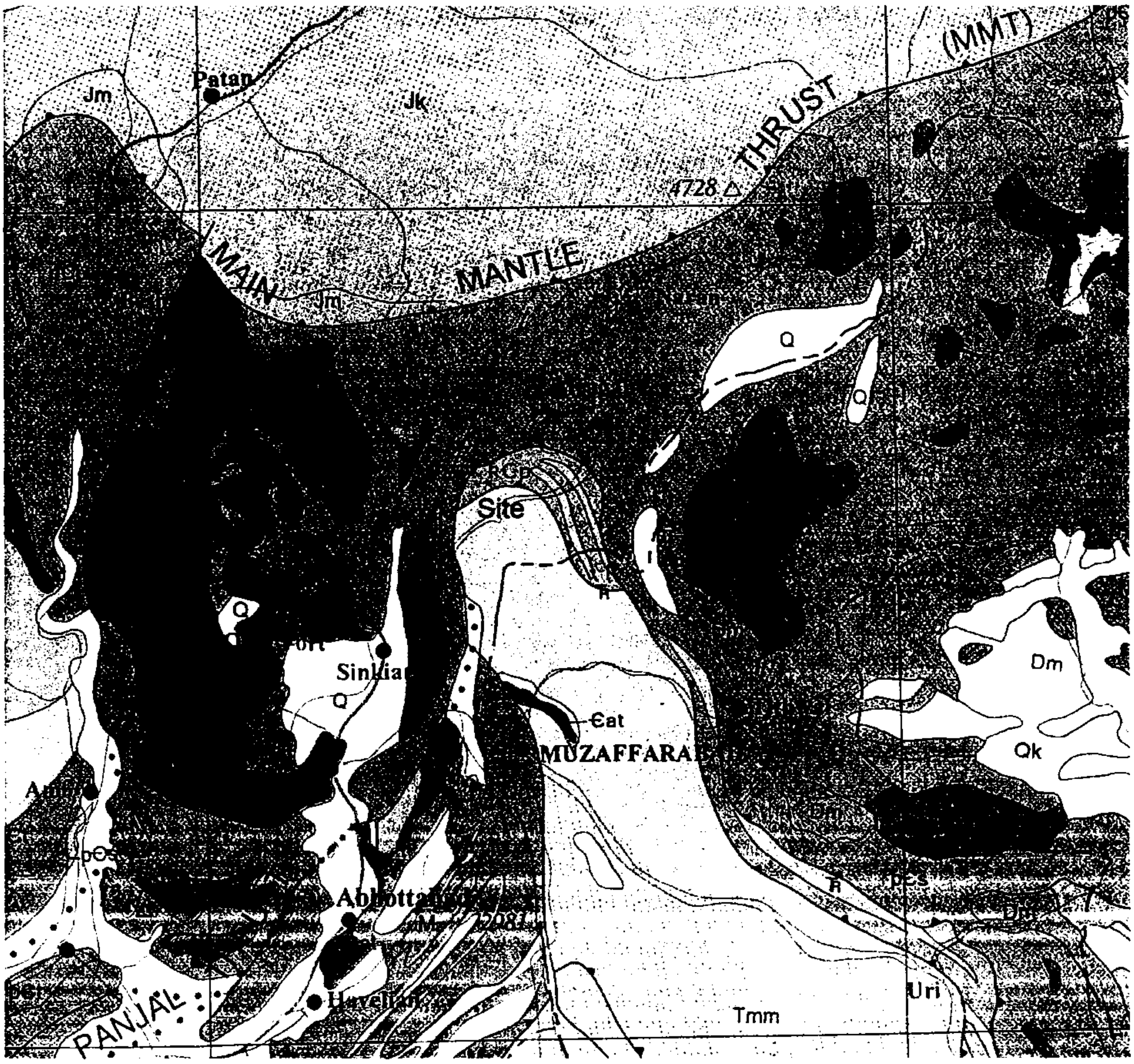


Figure 6.3 – Geologic Map of the Project region showing location of faults with respect to project site (after GSP, 1995)

6.2 EARTHQUAKE RECORD

6.2.1 General

Earthquakes are generated by tectonic processes in the upper part of the earth called lithosphere that is divided into several rigid parts called "Plates". Due to the movement of these plates, stress build-up takes place and results in the deformation of the crustal mass. This energy accumulation gives birth to seismic events. The contact zones between adjacent plates are, therefore, considered as the most vulnerable parts from the seismic hazard point of view.

The information about earthquakes in this region is available in two forms, *i.e.* historically recorded and instrumentally recorded earthquakes. The instrumentally recorded earthquake data is available only since 1904. Before this, the source of earthquake information is through the historical records and published literature.

6.2.2 Historical Earthquake Data

Historical Earthquake data consists of 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 Appendix-A of **Annex V**. From Appendix-A, it is reflected that northern Pakistan and Kashmir as a whole has remained a house of damaging earthquakes. Taxila (25 A.D.) event is probably the most conspicuous one that changed style of building-construction out rightly in the region of western Himalayas.

Based on the study of regional earthquakes in the eastern Himalayas by Bilham (2005), information about two strong earthquakes of Kangra Mw 7.8 earthquake in north of India in 1905 and Pakistani-administered Kashmir Mw 7.6 earthquake on October 08, 2005 along Himalayan Decollement is available in terms of earthquake damage, casualties and rupture zone (**Figure 6.4**).

6.2.3 Instrumental Earthquake Data

During the present phase of the studies, a composite list of seismic events that occurred in the project region and adjoining areas has been prepared. It is based upon earthquakes reported by International Seismological Center (ISC), United States Geological Survey (USGS), Tarbela Seismic Observatory (Pakistan), Micro Seismic Study Program of PAEC and Pakistan Meteorological Department and other international agencies. The composite list includes events within an area between latitudes 32° to 37° and longitudes 71° to 76° for the seismic study of the Balakot Hydropower Project. This composite earthquake catalogue for the project region is presented in Appendix-B of **Annex V – Seismic Hazard Evaluation**.

All available types of magnitudes in the catalogue were converted into a uniform magnitude-scale *i.e.* M_W (Moment magnitude) and given in Appendix-B of **Annex V**. M_W represents the area source, rather than a point source and the same type of magnitude is mostly being used in the seismic hazard analysis.

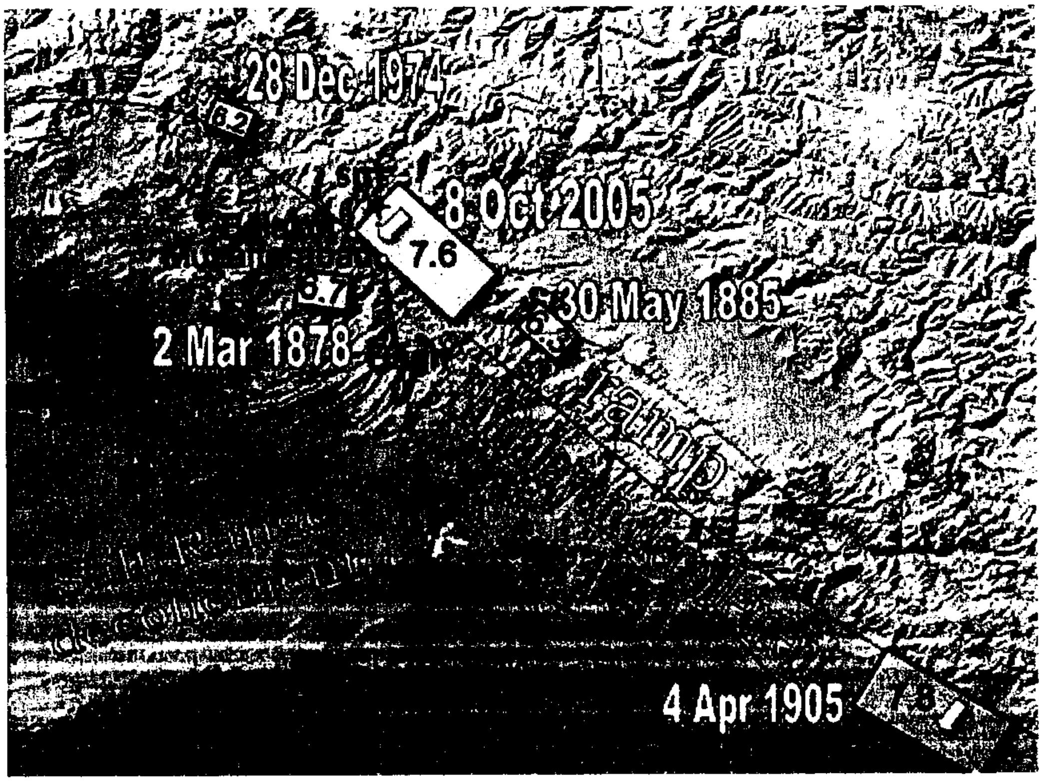


Figure 6.4 – Historical earthquakes in north of Pakistan and India (the content in the box marked with earthquake magnitude is roughly the fracture zone) (after Bilham, 2005)

6.2.4 Kashmir Earthquake of October 08, 2005

A powerful earthquake with a magnitude of Mw 7.6 struck the northern part of Pakistan on October 08, 2005 and caused widespread damage in Azad Kashmir and adjoining areas of NWFP. The epicenter 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 NWFP and Muzaffarabad, Bagh and Rawalakot in Azad Kashmir, where the entire population was affected. 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 the collapse of houses. The earthquake was followed by a series of more than one thousand aftershocks, hundreds of them exceeding magnitude 4.

This earthquake was caused by the movement due to rupture along a thrust fault named the “Muzaffarabad fault” or “Balakot-Muzaffarabad-Bagh” which runs parallel to the 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 that a predominant thrust motion and its strike is compatible with the strike of the Balakot-Muzaffarabad-Bagh fault.

A team of MSSP of PAEC carried out detailed field studies of the area affected by the October 08, 2005 earthquake. They mapped a complex, clearly segmented, at least 112 km long surface rupture along the fault (**Figure 6.5**). The isoseismal intensity map prepared by them (**Figure 6.6**) shows that maximum intensity exceeded XI on Modified Mercalli intensity (MMI) scale and the intensity observed at the Balakot project site was IX.

Two moderate earthquakes of local magnitude 5.6 and 5.4 occurred in Kaghan valley on February 14, 2004 about one year prior to the October 08, 2005 earthquake. The epicenters of these earthquakes were located near the town of Paras close to which the dam site is located. The composite fault mechanism solution of these earthquakes indicated dominantly thrusting on fault plane which dips towards NE (M. Qaisar *et al.*, 2008). It is worth mentioning that the focal mechanism of these earthquakes is very similar to that of October 08, 2005 earthquake. The maximum intensity of VIII was recorded at Paras.

Recently, on July 08, 2017, the epicenter of an earthquake of Richter magnitude M= 5.2 was recorded by the seismic network of Pakistan Meteorological Department at a distance of about 8 km north of the dam site of the Balakot HPP. The depth of earthquake was 13 km, with epicenter at 34.73 ° N and 73.47 ° E. The tectonic setting and local seismicity of the project area shows that it lies in a highly seismic area.

6.2.5 Analysis of Earthquake Data of Project Region

The seismicity of the project region observed during the last hundred years compiled for the present Study and presented in Appendix-B of **Annex V** is plotted in GIS format on **Figure 6.7**. This plot shows the presence of low to high seismicity all around the project area which indicates the presence of active tectonic features. The cluster of seismicity in the northwest of the Project area is related to the active Hindukush seismic zone and Main Karakoram Thrust. The cluster of seismicity near Muzaffarabad and Balakot with southeast-northwest orientation is mainly due the aftershocks of the October 2005 earthquake.

Another cluster of earthquakes in the northeast of the project area is related to the active seismic zone of Nanga Parbat-Haramosh massif. In the east and south of the project area low to moderate level of seismicity is observed. This implies that the regional tectonic features around the project area are seismically active at low to high level due to stresses developed as a result of collision of the tectonic plates.

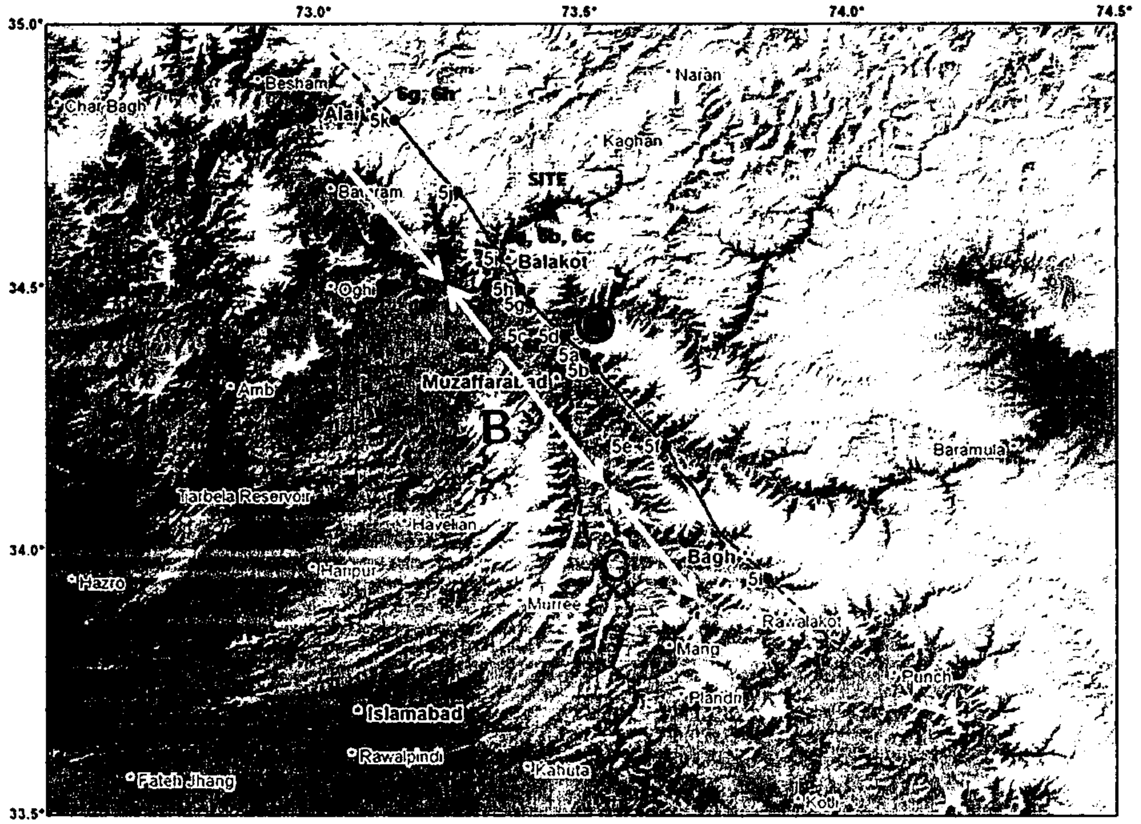


Figure 6.5 – Map showing epicenter of the 8 October 2005 earthquake (red circle) and trace of coseismic surface rupture (red line) (after Zahid Ali *et al.*, 2009)

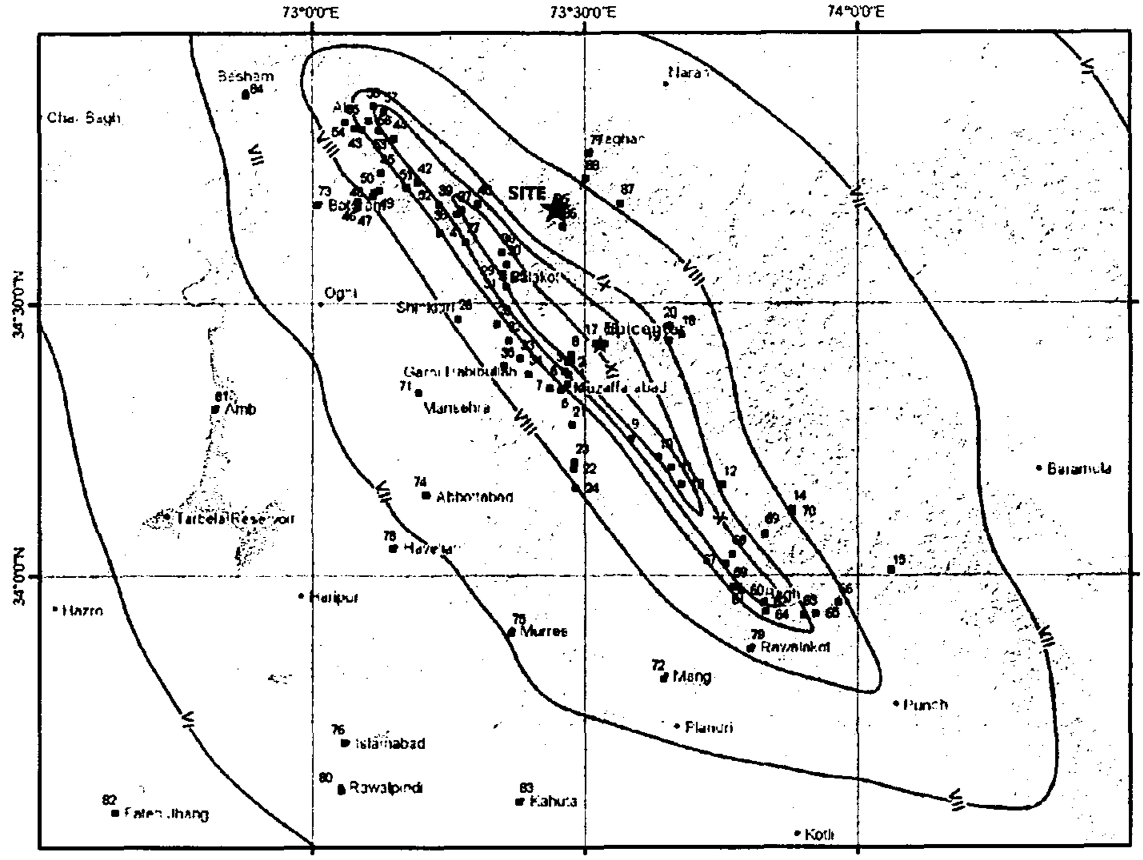


Figure 6.6 – Map showing distribution of MMI intensity observations in the near region of the 8 October 2005 earthquake (after Zahid Ali *et al.*, 2009)

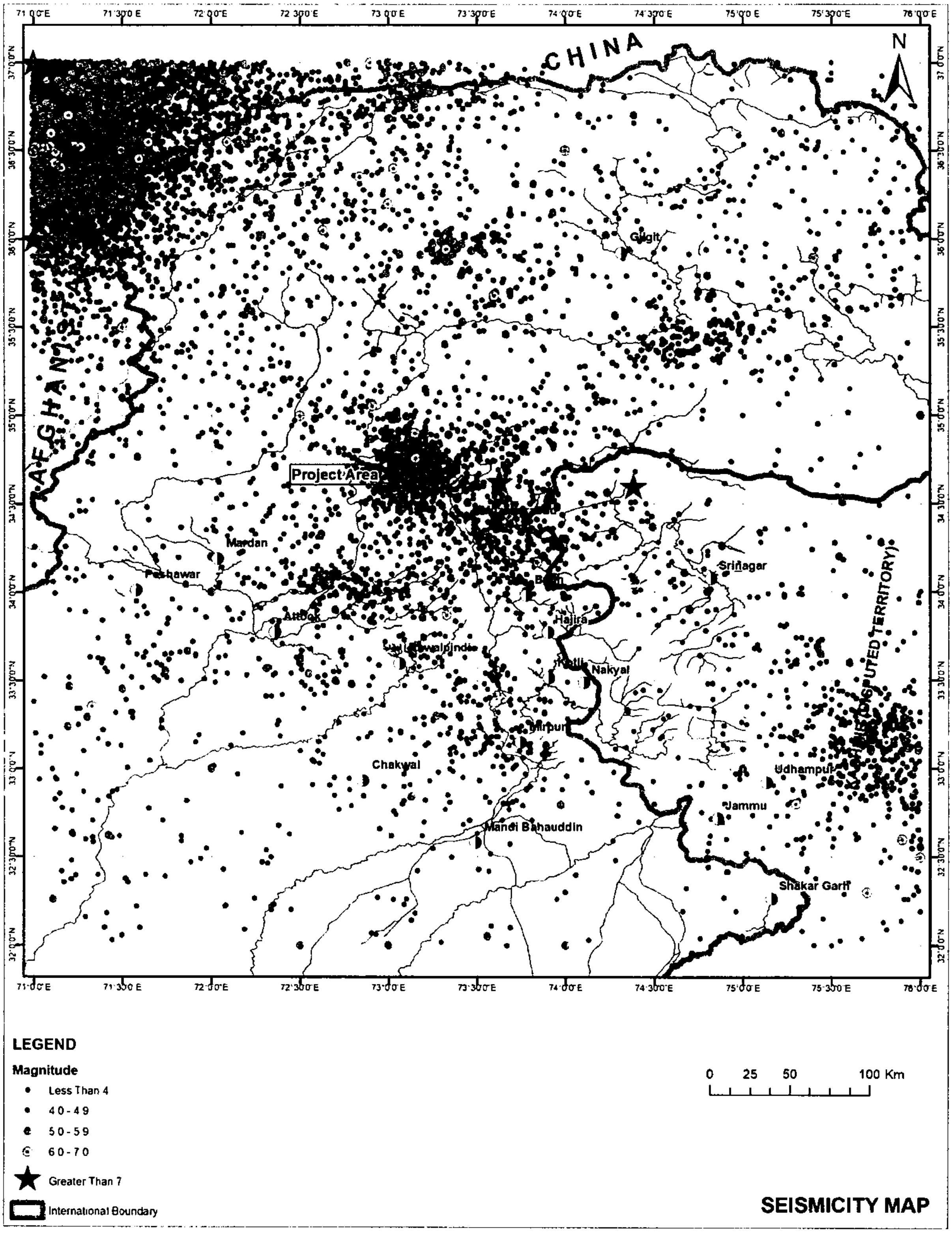


Figure 6.7 – Map showing seismicity recorded during last hundred years in the project region

6.3 SEISMOTECTONIC MODEL

From the available tectonic and seismic data of the project region presented above, a preliminary understanding about the seismotectonic set up of the project can be developed (*vide* **Annex V** for more details). Based on this understanding, the critical seismogenic features which are located near the project site and may influence the seismic hazard for the Balakot Hydropower Project are:

- Main Boundary Thrust (MBT) in the northeast;
- Panjal Fault in the northeast;
- Balakot-Muzaffarabad-Bagh Fault in the south-southwest; and
- Main Mantle Thrust (MMT) in the north.

The available seismic and tectonic data provides several evidences of the seismic activity along all these faults and therefore seismic potential associated with these faults should be considered for the evaluation of the seismic hazard.

In order to account for all the observed seismicity, the project region is also divided into seismic area source zones, keeping in view the homogeneity of the tectonic and seismic characteristics.

6.4 SEISMIC HAZARD ANALYSIS

The guidelines provided by the International Commission on Large Dam (ICOLD Bulletin 148, 2016) for selecting seismic parameters for large dams seismic hazard evaluation has been followed. Both probabilistic and deterministic methods of seismic hazard analysis were used for the evaluation of the seismic hazard to which the project is exposed.

6.4.1 Probabilistic Seismic Hazard Analysis (PSHA)

In the probabilistic seismic hazard analysis (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 earthquakes 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 epicenter 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 a 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.

For the definition of seismic sources, either line (fault source) or area sources can be used for source modeling. Because of the uncertainty in the epicenters location, it is not possible to relate the recorded earthquakes to the faults of the study area and to develop recurrence relationship for each fault and use them as exponential model. Moreover, subsurface extension and dimensions of the faults are not known. The project region was therefore divided into seven 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 seismic area source zone. 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. In order to account for the long-term seismicity, fault sources with Characteristic earthquake model were also incorporated in PSHA, in addition to area sources model. For more details on area sources, fault sources and the earthquake recurrence model used, *vide* **Annex V**.

The results of the probabilistic seismic hazard analysis in terms of horizontal peak ground accelerations at the dam and powerhouse sites for different return periods (inverse of annual frequency of exceedance) obtained are summarized in **Table 6.1** and **Table 6.2**, respectively.

Table 6.1 – Peak Ground Acceleration (PGA) for different return periods obtained through PSHA for the Dam site

Return Period (Years)	**PGA** (g)
145	0.17
475	0.29
1,000	0.41
3,000	0.65
10 000	0.94

Table 6.2 – Peak Ground Acceleration (PGA) for different return periods obtained through PSHA for the Powerhouse site

Return Period (Years)	**PGA** (g)
145	0.16
475	0.27
1,000	0.37
3,000	0.62
10 000	1.02

6.4.2 Deterministic Seismic Hazard Analysis (DSHA)

In the deterministic seismic hazard analysis (DSHA), 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 Boundary Thrust (MBT) in the northeast;

- Panjal Fault in the northeast;
- Balakot-Muzaffarabad-Bagh Fault in the south-southwest; and
- Main Mantle Thrust (MMT) in the north.

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 fault has been taken for calculating the maximum potential magnitude of the fault. The maximum earthquake magnitude (in moment magnitude M_W) of each fault was calculated using Wells & Coppersmith (1994) relationships between fault rupture length and magnitude and is given in **Table 6.3**. As the deterministic analysis is carried out for the dam site only, the closest distance of the dam site from these faults is also given in **Table 6.3**.

Table 6.3 – Critical faults and their maximum earthquake potential

Tectonic Feature	Fault Length (km)	Fault Rupture Length (km)	Maximum Magnitude Potential (1) (Mw)	Closest Distance From Fault (km)
Main Boundary Thrust (MBT)	400	200	7.8	2
Panjal Thrust	300	150	7.7	10
Balakot-Muzaffarabad-Bagh Fault	230	115	7.6 (2)	13
Main Mantle Thrust (MMT)	220	110	7.5	26

(1) Maximum potential magnitude calculated using Wells & Coppersmith (1994) relationship.

(2) Based on recorded magnitude of October 2005 Kashmir earthquake.

The peak horizontal ground acceleration at the site caused by the earthquake of maximum magnitude occurring at the closest distance to the fault was then calculated by using the latest attenuation relationships developed by various researchers from strong motion data from the USA and worldwide. These relations were used due to the absence of enough strong motion data for the south Asian region; no attenuation relation for this region is available. For more details on the attenuation relationships used *vide* **Annex V – Seismic Hazard Evaluation**. The peak horizontal ground acceleration (PGA) values obtained at dam site are given in **Table 6.4**.

- Panjal Fault in the northeast;
- Balakot-Muzaffarabad-Bagh Fault in the south-southwest; and
- Main Mantle Thrust (MMT) in the north.

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Table 6.4 – Peak Horizontal Ground Acceleration (PGA)

Tectonic Feature	Fault Type	Maximum Magnitude Potential (Mw)	Closest Distance from Fault (km)	Peak Horizontal Ground Acceleration (g)							
				Abrahamson & Silva NGA (2008)		Boore-Atkinson NGA (2008)		Campbell & Bozorgnia NGA (2008)		Average PGA of three equations	
				50%	84%	50%	84%	50%	84%	50%	84%
Main Boundary Thrust (MBT)	T	7.8	2	0.45	0.77	0.42	0.74	0.56	0.95	0.48	0.82
Panjal Thrust	T	7.7	10	0.25	0.43	0.26	0.46	0.31	0.52	0.27	0.47
Balakot-Muzaffarabad-Bagh Fault	T	7.6	13	0.78	1.34	0.34	0.60	0.46	0.77	0.53	0.90
Main Mantle Thrust (MMT)	T	7.5	26	0.12	0.21	0.15	0.26	0.15	0.25	0.14	0.24

6.5 SELECTION OF SEISMIC DESIGN PARAMETERS

6.5.1 Definitions

Maximum Credible Earthquake (MCE)

According to the definition given in ICOLD guidelines (2016), "the MCE (Maximum Credible Earthquake) is the largest conceivable earthquake that appears possible along a recognized fault or within a geographically designated tectonic province, under the presently known or presumed tectonic framework". The MCE can best be evaluated through a deterministic procedure. In the probabilistic seismic hazard evaluation, the MCE is linked to a very long return period.

Safety Evaluation Earthquake (SEE)

As per ICOLD guidelines (2016) the Safety Evaluation Earthquake (SEE) will produce the maximum level of ground motion for which the dam should be designed or analyzed. For dams whose failure would present a great social hazard, the SEE will normally be characterized by a level of motion equal to that expected at the dam site from the occurrence of deterministically evaluated MCE or of the probabilistically-evaluated earthquake ground motion with a very long return period, for example 10 000 years. Deterministically-evaluated earthquakes may be more appropriate in locations with relatively frequent earthquakes that occur on well-defined sources, for example near plate boundaries. For extreme or high consequence dams, the SEE ground motion parameters should be estimated at the 84th percentile level if developed by a deterministic approach and need not have a mean annual exceedance probability (AEP) smaller than 1/10 000 if developed by a probabilistic approach.

It will be required at least that there is no uncontrolled release of water when the dam is subjected to the seismic load imposed by the SEE. Depending on the circumstances (*e.g.* the importance of the dam, the consequences of a dam failure) it is recommended to design safety-critical elements such as the bottom outlet and/or spillway gates for the SEE.

Should failure of the dam present no hazard to life, a level of motion less than that associated with the Maximum Credible Earthquake may be acceptable to represent the Safety Evaluation Earthquake, based on alternative considerations such as the cost of the designed dam resulting from a specified level of motion and the cost of failure of the completed structure. This should be considered a special case and should be based on a socially accepted agreement.

Operating Basis Earthquake (OBE)

According to ICOLD guidelines "Operating Basis Earthquake (OBE) represents the level of ground motion at the dam site at which only minor damage is acceptable, the dam, appurtenant structures and equipment should remain functional and damage easily repairable from the recurrence of the earthquake not exceeding the OBE". Because of the above definition, the OBE is best determined by using a probabilistic procedure. OBE ground motions are significantly lower than those for MCE.

Design Basis Earthquake (DBE)

The term "Design Basis Earthquake" is mainly used in connection with the seismic design of appurtenant structures. Such structures can be designed against earthquakes following, for example, the seismic code for buildings and structures. Consequently, the site-specific design basis earthquake should have a return period equal to that specified in the seismic building codes, which is 475 years in the case of Eurocode 8 and several other codes.

6.5.2 Seismic Design Parameters

Seismic design parameters are selected on the basis of the results provided by probabilistic and deterministic approaches, and in compliance with the recommendations of ICOLD Bulletin 148 (2016).

Safety Evaluation Earthquake (SEE) accelerations

As a failure of the dam of the Balakot Hydropower project would pose a great social hazard, it falls into a high-risk (high consequences) category. Therefore, it is recommended to take the SEE as being equal to the controlling Maximum Credible Earthquake (MCE).

For the Balakot dam, the most critical tectonic feature controlling the MCE is the northeast dipping Balakot-Muzaffarabad-Bagh Fault which may cause maximum acceleration at the dam site. This would be a magnitude 7.6 earthquake occurring at a distance of 13 km from the site.

Based on the results of the deterministic analysis given in **Table 6.4**, the maximum value of peak horizontal ground acceleration (PGA) obtained at dam site associated with MCE along the fault at closest distance from dam site is of the order of 0.90g (84-percentile). This PGA value is close to the maximum ground motion having 10 000 year return period obtained through probabilistic analysis, which is 0.94g.

Operating Basis Earthquake (OBE) accelerations

The OBE accelerations are selected from the results of the probabilistic analysis. The purpose of the OBE design is to protect against economic losses from damage or loss of service for all the project structures. The performance requirement is that the project functions with little or no damage or interruption under OBE conditions. Being close to active tectonic features, the OBE is recommended to be taken corresponding to a return period of 475 years (*i.e.* 20% probability of exceedance in 100 year project life) for which the PGA value is 0.29 g for the dam site and 0.27 g at the powerhouse site.

Design Basis Earthquake (DBE) accelerations

For the design of all other appurtenant structures of the project, including tunnels and powerhouse structure, ICOLD recommends to use ground motion having a 475 year return period, which is termed DBE accelerations (Weiland, 2011). The recommended ground motion for DBE is therefore 0.27g (for rock foundation condition with V_{s30} equal to 1000 m/sec).

6.6 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations based on the study of seismotectonic setting of the Balakot Hydropower Project and the results of seismic hazard evaluation are as follows:

- The project is located on the northern tip of the Hazara-Kashmir syntaxial bent, close to the boundary between the Indian plate and Kohistan Island arc which is sandwiched between the Indian and Eurasian tectonic plates.
- As the project area is located within the collisional zone of the plate boundaries, it is seismically very active.

- A number of large to moderate intensity earthquakes have been recorded in the project region during the last 100 years.
- The main seismotectonic features considered critical for the seismic hazard for the project are as follows:
    - Main Boundary Thrust (MBT);
    - Panjal Fault;
    - Balakot-Muzaffarabad-Bagh Fault; and
    - Main Mantle Thrust (MMT).
- As per recommendation of the ICOLD guidelines, deterministically-evaluated earthquakes may be more appropriate for SEE in locations with relatively frequent earthquakes that occur on well-defined sources, for example near plate boundaries. For the design of the dam of the Balakot Hydropower Project, therefore, the recommended horizontal Peak Ground Acceleration (PGA) associated with the SEE is 0.90 g (84-percentile).
- The recommended horizontal Peak Ground Acceleration (PGA) associated with the OBE is 0.29 g (with a return period of 475 years) for the design of the dam.
- The recommended horizontal Peak Ground Acceleration (PGA) associated with the DBE is 0.27 g (with a return period of 475 years) for the design of other appurtenant structures including tunnels and powerhouse.

7 GEOLOGY

7.1 SCOPE OF FIELD INVESTIGATIONS

Mirza Associates *et. al.* prepared the feasibility study report (FS2013) in December 2013. The PPTA Consultant, at the request of Asian Development Bank (ADB), reviewed the FS2013. As a result of the review, ADB requested the PPTA Consultant to develop a pre-feasibility level program to identify and investigate alternative dam and powerhouse sites. The PPTA Consultant conducted an alternative locations and layout analysis study and submitted a report to ADB. Based on the site investigation results, the PPTA Consultant adopted Dam B location as the dam site for the 300 MW Balakot Hydropower project. Additionally, the headrace tunnel alignment was re-routed and a powerhouse location with a new tailrace route was sited. These studies were divided into two phases, Phase II and Phase III. Both these phases have been completed. Phase I was carried out in the scope of the *D2.2A – Alternative Locations and Layout Analysis Study.*

The scope of the Phase II & III studies included:

- geotechnical site investigations;
- geotechnical laboratory testing;
- evaluation of the results and reporting.

Geotechnical drilling was conducted to investigate the potential of the Kunhar River valley to have a suitable foundation for the development of a hydropower site. The Phase 2 drilling at the dam site was undertaken to define the subsurface stratigraphy and to characterize the ground for the foundation of the proposed dam.

The core logging, core photography and in-situ testing were undertaken by the drilling Contractor's geologists. For quality data collection and to keep consistency in the core logging, a site-specific geotechnical core logging manual was designed and provided to the Contractor's geologists (**Appendix A**). The PPTA Consultant site representatives monitored and supervised the drilling and core logging.

Eight boreholes were planned to be drilled at the dam site, by-pass tunnel, power tunnel intake and headrace tunnel. **Table 7.1** shows the details of the Phase II site investigations.

The locations of the drill holes are shown in **Figure 7.1** and **Figure 7.2**.

Table 7.1 - Drilling details of the completed boreholes

Sr. No.	Borehole No.	Depth (m)	Coordinates (UTM)		Elevation (m)	Drilled Depth (m)
			Easting (m)	Northing (m)		
Dam Site						
1.	BH-201	65	3242597.000	1166713.000	1323.966	65
2.	BH-202	70	3242574.973	1166717.966	1324.245	70
3.	BH-203	50	3242196.000	1166510.000	1253.550	50
4.	BH-204	50	3242224.969	1166482.061	1252.212	50
5.	BH-205	50	3242258.000	1166473.000	1282.054	50
6.	BH-206	35	3242292.000	1166460.000	1304.093	35
Tunnel Route						
7.	BH-207	149	3239640.142	1162131.293	1379.858	149
8.	BH-208	123.13	3237450.000	1160715.000	1350.446	124
Total Depth (m)		592.13	**Total Drilled Depth (m)**			593

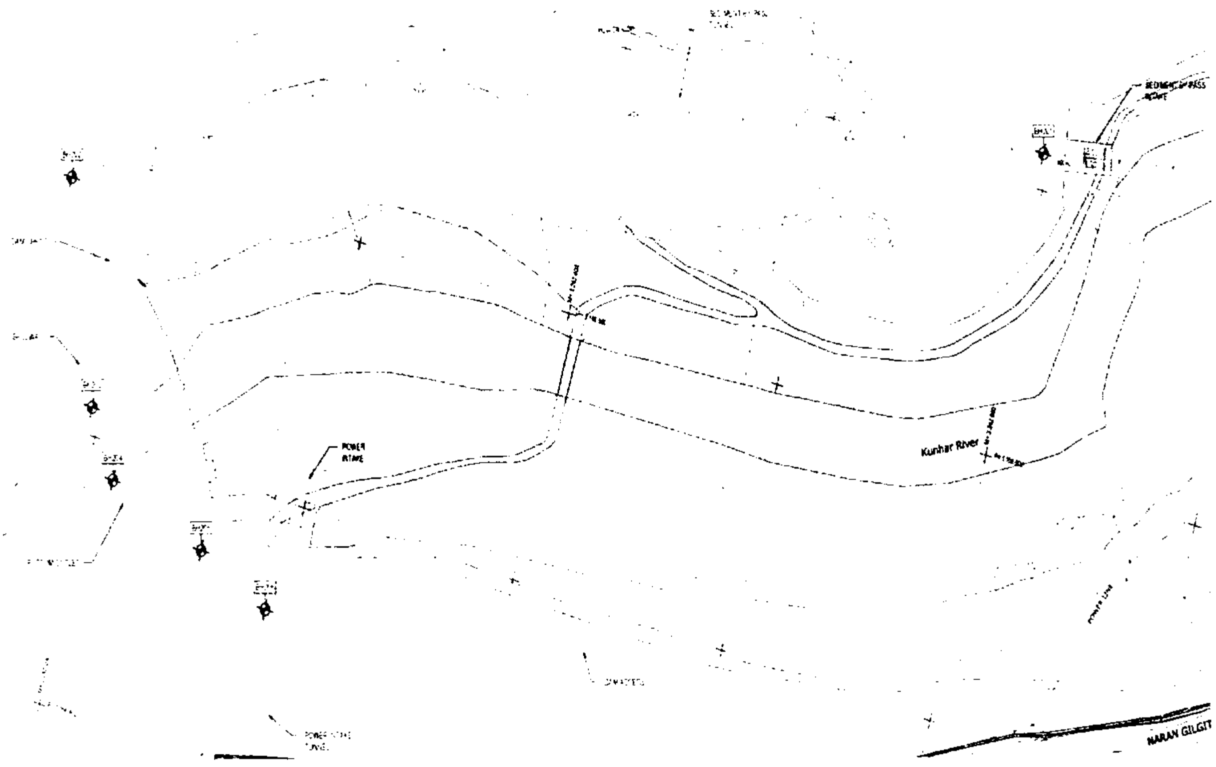

Figure 7.1 - Location of dam site, diversion tunnel and intake tunnel drill holes

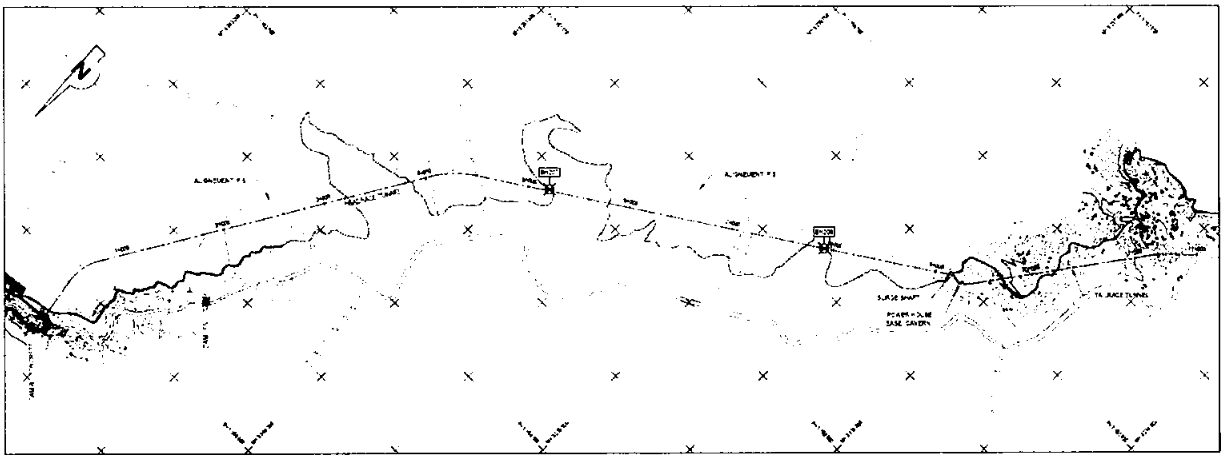

Figure 7.2 - Locations of headrace tunnel drill holes

Both soil and bedrock were logged at the drill site by the Contractor's geologists. In addition to logging, each drill run was photographed while the core was in the split tube as well as in the core box.

The bedrock parameters collected during geotechnical core logging include rock type description, Total Core Recovery (TCR), Rock Quality Designation (RQD), weathering, strength, discontinuity, depth, type, shape, roughness, alpha angle (angle with respect to core axis), infill type, and thickness and fractures per run. Faults and shears were the prime focus for the boreholes drilled in the dam sites and powerhouse areas, and where encountered during drilling, were also documented in the borehole logs. Geotechnical borehole logs were prepared for each borehole and are presented in Appendix C of **Annex IV**.

7.1.1 Laboratory Test Program

To estimate the engineering properties of the rock and to develop design parameters, representative samples of core were selected for various laboratory tests. **Table 7.2** shows the number of laboratory tests conducted on representative core samples. Geotechnical laboratory testing was conducted at the Central Material Testing Laboratory WAPDA Lahore, Pakistan, and petrographic analysis of the representative core sample was fulfilled by Professor Dr. M. Nawaz Chaudhry. **Table 7.2** shows the laboratory test program.

Table 7.2 - Laboratory Test Program Status - Dam

Sample No.	BH No.	Depth (m)		Specific Gravity	Porosity (%)	NMC (%)	Unconfined Compression Strength		Discontinuity Shear Strength		Slake Durability Index (%)	Modulus of Elasticity (MPa)	Modulus of Deformation (MPa)	Petrographic Analysis
		From	To				UCS (MPa)	Corrected UCS (MPa)	Cohesion (MPa)	Angle of Shear Resistance (deg)				
WS-01	BH-201	42.61	42.78	-	-	-	3.11	3.06	-	-	-	-	-	-
WS-02		45.40	45.57	-	-	-	-	-	-	-	94.4	-	-	-
WS-03		52.00	52.15	-	-	-	-	-	0.081	37.8	-	-	-	-
WS-08	BH-202	49.57	49.82	-	-	-	36.65	42.00	-	-	-	8.29x10^4	4.14x10^4	-
WS-09		54.82	55.11	-	-	-	-	-	0.105	34.6	-	-	-	-
WS-10		59.60	59.94	-	-	-	-	-	-	-	-	-	-	Greenschist (Phyllonite)
WS-02	BH-203	15.82	15.95	-	-	-	-	-	-	-	-	-	-	Claystone
WS-03		22.80	23.20	-	-	-	-	-	-	-	85.8	-	-	-
WS-06		33.32	33.63	-	-	-	117.23	117.64	-	-	-	-	-	-
WS-03	BH-204	27.96	28.33	-	-	-	-	-	-		98.4	-	-	-
WS-04		29.25	29.50	-	-	-	-	-	0.139	30.1	-	-	-	-
WS-06		41.56	41.77	2.89	2.91	0.45	-	-	-	-	-	-	-	-

Sample No.	BH No.	Depth (m)		Specific Gravity	Porosity (%)	NMC (%)	Unconfined Compression Strength		Discontinuity Shear Strength		Slake Durability Index (%)	Modulus of Elasticity (MPa)	Modulus of Deformation (MPa)	Petrographic Analysis
		From	To				UCS (MPa)	Corrected UCS (MPa)	Cohesion (MPa)	Angle of Shear Resistance (deg)				
WS-08	BH-204	18.75	19.18	-	-	-	-	-	-	-	98.4	-	-	-
WS-02	BH-205	16.20	16.55	-	-	-	-	-	-	-	-	-	-	Carbonate Cemented Sandstone
WS-07		35.36	35.58	-	-	-	-	-	-	-	85.7	-	-	-
WS-08		41.73	42.00	-	-	-	-	-	0.269	22.0	-	-	-	-
WS-03	BH-206	22.75	22.98	2.84	2.86	0.60	-	-	-	-	-	-	-	-
WS-04		25.68	25.92	-	-	-	-	-	-	-	-	-	-	Arenaceous Limestone (Arenaceous Carbonate Rock)
WS-09		26.15	26.56	-	-	-	-	-	0.207	31.8	-	-	-	-
WS-10		27.25	27.50	-	-	-	-	-	-	-	-	-	-	Arenaceous Limestone (ArenaceousCarbonate Rock)
WS-06	BH-206	28.76	28.90	-	-	-	-	-	0.021	35.6	-	-	-	-
WS-11		29.05	29.21	-	-	-	-	-	-	-	-	-	-	Calcareous Claystone

Sample No.	BH No.	Depth (m)		Specific Gravity	Porosity (%)	NMC (%)	Unconfined Compression Strength		Discontinuity Shear Strength		Slake Durability Index (%)	Modulus of Elasticity (MPa)	Modulus of Deformation (MPa)	Petrographic Analysis
		From	To				UCS (MPa)	Corrected UCS (MPa)	Cohesion (MPa)	Angle of Shear Resistance (deg)				
WS-12		29.80	30.30	-	-	-	-	-	0.082	36.7	-	-	-	-
WS-08		33.07	33.37	-	-	-	9.74	9.75	-	-	-	-	-	-
WS-02	BH-207	103.17	103.45	2.76	4.84	0.79	-	-	-	-	-	-	-	-
WS-03		106.00	106.50	-	-	-	61.60	61.65	-	-	-	-	-	-
WS-04		111.20	111.47	-	-	-	118.05	134.00	-	-	-	5.32x10^4	2.66x10^4	-
WS-08		129.88	130.20	-	-	-	-	-	0.121	38.7	98.4	-	-	-
WS-13		129.66	129.88	-	-	-	-	-	-	-	-	-	-	Claystone
WS-09		130.20	130.45	2.76	3.21	0.46	-	-	-	-	-	-	-	-
WS-10		135.80	136.02	-	-	-	-	-	-	-	98.2	-	-	-
WS-14		136.02	136.12	-	-	-	-	-	-	-	-	-	-	Arenaceous Claystone
WS-12		147.00	147.50	-	-	-	60.37	60.45	-	-	-	-	-	-
WS-01	BH-208	86.60	86.94	-	-	-	-	-	-	-	-	-	-	Arenaceous Claystone
WS-03		103.00	103.24	-	-	-	-	-	-	-	98.1	-	-	-

Sample No.	BH No.	Depth (m)		Specific Gravity	Porosity (%)	NMC (%)	Unconfined Compression Strength		Discontinuity Shear Strength		Slake Durability Index (%)	Modulus of Elasticity (MPa)	Modulus of Deformation (MPa)	Petrographic Analysis
		From	To				UCS (MPa)	Corrected UCS (MPa)	Cohesion (MPa)	Angle of Shear Resistance (deg)				
WS-04		117.05	117.43	2.83	4.84	0.90	-	-	0.052	41.3	-	-	-	-
WS-05		117.87	118.25	-	-	-	38.55	38.68	-	-	-	-	-	-
WS-06		120.16	120.62	2.84	4.83	0.55	-	-	-	-	-	-	-	-
WS-07		122.23	122.66	-	-	-	61.87	70.00	-	-	-	3.77x10^4	1.88x10^4	-
WS-08		123.44	123.78	-	-	-	-	-	0.073	39.9	-	-	-	-

7.1.2 Geotechnical Mapping

The prediction of the engineering performance of an excavation in a rock mass requires an understanding of the nature and distribution of the geologic structures within the rock mass. A natural rock mass is never a continuous, homogeneous, isotropic material, but is rather intersected by a great variety of geologic discontinuities such as faults, joints, bedding or foliation.

More than 90 percent of the scanline mapping was conducted with the help of a hand-held GPS during the alternative locations and layout analysis study. However, to remove inconsistencies in the past feasibility study mapping, the services of a Surveyor were taken to mark the lithologic contacts along the Naran Road, dam site, reservoir and tailrace tunnel area. The following characteristics were considered while collecting detailed geotechnical structural and rock strength data:

- orientation of discontinuities and division into "sets" having similar orientations;
- classification of discontinuities by type;
- continuity or persistence of fractures;
- spacing or frequency of discontinuities within sets;
- infilling and thickness of the discontinuities;
- surface shape and roughness (strength properties);
- rock type;
- degree of weathering or alteration (intact rock strength);
- seepage.

7.2 GEOLOGICAL STUDIES

7.2.1 Regional Geology

The information related to the regional geology and structure presented under this section is based on the available reports, records and maps, which mainly include technical research papers by Dr. Munir Ghazanfar from Punjab University and secondarily the 840 MW Suki Kinari Hydropower Project Feasibility Study Report (Volume 1) and Balakot Hydropower Project Feasibility Study Report (Volume 1 - Main Report).

Balakot Hydro Power Project is planned to be constructed within the Hazara-Kashmir syntaxis bounded by Main Boundary Thrust (MBT) and the Punjal Fault. The major regional structural features are briefly described in the following sections. **Figure 7.3** shows the regional geology and structure of the area.

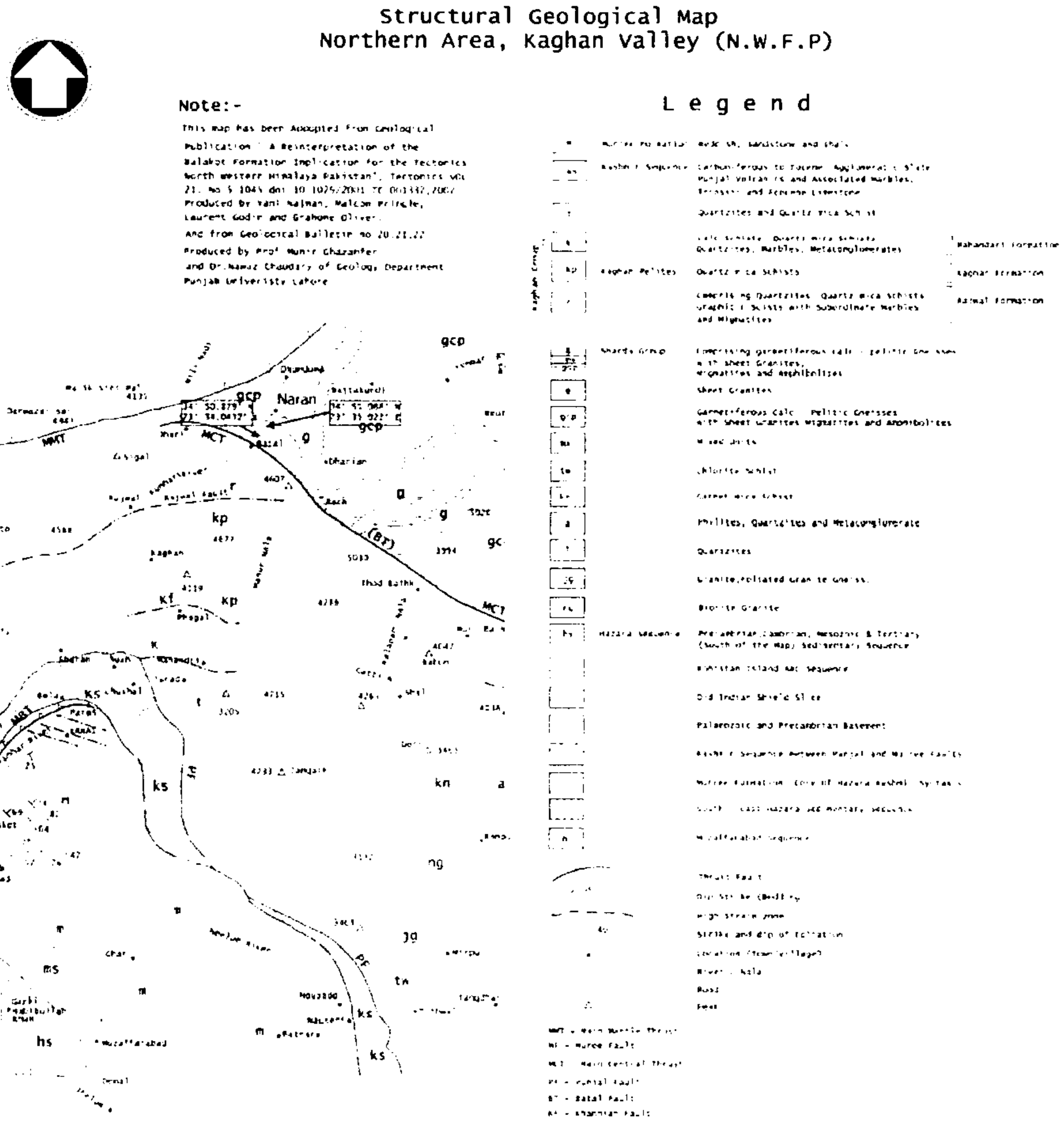

Figure 7.3 - Regional Geology and Structure of the Project Area

The Kaghan Valley provides an N-S transverse section through the middle part of NW Himalaya lying in Pakistan. It is drained by the river Kunhar. To its east lies the more-or-less parallel valley of the River Neelum (Kishanganga) in Azad Kashmir. To its west lies the valley of the River Indus draining the so-called Kohistan Himalaya. Tectonically, the lower part of Kaghan Valley comprises the Hazara Kashmir Syntaxis, an acute bend of strike at the western end of the Himalayan chain. This syntaxis is beautifully outlined by the Main Boundary Thrust (MBT). As we move from Balakot up the Kaghan Valley to Paras, for about 26 km along the road, we pass through sequences of Murree formations forming the core of the Hazara

Kashmir Syntaxis. Farther, between Paras and Jared, one passes through the eastern limb of the syntaxis formed by the so-called Carboniferous to Eocene sequence encloses between the Panjal and Murree faults. From Tutan, near Jared, right across Babusar, a very extensive and long section of rocks or its parts were termed as the Salkhalas by Wadia (1931) and later writers such as Calkins et al. (1975) and Bossart et al. (1984). Detailed geological mapping has revealed that this sequence in fact consists of a large number of lithogic units, which have now been mapped and grouped into broader units. Thus, it is possible to subdivide the entire so-called Salkhala sequence into the following broad units:

- a rather small Jared unit;
- a very large Kaghan group;
- an equally large Sharda group.

The Sharda group, which forms the western or the upper Kaghan Valley, is truncated by the Sothern Suture Zone or Main Mantle Thrust (MMT) of the northwest Himalayas, just north of Babusar. Further north of Babusar, across the MMT, we have a sequence of low-grade schists, amphibolites, diorites and norites with some ultrabasic shreds. The bulk of the sequence of the Kaghan Valley between Jared and Babusar, therefore, comprises Cambrian and Precambrian rocks and is sandwiched between Panjal Fault in the south and MMT in the north. Thus, from the point of view of stratigraphy, from south to north, the Kaghan valley comprises the Miocene Murree formation, the so-called Carboniferous to Eocene sequence, and the very wide Cambrian and Precambrian sequence.

The sequence between Balakot and Malkandi (near Paras) is sedimentary, although Bossart *et al.* (1984) placed it in the prehnite-pumppellyite facies. Up from Malkandi, the entire sequence is metamorphosed in a progressive manner up to silliminite grade or upper amphibolite facies; there is, however, a break in this progression near Batal. **Figure 7.3** shows the regional geology and structure of the project site. The main structural features are discussed briefly in the following section.

7.2.2 Main Boundary Thrust (Murree Fault)

The Main Boundary Thrust (MBT), also known as the Murree Fault, is a steeply dipping fault that has been influenced by the tectonic movements which formed the Hazara-Kashmir syntaxis to the north of the project area. The Murree Fault represents a thrust between the metamorphosed sequence west of River Kunhar and a sedimentary sequence of the axial zone of Hazara Kashmir Syntaxis occurring east of River Kunhar. In the Balakot area, this fault is generally vertical or inclined steeply to the west. Trending north from Nauseri in the Neelum Valley in Azad Kashmir, the Murree thrust crosses the high Kaghan ridge and, traversing the slopes of Bhunja Katha, appears near the Malkandi on the roadside in Kaghan Valley. From here it is folded into a hairpin bend along with the rest of the structures and geologic sequence on the limbs of the Hazara Kashmir Syntaxis, passing around the east-west-trending apical part of the syntaxis and bending south along the western limb of the syntaxis.

Running north-south along the Jalora Katha it turns NW-SE north of Balakot and then runs along the Barna Katha. Farther south, it passes under the town of Balakot and continues to Naugran for a distance of about four miles, concealed under the alluvial fill of Kunhar Valley. In the area of Naugran and Batkarar, the Murree Fault separates a slice of the Panjal Formation from the dolomite of the Abbottabad Formation. Farther south, it passes west of Muzaffarabad and then onwards along River Jhelum. The MBT is an active fault, with movement close to the village of Balakot considered to be the epicentre of a major earthquake in 2005.

7.2.3 The Panjal Fault

The Panjal Fault (Wadia, 1931), coming from Kashmir at the base of Pir Panjal Range, like the Murree Fault, bends around the Hazara Kashmir Syntaxis and trends in a NW-SE direction west of Balakot, separating graphitic schists of the Agglomeratic Slate sequence from the Balakot Gneiss of the Tanol Formation. On the western limb of the syntaxis from north to south, it passes through the villages of Makhan Mohri, Tungli, Bajanbaura, Dandar and Khanda. Farther south of Bamphora for some distance, all the way to Hassa and Batkarar, it combines with the Murree Fault.

In the Balakot area, especially north of Balakot, it dips generally west at 25° to 65°. South of Balakot, the dips range from 25° to 35° west. Calkins et al. (1975) called it a combination reverse strike slip fault, which dips from 59° E to vertical.

The fault is orientated in a NW-SE direction to the southeast of Paras, and then curves into an east-west trend near Paras, and finally into a NE-SW orientation near Hangral. The rocks to the south of the MBT belong to the Murree Formation (comprising shales, sandstones and mudstones), which is part of the sub-Himalayan terrain.

7.2.4 Himalayan Frontal Thrust

The Himalayan Frontal Thrust (HFT) is a northwest-southeast-trending intra-formational thrust fault. It is in the frontal zone of Himalayan Fold Belt and likely an extension of the Riasi Thrust, a main branch of MBT. It dips northeast and is marked by severe deformation and thrusting.

HFT is an active fault that crosses the Kunhar River near Balakot City. Around the Balakot area, the active fault trace is rather simple and straight, and obscure fault scarplets and low flexure scarps continuously develop. The main fault extends southeast and passes through a saddle between hills.

7.2.5 Stratigraphy of the Project

The site geology has been extrapolated from the mapping, drilling and available records and reports. The surficial geology comprises of alluvium, slope deposits, riverbed deposits and scree. The Murree Formation constitutes the bedrock of the project area. Following is the summary of the bedrock and surficial deposits constituting the project area.

The Murree Formation is outcropped at the dam sites, surge tank and powerhouse locations. The Murree Formation consists mainly of maroon-coloured shales with green patches and bands, greenish-grey sandstones, and generally maroon siltstone/mudstone/claystone.

The shales are maroon generally, though at places are purple or bright red. The colour sometimes changes laterally into patches of and bands of green. They are characterized by a splintery nature, presence of fracture cleavage, lineation and tension gashes. Numerous veins of calcite and quartz are also present. At some places, the shales contain a few small-size pebbles.

The sandstone is greenish-grey to grey on the fresh surface and brownish on the weathered surface. It is coarse-grained, impure and calcareous, with minute rock pieces. The weathering is generally penetrative, and a one-or-more-centimetre-thick brown weathered layer may surround a greyish fresh core. The rock is well jointed and has quartz veins and tension gashes.

The siltstones are very similar to shales except for the coarser grain size.

The occasional-to-rare grey fossiliferous Eocene limestone bands within the Murree Formation may be inliers of Margla Hill limestone, but may also represent olistostromes, i.e syndepositional patches and slices of Margla Hill limestone detached from the parent and emplaced within the Murree during deposition.

7.3 DISCUSSION OF REGIONAL AND SITE-SPECIFIC GEOLOGY AND STRUCTURAL MODEL

The FS2013 developed a geological and structural model regarding the pertinent structure of the project. The review of the FS2013 model indicated a disconnect between the site-specific geology and structure model and the regional geology and structure model. The regional geology and structure indicated the presence of well-documented regional thrusts in the region, however the FS2013 site geology map and the scanline mapping did not show a single structural feature.

The review of FS2013 reveals that the previous Feasibility Report does not illustrate effects of regional structural features (thrusts and faults) on the proposed structures or a linkage between the regional and site-specific geological and structural models. Usually, the projects sited in areas with active megathrusts and shears do have small or large shear and fault zones in their vicinity.

The mapping carried out by the PPTA Consultant identified structural features (shear and fault) at the location of the proposed dam site and powerhouse as well as along the Naran Road between Sanghar and Paras. The PPTA Consultant identified several faults and shears during the scanline mapping, which have been shown on the mapping drawings.

Another important and crucial aspect was the alignment and location of the Main Boundary Thrust (MBT), especially in the reservoir area. The previous FS2013 report shows it crossing before the Kunhar River's main bend in the town of Paras. The Kunhar's right bank at this location shows the signs of instability marked by slides. Crossing the MBT before the bend means that the instability of the steep right bank slope is not associated with the active thrust.

The PPTA Consultant mapping revealed that the MBT does not cross before the bend; rather, it runs parallel to the river through the bend and crosses the river at the upstream end of the Paras town. It is worth mentioning that the alignment is accurate where the MBT crosses the Kunhar River, as well as where it crosses the Naran road upstream of the Paras town. It is not possible to pinpoint where the MBT actually runs along the Kunhar River bend because of the active sliding which, along with the fact that the MBT has created a mix zone. The most important aspect is that the MBT runs along the Kunhar River bend, which constitutes the right bank of the reservoir.

The presence of the MBT along the river bend has severe impacts regarding the reservoir sliding.

In addition to mapping, borehole drilling at the proposed dam site also revealed some shear zones. The boreholes drilled at the location of the excluded powerhouse and the tailrace tunnel alignment showed multiple tectonised sections in the subsurface.

7.4 DAM SITE INVESTIGATIONS

7.4.1 Surficial Geology and Geomorphology at Dam Site

The proposed dam site is located just downstream of the Sharan-Paras road bridge on the Kunhar River. The left bank is wide with mild slopes, whereas the right bank has moderately steep to steep slopes, marked by the bedrock at the riverbank, followed by the slope deposits.

7.4.1.1 Geology of the Right Bank

The sandstone, claystone, shale and siltstone beds of the Murree Formation are outcropped on the right bank. The sandstone beds are greenish-grey, fine-to-medium grained, and moderately to steeply dipping, with very closely to moderately spaced fractures, medium-strong to strong, and with negligible fracture infilling. The oxide and broken rock are the dominant infillings. The shales are maroon, fine-grained, splintery and weak, whereas the siltstone is thinly bedded and very weak to weak. On the right bank, the Murree Formation constitutes three fracture sets plus a random set. Two boreholes (BH-202 and BH-203) have been drilled in the right bank. The depth to the overburden range is between 17 m and 25.50 m.

7.4.1.2 Geology of the Left Bank

The left bank comprises predominantly of the riverbed deposits, with few riverbed sandstone outcrops toward the river. These outcrops are the part of the riverbed. The sandstone at the left bank is greenish-grey, fine-to-medium grained, moderately to steeply dipping, with very closely to closely spaced fractures, medium-strong to strong, and with negligible fracture infilling. On the left bank, the Murree Formation constitutes two fracture sets plus a random set. The river deposits comprise of, approximately, boulders 30%, cobble 20%, gravels 30%, sand 15% and trace silt.

Two boreholes (BH-107 and BH-108) were drilled in the left bank. The core logging results indicate a depth of overburden between 2.5 and 7 m, however the geophysical profiles (SRP 8, 9 & 10) have shown overburden up to a depth of 15 m. SRP-9 passes through the BH-108 location. Drilling results showed an overburden depth of 7 m, whereas the geophysical profile indicates an overburden depth of 10 m.

7.4.1.3 Power Intake Tunnel

The power intake tunnel proposed in the slope deposits immediately downstream of the Sharan-Paris road bridge on the left bank. The geophysical profile SRP-10 was conducted at the slope deposits near the Sharan-Paras bridge. The results showed overburden depth of 13 m, which potentially could reach 20 m.

The reconnaissance downstream of the bridge along the Kunhar River indicates the presence of the bedrock at the riverbed level. The slope deposits have a gentle to mild slope in the lower parts and attain a moderate to steep slope in the upper reaches. These deposits comprise of gravel- to cobble-size angular rock fragments, sand, silt and clay.

7.4.2 Results of Dam Site Investigations

7.4.2.1 Geotechnical Mapping of Dam Site

The FS2013 geology map was used to map riverbed deposits, slope deposits and scree deposits. A Clar compass, geological Brunton and GPS were used to collect rock mass data. During Phase 2, the services of a surveyor were rendered to delineate the lithological rock contacts and surficial deposits. A total of eight scanlines were mapped at the location of the dam site, with six at the location of the dam. The Bieniawski RMR 1989 and Barton Q 1974 rock mass classification systems were employed to collect the rock mass data.

7.4.2.2 Site Characterization of Dam Foundation

The rock mass data was processed and interpreted with dips. Histograms of rock mass parameters showing the mean, minimum and maximum values, along with the standard deviation, were worked out for each scanline. The results of right bank rock mass rating are presented in **Table 7.3**.

Table 7.3 - Rock Mass Ratings of Dam Right Bank Scan Lines

Scanline #	DAM RIGHT BANK SCAN LINES BIENIAWSKI 1989 ROCK MASS RATING						
	Parameters	Mean Values	Mean RMR	Min Values	Min RMR	Max Values	Max RMR
2	ISRM Strength	25	4	15	2	50	7
	RQD %	100	20	100	20	100	20
	Spacing (m)	0.718	15	0.675	15	0.8	15
	Joint Condition	13	13	0	0	25	25
	Ground Water	12.00	12	10	10	15	15
	RMR		**64**		**47**		**82**
3	ISRM Strength	25	4	15	2	50	7
	RQD %	100	20	97	20	100	20
	Spacing (m)	2.8	20	2.8	15	2.8	15
	Joint Condition	14	14	0	0	25	25
	Ground Water	12.00	12	10	10	15	15
	RMR		**70**		**47**		**82**
4	ISRM Strength	15	2	8	2	25	4
	RQD %	100	20	100	20	100	20
	Spacing (m)	1.234	15	2.8	15	1.234	15
	Joint Condition	0	0	0	0	0	0
	Ground Water	12.00	12	10	10	15	15
	RMR		**49**		**47**		**54**
5	ISRM Strength	50	7	25	4	75	7
	RQD %	63	13	40	8	85	17
	Spacing (m)	0.067	8	0.027	5	0.147	8
	Joint Condition	15	15	0	0	25	25
	Ground Water	12.00	12	10	10	15	15

Scanline #	**Parameters**	**DAM RIGHT BANK SCAN LINES BIENIAWSKI 1989 ROCK MASS RATING** **Mean Values**	**Mean RMR**	**Min Values**	**Min RMR**	**Max Values**	**Max RMR**
	RMR		**55**		**27**		**72**
6	ISRM Strength	20	2	15	2	25	4
	RQD %	0	3	0	3	0	0
	Spacing (m)	0.01	5	0.01	5	0.02	5
	Joint Condition	13	13	10	10	20	20
	Ground Water	12.00	12	10	10	15	15
	RMR		**35**		**30**		**44**
	AVERAGE RMR ALL SCANLINES		56.4		39.6		66.8

Table 7.3 indicates that right bank rock mass ratings range from poor to good rock class. The rock mass ratings calculated from scanline mapping of the left bank of the dam also fall in the same category as those of the right bank.

7.4.2.3 Right Bank Drilling Results

In addition to rock mass ratings from scanline mapping data, the RMR and Barton Q rock mass ratings were also worked out for right- and left-bank boreholes. The rock mass ratings, inclusive of all rock types, were worked out for BH-202, and are shown in **Table 7.4**

Table 7.4 - RMR and Barton Q Rock Mass Ratings BH-202

ROCK MASS RATINGS - BOREHOLE BH-202 **RMR STATS**		**BARTON Q STATS**	
Minimum RMR	11	Minimum Q	0.008
Maximum RMR	69	Maximum Q	16.083
Average RMR	40.56	Average Q	1.834
STDEV	14.56	STDEV	3.073

ROCK WISE RMR STATS - BOREHOLE BH-202 Value Ranges	ROCK TYPES Sandstone	Claystone	Siltstone
Minimum	12	11	50
Maximum	71	53	53
Average	42	35	52
STDV	14.287	14.04	1.527

ROCK WISE BARTON Q STATS - BOREHOLE BH-202			
Value Ranges	ROCK TYPES		
	Sandstone	Claystone	Siltstone
Minimum	0.029	0.026	1.948
Maximum	20.086	2.718	2.718
Average	2.476	0.789	2.366
STDV	4.463	0.804	0.389

Sandstone RMR ranges from poor to good quality, claystone RMR ranges from poor to fair, and siltstone RMR falls in the fair quality rock range. Sandstone Q ranges from poor to good quality rock, claystone Q ranges from very poor to poor, and siltstone Q falls in the poor quality rock range. The rock mass ratings worked out for the rock types encountered during drilling of BH-203 are shown in **Table 7.5**.

Table 7.5 - Shows RMR and Barton Q Rock Mass Ratings – BH-203

ROCK MASS RATINGS - BOREHOLE BH-203			
RMR STATS		BARTON Q STATS	
Minimum RMR	15	Minimum Q	0.039
Maximum RMR	71	Maximum Q	20.086
Average RMR	43	Average Q	2.541
STDEV	15.86	STDEV	3.641

ROCK WISE BARTON Q STATS - BOREHOLE BH-203		
Value Ranges	ROCK TYPES	
	Sandstone	Claystone
Minimum	0.108	0.039
Maximum	11.524	20.086
Average	3.22	1.777
STDV	3.111	4.091

ROCK WISE RMR STATS - BOREHOLE BH-203		
Value Ranges	ROCK TYPES	
	Sandstone	Claystone
Minimum	14	18
Maximum	66	71
Average	50	37
STDV	11.008	17.21

The above table shows that the RMR ranges of sandstone and claystone fall in the range of very poor to good quality rock. The Q ratings of sandstone range from very poor to fair, and the claystone Q ranges between very poor to good quality rock. At borehole BH-202, sandstone, siltstone and claystone rock types were encountered, whereas at BH-203 borehole no siltstone was encountered during the drilling.

7.4.2.4 Left Bank Drilling Results

Boreholes BH-204 and 205 were drilled at the left bank. RMR and Barton Q rock mass ratings were also worked out for these left bank boreholes. The rock mass ratings, inclusive of all rock types, were worked out for BH-202, and are shown in **Table 7.6.**

Table 7.6 - RMR and Barton Q Rock Mass Ratings BH-204

ROCK MASS RATINGS - BOREHOLE BH-204			
RMR STATS		BARTON Q STATS	
Minimum RMR	10	Minimum Q	0.022
Maximum RMR	82	Maximum Q	68.185
Average RMR	53	Average Q	6.344
STDEV	13.014	STDEV	10.271

BARTON Q STATS - BOREHOLE BH-204			
Value Ranges	ROCK TYPES		
	Sandstone	Claystone	Siltstone
Minimum	0.8	0.022	0.459
Maximum	68.185	68.18	68.185
Average	6.34	7.26	5.954
STDV	10.373	10.919	14.333

RMR STATS - BOREHOLE BH-204			
Value Ranges	ROCK TYPES		
	Sandstone	Claystone	Siltstone
Minimum	42	10	37
Maximum	82	68	82
Average	53	55	49
STDV	13.094	13.18	14.864

The above table shows that sandstone RMR ranges from fair to very good quality rock, claystone RMR ranges from very poor to good quality rock, and siltstone RMR ranges between poor and good quality rock.

Table 7.7 - RMR and Barton Q Rock Mass Ratings BH-205

ROCK MASS RATINGS - BOREHOLE BH-205			
RMR STATS		BARTON Q STATS	
Minimum RMR	12	Minimum Q	0.007
Maximum RMR	66	Maximum Q	11.524
Average RMR	37.11	Average Q	1.73
STDEV	17.861	STDEV	2.51

BARTON Q STATS - BOREHOLE BH-205			
Value Ranges	ROCK TYPES		
	Sandstone	Claystone	Siltstone
Minimum	0.035	0.028	0.062
Maximum	1.118	8.257	11.524
Average	0.717	1.557	3.279
STDV	0.406	2.057	3.309

RMR STATS - BOREHOLE BH-205			
Value Ranges	ROCK TYPES		
	Sandstone	Claystone	Siltstone
Minimum	14	12	19
Maximum	45	63	66
Average	36	35	48
STDV	11.811	18.597	13.994

The above table shows that Sandstone RMR ranges between very poor to fair quality rock, claystone RMR ranges between very poor to good quality rock, and siltstone RMR ranges between very poor to fair quality rock.

RocData, a software of RocScience, was employed to model rock properties. Rock properties, both general and with 20-m-deep foundation, of sandstone, claystone and siltstone were worked out for the left and right banks of the dam. **Table 7.8**, **Table 7.9** and **Table 7.10** detail these properties.

Table 7.8 - Sandstone Rock Properties Dam Foundation

SANDSTONE ROCK PROPERTIES DAM FOUNDATION		
	WITH 20-M-DEEP FOUNDATION	GENERAL
Hoek Brown Classification		
UCS (MPa)	44	44
GSI	45	45
mi	17	17
Disturbance Factor (D)	0.7	0.7
Intact Modulus (MPa)	12100	12100
Modulus Ratio	275	275
Hoek Brown Criterion		
mb	0.828	0.828
s	3.45E-04	3.45E-04
a	0.508	0.508
Failure Envelope Range		
Sigma3max (MPa)	0.46	11
Mohr Coulomb Fit		
Cohesion (MPa)	0.21	1.653
Friction Angle (°)	50.525	24.821
Rock Mass Parameters		
Tensile Strength (MPa)	0.018	0.018
UCS (MPa)	0.767	0.767
Global Strength (MPa)	5.172	5.172
Modulus of Deformation (MPa)	946.927	946.927

The above table shows a value of cohesion of 0.21 and an angle of internal friction of 50.25 for sandstone.

Table 7.9 - Siltstone Rock Properties Dam Foundation

SILTSTONE ROCK PROPERTIES DAM FOUNDATION		
WITH 20-M-DEEP FOUNDATION		GENERAL
Hoek Brown Classification		
UCS (MPa)	35	35
GSI	50	50
mi	7	7
Disturbance Factor (D)	0.7	0.7
Intact Modulus (MPa)	13125	13125
Modulus Ratio	375	375
Hoek Brown Criterion		
mb	0.449	0.449
s	7.13E-04	7.13E-04
a	0.506	0.506
Failure Envelope Range		
Sigma3max (MPa)	0.44	8.75
Mohr Coulomb Fit		
Cohesion (MPa)	0.205	1.08
Friction Angle (°)	43.43	20.277
Rock Mass Parameters		
Tensile Strength (MPa)	-0.056	-0.056
UCS (MPa)	0.896	0.896
Global Strength (MPa)	3.102	3.102
Modulus of Deformation (MPa)	1408.074	1408.074

The above table shows a value of cohesion of 0.25 and an angle of internal friction of 43.43 for siltstone.

Table 7.10 - Claystone Rock Properties Dam Foundation

CLAYSTONE ROCK PROPERTIES DAM FOUNDATION		
	WITH 20-M-DEEP FOUNDATION	GENERAL
Hoek Brown Classification		
UCS (MPa)	25	25
GSI	40	40
mi	4	4
Disturbance Factor (D)	0.7	0.7
Intact Modulus (MPa)	6250	6250
Modulus Ratio	250	250
Hoek Brown Criterion		
mb	0.148	0.148
s	1.67E-04	1.67E-04
a	0.511	0.511
Failure Envelope Range		
Sigma3max (MPa)	0.404	6.25
Mohr Coulomb Fit		
Cohesion (MPa)	0.102	0.48
Friction Angle (°)	31.664	13.304
Rock Mass Parameters		
Tensile Strength (MPa)	-0.028	-0.028
UCS (MPa)	0.293	0.293
Global Strength (MPa)	1.212	1.212
Modulus of Deformation (MPa)	363.939	363.939

The above table shows a value of cohesion of 0.102 and an angle of internal friction of 31.66 for Claystone.

7.4.2.5 Kinematic Stability Analysis of the Dam

The kinematic stability analysis was made for each scanline on the dam's right bank. The results are presented in **Table 7.11**.

Table 7.11 - Results of Kinematic Stability Analysis of Right Bank of Dam

KINEMATIC STABILITY ANALYSIS - DAM B RIGHT BANK									
SCAN LINE # 2		SCAN LINE # 3		SCAN LINE # 4		SCAN LINE # 5		SCAN LINE # 6	
FAILURE MODE	PROBABILITY OF FAILURE (%)	FAILURE MODE	PROBABILITY OF FAILURE (%)	FAILURE MODE	PROBABILITY OF FAILURE (%)	FAILURE MODE	PROBABILITY OF FAILURE (%)	FAILURE MODE	PROBABILITY OF FAILURE (%)
Planar Sliding	15.38	Planar Sliding	40	Planar Sliding	75	Planar Sliding	8.33	Planar Sliding	14.29
Wedge Sliding	50	Wedge Sliding	77.78	Wedge Sliding	100	Wedge Sliding	19.7	Wedge Sliding	47.62
Direct Toppling	0	Direct Toppling	0	Direct Toppling	0	Direct Toppling	3.03	Direct Toppling	0

Table 7.11 indicates that wedge sliding is the predominant mode of failure. It also shows that the scanline 3 and 4 areas are more prone to planar and wedge sliding. It also displays that the probability of wedge sliding ranges from 20 percent to 100 percent. The probability of planar sliding ranges between 8 and 75 percent. Per this analysis, there is no potential for direct toppling.

7.4.2.6 Rock Quality Designation (RQD) Analysis

The Rock Quality Designation index (RQD) was developed by Deere (Deere *et al.*, 1967) to provide a quantitative estimate of rock mass quality from drill core logs. RQD is defined as the percentage of intact core pieces longer than 100 mm in the total length of core as given in **Table 7.12**.

Table 7.12 - Classification of Bedrock Quality*

RQD Classification	RQD Value (%)
Very Poor quality	<25
Poor quality	25 to 50
Fair quality	50 to 75
Good quality	75 to 90
Excellent quality	90 to 100

*Canadian Foundation Engineering Manual 4th Edition, Canadian Geotechnical Society 2006

Histograms were derived from the measured RQD values from boreholes drilled at the dam area to classify the rock quality as per the table above. RMR ratings worked from BH-202 and BH-203 were also plotted against the elevation to ascertain rock quality. The RMR plots of boreholes 202 and 203 plots are shown in **Figure 7.4.**

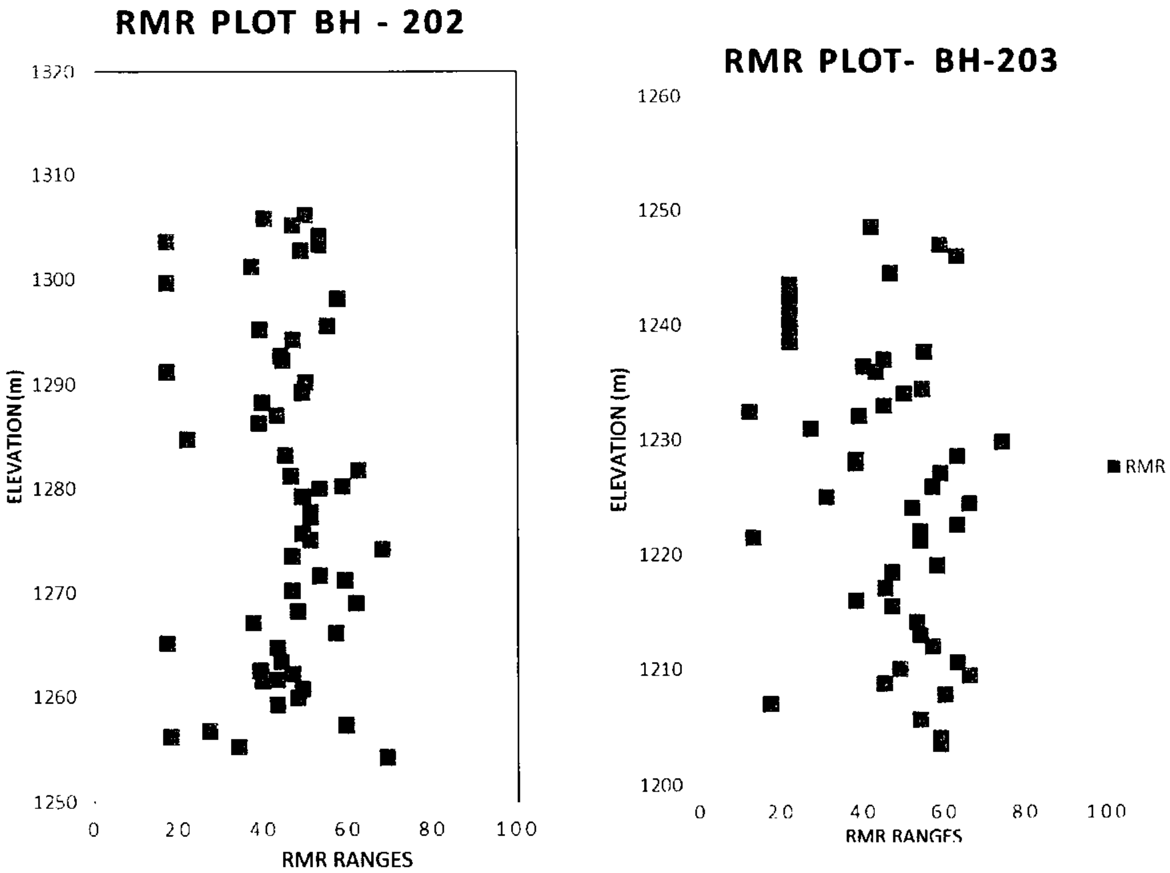

Figure 7.4 - RMR Plot of BH-202 and BH-203 Borehole

The above RMR plots shows that the average RMR ratings of the BH-202 and 203 boreholes falls under the Fair category.

RMR ratings were also plotted against elevation for boreholes 204 and 205; plots are shown in the following Figure.

The above RMR plots shows that the average RMR ratings of BH-204 fall under the Fair category of rock mass, whereas the RMR of BH-205 falls under poor-quality rock mass.

The drilling results of the left and right banks of the dam site indicated some broken core zones and core loss zones, which were associated with the claystone rock type. Core logging data provided by the drilling Contractor did not show any record of a shear or a fault.

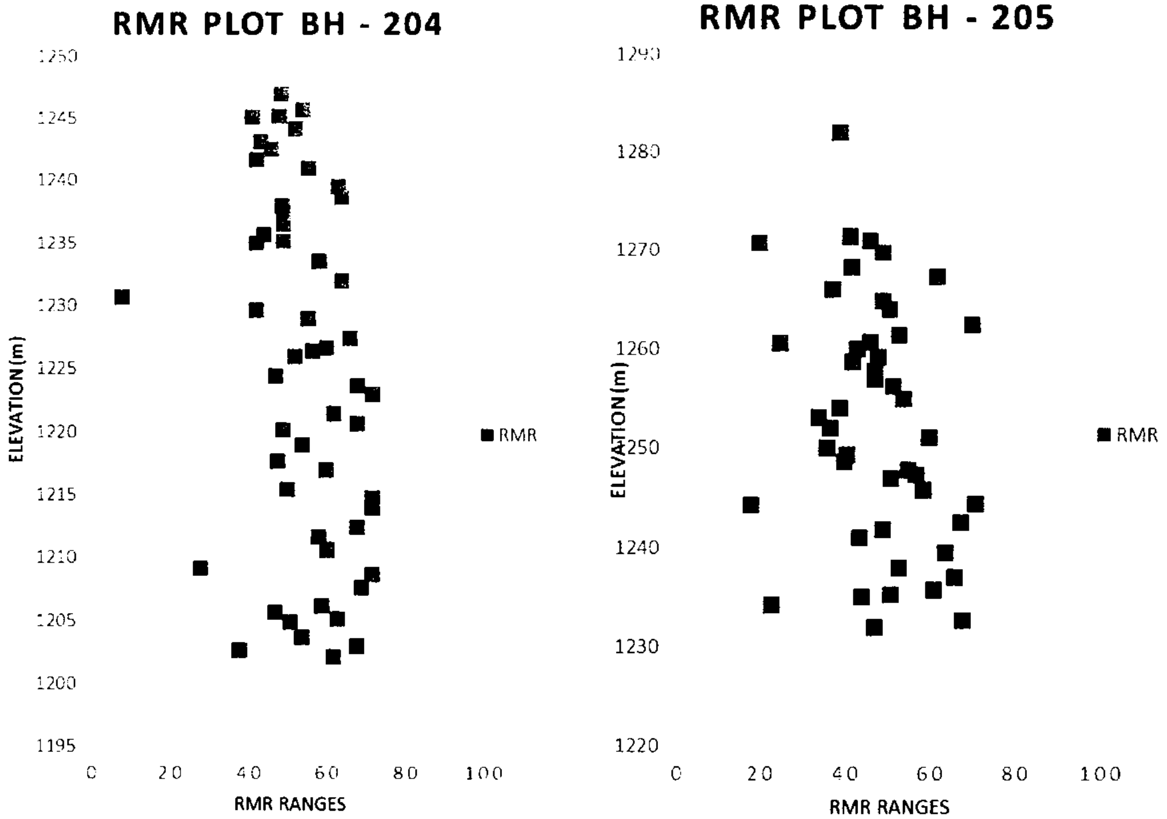

Figure 7.5 - RMR Plot of BH- 204 and BH-205 Borehole

7.5 SEDIMENT BY-PASS TUNNEL

The sediment by-pass tunnel is proposed in the riverbed deposits, and a sequence of siltstone/mudstone and shales. At the left bank, the diversion tunnel occupies an area constituted by riverbed deposits followed upward to Naran Road by houses and the cultivated fields, and on the right bank siltstone/mudstone and shales are outcropped. The right bank area is just downstream of a fault zone marked by an active slide. Considering the presence of bedrock on the right bank, bedrock rock is anticipated at a shallow depth at the left bank. The slope on the left bank is very mild, whereas the right bank is marked by a steep slope. To characterize the diversion/SBT tunnel ground conditions, geological mapping and drilling were conducted.

7.5.1 Geological Mapping

The geological mapping along the right bank (**Drawing 7**, sheet 3) shows the presence of a thinly bedded sequence of siltstone/mudstone and shales of the Murree Formation. The shales are maroon generally, though at places are purple or bright red. The colour sometimes changes laterally into patches and bands of green. They are characterized by a splintery nature, presence of fracture cleavage, lineation and tension gashes. Numerous veins of calcite and quartz are also present. At some places, the shales contain a few small-size pebbles.

The sandstone is greenish-grey to grey on the fresh surface and brownish on the weathered surface. It is coarse-grained, impure, and calcareous, with minute rock pieces. The weathering is generally penetrative and one-or-more-centimetre-thick brown weathered layer may surround a greyish fresh core. The rock is well jointed and has quartz veins and tension gashes. The siltstones are very similar to shales except for the coarser grain size. During the mapping, two faults were identified with dip and dip directions of 38/190 and 70/130. The trend of fault 70/130 orientation potentially crosses the diversion tunnel alignment.

7.5.2 Drilling Investigations

A borehole BH-201 was drilled up to 65 m depth at the location of the diversion tunnel (**Drawing 7**). The borehole drilling only intersected the claystone lithological unit. The results of drilling investigations are discussed in the following sections. The borehole logging data was used to develop RMR and Barton Q Stats. **Table 6.1** shows the RMR values of claystone in the diversion/SBT tunnel portal borehole.

Table 7.13 - RMR Values of Diversion Tunnel Borehole

ROCK MASS RATINGS - BOREHOLE BH-201			
RMR STATS		BARTON Q STATS	
Minimum RMR	10	Minimum Q	0.022
Maximum RMR	52	Maximum Q	2.432
Average RMR	32	Average Q	0.612
STDEV	12.478	STDEV	0.708

7.5.2.1 Rock Quality Designation (RQD) Analysis

Based on the geotechnical logging, RMR and Barton Q rock mass ratings were also worked out. RMR ratings were also plotted against the elevation of the borehole drilled at the diversion tunnel alignment to identify rock quality. The plot is shown in the following figureErro! A origem da referência não foi encontrada..

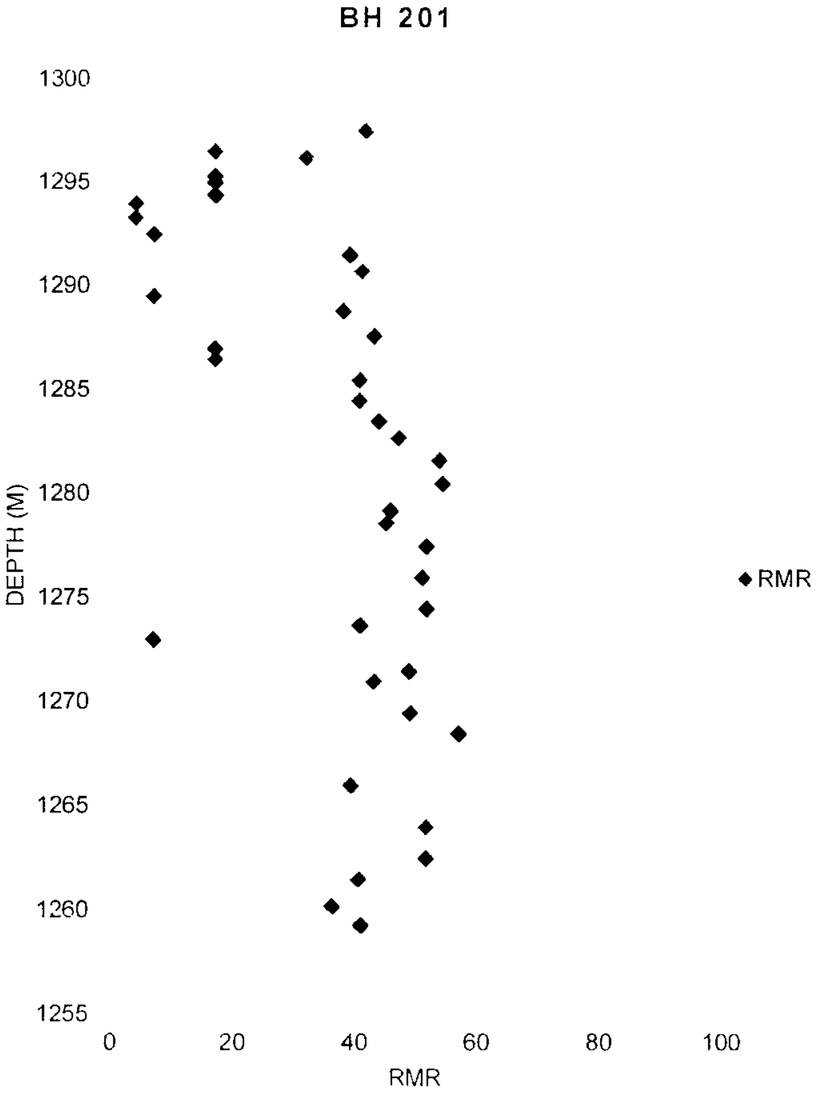

Figure 7.6 - RMR Plot of BH- 201

The average RMR of the tunnel portal falls under the Poor category.

The RMR data was used to ascertain rock properties by using RocScience RocData software. The plots of modelled rock properties for claystone for disturbance factors of 0, 0.5 and 1, with tunnel depths of 61 m, were developed. The average RMR of claystone rock units encountered in the sediment by-pass tunnel borehole BH-201 was worked out. The rock properties are based on the average of these rock units from both the drillholes.

Table 7.14 - Claystone Rock Properties for a 61-m-deep tunnel

CLAYSTONE ROCK PROPERTIES DIVERSION TUNNEL WITH 61 M DEPTH			
0 DISTURBANCE FACTOR		0.5 DISTURBANCE FACTOR	1.0 DISTURBANCE FACTOR
Hoek Brown Classification			
UCS (MPa)	25	25	25
GSI	32	32	32
mi	4	4	4
Disturbance Factor (D)	0	0	0
Intact Modulus (MP)	6250	6250	6250
Modulus Ratio	250	250	250
Hoek Brown Criterion			
mb	0.353	0.157	0.031
s	5.23E-04	1.55E-04	1.20E-05
a	0.52	0.52	0.52
Failure Envelope Range			
Sigma3max (MPa)	0.752	0.732	0.696
Mohr Coulomb Fit			
Cohesion (MPa)	0.187	0.128	0.064
Friction Angle (°)	33.704	27.13	15.744
Rock Mass Parameters			
Tensile Strength (MPa)	-0.037	-0.018	-0.01
UCS (MPa)	0.493	0.225	0.069
Global Strength (MPa)	1.816	1.18	0.506
Modulus od Deformation (MPa)	579.578	303.838	186.451

7.5.3 Conclusions and Recommendations

Based on the geological mapping and drilling investigations, as well as the data interpretations and analysis, the following conclusions are made.

7.6.1 Implications of the Reservoir Faults

The majority of dam foundations for large dams display some faults, however minor, and the geologic and seismologic challenge is to determine whether such faults are likely to rupture during the life of the structure (*i.e.*, are they "active"?) and, if so, with what displacements, with what geometries, with what magnitudes, and with what likelihoods. Over the years, many authors have discussed various definitions of "active" and "inactive" faults. Modern geological studies, together with vastly improved age-dating capabilities, have demonstrated unequivocally that there are all degrees of fault activity, and any categorization into active and inactive features is necessarily arbitrary. Per available geological records and information, the MBT is an active fault/thrust. MBT represents a thrust between the metamorphosed sequence west of the Kunhar River and the sedimentary sequence of the axial zone of Hazara Kashmir syntaxes occurring east of the Kunhar River.

Although there have been probably hundreds of cases worldwide of reservoir-triggered earthquakes, most have had very small magnitudes. There are two instances where the triggered events are known to have been associated with explicit surface faulting. One of these was at Koyna, India, in association with the M=6.3 triggered event of 1967 (Cluff, 1977), and the other at Oroville, California, USA, in association with the M=5.7 event of 1975 (Clark *et al.* 1976).

Allen (1982) suggested that reservoir-triggered earthquakes possibly could occur on a fault otherwise considered to be "inactive", because "the reservoir may produce a stress distribution quite unlike that which the area has experienced for many thousands of years."

Per Allen, "the likelihood of a reservoir-triggered earthquake with significant surface displacement on a fault with proven absence of late Quaternary displacements is exceedingly remote, particularly if the associated reservoir is not deep and large." At Balakot HPP, no field neotectonics study has been conducted so far, except the desktop study presented in **Annex V - Seismic Hazard Evaluation**.

7.6.2 Implications of the Scree Slides in the Reservoir

The right bank of the Kunhar River in the reservoir area shows some scree slides, whereas the left bank comprises generally river terrace deposits.

The right bank shows historic and current active landslide scars marked by the MBT (**Figure 7.7**).

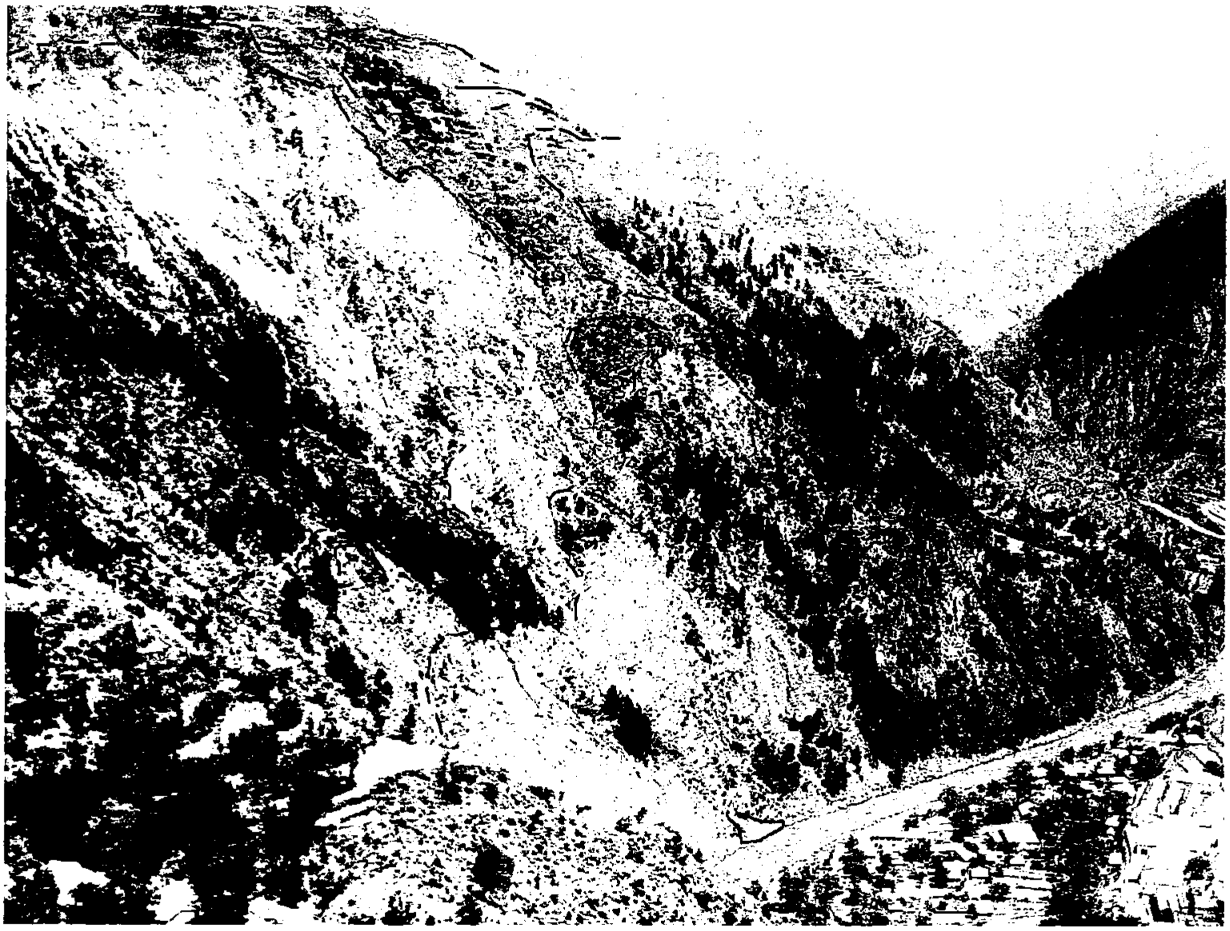

Figure 7.7 - Active slide area on the right bank of the Kunhar River marked by the MBT

Another slide area associated with cross faults is in the proximity of the Sharan-Paras bridge. This slide area is associated with the MBT. The thrust has crushed the metamorphic sequence and has made this an active slide area.

The review of the relevant literature indicates that the potential causes of the sliding in the reservoir area could be adverse material composition, uplift water pressure when impounding the reservoir, presence of weak structural layer, osmatic pressure caused by rapid water rise and fall in the reservoir, or erosion and under washing by wave and earthquake or induced by reservoir. The presence of adverse material composition, the MBT as a major weak structural layer and the manifestation of the active sliding at the face of reservoir bank, indicates the potential of bank slope instability.

At present, it is unknown how wide the weak/crushed zone is. It is also not known how much volume annually slides down into the Kunhar River. A few test pits are suggested to ascertain that volume as well as the width of the crushed zone, and to characterize the slope material. The second slide area near Sharan-Paras bridge is relatively small and potentially will not draw huge volumes of slide debris. However, in the upper reaches along the Paras-Sharan road, some historic sliding is visible and it is associated with the MBT alignment.

7.6.3 Reservoir Sliding Volumes

The mapping conducted by the PPTA Consultant indicated that the MBT does not cross the Kunhar River as shown in FS2013 report; rather, it follows the right bank of the Kunhar River for some distance upstream as shown in the figure below.

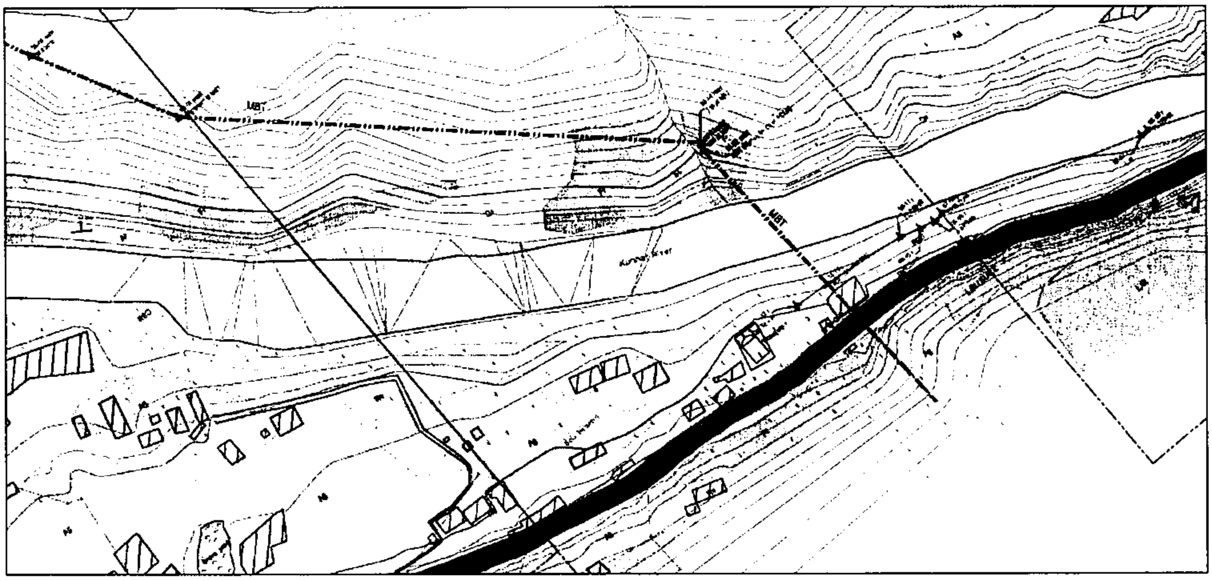

Figure 7.8 - Geological mapping of the reservoir. MBT alignment

The PPTA Consultant's mapping also showed that the MBT runs above the Murree Formation in the steep (+48°) right bank slope of the reservoir, which is comprised of talus deposits, slide deposits and fault-fractured rocks.

Because of the thrusting, the rocks on either side of the thrust have been crushed, mixed, disintegrated and pulverized to some extent. This thrust zone is covered with a thin talus and slide deposit's cover. Three test pits were excavated at the bottom of the slope. The purpose of the test pit excavation was to estimate the thickness of the talus/slide deposit's cover and fault-related crushed rocks. The test pits logs showed the crushed and mixed state of the fault zone rocks.

Test pit logs showed that the talus/slide cover thickness ranges from 5 to 10 m, however the thickness of the fault-related crushed rocks could not be ascertained because of the Excavator's depth excavation limitations.

Muhammad Bashart *et al.* published a paper in the Arabian Journal of Geosciences in April 2016, titled "Landslide susceptibility mapping using GIS and weighted overlay method: a case study from NW Himalayas, Pakistan". This paper indicates the presence of landslides in the reservoir area located in the town of Paras (**Figure 7.9**).

Figure 7.9 shows the presence of landslides in the reservoir area. During the site visit, land slide scars were observed in this area. It is well known that the slope movements induced by reservoirs involve various types of movement and geologic materials. Because they may be large and very rapid, rock slides related to reservoirs generally have been considerably more destructive than slope movements in surficial materials.

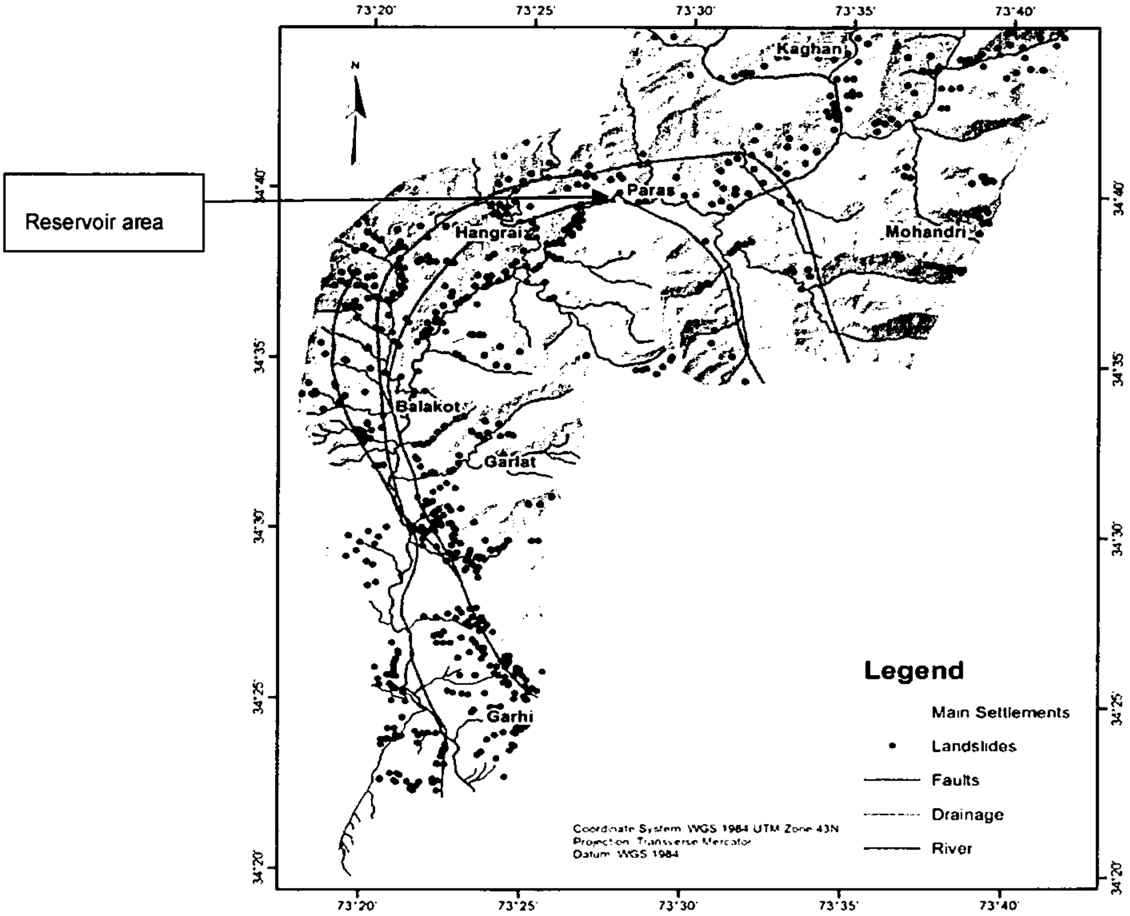

Figure 7.9 - Landslide map of the Kunhar River (after Basharat *et al.* 2016)

Potential landslide volumes and dimensions were estimated based on the FS2013 topographic cross sections of the slide-prone right bank of the reservoir, the results of test pit excavation, the geological model, and study of previous landslides in the area. To quantify the volume of slide material in the event of a major earthquake, excessive rains, and reservoir filling and drawdown, the following assumptions were made.

ASSUMPTIONS	
Length of the slope prone to sliding	150 m
Height of the slope prone to sliding	200 m
Width of the slope prone to sliding based on test pit excavated at the right bank	10 m
Presence of Main Boundry Thrust (MBT) crushed rock zone towards the toe of the slope	
The reservoir encompasses the Hazara-Kashmir Syntaxis with active faults such as MBT	
Presence of signs of historic land sliding within the reservoir area marked by slide scars	
Natural climate variability in Kunhar valley has a strong effect on landslides	
ESTIMATED VOLUMES	
Volume based on maximum height, length and depth	300,000 m3
Volume based on 30% height, length and depth	8100 m3
Volume based on 15 % height, length and depth	1012.5 m3
Volume based on 10 % height, length and depth	300 m3
Volume based on 5 % height, length and depth	37.5 m3

Based on the analysis of the available information and experience, it is suggested that a 5-percent height, length and depth scenario could be used as the potential volume of slide/mass wasting material added to the reservoir, almost on a daily basis. A severe earthquake event of magnitude 7 could lead to a 30 percent scenario. A historic event with an earthquake of more than 7 magnitude[4] and heavy rains for prolonged periods could lead to a total potential volume scenario (300 000 m^3).

An earthquake of higher magnitude (8+) may destabilise the entire slope on the right bank. At present, it is unknown how wide the weak/crushed zone is. It is also not known how much volume annually slides down into the Kunhar River. To collect this information, three test pits were excavated at the bottom of the slope. The purpose of the test pit excavation was to estimate the thickness of the talus/slide deposit's cover and fault-related crushed rocks. However, the test pit excavation ended within the fault-crushed material. The thrust/fault zone deposits were not intersected because of the excavator's depth excavation limitations. The width of the fault zone remained unknown.

The thickness of the MBT zone needs to be ascertained through drilling. To characterize the thrust, to estimate the thrust zone thickness and potential volumes of slides in the proposed reservoir, and to mitigate the potential distress, the following investigations are recommended to be carried out at the ensuing design stage.

- Drill three oriented HQ3-size boreholes along the left bank, starting from the northeast along the river bend with 10 m, 40 m and 20 m depths. The proposed boreholes are to be drilled at the left bank between the location where the MBT crosses the Kunhar

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[4] A 7.8 earthquake magnitude has an estimated return period from 5 000 to 10 000 years.

River and the main Paras suspension bridge. The final depth of the boreholes depends upon intersecting fresh bedrock across the thrust zone. Drill at least 5 m into the fresh bedrock across the thrust zone into the fresh bedrock. Perform geotechnical core logging with a focus on clearly identifying the contact of the fresh rock with the thrust zone rock.

- Work out potential slide volumes based on the results of the drilling.
- Conduct seismic stability analysis of the left bank.

The feasibility stage analysis of the reservoir wave originated by a landslide into the reservoir is presented in **Annex VII – Hydraulic Design**.

7.7 HEADRACE TUNNEL INVESTIGATIONS

7.7.1 General

The geology and structural model presented in the previous FS2013 indicated the presence of alternating anticlines and synclines all along the route of the proposed headrace tunnel. Not a single structural feature (fault/shear) was shown along or around the headrace tunnel alignment. The review of the FS2013 scanlines data indicated that some of the scanline's mapping data did not reflect the ground conditions. Considering this discrepancy, the headrace tunnel route was mapped along the Naran Road with the hand-held GPS and subsequently with the help of a surveyor to confirm the lithological boundaries.

7.7.2 Geology of the Headrace Tunnel

The proposed length of the headrace tunnel is 9.2 km, with an internal diameter of 8 m. The proposed tunnel passes through sedimentary rock types of the Murree Formation. The Murree Formation consists mainly of maroon-coloured shales with green patches and bands, greenish-grey sandstones, and generally maroon siltstone/mudstone/claystone. The shales are generally maroon, though at places are purple or bright red. The colour sometimes changes laterally into patches of and bands of green. They are characterized by a splintery nature, presence of fracture cleavage, lineation and tension gashes. Numerous veins of calcite and quartz are also present. At some places, the shales contain a few small-size pebbles.

The sandstone is greenish-grey to grey on the fresh surface and brownish on the weathered surface. It is coarse-grained, impure, calcareous and with minute rock pieces. The weathering is generally penetrative and a one-or-more-centimetre thick brown weathered layer may surround a greyish fresh core. The rock is well jointed and has quartz veins and tension gashes. The strength of the material varies between medium and high. Joints between blocks are frequently coated/filled with oxide and calcite with an aperture of less than 1 mm. The sandstone layers are locally weakly weathered to weathered. The bedded claystone and shales are finely grained, with a low compressive strength. Alternation of weak rock (claystone and shale) zones with hard rock (sandstone) layers is typical in this formation. The ratio of claystone to sandstone, which are found in layers with various thicknesses, and the possible presence of ground water during the excavation, could be the main factors affecting the stability of the tunnel face and unsupported opening.

7.7.3 Assessment of Ground Conditions Along the Tunnel

The site investigations to assess ground conditions along the headrace tunnel included scanline mapping and borehole drilling.

7.7.3.1 Geological Mapping Along the Naran Road

The proposed tunnel route in general is covered with forest and overburden material. All the mapping was conducted along the Naran Road starting from the tunnel intake to the proposed powerhouse location. The lithological contacts were picked with the help of a surveyor and are shown in **Drawings 8** and **9**. These lithological contacts are important to estimate their quantities as well as for the correctness of their location. It is worth mentioning that the majority of the previous lithological contacts (FS2013) were not found accurate.

It is also worth mentioning that most of the tunnel is far off the Naran Road, except for few locations where it passes under the road, especially where the boreholes BH-207 and BH-208 were drilled. Considering this, the relevance of the mapping data other than these locations is a projection and prediction.

The geological interpretative profile was drawn to show the geology as mapped by the FS2013 and the PPTA Consultant (**Drawing 9**). The thickness of various rock types of the Murree Formation mapped along the Naran Road range from a few centimetres to some meters. The rock type thicknesses are highly variable.

The headrace tunnel boreholes (BH-207 and 208) data was reviewed and analysed to estimate the thickness of different rock types encountered during the drilling at the proposed headrace tunnel level/depth. The drilling results of boreholes BH-207 and 208 indicate the presence of alternating claystone, sandstone and siltstone beds at the tunnel alignment elevations. **Table 8.1** shows the thickness of various rock types.

The percentages of rock types are variable at both drill hole locations; however, claystone appears to be the main lithologic unit to be encountered during the construction of the headrace tunnel.

Table 7.15 - Thickness of rock types at the headrace tunnel alignment

THICKNESS OF ROCK TYPES- HEADRACE TUNNEL DRILLHOLES			
Borehole	Rock Type	Percentage (%)	Borehole Column Length (m)
BH-207	Claystone	80.57	139 -148.2
	Siltstone	12	
	Sandstone	7.43	
BH-208	Claystone	43.13	113.8 - 124
	Siltstone	15.69	
	Sandstone	41.18	

7.7.3.2 Scanline Mapping

During the 2018 mapping campaign, a total of 37 scanlines were mapped along the Naran Road in proximity of the proposed headrace tunnel. During the scanline mapping, shears and faults were observed along the Naran Road. Some of these structural features could potentially intersect the proposed tunnel alignment.

The fault and shear orientation data were processed and analysed with dips using RocScience software. The results are presented in the following paragraphs. The structural data was analysed to get main fracture sets, 3D pole plot, symbolic plot, rosette plot and pole contouring.

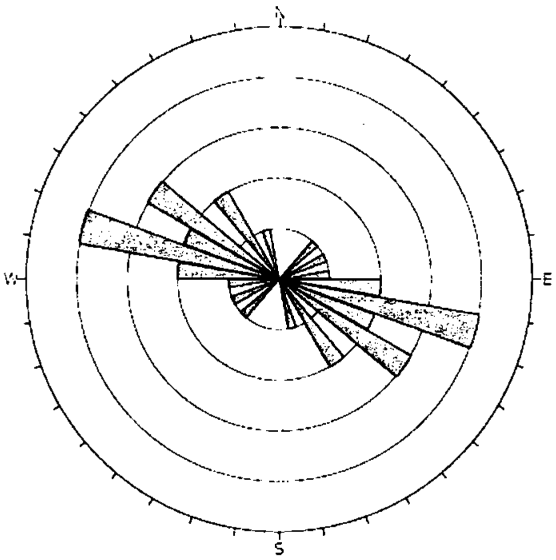


Figure 7.10 - Rosette Plot of Faults and Shears

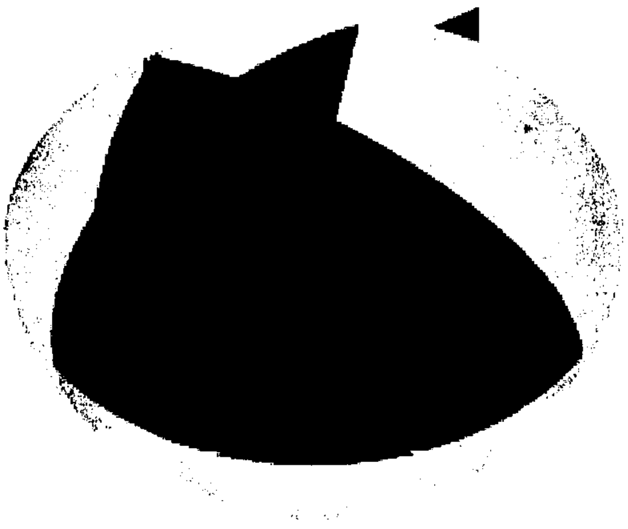
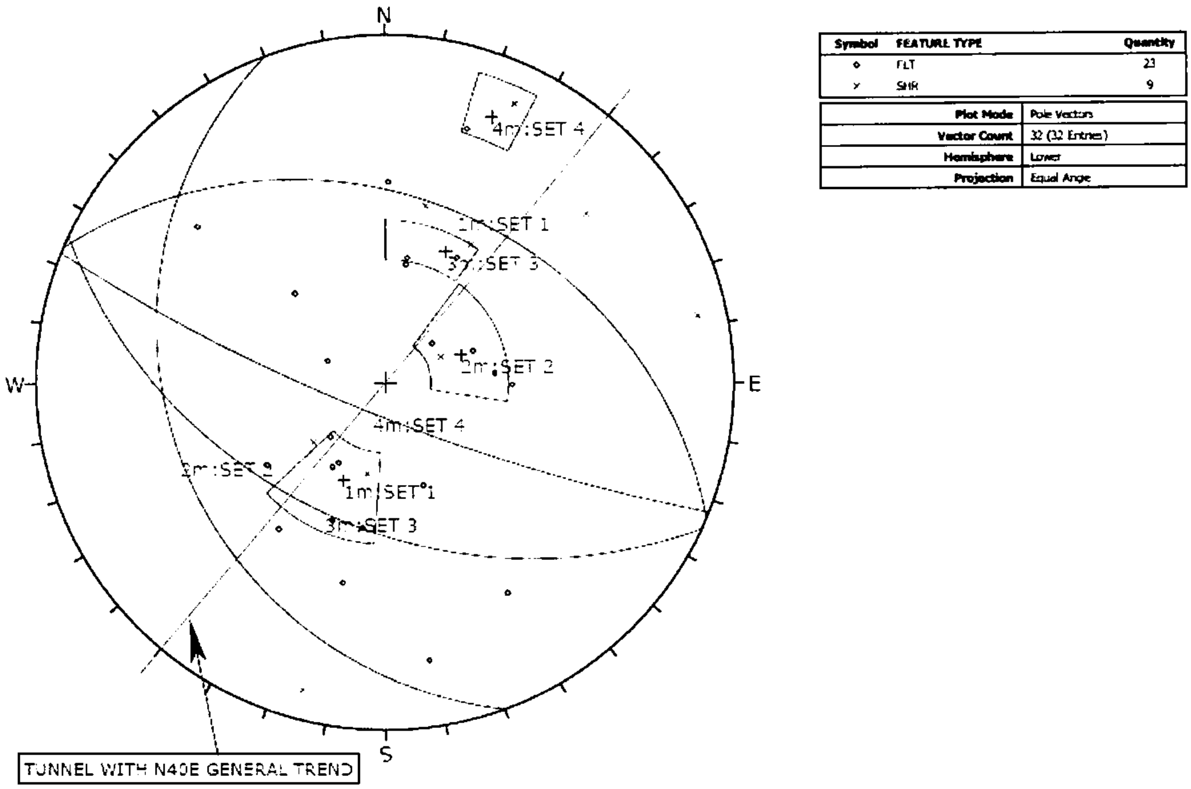


Figure 7.11 - 3D Pole Plot of Faults and Shears



Symbol	FEATURE TYPE	Quantity
◇	FLT	23
×	SHR	9

Plot Mode	Pole Vectors
Vector Count	32 (32 Entries)
Hemisphere	Lower
Projection	Equal Angle

Figure 7.12 - Symbolic Pole Plot with Tunnel Alignment of N40E

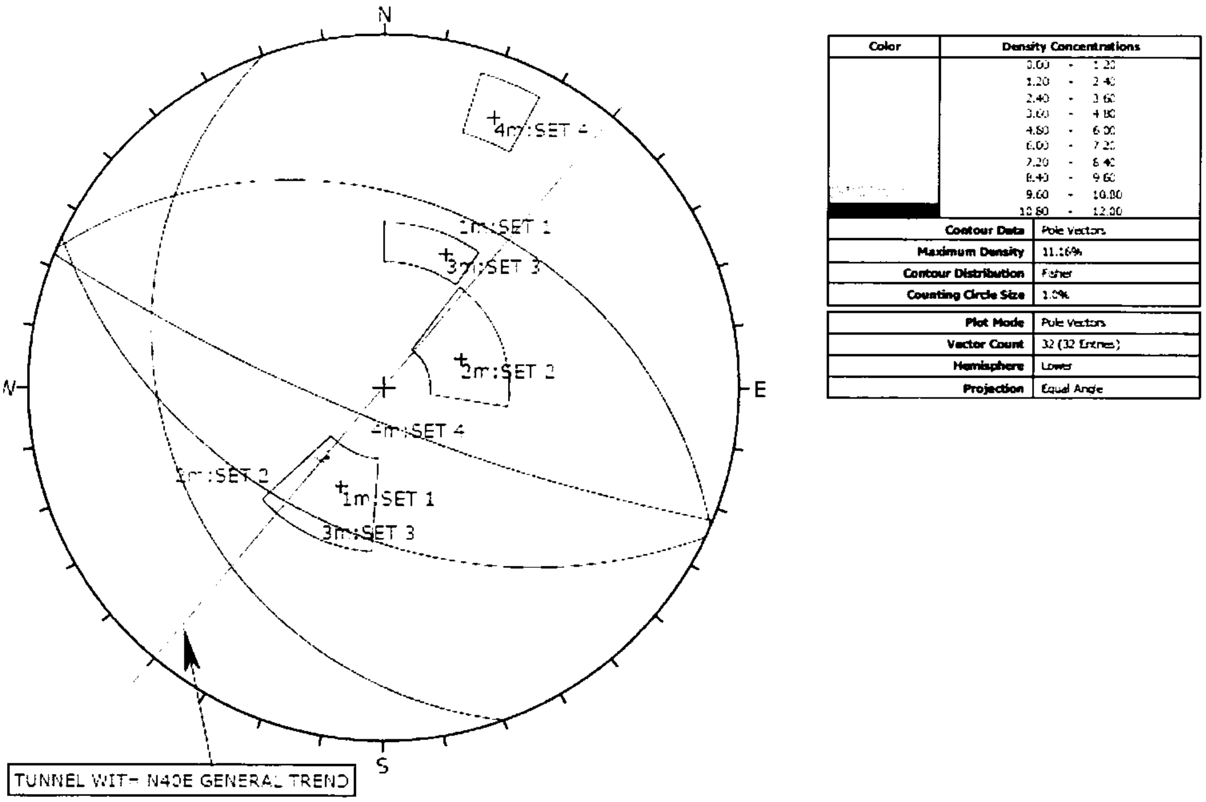


Figure 7.13 - Tunnel Alignment and Major Faults and Shears Sets

The previous figures indicate that the main dip and dip direction of the shears and faults range between 26 and 79, and 202 and 250, respectively. There is another low angle significant fault/shear set dipping towards the east. The low angle shears and faults pose instability issues in the underground excavation. The rock mass data was processed and interpreted with dips and processed for each individual scanline to get RMR and Barton Q Ratings.

7.7.3.3 Borehole Drilling

Two boreholes, BH-207 and BH-208, were drilled on the tunnel alignment to intersect the tunnel alignment ground. The BH-207 was drilled to 149 m depth; however, only the last 51 m were geotechnically logged. The BH-208 was drilled to 124 m depth, and the last 51 m were geotechnically logged and sampled. The borehole logging data was used to develop RMR and Barton Q Stats. **Table 7.16** shows the RMR values of sandstone, claystone and siltstone worked out from the tunnel borehole.

Table 7.16 - RMR Values of Tunnel Boreholes

RMR STATS - BOREHOLE BH-207			
Value Ranges	ROCK TYPES		
	Sandstone	Claystone	Siltstone
Minimum	45	16	25
Maximum	67	63	62
Average	58	37.93	42.75
STDV	6.353	17.584	15.671

RMR STATS - BOREHOLE BH-208			
Value Ranges	ROCK TYPES		
	Sandstone	Claystone	Siltstone
Minimum	12	7	38
Maximum	59	56	54
Average	40.75	29.05	44.44
STDV	14.011	16.112	6.126

7.7.3.4 Rock Quality Designation (RQD) Analysis

Based on the geotechnical logging, RMR and Barton Q rock mass ratings were worked out. RMR ratings were also plotted against depth for each borehole drilled at the tunnel alignment to identify rock quality, as shown in **Figure 7.14**.

The average RMR of the tunnel falls under the Fair category.

The RMR data was used to ascertain rock properties by using RocScience RocData software. The plots of modelled rock properties for sandstone, claystone and siltstone for disturbance factors of 0, 0.5 and 1 with tunnel depths of 440, 370 and 300 m were developed and shown as Appendix F of **Annex IV**. Average rock mass ratings (RMR) of claystone, sandstone and siltstone rock units encountered in the tunnel holes BH-207 and 208 were worked out. The rock properties are based on the average of these rock units from both the drill holes. The rock properties for a tunnel of 300 m and 440 m depth are shown in Appendix G of **Annex IV**. The modelled rock properties for sandstone, claystone and siltstone for a tunnel of 370 m depth with 0, 0.5 and 1 disturbance factor are shown in **Annex IV**.

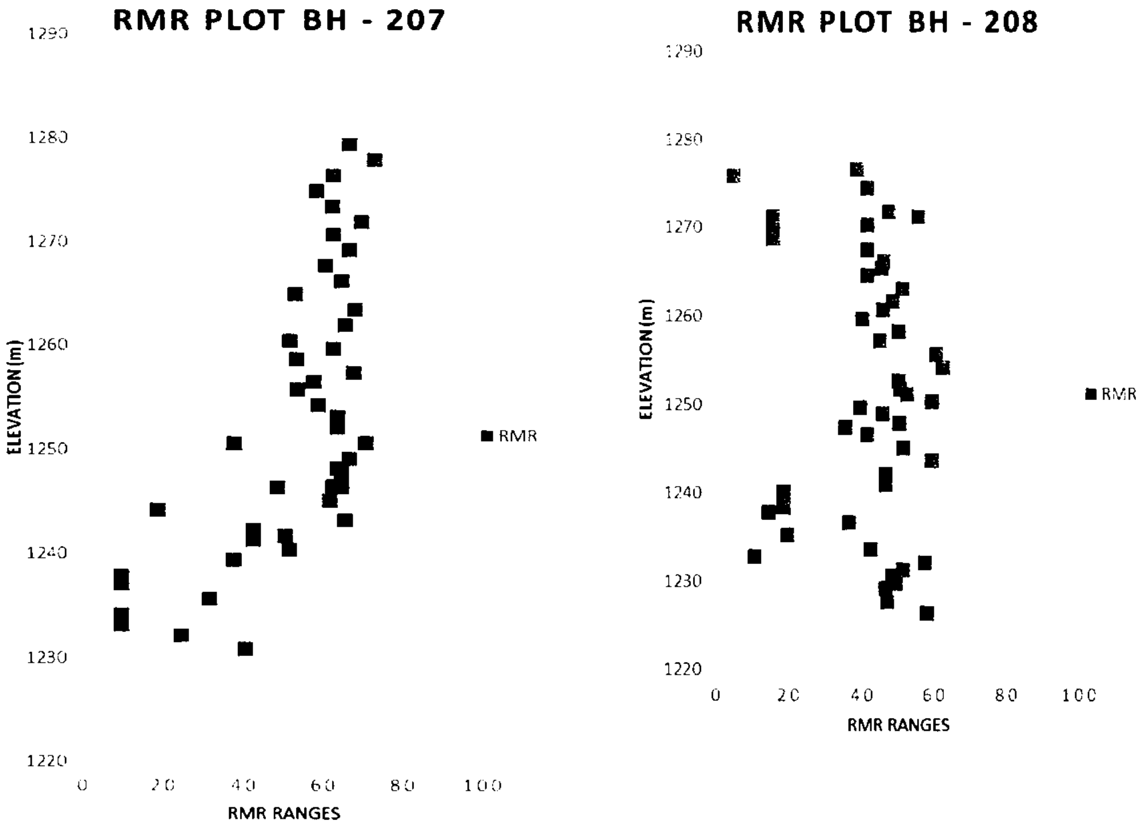


Figure 7.14 - RMR Plot of BH- 207 and BH-208 Borehole

7.7.3.5 Squeezing

ISRM has defined squeezing as time-dependent large deformation around the tunnel. which essentially is associated with creep caused by exceeding a limiting shear stress.

Simplified, squeezing can be described as time-dependent inward movement of the rock material towards the tunnel when subjected to tangential stress. Weak and soft rocks will, due to their plastic nature, behave very differently when subjected to tangential stress. In such rocks, the potential problem will be squeezing deformation. In extreme cases, reduction of the original tunnel diameter of several tens of centimetres due to squeezing may occur.

The occurrence and degree of squeezing highly depends on the ratio between rock mass strength and in-situ stress. This means that for weak or strongly foliated (crushed) rocks, squeezing may occur even at low overburden (low in-situ stress). At what ratio squeezing may occur is not defined, but a study on squeezing in tunnels in Japan showed that a ratio less than 2 resulted in squeezing. According to Chapman D *et al.* (2010), severe squeezing may occur when the uniaxial compressive strength of rock is less than 30 of the in-situ stress.

Squeezing is typically seen in week rocks like phyllite, shale, schist, claystone, mudstone and weathered clayey or micaceous metamorphic rocks. The presence of and quality of minerals such as micas, chlorite, serpentine and clay is therefore decisive. Highly sheared material and fault gauge is especially prone to squeezing. Highly tetanised rocks lack sufficient bonding or confinement, which results in a considerably reduced self-supporting capacity (Panthi, 2006).

7.7.4 Slake Durability Testing

The slake durability testing of eight core samples from various boreholes was conducted to estimate the durability of the claystone and siltstone rock types of the Murree Formation. Slake durability testing was performed at Central Material Testing Laboratory (CMTL) Lahore. The **Table 8.7** shows the details of testing.

Table 7.17 - Details of slake durability testing

Slake Durability Test Results			
Borehole	Depth (m)	Rock Type	Test Results (%)
BH-201	45.40-45.57	Claystone	94.4
BH-203	22.80-23.20	Claystone	85.8
BH-203	27.96-28.33	Sandstone	98.4
BH-204	18.75-19.18	Claystone	98.4
BH-205	35.36-35.58	Claystone	85.7
BH-207	129.88-130.20	Claystone	98.4
BH-207	135.80-136.02	Siltstone	98.2
BH-208	103.0-103.24	Siltstone	98.1

The results of the testing showed a high percentage of durability against slaking.

7.7.4.1 Conclusions and Recommendations

Based on the Phase II site investigation data interpretations and analysis, the following conclusions are made.

- Per the site investigation data, no faults and shears were identified at the dam site location.
- The analysis and interpretation of dam site boreholes' rock mass data suggest the use of the following design parameter for a 20-m-deep dam foundation and as a general criterion.

Parameter	20-M-Deep Foundation	General
Claystone		
C	0.102	0.48
Ø	32	13
Sandstone		
C	0.21	1.653
Ø	50	25
Siltstone		
C	0.205	1.08
Ø	43	20

- The scanline mapping along the Naran Road indicated presence of faults and shear zones. Some of these features could potentially intersect the proposed headrace tunnel. The main shear and fault sets have dip and dip direction of 34/023, 26/250, 45/205 and 79/202.
- The analysis and interpretation of tunnel boreholes' rock mass data suggest the use of following design parameter for a 370-m-deep tunnel with disturbance factor of 1, 0.5 and 0.
- Although the cover over the tunnel alignment is small (max 440 m), the presence of the weak rocks such as shale and claystone along the headrace tunnel alignment indicates potential of squeezing.
- Based on the interpretation and analysis of tunnel boreholes data, the rock mass ratings of claystone range between 12-59, sandstone 7-56 and siltstone 38-54. Claystone and sandstone fall under very poor to fair rock quality and siltstone falls under poor to fair rock quality.

Parameter	Disturbance Factor (D)		
	0	0.5	1
Claystone			
C	0.69	0.502	0.267
Ø	25	20	12
Sandstone			
C	1.724	1.379	0.894
Ø	46	41	31
Siltstone			
C	0.776	0.576	0.325
Ø	27	22	14

- Slake durability testing showed a high percentage of durability against slaking.

7.8 POWERHOUSE AND TAILRACE TUNNEL INVESTIGATIONS

7.8.1 Scope of Field Investigations

The Phase III studies were recently completed. These included site investigations conducted for the powerhouse and tailrace tunnel sites. They also deliberated the results of geotechnical mapping conducted for the outlet portal of the tailrace tunnel. The scope included:

- geotechnical site investigations;
- geotechnical laboratory testing;
- evaluation of the results and reporting.

7.8.2 Drilling

The Phase III site investigations included drilling of boreholes at the Powerhouse and the Tailrace tunnel. They also included mapping at the rock outcrop at the outlet portal of the Tailrace Tunnel. The details of Phase III site investigations are listed in **Table 7.18**.

Table 7.18 - Details of the site investigation

PHASE 3 SITE INVESTIGATION				
BH #	CORDINATES		Elevation (m)	Depth (m)
	M(x)	P(y)		
BH-301	3236242.021	1160052.98	1263.324	226
BH-302	3235759.98	1159449.99	1368.852	330
BH-303	3235499.992	1159130	1170.71	130

The Locations of Phase III boreholes are shown in **Figure 7.15**.

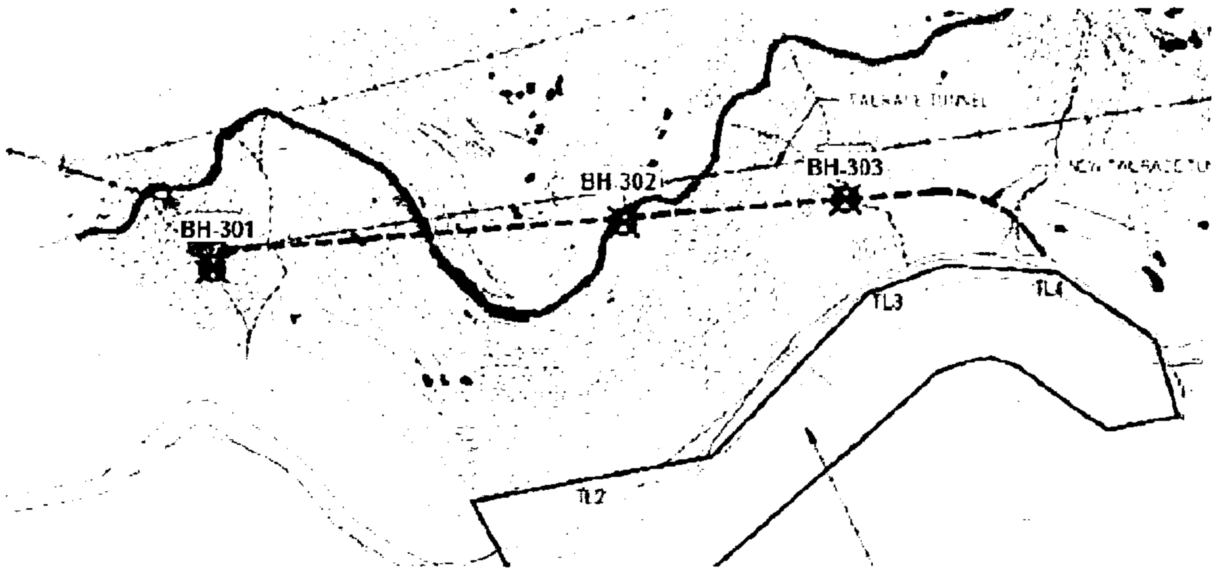


Figure 7.15 - The location of Phase III boreholes

Both soil and bedrock were logged at the drill site by the Contractor's geologists. In addition to logging, each drill run was photographed while the core was in the split tube as well as in the core box.

7.8.3 Laboratory Test Program

To estimate the engineering properties of the rock and to develop design parameters, representative samples of core were selected for various laboratory tests. **Table 7.19** shows the number of laboratory tests conducted on representative core samples.

The following laboratory tests for rock quality testing were performed during the geotechnical investigations.

- Specific Gravity, Moisture Content and Porosity.
- Unconfined Compressive Strength (RCU).
- Unconfined Compressive Strength with Deformation Modulus.
- Petrographic Analysis.
- Discontinuity Shear Strength Test.
- Slake Durability Test.

The summary of laboratory test results of rock core samples is given as **Table 7.19**.

Table 9.2 - Summary of Phase III Laboratory Testing

Borehole	Sample	From (m)	To (m)	Specific Gravity	Porosity	NMC %	UCS (MPa)	UCS Corrected (MPa)	Cohesion (MPa)	Angle of Shear Resistance	Modulous of Elasticity	Poison Ratio (MPA)	Modulous of Deformation (MPa)	Slake Durability	Petrographic Analysis
BH-301	WS-34	152.58	152.76				-	-						-	Arenaceous Mudstone
	WS-35	169.01	169.19				-	-						-	Carbonate Cemented Argillaceous Sandstone (Quartz Wacke)
	WS-36	171.82	171.97				10.3	10.33						-	-
	WS-37	181.03	181.15				-	-						98.9	-
	WS-47	256.5	258.8				-	-						98.6	-
	WS-48	262.1	262.3				-	-						-	Claystone WithIntraclasts
	WS-49	281.03	281.35				-	-						-	Calcareous Sandstone (Carbonate Cemented Lithic Arenite)
	WS-50	310.6	310.81				4.79	4.8						-	-
BH-302	WS-51	314.5	314.7				10.95	13			30600	0.25	12200		
	WS-52	324.8	325				-	-			-	-	-		
BH-303	WS-16	110.22	110.41	-	-	-	-	-	42.8	0.155	-		-	-	-
	WS-17	111.19	111.51	-	-	-	-	-	-	-	-		-	-	Silty Claystone
	WS-18	119.41	119.67	-	-	-	9.13	11	-	-	29000	0.11	13000	-	-
	WS-19	122.22	122.48	2.88	3.13	0.56	-	-	-	-	-	-	-	-	-
	WS-20	126.5	126.74	-	-	-	-	-	-	-	-	-	-	97.8	-

The data of laboratory test results is shown in Appendix D of **Annex IV**.

7.8.4 Geotechnical Mapping

The prediction of the engineering performance of an excavation in a rock mass requires an understanding of the nature and distribution of the geologic structures within the rock mass. A natural rock mass is never a continuous, homogeneous, isotropic material, but rather is intersected by a great variety of geologic discontinuities such as faults, joints, bedding or foliation. The scanline mapping was conducted of the area around the outlet portal of the Tailrace tunnel where rock is outcropped, as shown in **Drawings 11** and **12**.

7.8.5 Powerhouse Site Investigation Results

7.8.5.1 General

Borehole BH-301 was drilled to a depth of 226 m to investigate the ground conditions for the powerhouse. The drilling indicated that the thickness of the overburden soil is 7 m, and is followed by the Murree Formation's claystone, siltstone and sandstone rock units. The detailed core logs, core photographs and laboratory test results are shown in Appendix D of **Annex IV**.

This section presents the results of Phase III's site investigations. RMR and Barton Q rock mass ratings were worked out for powerhouse borehole BH-301. The Unconfined Compressive Strength (UCS) values obtained from the laboratory test were not used to work out RMR ratings because of the variability in the field strength (ISRM) values. The ISRM field

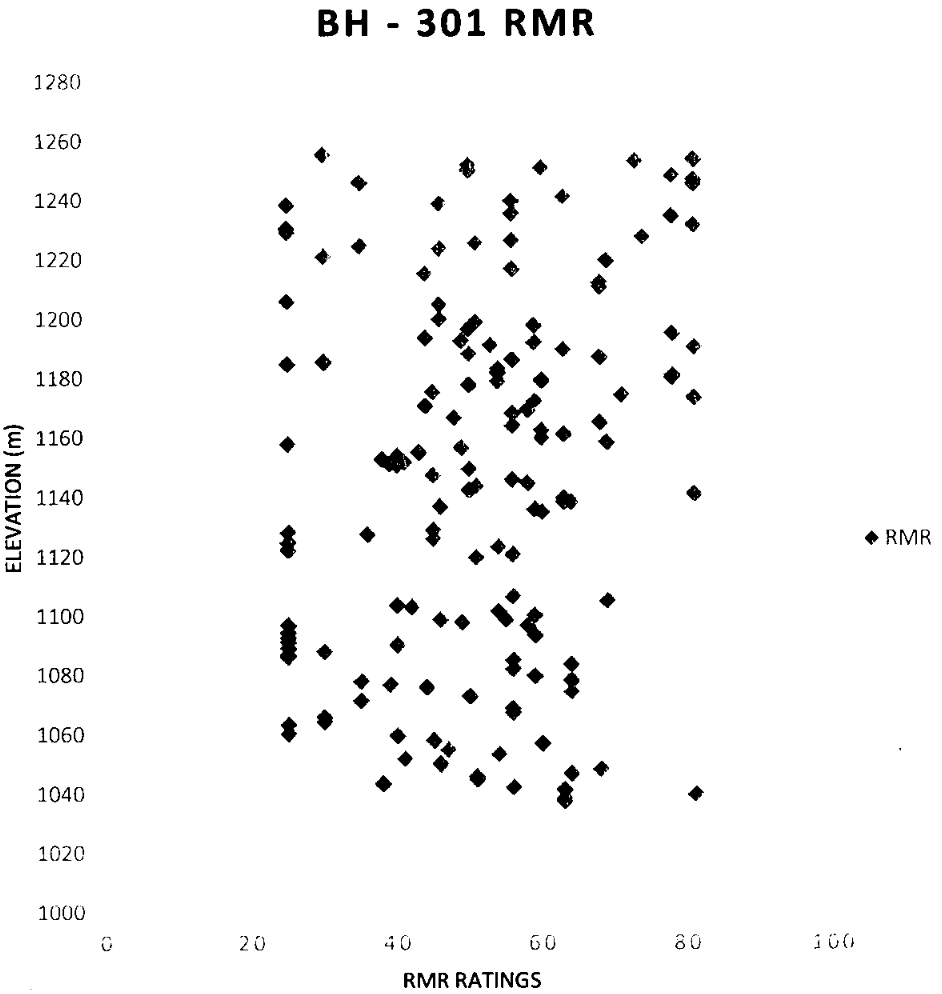


Figure 7.16 - RMR plot of BH-301

7.8.5.2 Rock Quality Designation (RQD) Analysis

The drilling results of borehole BH-301 indicated some broken core zones, which were associated with claystone and sandstone rock types. Core logging data provided by the drilling Contractor did not show any record of a shear or a fault.

7.8.5.3 Conclusions and Recommendations

Based on the Phase III site investigation data, interpretations and analysis, the following conclusions are made.

- Per the site investigation data, no faults and shears were identified at the location of BH-301, however it is worth mentioning that the HQ 3 borehole drilling only provide sub-surface information for a 61 mm diameter area, which may not be representative of the powerhouse site. Down the hillslope along the Tailrace tunnel at the BH-303 location, tectonised ground conditions were observed. Considering drilling limitations and the presence of tectonised zones, it is proposed to drill at least two more boreholes for better understanding of the ground conditions and to rule out the presence of potential tectonised zones.

- Analysis and interpretation of powerhouse site boreholes' rock mass data suggest the use of the following design parameter for a 226-m-deep cavern.

Parameter	250-M-Deep Foundation with 0 D	250-M-Deep Foundation with 0.5 D
Claystone		
C (MPa)	0.786	0.584
Ø (°)	33	28
Sandstone		
C (MPa)	1.219	0.992
Ø (°)	48	44
Siltstone		
C MPa	1.31	1.016
Ø (°)	42	39

7.8.6 Geological Mapping

The FS2013 geology map was used to map riverbed deposits, slope deposits and scree deposits. A Clar compass, geological Brunton and GPS were used to collect rock mass data. The services of a surveyor were rendered to delineate the lithological rock contacts and surficial deposits. The updated geology maps of the tailrace site are shown as **Drawing 10**. A total of two scanlines were mapped around the location of the outlet portal of the Tailrace.

The mapping shows that the bedrock is primarily composed of claystone and siltstone of the Murree Formation. The bedding dip angle of the siltstone and claystone ranges between 80 degrees and near-vertical, whereas the dip direction ranges between 010 – 040 degrees. A small shear was also observed in the claystone and siltstone, having a dip and dip direction of 88/040 degrees. No other significant adverse structural feature was spotted in this area. There is ample room in the bedrock outcrop to avoid the shear and to place the portal outlet.

It must be noted that the extensive vegetation cover of the terrain in the area significantly hampered a more comprehensive geological mapping, which had to rely on the exposed faces, either natural as in the previous photo, or man-made, such as road excavation slopes.

The scanline rock mechanics data was processed by RocScience Dips software to establish Ja, Jr, major panes, Rosset plot, 3D pole plot, RQD, joint frequency, joint spacing and shape, and is shown in **Annex IV**. A Kineamatic Stability analysis was also conducted, and the results are shown in **Table 7.20**.

Table 7.20 - Kinematic Stability Analysis of the Tailrace portal

Scanline #	Probability of Failure (%)		
	Planar Sliding	Wedge Sliding	Direct Topping
TL-4-1	8	15	3
TL-4-2	0	8	11

7.8.7 Results of Site Investigations

7.8.7.1 General

During Phase III of site investigations, two boreholes (BH-302 and BH-303) were drilled along the tailrace tunnel. Borehole BH-302 was drilled to a depth of 330 m and BH-303 was drilled to a depth of 130 m to investigate the ground conditions for the tailrace tunnel outlet portal. The drilling indicated that the thickness of the overburden soil at BH-302 is 14 m, which is followed by the Murree Formation's claystone, siltstone and sandstone rock units. The drilling indicated that the thickness of the overburden soil is 2.5 m, which is followed by the Murree Formation's claystone rock units.

7.8.7.2 Borehole 302 Drilling Results

This section presents the results of the Phase III site investigation, which included drilling and laboratory test programs. The detailed core logs, core photographs and laboratory test results are shown in **Annex IV**.

RMR and Barton Q rock mass ratings were worked out for the BH-302 and BH-303 boreholes. The Unconfined Compressive Strength (UCS) values obtained from the laboratory test were not used to work out RMR ratings because of the variability in the field strength (ISRM) values. The ISRM field strength values for each rock type were averaged out. These average ISRM strength values were used to develop the RMR rating. The rock mass ratings inclusive of all rock types were worked out for BH-302 and are shown in **Table 7.21**.

Table 7.21 - RMR and Barton Q Rock Mass Ratings BH-302

BH-302 RMR & Q STATS				
ROCKMASS CLASSIFICATION	MINIMUM	MAXIMUM	AVERAGE	STDEV
ALL ROCK TYPES				
RMR	14	89	56	16
Q	0.035	148	16	30
CLAYSTONE				
RMR	14	87	56	25
Q	0.035	118	13	25
SANDSTONE				
RMR	21	87	48	18
Q	0.077	118	9	21
SILTSTONE				
RMR	21	87	47	18
Q	0.077	118	9	9

The RMR ratings of BH-302 were also plotted against the borehole elevations to observe how these change along the elevations of the borehole. The RMR plot is shown as **Figure 7.17**.

The average RMR and Barton Q ratings are 56 and 16 respectively. The RMR rock mass ratings for claystone, siltstone and sandstone ranges between 47 and 56, which renders rock mass as fair. The Barton Q values ascertained from the RMR range between 9 and 13, a fair to good rock quality. RocData, a software of RocScience, was employed to model rock properties, which are depicted in **Annex IV**.

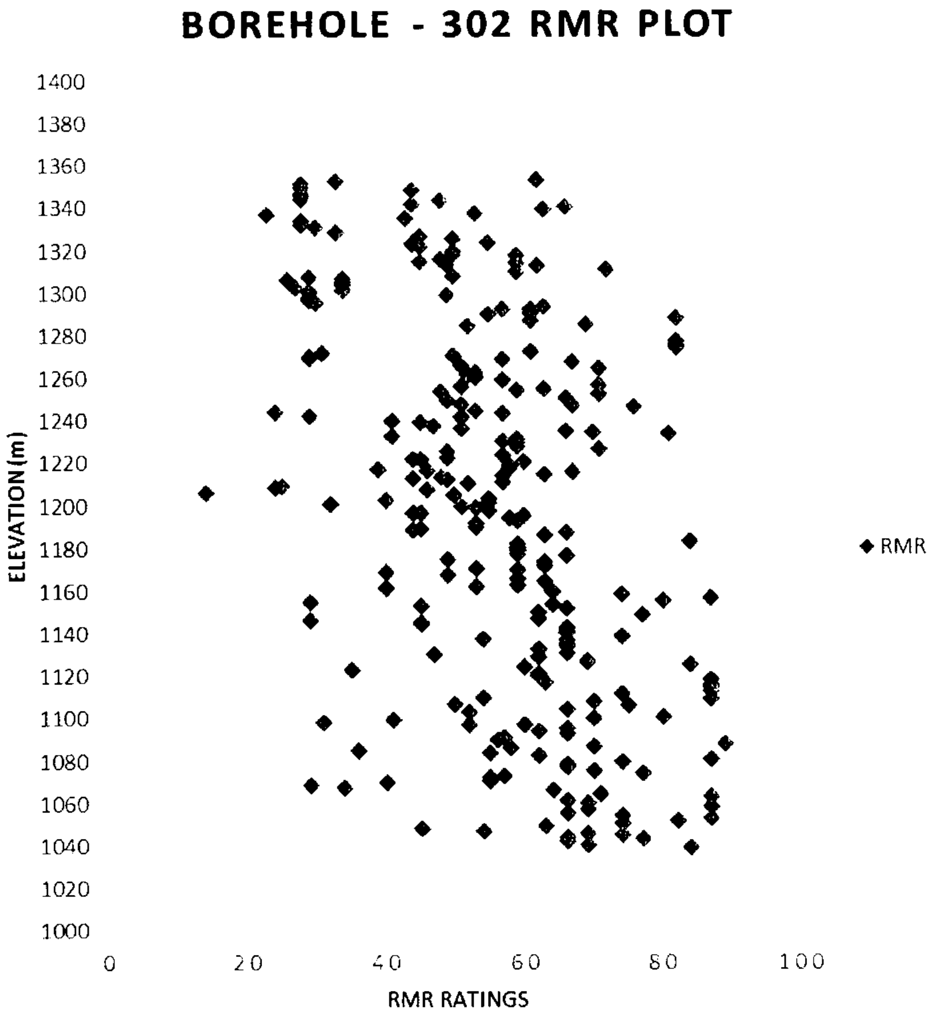


Figure 7.17 - RMR plot of BH-302

7.8.7.3 Rock Quality Designation (RQD) Analysis

The drilling results of borehole BH-302 indicated some broken core zones, which were associated with claystone and sandstone rock types. Core logging data provided by the drilling Contractor did not show any record of a shear or a fault.

7.8.7.4 Conclusions and Recommendations

Based on the Phase III site investigation data interpretations and analysis, the following conclusions are made.

- Per the site investigation data, no faults and shears were identified at the location of BH-302.

- Analysis and interpretation of dam site boreholes' rock mass data suggest the use of the following design parameter for a 250-m-deep tunnel.

Claystone		
Parameter	250-M-Deep Foundation with 0 D	250-M-Deep Foundation with 0.5 D
C (MPa)	1.103	0.841
Ø (°)	30	26
Sandstone		
C (MPa)	1.483	1.18
Ø (°)	42	37
Siltstone		
C MPa	1.136	0.869
Ø (°)	34	29

7.8.7.5 Borehole 303 Drilling Results

This section presents the borehole BH-303 drilling results. RMR and Barton Q rock mass ratings were worked out for BH-303 borehole. The Unconfined Compressive Strength (UCS) values obtained from the laboratory test were not used to work out RMR ratings because of the variability in the field strength (ISRM) values. The ISRM field strength values for each rock type were averaged out. These average ISRM strength values were used to develop RMR rating. The rock mass ratings inclusive of all rock types and rock type wise were worked out for BH-303 and are shown in **Table 7.22**.

Table 7.22 - RMR and Barton Q Rock Mass Ratings BH-303

BH-303 RMR & Q STATS				
	MINIMUM	MAXIMUM	AVERAGE	STDEV
CLAYSTONE				
RMR	24	87	48	18
Q	0.108	119	9	18

The RMR ratings of BH-303 were also plotted against the borehole elevations to observe how these change along the depth of the borehole. The RMR plot is shown as **Figure 7.18**.

The average RMR and Barton Q ratings of Claystone are 48 and 9 respectively. The RMR rock mass ratings for claystone renders rock mass as fair. The Barton Q values ascertained from the RMR range is 9 which categorise Claystone as poor rock quality.

RocData, a software of RocScience, was employed to model rock properties. General and with 130-m-deep tunnel rock properties of claystone were worked out for the tailrace tunnel.

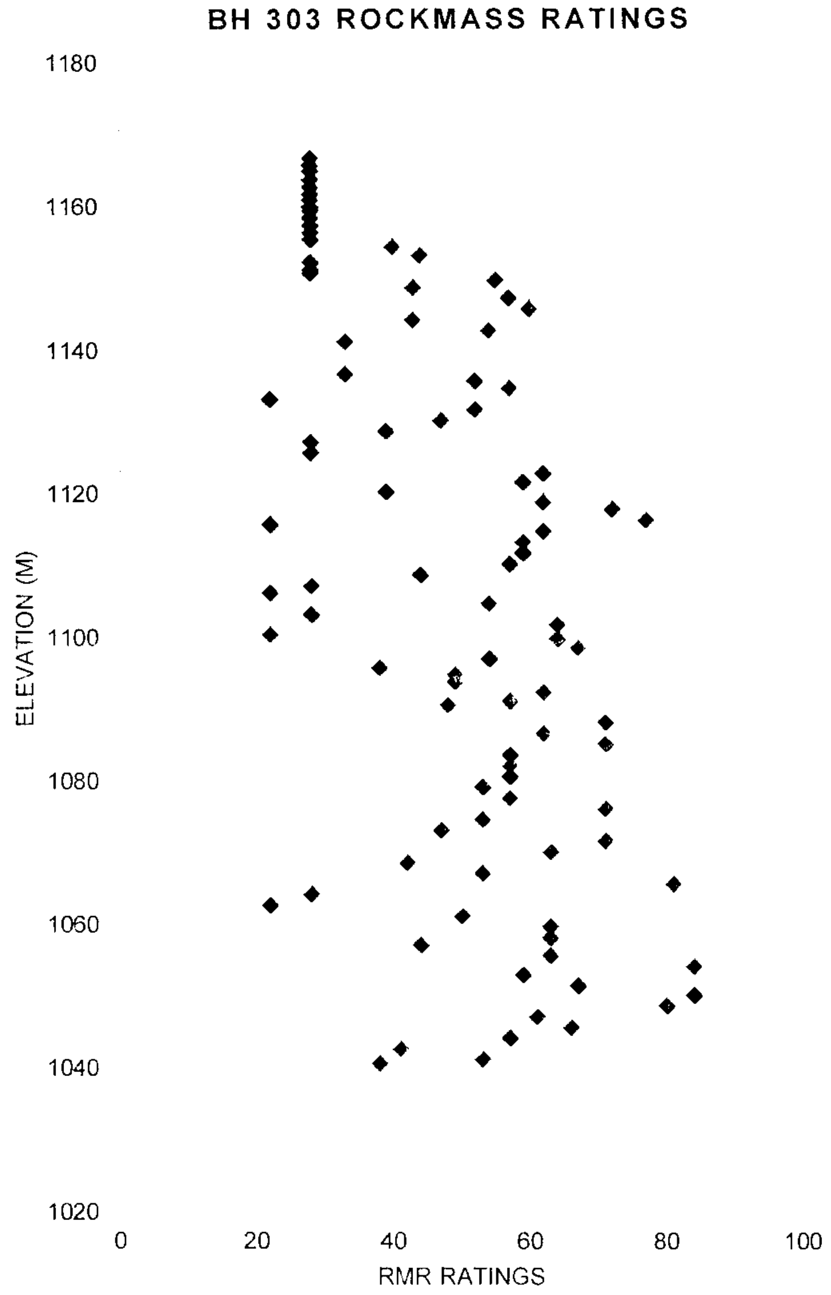


Figure 7.18 - RMR plot of BH-303

7.8.7.6 Rock Quality Designation (RQD) Analysis

The drilling results of borehole BH-303 indicated some core loss and broken core zones from 2.5-15.3, 17.5-20.0, 26.5-48.0, 54.50-55.0, 62.0-67.5, 72.2-73.7, 74.9-80 and 105.1-108.0 m depths. The drilling also showed a few tectonised zones.

7.8.7.7 Conclusions and Recommendations

Based on the Phase III site investigation data interpretations and analysis, the following conclusions are made.

- Considering the poor ground conditions marked by core loss/broken core and tectonised zones as observed during drilling, it is proposed to estimate the thickness of these zones through additional drilling during the design stage.
- Analysis and interpretation of the tailrace tunnel borehole rock mass data suggest the use of following design parameter for a 130-m-deep tunnel.

Claystone		
Parameter	130-M-Deep Tunnel with 0 D	130-M-Deep Tunnel with 0.5 D
C (MPa)	0.438	0.319
Ø (°)	33	28

8 RESERVOIR SEDIMENTATION AND FLUSHING

8.1 GENERAL CONSIDERATIONS

The analysis presented in this chapter concerns the simulation of the delta profile of the sediments trapped in the Balakot reservoir, the distribution of sediment sizes entering the power intake tunnel, the flushing operations of the Balakot reservoir and the transport of the sediments resulting from the Suki Kinari reservoir flushing

For this stage of the studies, HEC-RAS is used to perform a sediment transport analysis, using the unsteady flow calculations.

For a more detailed analysis *vide* **Annex III – Sediments**.

8.2 SEDIMENTATION MODEL

The model used to simulate the normal operation of the Balakot dam includes all the structures of the Balakot Hydropower scheme (dam, sediment by-pass tunnel, the upstream cofferdam and the power intake). This model considered the mean daily flows and the mean annual sediment load of 420 kton (Cross Section 6900). Several initial conditions and transport parameters were defined, such as the Laursen's formula transport capacity, Exner 5 and Active Layer methods to simulate the sorting and armoring and Rubey's formula to fall velocity. For each cross section, a maximum erosion depth of 0 m (which implies that possible erosions of the existing riverbed are disregarded) and an initial bed gradation curve were defined. This curve was based on weighing the gradations of the sediments from the Balakot sub-catchment area (70%) and of those resulting from the operation of the Suki Kinari dam (30%). These percentages correspond to the estimates obtained for the total amount of sediments that reach the Balakot dam site.

Figure 8.1 shows the bed gradation curve defined for the Balakot dam site.

Considering one average year of flows and the sediment transport processes, the delta longitudinal profile along the Balakot reservoir was computed (**Figure 8.2**). Coarser sediments will be deposited in the upstream part of the reservoir, while less coarse sediments will be deposited further downstream. The finer sediments (< 0.125 mm) will stay suspended and will be derived downstream: by the sediment by-pass tunnel, during the flood seasons, whenever the river's flow is higher than the design discharge of the power intake; or flowing into the power intake and passing through the turbines. After one year of normal operation of the Balakot scheme, the top of the upstream cofferdam/weir shall have an accumulated sediment height of 10 cm.

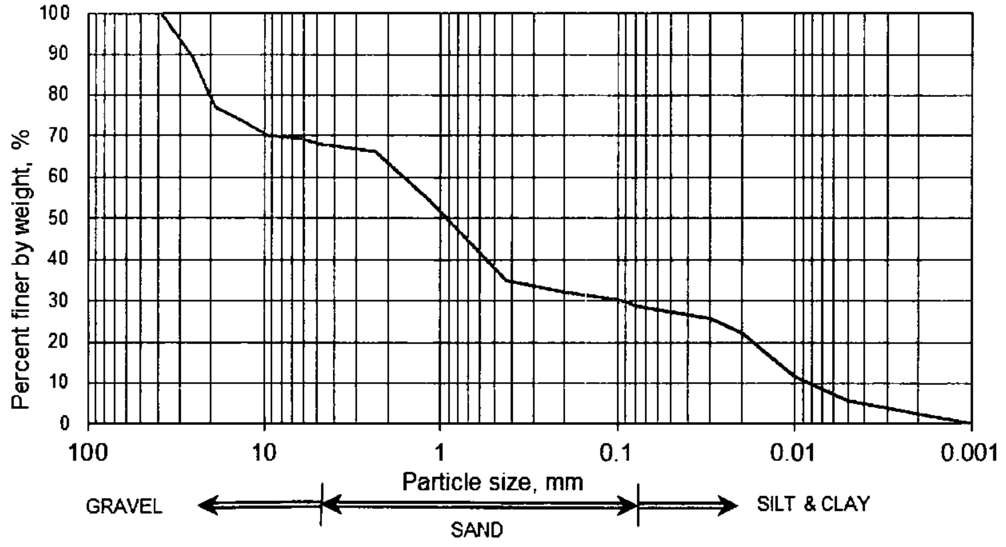


Figure 8.1 – Bed gradation curve adopted on the present study for the Balakot dam site

Additionally, according to **Figure 8.3** it is possible to verify that only clay and silt grains, with particles sizes smaller than 0.0625 mm will reach the power intake tunnel. If some peaks of sediment occur, caused by the flood season or landslides events, it is possible that some particles with sizes between 0.0625 and 0.125 mm enter the power tunnel as well. Even for these situations, these particle sizes are not expected to affect the turbines.

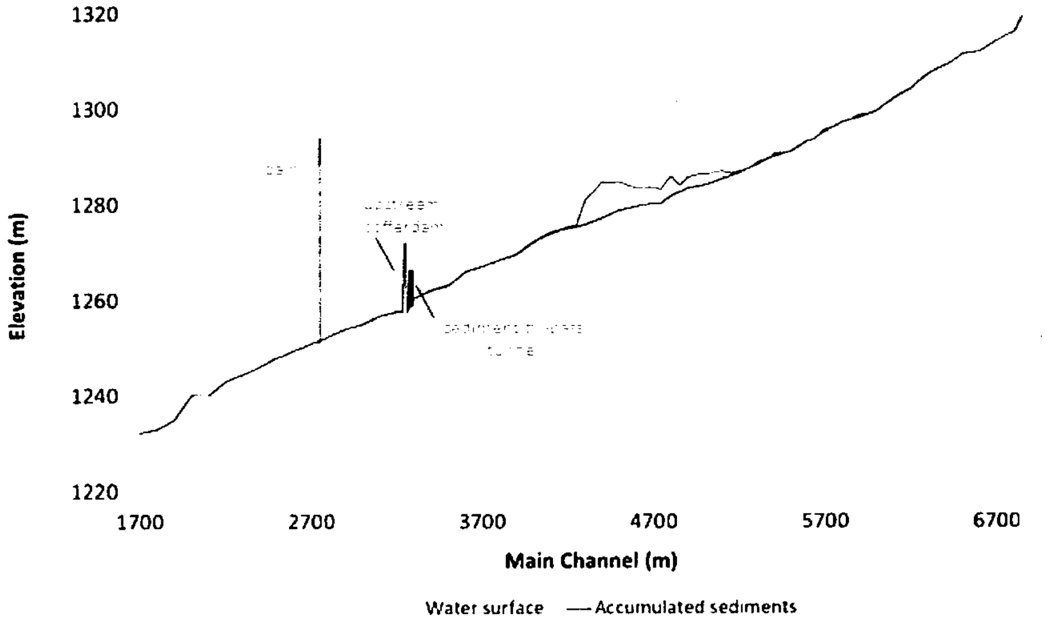


Figure 8.2 – Longitudinal profile of the sediments delta after one average year

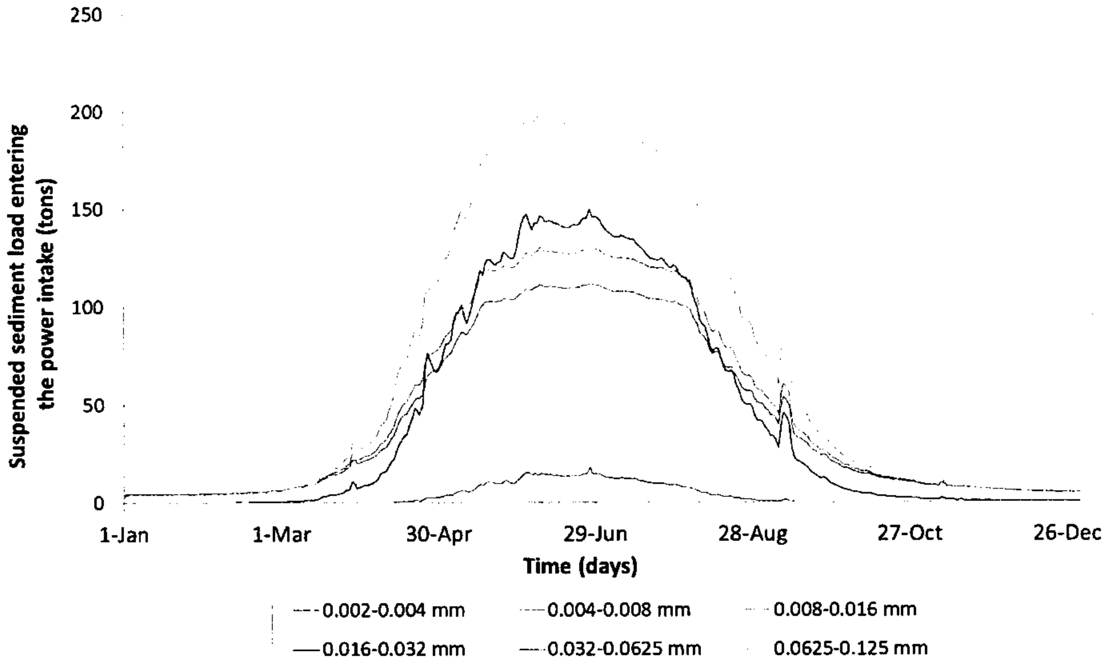


Figure 8.3 – Suspended sediment load entering the power intake, by grain classes

Figure 8.4 presents the daily sediment concentration entering the power intake, for a simulation of an average year. The mean sediment concentration is 23 g/m^3, with minimum and maximum values of 7 and 46 g/m^3, respectively, which is considered quite acceptable.

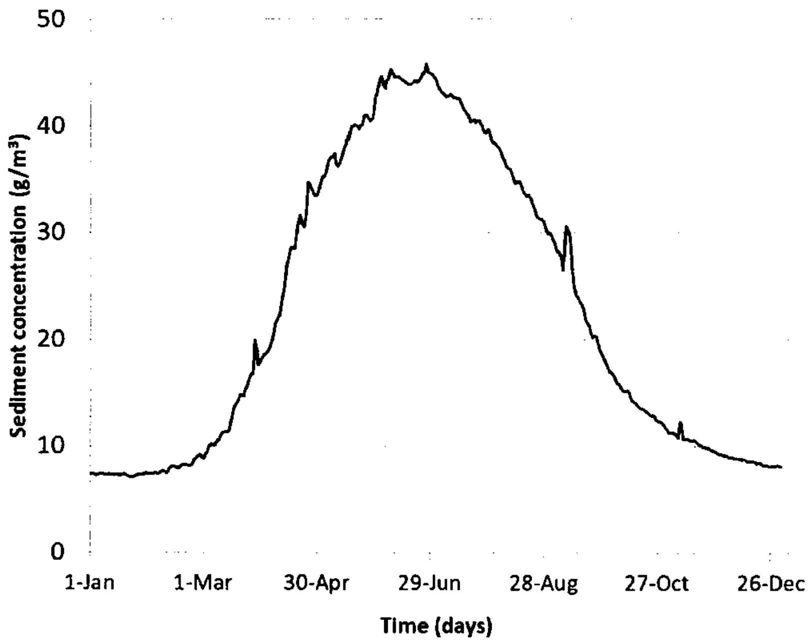


Figure 8.4 – Daily sediment concentration entering the power intake, during an average year of simulation

With the results obtained in this study it is possible to conclude that the sediment volume trapped in the Balakot reservoir is about 77% of the total sediment inflow. This percentage is higher than the one presented in the FS2013 of Balakot (MIRZA *et al*, 2013) - 37% in the first year - and higher than reference values (e.g. Batuca *et al*, 2001), which, nevertheless, do not account for the granulometry of the sediments. According to the bed gradation of the Balakot reservoir, that was defined as sediment data for simulation purpose, the coarser particles, with a size larger than 0.125 mm, are about 70% of the total grains. Therefore, as shown, those particles will be deposited and trapped in the Balakot reservoir. Additionally, about 80% of the particle with sizes between 0.032 and 0.125 mm will also be deposited in the Balakot reservoir, totalizing the referred 77% of the total sediment inflow. Nevertheless, due to the high uncertainty associated with this estimate regarding the annual sediment load and its granulometry, an average sediment load 100% higher is also be simulated.

Figure 8.5 presents the longitudinal delta profile after one average year of simulation and **Figure 8.6** represents the sediment deposits, by grain classes, along the Balakot reservoir and further downstream, for an average year, considering the duplication of the mean annual sediment load. Comparing the **Figure 8.5** and **Figure 8.6** to **Figure 8.2** and **Figure 8.3**, it is possible to observe that despite the increase of the total sediments inflow into the Balakot reservoir, the sizes of the grains that will reach the Balakot dam are similar. The only difference between both simulations is the geometry of the delta profile. For a higher sediment inflow, the profile presents a more elongated geometry.

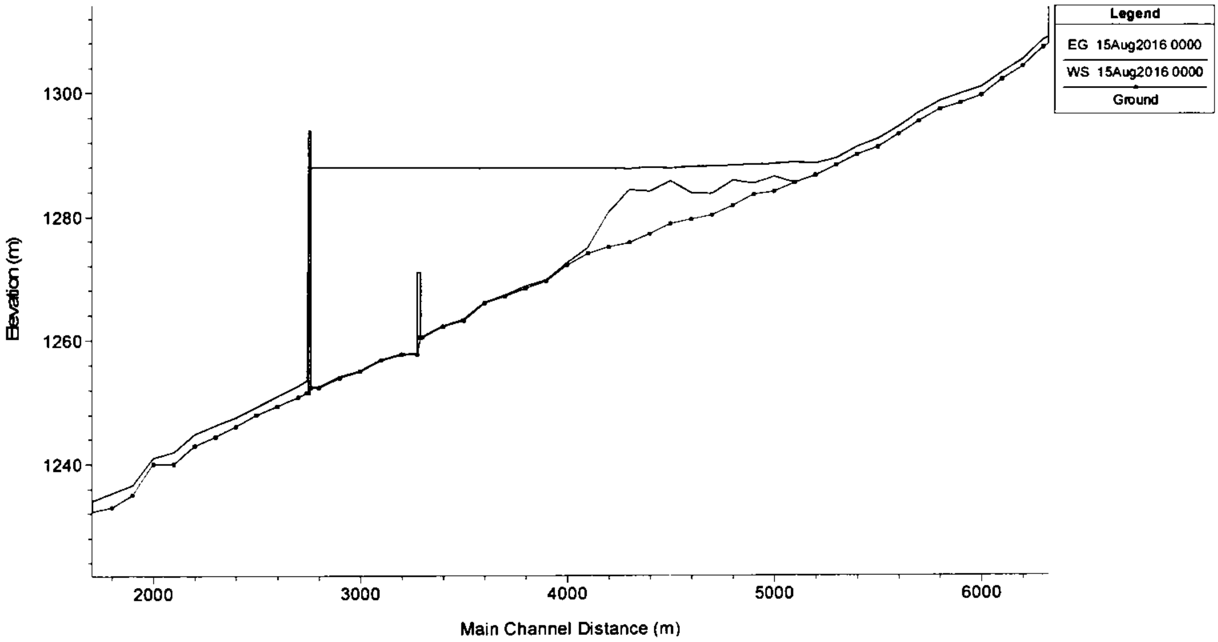


Figure 8.5 – Longitudinal delta profile after one average year, considering the duplication of the total mean annual sediment load

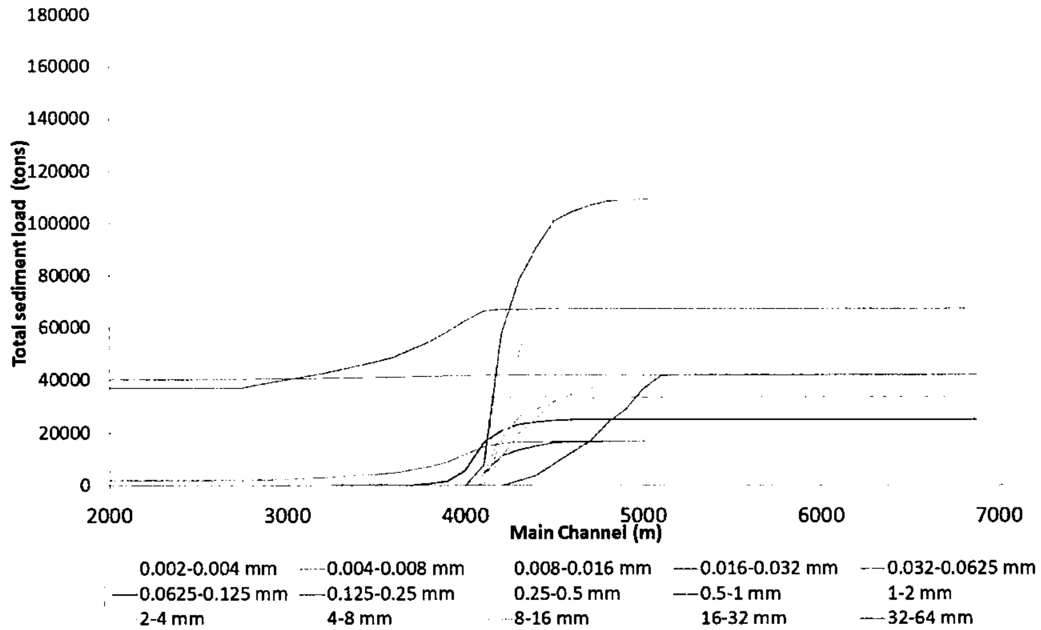


Figure 8.6 – Sediment deposits, by grain classes, along the Balakot reservoir and further downstream, for an average year, considering the duplication of the total mean annual sediment load

8.3 SEDIMENT MANAGEMENT

The sediment inflow to the Balakot dam site is significant and constitutes a relevant issue for the planning and design of the hydropower scheme. This sediment inflow is also controlled by the reservoir of the Suki Kinari dam, presently under construction. An effective sediment management plan must be considered for Balakot HPP to avoid problems such as: strong reduction of the active volume of the reservoir, the increase of suspended sediment concentration in the turbine flow, and the risk of sediment blocking and damage ofn the dam outlet structures.

The Balakot HPP planning and design is focused on the sediment inflow routing, and on the periodic removal of the sediments accumulated in the reservoir. The following features/structures for sediment management were considered: low level outlets (for sediment routing and flushing), sediment by-pass tunnel (for sediment routing) and natural settling basin (for fine particle settling).

This subchapter concerns the analysis of the sediment model results of the Balakot reservoir flushing operations. This analysis considers successive flushings, during the flood season, taking advantage of the diversion of river flows higher than the power plant design discharge (154 m^3/s); the planned sediment flushing, in a short period of time, with the discharge of the accumulated sediments in the Balakot reservoir; and the indispensable coordination with Suki Kinari dam operation.

The sediment by-pass tunnel was defined to divert the river flows higher than the power plant design discharge and up to a 5-year return period flood (600 m^3/s). So, during the flood season, when most of the river flow is higher than 154 m^3/s (power plant design discharge) the gates of the sediment by-pass tunnel are operated with the purpose of maintaining the normal operation level (NOL). That will allow the excessive river flow to be diverted as well as the corresponding suspended sediments. Regarding this operation, it is not expectable that a significant amount of sediments deposited in the reservoir move, because the flow velocity in the reservoir will still be low. Considering the reference mean annual sediment load inflow into the Balakot reservoir (420 kton/year), the amount of sediments that will be removed by the sediment by-pass model after one year of Balakot dam operation is about 15 kton (4% of the total mean annual sediment load). As expected, the sediments that will be removed by the sediment by-pass tunnel during the normal operation of the Balakot dam are only the suspended sediments with the grain sizes smaller than 0.125 mm. The sediments with the coarser grain sizes are deposited in the upstream area of the Balakot reservoir.

In this Report, the unsteady flow model of HEC-RAS was also used to simulate the flushing operation of the accumulated sediments in the Balakot reservoir. To perform this operation, it was necessary to define a two staged simulation: first, the normal operation of the Balakot dam with the accumulation of the sediments during a period of time and, afterwards, the flushing of the accumulated sediments. The previous model, developed to simulate the normal operation of the Balakot dam, had to be adjusted and some simplifications were introduced.

With the numerically stabilized model, the flushing operation simulations and the analysis of the results could be performed. Different discharges, 100, 200 and 300 m^3/s, were considered and two different bed armoring and sediment sorting methods were adopted. In these simulations (normal operation of the dam) the Thomas (Exner 5) method was chosen as the more accurate method to characterize the armoring layer provided by the coarser elements of the Kunhar riverbed. In this phase, the flushing operation with a different armoring and sorting method (Active Layer method) was also simulated. The Active Layer (Brunner, 2016) method mixes the sediments that will be deposited in the river bed and distributes these sediments between the active and inactive layers - 30% stay in the active layer and the remaining 70% go to the inactive layer. **Figure 8.7** shows the transport of the accumulated sediments after 24 h of flushing operation for discharges of 100, 200 and 300 m^3/s, considering the sediment data presented in **Annex III** (armoring layer Thomas method).

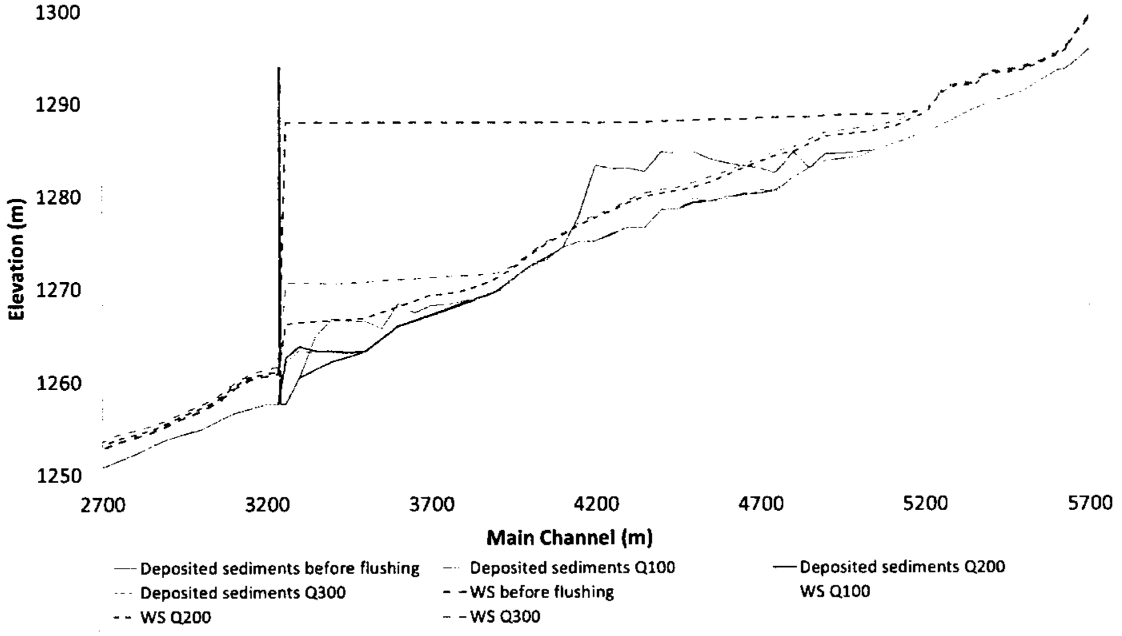


Figure 8.7 – Deposited sediments profiles after 24 h of flushing operation for different discharges, considering the armoring layer Thomas method

It was possible to verify that during the flushing operation, the deposited sediments were transported near to the by-pass tunnel and started to leave the reservoir. It could also be observed that smaller discharges allow the flushing of a larger volume of sediments than higher discharges. This behaviour could be justified by the fact that for larger flows the level necessary to get the discharge into the by-pass is higher, and the flow cannot effectively drag the accumulated sediments, because the velocity upstream of the by-pass is not high enough, and the amount of flushed sediments stagnates. Considering the Thomas method, since the sediments that could be transported are the ones of the cover layer (coarser sediments), the smaller particles that were deposited were not flushed. So, to turn around this situation, the flushing operation with an armoring and sorting method that considers a bed layer with mixing granulometry of sediments (Active Layer method) was also simulated. The Active Layer method could flush a more graded size distribution of the deposited sediments. However, the amount of sediments that were flushed is smaller than the one obtained by the Thomas method. These results are physically understandable and uncertain, once these methods were developed for sediment transport in rivers, where the flow occurs in conditions rather different than the flushing ones.

One aspect that must be considered regarding the future Balakot sediment management operations is the most likely necessity of having mechanical help to move sediments downstream and to move them closer to the entrance of the by-pass tunnel. To account for this likely requirement, accesses to the river bed shall be provided to facilitate those operations.

The present study also includes the assessment of the impact of the Suki Kinari dam operation on the Balakot reservoir sedimentation, considering the sediments resulting from the normal operation of the Suki Kinari scheme (the retention of the Suki Kinari sub-catchment area and the sediments derived through the Suki Kinari powerhouse) and the study of the transport of the sediments resulting from the Suki Kinari reservoir flushing operation. In this study a sensitive analysis of different discharges values and sediments volumes resulting from Suki Kinari flushing operation was performed.

Figure 8.8 shows the time evolution of the sediments across the Balakot reservoir (upstream cross section) resultant from the Suki Kinari flushing operation, considering a discharge of 175 m^3/s and different volumes of flushed sediments.

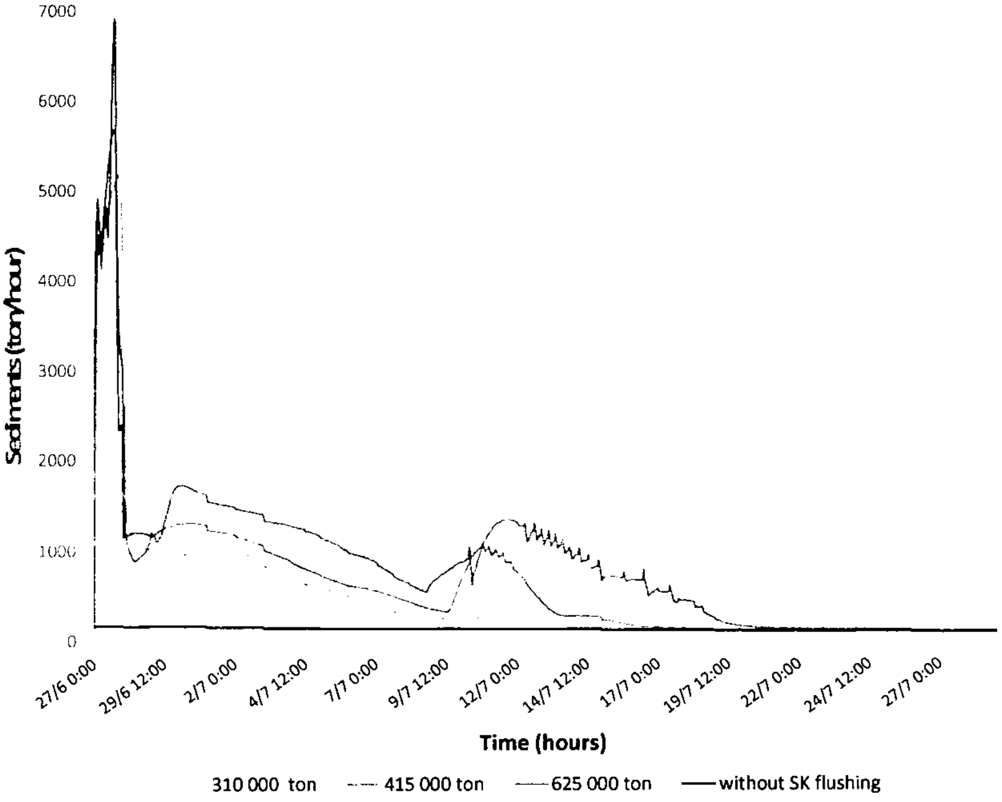


Figure 8.8 – Sediments reaching the Balakot reservoir (upstream cross section) considering the same discharge and different volumes of sediments resulting from Suki Kinari flushing operation

Although the Suki Kinari flushing operation only lasts 24 h, the total volume of sediments takes almost three weeks to fully reach the Balakot reservoir (upstream cross section). The figure above shows that for the same discharge, higher volumes of flushed sediments take longer to reach the Balakot reservoir. However, in the last days of the simulation period, the amount of sediments that reach the Balakot reservoir is not significant, comparatively to the very high values obtained in the first day and the total volume of sediments resultant from the flushing operation. Along the distance between the Suki Kinari dam and the Balakot reservoir (upstream cross section), there are sloping areas and quasi-flat areas. The flat areas promote a higher accumulation of sediments, which originates a decrease of sediments that will reach the Balakot reservoir. However, when eventually the flow decreases, the sediments will be dragged. As a consequence, the accumulation of the sediments in the quasi-flat areas, followed by the drag of these sediments, will originate peaks of sediments inflow in the downstream cross sections, as shown in the graphic.

Considering the discharge of 175 m^3/s and the total volume of sediments of 415 kton, **Figure 8.9** shows the sediments that reach the upstream cross section of the Balakot reservoir by grain classes.

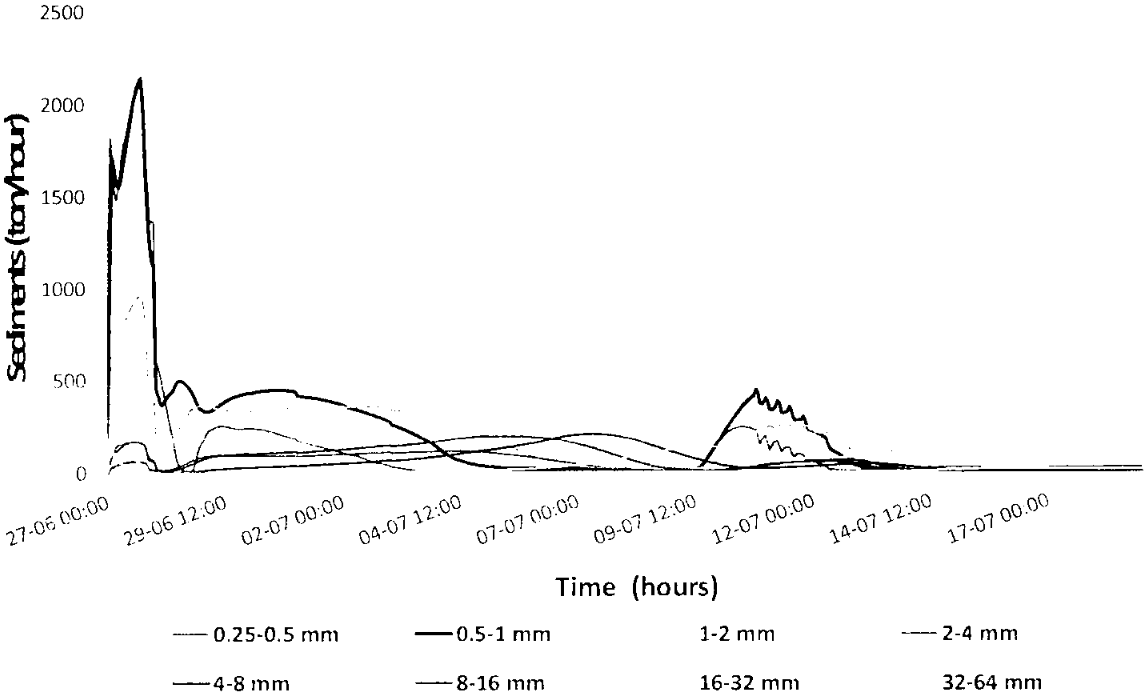


Figure 8.9 – Sediments reaching the upstream cross section of the Balakot reservoir, considering the mean data, by grain classes

As expected, the sediments with smaller grain sizes reach the Balakot reservoir earlier than the coarser sediments. As shown in this figure, the referred delayed sediments inflow peak is mainly formed by the smaller grain sizes. This phenomenon is probably due to the fact that after the accumulation of the sediments in the flat areas, the smaller granulometries are the first to be dragged when the flow decreases.

Additionally, a sensitivity analysis to the discharge was performed considering a mean volume of sediments resulting from the Suki Kinari flushing operation (415 kton). The transport of these sediments along the distance between the Suki Kinari dam and the Balakot reservoir for a minimum and a maximum average daily flows during the wet period (May to August), 90 and 250 m^3/s respectively, was analysed (**Figure 8.10**).

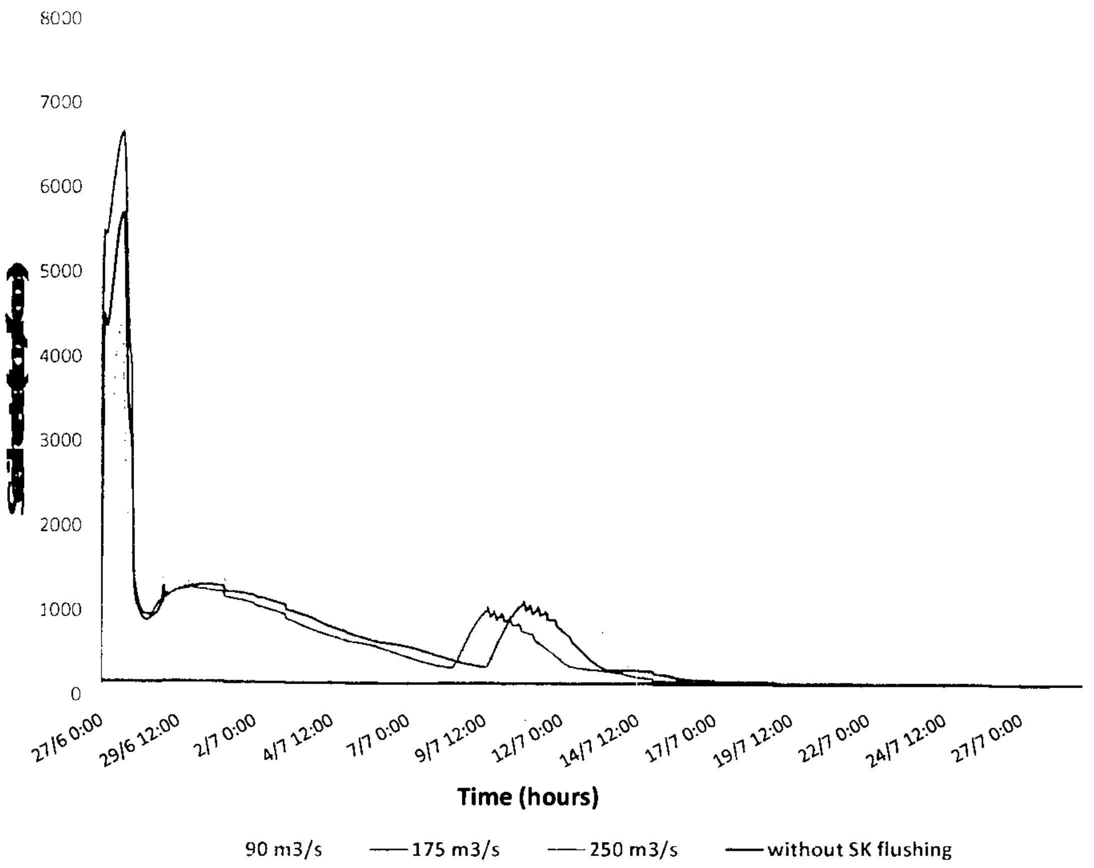


Figure 8.10 – Sediments reaching the Balakot reservoir (upstream cross section) resulting from a Suki Kinari flushing operation, considering different discharges and 415 kton of flushed sediments

The graphic above shows that, for the same volume of flushed sediments, the lower discharge originates a peak of sediments lower than the ones simulated for the higher discharges, and that the total volume of sediments resulting from the Suki Kinari flushing operation takes longer to reach the Balakot reservoir, as expected

The previous analysis showed that the flushing operation of Suki Kinari will have an important impact on the Balakot reservoir, which will have to be considered in the Balakot dam operation. However, the distance between the Suki Kinari dam and the Balakot reservoir is significant and the total volume of sediments resulting from this operation reaches the reservoir during an extended period. Therefore, the impact of the Suki Kinari flushing operation in the Balakot reservoir will last much longer than the duration of the Suki Kinari flushing itself.

Even considering the staged entry of the sediments into the Balakot reservoir, it will be extremely important that when Suki Kinari initiates the flushing operation, the Balakot dam be ready to initiate its flushing operation as well, and that the power plant can be shut down as soon as the peak sediment wave reaches the Balakot reservoir.

Given the uncertainties associated with the sediments loads and transport times into the Balakot reservoir, it will be important to install a reliable sediment detection system to control the sediment deposition in the Balakot reservoir and a turbidity measurement system to detect changes in the suspended sediment concentration. These systems should allow the detection of high sediment loads inflow, either motivated by natural phenomena, or by flushing operations of the upstream reservoir. The updating of the bathymetric contour map of the Balakot reservoir to control the volume of the accumulated sediments, after each flood season or after a flushing operation of Suki Kinari, is also highly recommended. This bathymetric contour map can be, nowadays, easily produced with an Acoustic Doppler Current Profilers (ADCP).

It must be noted that the quantitative assessment of sediment in rivers is based on empirical formulas, with several parameters that are difficult to estimate for any case study and that, very frequently present significant discrepancies with monitoring data. Moreover, it must be pointed out that the numerical model HEC-RAS, similarly to other available models, was developed to perform the sediment transport in rivers, where the flow occurs in rather different conditions from the flushing operation ones. Despite the sensitivity analysis performed for the armoring and sorting method, the erosion of the accumulated sediments during the flushing operation and the amount of the flushed sediments during each operation may be present important deviations relatively to reality. Therefore, the PPTA Consultants envisages the development of a physical model to better assess the behaviour of the sediment transport in the reservoir and the flushing operation efficiency.

Although physical models for sediments transport present serious challenges as well, they will help to figure out the sediment movements along the reservoir bed and along the by-pass, during the flushing operation and, consequently, a more reliable estimation of the duration of this operation and the amount of flushed sediments.

8.4 IMPLICATIONS OF CLIMATE CHANGE

According to the report D2.3 – *Climate Change and Vulnerability Assessment*, based on the Sediment Appraisal of Pakistan Rivers SWHP, the sediment transport on the Kunhar River will increase for both scenarios and along the two periods: 2021-2060 and 2061-2099. The percentual increase for these periods is expected to be about 30% and 40%, respectively, relatively to 2015.

Figure 8.5 and **Figure 8.6** show the result of a simulation with twice the sediments of an average year entering the reservoir of Balakot. No specific problems were detected for this situation. Only the sediment delta will increase more significantly. Therefore, the possible increase in sediments inflow due to climate change will not pose any major problem to the sediment management scheme designed for Balakot. It only will have to be operated more frequently.

The sediment management scheme designed for Balkot, based on a large flushing outlet, with a control weir downstream, and on two large bottom outlets, as well as the sediment monitoring plan that will be implemented, shall be able to deal with such increases. The flushing procedure and the mechanical help to move the sediments downstream will be the same, being expected that with the increase of the sediment inflow, the number of flushing operations will increase progressively along those periods.

Notwithstanding, it must be pointed out that the most challenging problem regarding sediments will be related with the Suki Kinari sediment flushing operations, that will produce a total amount of sediments in a relatively short period.

9 SCHEME SIZING AND OPERATION

9.1 GENERAL CONSIDERATIONS

The present chapter describes the analysis performed to optimize the capacity of the Balakot hydropower scheme in relation to its design discharge and to present the results of the scheme operation simulation. To that end, a specific energy simulation model was developed and employed.

A detailed explanation of the performed analysis is presented in **Annex X – Simulation and energy assessment**.

The objective of the capacity optimization exercise is to define the capacity of the power plant and its main structures in such a way that it maximizes the sustainable potential of the site. To that purpose, as the scheme general layout has already been optimized under varied assumptions[5] (in terms of gross head, power circuit arrangement and reservoir active storage and operation), the analysis is focused on the selection of the design flow of the power plant, that yields a correspondent installed capacity. Therefore, the analysis is performed by calculating selected economic indicators for varied design flow levels.

It must be noted that the precedent D2.2A report considered the total design flow adopted in the FS2013 of 154 m^3/s (evenly distributed by the three groups). Such value corresponds to a design to modular flow (87 m^3/s) ratio of 1.8, which is considered usual for run-of-river hydropower schemes[6]. Even if the Balakot scheme has some particular aspects that make it depart noticeably from a pure run-of-river, due to the regulation provided by the upstream Suki Kinari scheme and the envisaged daily peaking operation, it is anticipated that the optimum design flow will not fall out of the 1 to 2 range of the design flow/modular flow ratio. Hence, it was decided to carry out the analysis for values in the range 0.8 to 2, in steps of 0.2 (7 values).

The costs and benefits were therefore estimated for the adopted scheme layout and adjusted for the different design discharge values. The costs were estimated based on scheme adjustments of the variable costs (relative to capacity). The energy estimates were obtained with the energy simulation model previously referred. The correspondent benefits (or revenues) were estimated base on long run marginal cost (LRMC) energy valuation assumptions.

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[5] See *D2.2A - Alternative Locations and Layout Analysis Study.*

[6] There is no rule for the optimum design flow/modular flow ratio, as this depends on several features as hydrological regime, power scheme characteristics, correspondent costs, revenues, etc. However, based on past and extensive experience, ratios in the range of 1 to 2 in run-of-river schemes (or without significant regulation capacity) are deemed normal.

9.2 CAPACITY OPTIMIZATION

9.2.1 Optimization Criteria

The optimization criteria for the installed power was based on the economic benefit, appraised through the net present value (NPV) and the levelized cost of energy (LCOE) indicators.

The NPV is the value of all future cash flows (positive and negative) over the entire life of an investment discounted to the present. LCOE is calculated by summing all the costs incurred during the lifetime of the HPP divided by the units of energy produced during the same period and is expressed in USD/MWh. In calculating LCOE, the time value of money has to be accounted for, which is reflected by discounting the operating costs and generated energy trough the applicable discount rate. LCOE has the important advantage over other indicators of allowing a direct comparison across different projects and generation technologies.

The calculations were performed at a project level, that is, without consideration to amortization, depreciation, taxes, as well as debt and interest. Moreover, the model of constant prices, also implicit in the LCOE calculation, may have shortcomings on high inflationary environments, in particular when the inflation differently affects the economic components. Therefore, the economic results depicted in this chapter must be used for its sole purpose – the comparison of alternatives – and not regarded as project valuation metrics.

9.2.2 Costs

Cost estimates for each alternative were appraised for investment and operational components. Investment includes direct implementation costs - mostly construction and equipment supply and installation - and indirect costs. Indirect costs for this mater are mostly related to preliminary works, engineering services and contingencies. The investment was estimated for the following categories: preliminary works, civil works, hydraulic steel structures (HSS), mechanical and electrical works, and other costs. The following table depicts the capital cost (CAPEX) estimates.

The geometric dimensions underlying the cost projections – intake, tunnels, surge shafts, cavern – where estimated maintaining the same operational criteria of the base solution, namely same flow velocities at the intake, same flow velocities in the tunnels, approximate equal surge levels in the upstream shaft (downstream was considered constant among alternatives). The cavern size was adjusted according to the anticipated space requirements in each case.

Equipment costs were mostly projected based on turbine flow and installed capacity. Indirect costs kept the same proportion.

The following table shows the (direct) cost estimate of the investment for the different flow levels previously mentioned.

Table 9.1 – Estimated project capital costs for different design flows ('000 USD, except where indicated otherwise)

Cost item	**Design flow** (m³/s) / ***Installed capacity*** (MW) (1)													
	66 / *127*		**87 / *167***		**105 / *202***		**123 / *236***		**141 / *271***		**156 / *299***		**174 / *334***	
Preliminary Works														
Mobilization & De-mobilization	15 000	*30%*	15 000	*30%*	15 000	*30%*	15 000	*30%*	15 000	*30%*	15 000	*30%*	15 000	*30%*
Access Roads to the Works Sites	2 000	*4%*	2 000	*4%*	2 000	*4%*	2 000	*4%*	2 000	*4%*	2 000	*4%*	2 000	*4%*
Camps and Housing During Construction	10 000	*20%*	10 000	*20%*	10 000	*20%*	10 000	*20%*	10 000	*20%*	10 000	*20%*	10 000	*20%*
Environmental Mitigation Cost & Land Acquisition	19 591	*40%*	19 591	*40%*	19 591	*40%*	19 591	*40%*	19 591	*40%*	19 591	*40%*	19 591	*40%*
Reservoir Slope Stabilization and Construction Difficulties	2 800	*6%*	2 800	*6%*	2 800	*6%*	2 800	*6%*	2 800	*6%*	2 800	*6%*	2 800	*6%*
Sub-total Preliminary Works	**49 391**		**49 391**		**49 391**		**49 391**		**49 391**		**49 391**		**49 391**	

(1) Output capacity / at the transformer

Table 9.1 (Continued)

Cost item	**Design flow** (m^3/s) / ***Installed capacity*** (MW) (1)													
	66 / *127*		**87 / *167***		**105 / *202***		**123 / *236***		**141 / *271***		**156 / *299***		**174 / *334***	
Civil Works														
Dam and associated works	45 805	26%	45 805	22%	45 805	20%	45 805	18%	45 805	17%	45 805	16%	45 805	15%
Power Intake	2 989	2%	4 483	2%	5 230	2%	5 978	2%	6 725	2%	7 472	3%	8 219	3%
Headrace Tunnel	72 117	40%	91 323	45%	107 455	47%	123 362	49%	139 093	51%	152 091	53%	167 577	54%
Surge Shaft	2 111	1%	2 463	1%	3 041	1%	3 457	1%	3 898	1%	4 127	1%	4 609	1%
Pressure Shaft	4 057	2%	5 110	2%	6 014	3%	6 918	3%	7 822	3%	8 575	3%	9 480	3%
Penstocks	1 595	1%	2 009	1%	2 363	1%	2 717	1%	3 070	1%	3 365	1%	3 718	1%
Powerhouse (2)	40 512	23%	42 417	21%	44 051	19%	45 685	18%	47 318	17%	48 679	17%	50 313	16%
Tailrace	9 126	5%	11 556	6%	13 598	6%	15 611	6%	17 601	6%	19 246	7%	21 206	7%
Sub-total Civil Works	**178 311**		**205 167**		**227 557**		**249 531**		**271 333**		**289 361**		**310 927**	

(1) Output capacity / at the transformer.

(2) Includes DS surge shaft, road accesses and exterior switchyard platform.

Table 9.1 (Continued)

Cost item	**Design flow** (m³/s) / ***Installed capacity*** (MW) (1)													
	66 / *127*		**87 / *167***		**105 / *202***		**123 / *236***		**141 / *271***		**156 / *299***		**174 / *334***	
HSS, Mechanical & Electrical Works														
Hydraulic Steel Structures	8 700	*8%*	8 900	7%	9 100	*6%*	9 300	*5%*	9 500	*5%*	9 700	*5%*	9 900	*4%*
Powerhouse Mechanical Works	43 812	*42%*	56 053	43%	65 600	*43%*	74 445	*43%*	82 586	*43%*	88 326	*43%*	95 121	*43%*
Electrical Works	51 543	*50%*	66 245	50%	77 900	*51%*	88 853	*51%*	99 103	*52%*	106 601	*52%*	115 503	*52%*
Sub-total Equipment	**104 055**		**131 198**		**152 601**		**172 598**		**191 190**		**204 627**		**220 524**	
Other costs														
Engineering services	26 541	46%	30 861	45%	34 364	45%	37 722	45%	40 953	45%	43 470	45%	46 467	45%
Insurance during contruction	6 666	11%	7 751	11%	8 631	11%	9 474	11%	10 286	11%	10 918	11%	11 671	11%
Duties of Equipment Cost	5 203	9%	6 560	10%	7 630	10%	8 630	10%	9 559	10%	10 231	11%	11 026	11%
Contingencies	19 905	34%	23 145	34%	25 773	34%	28 291	34%	30 714	34%	32 602	34%	34 850	34%
Sub-total Other costs	**58 314**		**68 316**		**76 397**		**84 117**		**91 513**		**97 222**		**104 014**	
TOTAL	**390 071**		**454 073**		**505 946**		**555 637**		**603 426**		**640 601**		**684 856**	

Output capacity / at the transformer

The following figure depicts the cost variation by the different categories under consideration, as well as a line representing the evolution of the unit cost per installed kW. As can be seen, there is a significant scale effect, with the lower flow/power limit having about 3050 USD/kW, while the higher threshold coming slightly below 2050 USD/kW.

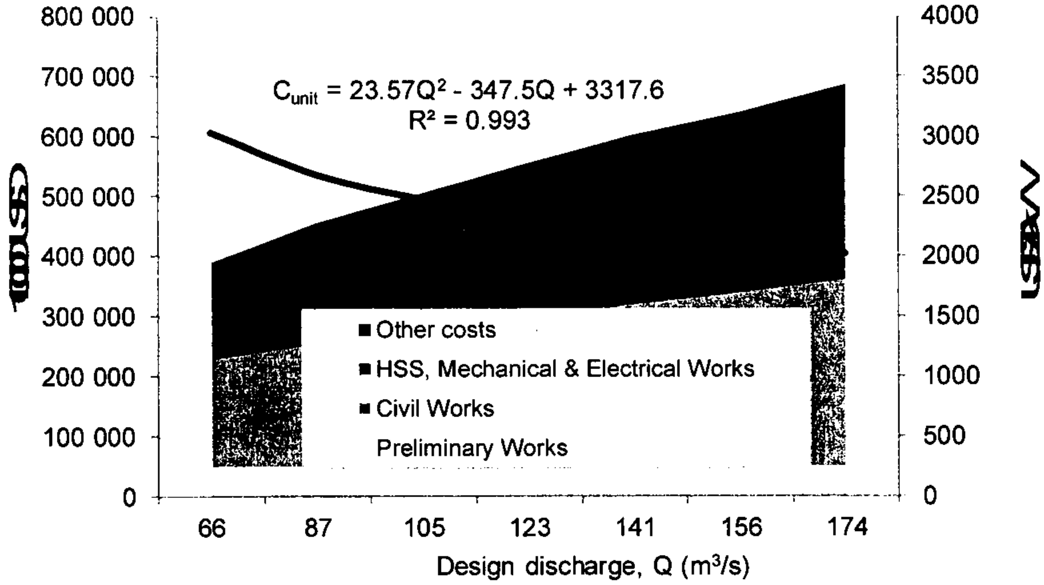

Figure 9.1 – Estimated project costs for different design flows

The operation expenditures (OPEX), mostly comprising O&M costs, where taken from 2,75% of the Investment (for the lowest capacity) to 2,45%, in steps of 0,05%. Such variation, although quite smooth, is intended to reflect the scale effects that also impact the OPEX.

9.2.3 Energy Estimates

The energy estimates where obtained, for the different values of design flow, with the scheme operation simulation model. The scheme is envisaged to operate with daily peaking, as referred. The main assumptions where the following:

- 55 year daily flow series from the hydrological year 1960/61 to 2014/15, of the Garhi Habibullah and Talhata stations, transposed to the relevant section;
- Regulation effect of the Suki Kinari scheme similar to the base case (see **Annex X - Simulation and energy assessment**);
- same scheme efficiency curve among alternatives (hydraulic and equipment);
- operation regime 3 (see 9.3.2);
- ecological flow regime as for the base case (constant 6.1 m^3/s).

The projected average energy estimates are presented in the following table.

Table 9.2 – Estimated annual energy for different design flows/capacities (GWh)

Parameter	**Design flow** (m³/s) / ***Installed capacity*** (MW)						
	66 / *127*	**87 / *167***	**105 / *202***	**123 / *236***	**141 / *271***	**156 / *299***	**174 / *334***
Annual Energy	717	850	946	1028	1099	1149	1201
Peak	184	239	281	319	354	381	412
Off-peak	533	611	665	709	745	768	789

The referred values are depicted in **Figure 9.2**.

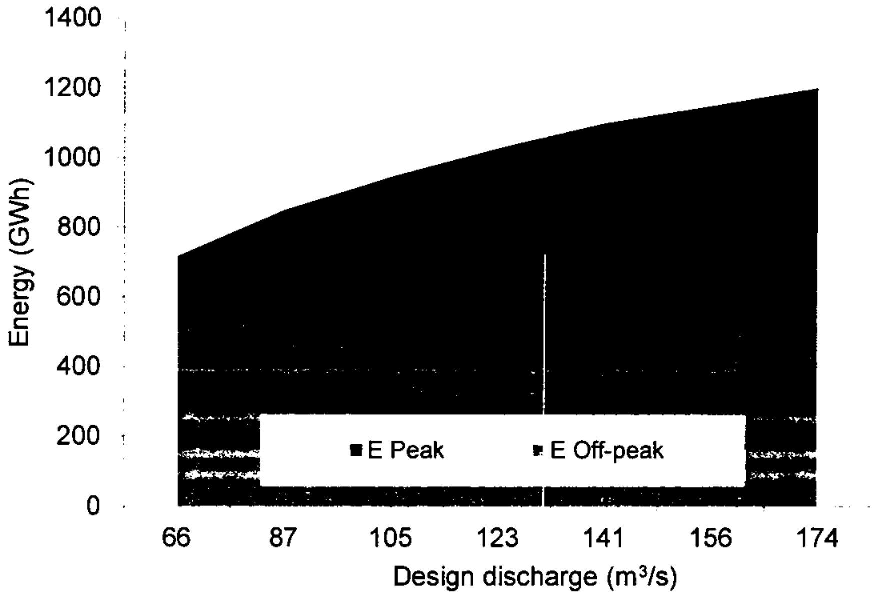

Figure 9.2 – Projected annual energy for different design flows

9.2.4 Revenues

The revenues were estimated based on shadow prices, for the energy estimates, under the Long run marginal cost approach[7].

The capacity LRMC at generation level is assumed to be 80% of the capital cost of an OCGT, which is the more suitable and efficient plant for quick supply of energy. It is inexpensive to install, but expensive to operate. The hydropower facilities contribute to both peak and off-peak segments of the power mix. WAPDA's present and future power mix situation suggests

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[7] The project's economic analysis, including assumptions, framework and results is fully developed and presented in the *D3.1 – Economic Analysis* report.

that equivalent thermal peaking facility is likely OCGT and equivalent base load facility is likely to be the CCGT. 80% cost at generation level is taken to the project applicable 500 kV voltage level, after system losses are taking into account.

The summary of LRMC values (2018 estimates) are stated in the following table.

Table 9.3 – LRMC values

Description	Operation Cost (USD/MWh)	
	Peak	Off-peak
500 kV Level	151.0	73.5

Taking the energy prices proxies referred above, the net revenues presented in the following table were calculated. Net revenues are calculated as the revenues from electricity sale, which correspond to the valuation of the potential average generation, deducted from plant's energy losses. In this case, energy losses correspond to internal consumption and sediment management operations. Such losses were considered as corresponding to 1% of the annual production.

The revenues for the different levels of design flow under consideration are presented in the following table, which also includes the correspondent levelized price.

Table 9.4 – Projected revenue for different design flows

Parameter	Unit	Design flow (m^3/s) / *Installed capacity* (MW)						
		66 / *127*	87 / *167*	105 / *202*	123 / *236*	141 / *271*	156 / *299*	174 / *334*
Annual Revenue	1000'USD	66 290	80 188	90 395	99 278	107 129	112 839	119 001
Levelized Price	USD/MWh	92.5	94.3	95.6	96.6	97.5	98.2	99.1

The same values are depicted in **Figure 9.3**.

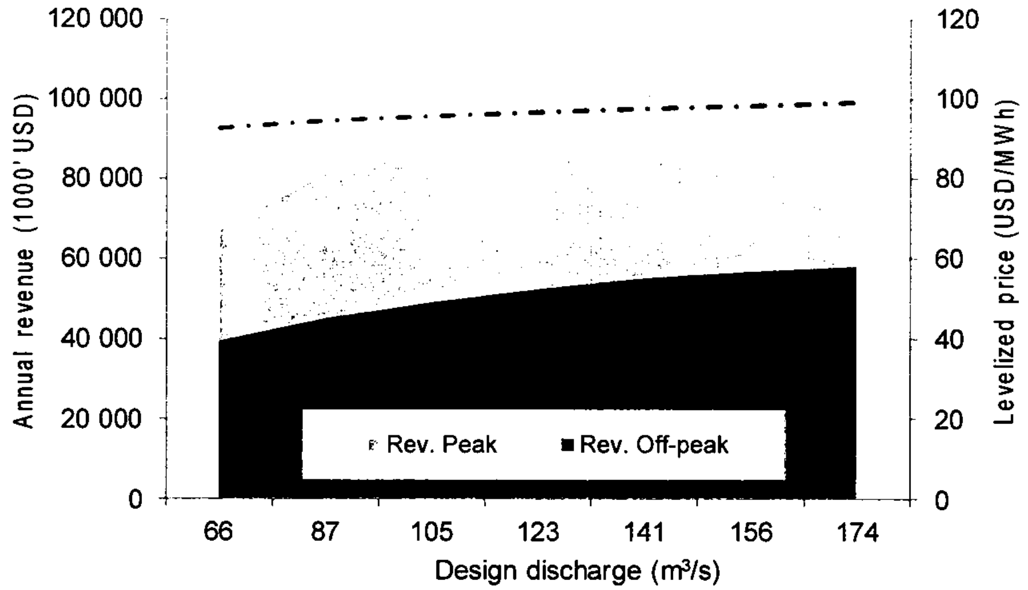

Figure 9.3 – Projected revenue for different design flows

9.2.5 Economic Indicators

The selected economic indicators – simplified NPV and LCOE – were calculated for the different design flow levels based on the previous cost and revenue estimates, and the following economic assumptions:

- 35 year project life, with 6 years for implementation and 30 years revenue stream;
- constant prices analysis (no adjustment for differential inflation);
- no additional investments after the initial and no project terminal value;
- 10 % discount rate.

The obtained results are presented in **Table 9.5**.

Table 9.5 – Estimated NPV' and LCOE' for different design flows ('000 USD, except where indicated otherwise)

Parameter	**Design flow** (m³/s) / ***Installed capacity*** (MW)						
	66 / 127	***87 / 167***	***105 / 202***	***123 / 236***	***141 / 271***	***156 / 299***	***174 / 334***
Revenues (Benefits)	66 290	80 188	90 395	99 278	107 129	112 839	119 001
OPEX	10 727	12 260	13 408	14 447	15 387	16 015	16 779
Simplified Cash Flow	55 563	67 928	76 988	84 831	91 742	96 824	102 222
PV of CF (1)	**295 664**	**361 459**	**409 671**	**451 407**	**488 182**	**515 225**	**543 951**
Preliminary Works	49 391	49 391	49 391	49 391	49 391	49 391	49 391
Civil Works	178 311	205 167	227 557	249 531	271 333	289 361	310 927
HSS, Mechanical & Electrical Works	104 055	131 198	152 601	172 598	191 190	204 627	220 524
Other costs	58 314	68 316	76 397	84 117	91 513	97 222	104 014
Investment	390 071	454 073	505 946	555 637	603 426	640 601	684 856
PV of Investment (2)	**283 143**	**329 601**	**367 254**	**403 324**	**438 013**	**464 997**	**497 121**
Simplified project NPV	**12 521**	**31 859**	**42 417**	**48 084**	**50 169**	**50 228**	**46 830**
Net Annual Energy (GWh)	710	842	937	1 018	1 088	1 138	1 189
PV of Net Annual Energy (GWh) (3)	3 777	4 478	4 984	5 416	5 790	6 053	6 327
PV of OPEX	57 081	65 238	71 345	76 874	81 880	85 220	89 285
Simplified LCOE(USD/MWh)	**90.1**	**88.2**	**88.0**	**88.7**	**89.8**	**90.9**	**92.7**

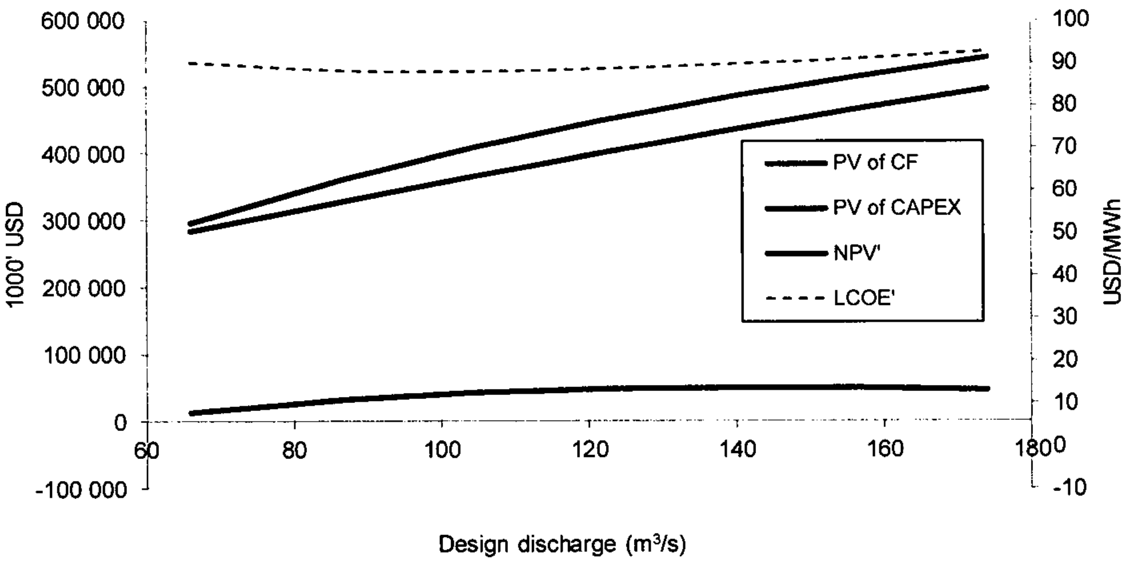

Figure 9.4 – Present value of cash flows, NPV' and LCOE' for different design flows

In order to observe how the project would react to changes in the base assumptions, a sensitivity analysis was performed considering + and -10% variations on the revenues and the investment. For this analysis the NPV' indicator was selected. The results are presented in **Figure 9.5**.

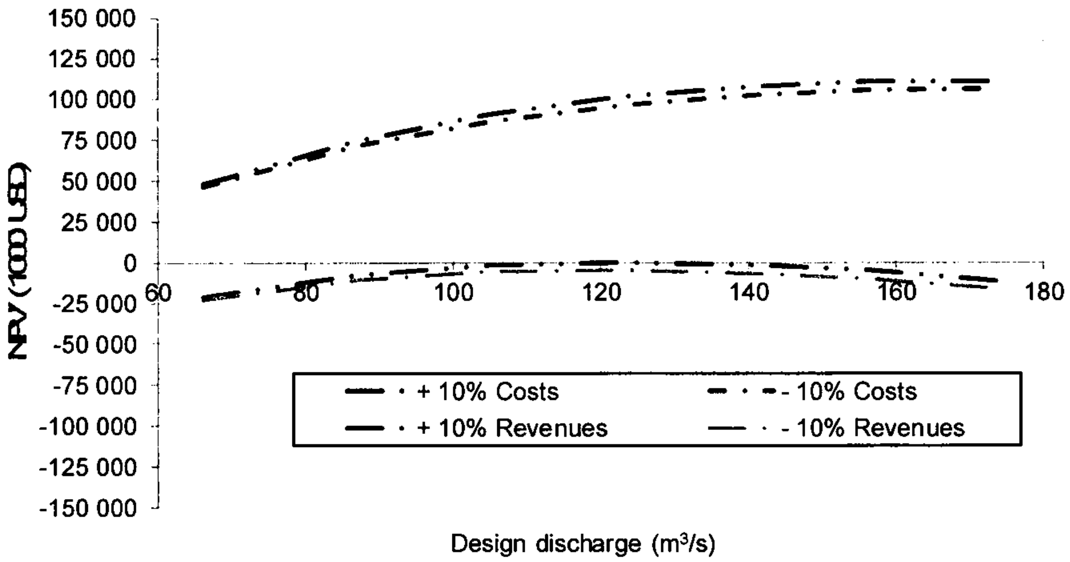

Figure 9.5 – Sensitivity analysis of the NPV's for different design flows

9.2.6 Selected Design Flow

The analysis sought to identify the results of the selected economic indicators, which, according to the adopted criteria, and despite the admitted simplifications, are considered to be an appropriate decision base for the design flow/capacity to be adopted for the Balakot HPP.

The obtained results indicate the highest NPV' estimate of approximately 40 MUSD for a design flow of 156 m^3/s, which corresponds to an installed capacity of ~ 305 MW (at the transformers). The lowest LCOE (91.6 USD/MWh), however, is obtained for a design flow of 105 m^3/s, which correspond to an installed capacity of ~ 205 MW.

The sensitivity analysis of the NPV' shows that it varies significantly with the scenarios under consideration, as would be expected. For the "pessimistic" scenarios the more favourable design flow is in the range 100-140 m^3/s. When considering the "optimistic" ones, the preferred options would be in the 140-170 m^3/s range.

In light of the obtained results and considering: i) that differences in the "base" scenario for the higher flow levels is not very significant (the difference in the LCOE correspondent to 156 m^3/s to the lowest LCOE is only +1.7%); ii) that the NPV is a preferred metric over LCOE for maximizing the project economic benefit; iii) that the climate change analysis points to higher generation in the future, which would favour higher design flows (see 9.3.3); it was decided to set the design flow to 154 m^3/s, which is the value that has already been considered in precedent studies, namely in the FS2013 and D2.2A reports.

9.3 RESERVOIR OPERATION AND ANNUAL ENERGY

9.3.1 General Considerations

The following sections describes the analysis performed to evaluate the energy generation from the Balakot Hydropower scheme considering different operating regimes and the flow regulation effect of the Suki Kinari reservoir upstream. To that end, a specific energy simulation model was developed. The energy assessment model was used to simulate the energy production considering that the powerhouse is equipped with 3 similar Francis groups, has a total design flow of 154 m^3/s and a nominal gross head of 229 m.

A detailed explanation of the performed analysis is presented in **Annex X – Simulation and energy assessment**.

The energy assessment model was used to simulate the energy production considering the simultaneous operation of the Balakot and Suki Kinari schemes, according to the general arrangement presented in **Figure 9.6**.

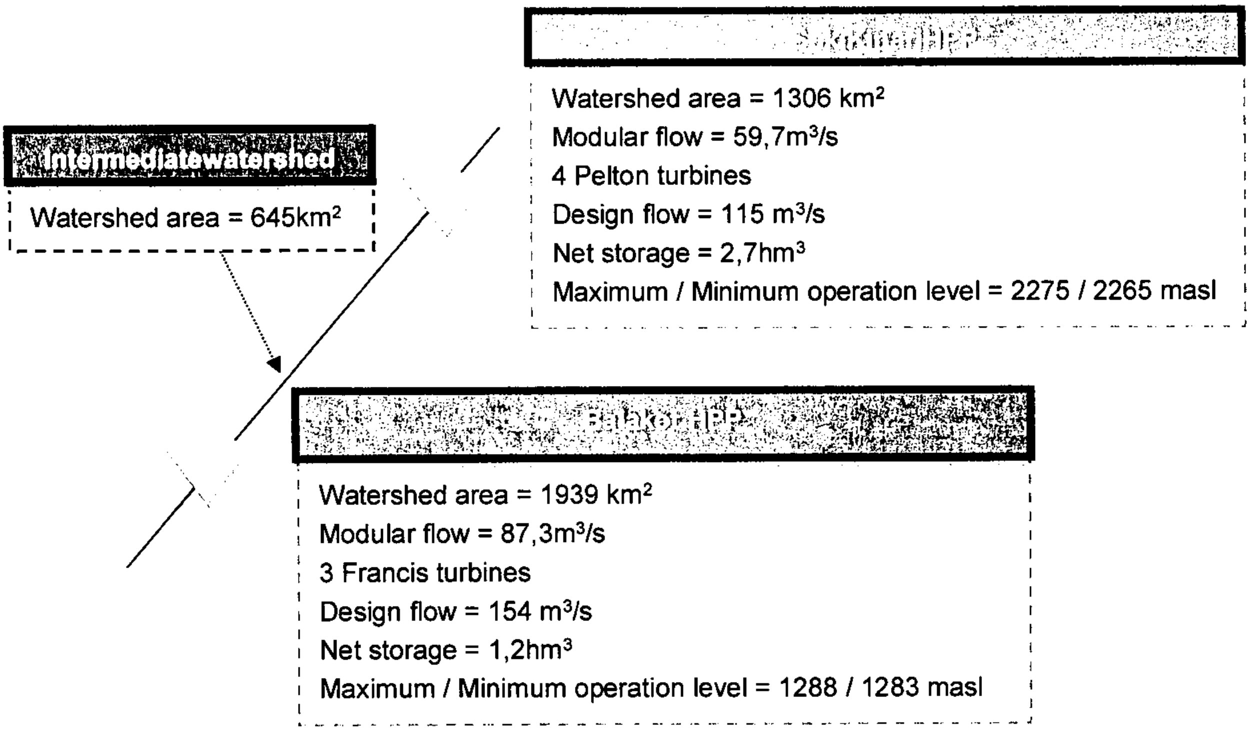

Figure 9.6 – Main characteristics of the Balakot and Suki Kinari hydropower schemes

To evaluate the energy production a specific simulation model was tailored for the cascade scheme in question. The algorithm uses a numerical scheme for the solution of the continuity equation, applied daily during the simulation period to evaluate the generation flows, production times, spilled flows and reservoir storage in each day.

The model input data are daily inflow series, ecological flow, reservoir storage and flooded areas curves, reservoir evaporation, tailwater rating curve, powerhouse global efficiency curve and operation regime. The main results obtained with the model are generation water volumes, in peak and off-peak periods, evaporated and spilled volumes and energy production, in peak and off-peak periods.

The inflow series used were transposed from the Garhi Habibullah and Talhata stream gauging stations, to the dam location, in a total of 55 years daily average flows. The daily inflow was divided in peaking period and off-peak periods, considering the influence of the Suki Kinari (SK) hydropower regulation.

It was assumed a constant ecological flow release of 6.1 m³/s throughout the year (as the recommended option in the *Environmental Flow Assessment*[8] for peaking operation), and

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[8] *Balakot Hydropower Project. Environmental Flow Assessment. Draft Report.* HaglerBailly Pakistan, 2018.

evaporation rate based on the records of the measurements in the Balakot climatological station.

The global efficiency of the powerhouse is a function of the generation discharge that translates the head losses in the hydraulic circuit and the efficiency of electromechanical equipment (**Figure 9.7**). For the computation of the powerhouse global efficiency were calculated the head losses in the power circuit and considered the efficiency curves of the Francis turbines, generator and transformer. It was assumed a maximum efficiency of 95.0% for one Francis turbine, 97.1% for the generator and 99.0% for the transformer.

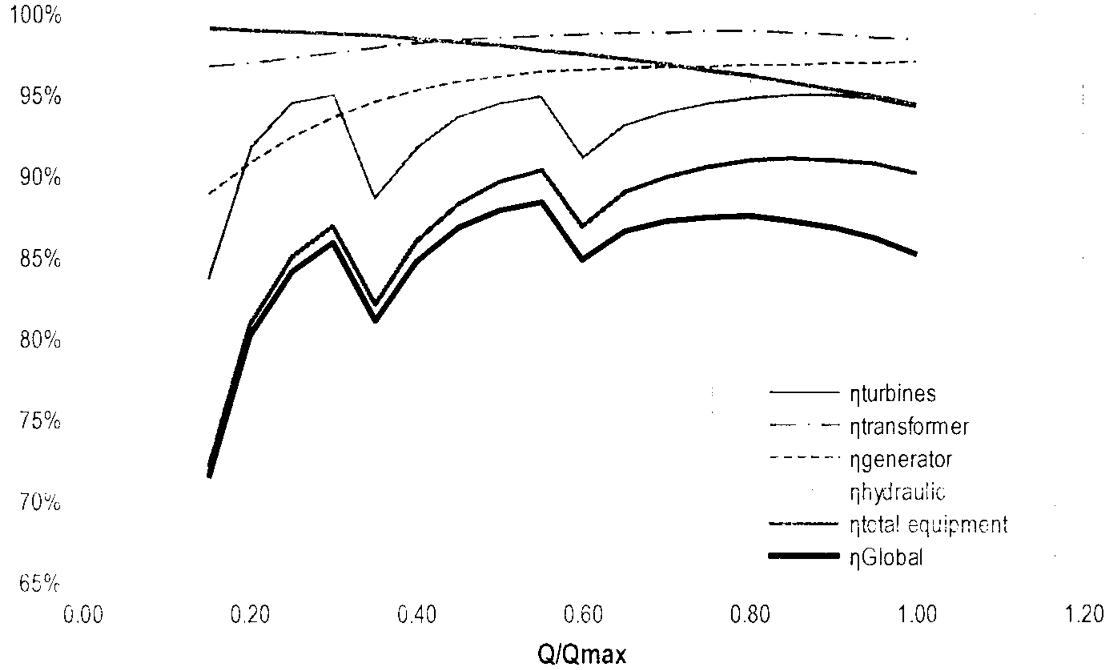

Figure 9.7 – Powerhouse global efficiency curve

9.3.2 Simulation Results

The energy assessment model can simulate different operation regimes, including peaking schemes. For the simulation of the Balakot Hydropower scheme it was considered the Normal Operation Level, NOL = 1288.0 m, a maximum drawdown of 5.0 m in the reservoir and two daily peaking periods of 2 hours (total of 4 hours of peaking each day).

Three different operation regimes were considered (similarly and simultaneously in Balakot and Suki Kinari):

1. reservoir refills back to the maximum level after each peaking period;
2. reservoir storage volume is used up to its maximum in each peaking period;

3. combination from the two previous as recommended in the D2.2A - *Alternative Locations and Layout Analysis Study:* operation regime 1 during the low flow season (October to March) and operation regime 2 during the high flow season (April to September).

The main results of the simulations with the three operation regimes are presented in **Table 9.6**.

Table 9.6 – Annual average results of the energy simulations

	Operation regime 1	Operation regime 2	Operation regime 3
Inflow volume (hm^3)	2 755.0	2 755.0	2 755.0
Ecological volume (hm^3)	192.7	192.7	192.7
Evaporated volume (hm^3)	0.51	0.50	0.51
Reservoir elevation (m)	1 287.6	1 285.6	1 287.6
Reservoir storage (hm^3)	3.6	2.9	3.6
Gross head (m)	228.7	226.7	228.7
Spilled volume (hm^3)	430.6	429.4	430.5
Nr. of days with spills	164.4	105.1	161.4
Peak generation volume (hm^3)	707.8	709.1	707.9
Off-peak gen. volume (hm^3)	1 423.4	1 423.4	1 423.4
TOTAL generation volume (hm^3)	2 131.2	2 132.5	2 131.3
Peak generation time (h)	1 460.8	1 460.8	1 460.8
Off-peak generation time (h)	2 567.5	2 567.5	2 567.5
TOTAL generation time (h)	4 028.3	4 028.3	4 028.4
Avg. daily generation time (h)	11.0	11.0	11.0
Maximum power (MW)	294.6	294.7	294.7
Load factor (gross)	45.3%	45.2%	45.3%
Peak energy (GWh)	377.5	375.4	377.5
Off-peak energy (GWh)	765.5	764.5	765.4
TOTAL energy (GWh)	1 143.0	1 139.9	1 142.9

Both operation regimes 1 and 3 result in similar production estimates, with a maximum power of 295 MW (transformer), an average peak energy production of 378 GWh and a total energy production of 1143 GWh. However, operation regime 1 leads to a slightly higher number of spill days. **Figure 9.8** depicts the yearly variation of the energy production for the whole simulation period. In **Figure 9.9** is plotted the monthly distribution of the peak and off-peak energy production. These graphics are only presented for the simulation of the Operation regime 3 (recommended), due to the similarity of all simulations.

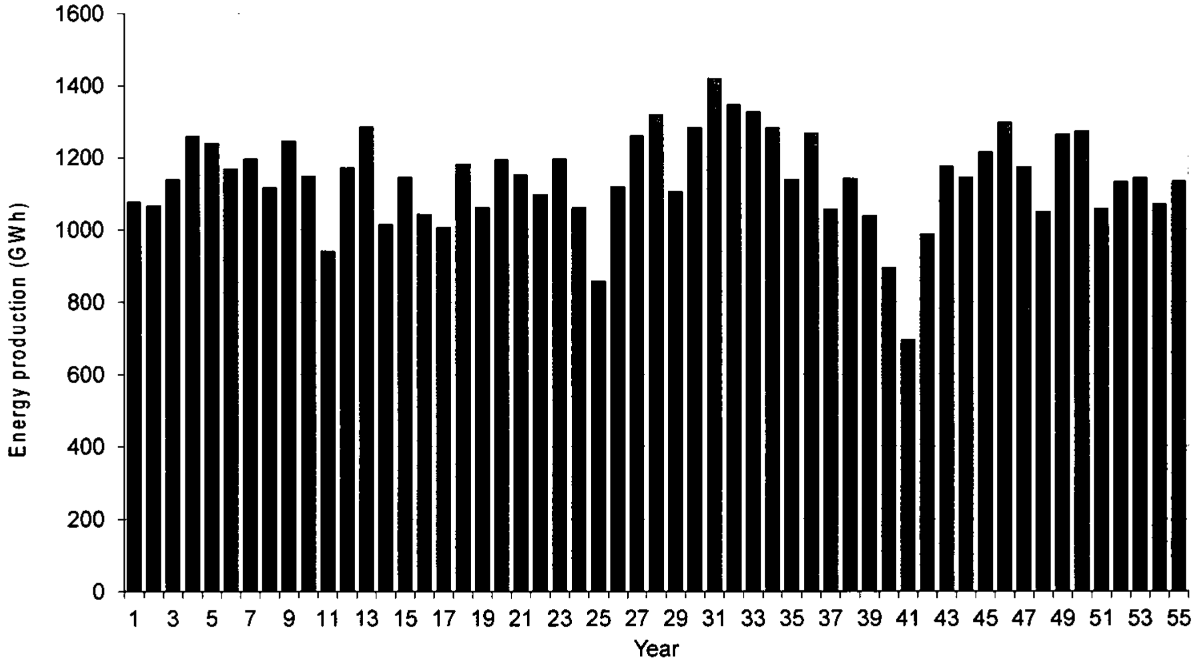

Figure 9.8 – Yearly variation of the energy production (operation regime 3)

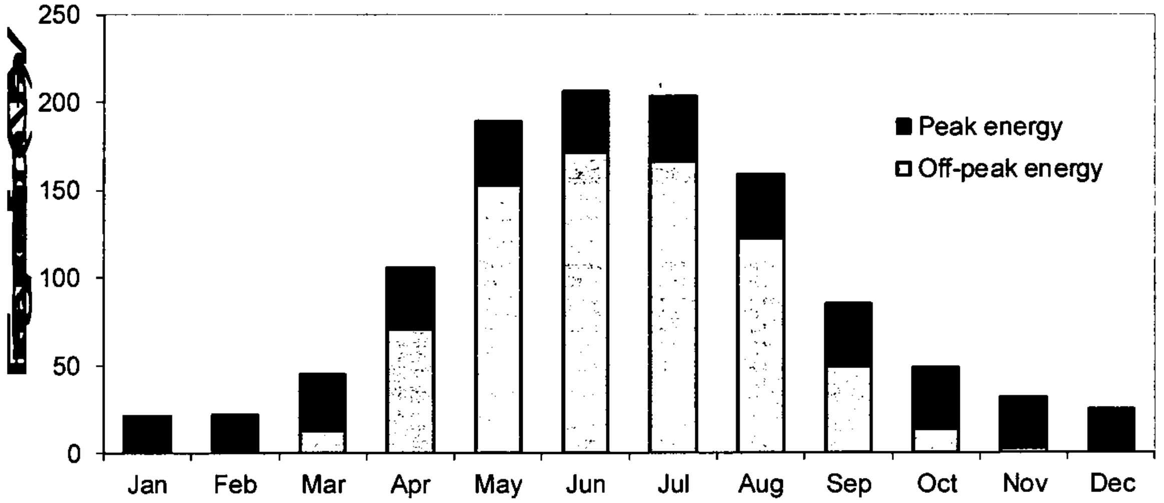

Figure 9.9 – Monthly distribution of the peak and off-peak production (operation regime 3)

In **Figure 9.10** are plotted the power duration curves of the scheme. In one curve the monthly average peak power is plotted against its frequency. Results show that peak power is above 290 MW (at the transformers) more than 55% of the time and a peak power of 160 MW, more than 90% of the time. Average daily power, in the other hand, is highly dependent on water availability, therefore the average 24 h power associated to a 90% frequency (firm capacity) is about 27 MW. In fact, daily operation at full capacity is only achieved, on average, approximately 10% of the time (about one month per year).

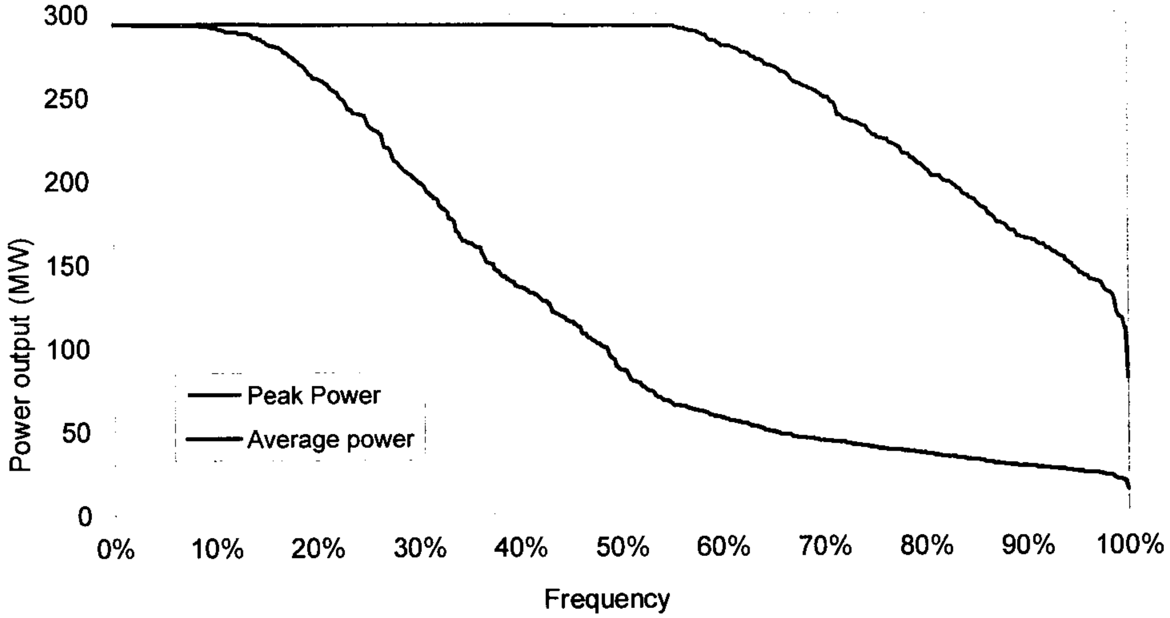

Figure 9.10 – Peak power duration curve

9.3.3 Influence of Climate Change

Climate change is anticipated to have a significant impact in the Kunhar river basin, encompassing precipitation quantity and yearly distribution, evaporation and snowmelt. To analyse how the expected changes could impact the Balakot plant generation pattern, energy simulations with projected flow series for the periods 2021-2060 and 2061-2099 where performed[9]. The daily flow series were calculated with the calibrated HEC-HMS model, using as inputs the results of the downscaled climate series from the HadCM3[10]. The energy model used the same configuration as previously described for the scheme selected solution and operation regime.

Figure 9.11 depicts the average monthly energy of the Balakot hydropower plant for the different scenarios and periods under consideration.

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[9] In rigor each period is of 39 years, starting in the hydrological years of Oct 2020/Sep 2021. The energy simulation model is designed to run in hydrological years, hence the flow series were arranged accordingly.

[10] See *D2.3 – Climate Change and Vulnerability Assessment*. Although the report considers two climate models (HadCM3 and NorESM1-M), the hydrological modelling results from HadCM3 were used for the energy simulation, as the projected flows series exhibited similar patterns in both cases.

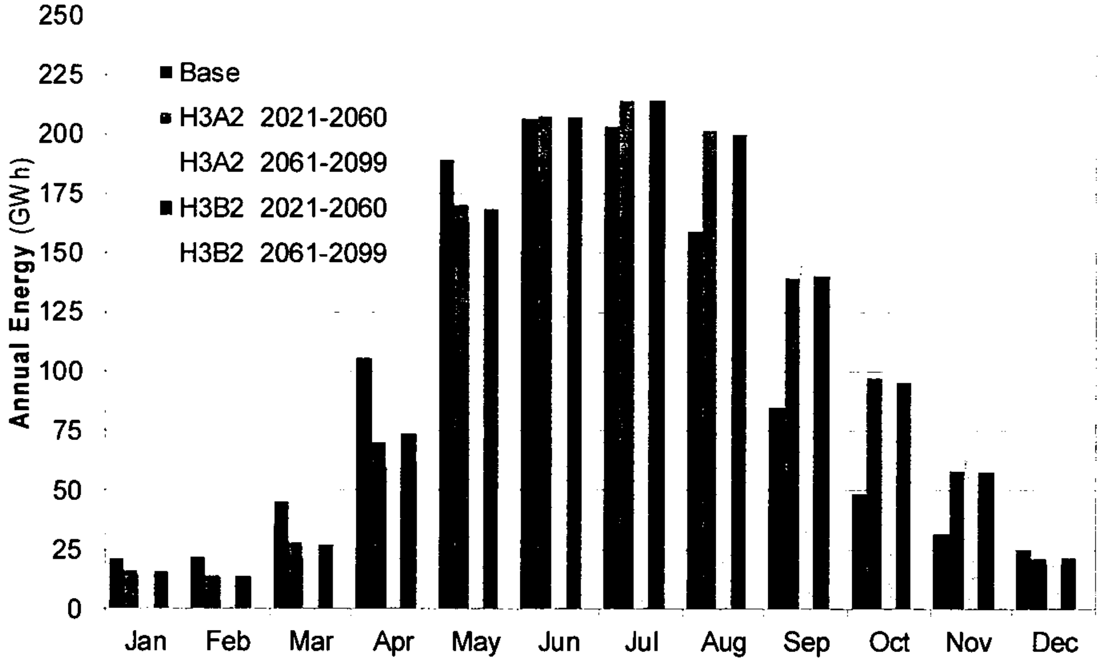

Figure 9.11 – Average monthly energy for base case and two climate change scenarios and periods

As the results show, there is a global increase in production in every climate change scenario in comparison to the "Base". For the H3A2 scenario is projected an annual energy increase to 1244 GWh (+8.8%) for the period 2021-2060 and to 1242 GWh (+8.7%) for the period 2061-2099, when compared to Base (1143 GWh). However, the reported increase is not evenly distributed throughout the year, with energy increase in the months of June (minor), July, August, September October and November, slight decrease in December, January and February, and marked decrease in March, May and April.

Scenario H3B2, although with some minor differences, displays a similar pattern and results to the H3A2. In this case is projected an annual energy increase compared to the Base to 1237 GWh (+8.2%) for the period 2021-2060 and to 1235 GWh (+8.0%) for the period 2061-2099.

The following figure shows the plant annual energy percentage variation in the climate change scenarios relative to the Base. Here is possible to clearly observe, on the one hand, that the global rise is almost exclusively due to the increase in Autumn (September, October and November) and, on the other hand, the clear shift from Spring and Winter to Summer and Autumn in both scenarios and periods.

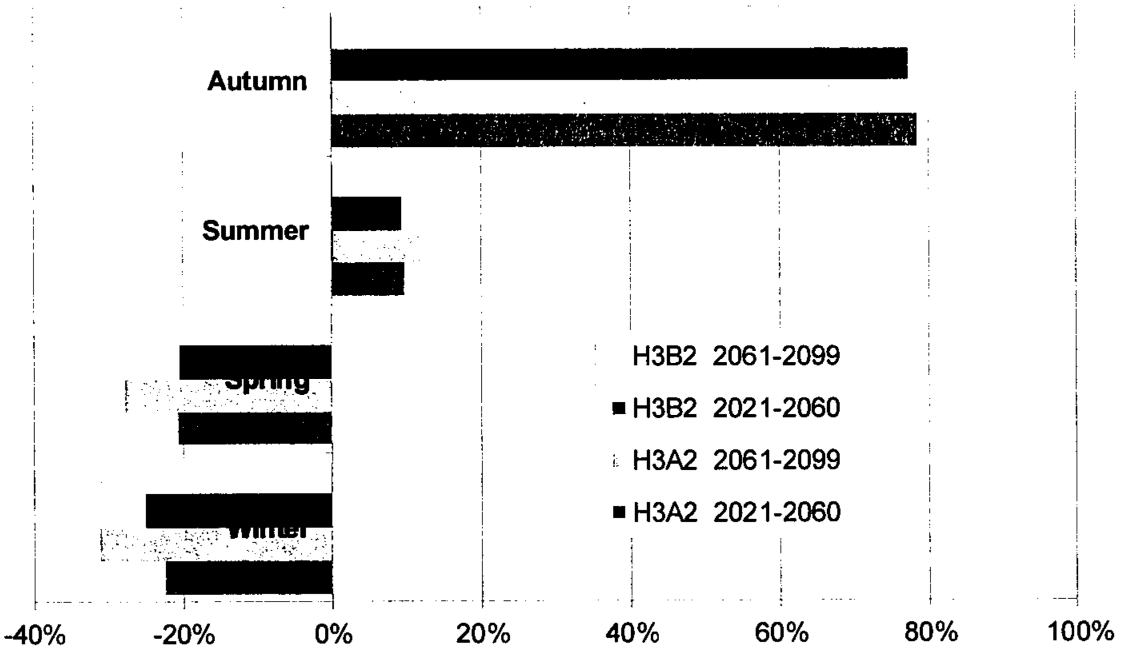

Figure 9.12 – Annual energy variation for two climate change scenarios and periods

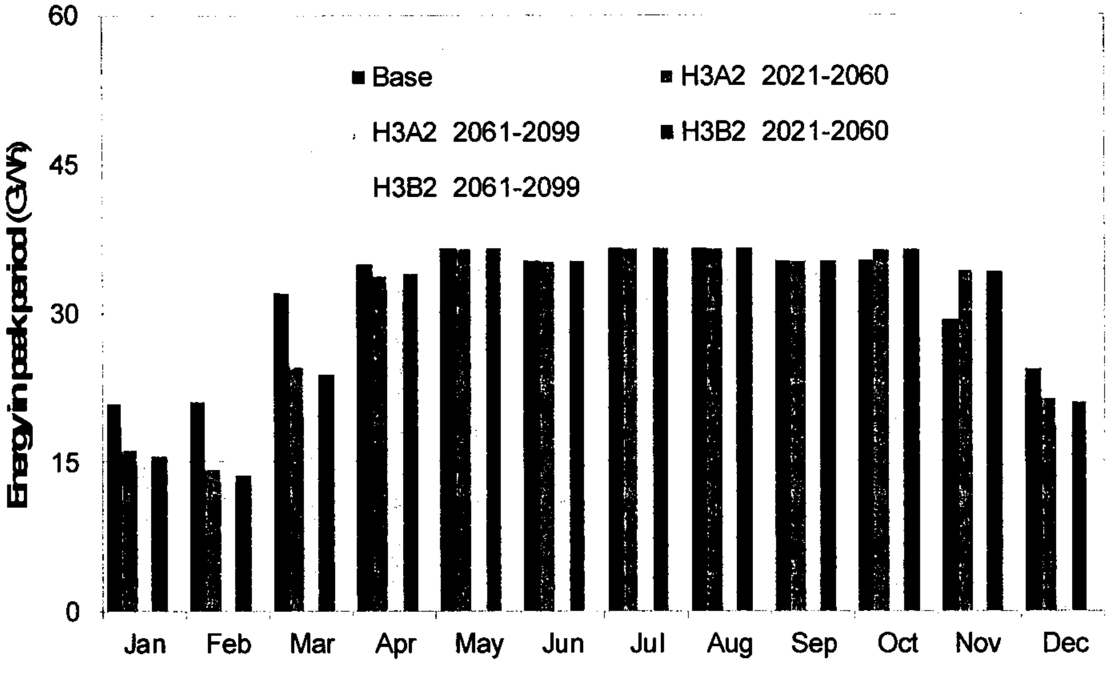

Figure 9.13 depicts the monthly average energy generation during the 4 h daily peak period. The graphic shows that the peaking ability of the plant remains stable most of the year among scenarios, with a reduction in the months of December, January and February.

These results can hardly be considered surprising, as the observed decreases correspond to the lower flow months (where most of the resource availability is used in peak production), which in turn are expected to see a flow decrease in the future.

The overall decrease in annual average peak energy, when compared to Base (378 GWh), is to 361 GWh (-4.3%) for the period 2021-2060 and to 349 GWh (-7.5%) for the period 2061-2099 in the H3A2 scenario, and 359 GWh (-5.0%) for the period 2021-2060 and to 353 GWh (-6.4%) for the period 2061-2099 in the H3B2 scenario.

In light of the presented results, it can be concluded that the Balakot hydropower plant is expected to increase the overall annual energy production in about 8% for the future, while reducing its peaking ability in about 5%.

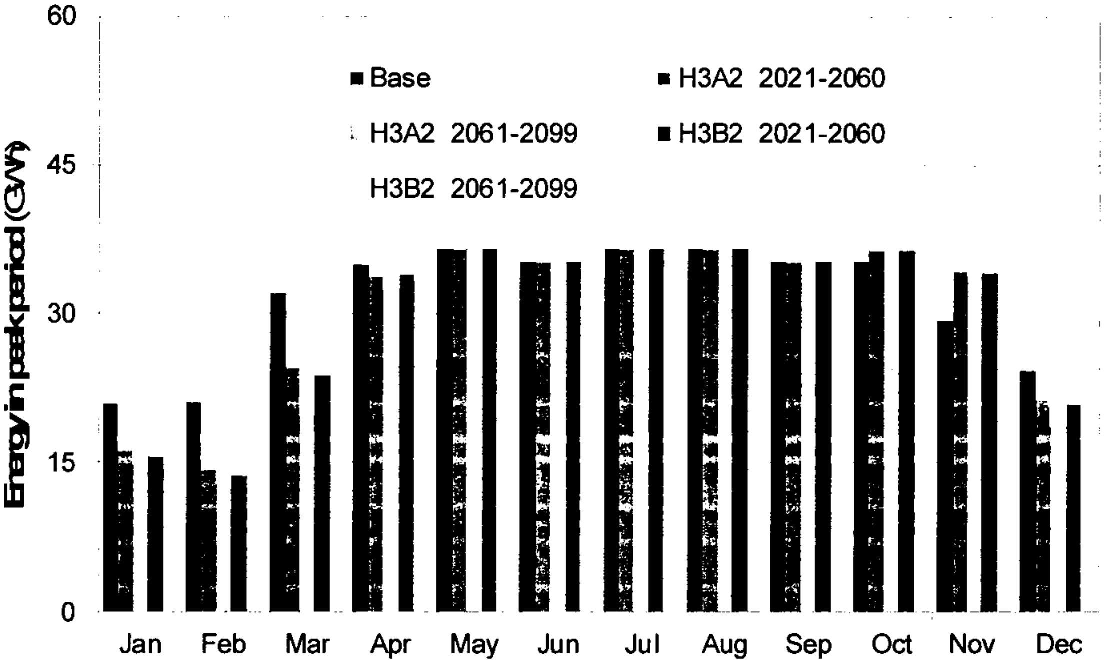

Figure 9.13 – Average monthly peak energy for the base case and two climate change scenarios

9.3.4 Influence of Flushing Operations

The solution that is envisaged for the Balakot dam and reservoir includes specific structures for flushing operations (*e.g.* sediment by-pass tunnel and high capacity bottom outlets). Periodic flushing is required to keep the Balakot reservoir operational, otherwise it will become laden with sediments in a relatively short period, as the **Annex III- Sediments** indicates.

The timings for flushing operations will be defined during the plant exploration stage and based on criteria such as accumulated sediments in the reservoir, sediment inflows, flushing operations from the upstream Suki Kinari and hydrological conditions. Therefore, it is not possible to define beforehand what will be the frequency and schedule of flushing operations at Balakot.

However, based on the results of the sediment studies it is possible to estimate the average frequency and duration of the flushing operations. Hence, it is assumed that each flushing operation may lead to a stop of the production for 1 day (24 h). This operation will likely occur during the high flow season, in which the plant operates at full capacity (or near), with an average power output of 295 MW.

Therefore, the flushing operation is expected to lead to a decrease in production of 7.1 GWh/day, which translates to an average annual production loss of ~7 GWh. Assuming that one flushing operation may be needed every 2 years, the average energy loss due to flushing would be 3,5 GWh (0.3% of average annual energy).

Additionally to the planned flushing operations, it is expected that sediment inflow peaks, associated with floods or landslides, for instance, may determine the plant shutdown for protection of the equipment. Taking this possibility into account, a 0.5% average annual loss due to sediment management operations is proposed to be considered.

10 DAM AND ASSOCIATED STRUCTURES

10.1 GENERAL ARRANGEMENT

The proposed dam for the Balakot HPP is located on the Kunhar River in Kaghan Valley, between Balakot and Kaghan, Manshera District of Khyber Pakhtunkhwa (KPK), Pakistan. The dam axis is located approximately 120 m upstream of the confluence of Bolo Katha Nullah and Kunhar River, approximately 1.1 km downstream of the village of Paras. The project location is presented in **Drawing 1**.

The dam structure is a concrete gravity dam, with a curved axis in plane with a radius of 187 m and a maximum height of 58 m above foundation level. The dam crest elevation is 1292.00 masl and the crest length is approximately 130 m. A crest width of 8.5 m is proposed to ensure adequate access for vehicles, cranes and other maintenance equipment.

The dam structure will create a 2.2 km long reservoir, with a gross storage of 3.6 million m³ at the normal operation level (NOL) E.L. 1288.00 m.

The dam includes a gated ogee crest spillway and a low-level gated spillway. The latter one intends to allow for flushing suspended sediment entering the reservoir and that may deposit close to the power intake.

The upper spillway is equipped with three radial gates. The low-level spillway is equipped with two sluice gates. Each spillway bay may be protected with stop logs for repair and maintenance works.

The upper spillway is followed by a chute channel and a slotted flip bucket. The low-level spillway is followed by an outlet structure and a compound flip bucket, including a curve in plan and a transverse slope of the lip of the bucket. The proposed flip bucket structures will contribute to increase energy dissipation along the jets trajectories and enlarge the riverbed impact area.

Next to the dam structure, the river flow is diverted to the power circuit through the left bank power intake.

A sediment by-pass tunnel is also proposed as part of a comprehensive sediment management approach for the Balakot HPP. The tunnel intake is located at the right bank around 510 m upstream of the dam axis. The total length of the by-pass tunnel is 640 m with a downward slope of 1.5%. The tunnel outlet structure is located around 220 m downstream of the dam axis.

The access road to the dam structure and power intake is proposed to start at the Sharan Road, which connects to National Highway N–15 on the left side of the Kunhar River, nearby

Paras village. Such will require the construction of a new 550 m long road infrastructure. This access road is proposed to be extended along the right bank up to the sediment by-pass tunnel intake.

The proposed arrangement for the concrete dam and related structures is presented in the **Drawing 11** and **Figure 10.1**.

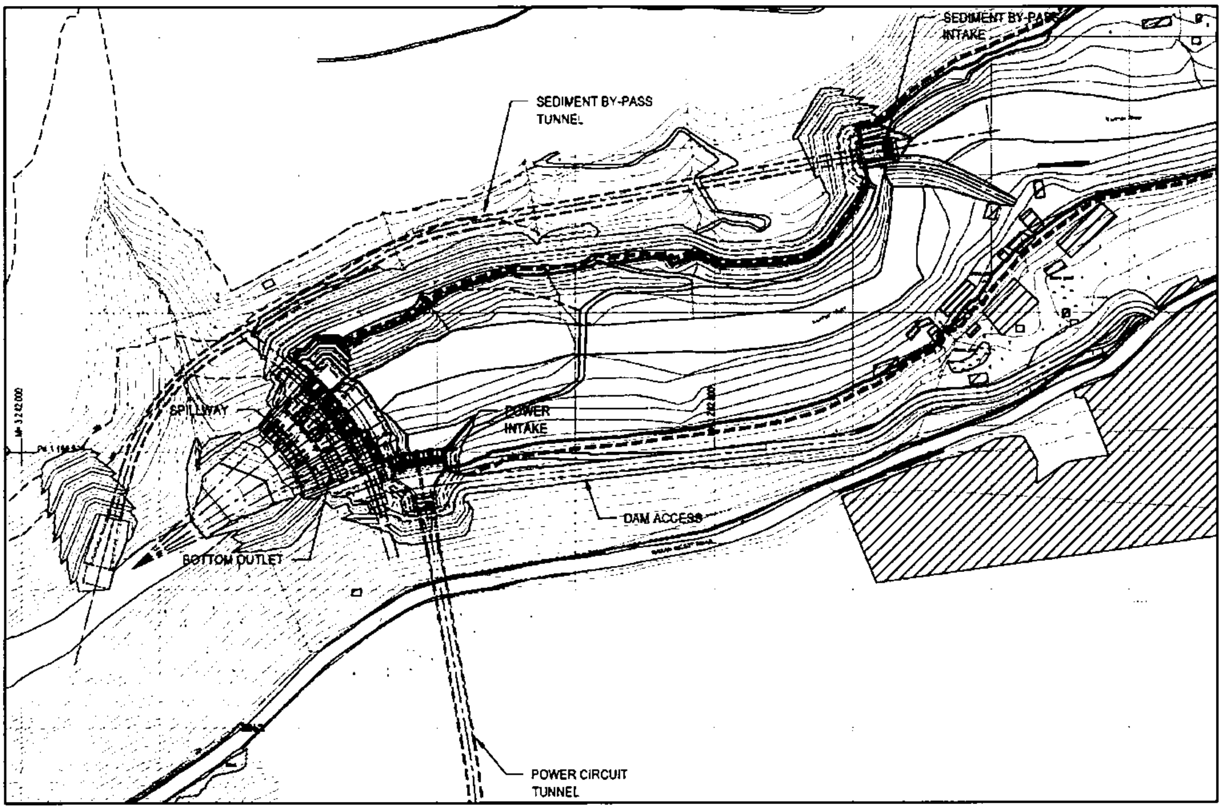

Figure 10.1 – Proposed arrangement for the dam and related structures

10.2 DAM PROFILE

The dam profile is composed by an upstream vertical slope at a higher level, followed by a 1H:1.5V slope at a lower level, and a downstream 1.2H:1V slope. The dam crest level is set at E.L. 1292.0 masl and the dam crest width is 8.5 m. The upper spillway crest at level is set at E.L. 1278.0 masl.

The concrete gravity dam solution has a maximum height of 58 m above the anticipated lowest point of the foundation.

As is usual for this type of structure, the dam is composed of several blocks separated by structural (water-tight) joints. In the upper spillway area, the joints will be materialized in the pillars, in order to reduce the potential equipment damage in case of seismically induced differential block movements.

The typical dam cross section is presented in the **Figure 10.2**. The dam cross section is detailed in **Annex VI – Dam Stability**.

The general definition of the dam structure is presented in **Drawing 13**.

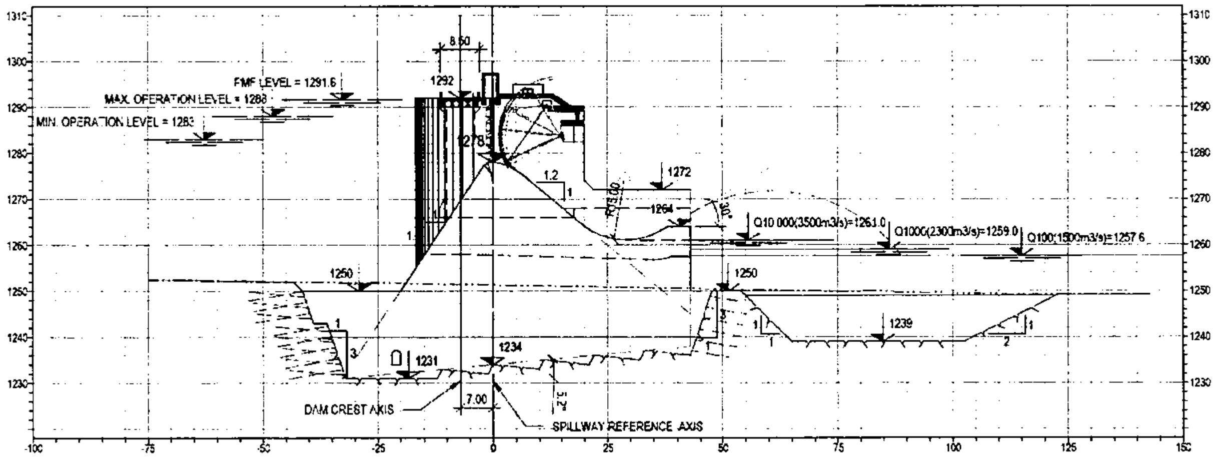

Figure 10.2 – Typical dam cross section

10.3 SPILLWAY AND FLUSHING OUTLETS

The spillway is designed to pass the design flood of 3500 m^3/s (T=10 000 years) at the normal operation level (NOL) E.L. 1288.00 m and was checked for passing the PMF (5000 m^3/s) without endangering the safety of the structure.

Consequently, the proposed layout is composed by an upper gated ogee crest spillway and a low-level gated spillway, that also operates as bottom/flushing outlet.

The upper spillway is a gated ogee crest with three (3) bays, each of 11.00 m width, separated by two pillars with hydrodynamic shape in plan. The ogee crest elevation is EL.1278.00 m, which is approximately 27 m above the Kunhar river thalweg at the dam cross section. The ogee crest is followed by a converging chute channel, approximately 26 m long. For energy dissipation purpose, a slotted flip bucket arrangement has been adopted. The lip of flip bucket is set at elevation EL.1264.00 m, which is 3 m above the tailwater level for the design discharge.

The low-level spillway has two (2) partially steel lined bays with approximately 30 m, each controlled by a sluice gate 6.0 m wide x 8.0 m high. The invert level of the lower spillway is E.L. 1258.00 m, which is approximately 7 m above the river bed at dam site. Each bottom outlet has an open channel terminal structure with a length of approximately 25 m and a constant width of 6 m. The low-level outlets will be operated under pressurized flow conditions. Their discharge capacity with a NOL in the reservoir is 1322 m^3/s.

In order to limit and localize the plunge-pool scour at the Kunhar river bed, a compound flip bucket is considered at the end of the terminal structure, including a curve in plan and a transverse slope of the bed of the bucket, which aims at deviating the impingement region from the left river bank as much as possible as well as increase the energy dissipation and sprinkling of jet issuing into the air by creation of rotation in the jet core. Therefore, the lip of flip bucket is set with a minimum elevation of EL.1258.00 m, which is approximately 1 m above the tailwater level for the bottom outlet design flood of approximately 1322 m^3/s with all gates fully open. The transverse slope of the lower plane of the bucket is defined at 30°, resulting in a lip of the flip bucket varying from EL. 1258.0 to EL.1261.0 masl.

Site geological and geotechnical investigations suggest that a plunge pool formation is very likely to occur caused by the plunging jets from the upper spillway and low-level spillway/flushing outlets.

For the Balakot HPP there is a risk that the lateral expansion of plunge pool could affect the stability of the slopes. This could be quite critical for the Balakot scour pit, since both river banks (particularly the right one) are relatively steep. Additionally, there is always the risk that the backwards erosion of the plunge pool may affect the dam foundation.

Consequently, a pre-excavated plunge pool is proposed to control the scour caused by the sinking jets from the upper spillway and low-level spillway / flushing outlets. The pre-excavation of the pool was considered to increase the water cushion and the volume of water able to dissipate the energy and better control the scour process. The excavation will also contribute to a better assessment of the slopes' stability and shall provide better information to decide on slope complementary stability measures or on reshaping of the pre-excavation. The requirement of the Kunhar river channel lining at the jet impingement area shall be further assessed at a subsequent phase of the studies, in particular in light of the physical model results.

The pre-excavation of the plunge pool was designed for the 1000-year return period flood. Therefore, the scour depth below the tailwater level is estimated at 20.2 m. Thus, the bottom elevation of scouring pit is estimated at E.L. 1239.0 m, which is approximately 12 m below the current river bed.

The hydraulic design of the spillways and flushing outlets is detailed in the **Annex VII - Hydraulic Design**. Nevertheless, additional physical and numerical model studies will have to be carried out for verification and optimization, namely to assess the behaviour of the approaching flow to the spillways, their discharge capacity, the hydraulic performance of the chute channel, flip bucket geometry and plunge pool stability. These model tests are expected to be specified and ordered by the EPC contractor.

The proposed layout for the spillway (composed by the upper gated spillway and low-level spillway) and is presented in **Figure 10.3**. The definition of the spillway is presented in the **Drawing 14.**

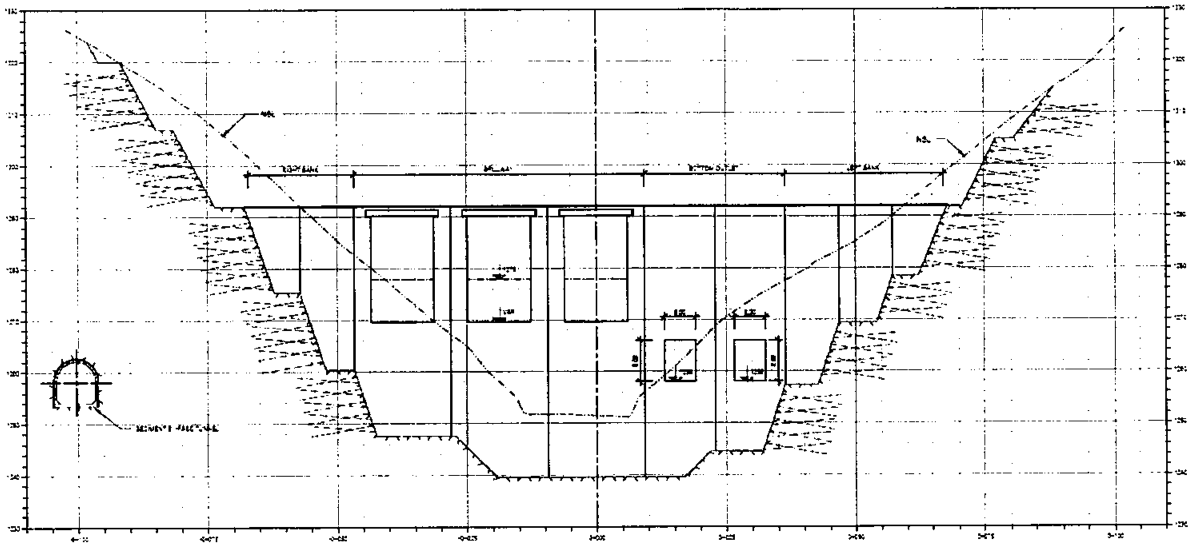

Figure 10.3 – Spillway proposed layout

10.4 SEDIMENT BY-PASS TUNNEL

The sediment inflow to the Balakot dam site is significant and constitutes a relevant issue for the planning and design of the hydropower scheme. Therefore, a sediment by-pass tunnel (SBT) is proposed as part of a comprehensive sediment management approach for the Balakot HPP.

The sediment by-pass tunnel is designed to route the sediment inflow to downstream of the dam and to maintain the normal operation level (NOL) at the reservoir, diverting excessive river flows higher than the Balakot HPP design discharge (154 m^3/s) and up to a 5-year return period flood peak (600 m^3/s).

The tunnel intake is located at the right bank around 510 m upstream of the dam axis. The location of the tunnel intake was selected according to topographic and geomorphological site conditions and ensuring a distance higher than 300 m from the power intake, to promote deposition of fine sediments before these reach the intake. The sediment deposition analyses are detailed in **Annex III – Sediments**.

The invert elevation of the tunnel intake is set at E.L. 1261.00 m. Thus, the inflow condition in the tunnel intake is pressurized with 24.75 m energy head at normal operation level and gate fully open.

The intake has an inlet trumpet with 7.5 m width and 4.5 m height. A tainter gate regulates the tunnel inflow, imposing free surface conditions throughout the tunnel.

The total length of the by-pass tunnel is 650 m with a downward slope of 1.5%.

The tunnel cross section has an archway shape with a width of 7.5 m and a height of 8.0 m. In order to avoid potential abrasion problems, a high strength concrete lining is considered[11]. There is an outlet structure with a length of 36 m in the downstream section of the tunnel, promoting a drop of about 3.5 m into the Kunhar River. The tunnel outlet structure is located around 220 m downstream of the dam axis.

Additionally, a submerged guiding structure (weir) with approximately 120 m is planned to divert the transported sediment in Kunhar river to the inlet structure. The guiding structure is a concrete gravity solution with upstream slope of 0.3:1 (H:V) and downstream slope of 0.8:1 (H:V), ensuring stability of the weir profile. The crest is set at E.L. 1272.00 m, which is approximately 14 m above the Kunhar river bed.

The proposed layout for the sediment by-pass tunnel is presented in **Figure 10.4**.

The hydraulic design of the sediment by-pass tunnel is presented in the **Annex VII - Hydraulic Design**. The sediment by-pass tunnel arrangement and characteristics shall be further confirmed and revised (if necessary) by the EPC contractor, based on physical and numerical model tests.

The definition of the sediment by-pass tunnel is presented in the **Drawings 18** to **21**.

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[11] The definitive lining of the SBT shall be confirmed at the detailed design stage, namely considering the results from the physical modelling. Such definition shall also take into account the operative experience with other operating similar structures.

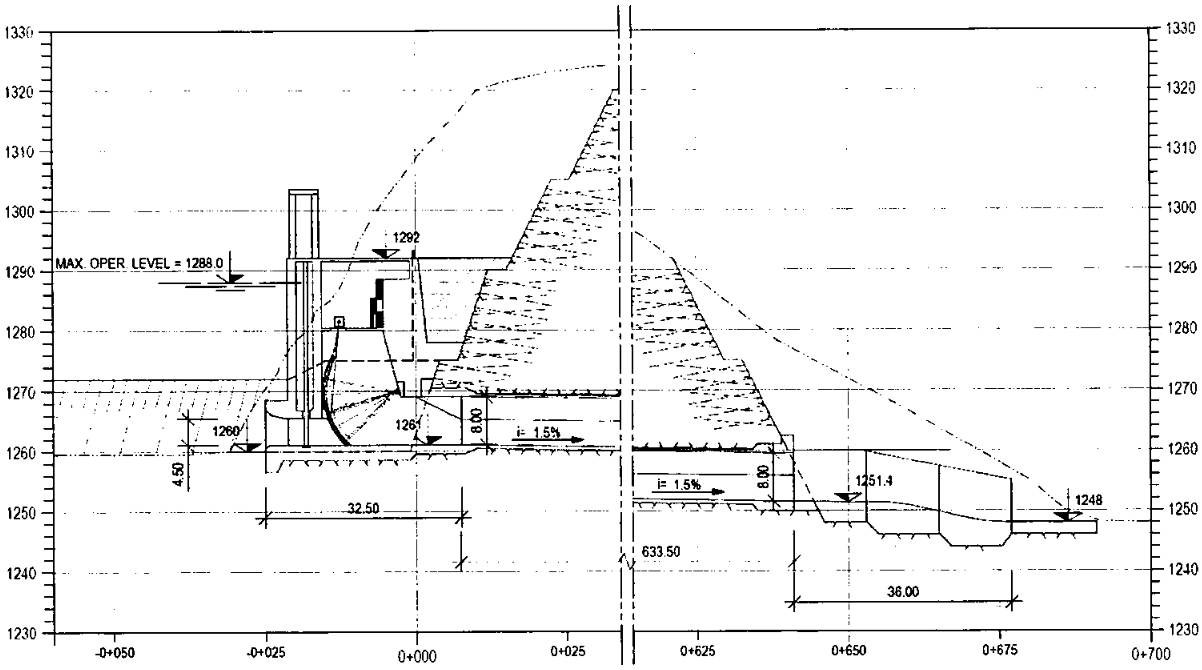

Figure 10.4 – Proposed longitudinal layout for the sediment by-pass tunnel

10.5 RIVER DIVERSION WORKS

For the construction of the Balakot dam it will be necessary to divert the river during the first phase of the construction of the dam. Once this stage is complete, the river may overtop part of the dam already built, without damaging the structure or its foundation.

Thus, a construction diversion scheme composed by openings left in the dam body, corresponding to the low-level spillway section and a right bank diversion tunnel (which will be converted into the sediment by-pass tunnel) is considered.

This method has wide application in concrete dams since it takes advantage of the openings left in the dam body to divert part of the flow, reducing the dimensions of the necessary diversion structures. Thus, the diversion tunnel will ensure the passage of the normal flow of the river and the flood passage up to around 400 m^3/s which is approximately the 45-years return period peak flow during the low-flow period and the 2-year return period flood. For higher flood discharges, the temporary openings left in the dam body are considered to ensure the flood passage for higher return period floods up to approximately 900 m^3/s (~20-years return period flood).

The implementation of this solution is anticipated as more cost-effective comparatively to an alternative diversion structure that could permanently ensure the diversion of the whole design discharge for a comparable risk level. However, the design flood risk, and consequently the river diversion design, is expected to be borne by to the EPC contractor. The Contractor has to propose the design for the definitive river diversion scheme.

Taking into consideration the geomorphological conditions at the dam site and proposed layout for the Balakot dam and related structures, the river diversion will be divided in two stages.

In the diversion stage I, the original river bed is considered to contain the Kunhar river flows and the following structures are built:

- diversion tunnel at the right bank (including sediment by-pass tunnel inlet and outlet structures);
- section of the upstream concrete cofferdam at the right bank (which will be further converted to the guiding structure).

For the construction of the diversion tunnel inlet, a temporary structure should be constructed in the right bank to provide safe workplace during the flood season.

After construction of the diversion tunnel and its inlet and outlet structures, the upstream concrete cofferdam can be completed, closing its open section at the left bank of the river. This operation will need to be carried out during the low flow period, with a temporary diversion to conclude the weir. Additionally, the downstream cofferdam can be also constructed, allowing to divert the river flow through the tunnel and proceed to the stage II of diversion.

During the stage II, the dam and related structures can be constructed and completed. The construction works during this stage should be planned to get the maximum period of low flows (which lasts about 7 months generally from October to April) for preparation of foundations and bringing up the concrete structures above the bed elevation before the next flood season.

For the upstream cofferdam (which will be further converted to guiding structure to the sediment by-pass tunnel), a concrete gravity solution is considered. The respective crest elevation is EL.1272.0 masl, which is approximately 14 m above the Kunhar river bed.

A concrete gravity solution for the downstream cofferdam is also considered, allowing overtopping during major floods. Therefore, the downstream cofferdam was designed for the diversion tunnel maximum discharge of 400 m^3/s without overtopping the upstream cofferdam. The downstream cofferdam crest elevation is set at 1252.5 masl, which is approximately 5 m above the Kunhar river thalweg.

The hydraulic design of the river diversion works is presented in the **Annex VII - Hydraulic Design**.

The layout of the proposed river diversion scheme is presented in the **Drawing 16**.

10.6 ACCESSES

Access roads are required during both the construction phase and for operation of the Balakot HPP.

The access road to the dam structure and power intake is proposed to start at the Sharan Road, which connects to National Highway N–15 on the left side of the Kunhar River, nearby Paras village. Such will require the construction of a new 550 m long road infrastructure. The layout of the proposed road access to the dam structure and power intake is presented in **Drawing 17**.

The access road to the dam structure is proposed to be extended from the dam bridge deck along the right river bank up to the sediment by-pass tunnel intake portal. This access road to be constructed is about 450 m long. The layout of the access road to the sediment bypass tunnel intake is presented in **Drawing 22**.

11 DAM STABILITY

11.1 GENERAL

This chapter presents a summary of the dam stability analysis of the proposed dam solution for the Balakot dam. The detailed calculations that were performed are depicted in **Annex VI - Dam stability**.

11.2 STRUCTURAL MODELLING

As usual for feasibility project stages, the structural modelation of the dam was performed following the linear pseudo-static approach (also known as the seismic coefficient method).

According to FEMA Federal Guidelines for Dam Safety – Earthquake Analyses and Design of Dams, in the pseudo-static (seismic coefficient) method "seismic inertia forces due to weight of the structure and to hydrodynamic pressures are included as part of the driving force, and a static analysis of sliding is performed. Treating the system above the failure surface as a rigid block, the inertia force associated with the mass of the structure is computed as the product of the assumed earthquake acceleration (seismic coefficient x g) and the mass of the block. Similarly, the product of the earthquake acceleration and the added-mass of water that is moving with the structure, according to the theory of Westergaard, produces inertia forces due to the hydrodynamic pressures. The motion of the structure relative to the failure surface is resisted by the shear strength mobilized between the structure and the failure surface by the friction and/or cohesion. When the earthquake forces are included in the sliding stability analysis, the calculated factor of safety against sliding (i.e., ratio of the resisting to driving shear forces) may become less than one. When this occurs, the sliding is assumed to occur for as long as the ground acceleration is greater than the critical value required for the driving force to exceed the resistance. However, due to oscillatory nature of the earthquake ground motion, the sliding displacement is limited and can be estimated by the "permanent displacement approach", which was also utilized in the present document.

11.3 LOAD CASES DEFINITION

The load cases considered in the stability calculations performed are the following (for a more detailed load cases definition *vide* **Annex VI – Dam Stability**):

- Dead weight of the dam body;
- Upstream water weight;
- Upstream horizontal hydrostatic pressure;

- Downstream horizontal hydrostatic pressure;
- Uplift water pressure;
- Upstream sediment pressure;
- Seismic inertial loads; and
- Upstream seismic hydrodynamic pressure.

11.4 LOAD COMBINATIONS DEFINITION

The design scenarios considered in the dam stability analysis and its inherent load combinations definition are the following (for a more detailed load combinations definition *vide* **Annex VI – Dam Stability**):

- Normal Operation scenario – represents the long-term static condition of the dam with the reservoir water level at the Maximum Operation Level (1288,00);
- Maximum Flood Operation scenario – represents a static load condition of the dam with the reservoir water level at the Maximum Flood Level (1291,10);
- Operating Basis Earthquake scenario – represents a short-term dynamic load condition of the dam, which consists in the occurrence of the Operating Basis Earthquake (OBE) during a Normal Operation scenario, *i.e.* with the reservoir water level at the Maximum Operation Level (1288,00);
- Safety Evaluation Earthquake scenario – represents the most severe short-term dynamic load condition of the dam, which consists in the occurrence of the Safety Evaluation Earthquake (SEE) during a Normal Operation scenario, *i.e.* with the reservoir water level at the Maximum Operation Level (1288,00);
- The Grout/Drainage Curtains Damage scenario – represents an unusual scenario, for which, with the reservoir water level at the Maximum Operation Level (1288,00), it is considered that the grout/drainage curtains are damaged and fully non-operational.

Table 11.1 presents a summary of the load combinations per design scenario.

Table 11.1 – Load combination summary per design scenario

Load cases	Design Scenarios				
	Normal Operation	Maximum Flood	Operating Basis Earthquake (OBE)	Safety Evaluation Earthquake (SEE)	Grout/Drainage Curtains Damage
Dead weight of the dam	Yes	Yes	Yes	Yes	Yes
Upstream vertical hydrostatic pressure	Maximum Operation level	Maximum Flood level	Maximum Operation level	Maximum Operation level	Maximum Operation level
Upstream horizontal hydrostatic pressure	Maximum Operation level	Maximum Flood level	Maximum Operation level	Maximum Operation level	Maximum Operation level
Downstream horizontal hydrostatic pressure	Variable downstream water level	Variable downstream water level	Variable downstream water level	Variable downstream water level	Variable downstream water level
Uplift water pressure	Fully operational curtains	Fully operational curtains	Fully operational curtains	Fully operational curtains	Non-operational curtains
Upstream sediment pressure	Yes	Yes	Yes	Yes	Yes
Seismic inertial Loads	No	No	$k_h = 0.29$ $k_v = 0.078$	$k_h = 0.90$ $k_v = 0.27$	No
Upstream seismic hydrodynamic pressure	No	No	$k_h = 0.29$	$k_h = 0.90$	No
Upstream sediment dynamic pressure	No	No	$k_h = 0.29$	$k_h = 0.90$	No

11.5 DAM STABILITY ANALYSIS

The dam stability analysis is based on the equilibrium state analysis of the dam, considering the dam block under analysis one meter thick and with a rigid body behaviour. For the dam to be considered as stable the following requirements should be satisfied:

- safety against sliding at any horizontal plane shall be guaranteed;
- safety against overturning about any point of the dam shall be guaranteed;

- allowable stresses in both the concrete and foundation shall not be exceeded.

Given the feasibility stage of this document, and although other horizontal planes could be chosen, the safety against sliding was only checked at the dam base level, on the interface between rock and concrete. Concerning the safety against overturning, the calculation was performed considering the dam's toe as the point of reference.

The sliding stability analysis was performed for two representative one meter thick dam blocks – spillway section and the highest generic section – and consisted in the determination of the factor of safety against sliding ($FOS_{sliding}$) at the dam base level, on the interface between rock and concrete. The factor of safety against sliding ($FOS_{sliding}$) is given by the ratio between the friction force and the sum of the total tangential forces acting on the base plane. The friction force is equal to the product of the friction coefficient by the sum of the total normal forces acting on the base plane. As such, the factor of safety against sliding has been calculated using the following formula:

$$FOS_{sliding} = \frac{\sum F_N \times \tan\phi + \mathrm{L} \times \mathrm{Cu}}{\sum F_T} \qquad (2)$$

where,

$\sum F_N$ = sum of total normal forces acting on the base plane (kN/m)

$\sum F_T$ = sum of total tangential forces acting on the base plane (kN/m)

$\tan\phi$ = friction coefficient

ϕ = angle of internal friction (°) (*vide* **Annex VI – Dam Stability** for more details)

L = Length of the cross-section base

Cu = cohesion (kPa) (*vide* **Annex VI – Dam Stability** for more details)

The overturning stability analysis was also performed for two representative one meter thick dam blocks – spillway section and general section –and consisted in the determination of the factor of safety against overturning ($FOS_{overturning}$) calculated about the dam toe. The $FOS_{overturning}$ is given by the ratio between the sum of the stabilizing moments and the sum of the destabilizing moments about the dam toe. As such, the factor of safety against overturning has been calculated using the following formula:

$$FOS_{overturning} = \frac{\sum M_{stb}}{\sum M_{dstb}} \qquad (3)$$

where,

$\sum M_{stb}$ = sum of the stabilizing moments about the dam toe (kNm/m)

$\sum M_{dstb}$ = sum of the destabilizing moments about the dam toe (kNm/m)

The foundation stress analysis was also performed for the same two representative one meter thick dam blocks – spillway section and general section – and consisted in the determination of the resultant foundation stress diagrams due to the action of the considered load cases in each design scenarios, considering the dam as a rigid block. The resultant foundation stress diagram consists in the composite stress diagram obtained by the sum of the foundation stress diagram due to the normal forces acting on the foundation plane with the foundation stress diagram due to the moment at the centre of the dam foundation. If the resultant foundation stress diagram obtained comprises a negative stress values length, the stress diagram must be recalculated considering that the stresses within that length are null, as the tensile strength of the foundation must not be accounted for. When the upstream foundation stresses are null, cracking may occur and the uplift pressure must be fully applied within the crack width, with the exception of the dynamic scenarios due to the cyclic nature of the seismic action.

The dam stability criteria adopted for the dam stability analysis was based on the definition of minimum allowable factors of safety against either sliding or overturning phenomena. These minimum factors are dependent of the design scenario under analysis, being higher for the long-term conditions and lower for short term conditions. Therefore, for the dam to be considered as safe for each of the design scenarios, the factors of safety obtained by the dam stability analysis according to the methodology presented in this chapter should be higher or equal to the minimum allowable factor of safety for each of the design scenarios. **Table 11.2** presents the minimum allowable factors of safety against sliding and overturning per design scenarios.

Table 11.2 – Dam Stability criteria – Minimum allowable factors of safety per design scenario

Dam stability criteria	Design Scenarios				
	Normal Operation	Maximum Flood	Operating Basis Earthquake (OBE)	Safety Evaluation Earthquake (SEE)	Grout/Drainage Curtains Damage
Minimum allowable FOS $_{\text{sliding}}$	2.0	1.7	1.3	N/A	1.3
Minimum allowable FOS $_{\text{overturning}}$	2.5	2.0	1.5	1.1	1.5

11.6 DAM STABILITY RESULTS

The following tables present the dam stability analyses main results obtained. **Table 11.3** and **Table 11.4** present the safety evaluation results per design scenario, for a spillway section and a generic section, respectively. As can be seen, the dam stability criteria depicted in section 11.5 is entirely fulfilled for all design scenarios considered (except for the sliding stability in the SEE scenarios), for both dam sections analysed. In terms of foundation stresses, the results obtained are considered to be within adequate values. Therefore, the concrete gravity dams' current configurations can be considered as structurally stable for those design scenarios.

Regarding the sliding stability in the Safety Evaluation Earthquake (SEE) scenario, the obtained factors of safety against sliding are lower than 1.0 , and therefore movement of the dam is expected. In order to estimate the accumulated seismic displacement of the dam, the Permanent Displacement Method was employed (*vide* **Annex VI – Dam Stability** for more details). **Table 11.5** presents the obtained seismic permanent displacement of the dam for the SEE scenario per dam location and dam section analysed. The obtained values have a maximum of 1 m, which given the thickness of the dam blocks is considered an acceptable value that ensure the non-uncontrolled release of water requirement.

Table 11.3 – Safety Evaluation per design scenario. Spillway section

Safety Evaluation		Design Scenarios				
		Normal Operation	Maximum Flood	Operating Basis Earthquake (OBE)	Safety Evaluation Earthquake (SEE)	Grout/Drainage Curtains Damage
Sliding Stability	$\sum F_N$ (kN/m)	54 571	55 275	53 243	42 992	43 400
	$\sum F_T$ (kN/m)	11 250	13 009	36 117	86 106	11 250
	ϕ (°) / cu(kPa)	40/0	40/0	35/150	35/75	40/0
	$FOS_{sliding}$	4.07	3.57	1.35	0.42*	3.24
Overturning Stability	$\sum M_{stb}$ (kNm/m)	2 242 094	2 242 094	2 482 885	2 482 885	2 242 094
	$\sum M_{dstb}$ kNm/m)	309 400	316 615	890 538	2 055 778	867 151
	$FOS_{overturning}$	7.25	7.08	2.79	1.21	2.59
Foundation stresses	σ_{heel} (MPa)	0.521 (<1.13)	0.495 (<1.13)	0.215 (<1.7)	0	0.252 (<1.13)
	σ_{toe} (MPa)	0.887 (<1.13)	0.930 (<1.13)	1.158 (<1.7)	2.885 (<3.39)	0.867 (<1.13)

*must be evaluated via permanent displacement method

Table 11.4 – Safety Evaluation per design scenario. Generic section

Safety Evaluation		Design Scenarios				
		Normal Operation	Maximum Flood	Operating Basis Earthquake (OBE)	Safety Evaluation Earthquake (SEE)	Grout/Drainage Curtains Damage
Sliding Stability	$\sum F_N$ (kN/m)	29 043	29 154	28 514	22 552	20 651
	$\sum F_T$ (kN/m)	7 803	9 282	23 159	53 507	7 584
	ϕ (°) / cu(kPa)	40/0	40/0	35/150	35/75	40/0
	$FOS_{sliding}$	3.12	2.64	1.30	0.39*	2.28
Overturning Stability	$\sum M_{stb}$ (kNm/m)	1 312 606	1 312 606	1 419 225	1 419 225	1 312 606
	$\sum M_{dstb}$ kNm/m)	283 409	307 773	580 057	1 199 542	619 807
	$FOS_{overturning}$	4.63	4.26	2.45	1.18	2.12
Foundation stresses	σ_{heel} (MPa)	0.519 (<1.13)	0.483 (<1.13)	0.278 (<1.7)	0	0.316 (<1.13)
	σ_{toe} (MPa)	0.353 (<1.13)	0.392 (<1.13)	0.578 (<1.7)	1.543 (<3.39)	0.304 (<1.13)

Table 11.5 – Seismic Permanent Displacements per dam section

Permanent displacement Method	Dam sections	
	Spillway section	Generic section
Critical acceleration k_c	0.37g	0.33g
Permanent displacement d_m (m)	0.68	1.02

This level of displacement, however, will certainly induce damage to the dam, particularly in the grout/drainage curtains of the dam foundation, and therefore, it is necessary to assess the stability of the damaged dam for the static load conditions after the occurrence of the seismic event. In order to do so, an additional analysis of the dam stability was performed, considering the load cases associated with the grout/drainage curtain damage scenario, with a reduced internal friction angle for the concrete/foundation interface of 30°.

Table 11.6 presents the post SEE event stability evaluation of the damaged dam, per dam section analysed. As **Table 11.6** shows, the foundation stresses are not significant and the factors of safety against sliding and overturning are considerably greater than 1.0. Therefore, the dam stability in a post SEE scenario is considered guaranteed.

Table 11.6 – Post SEE safety evaluation of the damaged dam

Safety Evaluation		Spillway section	Generic section
Sliding Stability	$\sum F_N$ (kN/m)	43 400	20 651
	$\sum F_T$ (kN/m)	11 250	7 584
	ϕ (°)	30	30
	$FOS_{sliding}$	2.23	1.57
Overturning Stability	$\sum M_{stb}$ (kNm/m)	2 242 094	1 312 606
	$\sum M_{dstb}$ (kNm/m)	867 151	619 807
	$FOS_{overturning}$	2.59	2.12
Foundation stresses	σ_{heel} (MPa)	0.252 (<1.13)	0.316 (<1.13)
	σ_{toe} (MPa)	0.867 (<1.13)	0.304 (<1.13)

11.7 CONCLUSIONS AND RECOMMENDATIONS

The concrete gravity dam solution was analysed following the linear pseudo-static (seismic coefficient) method for the most pertinent design scenarios. The safety evaluation was done by comparing the factors of safety (*i.e.* the ratio between the stabilizing forces/moments and the destabilizing forces/moments) obtained for two representative dam sections – spillway section and the highest generic section – with the adopted minimum allowable factors of safety for each design scenario.

The results obtained show that the proposed concrete gravity dam solution complies with the stability criteria for all scenarios, except for the sliding stability verification in the Safety Evaluation Earthquake scenario. In fact, and as mentioned, "the factor of safety against sliding required by the pseudo static method (*e.g.*, >1.0-1.5 at all times) may not be attainable for larger seismic forces representative of moderate to high intensity earthquake ground motions" (FEMA's Federal Guidelines for Dam Safety – Earthquake Analyses and Design of Dams, 2005), and thus, a more suitable method of analysis was employed for these extreme conditions - the Permanent Displacement Method. With this method it was possible to estimate the seismically induced Permanent Displacement due to the occurrence of the SEE, and the values obtained were considered compatible with the no uncontrolled release of water requirement. However, given that dam movement may occur for the SEE scenario, some degree of dam damage is expected. In order to assess the damaged dam stability for the post SEE scenario, a safety evaluation was performed considering that the grout/drainage curtain at the dam foundation is damaged and non-operational, with a reduced friction coefficient in the foundation/rock interface. The results obtained point to a stable dam state in such conditions and, therefore, the analysed concrete gravity dam solution was considered as safe for all design scenarios.

It is worth mentioning, however, that for the final design stage of the dam, further comprehensive structural analyses (nonlinear three-dimensional time dependent dynamic analyses) of the dam and its foundation are mandatory for the dynamic structural behaviour assessment of the structural system. There is a risk that, with the use of those non-linear three-dimensional time dependent analysis methods, the computed seismic behaviour of the dam may be worse than the estimated with the more simplified feasibility stage analysis methods, and consequently the resultant seismic permanent displacements may be higher than estimated. Additionally, given the sensitivity of the concrete gravity dam type stability to variations of foundation geotechnical characteristics (either in friction coefficient or allowable bearing pressure), it is possible that in the final design stage, with a broader knowledge of the geological-geotechnical context of the dam foundation, it may be necessary to tweak the geometrical configuration of the dam to a better fit into the actual conditions.

12 DAM BREAK ANALYSIS

12.1 SCOPE AND OBJECTIVES

The main objectives of the dam break analysis are the following:

- Determination of the dam breach discharge hydrographs.
- Determination of the extent and time of arrival of the flood waves.
- Assessment of the potential impact category.

12.2 DAM BREAK SCENARIOS

The dam break study evaluates the consequences of the Balakot dam failure (Scenario A) and cascade Balakot-Suki Kinari dams rupture (Scenario B) separately. The following theoretical dam break scenarios were assessed:

- Scenario A (Balakot dam breach):
  - Scenario A-1: "Rainy day" dam failure of Balakot dam (flood-induced dam failure);
  - Scenario A-2: "Sunny day" (normal conditions) dam failure (earthquake induced dam failure).
- Scenario B (Cascade Dam failure – both Suki Kinari and Balakot dams breach):
  - Scenario B-1: "Sunny day" (normal conditions) cascade dams' failure (earthquake induced dam failure).

A "rainy day" dam failure or overtopping type failure typically occurs during large flood inflow conditions, where the reservoir water level rises high enough to breach or overtop the dam. For the proposed dam, there are two spillways (lower level and upper level), which have been designed to accommodate the probable maximum flood that may occur. The Balakot spillway provides a very large factor of safety for the dam, which results in a very low probability of failure due to overtopping. Despite this factor of safety being incorporated in the Balakot dam design, there may be a possibility that some unforeseen event leads to the dam failure occurring at a time when there is an extreme inflow to the dam reservoir area.

On the other hand, a "sunny day" dam failure is generally assumed to occur when the reservoir is at its Normal Operating Level (NOL). Examples of sunny day dam failures include extreme earthquake loading. Also, for the case of the seismic action, the Balakot dam is designed to withstand the MCE with minor displacements, therefore reducing the likelihood of a failure due to this action.

The two referred scenarios are considered to provide a reasonable representation of the range of conditions resulting from the possible failure modes of the Balakot dam.

The third scenario considers a failure of the upstream Suki Kinari through its rockfill body. Such could be motivated by overtopping, due to flood or landslide induced. In this scenario normal conditions ("sunny day") are considered, that is no natural flood flows in the Kunhar river.

12.3 STUDY AREA AND RIVER SYSTEM SCHEMATIC

The present dam break study aims at evaluating the consequences in the Kunhar valley for two different scenarios: Balakot dam breach (Scenario A) and cascade Balakot-Suki Kinari dams breach (Scenario B). Therefore, the hydraulic model of the Kunhar River was developed from Suki Kinari dam site to just downstream of Patrind dam site (located downstream of Garhi Habibullah). The flood wave propagation for each scenario was fully simulated, in order to investigate the potential Patrind dam overtopping due to the breach of the upstream cascade dams. The Patrind spillway (composed by an upper and low-level spillway) was assumed in operation during the arrival of the cascade flood wave.

The setting up of the model was carried out by considering approximately 90 km river length with 1752 cross-sections (app. 50 m average spacing). The Suki Kinari dam axis is situated at section number 87 400 and Balakot dam axis is located at section number 46 800, respectively.

12.4 BOUNDARY AND INITIAL CONDITIONS

Boundary conditions are necessary to define the upstream and downstream limits of the river system. The unsteady component of the HEC-RAS can perform subcritical, supercritical or mixed flow regime computation. In this study mixed flow regime simulation is selected in the HEC-RAS software. The considered upstream boundary conditions are depicted in **Table 12.1**.

In Scenario A-1, the hydraulic model is used to simulate the Balakot dam breach outflow hydrograph and the flood wave propagation throughout the Kunhar River, resulting from the dam failure occurred during large flood inflow conditions. Therefore, the upstream boundary condition was assumed as the PMF inflow hydrograph. During this scenario it is assumed that the spillway is not operational, causing the overtop of the dam. Conservatively, the dam breach is assumed to occur for the reservoir water level at 1298.5 masl (*i.e.* 6.5 m above the dam crest elevation).

In Scenario A-2, the theoretical sunny day ("normal day") Balakot dam failure is analysed, which could result from extreme earthquake loading. Therefore, the upstream boundary condition was assumed as the mean annual flow at the Balakot dam site, estimated as 87 m^3/s, as presented in *Annex VII – Hydraulic Design*. Regarding the initial conditions, the reservoir water level is assumed at the normal operation level of 1288.0 masl.

In Scenario B-1 the hydraulic model is used to simulate the Suki Kinari dam breach outflow hydrograph and the flood wave propagation downstream up to Balakot dam and, consequently, the Balakot dam breach outflow and propagation throughout the Kunhar River valley downstream up to Patrind. Therefore, the upstream boundary condition at Suki Kinari was assumed as the mean annual flow at the Suki Kinari dam site, estimated as 60 m^3/s, as presented in *Feasibility Study* of the *Suki Kinari Hydropower Project* (Mott MacDonald, 2008). Regarding the initial conditions, the Suki Kinari and Balakot reservoirs water levels are assumed at the normal operation levels of 2233.0 and 1288.0 masl, respectively.

The downstream boundary condition at the last cross-section was set as normal depth for the simulated scenarios.

Table 12.1 – Boundary conditions for the considered scenarios

Scenario	Failure Mode	Operating Conditions	Natural catchment flow conditions
Scenario A-1 (Balakot dam breach)	Rainy day (flood-induced dam failure)	Assumed the spillway is not operational	Probable Maximum Flood (PMF)
Scenario A-2 (Balakot dam breach)	Sunny day (earthquake induced dam failure)	Reservoir elevation at NOL	Mean Annual Flow
Scenario B (Cascade Dams – Suki Kinari and Balakot breaches)	Sunny day (earthquake induced dam failure)	Reservoirs elevation at NOL	Mean Annual Flow

12.5 DAM BREACH PARAMETERS ESTIMATION

The estimation of the breach location, size, and development time are critical to obtain reliable estimates of the outflow hydrographs and downstream inundation. Once the breaching parameters are estimated, the HEC-RAS can be used to compute the outflow hydrograph from the dam breach and perform downstream routing. The user is required to enter information like: failure location, failure mode, breach development time, breach shape, weir and piping coefficient, and trigger mechanism into HEC-RAS model to define a dam breach.

The Balakot dam break analysis was performed under an overtopping failure condition for the retained scenarios, considering a rectangular breach shape and assuming the failure to occur in the dam's monolith blocks. For the Suki Kinari dam break analysis under Scenario B-1 (sunny day scenario), a piping failure condition was considered, assuming a trapezoidal breach shape. Empirical guidelines provide a range of theoretical estimates for each component breach parameter (breach bottom width, side slopes and development time). Based on these empirical guidelines, the considered dam's breach parameters are presented in **Table 12.2**.

Table 12.2 – Breach parameters for Suki Kinari and Balakot dams

Parameter	Balakot Dam	Suki Kinari Dam
Dam Crest Elevation (m)	1292.0	2239.5
Reservoir volume ($10^6 m^3$)	3.3	14.4
Failure mode:	Scenario A-1: Overtopping Scenario A-2: Structural failure of monolith blocks Scenario B-1: Overtopping	Scenario B-1: Pipping
Reservoir Level at time of breach (m)	Scenario A-1: Max. overtopping under PMF: 1298.5 (i.e. 6.5 m above dam crest) Scenario A-2: 1288.0 (NOL) Scenario B-1: 1292.0 (dam crest elevation)	Scenario B-1: 2233.0 (NOL)
Breach width:	Scenario A-1: 18 m (width of the central monolith block) Scenario A-2: 36 m (width of the two central monolith blocks) Scenario B-1: 18 m (width of the central monolith block)	Scenario B-1: Bottom width: 5 m (width of the original river cross section) Average width: 118 m Top Width: 230 m
Slide slope	Vertical	1H:1V
Breach formation time (hr)	Scenario A-1: 0.1 hr Scenario A-2: 0.1 hr Scenario B-1: 0.1 hr	Scenario B-1: 1.0 hr

Scenario A-1: Rainy day dam failure of Balakot dam (flood-induced dam failure)
Scenario A-2: Sunny day dam failure of Balakot dam (earthquake induced dam failure)
Scenario B-1: Sunny day cascade dam's failure (earthquake induced dam failure)

To model the dam breach process in HEC-RAS for the considered scenarios, unsteady flow calculations were performed. A simulation period of 24 hours was used with the dam breach initiated at the start of the simulation. The Suki Kinari and Balakot dams were modelled as an "inline structure" in the HEC-RAS model.

12.6 DAM BREAK SIMULATIONS AND RESULTS

12.6.1 Outflow Hydrographs

The HEC-RAS numerical model was used to determine the discharge hydrograph from the Balakot and Suki Kinari dam failures, based on the physical parameters of the dam's and considered characteristics of breaches as presented in section 12.5. The Balakot and Suki Kinari breach outflow hydrographs estimated from hydraulic modelling for the considered scenarios are presented in **Figure 12.1** and **Figure 12.2** respectively.

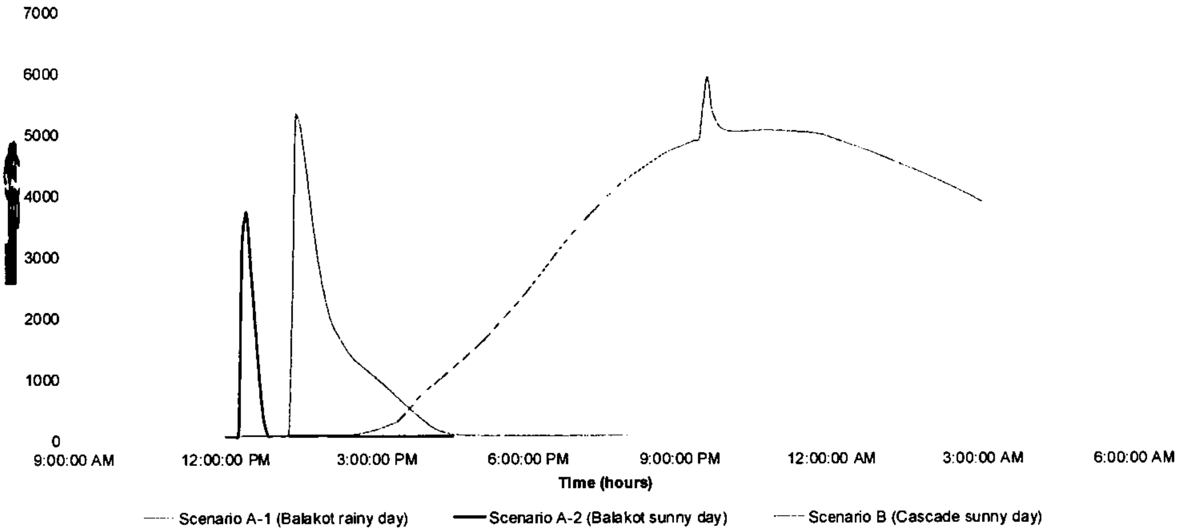

Figure 12.1 – Breach outflow hydrographs estimated from hydraulic modelling for the considered scenarios – Balakot dam

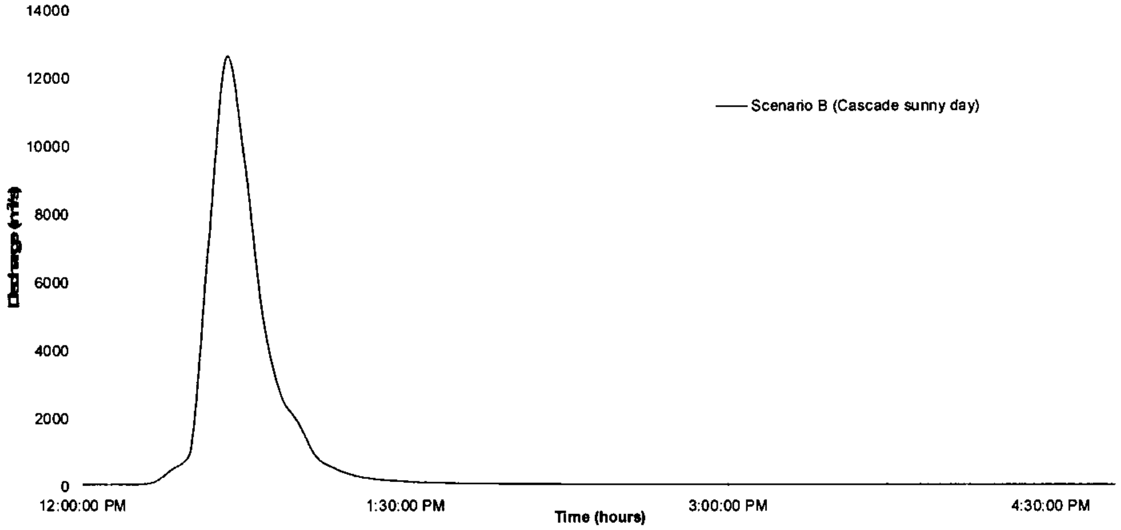

Figure 12.2 – Breach outflow hydrographs estimated from hydraulic modelling for the considered scenarios – Suki Kinari dam

12.6.2 Flood Propagation

Dam break analysis results at critical cross sections are summarized in the following tables. These results include information on distance from the most downstream model section[12], indication of the location, peak discharge, maximum water surface elevation, maximum average flow velocity in the section and maximum flow depth. Regarding the maximum flow depth, it must be noted that outside the detailed topographic survey area (mostly encompassing the Balkot scheme implantation), the interpolated topography from the SRTM grid does not accurately characterizes the geometry of the river bed. Therefore, in these areas, particularly in the open ones in the downstream zone, the maximum flow depth estimate is not reliable and tends to be underestimated.

Table 12.3 – Dam break simulation results at selected cross sections for Scenario A1

Section	Location	Peak Discharge	WS	Velocity	Depth
#	km	m³/s	m	m/s	m
46750	DS of Balakot dam	6256	1261.2	33.6	11.2
41750		5959	1191.3	43.6	5.1
36750		5830	1103.4	16.3	5.4
30000	US of Balakot town	5759	1008.9	32.4	8.3
20000		5684	890.5	9.9	3.6
12150	US of G. Habbib.	5618	824.6	7.4	5.9
6000		5422	793	3.7	7.8
3900	US of Patrind reservoir	5407	781.8	18.9	8.2

The results show that Scenario A1 (associated to the PMF at Balakot) produces the highest values and has the largest impact in the downstream valley. The dampening of the flood peak from Balakot to Patrind is almost insignificant along the 43 km, which is explained by the huge flow volume of the PMF hydrograph. By comparison, in "sunny day" condition, the peak lamination is very significant - about 75% - which is justified by the relatively low storage volume of the Balakot reservoir.

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[12] Initial section immediately downstream of the Patrind dam. Section number is the distance, in m, along the river bed, to te initial section.

Table 12.4 – Dam break simulation results at selected cross sections for Scenario A2

Section #	Location km	Peak Discharge m³/s	WS m	Velocity m/s	Depth m
46750	DS of Balakot dam	4342	1259.5	30.3	9.5
41750		2951	1190	36.5	3.8
36750		2508	1101.6	13.6	3.5
30000	US of Balakot town	2148	1006.5	23.7	5.8
20000		1913	889.1	8.4	2.3
12150	US of G. Habbib.	1622	822.3	4.5	3.7
6000		1150	789.1	3.2	4.0
3900	US of Patrind reservoir	1070	778.1	12.2	4.5

Table 12.5 – Dam break simulation results at selected cross sections for Scenario B

Section #	Location km	Peak Discharge m³/s	WS m	Velocity m/s	Depth m
87350	DS Suki Kinari	12777	2205.4	23.6	12.2
49750	US Balakot dam	7469	1307.6	18.3	12.3
46750	DS Balakot dam	5341	1260.4	32.3	10.4
41750		4728	1190.8	41.0	4.6
36750		4487	1102.7	15.5	4.6
30000	US Balakot town	4209	1008.1	29.4	7.4
20000		3894	889.9	9.5	3.1
12150	US G. Habbib.	3519	823.6	6.0	5.0
6000		2625	790.9	3.5	5.7
3900	US Patrind	2565	779.8	15.6	6.2

The resulting hydrographs from the model for scenario B – cascade rupture – indicate a very severe flood wave which impacts the Kunhar River from the Suki Kinari dam and Balakot dam site to the Patrind HPP. This scenario produces the highest peak flow in the Suki Kinari dam section, as would be expected given the height of the dam and volume of the reservoir (notwithstanding the longer failure time), although it is strongly reduced in the initial reach, as usual in dam break flood waves. The peak is attenuated to about 50% at Paras/Balakot dam, approximately 40 km downstream of Suki Kinari. When reaching Patrind, the flood peak is already quite dampened, to about 2560 m³/s (20% of the maximum). These values compare to a natural flood of 200 to 500 years, according to the Patrind HPP Feasibility Study (PES/Fichtner, 2007).

The Patrind HPP spillway capacity is 2800 m³/s. The safety check flood without overtopping of the dam, according to the Patrind HPP Feasibility Study, is 5300 m³/s [13]. Therefore, it can be concluded that the risk of Patrind dam overtopping due to a Balakot dam failure is low.

It is necessary to estimate the population-at-risk (PAR) in order to assign the dam a potential impact category. A preliminary count of houses at risk in the floodable areas indicated number of houses flooded to a depth of greater than 3 m (although the criteria was loosened to account for the topography limitations). The PAR was estimated for each of the three scenarios under consideration, as shown in the following sections. The PAR calculation was based on the estimate of the affected households through GoogleEarth Pro and the average household size. The considered average household size is a 6 person aggregate[14].

The most important urban areas in the valley downstream of Balakot dam (and Suki Kinari dam also), within the modelled reach, are the Balakot town and Garhi Habibullah. The 2017 Pakistan Census estimates the total population of the Balakot Tehsil at 273 089. Population living in Balakot town is 14 681 and population living in G.Habibullah 25 323, respectively.

12.6.3 Scenario A1 (Rainy Day, Balakot)

This is the worst impact scenario for the (sole) Balakot dam failure, which is associated with a major flood event (taken as the PMF). Although in event therefore would certainly exits important impacts upstream of Balakot, these were not considered as they would be associated to a natural flood. Therefore, the impacts would be felt downstream of Paras, in Balakot and Garhi Habibullah. The flood wave reaches Balakot town with a peak flow of 5800 m³/s. In this scenario it is not significant to refer the progression of the rupture wave peak. As the **Figure 12.1** clearly showed, the impact of the rupture is negligible in the natural flood (contributing less than 1 000 m³/s). In any case, the progression of this peak in "wet" conditions is quite rapid, reaching Balakot town area in approximately 20 min and Patrind after about 1 hour.

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[13] It must be noted the different hydrological assessments for the Balakot and Patrinfd projects, where in the first the PMF is estimated at 5000 m³/s and in the second at 4060 m³/s.

[14] The household size was settled based on the survey conducted in the scope of the Balakot Environmental and Social Impact Assessment (Hagler Bailly, 2018). Different household sizes were surveyed along the valley in a range of 5.5-6.5, with an average value of 6.1. A slightly lower value than the average was adopted in this study to cater for the more urban characteristics in the lower part of the valley (where a larger impact is anticipated).

The PAR estimate for Scenario A1 is depicted in **Table 12.6**, where a very significant number of potential casualties is estimated. However, it must be highlighted that this scenario is dominated by the catastrophic flood event (the PMF) and not so much by the dam failure itself.

Table 12.6 – Population at risk along Kunhar River (Scenario A1)

Location	Houses	Commercial Buildings	Agriculture Land (Hectares)	Population
Balakot	322	138	40	1932
G. Habibullah	912	228	30	5472
Total	**1234**	**366**	**70**	**7404**

12.6.4 Scenario A2 (Sunny Day, Balakot)

Scenario A2 depicts a situation where the Balakot dam is at its normal operating level and an external event triggers the failure, as an extreme earthquake. In such situation, the riverbed downstream is in "dry" conditions and the impact would be felt from Paras to Garhi Habibullah, encompassing the Balakot populated area. The estimate of affected buildings, property and population is presented in **Table 12.7**.

Table 12.7 – Population at risk along Kunhar River (Scenario A2)

Location	Houses	Commercial Buildings	Agriculture Land (Hectares)	Population
Balakot	35	15	7	209
G. Habibullah	76	9	3	456
Total	**111**	**24**	**10**	**665**

In this scenario the estimated PAR is much lower than the previous and the flooding at Balakot and Garhi Habib in this case can be compared to a low frequency natural flood event (about 200 year return period). In this case the peak reaches Balakot town about 35 min after peak rupture, and the Patrind reservoir after 2 hours, with a very dampened peak.

12.6.5 Scenario B (Sunny Day, Cascade)

This Scenario corresponds to the dam cascade rupture of Suki Kinari and Balakot, therefore impacting the full modelled extension (88 km) from Suki Kinari Dam section to Patrind. As the previous results indicate, this scenario is the only one including the failure of Suki Kinari dam, therefore being the sole case were impacts in the Kunhar river are modelled between this dam and the Balakot dam section. The referred reach extends for about 38 km and includes in the valley the settlements of Kaghan, Khanian, Mahandri, Jared and Paras. However, it must be noted that most of these settlements are small and the majority of the construction is placed well above the riverbed levels. Such is not unrelated to the steep slopes in the lower part of the river valley and that the predominant economic activity is agriculture, where arable land is mostly at higher levels. It is also worth noting that many houses along this stretch are spread throughout the valley.

A preliminary count of houses in Kaghan, Khanian, Balakot and G.Habibullah at risk in the floodable areas indicated approximately 1370 houses and commercial buildings potentially affected. The flood wave from Suki Kinari reaches Paras/Balakot dam with a peak flow of about 7 000 m^3/s and in approximately 45 min after the upstream dam full failure. The flood peak reaching Balakot town is estimated at 4200 m^3/s and occurs 1:15 h after the Suki Kinari full rupture.

The estimated number of affected houses, commercial buildings, agriculture land and calculated population at risk is presented in **Table 12.8**. A PAR of approximately 6150 people is estimated. The following figures depicts the project inundation in Balakot town and Garhi Habibullah areas.

Table 12.8 – Population at risk along Kunhar River (Scenario B)

Location	Houses	Commercial Buildings	Agriculture Land (Hectares)	Population
Kaghan	3	2	-	18
Khanian	13	3	-	78
Balakot	327	110	35	1962
G. Habibullah	682	230	12	4092
Total	**1025**	**345**	**47**	**6150**

12.7 CONCLUSIONS

Suki Kinari (under construction) and Balakot dams are proposed on the Kunhar River. This study examines the potential downstream effects in the event of a hypothetical failure of the dams by using a one-dimensional unsteady hydraulic model. As mentioned earlier in this document, the dam break analysis is undertaken in order to determine the potential downstream effects, which in turn guides the setting of standards to adopt for the dam design, construction and operation.

In this particular case, the dam design incorporates features which aim to prevent a catastrophic failure from occurring, including adoption of high design standards within the dam building industry. While this may seem to make the results from the dam break analysis somewhat redundant, it is important to consider the potential impacts, particularly in terms of an Emergency Action Plan, in the highly unlikely event of imminent failure of the dam.

The dam break modelling results show that significant out of channel flow occurs in the Kunhar river, in particular impacting Balakot town area and Garhi Habibullah. The effects from such a failure would likely be severe in terms of damage to infrastructure and would include significant population-at-risk (flooded to a depth greater than 3 m), which in the most negative scenario attributable to dam break is estimated at 6150 people (cascade failure).

The impact on infrastructure can be considered low in terms of asset value, as the existent infrastructure in the impact area is reduced (most salient are the road bridges at Balakot and Garhi Habibullah, and the national road N15 along the Kunhar valley, connecting Manshera to Chilas). However, in terms of regional connectivity, the impact could be considered quite significant, as key routes and river crossing would be affected.

The analysis has shown that the dam should be classified as having a potential impact category of 'High', due to the population-at-risk and the likely damage to the existing infrastructure being major or catastrophic. Output from the analysis is also available as layers to be used in a geographic information system, which in turn can be incorporated into an Emergency Action Plan for the Balakot dam.

13 POWERHOUSE AND POWER CIRCUIT DEFINITION

13.1 GENERAL ARRANGEMENT

The powerhouse and power circuit layout for the Balakot HPP is broadly similar to the solution detailed in the FS2013 and comprises the following main components:

- Power circuit consisting of power intake, a single headrace tunnel, an upstream surge shaft, a pressure shaft/tunnel, penstock, manifolds, downstream surge shaft and tailrace tunnel;
- Underground (cavern) powerhouse structure with adjacent transformer/substation cavern.

The power intake was arranged on the left bank of Kunhar River. The power intake structure is of the frontal type (with lateral disposition) and has four (4) bays divided by three (3) 2 m wide vertical piers with hydrodynamic shape in plan. The invert of the intake is placed at elevation 1271.00 m.

Following the power intake, a single headrace tunnel is envisaged with an inner diameter of 8 m. The length of headrace tunnel is around 9.1 km. The design headrace discharge is 154 m^3/s.

Since the Balakot HPP is characterized by a very long headrace tunnel, an upstream surge shaft is envisaged. The surge shaft top elevation is 1340.00 m, the bottom elevation is 1228.0 m and the height of surge shaft is approximately 122 m.

Downstream of the surge shaft section, a transition to the steel lined pressure tunnel is arranged. The pressure tunnel has a total length of around 200 m and includes the upper pressure tunnel (vertical curve), the pressure shaft and the lower vertical curve. The section of the pressure tunnel has an internal diameter of 5.6 m.

At the end of the pressure tunnel, a penstock is envisaged and three manifolds consecutively branch off at an angle of around 50°. The length of the sub-horizontal part, up to the first branch, is 51.5 m. Each manifold has the internal diameter of 3.2 m. A straight alignment is provided towards the turbines over a length of around 20 m.

The proposed underground powerhouse is a conventional cavern structure for three identical Francis units with vertical axis of 100 MW installed capacity (at the generator). The turbine axis is defined at the elevation 1054.0 m according to the requirements to prevent cavitation at the turbine units.

The single-phase transformers (10 units) are arranged in a narrower and longer cavern located nearby the main powerhouse cavern (machine hall).

For access to the powerhouse cavern and further to the transformers/substation cavern a common access road and tunnel is envisaged.

The general arrangement of the base solution for the powerhouse and substation is presented in **Drawing 26**.

13.2 INTAKE

The power intake was arranged on the left bank, as close as possible to the dam, in order to mitigate the suspended sediments entering the power circuit and obtain effective flushing of bed load that may accumulate in front of the intake.

In addition, the invert elevation of power intake was lifted as high as possible to meet the required submerged depth and sufficient daily flow regulation (more than 1 hour volume to provide a safety margin against unaccounted factors), as well as to promote the draw of the surface layer reservoir water containing less suspended sediments. Thus, the invert of the intake is placed at elevation 1271.00 m.

The total design flow of 154 m^3/s was considered for the powerhouse equipped with three (3) equal Francis turbines.

The power intake structure has four (4) bays divided by three (3) 2 m wide vertical piers with hydrodynamic shape in plan. Trash racks are arranged at the upstream section at a 75° angle. The two control gates in the passage are 8 m high and 4 m wide.

Downstream of the gate control section, a transition of 25 m tunnel length (around 3D) is ensured to the headrace tunnel current cross section.

Figure 13.1 shows the schematic layout proposed for the water intake structure.

The hydraulic design of the power intake is presented in **Annex VII – Hydraulic Design**.

The intake structure will have four inclined trash racks, with an automatic trash rack cleaner installed in the upper platform. Downstream of the entrance, and immediately before the convergence to the headrace current section, there will be two groups of gates to isolate the power circuit when needed: one to close with passing flow and the others to protect the first. The downstream gates will have air vent ducts installed immediately downstream.

The definition of the power intake is presented in **Drawing 15**.

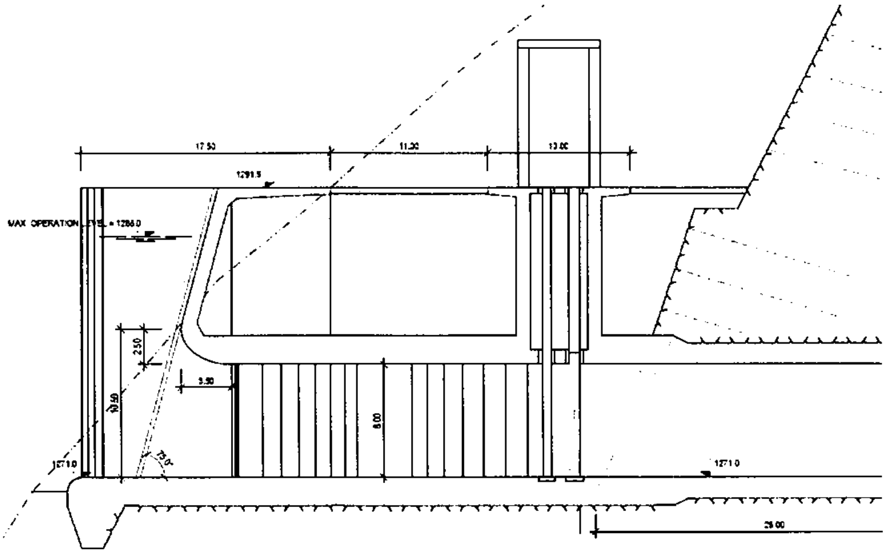

Figure 13.1 – Proposed layout for the power intake

13.3 HEADRACE TUNNEL

The headrace tunnel is implanted on the left bank of the Kunhar River, considering a single-tunnel arrangement. The tunnel general alignment was defined following the FS2013, generally parallel to the river alignment. However, it was subject to some adjustments due to the modification of the power intake location, as well with the objective of optimizing the cover depths.

The starting point of headrace tunnel is connected with the end of the power intake, and the end of the headrace tunnel connects to the surge shaft above, and vertical curve to the pressure shaft downstream. Consequently, the invert elevation at the starting point of the tunnel is 1271.00 m. At the surge shaft the headrace tunnel axis is set at elevation 1220.00 m. The referred elevation was defined based on the maximum downsurge level estimate, which must be confirmed in subsequent stages of the design.

The length of the headrace tunnel from the intake transition to the section transition after the upstream surge shaft is 9120 m. The tunnel has a constant downward slope of 0.56%. The slope of the headrace tunnel is not required to be constant and may be adjusted for construction purposes, although hydraulic conditions that always assure pressure flow must be observed. The tunnel has a current section of 8 m internal diameter along its length and will be fully concrete lined.

The construction of the tunnel is envisaged to be performed with traditional excavation methods. Hence, three adits are projected to allow swift progress with 6 work fronts.

The alignment, layout and cross-sections of the headrace tunnel are presented in **Drawings 23** and **24**.

13.4 UPSTREAM SURGE SHAFT

The upstream surge shaft is a circular concrete lined structure with 14,5 m internal diameter. The general definition of the surge shaft for is presented in **Drawing 25**. The structure height is about 122 m, from the top of the headrace section to the top of the crown.

13.5 PRESSURE SHAFT/TUNNEL AND PENSTOCK

Ahead of the upstream surge shaft, a transition to the pressure tunnel is arranged. The pressure tunnel has a total length around 200 m and includes two vertical curves and a vertical shaft. The upper curve has a 30 m radius and 47 m development, the vertical shaft a 117 m extension and the lower vertical curve a 20 m radius and 31 m length. A steel lining circular section of 5.6 m internal diameter is considered.

At the end of the pressure tunnel (penstock), three manifolds consecutively branch off the penstock at an angle of around 50°. The manifold is arranged for the tri-furcating the 5.6 m diameter steel lined penstock into three 3.2 m diameter conduits that are connected with safety spherical valves and further leading to the turbines.

The general definition of the pressure shaft/tunnel is presented in **Drawing 25**.

13.6 POWERHOUSE

The proposed underground powerhouse is composed of conventional cavern structures for three identical Francis units with vertical axis and for the power transformers and GIS equipment.

Within the powerhouse main cavern, the inlet spherical valve is envisaged immediately upstream of each turbine unit. After passing through the turbines, the water is discharged via the draft tube extension into a common tailrace tunnel and from there to the tailrace outlet portal. The general plan arrangement of the powerhouse complex is depicted in the following figure.

The main access to the powerhouse underground complex is done through an approximately 620 m long tunnel that, along most of its length, will also accommodate ventilation conduits and power cables. The tunnel will branch to a secondary tunnel for access to the exterior switchyard platform. The access tunnel current section is rectangular 7 m wide (interior) on the lower part, for vehicle circulation, and crowned at the top with 4.7 m clear height.

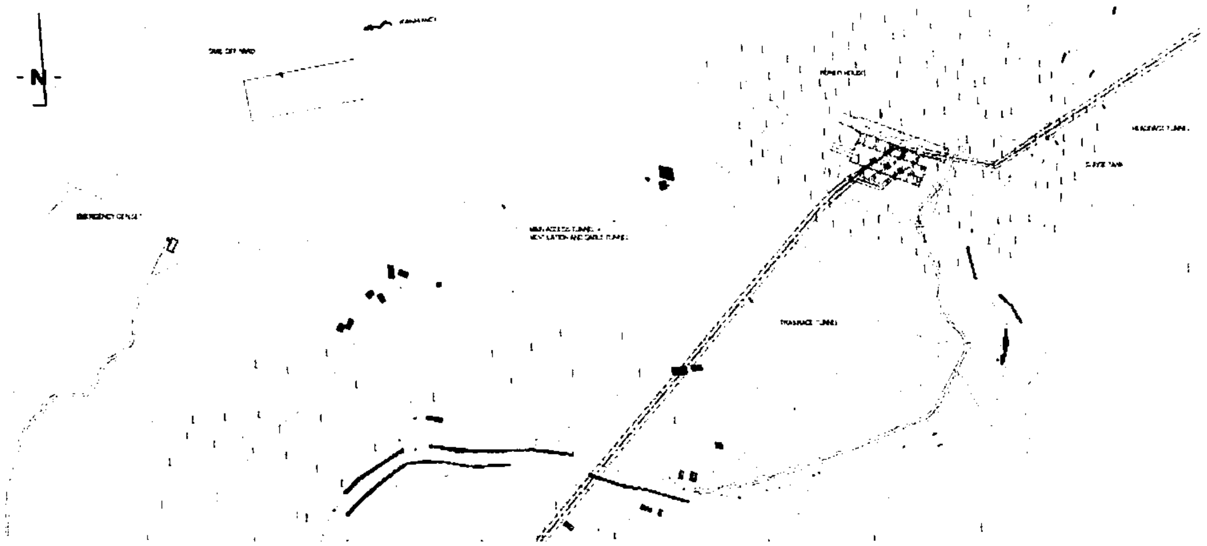

Figure 13.2 – Powerhouse complex plan view

The turbines' axis is defined according to the estimated requirements to prevent cavitation at the turbine units at elevation 1054.00 m[15]. The distance between the turbine units centre lines is about 14 m. The tentative (excavated) dimensions of the powerhouse main cavern are as follows:

- Width: 20.0 m;
- Length: 71.0 m above machine floor; 57.4 m at generator and turbine floor;
- Height: 34.0 m.

The cover depth of the underground power house is approximately 230 m.

The single phase transformers are arranged in a smaller cavern next to the main powerhouse cavern (machines hall). The transformers cavern is approximately 14 m wide, 15 m high and 88 m long (excavated dimensions).

The general plan and definition of the powerhouse is presented in **Drawings 26** and **27**.

13.7 DOWNSTREAM SURGE SHAFT

The downstream surge shaft is a circular concrete lined structure with 3 m internal diameter. The general definition of this surge shaft is included in **Drawing 27**. The structure height is 244 m, from the top of the tailrace section to the top open air section. The main function of the downstream surge shaft is to allow aeration of the tailrace tunnel in the case of transient originated sub-atmospheric pressures.

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[15] The definitive turbine axis elevation must be confirmed by the turbine supplier.

13.8 SWITCHYARD

The external switchyard (take-off yard) is projected to be arranged in a excavated/embankment structure to be built on the left bank of the Kunhar River, about 1500 m upstream of the tailrace outlet portal. The platform will be built in a wider area of the river valley, keeping the upper area above the flood levels and considering and adequate freeboard. The access to the switchyard platform will be done through the powerhouse main access tunnel with a 150 m secondary tunnel. The design of the take-off yard, including the confirmation of the engineering and economic suitability of the proposed solution, shall be done during the EPC design stage.

13.9 TAILRACE

A tailrace structure is envisaged to convey the turbine discharge to the outlet structure on the left bank of the Kunhar River. The tailrace structure consists of the tailrace tunnel itself, a well for stoplogs and a tailrace outlet.

From its starting point to the portal of the outlet structure, the length of the concrete lined headrace tunnel is approximately 1570 m. The invert elevation at the starting point of the tailrace tunnel is set at 1036.00 m. The tunnel has a current ascending gradient of 0.23%, except in the final 50 m where this gradient is 15%.

The proposed tunnel section is circular in the interior, with 8 m diameter, and similar to the headrace section. The final part has an archway section (approximately 50 m) starting at the stoplog well.

The tailrace tunnel can be isolated from the river level for inspection or maintenance with the stoplogs to be operated from the stoplog well. To that end, the tailrace must be emptied through the dedicated dewatering system (pumping station) to be installed in the powerhouse.

The general definition of the tailrace is presented in **Drawings 29** to **31**.

14 HYDROMECHANICAL AND ELECTROMECHANICAL EQUIPMENT

14.1 GENERAL CONSIDERATIONS

The hydromechanical equipment mainly encompasses the racks, gates and stoplogs. The conduits/tunnels steel blinding is considered in the civil works components (in the scope of the Report, not necessarily for supply purposes). The electromechanical equipment includes the turbines, cranes, lifting beams, turbidity/sediment measurement installations and the powerhouse auxiliary mechanical equipment. The group's generators are considered in the electrical equipment. The present chapter also includes a description of the chief auxiliary systems of the powerhouse complex. The detailed description of the hydromechanical and electromechanical equipment, including its functional requirements, as well as design and construction requirements, is included in the **Annex IX – Hydromechanical and Electromechanical equipment**.

Parts of the text presented under the current chapter and in Annex IX may have been collected from the FS2013 with due permission from PEDO, notwithstanding possible and necessary adjustments.

14.2 HYDROMECHANICAL EQUIPMENT

Different type of gates will be used at various structures of the hydropower scheme. Their locations in the project, provision purpose, operation procedure, specifications, installation elevations, and control mechanisms are described as under:

- upper spillway gates;
- power tunnel intake gates;
- bulkhead gates;
- sediment by-pass tunnel intake gates;
- low level outlet gates;
- stoplogs;
- trash racks;
- draft tube gates;
- tailrace outlet gate.

ASTM A-36 or ASTM A572 Gr.50 structural steel is recommended for the fabrication of the different gates of the project with the designed thickness for various gates, stoplogs and trash racks. The following section depicts the key features of the main hydromechanical equipment / hydraulic steel structures.

14.2.1 Upper Spillway Gates

Type	surface radial gate
Quantity of gates	3
Clear width of radial gate	11.00 m
Clear height	10.00 m
Sill elevation	aprox. 1277.00 m a.s.l.
Maximum water level	1288.00 m a.s.l.
Operating platform level	1292.00 m a.s.l.
Operation conditions	full differential head
Operating equipment	two single action hydraulic cylinders

14.2.2 Low level gated spillway / Bottom outlet gates

Type	fixed wheel gate
Quantity of gates	2
Clear width	6.00 m
Clear height	8.00 m
Sill elevation	1258.00 m a.s.l.
Maximum water level	1288.00 m a.s.l.
Operating platform level	1292.00 m a.s.l.
Maximum water head	30.0 m
Operation conditions	full differential head
Operating equipment	single action hydraulic cylinders

14.2.3 Radial gate of the Sediment by-pass tunnel

Type	radial gate
Quantity of gates	1
Clear width of radial gate	7.50 m

Clear height	4.50 m
Sill elevation	1261.00 m a.s.l.
Maximum water level	1288.00 m a.s.l.
Operating platform level	1292.00 m a.s.l.
Operation conditions	full differential head
Operating equipment	two single action hydraulic cylinders

14.2.4 Sluice Gate

Type	sliding gate
Quantity of gates	1
Number of gate sections	2
Clear width	7.50 m
Clear height	4.50 m
Sill elevation	1261.00 m a.s.l.
Maximum water level	1288.00 m a.s.l.
Operating platform level	1292.00 m a.s.l.
Maximum water head	27.0 m
Operating conditions	still waters
Lifting device	gantry crane

14.2.5 Trash Racks

Type	removable type panels
Quantity of trash racks	4
Width of opening	8.00 m
Height of opening	aprox. 11.5 m
Sill elevation	1271.00 m a.s.l.
Maximum water level	1288.00 m a.s.l.
Operating platform level	1292.00 m a.s.l.
Design differential head	3.0 m
Lifting device	mobile crane

14.2.6 Bulkhead Gate

Type	Sliding
Quantity of Bulkhead gates	1
Number of Bulkhead gate sections	3
Number of embedded parts	2
Clear width	4.00 m
Clear height	8.00 m
Sill elevation	1271.00 m a.s.l.
Maximum water level	1288.00 m a.s.l.
Operation platform level	1292.00 m a.s.l.
Maximum water head	17.0 m
Operating conditions	still waters
Lifting device	gantry crane

14.2.7 Power Intake Gates

Type	fixed wheel gate
Quantity of gates	2
Clear width	4.00 m
Clear height	8.00 m
Sill elevation	1271.00 m a.s.l.
Maximum water level	1288.00 m a.s.l.
Operation platform level	1292.00 m a.s.l.
Maximum water head	17.0 m
Operation conditions	full differential head
Operating equipment	single action hydraulic cylinder

14.2.8 Tailrace Stoplogs

Type	Sliding
Quantity of Stoplogs	2
Number of Stoplog sections	3
Number of embedded parts	2
Clear width	3.25 m
Clear height	8.00 m
Sill elevation	1052.45 m a.s.l.
Maximum water level	1065.0 m a.s.l.
Operation platform level	1087.20 m a.s.l.
Maximum water head	12.55 m
Operating conditions	still waters
Lifting device	mobile crane

14.2.9 Draft Tube Gates

Type	fixed wheel gate
Quantity of gates	3
Clear width	3.00 m
Clear height	2.80 m
Sill elevation	1047.00 m a.s.l.
Maximum water level	1065.00 m a.s.l.
Operation platform level	1051.18 m a.s.l.
Maximum water head	18.0 m
Operation conditions	full differential head
Operating equipment	single action hydraulic cylinder

14.3 ELECTROMECHANICAL EQUIPMENT

14.3.1 Turbines

The Balakot HPP shall be equipped with three turbines, designed for the following main conditions:

Type	Francis
Axis	Vertical
Reference head	218 mwc
Unitary flowrate	51.3 m^3/s;
Reference synchronous speed	272,7 rpm
Power at shaft	103.2 MW

Each turbine will be equipped with an upstream Main Inlet Valve (MIV), spherical type, to isolate the turbine in idle operation conditions of the units.

The turbines shall be composed, essentially, by the following tailored fit components:

- Runner;
- Spiral case;
- Distributor with wicket gates and regulation rings;
- Machined Shaft, with flange connections;
- Guide bearing;
- Shaft seal;
- Draft tube;
- Individual speed governors, with electrical and hydraulic components, including HPUs;
- Individual lubrication sets;
- Individual water-cooling system.

The spherical valves shall be included in the scope of supply of the turbines, as far as its dismantling joint.

14.3.2 Overhead Cranes

It is foreseen the installation of two double girder overhead cranes in the powerhouse, in order to allow the assembly of the units in the erection stage of the powerplant and for O&M matters, in the exploration stage.

Each of these cranes shall present a reference capacity of 100 t in the main winch and a capacity of 8 t in the auxiliary winch.

In the transformers cavern it shall be installed one double girder overhead crane with two winches, main and auxiliary, with the reference capacities of 80/5 t.

All movement possibilities of the described cranes will be electrical commanded.

14.3.3 Trash Rack Cleaning Machine

It is considered, as base solution, the installation of a cable-driven trash rack cleaning machine of the moveable type in the power intake structure.

The machine will cover the four trash racks considered, moving itself in rails at the manoeuvring platform.

The command will be automatic, with operation with the detection of head losses in the trash racks or by predefined time cycles.

14.3.4 Turbidity/Sediment Measurement Systems

14.3.4.1 Turbidity

Turbidity is the amount of cloudiness in the water that can be caused by silt, sand and mud, bacteria and other germs, or even chemical precipitates. It is usually measured in nephelometric turbidity units (NTU).

Turbidity meters utilize a light and photo detector to measure light scatter. The required equipment must have features that help improve the quality of the data and extend the time between maintenance trips. It will be equipped with mechanical wipers or shutter technology that activate prior to a measurement and keep the sensor clear of interference.

14.3.4.2 Sediment measurement

Simple mechanical instruments are very attractive for sediment transport measurements in rivers because of their robustness and easy handling, particularly when used at isolated field sites.

In rivers with sand beds or coarser beds, where the suspended sediment load dominates the total load in transport *i.e.* in many developing country rivers, pump sampling is the most accurate of the available methods.

By sampling at a number of locations in the flow sediment concentration profiles can be determined, and the mean sediment concentration established.

14.4 AUXILIARY SYSTEMS

14.4.1 Compressed Air System

The powerhouse compressed air system will be common for all the units. Two groups of reciprocating multi-stage type compressors, driven by electric motors, will be provided to feed compressed air at the design pressure to the air receivers of different equipment.

Compressed air after passing through air-driers will be fed to the air receivers. These receivers will be connected through pressure reducing valves, with the governor air/oil pressure tanks, inlet valve operation system, switch yard, breaker system, etc.

Pressure of the air taken from the main air receiver will be to use in the service air system, to operate different pneumatic tools and to carry out repair and maintenance of the powerhouse equipment.

14.4.2 Governor Air System

A governor oil tank is provided with each generating unit. Compressed air at design pressure and volume will be supplied to each governor oil tank. The compressor storage tank will have a working air pressure above the governor oil tank air pressure. On completion of one operation of the unit, the governor oil tank will be recharged with pressurized air within the minimum possible time for next operation of the servomotors.

Same compressed air/oil system will also be utilized to open the inlet valve to start the generating unit.

14.4.3 Generator Air Brake System

Compressed air is provided to operate the generator brakes, to bring a running unit in standstill position. The air receiver will be fitted with moisture drain valve, pressure gauge, pipes with fitting and pressure relief valve.

An air drier of adequate design capacity will be installed on the suction side of both the sets of compressors to supply complete dry air to the generator brake system.

14.4.4 Service Air System

A low pressure compressed air system at 8 bars (approx.) is provided in the project to meet the maintenance of the plant, unit transformer firefighting system, and cleaning requirements in the powerhouse, switch yard and dam site, etc.

This system will also work for various other functions *i.e.* to operate the inflatable turbine maintenance shaft seal, replenish the generator brake air receiver, changeover of automatic cooling water strainers with fixed interval of time, and actuation of air operated valves of different auxiliaries system of the powerhouse.

14.4.5 Cooling water system

The cooling water system will be common for all the units. The cooling system water will be taken from the penstocks upstream to the inlet valve of all the three turbines. All the three pipes taken from the penstocks of the units will be connected to a common header, through isolating valves.

The major parts of the machine requiring cooling through cooling water system are: unit transformers oil coolers, turbine guide bearing oil coolers, generator bearing oil coolers, and generator air coolers. The cooling water will also be supplied to the turbine shaft seals.

The cooling water system is designed as an open circuit system. The water taken from the common header, after passing through the required equipment to be cooled, will drain into the tailrace.

In case of non-availability of water from the penstock pipes, two water tanks of 50 m^3 capacity each will be provided at higher elevation than the powerhouse top level to ensure an interrupted gravity flow water supply to different water coolers of the unit before stoppage of machine, in case of emergency.

In case of prolonged shut down of the power plant, water for the storage tanks will be taken from the tailrace.

14.4.6 Service Water System

Service water system is required in the powerhouse to supply the coolers of the air compressors (if not air cooled), the fire extinguishing of the unit transformers. It will also supply, the powerhouse, the switchyard, etc., for cooling purpose of the space, other than the offices and control room, during summer season.

Service water supply will be common for all the units. To ensure the availability of water all the time, particularly for firefighting, the service water will be tapped from the penstock, upstream of the inlet valves of all the turbines through pipes.

14.4.7 Potable Water System

Potable water is required for drinking purpose. The drinking water line will be taken from the cooling water common header. It will be processed through different types of strainers for the purpose of filtration. On the last stage, the water will be processed through chlorination for the elimination of bacteria with the help of automatic timer controlled dropper machine.

A potable water storage tank is to be provided for the purpose within the powerhouse. Compressed air from the powerhouse service air system will be provided from the top of the water tank at design pressure to feed potable water within the entire powerhouse building up to top floor and the switchyard.

14.4.8 Unit Dewatering System

For the inspection and maintenance of the underwater parts of the turbine the water inside the machine will be allowed to drain from the scroll case through gravity flow into the tailrace up to the tailrace level.

The draft tube gates will be lowered to the sill level with the confirmation, that sealing system of the draft tube gates is working satisfactorily. The unit drain valve installed downstream of the inlet valve will be opened to drain the water from the unit to the dewatering tanks.

Four submersible type dewatering pumps will be installed in the dewatering tank to pump the water from the tank to the tailrace.

14.4.9 Station Drainage System

The station drainage system is designed to collect waste water through drains, which leads the water to the powerhouse drainage sumps. The waste water is collected from different sources *i.e.* leakage from plant cooling equipment, washing of floors and machines, seepage from tunnel, leakage from valves and the turbine shaft seals.

All the waste water coming from these sources will be collected in the sump tanks provided in the basement of the power station. Four submersible pumps will be installed in the sump tanks, which will discharge water from the storage tank to the exterior.

14.4.10 Tailrace Dewatering System

The tailrace tunnel dewatering circuit will essentially consist of an access tunnel, a collection pit for submersible pumps installation and an elevate conduit with hydraulic protection vessels. The admission to the pit, originating from the initial zone of the tailrace tunnel, shall be closed by a sectioning gate.

The pumps will be bore type for direct installation in the suction pit. Its capacity should be such as to ensure that the tailrace tunnel will be emptied within a period not exceeding six days. The pumps motors will be supplied from a dedicated MV/LV transformer station installed in the pit submersible pumps access tunnel.

The pumped water will be conveyed to the Kunhar river through the drainage tunnel, connected to the powerhouse access tunnel.

14.4.11 Firefighting System

The firefighting system of the powerhouse will consist of fire alarm system fitted with thermal and smoke detectors. Auto, argonite or FM200, gas fire extinguishing system for the generators, auto water sprinklers system for the unit transformers, fire hose system with pressurized water fitted with pressure nozzles at different fire points within the powerhouse to extinguish the fire in offices, site stores, and open area.

Portable and trolley mounted argonite, FM200 gas fire extinguishers, trolley mounted type ABC (filled with mono ammonium phosphate, yellow chemical dry powder) fire extinguishers, fire beaters, sand and water filled buckets, and pressurized water filled cylinders, will be kept at different floors in the required number at different fire points, at appropriate distance from each other within the power house.

Important locations to protect from the fire like, battery room, diesel generator room, diesel storage room, cable gallery, relay room, generator exciter room, main control room etc. must be provided with fire points.

Water for firefighting will be taken from the service water line of the powerhouse. During the shutdown of the powerhouse and non-availability of water in continuous supply from the penstocks, two 50 m^3 water tanks will be placed at a higher elevation than the top level of the caverns to ensure gravity water supply in case of fire.

A set of water pumping stations with standby arrangement will be provided, to pump the tailrace water to the storage tanks in case of prolonged shut down of the powerhouse.

The fire extinguishing system for the generators comprises the designed number of aragonite or FM200 gas filled cylinders and its auto operation through auto sensing fire/smoke detectors.

For the unit transformers fire extinguishing system, water will be taken from the service water system through the firefighting line. A separate water header will be provided for the same purpose, which will remain pressurized at the design pressure all the time.

Deluge valve system will be provided to extinguish the fire of the unit transformers, with the design number of sprinkle nozzles installed over each unit transformer.

Fire points will be provided at different floors and locations within the powerhouse. The fire points will be equipped with flexible convey pipes with stand-by lengths fitted with brass push type connectors to extinguish the fire at any location inside the building.

14.4.12 HVAC System

Heating, ventilation and air conditioning system of the powerhouse, during summer and winter is provided for healthy and comfortable working conditions of men and machinery.

Two air cooling water chillers (one on-line and the other stand-by) will be installed in the powerhouse at the turbine floor. The coolers will be fitted with heavy duty air blower to throw fresh air across the copper pipes, fitted inside the condensers. The cooling water supply to the chillers will be arranged from the service water line in the open circuit.

The cold air will be led through insulated ducts to the generator hall, turbine floors, loading bay, workshop, side rooms; corridors etc., and circulate through different openings within the powerhouse building.

The hot air of the generator hall coming out from all the running generators and other sources, will be taken out during the summer season with the help of heavy duty exhaust fans fitted at the top of the generator hall.

In addition to water chillers cooled air supply, fresh air will also be arranged to circulate into the powerhouse at different floors, to maintain the generator hall temperature at an acceptable level.

Design criteria for the ventilating and air conditioning system shall be according to American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

14.4.13 Lubrication Oil Treatment System

Lubrication oil treatment/handling system will consist of storage tanks fitted with the pumps and pipes installed between the oil storage room, machine hall and the turbine floor.

A mobile oil purification plant will be provided in the powerhouse to filter the oil and eliminate the moisture from the oil before filling the governor oil tanks up to the design level.

14.4.14 Passenger Lift

The powerhouse will have two permanently installed passenger lifts to provide fast access and transport to the staff, including shifting of petty equipment to all the floors. The lifts will have a loading capacity of at least 1000 kg each, and a speed of 45 m per minute.

The lifts can be installed and used during the powerhouse construction.

Lift operation will be automatic and of the selective type with one selection button in the car for each landing to be served.

A lift machinery room will be provided above the top landing. Space will be provided in the room for a power supply cabinet, lift control cabinet and for routine inspection and maintenance activities.

14.4.15 Workshop

Balakot powerhouse will be located in a completely remote area. During the operation of the powerhouse, a complete and independent mechanical workshop in all respects with various kinds of tools and plant will be required to carry out routine maintenance, emergency repair, annual maintenance and overhauling of the turbines, generators and their associated parts.

All sorts of general and special tools and equipment will be kept in the workshop store in surplus as stand-by to avoid any stoppage of work due to the non-availability of tools during the work.

An overhead bridge crane will be provided in the workshop to load/unload the jobs on the machines.

15 ELECTRICAL EQUIPMENT

15.1 GENERAL

The main electrical installations for the cavern type 300 MW (with 10% overload max. 330 MW) Balakot Hydropower Project comprise three vertical shaft synchronous generators coupled to the respective Francis reaction type turbines, generator circuit breakers, generator isolated phase bus, bank of three single phase unit step-up transformers, 500 kV Gas Insulated lines to transfer power from the transformers to the 500 kV GIS switchyard and from GIS switchyard to 500 kV overhead transmission lines.

The control room will be equipped with the Plant Control System (PCS) for control and supervision of the plant. Local computerized control units inside the powerhouse complex and the intake will perform all the local automatic functions and be connected to the station computer by a fiber optic bus system.

Auxiliary power systems and safety installation will have adequate duplicate systems in order to provide high operational reliability and personnel safety. All equipment and systems will be in accordance with state-of-the-art technology and proven reliability, as recorded from actual service standards.

During the feasibility stage, all electrical equipment and systems have been designed in accordance with the latest editions and amendments of codes and standards of the following Institutions:

a)	IEC	International Electrotechnical Commission
b)	DIN	*Deutsches Institut fur Normung*
c)	ASTM	American Society for Testing and Materials
d)	ANSI	American National Standards Institute
e)	NEMA	National Electrical Manufacturers Association
f)	ASME	American Society of Mechanical Engineers
g)	IEEE	Institute of Electrical and Electronics Engineers
h)	ICEA	Insulated Cable Engineers Association
i)	AWS	American Welding Society
j)	NFPA	National Fire Protection Association
k)	PETSAC-2014	Pakistan Electric and Telecom Safety Code

The available relevant Pakistani standards and codes have also been considered, and incorporated wherever necessary.

Parts of the text presented under the current chapter may have been collected from the FS2013 with due permission from PEDO, notwithstanding possible and necessary adjustments.

15.1.1 Voltage Consideration

The IEC standard defines the following voltage classes:

a) low voltages are used to supply utilization equipment and are 1 kV or less;

b) medium voltages are used as the primary distribution voltages to be used to feed the primary windings of the step-down transformers to provide low-voltage systems. These voltages are greater than 1 kV but less than 36 kV;

c) high voltages are used to transmit electrical power between transmission substations and are all voltages from 36 kV to 230 kV; and

d) extra high voltages are used to transmit large quantity of electrical power between transmission substations and are all voltages above 230 kV.

15.1.2 DC Source Requirements for Control

The following DC systems have been studied and recommended:

a) For protection, control and DC operating mechanism of motors, 110 V DC shall be considered 110 V DC is secure, safe and equipment is easily available. The power supply to the power station DC auxiliaries, 500 kV switch yards control and protection for DC motors shall be provided from a set of 110 V DC main volt connected to two sets of batteries and batteries charges. Nominal:

   110 V DC Voltage:

   110 V DC +20%, - 20%;

b) For power line carrier (PLC) communication systems: two sets of 48V DC batteries system along with batteries charges Nominal, 48V DC

   Voltage: 48V DC +10%, - 10%; and

c) For instrumentation from two sets of AC / DC converters: 24V DC.

15.1.3 AC Source Requirements

Electrical equipment will be designed for continuous operation from the powerhouse auxiliary power supplies within the following limits:

Nominal: 400/230 V AC

Voltage: 400 V (3-phase) or 230 V (1-phase), +10%, -15%

Frequency: 50 Hz, +5%, -5%

15.1.4 Protection and Coordination Philosophy

The primary objectives of the electrical system protection and co-ordination are to prevent injury to personnel, to minimize damage to the system components and to limit the extent and duration of the outages that result from operation of the system protective devices. The protection is achieved with the help of detection devices like relays, and instruments, and interruption devices like fuses and circuit breakers.

Co-ordination philosophy shall be followed by NTDC system requirements for equipment failure and fault clearance and hence set each protective device so as to minimize the portion of the electrical system affected by a fault. Therefore, the system design is to fulfil the following requirements:

a) When operating properly, only the primary protective device nearest to the fault in the supply direction must respond;

b) If this device fails, the backup device next to it in the direction of power flow will respond; and

c) Routine current spikes must not cause disconnection.

15.1.5 Equipment Location

The electrical equipment has been specified and selected so that it is suitable for the location where it is to be installed. Placement of all electrical equipment shall have a proper safe clearance especially when there will be extra high voltage in a confined space. Both the basic design of the equipment and requirements of the IEC have been taken into account when locating electrical equipment.

Major electrical equipment locations such as transformers, switchgear assemblies, switchboards, and motor control centers have been planned in dedicated rooms, buildings or other areas. Installation of smaller equipment such as individual motor starters and panel boards has been recommended in spaces that are ventilated and dry. All equipment rated above 600 volts, except pad-mounted transformers and metal enclosed outdoor switchgear assemblies, have been located in dedicated spaces that are only accessible to qualified persons. Rooms containing motor control centers will be ventilated and not air-conditioned.

Being a cavern type power plant, the emergency DG set is recommended outside the cavern at some suitable place for avoidance of any fumes, smoke and explosive fuel.

15.1.6 Equipment Enclosures

Electrical equipment enclosures have been specified so that they are designed for the conditions to which they are going to be subjected to when installed as defined by IEC-60529.

Indoor enclosures will provide the Ingress Protection (IP) degree, as published by IEC, not less than IP 44 and outdoor enclosures will provide the ingress protection degree not less than IP 54.

15.1.7 Color Codes

Color codes are in accordance with the general application of the latest revision of IEC Standards-60445.

15.1.8 Name Plates and Markings

All major equipment when provided for installation will have a securely fastened corrosion resistant name plate showing the manufacturer's name, model and serial number, year of manufacture, main characteristic data of the respective equipment as specified in the applicable standards or necessary for proper identification of the equipment involved.

All the name plates and markings are both in the English as well as in Urdu language.

15.2 GENERATORS

15.2.1 General Description

Three (03) generators of 100 MW each shall be air cooled, vertical shaft three phase synchronous generators coupled to Francis turbines. A generator design using direct water cooling is not acceptable. The generator shall be suitable for direct couple to Francis type vertical shaft turbine.

The generator design is governed by the turbine output and stability requirements. The generators, excitation equipment and auxiliaries shall be designed, constructed and tested in accordance with applicable IEC standards unless otherwise stated there in. All parts of the generators and the collection thereto shall be design to withstand the mechanical and electrical forces due to a rated voltage three phase short circuit at generator terminals, without in accruing any damage.

Each generator shall be furnished as follows.

- The one generator included stator with frame.
- A rotor.
- One generator guide bearing.
- One generator thrust bearing.
- Generator will have one combined thrust bearing and guide bearing.
- One generator rotor shaft.
- Excitation and voltage regulation system.
- MV terminal box for terminal connection.
- Permanent magnet generator for measuring rotation speed for governor.
- One generator neutral grounding transformer along with shunt resistor.
- Turbine generator, shaft shall be designed in order that the first critical speed of the shaft shell be greater than 1.5 times the over speed. The generator and the guide bearings shall be bolted on a base plat anchored on a concrete.

The following main data are proposed for each of the three identical units.

15.2.2 Main Data

Standards and Characteristics:

Applicable standard	IEC 60034
Generator Rating	120 MVA (with 10% overload max. 132 MVA)
Generator Rated Output	100 MW (with 10% overload max. 110 MW)
Rated Voltage/Max	18kV
Power Factor	0.85 lagging, 0.9 leading
Max. Ambient Temperature	45 degree
Min. ambient Temperature	-10 degree
Altitude	1500 m

Insulation class	Stator/rotor/excitation/F/F/F
Temperature Rise Class	Stator/Rotor/Excitation/B/B/B
Ingress Protection	IP23
Cooling system	Air-cooled
Type Of Rotor	Cylindrical + Laminated Damping
Rated Speed	333.3 RPM
Runaway Speed	559 RPM
Frequency	50 Hz
No. of Poles	18
Coupling type	Direct
Lubrication	Oil self-lubrication
Terminal Box	18 kV (Design Voltage)
Number of Units	3

15.2.3 Weight of Generator

The weight of the different parts of the generator and total weight are estimated as under:

Weight of Rotor	194 Tons
Weight of Stator	109 Tons
Total Weight of generator	353 Tons

The weights have been calculated by the following formula:

$$W = (N/400)-0.4 \text{ x } (p/37.5)0.8 \text{ x } K \qquad (4)$$

where:

W, weight in Tons

N, synchronous Speed

P, power in MW

K =

for Rotor	80
for Stator	45
for Total Weight	146

(Ref: Hydropower Development Course - GTZ)

15.2.4 Stator and Rotor Winding

The welded steel stator frame will be split into the fewest number of segments consistent with the shipping limitation. The stator will be designed to withstand the mechanical forces during operation. The frame will be provided with structural features for supporting and clamping of the stator core. The stator is to be erected on its own foundations, the diameter being such that access to the turbine will not be restricted.

The stator core will consist of thin high grade non-ageing silicon steel segments. Each segment will have a heat resisting insulating varnish to prevent eddy current losses. Radial ventilation ducts are to be provided at intervals by means of steel sheets with spacing strips. Care will be required in the fixing arrangement for the core to ensure satisfactory performance.

The stator winding must have anti flash discharge protection. The stator winding shall have high conduction copper typical in the range of 99.99% pure and divided into elementary conductors so that additional losses at the level of slot should be negligible. The inlet of different phases shall be concentrated in terminal box and neutral of the generator shall also be brought into the terminal box.

The stator winding will have class “F” insulation and the winding is to be star connected. The neutral of the generator shall be grounded through grounding transformer along with shunt resistor. The maximum allowable temperature rise shall be limited to class B temperature rise for stator coil insulation.

15.2.5 Shaft, Rotor and Rotor Windings

The shaft will be made of forged steel and machined to specified specifications. The rotor shaft shall have enough strength and rigidity to operate safely at any speed up to run away speed without detrimental vibration or objectionable deformation.

The rotor rim will be built of magnetic steel plates. The rotor poles made of magnetic punching will be clamped between steel end pieces by means of through bolts.

Each pole will be equipped with a damping winding made of copper rods inserted in the semi closed slots in the periphery of the pole. The rods are brazed together at both ends, and all poles are connected together to form a continuous “cage winding”.

The field coils consist of copper bars brazed together to form a rectangle coil conforming to the shape of the pole core. The field coil shall be wound with flat copper wires and shall be thermoset into an integral part indefinite shape after epoxy glass plates are set between turns so that it can withstand centrifugal force during runaway speed.

Each turn is to be insulated by “class F” insulation. The coil will be insulated against the pole core by glass fiber fabric integrated in polyester or similar material. The maximum allowable temperature rise shall be limited to class B temperature rise for rotor coil insulation. Axial flow fans shall be installed for cooled air circulation. The air circuit shall start from air cooler, to rotor winding, then enter into stator core and back to air coolers. The hot air shall enter into the air cooler by means of outlet into bottom of air cooler.

15.2.6 Bearings

The generator will have one combined thrust bearing and guide bearing located above the rotor and one guide bearing below the rotor. The thrust bearing will be designed to carry the combined weight of the generator, rotor, shaft and turbine runner, as well as hydraulic thrust during operation. The upper guide bearing is considered essential to ensure that the rotor operates smoothly under all design conditions (short circuit, hydraulic transient, etc.) and is properly supported to withstand the seismic forces.

15.2.7 Bearing Lubricating Oil

Each bearing will have lubricating oil bath in its housing. The circulating oil path shall be smooth enough for cooling and lubrication. The bearing will be immersed in the oil and so arranged that lubrication of the bearing surface will not be dependent on any external oil pumps and system. The type of oil (preferably biodegradable) will be the same as used for the turbine bearing and the governor oil system, thus simplifying operation and maintenance. Oil cooler will be provided for each bearing oil reservoir. The coolers will be mounted external to the oil reservoir and preferably will be mounted outside the generator housing. If pumps are required, a fully redundant system and all motor starting control and protective equipment need to be furnished. The cooling water will be drawn from the unit cooling water system. Means will be provided to detect presence of water in the lubricating oil. A glass observing hole shall be provided for oil conditions on bearing covers. Oil quantity and pressure shall be regulated through a magnetic operated throttle valve connected to the pipe lines and pressure gauges.

15.2.8 Slip Rings on Upper Part of Generator Shaft

The slip ring compartment will be located on the upper part of the generator shaft. The slip ring assembly will be designed for self-cooling by air drawn from the machine hall. An arrangement for collection of carbon dust from the brushes is foreseen and will be provided.

15.2.9 High Pressure Oil System

The thrust bearing pads will be provided with high pressure oil system to force a film of oil across the bearing surface for starting and stopping the unit so as to reduce wear on the Babbitt-metal (an alloy of tin, copper and antimony) coated segments.

A complete high pressure oil system including an AC motor driven pump will be installed for the thrust bearing of each generator. A standby DC pump will also be provided invariably, which will operate automatically in case of failure of the AC pump. The high pressure oil system pumps and control system will be located outside the generator housing. The check valves provided in the oil line to the individual thrust bearing pads will also be installed outside the bearing housing. The oil will be drawn from the thrust bearing housing.

15.2.10 Brake and Lifting System

A set of brake jacks having non-asbestos lining will be provided for each generator. These will be located below the rotor and will act on a brake ring attached to the underside of the rotor rim. During braking, the brake jacks will be actuated by air pressure supplied from the compressor unit. The brakes will be designed to operate between preset speed limits. The braking system will be suitable for automatic and manual control from the Local Control Unit and Unit Local Control Panel. Provision will also be made for jacking up the rotating parts to allow thrust bearing pads to be inspected and maintained. The jacks can be locked on the upper position by locking pins or spacers. The hydraulic system for this purpose will be combined with the brakes. This will be under manual control but interlocked with the automatic sequence system and the brakes.

15.2.11 Cooling and Heating System

The generator to be air cooled and self-ventilated by axial or radial ventilation through the rotor itself has been planned to act as a fan. The air will be re-cooled by air / water heat exchanger situated outside the stator housing. The generator shall not be designed to use water directly for cooling purposes. Through this design, a closed air loop system inside the generator pit will be formed thus avoiding pollution through atmospheric impurities. The water-cooling system for the generator will be split into two independent systems:

a) one for the oil circuit for bearings of the generator and turbine; and

b) The second for the air / water cooling of the generator stator and step-up transformers.

Each generator will be provided with electrical stator heaters suitable for 400 V AC, three wire supply with a capacity and thermostatic setting to maintain a temperature inside the generator enclosure of 5°C above the powerhouse ambient temperature. The heaters will be switched on automatically whenever the machine is at standstill and controlled by the thermostat and switched off automatically when the machine will start. The provision will also be made for manual control of heaters to bypass automatic control whenever required.

Each generator will have a closed air cooling system with air/water heat exchangers evenly spaced around the circumference of the stator frame. The air temperature after coolers shall not exceed 30 degree C and inlet design temperature of hot air will not increase beyond 35 degree °C. RTD will be the integral part for continuous measurement of hot air temperature. The cooling water will be drawn from the unit cooling water system. The pressure of cooling water will be in the range of 0.1 to 0.2 MPa.

15.2.12 Tests

1. Shop Tests: All test procedures shall be carried out in accordance with IEEE 11501 or IEEE Std 112 in continuation with IEEE Std. 118, 119 & 120.
2. Routine Tests: Routine tests on the generator shall be performed. Routine tests shall include:
   a) Resistance of armature and field windings.
   b) Polarity of field coils
   c) Check of mechanical balance
   d) Check of no-load field current or exciter field current.
   e) Voltage balance
   f) Phase sequence
   g) No-load saturation curve
   h) Insulation and high potential tests
   i) Over speed test at 125% speed for 1 minute
3. Type Tests: The generator shall have the following tests performed:
   a) Short circuit saturation curve.
   b) Temperature test.
   c) Stray Load Losses
   d) Core Loss

e) Stator and Rotor Winding Resistance Measurement.

f) Voltage deviation factor.

g) I^2R for Stator & Rotor.

h) Three phase line to line short circuit test at any convenient voltage in the 0.4 to 0.5 p.u. volts.

4. Characteristics Test Curves: Following completion of type tests, Manufacturer shall provide characteristics curves of the brushless excitation system. These curves shall show:

a) Exciter field amps and volts versus generator line current at 0.80 Pf. and maximum and minimum temperature rises.

b) Exciter field amps and volts versus generator line current at 1.0 Pf and maximum and minimum temperature rises.

c) As for (a) above, but with one diode failed.

The above six curves shall be plotted from no-load to maximum rated load at rated generator voltage. Following approval of curves by the Engineer, they shall be incorporated by the Manufacturer into the Emergency Diesel Generating Set Maintenance Manual.

15.2.13 Fire Protection System

Each generator will be provided a completely independent fire detection and protection system, capable of detecting and quenching any combustion occurring within the generator enclosure. The system will provide for total flooding of the enclosure with Argonite and maintaining the necessary Argonite concentration for at least 20 minutes after the first gas discharge. Fire detection equipment will comprise thermal and smoke detectors both within the generator and the generator enclosure.

Section **15.19** explains more on the fire detection and protection of the main Generators.

15.2.14 Transport Consideration

The large parts of the generators' assembly will be designed and manufactured keeping in view transportation weights and dimensions not exceeding the maximum transport limits. The height limit of any part of generator equipment shall not be increased beyond 5 meter including the height of trailer bed. Components exceeding these limits will be designed to enable assembly of the components at site.

Currently, Suki Kinari HPP is planning to transfer its large components to the site. The main hurdle is Balakot Bridge which can handle maximum 60 tons weight. The contractor is working to rehabilitate the existing bridge, which will be ultimately beneficial for the Balakot project. But still the maximum transportation weight and dimensions will be determined in the detailed design stage.

15.2.15 Protection Equipment

Separate relay protection cubicles comprising microprocessor based relays are assumed. The relays will preferable be of the same make (manufacture) to build a uniform modular system. The function of the protection relays will not depend on the control system. The relays are organized in two groups, so that one group provides back-up protection for the other.

The final selection of relays will be made during the detailed design phase. The main generator protection consists of:

a) Generator differential relay
b) Stator earth fault relay (95% stator winding protection)
c) Stator earth fault relay (100% stator winding protection)
d) Over-voltage relay
e) Minimum impedance relay
f) Reverse power relay
g) Negative sequence current relay
h) Loss of excitation relay (minimum reactance relay)
i) Rotor (field winding) earth fault relay
j) Turn to turn fault relay
k) Over-fluxing relay
l) Shaft current relay
m) Excitation transformer over current relay
n) Rotational speed relay
o) Circuit breaker failure relay (Generator CB)
p) Thermal protection
q) Mechanical protection
r) Lock out relay

The overall protection scheme shall have the following prominent features which will be incorporated in the design phase:

- The protection shall have the trip circuit supervision relay to confirm the trip circuit healthiness.

- The control circuit of the relays shall have voltage supervision relay to check the voltage source healthiness.
- The design of protection circuit will be in such a way that it must have a lock out relay for important protection like differential protection, stator earth fault protection etc.
- All the protection shown in the scheme must be ANSI coded and the relays suggested to be numerical type microprocessor based.
- The relays purposed to be low burden, fast reacting with multiple programmable type tripping and alarms contacts and fault clearing time will not be more than 60-80ms for stable system.
- The relays purposed to be plug type mounted on swing out frame for rapid replacement or shall have a mechanism for easy replacement.
- The protection scheme must have options for testing equipment connection and each relay must have test plug facility which has facility of shortening of circuit.
- It is also purposed that protection system must have Alarm, acknowledgement, and lamp test buttons.
- All current transformer (CT) and potential transformers (PT) will be specifically device for protection loss and where metering is required will be specifically used for metering purposes

15.2.16 Synchronous Control and Check System

The automatic synchronization equipment to be provided will be solid state and will include speed and voltage matchers, automatic synchronizer, synchro check device and any required accessories, suitable for mounting inside the designated main control switch board.

The synchronism verifier relay shall check the conditions of synchronism existing between two system voltages at the two terminals of each circuit breaker and close the respective circuit breaker when the voltages are within the set limits in phase and frequency. Also included shall be the feature that the relay will allow circuit breaker closure when one of the sources is de-energized. If the two systems are not in synchronism, then closing of the circuit breaker shall be blocked.

Each circuit breaker shall be provided with an independent synchronism check relay for manual closing *i.e.* closing through control switch on the remote control panel in the control room and through SCADA. Synchronism check for auto-reclosing shall be initiated by built-in function of distance relay to the circuit breakers of the respective transmission line feeder.

Status (On, Off) of the relevant disconnectors and circuit breakers shall be taken into account in the selection of the voltage transformers to be connected to the synchronism check relays and the synchronizing instruments so that the applied voltages to these devices will correspond to the system voltages that are actually present at the two terminals of the circuit breaker which is to be closed. The scheme shall ensure that the voltage transformers will not be paralleled at the secondary side.

The operating time of the relay shall be adjustable in the range 0 to 100 seconds. The relay shall have phase angle setting range of 5 to 80 degrees.

Synchronism-check relay shall have provision for the following conveniently selectable modes and combinations thereof: incoming system live, running system dead (live line, dead bus) Incoming system live, running system live (live line, live bus) Incoming system dead, running system live (dead line, live bus) Incoming system dead, running system dead (dead line, dead bus).

A three-position synchronism selector switch, marked with positions Auto / Off / Manual, shall be provided adjacent to each discrepancy type circuit breaker control switch on the remote control panel in the control room. Besides selecting the appropriate voltages and applying these to the synchronism check relay of the respective circuit breaker and the common synchronizing instruments, the selector switch shall activate the synchronism check scheme as follows:

Switch in Off position: No voltage applied to the respective synchronism check relay. No voltage applied to the common synchronizing instruments. Closing command to the circuit breaker is blocked.

Switch in Auto position: Voltages applied to the respective synchronism check relay and the common synchronizing instruments. Upon turning the circuit breaker control switch to command position, synchro-check scheme is activated. Circuit breaker control switch is released but the synchro-check scheme remains activated. The scheme remains activated until the circuit breaker closes and/or the selector switch is turned to Off position. If synchronism check is un-successful within an adjustable pre-set time an alarm is activated.

Switch in Manual position: Voltages applied to the respective synchronism check relay and the common synchronizing instruments. Upon turning the circuit breaker control switch to command position, synchro-check scheme is activated. Circuit breaker control switch is kept in the command position to keep the synchro-check scheme activated. The scheme remains activated until the circuit breaker closes and/or the selector switch is turned to Off position. If synchronism check is unsuccessful within an adjustable pre-set time, an alarm is activated.

Circuit breaker close command from SCADA shall bypass the synchronism selector switch but shall activate the synchro-check scheme as described for Auto position of the selector switch.

15.2.17 The MV Terminal

The MV terminal box is purposed to be designed and manufactured to include the following:

- A terminal casing secured by bolts to a box of frame, with interposition with and intermediate frame.
- A covered secured by the bolts to the casing.
- A seal to insure tightness between cover and casing and outlet weight for adoption of the stuffing box for the insulated bus duct.
- This plate shall be secured by screws on the casing.
- A grounding terminal.
- Three connection bars for phases and one for neutral along with insulator.

15.2.18 Tachometer

A permanent magnet generator is purposed to be provided for monitoring speed and detecting set values for stopping, synchronizing and over speed. The system shall include set of electronic module with 110 V DC supply. Wiring between permanent magnetic generator and module shall be shielded and grounded at the module.

15.2.19 Temperature Detector

The number of RTDs used for stator winding and bearing temperature measurements for each generator is purposed to be 12 for stator winding and 2 RTD's for each bearing.

15.3 EXCITATION SYSTEM

15.3.1 General Requirements

The excitation system will be of the static type. This system is fed from an excitation transformer supplied directly from the generator terminals, a thyristor converter, and field flashing circuit, de-excitation circuit, and field circuit breaker and over voltage protection. A solid-state automatic voltage regulator (AVR) with redundant controls will be provided to maintain maximum reliability. Local automatic, remote automatic and manual standby controls will be provided along with indications. The excitation output will be connected by cable to the generator slip rings through a field circuit breaker.

The excitation system is purposed to include all equipment necessary to fulfil the operational and functional requirement under all operating conditions of the generated units. The equipment will have to meet the following requirements:

- The equipment is designed for continuously rated at 110% of the excitation required for rated generated output at 105% rated voltage.
- The sealing excitation voltage shall be not less than 160% of the rated field voltage at class B rotor temperature rise.
- The excitation equipment will be designed to produce sealing exciting output couples to the rotor, for 5 second, following continuous operation at rated output, without exceeding component design temperatures.
- The nominal excitation response, as define in IEC 60034-3, will not be less than two per unit per second. The equipment is designed and protected so as to with stand short circuit across the direct current output terminal without permanent damage.
- The equipment is designed to maintain set point voltage under load rejection condition up to a nominal over speed trip setting of 130%.
- The equipment is designed to provide field flashing from 400 V oblige 230 volt AC auxiliaries supply system for excitation initiation during normal start-up and from the power plant 110 V DC batteries under “black start conditions”.
- The excitation system is designed to suppress the generator field under fault condition using thyristor inversion under automatic or manual control. The maximum induced rotor voltage shall be limited to prevent rotor inter turn damage.
- Design of the excitation system in such a way it is capable to limit the harmonic voltage distortion on the 18 kV bus to less than 5% and maintain voltage control at 70% of the rated voltage during a close up fault on 500 kv side of the plant service transformer.

The excitation system will consist of excitation cubical, voltage regulating equipment, and power supply and excitation transformer. Automatic voltage control will static, preferably of digital type and accomplished by continued comparison of average 3 phase voltage of the generator with a reliable and stable reference voltage source and measured difference of average generator terminal voltage from the reference shall be used for control purpose. The automatic voltage regulator (AVR) will continually respond quickly to correct any change in the generator voltage and maintain the generator terminal voltage under steady load conditions within a range of +5 and -5% without hunting. The AVR equipment shall be designed for remote control from the control room and will have the control of automatic control adjustment, control of MVAR adjustment, control of exciter field circuit breaker, and change over switching between automatic and manual mode. The AVR will have all necessary equipment and protective oblige alarm function.

It will also be designed to control the generator voltage manually from the control panel and automatic through AVR. The function for parallel operation of generators will be the part of the AVR system. The AVR adjusting function will have a range of voltage control from 10% below normal to 10% above normal with all usual standard features. Excitation shall be provided with follow up circuit with bump less switching from automatic to manual control and equipped with all usual standard feature.

15.3.2 Type of Thyristor Convertors

The converter shall comprise three phase bridge connected fully controlled thyristor. The unit is purposed to be rated to provide an excess capacity of not less than 100% of that required for max continuous excitation. The equipment shall withstand the maximum voltage raise on load rejection.

Thyristor is purposed to be forced air cooled. Filter air is to be circulated by fans and the cooling system is purposed with 100% duplicate circulating fans equipped with automatic change over and all necessary alarms and indications.

The minimum protection for each thyristor converter is purposed as follows:

- Thyristor over current protection. The overcurrent protection in the form of especially designed HRC fuses for each parallel circuit of all arms of the bridge shall be provided. The overcurrent protection will protect each thyristor in the event of an internal thyristor short circuit and a short circuit at the DC load. Fuse failure indication will be provided in the cubical.
- Thyristor over temperature alarm.
- First oblige 2nd thyristor failure alarm.
- Bridge arm failure alarm.
- Multiple thyristor failure trip.
- Voltage and current suppression. The max voltage surge to which any circuit may be subjected under any operating or fault condition shall not exceed 80% of the peak transient inverse rating of the thyristor.
- Transient over voltage protection.

15.3.2.1 Thyristor replacement

The thyristor replacement will not affect the current sharing and will be replaced in 15 minutes after a fault.

15.3.2.2 Firing circuit Control

The thyristor firing circuit will be taken from excitation supplied terminals. They must be designed so that stable voltage control is maintained under all normal and fault condition.

15.3.2.3 Converter Bus bars

Bus bars with phase isolating barriers will be designed to avoid the possibility of short circuit.

15.3.3 Field Suppression Equipment

A field suppression device in corporation a non-inductive de energizing resistors, with the field suppression switch, is suggested to be provided. This equipment will be mounted in a sheet steel cubical. The field switch will be a double pole air circuit breaker with arc chutes and will interrupt the max field current of the generator under all condition of services, including short circuit condition, without incurring damage which would require component maintenance. The field switch will be capable of operation by hand at field switch cubical. The nominal closing interrupting voltage will be 1 time volt DC, but the trip coil will be operate between 15% and 120% of the nominal voltage.

In the event of the generator fault, the master trip relay shall trip the field switch. Operation of the field circuit breaker over current tripping device will operate the generator protection. A non-inductive resistor will be connected across the generator rotor before the main contents break the rotor current. This resistor will be not more than the hot rotor winding resistance. Content of the field switch will be provided for remote status indication and interlocks

15.3.4 Type of Excitation Control

The excitation control equipment will have a design to maintain stable voltage control under all condition of generator operation. This equipment will consist of approval AVR with manual standby and local oblige remote, auto oblige manual change over selection and under excited reactive power limiter, manual follow up device, manual follow up limiter, voltage setting control and generator transformer over fluxing control device will be the integral part of excitation control and initiator to indicate faulty condition and to sound the an alarm in the event of the fault will be the part of excitation control.

A continuously acting, no "dead band inverter", static digital dual channel type of AVR will be provided. A manual control will also be provided where by the generator voltage will be capable of varying continuously from 80% to 115% of the rated voltage under normal operation.

15.3.4.1 Automatic Voltage Regulator (AVR)

The AVR will be capable of working over the complete load, voltage and frequency range of the generator within the prescribed limits defined below:

- Under steady state load condition, and over the whole of the operating range of the excitation system, the generator voltage shall be maintained within +0.5 and -0.5 of the setting value without hunting.
- Under steady state open circuit condition, the generator terminal voltage raise will be not more than +5 and -5 % of the setting value for all speeds between rated speed and 150% of the rated speed.
- Under AVR control, the generator open circuit voltage response will be such that for a -10% of step change, the time for the machine terminal voltage to return with +0.5% and -0.5 of rated value will not exceed 0.5 second.

Each AVR channel will include:

- Local auto, remote Auto and local manual switching inside the enclosure.
- Automatic follow up when tripping from open channel to the other or to the manual, so that no significant change of excitation will occur.
- A manual control follow up limiter, which will stop the follow up from reducing the manual setting below safe limit at any load output.
- An under-excitation VAR limiter with a setting dependant on KW loading. The limiter will prevent the excitation from reducing to such a level that the machine becomes unstable. When the limit is in operation, the over chutes will never exceed 5% of the VAR setting.
- A manual excitation range of 0 to 115% for commission purposes.
- And adjustable over fluxing control, to ensure the connected step up transformer are not over fluxed.
- Voltage drop compensation in a range of 0 to 120% of step up transformer impedance.
- Parallel running (cross compounding) and connections to ensure stable operation and sharing of reactive power with other generators in the stations.

- Series compounding to ensure satisfactory operation of the areas for large voltage dip on the system.

Each of the two AVR channels will have three phase voltage transformer which will be fed from the generator terminals. The reference voltage will be unaffected by changes in the ambient temperature or fluctuation in supply voltage or frequency, including full load rejection or close up fault on the 500 KV system.

15.3.5 Excitation Auxiliaries Equipment

15.3.5.1 Rotor earth fault protection equipment

Rotor earth fault protection equipment as approved during design stage will be included in the excitation system. The protection relay will provide continuous digital insulation resistance, indication alarms in the event of the single earth fault on the generator rotor winding whilst the machine is running or at rest. The device will continuously monitor the insulation resistance of the whole of the rotor winding. The insulation resistance level will be suggested above 10 000 ohm and the operation of the relay will be time delayed by 1 to 10 seconds. Any voltage that will be produced by the excitation circuit and appearing across the relay circuit will not cause operation. The protection equipment will be designed to with stand continuously any voltage development by the excitation circuit in the event of rotor earth fault.

15.3.5.2 Excitation power Transformer

The three-phase excitation transformers will be dry type, naturally cooled and suggest to meet class B temperature raise limits when caring the designed rating with the worst harmonic losses associated with the thyristor unit. The transformer shall meet the requirements of IEC 60076 and IEC 60726 with class F insulation. The flux density of the excitation transformer shall not exceed 1.65T (Tesla) at rated output conditions. Current transformers for each excitation transformer will be provided for HV connection for over current protection. Each transformer enclosure will consist of a rigidly constructed steel frame work which will be completely clad in sheet steels.

15.4 GENERATOR NEUTRAL EARTHING EQUIPMENT

The neutral ends of the generator windings will be star connected in the MV terminal box. The neutral earthing equipment for each generator will comprise a single-phase dry distribution type transformer with its primary winding connected between generator neutral and earth and with a necessary winding shunted by a load resistor. A removable disconnect link will be provided for isolation of the transformer from the neutral connection.

The design will be such that the fault current is limited to less than 10 amps in the earthing transformer primary at nominal generated voltage. The design value of 10 amps has been adopted to ensure effective limitation of transient over-voltage and arc damage. The earthing transformer primary will be rated for 18 kV.

One current transformer (CT) will be connected in series with the loading resistor. It will have a primary rating, which matches the loading resistor current for earth fault at the nominal generated voltage and a secondary rating of 1(one) amp. The CT will be suitable for driving a series connected protective relay.

15.5 GENERATOR ISOLATED PHASE BUS (IPB)

The conventional means of carrying large generator full load currents to the generator transformers is by means of IPB. It will be fitted with branch connections to the unit auxiliary transformer, excitation transformer, voltage transformers and surge arrestors. A generator circuit breaker with isolating and ground switches will also be fitted in the IPB connections.

The isolated phase connections will be sealed and the system designed for natural cooling by convection from the bars conduction through the enclosures and natural convection / radiation externally with no continuous flow of cooling air through the enclosures.

Each enclosure will have SF6 gas for insulation purposes and the enclosure should be minimum IP65. The IPB ends are connected from generator, GCB and primary of transforms through flexible links to absorb all type of vibrations and contraction of bus bars due to temperate contraction and expansions. The IPB will be sealed and expansion windows shall be provided at appropriate distance for internal expansion. The rating of IPB will be in such a way that it shall with stand 110% of maximum generator current and shall comply IEC standards.

15.6 GENERATOR CIRCUIT BREAKERS (GCBS)

The main reasons for recommending installation of generator circuit breakers are:

a) Simplified layout and lower initial cost. There is no need for additional 500 kV transformers for the units service supply.

b) Simplified operational procedure with GCB synchronization instead of synchronization with 500 kV circuit breaker.

c) The protection of high cost equipment such as generator, transformer and cables is improved. Allows better selectivity and stator fault clearance time typically 60~80 m sec.

d) Improved reliability gives higher availability.

e) In case of non-availability of generating units for some reason, GCB will make it possible to feed units service supply from the 500 kV National Grid.

The GCB's will be as per IEC 62271 and capable to withstand with the short-circuit values in case of three phase short circuit occurs.

The GCB's will have the following ratings:

i.	Rated Voltage	18 kV
ii.	Max. Continuous Voltage	18kV +10%
iii.	Rated Current	12 kA
iv.	Rated Breaking Current	100 kA
v.	Rated Breaking Time	100 m sec
vi.	Applicable Standards	IEC 6044-1; IEC 6044-2
vii.	Model	HECS-100M ABB or equivalent
viii.	Duty Cycle	O – t – CO – t' – CO

where O = Open
CO = Close – Open
t' = 3 minutes'
t = 15 seconds for circuit breakers not rated for rapid reclosing"

The Generator Circuit Breaker (GCB) will be single pole Vacuum, high current type, suitable for indoor use. GCB will be complete with a motorized disconnector, a set of current transformers and two motorized earthing switches, one each on either side of the circuit breaker.

The GCB specifications will be in such a way that it protects the main generator winding under severe three-phase short circuit fault. The unit service supply will be routed through the generator circuit breaker, while field disconnect switch will be provided which in case, if unit is not operational, disconnect switch will be open and unit auxiliaries be feed from the 500 kV grid. The GCB will be equipped with two trip circuits coils for redundancy purposes, in case one coil fails the other will open the circuit breaker. Trip coil healthy status will have the indication on the main annunciator panel.

- The GCB specifications shall be in such a way that it protect the main generator winding under severe three-phase short circuit fault.
- The unit service supply shall not be routed through the GCB, as in case any fault the main GCB will trip and emergency DC supply can only be option. A detailed study is required for this option and shall be discussed.
- The GCB shall be equipped with two trip circuits coils for redundancy purposes.

- The specifications for CT's and PT are used for protection purposes with GCB is not given in the existing GCB.
- The GCB shall be vacuum type instead of SF6 type, being the system voltage low and SF6 requires more maintenance than VCB.

15.7 TRANSFORMERS

15.7.1 Generator Step-up Transformer

A three phase transformer costs about 15% less than a bank of three single phase transformers and occupies less space. However, the bank of three single phase transformers has been selected for the generator step up transformers of Balakot HPP due to the following advantages:

a) easy transportation;
b) replacement of a single phase transformer is easier and less time consuming as compared with a three phase transformer; and
c) selection of single phase transformers will require only one single phase transformer as spare instead of one three phase transformer, thereby further reducing the space requirement for spare transformers (which in a cavern with high excavation costs is a relevant factor).

The spare single phase transformer will be mounted on rails in a spare bay with auxiliaries ready to replace a faulty unit.

Each single phase transformer will have the following ratings:

Rated Output	43.3 MVA (with 10% overload max: 47.33 MVA)
Rated Output of the Bank	130 MVA (with 10% overload max: 142 MVA)
Quantity	03
Rated Power Factor	0.85
Ratio Voltage	18 / 500 kV (for Units 2&3,)
Ratio Voltage	18/132 kV (for Unit # 1)
Power Frequency	50 Hz
Vector Group (three phase bank)	DNy11
Tap Changer on HV Winding	Off-load

Tapping Range	± 4x 1.25 %
Cooling	OFWF (Oil Forced, Water Forced)
Rated Lightning Impulse Withstand Voltage:	
Primary	95 kV
Secondary	1550 kV IEC – 76 For Unit 2&3, 650 for Unit # 1

The delta-connected winding on the primary side will provide a closed circuit for possible third harmonic currents originating from the generator. The high voltage winding is star connected with the neutral link taken out on a separate terminal for direct connection to earth, in order to satisfy the requirement of directly grounded neutral in the 500 kV grids. The transformers will be designed to connect to IPB on the 15.75 kV side and to GIL on 500 kV side & 132 kV for unit # 1.

15.7.2 500/132 kV Interconnection Transformer

A three phase 120 MVA, 500/132 kV transformer is suggested to connect the local existing 132 kV Balakot Grid with 300MW Balakot HPP as per client requirement.

Each single phase transformer will have the following ratings:

Rated Output	120 MVA (with 10% overload max: 132 MVA)
Rated Power Factor	0.85
Ratio Voltage	500 / 132 kV
Power Frequency	50 Hz
Vector Group (three phase bank)	YNy11
Tap Changer on HV Winding	On-load
Tapping Range	± 4x 1.25 %
Cooling	OFWF (Oil Forced, Water Forced)
Rated Lightning Impulse Withstand Voltage	
Primary	1550 kV IEC - 76
Secondary	650 kV IEC – 76

15.7.3 Plant Auxiliary Transformer

The total maximum load of the hydropower plant is normally 1% of the total station load. Hence 26 MVA Station Auxiliary Transformer is suggested having two secondary windings. The transformer has 500/11/11 kV winding having each winding of 13 MVA.

The transformer will have the following ratings:

Rated Output	26 MVA
Rated Power Factor	0.85
Ratio Voltage	500 /√3/ 11/11 kV
Power Frequency	50 Hz
Vector Group (three phase bank)	YNdd11
Tap Changer on HV Winding	Off-load
Tapping Range	± 2x 2.5 %
Cooling	OFWF (Oil Forced, Water Forced)
Rated Lightning Impulse Withstand Voltage	
Primary	1550 kV
Secondary	95 kV IEC - 76

15.7.4 Unit Auxiliary Transformers

Three identical transformers 18/0.4 kV, 1 MVA for the units auxiliary services shall be located in enclosures in the electrical switchgear room of the power plant; they shall be dry indoor type, rated 1000 KVA, and shall supply low voltage to auxiliary switchboard of each unit.

Each transformer shall be capable of meeting the complete requirements for the units auxiliaries of the Project. The capacity of the transformer shall be proved during its detailed design.

The maximum temperature rise values shall not exceed:

Windings	85 K
Other parts	85 K

As far as applicable, the transformers shall meet all requirements detailed in this Specification. Class F insulation material shall be used with the windings impregnated and cast under vacuum into molds of glass fiber reinforced epoxy resin. The windings shall not absorb any humidity. The insulation material shall be barely inflammable and self-extinguishing.

The transformer shall be designed for natural air-cooling and be housed in a steel sheet or aluminium sheet enclosure of adequate mechanical strength.

The following accessories shall be provided:

- Three (3) resistance type temperature detectors (Pt 100) inserted in the LV winding, for local temperature measuring.
- LV temperature monitoring device applying several sensors, with separate contacts for warning and tripping.

15.7.5 Technical Description of the Power Transformers

All step-up, inter-connecting and auxiliary power transformers will be of conventional design with concentric winding arranged on a core made of insulated steel laminations. The mechanical and electrical design of the transformers and their accessories will strictly follow the IEC recommendations. The transformer tank will be designed to withstand an over pressure of one bar as well as to allow vacuum during dry out before oil filling. The transformers will follow the ambient climatic conditions of -10 to 45 degree Celsius. The maximum permissible temperature rise will be:

Oil	50 K (top oil)
Winding	55 K hottest layers

The transformer will be able to operate safely for 30 sec with a voltage of 1.3 times the rated voltage and be able to operate continuously at the nominal rating within the limit of temperature raises, at voltage variation of +10 and -10% and frequency variation of +5 and -5% and at any voltage ratio to be adjusted by the exchanger.

The short circuit capability of the transformer will be such that it can stand for 3 sec without damage or deterioration, secondary short circuit when fed from the primary side with the maximum possible fault current.

15.7.6 Construction Features

15.7.6.1 Windings

Oil immersed transformers will be provided with high conducted electrolytic copper windings. Insulation material of oil immersed transformers will be as per IEC standards. The insulation of windings and connections will be free from insulation compositions likely to soften, shrink or to collapse during service. All windings and insulation will have KEMA or equivalent test results.

15.7.6.2 Bushings

Bushing will be free from defects and thoroughly verified. The glaze will not form a dependence factor from insulation and will be of uniform shape of brown, covering completely all exposed parts of the insulators. The outdoor insulation and fittings will be unaffected by atmospheric condition due to weather, fumes, ozone, acids, alkalis, dust or rapid change in air temperature.

Bushing will be arranged to facilitate for mounting and dismounting there built in current transformer are provide, bushings will be arranged to permit its removal without interfering with pertinent current transformer. Each V bushing be of oil filled, while neutral terminals will be brought out to bushings similar to the face bushings. The 18 kV bushing shall be of oil filled type and provision will be made to prevent any stresses due to expansions and contractions in any part if the bushing that can lead to development of bulges, hair line cracks and other defects.

Special adjustable coordinating arc horn will be provided on the high voltage bushings and the gap setting will be adjusted with reference to the impulse strength. The arc horn will be arranged so as to leave adequate clearance from the bushings to prevent any damage to the bushing during the flash over across the horn gaps. The design of the arc horn will be such as to minimize the electrical discharge or radio interference.

15.7.6.3 Magnetic Core

The core and its clamping plates will form a rigid unit structure that will maintain its form and position under swear stresses encountered during shipment, insulation and short circuits. Care will be taken to secure evenly distributed mechanical pressure over the whole lamination to prevent the settling of the core and to eliminate noise and vibrations when the transformer is in operation.

Core lamination will be made from cold rolled grain oriented, high permeability silicon steel free from burrs. The core joint will be interleaved, and each lamination will be insulated with a material that will not deteriorate due to pressure and the action of hot oil. The maximum flux

The pressure of water is to be kept lower than the pressure in the oil circuit. Two independent full capacity cooling systems will be installed to allow maintenance work during operation.

15.7.7.1 Transformer Oil

The transformer oil will be mineral, free from additives, and acid refined with properties compliant with the IEC standard 60296.

15.7.7.2 Piping and valves

All necessary oil piping, oiled rain, filling valves and sampling tabs will be an integral part of the step up transformers. The material used in the heat exchanger will be in such a way that it has an minimum 20-year operation life against rust and leakage.

15.7.7.3 Oil conservator

A complete conservator vessel with sump and drain well will be positioned in such way that it will not obstruct the electrical connection to the transformers and having sufficient capacity to allow oil expansion from 0 to 110 degree Celsius. It will be designed in such a way that it could be completely drained by mean of the drain valve mounted when in service. A road type oil level gage will be provided, showing the full oil level range for each individual section that is main tank, on load tap changer. Each conservator shall be fitted with two parallel breathers of normal size in which silica gel could be filled as a dehydrating agent. Each breather will be provided with separate isolating valves.

15.7.8 Grounding of Transformers

Two earthing terminals of adequate size shall be provided and installed diagonally at the bottom of each transformer tank. Earthing connections shall be provided as specified in relevant IEC standards.

15.7.9 Transformer Terminals

Uncovered bushings on transformers are admitted for grounded neutrals at HV side line terminals only (suitable for GIL/Cable, as may be the case, connections). All other line terminals shall be provided with sealed cable and boxes or with flanges for sealed connection of the bus duct enclosures. At the 18/11 kV side of the step-up and auxiliary transformers, sealed cable boxes shall be provided.

The transformer neutrals shall be equipped with bushing type current transformers for earth fault protection. The current transformers shall comply with the general requirements as per IEC 60076. IPBD shall be brought into the terminals box through an extension box, where flexible connections with LV side bushings may be connected and the dimensions of the terminal box are to be adapted to the size of the IPBD.

If the neutral bushing is part of a common cable connection box, a suitable cable gland shall be provided for penetration of the neutral conductor. Isolating facilities shall be provided within the terminal box for disconnection of the flexible links for testing purposes.

15.7.10 Instrumentation and Control

15.7.10.1 Electrical controls

Each auxiliary motor shall have its own motor starter of adequate size, fitted with thermal and magnetic overcurrent release.

The electrical and/or mechanical control and monitoring equipment shall be complete in every respect; the associated equipment including contactors, MCBs and all auxiliary devices shall be accommodated in the marshalling kiosk, as specified.

15.7.10.2 Fan units

- Motors or group of motors shall be automatically controlled by a relay combination considering the winding temperature for ON and the oil temperature for OFF control, respectively.
- Provisions shall be made for sequencing the starting order for individual groups.
- A group alarm per transformer shall be initiated, if any fan unit fails.
- Electrical isolation of each motor circuit to facilitate replacement or repair of individual units shall be provided.
- Changeover from automatic to manual control and vice-versa shall be provided.

15.7.10.3 Measuring and monitoring

All equipment shall be wired up to terminal blocks inside the marshalling kiosk. All remote reading thermometers and thermostats shall be provided with contact units of the snap-action type rated for 110 V DC, 2A. All contacts shall be adjustable to scale and shall be easily accessible on removal of the cover. Remote reading thermometers shall be arranged inside or nearby the marshalling kiosk. Alarm and tripping signals shall be announced in the control room on the operator's console.

The following minimum scope of equipment shall be supplied for each transformer:

- One (1) double float Bucholz relay with two contacts and accessories.

- One (1) contact assembly for mounting on the diaphragm of the tank pressure relief device.
- One (1) dial type, float operated, magnetic type oil level gauge with one low level normally open contact for each oil system.
- Temperature monitoring of transformers:
    - Two (2) remote reading dial type mercury thermometer for measuring the oil temperature, with three normally open contacts, one for OFF control of cooling equipment, and two for temperature alarm and tripping.
    - One (1) image coil for measuring the winding temperature, with one (1) resistance type thermometer with indication.
    - One (1) remote reading dial type mercury thermometer with three normally open contacts, one for ON control of cooling equipment and two for temperature alarm and tripping.
    - Temperatures of all the transformers shall be displayed / recorded at the Main Control Room Operator's Console.

15.7.10.4 Marshalling Kiosk, Wiring and Conduits

As far as applicable, a rigid, weather-proof marshalling kiosk shall be provided for each transformer for accommodation of electrical control, measuring and monitoring equipment, alarm circuits, MCBs and current transformer secondary.

The marshalling kiosk shall be suitably designed to prevent the ingress of water and dust and shall be provided with hydro-statically controlled heating elements to prevent condensation of moisture.

A gland plate with suitable fittings for entrance of multicore cables shall be provided, duly sealed or plugged during transport. The kiosk shall be lighted by hand controlled fluorescent lamps. An adequately sealed, hinged door shall be provided with locking facilities.

15.7.11 Tests

15.7.11.1 Factory acceptance tests

Each transformer and its related equipment shall be subjected to acceptance tests to be performed at the Contractor's workshop in order to verify the conformity with the guaranteed and other design data. These tests shall include the following measurements and evaluations:

- Measurement of Ω resistances.

- Measurement of zero sequence reactance.
- Measurement of winding capacitances.
- Measurement of voltage ratio on all steps and check on polarity and vector group.
- Measurement of no-load current and losses.
- Measurement of impedance voltage and short-circuit losses.
- Determination of efficiencies.
- Induced and separate source high voltage withstand tests.
- Full wave impulse voltage withstand test.
- Heat run test.
- Noise level measurement.
- Determination of errors and accuracy of built-in current transformers.
- Functional tests of all electrical control and supervisory equipment.
- Visual inspection.

15.7.11.2 Tests on site

- Visual inspection.
- Dielectric test of oil.
- Megger test (all windings against each other and against earth).
- Functional test of all control and protection equipment.
- A static pressure test of the complete assembly tank.
- Winding Turn Ratio Test.
- Capacitance and Dissipation Factor test.
- Winding Resistance Test.

15.7.12 Painting

As far as practicable, all exterior metal parts including tank and radiators shall be hot-dipped galvanized and be provided with adequate durable and weather proof two coat paint finish. Parts not hot-dipped galvanized, shall have a 4 coat painting (rust primer, filler, 1st and 2nd finishing coat). The colour of the final paint shall correspond to the RAL color code 9006.

Painting material and procedure shall be in accordance with relevant items of IEC standards taking into account a maximum metal temperature of 130 °C.

15.7.13 Name Plates and Other Designation Plates

The following plates made of Laminated Steel is suggested:

- A rating plate according to IEC 60076.
- A diagram plate showing in an approved manner the internal connections and the voltage vector relationship of the several windings in accordance with IEC 60076, and in addition a plan view of the transformer giving the correct physical relationship of the terminals.
- A plate showing the location and function of all valves and air release cocks or plugs. This plate shall also warn the operator to refer to maintenance instructions before applying vacuum treatment.
- Numbered plates for all valves, cocks, etc.
- A plate showing all electrical circuits and terminal blocks. This plate shall be located at the inner side of the hinged door of the marshalling kiosk.

15.8 500 KV / 132 KV EXTRA HIGH VOLTAGE OUTDOOR CONNECTION

Each step-up transformer will be connected to the 500 kV switchyard via single core, single phase, 500 kV cross linked polyethylene (XLPE) cables or Gas Insulated Lines. A comparison of both is given and the PPTA Consultant recommends the GIL as more suitable for the 500 kV high voltage connection from a cavern type power plant to the GIS and then to outside 500 kV circuits.

15.8.1 500 kV /132 kV Gas Insulated Lines (GIL)

Gas insulated line (Bus) is the main option for the connection between unit transformers and the GIS switchgear. The GIL has some advantages over the XLPE cables and these are favoured to be used in underground and cavern type applications than XLPE Cables.

Some of the advantages of GIL are:

- GIL's have more reliability, low failure rates and long service life as compared to XLPE.
- Current carrying capacity is higher without excessive heating of the outer surface.
- No large current interruption and no moving parts.
- High transmission availability and low power losses.

15.8.3 XLPE Cables (Optional)

15.8.3.1 500 kV XLPE cables

Each step-up transformer may be connected to the 500 kV switchyard via single core, single phase, 500 kV cross linked polyethylene (XLPE) cables. As properly installed and maintained XLPE power cables give more reliable operation than oil filled cables.

The cables and connections shall be designed for continuous operation under the following conditions:

Rated System Voltage	500 kV
Highest System Voltage	550 kV
Switching Impulse Withstand Voltage	1175 kV
Lightning Impulse Withstand Voltage	1550 kV
Rated Current Capacity	120 Amp
Frequency	50 Hz
Rated Maximum Conductor Temperature Under Normal Operating Conditions	not more than 90 °C

15.8.3.2 132 kV XLPE cables

The Interconnection transformer may be connected to the 132 kV GIS via single core, single phase, 132 kV cross linked polyethylene (XLPE) cables. The cables and connections shall be designed for continuous operation under the following conditions:

Rated System Voltage	132 kV
Highest System Voltage	145 kV
Switching Impulse Withstand Voltage	275 kV
Lightning Impulse Withstand Voltage	650 kV
Rated Current Capacity	150 Amp
Frequency	50 Hz
Rated Maximum Conductor Temperature Under Normal Operating Conditions	not more than 90 °C

15.8.3.3 Comparison of XLPE to GIL's

- XLPE has current limitation under different temperature conditions.
- Service life of XLPE cables is less then GIL's.
- XLPE is more immune to the corrosive environment then GIL
- In the case of damage, XLPE is more difficult and expensive to replace then GIL.

15.8.3.4 IEC standards

XLPE cable systems specified according to IEC are among many other standards accepted. IEC standards are considered to express an international consensus of opinion.

Some frequently used standards are:

IEC 60228	Conductors of insulated cables
IEC 60287	Electric cables - calculation of the current rating
IEC 60332	Tests on electric cables under fire conditions
IEC 60853	Calculation of the cyclic and emergency current rating of cables
IEC 61443	Short-circuit temperature limits of electric cables with rated voltages above 30 kV (Um=36 kV)
IEC 62067	Power cables with extruded insulation and their accessories for rated voltage above 150 kV (Um=170 kV) up to 500 kV (Um=550 kV). Test methods and requirements

15.9 500/132 KV GAS INSULATED SUBSTATION (GIS)

The GIS technology has been proving its worth day by day in applications all over the world. When a cavern type power plant is suggested, GIS is more appropriate to be used given its compact design and minimum space requirements. The significant advantages are system security, reliable performance, economical usage and an external long service life even under rough conditions.

The GIS are safer then AIS, have more reliability against the external negative influences, minimum service intervals due to its enclosed nature, more compact then AIS and can be fit in a very small spaces like cavern type power plants where the available space is very small. The system modular architecture makes the whole assembly to permit individual sections can be maintained without taking major safety measures. The GIS contains every single component of switchgear, from Circuit Breaker to Disconnect Switch to CT to PT within a single small enclosure in compact form. A typical 1½ Breaker scheme switch gear is shown in **Figure 15.1** below.

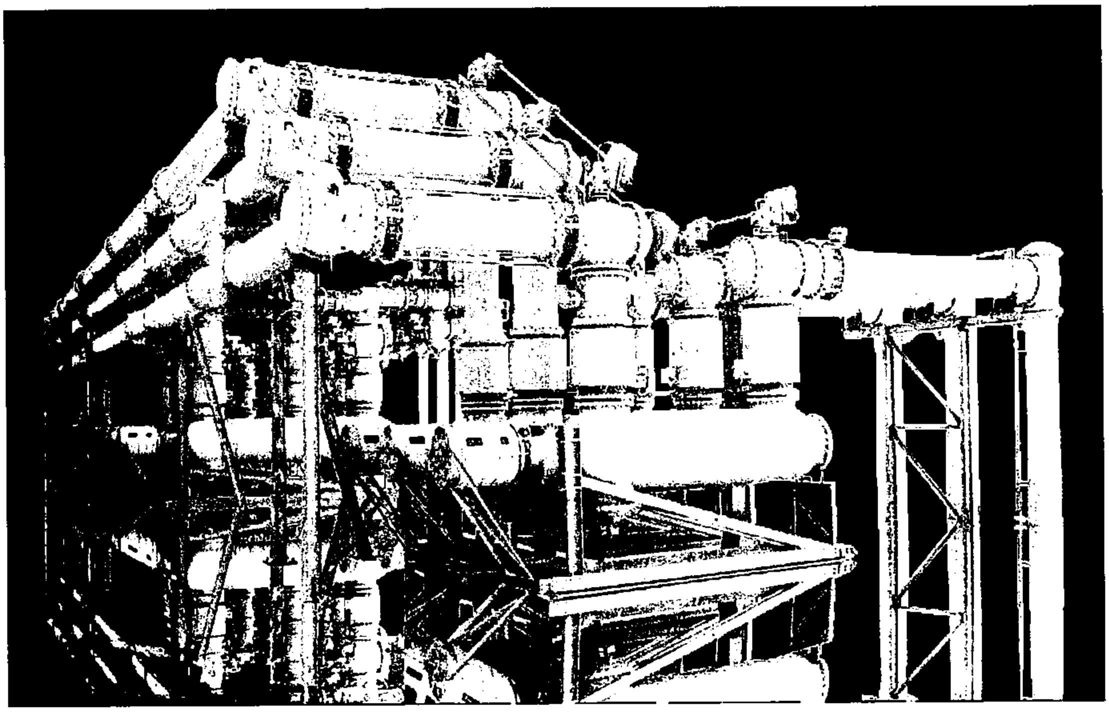

Figure 15.1 – Typical 1½ Breaker Scheme GIS

The minimum specification of the different parts is given in the following sections.

15.9.1 Circuit Breaker

The circuit-breaker, using SF6-gas for insulation and arc-quenching purposes, has been continuously developed and improved over the years. Extensive operating experience, as well as continuous research and development activities, are the basis when anticipating future market requirements. The 500 kV GIS shall have the following prominent features:

- Reliable making and breaking capacity for heavy load and short-circuit currents.
- Easy access to active parts for inspection and overhaul.
- Must have low noise level.
- Shall have separate contact system for continuous current and current interruption.
- Must have high dielectric withstand in open and closed positions.
- Shall be single-phase auto-reclosing.
- Must have compact hydro-mechanical spring operating mechanism.
- Shall have continuous self-supervision of the hydraulic system.

- Shall be KEMA type tested or equivalent, according to latest IEC, ANSI and WAPDA standards.
- Should have maintenance-free design.

15.9.1.1 Breaker design

Each circuit-breaker in the GIS shall comprise three single phase metal-enclosed breaker poles. Each pole shall consist of the operating mechanism, the interrupter column with two interrupting chambers and the enclosure with the basic support structure. To guarantee simultaneous interruption, the chambers shall be mechanically connected in series. One grading capacitor for each chamber shall assure an equalized voltage distribution across the interrupting chambers. In case of an overhaul, the interrupter column should easily be removed from the enclosure.

The circuit-breaker shall be of the single-pressure type and works on the latest arc-quenching technology. During an interruption, a compression piston in the chamber shall generate the SF6-gas pressure required to extinguish the arc between the contacts.

15.9.1.2 Circuit-breaker operating mechanism

Each pole of the circuit-breaker shall be equipped with a hydro-mechanical spring operating mechanism. The compact, modular design of the circuit-breaker operating mechanism shall consist of:

- housing;
- position indicator;
- power-pack for energy storage without any kind of external hydraulic pipe;
- monitoring module for control purpose.

It shall combine the advantages of the hydraulic operating mechanism with those of the spring energy storage type, which shall guarantee additional safety margins for circuit-breaker performance in service.

The operating mechanism shall guarantee easy access to all components inside the drive for overhaul and repair. Sealing of the pressure operated hydraulic circuit against the atmosphere shall be achieved entirely by highly reliable static seals.

15.9.1.3 Working principle

A hydraulic pump shall move oil from the low-pressure reservoir to the high-pressure side of the energy storage piston, connected to the disc springs. The output piston, which shall be connected to the operating rod of the circuit-breaker column, shall be controlled by a change-over valve. For opening, it switches hydraulically to the open position

After the trip coil shall be actuated for opening the breaker and shall connect the bottom side of the output piston with the low-pressure reservoir. The circuit-breaker after the operation shall move to open position where it will be retained due to the hydraulic pressure. For closing the circuit-breaker, the change-over valve shall connect the bottom side of the output piston to the high-pressure reservoir after actuation of the closing coil. Now, both sides of the output piston shall be connected to the high pressure and the circuit-breaker shall move to its closed position due to the differential pressure principle.

15.9.2 The Disconnector

The disconnector shall be based on a modular design. It shall available either as in-line or angular disconnector. The angular disconnector integrated in the busbars ensures the highest degree of flexibility in the layout. It shall also be possible to accommodate a maintenance earthing switch in the same enclosure.

The operating mechanism shall be of modular design. The modular design shall enable rapid replacement of complete modules, thus ensuring greater service friendliness and excellent access for maintenance and repair.

15.9.2.1 Disconnector features

The DS shall have the following features:

- shall gave reliable SF6-gas insulation across the isolation distance;
- must have reliable switching capacity for small capacitive currents and bus-transfer currents;
- shall withstand with high capacity for carrying rated and short-circuit currents;
- reliable switching of small capacitive and bus-transfer currents;
- must be equipped with manual operation by hand crank possible;
- shall have reliable 3-pole operating mechanism;
- must have location of drive unit outside SF6-gas compartment;
- separated mechanically coupled position indicator;
- must have viewing port for checking position and condition of contacts;
- shall comply with the latest IEC, WAPDA and ANSI standards.

15.9.3 The Earthing Switch

The earthing switch should be mounted at any position by using a connection element, thus ensuring the greatest flexibility in switchgear layout. It shall be used to earth insulated sections of the installation to protect personnel during overhaul and assembly work.

The maintenance earthing switch shall have the same type of operating mechanism as the disconnector. The fast-acting earthing switch shall also be employed for earthing capacitance (cables, transmission lines, etc.).

The controlled "Open" operation results from a slow linear contact motion directly driven by an electric motor, which shall be located in one of the outer phases and connects the other phases by rotating shafts. This shall enable optimal switching movement during contact opening. The fast "Close" operation shall be spring-actuated. After a closing command, the electric motor and the rotating shafts will compress the spring of a phase. After reaching the required state of charge, they will automatically release until the next closing command is activated.

15.9.3.1 The earthing switch feature

- Must have reliable earthing of main circuit;
- must have insulated operating mechanism;
- be capable of switching induced capacitive and inductive currents;
- must have manual operation by hand crank possible;
- shall have location of drive unit outside the SF6-gas;
- shall have position indicator mechanically coupled to the moving contact;
- shall have viewing ports for checking position and condition of contacts;
- shall have safety elements such as padlocks can be provided;
- be fully type-tested for conformity to latest IEC, WAPDA and ANSI standards;
- must have high short-circuit current making capability;
- must have high short-circuit current carrying capacity in closed position under three phase faults.

15.9.4 The Voltage Transformer (VT's)

VT's are used for system protection or revenue metering. These shall be based on the electromagnetic transformer principle, where primary and secondary windings shall be galvanically separated from one another. The single-pole inductive voltage transformers shall be connected to the switchgear with a standardised connecting flange and a partition insulator. The primary winding shall be wound on top of the core and the secondary windings. The latter shall be connected to the terminals in the external terminal box through a gas-tight multiple bushing.

15.9.4.1 Voltage transformer features

- Utilisation of SF6-gas as insulating medium, together with plastic foil in the windings.
- High secondary output and accuracy.
- Ratio and number of secondary windings according to actual GIS plant requirements.
- Effective damping of very fast transients, transmitted to the secondary side.
- Shall have rectangular type core of low loss magnetic sheets.
- No ferroresonance possible in absence of circuit-breaker grading capacitors.
- Shall have horizontal or vertical mounting possibilities.
- Separate gas volume with density monitoring.
- Over-pressure relief device must be provided.
- Secondary fuses shall be provided.

15.9.5 The Current Transformer

The ring core current transformers concentrically shall enclose the primary conductor. The core support shall be provided by the pressure-proof enclosure, which shall be insulated from the basic flange to prevent the return current from passing through the cores.

15.9.5.1 Current transformer features

- Simple ring-core type windings integrated in the main current path.
- SF6-gas as main insulation medium.
- Secondary windings on ring-cores, located inside of the SF6-gas compartment and mechanically protected.
- Efficient damping of the very fast transients transmitted to the secondary side.
- Any accuracy class defined by international standards.
- Maintenance-free type.

15.9.6 The Connecting Elements

Switching systems need to be as varied as the purposes for which they are intended. The connecting elements in all shapes and sizes: cross-shaped, elbows and T-elements, as well as simple straight sections, are the links that join up individual GIS components.

Compensators of various types shall allow for heat expansion, vibrations during operation and tolerances in the lengths of specific components. Moreover, lateral dismantling units shall guarantee hassle-free assembly and dismantling.

15.9.6.1 The terminal connections

GIS shall include the connecting elements for peripherals such as the SF6-air bushings, the enclosures for the cable terminations and the enclosures for the transformer terminals.

15.9.6.2 The transformer termination

The transformer connection shall enable transformers to be connected directly to the switchgear using bellows.

15.9.6.3 Features

- Must have effective compensation of vibrations.
- Connection between the SF6 switchgear and the transformer.
- Isolation of the SF6 switchgear from the transformer for testing possible.
- Interface according IEC 61639.
- Maintenance-free.

15.9.6.4 The GIL / cable termination

GIL or Cable connections normally consist typically of an epoxy resin barrier insulator and can be either of dry type or of fluid-filled type.

15.9.6.5 Features

- Interface according IEC 62271-209.
- The GIS and the high-voltage cable can be galvanically separated and the high-voltage tests be carried out independently.
- Shall have removable link easily accessible.
- Must have flange available to attach a test bushing.

- Easy mounting of the cable at any rotation angle.
- Maintenance-free.

15.9.7 Technical Data of 500/132 kV GIS

Description	Unit	132 kV	500 kV
Rated Voltage	kV	145	550
Rated Continuous Busbar Current	Amp	3150	4000/6300
Rated Continuous Feeder Current	Amp	1600	4000/5000
Rated Power Frequency Withstand Voltage	kV	295	740
Rated Lighting Impulse Withstand Voltage	kV	675	1675
Rated Lighting Impulse Withstand Voltage across open contact	kV	675+120	1675+450
Rated Switching Impulse Voltage	kV	NA	1300
Partial Discharge	pC	<3	<3
Rated Short Time Withstand Current	kA/s	40/3	50/3
Rated Filling Pressure (20°C, abs) of Components	kPa	480/680	480/680
Minimum Functional Pressure of Components	kPa	390/600	390/600
Circuit Breaker Rated Filling Pressure (20°C, abs)	kPa	680	680
Minimum Functional Pressure of Circuit Breaker	kPa	600	600
Rated Time Constant	ms	120/45	120/45
Rated Frequency	Hz	50	50

15.10 DC SYSTEM

Power supply to the power station DC auxiliaries, 500/132 kV GIS controls and protection shall be provided from a 110 V DC main board, comprising one set of bus-bars connected to a battery and two battery chargers.

The DC system batteries shall be located in a separate room. The AC power supply for the battery chargers shall be from the 400 V station common auxiliaries' switchboard. A separate DC distribution board, complete with all devices such as breakers and terminal blocks etc. shall be provided and installed in the powerhouse DC distribution room for supplying all DC loads for the 500/132 kV Switchyard. This dedicated distribution board shall be fed from the main 110 V DC board installed in the same room.

The DC supply system will consist of several battery banks with battery chargers and distribution cubicles. The DC supply system will provide safe and reliable supply of power. The system will be independent from all other power systems and ensure reliable execution of the control functions both for normal operation and during possible failure conditions.

Mainly for power plant and for the GIS protection and operation two sets of DC battery bank is suggested while for intake one DC power supply bank is sufficient. The list is hereunder:

i.	110 V Power House Batteries	2 No.
ii.	110 V Power Switchyard Batteries	2 No.
iii.	110 V intake Battery	1 No.
iv.	48V Power House cum Switchyard	2 No

15.10.1 Batteries

15.10.1.1 Requirements

The batteries shall be lead acid, enclosed type or Gel Type Dry Batteries. 110 V shall be used for operation of all control, while 48V shall be used for signalling, and relaying equipment as specified.

15.10.1.2 Rating

The DC systems shall be in accordance with the relevant IEC and IEEE publications and requirements listed below:

Nominal system voltage, volts.	110 V (48V)
Battery Voltage during Float Charging	121V (54V)
Discharge Voltage (at 1.8 V per cell)	99 V (43 V)
Nominal voltage per cell, volts.	2.0
Temperature range, degree °C.	-15 to 45
Aging factor, minimum.	1.25
Rated discharge capacity at 10 hours rate	350 AH

15.10.1.3 Construction

The batteries shall be of compact design with a small weight to capacity ratio. The construction shall ensure minimum self-discharge and low internal resistance. Adequate measures shall be taken for prevention of internal short circuits and protection of the element against mechanical damage.

The positive plates shall be tubular type. The electrolyte shall have nominal specific gravity of 1.2 at 25 °C when the cells are fully charged. The posts and inter-cell connectors shall be of adequate size to safely handle batteries rated one minute current. The inter-cell connectors shall be lead plated copper, covered with plastic insulating sheath. The cell containers shall be moulded in strong, impact-resistant transparent plastic boxes of high insulating strength.

The polarity of positive cell terminals shall be plainly and durably marked "+" and the negative cell terminals as "-". The terminals and cell connectors shall be of corrosion resistant material.

15.10.1.4 Life

The batteries of like design and rating have successfully met all test requirements and have been in satisfactory service for at least 10 years. The end of the service life shall be the time when the battery will no longer deliver 80% of its rated capacity. The batteries shall have 15 years guaranteed life expectancy.

15.10.2 Battery Chargers

15.10.2.1 General

The battery chargers for 110 V as well as for 48 V DC systems shall be static rectifier type, fully automatic and solid state type, regulated for input voltage 400 V, 50 Hz, three phase. These shall have no moving parts. The rectifiers shall be full wave bridge type using silicon thyristor. AC and DC circuit breakers of adequate capacities shall be provided to protect the chargers against overload and short circuits.

Two identical chargers shall be the integral part for each battery system. Both the chargers shall be connected via DC switchboard to the battery bank and shall receive power supply from the respective buses of the 400 V switchgear. Each charger shall be sized to supply power to the full DC load of the entire power plant with the battery disconnected.

Each charging equipment shall be contained in ventilated steel cubicle, mounted adjacent to its associated DC Distribution board to form a board of matching design and appearance.

15.10.2.2 Ratings

The chargers shall be designed and tested for the following ratings and characteristics:

Duty Class	100% continuous
AC supply	400 V, 3 phase
AC voltage fluctuation	+ 10%, -15% of rated value
Frequency, Hz	50
Frequency fluctuation	48-52 Hz
Minimum rated output DC	300 Amp current
Rated output DC voltage	110 V (48 V in case 48 V system)
DC output voltage variation	+10%, - 15% of rated value
Regulation in DC output Voltage for AC main fluctuation of +10% -15%, Frequency fluctuation of ±5% and 0-100% load change.	0.5%
Audible noise	less than 65 dB
Insulation resistance	Greater than 3 Mega ohm
Paint color	As per IEC Standards
Temperature Range	-15 to 45 deg. °C

15.10.2.3 Technical characteristics

The chargers shall automatically maintain the battery normally floating so that no discharge takes place under normal conditions and batteries remains fully charged. Chargers shall maintain the float charge automatically irrespective of variations of input AC supply as specified herein. Voltage of float charge shall be adjustable. Chargers shall be capable of boost charging at a higher rate to recharge the battery after heavy discharge. A timer relay graduated from 0 to 24 hours shall be incorporated in the design for selection and setting of boost charge rate. The voltage/current characteristics of boost charge shall have tape-ring characteristics in order to minimize gasification. Necessary markings shall be provided for maximum boost charge current on the ammeter provided.

The rating of the charger on float charge shall be equal to normal battery standing load plus the charge rate of battery. The chargers shall be capable of charging a fully discharged battery to full charge within a maximum of 12 hours while supplying connected loads. Provisions in the design shall also be made for initial charging of the batteries.

Temperature rise of the winding and the core of the transformer of the chargers shall not exceed 30 °C over-ambient temperature.

15.10.2.4 Construction

The charger cabinet shall be of sheet steel floor mounting type. The cabinet shall be adequately ventilated and shall be completely vermin proof.

The following equipment shall be mounted on the front of each charger cabinet. Each component shall be labelled for identification.

1. ON/OFF main switch with green pilot lamp for ON position.
2. A four-position output selector switch for the following settings:
    a) OFF
    b) Float
    c) Boost
    d) Automatic float/boost
3. A red pilot lamp to indicate boost operation
4. Following flush mounted meters with proper scales shall be provided:
    a) One DC Voltmeter
    b) One DC Ammeter
    c) One AC voltmeter with phase selector switch

All non-current carrying metallic parts of the cabinet shall be suitably and effectively connected to the grounding system. Doors shall be connected to the enclosure by means of separate flexible grounding straps.

Terminals of suitable size shall be provided inside the charger. The positive terminal shall be marked “POS.” or "+" and colored red. The negative terminal shall be marked “NEG.” or "-" and colored Black. The AC terminal shall be marked "AC". A hinged door with provision of locking shall be provided for access to the components from the front of the charger.

15.10.3 Battery Fuses

Bolted cartridge fuses shall be provided in both positive and negative leads and positioned as close to the battery as possible. The fuses shall be rated at five times the charger float output rated current. Monitoring of the battery fuses shall be provided on the DC distribution and an alarm (red LED) shall be generated in the event of blowout of the fuse. A cartridge fuse shall be provided in the charger-input lead to the negative pole of the battery and rated at twice the charger float output rated current. These fuses shall be mounted preferably on the end of the battery stand or rack. The fuse links shall be mounted in fuse carriers with an insulated barrier between the poles.

15.10.4 Protection and Signalling

The following measures shall be taken for the 110 V/ 48 V DC system:

a) A ground fault detection relay designed to detect and indicate a ground on DC ungrounded system shall be provided inside the battery charger and ground fault indication shall be brought to the control room for display at the operator's console.

b) Provisions shall be made to indicate and protect each charger against charger faults.

c) A phase supervision relay (PSR) shall be provided to put the charger off and protect the rectifier bridge in case of failure of one or two phases.

d) Arrangement shall be made on DC side to prevent any reverse flow of power. Surge suppression circuitry shall also be provided both on AC and DC side to protect the charger against transient faults.

The following alarms, indications and audible alarms shall be provided for the 110 V system at the operator's console in the main control room. It shall also be possible to activate the event recorder function for these alarms:

- Battery is being discharged/charged excessively.
- Battery cell voltage drops to 1.75 volt per cell or below.
- Faulty charger.
- Main AC supply faults.
- Outgoing breaker trips.
- Battery breaker trips.

15.10.5 Factory Tests

The batteries and chargers shall be tested at the factory in accordance with relevant IEC publications or IEEE standards. These will include but not necessarily limited to the following:

1. Tests to record DC output voltage variation under float/charge conditions for the various settings for the DC current output variation from zero to maximum values.
2. Tests to record DC output voltage variation under float/charge conditions for the various settings of the DC output currents with variation in AC main voltage from 380 to 430 volts.
3. Tests to confirm maximum temperature rise of main transformer and other components of the battery charger.

Switchboards, Sub-distribution Boards and Panel Boards:

Type	Column cubicle
Installation	Indoor
Degree of protection	IP 32
Operating voltage (V)	110
Rated current (A)	400 Amp (to be given by the Designer)
Rated short circuit withstand	16 kA (to be finalized at design stages)
Number of outgoing circuits	To be finalized at design stages

Note: The number of outgoing circuits, short circuit withstand level and rated currents of switchboards, panel boards and sub-distribution boards shall be finalized during detail design stage and shall be subject to approval of the Engineer.

15.10.6 Inverter

The static inverter composed of wholly static devices such as diodes, thyristor switches, IGBT and other electronic elements shall be supplied for 110 V DC / 230 V AC to cope with the power demand of all control, measuring and monitoring equipment requiring a continuous and safe / essential power supply under all normal and emergency conditions.

The AC essential load is always fed from the inverter. Upon failure of the inverter or the inverter DC supply, the safe / essential AC system shall be fed from the AC system. The inverter shall be provided with a changeover device composed of a static switch and synchronizing unit so that the inverter output voltage is permanently in phase with the AC system, enabling uninterrupted switchover at any time.

The inverter shall be completely equipped with protection indication and signaling devices assuring satisfactory operation and protection against internal malfunction. The inverters and the chargers shall have a communication port with the automation system that uses ModBus/TCP/IP or other industrial protocols.

15.10.6.1 Main technical data

Rated capacity: Min. 15 kVA at 0.8 p.f.

Input voltage: 110 V DC, + 20-15%

Output voltage: 230 V AC, +2%

Frequency: 50 Hz, +1%

Wave form: sine, max. 5% distortion at linear load Overload capacity

1 sec.: 200%

1 min.: 150%

At least, the following instrumentation and control devices shall be provided:

- One (1) AC ammeter
- One (1) DC ammeter
- Two (2) AC voltmeter
- One (1) DC voltmeter
- One (1) frequency meter
- Selector switch inverter / by-pass operation
- Push button for by-pass operation test
- Single fault indication lamps as required with group alarm to the control room.

15.10.6.2 Distribution Boards

Power supply shall be supplied from the battery set and from the rectifiers/chargers.

15.10.6.3 Equipment

Distribution board equipment shall have excellent strength against electro-dynamic stresses. Switchboards shall be assembled in steel sections and fabricated and bolted sheet units of modular design, comprising:

- racks containing the switchgear;
- separate compartments for:
    - two-phase busbars;
    - power and control connections;

- general accessories.

Controls, metering devices, fault indicators and position indicators shall be mounted on the front face.

15.10.6.4 Components

- Incoming feeder circuit breaker (charger / rectifier).
- Incoming feeder fused switch (battery).
- Outgoing feeders for the supply of generating units, lines, circuit breakers, common auxiliaries, control system polarities including control and monitoring devices projection devices, signalling devices and lamps, alarms.
- Outgoing feeders, complete with all protective devices shall be supplied as spares.

Interlocks shall be provided to prevent switching errors and other inappropriate action, and accidental contact with live parts.

15.10.6.5 Metering and Signalling

Information concerning busbar voltage and current in incoming lines, switchboard faults and positions of main items of switchgear necessary for correct operation shall be in accordance with the general principles and technology specified elsewhere herein for control systems.

Battery fuses, to be provided, will be quick acting, current limiting type and be provided with suitable arrangement to activate an alarm when they are blown out. Moulded circuit breakers in place of fuses can be considered.

15.11 STATION AC AUXILIARY SUPPLY

15.11.1 11 kV Auxiliary Supply System

The medium voltage (11 kV) and low voltage (400 V AC) installations have been planned to provide a reliable supply for all functions of the powerhouse as shown in **Drawing 44**. The 11 kV AC station auxiliary Switchgear will normally be fed from 500 / 11 / 11 kV 26 MVA, three windings station service supply transformer located in the switchyard. The 11 kV Main Switchgear has two buses, designated as SWGR-A & SWGR-B connected through a bus coupler, while each bus is fed from separate winding of station auxiliary supply transformer. The Main emergency diesel generating set is connected with Busbar A with electrical and mechanical interlocks with bus coupler and main incoming breaker IC1. The main 11 kV Switchgear is supplying the power to the power plant 400 V Switchgear, the Intake Structure Switch gear, the Switchyard Switchgear and of course two lines to the Power Plant Residential

Area. All outgoing feeders are 11 kV and feeding to 400 V Switchgear through distribution transformers. There are numerous 11/0.4 kV, different capacity distribution transformers shall be planned to feed the 400 V, double Busbar switch gears for the common and essential power supply.

15.11.2 General

The 11 kV switchgear shall be of the horizontal draw-out type, with double bus coupled through a bus coupler. Circuit breakers shall be mounted on trucks. The circuit breakers have to be designed for a maximum ambient temperature. As far as possible the number of types shall be reduced to a minimum due to interchangeability and maintenance.

The design of the individual unit compartments shall be such as to obtain different zones fully insulated from each other, namely:

- The circuit breaker / contactor compartment.
- The bus bar section.
- The control and monitoring compartment.
- The power cable connection compartment.

All faults occurring in any of the individual sections are to be restricted to that area and shall not cause (except for busbar faults) shut down of any other cubicle of the switchgear other than the faulty one itself. Busbars and joints shall be completely PVC shrouded or cast moulded.

All feeders shall be provided with a suitable mimic diagram. The position of the switches must be clearly indicated, supervision of control wiring health and lamp test is required. The switchgear has the following types of cubicles:

- eight (8) 11 kV outgoing feeder cubicles;
- two (2) 11 kV cable incoming switchgear cubicles, one from each winding of station auxiliary supply transformer;
- one (1) 11 kV bus coupler switchgear cubicles;
- two (2) voltage monitoring cubicle/cell for synchronizing;
- one (1) 11 kV Feeder for Emergency Diesel Generating Set;
- one (1) spare 11 kV switchgear cubicles.

15.11.3 Technical Data of 11 kV Switchgear

Design Voltage	12 kV
Type of cubicles	metal-clad cubicles on rails
Short circuit current (3s)	30 kA
Rated lightning impulse withstand voltage	75 kV

15.11.4 Distribution Transformers

All 400 Volts Switchgears are fed from 11 kV Outgoing feeders of Main 11 kV Switchgear through distribution transformers. The Transformers are 11/0.4 kV Dd11 type whose capacity will be determined at the time of final power plant design.

15.11.5 400 V Switchgear

There are 4 x 400 V Switchgear suggested for complete electrical loading of the 300 MW Balakot HPP. These are 400 V Switchgear in Power Plant with double bus feed, 400 V Switchgear for switchyard, 400 V Switchgear at Intake structure and 400 V Switchgear in Residential Colony, while there are 3 x 400 V Unit Auxiliary Power Supply switchboards which are directly fed from unit GCB as well as from 400 V power plant Switchgear. Each 400 V Switchgear has a bus tie breaker. The two parts will provide 400 V AC supply for normal and essential functions respectively. The bus tie breaker for intake structure will normally be closed and interlocked with the circuit breaker of 100 kW, 400 V intake emergency supply diesel generator.

In general, 400 V AC unit service supply is taken from the respective 18/0.4 kV unit auxiliary transformer in operation. During starting of each unit, the unit service supply will be taken from 400 V AC essential supply board.

In case of a failure of the unit service board supply, it will automatically switch over to the 400 V AC essential supply system. In an emergency condition, the essential supply board will be fed by the 1000 kW, 400 V AC diesel generator, through 11 kV Switchgear, so that the unit can be started and synchronized to the grid.

230 V AC uninterruptible power supply from 110 V DC system will be provided for essential services such as control system, firefighting control panel, emergency lighting etc. This arrangement will ensure enough reliability to secure all essential power need for security, protection and a black start up.

15.11.6 Intake Area

The 11 kV supply to the intake premises will be fed by the 500/11 kV station service supply transformer and 2 x 11 kV overhead feeder for redundancy purposes. Intake supply transformer of 11/0.4 kV will be installed at the intake premises and connected to the 400 V AC intake supply board. The 400 V AC intake supply board will be energized by an emergency diesel generator of 100 kW, 400 V, when the normal supply is not available.

15.11.7 AC Distribution Board

The AC distribution system will be designed as a 400 V, 3-phase four wire system. Each secondary board will be supplied by two feeders from each of the related main boards. Only one feeder will supply the secondary board at any one time, and the two circuit breakers installed on the incoming feeders will carry out the selection of supply feeders. A voltage relay will automatically initiate the changeover, when no voltage is detected on the bus bar.

The essential load distribution system will be continuously energized during the normal operation to ensure the system availability. The distribution system will supply low voltage power to all the station's services, lighting and battery chargers, and local control cabinets with necessary motor starter and sub-distribution panels. DC/AC power converters will provide uninterrupted power supply to the essential control functions from the battery banks

15.11.8 Motor Control Centers (MCCs)

All motors will be controlled through motor starter units assembled in motor control centers (MCCs). The number of MCCs will be determined by the cable length and location of the motors and equipment.

15.11.9 Circuit Breakers

The low voltage circuit breakers (CBs) will be of the following design:

a) CBs greater than 400 Amps will be of withdrawable design.

b) CBs less than 400 Amps will be of fixed type.

15.11.10 Station Auxiliary Transformers

Four-unit auxiliary transformers (18 / 0.4 kV) will be supplied from each of the Three generating units. All unit auxiliary transformers will be of indoor, dry cast resin insulated type and installed in the corresponding unit panels.

15.12 MAIN EARTHING AND LIGHTING PROTECTION SYSTEM

15.12.1 Main Earthing System

The earthing system for the powerhouse and switchyard will be designed according to well established principles and consist of earthing copper electrodes embedded under concrete foundation in the powerhouse and in the soil foundations for the switchyard with double connections (risers) to the installed equipment. A mesh of suitable conductor dimensions will be laid in the switchyard and counterpoise (electrical ground that is not connected to earth) will be laid where necessary.

The earthing electrodes will be designed to provide a common equi-potential reference for the installed equipment, both in the powerhouse and in the switchyard, and will have sufficient dimensions to reduce voltage transient from possible earth fault at any equipment to an acceptable low level, in accordance with ANSI standards. Each plant item will be earthed at two point's diagonal to each other. All metal parts other than those forming part of any electrical circuit will be connected at regular intervals to this system.

15.12.1.1 General

The grounding system of the Power House and GIS substation shall also be connected to the Power Plant grounding system The intent of grounding system is to protect personnel from shock, hazards and the equipment from damage, by controlling voltage gradients during short circuit and earth fault.

The grounding system shall consist of bare soft drawn copper cable grid embedded in the ground at a depth of 1000 mm below reference ground level. A final topping of river run gravel of 25 to 40 mm shall be provided. The mesh shall be connected to ground rods driven in ground, and to all metal structures and equipment in the substation as specified herein. The grounding grid shall be extended to outside the cavern where required extra conductor shall be placed in rectangles at the corners of the grounding grid to keep the touch and step potentials within specified limits.

Additional ground rods shall be provided at the points where impulse discharges are expected. Every intercrossing of copper cable shall be welded by thermic process.

Grounding system shall be designed in accordance with IEEE Guide for safety in Substation grounding (IEEE Standard 80-2000 Publication). However, the following requirements shall be observed:

Symmetrical short circuit current, minimum,	kA,rms.50
Duration of short circuit,	1 sec.
Conductor size for underground grounding grid	sq.mm 240
Conductor size for down leads connection of equipment with grounding grid,	sq.mm 240
Diameter of ground rod, minimum,	16 mm.
Length of ground rod, minimum,	3 m
Touch potential without crushed rock, maximum	According to IEEE 80-2000
Step potential without crushed rock, maximum	According to IEEE 80-2000
Resistance of grounding grid and ground rods, maximum, ohms.	0.25

During design phase, tests are required to determine ground resistivity prior to design of grounding system along with sufficient evidence supported by calculations and profiles for tolerable touch and step potentials over the grounding grid, to show that the specified requirements are met.

15.12.1.2 Conductor

Grounding conductor cable shall be soft drawn bare stranded copper, of electrolytic grade.

Risers for grounding the surge arresters, circuit breakers, equipment neutrals, steel structures etc. shall be of 240 sq.mm.

15.12.1.3 Ground Rods

The ground rods shall be copper covered steel rods. Each ground rod shall have conical machined point at one end and shall be chamfered at the other end. The copper cover shall be heat welded to uniform thickness. The copper thickness shall not be less than 0.38 mm. The ground rods shall be driven at the grounding points of the surge arresters and other points as required depending upon the grounding grid calculations.

15.12.1.4 Grounding Connectors

The ground connectors above the ground surface for connecting the equipment, fences and down leads to the grounding mesh shall be cast bronze bolted type lugs or high copper alloy ground connectors. All bolts shall be of silicon bronze alloy cold formed with rolled threads.

Bimetalic washers and connectors shall be provided wherever required. All connections buried in the ground or embedded in concrete shall be of welded type made by Thermite or Cadweld process.

15.12.1.5 Equipment Grounding

- **Switchracks and Structural Steel**: switchracks and steel structures shall be grounded with 240 sq.mm conductor from two different diagonally opposite legs. A square structure shall be grounded at two points diagonally opposite to each other. In case of structures consisting of several bays each leg shall be grounded.

  A grounding conductor shall run throughout the length of the cable trays in the outdoor high voltage connections, GIS room and the control room. The grounding conductor shall be connected to the substation grounding mesh at regular intervals. This conductor shall be appropriately clamped to the cable trays.
- **Metallic Conduit:** all metallic conduits shall be connected to the grounding grid by connections at each manhole or terminating point. Conduits terminating in metal junction boxes located adjacent to each other, a 35 sq.mm wire may be used to interconnect them together and at one point connected to the grounding grid. Cable trays and racks in trenches shall be grounded as well.
- **Transformers:** each transformer tank shall be grounded at two points diagonally opposite to each other. These connections shall be made from two different points of the grounding mesh. Transformer earthing neutral shall be earthed to two different points of the earthing mesh with a minimum of 240 sq.mm copper conductor.
- **500/132 KV GIS:** metal structure of each cell of 500 kV and 132 kV GIS shall be connected with the ground grid through two different points with 240 sq.mm grounding conductor. The grounding mesh shall run around the GIS and the grounding shall be done at equal intervals.
- **Surge Arresters**: All 500/132 kV Surge arresters outside of the caverns shall be connected to the grounding grid by insulated cable of appropriate size but not less than 185 sq.mm for 500 kV system and 95 sq. Mm for 132 kV system, which shall be able to conduct the lightning and switching surges to ground effectively without generating any potential gradient. A 240 sq.mm conductor shall ground the supporting structure. Additional grounding rods shall be driven adjacent to the surge arrester connected to the grounding grid.

The final design shall provide ground details of all metallic equipment, supplied inside Control Building such as Control Panels, transformers auxiliary control panels. Recorder Panels, Relay

Panels, AC and DC distribution Boards, PLC panels, chargers, cabinets, metallic piping, metallic supports of equipment, cable trays etc. with the station grounding grid.

15.12.2 Lightning Protection System

All superstructure as applicable will be provided with a lightning protection system comprising conductor sufficiently sized, spaced and connected to the main earthing loop or to the separate earthing electrodes.

15.13 COMPUTERIZED PLANT CONTROL SYSTEM

The plant will be equipped with a state-of-the-art computerized control system as shown in **Drawing 46**. The main advantage of this type of control over the traditional hardwired type is replacement of the large number of cables and wires for communication between different points of control of the plant by fiber optical cable.

All switching, instrumentation, alarm and control settings will be through a computer program, which is easier to install, analyze and maintain. The risk of faulty connection is reduced considerably. The installation provides more clarity thus facilitating a fast and simple error diagnostic. Future modification can easily be introduced without disturbing the operation of the plant.

The control system will be divided in the following hierarchical level:

a. Plant Control System (PCS): a computerized plant control system (PCS) located in the main control room for the supervisory control of the power plant with video screen and operator keyboard.
b. Local Control Units (LCUs): one computerized local control unit for each generating unit, one for 500 kV switchyard and two for the auxiliary systems and one for the intake. The protection relays are to be part of the local control unit but operationally independent of the computer.
c. Manual Control Level (MCL): manual operation from the object control panel.

15.13.1 Plant Control System (PCS)

The computerized PCS is installed for the monitoring and supervisory control of the power plant.

Operation of the system is performed in the control room. The PCS will control the process *i.e.*, command procedures, automatic control procedures, interlocking routines etc., via the actual LCU. In this mode, the LCU manual control panel is disconnected but all LCU indications are active.

No failure in PCS will interrupt or block the operation of the power plant.

15.13.2 Plant Control Software Functions

The software functions will be finally decided during the detailed design phase. The following design requirements are recommended.

The plant system software will include all normal SCADA and MMI (Man Machine Interface) such as:

a) Data acquisition from all LCUs, including status signals, alarms, analogue measurement etc.

b) Transferring command control outputs to the LCUs.

c) Alarm handling and event recording.

d) Dynamic presentation of the start/stop sequence for each generator set.

e) Time synchronization and time lagging system.

f) Online trends, change of data and change of pictures.

g) Post mortem review.

h) Well supported spread sheet with on-line link to SCADA system.

15.13.3 Local Control Units (LCUs)

The solution considered in the Study consists of distributed control, with equipment and control units of the modular type, based on micro-processed technology (computers and PLC's). However, it is suggested that the number of LCUs should not be limited to that indicated in the document, leaving it open for the detail project to consider more specific units for the control of autonomous subsystems, like pumping, cooling, etc.

All equipment will be of modular design. Particularly major units of the LCUs such as the microprocessor modules, memory modules, communication modules, I/O modules, internal power supplies etc., will be easily serviceable and replaceable.

The LCUs will comprise programmable logic controllers (PLCs) based on microprocessor technology and will perform all functions for accessing, analyzing and acting on the information from the process and perform the operational tasks commanded by the PCS.

In the 'local control' mode, the manual control panel of the LCU will be in operation. Operation of the devices connected to the LCU is then performed directly.

The number of LCUs should not be limited to that indicated in this document and must be defined during the detailed design phase.

15.13.3.1 Local Control Units for the Generating Units (LCU1~ LCU4)

The LCUs for the generating units will be programmed for fully automatic start and stop procedure for the units including synchronization and all parallel operations.

The operation and function of the voltage regulators and the turbine governors will not depend on the LCUs. The initiated procedure will sequentially command all actions. The sequence of operations and immediate status will be transferred to the PCS.

15.13.3.2 Local Control Unit for the Power Station Auxiliary Supply (LCU5)

LCU will supervise the plant auxiliary power supply system and provide automatic switching to the available power sources, according to the agreed priority schedule.

In addition to the auxiliary power supply, including the medium voltage equipment, the LCU will supervise the drainage pumps, ventilation system, cooling water pumps, chilled water system, and the light and small power. The firefighting system will have an independent control system.

15.13.3.3 Local Control Unit for 500 kV Switchyard (LCU6)

The LCU and protection relays will be located on a control room or a separate building in the switchyard.

The LCU will be interconnected to the local control panels for the 500 KV switchyard and the relays protection panels.

15.13.3.4 Local Control Unit for the 11 KV Sub-Station of Powerhouse (LCU7)

The LCU will be installed in the cabinets with process interface to the 11 kV systems. The interlocking and local monitoring and operation for each individual switch bay will be done locally from the 11 kV switchgear. The bay control will either be based on a conventional or a computerized solution. Any microprocessor-based solution will utilize the control characteristics of the relay protection system and reduce the number of components in the control system.

15.13.3.5 Local Control Unit for the Intake Area (LCU8)

The LCU is located on the intake gate house. The LCU will cover the standby diesel generating unit, the power supply, the transmission of signals from the gate equipment to the power house and the water level controller.

The water level controller will maintain a set point for the water level at the intake. The controller will calculate optimum operation of the units and the control of intake gates and spillway gates. As an additional function, the water level controller may indicate to the operator when one generating unit will be started or stopped.

15.13.4 Manual Control Level (MCL)

The LCUs can be put out of automatic operation for full featured manual operation of all units. In this mode, each operation is performed locally on each device.

In addition, manual operation can be performed directly on the equipment, i.e., on the generating units, switchgear panels, motor control cubicles (MCC) etc. All monitoring and control will then be done locally from the LCU mimic panel. The design of the local control panels will include equipment for indicating status and control of the major parts such as generators, turbines, breakers, switches, and control of alarm level set point etc. Start, stop and other control functions of the units will be possible by manual operation. Synchronization of each unit and parallel operation of all the three units will be possible from a separate synchronization cubicle (with all necessary instruments and manual control facilities).

15.13.5 Data Communication System

The communication between the PCS and the LCUs will consist of a fiber-optical cable system. The communication layout will be star system.

15.13.6 Communication with National Power Control Center (NPCC)

The control system concept allows for serial and network communication with third party systems ("open system") on the basis of standardized protocols *e.g.* IEC 60870-5-101, IEC 60870-5-103, and IEC-60870-5-104 etc. In case the communication has to use non-standardized protocols or proprietary protocols of third-party systems, such protocols can be fulfilled by a gateway. The main communication link between the power station and the NPCC will be provided by Optical Fiber in Ground Wire (OFGW) in the 500 kV transmission line.

15.13.7 Time Synchronization

Time management in the entire automation system and the performance capability of the functional units will be designed such that all necessary automation and monitoring tasks are fulfilled.

The time management functions in automated systems handle time setting for real-time clocks and keep these real-time clocks synchronized. A Network Time Protocol (NTP) redundant time server with Global Positioning System (GPS) receiver will be used for central time acquisition.

15.14 SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA)

15.14.1 General

WAPDA and NTDC established a computer-based SCADA and Energy Management System for monitoring and control of its power stations and transmission network of 500 kV and 220 kV. The system comprises NPCC at Islamabad with Regional Control Centers (RCCs) at Islamabad (North) and Jamshoro (South).

The Balakot HPP is specified for remote control from the NPCC and will also be controllable from the local PCS system. However, control from the PCS will only be allowed if authorized by the NPCC. Normally these controls will be with the NPCC. Remote control will only be possible from one location at a time.

The scope of the SCADA, in accordance with the current WAPDA and NTDC practice for remote monitoring and control of 500 / 220 kV substations and generating stations, is summarized below.

15.14.2 Indications

a) Open and close indications for all 500 kV circuit breakers and disconnect switches, and reactors disconnect switches.

b) Position indication for all the local and remote switches, one for each 500 kV circuit breaker and one for each generator.

c) Automatic Load and Frequency Control (ALFC) in / out of operation.

d) Voltage status of each bus bar.

e) Grouped bays fault alarms for each 500 kV bay.

f) Telecommunication alarm for failure in the data transmission network.

g) Information on the equipment of the Water Supply (gates, etc.).

h) Alarm and trip information, independent or grouped.

15.14.3 Measurements

a) Active and reactive power of all 500 kV lines.

b) Active and reactive power of all generators.

c) Voltage of end 500 kV bus bar.

d) Measurement of station frequency.

e) Hydraulic measures of the installation (levels, flow rates, etc.).

15.14.4 Controls

a) Tripping and closing of all 500 kV circuit breakers.

b) Raising and lowering of generator output power.

Generating units of WAPDA / GENCOs will follow the scheme implemented by NPCC.

15.15 EMERGENCY DIESEL GENERATION SET FOR THE POWERHOUSE

15.15.1 General

This diesel generator set shall be rated for emergency power supply purposes of the power plant. Keeping in view the height of the power plant from mean sea level and one unit 1% loading, a 1000 kW diesel generating set is considered for emergency power supply. The diesel generating set will be placed outside the cavern to prevent the smoke inhalation inside the cavern and to prevent any type of fuel explosion inside the cavern.

The diesel generator set shall run on diesel fuel oil. All necessary piping, pumps etc. shall be provided. The diesel generator set will be connected to the 11 kV Switchgear with cables through a 0.4/11 kV step-up transformer. The circuit breaker within the 11 kV switchgear shall be used as generator circuit breaker. All necessary protection, interlocks and synchronization functions shall be provided. An automatic start up and synchronization system shall be provided. The start and synchronization of the diesel generator set shall also be possible by manual operation.

15.15.2 Equipment Description

The emergency diesel generating set shall consist of a brushless, self-exciting, self-regulating synchronous generator directly coupled to a diesel engine complete with all the required auxiliaries including lubricating oil system, engine cooling system, fuel system, starting system, excitation system, auxiliary power system and complete controls. The unit shall be furnished with adequate guards to protect personnel from rotating and moving parts and from hot surfaces. The engine alternator shall be direct-coupled to form a single robust mechanical unit and shall be mounted on heavy base frame of all welded design with correct alignment and the base frame shall be drilled for holding down bolts or anti-vibration mountings, whichever is most suitable.

15.15.3 Rating

The diesel generating set shall have a continuous rating of about 1200 kVA at 0.8 power factor, 50 Hz. The alternator shall be designed for operation at 400 V phase to phase.

The diesel engine driven generating set shall be of fully automatic main failure electric start type. That is, it should have a system in its control panel containing automatic start/stop logic systems, designed to accept a signal from under voltage detection equipment through an under-voltage relay. Following a loss of voltage, the machine shall be capable of starting from a remote signal and reach synchronous speed within a maximum of 10 seconds. The set shall continue to feed the load until mains supply is again available, then it shall automatically stop and shall remain in readiness for the next emergency. The control system shall be interfaced with control room to enable automatic start-up and manual start-up from the operator's console in the main control room. The diesel generator set shall be capable of being started from its local control panel. The electrical protection systems of the diesel generator set shall be designed and provided by the Contractor. Contractor's design shall be acceptable to the Engineer.

15.15.4 Diesel Engine

The engine covered by these specifications shall be able to operate on diesel oil as described by ASTM or ISO Specifications. The engine shall be provided with required auxiliaries, guarantees of fuel consumption, parallel operation and acceptance tests.

15.15.5 Governing

The Contractor shall assume full responsibility for selection, design and adjustment of the governing systems for stable governing *i.e.* without hunting. The speed of the unit shall be adjustable over a range of + 5% from the normal engine operating speed. The speed droop characteristic over the load range from zero load to full load shall be adjustable from 0 to 5% of rated speed at 50Hz. Means for remote speed control shall also be provided. Means shall be provided on the engine to shut down the engine automatically in the event that the engine speed exceeds the "shutdown" speed.

15.15.6 Starting

The set shall include all equipment necessary to start and run the diesel unit without any external source of AC or DC power and shall be capable, at all ambient temperatures, of starting and assuming full load at rated frequency in 10 seconds of the receipt of a start signal. The diesel generating set shall be supplied complete with its own lead-acid battery, battery charging equipment and trays fitted on the base frame for holding the batteries.

15.15.7 Fuel System

A fuel oil system for the unit shall be provided. The system shall not require any manual or electric priming before starting. A manual fuel pump shall be fitted so that fuel can be transferred to the set mounted fuel tank from reservoir, if required to do so. A 5000 Lit Day tank shall be the integral part of the system.

15.15.8 AC Generator

The generator shall be directly coupled to the diesel engine. The generator shall conform to the applicable standards. The generator shall be rated as follows:

Capacity:	1200 kVA
Voltage:	400 V
Phases:	3 Phase, 4 wire, grounded neutral
Frequency:	50 Hz
Power Factor:	0.8 lagging
Exciter:	Brushless with rotating diodes

The generator shall be suitable for continuous operation at 10% above or below rated voltage.

15.15.9 Temperature Rise

Generator temperature rises at continuous rating in an ambient of 50 °C shall not exceed 70 °C by resistance measurement on the field. The exciter temperature rise shall not exceed 50 °C by resistance measurement on field or armature when the main generator is on continuous rating.

15.15.10 Generator Stator Insulation and Windings

The stator winding shall be Class F. All winding materials and slot wedges shall be non-hygroscopic and be classified as Class F also. All connections, rings and joints shall be sized such that their temperature rises are within Class B limits and all insulation materials, varnishes and impregnates shall be fully compatible. The winding design and insulation processes shall be such as to eliminate coil or wedge migration due to Diesel engine vibration.

15.15.11 Voltage Regulating Equipment

A set of voltage regulating equipment designed to meet the requirements of this specification. The regulator shall include but not be limited to:

1. A series boost current operated device to maintain excitation under fault and over load conditions.
2. Any necessary cross-compensating circuits to permit stable, parallel operation with the other engine, while running isolated from the power system.
3. Any necessary devices to permit stable parallel operation of the engine with the power system under manual/remote control.

15.15.12 Tests

The set furnished shall be subject to tests in the shop and at site in the presence of the Engineer for conformity to requirements of the Specifications.

Diesel Engine

All mechanical parts shall be run under simulated operating conditions at the Manufacturer's works. All tests shall be conducted in accordance with the appropriate codes for testing. The tests to be carried out shall include, but not be limited to, the following:

1. Dynamic balancing together with over speed tests of the generator exciter and rectifiers.
2. Bench testing of all accessories.
3. Zero load operation of the diesel engine assemblies to test the following:
    a) Vibration.
    b) Lubricating system.
    c) Fuel system.
    d) Governor system.

- e) Temperature control system.
- f) Over speed trip.
- g) Individual accessories.

The diesel engine and AC generator shall be test-run continuously for 24 hours to ensure smooth running and satisfactory operation of the machines and accessories.

Generator

1. Shop Tests: all test procedures shall be carried out in accordance with IEEE 11501 or UTE C51 100.
2. Routine Tests - routine tests on the generator shall be performed. Routine tests shall include:
   - a) Resistance of armature and field windings.
   - b) Polarity of field coils.
   - c) Check of mechanical balance.
   - d) Check of no-load field current or exciter field current.
   - e) Voltage balance.
   - f) Phase sequence.
   - g) No-load saturation curve.
   - h) Insulation and high potential tests.
   - i) Over speed test at 125% speed for 1 minute.
3. Type Tests - the generator shall have the following tests performed:
   - a) Short circuit saturation curve.
   - b) Temperature test.
   - c) Segregated losses.
   - d) Voltage deviation factor.
   - e) Three phase line to line short circuit test at any convenient voltage in the 0.4 to 0.5 p.u. volts.
4. Characteristics test curves: following completion of type tests. Manufacturer shall provide characteristics curves of the brushless excitation system. These curves shall show:
   - a) Exciter field amps and volts versus generator line current at 0.80 Pf. and maximum and minimum temperature rises.

b) Exciter field amps and volts versus generator line current at 1.0 Pf and maximum and minimum temperature rises.

c) As for (a) above, but with one diode failed.

5. Control system tests

Functional tests are required to be performed both at factory and at site to demonstrate the correct functioning of all control, protection, metering and alarm functioning.

6. Performance tests

The following tests shall be required at the time of commissioning of generating sets at site:

a) Preliminary tests on individual components.
b) Continuous one-hour heat run at 50 percent load rating in parallel with the system.
c) Continuous one-hour heat run at 75 percent load rating in parallel with the system.
d) Continuous four-hour heat run at 100 percent load rating in parallel with the system.
e) Part load heat runs to demonstrate satisfactory operation and establish fuel consumption at the respective loads.
f) The tests shall also include:
    - Performance of Governing characteristics and protective systems.
    - Starting characteristics of the units. The units shall start at least five (5) times in six (6) consecutive starting attempts.
    - Starting power requirements to demonstrate the ability of the machine to start the specified number of times without need to recharge the batteries.

15.16 EMERGENCY DIESEL GENERATOR SET FOR THE INTAKE AREA

Same as section 15.15. The size of 100 kW is acceptable, the other conditions are the same as defined in section 15.15 above.

15.17 TELECOMMUNICATIONS

15.17.1 General

A telephone network will be established to provide telephone connection to the entire plant including the powerhouse, administration center, residential colonies, workshops and stores,

15.18.3 Safety Lighting

The safety lighting shall be arranged to illuminate all exits and entrances of the cavern and to provide illumination in operation and control areas. The safety lighting shall be complete with self-contained safety lighting blocks.

These fittings shall be composed of:

(i) self-contained, to be switched on automatically in the event of a power cut in the normal lighting circuit;

(ii) shall be powered by Ni-Cd battery with built-in charger;

(iii) minimum autonomy 3 hours;

(iv) Illumination 40 lumen.

15.18.4 Principle of Lighting Apparatus Energizing

Lighting apparatus shall be fed by sub-distribution boxes. Each feeder system shall be protected at the head of the circuit by a four pole miniature circuit breaker. Each circuit shall be individually protected by fuses.

Relevant standards, as IEC, shall fully apply for design, manufacturing and testing of all equipment.

15.18.5 Lighting Apparatus

Lighting apparatus shall include:

(i) fluorescent lamps;

(ii) mercury vapour lamps;

(iii) incandescent lamps;

(iv) self-contained safety lighting blocks and all accessories required for fixing in place, including outdoor lighting.

15.18.6 Illumination Levels

The illumination levels for the various areas shall conform to the recommendations of the relevant IEC standards.

Normal illumination levels shall be:

• Machine hall	200 Lux
• Electrical rooms	300 Lux

Control Room	400 Lux
Cavern Streets of power plant	100 Lux
Other rooms	200 Lux

15.19 FIRE SAFETY INSTALLATIONS

15.19.1 Generator Fire Protection System

Each generator will be provided a completely independent fire detection and protection system, capable of detecting and quenching any combustion occurring within the generator enclosure. The system will provide for total flooding of the enclosure with Argonite and maintaining the necessary Argonite concentration for at least 20 minutes after the first gas discharge.

Fire detection equipment will comprise thermal and smoke detectors both within the generator and the generator enclosure. Automatic release of Argonite into the generator will require operation of a smoke detector together with either generator electrical protection or thermal detector operation. Manual release of Argonite will be provided only by manual operation of the valve trip mechanism at each generator.

Advantages of Argonite:

a) Aragonite is an inert gas blend consisting of a 50:50 mixture of two gases found naturally in the atmosphere: Argon (Ar) and Nitrogen.

b) Argonite is also known as 'clean agent' as it leaves no residue behind after its use and is governed by NFPA 2001 - Standard for Clean Agent Fire Extinguishing Systems. For effective fire suppression, it requires a concentration of at least 30% in a closed space. It extinguishes the fire by replacing oxygen in the air and hence smothers the fire. Due to its high concentration requirement, it is required to keep Argonite in large quantity but it is comparatively much cheaper than other 'clean agents' like FM 200.

c) Argonite is an inert gas that extinguishes fire based on the principle of oxygen depletion. In a closed space almost all fires are extinguished in less than 60 seconds when the oxygen concentration falls below 15%. Aragonite reduces the oxygen concentration to approximately 12.5%, an acceptable level for human exposure over short periods of time. In occupied spaces, people can breathe Argonite at extinguishing concentrations without fear. There are no toxicological factors associated with the use of Aragonite. Argonite will not decompose or produce any byproducts when exposed to a flame from a fire condition.

15.19.2 Transformer Fire Protection System

Fire protection system including fire detection and fire extinguishing by sprayed water with one main storage tank, shall be supplied for each step- up power transformer. Transformer shall be provided with its own individual fire detection system and water spraying cage.

15.19.3 Detection System

The Detection system shall be based on Quartz capsule type thermostatic detectors secured to the transformer distributed on the sides of transformer tank. These detectors shall record any abnormal temperature rise caused by a terminal or tank fire or by a fire on the ground near the transformer. The detectors shall be interconnected in parallel by a cable protected by a self-extinguishing sheath and which is connected to a fire detection cabinet located near the fire extinguishing system by means of a junction box, facilitating dismantling in case of displacement of the transformer.

One of the detectors shall be equipped with an "end of line" resistor enabling the guard current to monitor the complete installation. Moreover, the installation of the equipment shall be designed so as not to interfere with the operation of the fire protection system.

The fire detection cabinet shall include relays, providing contacts for the power supply of a local lamp indicator and, if necessary, on the remote control panel. The contacts shall indicate the outbreak of fire or a break in the monitoring current flowing through the detector circuit, in case of the cable being cut or loosening of the terminals. The cabinet shall also include an ON/OFF switch with the possibility of its position being transmitted to the central control panel. The fire detection system shall operate in the indicating mode or provide for automatic operation of the fire protection system.

15.19.4 Water Fire Extinguishing System

The fire extinguishing system shall be based on spraying the transformer with water. This water shall be taken from the penstock before the inlet valves of the turbine. The transformer shall be equipped with a spraying cage enabling it to be completely surrounded by a cloud of pressurized sprayed water droplets. The spray nozzles shall generate perfectly homogeneous cones, which will cover the likely burning area, resulting in the extinction of the fire affecting the equipment.

The fire protection system shall be operated without any danger when the equipment is energized. The spray-bars and their water supply header shall be hot-galvanized after forming and assembled in-situ without damaging the galvanizing.

The following accessories shall be supplied for each station step-up transformer:

a) fire detection cabinet;
b) quartz thermostatic detectors;
c) sprayers.

15.19.5 Fire Alarm and Detection System

The following locations in the power plant will be monitored by a fire alarm and detection system:

- the powerhouse machine hall;
- the control room, electrical switchgear room and auxiliary equipment room;
- the high voltage GIS Room;
- the transformers hall.

The detection system shall be based on ionic smoke detector and heat rate of rise detectors, distributed in the relevant protected rooms of the power plant, in accordance with the manufacturer's recommendation. Detectors shall be connected to a central alarm and detection panel on which visual and audible alarm facilities will be provided and shall be properly divided into the suitable rooms. Alarm shall be made inside and outside the power plant through flashing lights and siren.

15.19.6 Fire Extinguishers

Fire extinguishers shall be supplied in each room. The extinguishers shall be approved in accordance with relevant IEC standards. They shall be suitable for extinguishing oily fires. Powder fire extinguishers shall be supplied in each room of the plant as follows:

(i) one 9 kg powder extinguisher for each unit in the machine hall;
(ii) three 6 kg powder extinguishers one for the storage room;
(iii) one 25 kg wheeled powder extinguisher for the each electrical switchgear room;
(iv) one 6 kg powder extinguisher for each unit adjacent to respective excitation system and other panels in the machine hall.

15.20 VIDEO SUPERVISION

A video supervision system for the power plant and intake area has been planned. The signals will be transferred via communication link to the centralized supervision panel in the control room. The supply will be un-interruptible through a 110 V DC system.

In the powerhouse area several cameras will be installed to supervise all the entrance points and the switchyard. Six small monitors with required control panel will be installed in the control room. All signals will be transferred to the control room for monitoring and control purpose. During the critical phase, each of the signals can be switched to one large TV screen, placed in the same area as the small screens, for better viewing. The power will be made available from the 110 V DC system.

As the power plant is normally remote-controlled, the CCTV system should consider fixed or mobile cameras for monitoring the main equipment and areas of high concentration of equipment.

16 POWER TRANSMISSION

The grid interconnection study GIS) of the Balakot Hydropower project was developed by Power Planners International (PPI). The most recent version of the draft GIS is included in **Annex XII**.

The PPTA Consultant suggested in the development of the Feasibility Study that, along with previously anticipated 500 kV connection, a 132 kV level power evacuation for the Balakot Grid station is contemplated. Such will have three distinct advantages

1. The local community *i.e.* Kaghan Valley population shall get direct benefit of the 300 MW Balakot project.
2. The power plant gets a second source of power supply for black start operations.
3. The area has a severe problem of voltage fluctuation and that could be mitigated with the referred connection.

The installed capacity of the plant would comprise of three generating units of 100 MW each, among which two will be at 500 kV and one unit will be at 132 kV. These three units would deliver a maximum net power of 296 MW to the grid.

Therefore, as per the scheme proposed, the power plant will be connected at two different voltage levels supplying the power to NTDC at 500 kV level and to PESCO at 132 kV level. The following scheme of interconnection is proposed in the GIS:

- Due to the location and power capacity of Balakot HPP, the most feasible interconnection scheme would be looping in-out Balakot HPP 500/132 kV grid station at the 500 kV single circuit between Sukhi Kinari and Maira Switching Station. The looping distance is about 2 km. The conductor used will be Bunting/High capacity conductor.
- The interconnection at 132 kV level would be looping in-out at the 132 kV single circuit of Balakot to Manshera-N. The looping distance is about 10 km and the conductor used will be Rail.
- An interconnecting transformer of 500/132 kV of 120 MVA is also proposed to ensure the reliability.
- It is also proposed that the existing 132 kV Single circuit between Balakot and Mansehra to be re-conducted from Lynx to Rail.

The 500 kV power evacuation arrangement is schematized in **Figure 16.2**. The same arrangement for the 132 kV level is shown in **Figure 16.3** (*Note: the figures refer 103 MW as the GIS has not yet been updated to the current 300 MW installed capacity*).

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	0.8 Lagging; 0.90 Leading

Short Circuit:

500 kV Substation Equipment Rating of 50 kA and132 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.

Electrically, the nearest proposed substations to Balakot HPP would be Shuki Kinari HPP and Maira 500 kV Switching Station The 500 kV network in the area near Balakot HPP is skchematized in the following figure.

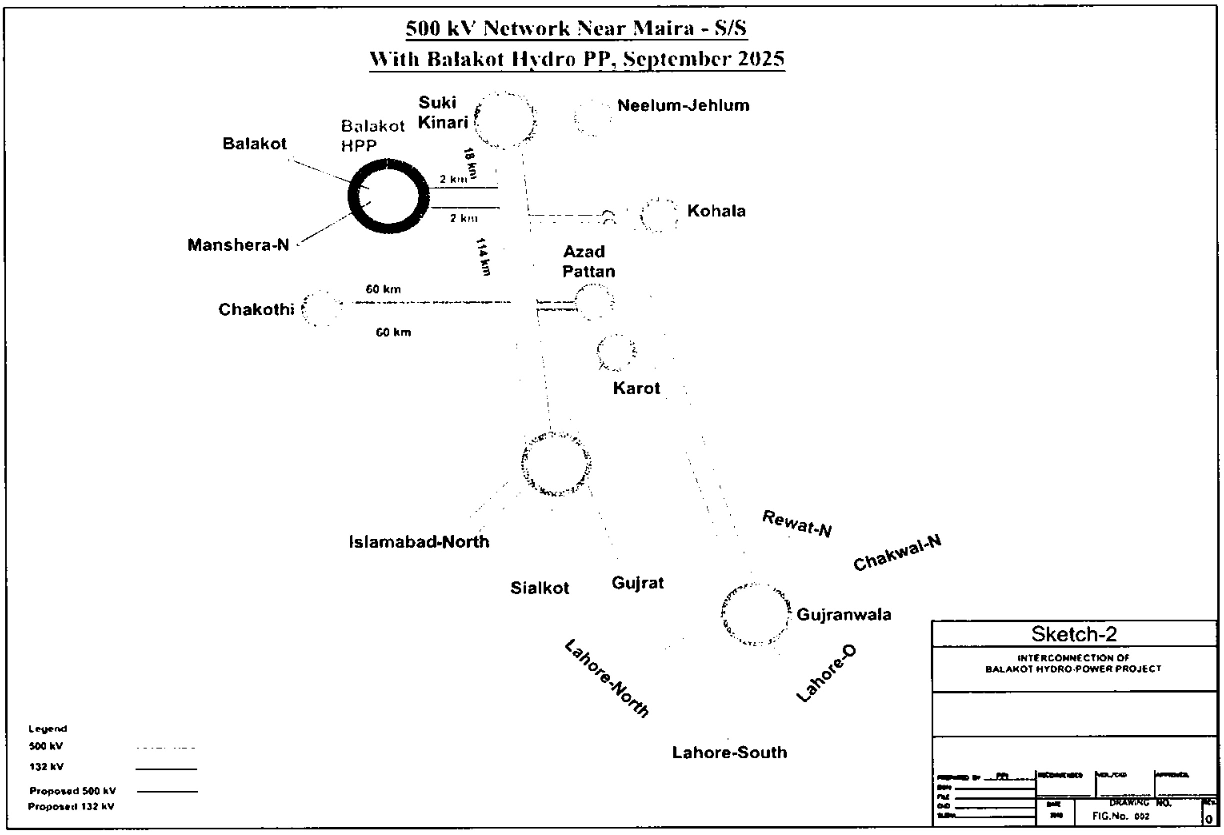

Figure 16.1 – Proposed NTDC Network

In view of (initially) planned COD of Balakot HPP in December 2024, the above proposed interconnection scheme has been assessed in the GIS for steady state conditions through detailed load flow studies, short circuit analysis and stability criterion for September 2025 for maximum hydel power dispatches in the grid during summer.

Steady state analysis by load flows, short circuit and stability criterion reveals that proposed scheme is adequate to export 300 MW output from the plant under normal and contingency conditions. Since the plant operates throughout the year, detailed analysis for Balakot HPP has also been carried out for off-peak load conditions of year 2025.

In an extended term scenario, September 2030 has been studied to evaluate the performance of the proposed interconnection scheme. The system conditions of normal and N-1 contingency have been examined for all scenarios to meet the reliability criteria. Additionally, short circuit analysis has also been carried out for a complete check of the system.

The short circuit levels of the Balakot HPP 500 kV are 16.30 kA and 12.51 kA for 3-phase and 1-phase faults, respectively, in the year 2030. Therefore, industry standard switchgear of a short circuit rating of 50 kA would be sufficient for installation at the 500 kV switchyard of Balakot HPP. The short circuit levels of the Balakot HPP 132 kV are 15.82 kA and 12.00 kA for 3-phase and 1-phase faults, respectively, in the year 2030. Therefore, industry standard switchgear of a short circuit rating of 40 kA would be sufficient for installation at the 132 kV switchyard of Balakot HPP. There are no violations of the power rating of the equipment in the vicinity of Balakot HPP in the event of fault conditions.

The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability has been tested for the worst cases, *i.e.* three phase fault right on the 500 kV and 132 kV bus bar of Balakot HPP substations followed by trip of a single circuit from Balakot HPP for fault clearing of 5 cycles (100 ms), as understood to be the normal fault clearing time of 500 kV and 132 kV protection system. Also, 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 system is stable for all the tested fault conditions.

During 2030 peak scenario, if any 500 kV circuit will trip, maximum 160 MW will flow from 500 kV to 132 kV side which was mitigated by 110% overloading of interconnecting transformer for a short period of time and if limits cross, it will trip on instantaneous overcurrent protection. The above scenario will only happen when Karot HPP will generate maximum power.

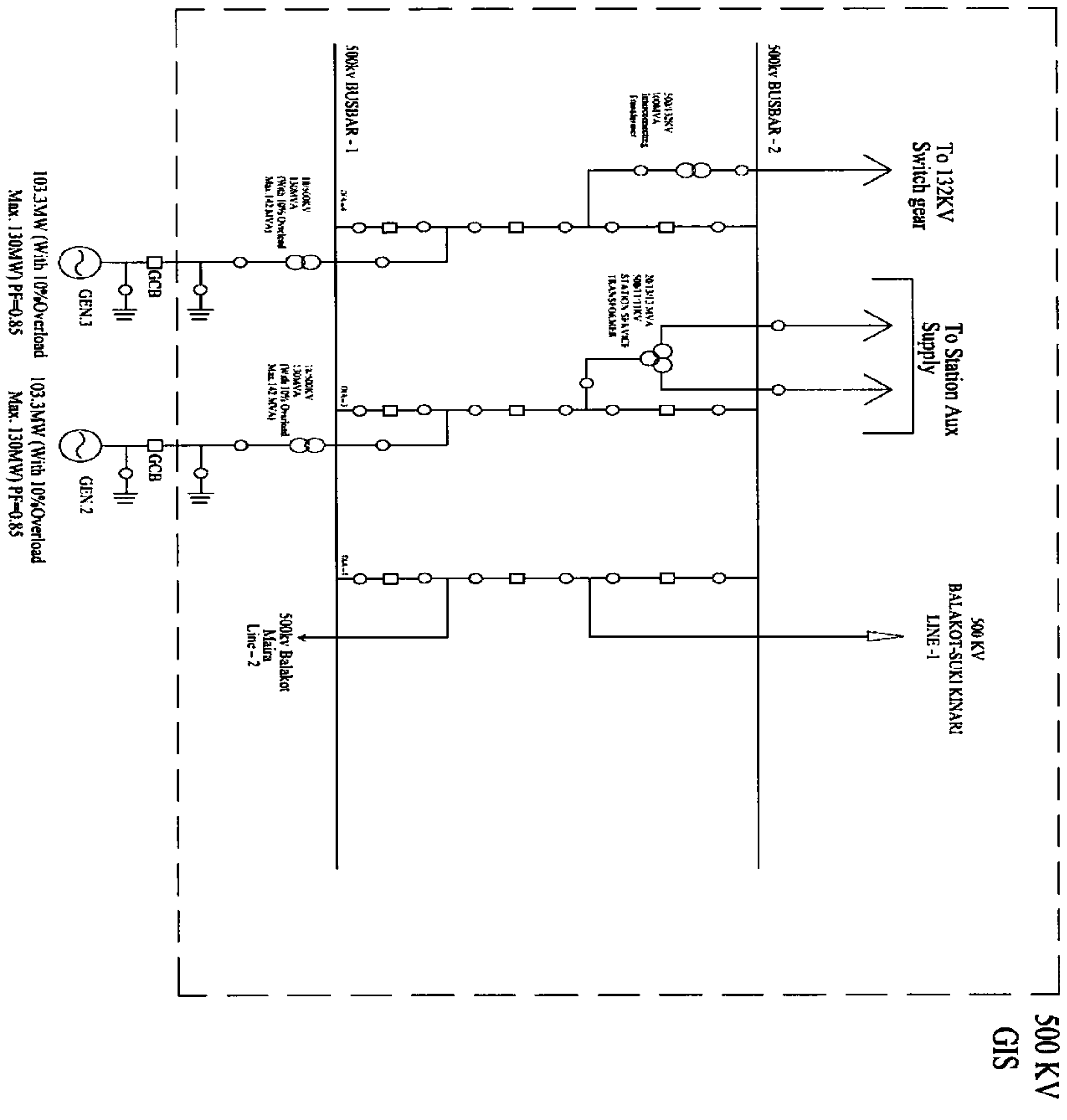

Figure 16.2 – 500 kV Power evacuation scheme

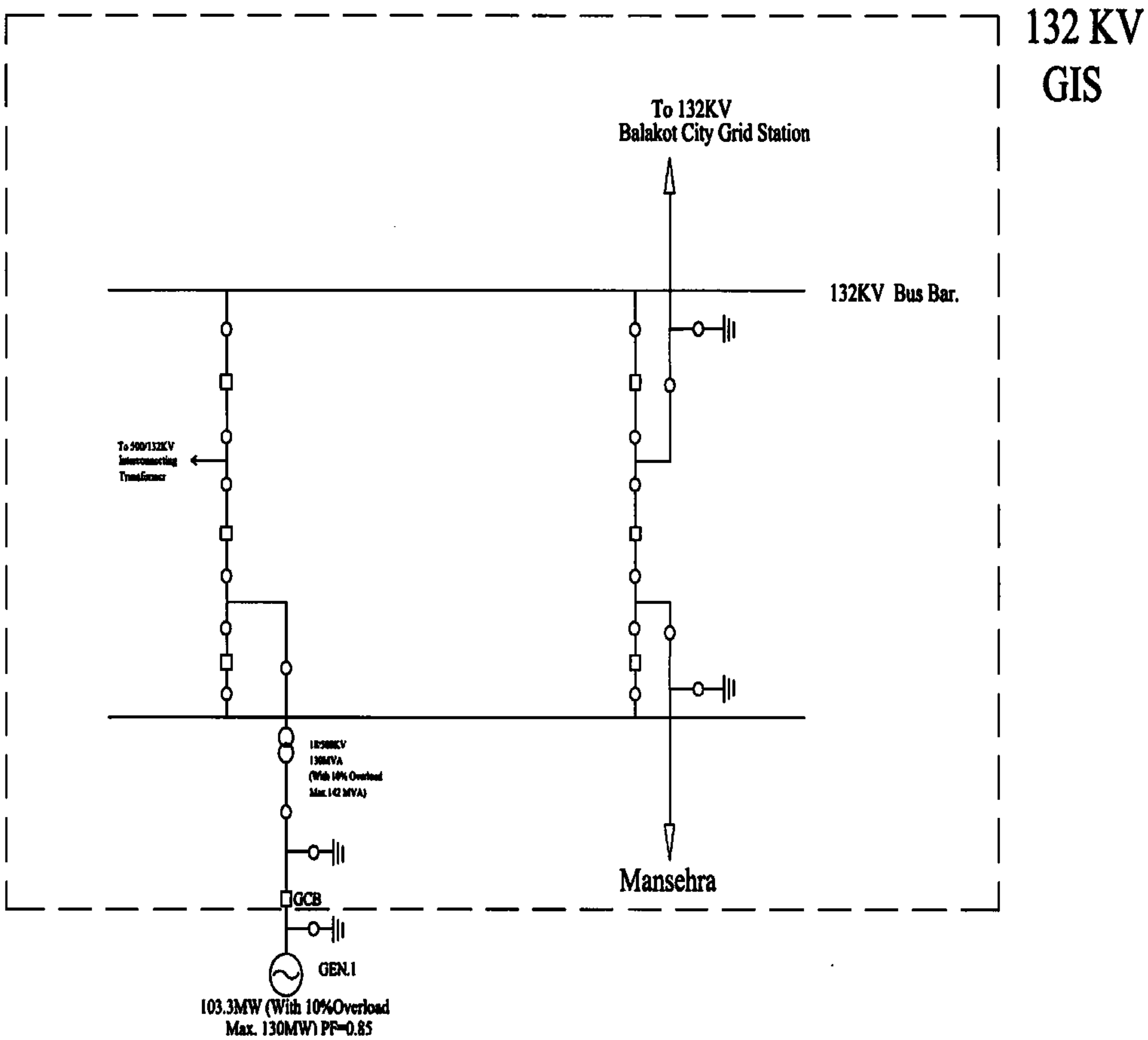

Figure 16.3 – 132 kV power evacuation scheme

17 AUTOMATION AND REMOTE CONTROL

A single Control Center for the remote control of the Balakot Power Plant in conjunction with two other Power Plants (Batakundi and Naran) is considered, taking into account the seasonal difficulty of access to these two Plants.

This solution also allows for a significant reduction of the human resources required for the operation of the three Plants, compared to the operation of each Plant in an individual way.

The purpose of this solution is to guarantee the safety and reliability of the installation, as well as the ease and speed of maintenance and repair operations, and is based on the following assumptions:

- robust and suitable equipment for industrial environments, based on multiprocessor, in a decentralized philosophy and divided into sub-processes as independent and autonomous as possible;
- two redundant networks in TCP / IP fiber type and IEC 60870-5-104 protocol;
- main equipment and systems (Power Supplies, Servers and Databases) redundant with hot-standby operation, as a guarantee of security and reliability of the installation.

All the three hydropower projects i.e. Batakundi, Naran and Balakot, will have independent Plant Control System (PCS) located in their respective control rooms. The PCS for Balakot has been described in detail in section 15.13.1 of this Report (**Drawing 46**). The PCSs for Batakundi and Naran HPPs will be covered in their respective feasibility reports.

The Batakundi and Naran HPPs remain inaccessible from mid-November to mid-May due to snowfall. Balakot HPP will be accessible throughout the year. This option has been developed for the remote control of Naran and Batakundi HPPs from Balakot HPP. A central control room will be located at Balakot HPP from where the Batakundi and Naran HPPs will be remotely controlled through computer supervisory and control system. The provision has also been made for the remote control of Balakot HPP from this central control room (**Drawing 46**).

Parts of the text presented under the current chapter may have been collected from the FS2013 with due permission from PEDO, notwithstanding possible and necessary adjustments.

17.1 CENTRAL REMOTE CONTROL SYSTEM

Currently, state of the art control systems for power stations require the usage of a multiprocessor system designed for application in the process environment in a functionally decentralized manner. The tasks of these facilities are manifold, and generally they have to guarantee the safe and secure operation of the entire system and offer high availability and shortest repair time.

A functionally distributed Automation and Control System has been proposed. Functional decentralization of the "hydroelectric power station" process means division of the process into sub-processes, which are as independent of each other as possible. The structure of these sub-processes is reflected in the design of the process control technology, which is divided into autonomous function areas.

The backbone of the proposed control system is represented by the station bus, which is a two fiber-optics communication star network, based on Transmission Control Protocol/Internet Protocol (TCP/IP) Ethernet using IEC 60870-5-104 protocol ensuring that the highest availability is guaranteed by intrinsic redundancy, dynamic failure reaction and automatic fault elimination.

Ethernet switches with rugged, industry-compatible structure are to be used. This also ensures highest reliability. Main features are the fast switch-over times of less than 500ms and high degree of cascadability, which means flexible network planning.

17.1.1 Control Levels

The control system provides two control levels:

a. remote control level;

b. plant control level.

Normally all the three plants will be supervised and controlled at the remote control level. The on-site plant control level will serve as a backup.

Plant and local control levels are integral part of the computerized control and monitoring system. The process control level is using the control and supervision devices on the different equipment of the plant as *e.g.* turbine governor, excitation, AC distribution boards, switchyard equipment etc.

The local area network (LAN) connects the equipment on plant control level with the main components of the local control units (LCUs).

17.1.2 Remote Control Level

The remote control level consists of data servers, workstations, mimic board, printers, communication devices to dispatch center, and GPS master clock. Both operator stations are equipped with identical software and therefore the complete power station, the units and all the power plant attributes, including the switchyard can be operated and supervised from both the stations in identical manner.

17.1.3 Communication with NPCC

The control system concept allows of course serial and network communication with third party systems (open system) on the basis of standardized protocols, *e.g.* IEC 60870-5-101, IEC 60870-5-103, IEC-60870-5-104 etc. (see section 15.13.6).

17.1.4 Time Synchronization

Time management in the entire automation system and/or the performance capability of the functional units will be designed such that all necessary automation and monitoring tasks are fulfilled (see section 15.13.7).

17.2 COMPUTER SYSTEM IN THE CENTRAL CONTROL ROOM

17.2.1 SCADA Servers

Two (2) redundant SCADA servers will be provided in the control room. The SCADA server is a “data processing” component of the system. The information gathered by the automation units are processed, archived, and made available here for output to the display and records.

The data model of a server will be able to handle at least 30 000 data points.

The remote control interface is implemented via the process LAN. The corresponding driver will be integrated in the control system and will also be configured there.

To the possible extent, the latest version of the database system will be used as the archiving and data management system for all the data point definitions, and as a long-term archive redundant servers will be used. These are supplied with process data in parallel, have an identical process map, and run their identical internal programs. Command outputs are performed on only one process control server.

If the process control component (PC) fails, the hot stand-by computer (SB) takes over the operational control without loss of data. Operational states are changed automatically in case of an error. All devices (workstations and printers) required for operations are then automatically assigned to the process control computer (PC).

Windows will be used as the operating system. Both computers in the redundancy setup will be equipped with two Ethernet network cards. The power supply for the two servers will be redundant.

17.2.1.1 Process Coupling

Both SCADA servers are supplied with data from the process. The actual data output from the standby system to the process and display components is blocked at the furthest possible point (at the communication point to the process).

17.2.1.2 Cross-Connections

Cross connections between the two systems will be minimized, in order to prevent the infiltration of functional failures from the failed system into operational system as much as possible. There will be nearly no data traffic between the two systems, except during the startup in order to compare the data, archives, parameters, and so on. During the operation, only operational actions that affect the process model (such as acknowledgements and value substitutions) are cross-coupled. Archives will be written to both the servers in parallel and compared during the startup.

When starting up, the previously failed server synchronizes itself with the process control server by means of cross-coupling. When a consistent identical state has been reached, the newly started computer signals “standby” status to the process control server, and is available for taking over the process control, if needed.

17.2.1.3 Redundancy Change Over

The decision to perform an automatic redundancy switchover is made by system selection. Error classes of the PC and SB server are permanently compared, and a decision is made as to which server has a better availability. This system is then chosen as the process control computer.

If this should cause a redundancy switchover, the former standby system is immediately available as the new process control system. As it is supplied with process data continuously, so it is ensured that no data will be lost.

A redundancy switchover can also be initiated manually in a system map.

17.2.1.4 System Monitoring

The following internal system monitoring will be performed:

For the software:

a. check for program crash;
b. check the reaction time of a program - Correct processing of a program Watchdog monitoring of the server - Check for data consistency.

For the Hardware:

a. continuous LAN monitoring;
b. periodic monitoring of devices that are not continuously addressed by software;
c. devices are monitored by querying the status indicators with each access.

17.2.2 Operator's Workstations

Two (2) operator's workstations will be provided in the control room. PCs that can be installed in the control desk are to be used for the display workstations. Windows 10 or above should be used as the operating system for all the workstation computers.

The two operator stations will each be equipped with two 22" thin film transistors (TFT) monitors, a keyboard with 12 function keys, and an optical mouse with two buttons and a scroll wheel.

The display systems handle all visualization tasks at the workstation (operator station) such as image display, curve display, process control, etc.

17.2.3 Engineer's Workstation

One (1) engineer's workstation is provided for SCADA system engineering, maintenance and training in the control room with the following functions:

a. parameterization of the LCUs;
b. debugging of the LCUs application logic.

17.2.4 Printers

Three (3) printers will be provided in the control room.

A network-capable A3 color laser printer (600 dpi resolutions) will be used for outputting hard copies of the screen displays and trend curves. Two network capable black and white A4 laser printers are required for outputting the lists and logs.

All the printers will be connected to the HMI LAN via the 10/100 Based.

17.2.5 Ethernet Interface

It has the flowing components:

a. operator's console and mimic board;

b. one (1) control desk designed for the installation of the operator workstations, printers, etc.

17.2.6 Equipment for Communication with NPCC

The equipment required for communication with NPPC will be provided in the control room.

18 TRANSPORTATION AND INFRASTRUCTURE PLANNING

18.1 PROJECT ACCESS

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

- Port of Supplier Country to port in Pakistan by ocean/sea freight;
- Port in Pakistan to project site entirely by road; and
- Port in Pakistan to Project site by railway network to Havelian and then by road.

The air, ocean and land access routes which are best to approach the site are described below.

18.2 PORT OF SUPPLIER COUNTRY TO PORT IN PAKISTAN BY OCEAN/SEA

Arabian Sea is located in the south of Pakistan and currently there are three ports in operation that are Karachi Port, Bin Qasim Port and Gwadar Sea Port. Karachi port and Port Qasim are in or near the port city of Karachi and Port of Gwadar is in Province of Baluchistan. All of these ports are being operated by Port Trust and capable of handling all types of ships and cargo. The Project Site from these sea ports could be accessed either by railway tracks or by using road infrastructure comprising of national highway and motorways. The short description of these ports is given below.

18.2.1 Karachi Port

At present Karachi Port (**Figure 18.1**) is the hub of Pakistan's major trading through the sea, because 75 percent of the overall international trade is being conducted/handled at this port. It is a deep natural port with 11 km long approach channel to provide safe navigation to tankers up to 75 000 DWT, modern container vessels, bulk carriers and general cargo ships. The port has 30 dry cargo berths including two container terminals and three liquid cargo-handling berths. The total port area is 100 hectares and an additional 60 hectares is available in close proximity of the port for storage of goods.

Figure 18.1 – Karachi Sea Port

18.2.2 Port Bin-Qasim

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

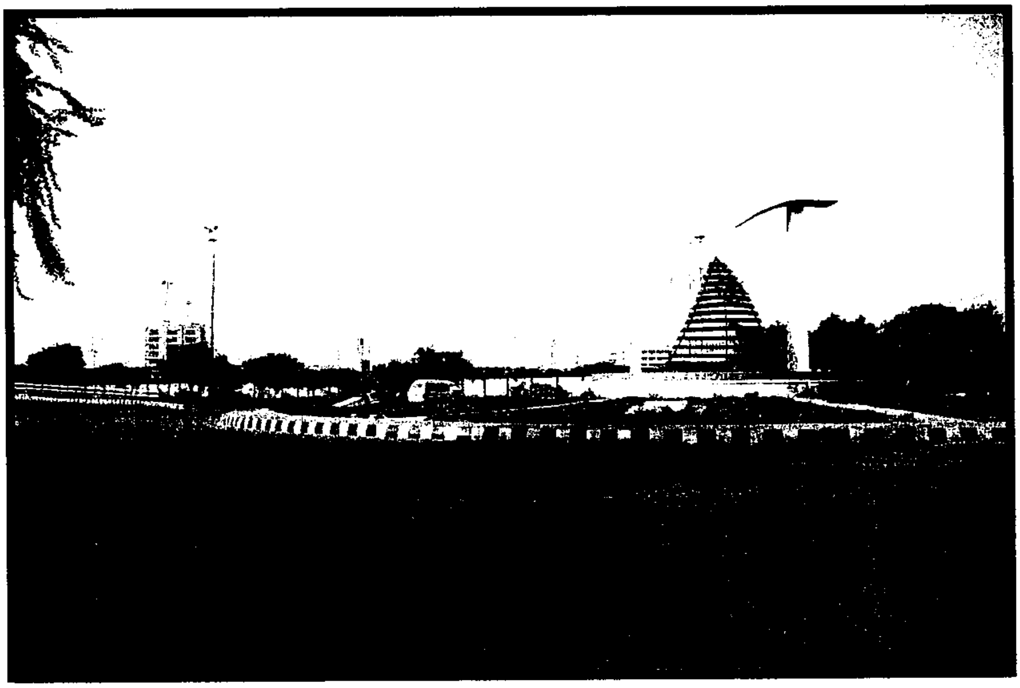

Figure 18.2 – Panoramic view of Port Qasim

18.2.3 Gwadar Sea Port

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

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

The port (**Figure 18.3**) is located 533 km from Pakistan's largest city, Karachi, and is approximately 120 km from the Iranian border. It is located 380 km away from Oman, and near key oil shipping lanes from the Persian Gulf. The greater surrounding region is home to around two-thirds of the world's proven oil reserves. It is also the nearest warm-water seaport to the landlocked, but hydrocarbon rich, Central Asian Republics, as well as Afghanistan.

The port is situated on a rocky outcropping in the Arabian Sea that forms part of a natural hammerhead-shaped peninsula protruding out from the Pakistani coastline. The peninsula, known as the Gwadar Promontory, consists of rocky outcropping reaching an altitude of 168 m (560 feet) with a width of 4 km (2.5 miles) that are connected to the Pakistani shore by a narrow and sandy 12 kilometer long isthmus. The isthmus separates the shallow Padi Zirr bay to the west, from the deep water Demi Zirr harbor in the east.

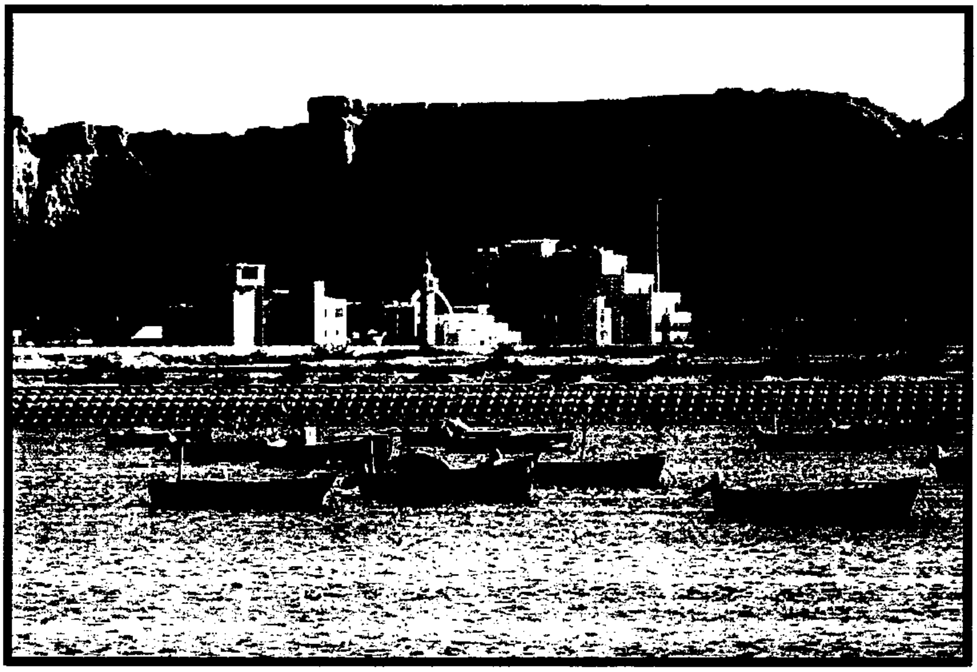

Figure 18.3 – Panoramic view of the Port of Gwadar

18.3 PORT IN PAKISTAN TO PROJECT SITE ENTIRELY BY ROAD

The port of Karachi and Gwadar are well linked with other parts of the country through National Highways and Motorways and CPEC (**Figure 18.4**). Pakistan has a motorway network starting from Peshawar to Karachi and Gwadar. Motorways are numbered from M1 to M10. M1 (155 km) links Peshawar with Islamabad, M2 (367 km) links Islamabad to Lahore, M3 (54 km) between Pindi Phattian on M2 to Faisalabad, M4 (233 km) Faisalabad to Multan, M5 (1 160 km) Lahore to Karachi, M6 (100 km) Multan to Dera Ghazi Khan, M7 (350 km) Dadu to Hub, M8 (892 km) Retodero to Gwadar, M9 (136 km) Hyderabad to Karachi, and M10 (57 km) Karachi Northern Bypass. Some of these Motorways are under construction, though they will be in operation before start of construction of the Balakot hydropower project.

National Highway (N1 to N55) and Express Highway networks, starting from southern Pakistan, connect all cities of the country. Other important routes are along CPEC road, which are being constructed between the Port of Gwadar and China Boarder with funding from China.

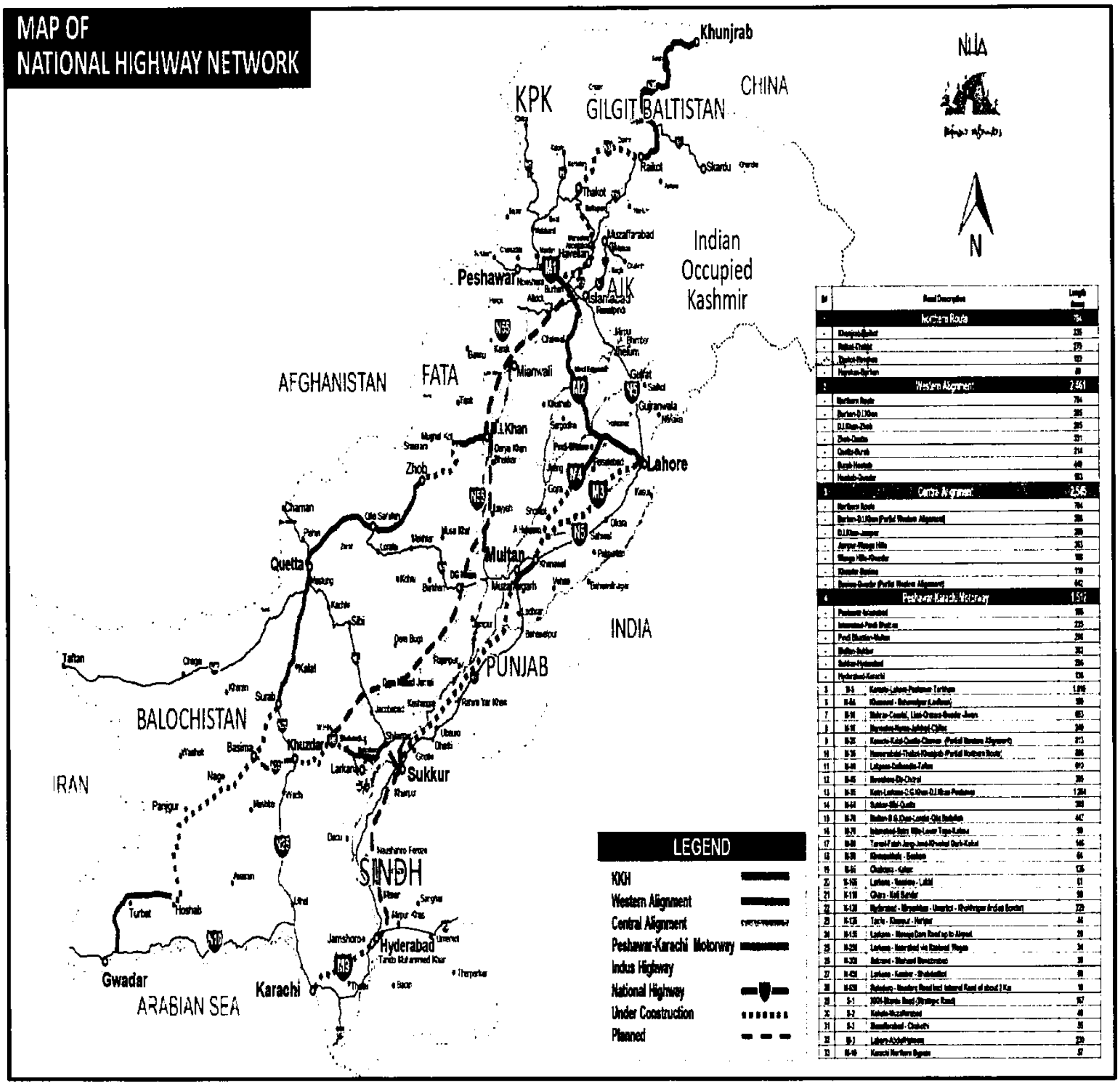

Figure 18.4 – Motorways, National Highways and CPEC routes in Pakistan

CPEC (**Figure 18.4**) has three routes namely the Northern Route, the Western Route and the Central Route. Northern Route starts from Khunjrab near the China Border and ends at Burhan at M1 with length of 874 km; Western Route between Burhan and Gwadar, with length of 1677 km, via Hakala, D.I.Khan, Zhob, Quetta, Hoshab, Gwadar; and Central Route between Burhan and Gwadar with length of 1761 km, partly transverses the Western Route, and then from D.I.Khan to Jampur, Khuzdar, Besima and Gwadar.

However, the following most suitable road routes are available to access the Project area and project site from port city of Karachi and Gwadar by traversing along National Highway, Expressway and Motorways.

18.3.1 Route 1: from Gwadar through Quetta

Gwadar Port – Quetta – D.I.Khan – Burhan – Havillian – Manshera – Project Site

By following the Western Rout of CPEC Road from Gwadar via Hoshab, Surab, Quetta, Zhob, D.I Khan, Hakla, Burhan and then following Northern Route of CPEC, reaching Manshera via Hazara Expressway to Abbottabad then via CPEC Route Abbottabad-Thakot or from Abbottabad to Manshera via N35 Karakorum Highway (KKH). From Manshera to Balakot and Paras (project dam site) via N15 which cross sharp bends over Balakot hills before entering to Balakot City. Bridge over Kunhar River is in dangerous condition. From Balakot city to the Project site the road is in good condition, however speed limits have to be followed.

Suki Kinari hydropower project, located upstream of Balakot HPP, is under-construction. Therefore any improvement in N15 and including Balakot Bridge over Kunhar River will be rehabilitated by Suki Kinari HPP to meet transportation requirements. It is supposed that no improvement will be needed for N15 during transportation of Balakot heavy equipment. However, cost for clearance of road after rain and sliding during project construction period will have to be included in the project cost. The road distance from Gwadar to Burhan is 1677 km, Burhan to Abbottabad 59 km and Abbottabad to Manshera is 20 km, while from Manshera to Balakot and Balakot to Paras is 45 km and 34 km, respectively.

18.3.2 Route 2: from Gwadar through Faisalabad

Gwadar Port – Turbat – Hoshab – Khuzdar – Retodero – Shkarpur – Sukkur
Multan – Faisalabad – Burhan - Havillian – Manshera – Balakot – Project Site

Gwadar-Retodero is M8 about 892 km out of which 193 km from Gwadar to Khuzdar is completed and in operation from 2016. Retodero to Shikarpur to Sukkur via National Highway and from Sukkur to Burhan via M5, M4, M3, M2 and M1. Then Burhan to Site as defined under Route 1 above.

18.3.3 Route 3: from Karachi through Faisalabad

Karachi Port – Hyderabad – Sukkur – Multan – Faisalabad – Burhan
Havellian – Manshera – Balakot – Project Site

Karachi Port is connected with other parts of the country via National Highways and Motorways. These were constructed recently and few are under construction, however they will be available before start of construction of the Balakot HPP. Karachi Port is connected to Multan via M9 and M5. Multan is connected with Havellian via M5, M4, M3, M2, M1 and Hazara Express. From Havellian to the Project Site N35 or from Havellian to Manshera via CPEC Northern Route and then N15 will be used up to Project Site.

18.4 PORT IN PAKISTAN TO PROJECT SITE BY RAILWAY AND ROAD

Pakistan Railway network (**Figure 18.5**) connects Port city of Karachi to the Northern Part of Pakistan. The main broad gauge line from Karachi to Havellian with 22.5 tons axle load is operative. The nearest operational railway station from the project location site is Havellian. Loading and unloading of heavy equipment is possible through this Station. From Haveliian to Project site, N35 or Northern Route of CPEC up to Manshera, and then via N15 to Project Site.

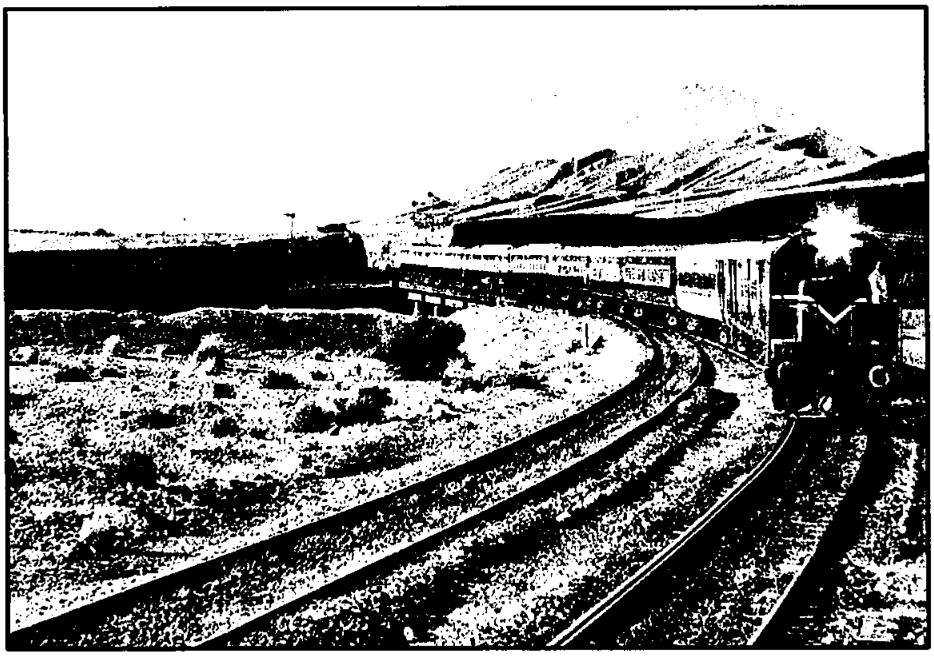

Figure 18.5 – Site Accessibility through Railway

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

18.5 SITE ACCESSIBILITY BY AIR WITHIN COUNTRY AND FROM ABROAD

A number of national and international airports are operational in Pakistan. Bacha Khan International Airport – Peshawar and Benazir Bhutto International Airport – Islamabad are the two most nearest international airports to the site. International Air line like Pakistan Air, Turkish, Thai, British, Emirates, Itihad, Qatar, etc. are operating in Pakistan.

18.6 CONSTRUCTION AND M&E EQUIPMENT

As aforementioned, bridges and culverts in Pakistan are mostly designed for Class-AA Loading (70 ton Military Tank). It is practically understood, however, that over time this capacity has depreciated; so there is great deal of requirement to minimize the axle loading to the bare possible level.

For Balakot HPP, the plant capacity is nearly 300 MW (3x100 MW). For this size of generation units, the provisional weights of major equipment as under:

- Rotor 194 t (estimate diameter 6.5 m)
- Stator 109 t (estimated diameter 6.6 m)
- Transformer (oil filled) 240 t - shipping dimensions 3 x(3 m x 2.5 m x 5.5 m)
  Oil weight 45 t (set of 3 single phase transformers)

Considering the above provisional weights of the largest and heaviest parts and the corresponding culverts and bridges capacity, it is well believed that breakup assemblies have to be transported to the project loading bay of the powerhouse for complete assemblies over there.

18.7 COMMUNICATION

The following communication facilities are available throughout Pakistan and particularly in Manshera District and in the Balakot Project area. Such facilities could be helpful during the transportation and safe handling of the equipment:

- cellular mobile network;
- PTCL landline;
- PTCL broadband network.

18.7.1 Telephone/Internet

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

Further, a number of mobile phone companies and wireless phone companies are also operating in the project area. Nowadays mobile connection and its operation is much easier and cheaper in Pakistan.

18.7.2 Entertainment /Television

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

18.7.3 Petrol, Diesel and Lubricant

In the town of Balakot, Shell Pakistan and Pakistan State Oil operate fuelling stations. No petrol station is operating in Paras.

18.7.4 Hotels and Restaurants

Naran valley is a famous touristic destination. People from different parts of the country travel for enjoying their holidays there. The summer season is very famous for tourists. A number of good quality hotel, resorts and restaurants are being operated by locals in the City of Balakot, Kaghan, Naran. Accommodation and good quality of food is available everywhere along the Naran valley. Pakistan Tourism Department is also operating one lodge at Balakot and Naran Town, which offer good quality of food.

19 BILL OF QUANTITIES AND COST ESTIMATE

19.1 GENERAL CONSIDERATIONS

The civil works quantities estimates are based on the preliminary design of the different components of the hydropower scheme. The quantities have been appraised from the general arrangement and layout drawings of the structures developed in the Report.

Cost estimates were produced based on the key works and components assumed unit prices. The investment project cost is disaggregated by the following main areas: preliminary works, civil works, HSS, Mechanical and Electrical Works and Other Costs. The Other Costs category encompasses Engineering services, Miscellaneous, Duties of Equipment Cost and Contingencies.

The yearly annual cost estimate for operation phase, mostly comprising operation and maintenance, is also presented.

19.2 WORK QUANTITIES

The work quantities required for the erections of the Balakot hydropower scheme were estimated at a feasibility level and are presented in **Annex XIII – Work Quantities**.

The following table depicts the main quantities for the different components of the project and work type. The work types are aggregated in a broader spectre, as they are not exactly the same (*e.g.* there are different types of concrete).

Table 19.1 – Main civil works quantities

Work type	Unit	Dam and SBT	Power circuit	Powerhouse	Other	Total
Excavation (surf)	m^3	297 960	47 532		303 120	**648 612**
Excavation (under)	m^3	50 600	859 045	143 830		**1 053 475**
Concrete (sur)	m^3	177 730	22 017			**199 747**
Concrete (under)	m^3	16 300	258 089	53 770		**328 159**

As can be seen, the hydropower scheme erection requires mostly excavation and concrete laying works, in quite significant quantities. The total excavation for the project, both surface and underground, is estimated at 1.7 x 10^6 m^3. The estimated total concrete volume is approximately 528 000 m^3.

Regarding the tunnels, which make a very significant part of the work to be deployed (both in terms of time and cost), it is not possible to determine with complete accuracy the ground conditions which will be encountered without a full geotechnical investigation of the proposed route. However, given the characterization already performed, it is considered that the geological risk is within acceptable limits for the current feasibility stage.

In any case, a scenario of anticipated geological conditions was considered, based on the findings resulting from the geological investigations and, in particular, the geological mapping campaign (notwithstanding its limited representativity for the tunnels' depths). Such scenario considers the anticipated distribution of lithologies along the alignments, the geological structural features and the global geological model of the project area,

The headrace and tailrace tunnels assumed three different types of primary support, where type II assumes an extra layer of shotcrete (15 cm) and less spaced anchors than type I, and type III assumes 1 m spacing steel ribs. The considered incidences where the following:

Headrace: 80% type I / 15% type II / 5% type III

Tailrace: 80% type I / 10% type II / 10% type III

The indicated scenarios reflect the performed geological and geotechnical appraisal and are deemed to be on the conservative side.

19.3 COST ESTIMATES

19.3.1 Investment

The Investment was estimated for the following categories: Preliminary Works, Civil Works, Hydraulic Steel Structures (HSS), Mechanical and Electrical Works, and Other costs. The following table depicts the Preliminary Works cost estimates.

Table 19.2 – Preliminary Works cost estimates ('000 USD)

Component / Work	Cost	
Mobilization & De-mobilization	15 000	30.4%
Access Roads to the Works Sites	2 000	4.0%
Camps and Housing During Construction	10 000	20.2%
Environmental Mitigation Cost & Land Acquisition	19 591	39.7%
Reservoir Slope Stabilization	2 800	5.7%
Sub-total Preliminary Works	**49 391**	

Table 19.3 – Civil Works cost estimates ('000 USD)

Component / Work	Cost	
River diversion works	636	0.2%
Dam and associated works	25 051	9%
Sediment by-pass tunnel	20 118	7%
Power Intake	7 472	3%
Headrace Tunnel	151 774	53%
Surge Shaft (US)	4 127	1%
Pressure Shaft	8 593	3%
Penstocks	3 371	1%
Powerhouse	38 117	13%
Surge Shaft (DS)	845	0.3%
Tailrace	19 206	7%
Road Accesses	9 060	3%
Switchyard platform	476	0.2%
Sub-total Civil Works	**288 846**	

to **Table 19.5** – Other Costs estimates ('000 USD)

Component / Work	Cost	
Engineering services (8%)	43 250	46%
Insurance during construction (2%)	10 592	11%
Duties of Equipment Cost (5%)	8 562	9%
Contingencies (6%)	32 438	34%
Sub-total Other costs	**94 842**	

The following table depicts the summary of the Investment estimate, by main category:

Table 19.6 – Investment summary ('000 USD)

Component / Work	Cost	
Preliminary Works	49 391	8%
Civil Works	288 846	45%
HSS, Mechanical & Electrical Works	202 392	32%
Other costs	94 842	15%
Total Investment	**635 471**	

depict the estimates for the Civil Works, Hydraulic Steel Structures (excluding tunnel linings), Mechanical and Electrical equipment, and Other Costs.

Civil works cost estimates were based on the wok quantities evaluated for each component/structure, as defined in the drawings, and the respective estimated unit costs. The steel lining cost of the tunnels (pressure shaft and penstocks) is considered under the Civil Works component.

Table 19.3 – Civil Works cost estimates ('000 USD)

Component / Work	Cost	
River diversion works	636	0.2%
Dam and associated works	25 051	9%
Sediment by-pass tunnel	20 118	7%
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Tailrace	19 206	7%
Road Accesses	9 060	3%
Switchyard platform	476	0.2%
Sub-total Civil Works	**288 846**	

The Contingencies provision, under Other Costs, can be considered high when compared to industry practice and reflects the perceived current risk profile of the project. As the project is foreseen to be developed under a single EPC contract, the Contingencies represent the variations in the base cost due to risk appraisal by the Contractor (as the EPC shall have a fixed price). Despite most risk factors being already identified and its expected impact embedded in the remaining costs estimates, there are site specific factors that may translate in cost increases, as is the case with additional sediment management measures or reservoir slope stabilization measures, among others. Regarding design specific risks, it is considered the cost of necessary adjustments to the dam geometry in result of the 3D dynamic structural modelling, as well as the physical hydraulic modelling. In the case of the dam geometry, it is included under this item the possibility of increasing the dam body shear key size.

One of the key risk factors in the project is related to encountered geological conditions. In this case the correspondent civil works cost estimates reflect the most likely scenario according to available information, although significant cost variations may occur. Notwithstanding the possible referred cost variation, it must be noted that the economic risk is, in the case of the tunnels, transferred to the Pakistan State under present NEPRA's tariff framework.

Table 19.4 – HSS, Mechanical and Electrical Works cost estimates ('000 USD)

Component / Work	Cost	
Hydraulic Steel Structures	9 640	*5%*
Powerhouse Mechanical Works	88 450	*44%*
Electrical Works	104 302	*52%*
Sub-total Equipment	**202 392**	

Table 19.5 – Other Costs estimates ('000 USD)

Component / Work	Cost	
Engineering services (8%)	43 250	46%
Insurance during construction (2%)	10 592	11%
Duties of Equipment Cost (5%)	8 562	9%
Contingencies (6%)	32 438	34%
Sub-total Other costs	**94 842**	

The following table depicts the summary of the Investment estimate, by main category:

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Component / Work	Cost	
Preliminary Works	49 391	8%
Civil Works	288 846	45%
HSS, Mechanical & Electrical Works	202 392	32%
Other costs	94 842	15%
Total Investment	**635 471**	

It should be noted that the referred value does not include the promoter's direct administration cost, such as maintaining a project management unit, as well as legal or financial advice/support.

19.3.2 Annual Costs

The annual cost for operating the scheme, or operational expenditure (OPEX), which comprises O&M, insurance, fees and licenses, is taken as a yearly cost correspondent to about 2,5% of the Investment. Therefore, an expenditure of 16 million USD *per annun* is projected.

The referred annual cost estimate included the following main item categories:

- Regular operation of the hydropower scheme and associated equipment;
- Preventive maintenance of the plant;
- Non-scheduled/emergency maintenance interventions;
- Mechanical movement of deposited sediment inside the reservoir.

20 PROJECT IMPLEMENTATION AND CONSTRUCTION PLANNING

20.1 GENERAL

This section of the Report deals with Project Implementation and Construction Planning, which covers the scope of the construction activities and the assessment of time required for its completion in conjunction with the corresponding construction methods and construction equipment. The construction and implementation schedule for the project has been prepared on the basis of the envisaged construction methods and planning. Parts of the text presented under the current chapter may have been collected from the FS2013 with due permission from PEDO, notwithstanding possible and necessary adjustments.

In order to make an overall assessment of different components of the Project vis-à-vis their completion timings, the following aspects are considered:

- pre-construction activities including setting-up of colonies and approach roads;
- work magnitude and available resources;
- quantities of major items of civil works;
- construction planning and scheduling.

The need for construction work to be done around the clock or in two or three shifts will be decided by the main civil works contractor to meet the goals of timely completion of the project, depending on the work fronts that decide to be implemented. Whenever possible different construction activities should occur in parallel.

The deadline for completion of the project activities is sixty-five (65) months. The referred time includes the construction of infrastructure works, such as rehabilitation and construction of access roads, supply of external water supply, sewerage network, energy supply and installation of colonies and camps with all facilities.

The envisaged Project implementation schedule is included in **Annex XVI**.

20.2 CHARACTERISTICS OF PROJECT AREA

Balakot is the main town located on the Kunhar River and is situated 247 km from Peshawar. The accessibility to Kaghan valley from down country is through Abbottabad and Mansehra. The dam and powerhouse sites for Balakot HPP are accessible from Balakot town by Balakot-Jalkhad Road. The road is constructed at a gentle gradient and is paved throughout the way up to Jalkhad.

The major electro-mechanical and heavy steel structure components will be imported from abroad by sea and most likely delivered to Karachi Port. In this case, the consignments shall be transported from Karachi to the project site by travelling a long distance of about 1600 km by road. The project transportation alternatives are discussed in Chapter 18.

The main construction materials like cement, reinforcement steel bars and structural steel are locally available in the vicinity of Islamabad and Abbottabad. The transportation of this heavy equipment on trailers to the project site is a tough task, that must be done with careful handling, since it is a special transportation.

The weather in the project area is characterized by moderate summers and severe cold winters, which may be an important conditioning for the construction progress. The monthly temperatures and precipitation data are presented in Chapter 5

20.3 PREPARATORY WORKS

20.3.1 General

Some preparatory infrastructures works are essential for the start of works and must be completed well before the actual start of construction to ensure completion of the project on schedule. Therefore, the following tasks should be performed prior to the commencement of major project works.

- reformulation of roads and bridges;
- acquisition of land for project area;
- construction of permanent residential colonies with external and internal water supply and sewerage system;
- construction of 11 KV sub-station for supply of power to project site;
- additional field investigations required for the Basic and Detailed Design.

20.3.2 Access and Internal Roads

A number of access and internal roads will be required to facilitate the construction of the various components of the project. A list of these access and internal roads is given here under:

- Main Access road to the Colonies.
- Powerhouse Colony roads.
- Dam Site Colony roads.
- Road to the Powerhouse Access Tunnel.

- Road to the upstream Surge Shaft.
- Dam Site Diversion Road
- Roads to Access the tunnel Adits.
- Roads inside the Reservoir.

20.4 RESIDENTIAL ACCOMMODATION

20.4.1 General

The Contractor shall supply temporary facilities for executing the works. All temporary facilities and work of any kind whatsoever required by the Contractor to complete the Works shall include but not be limited to:

- accommodation for labour and staff employed for the work;
- offices, stores and workshops;
- communications;
- protection works against floods;
- other temporary facilities for the Employer.

There are two main sites where the residential facilities will be likely be required i.e, the dam and powerhouse sites. Besides these two main locations, the Contractor's camp would also be established before the main project work starts.

20.4.2 Staff Colony

It is anticipated a residential staff colony on the left bank of the Kunhar River, near the proposed powerhouse. The area envisaged for this set up would be about 3 ha.

The colony shall accommodate the staff working at both the dam as well as the powerhouse and is expected to be placed at a relatively high ground at some distance away from the main road.

The colony shall have all the essential community services like mosque, school, dispensary, shopping centre and recreational facilities, roads, water supply/sewerage disposal system and the electricity arrangement etc.

20.6.2 Construction Machinery

The economic life for most of the construction machinery is five (5) to seven (7) years and as such brand new equipment should be deployed on the project. The equipment should be "heavy duty" and imported from abroad. In this regard, the general trend is that the foreign companies tend to bring equipment from their parent countries. However, in case, a portion of the overall job is assigned to some local contractor, the best available equipment should be inducted.

20.6.3 Materials Required for Construction

20.6.3.1 Drilling Items and Explosive Materials

Large quantities of drilling bits, rods and other accessories will be necessary due to the huge quantities of rock excavation. The consumption of these imported items is generally difficult to assess. However, a sustainable inventory will have to be maintained.

Wah-Bofors factory in Wah near Islamabad is capable of supplying all the explosives and blasting items required for the project.

20.6.3.2 Cement

Cement is abundantly available in Pakistan. Nevertheless, storage of cement at site is essential to ensure continuity of construction works. During the rainfall and landslides, there is the risk of supply hold-up due to the route being interrupted for a few days. The cement must be stored at site, sheltered from the elements and protected from humidity.

Mostly ordinary Portland cement will be used. Sufficient production capacity of about 30,000 tonnes per day is available with the existing cement factories in Pakistan and cement can be transported to the project site using trucks or long trailers.

The table given below indicates the present daily production of seven factories in the vicinity of the project. Any of these factories can furnish the requisite quantity of cement for concrete works at the project site.

Table 20.1 – Cement Production Capacities in Various Factories (information from FS2013)

Factory	Capacity (ton/day)	Approx. distance km
DG Cement, Kalar Kahar	6 700	292
Maple Leaf, Daudkhe	5 158	427
Bestway, Hattar	3 450	128
Askari, Wah	3 300	139
Askari, Nizampur	4 000	390
Fauji, Attock	3 150	229
Saadi, Haripur (Hattar)	2 500	128

20.6.3.3 Reinforcing Steel

A significant quantity of reinforcing steel is required for this project. Several factories in the country produce small quantities of reinforced steel bars, in the form of plain and deformed bars.

There is no factory of re-rolling reinforcing steel bars in the vicinity of the project. The nearest location from where the reinforcing steel bars of the desired specifications are available is Islamabad, 373 km from Balakot, where both hot and cold rolled reinforcing steel bars are available in the desired quantity.

Steel sheets of various thicknesses are produced at Karachi Steel Mills, which can be used to fabricate steel formwork. These can also be used for fabricating steel liners and other miscellaneous items required in connection with the construction activities. Alternatively, steel items can be imported from abroad. Most likely source of supply of steel items could be nearby countries such as China.

20.7 PROJECT IMPLEMENTATION

It is expected that after completion of the Feasibility Study, the project will be awarded to a qualified EPC Contractor through an International Competitive Bidding (ICB) process.

After the Project has reached financial and the EPC Contractor selected, the implementation period shall initiate. The envisaged two phases of implementation of the project are given as under:

Phase I: Project Construction Works with Detailed Engineering Design of

Completion Period: 56 months will be required for completion of all the components of the project, including infrastructure and preparatory works.

Phase II: Testing and Commissioning of the Powerplant

A period of 9 months will be required for accomplishment of the requisite testing and commissioning of the powerplant.

20.8 CONSTRUCTION METHODS AND PROGRESS RATES

20.8.1 General

The construction methods indicated in this section are those considered appropriate in the project construction planning for the current stage. However, these do not prevent the EPC Contractor from using other acceptable methods in benefit of time and costs.

20.8.2 Preliminary Activities

It is essential to prepare the contract documents for the works on EPC basis well in time to achieve the target of completing the main works of the project in 5,5 years (66 months).

20.8.3 Basic design/development of Physical models

The development of the Basic Design is the first activity of the Contractor without which it will not be able to initiate site operations. At the same time, it should also initiate the physical models that are essential to assess the options taken in the feasibility study. The expected duration of these activities is 12 months.

20.8.4 Preparatory works

In the preparatory works it is included the infrastructures, technical facilities, and industrial installations such as main access to site, internal roads, campsite, water and power supply, drainage, mechanical workshop, warehouse, carpentry yard, rebar yard, prefabricated element yard, offices, etc.

An adequate logistics base shall be constructed for storage and transfer of most of the supplies to the Site, such as equipment, fuel, reinforcement steel, etc.,

The expected duration of these activities is 12 months. The survey works and other site investigation are also included in the preparatory works with 18 month of expected duration.

20.8.5 Water Diversion through Diversion Tunnel/Sediments By-pass Tunnel

A first phase for project detailed design for these activities is predicted with the duration of 8 months.

The purpose of the induction of the water diversion is to prevent the entry of river water into the working area of the main dam during floods. To establish the diversion of the river it is planned to construct two cofferdams I and a diversion tunnel (that will be converted to SBT).

The excavation work on the diversion tunnel will be taken-up from both the ends at a rapid pace for carrying out the river diversion to commence the excavation and construction works of the dam. The expected duration of these activities is 12 months for the diversion tunnel and 6 months for the cofferdams.

On completion of all the activities on the diversion tunnel, the flow of Kunhar River will be diverted through the diversion tunnel during the low inflow season.

The water diversion will be completed in 24 months.

20.8.6 Intake structure

After completion of river diversion, the excavation in open working area can commence. The excavation can be carried out with dozers, backhoes and shovels depending on the condition of the rock.

The intake structure will be completed in 18 months, including detailed design, excavation, concrete works and equipment assembly.

20.8.7 Main Dam

A first phase for project detailed design of the main dam, including physical models, is expected to have a total duration of 20 months.

The excavation in open working area for the dam can start only after the completion of the diversion works. The excavation will be carried out with dozers, backhoes and shovels or drill and blast, depending on rock conditions.

The muck will be removed to the disposal area with front end loaders and dumpers.

Grout and drainage curtain will be provided from the gallery within the dam section and abutments. Drainage holes will be drilled from the gallery using percussion method. Grouting will be carried out using a conventional split-space method.

Residual seepage will be taken care of by gravity or pumping according to the site conditions.

The excavation works are expected to have a total duration of 20 month.

The concreting and grouting works will start after the completion of the detailed design, and will have duration of 24 months.

The main dam will be completed in 44 months, including detailed design, excavation, concrete works and equipment.

20.8.8 Headrace Tunnel and Adits

The proposed 9.1 km long headrace power tunnel is a critical structure of the project, which will pass different strata of the rock at the left bank of Kunhar River. Excavation works at this tunnel have been split into reasonable lengths of the reaches /segments, keeping in view, the topographic configuration of the natural surface. This has been proposed to save time and cost. Three (3) access tunnels/adits at different locations will be provided as approaches to the headrace tunnel for execution of tunnel excavation in suitable lengths and mucking out the excavated material through these access tunnels.

The tunnel is envisaged to be excavated by conventional methods. The tunnel will be excavated in full face where good quality rock is encountered. Headings and benching will be required in areas of poor to fair rock quality. All segments of this tunnel will be excavated in two directions through the access tunnels.

The excavation of the tunnel will require a good transportation system for easy and safe movement for working staff at site, the excavation equipment going in and out of tunnel and transportation of muck. The underground train with skip carts on properly laid rail-track can also be considered for muck removal. Suitable dewatering and drainage arrangement for disposal of the spring and seepage water will be required.

The underground excavation of the headrace tunnel will be started simultaneously with the river diversion, by conventional drilling and blasting method.

A huge quantity of concrete is involved in the construction of the headrace tunnel and surge shaft lining. It is assumed that this activity will be completed in 32 months.

After completion of the tunnel excavation, rock-bolting and shotcreting works, the concrete lining in the headrace tunnel can be started. Sufficient capacity of concrete batching plant will be installed near the project site.

The expected duration of these activities is 45 months, including detailed design, excavation and rock support, concrete lining and equipment.

20.8.9 Surge Shafts, Pressure Shaft and Penstocks

An access road linked to the surge tank will be constructed up to the crest level for carrying out its excavation from the top. Some excavation on the hillside will have to be done to form a bench at the top. The vertical upstream surge shaft will be about 120 m high with 14.5 m diameter connecting to the headrace tunnel at its bottom.

Excavation of the headrace tunnel shall be completed before commencement of excavation at the surge tank. The shaft could be excavated by conventional drill and blast method and/or raise boring. To provide a safe working environment, mobile crane or hoist system should be provided for handling and lifting of the muck from the tunnel. Air ventilation system, and pumps for dewatering must also be provided. The muck will be disposed of to the designated areas. Excavation of the pressure shaft will be taken up on completion of the excavation for the pressure tunnel for disposal of muck as well as concreting through this tunnel.

The pressure tunnel has been designed for an inner diameter of 5.60 m. At the end and adjacent to the upstream of the powerhouse, it will be bifurcated into three branches for installation of the Francis turbine runners on its spiral casing. The excavation of this tunnel will be implemented from the powerhouse end by extending its small portion up to the upstream of powerhouse. On completion of the pressure tunnel, the extended portion of this tunnel will be plugged with concrete. Excavation of the pressure tunnel is envisaged to be carried out by conventional methods.

The steel lining of this tunnel will be implemented when all the construction activities like excavation; concrete/steel lining in the pressure shaft is completed in all respect. The steel lining in this tunnel shall be started at its upstream end and installed towards the downstream direction.

All safety measures will be adopted and monitored for excavation of the high surge tank and pressure shaft.

The excavation work of the underground structures will be carried out mostly by conventional drilling and blasting method.

After completion of excavation of the upstream surge shaft, the concrete lining in this structure can be taken up immediately by starting from its bottom to top with slip forms moving in an upward direction.

The pressure tunnel will be fully steel lined. The steel liner will be manufactured in the workshop at site from the steel plates and welded into 4 m long steel cans. This process is estimated to take about 10 to 15 days plus testing and welding of one can to another can.

The concrete lining in the pressure shaft is required to be completed prior to the commencement of steel lining. The installation of penstock steel first can in the pressure tunnel will be started from the upstream end moving towards the powerhouse. The concrete around penstock can will be poured through pumping or skip buckets with hopper. After setting of the concrete, another steel can will be installed followed by concreting, around it until completion of the entire portion of this pressure tunnel.

The expected duration of these activities is 28 months, including detailed design, excavation and rock support, and concrete lining.

20.8.10 Transformer cavern

The transformers hall is also proposed with its orientation same as of the main cavern. It is connected to the power cavern and to the switch yard via cable tunnel. The machine hall and transformer hall will be excavated from the powerhouse access tunnel and will be carried out by conventional methods.

A cable tunnel connecting the transformer hall with the switch yard of 480m length for the cables is proposed.

The expected duration of these activities is 26 months, including detailed design, excavation and rock support, and concrete lining.

20.8.11 Powerhouse

The powerhouse main cavern has the following dimensions 71 m x 20 m x 34 m (L x W x H), with six floors at different levels. Excavation of the powerhouse cavern and tailrace tunnel will be carried out by conventional method. Dozers, backhoes, shovels etc. will also be used for excavation of the middle portion. The excavation will be done up to the lowest elevation of the powerhouse pit and removed by deploying front-end loaders, shovels with dumpers etc.

The initial length of the powerhouse access tunnel and headrace access tunnel are likely to be in deformed and disturbed rock. Surface deposits will either be removed or excavated by open cut into the highly weathered bedrock.

The expected duration of these activities is 31 months, including detailed design, excavation and rock support, and concrete lining.

20.8.12 Tailrace Tunnel

A shotcrete lined tailrace tunnel is proposed for flushing out the water from the powerhouse. Its length shall be 1565 m with a inner diameter of 8.0 m. The tailrace tunnel will be excavated by drill and blast from a portal on the river bank to the powerhouse. The portal will be excavated as an open cut through the surface material. The expected duration of these activities is 31 months, including detailed design, excavation and rock support, and concrete lining.

20.8.13 Mechanical and Electrical Equipment

All the E&M equipment, which includes turbine and generator parts, transformers, gate equipment, HV & MV switchgear, cranes, and other auxiliaries will be transported from the entrance port to the site on trailers and containers via the National Highways/Motorways. The largest and the heaviest pieces of equipment foreseen are:

- Turbine runner.
- Generator transformer.
- Powerhouse main bridge crane girder.

The first items of equipment to be installed in the powerhouse are the bridge cranes, for which the civil contractor will complete the civil works in erection bay and the erection of crane rails. The cranes will be tested for traveling, traversing and carrying of the designed load with all protections in place, after completing installation of all parts of the cranes.

The expected duration of these activities is 42 months, including detailed design, commissioning, manufacture, transportation, and installation. Equipment testing is expected to take 9 months.

21 CONCLUSIONS, RECOMMENDATIONS AND PARTICULAR REQUIREMENTS FOR EPC STAGE

The following main conclusions arise from the Report:

- The proposed hydropower scheme arrangement was developed in the wake of a number of preceding studies that sought to optimize the solution. The most recent study[16] anticipated a scheme mainly composed by a concrete gravity dam on the retained location with a sediment by-pass tunnel, a 9 km long headrace tunnel, an upstream surge shaft, a pressure circuit encompassing pressure shaft and penstocks, a cavern powerhouse with 3 units and a 2.2 km long pressure tailrace tunnel. The plant had a 228 m net head and a design flow of 154 m^3/s.
- Further developments after the completion of D2.2A dictated some adjustments to the envisaged configuration, mostly to mitigate identified risks, but also to account for new information and as a result of the refinement in design level. The most significant modifications were: i) reduction of the tailrace length in about 600 m and increase in the tailwater level, with correspondent reduction of the gross head; ii) inclusion of a downstream surge shaft to protect the tailrace against depressions; iii) relocation of the switchyard and arrangement of the tunnel accesses in the powerhouse complex.
- The hydrology and sediments are generally kept according to the precedent D2.2A study. The proposed design peak discharge for the spillway, corresponding to a 10 000 year period, is 3 500 m^3/s. The proposed safety check flood, corresponding to the Probable Maximum Flood (PMF) peak, is 5 000 m^3/s. The modular flow at the intake section is 87 m^3/s. The proposed estimate for the mean annual sediment load at Balakot intake section, considering the effect of the upstream reservoir of Suki Kinari, is 420 kton.
- The Report also includes a reservoir sedimentation and flushing analysis, based on a simulation model. The obtained results indicated a trap efficiency of the reservoir of 77%. It was also possible to determine that only very small particles (0.0625 to 0.125 mm) are anticipated to enter the power circuit. However, it is expected that the significant capacity of the flushing arrangements will be able to maintain the reservoir operational throughout the project life, although requiring periodic mechanical interventions inside the reservoir to move sediments closer to the flushing intakes. Coordination with Suki Kinari flushing operations is also considered of the utmost importance.

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[16] *D2.2A - Alternative Locations and Layout Analysis Study.*

- The neo-tectonic and seismic studies recommend PGA's associated with the SEE and OBE of 0.90g and 0.29g, respectively.
- The geological studies included field investigation works in the proposed dam location and in the headrace tunnel alignment. Geological mapping was also carried out. Per the site investigation data, no faults and shears were identified at the dam site.
- Historical landslide areas were identified within the reservoir rim, in particular associated with the MBT, and indicating a potential for slope instability. An analysis of the impact in the reservoir of a large-scale landslide was performed considering a volume displacement of 300 000 m^3 in front of Paras. The results of such scenario simulation lead to a dam overtopping of about 2 m. The dam is deemed stable under such conditions.
- The scan line mapping along the Naran Road indicated presence of faults and shear zones. Some of these features could potentially intersect the proposed headrace tunnel. The main shear and fault sets have dip and dip direction of 34/023, 26/250, 45/205 and 79/202.
- The presence of the weak rocks along the tunnel alignment, such as shale and claystone, indicates potential of squeezing. Based on the interpretation and analysis of tunnel boreholes data, the rock mass ratings of claystone range between 12-59, sandstone 7-56 and siltstone 38-54. Claystone and sandstone fall under very poor to fair rock quality and siltstone falls under poor to fair rock quality.
- Phase III site investigations included drilling of boreholes at the powerhouse and tailrace tunnel. Borehole BH-301 was drilled at the powerhouse site and no faults and shears were identified. The obtained RMR and Barton Q ratings indicate a good quality rock mass. Boreholes BH-302 and BH-303 were executed along the tailrace alignment. For BH-302, RMR and Barton classification render the rock mass as fair to good quality. In the case of BH-303, the same criteria points to a fair to poor rock mass quality.
- The capacity optimization analysis showed that the economic difference, measured by the NPV, for design flows in the approximate range of 120 to 160 m^3/s (roughly corresponding to 240 - 310MW), would not be very significant. A turbine design flow of 154 m^3/s was selected, which corresponds to an installed capacity at the generators of 300 MW.
- A hydropower scheme simulation model was used to determine energy generation. Such model was developed for a daily time step and considered the intraday regulating effect of the Suki Kinari scheme upstream. Average annual energy is approximately 1140 GWh, where about 380 GWh in peak hours, leading to a plant capacity factor of

43%. The average firm peak power, for a 90% exceedance probability, is about 160 MW (the firm average power is about 27 MW). Full power during peaking period is estimated to be achieved, on average, about 55% of the time. The decrease in production relative to the previous studies is due to the reduction in the gross head and, importantly, the increase in the ecological flow.

- Therefore, the proposed hydropower scheme in this Report has the following main components: 58 m high gravity concrete dam, 600 m long sediment by-pass/diversion tunnel, 9.1 km long concrete lined headrace tunnel with 8 m internal diameter, 122 m high surge shaft with 14.5 m inner diameter, 5.6 m diameter steel lined pressure shaft and penstock, cavern power house for 3 Francis groups with 300 MW installed capacity (for a 218 m net head and 154 m^3/s turbine flow), 244 m high downstream surge shaft with 3 m internal diameter, and 1.6 km long tailrace tunnel.
- The work quantities for the scheme construction were estimated. The dam and associated structures concrete volume is approximately 194 000 m^3. The project overall excavation volume is estimated at 1.7 million m^3, where about 60% correspond to underground excavation.
- The estimate for the project investment is 635.5 million USD, not including administration, legal and financing costs. The operational expenditures are estimated at 16 million USD per year.

Based on the on the developed work, the PPTA Consultant has the particular recommendations and requirements presented below (**Table 21.1**) for the subsequent stages of design development and project implementation, especially for the Base Design and Detailed Design to be carried out in the scope of the EPC contract.

Table 21.1 – Recommendations and requirements for subsequent stages of the project

Area / Element	Phase	Type	Concern	Action
Topographic survey	D	RQ	Compatibility among different surveys.	Perform a verification and adjustment, if required, among surveys.
Reservoir / catchment	O	RQ	Slope instability in the vicinity of the reservoir.	Monitor identified potential sliding areas.
Sediments / abrasion	D + O	RQ	Sediment peaks in the river can cause excessive wear of the power circuit equipment, in particular the turbines.	Install and operate a real-time sediment monitoring system.
Sediments / flushing	D + O	RQ	Have information about incoming sediments to the reservoir and deposited sediments.	Install and continuously operate a turbidity measurement system at the reservoir entrance. Carry out frequent bathymetric surveys of the reservoir.
		RQ	Move deposited sediments inside the reservoir.	Design and construct accesses in the reservoir that allow earth moving equipment to operate efficiently.
Geology / Geotechnical information	D	RQ	The available information to reliably characterize the structure's ground conditions is insufficient, in particular for the headrace and tailrace tunnels.	Carry out supplementary geological and geotechnical investigations for the detailed design.
Sediment by-pass tunnel	D	RQ	Optimize the flushing arrangements (SBT) design and flushing procedures.	Develop and test with a physical model the SBT and the sediment flushing operations. The model shall include the sediment transport process within the reservoir.
Sediment by-pass tunnel	D	RQ	Design the tunnel lining to resist long term abrasion from flowing sediments.	Characterize the sediment flow regime in the tunnel, taking into account the physical modelling. Specify the lining to prevent long term abrasion, namely considering the experience from other projects.
Power intake / hydraulics	D	RE	Optimize the power intake for vortex avoidance and floating debris dragging.	Develop and test with a 3D hydraulic model (CFD software model).
Dam / stability	D	RQ	The tri-dimensional effects of the seismic action in the dam must be taken into account in the final dam stability verifications.	Develop and test with a 3D structural analysis software model.
Dam / spillway	D	RQ	The theoretical calculations may not fully and adequately reproduce the hydraulics along the chute, jet behaviour and erosion of the plunge pool.	Develop and test with a full physical model.

Legend: Phase - Design (D) / Operation (O)
Type - Recommended (RE) / Required (RQ)

Table 21.1 (continued)

Area / Element	Phase	Type	Concern	Action
Dam / rupture risk	D	RQ	The dam break risk is classified as high and measures should be in place in case of threat or accident.	Prepare and implement a Dam Emergency Action Plan.
	D + O	RE		Design and install a warning system in the downstream valley (action to be decided by the project Owner; recommended to be done in coordination with the other projects in the cascade).
Power circuit / hydraulic transients	D	RQ	The assumptions of the hydraulic transient analysis may not reflect the specific characteristics of the final design and of the equipment to be installed.	Perform a hydraulic transient analysis (ideally by the generation equipment supplier) with the definitive characteristics of the scheme.
Powerhouse / layout	D	RQ	Additional geological information is required to validate the design of the powerhouse and optimize its orientation.	Obtain additional geological investigation at the powerhouse level. The construction of a exploration tunnel along the tunnel access alignment is highly recommended.
Powerhouse / turbines	D	RQ	The sediments entering the power circuit may contain hard mineral elements (Mohs hardness > 6) that may cause excessive wear of the power circuit equipment, in particular of the turbine blades.	Turbine design and construction must be specifically adapted to high erosion potential of the water.
	D	RE	Opportunity to increase efficiency and the life of the equipment.	The turbine supplier is encouraged to investigate and propose splitter blades in the turbine design.
Powerhouse / pumping stations	D	RQ	Sediment loaded water in the power circuit may cause malfunction of the powerhouse pumping installations for dewatering and, particularly, for the tailrace emptying.	The design of the pumping systems must take into account the sediment loads, with implications in the intake level, filters, sump arrangements and pumping equipment selection.
Switchyard	D	RQ	The area for the implantation of the external switch yard platform is recommended in the Report, though the suitability for the construction of the platform must be previously verified.	Execute detailed bathymetric and topographical survey of the area, as well as geological investigations works prior to the design. Detailed hydraulic calculations are required to evaluate possible impact on the water level profile and to design the platform protection against erosion.

Legend: Phase - Design (D) / Operation (O)
Type - Recommended (RE) / Required (RQ)

Environmental Impact Assessment

November 2019

Pakistan: Balakot Hydropower Development Project

Volume A – Main Report

Prepared by Pakhtunkhwa Energy Development Organization (PEDO), with support from Hagler Bailly Pakistan for the Asian Development Bank. This is the updated version of the final draft originally posted in September 2019 available on https://www.adb.org/projects/documents/pak-49055-007-eia.

Hagler Bailly Pakistan

Balakot Hydropower Development Project

Environmental Impact Assessment

Volume I – Main Report
Final

HBP Ref.: R9E06BPK

July 31, 2019

Contents

Exhibits

1. Introduction

The Pakhtunkhwa Energy Development Organization (PEDO) intends to construct a 300 megawatt (MW) run-of-river hydropower plant (referred to as "Project" in this report) at Balakot, in Mansehra District of Khyber Pakhtunkhwa (KP), Pakistan. The Project called Balakot Hydropower Development Project (BHDP) will be located on the Kunhar River about 18.6 kilometer (km) upstream of the town of Balakot. **Exhibit 1.1** shows the location of the Project.

A feasibility study of the Project was prepared in 2013 (the "FS 2013").[1] The Asian Development Bank ("ADB" or the "Lenders") is evaluating the Project for financing under its Hydropower Investment Development Program. As part of the evaluation of the Project, ADB, on advice of technical consultants, deemed the design proposed in 2013 as unfeasible and had it modified by Aqualogus. Aqualogos proposed and assessed dam site and powerhouse option alternatives and released a draft report of their findings in May 2018. Hagler Bailly Pakistan (Private) Limited (HBP) contributed to the environmental and social assessment of options. ADB has now acquired the services of HBP as Safeguard Consultants to prepare the documents required for ensuring that the project meets the environmental and social safeguards of the ADB, and also conforms to environmental legislation of KP.

The complete package of the environmental and social safeguard documents comprises the following:

1. Knowledge Summary (A brief summary of the entire report)
2. The Environment Impact Assessment (EIA) in three volumes:
    a. The Main EIA Report (**this Report**)
    b. Appendices to the Main Report
    c. Supporting Studies including Environmental flow Assessment Report and Biodiversity Action Plan
3. Poverty, Social and Gender Analysis Report (PSGA)
4. Summary of Poverty Reduction and Social Strategy (SPRSS)
5. Land Acquisition and Resettlement Plan (LARP)

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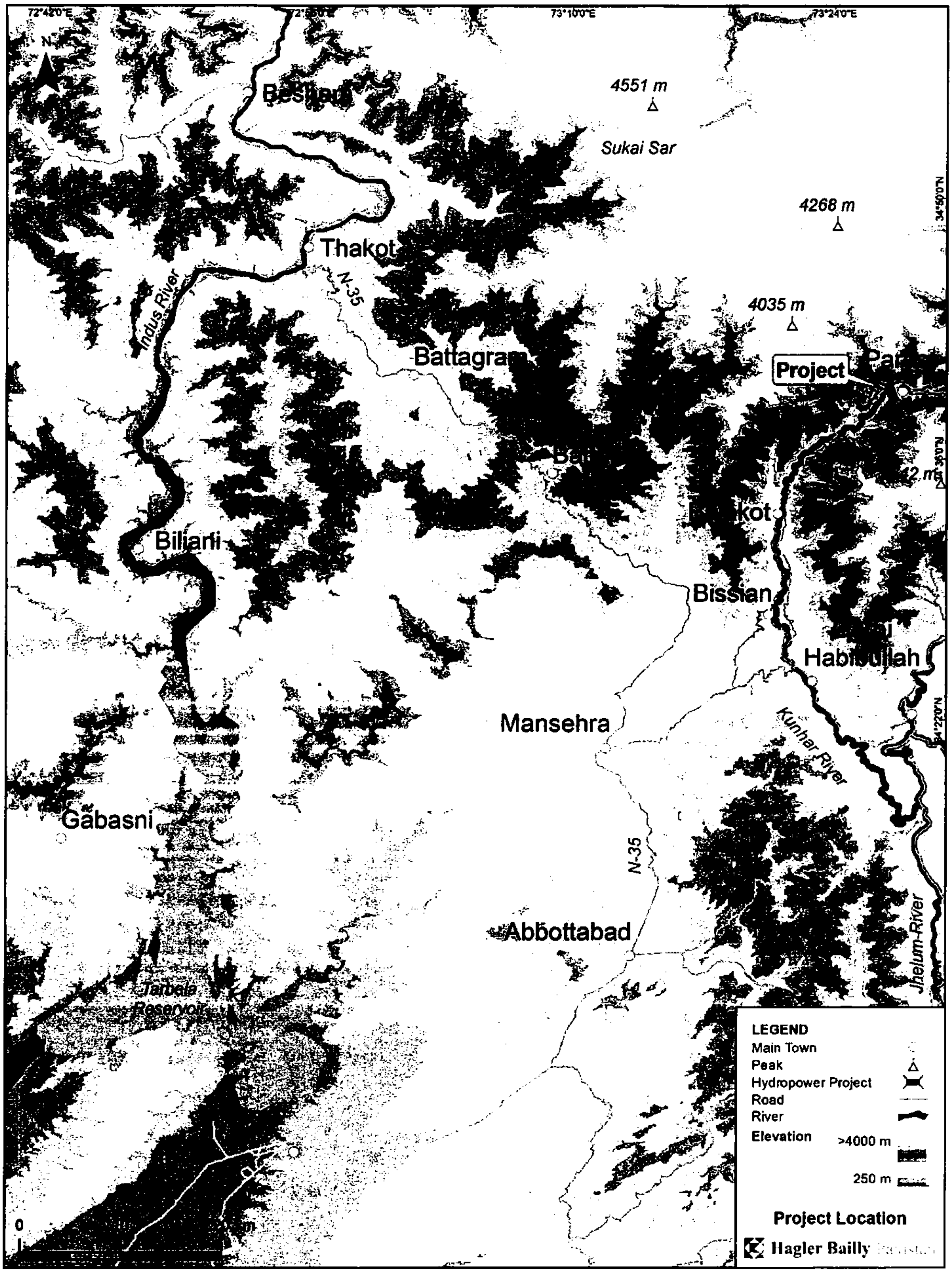
[1] Mirza Associates Engineering Services (Pvt.) Ltd., Feasibility Study of Balakot Hydropower Project, for Pakhtunkhwa Energy Development Organization (PEDO), December 2013

Exhibit 1.1: Project Location



1.1 Project Proponents

PEDO was established by the Government of KP in 1986 as the Small Hydel Development Organization. Its objectives included the following:

- To identify and develop hydel potential up to 5 MW.
- To construct small hydel stations for isolated load centers.
- To operate and maintain off grid small hydel stations.

In 1993, it was converted to an autonomous body and renamed the Sarhad Hydel Development Organization which was renamed Pakhtunkhwa Hydel Development Organization (PHYDO) in 2013 following change of the provinces name from Northwest Frontier Province to Khyber Pakhtunkhwa. The 18th Amendment to the Constitution of Pakistan vested full authority to the provinces to develop power projects of any capacity through the public or private sector. Consequently, the provincial assembly of Khyber Pakhtunkhwa through the Pakhtunkhwa Energy Development Organization (Amendment) Act 2014 renamed PHYDO to Pakhtunkhwa Energy Development Organization and expanded its mandate to include all types of power generation sources. The key powers and duties of PEDO under the amended Act includes:[2]

1. Prepare a comprehensive plan for the development and utilization of the power and energy resources of the KP.
2. Frame a scheme, or schemes, for the KP providing for the generation, transmission and distribution of power; and the construction, maintenance and operation of power houses, grids and microgrids, transmission and distribution lines specially in the remote mountainous areas of KP.
3. Act as adviser to the Government on all matters regarding issuance of licenses and joint ventures in the power sector.
4. Have control over the operation of all power houses, grids, transmission and distribution lines in KP constructed by, or transferred to, PEDO
5. Make recommendations to Government for prescribing standards for the maintenance of power houses, grids, microgrids and transmission and distribution lines of the Organization
6. Restrict or prohibit by general or special order, the clearing and breaking up of land in the catchment area of any river;
7. Establish thermal, solar, wind or other alternate renewable energy based power houses, erect test masts, collect wind and solar data for power generation, lay or cause to be laid, pipelines for supply of fuel, establish fuel supply means, engage in transmission, trading, distribution and sale of energy to industries and domestic consumers, manage demand discipline, cause setting of tariff, recover and collect charges, fees and tariffs and do all other

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[2] The Pakhtunkhwa Energy Development Organization Act, 1993. Khyber Pakhtunkhwa Act No. I of 1993. http://kpcode.kp.gov.pk/homepage/lawDetails/30.

things necessary and incidental with power produced or generated by or through the Organization;

1.2 Project Overview

The Project is a run-of-river hydropower project (**Exhibit 1.2**). The proposed site of the dam is 18.6 km upstream of Balakot town, whereas the underground powerhouse will be located in near the village of Barkot, 8.0 km upstream of Balakot town.

The dam will be a concrete gravity dam with a maximum height of 35 meters (m) from the river bed and dam crest length of 130 m. The dam top elevation will be 1,292 m above mean sea level (amsl). The dam will create a reservoir that will operate between the maximum operating level of 1,288 m and the minimum operating water level of 1,283 m. The reservoir volumes corresponding to the maximum and minimum operating levels are 3.6 million cubic meter (m^3) and 2.4 million m^3, respectively. The surface area of the reservoir will be approximately 28 hectares (ha) and it will extend 2.2 km upstream of the dam.

A headrace tunnels extending 9.1 km will divert water from the reservoir created by the dam to the powerhouse.

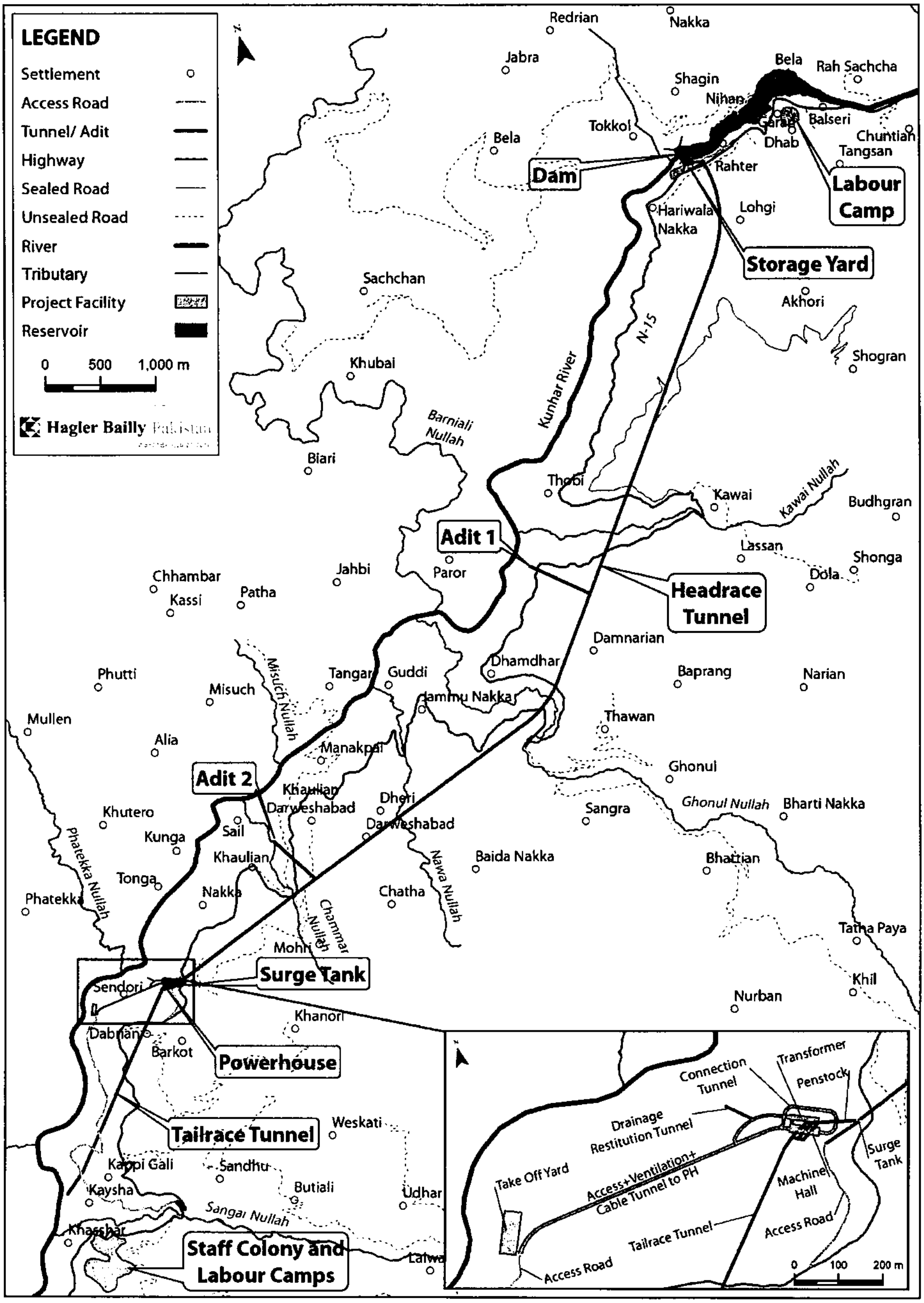
The powerhouse will be underground cavern-type powerhouse. A 1.565-km long tailrace tunnel will discharge the water back to the Kunhar River. The total distance between the dam and the outfall of the tailrace tunnel will be about 13.4 km.

A circular surge tank, having a 14.5 m diameter, is proposed at the end of the low pressure headrace tunnel with a surge height of 122m.

The total installed capacity will be 300 MW. The average annual energy generation will be 1,143 Gigawatt-hour (GWh).

The Modular flow at the intake is 87 m^3/s. The design discharge is 154 m^3/s.

Exhibit 1.2: Project Facilities Layout



1.3 Objectives and Scope of the EIA

The overall purpose of the EIA is to identify the potential environmental and social impacts 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 identified measures to minimize any anticipated adverse impact of the proposed Project, at least to the level that it meet the national and good international industry practice (GIIP) criteria for evaluation of environmental and social impacts.

The specific objectives of this EIA is to:

- Assess the existing environmental conditions in the Project area, including the identification of environmentally sensitive areas.
- Assess the proposed activities to identify their potential impacts, evaluate the impacts, and determine their significance.
- Propose appropriate mitigation measures that can be incorporated into the design of the proposed Project, or how it is constructed or operated, to ensure that the potential impacts of the Project are within the acceptable limits—as defined by environmental laws, ADB safeguard policies, and GIIP—and where feasible the impacts are further minimized.
- Assess cumulative impacts of proposed hydropower projects on Kunhar River and provide recommendations to the concerned regulators to undertake measures for protection of the environment.
- Prepare an EIA report for submittal to the KP Environmental Protection Agency (KP-EPA) and the lenders.

The scope of the EIA includes the assessment environmental and social impacts of all activities during construction and operation stages that will be undertaken to make the Project a reality. However, the scope does not include the manufacturing of the hydropower plant equipment, its transportation from the place of manufacture through ships on international water and the unloading of the same on the Karachi ports.

To evacuate power from the proposed Project, a 500 kV transmission line to be constructed by National Transmission and Despatch Company (NTDC) falls in the category of associated project.[3] The length of the transmission line is not known at this stage as the interconnection point is not yet finalized.

To achieve environmental or social outcomes consistent with the KP regulatory requirements and the ADB safeguards policies, it is essential that NTDC undertake the EIA of the transmission line following the requirements stated in **Section 2** of this report and develop a sound Environmental Management Plan (EMP). The scope of this EIA does not include the design, construction, and operation of the transmission line for evacuation of the power produced by the Balakot HPP, however, recognizing the potential impacts and risks associated with the transmission line, measures to ensure that

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[3] IFC defines associated facilities as "facilities that are not funded as part of the project and that would not have been constructed or expanded if the project did not exist and without which the project would not be viable"

a full EIA of the transmission line is undertaken, the EMP identifies and defines a set of management measures to be taken in the contractual arrangement with NTDC.

1.4 Study Areas

The spatial boundaries of the Study Areas for the EIA were selected to cover all areas where any measureable 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 Areas took into account the environmentally sensitive receptors[4] that are most likely to be impacted by the Project's development activities. It also took into account the different stages of the Project specifically construction and operation. To ensure assessment of cumulative impacts, the Study Areas were selected to be large enough to allow the assessment of the Valued Ecosystem Components (VECs) that may be affected by the Project activities.

The permanent footprint of the proposed Project includes the area that will be acquired for the dam, reservoir, powerhouse, and other facilities. Temporary footprint includes the land that will be required or disturbed due to the facilities that will be developed during the construction phase in the dam, powerhouse and other infrastructure components.

The Study Areas are considerably larger than the Project footprint. The proposed Project has different types of impacts spread over relatively large area. Therefore, a single study area for all types of impacts is difficult to define.

The ecological Study Area was defined as follows:

- **Aquatic Study Area**: The part of the Kunhar River starting from Faridabad upstream of the Project to Bissian downstream of the Project. It includes tributaries in this stretch but only those with a significant perennial flow that support breeding of fish.
- **Terrestrial Study Area**: This was defined as a 1 km buffer around locations where Project-related facilities are to be located.

The socioeconomic Study Area:

- **500 m buffer on each side of river**: along reaches that may be impacted due to the Project, and the zone where there is river dependence (either through use of drift wood, use of sediment as building materials) is a zone of 500 m of the river.
  - All settlements with a center within the 500 m buffer is included.
  - All settlements with more than 50% of their land area within the 500 m buffer are also included.
- **1 km buffer around Project facilities:** for coverage of communities that will be directly impacted through either resettlement, or construction related impacts.

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[4] Sensitive receptors include, for example, residential areas, schools, places of worship, habitat of threatened or vulnerable flora and fauna species, drinking water sources, wetlands, and cultural heritage sites.

- **Upstream Extent:** selected as tailrace tunnel of Sukki Kinari HPP, upstream of the dam, as the dam as a barrier may affect communities reliant on ecological resources (such as fish).
- **Downstream Extent:** The downstream extent of the Study Area is at the start of reservoir of the Patrind HPP.

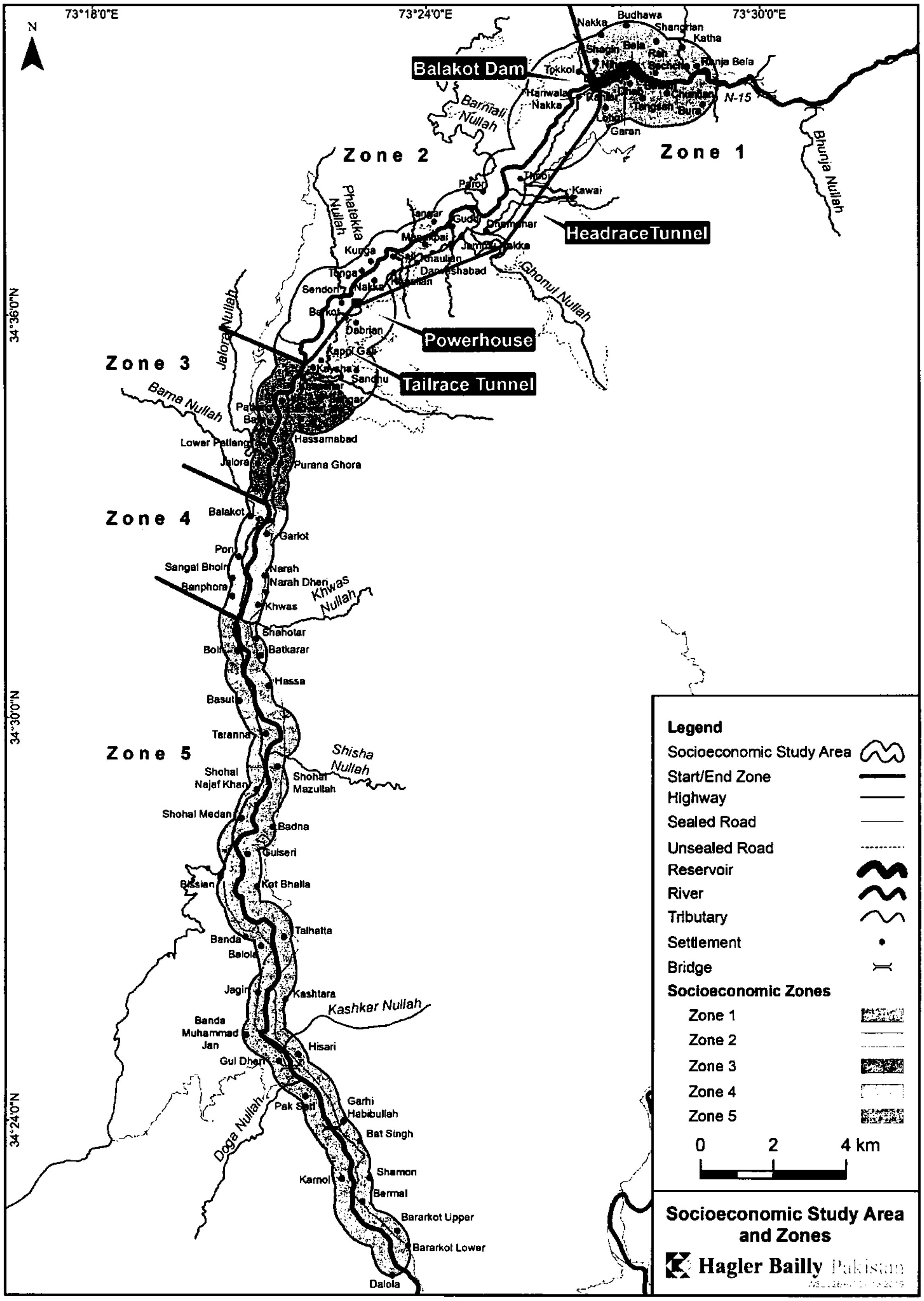
Keeping in view expected variations between rural and urban areas, impact due to the Project, flow variations along different reaches of the Kunhar River due to tributaries, as well as changes due to other hydropower projects, the Study Area is divided into different zones along the Kunhar River:

- **Zone 1:** Upstream of Balakot Dam (including Balakot Reservoir Area)
- **Zone 2:** Downstream of Balakot Dam up to Upstream of Balakot Tailrace Outlet
- **Zone 3:** Downstream of Balakot Tailrace Outlet up to Upstream of Balakot City
- **Zone 4:** Balakot City along Kunhar River
- **Zone 5:** Downstream of Balakot City up to the reservoir of Patrind Hydropower Project
- **Zone 6:** 1 km buffer around Project facilities

The Study Area used for the physical environment was the same as that for the socioeconomic environment

Exhibit 1.3 shows the Study Areas defined for this baseline study.

Exhibit 1.3: Study Areas



1.5 Study Team

The EIA has been developed by a team of professionals working with HBP or are associated with HBP, who are the leading experts in their respective fields in the country. In addition to HBP, a senior consultant from Southern Waters Ecological Research and Consulting (South Africa) as well as Engititan (Pvt.) Ltd. contributed to the EFlow assessment. **Exhibit 1.4** shows the names of the study team members and their roles.

Exhibit 1.4: Study Team

Name	*Education and Experience*	*Role and Main Activities*
HBP		
Hidayat Hasan	▶ PhD Coursework, Atmospheric Physics ▶ MSc Physics ▶ BSc Physics, Chemistry, Mathematics ▶ 23 years of experience in environmental and social impact assessment	▶ Project Team Leader ▶ Supervision of Compilation and standardization of the Project reports ▶ Technical support to the socioeconomic and LARP team
Vaqar Zakaria	▶ BS and MS in Chemical Engineering, MIT, USA ▶ 26 years of experience in environmental assessment and monitoring	▶ Project Supervision ▶ Technical Team Leader (EFlow Assessment) ▶ Supervision of the Biodiversity Action Plan ▶ Supervision of the Cumulative Impact Assessment
Anwar Fazal Ahmed	▶ MSc (Hons) Rural Development ▶ MA Economics ▶ 16 years of experience in resettlement planning and implementation	▶ Social Safeguards Expert (Land Acquisition and Resettlement) ▶ Household socioeconomic data collection, analysis and reporting.
Aziz Karim	▶ MSc Biochemistry ▶ BSc Biochemistry, Microbiology, Chemistry ▶ Over 10 years of experience in environmental assessment	▶ Technical Team Leader (Physical Environment) ▶ Coordination of Physical Environment field teams ▶ Supervision of physical data collection (noise, air quality, traffic and visual) ▶ Water quality, visual and traffic analysis and reporting

Name	*Education and Experience*	*Role and Main Activities*
Hassan Bukhari	▶ MS Natural Resources and Environment ▶ BS Physics ▶ 2 years of experience in environmental assessment	▶ Water quality, noise, traffic and air quality data analysis and reporting ▶ Physical impact assessment ▶ Inputs to aquatic ecology impact assessment ▶ Environmental Flow (EFlow) Assessment support
Saeed Nawaz	▶ BA Journalism and Education ▶ FSc Physics, Chemistry, Biology ▶ 19 years of experience in water, wastewater and soil sample analysis	▶ Hydrocensus and water sample data collection ▶ Water physical parameters laboratory analysis
Sadia Asghar	▶ BSc Environmental Engineering ▶ FSc Pre-Engineering ▶ 2 years of experience in environmental assessment	▶ Climate data review, analysis and reporting ▶ Physical baseline reporting ▶ Air quality, traffic and visual impact assessment
Kamran Minai	▶ MSc Environmental Science and Management ▶ BSc Biology ▶ 2 years of experience in environmental assessments	▶ Project management activities ▶ Compilation and standardization of the Project reports ▶ Quality assurance checks ▶ Coordination of Terrestrial Ecology field teams ▶ Compilation of Ecological Baseline ▶ Terrestrial ecology desktop research, data collection, analysis and reporting ▶ Terrestrial ecology impact assessment ▶ Aquatic ecology impact assessment
Ahmad Shoaib	▶ M.Phil. Fisheries and Aquaculture ▶ B.S (Hons.) Applied Zoology ▶ B.S (Hons.) Fisheries and Aquaculture ▶ 3 years of experience in aquaculture and 1 year of experience in fish surveys for environmental assessments	▶ Aquatic ecology field investigation, data analysis and reporting ▶ Development of Monitoring and Evaluation Plan for the BAP.
Muhammad Usman Berches Niazi	▶ M.Sc. Geography ▶ B.A. Geography and Economics ▶ 4 years of experience in Geographic Information Systems (GIS)	▶ Socioeconomic data collection (settlement and ecosystem services), community consultations, and compilation ▶ Socioeconomic, physical and ecological report maps

Name	*Education and Experience*	*Role and Main Activities*
Jan Muhammad	▶ MS Economics ▶ 8 years of experience in social development	▶ Translation of the Background Information Document (BID) into Urdu
Ghulam Murtaza	▶ MSc Sociology (in progress) ▶ BA Sociology ▶ FSc Pre-Engineering ▶ 7 years of experience in geographic information systems (GIS) and 8 years of experience in ecology field surveys	▶ Socioeconomic, physical and ecological report maps
Khalil Ejaz Awan	▶ MBA Business Administration ▶ Over 11 years of experience in administration and 2 years of experience in socioeconomic data collection.	▶ Administrative and logistic support
Imran Khalid	▶ Certification in MS Office and Hardware ▶ Graduation ▶ 12 years of experience in formatting and designing of technical documents	▶ Document formatting services
Umer Jahangir	▶ Graduation ▶ 7 years of experience in formatting and designing of technical documents	▶ Document formatting services
HBP Associates		
Dr Mohammad Rafique	▶ PhD Zoology ▶ MPhil Genetics ▶ MSc Zoology ▶ BSc ▶ 27 years of experience in fisheries assessments	▶ Biodiversity expert and lead aquatic ecologist ▶ Aquatic ecology field investigation, data analysis and reporting
Dr. Jamil Ahmad	▶ PhD Sociology ▶ Masters Anthropology ▶ Bachelor of Arts History ▶ 20 years of experience in socioeconomic studies and data collection	▶ Social Development Specialist ▶ Socioeconomic data collection ▶ Socioeconomic baseline reporting ▶ Socioeconomic impact assessment
Muhammad Munir Sheikh	▶ MS Hydrology ▶ MSc. Mathematics ▶ 30 years of experience in climate studies, assessments and authorship	▶ Climate change expert ▶ Climate change risk and vulnerability assessment

Name	Education and Experience	Role and Main Activities
Rizwana Waraich	▶ Master in English Literature ▶ Master in Business Administration (Human Resource Management) ▶ Bachelor of Arts in Economics and Statistics ▶ More than 15 years of experience in socioeconomic data collection, analysis and reporting with a focus on gender issues	▶ Gender Expert ▶ Socioeconomic data collection with a focus on gender-related data ▶ Gender analysis and reporting
Mishkatullah	▶ MSc (Hons) Agriculture and Entomology ▶ BSc (Hons) Agricultural Entomology ▶ FSc Pre-Engineering ▶ 12 years of experience in entomological studies	▶ Aquatic ecology field investigation (macroinvertebrates), data analysis and reporting
Rafaqat Masroor	▶ PhD Zoology (Herpetology) ▶ MSc Zoology ▶ BSc Zoology, Botany, Geography ▶ 14 years of experience in wildlife studies and conservation assessments	▶ Terrestrial ecology field investigation and data collection
Wajid Saghir	▶ MSc Botany ▶ BSc Botany, Zoology and Psychology ▶ 5 years of experience in plant studies for environmental assessments	▶ Terrestrial and riparian vegetation data collection and reporting
Buland Akhtar Siddiqui	▶ Certification in Project Management Professional (PMP) ▶ MS Computer Science ▶ Diploma in Computer Applications ▶ BSc Mathematics and Physics ▶ 20 years of experience in data analysis and management, more than 10 years of experience in project management	▶ Ecological and socioeconomic data analysis
Mohammad Arshad	▶ MSc Forestry ▶ Over 7 years of experience in social development including Resettlement Action Plans	▶ Household socioeconomic data collection
Muhammad Yasir Asad	▶ MS Sociology ▶ 6 years of experience in social development	▶ Household socioeconomic data collection
Arslan Tariq	▶ MS (M. Phil) Environmental Science	▶ Household socioeconomic data collection

Name	*Education and Experience*	*Role and Main Activities*
Madeha Aslam	▶ MA. Anthropology	▶ Household socioeconomic data collection
Sadaf Rani	▶ Master in Commerce – Finance	▶ Household socioeconomic data collection
HBP Consultants		
Bilal Khan	▶ BSc Geology ▶ BEng Environmental Engineering ▶ Over 10 years of experience in hydrology, geology and environmental impact assessment	▶ Hydrology modeling ▶ Climate Change Risk Assessment
Cate Brown	▶ PhD Zoology ▶ MSc Zoology ▶ BSc (Hons), Zoology ▶ BSc Zoology, Biochemistry ▶ 26 years of experience in aquatic ecology and integrated environmental flow assessment	▶ EFlow Expert ▶ Support for EFlow Assessment
Hussain Ali	▶ MEng Civil and Environmental Engineering ▶ 10 years of experience in environmental engineering	▶ Organization and supervision of river cross-section surveys

1.6 Organization of the Report

The EIA is organized in 10 chapters. Following this chapter, **Section 1** (*Introduction*), there are two chapters that provide the information that put the Project into context. These are

- **Section 2** (*Policy Legal and Administrative Framework*) describes the legal, policy, and requirements lenders applicable on the EIA process and the project design.
- **Section 3** (*Project Description*) describes the Project facilities, its main components, the construction activities, transport route, land requirement and the technical design summary.

The impact of the Project is assessed on the existing environment. The current status of environmental conditions are discussed in the following three chapters:

- **Section 4** (Description of the Environment) is divided into three parts:
  - **Section 4.1** (Physical Baseline) describes the geology, soils, hazards, topography, land use, climate, air quality, sound levels, visual character, and the water resources of the Study Area.

  - ▷ **Section 4.2** (Ecology Baseline) describes the fish, macro-invertebrates, riparian vegetation, terrestrial flora, mammals, avifauna, and herpetofauna of the Study Area.
  - ▷ **Section 4.3** (Socioeconomic Baseline) provides a narrative description of the socioeconomic zones, a description of the demographics, ethnicity, religion, governance, and administrative setup, social service infrastructure, physical infrastructure, local economy household socioeconomic conditions, indigenous people, and cultural heritage of the Study Area.
- **Section 5** (*Analysis of Alternatives*) identifies and the analyzes various alternatives to the Project and its design, this includes 'no project' option, alternative technology and scale of power generation, alternative Project location and layout, peaking and non-peaking operation, environmental flow and management option, and options for equipment and supplies transportation.
- **Section 6** (*Information Disclosure, Consultation, and Participation*) describes the scoping consultations undertaken for the Project and the results of consultations.

The impact assessment is organized in three chapters:

- **Section 7** (*Anticipated Environmental Impacts and Mitigation Measures*) is the main assessment chapter that assesses the impact of the proposed Project design, construction and operation on the physical, ecological and socioeconomic environment of the area. The aspects that are covered include aquatic ecology, terrestrial ecology, air quality, hydrology and water quality, noise, soil, topography, land stability, land acquisition, livelihood and well-being, macroeconomic impacts, aesthetics and tourism, climate change, cumulative impacts, traffic and road.
- **Section 8** (Grievance Redress Mechanism) that provides the framework for reporting, recording, and taking actions on complaints of the community.
- **Section 9** (*Environmental Management Plan*) provides details on management and mitigation measures to be carried out during the design, construction and operation phases of the Project. It also categorizes these measures based on the responsibilities of various members of the Project execution team and lays out the main aspects for monitoring of the implementation of management and mitigation measures.

Finally, the outcome of the impact assessment is combined to produce the following chapter:

- **Section 10** (*Conclusions and Recommendations*). It brings together the salient findings of the assessment.

2. Policy, Legal, and Administrative Framework

This section provides a summary of the national and international legislation and guidelines that are relevant to the assessment of the Project's environmental components. The review of the legal and institutional framework and relevant laws help identify the policy directives and required procedures to investigate social responsibility, environmental accountability and financial soundness of the Project.

2.1 Provincial Legislative and Regulatory Framework

The development of statutory and other instruments for environmental protection and management has steadily gained priority in Pakistan since the late 1970s. The Pakistan Environmental Protection Ordinance 1983 was the first piece of legislation designed specifically for protection of the environment. The promulgation of this ordinance was followed in 1984 by the establishment of the Pakistan Environmental Protection Agency, the primary government institution dealing with environmental issues. Significant work on developing environmental policy was carried out in the late 1980s, which culminated in the drafting of the Pakistan National Conservation Strategy. Provincial environmental protection agencies were also established at about the same time. The National Environmental Quality Standards (NEQS) (**Appendix A**) were established in 1993. The enactment of the Pakistan Environmental Protection Act 1997 (PEPA 1997) conferred broad-based enforcement powers to the environmental protection agencies. Publication of the Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations 2000 (IEE-EIA Regulations 2000) provided the necessary details on the preparation, submission, and review of an IEE and EIA. In addition to the PEPA 1997, Pakistan's statute books contain a number of other laws that have clauses concerning regulation and protection of the environment.

One of the key components of the 18th Amendment to the Constitution, passed by the parliament in 2010, was devolution of power from the federal to provincial governments. Through this amendment, the concurrent legislative list of the constitution was abolished, and all legislative powers on subjects included in the concurrent legislative list, which included environmental protection, were transferred to the provinces. Thus, after the passage of the 18th amendment, the federal government lost its power to legislate on environmental protection, and only provincial governments could make laws regarding protection of the environment.

2.1.1 Statutory Framework for Environment

The key national environmental legislation was the Pakistan Environmental Protection Act (PEPA 1997). After devolution through the 18th Constitutional Amendment 2010 the provinces have sole authority and responsibility to legislate on 'environment and ecology'. In this respect Khyber Pakhtunkhwa Environmental Protection Act 2014 (KP Act 2014), promulgated in 2014, is the relevant environmental act that will apply to this Project. This Act is largely based on PEPA 1997, with minor changes. Under the Act, all decisions made under PEPA 1997 are protected and applicable (Section 40(2)). Hence the environmental approval and conditions of approval, which were conferred before the enforcement of this act, are fully valid and applicable.

2.1.2 Khyber Pakhtunkhwa Environmental Protection Act 2014

The KP Environmental Protection Act 2014 is applicable to a broad range of issues and extends to air, water, industrial liquid effluent, and noise pollution, as well as to the handling of hazardous wastes. The articles of KP Act 2014 that have a direct bearing on the proposed Project are listed below.

The details are discussed in the following sections:

- Article 11 that deals with the KP environmental quality standards (KPEQS) and its application.
- Article 12 that deals with discharges, emissions and waste disposal.
- Article 13 that deals with IEE and EIA with review and approval process.
- Article 14 that prohibits import of hazardous waste.
- Article 15 that provides rules on handling of hazardous substances.
- Article 16 that provides regulations on motor vehicles.
- Article 17 that prohibits various acts detrimental to the environment.

The main features of the KP Act 2014 are discussed in **Exhibit 2.1**.

Exhibit 2.1: Khyber Pakhtunkhwa Environmental Protection Act 2014

Purpose	To provide for the protection, conservation, rehabilitation and improvement of the environment, for the prevention and control of pollution, and promotion of sustainable development
Definition of *Adverse Environmental Effect*	pollution or impairment of, or damage to, the environment, and includes,--- i. impairment of, or damage to, human health and safety or to property or biodiversity; ii. pollution to physical, biological, social, economic environment or to geological, hydrological resources or various land forms; iii. damage to public comfort, aesthetic conditions, ecological balance and meteorological conditions; iv. damage to aquifers, vegetal canopy, cultural heritage or archeological sites; and v. any other adverse environmental effect as may be specified in the rules
Definition of *Air Pollutant*	Any substance that causes pollution of air and includes soot, smoke, dust particles, odor, light, electro-magnetic radiation, heat, fumes, combustion exhaust, exhaust gases, noxious gases, hazardous substances and radioactive substances;
Definition of *Biodiversity Or Biological Diversity*	The variability among living organisms from all sources, including inter-alia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, includes diversity within species, between species and of eco-systems;
Definition of *Environment*	i. air, water and land; ii. all layers of the atmosphere; iii. all organic and inorganic matter and living organisms; iv. the ecosystem or flora and fauna, and ecological relationships; v. buildings, structure's, roads, facilities, installations and works; vi. all social or cultural and economic conditions and activities affecting community life; and vii. the inter-relationships between any of the factors specified in sub-clauses (i) to (vi)
Definition of *Hazardous Waste*	The waste which contains hazardous substances or as may be prescribed and includes healthcare risk wastes and radioactive waste
Definition of *Hazardous Substance*	viii. a substance or mixture of substances, except the pesticide as defined in the Agricultural Pesticides Ordinance, 1971 (II of 1971), which, by reason of its physical, chemical or biological properties or toxic, explosive, flammable, corrosive, infectious, radioactive, persistent or having any other characteristics as may be prescribed, or is likely to cause, directly or in combination with other substances, an adverse environmental effect; and ix. any substance which may be prescribed as a hazardous substance;

Definition of *Discharge*	Spilling, leaking, pumping, depositing, seeping, releasing, flowing out, pouring, emitting, emptying or dumping;
Definition of *Ecosystem*	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit;
Definition of *Effluent*	Any material in solid, liquid or gaseous form or combination thereof being discharged from industrial activity or any other source and includes a slurry, suspension or vapour;
Definition of *Industrial Activity*	Any operation or process for manufacturing, making, formulating, synthesizing, altering, repairing, crushing, grinding, cleaning ornamenting, finishing, packing or otherwise treating any article or substance with a view to its use, sale, transport, delivery or disposal, or for mining, for oil and gas exploration and development, or for pumping water or sewage, or for generating, transforming or transmitting power or for any other industrial or commercial purposes;
Definition of *Industrial Waste*	Waste resulting from an industrial activity;
Definition of *Pollution*	The contamination of air, land or water by the discharge of emission of effluent or wastes or air pollutants or noise or other matter which either directly or indirectly or in combination with other discharges or substances alters unfavorably the chemical, physical, biological, radiational, thermal or radiological or aesthetic properties of the air, land or water or which may, or is likely to make the air, land or water unclean, noxious or impure or injurious, disagreeable or detrimental to the health, safety, welfare or property of persons or harmful to biodiversity;
Definition of *Noise*	The intensity, duration and character of sound from all sources, and includes vibration;
Definition of *Sewage*	Liquid or semi-solid wastes and sludge from sanitary conveniences, kitchens, laundries, washing and similar activities and from any sewerage system or sewage disposal works;
Definition of *Waste*	Substance or object or material which has been, is being or is intended to be, discarded or disposed of, and includes liquid waste, solid waste, waste gases, suspended waste, industrial waste, agricultural waste, radioactive and nuclear waste, mist, animal waste, electronic waste, municipal waste, hospital waste, pharmaceutical waste, plastic and polythene waste and residues from the incineration of all types of waste.
Definition of *Climate Change*	A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods;
Definition of *Emission*	The extent of pollutant's discharges per unit time or the extent of pollutant per unit volume of gas, liquid or vapor emitted
Definition of *Factory*	Any premises in which industrial activity is being undertaken;
Functions of the Agency	Administer and implement the provisions of this Act and the rules made there under;
	Prepare, in coordination with the appropriate Government Agency or local council and in consultation with the concerned sectoral Advisory Committees where established, environmental policies for the approval of the Council

	Prepare, revise and establish the Khyber Pakhtunkhwa Environmental Quality Standards with the approval of the Council: Provided that before seeking approval of the Council, the Agency shall publish the proposed Khyber Pakhtunkhwa Environmental Quality Standards for public opinion in accordance with the prescribed procedure;
	Ensure enforcement of the Khyber Pakhtunkhwa Environmental Quality Standards; resources, solid waste management and water sanitation
	Establish standards for the quality of the ambient air, water and land, by notification establish different standards for discharge or emission from different sources and for different areas and conditions as may be necessary: Provided that- (a) where these standards are less stringent than the Khyber Pakhtunkhwa Environmental Quality Standards prior approval of the Council shall be obtained; and (b) list of areas, with the approval of the Council, in which any class of activities or projects shall not be carried out or shall only be carried out subject to certain specified safeguards;
	Co-ordinate with other Provinces, Federal Government, National and International Organizations for the implementation of environmental policies, issues concerns and programs as may be prescribed
	Co-ordinate and facilitate the Government departments, agencies, organizations and institutions in the Khyber Pakhtunkhwa in adaptation to address the impacts of climate change;
	Establish systems and procedures for surveys, surveillance, monitoring, measurement, examination, investigation, research, inspection and audit to prevent and control pollution, and to estimate the costs of cleaning up pollution and rehabilitating the environment in various sectors
	Carry out and conduct environmental monitoring and implementation of environmental approvals provided in this Act;
	Carry out and conduct environmental audits of old industrial units in accordance with rules(Old industrial units means those established before the commencement of this Act)
	Issue licenses for the consignment, handling, transport, treatment, disposal, storage, handling or otherwise dealing with hazardous substances;
	Assist Government Agencies, local councils, local authorities and other persons to implement schemes for the proper disposal of wastes so as to ensure compliance with the Khyber Pakhtunkhwa Environmental Quality Standards
	Provide information and guidance to the public on environmental matters

	Specify safeguards for the prevention of accidents and disasters which may cause pollution, collaborate with the concerned persons in the preparation of contingency plans for control of such accidents and disasters, and co-ordinate implementation of such plans;
	Review and approve mitigation plans and give guidance and directions, where necessary, for cleanup operations ordered under this Act
Prohibition of certain discharges or emissions	(1) Subject to the provisions of this Act, rules, notifications and guidelines made thereunder i. no person shall discharge or emit or allow the discharge or emission of any effluent or wastes or air pollutant or noise, load, concentration or level which is in excess of the Khyber Pakhtunkhwa Environmental Quality Standards or, where applicable, the standards established under sub clause (vii) and (viii) of sub-section (1) of section 6; and ii. No person shall discharge effluents, emissions or wastes in excess of load permitted in the conditions of environmental permit or environmental approval or license. (2) The Agency, with the approval of Government, may levy a pollution charge on any person who contravenes or fails to comply with the provisions of sub-section (1), to be calculated at such rate, and collected in accordance with such procedure as may be prescribed. (3) Any person who pays the pollution charge levied under sub-section (2), shall not be charged with an offence with respect to that contravention or failure.
Initial Environmental Examination and Environmental Impact Assessment	1) No proponent of a project shall commence construction and operation unless he has filed with the Agency an initial environmental examination or where the project is likely to cause an adverse environmental effect, an environmental impact assessment, and has obtained from the Agency, environmental approval in respect thereof. (2) The Agency shall (a) review the initial environmental examination and accord its approval or require submission of an environmental impact assessment by the proponent; or (b) review the environmental impact assessment and accord its approval subject to such conditions as it may deem fit to impose, 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. (3) Every review of an environmental impact assessment shall be carried out with public participation and no information will be disclosed during the course of such public participation which relates to: (a) trade, manufacturing or business activities, processes or techniques of a proprietary nature, or financial, commercial, scientific or technical matters which the proponent has requested should remain confidential, unless for reasons to be recorded in writing, the Director-General of the Agency is of the opinion that the request for confidentiality is not well-founded or the public interest in the disclosure outweighs the possible prejudice to the competitive position of the project or its proponent; or

	(b) International relations, national security or maintenance of law and order, except with the consent of Government; or (c) Matters covered by legal professional privilege. (4) The Agency shall communicate its approval or otherwise within a period of four months from the date of the initial environmental examination or environmental impact assessment is filed complete in all respects in accordance with the prescribed procedure, failing which the initial environmental examination or, as the case may be, the environmental impact assessment shall be deemed to have been approved, to the extent to which it does not contravene the provisions of this Act and the rules, provided that delay is not on part of the proponent for the provision of additional information asked for during the review process or conductance of public hearing of the project. (5) Subject to sub-section (4), Government may in a particular case extend the aforementioned period of four months if the nature of the project so warrants. (6) The provisions of sub-sections (1), (2), (3), (4) and (5) shall apply to such categories of projects and in such manner as may be prescribed. (7) The projects or any activity of a proponent not covered under sub-section (6), specified in guidelines shall obtain a general environmental approval in a manner prescribed in guidelines in respect thereof. (8) The Agency shall maintain separate Registers for initial environmental examination and environmental impact assessment projects, which shall contain brief particulars of each project and a summary of decisions taken thereon, and which shall be open to inspection by the public at all reasonable hours and the disclosure of information in such Registers shall be subject to the restrictions specified in sub-section (3).
Handling of Hazardous Substances	Subject to the provisions of this Act, no person shall generate, collect, consign, transport, treat, dispose of, store, handle, deal in and use or import any hazardous substance except--- (a) under a license issued by the 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 or the Province of the Khyber Pakhtunkhwa is a party.

Regulation of motor vehicles	(1) Subject to the provisions of this Act, and the rules, notification and guidelines made thereunder, no person shall operate a motor vehicle from which air pollutants or noise are being emitted in an amount, concentration or level which is in excess of the Khyber Pakhtunkhwa Environmental Quality Standards or where applicable the standards established under clauses (vii) and (viii) of sub-section (1) of section 6. (2) For ensuring compliance with the standards mentioned in sub-section (1), the Agency may direct that any motor vehicle or class of vehicles or locomotive shall install such pollution control devices or other equipment or use such fuels or undergo such maintenance or testing as may be prescribed. (3) Where a direction has been issued by the Agency under sub-section (2) in respect of any motor vehicles or class of motor vehicles, or locomotives, no person shall operate any such vehicle till such direction has been complied with.

2.1.3 Preparation and Submission of EIA

Article 13 of KP Act states that "No proponent of a project shall commence construction and operation unless he has filed with the Agency an initial environmental examination (IEE) or where the project is likely to cause an adverse environmental effect, an environmental impact assessment (EIA), and has obtained from the Agency, environmental approval in respect thereof".

Hydroelectric power generation projects with capacities greater than 50 MW require an EIA as per the categorization of the IEE-EIA Regulations 2000. The law requires that the EIA must be submitted and approved by the provincial EPA before any construction activities can commence.

2.2 Environmental Standards

2.2.1 National Environmental Quality Standards

KP EPA is yet to formulate the *Khyber Pakhtunkhwa Environmental* Quality Standards (KPEQS) as per Article 6 (v) of the KP Act 2014. So, the National Environmental Quality Standards (NEQS) will be applicable to the Project. Article 11(1) of the PEPA 1997 states that
"Subject to the provisions of this Act and the rules and regulations made thereunder no person shall discharge or emit or allow the discharge or emission of any effluent or waste or air pollutant or noise in an amount, concentration or level which is in excess of the National Environmental Quality Standards."

NEQS have been established for gaseous emission, liquid effluent, ambient air quality, noise and drinking water. From the date of enforcement of the NEQS, all projects, whether in operation on the date or constructed later, are required to comply with these standards.

The Project needs to comply with all applicable standards, and Project proponents and contractors should ensure that no activity will result in the emission of pollutants and effluents exceeding limits as prescribed in the NEQS. The applicability of the NEQS to the Project is described in **Exhibit 2.2**. The complete set of NEQS are included in **Appendix A**.

Exhibit 2.2: NEQS Applicable to the Project

NEQS	*Applicability During Construction*	*Applicability During Operation*
Gaseous Emission	All power generators	Any back-up generator
Noise emission	All noise sources	Not applicable
Emission from motor vehicles	All project vehicles	All project vehicles
Noise from motor vehicles	All project vehicles	All project vehicles

NEQS	*Applicability During Construction*	*Applicability During Operation*
Ambient air quality	Changes in air quality of the surrounding are due to construction activities	Not applicable
Liquid effluent	Sanitary waste and other liquid waste discharged to the environment	Sanitary waste and other liquid waste discharged to the environment
Drinking water	Water supplied by the owners and contractors to staff	Water supplied by the owners and contractors to staff

2.2.2 ADB's Guidelines for Project Emission

The ADB requires that "During the design, construction, and operation of the project the borrower/client will apply pollution prevention and control technologies and practices consistent with international good practice, as reflected in internationally recognized standards such as the World Bank Group's Environment, Health and Safety Guidelines. These standards contain performance levels and measures that are normally acceptable and applicable to projects. When host country regulations differ from these levels and measures, the borrower/client will achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, the borrower/client will provide full and detailed justification for any proposed alternatives that are consistent with the requirements presented in this document."

The IFC's EHS Guidelines[1] will be used as the basic criteria for evaluating the emissions (gaseous, effluent, noise, etc.) from the Project. Fundamentally, the NEQS as well as the IFC EHS Guidelines will be applicable following the guidelines cited above.

2.3 Other Environmental Laws

2.3.1 Land Acquisition Act 1894

The national law governing land acquisition is the Land Acquisition Act 1894 (LAA 1894) and successive amendments to it. The LAA 1894 regulates the land acquisition process and enables the government to acquire private land for public purposes through the exercise of the right of eminent domain. Land acquisition is a provincial responsibility in Pakistan and provinces also have their own province-specific implementation rules.

The LAA 1894 and its implementation rules require that, following an impact identification and valuation exercise, land and crops are compensated in cash at the current market rate to titled landowners. In past practice land acquisition was usually based on the last 3 to 5 years average registered land–sale rates. However, in several recent cases like Faisalabad Khanewal motorway project and the Expressway 35 project, the median rate over the past 1 year, or even the current rates have been applied. Under

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[1] Sustainability Overview webpage on the official website of the International Finance Corporation – World Bank Group, http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/our+approach/risk+management/ehsguidelines

section 23 of LAA 1894 and its amendments, in addition to the market–value of the land a sum of 15% of the amount as compulsory acquisition surcharge is also paid to the affected persons (APs), if the acquisition has been made for public purpose and a sum of 25% on such market–value if the acquisition has been made for a Company. The APs, if not satisfied, can go to the Court of Law to contest the compensation award of the LAC.

The various sections relating to the land acquisition are briefly discussed below and summarized in **Exhibit 2.3**.

Exhibit 2.3: Key Feature of the LAA 1894

Section	*Actions [Person Responsible]*	*Purpose and Effect*
4	▶ Publication in the official gazette of a notification that a "land in any locality is needed or is likely to be needed for any public purpose or for a Company" [Collector] ▶ Public notice of the substance of such notification at convenient places in the said locality [Collector]	Allows preliminary investigation. In affect it demonstrates the interest of the government that the "land in any locality is needed or is likely to be needed for any public purpose or for a Company" Allows the Collector to authorize persons to enter, and where necessary, clear the land to: survey the land; undertake soil and other studies for determining the suitability of the land; measure land and demarcate boundaries by placing markers.
5 and 5A	▶ Publication in the official gazette by the government a) the intention of the government that any particular land included in Section 4 notification is needed for public purposes or for a Company, b) the administrative location of the land, c) the purpose of land acquisition, d) its approximate area, and e) location where the development plan for the land, if required, is available for public inspection, if required, [DC, if land required for public purposes or the provincial government if land required for a Company] ▶ Public notice of the substance of such notification at convenient places in the said locality Collector	Notifies the intention of the government to acquire land for the particular purpose in order to give opportunity to the interested persons (persons who would be entitled to claim an interest in compensation if the land were acquired) to file an objection to the land acquisition. The objection can be filed within 30 days.
6	▶ The Collector, if satisfied after reviewing the report made under section 5–A, subsection (2), will make a declaration in the official Gazette with conclusive evidence, stating that particular land is required for public/private purpose. The declaration will include the location of the land, the purpose and its approximate area. ▶ The declaration shall be made only after ensuring that the compensation is to be paid by the company.	Provides the declaration from the collector for the purchase of required land. Declaration is published and communicated to the public in large to notify the acquisition of land including its location, area and purpose.
7	▶ After declaration under Section 6 Collector, to take order for the acquisition of the land.	Official orders are given by the [Executive District Officer (Revenue)], directing the Collector, to initiate the formal land acquisition process.
8	▶ If the required land is not demarcated under section 4, the Collector, will give orders to mark, measure and plan out the required land.	Demarcation of required land as per the exact requirement of the project.

Section	*Actions [Person Responsible]*	*Purpose and Effect*
9	▶ The Collector to issue public notice at convenient places on or near the land to show intentions for acquiring required land and inviting to file claims for compensation, objections to measurements etc., indicating date, time and place for all the land owners, indicating such date not earlier than 15 days. ▶ The Collector also to serve notice, by post, to the occupier or to the known land owners (if any), residing within the revenue district or elsewhere. ▶ The Collector shall also serve notice, not less than 15 days prior to the date fixed under sub–section (2) of section 9, to the land owners about the inquiry to be held under section 11 for determination of claims and objections.	To inform the land owners and public at large, well ahead the time, about the acquisition of the demarcated land to ensure that interested persons are given sufficient time to object or claim.
10	▶ The collector will also require and send a notice to any other interested person (co–proprietor, sub–proprietor, mortgagee, tenant or otherwise) with interest/claim pertaining to the required land. ▶ Any person claiming any interest under this section or section 9 will be bound to do so within the meaning of section 175 and 176 of Pakistan Penal Code.	To ensure that there are no financial discrepancies left unaddressed during the process of land acquisition and every person associated with the land is duly informed and their objection/claims are appropriately addressed.
11	▶ On the fixed date, the Collector to enquire into the claims and objections of interested persons with regard to measurements made under section 8, value of the land (at the date of the publication of the notification under section 4, sub–section (1) and respective claims. The Collector can make an award (under his jurisdictions) of true area of the land, compensation which in his opinion should be allowed for the land and the distribution of the compensation among all the known or believed to be interested in the land, whether they have appeared before him or not.	To determine the actual land owners and precise measurements of the required land. This section also ensures that the compensation paid is true representation of the value of land. To ensure that the compensation is fairly distributed among all the owners of the land.
12	▶ The award filed in the Collector's office shall be deemed conclusive, whether the interested persons have appeared before the Collector or not. ▶ The Collector shall issue immediate notice of the award to the land owners whether they have appeared personally or by their representatives when the award is made.	To avoid potential future conflicts between the government and the owners of the land. This ensures that the decision made by the collector is final. To convey complete information in a timely manner to the land owners. This section ensures that the land owners have complete information on the award irrespective of their presence in Collector's office.

Section	*Actions [Person Responsible]*	*Purpose and Effect*
12 –A	▶ The Collector can rectify any mistake (typographical, arithmetical errors) in the award by his own motion or on the application of any of the parties.	To ensure that there are no errors or mistakes in the award or the assessment of the land. This ensures that the measurement and valuation of the land is done justly.
13	▶ The Collector may conduct or discontinue and reschedule the enquiry for any reason, any day/time fixed by him.	To implement check and balance on the system. This ensures sense of responsibility on the government officers.
14	▶ The Collector is empowered by this section to call, and enforce the attendance of witnesses, including the interested parties or any of them to produce the documents by the same means, and in the same manner as provided the case of a Civil Court under the Code of Civil Procedures.	To avoid future conflicts and increase transparency in the land acquisition process. To ensure that only the rightful legal owners who have proper documents are paid the award and no illegal claims are entertained.
15	▶ The Collector shall be guided by section 23 and 24 in determining compensation.	
16	▶ Under this section, the collector may take possession of the land, after the compensation paid to the owner of the land or deposited in the Civil Court in his name by the acquisitioning authority and the required land, shall then be granted to the government without any further claim.	To ensure smooth transfer of land rights from the owner to the acquisitioning authority. This gives security to the acquiring authority that once the award is paid in full, the Collector will take the possession of the land.

2.3.2 Key Biodiversity Laws

There are a number of other laws in the statute books of Pakistan which have a bearing on the environmental performance of the Project. The three primary laws are described in **Exhibit 2.4**.

Exhibit 2.4: Three Key Laws Relevant to the Project

Law	*Description*	*Applicability to the Project*
The Khyber Pakhtunkhwa Forest Ordinance, 2002	This Act authorizes provincial forest departments to establish forest reserves and protected forests. The Act prohibits any person from: setting fires in the forest; quarrying stone; removal of any forest produce; or causing any damage to the forest by cutting trees or clearing areas for cultivation or any other purpose without express permission of the relevant provincial forest department.	The Project area does not include any forest reserve or protected forests established by the provincial forest department. There is limited forest cover around the Project facilities locations. Therefore, this law is not applicable to the Project.
The Khyber Pakhtunkhwa Wildlife and Biodiversity (Protection, Preservation, Conservation and Management) Act, 2015	This law was enacted to protect the province's wildlife resources directly and other natural resources indirectly. It classifies wildlife by degree of protection, i.e., animals that may be hunted on a permit or special license, and species that are protected and cannot be hunted under any circumstances. The Act specifies restrictions on hunting and trade in animals, trophies, or meat. The Act also defines various categories of wildlife-protected areas, i.e., National Parks, Wildlife Sanctuaries, and Game Reserves.	Parts of the Kunhar River are protected due to the presence of trout species. Furthermore, there are protected areas within the Mansehra District. If the Project and related activities is found to impact Protected Areas, this law will be applicable.
NWFP Fisheries Rules 1976	This law prohibits destruction of fish by explosives, poisoning water and the hunting of protected fish species. The law also forbids the use of net or fixed engine traps without a permit or license. The law grants power to the Director General (DG) Fisheries to issue permits to catch fish. It protects fish against 1) Destruction of fish by explosives, and 2) Destruction of fish by poisoning water.	This law was applicable to the Project as there was a possibility of catching fish as sustenance by the Project staff and also makes it obligatory to obtain a license from the fisheries department before commencing any fishing activities.

2.3.3 Other Laws

In addition to the laws cited above, a number of other laws were reviewed for provisions that can affect the environmental and social performance of this Project. A list is provided in **Exhibit 2.5**. These were reviewed and the results of the review are provided in this section, in particular information about their potential to impact the Project.

Exhibit 2.5: Other Laws Reviewed

Antiquities Act, 2016	Industrial Relations Act, 2010
Delimitation of Local Councils Act, 2015	Forestry Commission Act, 1999
Environmental Protection Act, 2014	Irrigation and Drainage Authority Act, 1997
Factories Act, 2013	Kaghan Development Authority Act, 1996
Forest Ordinance, 2002	Minimum Wages Act, 2013
Industrial and Commercial Employment (Standing Orders) Act, 2013	Payment of Wages Act, 2013
Energy Development Organization Act, 1993	Rivers Protection Ordinance, 2002
Integrated Water Resources Management Board Ordinance, 2002	Worker's Compensation Act, 2013
Prohibition of Employment of Children Act, 2015	The Khyber Pakhtunkhwa Local Government Act, 2013
Protection of Trees and Brushwood Act, 1949	The West Pakistan Firewood and Charcoal (Restriction) Act, 1964
Rural Drinking Water Supply Scheme Act, 1985.	Wildlife and Biodiversity (Protection, Preservation, Conservation and Management) Act, 2015
The Khyber Pakhtunkhwa Right to Information Act,2013	

Energy Development Organization Act, 1993

The Pakhtunkhwa Energy Development Organization (PEDO) is granted authority by this Act to develop the energy resources in KP. Under this Act, development of hydropower is transferred to PEDO.

The Project is being developed by PEDO, which is operating under this Act. It is necessary for PEDO to comply with all regulations under this Act.

Forest Ordinance, 2002

The Forest Ordinance, 2002 has been instated to protect, conserve, manage and sustainably develop forests and other renewable natural resources. The ordinance empowers the government to declare any forest land as reserved or no longer reserved, designate reserve forests for village communities to use, declare forest land or wasteland as Protected Forests or remove protected status, control Guzara Forests, Mazri and Mazri produce, as well as timber and timber produce. Under the ordinance the government is granted powers forest management, with authority given to forest officers. The government, through its officers, has the right to exercise penalties on violations on prohibitions as laid out in the ordinance.

Certain plant species are protected under the Act when found in reserved forests, protected forests and protected wastelands. A list of these species is provided in Schedule I of the Act.

The Project is not expected to impact Reserve Forests, Protected Forests, Village Forests or Guzara Forests. Reserved Forests are located around the Project facilities. The Project will have an impact on forested areas. It is important to ensure that Project-related activities do not encroach on any of the above-mentioned types of forests. It is also important that Project staff not engage in the collection or trade of forest produce.

Forest Development Corporation Ordinance, 1980

The Forest Development Corporation has been established under this ordinance. The corporation functions to "make suitable arrangements for the

> (i) economic and scientific exploitation of forests;
>
> (ii) sale of forest produce;
>
> (iii) establishment of primary wood-processing units;
>
> (iv) regeneration in areas to be specified by Government; and
>
> (v) performance of such other functions as may be assigned to it by Government."

The Project will not be impacted by this ordinance. It should be ensured that Project staff do not engage in activities that are under the jurisdiction of this corporation for example in the trade of forest products.

Forestry Commission Act, 1999

The Act is aimed at establishing a Forestry Commission to improve the protection, management sustainable development of forests in KP. Under this Act the Commission established is empowered and entrusted to further this aim by taking steps such as giving vision and a framework for the sustainable development of forests in KP, guiding and overseeing the process of institutional and legislative reforms in the Department, advocating policies for sustainable development of forests etc. The Project will not be impacted by this Act, however, any initiatives undertaken by the Commission may be of interest to the Project for biodiversity management and mitigation.

Protection of Trees and Brushwood Act, 1949

The Act provides protection for trees and brushwood. Under this Act it is illegal to clear trees and brushwood belonging to the local government. The Project is being developed by PEDO, therefore, it is owned by the local government. Project-related activities should only be undertaken on land acquired for the Project. They should not clear trees or brushwood outside the acquired area.

Wildlife and Biodiversity (Protection, Preservation, Conservation and Management) Act, 2015

The Act has been instated to consolidate the laws relating to protection, preservation, conservation and management of wildlife in KP. Its aims include the following:

> "(a) strengthening the administration of the organization[2] to effectively manage wild animals and their habitats;
>
> (b) to holistically manage Protected Areas in a sustainable manners for the best interest of the indigenous communities and local stakeholders;
>
> (c) securing appropriately the goods and services produced from wild animals and their habitats at the level of local communities;
>
> (d) fulfilling the obligations envisaged under the biodiversity related multilateral environmental agreements ratified by the Government of Pakistan;
>
> (e) promotion of public awareness and capacity building for proper appreciation of the environmental significance and socio-economic values of wildlife; and
>
> (f) conservation of biological diversity and realization of its intrinsic and extrinsic values through sustainable use and community participation."

The Act empowers Wildlife Officers to enforce the laws relating to wildlife conservation and management and to use reasonable force to do so, if necessary. It places restrictions on hunting, possession and display of wildlife, trade and trafficking of wildlife or wildlife products, and protected areas. Wildlife offences and penalties for those offences are provided in the Act.

The Project and Project-related activities will be affected by the Act if there is violation of the rules pertaining to wildlife. This will be the case if staff engage in activities prohibited under the Act such as hunting, possession and display of wildlife, trade in wildlife and wildlife products, introduction of alien invasive species and so on. To ensure compliance with law, staff should report any wildlife sightings to the concerned government department.

Rivers Protection Ordinance, 2002

The ordinance has been instated to provide for the protection of aquatic ecology, water quality, economic and environmental value of rivers and their tributaries in KP. The ordinance has been instated keeping in view the increasing developments along rivers in KP and the need to maintain the quality of the rivers for public use. The rules set out will be applicable on any length of a particular river or stream or any part of a river or its tributary that has been specified by the Government. The Project is a hydropower project being developed on the main Kunhar River. If the Government of KP has designated the Kunhar River or specifically a stretch of the Kunhar River which includes the stretch to be used by the Project, then the rules set out in this ordinance will be applicable.

The rules laid out in the ordinance relate mainly to encroachment onto the river and pollution of the river. It is important that Project-related activities do not pollute the river

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[2] Wildlife Department, KP

and that all construction activities along the river banks be carried out within the area designated for them.

Integrated Water Resources Management Board Ordinance, 2002

The Integrated Water Resources Management Board has been established to devise and oversee the implementation of an integrated water resources management strategy aimed at sustainable economic, social and environmental returns on water resource development. Under the ordinance a Board has been established, the functions of which include conducting studies to accurately assess the various demands of water for consumptive or non-consumptive use. This includes the use of water resources for hydropower itself, as well as areas that will potentially be affected by the Project such as fisheries, water-related sports, environmental sustainability, forestry, lakes and water bodies etc. The Managing Director of PEDO is a member of the Board established under this ordinance.

The Project will be affected by this ordinance as it is impacting the flow of the Kunhar River. Any policies, rules and procedures put in place by the Board need to be complied with. In addition to this studies conducted as part of this assessment should be shared with the Board.

Rural Drinking Water Supply Scheme Act, 1985

The Act has been instated to facilitate the execution of schemes for supply of drinking water in rural areas. Project-related activities should not disrupt any schemes established under this Act. As long as Project-related activities take place within the land acquired for the Project, this law will not affect the Project.

Irrigation and Drainage Authority Act, 1997

The Act addresses the irrigation and drainage system in KP by requiring the adoption of a strategy for streamlining it. It includes the implementation of policies in the water resources sector to improve and sustainably develop supply for irrigated agriculture along with operating and maintaining irrigation, drainage, storage reservoirs and flood control infrastructure in KP. The Project will not be affected by the Act if it does not affect the irrigation system in KP. Irrigation is not expected to be impacted by the Project.

The West Pakistan Firewood and Charcoal (Restriction) Act, 1964

The Act prohibits the burning of firewood and charcoal in factories, brick-kilns, limekilns and other specified places. The Project can be considered a factory under the definition provided in the Act. The Project owner and developer should ensure that no burning of firewood and charcoal is carried out in premises under its control.

Antiquities Act, 2016

The Antiquities Act, 2016 is applicable to the Project. Chapter IV, Clause 56 'Execution of mega project' requires a clearance to be obtained from the Director (as defined in the Act) before construction of a dam. Chapter VI, Clause 70, 'Regulation of mining, quarrying, etc.' gives the Director authority to prohibit mining, quarrying, excavation, blasting and movement of heavy vehicles for the purpose of protecting or preserving any immovable antiquity.

Factories Act, 2013

The Factories Act, 2013 provides for the regulation of labor in KP. A factory is defined as "…any premises, including the precincts thereof, whereon ten or more workers are working, or were working on any day of the preceding twelve months, and in any part of which a manufacturing process is being carried on or is ordinarily carried on with or without the aid of power, but does not include a mine, subject to the operation of the Mines Act, 1923 (Act No. IV of 1923);" Based on this definition, the Act is applicable to the Project.

The Act regulates a range of conditions relating to labor. These include health and safety, restrictions on working hours of adults, holiday with pay, and special provisions for adolescents with children. It also provides for government inspection staff to function as directed by the government, penalties and procedures relating to violations of the Act as well as supplemental information for staff (such as display of factory notices, removal of difficulties, protection against discrimination etc.). The Project needs to comply with the requirements under these regulations.

Industrial and Commercial Employment (Standing Orders) Act, 2013

The Industrial and Commercial Employment (Standing Orders) Act, 2013 provides for the regulation of industrial and commercial employment in KP. It provides a list of standing orders for workers in the province. These include classification of workers based on types of contracts, identification of workers, the requirement for documenting terms and conditions, publications of working times, publication of wage rates, shift working, payment of wages, incentive schemes, insurance, bonuses, stoppage of work, closure of establishment, termination of employment, punishments, liability of the employer, amongst others.

The Project is required to comply with the clauses in this Act. The terms and conditions for the workers need to be published and all matters related to agreements between workers and the developer, outlined in the Act, need to be documented and adhered to.

Prohibition of Employment of Children Act, 2015

The Act has been instated to prohibit the employment of children and to regulate the employment of adolescents in KP. The Project will be impacted by the Act only if it employs children under the age of 14. The Project should not employ children or adolescents for any Project-related activities. Under the Act, staff designated by the government, can inspect the Project facilities to ensure compliance with its rules. The inspector may require the establishment to provide evidence of age of staff in case of dispute over age.

Industrial Relations Act, 2010

The Act has been instated to regulate relationships between workers and employers. It outlines the rights and responsibilities of the workers and the employer. For example, workers and employers can, without distinction, establish and join associations of their own choice. Every trade union and employer's association shall frame its own constitution and rules to elect its representatives.

The owners and developers of the Project need to ensure that no unfair conditions are placed on labor in terms of employment practices. The workers also must not partake in any unfair labor practices. Furthermore, under the Act, participation of workers in management is important. Under the Act the government can appoint an inspector to ensure compliance with provisions of the Act. The Act also provides for penalties in case of violations of provisions in the Act.

Minimum Wages Act, 2013

The Act provides for the regulation of minimum rates of wages and various allowances for different categories of workers employed in certain industrial and commercial undertakings and establishments. The Project needs to ensure that all workers are paid at least minimum wages. If this is ensured, the Act will not affect the Project.

Payment of Wages Act, 2013

The Act regulates the payment of wages to persons employed in factories, industrial establishments and commercial establishment in KP. The Project can be considered a factory under the definition in the Act. Therefore, it needs to comply with the provisions of the Act by ensuring payment of wages by all responsible people.

Worker's Compensation Act, 2013

The Act provides for workers or their legal heirs compensation for injury or death by accident. The Project owner will be liable to provide compensation if personal injury is caused to a worker by accident during the course of his employment.

Kaghan Development Authority Act, 1996

The Act instates the development of an authority to develop Kaghan and other regions of Hazara Division. The Kaghan Development Authority is empowered by the Act for environmental upgradation and uplift of the common. The Authority is involved in development of schemes in diverse types of scheme, examples of which include education, health, agriculture and industry, forest conservation, preservation of wildlife, promotion of tourism, improvement of water supply, land slide management, sewerage and drainage etc.

The Project will have an impact on the area under the jurisdiction of the Kaghan Development Authority. The Project is being developed by PEDO, therefore, it is owned by the Government of KP. Under the Act the Authority shall discharge its functions, guided by directions from the government. This highlights the importance of PEDO to coordinate with the Kaghan Development Authority, especially as Project-related activities will place added pressure on the service infrastructure in the area, which is under the Authority. However, the Act is not binding on the Project.

The Khyber Pakhtunkhwa Local Government Act, 2013

The Act has been instated to construct and regulate local government institutions in KP and to consolidate laws relating to these institutions. The Act defines the functions and powers of various heads of local government such as District Councils, Villages, City Districts etc.

The local government is a stakeholder with whom the Project needs to coordinate. Any changes in the organization, powers and functions of the local government, directed by the Act, can affect the Project.

Delimitation of Local Councils Act, 2015

The Act mainly concerns the defining of local councils by providing for the delimitation of village councils, neighborhood councils and territorial wards for general seats to tehsil councils, and district councils, for elections to local councils in KP. The Act may affect the Project if there is a change in the delimitation of local councils.

The Khyber Pakhtunkhwa Right to Information Act, 2013

The Act provides for ensuring transparency and access to information in KP. The Project is a public sector Project, therefore, it needs to provide information to the public and not compromise transparency under this Act.

2.4 Federal and Provincial Conservation Strategies

Pakistan National Conservation Strategy (PNCS)[3] was prepared jointly by the then federal Ministry of Environment with assistance from the International Union for the Conservation of Nature (IUCN). It was approved by the federal cabinet in 1992 as the basic policy document on environmental sustainability.

The Sarhad Provincial Conservation Strategy (SPCS)[4] was prepared by the Government of KP with assistance from IUCN. It was approved by the provincial cabinet in 1996 and was considered a sustainable development action plan for the KP.

Both these documents are no longer used for planning purposes and as such are obsolete as a policy document. However, they can be used where relevant as a guideline.

National Sustainable Development Strategy, 2012 (NSDS): The NSDS envisions the evolution of a just and harmonious society via the promotion of vibrant and equitable economic growth without the over-exploitation of natural resources and the fair distribution of development dividends to all, in particular marginalized, poor, and vulnerable in society and to future generations. The strategy is aligned with the emerging concept of 'green economy' as an alternate to the Framework for Economic Growth (2011), prepared by the Planning Commission of Pakistan.

National Climate Change Policy (2012): The National Climate Change Policy, approved by the Government in 2012 has the overall goal 'to ensure that climate change is mainstreamed in the economically and socially vulnerable sectors of the economy and to steer Pakistan towards climate resilient development'. One of the major objectives of this policy is conservation of natural resources and long term sustainability further elaborated through specific measures under forestry, biodiversity, and other vulnerable ecosystems. With respect to forestry, the National Climate Change Policy (NCCP) outlines the need to restore and enhance Pakistan's forest cover under sustainable forest management to 'withstand present and probable future impacts of climate change.'

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[3] The Pakistan National Conservation Strategy, 1992.

[4] The Sarhad Provincial Conservation Strategy, 1996, Government of North West Frontier Province in collaboration with IUCN–The World Conservation Union.

Biodiversity-related policy measures include setting national biodiversity indicators and provision of requisite financial resources for implementation of the BAP (2000).

To support the Climate Change Policy, in 2013 the Government prepared a Framework for Implementation of the Climate Change Policy (2014-2030) which lists priority, short-term, medium-term and long-term actions to be implemented in various sectors including forestry.

2.5 Institutional Framework

The success of environmental assessments as a means of ensuring that development projects are environmentally sound and sustainable depends in large measure on the capability of regulatory institutions for environmental management. The institutional framework for decision-making and policy formulation in environmental and conservation issues is briefly described below.

The Khyber Pakhtunkhwa Environmental Protection Agency (KP EPA) is primarily responsible for administering the provisions of the KP Environmental Protection Act, 2014. The institutional framework for decision-making and policy formulation in environmental and conservation issues is summarized in **Exhibit 2.6**.

Exhibit 2.6: Institutional Responsibilities

Agency	*Law*	*Functions*	*Relevance to the Project*
KP Environmental Protection Agency and KP Environmental Protection Council	KP Environmental Protection Act 2014	Enforcement of provisions of the KP Environmental Protection Act 2014 in KP	KP-EPA has the key jurisdiction in the context of environmental protection over the Project
Pakhtunkhwa Energy Development Organization (PEDO)	The Sarhad Hydel Development Organization Act, 1993	Preparation of a comprehensive plan for the development and utilization of the power and energy resources of KP, and framing of a scheme or schemes for the province for generation, transmission and distribution of power.	Being the developer, PEDO needs to ensure compliance with the requirements of the KP EPA and lender agencies.
National Electric Power Regulatory Authority (NEPRA)	Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997	Regulating the provision of electric power services, specifically grant licenses for generation, transmission and distribution of electric power. The Act requires the licensee to follow performance standards laid down by the Authority for distribution and transmission of electric power, including safety, health and environmental protection instructions issued by the Authority or any Governmental agency, with the least environmentally harmful supply of electricity.	The Authority requires preparation and approval of EIA from the respective EPA as a condition of grant of generation license. Beyond this the authority has no direct role in environmental management as per current practice.
Provincial Disaster Management Authority KP	National Disaster Management Act (Amended) 2012	The Authority may: lay down policies on disaster management; lay down guidelines to be followed by government; and take such measures for the prevention of disaster or the mitigation or for preparedness and capacity building for dealing with disaster situation as it may consider necessary.	Will be the key agency in case of any natural or human-made emergency and disaster in the Project area.
Fisheries Department, KP	NWFP Fisheries Rules 1976	The Fisheries Department has the authority to enforce the laws and regulations provided in the Fisheries Rules, 1976. This includes regulation of fishing methods using permits and licenses, the species that can be caught and associated penalties for violation of regulations pertaining to wild fish.	All wild fish fauna is under the jurisdiction of the Fisheries Department, therefore, they need to be informed about any impacts on fish fauna and related mitigation measures need to be agreed with them.

Agency	*Law*	*Functions*	*Relevance to the Project*
Forest Department, KP	The Khyber Pakhtunkhwa Forest Ordinance, 2002. Khyber Pakhtunkhwa Ordinance No. XIX of 2002.	The Forest Department enforces the provisions of the Forest Ordinance, 2002 to meet its objectives which include protection, conservation, management and sustainable development of forests by engaging the community and defining the role of the government.	All forest areas including reserved forests, village forests, protected forests, guzara forests and wastelands, and produce from forests is under the jurisdiction of this department. They need to be informed about impacts on forests and they need to agree with related mitigation measures.
Wildlife Department, KP	The Khyber Pakhtunkhwa Wildlife and Biodiversity (Protection, Preservation, Conservation and Management) Act, 2015	The Wildlife Department enforces the provisions of the Khyber Pakhtunkhwa Wildlife and Biodiversity Act, 2015 to meet its objectives which include strengthening the administration of the organization to effectively manage wild animals and their habitats, to fulfil the obligations of the government under its commitments to managing biodiversity, and promoting public awareness for the value of wildlife and conservation.	All wildlife is under the jurisdiction of this department. The department needs to be informed of impacts on wildlife and they need to agree to related mitigation measures.
Local Governments	The Khyber Pakhtunkhwa Local Government Act, 2013 Act No. XXVIII	Under this Act the local governments are established and function within the provincial framework. Local areas for local government include villages, neighborhoods, tehsils, towns, districts, and city districts. The Act foresees a role for the district government in environmental management.	The District Administration in Mansehra, if it has enacted any of the procedures for environmental management, will be involved in certain aspects of environmental management of the Project.

2.5.1 Environmental Protection Agency

The KP EPA was established in 1989. It is a monitoring and regulating agency with the following main functions:

- Administer and implement the KP Environmental Protection Act 2014, its rules and regulations.
- Review the IEE-EIA, including preparation of procedures and guidelines.
- Preparation, revision and enforcement of NEQS (industries, municipalities and vehicular emissions).
- Establish and maintain laboratories, certification of laboratories, for conducting tests and analysis.
- Assist local councils/authorities and government agencies in execution of projects.
- Establish a system for surveys, monitoring, examination and inspection to combat pollution.
- Conduct training for government functionaries and industrial management.
- Provide information and education to the public on environmental issues.
- Publish an annual state of the environment report. Survey qualitative and quantitative data on air, soil, water, industrial/municipal and traffic emissions.
- Take measures to promote environment related research and development activities.

2.5.2 Environmental Protection Council

The Pakistan Environmental Protection Council established in 1984 does not have regulatory power over KP. The KP environmental protection Act 2014 allows for a provincial level environmental protection council which has yet to be established. It will be the highest inter-ministerial statutory body in the province and will be responsible for:

- Formulating environmental policies.
- Overseeing enforcement of environmental law.
- Approval of the NEQS.
- Incorporation of environmental considerations into development plans and policies.

2.6 Asian Development Bank Policies and Guidelines

The Safeguard Policy Statement (SPS) builds upon the three previous safeguard policies on the environment, involuntary resettlement and indigenous peoples, and brings them into one single policy that enhances consistency and coherence, and more comprehensively addresses environmental and social impacts and risks. The SPS aims to promote sustainability of Project outcomes by protecting the environment and people from Project's potential adverse impacts by avoiding adverse impacts of projects on the environment and affected people, where possible; minimizing, mitigating, and/or compensating for adverse project impacts on the environment and affected people when avoidance is not possible; and helping borrowers/clients to strengthen their safeguard systems and develop the capacity to manage environmental and social risks.

The following ADB policies and guidelines may be applicable to the proposed Project:

- ADB's 2009 Safeguard Policy Statement (SPS) – Safeguards Requirement (SR) 1 on Environment, SR2 on Involuntary Resettlement (IR), and SR 3 on Indigenous Peoples (IP);
- ADB Social Protection Strategy (2001);
- ADB Gender and Development Policy (1998);
- Access to Information Policy (2018);[5] and
- Relevant ADB Operations Manual (OM) such as OMF1 for Safeguards Policy Statement, OML3 for Access to Information Policy[6], OMD10 for Non-sovereign Operations, OMC3 for Incorporation of Social Dimensions into ADB Operations, OMC2 for Gender and Development;[7]
- ADB's Accountability Mechanism Policy (2012)[8]

The ADB's environmental policy is grounded in its Poverty Reduction Strategy and its Long-Terms Strategic Framework. To ensure the reduction of poverty through environmentally sustainable development, the ADB's Environment Policy contains five main elements: (i) promoting environment and natural resource management interventions to reduce poverty directly, (ii) assisting developing member countries to mainstream environmental considerations in economic growth, (iii) helping maintain global and regional life support systems that underpin future development prospects, (iv) building partnerships to maximize the impact of ADB lending and non-lending activities, and (v) integrating environmental considerations across all ADB operations.

Under the last element, the ADB pledges to address the environmental aspects of its operations through the systematic application of procedures for (i) environmental analysis for country strategy and programming; (ii) environmental assessment of project loans, program loans, sector loans, loans involving financial intermediaries, and private sector loans; (iii) monitoring and evaluation of compliance with environmental requirements of loans; and (iv) implementation of procedures for environmentally responsible procurement. In the context of policy-based lending and policy dialogue, the ADB will

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[5] Asian Development Bank (ADB), September 2018, Access to Information Policy, Available at https://www.adb.org/sites/default/files/institutional-document/450636/access-information-policy.pdf. Accessed on 18 June, 2019.

[6] Asian Development Bank (ADB), Janaury 2019, Access to Information Policy Operations Manual, Available at https://www.adb.org/sites/default/files/institutional-document/31483/om-l3.pdf

[7] Asian Development Bank (ADB), September 2016, Operations Manual, Institutional Document, ADB, Available at https://www.adb.org/documents/operations-manual

[8] Asian Development Bank (ADB), 2012, Accountability Mechanism Policy, ADB Available at https://www.adb.org/sites/default/files/institutional-document/33440/files/accountability-mechanism-policy-2012.pdf

identify opportunities to introduce policy reforms that provide incentives to improve environmental quality and enhance the sustainability of natural resource management.

ADB classifies projects into category A (with potentially significant environmental impact); category B (with potentially less significant environmental impact); or, category C (unlikely to have significant environmental impact).[9] An IEE is required for category B projects and an EIA, requiring greater depth of analysis, for category A projects. No environmental assessment is required for category C projects although their environmental implications nevertheless need to be reviewed. The proposed Project has been classified as a category A project for environment.

The ADB requires public consultation and access to information in the environment assessment process. It specifies the need for meaningful consultation, which involves a two-way communication between the borrower/client and the affected communities and stakeholders. It also involves the active participation of affected communities and stakeholders in various stages in the project design and implementation. The following principles are applicable to meaningful consultations:[10]

1. begins early and is carried out on an ongoing basis throughout the project cycle,
2. ensures timely disclosure of relevant information,
3. is free of intimidation or coercion,
4. is gender-inclusive and responsive, and tailored to the needs of disadvantaged and vulnerable groups, and
5. incorporates relevant views of affected people and other stakeholders into project design and decision-making.

The Environmental Management Plan (EMP) is a key component of the EIA. The ADB places strong emphasis on the preparation of EMPs during project processing. The EMP sets out conditions and targets to be met during project implementation. It is also required to develop procedures and plans to ensure that the mitigation measures and monitoring requirements approved during the environmental compliance review will actually be carried out in subsequent stages of the project.

The ADB, however, recognizes that the specific construction and operational activities may not be defined well enough at the feasibility stage of the project cycle to provide the details required for an effective EMP. The ADB therefore requires that the Borrower ensure that a revised EMP be prepared at the beginning of the implementation stage. The Company will be the project proponent and will be responsible for preparing the revised EMP.

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[9] A fourth category, FI (credit line for subprojects through a financial intermediary, or equity investment in a financial intermediary), requires that an appropriate environmental management system should be developed and assessment carried out.

[10] Asian Development Bank (ADB), Environmental Safeguards: A Good Practice Sourcebook Draft Working Document, December 2012.

2.6.1 ADB's Safeguard Policy Statement 2009

Built upon the three previous safeguard policies on the Involuntary Resettlement Policy (1995), the Policy on Indigenous Peoples (1998) and the Environment Policy (2002), the Safeguard Policy Statement was approved in 2009. The safeguard policies are operational policies that seek to avoid, minimize or mitigate adverse environmental and social impacts including protecting the rights of those likely to be affected or marginalized by the developmental process.

According to **Section 8**, Biodiversity Conservation and Sustainable Natural Resource Management of ADB's Safeguard Policy Statement 2009, "the borrower/client will assess the significance of project impacts and risks on biodiversity and natural resources as an integral part of the environmental assessment process. The assessment will focus on the major threats to biodiversity, which include destruction of habitat and introduction of invasive alien species, and on the use of natural resources in an unsustainable manner. The borrower/client will need to identify measures to avoid, minimize, or mitigate potentially adverse impacts and risks and, as a last resort, propose compensatory measures, such as biodiversity offsets, to achieve no net loss or a net gain of the affected biodiversity."

Critical Habitat is defined by ADB's SPS 2009 as follows: Critical habitat is a subset of both natural and modified habitat that deserves particular attention. Critical habitat includes areas with high biodiversity value, including habitat required for the survival of critically endangered or endangered species; areas having special significance for endemic or restricted-range species; sites that are critical for the survival of migratory species; areas supporting globally significant concentrations or numbers of individuals of congregatory species; areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and areas having biodiversity of significant social, economic, or cultural importance to local communities. Critical habitats include those areas either legally protected or officially proposed for protection, such as areas that meet the criteria of the World Conservation Union classification, the Ramsar List of Wetlands of International Importance, and the United Nations Educational, Scientific, and Cultural Organization's world natural heritage sites.

No project activity will be implemented in areas of critical habitat unless the following requirements are met:

- There are no measurable adverse impacts, or likelihood of such, on the critical habitat which could impair its high biodiversity value or the ability to function.
- The project is not anticipated to lead to a reduction in the population of any recognized endangered or critically endangered species or a loss in area of the habitat concerned such that the persistence of a viable and representative host ecosystem be compromised.
- Any lesser impacts are mitigated in accordance with para. 27 (Mitigation measures will be designed to achieve at least no net loss of biodiversity. They may include a combination of actions, such as post project restoration of habitats, offset of losses through the creation or effective conservation of ecologically comparable areas that are managed for biodiversity while respecting the ongoing

use of such biodiversity by Indigenous. Peoples or traditional communities, and compensation to direct users of biodiversity.

When the project involves activities in a critical habitat, the borrower/client will retain qualified and experienced external experts to assist in conducting the assessment.

ADB's safeguard policy framework consists of three operational policies on the environment, indigenous peoples and involuntary resettlement. A brief detail of all three operational policies has been mentioned below:

Environmental Safeguard: This safeguard is meant to ensure the environmental soundness and sustainability of projects and to support the integration of environmental considerations into the project decision-making process. The requirements apply to all ADB-financed and/or ADB-administered sovereign and non-sovereign projects, and their components regardless of the source of financing, including investment projects funded by a loan; and/or a grant; and/or other means, such as equity and/or guarantees (hereafter broadly referred to as projects). This policy and its requirements pertaining to environmental assessment, baseline, and impact assessment will apply to this project and the EIA will be undertaken to ensure that the Project is designed to comply with the policy.

Involuntary Resettlement Safeguard: This safeguard has been placed in order to avoid involuntary resettlement whenever possible; to minimize involuntary resettlement by exploring project and design alternatives; to enhance, or at least restore, the livelihoods of all displaced persons in real terms relative to pre- project levels; and to improve the standards of living of the displaced poor and other vulnerable groups. This policy and its requirements will apply to this project and the EIA and LARP will be undertaken to ensure that the Project is designed to comply with the policy.

Indigenous Peoples Safeguard: This safeguard looks at designing and implementing projects in a way that fosters full respect for Indigenous Peoples' identity, dignity, human rights, livelihood systems and cultural uniqueness as defined by the Indigenous Peoples themselves so that they receive culturally appropriate social and economic benefits; do not suffer adverse impacts as a result of projects; and participate actively in projects that affect them. Based on the available information no indigenous people live in the project area. However, this will be further confirmed during the study.

Information, Consultation and Disclosure: Consultation and participation are essential in achieving the safeguard policy objectives. This implies that there is a need for prior and informed consultation with affected persons and communities in the context of safeguard planning and for continued consultation during project implementation to identify and help address safeguard issues that may arise. The consultation process begins early in the project preparation stage and is carried out on an ongoing basis throughout the project cycle. It provides timely disclosure of relevant and adequate information that is understandable and readily accessible to affected people and is undertaken in an atmosphere free of intimidation or coercion. In addition, it is gender inclusive and responsive and tailored to the needs of disadvantaged and vulnerable groups and enables the incorporation of all relevant views of affected people and other stakeholders into decision making. ADB requires the borrowers/clients to engage with communities, groups or people affected by proposed projects and with civil society through information disclosure, consultation and informed participation in a manner commensurate with the risks to and impacts on affected communities. For projects with significant adverse environmental, involuntary resettlement or Indigenous Peoples impacts, ADB project teams will participate in consultation activities to understand the concerns of affected people and ensure that such concerns are addressed in project design and safeguard plans.

2.6.2 Social Protection Requirements

ADB's Social Protection Strategy (2001 SPS) requires the Borrower to comply with applicable labor laws in relation to the Project, and take the following measures to comply with the core labor standards[11] for the ADB financed portion of the Project:

- carry out its activities consistent with the intent of ensuring legally permissible equal opportunity, fair treatment and non-discrimination in relation to recruitment and hiring, compensation, working conditions and terms of employment for its workers (including prohibiting any form of discrimination against women during hiring and providing equal work for equal pay for men and women engaged by the Borrower);
- not restrict its workers from developing a legally permissible means of expressing their grievances and protecting their rights regarding working conditions and terms of employment;
- engage contractors and other providers of goods and services:
- who do not employ child labor[12] or forced labor[13];
- who have appropriate management systems that will allow them to operate in a manner which is consistent with the intent of (A) ensuring legally permissible equal opportunity and fair treatment and non-discrimination for their workers, and (B) not restricting their workers from developing a legally permissible means of expressing their grievances and protecting their rights regarding working conditions and terms of employment; and
- whose subcontracts contain provisions which are consistent with paragraphs (i) and (ii) above.

2.6.3 Access to Information Policy (2018)

The objective of the The Access to Information Policy (2018) is to promote stakeholder trust in ADB and to increase the development impact of ADB activities. The policy reflects ADB's commitment to transparency, accountability, and participation by stakeholders in ADB-supported development activities in Asia and the Pacific. It also recognizes the right of people to seek, receive, and impart information about ADB's operations.

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[11] The core labor standards are the elimination of all forms of forced or compulsory labor; the abolition of child labor; elimination of discrimination in respect of employment and occupation; and freedom of association and the effective recognition of the right to collective bargaining, as per the relevant conventions of the International Labor Organization

[12] child labor means the employment of children whose age is below the statutory minimum age of employment in the relevant country, or employment of children in contravention of International Labor Organization Convention No. 138 'Minimum Age Convention" (www.ioo.org)

[13] forced labor means all work or services not voluntarily performed, that is, extracted from individuals under threat of force or penalty

The policy applies to documents and information that ADB produces, requires to be produced by its borrowers or clients, or are produced and provided to ADB by other parties in the course of ADB operations.

2.6.4 Gender and Development Policy 1998

ADB's Gender and Development Policy (1998) adopts gender mainstreaming as a key strategy for promoting gender equity, and for ensuring that women participate in and that their needs are explicitly addressed in the decision-making process for development activities. The key elements of ADBs gender policy are: (i) Gender sensitivity, to observe how the project affects women and men differently and to take account of their different needs and perspectives in resettlement planning; (ii) Gender analysis, which refers to the systematic assessment of the project impact on men and women and on the economic and social relationships between them; (iii) Gender planning, which refers to the formulation of specific strategies to bring about equal opportunities to men and women; and (iv) Mainstreaming, to consider gender issues in all aspects of ADB operations, accompanied by efforts to encourage women's participation in the decision-making process in development activities.

The SPS and safeguards requirements also reiterate the importance of including gender issues in the preparation of safeguards documents at all stages to ensure that gender concerns are incorporated, including gender-specific consultation and information disclosure. This includes special attention to guarantee women's assets, property, and land-use rights and restoration/improvement of their living standards; and to ensure that women will receive project benefits.

2.6.5 Climate Change Risk Management Framework

The climate risk management approach of the ADB aims to reduce risks resulting from climate change to investment projects in Asia and the Pacific. ADB's framework identifies climate change risks to project performance in the early stages of project development, and incorporates adaptation measures in the design of projects at risk. ADB climate risk management framework comprises the following steps:

(i) context-sensitive climate risk screening at the concept development stage to identify projects that may be at medium or high risk;
(ii) climate change risk and vulnerability assessment during preparation of projects at risk;
(iii) technical and economic evaluation of adaptation options;
(i) identification of adaptation options in project design; and
(ii) monitoring and reporting of the level of risk and climate-proofing measures.

2.7 International Treaties and Agreements

Exhibit 2.7 lists important international environmental treaties that have been signed by Pakistan and may have relevance to the Project. They concern climate change and depletion of the ozone layer; biological diversity and trade in wild flora and fauna; desertification; waste and pollution; and cultural heritage.

Exhibit 2.7: International Environmental Treaties Endorsed by Pakistan

Topic	*Convention*	*Date of Treaty*	*Entry into Force in Pakistan*
Climate change and the ozone layer	United Nations Framework Convention on Climate Change - the primary objective is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.	1992	1994
	Kyoto Protocol to the United Nations Framework Convention on Climate Change - enabled by the above Convention on Climate Change. It has more powerful and legally binding measures. It sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas emissions.	1997	2005
	Vienna Convention for the Protection of the Ozone Layer - acts as a framework for the international efforts to protect the ozone layer with a primary objective to protect human health and the environment against adverse effects resulting from human activities that modify or are likely to modify the ozone layer.	1985	1993
	The Montreal Protocol on Substances that Deplete Ozone Layer and associated amendments - enabled by the Vienna Convention, it is designed to protect the ozone layer by phasing out the production and consumption of a number of substances believed to be responsible for ozone depletion.	1987	1993
Waste and pollution	Basel Convention on the Control of Trans Boundary Movements of Hazardous Wastes and their Disposal - regulates the trans boundary movement of hazardous waste and other waste with a stated purpose to protect human health and the environment against the adverse effects from generation and management of hazardous waste and other waste. The Convention provides for three sets of measures with binding obligations. These are: Strict control of trans boundary movement of hazardous waste; Environmentally sound management of hazardous waste; and Enforcement and implementation of the provisions of the convention at international and national levels.	1989	1994
	International Convention on Oil Pollution Preparedness, Response and Co-operation	1990	1995
	Stockholm Convention on Persistent Organic Pollutants - seeks to protect human health and the environment from Persistent Organic Pollutants, which are chemicals that remain intact in the environment for long periods, become widely distributed geographically and accumulate in the fatty tissue of humans and wildlife.	2001	2008

Topic	*Convention*	*Date of Treaty*	*Entry into Force in Pakistan*
	International Convention for the Prevention of Pollution from Ships (MARPOL) – is the main international convention that's covers prevention of pollution of the marine environment by ships from operational or accidental causes. The Convention includes regulations aimed at preventing and minimizing pollution from ships, both accidental pollution and that from routine operations, and currently includes six technical Annexes.	1983	
Desertification	International Convention to Combat Desertification – with an objective to combat desertification and mitigate the effects of drought. It is supported by international cooperation and partnership arrangements, with the aim of achieving sustainable use of land and water resources and sustainable development in affected areas.	1994	1997
Biodiversity and the protection of plants and animals	Convention on Biological Diversity – covering ecosystems, species, and genetic resources and also the field of biotechnology. The objectives are: ▶ conserve of biological diversity; ▶ sustainable use of its components; and ▶ fair and equitable sharing of benefits arising from genetic resources.	1992	1994
	Cartagena Protocol on Biosafety to the Convention on Biological Diversity - addresses potential risks posed by living modified organisms resulting from modern biotechnology.	2000	2009
	Bonn Convention on the Conservation of Migratory Species of Wild Animals - aims to conserve terrestrial, marine and avian migratory species throughout their range. It is concerned with the conservation of wildlife and habitats on a global scale.	1979	1987
	Memorandum of Understanding concerning Conservation Measures for the Siberian Crane - parties undertakes to provide strict protection to Siberian Cranes, and identify and conserve wetland habitats essential for their survival.	1998	1999
	Convention on International Trade in Endangered Species of Wild Fauna and Flora - to ensure that international trade in specimens of wild animals and plants does not threaten their survival.	1973	1976

Topic	*Convention*	*Date of Treaty*	*Entry into Force in Pakistan*
	International Plant Protection Convention (1997 Revised Text) - to prevent the international spread of pests and plant diseases. It requires maintenance of lists of plant pests, tracking of pest outbreaks, and coordination of technical assistance between member nations.	1951/52	1954
	Agreement for the Establishment of the Near East Plant Protection Organization - to establish the Near East Plant Protection Organization (NEPPO), which promotes international co-operation with a view to implementing International Plant Protection Convention.	1993	2009
	Plant Protection Agreement for the Asia and Pacific Region and amendments – establishes the Asia and Pacific Plant Protection Commission to review and promote the region's progress in the implementation of the Agreement. Trade in plants and plant products are regulated by certification, prohibition, inspection, disinfection, quarantine, destruction, etc., as necessary.	1955 (amendment 1967)	1958 (amendment 1969)
	Convention on Wetlands of International Importance especially as Waterfowl Habitat and associated protocols and amendments - to promote conservation and sustainable use of wetlands. The Ramsar List of Wetlands of International Importance now includes almost 1,800 sites (known as Ramsar Sites). There are currently 19 Ramsar sites in Pakistan.	1971 (amended 1987)	1976 (amended 1994)
Cultural heritage	Convention concerning the Protection of the World Cultural and Natural Heritage - requires parties to adapt a general policy on the protection of the natural and cultural heritage, to set up services for such protection, to develop scientific and technical studies, to take appropriate legal, technical, scientific and administrative measures and to foster training and education for such protection.	1972	1976

Pakistan is a party to a number of conventions in relation to biodiversity, including the Convention on the Conservation of Migratory Species of Wild Animals (CMS), the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES), the Convention on Wetlands of International Importance (Ramsar Convention) and the United Nations Convention on Biological Diversity (CBD).

The CBD defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems". As a signatory country, Pakistan has a responsibility to:

- Safeguard its biodiversity.
- Introduce procedures requiring environmental impact assessment (EIA) for projects likely to have significant impacts on biological diversity.
- Introduce legislative provisions that ensure environmental policies and procedures are duly taken into account.

There are no direct bearing of these treaties on the Project. Wherever required, the federal or provincial governments have enacted laws to comply with the provisions of the treaties listed in this section. Thus the obligations of the Project are to comply with pertinent laws only.

2.8 Guidelines

2.8.1 World Bank Group

The ADB recognizes the environmental safeguards documents of the World Bank Group including the International Finance Corporation as an example of good international industry practice.

The specific requirements are as follows:

> Apply pollution prevention and control technologies and practices consistent with international good practices as reflected in internationally recognized standards such as the World Bank Group's Environmental, Health and Safety Guidelines. .... [Page 16 of SPS 2009]
>
> During the design, construction, and operation of the project the borrower/client will apply pollution prevention and control technologies and practices consistent with international good practice, as reflected in internationally recognized standards such as the World Bank Group's Environment, Health and Safety Guidelines. These standards contain performance levels and measures that are normally acceptable and applicable to projects. When host country regulations differ from these levels and measures, the borrower/client will achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, the borrower/client will provide full and detailed justification for any proposed alternatives that are consistent with the requirements presented in this document. [Page 36 of SPS 2009]

> The borrower/client will provide workers12 with a safe and healthy working environment, taking into account risks inherent to the particular sector and specific classes of hazards in the borrower's/client's work areas, including physical, chemical, biological, and radiological hazards. The borrower/client will take steps to prevent accidents, injury, and disease arising from, associated with, or occurring during the course of work by (i) identifying and minimizing, so far as reasonably practicable, the causes of potential hazards to workers; (ii) providing preventive and protective measures, including modification, substitution, or elimination of hazardous conditions or substances; (iii) providing appropriate equipment to minimize risks and requiring and enforcing its use; (iv) training workers and providing them with appropriate incentives to use and comply with health and safety procedures and protective equipment; (v) documenting and reporting occupational accidents, diseases, and incidents; and (vi) having emergency prevention, preparedness, and response arrangements in place. The borrower/client will apply preventive and protective measures consistent with international good practice, as reflected in internationally recognized standards such as the World Bank Group's Environment, Health and Safety Guidelines. [Page 38 of SPS 2009]

The ADB recommends using the IFC's Environmental Health and Safety (EHS) guidelines for emission and effluent.[14] It also refers to the IFC's Performance Standard 3: Resource Efficiency and Pollution Prevention, for assessment and compliance with greenhouse gas emission standards.[15] There are a total of eight IFC Performance Standards which were published in April 2006 and revised in 2012. In addition to this, the World Bank Group's Environmental and Social Framework includes ten Environmental and Social Standards (ESS). ESS4. Community Health and Safety addresses the health, safety, and security risks and impacts on project-affected communities. Annex 1 of ESS4 "Safety of Dams" applies to new, existing and under-construction dams.[16] For large dams the World Bank requires:

- reviews by an independent panel of experts (the Panel) of the investigation, design, and construction of the dam and the start of operations;
- preparation and implementation of detailed plans: a plan for construction supervision and quality assurance, an instrumentation plan, an operation and maintenance plan, and an emergency preparedness plan;
- prequalification of bidders during procurement and bid tendering,
- periodic safety inspections of the dam after completion.

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[14] The International Finance Corporation, Environmental, Health, and Safety General Guidelines, The World Bank Group, April 2007.

[15] Asian Development Bank (ADB), Environmental Safeguards: A Good Practice Sourcebook Draft Working Document, December 2012.

[16] The World Bank Group, The Environmental and Social Framework, March 30, 2017, < http://www.worldbank.org/en/programs/environmental-and-social-policies-for-projects/brief/the-environmental-and-social-framework-esf>, accessed May 1, 2017

2.8.2 World Commission on Dams 2000

The World Commission on Dams (WCD) established the most comprehensive guidelines for dam building. It describes an innovative framework for planning water and energy projects that is intended to protect dam-affected people and the environment, and ensure that the benefits from dams are more equitably distributed. The WCD framework covers key areas for improved planning of dams, including the need to fully assess all available options for meeting water and energy needs; addressing outstanding social issues from existing dams before building new ones, gaining public acceptance for key decisions, and the importance of protecting healthy rivers.[17] The Project is being constructed in an area with natural resources of value both in terms of ecology and socioeconomics. It is being financed by an international funding body, the ADB, therefore, international standards, guidelines and best practices need to be considered.

2.8.3 Pakistan Environmental Protection Agency

Regulation 7 of the IEE-EIA Regulations 2000 pertains to the guidelines. It states that: '(1) The Agency may issue guidelines for preparation of an IEE or EIA or an environmental checklist, including guidelines of general applicability and sectoral guidelines indicating specific assessment requirements for planning, construction and operation of projects relating to a particular sector. (2) where guidelines have been issued under sub-regulation (1), an IEE or EIA shall be prepared, to the extent practicable, in accordance therewith and the proponent shall justify in the IEE or EIA or in environmental checklist any departure therefrom.'

The relevant guidelines are the follows:

- *Policy and Procedures for Filing, Review and Approval of Environmental Assessments*, Pakistan Environmental Protection Agency, September 1997

  These guidelines define the policy context and the administrative procedures that will govern the environmental assessment process, from the project pre-feasibility stage, to the approval of the environmental report. The section on administrative procedures has been superseded by the IEE-EIA Regulations, 2000.

- *Guidelines for the Preparation and Review of Environmental Reports*, Pakistan Environmental Protection Agency, 1997

  These guidelines target the project proponents and specify:

  - The nature of the information to be included in environmental reports
  - The minimum qualifications of the EIA conductors appointed
  - The need to incorporate suitable mitigation measures at every stage of project implementation
  - The need to specify monitoring procedures.

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[17] International Rivers, The World Commission on Dams, Available at <https://www.internationalrivers.org/campaigns/the-world-commission-on-dams>, accessed April 18, 2017

The terms of reference for the reports are to be prepared by the project proponents themselves. The report must contain baseline data on the project area, detailed assessment thereof, and mitigation measures.

- *Guidelines for Public Consultation*, Pakistan Environmental Protection Agency, May, 1997

  These guidelines support the two guidelines mentioned earlier. It deals with possible approaches to public consultation and techniques for designing an effective program of consultation that reaches out to all major stakeholders and ensures the incorporation of their concerns in any impact assessment study.

- *Guidelines for Sensitive and Critical Areas*, Pakistan Environmental Protection Agency, October, 1997

  The guidelines on sensitive areas are more specific in that they identify the officially notified protected areas in Pakistan, including critical ecosystems, archeological sites, etc., and present checklists for environmental assessment procedures to be carried out inside or in the vicinity of such sites. Environmentally sensitive areas include, among others, archeological sites, biosphere reserves and natural parks, and wildlife sanctuaries and preserves. The guidelines state that the approach recommended in the document should extend to areas in the vicinity of such sensitive and critical sites, although the term 'vicinity' is not explicitly defined.

3. Project Description

This section provides a brief description of the Project. The description is based on the Feasibility Study carried out for the Project in June 2019.[1]

The Project is a run-of-river type, located on the Kunhar River in the Khyber Pakhtunkhwa (KP) province of Pakistan, in the 12 km stretch from Paras to Sangar Village. The hydel power potential available in the 20 km stretch of the river from Paras to Sangar tributary will be utilized for the Project.

The Kunhar River originates from the glaciers above Lulusar Lake in the Kaghan Valley of KP. Glaciers of Malka Parbat and Makra Peak and the waters of Saiful Muluk Lake feed the river. It passes through Jalkhand and meets Jhelum River at Rarra. The drainage area of the river is 2,535 km^2, with elevation ranging from 600 to 5,000 m.[2] It is one of the biggest tributaries of the Jhelum River Basin and the only main tributary situated entirely in Pakistan's territory. Snowmelt from the Kunhar Basin contributes 65% of the total discharge of the Kunhar River and 20-40% of the Jhelum River at Mangla.[3]

All parts of the Project are located on the left bank of the Kunhar River. The dam site (34° 39' 36.510" N, 73° 27' 1.340" E) is about 18.6 km upstream of the town of Balakot. The powerhouse (34° 36' 15.143" N, 73° 22' 49.943" E) is located 8 km upstream of Balakot, near Kappi Gali Village.

Exhibit 3.1 shows a map of the location of the Project. **Exhibit 3.2** provides the general layout of the Project.

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[1] Aqualogus, June 2019, Draft Final Report D2.2B – Feasibility Study for the 300 MW Balakot Hydropwoer Project, for the Asian Development Bank and Pakhtunkhwa Energy Development Organization

[2] Mahmood R, Jia S, Babel M. S., January 16, 2016, Potential Impacts of Climate Change on Water Resources in the Kunhar River Basin, *Water, Multidisciplinary Digital Publishing Institute*, Basel, Switzerland

[3] Ibid

Exhibit 3.1: Project Location

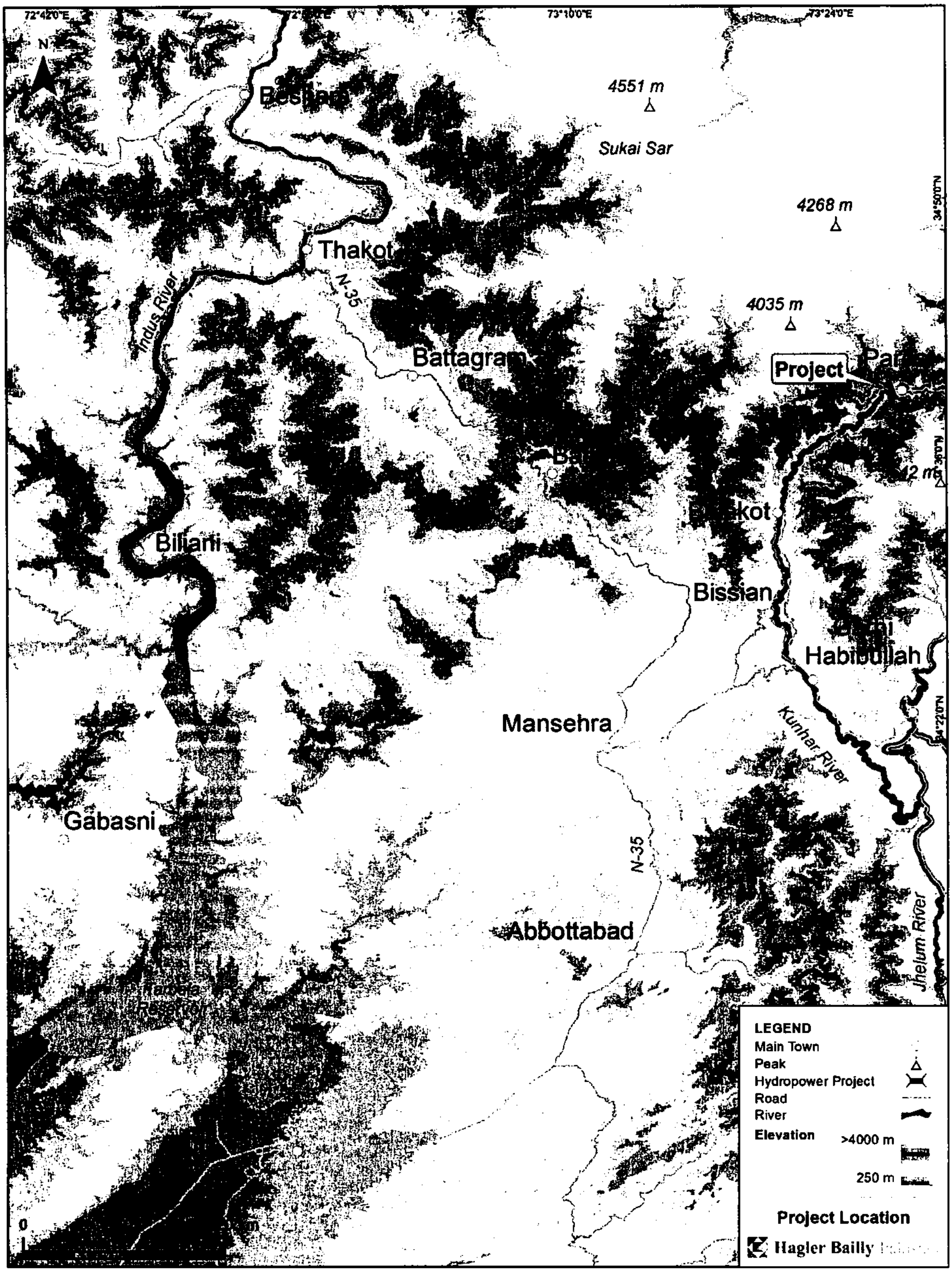
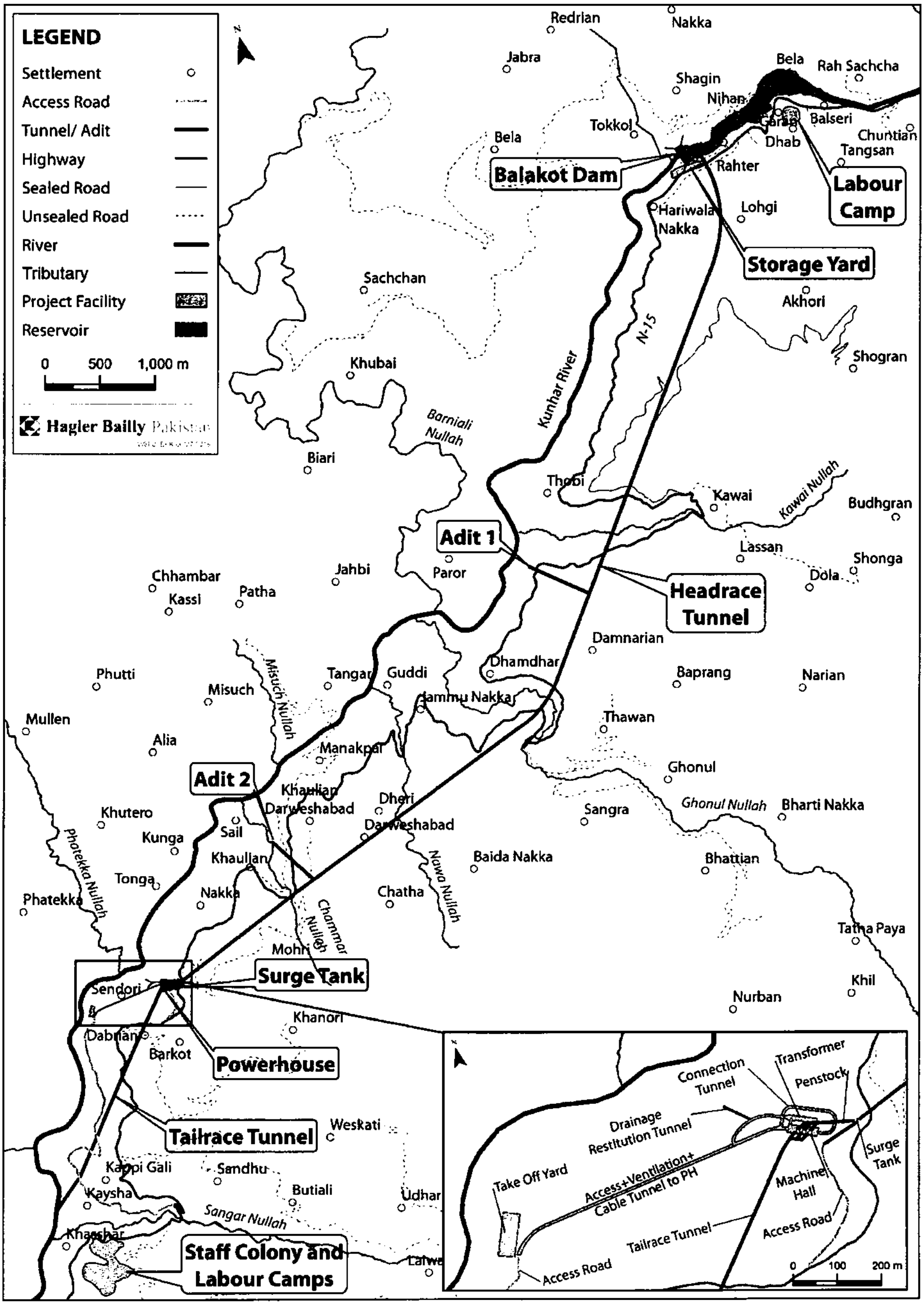


Exhibit 3.2: Project Layout



3.1 Main Component of the Project

3.1.1 The Main Dam

The dam area layout is shown in **Exhibit 3.3**. The intake is shown in **Exhibit 3.4**. The sediment bypass tunnel is shown in **Exhibit 3.5**. The layout of the powerhouse is shown in **Exhibit 3.6**. The layout of the powerhouse accesses is shown in **Exhibit 3.7.**

The main dam will be a concrete gravity dam, with a height of 35 m from the river bed, comprising low level/flushing outlets and a gated spillway. It has been designed to pass floods of 3,500 cubic meter per second (m^3/s or cumecs), with an upper gated ogee crest spillway and a low level gated spillway. This layout consists of three radial upper spillway gates having an opening of 11 meter (m) height and 10 m width as and two low level spillway sluice gates of 8 meter (m) height and 6 meter (m) width. The gates are hydraulically operated for flood discharge and are set at the crest level of 1,258 meters above sea level (masl).

The river diversion scheme consists of a left bank diversion tunnel which will be further converted to a sediment by-pass tunnel as well as additional openings in the dam body for the low-level spillway. An upstream coffer dam is also deliberated and will compromise of a concrete gravity solution with a crest elevation of 1272m which will be further converted into a guiding structure for sediment management.

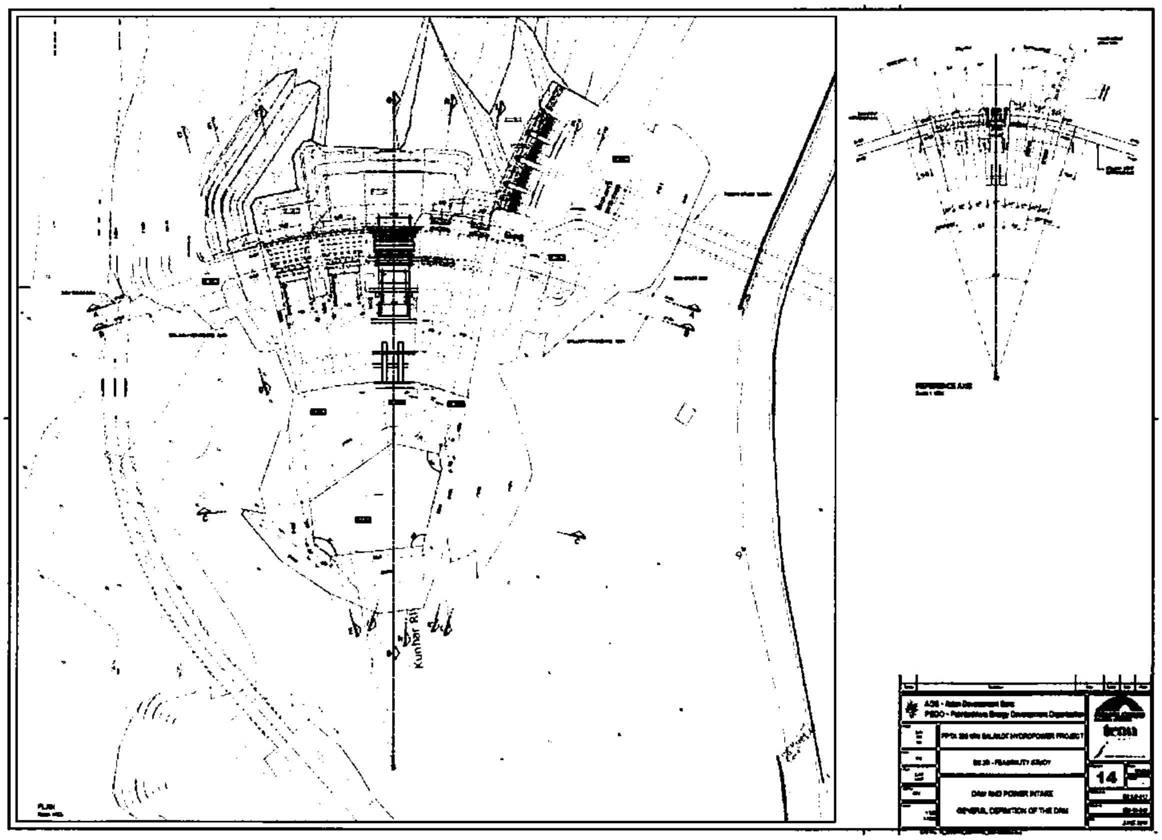
Lateral power intake structure: This will be located on the left bank of Kunhar river and will comprise 4 bays split by three vertical piers to provide a design discharge of 154 m^3/s. It will include trash racks for passing the design discharge. Two rectangular 4 m wide by 8 m high control gate equipped with upstream sealing will be provided.

Low pressure headrace tunnel: This will be a length of about 9.1 km and a diameter of 8 m.

3.1.2 Powerhouse

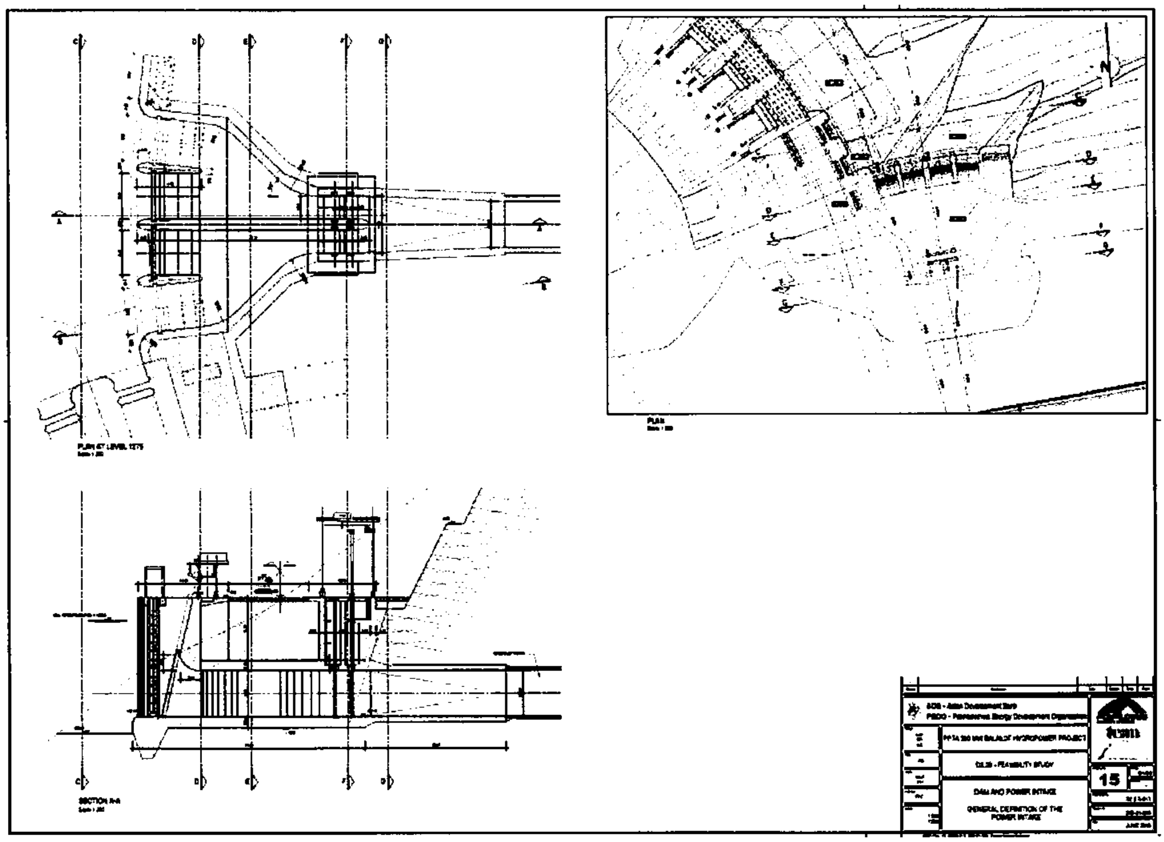
The layout of the powerhouse is shown in **Exhibit 3.6**. The transformer hall cavern will have dimensions of length 88 m, width 14 m and height 20 m. It will consist of single phase generator transformers (3 per unit, plus one spare) for a total of 10 which will be placed in a separate fire-protected enclosure. It will also consist of a transformer transfer facility through rails starting from the unloading bay to the powerhouse. Geographic Information Systems (GIS) equipment and the facility for transfer of the power cable to the cable tunnel will also be provided.

Exhibit 3.3: Dam Layout – Concrete Gravity



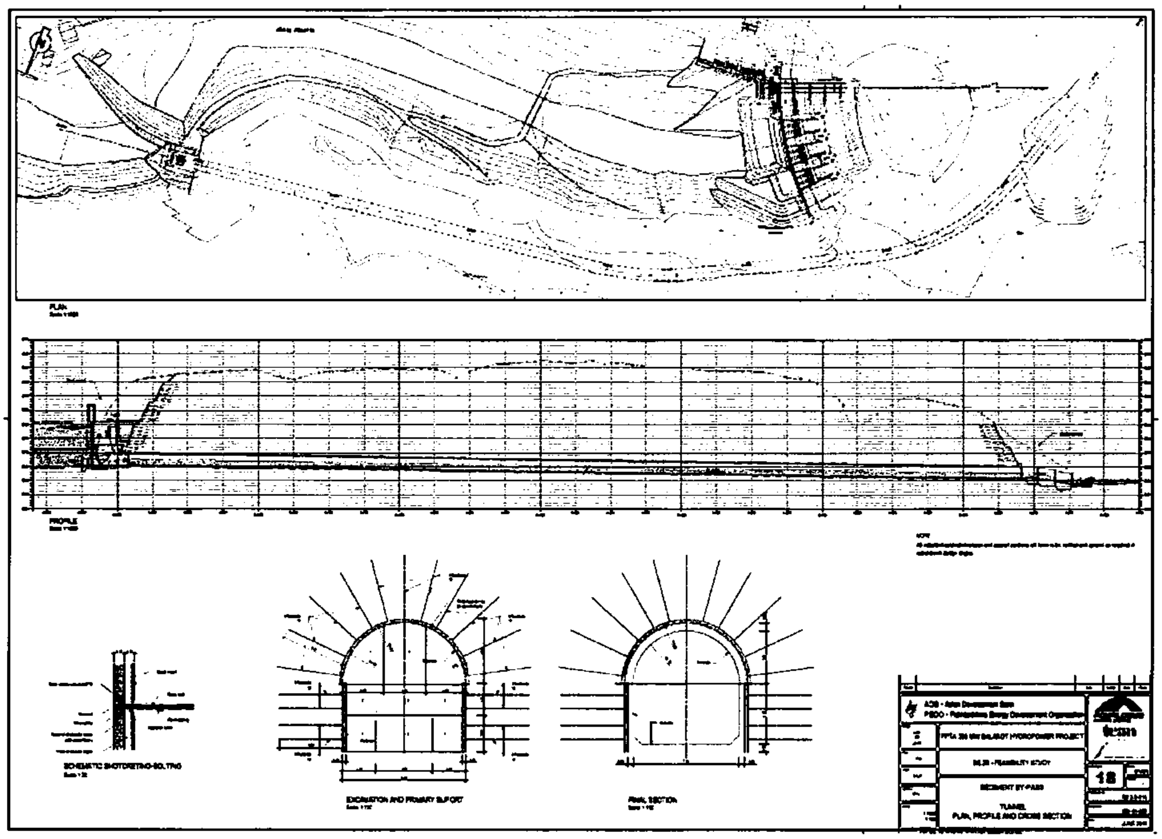
Source: Aqualogus, June 2019, Draft Final Report D2.2B – Feasibility Study for the 300 MW Balakot Hydropwoer Project, for the Asian Development Bank and Pakhtunkhwa Energy Development Organization

Exhibit 3.4: Concrete Dam – Intake



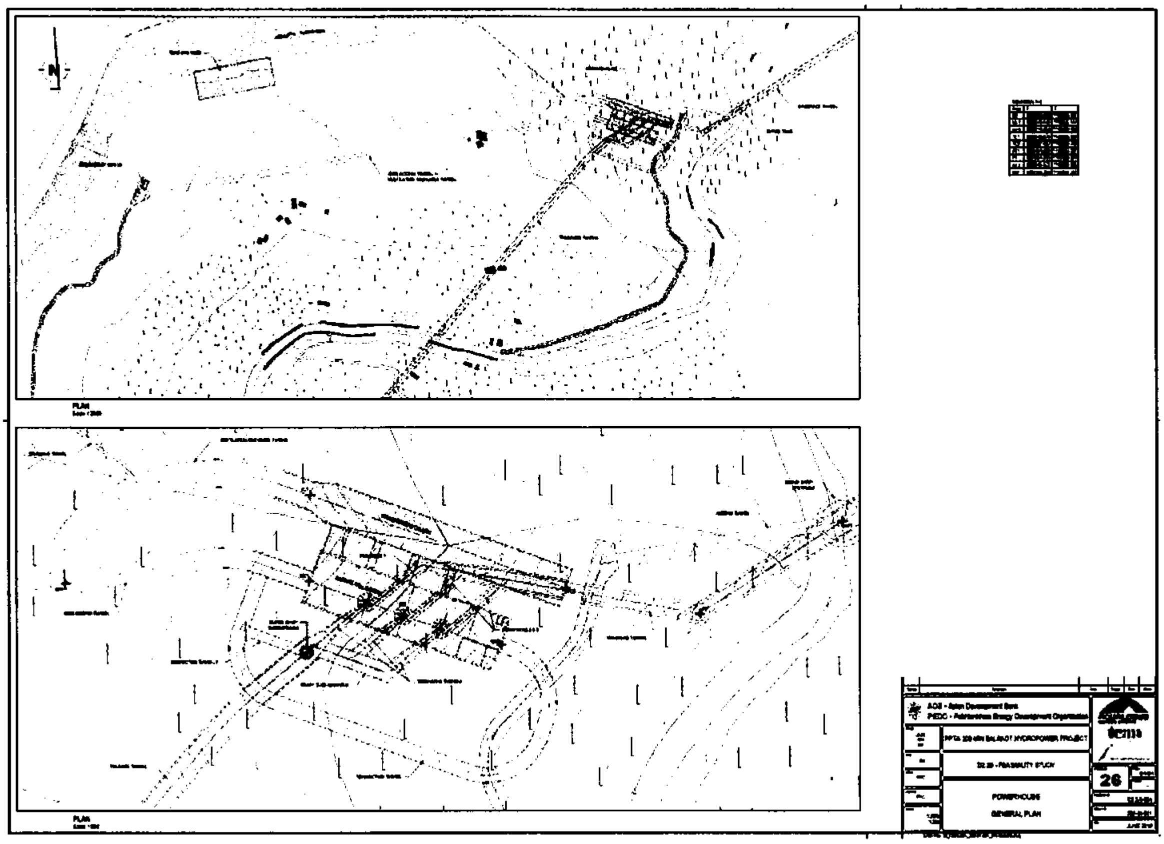
Source: Aqualogus June 2019, Draft Final Report D2.2B – Feasibility Study for the 300 MW Balakot Hydropwoer Project, for the Asian Development Bank and Pakhtunkhwa Energy Development Organization

Exhibit 3.5: Concrete Dam – Sediment Bypass Tunnel



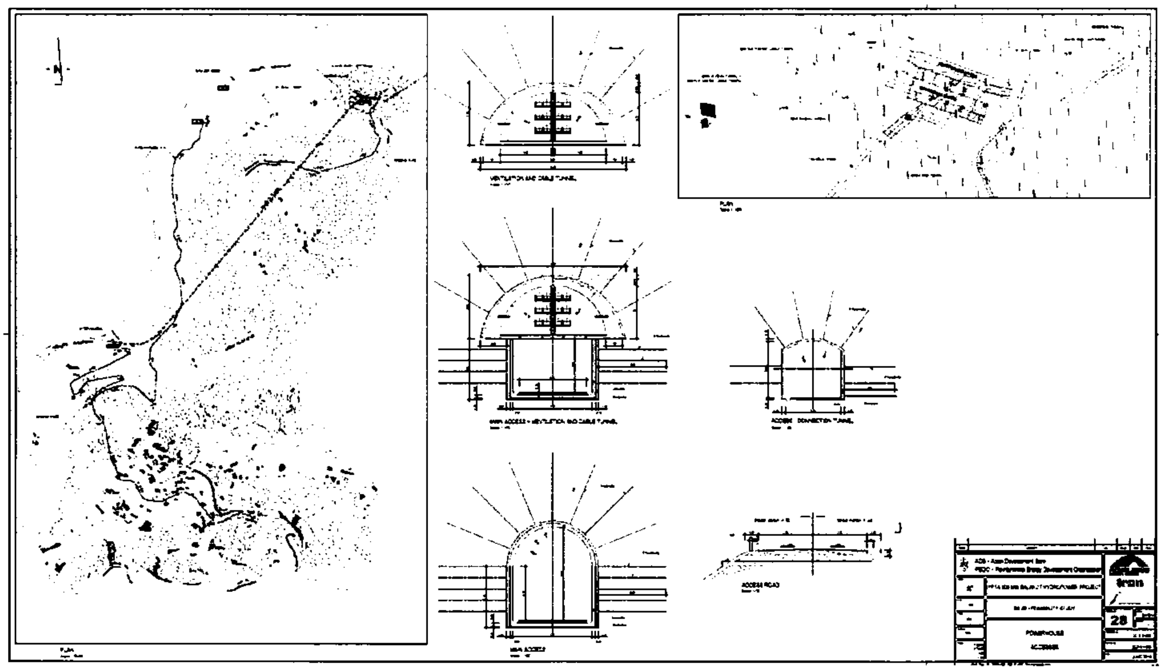
Source: Aqualogus, June 2019, Draft Final Report D2.2B – Feasibility Study for the 300 MW Balakot Hydropwoer Project, for the Asian Development Bank and Pakhtunkhwa Energy Development Organization

Exhibit 3.6: Powerhouse Area Layout



Source: Aqualogus, June 2019, Draft Final Report D2.2B – Feasibility Study for the 300 MW Balakot Hydropwoer Project, for the Asian Development Bank and Pakhtunkhwa Energy Development Organization

Exhibit 3.7: Powerhouse Accesses



An underground powerhouse has been proposed comprising the following structures:

- Underground Powerhouse Cavern
- Transformer/substation Cavern
- Single headrace tunnel
- Surge shaft, pressure shaft
- Manifolds
- Tailrace structure

The powerhouse cavern will be 71 m long, 20 m wide and 34 m high from the main inlet valve floor to the arch roof crown.

Free flow tailrace tunnel: Having a length of 1,565 m. It has a circular concrete lined tunnel with a diameter of 8 m.

Surge Tank: A circular surge tank, having a 14.5 m diameter, is proposed at the end of the low pressure headrace tunnel with a surge height of 122m.

Access Tunnel: The access tunnel is the main point of entry to the underground powerhouse complex. It is sized to accommodate two-way dump truck traffic during construction, and to provide the space needed to transport heavy equipment on low bay loaders or multi-wheeled transformers into the cavern.

3.2 Project Operation

The maximum and minimum reservoir operating levels will be 1,288 masl and 1,283 masl, respectively. The installed capacity will be 300 MW with mean annual energy output (average 55 years) of 1,143 GWh. Sediment flushing will be carried out when required with the discharge of about 100 cubic meter per second. During the low flow periods, the live storage will be used to store water during off peak hours to improve the flows for power generation in peak hours. It has been estimated that 1.2 million m^3 net storage would provide additional flows in four peak hours.

3.3 Technical Design Summary

Exhibit 3.8 provides the technical design summary. Several of these parameters are essential for the impact assessment. It is anticipated that any change in these by the Aqualogus during the updating of the FS will be communicated to HBP at the earliest. **Exhibit 3.9** shows the water levels at the dam site.

Exhibit 3.8: Salient Features of the Project Design

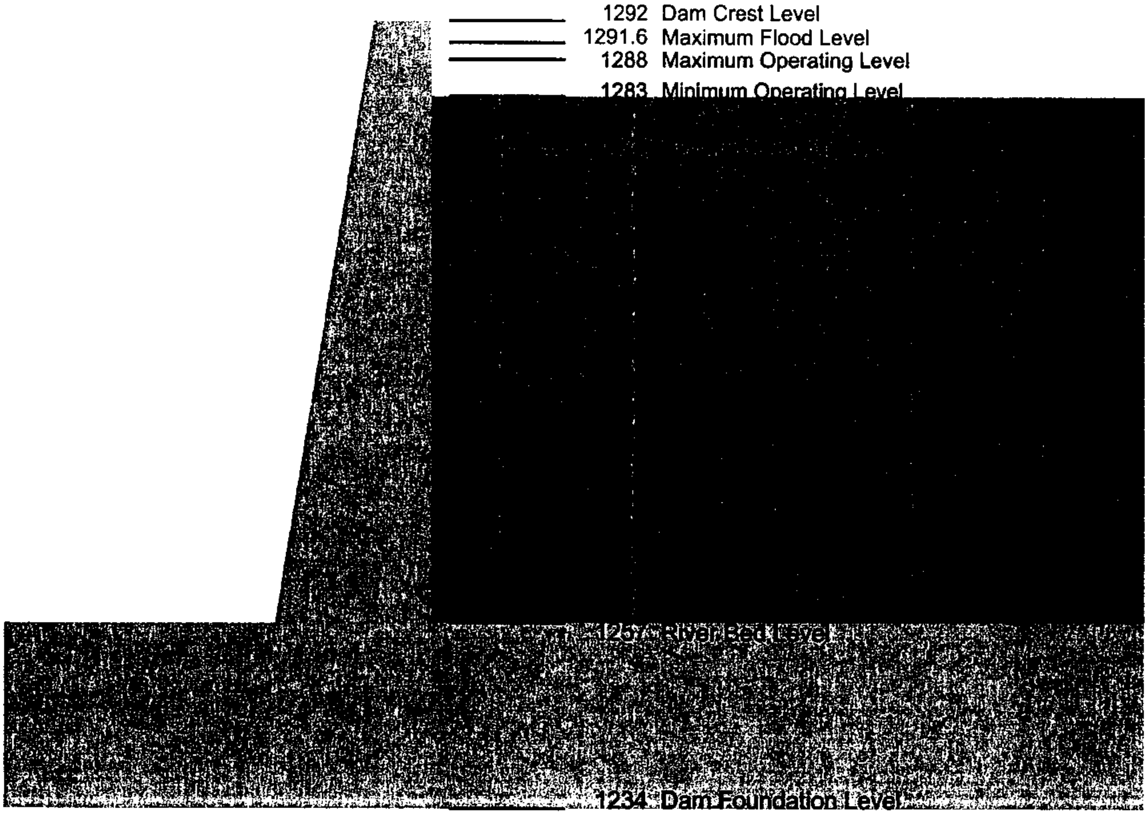
Design Aspect	*Value*
1. Hydrology and Design Flows	
River	Kunhar
Catchment area at dam site (km2)	1939
Modular flow at the intake (m3/s)	87
Design Discharge (m3/s)	154
Design Flood (m3/s) T= 10 000 years	3500
Probable Maximum Flood (m3/s)	5000
2. Reservoir	
Normal Operation Level (NOL)	1288.0
Minimum Operation Level (MinOL)	1283.0
Surface area (at NOL) (km2)	0.28
Length of Reservoir (at NOL) (km)	2.2
Gross storage capacity (at NOL) (x106 m3)	3.56
Live storage (at NOL) (x106 m3)	1.20
3. Dam Structure	
Type	Concrete Gravity Arch
Dam crest elevation (masl)	1292.0
Maximum height above river bed (m)	35.0
Maximum height above foundation (m)	58.0
Crest length (m)	130.0
4. Spillways and low-level outlets / flushing sluices	
Spillway type	Upper gated ogee crest spillway + low level gated spillway
Upper spillway crest elevation (masl)	1278.0

Design Aspect	*Value*
Upper spillway gates no. and type	3 (radial gates)
Upper spillway gates size (W x H) (m)	11 x 10
Low level spillway invert elevation (masl)	1258.0
Low level spillway gates no. and type	2 (sluice gates)
Low level spillway size (W x H) (m)	6 x 8
5. Sediment Management	
Solution	Sediment Bypass Tunnel (SBT) + flushing outlets
SBT type	Gated intake followed by archway tunnel
Intake size (W x H) (m)	7.5 x 4.5
Inlet invert elevation (masl)	1261.0
Tunnel cross section (W x H) (m)	archway (7.5 x 8.0)
Tunnel length (m)	650
Tunnel slope (%)	1.5
Outlet invert elevation (masl)	1248.0
Submerged guiding structure crest elevation (masl)	1272.0
Submerged weir/guiding structure height (m)	21 (estimated maximum above foundation)
6. River Diversion	
Construction Flood (m_3/s) (T= 20 years)	900
Diversion type	openings left in the dam body for the low-level spillway and a left bank diversion tunnel (which will be further converted to the sediment by-pass tunnel)
Upstream Coffer dam type	concrete gravity solution (which will be further converted to guiding structure)
Upstream Coffer dam crest elevation (masl)	1272.0
Downstream Coffer dam type	concrete gravity solution
Downstream Coffer dam crest elevation (masl)	1252.5
Diversion tunnel type	Archway (concrete lined)
Diversion tunnel no. (-)	1
Diversion tunnel size (W x H) (m)	archway (7.5 x 8.0)
Diversion tunnel length (m)	650
Diversion tunnel slope (%)	1.5
Diversion tunnel inlet invert El. (masl)	1261.0
Diversion tunnel outlet invert El. (masl)	1248.0

Design Aspect	*Value*
7. Power intake structure	
Intake type	Horizontal intake
Trash rack no.	4
Trash rack size (W x H) (m)	8 x 10
Service gates no.	2
Service gates size (W x H)	4 x 8 m
Intake crest elevation (masl).	1271.0
8. Headrace tunnel	
Tunnel section	Circular concrete lined (8.0 m inner diameter)
Length up to surge tank (m)	9137
Tunnel slope (%)	0.56%
9. Upstream surge shaft	
Type	concrete lined circular surge shaft
Internal diameter (m)	14.5
Surge shaft height (m)	122
Surge shaft bottom elevation (masl)	1220.0
10. Pressure tunnel/shaft and penstock	
Pressure tunnel/shaft main section type and size	Steel lined circular cross section (5.6 m internal diameter)
Pressure tunnel/shaft length (m)	152
Penstock length (m)	88
Branch Section Type	Manifold (3 branches)
Size of each branch (m)	3.2 m internal diameter conduits
Max. Length of branch (m)	□30
Pressure tunnel/shaft main section type and size	Steel lined circular cross section (5.6 m internal diameter)
11. Powerhouse and substation	
Powerhouse type	conventional underground cavern
Main cavern general dimensions (LxWxH) (m)	71 x 20 x 34
Turbine type	Francis
No. of units	3
Turbine axis elevation (masl)	1054.0
No. of generators	3
Transformer / Substation type	Underground cavern (adjacent to the main powerhouse cavern)

Design Aspect	*Value*
Transformer cavern general dimensions (LxWxH) (m)	88 x 14 x 20
12. Downstream surge shaft	
Type	concrete lined circular surge shaft
Internal diameter (m)	3.0
Surge shaft height (m)	244
Surge shaft bottom elevation (masl)	1055.0
13. Tailrace	
Type	Circular tunnel with transition to an archway section at the final length and Outlet portal
Tunnel section	Circular concrete lined (8.0 m diameter)
Length up to the final transition section (m)	1515
Tunnel slope up to the transition section (%)	0.23% (ascending slope)
Tunnel final section	Archway concrete lined section (8.0 W x 8.0 H)
Length from transition to outlet (m)	50
Tunnel slope up to the outlet portal (%)	15% (ascending slope)
14. Power and Energy	
Gross Head (m)	229.0
Design Net Head (m)	217.6
Installed plant capacity (MW)	300 (at the generator)
Average annual energy (GWh)	1143 (average of 55 years)
15. Project access facilities	
Access road to dam and related structures (length)	550 m (from Sharan Road, connection to National Highway N–15 at the left side of Kunhar River, nearby Paras village)
Access road to sediment by-pass tunnel (length)	440 m (from the dam bridge deck up to the sediment by-pass tunnel intake)

Exhibit 3.9: Water and Dam Levels of Project Dam



3.4 Project Requirements

3.4.1 Materials

Materials required to carry out the construction of civil works for the Project include concrete aggregate, cement, pozzolans, various types of fill materials, construction chemicals, steel products etc.

Borrow material is expected to be insignificant. The quanitity of quarry material is estimated at approximately 250,000 m^3. Sources of quarry material will be defined at a later stage, however, areas near Paras (for gravel), Naran, Kaghan and Garhi Habibullah (for sand) have been identified.

3.4.2 Water

A considerable quantity of water will be required during the construction of the Project for mixing/curing of concrete and for washing of aggregate etc. The Kunhar River at the dam site and powerhouse site will be the main sources of water that could be used during the construction of the Project. The water shall be readily available throughout the year. Other sources of water in the Project area are the perennial tributaries/nullahs and natural springs, which are mainly used for drinking and irrigation purposes.

3.4.3 Land Requirement

The total land requirement is 32.8 hectare (ha). Out of total 32.8 ha of required land 3.05 ha will be required for staff colony, 3.05 ha will be required for 2 construction camps, 1.32 ha will be required for access roads and 23.36 ha will be required for reservoir and dam.

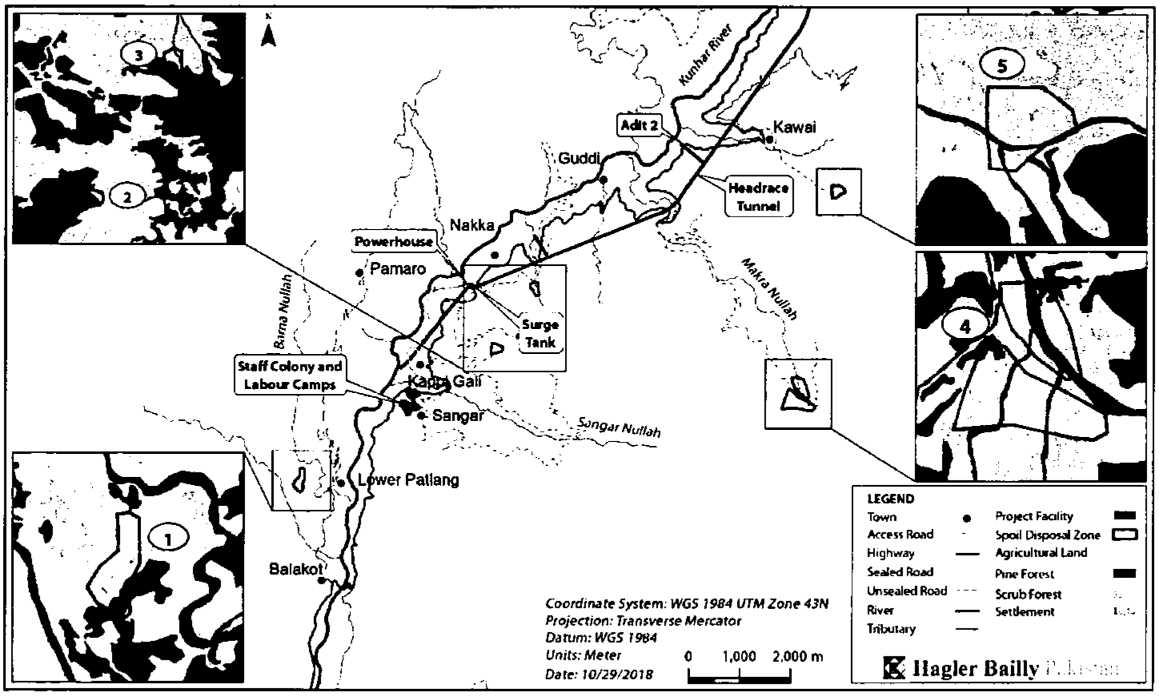
3.4.4 Spoil Disposal

Due to steep topography, exceeding excavation material will have to be placed in smaller kathas and high mountain areas. This will be a significant challenge, as the potential suitable zones are minimal. **Exhibit 3.10** provides a preliminary identification of possible zones which will be confirmed at a later stage.

Approximately 1.1 x 10^6 m^3 of spoil material will be generated. Based on current assessment this material cannot be used for construction.

Design of spoil areas will be done at a later stage as part of site specific conditions including orography, geology, permeability, hydrology etc.

Exhibit 3.10: Spoil Disposal Zones

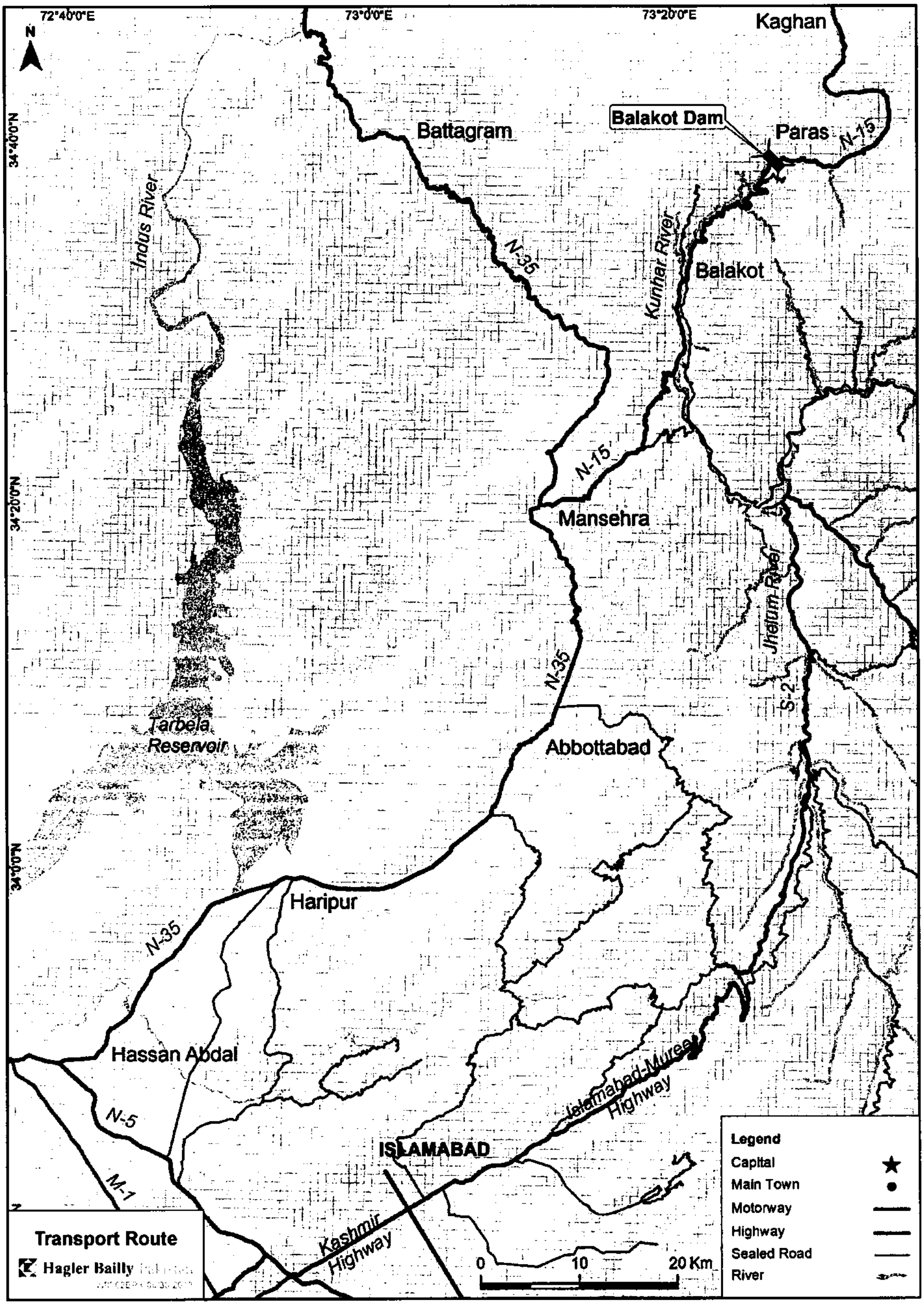


3.5 Access

The main access to the Kaghan Valley from areas south of Balakot is through Abbottabad and Mansehra. Dam and powerhouse sites are accessible from Balakot town from the Balakot-Jalkhad Road. The road is constructed at a gentle gradient and is metaled throughout the way up to Jalkhad.

Exhibit 3.11 shows the access route from the port city of Karachi to the Project Area.

Exhibit 3.11: Access Route



3.6 Regional Hydropower Developments

The Kunhar River is a tributary of the Jhelum River. A number of hydropower projects have been planned or are under construction in the Jhelum Basin, of which five are located on the Kunhar River. None of the projects are currently operational. **Exhibit 3.12** shows a list of these hydropower projects. **Exhibit 3.14** shows the cascade of projects on a map.

Exhibit 3.12: Hydropower Projects Planned or Under Construction on the Kunhar River

No.	*Project Name*	*Capacity (MW)*	*Dam Height (m)*	*Planned/Under Construction*
1.	Batakundi HPP	96	58	Planned
2.	Naran HPP	188	74	Planned
3.	Suki Kinari HPP	870	55	Under construction
4.	Balakot HPP or BHDP	310	45	Planned
5.	Patrind HPP	147	44	In operation
	Total	**1,601**		

3.7 Associated Facilities

The transmission line to be constructed by NTDC to evacuate power from the proposed Project falls in the category of associated facility. Total length of the transmission line will be 720 m and it will connect switch yard of BHDP to the Sukki Kinari – Maira transmission line.[4] **Exhibit 3.13** shows a schematic diagram of the proposed transmission line. To achieve environmental or social outcomes consistent with the ADB SPS, it is essential that NTDC undertake the environmental assessment of the transmission line and develop a sound ESMS consistent with the national and provincial legal environmental requirements as well as that of the ADB SPS. The scope of Consultant's assignment does not include the evaluation of the design, construction, and operation of the transmission line for evacuation of the power produced by the Project, however, recognizing the potential impacts and risks associated with the transmission line, measures to ensure that a full environmental and social assessment of the transmission line is undertaken, the EMP of this Project has identified and defined a set of management measures to be taken in the contractual arrangement with NTDC.

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[4] Associated facilities are not funded as part of the project (funding may be provided separately by the borrower/client or by third parties), and whose viability and existence depend exclusively on the project and whose goods or services are essential for successful operation of the project.

Exhibit 3.13: Schematic of Transmission Line

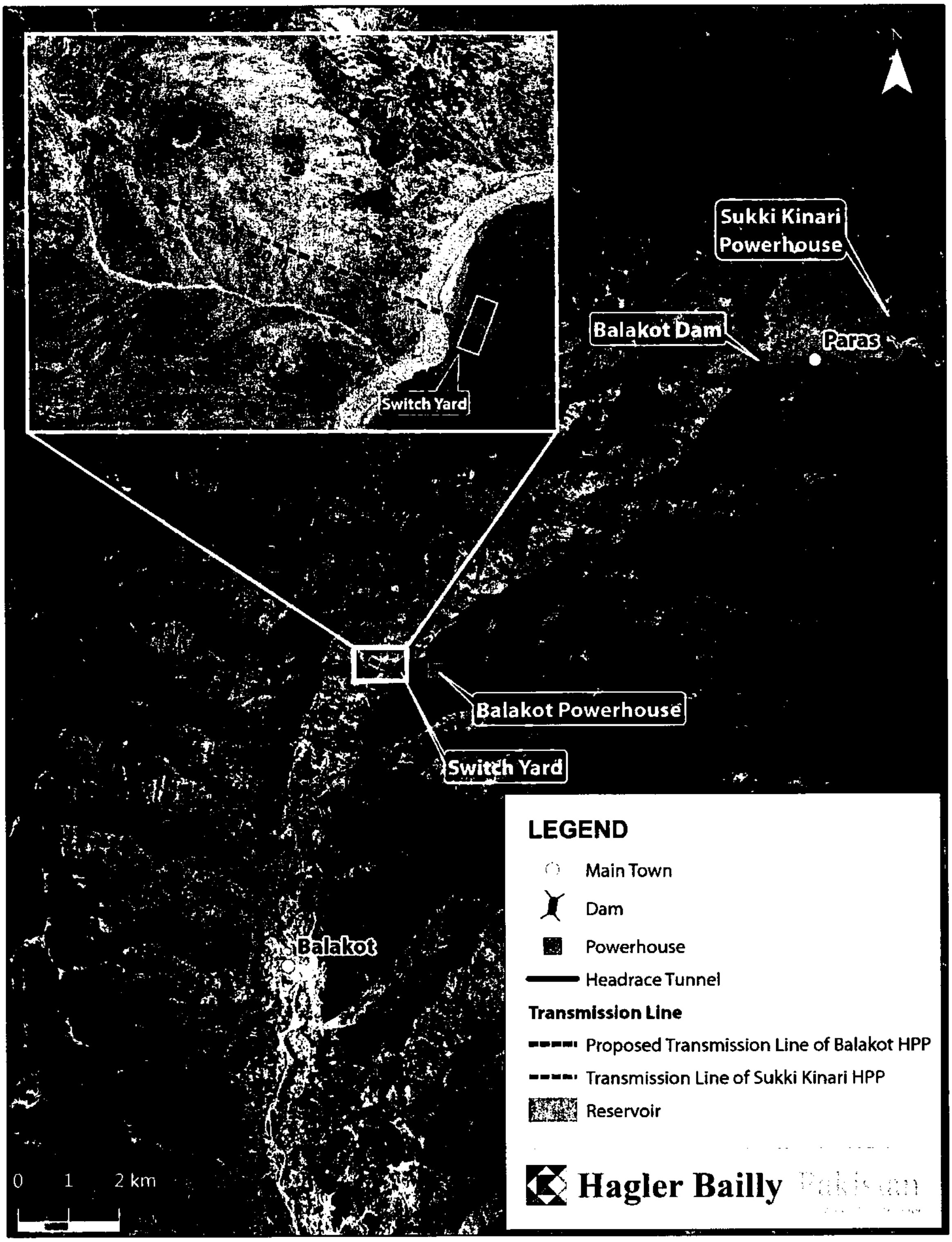
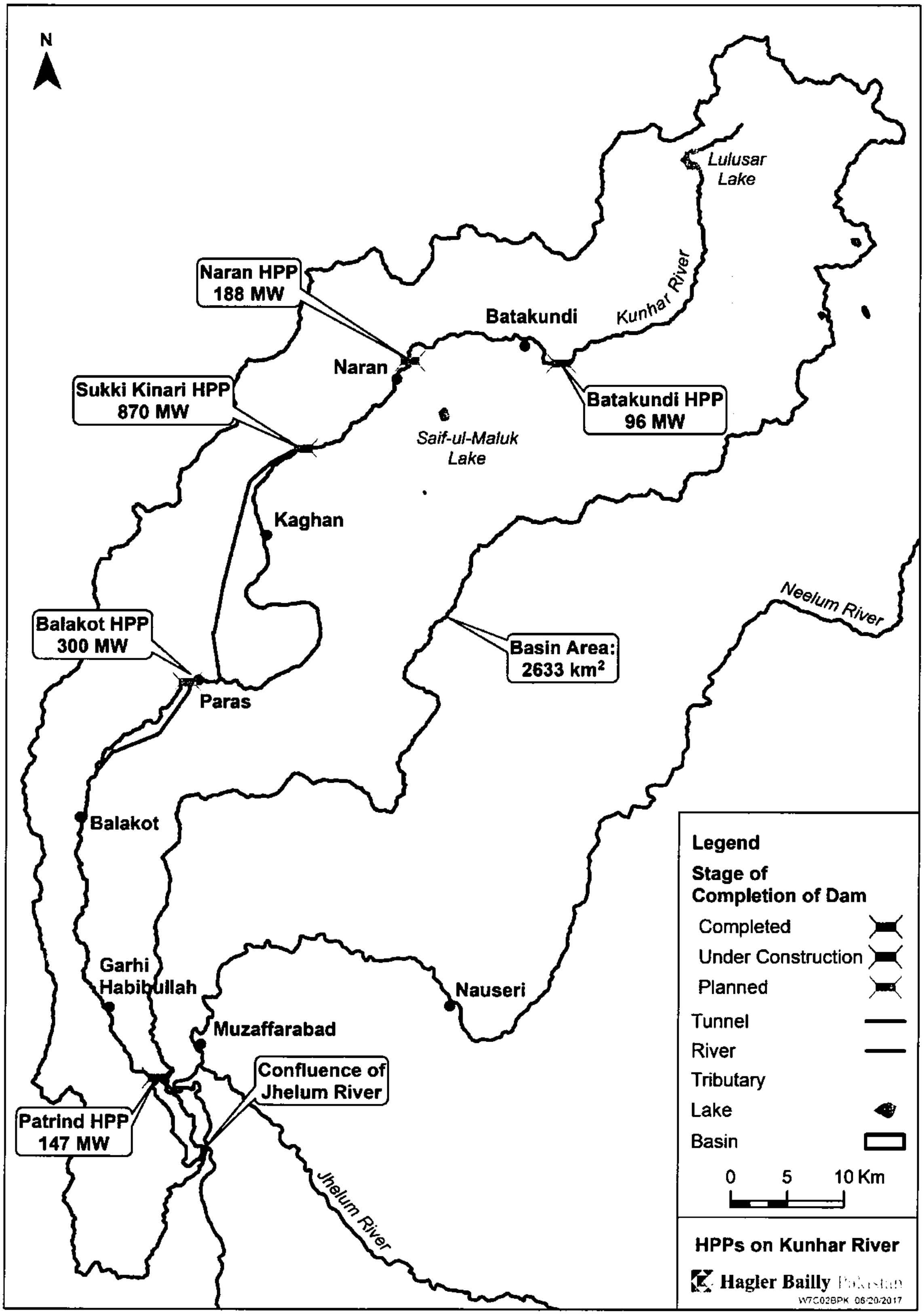


Exhibit 3.14: Hydropower Projects Planned or Under Construction on the Kunhar River



4. Description of the Environment

4.1 Physical Environment

The physical baseline includes a description of the topography, land use, geomorphology, visual character, climate, air quality, sound levels, and water resources of the Study Area.

4.1.1 Scope and Methodology

The specific tasks covered under the physical baseline study included:

- Review of the available literature on the physical environment of the Study Area.
- Analysis of secondary information to characterize baselines, particularly topography, land-use and climate.
- Field surveys for characterization of Study Area - specifically:
    - Soil quality
    - Visual character
    - Water resources (including water quality sampling and hydro census of community springs)
    - Air quality
    - Traffic levels
    - Noise levels

Where relevant baseline data is compared to the NEQS and where relevant, other standards, including the IFC-EHS Guidelines, that are applicable to the Project. The physical environment survey plan is included as **Appendix B**.

4.1.2 Topography

The Kunhar River flows at a high altitude, with most (59%) of its catchment above 3,000 meters above mean sea level (m amsl), through narrow steep gorges for much of its length. The relief in the catchment of the Project dam varies from 629 m amsl to 5,199 m amsl. The dam site is at an elevation of 1,257 m amsl and the powerhouse site at an elevation of 1,316 m amsl. A comparison of the distribution by elevation in the catchment of the Kunhar River and the catchment of the proposed Project dam is given in **Exhibit 4.1** and topography of the area mapped in **Exhibit 4.2.**

4.1.3 Land Use

Land use distribution is shown in **Exhibit 4.3**. Land use in the Study Area (see **Section 4.1.3**) is tabulated in **Exhibit 4.4** and graphed in **Exhibit 4.5**. Photographs of major land uses are given in **Exhibit 4.6**. An example of the classification method is shown in **Exhibit 4.7.** A brief discussion of the land use categories found in the Study Area is given below.

- Agricultural fields are mostly terraced, and used to grow crops such as wheat, maize and rice. Fruit trees are also common. It is the second most dominant land use covering 26% of the Study Area. The extent of agriculture expands downstream as the valley widens with 43% of Zone 5 under agriculture, compared to only 12% of Zone 2.
- Settlements include built-up area such as homes and shops. Homes are often in the middle of agricultural fields. Balakot town is the defining feature of Zone 4 where the settlement accounts for the largest land use category at 37%. Settlements make up 10% or less of the land use in the other zones.
- Water bodies such as rivers are used for fishing and for extraction of sand and gravel. The Kunhar River is very narrow in Zones 1 to 3 accounting for between 2% to 5% of the land cover. It widens in Zones 4 and 5 where its land cover increases to 11% and 14%, respectively.
- Pine forests make a significant portion of Zones 1 to 3 ranging from 22% to 29%. Pine forests account for only 6% and 8% of Zones 4 and 5, respectively.
- Scrub forests are is the most widely spread land use, covering 40% of the Study Area.

Exhibit 4.1: Catchment Elevation Distribution

Elevation Band (m amsl)	*Kunhar River Catchment*	*Project Dam Catchment*
<1000	3%	0%
1000-1999	16%	3%
2000 - 2999	21%	19%
3000 - 3999	34%	44%
4000 - 4999	25%	34%
5000+	0.02%	0.03%
Min	629	1,245
Max	5,199	5,199
Average	2,907	3,210

Exhibit 4.2: Topography of the Kunhar River Basin

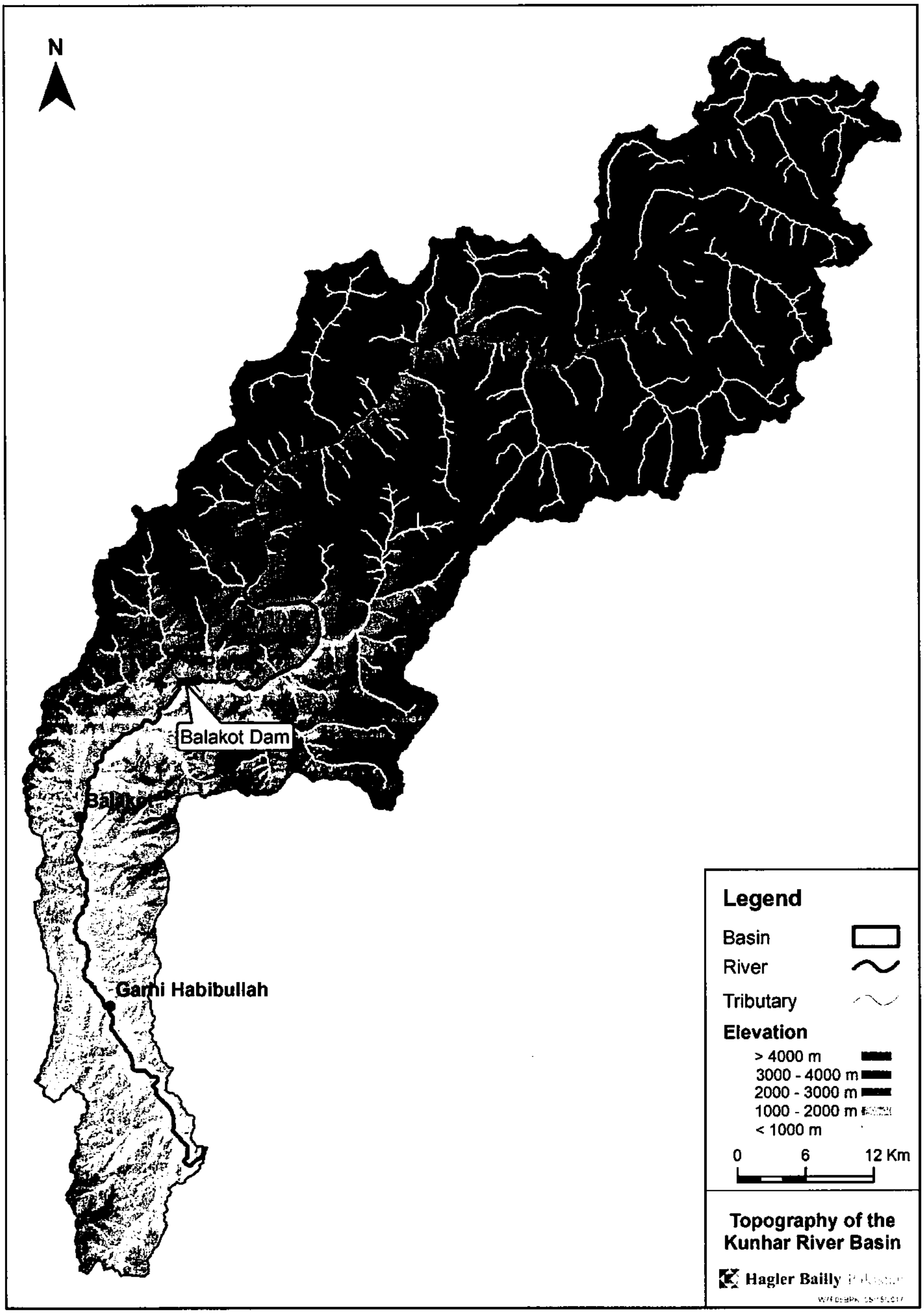


Exhibit 4.3: Land Use Distribution in the Study Area

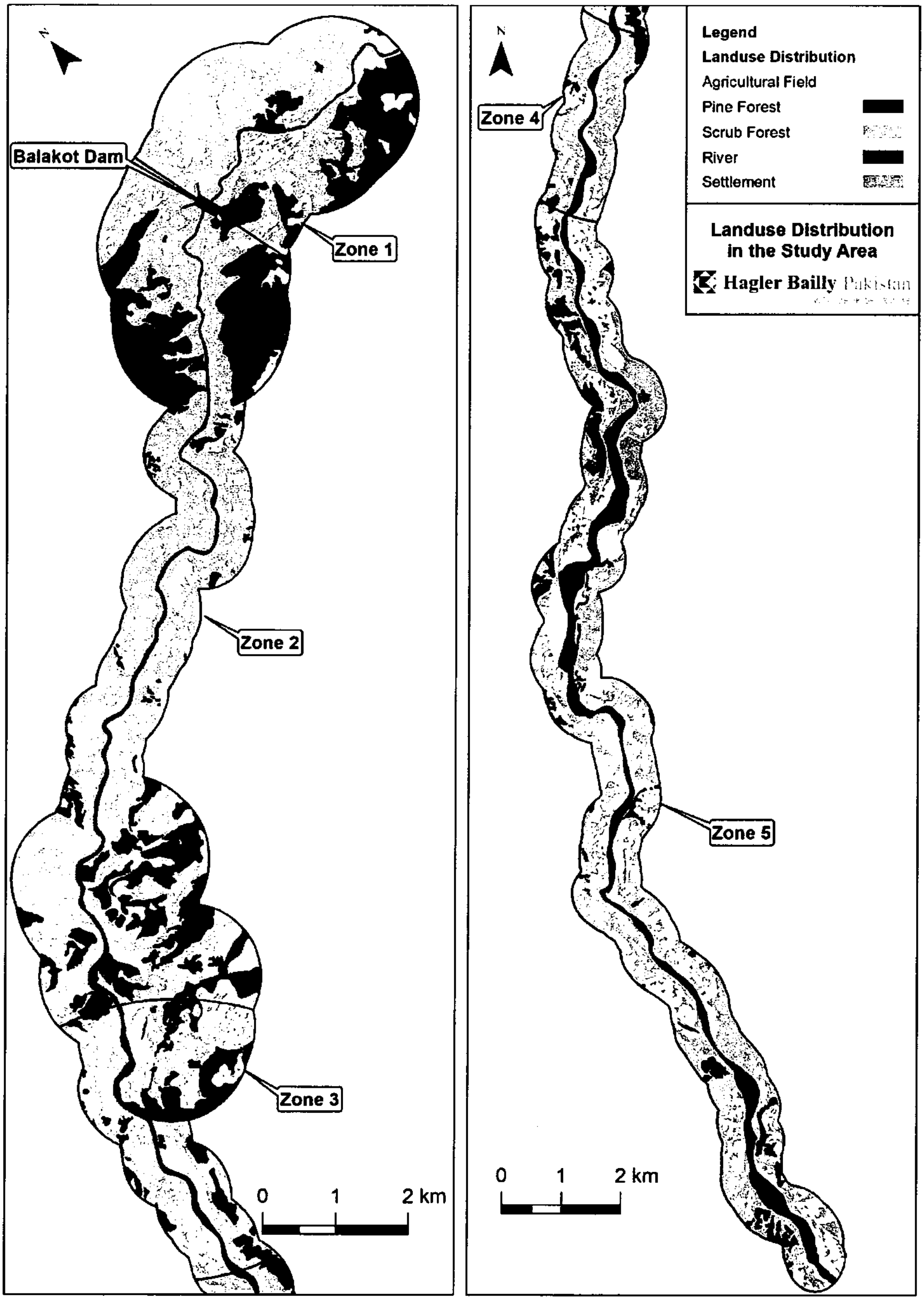


Exhibit 4.4: Land Use in the Study Area (km^2)

	Pine Forests	*Scrub Forests*	*Agricultural Fields*	*Settlements*	*Water Bodies*	***Total Area***
Zone 1	1.98	4.45	1.25	0.40	0.15	8.24
Zone 2	5.99	11.39	2.62	0.39	0.61	21.00
Zone 3	1.36	2.27	1.83	0.43	0.33	6.21
Zone 4	0.22	0.68	0.90	1.27	0.38	3.45
Zone 5	1.73	5.30	9.37	2.05	3.09	21.54
Study Area (Total)	**11.29**	**24.08**	**15.97**	**4.54**	**4.57**	**60.45**
Study Area (Percentage)	**19%**	**40%**	**26%**	**8%**	**8%**	**100%**

Exhibit 4.5: Land Use in the Study Area (%)

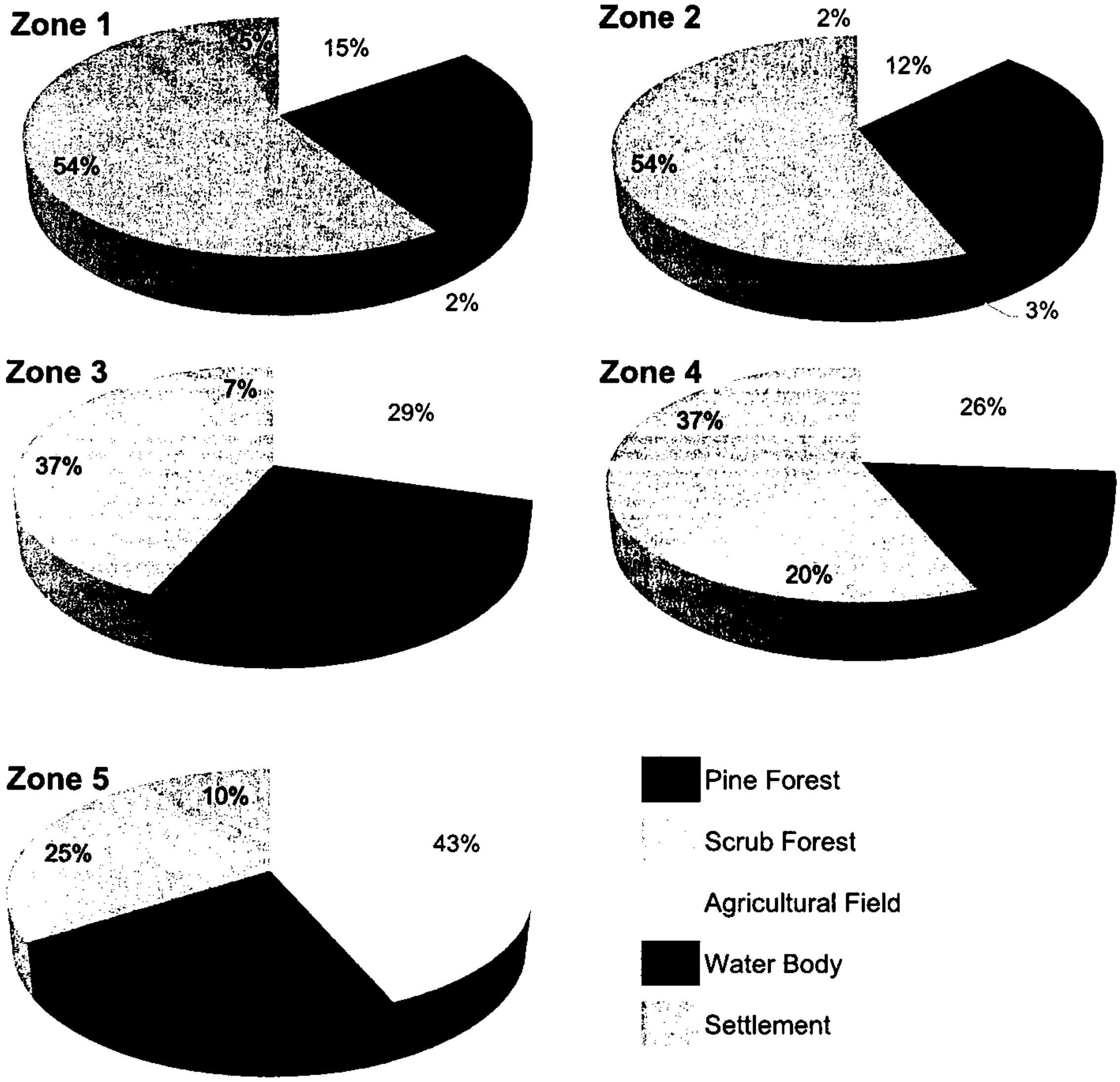
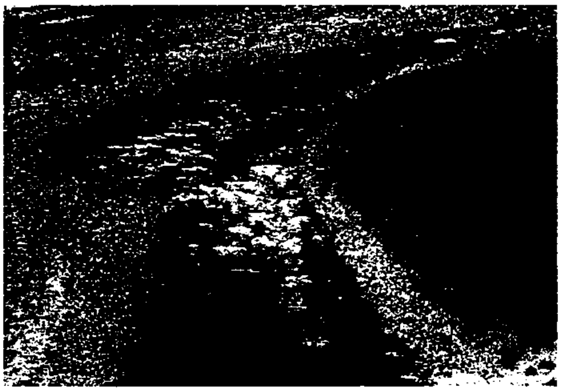


Exhibit 4.6: Photographs of Major Land Uses in the Study Area

Terraced agricultural fields at Dhamdar village

Terraced agricultural fields at Jalora village

Built up area next to the Kunhar River

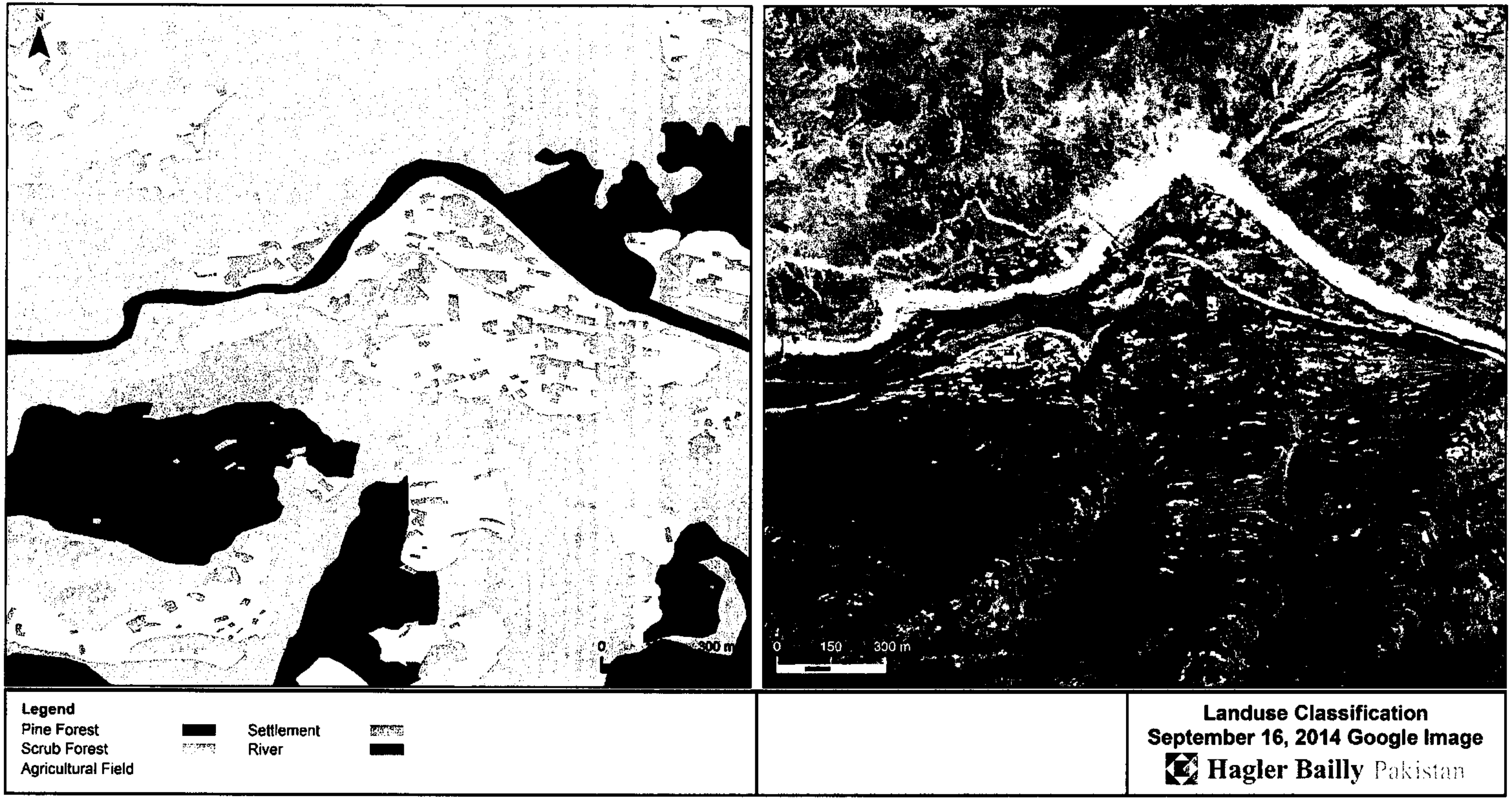


Kunhar River near Bissian village

Pine forest near Project dam site

Scrub forest near Project dam site

Exhibit 4.7: Land Use Classification Example



4.1.4 Geology, Soils and Seismic Hazards

This section largely summarizes information from the Feasibility Study, and supplemented with additional literature reviews.

Tectonics

The Project lies along a major and active continental margin, at the confluence of Eurasian and Indian Plates that has resulted in the Himalayan orogeny. The Project area has been affected considerably by tectonics which has produced some prominent faults like the Main Boundary Thrust (MBT), the Panjal Thrust[1], and the Himalayan Frontal Thrust[2] (HFT). MBT passes along the right bank of the Kunhar River, while the powerhouse area and headrace tunnel run parallel on the left bank. This fault is about 2.4 km west of Kunhar River at the dam site. The maximum distance of headrace tunnel from MBT is about 4.64 km. It continues in a southern direction through the rock formation some 2 km away from the powerhouse site. Major tectonic faults are shown in **Exhibit 4.8**.

Being part of the seismically active Himalayas, all the regional faults in the vicinity of the Project dam, have potential for generating future earthquakes at the Project site. However, the Muzaffarabad Thrust, of Holocene age, and its northwest continuation as Indus-Kohistan seismic zone is a proven active seismic zone, which not only generated 2005 earthquake (of magnitude 7.6), but also the 1974 Patan earthquake, 1906 Kangra earthquake, and 1555 Srinagar earthquake. Since this active fault is a northwest (NW) - southeast (SE) oriented thrust fault that dips at an angle of ~30° towards the NW, the epicenters of earthquakes associated with this fault are located along a linear belt extending from Allai-Kohistan through Paras (the Project reservoir site), and then further into Kashmir. This implies that regional geology and tectonics associated with this regional boundary fault is the controlling factor in seismic vulnerability of the any man-made structures in the Kaghan and Neelum Valleys.

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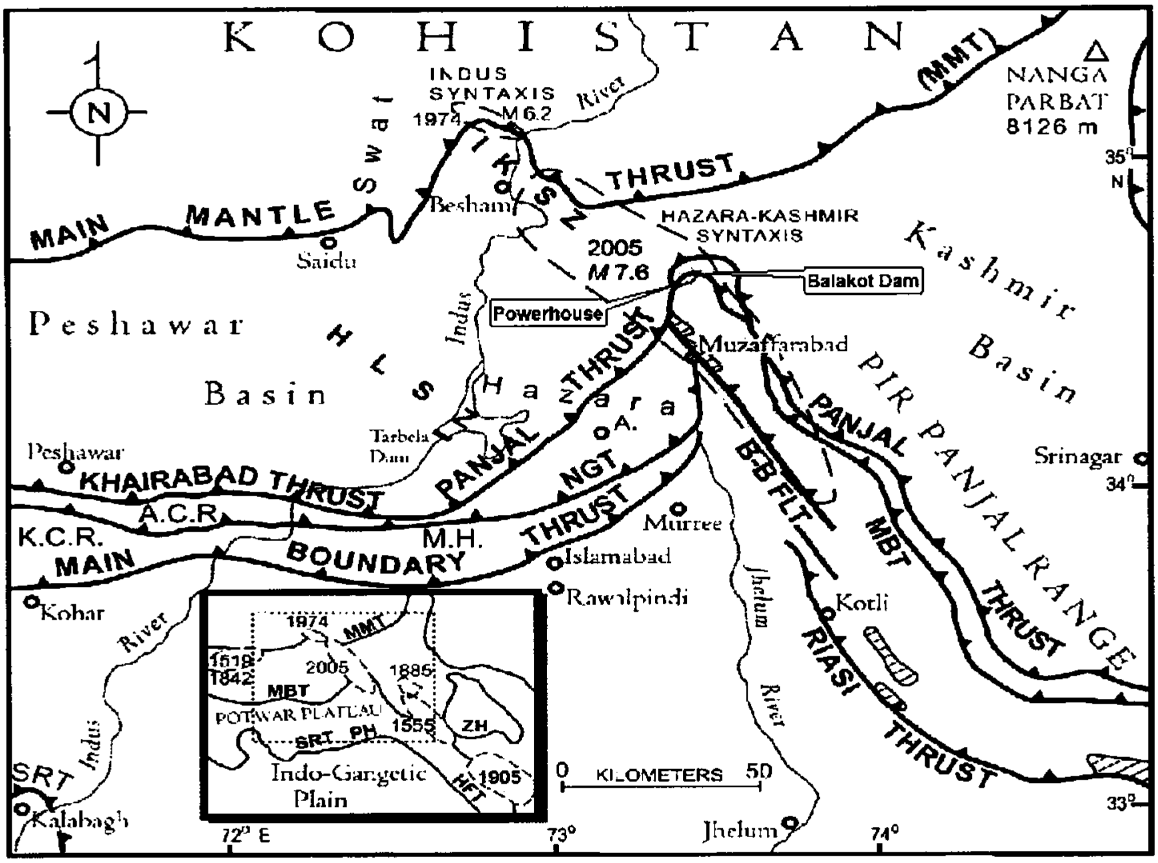
[1] In some literature, sections of the Panjal Thrust are synonymous with the Main Central Thrust (e.g. see Robert Yeats, Active Faults of the World, 2012, Cambridge University Press)

[2] This is considered part, or synonymous with the Muzaffarabad Thrust depending on the literature and synonymous with the Balakot-Bagh Frontal Thrust

Exhibit 4.8: Major Tectonic Faults in Relation to Dam and Powerhouse



Source: Hussain, Ahmad, Robert Yeats, and MonaLisa. "Geological setting of the 8 October 2005 earthquake." Journal of Seismology 13.3 (2009): 315-325; Notes: A.C.R., Attock–Cherat Range; K.C.R., Kala Chitta Range; M.H., Margalla Hills; B-B FLT, Balakot–Bagh fault; IKSZ, Indus Kohistan Seismic Zone; HLSZ, Hazara–Lower Seismic Zone; NGT, Nathia Gali thrust; HFT, Himalayan Front thrust; SRT, Salt Range thrust; PH, Pabbi Hills; A, Abbottabad; ZH, Zanskar Himalaya; diagonal pattern: Precambrian limestone inliers. Shaded pattern, meizoseismal zones of earthquakes with dates give; shading in main map shows the 2005 earthquake.

Earthquakes and Seismicity

Earthquakes occur very frequently in the Project area, which is within a highly seismically active area. Several regional faults, which are some of the most active faults in the Himalayas, pass through the close vicinity of the Project site. The area is known for recent seismic events including 2004 Paras Earthquake of magnitude 5.2 and 2005 Earthquake of magnitude 7.6, which is discussed further below.

In October 2005, an earthquake of magnitude 7.6 occurred along the Muzaffarabad Thrust. This formed a surface rupture zone approximately 80 km long with an average co-seismic vertical displacement of approximately 2.8 m.[3] The Riasi Thrust has been loaded due to the earthquake and possesses conditions for a strong earthquake of magnitude over 7 to occur, in addition to other faults including the Panjal Thrust, Nathia Gali Thrust, Murree Thrust and Jhelum Fault.

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[3] Ibid.

Due to the complex seismotectonic setting described above, it was considered necessary in the Feasibility Study, 2013 to conduct a critical evaluation of seismic hazards to quantitatively determine the level of seismic hazards the proposed Project may exposed to. The guidelines of the International Commission on Large Dams [ICOLD, 1989; modified 2010] require both deterministic and probabilistic seismic hazard analyses, which result in characterization of the design ground motions for different elements of the hydropower project.

- **Deterministic Seismic Hazard Analysis (DSHA):** DSHA involves selection of a seismic source with maximum magnitude potential and minimum distance from the site of interest. Hazards are computed in terms of maximum horizontal peak-ground acceleration (PGA) using a set of selected ground-motion prediction equations. The Feasibility Study, 2013 used, two next generation attenuation equations (Boore and Atkinson, 2008 and Akkar and Bommer, 2010) for computation of seismic hazards.
- **Probabilistic Seismic Hazard Analysis (PSHA):** PSHA primarily refers to a model for seismic hazard computations originally developed by Cornell (1968) and McGuire (1976) popularly termed Cornell–McGuire model (Klügel, 2008). The goal of PSHA is to quantify the rate (or probability) of exceeding various ground-motion levels at a site (or a map of sites) given all possible earthquakes.

Exhibit 4.9 shows a summary of the results of the above studies and the reported values briefly described below:

- The controlling Maximum Credible Earthquake (MCE) is the largest reasonably conceivable earthquake that appears possible along a recognized fault or within a geographically defined tectonic province, under the specific tectonic framework governing the region of interest. Inelastic behavior with associated damages and cracking is permissible under the MCE provided the water retaining integrity of the main dam body is retained. According to ICOLD (2010), MCE is estimated based on DSHA earthquake scenarios. The ground motion parameters of the MCE are taken as the 84 percentile.
- The maximum design earthquake (MDE) is the maximum level of ground motion for which a structure is designed. According to ICOLD (2010) guidelines, the MDE ground motion parameters are estimated based on PSHA, using the mean values of the ground motion parameters.
- According to ICOLD (2010) guidelines, the dam shall be capable of resisting the controlling Operation Basis Earthquake (OBE) within the elastic range, remain operational, and not require extensive repairs. All structural components, which are part of or built within the main dam body, will be designed to remain functional during and after an OBE event. The OBE is best determined by using PSHA. OBE ground motions are significantly lower than those for MCE and MDE and has return periods between 145-275 years, depending upon the local seismic conditions.

Exhibit 4.9: Summary of Seismic Design Criteria (PGA in g)

Criteria	*Return Period*	*Value (PGA in g)*	
		Dam Site	*Powerhouse Site*
Operation Basis Earthquake (OBE)	150	0.26	0.27
	475	0.37	0.38
Maximum Design Earthquake (MDE)	1,000	0.45	0.46
	2,500	0.57	0.58
	10,000	0.79	0.81
Maximum Credible Earthquake (MCE)		0.71	0.79

According to the revised Building code of Pakistan with Seismic Provision (PBC, 2007) the Project location is classified under seismic Zone 4 (see **Exhibit 4.10**) for which the Project is required to withstand a PGA greater than 0.32g (3.2 m/s^2) (see **Exhibit 4.11**).

Exhibit 4.10: Seismic Zones, PBC 2007

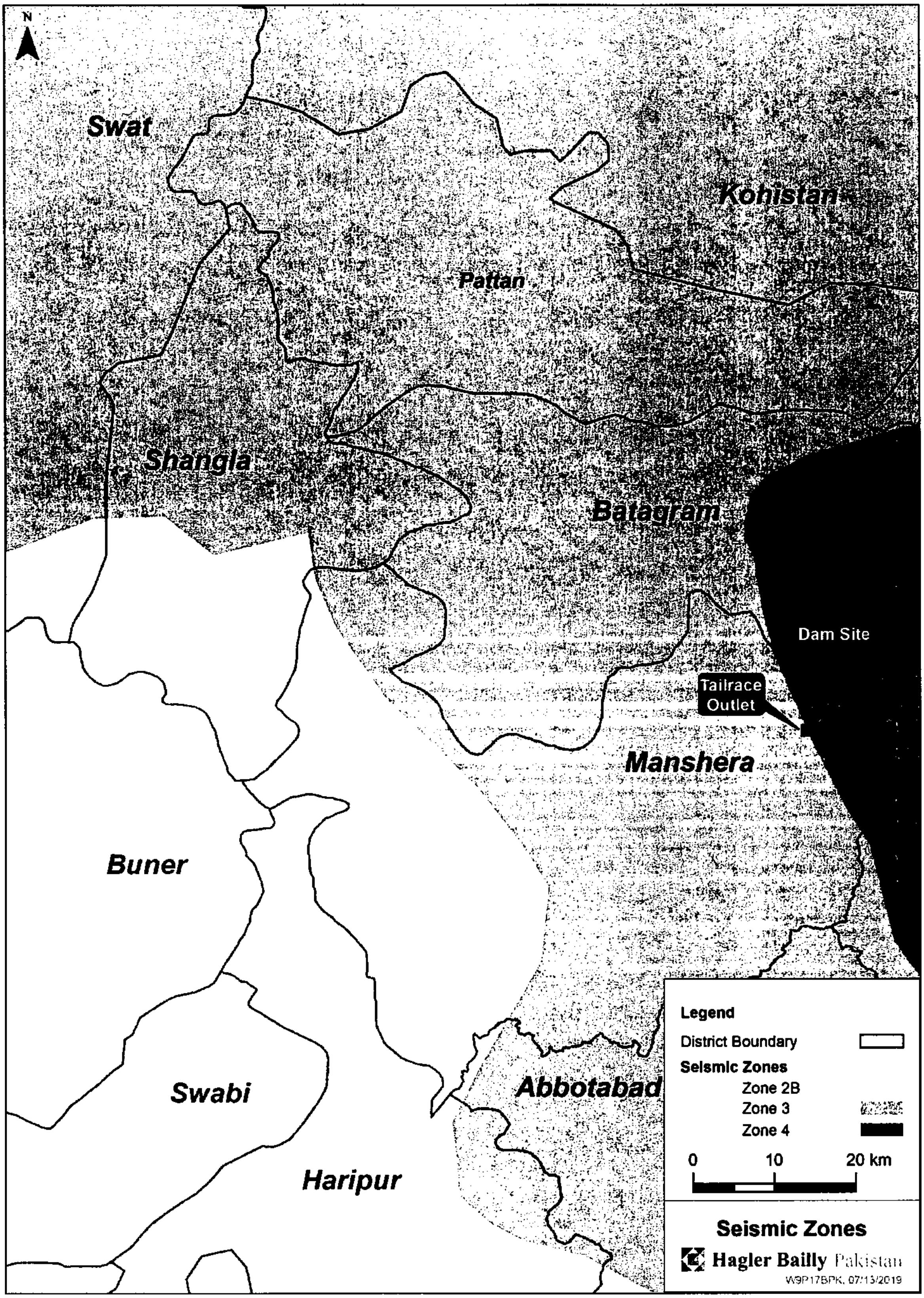
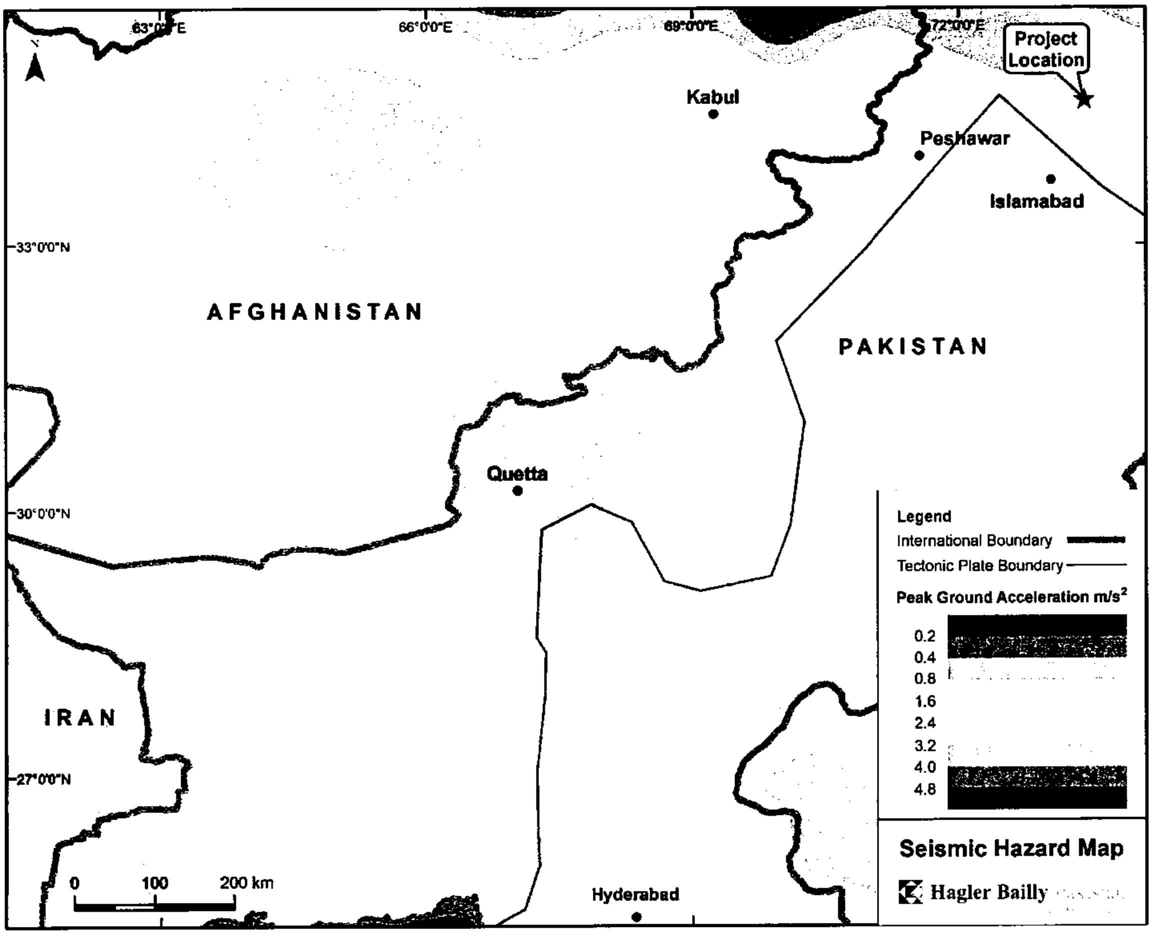


Exhibit 4.11: Seismic Zone Categorization, PBC 2007

Seismic Zone	*Peak Horizontal Ground Acceleration*
1	0.05 to 0.08g
2A	0.08 to 0.16g
2B	0.16 to 0.24g
3	0.24 to 0.32g
4	> 0.32g

The Global Seismic Hazard Map Project (GSHAP) is shown in **Exhibit 4.12**. The peak ground acceleration (PGA) with 10% probability of exceedance in 50 years (475 years average return interval) is between 1.6 meter per second squared (m/s^2) and 2.4 m/s^2 at the Project site.

Exhibit 4.12: Seismic Hazard Map of Paksitan



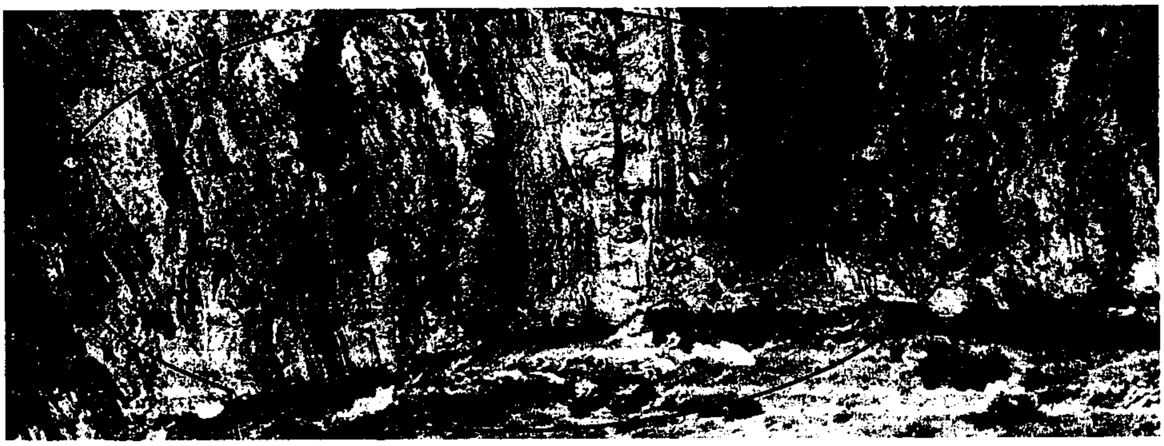
Source: Adapted from Giardini, D., Grünthal, G., Shedlock, K. M. and Zhang, P.: The GSHAP Global Seismic Hazard Map. Annali di Geofisica 42 (6), 1225-1228, 1999.

Lithology and Soils

The Project is located in rocks belonging to Murree Formations. The Murree Formation is of early Miocene age, and consists of dark red to purple and greenish grey sandstone and siltstone, purple to reddish brown shale, mudstone and lenses of conglomerates. These rocks are exposed at the dam site and consist of alternate beds of sandstone and shale as shown in **Exhibit 4.13**. Structurally, the formation shows a high degree of compression in the form of tight folding with repeated faulting and fracturing. At places, it shows open broad folds which have been weathered into steep ridges and valleys with a succession of cliffs and steep slopes.

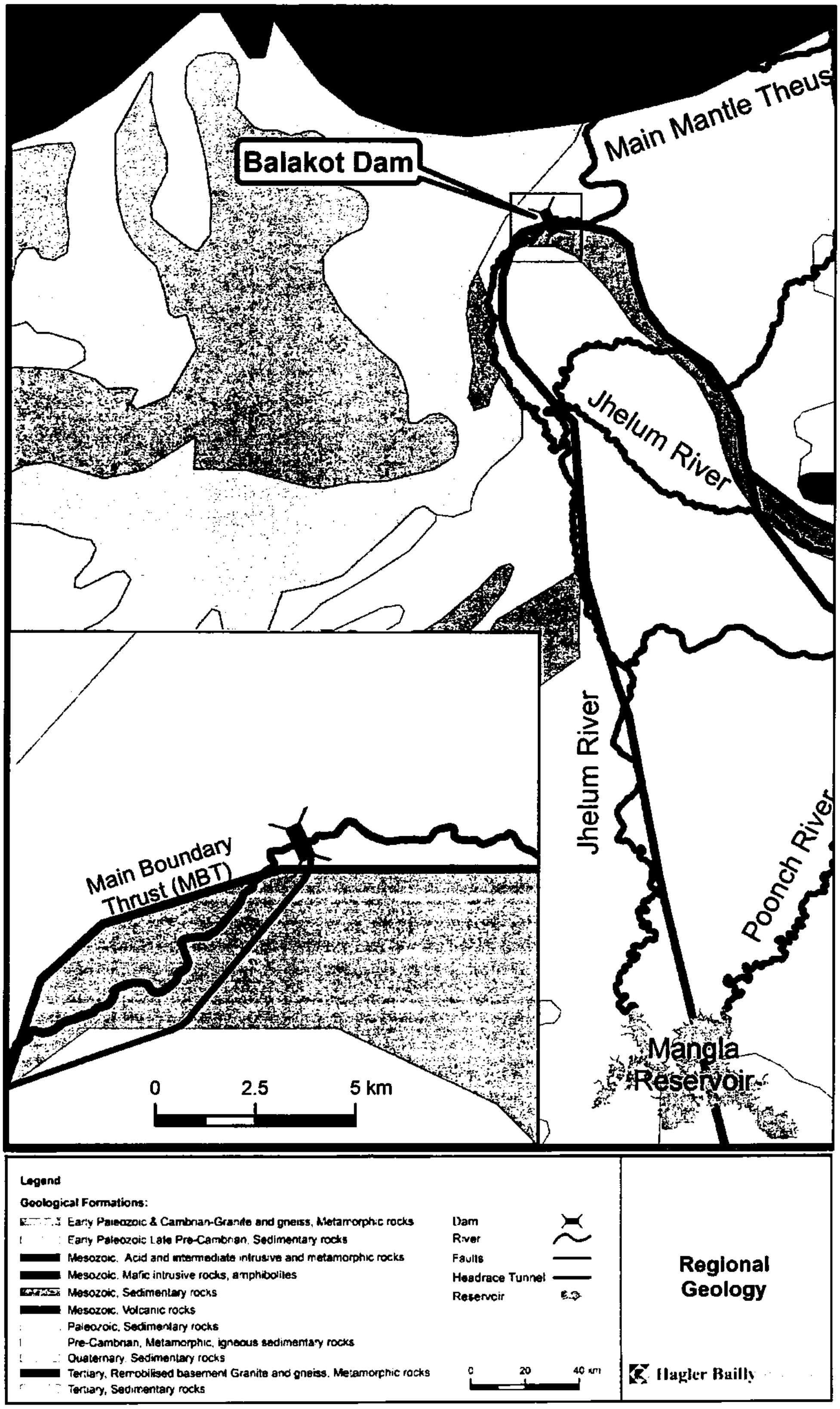
The Murree Formation exposed in the Balakot area represent as last stages of Neo-Tethys and the beginning of Siwalick system in the area which is indicated by sandstone and shale deposits. The lithological units in the region, are shown in **Exhibit 4.14**.

Exhibit 4.13: Alternate Bedding of Sandstone and Mudstone/Shale near the Dam Axis



Source: Aqualogus, June 2019, Draft Final Report D2.2B – Feasibility Study for the 300 MW Balakot Hydropwoer Project, for the Asian Development Bank and Pakhtunkhwa Energy Development Organization

Exhibit 4.14: Regional Geology



The soils of the Project area are composed of piedmont alluvial deposits, where upper layer of the plain/leveled land consists mostly of silty clay loam soils, rich in organic matter content. The subsurface strata is generally sandy loam with gravel. The soils of the hill slopes consist mostly of thin layered sandy loam soils, underlain by rocks or gravelly materials. The valley terraces in-between the mountains are very fertile and used for intensive cropping, while, the hill slopes are used for forest vegetative cover.

Soil samples were collected on April 13, 2017 and analyzed for establishing baseline conditions to establish soil fertility and identify any current soil contamination. A total of 4 samples were collected from locations listed in **Exhibit 4.15** and shown in **Exhibit 4.16**. Soil samples were analyzed in the HBP Laboratory and ALS Malaysia[4]. The detailed sampling methodology and lab analysis reports are provided in **Appendix C**. The sampling results are summarized in **Exhibit 4.17**.

Exhibit 4.15: Sampling Locations for Soil Quality

ID	*Coordinates*	*Description*	*Notes and Justification*
S1	34° 39' 38.16" N 73° 27' 42.32" E	Agricultural land, Paras	To check agricultural fertility and proposed location of labor camps which may lead to contamination
S2	34° 38' 49.53" N 73° 26' 28.79" E	Pine forest, Dam site	Location of dam site which may lead to contamination.
S3	34° 36' 12.12" N 73° 22' 56.61" E	Scrub forest, Powerhouse site	Location of powerhouse site which may lead to contamination.
S4	34° 34' 54.90" N 73° 22' 07.70" E	Agricultural land, Sangar	To check agricultural fertility and proposed location of labor camps which may lead to contamination.

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[4] HBP Lab conducted pH, EC and organic matter tests, whereas the remaining were conducted at ALS Malaysia

Exhibit 4.16: Soil Sampling Locations

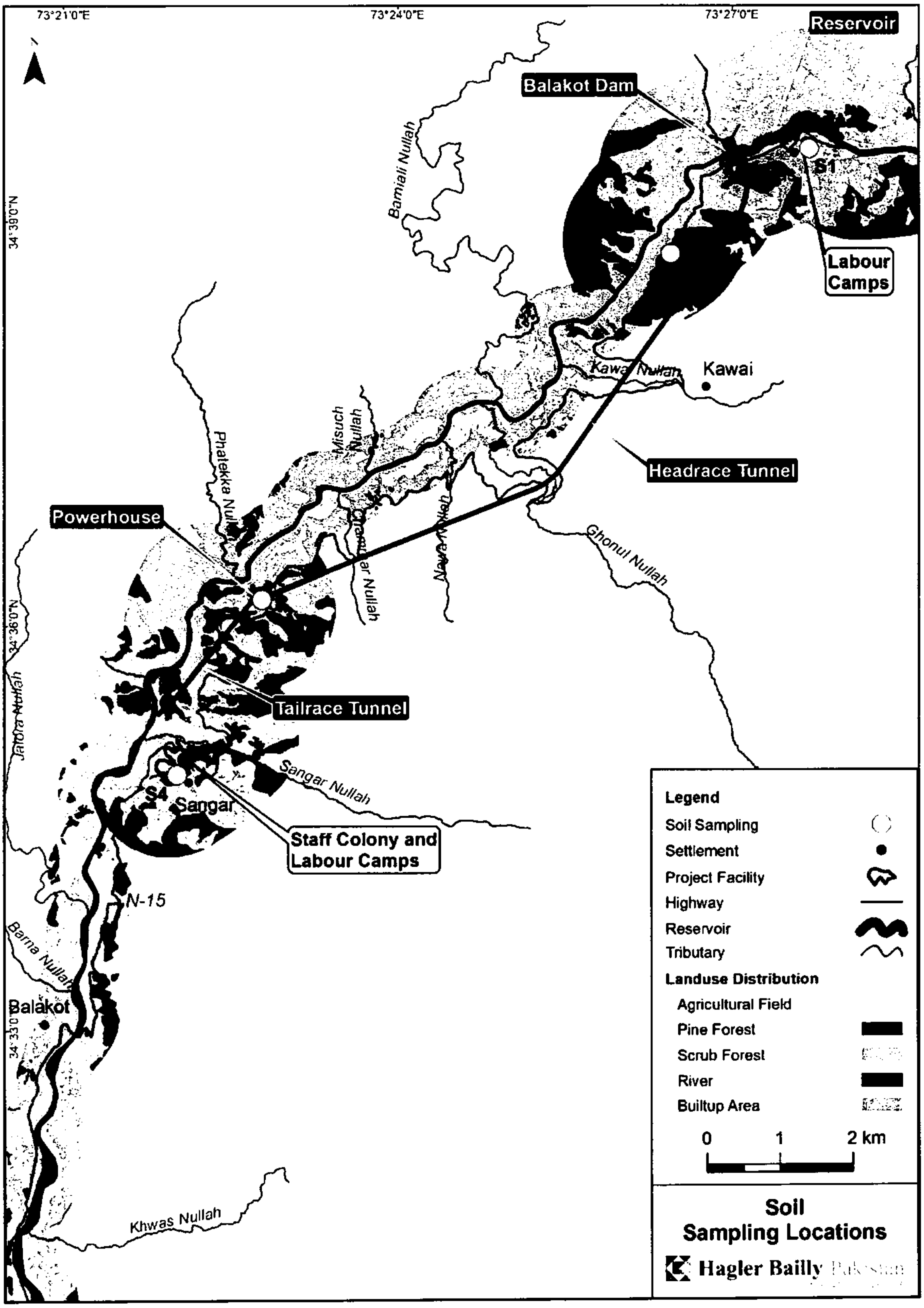


Exhibit 4.17: Soil Quality Test Results

Parameter	*Method*	*LOR*	*Unit*	*S1*	*S2*	*S3*	*S4*
				Agriculture	*Pine Forest*	*Scrube Forest*	*Agriculture*
Physical							
pH	CSSS	0.1		8.1	8.1	7.9	7.9
Electrical Conductivity (EC)	CSSS	1	µS/cm	233	474	377	258
Macro-nutrients and Organics							
Nitrate	APHA4500-NO3-H	0.1	mg/kg	11.6	<0.1	<0.1	1.8
Phosphate	APHA4500-P-F	1	mg/kg	<1	<1	<1	<1
Potassium	USEPA6010B	5	mg/kg	2,220	609	908	1,040
Organic Matter	CSSS	0.1	%	2.86	2.69	5.46	3.72
Organic Carbon	CSSS	0.05	%	1.64	1.55	3.13	2.13
Metals and Major Ions							
Arsenic	USEPA6010B	1	mg/kg	8	4	6	4
Barium	USEPA6010B	5	mg/kg	152	54	50	61
Boron	USEPA6010B	5	mg/kg	<5	<5	<5	<5
Cadmium	USEPA6010B	1	mg/kg	<1	<1	<1	<1
Chromium	USEPA6010B	1	mg/kg	43	25	56	17
Copper	USEPA6010B	1	mg/kg	34	19	28	23
Iron	USEPA6010B	1	mg/kg	25,100	14,200	22,600	11,000
Lead	USEPA6010B	1	mg/kg	17	12	16	16
Manganese	USEPA6010B	1	mg/kg	501	710	798	770
Mercury	USEPA7471A	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1
Nickel	USEPA6010B	1	mg/kg	54	37	88	20
Selenium	USEPA6010B	5	mg/kg	<5	<5	<5	<5
Silver	USEPA6010B	1	mg/kg	<1	<1	<1	<1
Zinc	USEPA6010B	1	mg/kg	78	38	72	58

Note: LOR = Level of Reporting, mg/kg = milligram per kilogram, µS/cm = micro Siemen per centimeter

Key observations on the basis of the results presented in **Exhibit 4.17** are as follows:

- **Physical:** The pH of soil samples at all sampling locations ranges between 7.9 and 8.1. The maximum pH is observed as 8.1 at S1 (agricultural land, Paras) and minimum as 7.9 at S3 (scrub forest, powerhouse site). Higher values of EC are observed under forest based land use system compared to the agricultural land. The maximum EC is observed as 474 µS/cm at S2 (pine forest, dam site).

- **Nutrients and Organics:** Organics at all sampling locations don't vary significantly. The maximum organic matter and organic carbon values are observed at S3 as 5.46% and 3.13%, respectively. Phosphates were not detected at any of the sampling locations. Nitrates are only observed on agricultural land (S1 and S4) with the maximum value as 11.6 mg/kg at S1. Potassium is also high at S1 (agricultural land, Paras) and S4 (agricultural land, Sangar) with the maximum value as 2,220 mg/kg at S1. Macronutrient contents shows high fertility at S1 (agricultural land, Paras) and S4 (agricultural land, Sangar).
- **Metals and Major Ions:** Metal contents do not vary significantly through the area sampled, indicating absence of contamination from any industrial activity or spills. Results for Boron, Cadmium, Mercury, Selenium and Silver were below the level of reporting.

4.1.5 Visual Character

The visual baseline documents the current aesthetic and visual conditions of the proposed Project site as seen from the nearby receptors.

Methodology and Sampling Locations

To document the visual baseline a survey was conducted on May 5, 2017. Visual survey locations are listed in **Exhibit 4.18** and shown in **Exhibit 4.19. Exhibit 4.20** shows the views of Project facility locations from nearby receptors.

Exhibit 4.18: Visual Survey Locations

ID	*Coordinates*	*Altitude (m)*	*Bearing of Image Center*	*Location*	*Rationale*
V1	34° 39' 46.6" N 73° 27' 16.6" E	1,356	Southeast	Right Bank: reservoir	View towards Paras where reservoir will inundate land
V2	34° 39' 00.6" N 73° 26' 29.4" E	1,335	West	Left Bank: downatream of dam site	View downstream of the dam site
V3	34° 36' 07.1" N 73° 22' 52.5" E	1,366	Northwest	Left Bank: powerhouse site	View towards construction activity site near the powerhouse site
V4	34° 35' 05.2" N 73° 21' 48.7" E	1,070	Northwest	Left Bank: tailrace outfall	View near the tailrace outfall

Exhibit 4.19: Visual Survey Locations

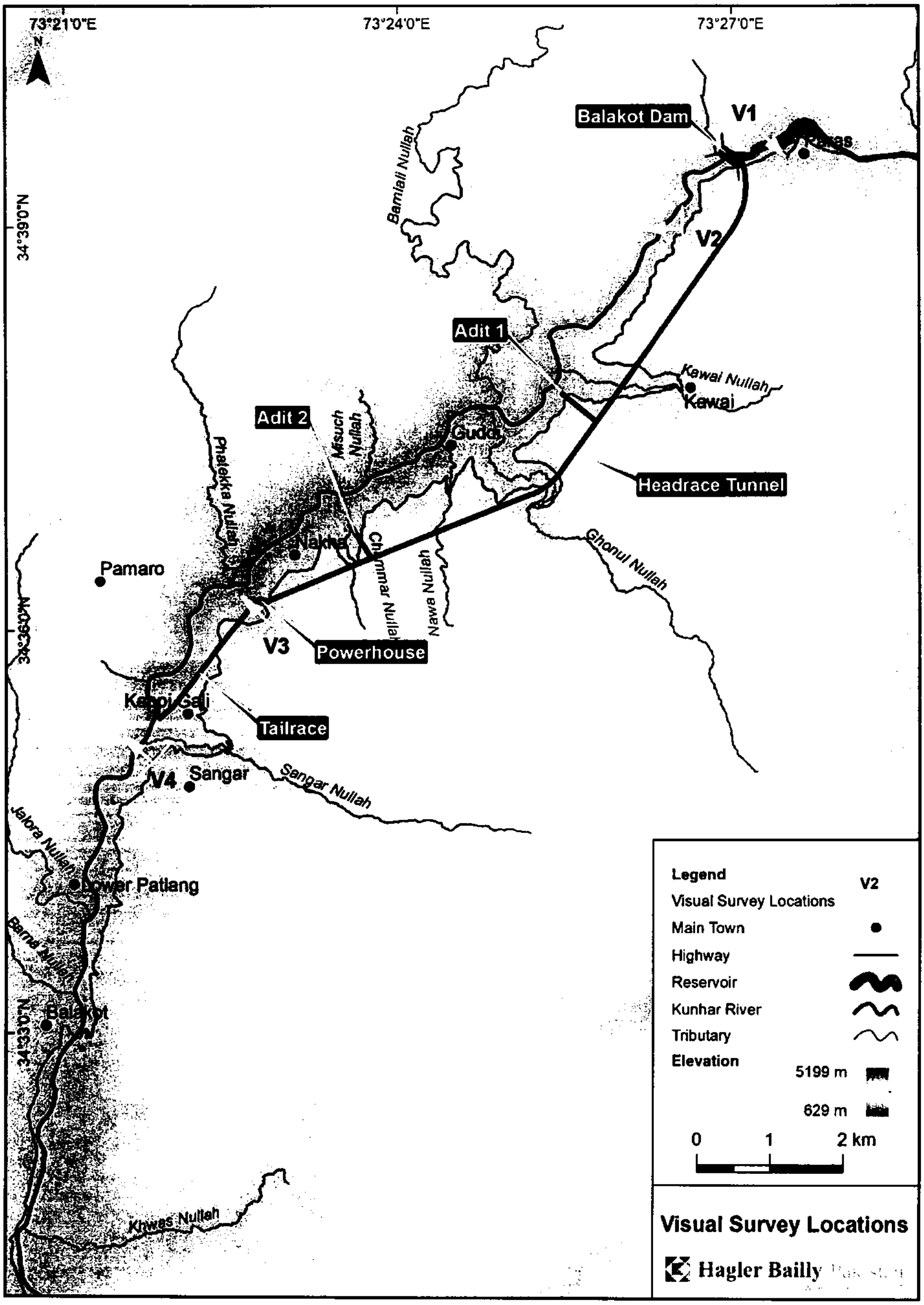


Exhibit 4.20: Visual Survey Photographs

View from V1 (180 degree view, at 1356 meters elevation, centered at bearing Southeast, right bank). The village of Paras and agricultural fields can be seen in the distance.

View from V2 (180 degree view, at 1335 meters elevation, centered at bearing West, left bank). River downstream of the Dam site can be observed. Steep hills and trees hinder visibility

View from V3 (180 degree view, at 1366 meters elevation, centered at bearing Northwest, left bank). View of the Powerhouse site. Mountainous terrain hindered visibility

View from V4 (180 degree view, at 1070 meters elevation, centered at bearing Northwest, left bank). View of the Kunhar River after the tailrace outfall. The valley starts to widen as the river approaches Balakot.

The following method was used for the visual survey:

- A compass was used to record the bearings, in degrees, for the photographs.
- GPS coordinates of the locations were recorded.
- A tripod was used to take the photographs.

Photographs were stitched to form 180° panoramic views in the direction of Project activities.

Results and Analysis

The mountainous landscape, deep gorges and vegetation greatly restricts visibility to a maximum of 0.5 to 1.5 km at receptor locations.

4.1.6 Climate Baseline

The objective of climate baseline is to characterize the climatic conditions in the Study Area. This includes characterization of the monthly trends in weather parameters (temperature, precipitation, relative humidity, wind speed and direction) and the extreme conditions that occur in the Study Area.

Data Sources

A regional climate overview was established using available data from Balakot weather station. This is the nearest Pakistan Meteorological Department (PMD) weather station to the Project. The description of weather station is presented in **Exhibit 4.21.**

Exhibit 4.21: Details of Balakot Weather Station

World Meteorological Organization (WMO) Identification Number	41536
Established	1957
Location	73° 21' E, 34° 32' N
Location with respect to dam site	16 km northeast
Location with respect to powerhouse site	8 km northeast
Elevation (m amsl)	980.0
Data period used in the analysis	1961-1990 (30 Years)

Data Analysis

The climate analysis of Project area was carried out by classifying it into different seasons as below.

Summer (mid-March to mid-June)

Characterized by high temperatures, moderate rainfalls with moderate humidity and high speed-winds.

Summer Monsoon (mid-June to mid-September)

The summer monsoon, hereafter referred to as the Monsoon, is characterized by high temperatures (although milder than the summer), significantly high rainfalls with high humidity and moderate speed-winds, slightly lower than summers.

Post-Monsoon summer (mid-September to mid-November)

Characterized by moderate temperatures, low rainfalls with moderate humidity higher than summers, as the humidity again reduces after monsoon and low speed-winds.

Winter (mid-November to mid-March)

Characterized by very low temperatures, moderate rainfalls, with an increasing amount of rainfall at the end of the winter, with relative humidity greater than post-monsoon summer and moderate speed-winds.

The summary of climate analysis is presented in **Exhibit 4.22**. The parameters are tabulated in **Exhibit 4.23** and graphed in **Exhibit 4.24** to **Exhibit 4.28.** Wind frequency distribution is presented in **Exhibit 4.29.**

Exhibit 4.22: Seasonal Variation

Season	*Temperature and Humidity*	*Rainfall*	*Wind*
Summer *(mid-March to mid-June)*	Daily maximum temperature averages between 19°C and 35°C. Daily minimum gradually increases from 8°C in March to 21°C in June. Morning humidity reduces from 67% in March to 54% in June. Same trend was observed in afternoon humidity that also reduces from 51% in March to 34% in June.	30% of total rainfall occur in summers with maximum amount of rainfall observed in March (189 mm). The mean number of rainy days during this period ranges from 6 to 10 per month. Monsoon generally starts by late June.	Predominant wind direction is southwest with mean wind speed of 1.1 m/s. however, wind keeps on changing direction between southwest and northwest. 24% of the time winds were calm during this period.
Monsoon *(mid-June to mid-September)*	Daily maximum temperature drops by a few degrees and averages between 30°C and 32°C. Daily minimum temperatures gradually decreases and varies between 17°C and 21°C. Morning humidity increases to 89% in August and then reduces to 81% in September. Same trend was seen in afternoon humidity. It increases to 66% in August and then reduces to 54% in September.	45% of total rainfall occur in monsoons with maximum amount of rainfall observed in July (359 mm). In August rainfall slightly reduces to 293 mm. The mean number of rainy days during this period are between 6 and 14 per month.	The wind speed decreases in monsoon with the mean speed of 0.6 m/s during this period. Winds are southwesterly. 30% of the time winds were calm during this period.
Post-monsoon summer *(mid-September to mid-November)*	Daily maximum temperature decreases by about 3°C and averages between 21°C and 27°C. Daily minimum temperatures start decreasing and drops to 6°C by November. Morning humidity decreases sharply to 75% in October and November. Afternoon humidity drops sharply in October to 44% and remains near 49%.	By the end of September the monsoon rainfall ends. Only about 5% of total rainfall occur in post-monsoon summer. Amount of rainfall significantly reduces to 45 mm in October. The number of rainy days are less than 5 during these months.	Further reduction in wind speed occur during this period with the mean speed of 0.6 m/s. Winds are southwesterly. 17% of the time winds were calm during this period.
Winter *(mid-November to mid-March)*	Daily maximum temperature averages between 14°C and 16°C. Daily minimum temperature averages between 2°C and 4°C. Morning humidity again increases to 78% and then drops to 72% in February. Afternoon humidity again increases to 59% in December and then drops to 55% in February.	The amount of rainfall starts increasing with the advent of winter. About 20% of the total rainfall occurs during this season with maximum amount in February (154 mm). The mean number of rainy days are between 5 and 8 per month.	Wind speeds tend to increase in start of January with the mean speed of 0.6 m/s during this period. Predominant wind direction is southwest however, also blows from northwest. 29% of the time winds were calm during this period.

Note: Morning measurements were made at 5:00 AM and afternoon measurements were made at 5:00 PM (Pakistan Standard Time)

A day is defined as *rainy days* if the total amount of rainfall for that day exceeds 2.5 mm.

Exhibit 4.23: Weather Parameters

Month	*Temperature (°C)*			*Humidity (%)*		*Rainfall (mm)*	*Number of Rainy days*	*Wind Speed (m/s)*	
	Mean	*Min*	*Max*	*5:00 AM*	*5:00 PM*			*Max*	*Mean*
Jan.	8.1	2.0	14.0	76	58	94.9	5.5	3.6	0.5
Feb.	9.6	3.9	15.4	72	55	153.5	7.8	3.6	0.9
Mar.	13.5	7.6	19.5	67	51	188.6	9.7	3.6	1.0
Apr.	19.0	12.6	25.3	62	46	134.3	8.4	3.6	1.1
May.	24.1	17.2	31.0	54	36	77.0	5.9	5.1	1.1
Jun.	28.2	21.0	35.3	54	34	98.4	6.8	6.2	1.1
Jul.	26.8	21.3	32.3	81	59	359.4	13.7	3.6	0.7
Aug.	25.9	20.6	31.3	89	66	292.5	12.4	3.6	0.5
Sep.	24.0	17.1	30.9	81	54	100.8	6.4	2.6	0.6
Oct.	19.4	11.5	27.5	75	44	44.7	2.9	3.6	0.7
Nov.	14.0	6.2	21.9	75	49	45.9	2.7	2.6	0.5
Dec.	9.4	2.9	16.0	78	59	81.2	5.0	3.6	0.4

Exhibit 4.24: Mean Monthly Temperatures (°C)

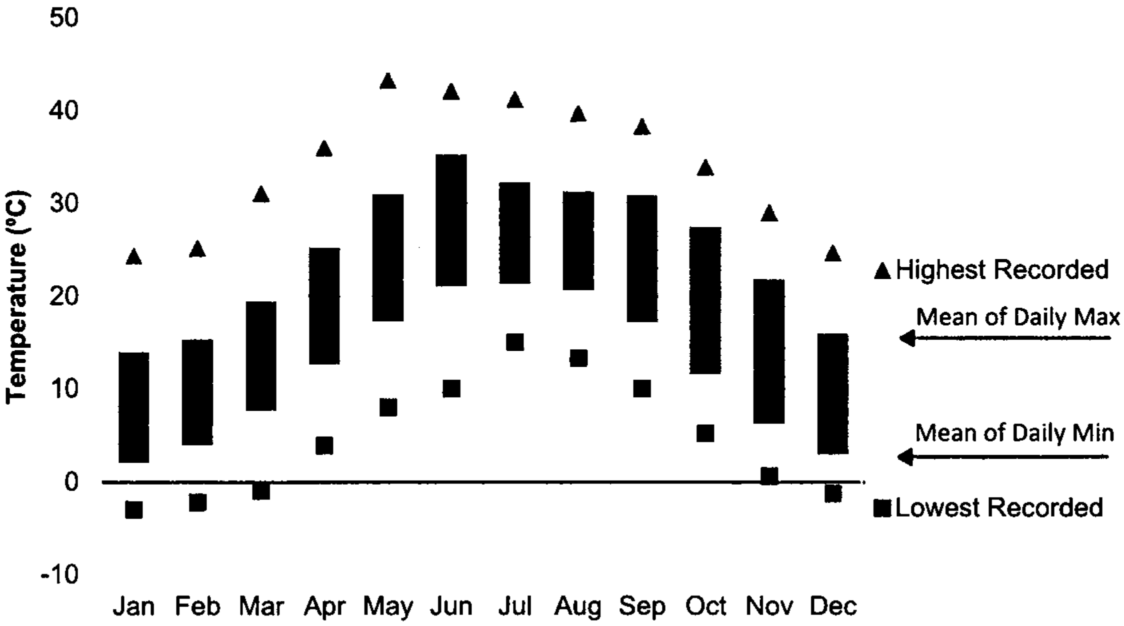


Exhibit 4.25: Mean Monthly Relative Humidity (%)

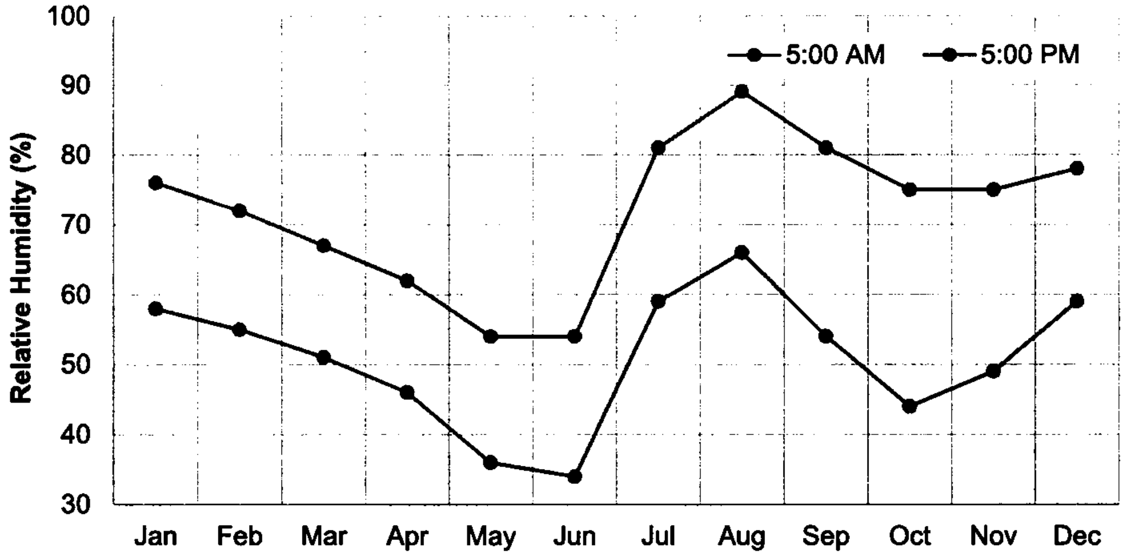


Exhibit 4.26: Mean Monthly Rainfall (mm)

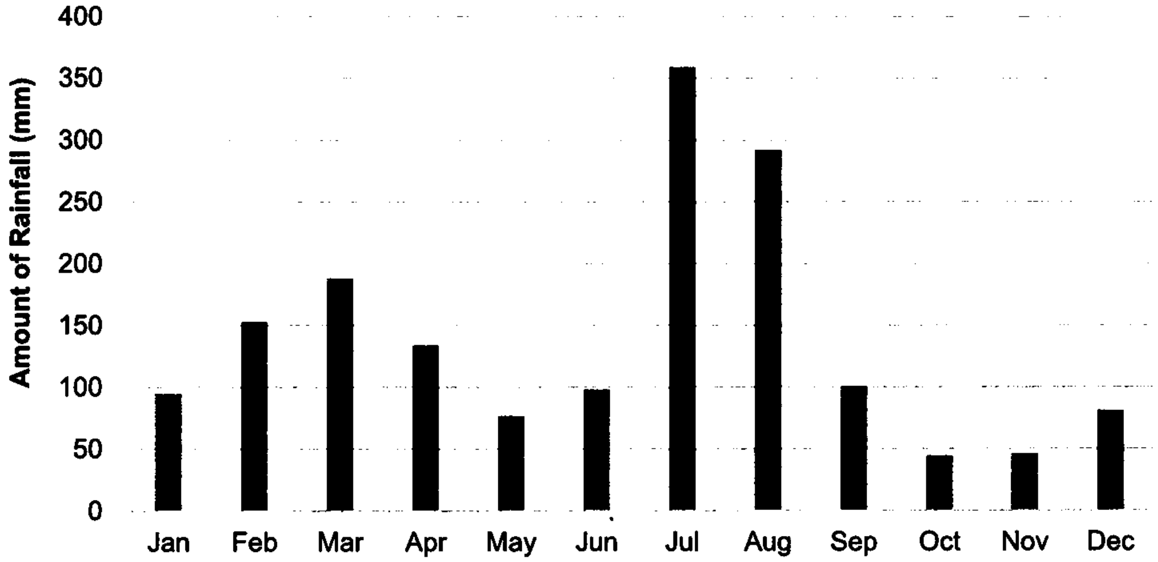


Exhibit 4.27: Mean Number of Rainy Days

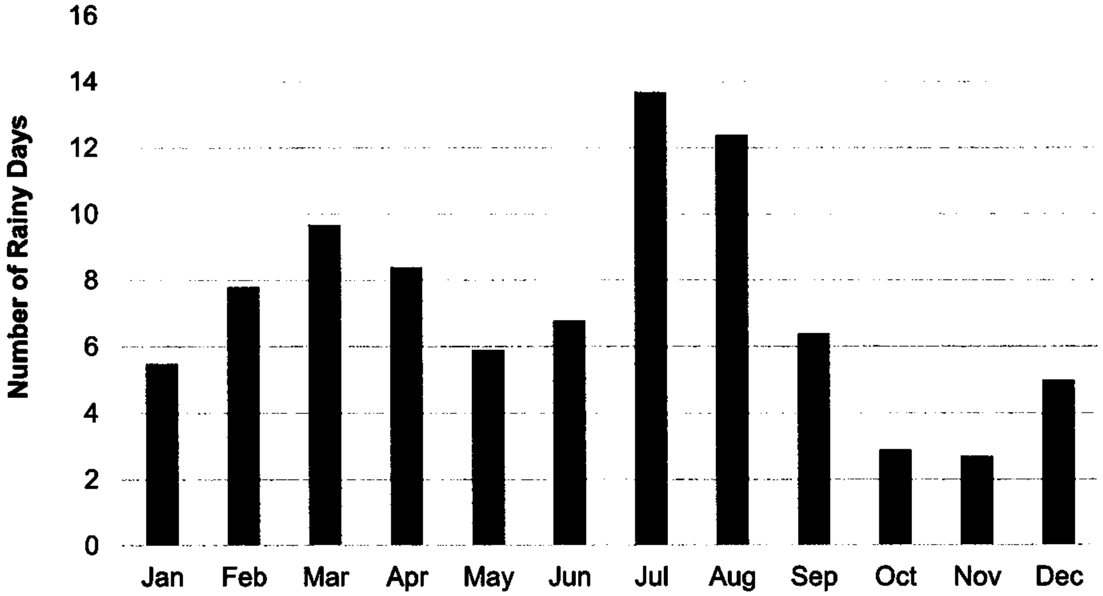


Exhibit 4.28: Mean Monthly Wind Speed (m/s)

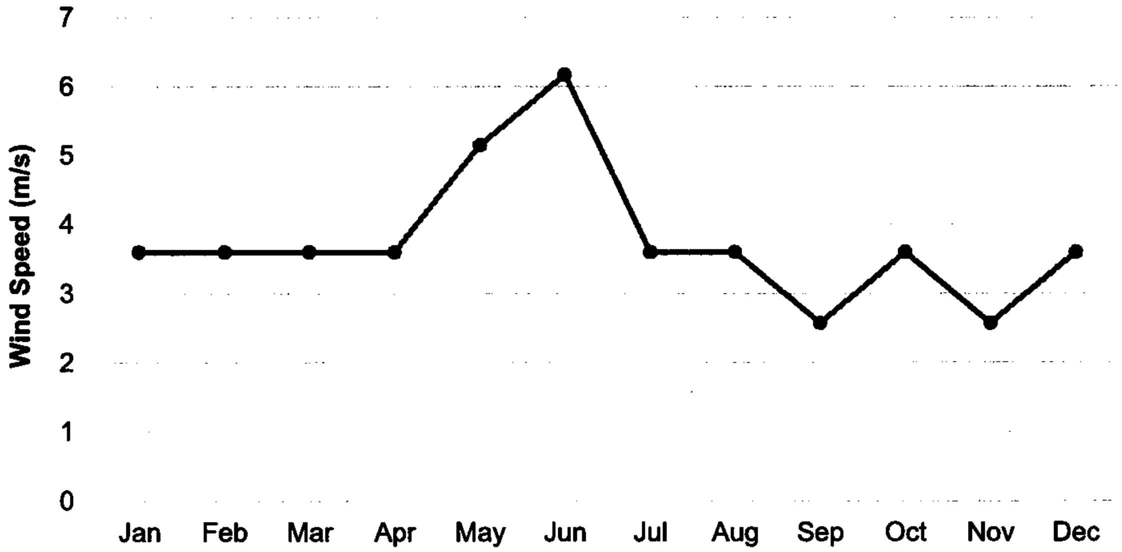


Exhibit 4.29: Wind Frequency Distribution (%)

Month	*Wind Speed Ranges (m/s)*									*Wind Direction*							
	Calm	*0.5 to 2*	*2 to 4*	*4 to 6*	*6 to 9*	*9 to 12*	*12 to 14*	*14 to 17*	*> 17*	*N*	*NE*	*E*	*SE*	*S*	*SW*	*W*	*NW*
Jan.	67%	27%	6%	0.2%	0%	0%	0%	0%	0%	0%	3%	0%	2%	1%	17%	0%	10%
Feb.	47%	44%	8%	0.5%	0%	0%	0%	0%	0%	1%	4%	0%	4%	0%	31%	0%	12%
Mar.	39%	43%	16%	1%	0%	0%	0%	0%	0%	0%	6%	0%	6%	1%	30%	0%	17%
Apr.	45%	39%	15%	1%	0%	0%	0%	0%	0%	0%	3%	0%	5%	1%	31%	0%	15%
May.	35%	46%	18%	1%	0%	0%	0%	0%	0%	0%	4%	0%	8%	2%	34%	0%	17%
Jun.	36%	44%	18%	2%	0.4%	0%	0%	0%	0%	1%	5%	0%	6%	2%	38%	0%	12%
Jul.	62%	28%	10%	1%	0%	0%	0%	0%	0%	0%	1%	0%	6%	1%	28%	0%	2%
Aug.	68%	28%	4%	0.2%	0%	0%	0%	0%	0%	0%	1%	0%	8%	1%	22%	0%	1%
Sep.	63%	35%	3%	0%	0%	0%	0%	0%	0%	0%	1%	0%	5%	2%	28%	0%	2%
Oct.	47%	49%	3%	1%	0%	0%	0%	0%	0%	0%	1%	0%	8%	7%	33%	0%	4%
Nov.	62%	37%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	2%	25%	0%	8%
Dec.	77%	21%	2%	0.2%	0%	0%	0%	0%	0%	0%	1%	0%	1%	0%	17%	0%	4%

Note: Calm are the winds less than 0.5 m/s.

N:North	S: South	E: East	W: West
NE: Northeast	SE: Southeast	SW: Southwest	NW: Northwest

Weather Extremes

Weather extremes for the Balakot weather station are given in **Exhibit 4.30** for temperature and in **Exhibit 4.31** for precipitation.

Exhibit 4.30: Temperature Extremes in the Study Area

Month	*Lowest Recorded*		*Highest Recorded*	
	Value	*Year*	*Value*	*Year*
Jan.	-3.0	1974	24.4	1971
Feb.	-2.2	1972	25.2	1985
Mar.	-1.0	1979	31.1	1971
Apr.	3.9	1989	36.0	1974
May.	8.0	1987	43.3	1988
Jun.	10.0	1979	42.1	1984
Jul.	15.0	1975	41.2	1985
Aug.	13.3	1988	39.7	1987
Sep.	10.0	1979	38.3	1962
Oct.	5.2	1982	33.9	1971
Nov.	0.6	1962	29.0	1979
Dec.	-1.3	1986	24.7	1988

Exhibit 4.31: Extreme Precipitation Conditions

Month	*Wettest Year*		*Heaviest Rainfall in 24 hour*		*Driest Year*	
	Rain (mm)	*Year*	*Rain (mm)*	*Year*	*Rain (mm)*	*Year*
Jan	226.0	1980	67.3	1973	0.0	1966
Feb	345.1	1980	80.8	1971	22.0	1985
Mar	373.6	1980	108.5	1973	14.0	1971
Apr	277.1	1965	105.1	1979	48.0	1974
May	191.7	1982	64.7	1979	6.0	1980
Jun	283.7	1978	84.1	1977	28.6	1990
Jul	914.9	1988	213.8	1988	113.6	1983
Aug	567.2	1983	245.0	1983	148.9	1989
Sep	199.3	1977	79.0	1978	3.3	1971
Oct	241.3	1987	88.0	1987	0.0	1984
Nov	192.7	1986	103.0	1986	0.0	1968
Dec	324.2	1990	80.1	1990	0.0	1981

Comparison of Climatic Normal with Recent Data

Climatic normal data for the time period of 1961 – 1990 was compared with more recent data from 1991 – 2011 for temperature and precipitation. Climatic normal are based on 30-year period and developed by the PMD. A comparison of the datasets is shown in **Exhibit 4.32** and graphed in **Exhibit 4.33** to **Exhibit 4.34.**

The following conclusions can be drawn:

- **Temperature:** There is slight variations in temperature observed in recent data as compared to climatic normal. The increase in mean temperatures in recent years is 0.2°C. This shows that overall temperature is increased at the Project site.
- **Rainfall:** The amount of rainfall only increased in the months of January, June and September by an amount of 1 mm, 3 mm and 29 mm, respectively. However, in the rest of the months the amount decreases. The decrease in annual amount of rainfall is 175 mm.

Possible reasons for the change in weather parameters may be because of climate change or urbanization, which can explain increased temperatures and decreased amount of rainfalls.

Exhibit 4.32: Comparison between Climatic Normal and Recent Data

Month	*Mean Temperature (°C)*		*Rainfall (mm)*	
	1961-1990	*1991-2011*	*1961-1990*	*1991-2011*
Jan	8.1	8.2	94.9	95.9
Feb	9.6	9.9	153.5	152.1
Mar.	13.5	14.1	188.6	152.5
Apr	19.0	19.0	134.3	104.1
May	24.1	24.2	77.0	72.5
Jun	28.2	27.2	98.4	101.4
Jul	26.8	26.8	359.4	324.3
Aug	25.9	26.0	292.5	236.7
Sep	24.0	24.1	100.8	129.8
Oct	19.4	19.8	44.7	40.2
Nov	14.0	15.1	45.9	36.9
Dec	9.4	10.5	81.2	49.6
Annual	**18.5**	**18.7**	**1,671.2**	**1,496.0**

Exhibit 4.33: Comparison of Monthly Temperatures (°C)

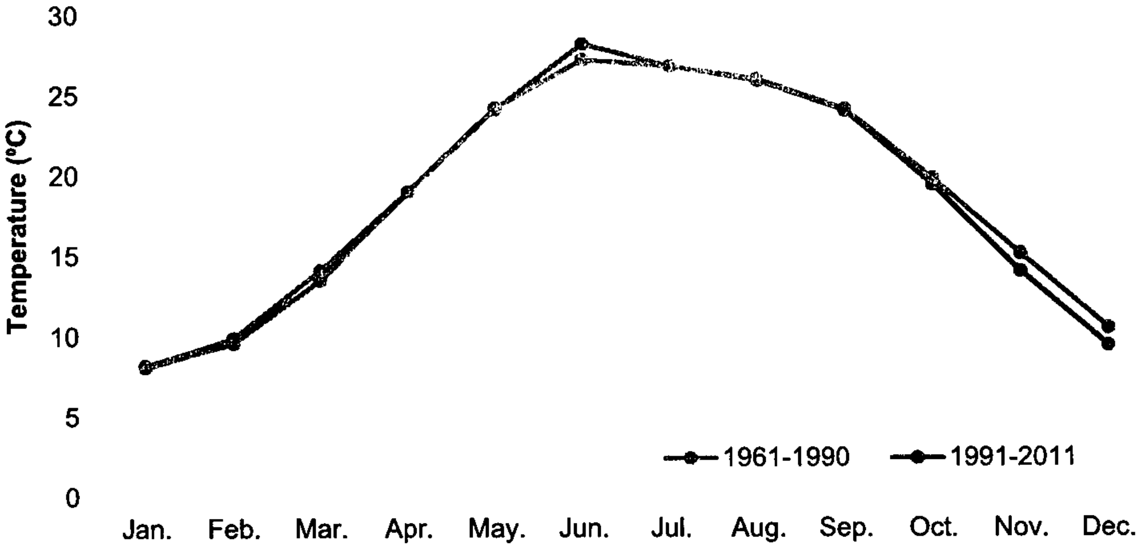
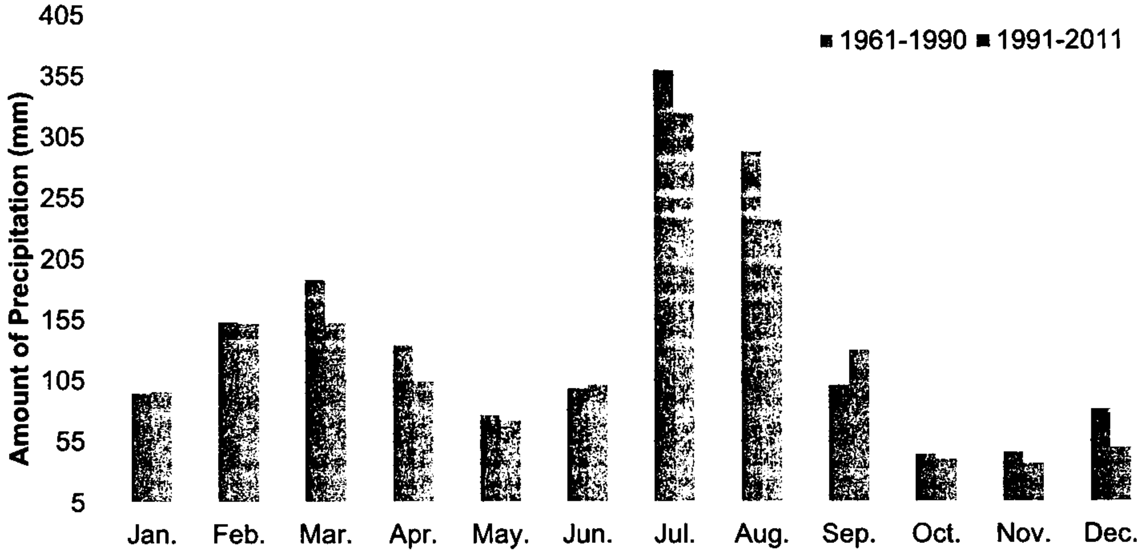


Exhibit 4.34: Comparison of Mean Monthly Rainfall (mm)



4.1.7 Water Resources

Water resources in the area consist of surface water including rivers and nullahs and groundwater including springs and boreholes.

Regional Hydrology

The Project Dam and Powerhouse are located on the Kunhar River. This section describes the hydrology of the Kunhar River up to its confluence with the Jhelum River.

The catchment area, Kunhar River, and its' principal tributaries up to its confluence are shown in **Exhibit 4.35**.

The Kunhar River originates from the glaciers above Lulusar Lake in the Kaghan Valley of KP. Glaciers of Malka Parbat and Makra Peak and the waters of Saiful Muluk Lake feed the river. It passes through Jalkhand, and meets Jhelum River at Rarra. The drainage area of the river is 2,535 km^2, with elevation ranging from 600 to 5,000 m.[5] It is one of the biggest tributaries of the Jhelum River Basin and the only main tributary situated entirely in Pakistan's territory. Snowmelt from the Kunhar Basin contributes 65% of the total discharge of the Kunhar River and 20-40% of the Jhelum River at Mangla.[6]

Although the Kunhar River discharges into the Jhelum River, flow changes due to the Project will not result in flow changes in the Jhelum River due to the near complete Patrind HPP downstream of the Project.

The Kunhar River has a steep gradient and flows through narrow gorges through much of its length. The bed elevation plot of the Kunhar River, and its key tributaries are shown in **Exhibit 4.36.**

Flow Regime

The Kunhar River had gauging stations installed by Surface Water Hydrology Project (SWHP), WAPDA. Gauging stations in the vicinity of the Project are shown in **Exhibit 4.35.** Gari Habibullah (1960-1994) and Naran (1960-2005).stations were closed and moved to and Talhata in 1995 and Kaghan in 2009 respectively.

Data from the Gari Habibullah gauging station was selected as the primary source of data due to its location and long term data availability. Furthermore, data from Talhata (which is 2 km upstream from the Gari Habibullah station) was appended to the Gari Habibullah data by adopting a catchment ratio approach shown below to create a 51 year record of gauging data (from 1960 to 2010):

$$Flow_{Gari\ Habibullah} = 1.01 \times Flow_{Talhata})$$

In the Feasibility Study it was noted that the flow data was found missing for year 1993 and October and November 2005. Hence a relationship between Naran and Gari Habibullah was developed using the mean daily flows for years 1960 to 1992, to estimate the missing year data for the year 1993 and for October and November 2005. The relationship[7] used is shown below:

$$Q_G = -0.0054Q_N^2 + 2.6158Q_N + 5.6281 \qquad R^2 = 0.9798$$

Where Q_G is the flow at Gari Habibullah and Q_N is the flow at Naran stream gauging station. Monthly average flows at each gauging station are shown in **Exhibit 4.37.** As can be observed peak flows are observed during June on the river throughout the river.

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[5] Mahmood R, Jia S, Babel M. S., January 16, 2016, Potential Impacts of Climate Change on Water Resources in the Kunhar River Basin, *Water, Multidisciplinary Digital Publishing Institute*, Basel, Switzerland

[6] Ibid

[7] Feasibility Study of Project 2013

Temperature Regime

The Kunhar River has two temperature regimes as illustrated in **Exhibit 4.38.** Upstream of Kaghan the water is cooler with average summer temperatures of 8-10 C whereas downstream of Kaghan temperatures are higher and near 12-13 C. The Jhelum River at its confluence with the Kunhar has a temperature of 16-17°C and the cooler waters of the Kunhar have a moderating influence on the Jhelum.

Exhibit 4.35: Kunhar River Catchment

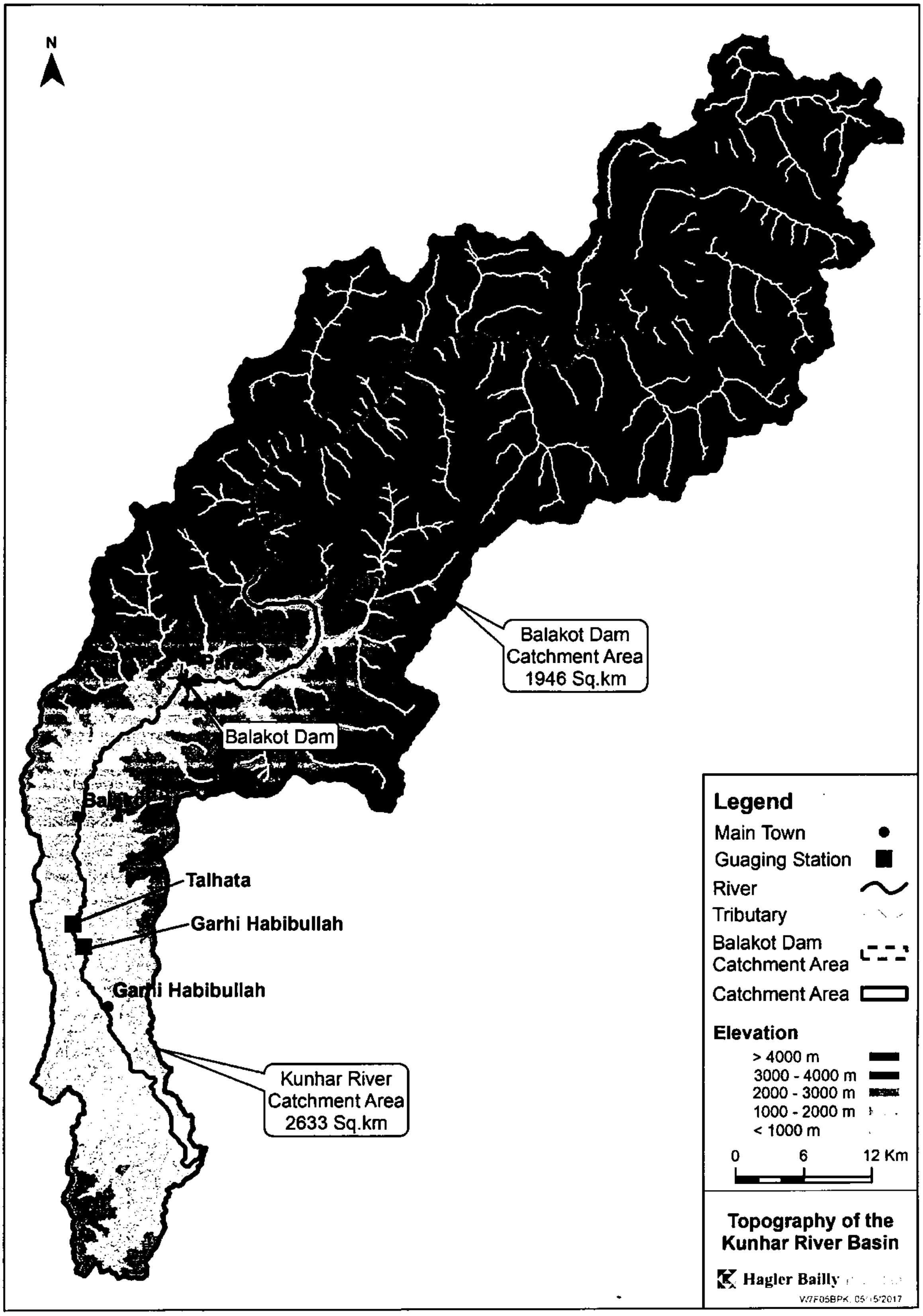


Exhibit 4.36: Kunhar River Bed Elevation

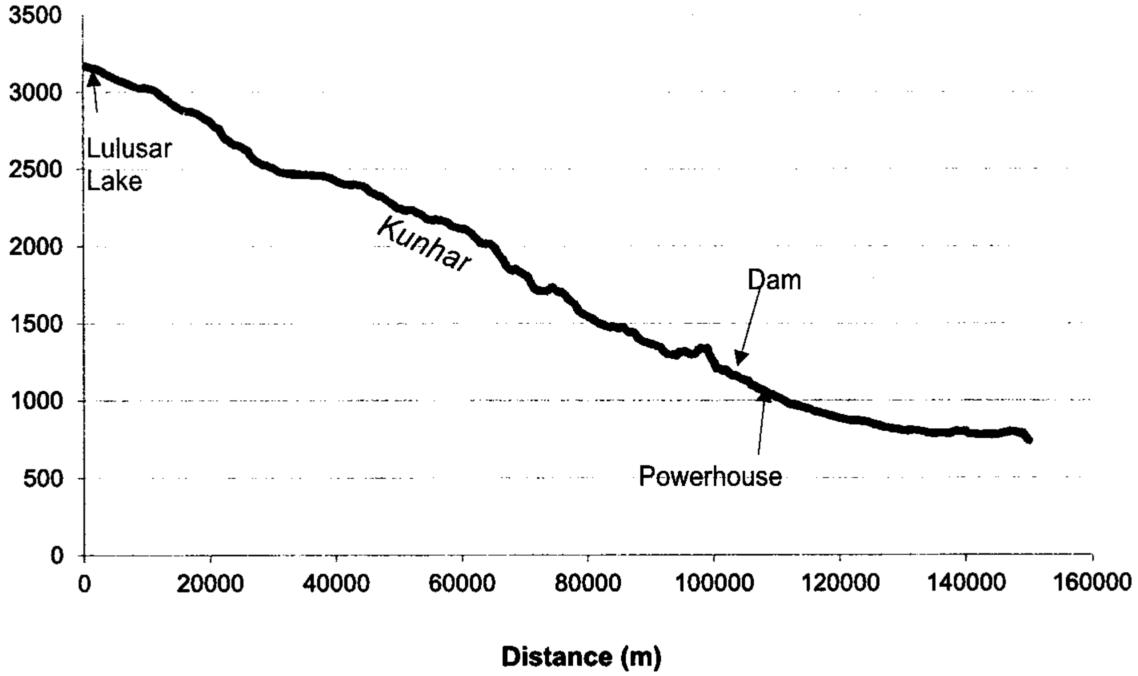


Exhibit 4.37: Daily Average Flow along Kunhar River

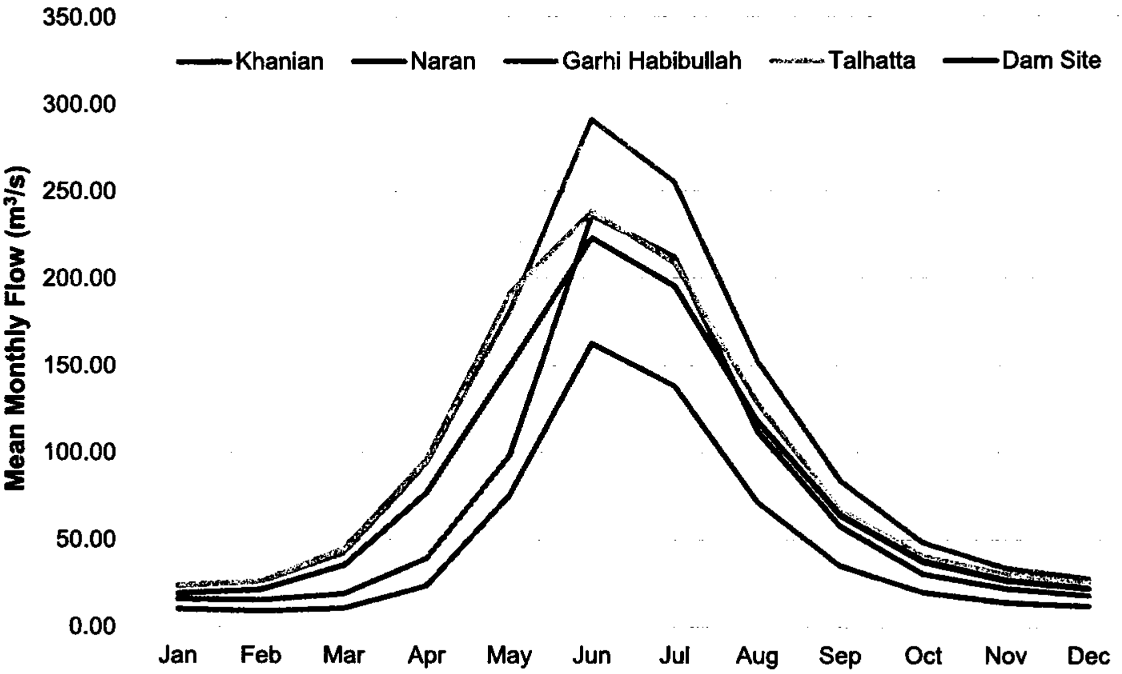
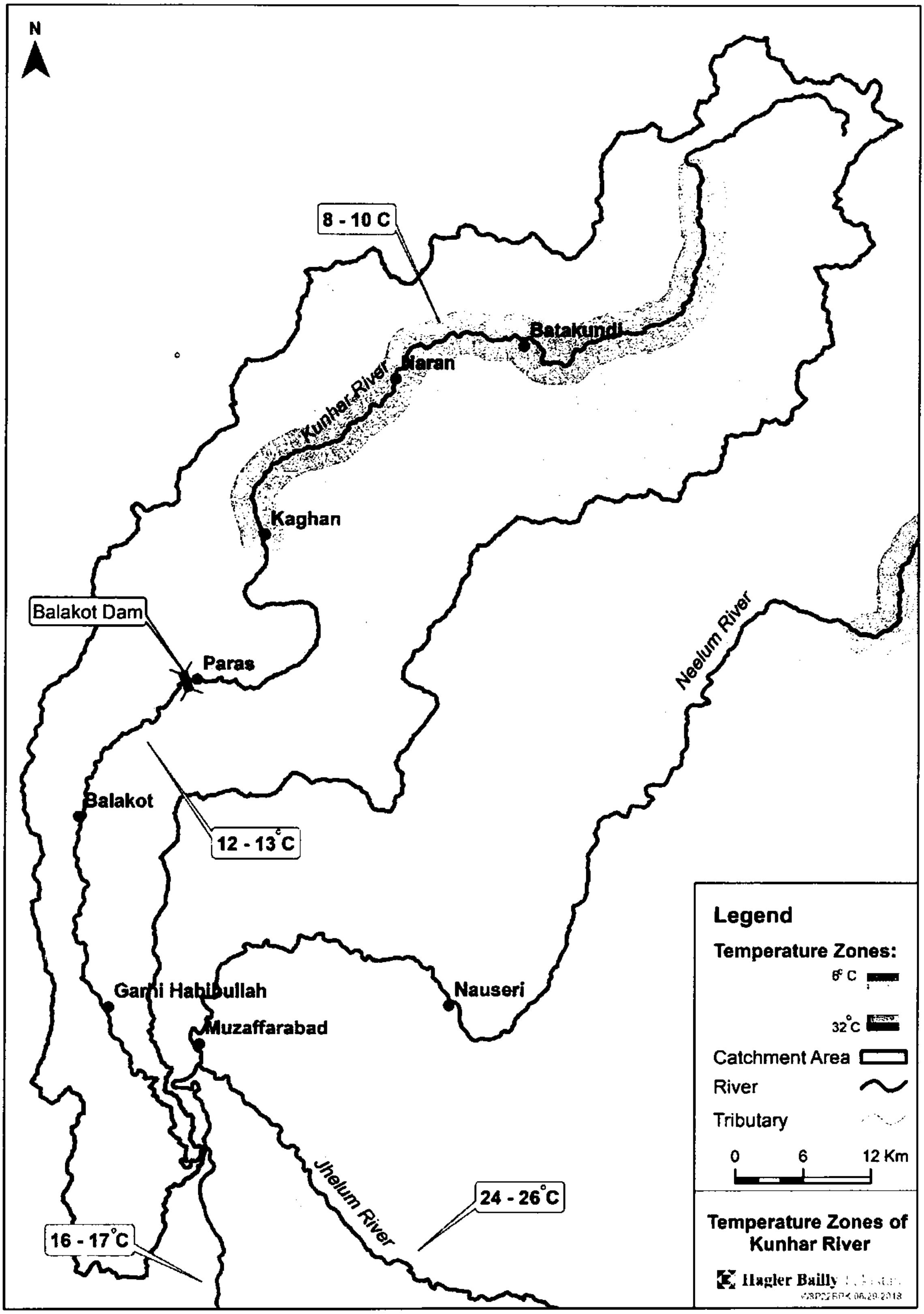


Exhibit 4.38: Temperature Zones of Kunhar River



Dam Site Hydrology

The hydrology at the dam site is typical of Himalayan rivers, characterized by peak flows in the month of June associated with melting of snow at higher elevations in the catchment, followed by declining flows in the summer supported by monsoon rainfall and continuing snowmelt in the months of July and August. The dry or low flow winter season typically extends from October through February when the flows are reduced to the order of one sixth of peak in the month of June.

The Project site hydrology based on the Feasibility Study is summarized below. The daily average flow at the dam site is shown in **Exhibit 4.37**. Annual run off frequencies at the dam site are summarized in **Exhibit** 4.39. Flood frequencies at the dam and powerhouse sites are summarized in **Exhibit 4.40**. Median values of hydrology parameters of ecological importance are presented in **Exhibit 4.41**. These are calculated via DRIFT (for details see **Environmental Flow Assessment Report** in **Volume 2C** of the **EIA**).

Exhibit 4.39: Flow Exceedance Frequency at Dam Site

Exceedance Time (%)	*Driest Year (2001)*	*Wettest Year (1992)*	*Average Flow Year (1963)*	*Mean Daily Flows (1960-2010)*	*All Daily Flows (1960-2010)*
100	11.4	18.1	16.8	19.6	6.5
90	13.7	23.5	19.1	20.9	19.4
80	16.7	30.4	23.7	23.6	23
70	20.8	55.8	28.3	28.3	27.3
60	23.8	68.2	34.1	37.1	34.3
50	31.1	108.3	41.6	50.3	48.6
40	40.1	143.5	70.5	78.3	73
30	55.4	172.2	112.8	120.6	108.4
20	73.6	218.1	150.2	171.1	154.5
10	104.7	274.4	232.1	221	215.9
–	182.3	1388.6	331.1	252.1	1388.6

Exhibit 4.40: Flood Frequency

Return Period (Years)	*Floods at Project Dam Site (m^3/s)*	*Floods at Project Powerhouse Site (m^3/s)*
2	414	447
5	752	813
10	1,060	1,146
50	1,887	2,040
100	2,280	2,466

Return Period (Years)	*Floods at Project Dam Site (m^3/s)*	*Floods at Project Powerhouse Site (m^3/s)*
500	3,263	3,529
1,000	3,714	4,016
10,000	5,312	5,745
Probable Maximum Flood	5,702	

Exhibit 4.41: Hydrology Parameters of Ecological Importance in Low Flow Section

Parameter	*Baseline Value*
Mean annual runoff (m^3/s)	90.5
Dry: minimum 5-day discharge (m^3/s)	17.4
Wet season: peak 5-day discharge (m^3/s)	319.6
Dry season: onset (calendar week)	43
Wet season: onset (calendar week)	16
Dry season: duration (days)	175
Wet season: duration (days)	133

Community Water Supply Census

A census was carried out to map the community water resources for villages near Project facilities. A 500 m buffer around the underground headrace tunnel in the uphill direction and up till the Kunhar River in the downward direction was demarcated for the survey to account for the distance to which the impact of the tunnel on ground water might possibly extend. This area and the surveyed water resource infrastructure are shown in **Exhibit 4.42**. The complete census results are presented in **Appendix D.**

Methodology and Sampling Locations

During the census, mountain springs were documented. The location and water quality at the origin of the spring was noted. The following key information was collected at each water source:

- Spring location (village name, neighborhood (if applicable) and geographical coordinates
- Ground elevation with respect to datum (mean sea level) to the accuracy of the GPS
- Spring usage:
  - Approximate water extraction rate
  - Approximate number of users
  - Water extraction method

- Basic chemical parameters (measured on site): pH, electrical conductivity (EC) and temperature
- Time and date of measurement
- Pictures

Results and Analysis

A total of 70 springs were identified and characterized within the hydrocensus area. Of the 70 springs, 1 went dry completely and did not used after the 2005 earthquake.

Small tanks are typically built around springs to store water, and act as constant head for water supply pipelines, or such that communities can manually draw water from the tank. Images depicting the water infrastructure are shown in **Exhibit 4.43**.

A detailed summary of the results is provided in **Exhibit 4.44**. Based on the pH and electrical conductivity, the water is fresh and potable.

The total number of households relying on the springs within the area covered by the hydrocensus is 1,905. The springs are the sole supply for the majority of households for potable water. 50% of active water sources are used to supply drinking water to livestock as well. This is in line with the socioeconomic surveys and discussions during the surveys across the Study Area, where it was reported the drinking water supply is largely, given some exceptions, from springs, and, given some exceptions, the livestock do not typically venture close to the river to drink river water, and are therefore, also reliant on spring water.

During the 2005 earthquake, the drinking water supply infrastructure for many communities within the Study Area, largely dependent on springs, was damaged. The communities reported that some springs also dried up after the earthquake.

Exhibit 4.42: Hydrocensus Locations

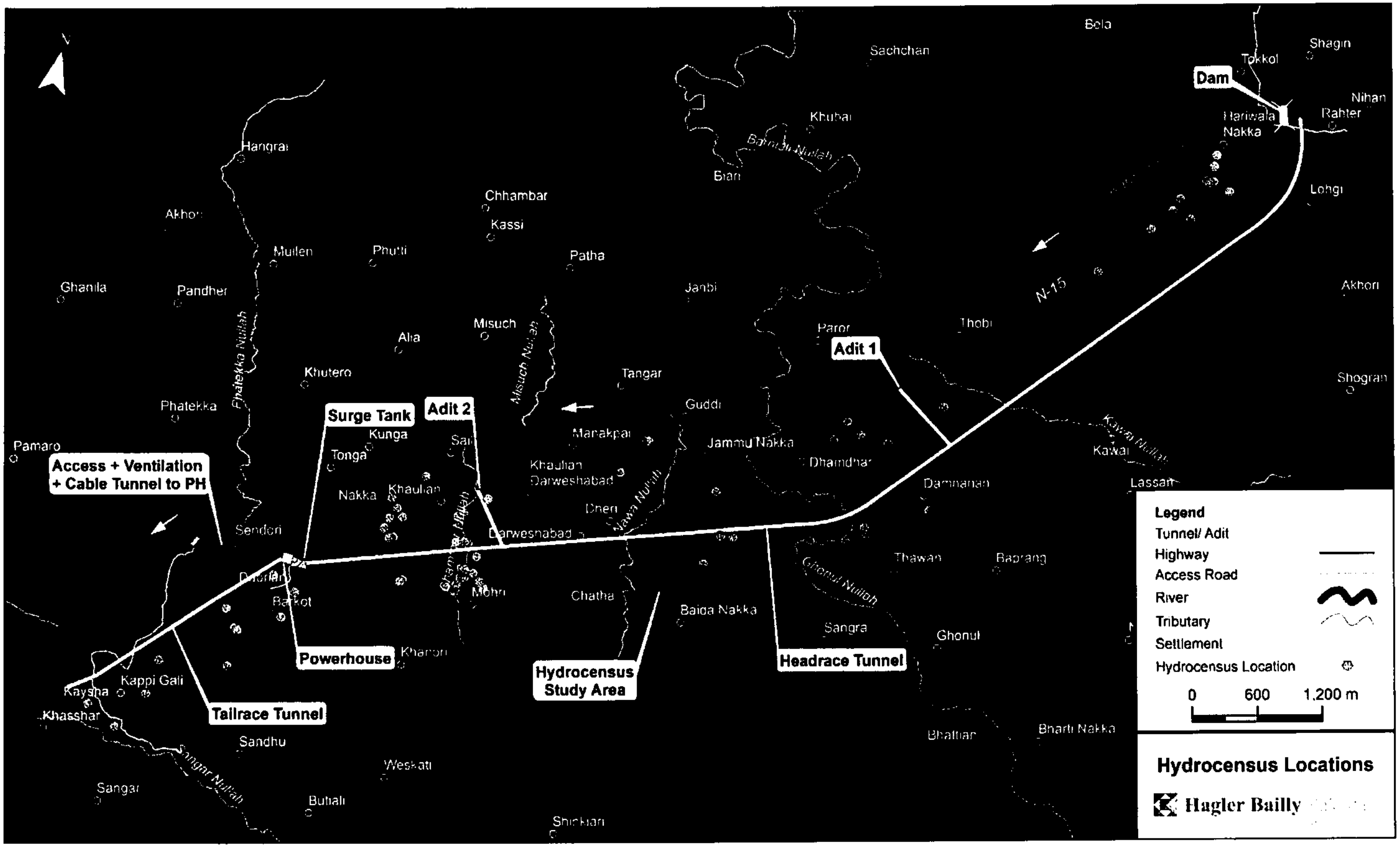
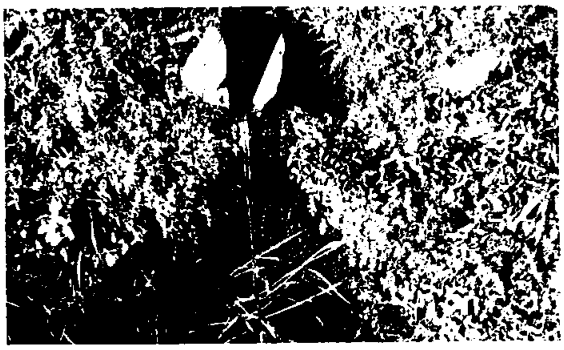


Exhibit 4.43: Photographs of Water Resource Infrastructure


Spring outlet at S-98


Spring outlet and collection structure at S-4


Spring outlet and collection structure at S-94


Spring outlet and collection structure at S-5


Free flowing spring at S-7


Spring outlet and collection structure at S-10

Exhibit 4.44: Summary of Mountain Spring and Borehole Census Results

Parameter Group	*Parameter*	*Value*
Number Surveyed	Mountain Springs	70
Status	Active	68
Elevation (m amsl)	Inactive	2
	Minimum	1,126
	Mean	1,413
	Median	1,392

Parameter Group	*Parameter*	*Value*
	Maximum	1,807
pH	Minimum	7.3
	Mean	8.0
	Median	8.1
	Maximum	8.5
Electrical Conductivity (µS/cm)	Minimum	222
	Mean	349
	Median	344
	Maximum	505
Temperature (˚C)	Minimum	12.0
	Mean	16.9
	Median	17.0
	Maximum	23.0
Average age of spring	Pre-1950 (i.e. more than 67 years)	72%
	Pre-2005 earthquake (i.e. between 67 and 12 years)	24%
	Post 2005 earthquake (i.e. less than 12 years)	1%
	Age not available	3%
Water use	Human drinking	77%
	Human other uses	66%
	Livestock use	50%
Household water usage (L/day) *Not counting dry springs*	Minimum	-
	Mean	252
	Median	200
	Maximum	1,000
Households using water (households per spring)	Minimum	-
	Mean	28
	Median	8
	Maximum	500
Livestock water use (livestock per spring	Minimum	-
	Average	32
	Median	6
	Maximum	200
Extraction method (# of springs)	Manual	31
	Pipe	44
	Both Manual and with Pipe	7
	Motor	0

Note: The analysis also includes springs that flow only during selected months of the year

Demand for River Water for Other Uses

River water is not used for irrigation as the slopes on the river bank are steep, cost of pumping water to agricultural lands located at elevations above the river is high, and agriculture depends on rain and water available from streams flowing down the mountain slopes. There is no large or medium scale industry that depends on water, and level of industrialization is very low. River water is not suitable for drinking as it is contaminated by fecal coliform, and communities use water from springs for drinking purposes. Livestock is also mainly dependent on spring water and water from open mountain streams flowing down the slopes. River water can be turbid in seasons, and use of river water by livestock is limited to a relatively small fraction of total households that are located close to the river. These uses are insignificant in comparison to the total flow of the river. Quantification of river water use was therefore not considered to be necessary. Identifications of community sources of drinking water, mainly springs, that could be potentially impacted by the project was carried out in detail and is described in the previous section.

Water Quality

Water quality samples from Kunhar River and community springs were collected and analyzed for establishing baseline conditions for surface and groundwater.

Methodology and Sampling Locations

A total of seven samples and two quality control duplicates were collected and analyzed. Of these, four surface water samples were collected and analyzed from different sections of the Kunhar River and one from a main tributary. Two were collected from community springs located along the headrace tunnel of the Project. **Exhibit 4.45** describes the sample locations and rationale for their selection. The locations are shown in **Exhibit 4.46**. The detailed methodology adopted for sample collection is presented in **Appendix E**.

Water was sampled in February and April. Samples taken in February were sent to SUPARCO Water for metals and HBP Lab for the remaining parameters, whereas samples collected in April were sent to ALS Malaysia for metals, Excel Labs Islamabad for microbiology and HBP Lab Islamabad for the remaining parameters. On-site water quality testing was also carried out with the hand-held meters for pH, conductivity, temperature and dissolved oxygen.

Results and Analysis

The results of the river water quality analysis are summarized in **Exhibit 4.47**. The complete results are given in **Appendix E**.

Key observations on the basis of the results are as follows:

- All the water quality parameters (with the exception of microbiology) are within NEQS and WHO drinking water standards.
- All river and tributary water samples were found bacteriologically contaminated and unsatisfactory for drinking due to fecal contamination. Of the two springs

tested, one contained bacteriological contamination while the other was satisfactory for drinking.

- Fifteen metals were analyzed for metal content at each sampling location. Results of the analyzed metals are found within permissible levels for drinking water NEQS. However, reported aluminum value at location W4 is highest among all samples and is exceeding both the NEQS and WHO standards. This can be attributed to higher colloidal particles in river water.
- No major differences were found within the water quality at all sampling locations.

Exhibit 4.45: Sampling Locations for Surface and Groundwater Quality

ID	*Coordinates*	*Description*	*Notes and Justification*	*Dates of Sampling*
W1	33° 39' 38.1"N 73° 28' 18.1" E	Upstream of Project Dam, Kunhar River	Background river water conditions	Feb. 28, 2017
W2	34° 35' 02.3" N 73° 21 44.0" E	Near Sangar village, Kunhar River	Kunhar River before Balakot town (upstream Balakot)	Feb. 28, 2017
W3	34° 29' 12.9" N 73° 21' 20.9" E	Near Tarana village, Kunhar River	Kunhar River after Balakot town (downstream Balakot)	Feb. 28, 2017
W4	34° 26' 38.6" N 73° 21' 32.0" E	Talhatta gauging station, Kunhar River	Reported use of river water by local residents	Apr. 14, 2017
W5	34° 37' 54.0" N 73° 26' 34.1" E	Kawai Nullah	Tributary water quality baseline conditions	Apr. 14, 2017
W6	33° 37' 47.6" N 73° 25' 45.8" E	Community spring near Kawai	Spring water quality along headrace tunnel	Apr. 14, 2017
W7	33° 35' 36.6" N 73° 22' 22.4" E	Community spring near Kappi Gali	Spring water quality along headrace tunnel	Apr. 14, 2017
W8	33° 37' 47.6" N 73° 25' 45.8" E	Duplicate of W6	Quality control sample	Apr. 14, 2017

Exhibit 4.46: Water Quality Sampling Locations

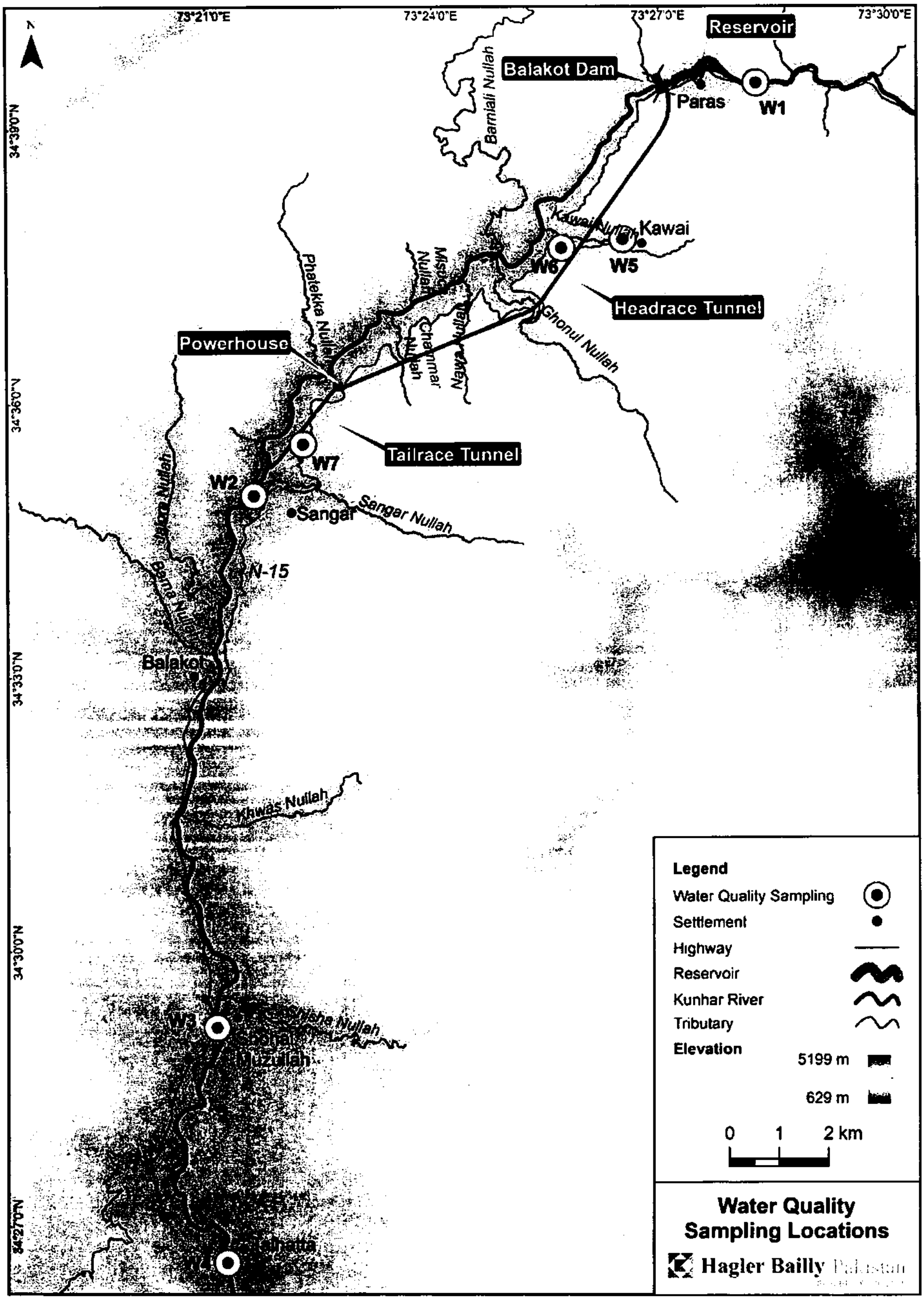


Exhibit 4.47: Water Quality Test Results

Parameter	*Unit*	*LOR*	*WHO Guideline*	*NEQS for Drinking Water*	*W1*	*W2*	*W3*	*W4*	*W5*	*W6*	*W7*	*W8*
Field Tests												
Temperature	°C	1	–	–	7.5	8.2	9.2	14.8	14.8	14.5	18.5	14.5
DO	mg/l	0.1	–	–	11.2	11.5	11.5	10.7	9.6	7.6	7.8	7.6
EC	µS/cm	1	–	–	260	312	285	218	348	472	363	473
General Parameter												
TDS	mg/l	10	<1,000	<1,000	194	218	208	130	178	322	206	323
pH		0.1	6.5 – 8.5	6.0 – 8.5	8.2	8.4	8.5	8.2	8.5	7.5	8.2	7.5
TSS	mg/l	4	–	–	–	43.5	40.5	107	15	<4	<4	<4
BOD	mg/l	5	–	–	<5	<5	<5	5.3	5.6	<5	<5	<5
COD	mg/l	5	–	–	<5	<5	5.3	10.4	11.8	<5	<5	<5
Turbidity	NTU	0/0.01*	<5	<5	1.66	4.83	4.72	15	6	4	6	4
Nitrate	mg/l	0.1/0.01*	50	50	0.025	0.047	0.053	0.28	0.23	<0.1	<0.1	<0.1
Phosphate	mg/l	0.1/0.02*	–	–	<0.02	<0.02	<0.02	<0.1	<0.1	<0.1	<0.1	<0.1
Metals (Total) and Major Cations												
Aluminum	µg/L	1	200	200	37	82	95	220	74.2	18.1	3.6	18.1
Antimony	µg/L	1	20	5	<1	<1	<1	<1	<1	<1	<1	<1
Arsenic	µg/L	1	10	50	<1	6	5	1.2	3	<1	7.9	<1
Barium	µg/L	1	700	700	7	15	18	27.9	87.3	38.8	300	36.8
Boron	µg/L	1	300	300	11	19	16	<1	4.7	16.3	<1	14.7
Cadmium	µg/L	1	3	10	<1	<1	<1	<1	<1	<1	<1	<1

Parameter	*Unit*	*LOR*	*WHO Guideline*	*NEQS for Drinking Water*	*W1*	*W2*	*W3*	*W4*	*W5*	*W6*	*W7*	*W8*
Chromium	µg/L	1	50	50	<1	5	8	1.2	<1	<1	<1	<1
Lead	µg/L	1	10	50	<1	<1	<1	1	3.3	<1	<1	<1
Manganese	µg/L	1	500	500	<1	21	24	79.3	10.2	<1	<1	<1
Mercury	µg/L	1	1	1	<1	<1	<1	<1	<1	<1	<1	<1
Nickel	µg/L	1	20	20	<1	7	9	3.5	<1	<1	<1	<1
Silver	µg/L	1	–	–	7	9	10	<1	<1	<1	<1	<1
Tin	µg/L	1	–	–	–	–	–	<1	<1	<1	<1	<1
Selenium	µg/L	1	10	10	<1	<1	<1	–	–	–	–	–
Zinc	mg/l	0.1	3	5	–	–	–	<0.1	<0.1	<0.1	<0.1	<0.1
Microbiology												
MPN of Coliforms:	No./100 ml			–	–	–	–	–	18+	1+	18+	1+
MPN of E.Coli	No./100 ml			–	–	–	–	–	18+	0	18+	0

Note:

LOR = Level of Reporting, DO = Dissolved Oxygen, EC = Electrical Conductivity, TDS = Total Dissolved Solids

TSS = Total Suspended Solids, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand, MPN = Most probable number

mg/l = milligram per liter, µg/L = microgram per liter, NTU = Nephelometric Turbidity Unit µS/cm = microsiemen per centimeter

" – "means that standards are not defined for this parameter or the parameter was not analyzed, * First LOR is for W1, W2 and W3. Second LOR is for remaining samples

4.1.8 Ambient Air Quality

This section describes the current ambient air quality in the area where Project activities are proposed.

The pollutants selected for evaluation, based on the expected emissions from the Project activities and the level of risk to human health posed by these pollutants, are as follows:

- Sulfur dioxide (SO_2)
- Oxides of Nitrogen (NO_x)—Mainly Nitrogen dioxide (NO_2) and Nitric oxide (NO)
- Respirable particulate matter—Coarse (PM_{10})[8] and Fine ($PM_{2.5}$)[9]

Emission Sources

There are two main sources of emissions in the Study Area, which are discussed below.

1. **Wood/Liquefied Petroleum Gas (LPG) burning**. Wood burning and LPG are used for cooking and heating. Due to the incomplete combustion in the primitive stoves wood is a significant source of PM_{10}, $PM_{2.5}$ whereas combustion of LPG is a significant source of NO_x but both sources also results in SO_2 emissions.
2. **Traffic**. Combustion of petrol and diesel is a source of NO_x and SO_2 emissions with diesel burnt in heavy transport vehicles is the main source of SO_2. Vehicle exhaust result in $PM_{2.5}$ emissions whereas tire movement, especially on tracks and unsealed road result in dust emissions (PM_{10} and $PM_{2.5}$).

Methodology and Sampling Locations

Air quality sampling was carried out at four different locations in the Study Area between March 19 and May 8, 2017. A description of sampling locations and the rationale of selection is given in **Exhibit 4.48**. The sampling locations, along with nearby settlements and roads are shown in **Exhibit 4.49**. The detailed methodology is provided in **Appendix F**.

Exhibit 4.48: Details of Air Quality Sampling Locations

Sample ID	*Coordinates*	*Location*	*Rationale for Site Selection*
A1	34° 39' 41.3" N 73° 27' 39.2" E	Paras	Near proposed labor camp in Paras
A2	34° 39' 01.1" N 73° 26' 30.9" E	Hariwala Nakka	Near proposed dam site
A3	34° 36' 18.2" N 73° 22' 57.6" E	Nalla	Near proposed powerhouse site
A4	34° 32' 57.2" N 73° 21' 17.1" E	Balakot	Near proposed labor camp in Sangar
A5	34° 39' 41.3" N 73° 27' 39.2" E	Paras	duplicate of A1

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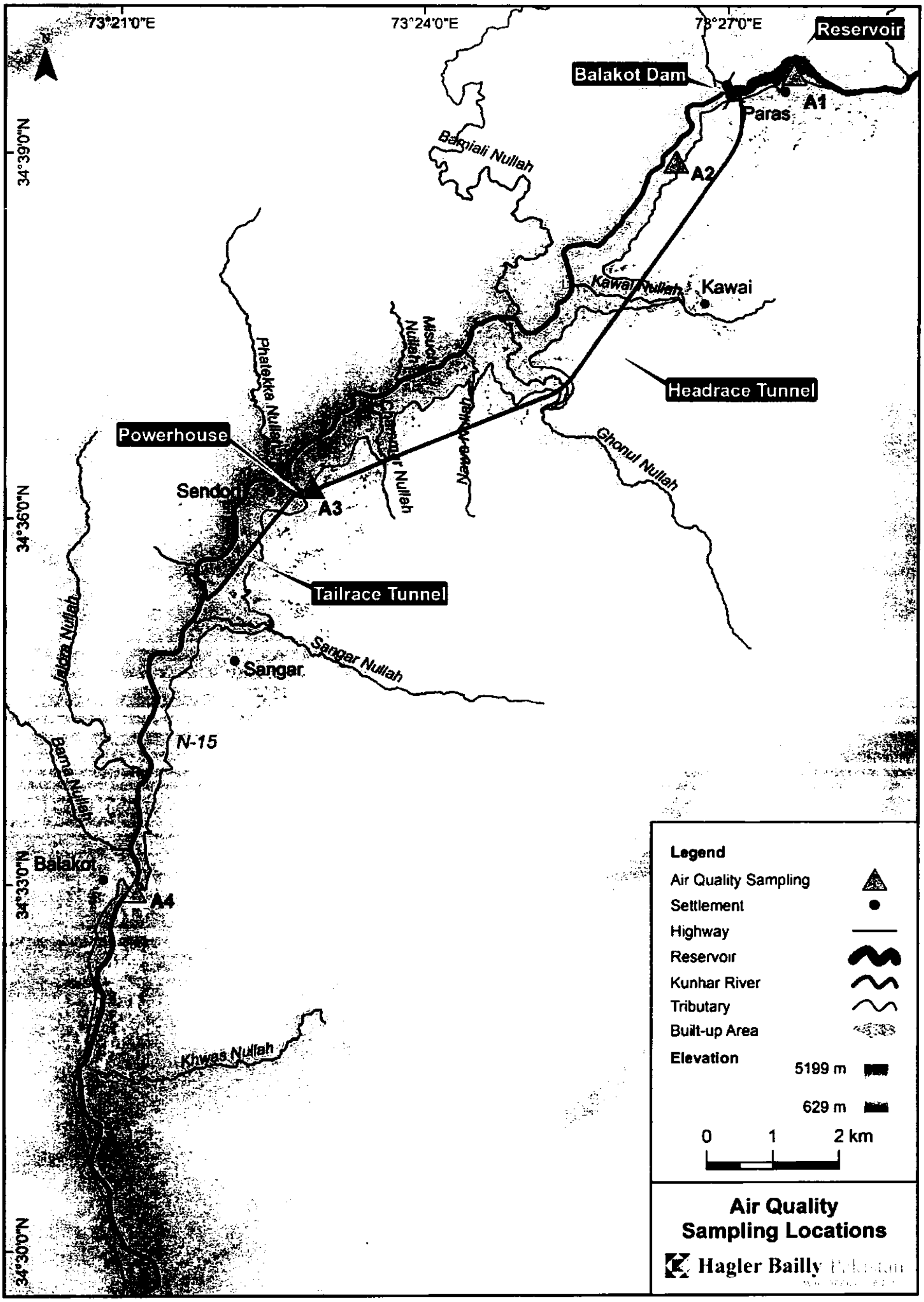
[8] PM_{10} is particulate matter 10 micrometers or less in diameter

[9] $PM_{2.5}$ is particulate matter 2.5 micrometers or less in diameter

Exhibit 4.49: Air Quality Sampling Locations



Results

The air quality sampling results are summarized in **Exhibit 4.50** and the values exceeding the NEQS and IFC-EHS limits are highlighted. The complete results are produced in **Appendix F**.

Exhibit 4.50: Results of Ambient Air Quality Sampling (µg/m^3)

Sample ID	*NO_x*	*NO_2*	*NO**	*SO_2*	*PM_{10}*	*$PM_{2.5}$*
LOR	0.033 µg of NO_x	0.01 µg of NO_2	-	0.03 µg of S	100 µg	100 µg
A1	6.9	6.1	0.8	1.8	104.7	65.2
A2	2.0	2.1	**	<1.3	78.6	52.4
A3	5.2	3.0	2.2	1.4	117.8	65.4
A4	16.8	13.8	3.0	20.1	130.9	78.5
A5 (duplicate of A-1)	7.1	5.6	1.5	<1.2	–	–
A6 (field blank)	1.5	0.4	1.1	<1.2	–	–
NEQS (annual)	**100*****	**40**	**40**	**80**	**120[a]**	**15[a]**
NEQS (24-hour)	**140*****	**80**	**40**	**120**	**150**	**35**
IFC (annual – interim target 1)	**–**	**–**	**–**	**–**	**70[a]**	**35[a]**
IFC (24-hour – interim target 1)	**–**	**–**	**–**	**125**	**150**	**75**

Note:

a: annual does not apply to particulate matter data reported above

"–" means either the data is not available or the standard is not defined.

* NO results are derived by subtracting NO_2 from NO_x.

** Where nitric oxide (NO) results have not been calculated result for NOx was lower than result for NO_2.

*** Standards for NO_x are not defined and calculated in terms of NO_2. NO_x annual standard = annual standard of NO_2 + 1.5 × annual standard of NO. Same is for 24-hour standards.

The following analysis of results are presented:

- The annual and 24-hour concentrations of SO_2, NO_x, NO_2 and NO comply with both the NEQS and IF-EHS limits. This leaves a wide room to incorporate emissions of the proposed Project. The maximum levels of SO_2, NO_x, NO_2 and NO are 20.1, 16.8, 13.8 and 3.0 µg/m^3, respectively observed at A4 (Balakot town). This is mainly due to the high traffic in the town and concentrated use of LPG and wood for domestic purposes.
- The 24-hour PM_{10} concentration comply with both the NEQS and IFC-EHS limits at all sampling locations. The 24-hour $PM_{2.5}$ concentration exceeds the NEQS at all sampling locations however, it complies with IFC-EHS interim target 1 at all locations except at A4 (Balakot town) where it exceeds both the NEQS and IFC-EHS limits. The highest readings of PM_{10} and $PM_{2.5}$ were recorded at A4 (Balakot town) along N-15 highway.

- The concentration of all pollutants at A2 (near dam site) are lowest among all sampling locations. A2 is mainly contributed by natural sources and is dominated by forest. The nearest settlement is about 780 m away from A2.

4.1.9 Traffic

Traffic baseline is prepared to assess the current traffic conditions on the road route that will be used for the Project related transportation of services during construction and operation of the Project. The objectives of the traffic study are to document present traffic situation, identify existing road capacity, bottle necks (congestion points) and potential impacts due to the Project traffic during construction and operation.

Transportation Route

The transport route for the Project is described in **Section 3**. A discussion on the possible alternate routes and the reason for the selection of this route is given in **Section 5**

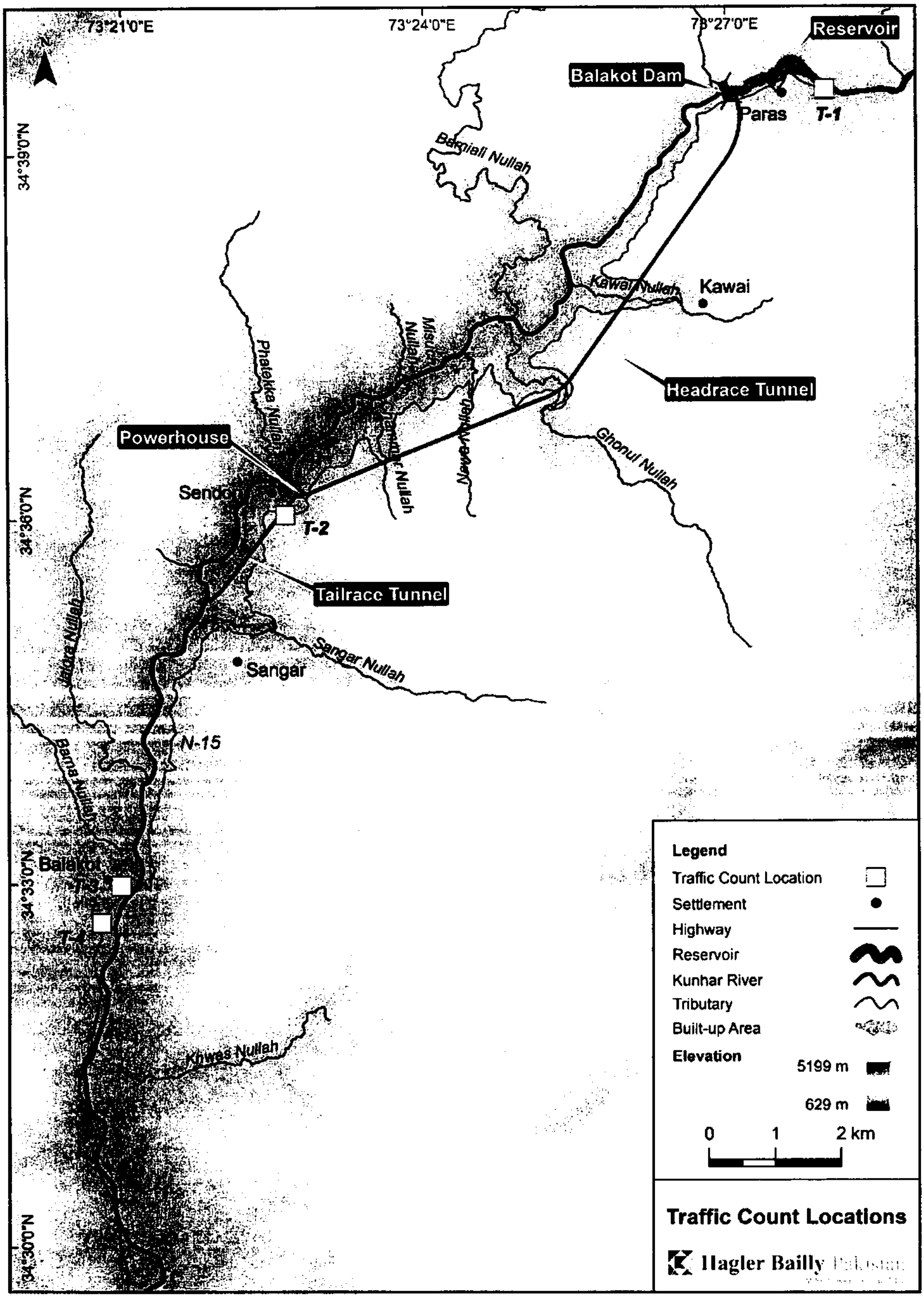
Methodology and Sampling Locations

Traffic counts were conducted at four locations listed in **Exhibit 4.51** and shown in **Exhibit 4.52.** A team of qualified surveyors was selected and a pilot count was conducted before the actual survey. At the counting site, two people were stationed for daytime and two for nighttime to separately count the daily traffic in both directions. The traffic count was recorded over a 24-hour period on a weekday (May 4, 2017) and a weekend (May 7, 2017).

Exhibit 4.51: Traffic Count Locations

ID	*Coordinates*	*Location*	*Rationale*
T1	34° 39' 39.1" N 73° 27' 57.8" E	Paras	Traffic at dam and reservoir site.
T2	34° 36' 06.8" N 73° 22' 52.5" E	Sendori	Traffic at powerhouse site.
T3	34° 33' 01.8" N 73° 21' 11.7" E	Balakot market	Traffic in Balakot town
T4	34° 32' 42.1" N 73° 20' 55.2" E	Balakot	Traffic in Balakot town

Exhibit 4.52: Traffic Count Locations



Passenger Car Equivalent (PCE) or Passenger Car Unit (PCU) is a metric unit used to assess traffic-flow rate.[10] PCU, is a measure of the relative space requirement of a vehicle compared to that of a passenger car under a specified set of roadway, traffic and other conditions. The value assigned to each of the classification of the vehicles may depend on a number of factors such as:

- dimensions, power, speed, acceleration and braking characteristics of the vehicle;
- road characteristics such as geometrics including gradients, curves, access controls, type of road: rural or urban, presence and the type of intersections;
- transverse and longitudinal clearances between vehicles moving on road, which in turn depends upon the speeds, driver characteristics and the classes of other moving vehicles;
- environmental and climatic conditions and;
- Traffic control methods, speed limits, and barriers.

The PCU for different classes of vehicles are not defined universally, however, the values used here are typical for Pakistani road conditions. The PCUs are calculated on the basis of traffic counts. **Exhibit 4.53** shows PCU factor for each vehicle.

Exhibit 4.53: Two-Way Traffic at each Traffic Count Location

Vehicle	*PCU Factor*
Motorcycles	0.50
Auto rickshaws	0.75
Cars (sedans)	1.00
Jeeps/Pickups	1.25
Mini Bus	1.50
Bus	2.00
Truck – 2 axle	2.50
Truck – 3 axle	3.00
Truck – 4 axle	3.50
Truck – 5 axle	4.00

Results and Analysis

The summary of the two-way traffic count at the sampling locations is presented in **Exhibit 4.54**. The hourly traffic volume is graphed in **Exhibit 4.55** for weekday and in **Exhibit 4.56** for the weekend. Detailed data is included as **Appendix G**. Key findings are presented below:

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[10] Ahuja, Amanpreet Singh (2004). *Development of passenger car equivalents for freeway merging section*

- There was an increase in traffic on the weekends for points T1 (about 25 to 30% more vehicles) and T2 (50% increase in vehicles heading to Balakot town) as they are on the transit route to tourist locations.
- Although the morning peak (9 am) shows a significant drop on the weekends at T3 and T4 (from 700-800 vehicles to 500-600 vehicles), the traffic volumes are still generally higher on the weekend with steady flows throughout the day.
- According to the police check post near T1 the traffic increases between 20 to 25 times the measured traffic during the peak tourist season months of June and July due to transit traffic going on to Naran, Kaghan and beyond.

Exhibit 4.54: Two-Way Traffic at each Traffic Count Location (Non-Season)

Summary	*Traffic point*	*Day Type*	*Bikes*	*Cars*	*Pick-up*	*Buses*	*Truck*	*Tractor/ Trailer*	*Total*	*%LTV*	*%HTV*	*Total PCUs*
Paras to Kaghan	T1	Weekday	100	647	427	18	144	2	1,338	88%	12%	1,637
		Weekend	189	775	521	31	151	3	1,670	89%	11%	1,976
Kaghan to Paras	T1	Weekday	98	623	384	8	133	9	1,255	88%	12%	1,538
		Weekend	149	846	466	30	160	1	1,652	88%	12%	1,969
Sendori to Paras	T2	Weekday	96	493	422	26	119	1	1,157	87%	13%	1,425
		Weekend	149	600	389	21	96	8	1,263	90%	10%	1,478
Paras to Sendori	T2	Weekday	71	479	341	10	98	8	1,007	88%	12%	1,239
		Weekend	147	776	427	41	162	2	1,555	87%	13%	1,882
Balakot to Dabrian	T3	Weekday	1,407	2,129	809	34	121	9	4,509	96%	4%	4,257
		Weekend	1,625	2,462	1,195	57	199	29	5,567	95%	5%	5,506
Dabrian to Balakot	T3	Weekday	921	1,727	529	34	99	8	3,318	96%	4%	3,197
		Weekend	1,064	2,498	965	35	204	24	4,790	95%	5%	4,916
Balakot to Mansehra	T4	Weekday	696	1,927	499	50	82	7	3,261	96%	4%	3,244
		Weekend	753	2,549	846	60	130	12	4,350	95%	5%	4,482
Mansehra to Balakot	T4	Weekday	1,209	2,195	1,044	54	93	11	4,606	97%	3%	4,498
		Weekend	897	1,948	859	39	123	8	3,874	96%	4%	3,902

Exhibit 4.55: Weekday Hourly Traffic PCU

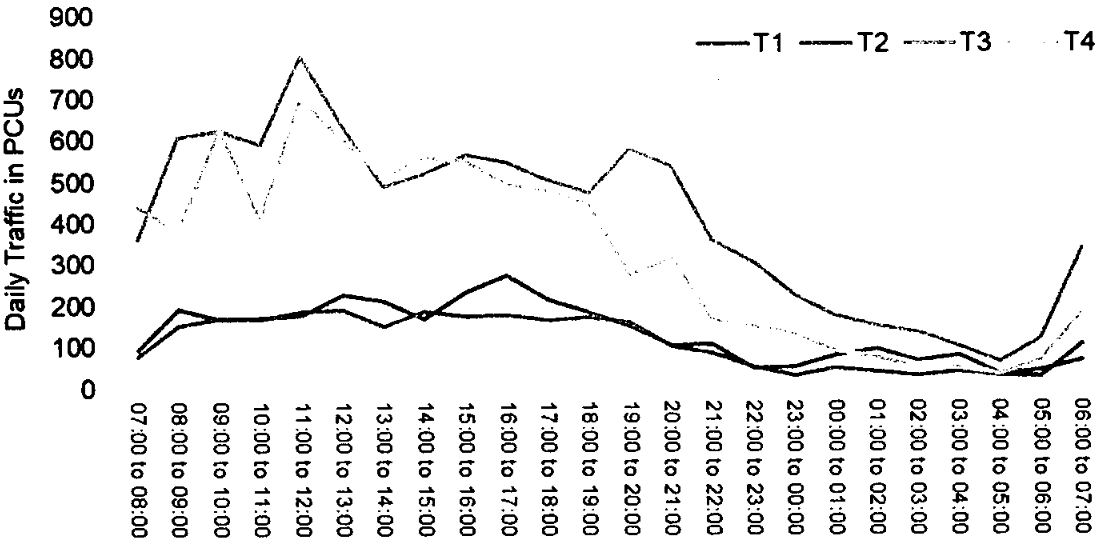
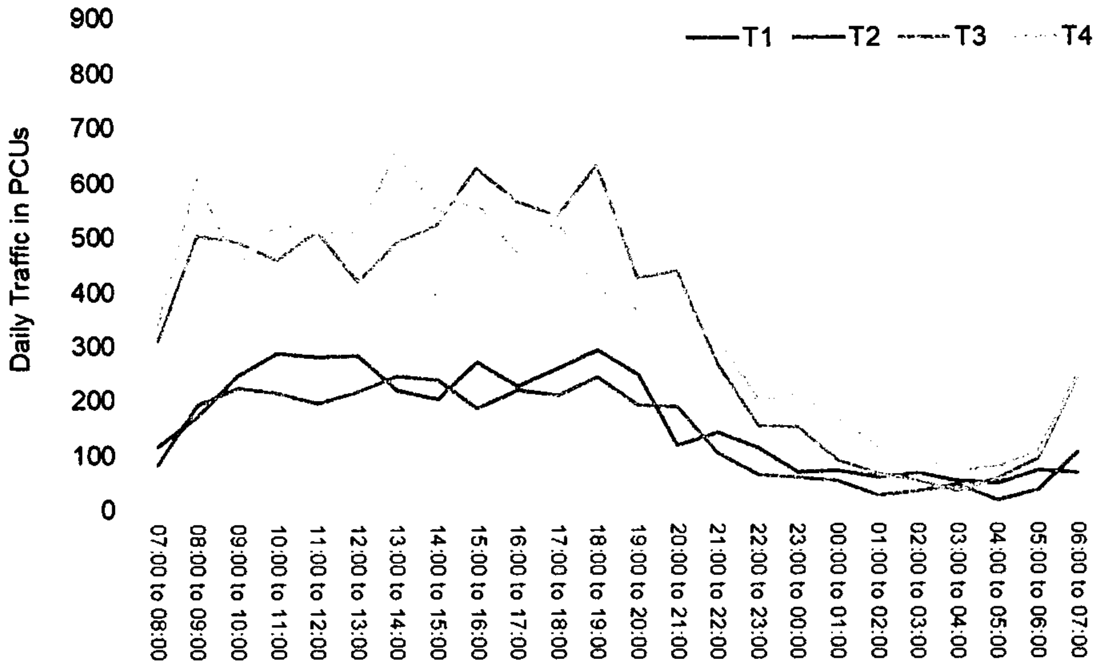


Exhibit 4.56: Weekend Hourly Traffic PCU



4.1.10 Noise Levels

This section defines the baseline ambient noise levels in the Study Area in a manner that can be used for the assessment of the noise impact of the proposed Project. Sound levels were measured at selected locations considered representative of the nearby receptors of possible noise pollution from the Project.

Noise is defined as a loud, undesired sound that interferes with normal human activities. If it affects the well-being of the surrounding community (environmental noise), it is considered a nuisance and normally has no direct health impacts. Exposure to very high noise levels (exceeding 85 dBA), particularly for prolonged period can cause hearing loss. This level of noise is usually encountered in the workplace around construction sites and is considered an occupational hazard.

In general, human sound perception is such that a change in sound level of 3 dB is just noticeable, a change of 5 dB is clearly noticeable, and an increase of 10 dB is perceived as a doubling of sound level.

The following is a brief description of terminology used in this assessment:

- *Sound*: A vibratory disturbance created by a vibrating object, which, when transmitted by pressure waves through a medium such as air, is capable of being detected by a receiving mechanism, such as the human ear or a microphone
- *Noise*: Sound that is loud, unpleasant, unexpected, or otherwise undesirable
- *Decibel (dB)*: A unitless measure of sound on a logarithmic scale, which indicates the squared ratio of sound pressure amplitude to a reference sound pressure amplitude. The reference pressure is 20 micro-pascals
- *A-Weighted Decibel (dB(A))*: An overall frequency-weighted sound level in decibels, which approximates the frequency response of the human ear. The typical human ear is not equally sensitive to all frequencies of the audible sound spectrum. As a consequence, when assessing potential noise impacts on people, an electronic filter is used that de-emphasizes certain frequencies in a manner corresponding to the human ear's decreased sensitivity to low and extremely high frequencies. All of the noise levels reported in this Section are A-weighted
- *Equivalent Sound Level (L_{eq})*: The equivalent steady state sound or vibration level, which in a stated period of time, typically one hour, would contain the same acoustical or vibration energy.

Methodology and Sampling Locations

Noise measurements were taken at four locations listed in **Exhibit 4.57** and shown in **Exhibit 4.59.**

Exhibit 4.57: Noise Sampling Locations

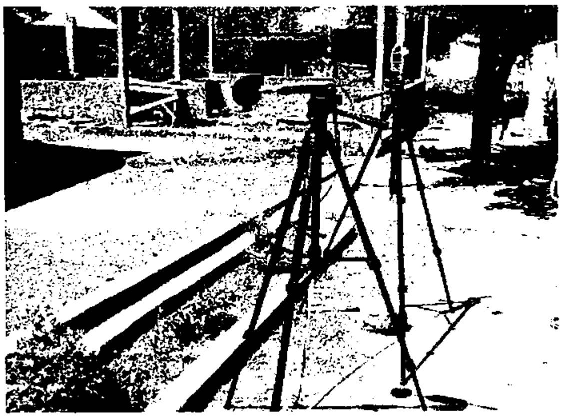
ID	*Location*	*Coordinates*	*Dates of Survey*	*Distance from River (m)*	*Elevation Difference from River (m)*	*Description*
N1	Paras	34° 39' 41.6" N 73° 27' 39.1" E	May 6 to 7, 2017	192	38	Small town, main road
N2	Powerhouse Site	34° 36' 10.1" N 73° 22' 42.7" E	May 4 to 5, 2017	576	201	Forest, main road
N3	Sangar	34° 34' 54.7" N 73° 22' 10.4" E	May 5 to 6, 2017	720	288	Small town, main road
N4	Balakot	34° 32' 44.3" N 73° 20' 56.0" E	May 7 to 8, 2017	210	19	Large town, main road

The noise levels were measured using portable Cirrus Research plc.'s sound level meter, Model CR:1720. The instrument meets the International standards IEC 61672-1:2002, IEC 660651:1979, IEC 60804:2001, IEC 61260:1995, IEC 60942:1997, IEC 61252:1993, ANSI S1.4-1983, ANSI S1.11-1986, and ANSI S1.43-1997 where applicable. The instruments have a resolution of 0.1 dB.

The meter was calibrated at the start of measurement at each site, using Cirrus Research plc.'s acoustic calibrator, Model: CR:514. The sound meter and calibrator were factory calibrated on September 28, 2015. The instrument was mounted on a tripod, to avoid interference from reflecting surfaces within the immediate neighborhood, and a wind shield was used in all measurements. Photographs of the sampling equipment setup are provided in **Exhibit 4.58.**

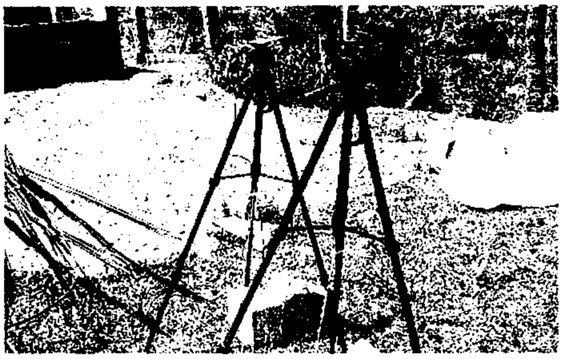
Noise readings were taken for 24 hours at each site between May 4 and May 8, 2017.

Exhibit 4.58: Noise Sampling Site Photographs



Sound meter at N1

Sound meter at N3



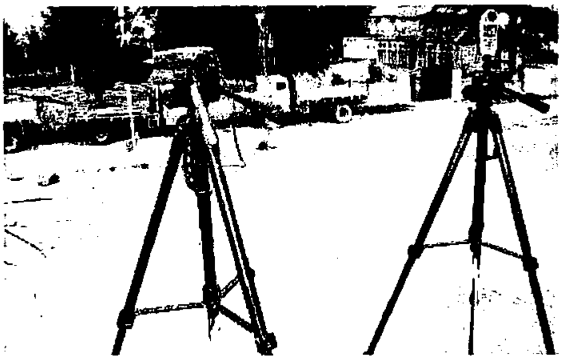
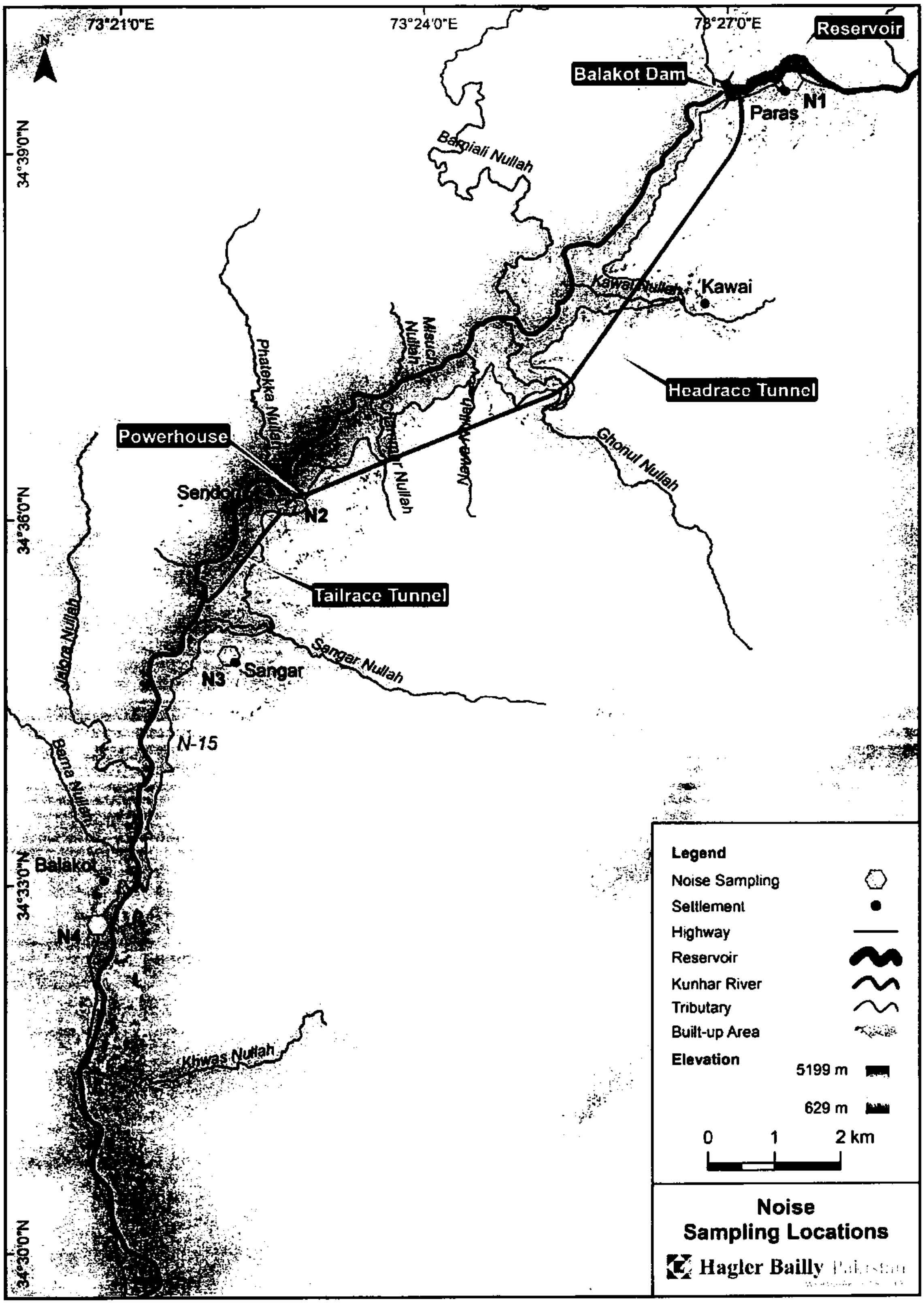


Exhibit 4.59: Noise Sampling Locations



Results

A summary of the results and NEQS are provided in **Exhibit 4.60.** L_{10} and L_{90} refer to percentile noise levels that are exceeded 10% and 90% of the time, respectively. The levels are calculated excluding the 10% upper and lower extreme ranges of the noise data. Hourly variations are captured in **Exhibit 4.61**. Weather data measured during the sampling exercise is given in **Exhibit 4.62.**

Exhibit 4.60: Summary Statistics of Sound Levels during the Survey

ID	*Location*	*24 hour (dBA)*				*Daytime*	*Nighttime*
		L_{10}	*L_{50}*	*L_{90}*	*L_{EQ}*	*L_{EQ}*	*L_{EQ}*
N1	Paras	46.0	46.6	44.8	49.5	44.4	41.6
N2	Powerhouse site	50.1	50.0	50.2	51.5	49.8	48.6
N3	Sangar	42.0	42.3	41.5	45.3	40.2	37.5
N4	Balakot	60.1	61.1	57.9	63.5	59.1	53.4
					NEQS Limits	**55**	**45**
					IFC Limit	**55**	**45**

Exhibit 4.61: Hourly Noise Levels

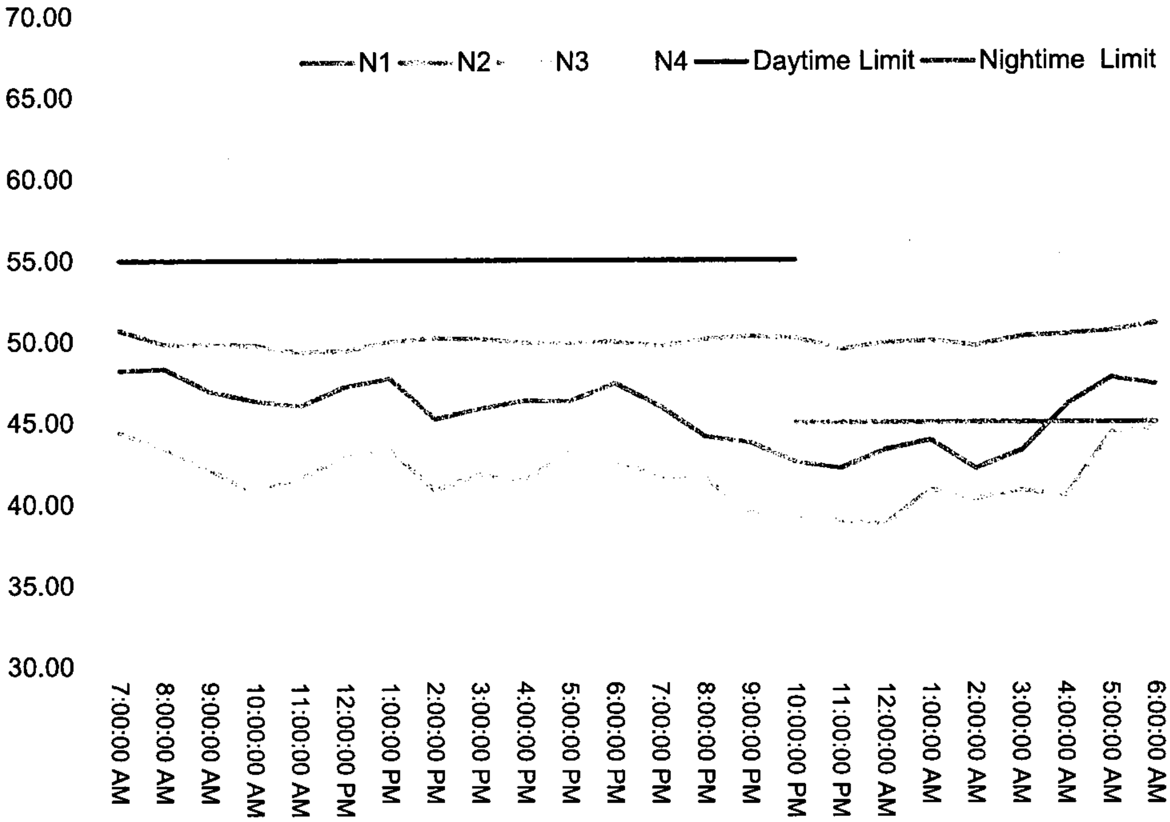


Exhibit 4.62: Weather Parameters during Noise Sampling

ID		*Temperature deg C*	*Wind Speed (m/s)*	*Relative Humidity (%)*	*Barometric pressure (mb)*
N1	Mean	23.6	0.2	49.4	870.6
N2	Mean	21.0	0.5	45.5	872.7
N3	Mean	21.0	0.5	45.5	872.7
N4	Mean	26.5	1.2	42.1	901.1

Small Town: Noise levels in both the small towns of Paras (N1) and Sangar (N3) are well within NEQS noise limits and within IFC-EHS limits for most hours other than early morning hours in Paras where the nighttime limits are crossed.

Large Town: The noise levels at N4, which was located within the market of Balakot Town were high and exceed both daytime and nightime NEQS and IFC-EHS limits. Natural sources such as wind (of which the speed went up to 5.4 m/s during sampling) and river noise may also have contributed to the high noise levels.

Forests: Noise levels at N2 are steady throughout the day and night at around 50 dbA as there are no varying antropogenic sources of noise in the area. Constant sources of noise include noise from the river and wind.

4.2 Ecology Baseline

The ecology baseline has been prepared to present the ecological conditions in the Project area.

4.2.1 Objectives and Scope

The baseline was prepared with the following objectives:

- Qualitative and quantitative assessment of terrestrial vegetation, periphyton[11], macro-invertebrates, fish, herpetofauna[12], birds and mammals.
- Identification of key species, their relative abundances and their conservation status.
- Compiling reports of wildlife sightings in the Study Area by the resident communities.
- Identification of any additional habitats, and microhabitats.
- Analysis to further develop the basis for evaluating the potential impacts of Project-related activities on the biodiversity, specifically identification and evaluation of critical habitats.

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[11] Aquatic organisms, such as certain algae, that live attached to rocks or other surfaces

[12] The reptiles and amphibians of a particular region, habitat, or geological period

4.2.2 Sources of Information

Sources of information for preparation of the ecological baseline included published literature and reports, and field surveys conducted for collection of data. The following report which provides ecological information collected recently in the proximity of Project area was consulted:

- Hagler Bailly Pakistan, March 20, 2017, Environment and Social Impact Assessment for Kohala Hydropower Project, Kohala Power Company (Pvt) Ltd
- Hagler Bailly Pakistan, September 2016, Biodiversity Strategy for Jhelum-Poonch River Basin – Preparatory Phase, Fish Surveys in Tributaries, for the International Finance Corporation

4.2.3 Study Areas

There are two types of ecological resources that are of concern, aquatic and terrestrial. Therefore, two types of Study Areas were defined, an Aquatic Study Area and a Terrestrial Study Area.

The Aquatic Study Area includes the stretch of the Kunhar River from Faridabad upstream of the Project to Bissian downstream of the Project. It was selected taking into consideration the maximum extent of impacts of the Project both upstream and downstream of it. The reservoir is expected to form along a stretch 2.8 km upstream of the dam. The Aquatic Study Area extends past the upstream end of the reservoir till just past Faridabad, to account for the maximum extent of the impact upstream of the reservoir. It extends downstream till Bissian, a location representative of the impacts of release from the tailrace tunnel. Approximately 10 km downstream of Bissian is the start of the reservoir of Patrind HPP, which has altered the riverine habitat and created a barrier downstream of the Project. The Aquatic Study Area also includes tributaries in this stretch but only those with a significant perennial flow that support breeding of fish are included. The Aquatic Study Area is shown in **Exhibit 4.63**.

The Terrestrial Study Area comprises a 1 km buffer around selected locations where Project-related facilities are to be located. Project-related activities will occur within the Project-related facilities. The flora and fauna within a 1 km radius of these activities is expected to be impacted by them. Sampling Locations were selected within all habitat types where Project facilities will be located. Sampling Locations were also selected at other sites in the Terrestrial Study Area, with representative sampling by proportion of habitat type. Scrub Forest makes up the highest percentage of the habitat in the Terrestrial Study Area followed by Pine Forest and Agriculture Area. **Exhibit 4.64** shows the Terrestrial Study Area.

Exhibit 4.63: Aquatic Study Area

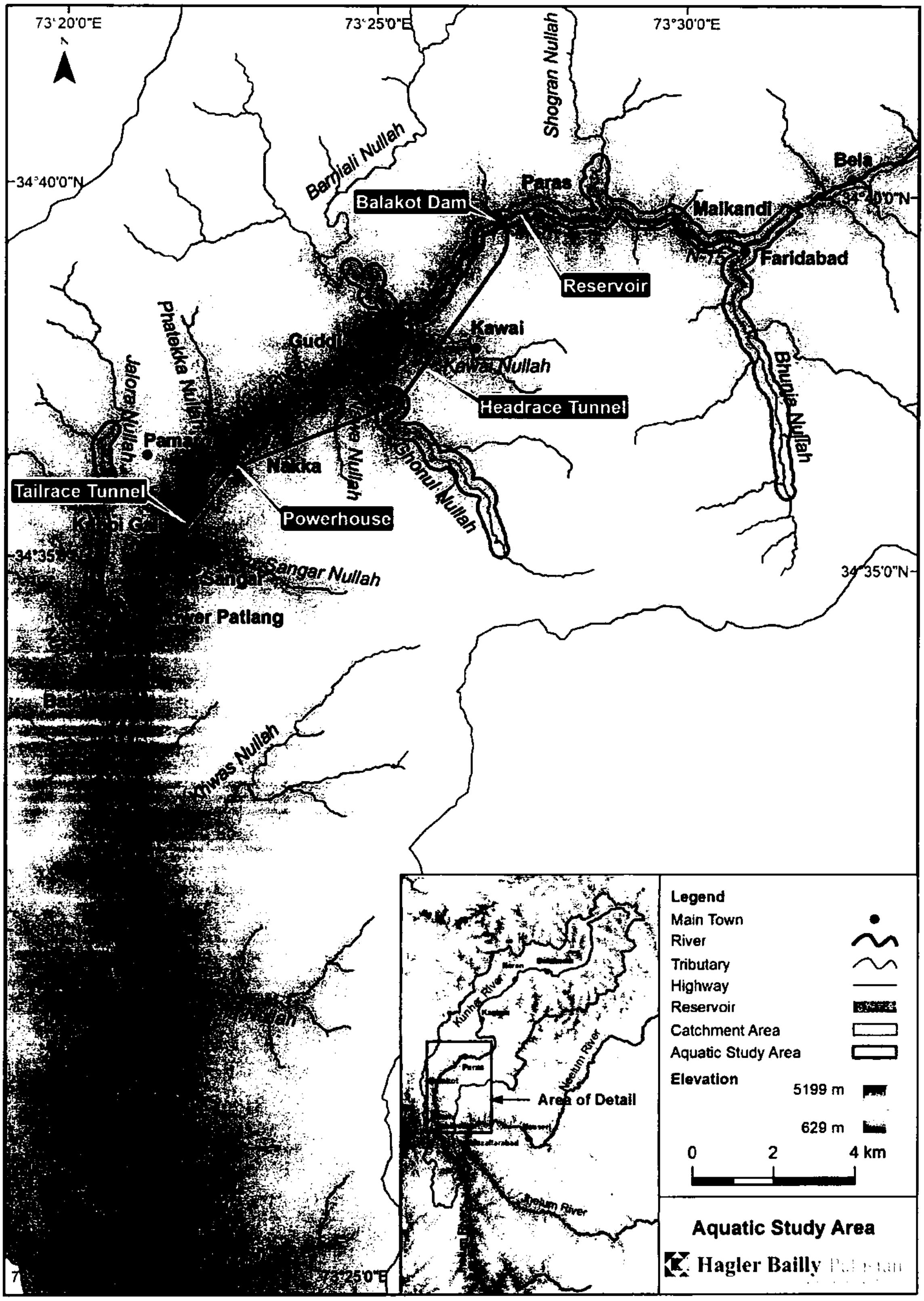
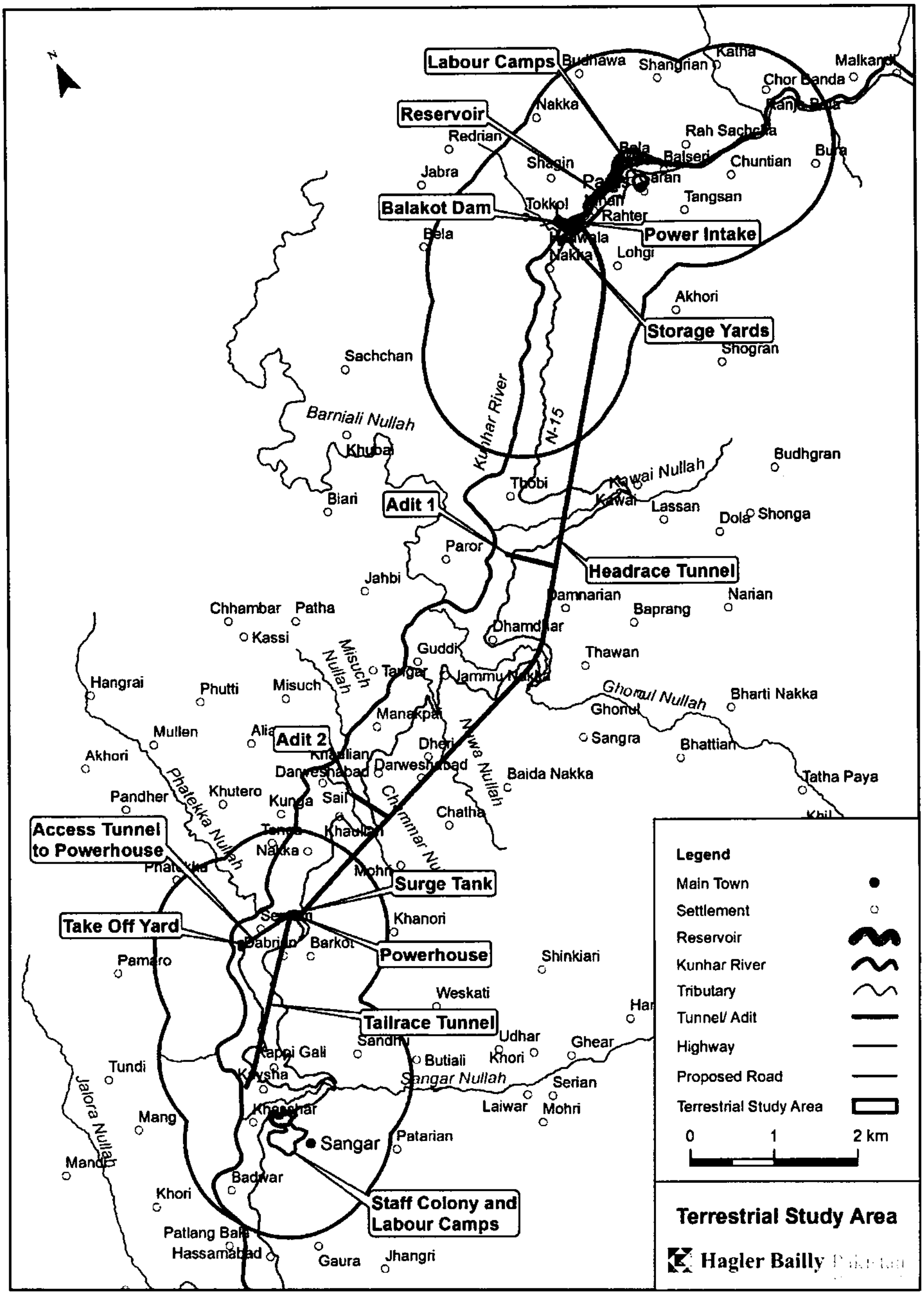


Exhibit 4.64: Terrestrial Study Area



4.2.4 Methodology

The field survey plan for data collection is provided in **Appendix H**. The methodology used for each biological resource is summarized below.

Surveys

The winter survey for fish fauna was carried out between February 24, 2017 and March 1, 2017. The spring survey for fish fauna was carried out between May 13, 2017 and May 16, 2017. The survey for terrestrial ecology was carried out between May 19, 2017 and May 23, 2017.

Representatives from the Fisheries Department, KP and the Wildlife Department, KP accompanied the teams to observe sampling. Photographs of staff from the Departments observing field sampling are provided in **Exhibit 4.65**.

Exhibit 4.65: Government Department Staff Observing Field Sampling, May 2017 Survey

Mr Qaiser Javed from Fisheries Department, KP observing samples collected for fish fauna

Mr Sarmad Shah, Sub-Divisional Forest Officer, Balakot, Wildlife Department, KP (extreme right) walking with the team to Sampling Location T8

Aquatic Ecology

Sampling for aquatic ecology was carried out for the following:

- Fish
- Macro-invertebrates
- Periphyton
- Riparian Vegetation

Sampling Locations

Sampling Locations for fish fauna, macro-invertebrates, periphyton and riparian vegetation are shown in **Exhibit 4.66**. The justification for the selection of these Sampling Locations is provided in **Exhibit 4.67**. The list of Sampling Locations in the tributaries is provided in **Exhibit 4.68.**

Fish

In the February 2017 Survey, sampling was carried out at the Sampling Locations shown in **Exhibit 4.66**. The sampling in May 2017 was also carried out at the same Sampling Locations. The methods for data collection included the use of two different types of nets, gill nets and cast nets, as well as electrofishing. Details of the use of each method are provided in **Appendix H**.

Statistical analysis was carried out to determine fish community structure and species diversity. The details of the application of these statistical methods is provided in **Appendix H**.

Macro-invertebrates

Macro-invertebrates sampling was conducted in the May 2017 Survey at the Sampling Locations shown in **Exhibit 4.66.**

The methods for sampling are described in **Appendix H**, along with details of how the samples were processed in the laboratory.

The data collected was used to generate information on the abundance of macro-invertebrates for each taxon.

Periphyton Biomass

Periphyton could not be collected during the February 2017 Survey. Sampling for periphyton was attempted in May 2017 Survey as well, however, periphyton was again not present due to the fast flow of the river, which erodes and washes out biomass on the cobblestones. The proposed Sampling Locations for both the February 2017 Survey and May 2017 Survey are shown in **Exhibit 4.66**. Methods for data collection and sample analysis are described in detail in **Appendix H**.

Exhibit 4.66: Sampling Locations for Fish, Macro-invertebrates, Periphyton and Riparian Vegetation

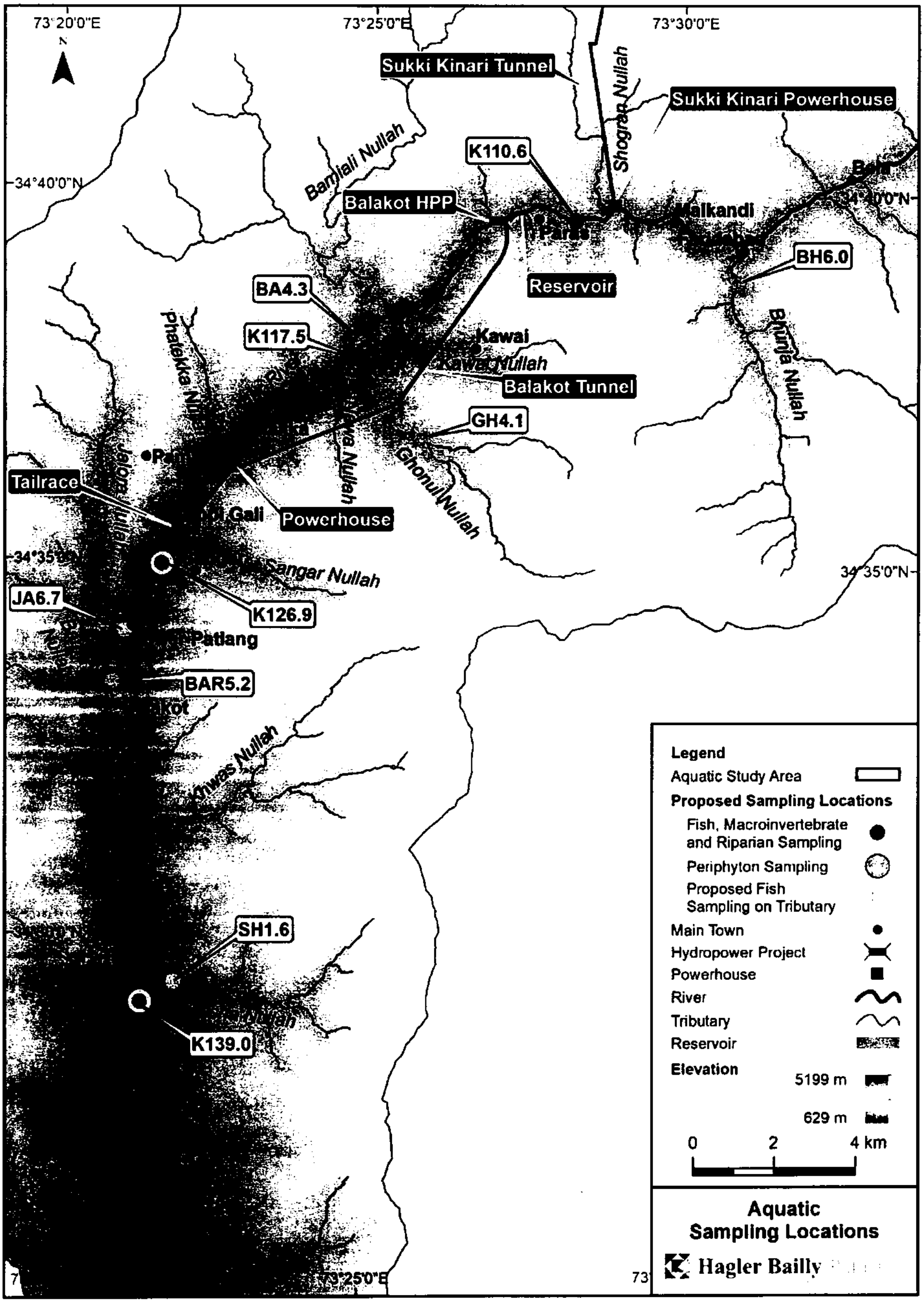


Exhibit 4.67: Justification for Selection of Sampling Locations on Main River

River Segment	*Sampling Location ID*	*Expected impacts from the Project*
Upstream of Dam	K110.6	This location is upstream of the reservoir of proposed dam and will be impacted by the barrier to migration created by the dam
Downstream of Dam	K117.5	This location will be impacted by the lower flows due to the diversion of the river flow into the power generation tunnel
Downstream of Diversion Tunnel	K126.9, K139.0	Both temperature and flow of water at this location will be impacted by variations in flow.

Exhibit 4.68: List of Sampling Locations for the Tributaries

Tributary (Local Name)	*Sampling Location ID*
Shogran Nullah	SH1.7
Bhunja Nullah	BH6.0
Barnialai Nullah	BA4.3
Makra Nullah	MA4.1
Barna Nullah	BAR6.7
Shisha Nullah	SH1.6

Riparian Vegetation

The methodology used for riparian vegetation is the same as that used for sampling of terrestrial flora. Sampling was carried out at the banks of all the aquatic ecology Sampling Locations (**Exhibit 4.66**).

Terrestrial Ecology

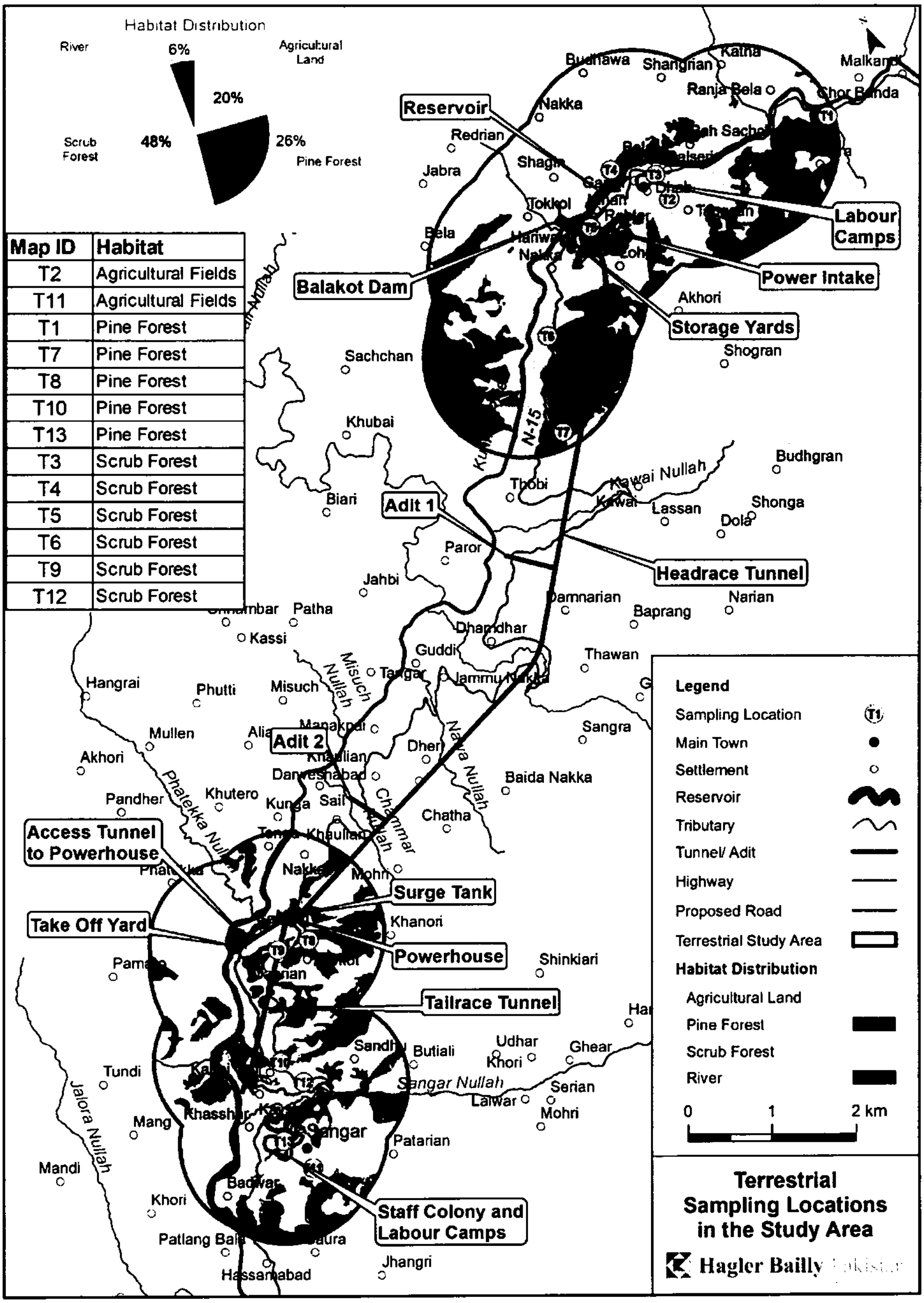
Sampling for terrestrial ecology included the following:

- Terrestrial Flora
- Mammals
- Avifauna
- Herpetofauna

Sampling Locations

Sampling Locations for terrestrial ecology are provided in **Exhibit 4.69**. The locations were determined taking into account three main habitat types identified using ***Google Earth***^{TM} satellite imagery. These include Agricultural Area, Scrub Forest and Pine Forest. The number of Sampling Locations were distributed between these habitat types within the Terrestrial Study Area, with 10 in the two Forest habitat types (six in Scrub Forest and four in Pine Forest) and four in Agricultural Area habitat type. Ground-truthing was carried out during sampling to determine the actual habitat at that sampling location. The habitat type of each Sampling Location, after ground-truthing, is provided in **Exhibit 4.69** and **Exhibit 4.70.**

Exhibit 4.69: Sampling Locations for Terrestrial Flora and Fauna



Map ID	Habitat
T2	Agricultural Fields
T11	Agricultural Fields
T1	Pine Forest
T7	Pine Forest
T8	Pine Forest
T10	Pine Forest
T13	Pine Forest
T3	Scrub Forest
T4	Scrub Forest
T5	Scrub Forest
T6	Scrub Forest
T9	Scrub Forest
T12	Scrub Forest

Exhibit 4.70: Habitat Types for the Terrestrial Sampling Locations

Sampling Locations	*Relative Position of Sampling Location*
T2, T11	Agricultural Area
T1, T7, T8, T10, T13	Pine Forest
T3, T4, T5, T6, T9, T12	Scrub Forest

Terrestrial Flora

The methods used for sampling and analysis of terrestrial flora are described in **Appendix H**. The data collection and analysis on terrestrial flora was used to generate information on the following:

- Cover
- Relative Cover
- Density
- Relative Density
- Frequency
- Relative Frequency
- Importance Value Index

The results of the sampling and analysis are provided in **Section 4.8**.

Mammals

Mammals were sampled at the Sampling Locations shown in **Exhibit 4.69**. The methods used for sampling were different for small and large mammals. These methods are described in detail in **Appendix H**. Sampling for mammals was used to collect information about the presence, abundance and distribution of mammal species in the three habitat types, Agricultural Area, Scrub Forest and Pine Forest, within the Terrestrial Study Area.

Avifauna

Avifauna was sampled at the Sampling Locations shown in **Exhibit 4.69**. The methods used for sampling are described in detail in **Appendix H**. Sampling for birds was used to collect information about diversity, abundance and distribution of bird species within the Terrestrial Study Area. It also identified the presence of any birds of conservation importance present within the Terrestrial Study Area.

Herpetofauna

Herpetofauna was sampled at the Sampling Locations shown in **Exhibit 4.69**. The methods used for sampling are described in detail in **Appendix H**. Sampling for herpetofauna was conducted to collect information about the presence, diversity, abundance and distribution of reptile and amphibian species within the Terrestrial Study Area.

4.2.5 Protected Areas or Areas of Special Importance for Biodiversity

There are both aquatic and terrestrial areas that are either protected or of special importance to biodiversity near the Project.

The part of the Kunhar River above Balakot Bridge (**Exhibit 4.71**) is protected as it is stocked by the Fisheries Department, KP. This includes protected status of the river and riparian areas, however, the exact area within the terrestrial areas is not known. There are also terrestrial Protected Areas within the Mansehra District. A map showing the terrestrial Protected Areas and areas of special importance for biodiversity is provided in **Exhibit 4.71**. A map showing the Important Bird Areas (IBAs) is shown in **Exhibit 4.72**.

Terrestrial Protected Areas

Information about the terrestrial Protected Areas, including national parks, wildlife sanctuaries and game reserves was obtained from the Wildlife Department of KP. This information is currently unpublished. The Protected Area closest to the dam site is the Manshi Wildlife Sanctuary, located 5 km away. The second closest is the Saif-ul-Maluk National Park, located 23.5 km from the dam site.

Mansehra Wildlife Division

There is a diversity of habitat types within Mansehra Wildlife Division consisting of Scrub forests, Chir pine Forests, Moist Temperate Forests, Dry Temperate Forests, Sub Alpine Forests, Alpine Pastures and Wetlands.

There are two types of wetlands found in Mansehra Wildlife Division.

- High altitude wetlands are found in upper Kaghan Valley. The most important amongst them are Saiful Maluk Lake, Lulusar Lake, Dudipat Sar Lake and Ansoo Lake etc.
- Low altitude wetlands are found in areas around Lower Kunar and Siran Rivers.

Exhibit 4.71: Map of Protected Areas

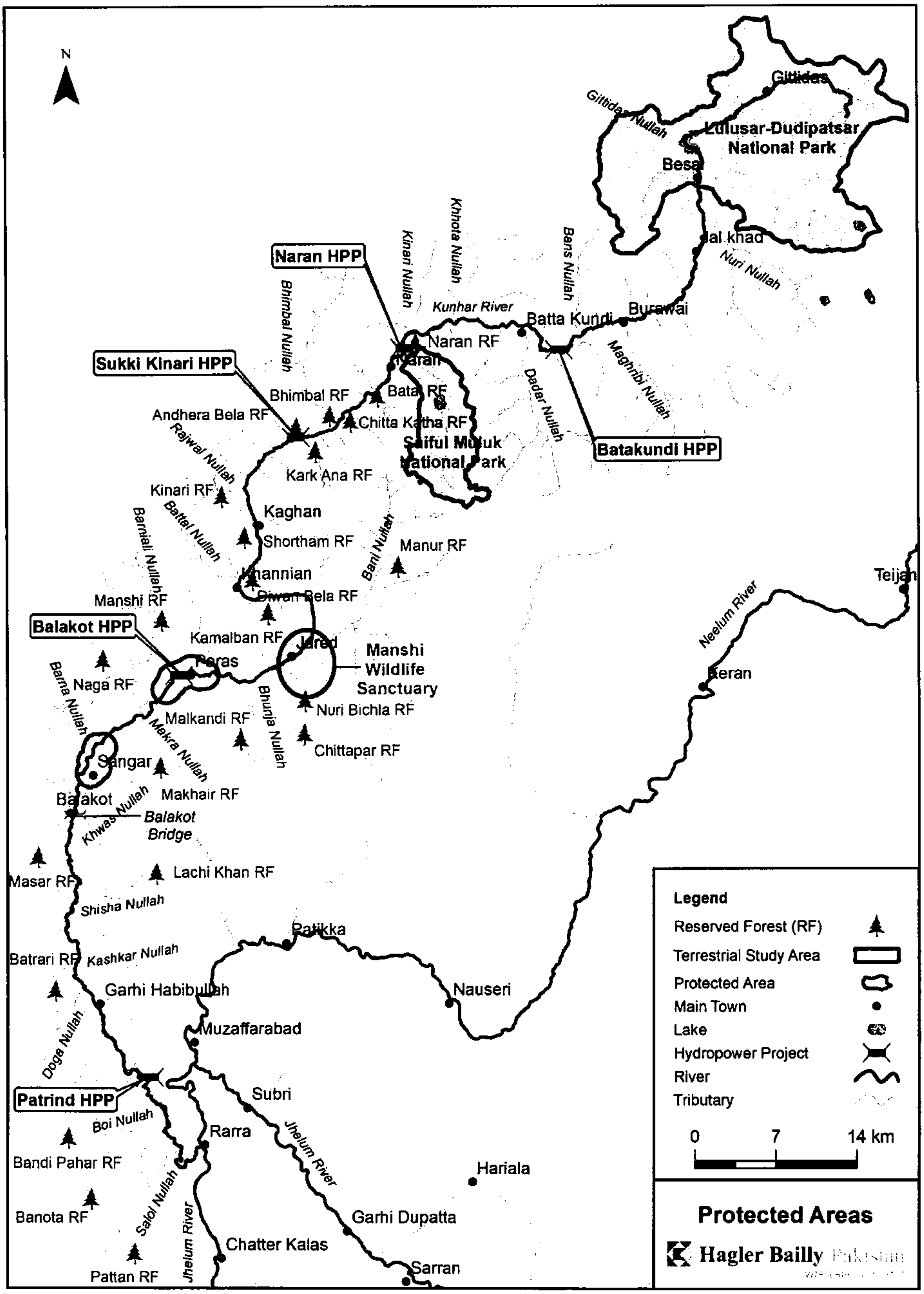
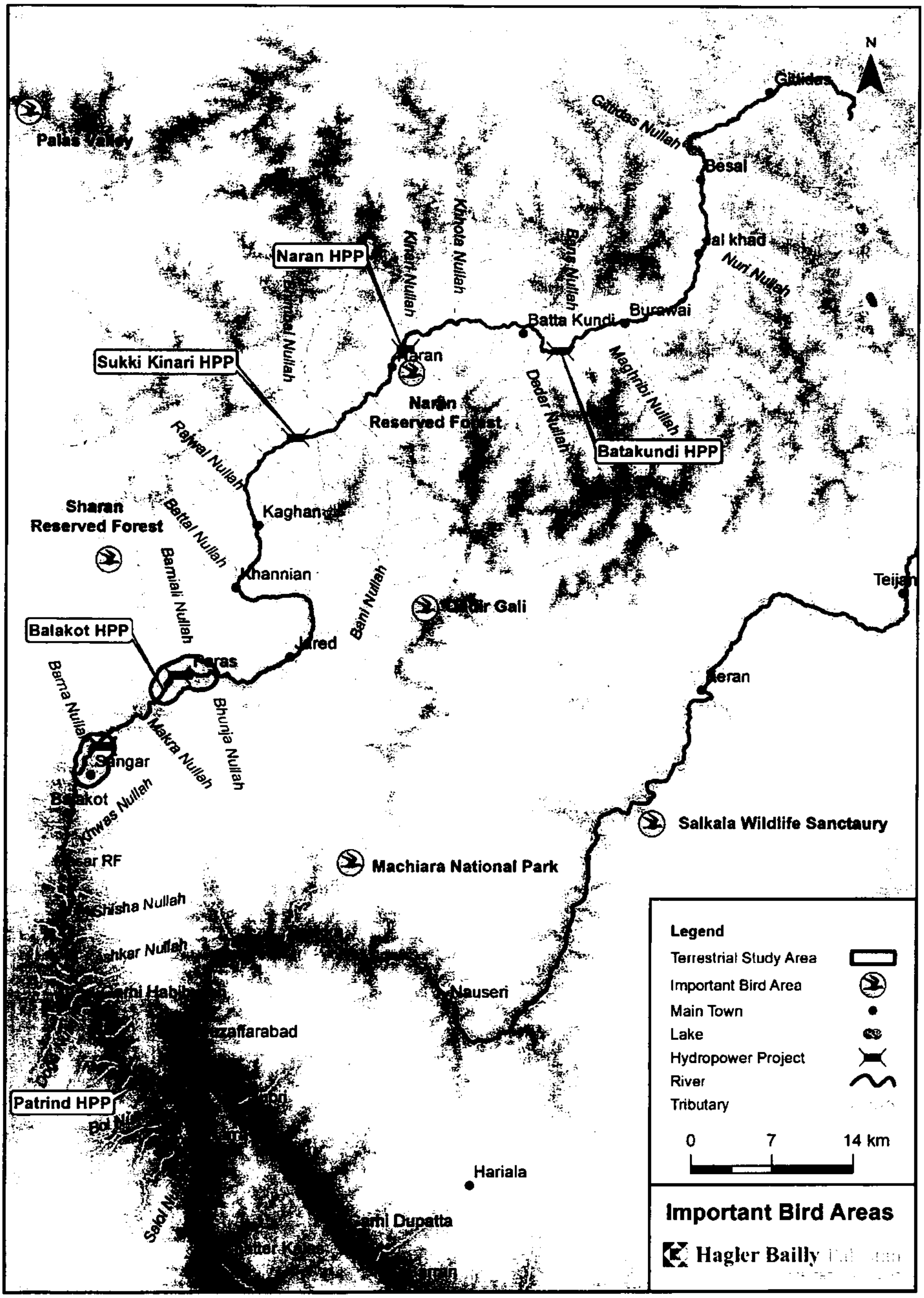


Exhibit 4.72: Map of Important Bird Areas



Due to diversity of habitat types there is a wide diversity of flora and fauna which makes Mansehra Wildlife Division a very important site for protection and conservation. The human population is increasing rapidly which is not only fragmenting habitat but also degrading it. Local communities are highly dependent upon natural resources which presents a challenge for conservation. Mansehra Wildlife Division maintains regular contact with the local communities to persuade them and to educate them about the importance of natural resources and to enlist their support in conservation of biodiversity. There are 12-15 communities organized to protect and manage Community Game Reserves and other protected areas in Mansehra. Similar efforts are being undertaken to organize communities living around the national parks of Kaghan Valley so that they help in protection and manage their natural resources, for example tapping into the benefits from eco-tourism. There is informal interaction with the communities of Upper Siran and Kanshian that are living around the habitat for re-introduction of Chir pheasants.

Terrestrial Protected Areas in the vicinity of the Terrestrial Study Area include ten community Game Reserves, two National Parks and one Wildlife Sanctuary. Other hot spots suitable for being declared as Protected Areas have been identified by the Wildlife Department, KP. Some of these patches of habitat are Bichla Manoor Reserve Forests, Sharhan Reserve Forests; Shogran Reserve Forests and adjoining habitat in Kaghan Valley, Hillan and Chorr in Battagram Districts. These areas are important for their biodiversity and in need of protection from habitat degradation and over exploitation. A description of each type of Protected Area is provided below.

National Parks

There are two National Parks in Mansehra Wildlife Division including the Saiful Maluk National Park and Lulusar-Dudipat National Park.

Saiful Maluk National Park

Saiful Maluk was declared a National Park on April 28, 2003. Total area of this national park is 12,026 acres. The human population around the National Park is about 20,000. Important fauna of the Park includes, Snow Leopard, Marmot, Brown Bear, Himalayan Ibex, Snow Cock, Snow Partridge and Himalayan Griffin Vulture.

Microtopographic features and morphological and physiological characteristics of the vegetation give rise to patterns which vary in size and are found intermittently. For example, Junipers is prostrate with spreading aerial parts. Its compact patches are found all over pastures, but particularly on rocky ridges. Salix occupies depressions on cooler aspects. Species of Polygonum have extensive rhizomes and several patterns are usually visible in pastures. Iris form more or less compact patches distributed all over the area, giving the impression of pure stands. Potentilla-Astragalus type vegetation is present.

The large number (63) of species indicates the richness of floral diversity. Prevailing conditions suggest that more palatable species have disappeared due to heavy grazing. Most forbs (17 species)[13] have poor palatability and are therefore abundant. Some forbs have medical value, and locals use them to treat both humans and livestock. Fresh leaves

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[13] A forb is a family of plants that have broad leaves and herbaceous structures.

or branches of some are used as food. Woody species are a good source of fuel wood and thatch. Dry branches and stems of Juniper and Salix are collected for fuel.

An estimated 0.1 million people visit the Saiful Maluk Park area every year. Threats to the national Park are over exploitation of natural resources, ill-planned tourism, pollution, illegal fishing, modification of land for cultivation, and ill-planned construction.

Lulusar Dudipat National Park

Lulusar-Dudipat was declared National Park on April 28, 2003. The human population around it is about 15,000, mainly nomadic and semi-nomadic peoples. The important fauna of the Park includes Snow leopard, Marmot, Brown Bear, Himalayan Ibex, Snow Cock, Snow Partridge and Himalayan Griffin Vulture.

An estimated 20,000 people visit the Park area every year. Threats to this National Park are the same as for the Saiful Maluk National Park.

Wildlife Sanctuaries

There is one wildlife sanctuary located 5 km from the Project, the Manshi Wildlife Sanctuary.

Manshi Wildlife Sanctuary

This sanctuary is located in Kaghan Valley at a height of about 2,438 meters above sea level. The total area is about 2,307 hectares.

Important wildlife species found here are Common Leopard, Black Bear, Grey Goral, Musk Deer, Jungle Cat, Grey Langur, Rhesus Monkey, Kokhlas Pheasant, Chukar, Snow Partridge and Monal Pheasant.

Important flora of the sanctuary is Deodar *Cedrus deodara*, Fir *Abies pindrows*, Biar *Pinus wallichiana*, Kain *Ulmus wallichiana*, Walnut *Juglans regia*, Bankhor *Aesculus spp.*, Guch *Vibernum*, Jangli Gulab *Rosa moschatta.* Medicinal plants include Ban Khakhri *Podophylum hexandrum,* Mamaikh *Paeonia emodi*, Chita podeena *Mentha longifolia*, Ratan jot *Geranium wallichianum* etc.

Game Reserves

There are 10 proposed Game Reserves located near the Project. These are listed below. Their locations and boundaries are not currently available. Details about them are provided in **Appendix I**.

- Pharana
- Behali
- Sheikh Abad
- Bhaili Ghatti
- Jallo
- Kareer
- Battal

- Palsala Dhanaka
- Lassan Thukral
- Khawajgan

The likelihood of notification of these Game Reserves is currently unknown. In addition to these there is a partridge breeding center at Lasan Nawab and Dhodial Pheasantry in Dhodial.

Information about the presence of proposed Game Reserves located in the wider area of the Project is of significance because it indicates that hunting is of interest in the area and that game animals are present. Awareness of this is important to regulate any hunting activities that Project staff might engage in.

4.2.6 Aquatic Ecology

Study of aquatic ecology covered fish fauna, macro-invertebrates, periphyton and riparian vegetation. Sampling was carried out within the Aquatic Study Area to determine species diversity and abundance. The results of sampling and literature review are reported in this section.

Fish

This section provides an overview of the fish fauna present in the Aquatic Study Area along with the results of the surveys carried out for this Project.

Overview of the Fish Fauna in Kunhar River

The long distance migratory species Alwan Snow Trout *Schizothorax richardsonii,* as well as the Himalayan Catfish *Glyptosternum reticulatum* and Kashmir Hillstream Loach *Triplopysa Kashmirensis* are widely distributed species and found in the Kunhar River upstream and downstream of proposed Project. The species Nalbant's Loach *Schistura nalbanti*, Stone Barb *Schistura alepidota*, Arif's Loach *Shistura arifi* and Flat Head Catfish *Glyptothorax pectinopterus* are mainly found in Kunhar River and tributaries downstream of the proposed Balakot dam but they are also recorded from few places upstream. The species Kunar Snow Trout *Schizothorax labiatus* is exclusively found in Kunhar River downstream of the proposed dam site. They tend to migrate in summers towards upper parts of the river. Two introduced species Brown Trout *Salmo trutta fario* and Rainbow Trout *Oncorhynchus mykiss* are found exclusively upstream of the proposed dam. These two are cold water species and of high food value. There is an extensive raceways[14] culture of Rainbow Trout in the areas upstream and downstream of the proposed dam. Alwan Snow Trout (both upstream and downstream of the dam) and Kunar Snow Trout (mostly downstream of the dam) are two other species of food value. They are not cultured but are captured from the river.

A total of ten species have been reported from the Kunhar River based on the surveys carried out in February 2017 and May 2017 as a part of this study, in July 2016 as a part

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[14] Raceway is based on the continuous water flowing through the culture tanks

of the Biodiversity Strategy for Jhelum Poonch River basin – Preparatory Phase,[15] and advice from Dr Muhammad Rafique, a fish expert with the Pakistan Museum of Natural History (PMNH). Out of these one species is a long distance migratory species and two are endemic to the Jhelum Basin. The complete list of fish species reported from the Kunhar River is given in **Exhibit 4.73**, along with information about their IUCN Red List Status, endemism and whether they are long-distance migratory or not.

Exhibit 4.73: List of Species Reported from the Kunhar River

No.	*Scientific Name*	*Common Name*	*IUCN Status*	*Endemic*	*Migratory*
1.	*Glyptosternum reticulatum*	Himalayan Catfish	Not Assessed		
2.	*Glyptothorax pectinopterus*	Flat Head Catfish	Not Assessed		
3.	*Salmo trutta fario*	Brown Trout	Not Assessed		
4.	*Oncorhynchus mykiss*	Rainbow Trout	Not Assessed		
5.	*Schistura alepidota*	Stone Barb	Not Assessed		
6.	*Schistura arifi*	Arif's Loach	Not Assessed		
7.	*Schistura nalbanti*	Nalbant's Loach	Not Assessed	✓	
8.	*Schizothorax labiatus*	Kunar Snow Trout	Not Assessed		
9.	*Schizothorax richardsonii*	Alwan Snow Trout	**Vulnerable**		✓
10.	*Triplophysa kashmirensis*	Kashmir Hillstream Loach	Not Assessed	✓	

Note: All species, except the Kunar Snow Trout were observed during the surveys (July 2016, February 2017 and May 2017). In the opinion of Dr Muhammad Rafique, a fish expert with the Pakistan Museum of Natural History (PMNH), the Kunar Snow Trout is also present in the Aquatic Study Area

Results of the July 2016, February 2017 and May 2017 Surveys

Fish surveys were carried out in February 2017 and May 2017 as a part of this study and July 2016 as a part of Jhelum-Poonch Biodiversity Strategy.[16] Fish sampling was carried out using cast nets, electrofishing and gill nets. The method used at each location depended on the morphology of the river or tributary, accessibility, the target fish species, and the possibility of finding the fish in a particular habitat in view of temperatures and fish activity at the time of sampling. It was not possible to apply all methods at all Sampling Locations. **Exhibit 4.74** shows the photographs of field activities performed during the surveys.

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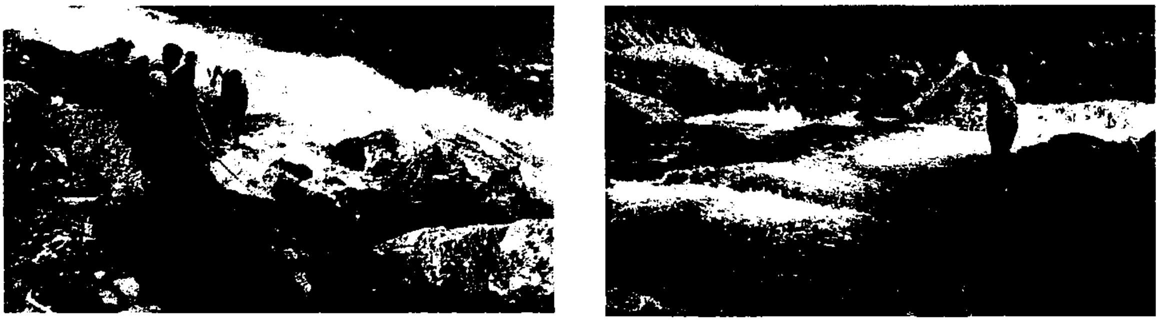
[15] Hagler Bailly Pakistan, September 2016. Biodiversity Strategy for Jhelum Poonch River basin – Preparatory Phase, for the International Finance Corporation, Washington D.C.

[16] Ibid

Exhibit 4.74: Photographs of Field Activities



a) Electrofishing

b) Cast netting

c) Gill Netting

d) Measuring Fish Length

e) Fish Breeding Maturity Observed

f) Releasing Fish Back to River

Results of the July 2016 Survey

During the July 2016 Survey, sampling was conducted at a total of three Sampling Locations in the Aquatic Study Area. All were downstream of Balakot Town.

- A total of 99 specimens of two fish species were collected from the Kunhar River.
- Maximum relative abundance (46 specimens) was observed at Sampling Location K143.9, Upstream of Banda Balola Village.
- The most abundant fish species observed in the main Kunhar River was Alwan Snow Trout. A total of 53 specimens were collected using electrofishing and cast nets.
- A total of 46 specimens of the endemic Kashmir Hillstream Loach were collected during the surveys, using electrofishing and cast nets.

Results of the February 2017 Survey

During the February 2017 Survey, sampling was conducted at a total of 10 Sampling Locations in the Aquatic Study Area. Four of these are located in the main Kunhar River while five are located in the tributaries. A total of 215 specimens of seven species were collected during the February 2017 Survey from the main Kunhar River and its tributaries, using cast nets, gill nets and electrofishing.

Main Kunhar River

- A total of 45 specimens of four fish species were collected from the main Kunhar River.
- Maximum relative abundance (28 specimens) was observed at Sampling Location K139.0, in the Kunhar River near its confluence with Shisha Nullah.
- The most abundant fish species observed was Alwan Snow Trout, with a total of 32 specimens collected, using electrofishing, gill nets and cast nets.
- The second most abundant fish species was Kashmir Hillstream Loach, with eight specimens collected. All the specimens were collected from Sampling Location K139.0.

Tributaries of Kunhar River

- A total of 170 specimens of six fish species were collected from the Kunhar River.
- Maximum relative abundance (62 specimens) was observed at Sampling Location SH1.6, located at Shisha Nullah near Bissian.
- The most abundant fish species observed from the tributaries of Kunhar River was Alwan Snow Trout. A total of 105 specimens were collected using electrofishing and cast nets.
- The second most abundant fish species was Nalbant's Loach, with 34 specimens collected.

Results of the May 2017 Survey

During the May 2017 Survey, sampling was conducted at a total of nine Sampling Locations in the Aquatic Study Area. Four of these are located in the main Kunhar River while five are located in the tributaries. A total of 549 specimens of nine species were collected from the main Kunhar River and its tributaries.

Main Kunhar River

- A total of 194 specimens of five fish species were collected from the main Kunhar River.
- Maximum relative abundance (146 specimens) was observed at Sampling Location K139.0, in the Kunhar River near its confluence with Shisha Nullah.
- The most abundant fish species observed during the surveys was Alwan Snow Trout with a total of 134 specimens collected, using electrofishing and cast nets.

- The second most abundant fish species was Kashmir Hillstream Loach, with 59 specimens collected. All the specimens were collected from Sampling Location. Kashmir Hillstream Loach was not collected from the tributaries.

Tributaries of Kunhar River

- A total of 355 specimens of eight fish species were collected from the Kunhar River.
- Maximum relative abundance (175 specimens) was observed at Sampling Location JA6.7, Jalora Nullah at the Confluence of Kunhar River, using cast nets and electrofishing.
- The most abundant fish species observed from the tributaries of Kunhar River was Alwan Snow Trout with a total of 170 specimens collected, using electrofishing and cast nets.
- The second most abundant fish species was Nalbant's Loach, with 90 specimens collected.
- The relative abundance of fish species observed during February 2017 Survey is shown in **Exhibit 4.75** while species richness is shown in **Exhibit 4.76**. The relative abundance of fish species observed during May 2017 Survey is shown in **Exhibit 4.77** while species richness is shown in while **Exhibit 4.78**.

A comparatively higher relative abundance and species richness was observed during the May 2017 Survey in comparison with February 2017 Survey. A warmer temperature range (13°C-16.5°C) in May 2017 Survey in comparisons with February 2017 Survey (8°C – 12°C) is the likely reason for higher relative abundance and species richness in the May 2017 Survey. The tributaries downstream of the proposed dam i.e. Jalora Nullah, Barna Nullah and Shisha Nullah are more productive and have a higher abundance of fish in comparison to the tributaries upstream of the dam site. Tributaries downstream are the prominent breeding grounds for most fish species i.e. Nalbant's Loach, Alwan Snow Trout, Arif's Loach, Stone Barb and Flat Head Catfish while comparatively lower breeding was observed in the tributaries upstream of the dam.

Exhibit 4.75: Relative Abundance Observed in main Kunhar River and Tributaries, February 2017 Survey

		Kunhar River					Tributaries							
	Sampling Location	K110.6	K117.5	K126.9	K139.0		BAR5.2	BA4.3	BH6.0	GH4.1	JA6.7	SH1.6		
		Upstream Paras Town	Kunhar River near Confluence of Barinali Nullah	Kunhar River near Sangar Town	Kunhar River near Confluence of Shisha Nullah	**Total Kunhar River**	Barna Nullah	Barniali Nullah near Confluence of Kunhar River	Bhonja Nullah Near Bhonja Village	Ghanool Nullah near Ghanool Village	Jalora Nullah	Shisha Nullah near Confluence of Kunhar River	**Total Tributaries**	**Total Survey**
Scientific Name	Common Name													
Glyptosternum reticulatum	Himalayan Catfish	–	–	–	4	**4**	–	–	1	–	–	–	**1**	**5**
Salmo trutta fario	Brown Trout	–	1	–	–	**1**	–	–	10	–	–	–	**10**	**11**
Schistura alepidota	Stone Barb	–	–	–	–	**–**	10	–	–	–	–	8	**18**	**18**
Schistura arifi	Arif's Loach	–	–	–	–	**–**	–	–	–	–	2	–	**2**	**2**
Schistura nalbanti	Nalbant's Loach	–	–	–	–	**–**	15	–	–	–	5	14	**34**	**34**
Schizothorax richardsonii	Alwan Snow Trout	6	4	6	16	**32**	35	3	3	–	24	40	**105**	**137**
Triplophysa kashmirensis	Kashmir Hillstream Loach	–	–	–	8	**8**	–	–	–	–	–	–	**–**	**8**
Relative Abundance		**6**	**5**	**6**	**28**	**45**	**60**	**3**	**14**	**–**	**31**	**62**	**170**	**215**

Exhibit 4.76: Species Richness Observed in main Kunhar River and Tributaries, February 2017 Survey

		Kunhar River					*Tributaries*							
	Sampling Location	*K110.6*	*K117.5*	*K126.9*	*K139.0*		*BAR5.2*	*BA4.3*	*BH6.0*	*GH4.1*	*JA6.7*	*SH1.6*		
		Upstream Paras Town	*Kunhar River near Confluence of Barinali Nullah*	*Kunhar River near Sangar Town*	*Kunhar River near Confluence of Shisha Nullah*	***Total Kunhar River***	*Barna Nullah*	*Barniali Nullah near Confluence of Kunhar River*	*Bhonja Nullah Near Bhonja Village*	*Ghanool Nullah near Ghanool Village*	*Jalora Nullah*	*Shisha Nullah near Confulence of Kunhar River*	***Total Tributaries***	***Total Survey***
Scientific Name	*Common Name*													
Glyptosternum reticulatum	Himalayan Catfish	–	–	–	✓	✓	–	–	✓	–	–	–	✓	✓
Salmo trutta fario	Brown Trout	–	✓	–	–	✓	–	–	✓	–	–	–	–	✓
Schistura alepidota	Stone Barb	–	–	–	–	–	✓	–	–	–	–	✓	✓	✓
Schistura arifi	Arif's Loach	–	–	–	–	–	–	–	–	–	✓	–	✓	✓
Schistura nalbanti	Nalbant's Loach	–	–	–	–	–	✓	–	–	–	✓	✓	–	✓
Schizothorax richardsonii	Alwan Snow Trout	✓	✓	✓	✓	✓	✓	✓	✓	–	✓	✓	–	✓
Triplophysa kashmirensis	Kashmir Hillstream Loach	–	–	–	✓	✓	–	–	–	–	–	–	✓	✓
	Richness	**1**	**2**	**1**	**2**	**4**	**3**	**1**	**3**	**–**	**3**	**3**	**6**	**7**

Summary

Most Abundant Species	*Schizothorax richardsonii*	**Highest Abundance Location**	SH1.6	**Highest Richness**	SH1.6, JA6.7, BH6.0, BAR5.2
2nd Most Abundant Species	*Schistura nalbanti*	**2nd Highest Abundance Location**	BAR5.2	**2nd Highest Richness**	K117.5, K139.0

Exhibit 4.77: Relative Abundance Observed in main Kunhar River and Tributaries, May 2017 Survey

		Kunhar River					Tributaries							
	Sampling Location	*K110.6*	*K117.5*	*K126.9*	*K139.0*		*BAR5.2*	*BA4.3*	*BH6.0*	*GH4.1*	*JA6.7*	*SH1.6*		
		Upstream Paras Town	*Kunhar River near Confluence of Barinali Nullah*	*Kunhar River near Sangar Town*	*Kunhar River near Confluence of Shisha Nullah*	**Total Kunhar River**	*Bama Nullah*	*Barniali Nullah near Confluence of Kunhar River*	*Bhonja Nullah Near Bhonja Village*	*Ghanool Nullah near Ghanool Village*	*Jalora Nullah*	*Shisha Nullah near Confulence of Kunhar River*	***Total Tributaries***	***Total Survey***
Scientific Name	*Common Name*													
Glyptostemum reticulatm	Himalayan Catfish	–	–	1	–	**1**	2	–	3	7	11	–	**23**	**24**
Glyptothorax pectinopterus	Flat Head Catfish	–	–	–	–	–	1	–	–	–	-	–	**1**	**1**
Salmo trutta fario	Brown Trout	–	–	–	–	–	–	–	1	–	-	–	**1**	**1**
Schistura alepidota	Stone Barb	–	–	–	5	**5**	19	–	–	–	17	15	**51**	**56**
Schistura arifi	Arifs Loach	–	–	–	–	–	3	–	–	–	3	3	**9**	**9**
Schistura nalbanti	Nalbant's Loach	–	–	–	–	–	37	–	–	–	32	21	**90**	**90**
Schizothorax richardsonii	Alwan Snow Trout	2	5	32	90	**129**	15	5	4	–	112	34	**170**	**299**
Triplophysa kashmirensis	Kashmir Hillstream Loach	–	–	8	51	**59**	–	–	–	–	–	–	–	**59**
Oncorhynchus mykiss	Rainbow trout	–	–	–	–	–	–	–	10	–	–	–	10	**10**
	Relative Abundance	**2**	**5**	**41**	**146**	**194**	**77**	**5**	**18**	**7**	**175**	**73**		**549**

Exhibit 4.78: Species Richness Observed in main Kunhar River and Tributaries, May 2017 Survey

		Kunhar River					*Tributaries*							
	Sampling Location	*K110.6*	*K117.5*	*K126.9*	*K139.0*		*BAR5.2*	*BA4.3*	*BH6.0*	*GH4.1*	*JA6.7*	*SH1.6*		
		Upstream Paras Town	*Kunhar River near Confluence of Barinali Nullah*	*Kunhar River near Sangar Town*	*Kunhar River near Confluence of Shisha Nullah*	***Total Kunhar River***	*Bama Nullah*	*Bamiali Nullah near Confluence of Kunhar River*	*Bhonja Nullah Near Bhonja Village*	*Ghanool Nullah near Ghanool Village*	*Jalora Nullah*	*Shisha Nullah near Confulence of Kunhar River*	***Total Tributaries***	***Total Survey***
Scientific Name	*Common Name*													
Glyptostemum reticulatm	Himalayan Catfish	–	–	✓	–	✓	✓	–	✓	✓	✓	–	✓	✓
Glyptothorax pectinopterus	Flat Head Catfish	–	–	–	–	–	✓	–	–	–	-	–	✓	✓
Salmo trutta fario	Brown Trout	–	–	–	–	–	–	–	✓	–	-	–	✓	✓
Schistura alepidota	Stone Barb	–	–	–	✓	✓	✓	–	–	–	✓	✓	✓	✓
Schistura arifi	Arifs Loach	–	–	–	–	–	✓	–	–	–	✓	✓	✓	✓
Schistura nalbanti	Nalbant's Loach	–	–	–	–	–	✓	–	–	–	✓	✓	✓	✓
Schizothorax richardsonii	Alwan Snow Trout	✓	✓	✓	✓	✓	✓	✓	✓	–	✓	✓	✓	✓
Triplophysa kashmirensis	Kashmir Hillstream Loach	–	–	✓	✓	✓	–	–	–	–	–	–	–	✓
Oncorhynchus mykiss	Rainbow trout	–	–	–	–	–	–	–	✓	–	–	–	✓	✓
	Richness	**1**	**1**	**3**	**3**	**4**	**6**	**1**	**4**	**1**	**5**	**4**	**8**	**9**

Summary

Most Abundant Species	*Schizothorax richardsonii*	**Highest Abundance Location**	JA6.7	**Highest Richness**	BAR5.2
2nd Most Abundant Species	*Schistura nalbanti*	**2nd Highest Abundance Location**	K139.0	**2nd Highest Richness**	JA6.7

Key Observations

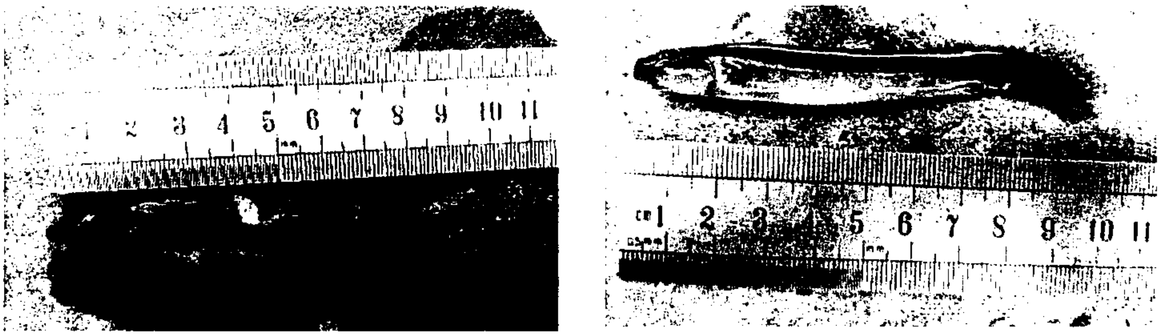
A list of the fish species captured is given in **Exhibit 4.79**, along with information on their IUCN status, endemism[17] and migratory status. Of the species captured, Alwan Snow Trout *Schizothorax richardsonii* is listed as Vulnerable in the IUCN Red List 2017. There are two species, Nalbant's Loach *Schistura nalbanti* and Kashmir Hillstream Loach *Triplophysa kashmirensis*, which are endemic to the Jhelum Basin.

Photographs of some of the fish species observed during the surveys are given in **Exhibit 4.80**. A map showing relative abundance and richness observed during the February 2017 Survey is given in **Exhibit 4.81**. A map showing relative abundance and richness observed during the May 2017 Survey is given **Exhibit 4.82**. A map showing a comparison of relative abundance observed during the February and May 2017 Survey is given in **Exhibit 4.83**. A map showing a comparison of species richness observed during the February and May 2017 Survey **Exhibit 4.84**.

Exhibit 4.79: Fish Fauna Recorded from Study Area in Kunhar River and Tributaries, July 2016, February 2017 and May 2017 Survey

No	*Scientific Name*	*Common Name*	*IUCN Status*	*Endemic*	*Migratory*
1.	*Glyptosternum reticulatum*	Himalayan Catfish	Not Assessed		
2.	*Glyptothorax pectinopterus*	Flat Head Catfish	Not Assessed		
3.	*Salmo trutta fario*	Brown Trout	Not Assessed		
4.	*Schistura alepidota*	Stone Barb	Not Assessed		
5.	*Schistura arifi*	Arif's Loach	Not Assessed		
6.	*Schistura nalbanti*	Nalbant's Loach	Not Assessed	✓	
7.	*Schizothorax richardsonii*	Alwan Snow Trout	**Vulnerable**		✓
8.	*Triplophysa kashmirensis*	Kashmir Hillstream Loach	Not Assessed	✓	
9.	*Oncorhynchus mykiss*	Rainbow Trout	Not Assessed		

Exhibit 4.80: Photographs of Fish Fauna Recorded from Kunhar River and Tributaries, July 2016, February 2017 and May 2017 Survey



a) Glyptosternum reticulatum

b) Schistura alepidota

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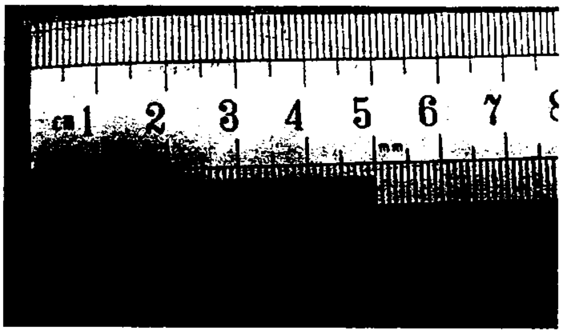
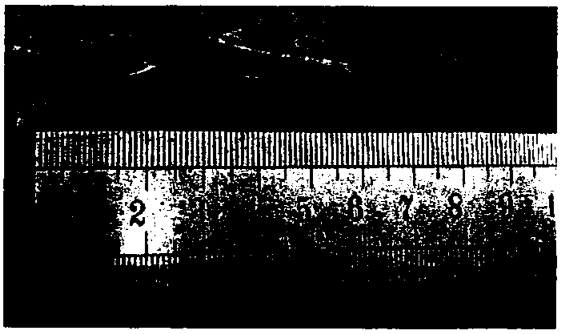
[17] Endemic species refers to species that are endemic to the Jhelum Basin.



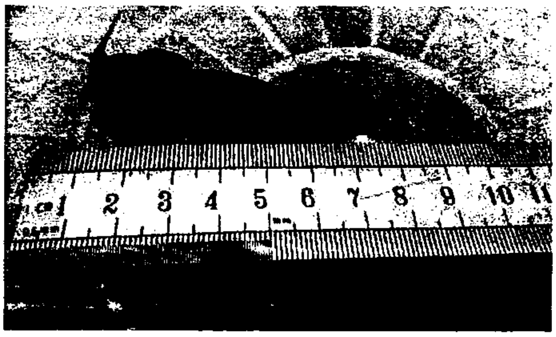
c) *Schistura arifi*



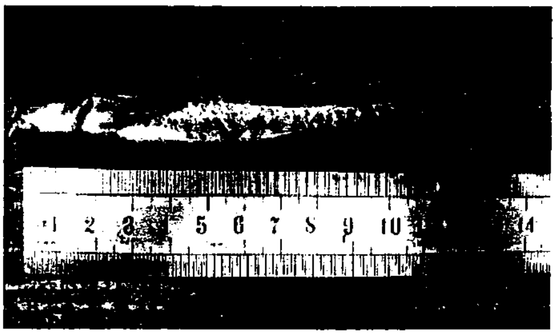
d) *Schistura nalbanti*

e) *Oncorhynchus mykiss*

f) *Schizothorax richardsonii*



g) *Glyptothorax pectinopterus*



h) *Triplophysa kashmirensis*

Exhibit 4.81: Fish Relative Abundance and Richness, February 2017 Survey

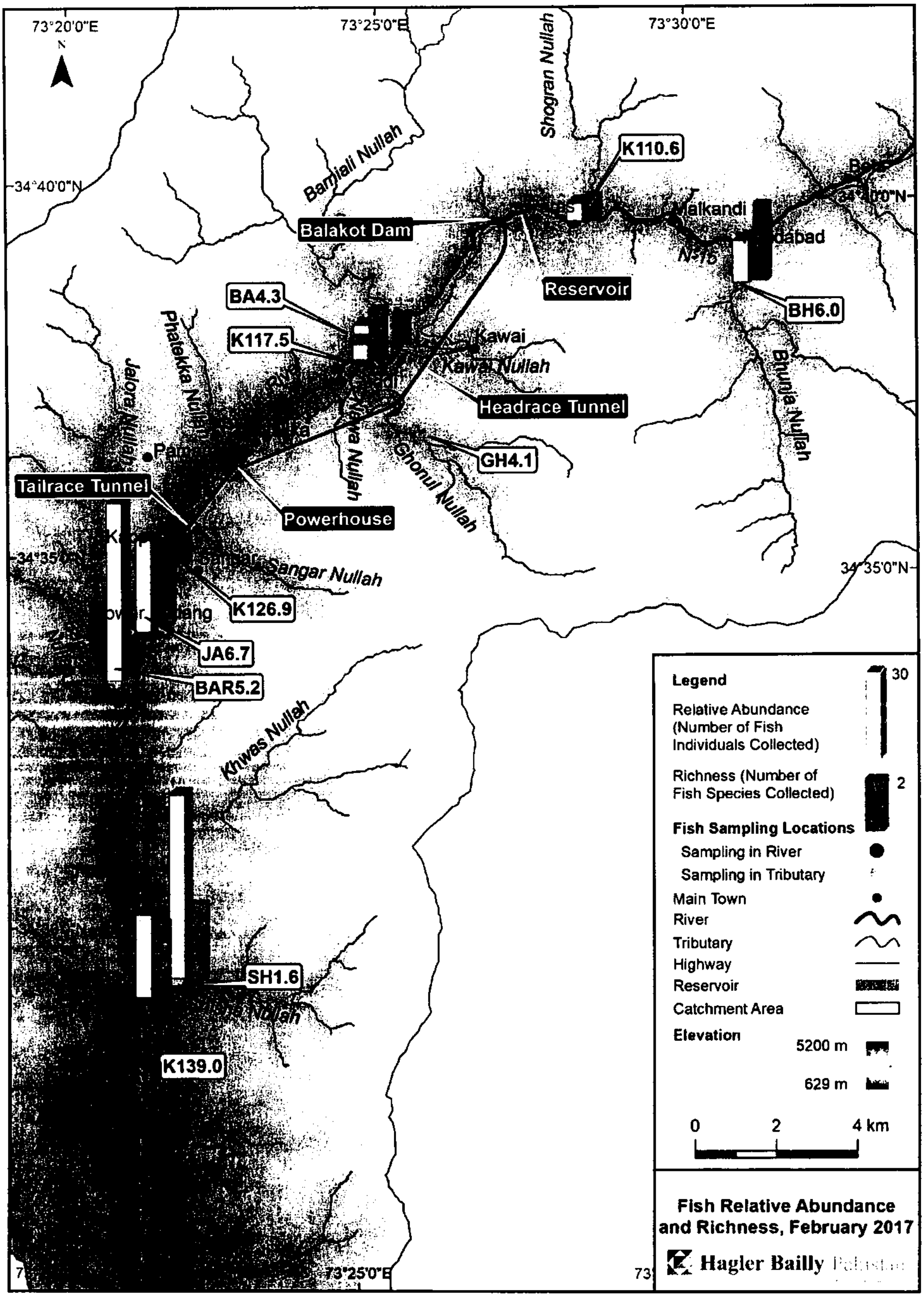


Exhibit 4.82: Fish Relative Abundance and Richness, May 2017 Survey

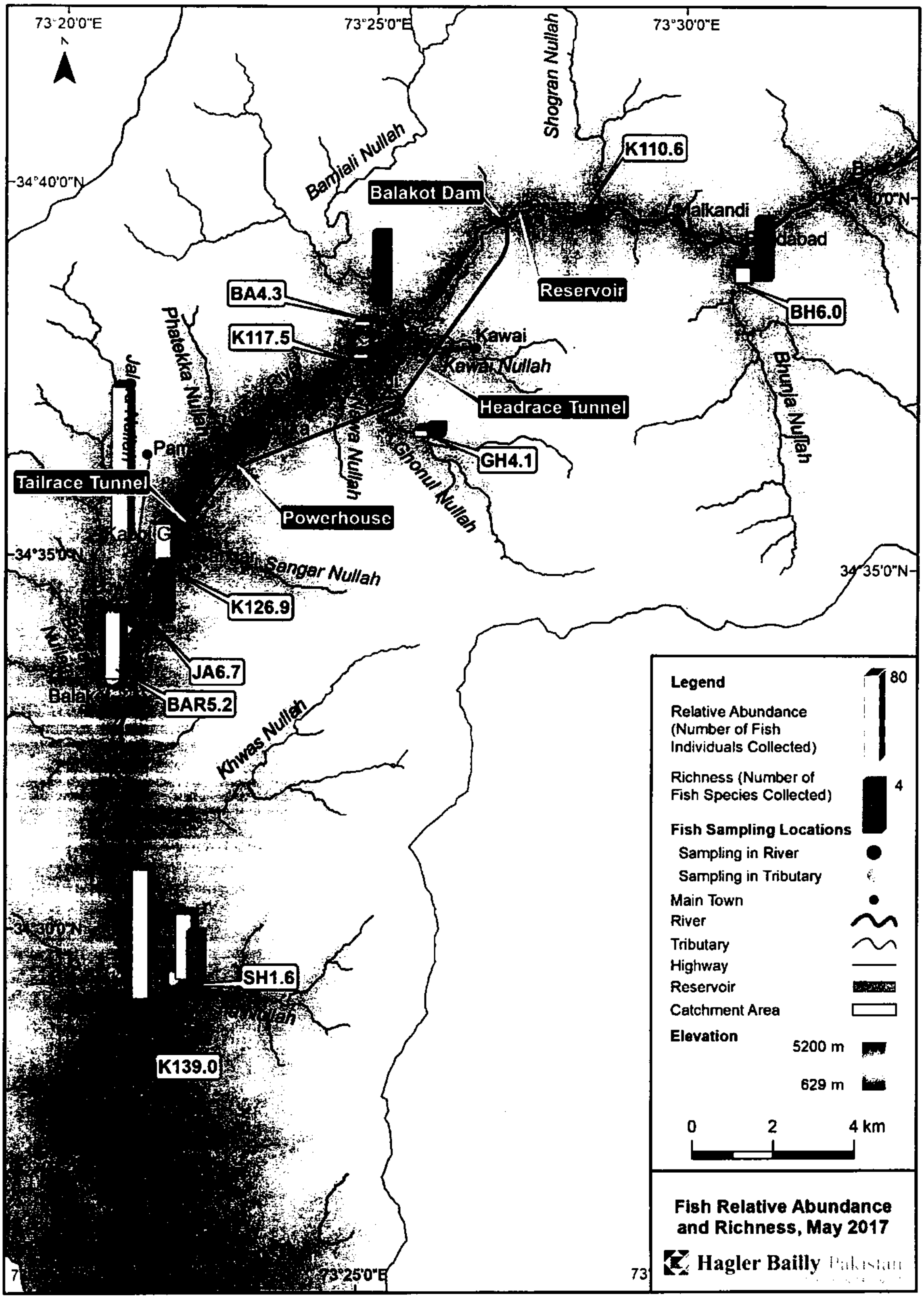


Exhibit 4.83: Comparison of Fish Relative Abundance, February and May 2017 Survey

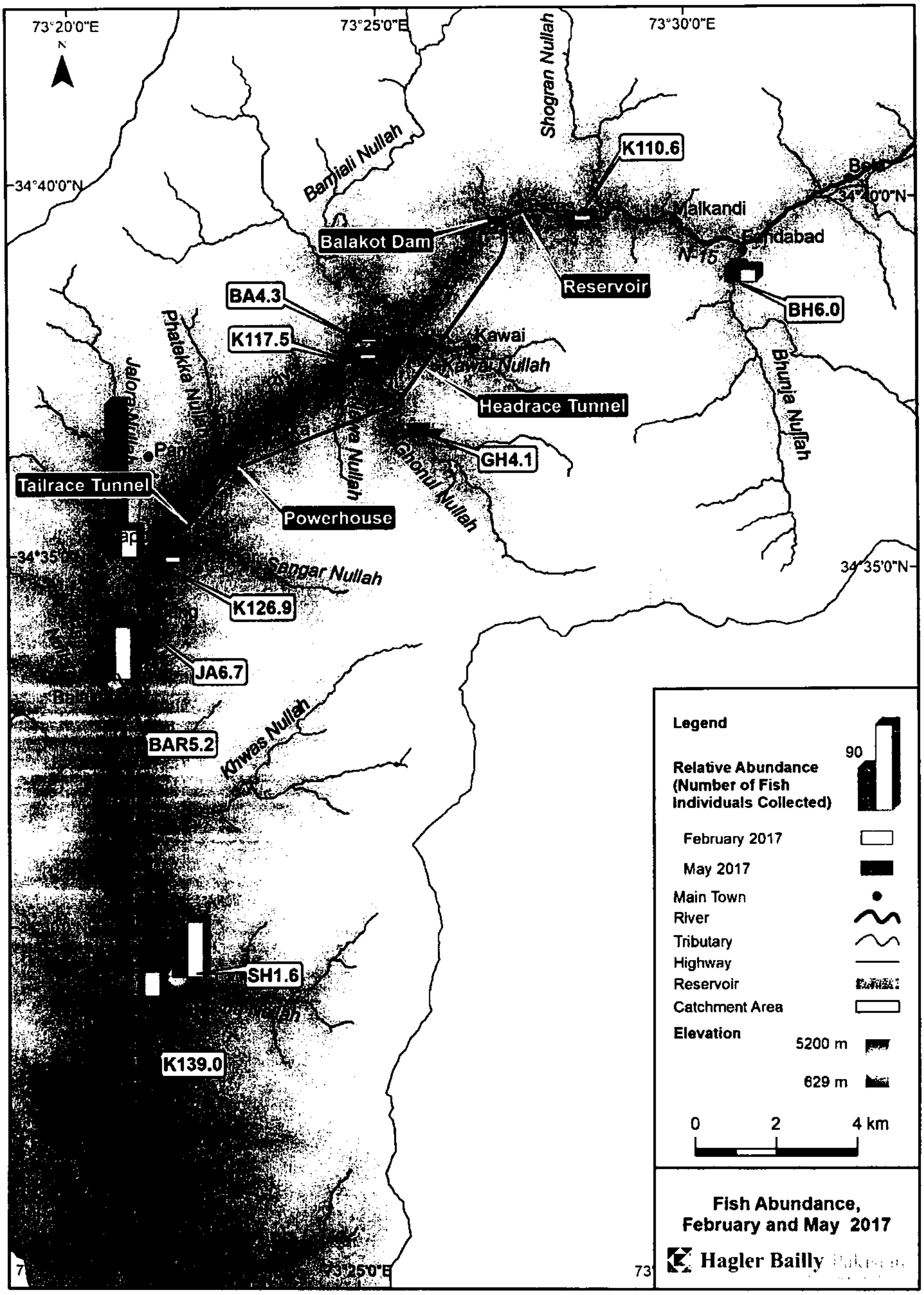
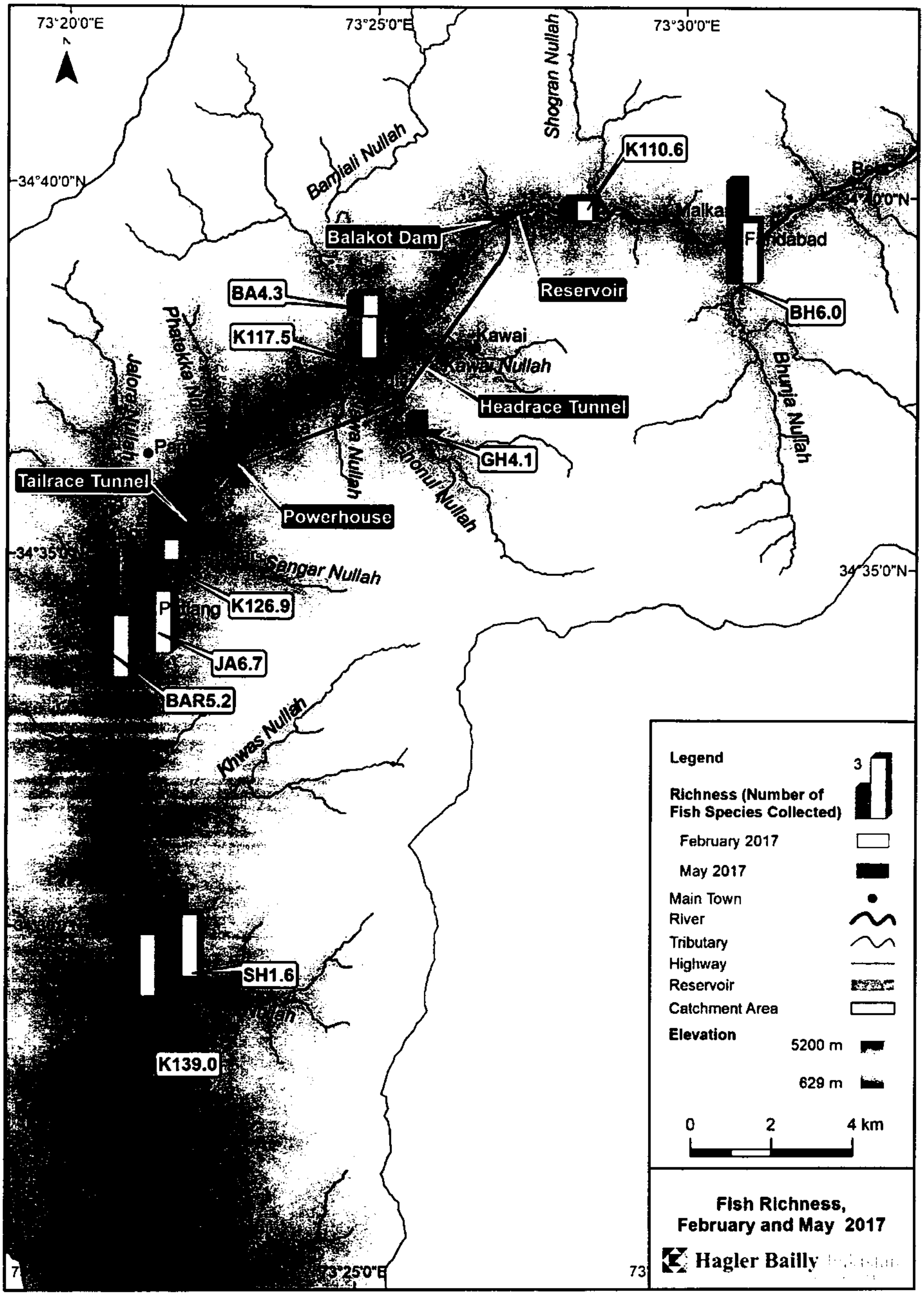


Exhibit 4.84: Comparison of Fish Species Richness, February and May 2017 Survey



Distribution of Fish of Conservation Importance

There are three species of conservation importance in the Kunhar River. These include the Alwan Snow Trout, listed as Vulnerable on the IUCN Red List and two endemic species, the Kashmir Hillstream Loach and Nalbant's Loach.

During the July 2016 Survey, the highest relative abundance of the Alwan Snow Trout was observed at Sampling Location K145.4, located downstream of Banda Balola Village at Kunhar River. The highest relative abundance for the Kashmir Hillstream Loach was observed at Sampling Location K143.9, located upstream of Banda Balola Village at Kunhar River. No specimens of Nalbant's Loach were observed during the July 2016 Survey.

During the February 2017 Survey, the highest relative abundance of the Alwan Snow Trout was observed at Sampling Location SH1.6 (Shisha Nullah near the Confluence of main Kunhar River). The highest relative abundance for the Kashmir Hillstream Loach was observed at Sampling Location K139.0, located at the main Kunhar River near the confluence of Shisha Nullah. The highest relative abundance for the Nalbant's Loach was observed at Sampling Location BAR5.2, located in Barna Nullah near the confluence of main Kunhar River. **Exhibit 4.85** shows the relative abundance of these three fish species observed during the February 2017 Survey.

During the May 2017 Survey, the highest relative abundance of the Alwan Snow Trout was observed at Sampling Location JA6.7 (Jalora Nullah near the Confluence of main Kunhar River). The highest relative abundance for the Kashmir Hillstream Loach was observed at Sampling Location K139.0, located at the main Kunhar River near the confluence of Shisha Nullah. The highest relative abundance for the Nalbant's Loach was observed at Sampling Location BAR5.2, located in Barna Nullah near the confluence of main Kunhar River. **Exhibit 4.86** shows the relative abundance of these three fish species observed during the May 2017 Survey.

Exhibit 4.85: Relative Abundance of Fish Species of Conservation Importance, February 2017 Survey

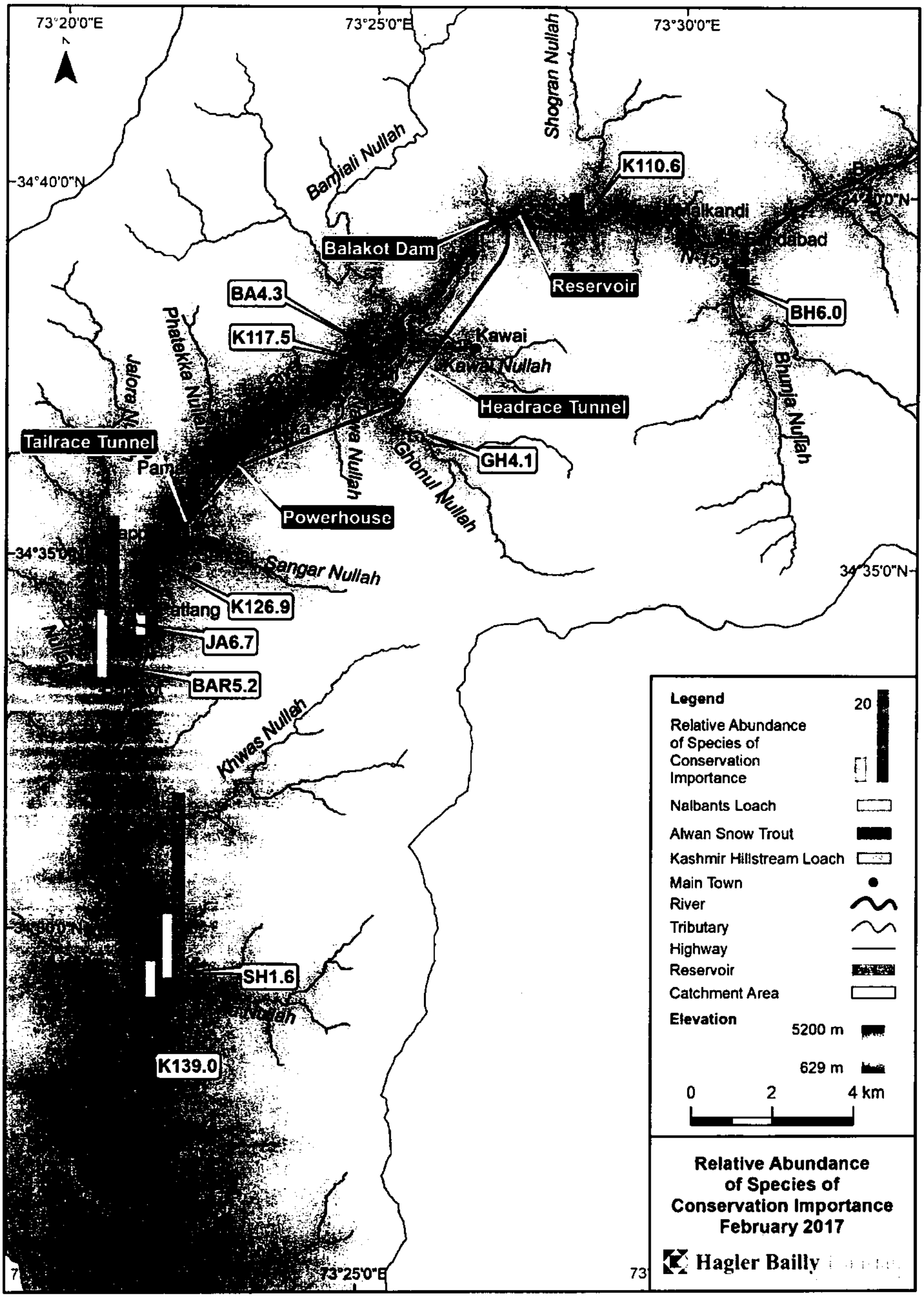
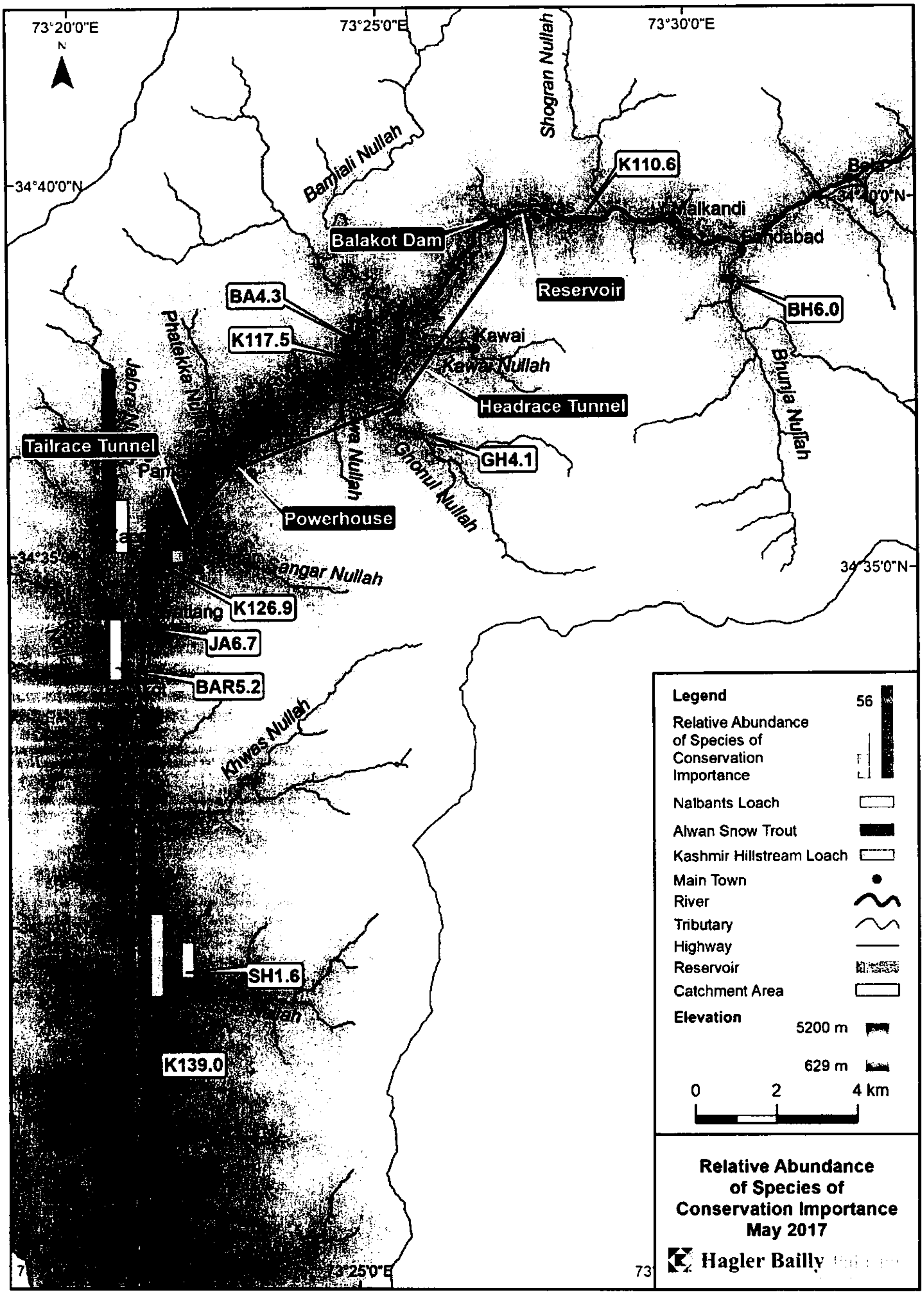


Exhibit 4.86: Relative Abundance of Fish Species of Conservation Importance May 2017 Survey



Catch per Unit Effort

Catch per unit effort is number of specimens captured with a particular sampling method applied in a given time or sampling unit at a particular location. **Exhibit 4.87** shows the catch per unit effort for various capture techniques used. The effort in case of cast nets (20 castings, fifteen each of two mesh sizes spread over a defined stretch of about 100 – 200 m), electrofishing (150 m^2 area) and gill nets (setting at evening and taking down in the morning means over-nightly adjusted) varied. To facilitate comparison, catch per unit effort at each site on the basis of combined catch from more than one capturing method is calculated and presented in **Exhibit 4.87**.

Exhibit 4.87: Catch per Unit Effort, July 2016, February 2017 and May 2017 Surveys

River/ Tributary	Sampling ID	Location	Cast Net	Gill Net			Electrofishing	Total
				50	62.5	75		
			Fish Captured/ 20 castings	Fish Captured/ Overnight netting	Fish Captured/ Overnight netting	Fish Captured/ Overnight netting	Fish Captured/ 150 sq. m	
July 2016 Survey								
Kunhar River	K138.9	Near Tranna Village at Kunhar River	13	N	N	N	N	**13**
Kunhar River	K143.9	Upstream Banda Balola Village at Kunhar River	19	N	N	N	27	**46**
Kunhar River	K145.4	Downstream Banda Balola at Kunhar River	40	N	N	N	N	**40**
Total			**72**	-	-	-	**27**	**99**
February 2017 Survey								
Kunhar River	K110.6	Upstream Paras Town	–	5	-	1	–	**6**
Kunhar River	K117.5	Kunhar River near Confluence of Barniali Nullah	–	1	3	1	–	**5**
Kunhar River	K126.9	Kunhar River near Sangar Town	3	2	1	-	–	**6**
Kunhar River	K139.0	Kunhar River near Confluence of Shisha Nullah	12	N	N	N	16	**28**
Barna Nullah	BAR5.2	Barna Nullah near Confluence of Kunhar River	–	N	N	N	60	**60**
Barniali Nullah	BA4.3	Barniali Nullah near Confluence of Kunhar River	–	N	N	N	3	**3**
Bhonja Nullah	BH6.0	Bhonja Nullah Near Bhonja Village	2	N	N	N	12	**14**
Ghanol Nullah	GH4.1	Ghanool Nullah near Ghanool Village	–	N	N	N	–	**0**
Jalora Nullah	JA6.7	Jalora Nullah	–	N	N	N	31	**31**
Shisha Nullah	SH1.6	Shisha Nullah near Confluence of Kunhar River	–	N	N	N	62	**62**
Total			**17**	**7**	**17**	**6**	**184**	**215**

River/ Tributary	*Sampling ID*	*Location*	*Cast Net*	*Gill Net*			*Electrofishing*	***Total***
				50	*62.5*	*75*		
			Fish Captured/ 20 castings	*Fish Captured/ Overnight netting*	*Fish Captured/ Overnight netting*	*Fish Captured/ Overnight netting*	*Fish Captured/ 150 sq. m*	
May 2017 Survey								
Kunhar River	K110.6	Upstream Paras Town	2	N	N	N	–	2
Kunhar River	K117.5	Kunhar River near Confluence of Barniali Nullah	5	N	N	N	–	**5**
Kunhar River	K126.9	Kunhar River near Sangar Town	41	N	N	N	–	**41**
Kunhar River	K139.0	Kunhar River near Confluence of Shisha Nullah	30	N	N	N	116	**146**
Barna Nullah	BAR5.2	Barna Nullah	–	N	N	N	77	**77**
Barniali Nullah	BA4.3	Barniali Nullah near Confluence of Kunhar River	–	N	N	N	5	**5**
Bhonja Nullah	BH6.0	Bhonja Nullah Near Bhonja Village	9	N	N	N	9	**18**
Ghanol Nullah	GH4.1	Ghanool Nullah near Ghanool Village	–	N	N	N	7	**7**
Jalora Nullah	JA6.7	Jalora Nullah	8	N	N	N	167	**175**
Shisha Nullah	SH1.6	Shisha Nullah near Confluence of Kunhar River	7	N	N	N	66	**73**
Total			**102**	N	N	N	**447**	**549**

N = Not Sampled

Fish Migration and Movement Patterns

During the low flow season (December and January), the main water channel contracts, but the flow in the river remains swift due to the steep river gradient. Thus, the oxygen concentration is high in winter and hence is not a limiting factor. However, the combination of low water temperature and the fast current make the river almost unfit for the survival of most of the fish species. This forces them to migrate and the species adopt different modes of migration to cope with the severe winters in the mountainous areas.

Three types of migration take place at the onset of winter season, longitudinal, lateral and local migration. Longitudinal migration is long distance migration, shown by fish which have strong pectoral fins and streamlined bodies such as Alwan Snow Trout *Schizothorax richardsonii* and Kunar Snow Trout *Schizothorax labiatus*. To avoid the extreme cold conditions, the Alwan Snow Trout migrate downstream in different parts of Kunhar River, side Nullahs which are comparatively warm and also take refuge in crevices and trenches in the slow moving areas of the river.

Lateral and local migration is demonstrated by fish which have no strong pectoral fins and their bodies are also not streamlined enough to cope with the flow of the river. Thus the species of the genera *Schistura* and *Triplophysa* show lateral migration as they move from the main river channel and nullah to side streams having comparatively higher temperature and slower water currents. They also occupy the crevices, boulder areas and trenches along the river bed. The species *Glyptosternum reticulatm* show local short migration and move to more suitable habitats occurring within the main river channel. These fish have adhesive apparatus in their thoracic region, which helps them to cling to the rock crevices and underneath large boulders where the water current is correspondingly lower.

During February – March, when the temperature of the Kunhar River starts to rise (7 °C – 9 °C), fish which have moved to side streams (lateral migration) return to the main river channel. The sub-mountainous fish fauna, that have a moderate temperature tolerance, now start their upstream migration which is of variable distances depending on their temperature preference.

During May and June, the variations that occur in water temperature becomes of primary importance in determining fish distribution within the Kunhar River. The water temperature rises up to 13-15°C. With the rise in temperature in June, the river upstream and downstream of Balakot is inhabited by Kashmir Hillstream Loach, which together with Alwan Snow Trout become amongst the most common species of the river during this season. This situation remains persistent during summer up to the advent of monsoon. With the onset of cold weather, the cool water fish fauna gradually start to migrate downstream to spend winter in suitable areas where they can find warm water habitats. However, some fish which are trapped in warmer side pools fed by springs and side streams/nullahs cannot migrate downstream and instead overwinter in these areas.

The fish species Brown Trout and Rainbow Trout (cold water species) which inhabit the upper reaches of river most of the year, also start downstream migration during end of November and start of December. The temperature at the upper reaches drops to 4-5°C and during this season these species can be found up to Balakot. They spend winter in these areas and then they start upstream migration during early springs when temperature is 7-8°C in the main river.

Fish Indicators and their Flow–related Needs

The following four species were selected as indicators for EFlow assessment using Downstream Response to Imposed Flow Transformations (DRIFT) model.

- Alwan Snow Trout *Schizothorax richardsonii*
- Kashmir Hill Stream Loach *Triplophysa kashmirensis*
- Nalbant's Loach *Schistura nalbanti*
- Rainbow Trout *Oncorhynchus mykiss*

All species selected as indicators demonstrate a comparatively higher degree of specialization in habitat preference in the Aquatic Study Area. In other words, the habitat range of these species was observed to terminate either moving upstream or downstream within the Aquatic Study Area. Changes in flow regime are therefore likely to have a comparatively higher level of impact on these species.

Alwan Snow Trout *Shizothorax richardsonii*

Preferences for flow dependent habitat, breeding, and migratory behavior of the *Schizothorax richardsonii* are summarized in **Exhibit 4.88. Exhibit 4.89** summarizes the annual cycle of breeding and growth of the *Schizothorax richardsonii.*

Exhibit 4.88: Preferences for Flow Dependent Habitat, Breeding, and Movement of the *Schizothorax richardsonii*

	Adults	*Juveniles*	*Spawning*
Depth	0. 5 – 1. 5 m	0. 1 – 0. 5m	0. 1 – 0. 3 m
Velocity	1 – 3 m/s	0 – 0. 5 m/s	1 – 2 m/s
Habitat	Swift running water with rocky beds	Quiet parts of the streams or in the side branches of the main streams	Spawns on gravelly / stony ground or on fine pebbles with gravel size of 50-60 mm
Substrate	Rocky/Cobbly/Gravely	Cobble/Gravel	Gravel
Temperature	14 – 20 °C	14 – 20 °C	18 – 22 °C
Dissolved O_2	6 – 8 mg/l and can survive 5-6 mg/l	6 – 8 mg/l	6 – 8 mg/l
Food	Insect larvae and eggs, Detritus	Micro-invertebrates	–
Breeding Period and Trigger	May-June in the Flood Season. Breeding is triggered by rise in temperature after the Dry Season. Spawning in side channels in shallow waters (10-30 cm) with boulders and low currents.		
Movement Pattern	Shows limited movement.		
Movement Timing	Limited movement to side channels for spawning.		

	Adults	Juveniles	Spawning
Movement Triggers	Availability of side pools with shallow waters, rise in temperature		
Other Flow-related Needs	Is sensitive to pollution. Can tolerate turbidity.		

Exhibit 4.89: Annual Cycle of Breeding and Growth of the *Schizothorax richardsonii*

Months	Flow Conditions	Fish Behavior
May – June	Flood Season	Breeding is triggered by snow melt and rise in turbidity. Fish move to breeding grounds in shallow side pools, and channels of the river with cobbles. Eggs hatch in this period, and fries and fingerlings remain in shallow waters in side channels under the cobbles.
July – October	Flood Season – Transition-2 and Dry Onset	Spent fish move to areas with boulders, cobbles in its general preferred habitat ranging from a depth of 0. 5 – 1. 0 m. Fries and fingerlings remain in the side channels. Both adult and young fish feed actively in this period to gain fat for wintering.
November – March	Dry Season	Fish move mainly to crevices under cobbles or in pools for overwintering. Food intake drops and also supplemented by fat reserves for survival.
April	Transition-1	Fish become active, takes maximum food and move to areas where it can get maximum food.

Kashmir Hillstream Loach *Triplophysa kashmirensis*

Preferences for flow dependent habitat, breeding, and migratory behavior of the *Triplophysa kashmirensis* are summarized in **Exhibit 4.90**. Annual Cycle of Breeding and Growth of the *Triplophysa kashmirensis* is shown in the **Exhibit 4.91** below.

Exhibit 4.90: Preferences for Flow–dependent Habitat, Breeding, and Movement of the *Triplophysa kashmirensis*

	Adults	Juveniles	Spawning
Depth of Water	Banks, shallow riffles (<0. 75 m)	Shallow side pools (<0. 75 m)	Shallow side channels and pools (<0. 30 m)
Velocity	Low to moderate (0 – 2 m/s)	Low to moderate (0 – 2 m/s)	Low to moderate (0 – 2 m/s)
Habitat	Pools, riffles, glides	Banks	Pools, riffles
Substrate	Rocky, stony	Cobbles	Stones, cobbles
Temperature	8 – 14 °C	10 – 12 °C	10 – 12 °C
Dissolved O_2	6–8 mg/l	6–8 mg/l	6–8 mg/l

	Adults	*Juveniles*	*Spawning*
Food	Earthworms, larvae, slime	Micro–invertebrates	–
Spawning Period	June–August		
Breeding Period and Trigger	May–August in the Flood Season. Breeding is triggered by rise in temperature after the Dry Season. Breeds both in river as well as in tributaries in suitable habitat.		
Movement Pattern	Does not show any significant movement except for breeding, when it moves to shallow side pools.		
Movement Triggers	Rise in water temperature, swollen river and expansion of habitat.		
Other Flow–related Needs	Is sensitive to pollution.		

Exhibit 4.91: Annual Cycle of Breeding and Growth of the *Triplophysa kashmirensis*

Months	*Flow Conditions*	*Fish Behavior*
June – August	Flood Season	Breeding is triggered by snow melt and rise in turbidity. Fish move to breeding grounds in shallow side pools, and channels of the river with cobbles and gravely beds. Eggs hatch in this season, and fries and fingerlings remain in shallow waters in side channels.
September – October	Transition–2 and Dry Onset	Spent fish move to banks of the mainstream. Fingerlings remain in shallow side channels. Both adult and young fish feed actively in this period.
November – March	Dry Season	Fish move mainly to crevices for overwintering. Food intake drops significantly as fish is inactive and also utilizes fat reserves for survival.
April – May	Transition–1 and Flood Season	Fish emerge and move to banks, avoiding fast flows, in search of food to get ready for the breeding season.

Nalbant's Loach *Schistura nalbanti*

Preferences for flow dependent habitat, breeding, and migratory behavior of the *Schistura nalbanti* are summarized in **Exhibit 4.92. Exhibit 4.93** summarizes annual cycle of breeding and growth of the *Schistura nalbanti.*

Exhibit 4.92: Preferences for Flow Dependent Habitat, Breeding, and Movement of the *Schistura nalbanti*

	Adults	*Juveniles*	*Spawning*
Depth of Water	Banks, shallow riffles (<0. 5 m)	Shallow side pools (<0. 5 m)	Shallow side channels and pools (<0. 30 m)
Velocity	Low to moderate (0–2 m/s)	Low to moderate (0–2 m/s)	Low to moderate (0–2 m/s)

	Adults	*Juveniles*	*Spawning*
Habitat	Pools, riffles, glides	Banks	Pools, riffles
Substrate	Rocky, stony	Cobbles	Stones, cobbles
Temperature	8 – 20 °C	10 – 20 °C	10 – 20 °C
Dissolved O2	6 – 8 mg/l	6 – 8 mg/l	6 – 8 mg/l
Food	Earthworms, larvae, slime	Micro–invertebrates	–
Spawning Period	June – August		
Breeding Period and Trigger	May – August in the Flood Season. Breeding is triggered by rise in temperature after the Dry Season. Breeds both in river as well as in tributaries in suitable habitat.		
Movement Pattern	Does not show any significant movement except for breeding, when it moves to shallow side pools.		
Movement Triggers	Rise in water temperature, swollen river and expansion of habitat.		
Other Flow–related Needs	Is sensitive to pollution.		

Exhibit 4.93: Annual Cycle of Breeding and Growth of the *Schistura nalbanti*

Months	*Flow Conditions*	*Fish Behavior*
June – August	Flood Season	Breeding is triggered by snow melt and rise in turbidity. Fish move to breeding grounds in shallow side pools, and channels of the river with cobbles and gravely beds. Eggs hatch in this season, and fries and fingerlings remain in shallow waters in side channels.
September – October	Transition–2 and Dry Onset	Spent fish move to banks of the mainstream. Fingerlings remain in shallow side channels. Both adult and young fish feed actively in this period.
November – March	Dry Season	Fish move mainly to crevices for overwintering. Food intake drops significantly as fish is inactive and also utilizes fat reserves for survival.
April – May	Transition–1 and Flood Season	Fish emerge and move to banks, avoiding fast flows, in search of food to get ready for the breeding season.

Rainbow Trout *Oncorhynchus mykiss*

Preferences for flow-dependent habitat, breeding, and migratory behaviour of the Rainbow Trout are summarized below in **Exhibit 4.94. Exhibit 4.95** summarizes the annual cycle of breeding and growth of the Rainbow Trout.

Exhibit 4.94: Preferences for Flow-dependent Habitat, Breeding, and Migratory Behavior of the Rainbow Trout *Oncorhynchus mykiss*

	Adults	*Juveniles*	*Spawning*
Depth of Water	Deep (>0.75 m)	Shallow (<0.75 m)	Shallow (0.15 - 0.75 m)
Velocity	Medium to high (>2 m/s)	Low to medium (0-2 m/s)	Low to medium (0-2 m/s)
Habitat	Riffles, pools, glides	Closer to the banks	Riffles
Substratum	Cobbles, also stony to gravely beds	Stony to gravely	Fine gravel
Temperature	6-12°C	6-12°C	<7°C
Dissolved O_2	8-10 mg/l	8-10 mg/l	10 mg/l
Food	Fish (Kashmir hill stream loach, high altitude loach), invertebrates	Invertebrates	–
Breeding Period and Trigger	Breeds in October through December in the Dry Season in continuous moderate flows. Breeding is triggered by drop in temperature below 6-7°C, typically in October.		
Movement Pattern	Migrates to tributaries and travels to suitable breeding grounds in the river to avoid competition and to find shallow clear waters suitable for breeding. Migrates back to the main river for wintering.		
Movement Timings	October-November for breeding, November for wintering.		
Movement Triggers	Change in flow pattern, reduction in turbidity, fall or rise in water temperature.		
Other Flow-related Needs	Is sensitive to pollution and therefore to poorly diluted effluents.		

Exhibit 4.95: Annual Cycle of Breeding and Growth of the Rainbow Trout *Oncorhynchus mykiss*

Months	*Flow Conditions*	*Fish Behaviour*
October-December	Dry Season	Breeding is triggered by a drop in temperature below 7-8 °C. The fish move to breeding sites in the main river and the tributaries to lay eggs in beds of fine gravel (redds[18]) in riffle flow.
January-February	Dry Season	Fries emerge after about 70 days and stay in the nursery grounds, mainly in side streams and shallow water, where food is available and the current speed is low. Adult fish migrate back from tributaries into deeper water in the mainstream for survival in the Dry Season.

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[18] A spawning nest made by a fish, especially a salmon or trout.

Months	*Flow Conditions*	*Fish Behaviour*
March-April	Dry Season-Transition Season 1	Fingerlings/juveniles stay in shallow waters near the banks and avoid fast flowing water.
May-July	Flood Season, Snow Melt	Fish avoid turbid waters, and move to clear waters in side streams as well as tributaries.
August-September	Flood Season-Transition Season 2	Fish have relatively uniform distribution in the river and tributaries and concentrate on feeding areas

Threats to Fish Fauna

During the three surveys carried out in 2016 and 2017, a number of observations were made which were identified as threats to the fish fauna in the Aquatic Study Area. These threats were noted and have been stated for four indicators fish species **(Exhibit 4.96)** along with the locations at which they were observed. Data on river-dependent activities, including sand mining and fishing, within the Aquatic Study Area, was collected as part of the socioeconomic baseline for this study. The results of this are provided in **Section 4.3.4**, *River-Dependent Socioeconomic Activities*.

Exhibit 4.96: Threats to Fish Species

No.	*Fish Species most Threatened*	*Locations*	*Threat*
1.	Nalbant's Loach	Tributaries of Kunhar River Lower reaches of main Kunhar River	Sand Mining City Runoff
2.	Kashmir Hillstream Loach	Kunhar River Tributaries of Kunhar River	Sand Mining City Run-off
3.	Alwan Snow Trout	Kunhar River Tributaries of Kunhar River	Sand Mining Fishing City Run-off
4.	Himalayan Catfish	Kunhar River Tributaries of Kunhar River	Sand Mining Fishing City Run-off

Macro-Invertebrates

Benthic macro-invertebrates are an important part of the food chain in aquatic ecosystems, especially for fish. Many invertebrates feed on algae and bacteria, which are at the lower end of the food chain. Some shred and eat leaves and other organic matter that enters or is produced in the water. Because of their abundance and position as 'intermediaries' in the aquatic food chain, benthos plays a critical role in the natural flow of energy and nutrients.[19]

Stream regulation by damming of rivers and ensuing impoundment are one of the most frequent causes of depletion of biological diversity of aquatic ecosystems resulting in

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[19] Williams D. D. and Feltmate, B. W. 1992. Aquatic Insects. CAB International Wallingford, Oxon. 360 pp.

interference with the natural process of dispersal.[20,21] Some authors have described several beneficial aspects of water regulation and impoundment, but the loss of aquatic habitat and the associated species and populations cannot be underestimated. Any variation in community structure of primary producers is reflected in subsequent changes in higher components of food chain e.g., benthic macro-invertebrates and fish fauna.[22]

The composition of invertebrate communities varies along and between rivers, with the main influences on distribution and abundance being current velocity, water temperature, substratum type, stability of both aquatic and riparian vegetation, dissolved substances, competition, and human practices. Large, stable substrata–such as boulders and cobbles–support larger, more productive invertebrate populations than do unstable gravels and sand. On mobile bottoms, such as gravel and sand, invertebrates are readily displaced and may be at risk through mechanical damage. A decrease in substratum size results in lower macro-invertebrate diversities and production.

Aubert, 1959[23] reported twenty species of stoneflies (extremely pollution intolerant organisms) belonging to seven genera from Pakistan (Hindukush including Gilgit-Baltistan and Chitral; Karakorum including Neelum valley, Kaghan valley; Rawalpindi including Murree). He reported six species of stoneflies species from Neelum Jhelum area which include *Nemoura (Amphinemura) mirabilis* (Muzaffarabad after the confluence of the Neelum and Jhelum Rivers), *Nemoura (Amphinemura) schmidi* (Kel, Neelum Valley), *Nemoura (Amphinemura) skardui* (Rampur Neelum Valley), *Nemoura* s. s. *lilami* (Kel, Neelum Valley), *Nemoura* s. s. *polystigma* (Lilam, Neelum Valley) and *Cholroperla kishanganga* (Kel, Neelum Valley).

Unpublished data collected[24] indicates that the benthic macro-invertebrate families observed in the study for the ecological baseline of NJHP also occur at the outlet zones of the lakes in the Kaghan Valley (Dudipatsar Lake, Gittidas wetland complex, and Lulusar Lake) and outlets of the lakes in the Neelum Valley (Patlian Lake and Rattigali Lake).

Based on a conversation with Mishkatullah, a macro-invertebrate specialist with the Pakistan Museum of Natural History, there is no peer reviewed information on benthic invertebrates of the Kunhar River. Unpublished research by Mishkahullah indicates that most of the benthic macro-invertebrate fauna of Kunhar river is similar to that of the outlet zone of the lakes of Kunhar watershed e.g., Dudipatsar Lake, Gettidas wetland complex, Lulusar Lake, Saif-ul-Maluk Lake.

During the May 2017 Survey a total of three locations were sampled to determine the abundance and diversity of macro-invertebrate fauna in the Aquatic Study Area. These Sampling Locations are located along the main Kunhar River. They are shown in **Exhibit 4.66**. The abundance and species diversity is shown in **Exhibit 4.97.** A map of the distribution of the abundance and species diversity is shown in **Exhibit 4.98**.

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[20] Richter, B.D., Braun, D.P., Mendelson, M.A., Master, L. L. 1997. Threats to imperiled freshwater fauna. Conservation Biology. 11, 1081-1093.

[21] Zalewski, M., Janauer, G. A., Jolankai, G., 1997. Ecohydrology. IHP-V, UNESCO. 7, 7-18.

[22] Ibid

[23] Aubert, J. 1959: Plécoptères du Pakistan. Memoires de la Societe vaudoise des Sciences naturelles, 75, Vol. 12, fasc. 3:65-91.

[24] Personal communication with Mishkatullah, Macro-invertebrate specialist in Pakistan Museum of Natural History

Exhibit 4.97: Macro-invertebrate Abundance and Richness, April 2016 Survey

No	*Taxa*	*K139.0 (Downstream of Balakot Town)*	*K126.9 (Upstream of Balakot Town)*	*K110.6 (Upstream of Paras)*	***Total***
1	*Acentrella sp.*	5	3	10	18
2	*Amphinemoura sp.*	1			1
3	*Atherix sp.*	1	1		2
4	*Baetis sp.*	45	82	110	237
5	*Belpharicera sp.*		1	3	4
6	*Chironomidae sp.*	10	24	26	60
7	*Elmidae sp.*	1	2	2	5
8	*Epeorus sp.*			1	1
9	*Heptagenia sp.*	1	1		2
10	*Hydropsyche sp.*	2		3	5
11	*Indonemoura sp.*	1	6	35	42
12	*Lepidostomatidae sp.*	1	1		2
13	*Tipulidae sp.*		8		8
14	*Rhithrogena sp.*	52	105	65	222
15	*Rhyacophila sp.*		2		2
16	*Simuliidae sp.*	12	10	6	28
Abundance		132	246	261	**639**
Species Richness (No. of species per sampling location)		12	13	10	

Principal observations are summarized below.

1. A total of 16 macro-invertebrate taxa were identified during the May 2017 Survey. Identification was at the sub-family/family level.
2. Abundance was found to be higher at Sampling Locations upstream of Balakot Town.
3. Maximum macro-invertebrate abundance was found at Sampling Location K110.6, located upstream of Paras. Second highest abundance was observed at Sampling Location K126.9 located near Sangar, upstream of Balakot Town. Lowest abundance was observed at Sampling Location K139.0, located downstream of Balakot Town. The most abundant macro-invertebrate taxon was *Baetis sp* followed by and *Rhithrogena sp*, both of which were much higher in abundance compared to the third most abundant taxon, *Chironomidae*. This is a common observation around the world as these taxa can live in variety of habitat including running and standing water. Ten pollution intolerant taxa (*Rhithrogena sp., Epeorus sp., Acentrella sp., Rhyacophila sp., Lepidostomatidae, Belpharicera sp., Atherix sp., Elmidae, Amphinemoura sp. and Indonemoura sp.*) were observed indicating good water quality. Three of the taxa observed are moderately pollution tolerant including *Hydropsyche sp.*, *Simuliidae* and *Tipulidae*.
4. Species richness was observed to be about the same across all Sampling Locations.
5. Maximum richness was seen at Sampling Location K126.9 located near Sangar. Based on a conversation with a macro-invertebrate expert[25] the abundance of the taxa more pollution tolerant taxa, such as *Chironomidae*, is low because of the absence of industry discharging into this stretch as well as the fast flow of the river during the summer season. The macro-invertebrate expert also noted that during summer the habitat is more suitable for macro-invertebrates compared to in winter. During winter the flow of water is lower and more waste accumulates. This leads to less-pollution tolerant taxa being adversely affected.

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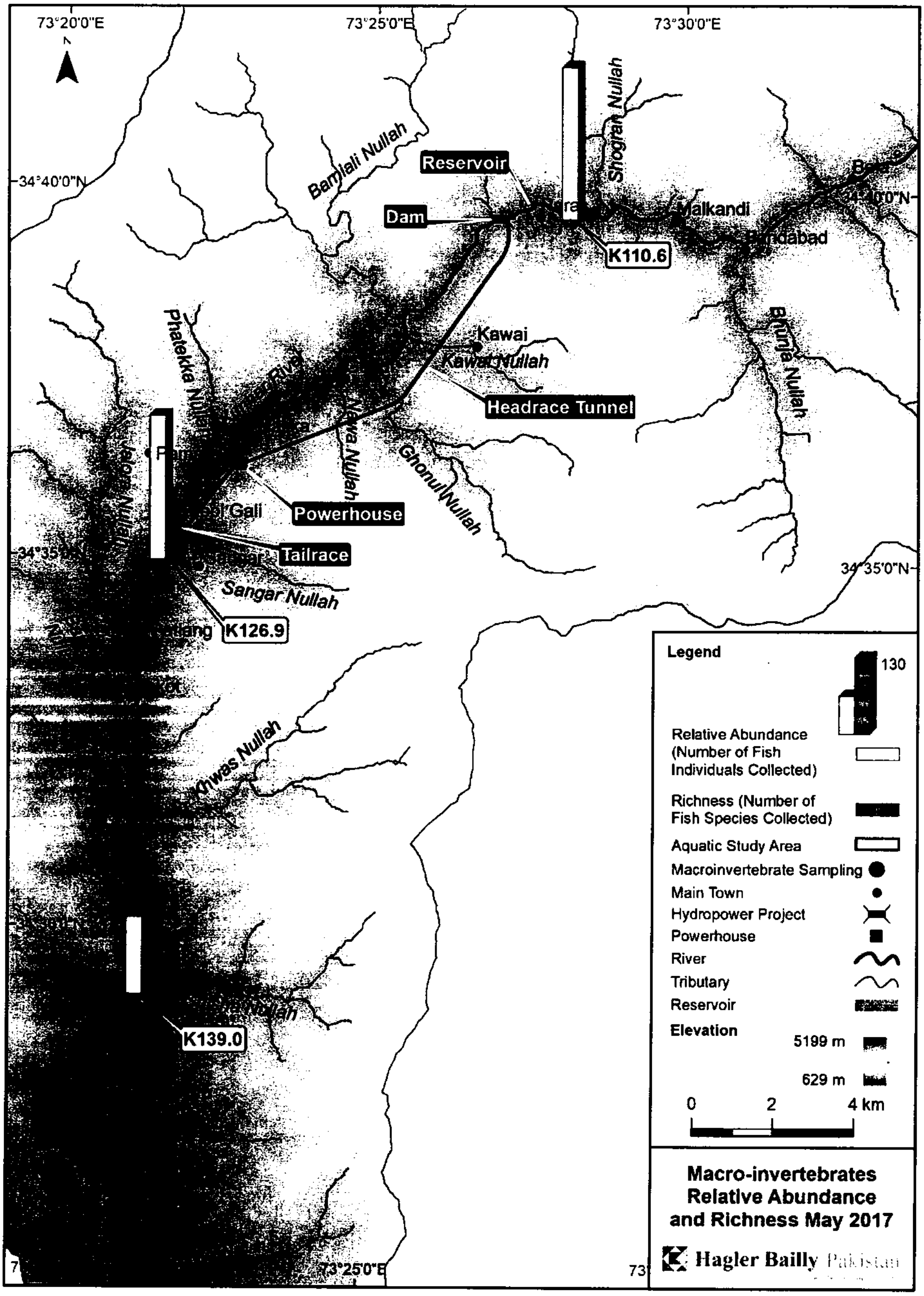
[25] Personal communication with Mishkatullah, Macro-invertebrate specialist in Pakistan Museum of Natural History

Exhibit 4.98: Distribution of Macro-invertebrate Abundance and Richness, May 2017 Survey



Riparian Habitat

The range of vegetation cover in the Riparian habitat type was observed to be between 1.48% and 0.52%. The average plant count was 27.50 per Sampling Location. Floral diversity in this habitat type was 3.25 species per Sampling Location. The dominant species include *Parthenium hysterophorus. Conyza Canadensis* and *Rumex dissectus*. Exceptionally high floods can cause extreme variations, with floodplain and bank vegetation completely removed, floodplains eradicated and new floodplains formed.

The vegetation cover, plant count and diversity by habitat type is provided in **Exhibit 4.99**. The phyto-sociological attributes are provided in **Exhibit 4.100**. Photographs of riparian vegetation are shown in **Exhibit 4.101.**

Average and maximum cover for riparian habitat type is relatively low compared to that for terrestrial habitat types. The riparian zone is generally well defined in the Study Area as the gradients along the river banks are steep, and impact of flood flow on the vegetation can be seen as a clearly defined line (see photograph at R1 in **Exhibit 4.101**). The riparian vegetation is naturally sparse as it is eroded by floods when the velocity of water is high. It is further degraded by extraction of wood and grazing along the banks that are easily accessible to the local community.

Exhibit 4.99: Vegetation Cover, Plant Count and Diversity in Riparian Habitat Type, May 2017 Survey

Habitat Types	*Plant Cover (%)*			*Plant Count (No. of Plants per Sampling Location)*			*Diversity (Average no of species per Sampling Location)*
	Avg	*Max*	*Min*	*Avg*	*Max*	*Min*	
Riparian	0.91%	1.48%	0.52%	27.50	58	14	3.25

Exhibit 4.100: Phyto-sociological Attributes of Plant Species in Habitats, May 2017 Survey

Species Name	*D1, Density*	*D3, Relative Density*	*C1, Average Cover*	*C3, Relative Cover*	*F1, Frequency*	*F3, Relative Frequency*	*IVI, Importance Value Index*
Riparian							
Conyza canadensis	1.92	20.91	0.01	10.99	0.50	15.00	15.63
Dalbergia sissoo	0.75	8.18	0.06	21.01	0.33	10.00	13.07
Dodonaea viscosa	0.08	0.91	0.05	1.80	0.08	2.50	1.74
Ficus carica	0.33	3.64	0.03	4.97	0.25	7.50	5.37
Mentha longifolia	0.33	3.64	0.01	1.69	0.08	2.50	2.61
Parthenium hysterophorus	1.58	17.27	0.02	17.10	0.75	22.50	18.96

Species Name	D1, Density	D3, Relative Density	C1, Average Cover	C3, Relative Cover	F1, Frequency	F3, Relative Frequency	IVI, Importance Value Index
Phragmites karka	0.67	7.27	0.02	5.07	0.08	2.50	4.95
Ricinus communis	0.08	0.91	0.02	0.83	0.08	2.50	1.41
Rumex dissectus	1.17	12.73	0.03	14.22	0.58	17.50	14.81
Solanum surrattense	0.08	0.91	0.02	0.91	0.08	2.50	1.44
Sonchus asper	0.33	3.64	0.02	2.48	0.25	7.50	4.54
Traxicum sp.	0.17	1.82	0.01	0.96	0.17	5.00	2.59
Typha elephantina	1.67	18.18	0.02	17.99	0.08	2.50	12.89
Total	**9**	**100**	**0.34**	**100**	**3.33**	**100**	**100**

D1: Density
The number of individuals of a species counted on a unit area.

D3: Relative density
The proportion of a density of a species to that of a stand as a whole.

C1: Average cover in sq m for a single species

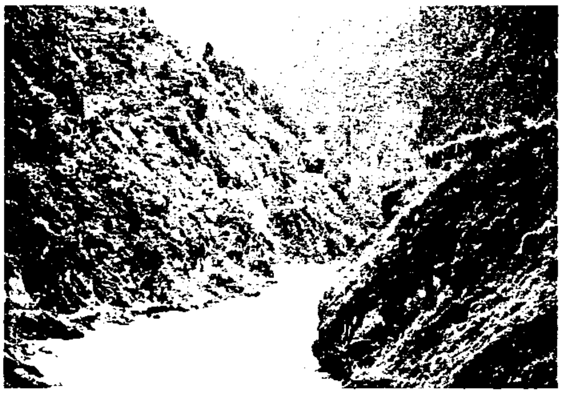
C3: Relative cover
The proportion of the total cover of a species to sum of the cover of all the species in area.

F1: Frequency
Percentage of sampling plots in which a given species occurs.

F3: Relative frequency
The proportion of the total frequency of a species to the sum of the frequency of all the plants of all species in the area.

IVI: Importance value index
It can be obtained by adding the values of relative density, relative cover and relative frequency and dividing it by three will give the importance value IVI of the species

Exhibit 4.101: Riparian Habitat



Riparian Habitat at R1 (K110.6, upstream of Paras)

Riparian Habitat at R2 (R2 K117.5 near Gudd Villagei)

Riparian Habitat at R3 (R3 K126.9 near Sangar Village)

Riparian Habitat at R4 (R4 K139.0 downstream of Balakot town)

4.2.7 Terrestrial Ecology

Sampling was carried out within the Terrestrial Study Area to determine the presence of species and habitat of importance to biodiversity within it. A literature review was also carried out to determine the biodiversity of the wider area. The results of both the surveys and the literature review are reported in this section.

Terrestrial Flora

Overview

This area is mountainous and comprises the outer ranges of the Himalayas. The elevation within the region ranges from 600 m to 4,800 m. The Terrestrial Study Area has an elevation range of 1,000 m to 1,500 m.[26]

There is limited research available on the flora of Balakot. However, within Mansehra District, research has been carried out on the floristic diversity as well as ethnobotany.

Mansehra District is reported to have forest cover of 25%. It consists mainly of Himalayan Moist Temperate Forest, typical of the Lower Kaghan Valley and Shogran. It is a mix of deciduous and coniferous forest and has high rainfall during monsoon season. Plants species include Quercus *Quercus dilatata*, Acer *Acer caesium*, Poplar *Populus ciliate*, Taxus *Taxus baccata*, Kail *Pinus wallichiana* with under shrubs such as Berberis *Berberis lyceum*, Honeysuckle *Lonicera alpigena*, Viburnum *Viburnum nervosum*, Nazar Panra *Skimmia laureola*, as well as Fragaria, Viola and Impatiens species.[27]

The Himalayan forest grazing lands located within an elevation of 1,000 m to 2,000 m have a forage productivity of 200-2,000 kg/ha.[28]

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[26] Nasir, Yasin J., and Rubina A. Rafiq. "Wild flowers of Pakistan." Karachi: Oxford University Press xxxiii, 298p., 104p. of plates-illus., col. illus. ISBN195775848 (1995).

[27] United Nations Development Programme, Pakistan (UNDP), Forests & Biodiversity Information/Data Report, [not dated].

[28] Hamid Sarfraz, Ashiq Ahmad Khan, Dr. Nasim Javed, Dr. Shahid Ahmad, Dr. Inam ur Rahim & Dr. M. Rafiq, Khyber Pakhtunkhwa Biodiversity Strategy & Action Plan, Final Draft, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Registered offices, Islamabad, June 26, 2016

A study to investigate the floristic diversity in Dilbori, located 30 km northwest of Balakot Town within the Mansehra District, was carried out in 2016.[29] The study reported a total of 104 species of plants belonging to 88 genera and 54 families. Of these 97 (93%) plant species belonged to angiosperms, 3 (3%) species to gymnosperms, 3 (3%) fungal species and 1 (1%) was a Pteridophytic species. None of the species are Endangered or Critically Endangered based on the IUCN Red List. One species, *Plantago lanceolata*, is listed as Vulnerable and two species, *Juglans regia* and *Lathyrus odoratus*, are listed as Near Threatened.

Habitat Types in the Terrestrial Study Area

Habitat classification approaches are subjective in nature, devised to assist in the understanding of ecological systems, the functions of those systems, and the interrelationship with species. Classically, wildlife habitat is described as containing three basic components: cover, food, and water (Morrison et al 2006)[30] with vegetation as the core descriptive component.

Habitats in the Terrestrial Study Area were classified relying primarily upon vegetation type. Following this classification approach, three types of habitats were defined: Scrub Forest, Pine Forest and Agricultural Land. Satellite imagery from ***Google Earth^{TM}*** was used to initially delineate spatial distribution of habitat types within the Terrestrial Study Area and this habitat characterization was confirmed during the field surveys. The use of the term Scrub Forest for a habitat type is appropriate because Scrubland is defined as a "diverse assortment of vegetation types sharing the common physical characteristics of dominance by shrub."[31] Most of the Terrestrial Study Area classified as Scrub Forest habitat type is covered by shrubs, with some herbaceous species and even fewer tree species. The relative percentages of each habitat type in the Terrestrial Study Area is provided in **Exhibit 4.102**. Photographs of different habitat types in the Terrestrial Study Area are shown in **Exhibit 4.103.**

Exhibit 4.102: Habitat Types for the Terrestrial Sampling Locations

Habitat Type	*Area (km^2)*	*Percentage*
Agricultural Area	5.4	20
Scrub Forest	12.7	48
Pine Forest	6.7	26
River	1.4	6
Total	**26.2**	**100**

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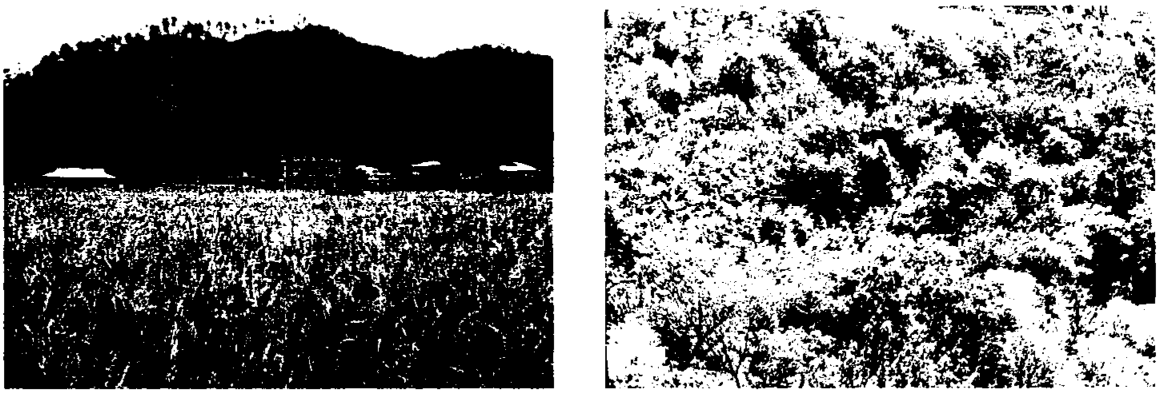
[29] Junaid Ahmed, Inayat Ur Rahman1, Abbas Hussain Shah1, Farhana Ijaz, Zulfiqar Khan1, Niaz Ali, Said Muhammad, Zeeshan Ahmed and Muhammad Afzal, First Floristic Checklist of Dilbori (Oghi), District Mansehra, KP, Pakistan, J. Appl. Environ. Biol. Sci., 7(3)41-48, 2017

[30] Morrison, M.L, Marcot, B., Mannan, W. 2006. *Wildlife–Habitat Relationships: Concepts and Applications.* Island Press, Washington, D.C.

[31] Encyclopaedia Britannica, < https://www.britannica.com>, accessed October 27, 2016

The area acquired for the Project is calculated as 75 ha. Based on ***Google Earth***^{TM} satellite imagery, within this acquired area, the different types of habitat present include 18 ha of Agricultural Area habitat, 48 ha of Scrub Forest habitat and 9 ha of Pine Forest habitat.

Exhibit 4.103: Photographs of different habitat types in the Terrestrial Study Area, May 2017 Survey



Agricultural Area

Scrub Forest

Pine Forest

A total of 42 species of plants were observed in the Terrestrial Study Area. None of the species observed in the area around the Project site were found to be globally/nationally threatened species, endemic species or protected species, with the exception of Common Walnut *Juglans regia*, which is Near Threatened based on the IUCN Red List.[32]

The vegetation cover, plant count and diversity by habitat type is provided in **Exhibit 4.104**. The phyto-sociological attributes for the species in the two habitat types for the May 2017 Survey is provided in **Exhibit 4.105**.

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[32] The IUCN Red List of Threatened Species. Version 2014.3. <http://www.iucnredlist.org>. Downloaded on 25 May 2017.

Exhibit 4.104: Vegetation Cover, Plant Count and Diversity by Habitat type, May 2017 Survey

No.	*Habitat Types*	*Plant Cover (%)*			*Plant Count*			*Diversity (Average no of species per Sampling Location)*
		Average	*Maximum*	*Minimum*	*Average*	*Maximum*	*Minimum*	
1.	Agricultural Area	5.3	6.6	4.0	42.50	61	24	7.50
2.	Scrub Forest	6.4	10.8	4.2	49.50	81	27	4.60
3.	Pine Forest	13.9	18.8	6.8	23.00	34	16	5.33

Exhibit 4.105: Phyto-sociological Attributes of Plant Species in Habitats, May 2017 Survey

Species Name	*D1, Density*	*D3, Relative Density*	*C1, Average Cover*	*C3, Relative Cover*	*F1, Frequency*	*F3, Relative Frequency*	*IVI, Importance Value Index*
Agricultural Area							
Ailanthus altissima	0.33	1.18	0.76	9.60	0.33	4.17	4.98
Berberis sp.	4.33	15.29	0.10	16.19	1.33	16.67	16.05
Cannabis sativa	1.33	4.71	0.01	0.75	0.33	4.17	3.21
Carissa opaca	1.00	3.53	0.00	0.01	0.33	4.17	2.57
Conyza canadensis	0.67	2.35	0.02	0.54	0.33	4.17	2.35
Ficus carica	0.33	1.18	0.49	6.19	0.33	4.17	3.85
Fragaria vesca	5.00	17.65	0.01	2.64	0.33	4.17	8.15
Indigofera sp.	2.00	7.06	0.08	6.25	0.67	8.33	7.21
Juglans regia	0.67	2.35	1.73	43.39	0.67	8.33	18.02
Launaea procumbens	1.33	4.71	0.02	0.89	0.67	8.33	4.64
Malvastrum coromandelianum	3.33	11.76	0.00	0.54	0.33	4.17	5.49
Oxalis corniculata	4.00	14.12	0.01	0.79	0.33	4.17	6.36
Punica granatum	1.00	3.53	0.22	8.12	0.67	8.33	6.66
Rumex dantatus	1.67	5.88	0.04	2.44	1.00	12.50	6.94
Rumex dissectus	1.33	4.71	0.03	1.67	0.33	4.17	3.51
Total	**28**	**100**	**3.53**	**100**	**8.00**	**100**	**100**

Species Name	*D1, Density*	*D3, Relative Density*	*C1, Average Cover*	*C3, Relative Cover*	*F1, Frequency*	*F3, Relative Frequency*	*IVI, Importance Value Index*
Scrub Forest							
Acacia modesta	0.47	2.36	0.37	9.04	0.27	4.82	5.41
Ailanthus altissima	0.87	4.38	0.20	9.00	0.40	7.23	6.87
Asparagus sp.	0.13	0.67	0.04	0.27	0.13	2.41	1.12
Berberis sp.	1.00	5.05	0.12	6.30	0.47	8.43	6.60
Cannabis sativa	3.60	18.18	0.01	1.41	0.33	6.02	8.54
Capsella bursa-pastoris	0.20	1.01	0.02	0.22	0.13	2.41	1.21
Conyza canadensis	1.07	5.39	0.01	0.52	0.27	4.82	3.58
Convolulus arvensis	0.53	2.69	0.01	0.31	0.07	1.20	1.40
Cotinus coggyria	0.20	1.01	0.06	0.58	0.07	1.20	0.93
Daphne mucronata	0.07	0.34	0.07	0.24	0.07	1.20	0.59
Dodonaea viscosa	0.07	0.34	0.09	0.33	0.07	1.20	0.62
Ficus carica	0.40	2.02	0.89	18.55	0.20	3.61	8.06
Fragaria vesca	1.00	5.05	0.01	0.37	0.13	2.41	2.61
Indigofera sp.	0.73	3.70	0.10	3.80	0.33	6.02	4.51
Juglans regia	0.07	0.34	3.55	12.29	0.07	1.20	4.61
Justicia adhatoda	0.33	1.68	0.08	1.46	0.07	1.20	1.45
Launaea procumbens	0.07	0.34	0.01	0.03	0.07	1.20	0.52
Malva parviflora	0.27	1.35	0.01	0.08	0.13	2.41	1.28
Melia azedarach	0.13	0.67	0.48	3.32	0.13	2.41	2.13
Mentha piperita	1.33	6.73	0.01	0.36	0.07	1.20	2.77
Morus nigra	0.20	1.01	0.28	2.92	0.13	2.41	2.11
Oxalis corniculata	2.67	13.47	0.00	0.30	0.20	3.61	5.79
Olea ferruginea	0.07	0.34	0.54	1.88	0.07	1.20	1.14
Pinus roxburghii	0.20	1.01	0.38	3.89	0.13	2.41	2.44
Populus ciliata	0.33	1.68	0.54	9.37	0.13	2.41	4.49
Robinia pseudoacacia	0.53	2.69	0.11	2.98	0.40	7.23	4.30
Rumex dantatus	0.13	0.67	0.02	0.16	0.13	2.41	1.08
Rumex dissectus	2.13	10.77	0.08	9.01	0.53	9.64	9.81
Lamium album	0.53	2.69	0.01	0.30	0.07	1.20	1.40
Solanum nigrum	0.07	0.34	0.04	0.15	0.07	1.20	0.56
Sonchus asper	0.07	0.34	0.03	0.12	0.07	1.20	0.55
Traxicum sp.	0.33	1.68	0.02	0.41	0.13	2.41	1.50

Species Name	D1, Density	D3, Relative Density	C1, Average Cover	C3, Relative Cover	F1, Frequency	F3, Relative Frequency	IVI, Importance Value Index
Total	**20**	**100**	**8.21**	**100**	**5.53**	**100**	**100**
Pine Forest							
Acer caesium	0.13	1.74	0.02	0.06	0.07	1.89	1.23
Ailanthus altissima	0.40	5.22	0.05	0.54	0.13	3.77	3.18
Berberis sp.	0.40	5.22	0.11	1.25	0.13	3.77	3.42
Capsella bursa-pastoris	0.07	0.87	0.03	0.06	0.07	1.89	0.94
Cedrus deodara	0.27	3.48	2.06	15.77	0.20	5.66	8.30
Conyza canadensis	0.20	2.61	0.02	0.09	0.07	1.89	1.53
Cotinus coggyria	0.07	0.87	0.21	0.40	0.07	1.89	1.05
Ficus carica	0.53	6.96	0.27	4.16	0.33	9.43	6.85
Fragaria vesca	0.33	4.35	0.02	0.15	0.07	1.89	2.13
Indigofera sp.	0.20	2.61	0.06	0.34	0.20	5.66	2.87
Launaea procumbens	0.27	3.48	0.01	0.11	0.07	1.89	1.82
Mallotus philippensis	0.07	0.87	0.43	0.83	0.07	1.89	1.20
Melia azedarach	0.13	1.74	0.89	3.42	0.13	3.77	2.98
Picea smithiana	0.07	0.87	0.64	1.23	0.07	1.89	1.33
Pinus roxburghii	0.93	12.17	1.45	38.78	0.53	15.09	22.02
Pinus wallichiana	0.47	6.09	1.83	24.44	0.27	7.55	12.69
Punica granatum	0.13	1.74	0.30	1.14	0.13	3.77	2.22
Robinia pseudoacacia	0.47	6.09	0.29	3.82	0.27	7.55	5.82
Rumex dissectus	0.93	12.17	0.08	2.01	0.27	7.55	7.24
Silybum marianum	0.20	2.61	0.02	0.13	0.07	1.89	1.54
Solanum nigrum	0.07	0.87	0.24	0.45	0.07	1.89	1.07
Sonchus asper	0.33	4.35	0.03	0.26	0.20	5.66	3.42
Urtica dioica	1.00	13.04	0.02	0.54	0.07	1.89	5.16
Total	**8**	**100**	**9.06**	**100**	**3.53**	**100**	**100**

D1: **Density**
The number of individuals of a species counted on a unit area.

C1: **Average cover** in sq m for a single species

C3: **Relative cover**
The proportion of the total cover of a species to sum of the cover of all the species in area.

F3: **Relative frequency**
The proportion of the total frequency of a species to the sum of the frequency of all the plants of all species in the area.

D3: **Relative density**
The proportion of a density of a species to that of a stand as a whole.

F1: **Frequency**
Percentage of sampling plots in which a given species occurs.

IVI: **Importance value index**
It can be obtained by adding the values of relative density, relative cover and relative frequency and dividing it by three will give the importance value IVI of the species

Agricultural Area

Agricultural Area habitat type constitutes 20% of the Terrestrial Study Area. The range of vegetation cover is between 6.6% and 4.0%. The average plant count is 42.50, which is the lowest of all habitat types. Floral diversity is 7.50 species per Sampling Location, which is the highest out of all habitat types.[33] The dominant species in include *Juglans regia*, *Berberis sp.*, and *Fragaria vesca*. Photographs of some plant species found in this habitat type are shown in **Exhibit 4.106**.

Exhibit 4.106: Plant Species in Agricultural Area, May 2017 Survey

Indigoferra spp. at T3

Convolvulus arvensis at T3

Asparagus spp. at T3

Scrub Forest

Scrub Forest habitat type is the dominant habitat in the Terrestrial Study Area, constituting 48%. The range of vegetation cover is between 10.8% and 4.2%. The average plant count is 49.50, which is the highest out of all habitat types. The floral diversity is 4.60 species per Sampling Location, which is lower than Agricultural Area habitat but more than that of Pine Forest habitat type. The dominant species include

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[33] Average number of species per Sampling Location with a single Sampling Location being three 5m by 5m quadrats on a 500m transect, making it an area of 300 m^2.

Rumex dissectus followed by *Cannabis sativa* and *Ficus carica*. Photographs of some plant species found in this habitat type are shown in **Exhibit 4.107**.

Exhibit 4.107: Plant Species in Scrub Forest, May 2017 Survey

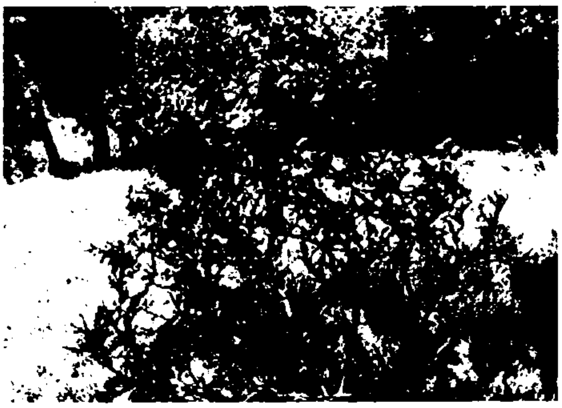
Lamium album at T5

Populus ciliata at T5

Carissa opaca at T2

Juglans regia at T2

Rumex dissectus at T4



Daphne mucronata at T9

Oxalus comiculata at T12

Cannabis sativa at T12

Justicia adhatoda at T12

Mentha piperita at T12

Morus nigra at T12

Acacia modesta at T12

Ficus carica at T12 (not in quadrat)

Pine Forest

Pine Forest habitat type constitutes 26% of the Terrestrial Study Area. The range of vegetation cover is between 18.8% and 6.8%. The average plant count is 23.00, which is the lowest out of all habitat types. The floral diversity is 5.33 species per Sampling Location, which is lower than Agricultural Area habitat but higher than that of Scrub Forest habitat type. The dominant species in this habitat type include *Pinus roxburghii*, *Pinus wallichiana*, and *Cedrus deodara*. Photographs of some plant species found in this habitat type are shown in **Exhibit 4.108**.

Exhibit 4.108: Plant Species in Pine Forest, May 2017 Survey

Pinus Wallachiana at T7

Acer caesium at T1

Urtica dioica at T1

Cotinus coggyria at T8

Ailanthus altissima at T8

Discussion

The indicators, including plant cover, plant count and diversity per Sampling Location describe the floral conditions within each habitat type.

Within Pine Forest habitat the average and maximum plant cover is higher than in the other two habitat types. The plant count within Pine Forest habitat type is lower than in the other two habitat types indicating that the number of plants in this habitat type are fewer and the higher cover is provided by the more frequent presence of species with large canopies such as *Pinus roxburghii* and *Pinus wallichiana*. The species diversity per Sampling Location is highest for Agricultural Area habitat type indicating that within this habitat type there is greater species diversity as compared to the Pine Forest and Scrub Forest habitat types. The lowest species diversity is in the Pine Forest habitat type.

Invasive Species

An alien or non-native plant or animal species is one that is introduced beyond its original range of distribution. Invasive alien species are non-native species that may become invasive or spread rapidly by outcompeting other native plants and animals when they are introduced into a new habitat that lacks their controlling factors as determined by natural evolution.[34]

Studies have indicated that 700 alien species are found in Pakistan. Of these six are considered to have extreme invasive nature including Paper Mulberry *Broussonetia papyrifera*, Mesquite *Prosopis juliflora*, Common Water Hyacinth *Eichhornia crassipes*, Giant Salvinia *Salvinia molesta*, Parthenium Weed *Parthenium hystrophorus*, and Lantana *Lantana camara*.[35]

Paper Mulberry, having East Asian origin is an invasive species in the Himalayan foothills which not only threatens natural vegetation of Islamabad but has also become a prime source of pollen allergy to about 46% of people Islamabad.[36] The species

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[34] International Finance Corporation, 2012, Guidance Note 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources

[35] Mohammad Niaz, May 4, 2009, Invasive alien species: A threat to biodiversity, Dawn News, accessed November 8, 2016

[36] Ibid

Parthenium Weed, originating in the Gulf of Mexico and Central South America, was introduced in India and later invaded Pakistan. It is an aggressive weed in wastelands, road sides, water courses, and plantations. It can thrive well in high temperature zones; global warming scenario will even favor this invader.[37] The species has replaced the native vegetation and shows vigorous growth by forming thick continuous mats along the roadsides in many cities of the country where the climatic conditions are favorable. It is also one of the major weeds of the disturbed areas causing allergy.[38] Other invasive species found in the northern Pakistan include Ailanthus *Ailanthus altissima*, Black Locust *Robinia pseudoacacia* and Lantana *Lantana camara*.[39]

A study conducted in District Manshera, Pakistan in 2006 identified 63 weed species belonging to 32 families as being common in agricultural areas.[40] Of these 23 weeds were perennial, 37 were annual and three were parasitic. In particular, two species *Cuscuta reflexa* and *Viscum album* were found to be major parasitic weeds on trees. *Viscum album* was found to be damaging the Near Threatened species Common Walnut *Juglans regia* while *Cuscuta reflexa* was found to be growing in all kinds of trees and bushes.

An analysis of invasive species in Riparian habitat and the habitat types in the Terrestrial Study Area was carried out. A total of seven invasive species were identified.

Riparian Vegetation

In the Riparian habitat a total of three invasive species were identified including Parthenium Weed *Parthenium hysterophorus*, Common Weed *Phragmites karka* and Castor Oil Plant *Ricinus communis*. Based on their IVI, Parthenium Weed (18.96) is the dominant species in the Riparian habitat.

Terrestrial Study Area

In the Terrestrial Study Area a total of four invasive species were identified, in all three habitat types. In the Agricultural Area habitat type, two invasive species were observed including Tree-of-heaven *Ailanthus altissima,* and Cannabis *Cannabis sativa* both with low IVIs of 4.98 and 3.21 respectively. This indicates that invasive species are not dominant in this habitat type. In Scrub Forest habitat all four invasive species were observed including Tree-of-heaven, Cannabis, Pink Cheeseweed *Malva parviflora* and Black Locust *Robinia pseudoacacia.* The species Cannabis and Tree-of-heaven have the second and fourth highest IVIs of 8.54 and 6.87 respectively in this habitat type indicating that they are dominant species in Scrub Forest habitat. The other two have lower IVIs. In Pine Forest habitat all four invasive species were observed. Both had relatively low IVI values in this habitat type with Black Locust having the sixth highest IVI of 5.82 and Tree-of-heaven having the tenth highest IVI of 3.18. This indicates invasive species are not dominant in this habitat type.

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[37] Ibid

[38] National Environment Information Management System (NEIMS), United Nations Development Program, May 4, 2010, Forests and Biodiversity Information/Data Report, National Environment Information Management System (NEIMS), United Nations Development Program

[39] Ibid

[40] Ghulam Mujtaba Shah, Mir Ajab Khan, Checklist of Noxious Weeds of Distract Mansehra, Pakistan, Pak. J. Weed Sci. Res. 12 (3): 213-219, 2006

The habitat types with the highest number of invasive species, totaling four, are Scrub Forest and Pine Forest. Two invasive species in these habitat types, Cannabis and Tree-of-heaven, are also amongst the dominant species in this plant community. In Riparian habitat, the invasive species Parthenium Weed is dominant, having the highest IVI in the plant community.

Risk Assessment

Most of the Project-related activities will take place on Scrub Forest habitat type, however, there will also be Project-related activity on Agricultural Area and Pine Forest habitat type. The invasive species already present on Scrub Forest habitat type include Tree-of-heaven, Cannabis, Pink Cheeseweed and Black Locust, of which the first two are dominant in that habitat type. Project-related activity in the Riparian habitat type will increase the risk of spread of Parthenium Weed, which is already dominant in that habitat type. Disturbance of areas covered within these habitat types increases the risk of spread of these invasive species, in particular. However, other invasive species can also spread and colonize the disturbed areas as Project-related activities such as transport of equipment and waste can facilitate their spread, along with natural modes of dispersion such as being carried on the bodies of birds and other animals, as well as through wind and water.

The risk of each species within the Terrestrial Study Area was assessed based on the following categories:

- Importance Value Index (IVI)
- Relative Cover

The invasive species were ranked based on IVI[41], in Riparian habitat and all other Terrestrial Habitats combined for the Terrestrial Study Area. The habitat types in Terrestrial Habitats include Scrub Forest, Pine Forest and Agricultural Area. The ranking is presented in **Exhibit 4.109**.

Exhibit 4.109: Importance Value Index (IVI)

Ranking	*Terrestrial Habitats (Agriculture Area, Scrub Forest and Pine Forest habitats)*	*Riparian Habitat*
1.	Cannabis *Cannabis sativa*	Parthenium Weed *Parthenium hysterophorus*
2.	Tree-of-heaven *Ailanthus altissima*	Common Weed *Phragmites karka*
3.	Black Locust *Robinia pseudoacacia*	Castor Oil Plant *Ricinus communis*
4.	Pink Cheeseweed *Malva parviflora*	

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[41] A composite index calculated using relative frequency, density and cover

The results of the ranking show that in Riparian habitat, Parthenium Weed is dominant followed by Common Weed and Castor Oil Plant. In Terrestrial Habitats the dominant species is Cannabis followed by Tree-of-heaven, Black Locust and Pink Cheeseweed.

The ranking based on relative cover is presented in **Exhibit 4.110.** The overall relative cover of all invasive species compared to that of all the plant species was 7.85% in Terrestrial Habitats and 23.00% in Riparian habitat.

Exhibit 4.110: Relative Cover (C3)

Ranking	*Terrestrial Habitats (Agriculture Area, Scrub Forest, and Pine Forest habitats)*	*Riparian Habitat*
1.	Tree-of-heaven *Ailanthus altissima*	Parthenium Weed *Parthenium hysterophorus*
2.	Black Locust *Robinia pseudoacacia*	Common Weed *Phragmites karka*
3.	Cannabis *Cannabis sativa*	Castor Oil Plant *Ricinus communis*
4.	Pink Cheeseweed *Malva parviflora*	

The results of the ranking based on relative cover show that in Terrestrial Habitats the highest relative cover is for Tree-of-heaven followed by Black Locust, Cannabis and Pink Cheeseweed. In Riparian habitat the highest cover is for Parthernium Weed followed by Common Weed and Castor Oil Plant.

The habitat most at risk is Riparian Habitat. This is because species cover for invasive species is higher in this than in Terrestrial Habitats. The dominant species in this habitat type is Parthenium Weed (based on IVI) which spreads as a result of disturbance. This indicates that Riparian habitat type is more disturbed than other habitat types.

Ethnobotany

Ethnobotany is the systematic study of the relationships between plants and people.[42] The popularity of herbal drugs is on the rise in many developed countries of the world, while in developing countries like Pakistan; medicinal plants contribute significantly to the income sources of people living in remote areas.[43]

Pakistan is among the top eight exporting countries of medicinal and aromatic plants in the world, exporting plants worth US$ 5.45 million per year. Over 60% of the total export originates from the Hindukush-Himalayas regions of the country.[44]

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[42] New World Encyclopedia, http://www.newworldencyclopedia.org/entry/Ethnobotany, accessed April 13, 2017

[43] Hassan Sher, Haidar Ali And Shafiqur Rehman, Identification And Conservation of Important Plant Areas (IPAS) For The Distribution Of Medicinal, Aromatic And Economic Plants In The Hindukush-Himalaya Mountain Range, Pak. J. Bot., 44: 187-194, Special Issue May 2012

[44] Hassan Sher, Haidar Ali And Shafiqur Rehman, Identification And Conservation of Important Plant Areas (IPAS) For The Distribution Of Medicinal, Aromatic And Economic Plants In The Hindukush-Himalaya Mountain Range, Pak. J. Bot., 44: 187-194, Special Issue May 2012

The country on the whole has serious problem with the loss of floral richness and diversity. Deforestation, followed by heavy grazing/browsing by domestic livestock; and unsustainable uses of various forms are the major factors behind the rapid loss of floral resources.[45]

Studies have been carried out on the ethnobotanical value of plants in the Mansehra District. The areas selected for the studies that are closest to the Terrestrial Study Area and representative of the fauna include Siran, Shogran and Kaghan Valleys.

Studies have shown that Siran has about 123 species, while Shogran hosts 117 species having high ethno botanical and medicinal importance.[46]

Within Siran Valley, a study carried out in 2006 reported the ethno-medicinal uses of 80 plant species belonging to 49 families. Of these, cultivated medicinal plants consist of 21 species with the rest being wild plants.[47]

Within Shogran Valley 50 plant species were selected to observe their pharmacological values. The study found that the plants were used for medicinal applications in skin treatment, as diuretics, expectorant, digestive, anti-inflammatory and for respiratory disorders. The species *Abies pindrow*, *Achillea millefolium*, *Cedrus deodara*, *Stellaria media*, *Trigonella foenumgraecum* and *Urtica dioica* have therapeutic application for treatment of variety of ailments.[48]

Within Kaghan Valley, studies were conducted in 2009 and 2010. These found 102 important plant species belonging to 93 genera and 61 families. Many of these plants were found to have more than one local use. These included use as fuel wood, forage/fodder, medicinal, edible, shelter making, timber wood and furniture wood.[49]

Mammals

The forests of the area provide habitat for mammal species including Yellow-throated Marten *Martes flavigula*, Giant Red Flying Squirrel *Petaurista petaurista*, Flying Squirrel *Hylopetes fimbriatus*, Leopard Cat *Prionailurus bergalensis*. Grey Langur *Semnopithecus entellus*, Rhesus Macaque *Macaca mulatta*, Common Leopard *Panthera pardus*, Himalayan Black Bear *Ursus thibetanus*, Grey Goral *Nemorhaedus goral*, Porcupine *Hystrix indica*. Murree Vole *Hyperacrius wynnei*. Turkestan Rat *Rattus*

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[45] Ibid

[46] Ibid

[47] Ghulam Mujtaba Shah and Mir Ajab Khan, Check List of Medicinal Plants of Siran Valley Mansehra-Pakistan, Ethnobotanical Leaflets 10: 63-71. 2006.

[48] Ume Ummara, Tasveer Zahra Bokhari, Adeela Altaf, Uzma Younis, Altaf Ahmed Dasti, Pharmacological Study of Shogran Valley Flora, Pakistan, International Journal of Scientific & Engineering Research, Volume 4, Issue 9, September, 2013

[49] Muhammad Rashid Awan, Zafar Iqbal, Syed Muqarab Shah, Zafar Jamal, Gul Jan, Muhammad Afzal, Abdul Majid and Alia Gul, Studies on traditional knowledge of economically important plants of Kaghan Valley, Mansehra District, Pakistan, Journal of Medicinal Plants Research Vol. 5(16), pp. 3958-3967, 18 August, 2011

turkestanicus, Long-tailed Field Mouse *Apodemus sylvaticus*. Whiskered Bat *Myotis muricola* and Grey Long-eared Bat *Plecotus austriacus*.[50,51]

Some of the species reported are included in the IUCN Red List 2014.[52] The Musk Deer *Moschus leucogaster* and Himalayan Grey Langur *Semnopithecus ajaxlis* are listed as Endangered, Black Bear *Ursus thibetanus* is listed as Vulnerable while the Common Leopard *Panthera pardus* and Grey Goral *Naemorhedus goral* are listed as Near Threatened.[53]

Sampling was carried out at 17 Sampling Locations during the May 2017 Survey to study the mammalian species abundance and diversity within the Terrestrial Study Area and Riparian habitat. The locations of these are shown in **Exhibit 4.64**. The results of the surveys, based on the sightings or signs of the mammals observed during the survey carried for this study are provided in **Exhibit 4.111**. A summary of the results by habitat type is provided in **Exhibit 4.112** which presents data on the signs and sightings for mammals (excluding rodents), abundance and diversity for the May 2017 Survey. Photographs of the signs of the Asiatic Jackal are shown in **Exhibit 4.113**. An Asiatic Jackal was sighted between Sampling Location T8 and T10 at night time (34°35’32.8”N, 73°22’41.9”E).

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[50] United Nations Development Programme, Pakistan (UNDP), Forests & Biodiversity Information/Data Report, [not dated].

[51] Hamid Sarfraz, Ashiq Ahmad Khan, Dr. Nasim Javed, Dr. Shahid Ahmad, Dr. Inam ur Rahim & Dr. M. Rafiq, Khyber Pakhtunkhwa Biodiversity Strategy & Action Plan, Final Draft, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Registered offices, Islamabad, June 26, 2016

[52] The IUCN Red List of Threatened Species. Version 2014.3. <http://www.iucnredlist.org>. Downloaded on 25 May 2017.

[53] Ibid

Exhibit 4.111: Abundance of Mammal Signs and Sightings, May 2017 Survey

No	*Scientific Name*	*Common Name*	*IUCN Status*[54]	*Agricultural Area*		*Scrub Forest*		*Pine Forest*		*Riparian*	
				Sightings	*Signs*	*Sightings*	*Signs*	*Sightings*	*Signs*	*Sightings*	*Signs*
	Canidae										
1.	*Canis aureus*	Asiatic Jackal	Least Concern		2				3	1	1
2.	*Vulpes vulpes*	Red Fox	Least Concern			1					
	Hystricidae										
3.	*Hystrix indica*	Indian Crested Porcupine	Least Concern						1		1
	Herpestidae										
4.	*Herpestes javanicus*	Small Asian Mongoose	Least Concern					1			

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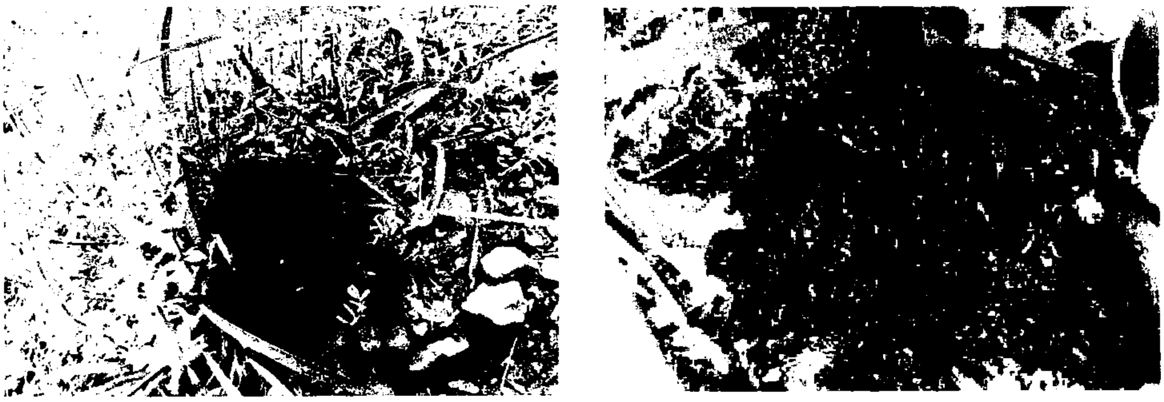
[54] The IUCN Red List of Threatened Species. Version 2014.3. <http://www.iucnredlist.org>. Downloaded on 25 May 2017.

Exhibit 4.112: Signs/Sightings Data for Mammals (excluding Rodents) Abundance and Diversity by Habitat Type, May 2017 Survey

Habitat	*No. of Sampling Locations*	*Total Signs/ Sightings*	*Average Signs/Sightings per Sampling Locations (Density)*	*No. of Species*
Agricultural Area	2	2	1.00	1
Scrub Forest	6	1	0.17	1
Pine Forest	5	5	1.00	3
Riparian	4	2	0.50	2
Total	**17**	**10**	**0.59**	**4**

Exhibit 4.113: Signs of Mammals, May 2017 Survey



Scat of Jackal at T11

The locals in the Terrestrial Study Area were questioned about the sighting of wildlife species in the vicinity of the Terrestrial Study Area. They stated that the Asiatic Jackal, Red Fox, Common Leopard and Wild Boar are very common in the area. They emphasized the fact that Wild Boar is damaging for crops. The mammals reported to be harmful to livestock included the Asiatic Jackal, and Common Leopard. The SFDO, Balakot, Sarmad Shah stated that the Black Bear is also common in the area.

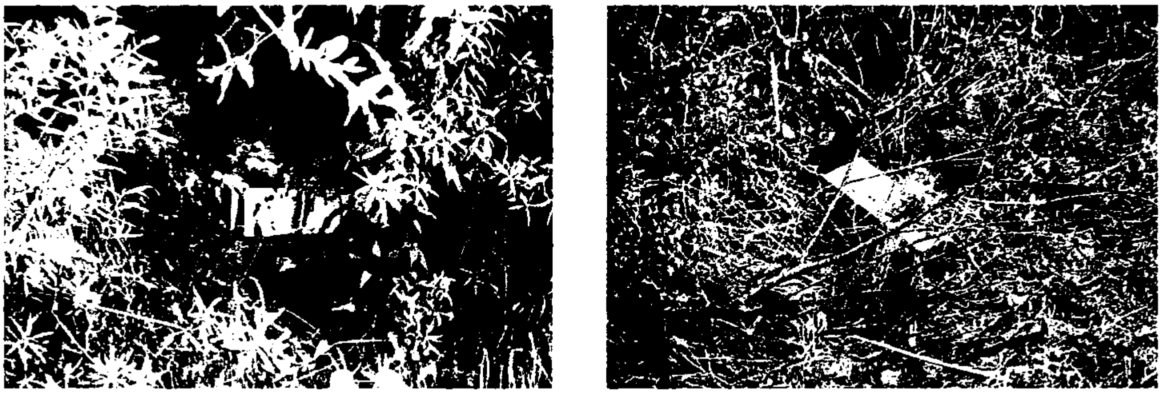
Small Mammals

Trapping for small mammals was carried out at three Sampling Locations, one in each of the habitat types. The locations and coordinates are provided in **Exhibit 4.114.** Photographs of small mammal traps are shown in **Exhibit 4.115**. No small mammals were captured.

Exhibit 4.114: Small Mammal Trapping Locations, May 2017 Survey

Habitat	*Closest Sampling Location*	*Latitude*	*Longitude*
Agricultural Area	T11	34°34'54.30"	73°22'7.90"
Scrub Forest	T12	34°35'20.60"	73°22'11.5"
Pine Forest	T8	34°36'04.79"	73°22'54.25"

Exhibit 4.115: Small Mammal Traps, May 2017 Survey



Avifauna

Surveys for bird diversity and abundance were carried in the Terrestrial Study Area in May 2017. A total of 17 Sampling Locations were visited with 13 in terrestrial habitat types and four in Riparian habitat type. A summary of the results by habitat type including the bird abundance and diversity is provided in **Exhibit 4.116**. The field data is provided in **Appendix J**.

Exhibit 4.116: Total Sightings, Density and Diversity by Habitat Type, May 2017 Survey

Habitat	*No. of Sampling Points*	*Total Sightings*	*Density (Average no of species per Sampling Location)*	*No. of Species*
Agricultural Area	2	370	165	15
Scrub Forest	6	981	164	25
Pine Forest	5	675	135	22
Riparian	4	785	196	16
Total	**17**	**2,771**	**163**	**48**

A total of 2,771 individuals belonging to 48 species were observed. Maximum abundance was observed at Sampling Location T4, located in Scrub Forest habitat. Abundant bird species observed at this Sampling Location included the Common Chiffchaff, the Common Kestrel, and the Indian Golden Oriole.

Maximum diversity was observed at Sampling Location T13, located in Pine Forest habitat. A total of 15 bird species were observed at this Sampling Location.

Abundant bird species in the Terrestrial Study Area included the Common Raven *Corvus corax*, the Bank Myna *Acridotheres ginginianus*, the White-cheeked Bulbul *Pycnonotus leucotis*, Black Drongo *Dicrurus macrocercus*, and Great Tit *Parus major*.

Of the bird species observed, none are Endangered or Critically Endangered based on the IUCN Red List of Threatened Species.[55] One species, the Rufous-vented Prinia P*rinia burnesii*, observed during the May 2017 Survey is listed as Near Threatened. Also, four species observed during the May 2017 Survey are listed on the CITES Species Appendices[56] including the Black Kite *Milvus migrans*, the Common Kestrel *Falco tinnunculus*, the Common Crane *Grus grus* and the European Honey Buzzard *Pernis apivorus*, all listed on Appendix II. All four species show migratory behavior and congregatory behavior based on the IUCN Red List of Threatened Species database.[57]

Some of the bird species photographed within the Terrestrial Study Area and Riparian habitat are shown in **Exhibit 4.117** and **Exhibit 4.118**, respectively.

A list of bird species reported from Terrestrial Study Area is provided in **Appendix K**. Information about the species listed as Near Threatened, the Rufous-vented Prinia is provided below.

The locals reported the presence of Vultures in the area, however, none were observed during the May 2017 Survey.

Rufous-vented Prinia *Prinia burnesii*

Adults of this species have streaked upper parts, whitish lores/eye-rings with a broad tail and rufous vent. Residents occur frequently along margins of larger rivers/lakes and especially in irrigation-barrage seepage zones. The species favors extensive tracts of reeds and cane grass.[58] The global population has not been quantified but the species is described as locally numerous in the Indus floodplain in Pakistan and locally frequent in parts of India. A moderately rapid and on-going decline is suspected, owning to habitat loss and degradation.[59]

Pheasants and Western Tragopan

There are three pheasant species of importance reported from the Terrestrial Study Area which include the Cheer Pheasant, the Kokhlass Pheasant, and the Kalij Pheasant. The Western Tragopan is also reported from here. Of these the Cheer Pheasant and the Western Tragopan are listed as Vulnerable while the Kokhlass and Kalij are listed as Least Concern.[60] None of these species were observed during the May 2017 Survey.

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[55] IUCN 2015. *The IUCN Red List of Threatened Species. Version 2015-4*. <http://www.iucnredlist.org>, accessed May 29, 2017.

[56] UNEP-WCMC. SPECIES+ CITES database. <http://www.speciesplus.net/species>, accessed May 29, 2017

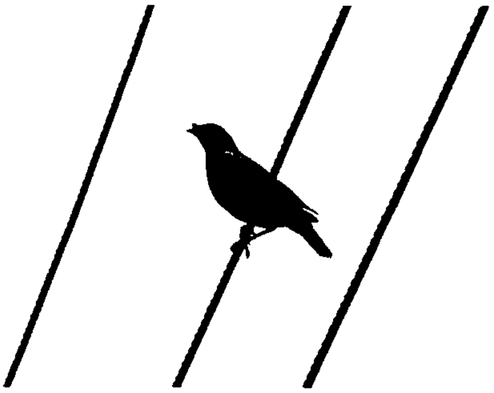
[57] IUCN 2015. *The IUCN Red List of Threatened Species. Version 2015-4*. <http://www.iucnredlist.org>, accessed May 29, 2017.

[58] Grimmett, R., Roberts, T., and Inskipp, T. 2008. Birds of Pakistan, Yale University Press.

[59] BirdLife International. 2017. Laticilla burnesii. The IUCN Red List of Threatened Species 2017: e.T22735835A111367374. Downloaded on 01 June 2017.

[60] IUCN 2015. *The IUCN Red List of Threatened Species. Version 2015-4*. <http://www.iucnredlist.org>, accessed May 29, 2017.

Exhibit 4.117: Bird Species in the Terrestrial Study Area, May 2017 Survey

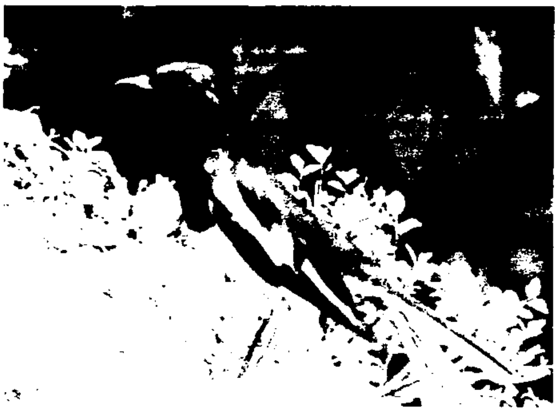


Jungle Myna near T2

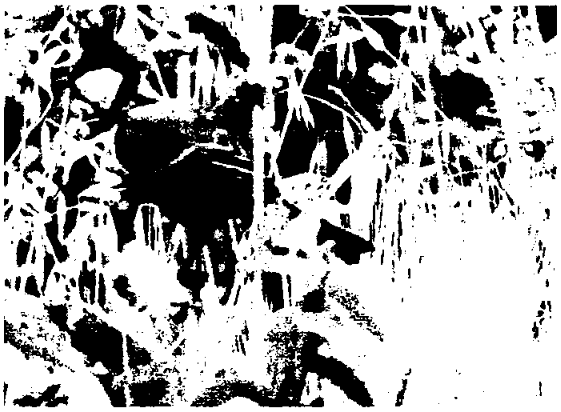
Black Drongo at T2

Long-tailed Shrike at T3

Striated Laughing Thrush at T3



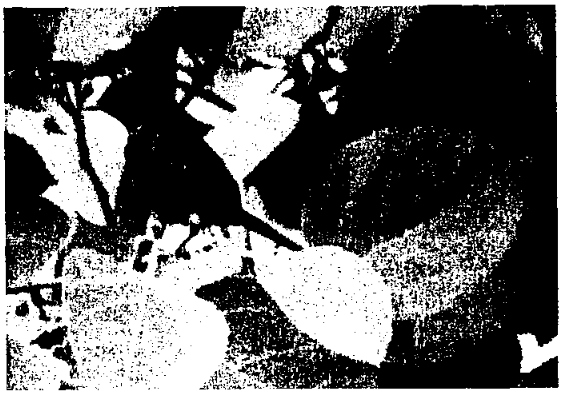
Oriental Magpie Robin at T3



Great Tit at T3

Siberian Stonechat at T8

Himalayan Bulbul near T13



Long-tailed Minivet at T13

Yellow-crowned Woodpecker at T13

Exhibit 4.118: Bird Species in Riparian Habitat, May 2017 Survey

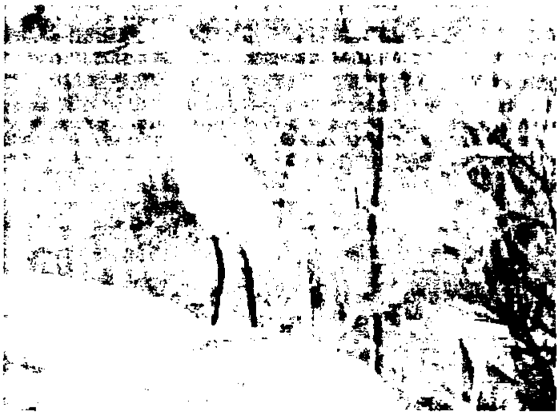

Blue Whistling Thrush at R1


Grey Bushchat near R2


Asian Black Bulbul at R2


Black Drongos at R2


White Wagtail at R3


Little Egret at R4

Herpetofauna

A total of 17 Sampling Locations were sampled during the May 2017 Survey. The locations of these Sampling Locations have been shown in **Exhibit 4.64**.

A summary of the Sampling Locations by habitat type, number of sightings, density and number of species is shown in **Exhibit 4.119.**

Exhibit 4.119: Herpetofauna Abundance and Diversity by Habitat Type, May 2017 Survey

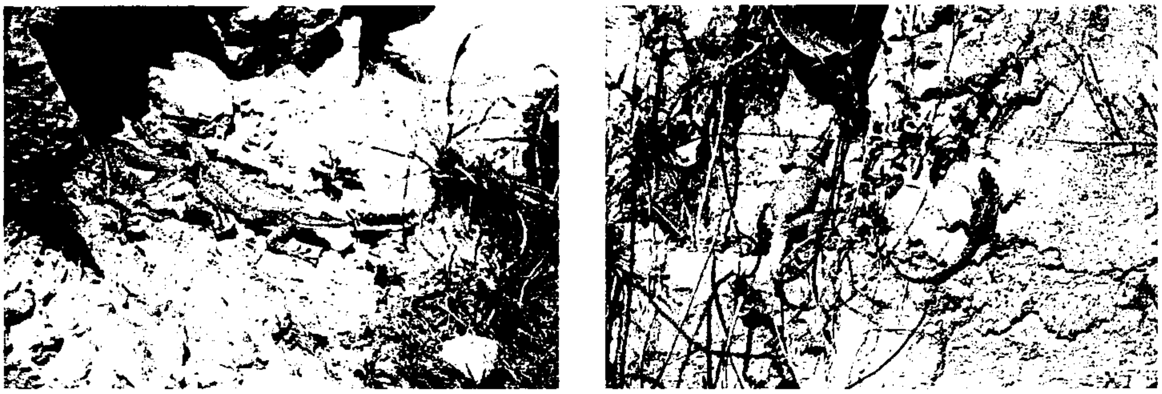
Habitat	*No. of Sampling Locations*	*Total Signs/ Sightings*	*Average Signs/Sightings per Sampling Location (Density)*	*No. of Species*
Agricultural Area	2	7	3.50	3
Scrub Forest	6	23	3.83	2
Pine Forest	5	26	5.20	4
Riparian	4	7	1.75	3
Total	**17**	**63**	**3.71**	**6**

A total of 63 reptile and amphibian specimens belonging to six species were observed in the combined Terrestrial Study Area and Riparian habitat. The highest density of herpetofauna was observed in the Pine Forest habitat (average of 5.20 signs/sightings per Sampling Location). The greatest diversity was also observed in the Pine Forest habitat with a total of four species. The highest abundance was observed at Sampling Location T1 in Pine Forest habitat with 20 individuals sighted. The second highest abundance was observed at Sampling Location T4 in Scrub Forest habitat with 16 individuals sighted.

Of the species observed in May 2017 Survey none are of conservation importance based on the IUCN Red List and three are listed on the CITES Appendices. These include the Jan's Cliff Racer *Platyceps rhodorachis* (I), the Caspian Cobra *Naja oxiana* (II) and Checkered Keelback *Xenochrophis piscator* (III). None of the species observed are endemic. Photographs of some of reptile species observed are shown in **Exhibit 4.120**.

A complete list of herpetofauna species reported from the Terrestrial Study Area, based on information from Rafaqat Masroor, a herpetofauna specialist with the Pakistan Museum of Natural History (PMNH), is provided in **Appendix K**.

Exhibit 4.120: Herpetofauna Species, May 2017 Survey



Agrore Valley Rock Agamas *Laudakia agrorensis* at T1

Asian Garden Lizard Calotes versicolor and its burrows at T4

Agrore Valley Rock Agama *Laudakia agrorensis* at T5

Asian Garden Lizard *Calotes versicolor* at T12

4.2.8 Habitat Assessment

Habitats can be classified as either natural or modified; ranging from pristine, undisturbed natural habitat at one end of the scale, through different degrees of modification or disturbance, up to highly modified or degraded areas that support an artificial assemblage of plants and animals. Despite a habitat being modified, it may support valuable biodiversity, including endemic or threatened species. Subsets of these habitat types are critical habitats and legally protected areas, both of which more commonly consist of natural or slightly modified habitat.[61]

Natural and Modified Habitats

ADB guidelines require the classification of the Study Area into Natural and Modified Habitats based on the definitions provided below.[62]

Natural Habitat: Land and water areas where the biological communities are formed largely by native plant and animal species, and where human activity has not essentially modified the area's primary ecological functions.[63]

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[61] Asian Development Bank (ADB), Environment Safeguards, A Good Practice Sourcebook Draft Working Document, December 2012.

[62] Ibid

[63] Ibid

Modified Habitat: Natural habitat that has been altered as a result of human activities such as agricultural, forestry or urban development, or through the introduction of alien species.[64]

The Aquatic Study Area is considered a Modified Habitat because of the changes in environmental flows as a result of regulation of the river. This is due to development of the under-construction Sukki Kinari HPP upstream of the Project and presence of the Patrind HPP downstream of the Project.

The Terrestrial Study Area is considered Modified Habitat because human activity has modified the land use and vegetation within most of it, even at higher elevations. There are patches of forests, mainly on very steep slopes, where access by people is limited. The locals report that wild animals such as the Common Leopard and Black Bear are common in the area, especially at higher elevations.

Critical Habitat

Critical habitat is an area that has high biodiversity value and may include sites that are legally protected or officially proposed for protection e.g. areas that meet the International Union for Conservation of Nature (IUCN) classification criteria, the Ramsar List of Wetlands of International Importance, and United Nations Educational, Scientific, and Cultural Organization (UNESCO) world natural heritage sites. Critical habitat includes:[65]

- habitat required for the survival of critically endangered or endangered species
- areas with special significance for endemic or restricted-range species
- sites that are critical for the survival of migratory species
- areas supporting globally significant concentrations or numbers of individuals of congregatory species
- areas with unique assemblages of species that are associated with key evolutionary processes or provide key ecosystem services
- areas with biodiversity that has significant social, cultural or economic importance to local communities

Critical Habitat is also a requirement under the International Finance Corporation's (IFC) Performance Standards (PS).[66] The IFC is financing the development of a number of HPPs in the Jhelum-Poonch Basin including the Gulpur HPP, Karot HPP, and Kohala HPP. It is also involved in a basin-wide assessment of the impact of HPP development and is planning on carrying out a Strategic Environmental Assessment (SEA) in the basin. Therefore, in order to maintain consistency with the criteria used for Critical Habitat Assessment, IFC PS6 has been applied. There is not conflict between IFC PS6

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[64] Ibid

[65] Ibid

[66] International Finance Corporation (IFC). January 2012. Policy on Social and Environmental Sustainability, Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources, The World Bank Group.

and ADB guidelines. The two are similar in their criteria with the IFC providing thresholds for assessment.

Critical Habitat Assessment as per IFC PS6 requires the defining of a Discrete Management Unit (DMU). This is based on the following:

"For Criteria 1 through 3, the project should determine a sensible boundary (ecological or political) which defines the area of habitat to be considered for the Critical Habitat Assessment. This is called the "discrete management unit," an area with a definable boundary within which the biological communities and/or management issues have more in common with each other than they do with those in adjacent areas (adapted from the definition of discreteness by the Alliance for Zero Extinction). A discrete management unit may or may not have an actual management boundary (e.g., legally protected areas, World Heritage sites, KBAs, IBAs, community reserves) but could also be defined by some other sensible ecologically definable boundary (e.g., watershed, interfluvial zone, intact forest patch within patchy modified habitat, seagrass habitat, coral reef, concentrated upwelling area, etc.). The delineation of the management unit will depend on the species (and, at times, subspecies) of concern."[67]

DMUs has been defined for each species under consideration in Criteria 1 through 3.

The criteria for Critical Habitat Assessment based on IFC PS6 along with their application to the biodiversity within the Aquatic Study Area is provided below:

1. Habitat of significant importance to Critically Endangered and/or Endangered species:

According to IFC's Guidance Note 6, Tier 1 sub-criteria for Criterion 1 are defined as follows[68]:

- Habitat required to sustain ≥ 10 percent of the global population of an IUCN Red-listed Critically Endangered (CR) or Endangered (EN) species where these are known, regular occurrences of the species and where the habitat could be considered a discrete management unit for that species.
- Habitat with known, regular occurrences of CR or EN species where the habitat is one of 10 or fewer discrete management sites globally for that species.

Tier 2 sub-criteria for Criterion 1 are defined as follows:

- Habitat that supports the regular occurrence of a single individual of an IUCN Red-listed CR species and/or habitat containing regionally-important concentrations of an IUCN Red-listed EN species where the habitat could be considered a discrete management unit for that species.
- Habitat of significant importance to CR or EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species.

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[67] Biodiversity Conservation and Sustainable Management of Living Natural Resources, Criterion 3, Guidance Note 6, International Finance Corporation, 1 January 2012

[68] Ibid

- As appropriate, habitat containing nationally/regionally-important concentrations of an EN, CR or equivalent national/regional listing.

Species that are listed as Critically Endangered or Endangered on the IUCN Red List were not reported from the Aquatic Study Area or the Terrestrial Study Area based on the surveys carried out in July 2016, February 2017 and May 2017. Therefore, this criteria does not trigger Critical Habitat.

2. Habitat of significant importance to endemic and/or restricted-range species:

According to IFC's GN6, Tier 1 sub-criteria for Criterion 2 are defined as follows:

- Habitat known to sustain ≥ 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species (e.g. a single-site endemic[69]).

Tier 2 sub-criteria for Criterion 2 are defined as follows:

- Habitat known to sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range species where the habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgement.

The Aquatic Study Area is of significant importance to endemic species and restricted range species. There are two endemic fish species found here including the Kashmir Hillstream Loach and the Nalbant's Loach, both of which were reported during the surveys carried out in February 2017. These species are also restricted range species, as defined by Guidance Note (GN) 6[70] for IFC 6. GN 6 states that for freshwater systems, a guideline for extent of occurrence is 20,000 sq km. Species in freshwater systems with an extent of occurrence less than 20,000 sq km are considered restricted range species. The extent of occurrence for the Kashmir Hillstream Loach and the Nalbant's Loach is less than 20,000 sq km, therefore, each species can be considered a restricted range species. The DMU for Nalbant's Loach and Kashmir Hillstream Loach is shown in **Exhibit 4.121**. It has been determined based on the maximum range of the species upstream of the Project, and from there to the dam of the existing Patrind HPP. The ranges of both species extends into the Jhelum River as well, however, the presence of the dam of the Patrind HPP has created a barrier. Based on expert judgement, the habitat in the DMU is known to sustain ≥ 1 percent but < 95 percent of the global population of both species, therefore, Tier 2 sub-criteria for Criterion 2 is triggered, making this a Critical Habitat. The distributions of the two species are shown in **Exhibit 4.122** and **Exhibit 4.123**, along with their extent of occurrence and its area. The area for the extent of occurrence of the Nalbant's Loach is 13,635 sq km and that of the Kashmir Hillstream Loach is 13,475 sq km. No endemic and/or restricted range species were observed in the Terrestrial Study Area.

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[69] An endemic species is defined as "one that has ≥ 95 percent of its global range inside the country or region of analysis" as stated in GN79 of Guidance Note 6, Biodiversity Conservation and Sustainable Management of Living Natural Resources. International Finance Corporation, January 2012

[70] Biodiversity Conservation and Sustainable Management of Living Natural Resources, Guidance Note 6, International Finance Corporation, 1 January 2012

Exhibit 4.121: Discrete Management Unit for the Nalbant's Loach and Kashmir Hillstream Loach

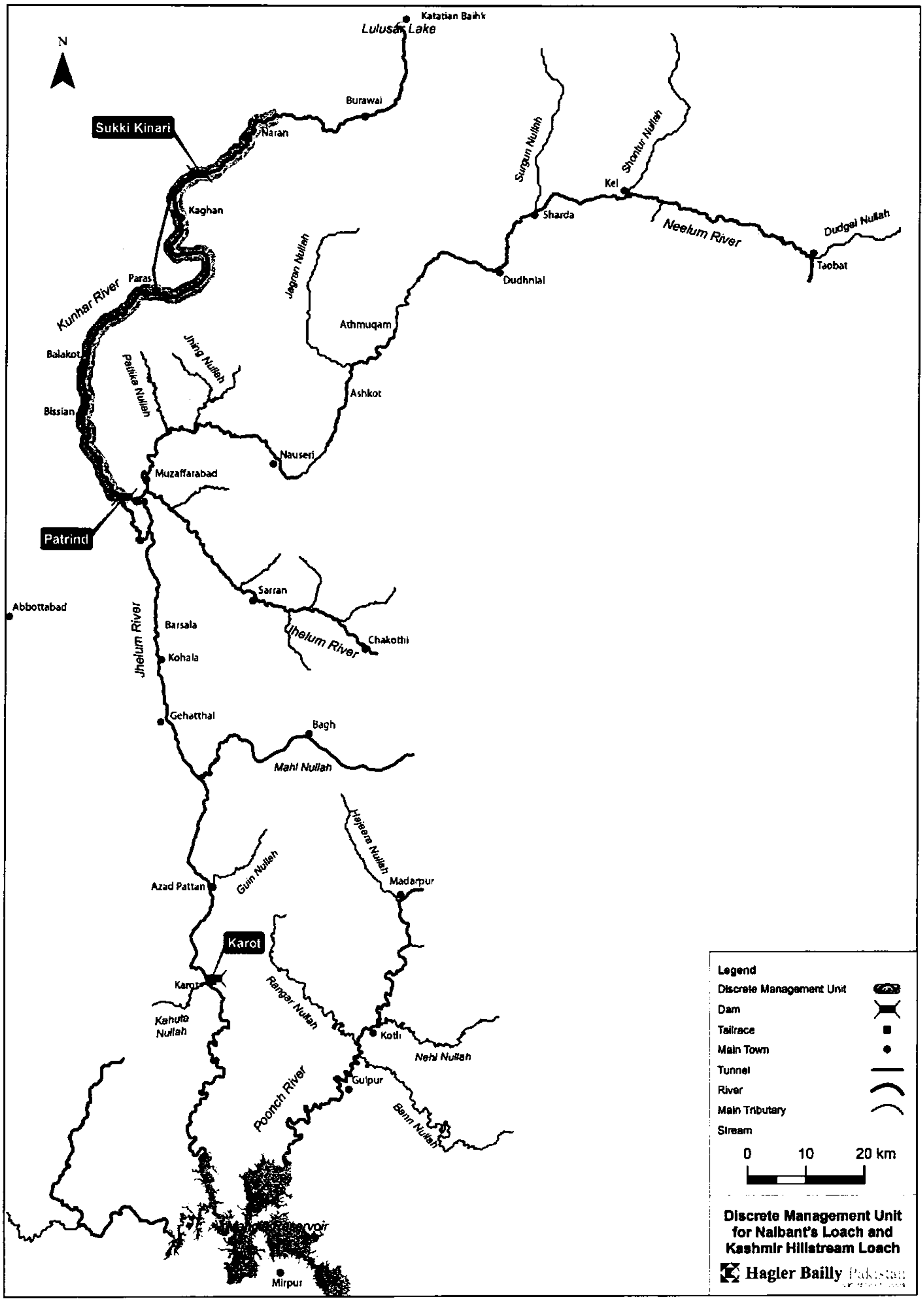


Exhibit 4.122: Distribution of the Nalbant's Loach

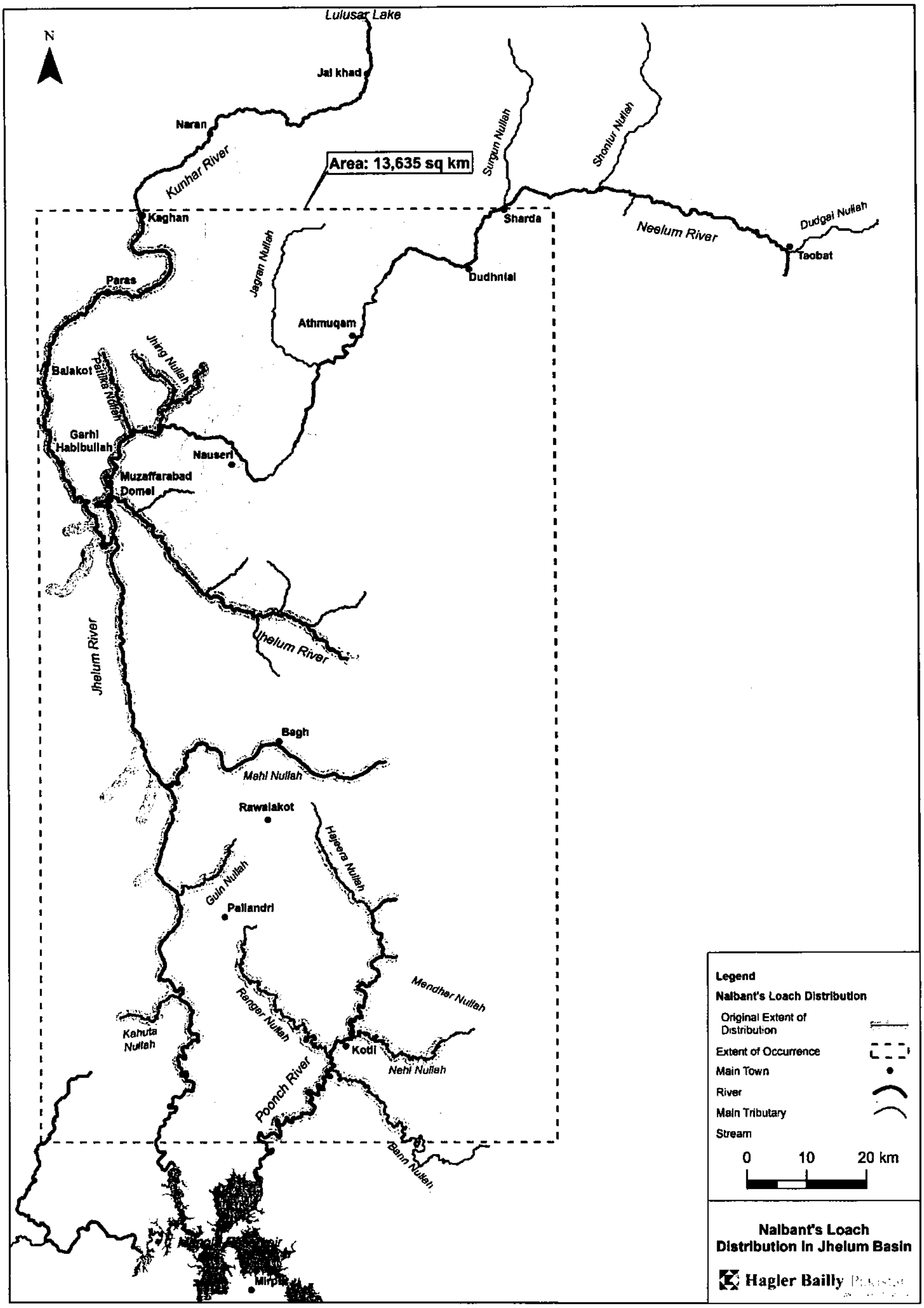
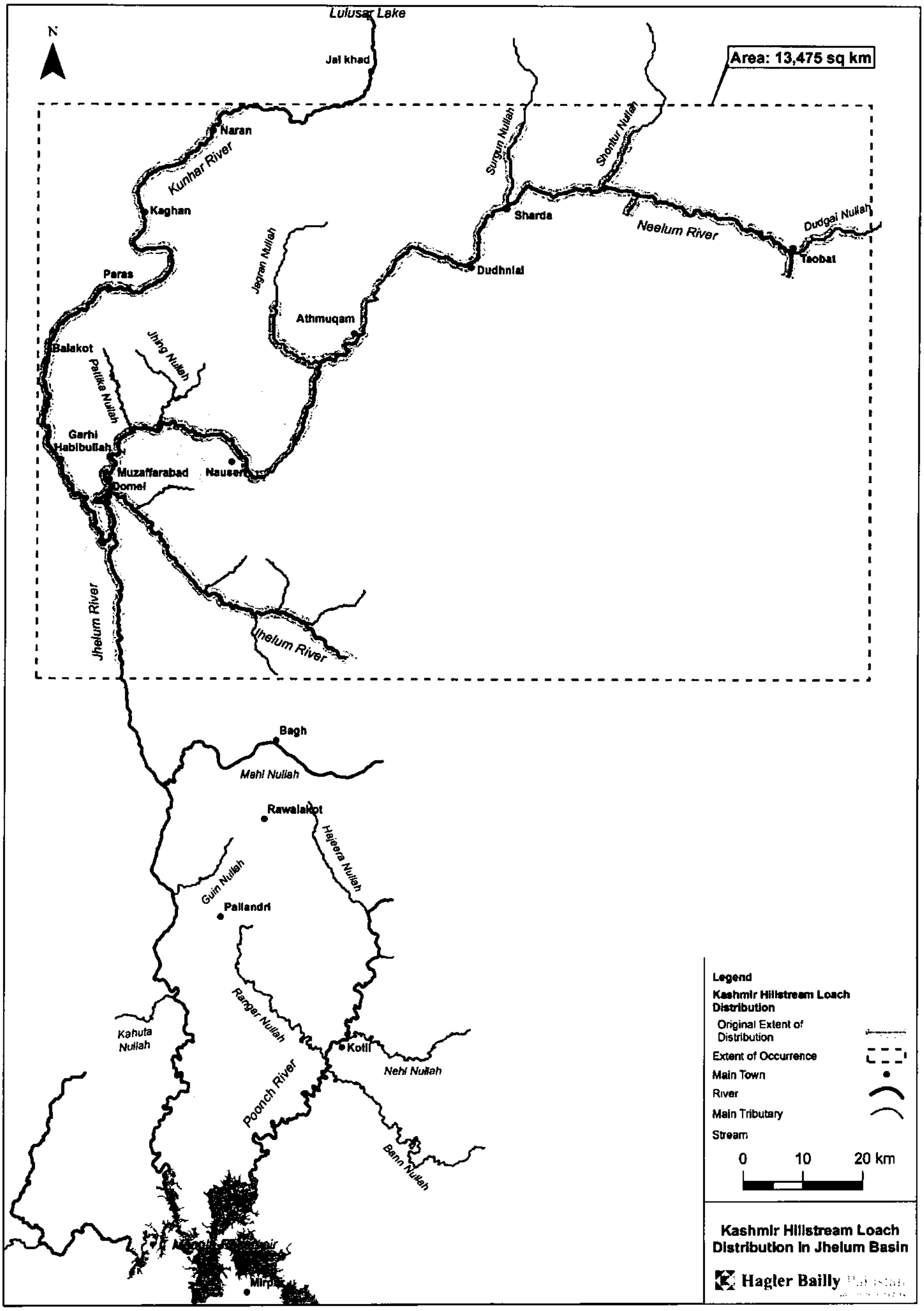


Exhibit 4.123: Distribution of the Kashmir Hillstream Loach



3. Habitat supporting globally significant concentrations of migratory species and/or congregatory species:

According to IFC's GN6, Tier 1 sub-criteria for Criterion 3 are defined as follows:

- Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 95 of the global population of a migratory or congregatory species at any point of the species lifecycle where that habitat could be considered a discrete management unit for that species.

Tier 2 sub-criteria for Criterion 3 are defined as follows:

- Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent but < 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that species, where adequate data are available and/or based on expert judgment.
- For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance.
- For species with large but clumped distributions, a provisional threshold is set at ≥5 percent of the global population for both terrestrial and marine species.
- Source sites that contribute ≥ 1 percent of the global population of recruits.

The Aquatic Study Area is not home to significant concentrations of migratory species and/or congregatory species. No congregatory species were reported to be present in the Aquatic Study Area. A migratory fish species, Alwan Snow Trout, was found during the February 2017 and May 2017 Surveys. The DMU for the Alwan Snow Trout is shown in **Exhibit 4.124**. It extends from the maximum range of the Alwan Snow Trout upstream of the Project, to the dam of the Patrind HPP. The DMU for this species has been chosen based on its distribution in the Kunhar River. The species is migratory and moves into Jhelum River as well. However, the presence of the dam of the Patrind HPP has blocked its migratory route in the Jhelum River. This species is also found in India, Nepal and Bhutan.[71] Based on expert judgement, the habitat within the DMU consists of less than 1% of the global population of the species. As a result, it does not trigger Tier 1 or Tier 2 criteria, therefore, this species does not trigger Critical Habitat.

Within the Terrestrial Study Area five migratory bird species were found including the Common Chiffchaff, Common Kestrel, Laughing Dove, Little Egret, and White Wagtail. Of these two are congregatory including the Common Kestrel and Little Egret. However, all five bird species are widespread and their populations do not trigger Tier 1 or Tier 2 sub-criteria for Criterion 3. As a result, they do not trigger Critical Habitat.

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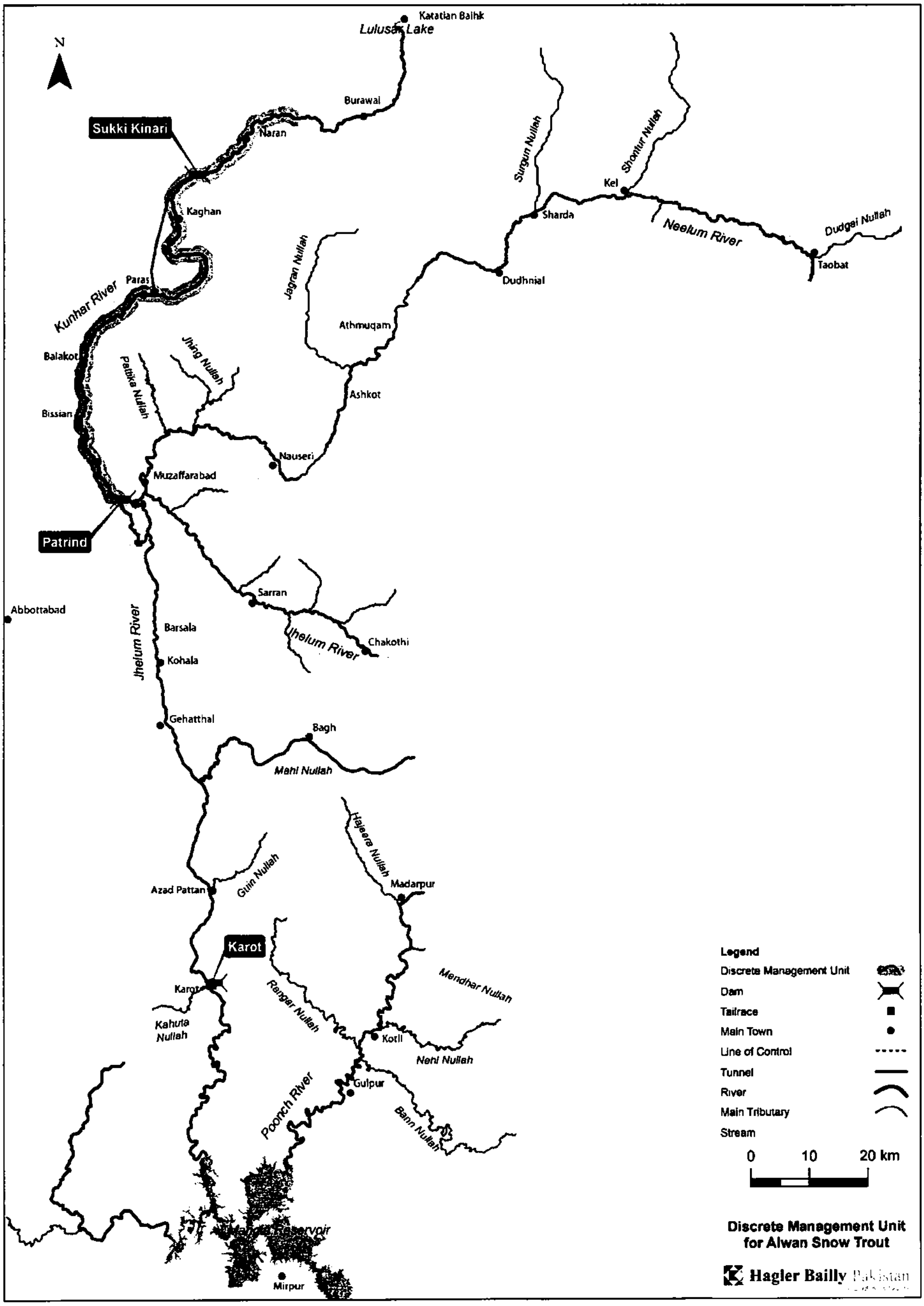
[71] Vishwanath, W. 2010. Schizothorax richardsonii. The IUCN Red List of Threatened Species 2010: e.T166525A6228314. http://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T166525A6228314.en. Downloaded on 07 June 2017.

Exhibit 4.124: Discrete Management Unit for Alwan Snow Trout



4. Highly threatened and/or unique ecosystems:

There is no information which indicates the Study Areas, or any part of them, are a highly threatened and/or unique ecosystem. Furthermore, there is no information which indicates the Study Areas are a part of a threatened or unique ecosystem.

5. Areas with unique assemblages of species or which are associated with key evolutionary processes or provide key ecosystem services:

There is no information which indicates the Study Areas, or any part of them, are associated with key evolutionary processes or provide key ecosystem services. While the species are functioning components of ecosystems, there are no unique assemblages of species or association of key evolutionary processes in the Study Areas.

ADB's Guideline for Critical Habitat Assessment not covered by IFC PS6

6. Areas with biodiversity that has significant social, cultural or economic importance to local communities

The last criteria provided in the ADB guidelines on Critical Habitat Assessment is not covered by the criteria under IFC PS6. The stretch of the Kunhar River within the Aquatic Study Area is part of the wider area that is important for sports fishing. Based on a conversation with Mohammad Tanvir, Assistant Director, Fisheries, District Manshera, this stretch of the Kunhar River is stocked with fish and over 100 permits, called Daily Trout Angling (DTA) licenses, are issued annually. The fishing season is from March to October after which fishing is not allowed due to the breeding season. This activity contributes to the local economy. However, data collected as part of the socioeconomic baseline indicates that sports fishing in the Aquatic Study Area is not of social, cultural or economic importance to the local communities. Therefore, this criteria does not trigger Critical Habitat.

4.2.9 Conclusion

The February 2017 and May 2017 Survey have revealed the presence of two endemic and restricted range fish species within the Aquatic Study Area which include the Kashmir Hillstream Loach and the Nalbant's Loach. In addition to these, a long distance migratory fish species, the Alwan Snow Trout, has also been reported. Five bird species that are migratory have also been observed during these surveys, with two of them being congregatory. No Critically Endangered or Endangered species were observed. Based on expert judgement, it has been determined that the Aquatic Study Area is of special significance for endemic and restricted range fish species, therefore, the DMUs for these fish species, shown in **Exhibit 4.124**, is designated as Critical Habitat under IFC PS6. The migratory and congregatory bird species are widespread globally and their populations do not trigger Critical Habitat. This determination is consistent with the criteria for Critical Habitat under ADB's Environmental Safeguards, 2012.

4.3 Socioeconomic Environment

This section provides a description of the existing socioeconomic conditions in settlements located in the socioeconomic Study Area of the Project.

4.3.1 Study Area

The Study Area is delineated using the following buffers and extents:

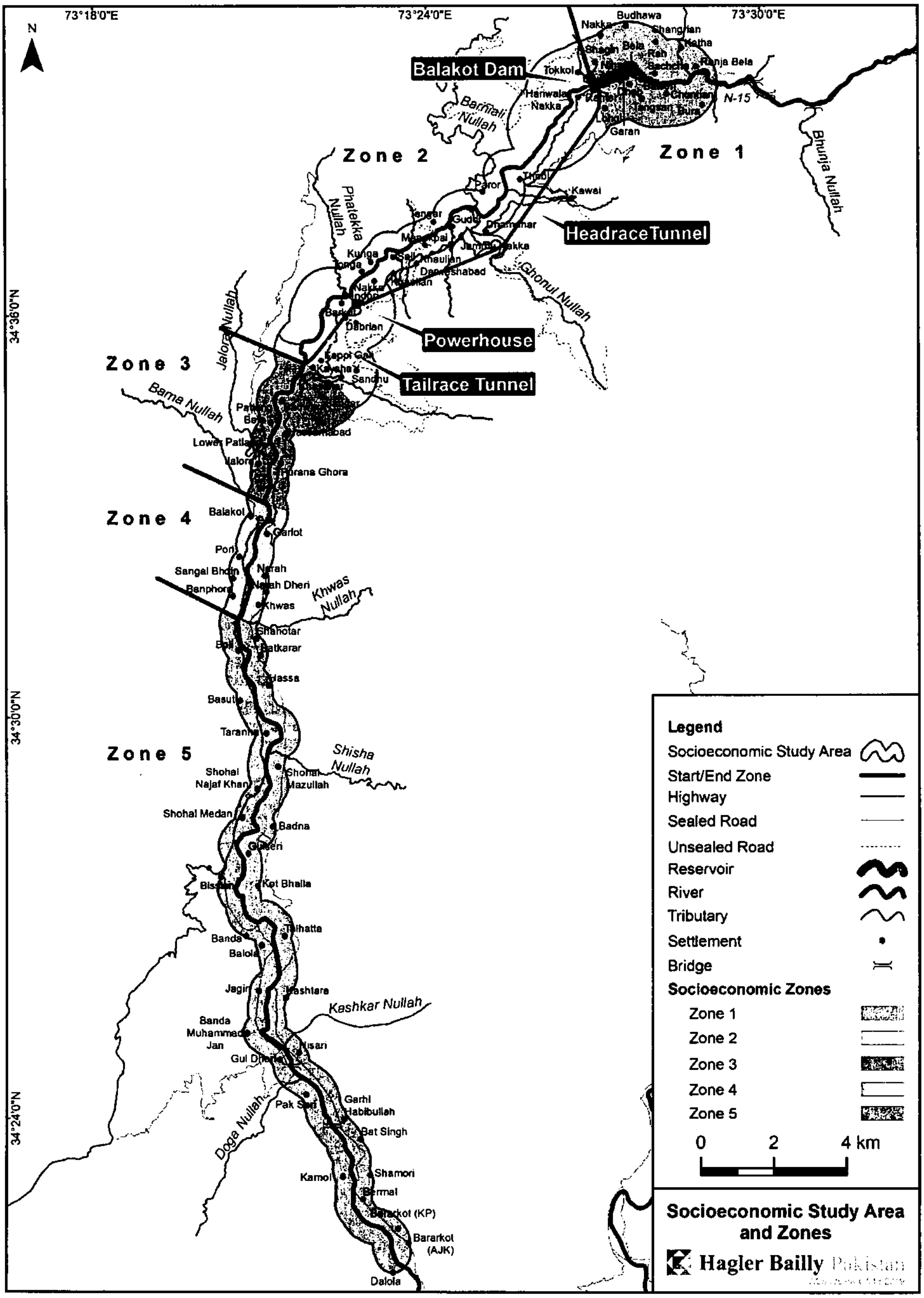
- **500 m buffer on each side of river**: along reaches that may be impacted due to the Project, and the zone where there is river dependence (either through use of drift wood, use of sediment as building materials) is a zone of 500 m of the river.
  - All settlements with a center within the 500 m buffer is included.
  - All settlements with more than 50% of their land area within the 500 m buffer are also included.
- **1 km buffer around Project facilities:** for coverage of communities that will be directly impacted through either resettlement, or construction related impacts. However, spoil disposal areas are not included in the study area as at the time of socioeconomic survey spoil disposal areas were not identified.
- **Upstream Extent:** selected as tailrace tunnel of Sukki Kinari HPP, upstream of the dam, as the dam as barrier may affect communities reliant on ecological resources (such as fish).
- **Downstream Extent:** The downstream extent of the Study Area is at the start of reservoir of the Patrind HPP.

Keeping in view expected variation between rural and urban areas, impact due to the Project, flow variations along different reaches of the Kunhar River due to tributaries, as well as changes due to other hydropower projects, the Study Area is divided into different zones along the Kunhar River:

- **Zone 1:** Upstream of Balakot Dam (including Balakot Reservoir Area)
- **Zone 2:** Downstream of Balakot Dam up to Upstream of Balakot Tailrace Outlet
- **Zone 3:** Downstream of Balakot Tailrace Outlet up to Upstream of Balakot City
- **Zone 4:** Balakot City along Kunhar River
- **Zone 5:** Downstream of Balakot City up to the reservoir of Patrind Hydropower Project
- **Zone 6:** 1 km buffer around Project facilities

Exhibit 4.125 shows the socioeconomic Study Area and Zones.

Exhibit 4.125: Socioeconomic Study Area and Zones



4.3.2 Methods of Data Collection

Primary data was collected at the settlement level by administering settlement level questionnaires and specific questionnaires for other aspects of interest.

Socioeconomic Aspects of Interest

Socioeconomic aspects of interest include the following:

- **Demography:** a description of the sample population and its characteristics, such as dependency ratio, population pyramid and sex ratio.
- **Infrastructure:** information on existing social and physical infrastructure, such as roads, police facilities, electricity availability, water and sanitation and postal services.
- **Health:** information on key health issues prevailing in the area and access to health facilities.
- **Education:** information on educational institutions and their accessibility.
- **Livelihood:** information on key occupations and income sources.
- **Income and poverty:** discussion on incomes, use of natural resources, expenditures and debts.
- **Dependence on ecosystems services:** such as dependence on ecological/natural resources, including the river, of the area as source of livelihood, enjoyment or to meet day to day requirements.
- **Gender:** All the socioeconomic information was gathered disaggregated by gender and vulnerability.

Surveys

The settlement level survey was completed by a social development expert appointed by HBP, in view of the complex and qualitative nature of information to be obtained in a semi-literate environment. Information was obtained in discussion with a group of 4 to 5 key informants including, but not limited to, the following:

- Union Council (local government) heads
- Educated persons (with Higher School Certificate as minimum level of education attained)
- School teachers
- Local government representatives and leaders
- Community based organization active in the area

The levels at which the survey was conducted are as follows:

- **Rural settlement survey:** was undertaken in selected settlements within each socioeconomic zone, excluding the Balakot zone. A pilot survey was carried out prior to start of the rural settlement survey. Based on the pilot survey results, settlements for rural settlement surveys were selected based on their use of the river (fishing, sand mining, domestic uses, and irrigation) and potential impacts of the Project. Detailed interviews were conducted with key informants (male and female) to gather information on selected settlement's social and economic setup including gender issues, with focus on infrastructure and livelihoods;

- **Business owner survey:** was implemented to obtain information on the costs and benefits of the river-dependent businesses, such as sand mining;
- **Urban focus group discussions:** were implemented in Balakot city. Information on the livelihoods, incomes, household demographics and household recreational activities was obtained through discussions with local government representatives and community groups.

The socioeconomic survey plan is provided in **Appendix L.**

4.3.3 Socioeconomic Conditions in the Study Area

Rural Settlements

The word "settlement" is the term used to describe the unit studied based on the assumption that a settlement is a cluster of houses where residents share a geographic area, and commute with the resources through a cultured pattern that they have developed in due course of time for the purpose. Settlements are "a city, town, village ghost or other agglomeration of buildings where people live and work."[72] The word village is usually used for similar social concepts but is intentionally avoided because it refers to a more permanent residential pattern with the major concentration of the population sharing a heritage as well as structured pattern of life for longer periods. "A village is a small settlement usually found in a rural setting. It is generally larger than a "hamlet" but smaller than a "town". Some geographers specifically define a village as having between 500 and 2,500 inhabitants."[73] Ideally a settlement usually is of 5 to 30 houses whereas a village begins when settlements are merged or create a common identity in due course of time. In this study the neighborhoods are termed settlements, to create a unit of similar size and bring homogeneity in the study unit. **Exhibit 4.126** shows the average size of surveyed settlements by zones.

Exhibit 4.126: Average Size of Surveyed Settlements by Zones

Zone	*Number of Surveyed Settlements*	*Minimum Number of Households*	*Maximum Number of Households*	*Average Number of Households*
1	8	8	120	46
2	7	4	75	21
3	4	3	37	23
4	0	0	0	0
5	11	17	1500	301
6	1	59	59	59
Total	**31**			**128**

Source: Field Survey March–April 2017 and June–July 2018

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[72] Dutta, Biswanath; Fausto Giunchiglia; Vincenzo Maltese (2010). "A Facet-Based Methodology for Geo-Spatial Modeling". GeoSpatial Semantics: 4th International Conference, GeoS 2011, Brest, France (PDF). p. 143

[73] Accessed on June 03, 2017 2215PST and retrieved from https://www.nationalgeographic.org/encyclopedia/village/

Based on **Exhibit 4.126**, it can be seen that the reservoir area falling in Zone 1 is inhabited by smaller settlements with the average number of houses in a settlement as 46, ranging from 8 households at Chuntian to 120 households at Barian Paras. A common trend observed in the Study Area is that on right side of the river most settlements are small, having few houses with most settlers being recent. Zone 2, studied through 7 settlements, had a similar pattern of a minimum of four houses to a maximum of 75 households in a settlement with an average of 24 houses per settlement. Zone 3 has a settlement with only three households. The maximum number of households in any settlement of the Zone was found to be 37, making the average number of households 23 for the four settlements visited. Zone 4 includes Balakot city where a settlement survey was not conducted. However, consultation and river dependent surveys were conducted. No rural settlements were visited or found in this Zone, falling within the parameters set for the study.

Zones 5 comprises settlements downstream of Balakot city. The 11 settlements visited were inhabited by a minimum of 17 households and a maximum of 1,500 households. The settlement with 1,500 households was exceptional as it was the urban center of Balakot. In Zone 6 only one settlement was studied, where the labor colony is to be established. It is inhabited by 59 households.

Household Size

The term 'household' is used for a structure wherein one or more than one family is residing. A household in most of these cases was owned by more than one family but practically resided by single family as other owners such as siblings of the same parent were living away from the household mainly in cities for their businesses and jobs. However, they were claiming residential rights as inherited through kinship.

As provided in **Exhibit 4.127**, the average household size in the Study Area was 6.2 individuals, with a minimum of 3.5 and a maximum of 10. Out of all the rural settlements, Zone 5 had the highest average household size followed by Zone 3. The average household size in rural areas was found to be smaller than that in the urban area of Balakot. The reasons could be multiple as not explored yet but we can assume, the destruction of the irrigation system in 2005 earthquake is one, if not the only, cause of this shift of residential pattern.

Exhibit 4.127: Average Household Size

Zone	*Number of Surveyed Settlements*	*Minimum Household Size*	*Maximum Household Size*	*Average Household Size*
1	8	5.0	7.5	6.1
2	7	3.5	8.0	6.1
3	4	3.8	10.0	6.4
4	0	-	-	-
5	11	4.3	10.0	6.5
6	1	5.5	5.5	5.5
Total	**31**			**6.2**

Source: Field Survey March–April 2017 and June–July 2018

Note: Zone 4 is Balakot city. As it is an urban area, rural settlement surveys were not conducted here.

Migration Trends

People in the pastoral communities within the Study Area have a trend of seasonal migration, with one home close to the river and one at higher elevations. They move their herds to the mountains for grazing.

In and out migration was observed to be insignificant over the past 7 years. The majority of out-migration took place after the earthquake in 2005 initially on a temporary basis but later with more permanent settlers.

Exhibit 4.128 shows migration trends and patterns in the Study Area. Overall out-migration was higher than in-migration. In Zone 3 in-migration is highest compared to all other zones (7.7%) followed by Zone 2 (3.0%).

Exhibit 4.128: Migration Trends and Patterns

Zone	*In Migration %*	*Out Migration %*
1	0.9%	0.4%
2	3.0%	0.1%
3	7.7%	0.0%
4	0.0%	0.0%
5	0.2%	1.4%
6	1.5%	0.0%
Total	**0.59%**	**1.15%**

Source: Field Survey March–April 2017 and June–July 2018

Castes

A caste is a social group identity which individuals get through their status as close class separated from other classes by distinctions of hereditary status or profession. It is different from the open class system for the reason that in the open class system one may change identity through wealth but in a caste it is forever and hereditary. In Balakot and adjoining Project settlements, it not only represents an individual's familial ties, but also political affiliations and social standing.

Exhibit 4.129 shows distribution of the population in the Study Area on the basis of caste. Within the Study Area Gujjars (30%) make up the highest proportion followed by Syed (12%) while other small groups comprise 29%.

Exhibit 4.129: Distribution of Population on Caste Basis

Castes	*Percent in Zone*						
	1	*2*	*3*	*4*	*5*	*6*	*Study Area*
Syed	71%	1%	0%	0%	11%	0%	12%
Awan	7%	7%	0%	0%	7%	0%	6%
Gujjar	5%	87%	52%	0%	26%	57%	30%
Raja	1%	0%	0%	0%	1%	0%	1%
Mughal	4%	1%	24%	0%	6%	27%	7%
Qureshi	1%	3%	8%	0%	10%	0%	9%
Pathan	1%	0%	0%	0%	5%	16%	5%
Other	10%	1%	17%	0%	34%	0%	29%
	100%	**100%**	**100%**	**0%**	**100%**	**100%**	**100%**

Source: Field Survey March–April 2017 and June–July 2018

Languages Spoken

Exhibit 4.130 shows the main languages spoken in the Study Area by zone, as a percentage. The predominant language is Hindko, however, Gojri is also widely spoken. Urdu, the language of communication is also understood everywhere especially amongst the youth. Based on observations from consultations, the Syed families have Hindko as their primary language; the professional workers have Pashto whereas the pastoral inhabitants speak Gojri. The youth of non-Hindko opt for Urdu as secondary language.

Exhibit 4.130: Main Languages Spoken in Study Area by Zones %

Language	*1*	*2*	*3*	*4*	*5*	*6*
Primary						
Urdu	0%	0%	0%	0%	4%	0%
Pashto	1%	0%	0%	0%	0%	10%
Punjabi	0%	0%	0%	0%	0%	0%
Pahari	0%	0%	0%	0%	0%	0%
Hindko	99%	27%	46%	0%	71%	30%
Gojri	0%	73%	54%	0%	25%	60%
Other	0%	0%	0%	0%	0%	0%
Secondary						
Urdu	100%	45%	66%	0%	97%	60%
Pashto	0%	0%	0%	0%	0%	0%
Punjabi	0%	0%	0%	0%	0%	0%
Pahari	0%	0%	0%	0%	0%	0%

Language	1	2	3	4	5	6
Hindko	0%	38%	34%	0%	0%	40%
Gojri	0%	17%	0%	0%	3%	0%
Other	0%	0%	0%	0%	0%	0%

Source: Field Survey March–April 2017 and June–July 2018

Exhibit 4.131 shows the distribution of the enrolled population by education levels.

Exhibit 4.131: Distribution of Enrolled Population by Education Levels by Zones

No	Education Level	1	2	3	4	5	6
1	Primary (Nursery to Class V) for Boys	284	250	0	0	1,342	0
2	Primary (Nursery to Class V) for Girls or Co-Ed	203	25	68	0	250	27
3	Middle (Class VI to VIII) for Boys	126	83	6	0	898	21
4	Middle (Class VI to VIII) for Girls or Co-Ed	71	0	23	0	130	0
5	Secondary (Class IX to X) for Boys	72	50	27	0	675	15
6	Secondary (Class IX to X) for Girls	31	2	1	0	48	0
7	Intermediate College for Boys/Girls	59	56	17	0	553	3
8	Degree College for Boys	40	25	0	0	192	0
9	Degree College for Girls	32	0	0	0	105	0
10	Technical and Vocational Training Institutes for Boys	5	0	1	0	21	0
11	Technical and Vocational Training Institutes for Girls	2	0	0	0	12	0
12	Madrassah	44	16	0	0	232	0

Source: Field Survey March–April 2017 and June–July 2018

Exhibit 4.132 shows the distribution of the enrolled population by gender, education levels and zones.

Exhibit 4.132: Distribution of Enrolled Population by Gender, Education Levels and Zones

No	*Zone*	*1*		*2*		*3*		*4*		*5*		*6*	
	Gender	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
1	Primary (Nursery to Class V) for Boys	213	71	149	101	–	–	–	–	635	707	–	–
2	Primary (Nursery to Class V) for Girls or Co–Ed	–	203	3	22	28	40	–	–	132	118	12	15
3	Middle (Class VI to VIII) for Boys	90	36	44	39	6	–	–	–	414	484	8	13
4	Middle (Class VI to VIII) for Girls or Co–Ed	10	61	–	–	7	16	–	–	85	45	–	–
5	Secondary (Class IX to X) for Boys	50	22	25	25	14	13	–	–	327	348	6	9
6	Secondary (Class IX to X) for Girls	8	23	–	2	–	1	–	–	10	38	–	–
7	Intermediate College for Boys/Girls	36	23	30	26	12	5	–	–	243	310	2	1
8	Degree College for Boys	32	8	13	12	–	–	–	–	126	66	–	–
9	Degree College for Girls	–	32	–	–	–	–	–	–	20	85	–	–
10	Technical and Vocational Training Institutes for Boys	5	–	–	–	1	–	–	–	21	–	–	–
11	Technical and Vocational Training Institutes for Girls	2	–	–	–	–	–	–	–	12	–	–	–
12	Madrassah	14	30	10	6	–	–	–	–	125	107	–	–
13	Other	–	–	–	–	–	–	–	–	–	–	–	–

Source: Field Survey March–April 2017 and June–July 2018

Exhibit 4.133 shows the percent of surveyed settlements reporting access to healthcare facilities by zone.

Exhibit 4.133: Percent of Surveyed Settlements Reporting Access to Health Facilities by Zones

No	*Facilities*	*1*	*2*	*3*	*4*	*5*	*6*
1	Dispensary	0%	14%	0%	0%	64%	0%
2	BHU	63%	57%	0%	0%	73%	0%
3	Health Center	0%	0%	0%	0%	9%	0%
4	Rural Health Center (RHC)	38%	14%	25%	0%	55%	0%
5	Hospital	75%	57%	75%	0%	55%	100%
6	Immunization (e.g. Polio drops)	25%	0%	50%	0%	55%	0%
7	LHV/LHW (Lady Health Visitors/Lady Health Workers)	25%	0%	50%	0%	55%	0%
8	Trained Midwife (dai)	0%	0%	0%	0%	18%	0%
9	Untrained Midwife (dai)	0%	0%	0%	0%	0%	0%
10	Pharmacy	50%	0%	0%	0%	45%	0%

Source: Field Survey March–April 2017 and June–July 2018

No disease was reported as an epidemic. The most common diseases reported in the adult male and female populations included flu/fever followed by tuberculosis, diabetes and goiter. The prevalence of these is within a negligible proportion of the population. In children, ages 15 and under, the most common disease was reported as typhoid, goiter and jaundice followed by flu/fever. Typhoid was reported across all settlements among adults and children. **Exhibit 4.134** shows the reported incidence of common diseases in the Study Area, as a percentage.

Exhibit 4.134: Reported Incidences of Diseases %

No	*Zones*	*1*			*2*			*3*			*4*			*5*			*6*
		M	*F*	*C U 15*	*M*	*F*	*C U 15*	*M*	*F*	*C U 15*	*M*	*F*	*C U 15*	*M*	*F*	*C U 15*	*M*
1	Flu/Fever	50%	30%	70%	100%	100%	100%	25%	25%	25%	0%	0%	0%	100%	100%	100%	10%
2	Malaria	1%	1%	0%	5%	5%	8%	0%	0%	0%	0%	0%	0%	5%	3%	7%	0%
3	Chicken Pox	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	Typhoid	12%	18%	18%	12%	11%	9%	10%	10%	10%	0%	0%	0%	4%	4%	7%	0%
5	Diarrhea/ Dysentery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	Tuberculosis	5%	8%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%
7	Goiter	5%	7%	13%	5%	5%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	Jaundice	6%	3%	7%	6%	3%	0%	5%	5%	0%	0%	0%	0%	5%	3%	1%	0%
9	Diabetes	5%	4%	0%	9%	4%	0%	0%	0%	0%	0%	0%	0%	14%	11%	0%	0%
10	Other	5%	5%	0%	7%	10%	0%	0%	5%	0%	0%	0%	0%	50%	50%	0%	0%

Source: Field Survey March–April 2017 and June–July 2018

Physical Infrastructure

Presence of roads, communication networks and other infrastructure are indicators of development in a region. The survey determined that there is much scope for development in the Study Area, as access to various infrastructures is low in most parts.

Roads and Transportation

The settlements situated on the left bank of Kunhar River in the Study Area are well connected to the rest of Pakistan through the carpeted Kaghan-Balakot highway. No road is available on the right bank, however, at some points there are jeepable tracks. The communities residing on the right bank are connected to the left bank through suspension bridges and unsealed roads. In most cases, people have to walk a maximum of 2 km to reach the Kaghan-Balakot highway. **Exhibit 4.135** shows the percentage of each type of road, blacktop and unsealed, by zone.

Exhibit 4.135: Roads in Transport Services %

No	*Nature of Facility*	*1*	2	3	4	5	6
1	Blacktop Road	13%	29%	0%	0%	55%	100%
2	Unsealed Road	25%	14%	0%	0%	9%	100%

Source: Field Survey March–April 2017 and June–July 2018

Water Supply Sources

All surveyed settlements in Zones 1, 2, 3, 5 and 6, reported having access to a public potable water supply system comprising of a central water storage system, where water collects from a mountain spring and is supplied to the community via a pipeline up to a central point in the community. Distances of the settlements to sources of water ranges from 500 m to 2 km.

The irrigation system collapsed in the earthquake in 2005, after which it could not be rehabilitated. Agricultural has shifted towards being rain fed. Previously the area was known for rice production.[74] Most communities in all zones identified water supply infrastructure as a need especially the revival of their irrigation channels to reduce dependency on rain fed agriculture.

The dependence on the main Kunhar River for drinking is negligible in all zones. The river water is used for agriculture and feeding animals as reported in some settlements. **Exhibit 4.136** shows the water supply source by zone.

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[74] Rice production needs flow of water in reasonable amounts and it was reported from all most all settlements in deep valleys on river banks that they had the practice of rice production before the earthquake in 2005.

Exhibit 4.136: Zone-wise Water Supply by Source %

No	*Zone wise Source of Water Supply*	*Zone 1*	*Zone 2*	*Zone 3*	*Zone 4*	*Zone 5*	*Zone 6*
1	Public water supply (government/municipal)	75%	29%	75%	0%	73%	100%
2	Spring/s	88%	100%	100%	0%	73%	100%
3	Well/s	0%	14%	0%	0%	55%	0%
4	Kunhar River	25%	0%	0%	0%	18%	0%
5	Tributaries of Kunhar River	0%	0%	25%	0%	0%	0%

Source: Field Survey March–April 2017 and June–July 2018

Sanitation and Waste Disposal

The Study Area with all settlements visited reports the availability of septic tanks for disposal of human waste. Pit latrine system was available in very few settlements, especially in Zones 1 and 2. The fields in respective settlements currently serves as the ultimate drain for wastewater and contaminated seepage associated with the household water use in the area. However, in Zone 1 at some points and almost all settlements in Zone 5 were observed using Kunhar River, for the purpose of drainage. This has increased contamination levels (see **Section 4.1.7**, *Water Resources*), presumably more in the winter, as the capacity of the river to flush the contaminants reduces in that season. There was no municipality sewerage system observed with proper drainage to save the river from contamination. **Exhibit 4.137** shows the type of sanitation by zone, as a percentage.

Exhibit 4.137: Type of Sanitation by Zone %

No	*Type of Sanitation*	*Zone 1*	*Zone 2*	*Zone 3*	*Zone 4*	*Zone 5*	*Zone 6*
1	Pit Latrine	0%	14%	0%	0%	0%	0%
2	Pit Latrine with Slabs	50%	14%	0%	0%	0%	0%
3	Septic Tanks	50%	71%	100%	0%	91%	100%
4	Open Latrine	0%	14%	0%	0%	9%	0%
5	Municipal Sewage System	0%	0%	0%	0%	9%	0%
6	Open Drains	0%	0%	0%	0%	0%	0%
7	Other	0%	0%	0%	0%	0%	0%

Source: Field Survey March–April 2017 and June–July 2018

Power and Fuel Source

As shown in **Exhibit 4.138**, the three major fuel sources in the Study Area include electricity, fuelwood and liquefied petroleum gas (LPG). Natural gas is not supplied in entire Kaghan Valley.

All settlements in the Study Area are connected to the main grid. Electricity is mainly used for lighting purposes and running household electrical appliances. For cooking and, water and space heating purposes, fuelwood and LPG are interchangeably used, depending on the availability and whichever is more economical.

Fuelwood is commonly used as a source of fuel. Communities source fuelwood from communal forests, paying only for the transportation cost. In urban areas fuelwood comes through markets. The suppliers source it from the communal forests but charge cutting, gathering and other labor charges, in addition to transportation. In Balakot and Garhi Habibullah supply of fuelwood is monitored by the government and managed through permits, in other zones this is informal communal activity. The local government discourages collection of fuelwood from forests to prevent deforestation.

Exhibit 4.138: Fuel Sources by Zone %

No	*Fuel Source*	*1*	*2*	*3*	*4*	*5*	*6*
1	Electricity	75%	71%	75%	0%	91%	100%
2	Fuelwood (Gathered)	100%	86%	75%	0%	27%	100%
3	Fuelwood (Market)	13%	0%	25%	0%	100%	0%
4	LPG	100%	14%	75%	0%	91%	100%
5	Kerosene	0%	0%	0%	0%	0%	0%
6	Diesel	0%	0%	0%	0%	0%	0%
7	Other (Solar)	13%	0%	25%	0%	0%	0%

Source: Field Survey March–April 2017 and June–July 2018

Exhibit 4.139 shows access to communication infrastructure by zone, as a percentage.

Exhibit 4.139: Zone-wise Access to Communication Infrastructure %

No	*Types of Communication Facilities*	*1*	*2*	*3*	*4*	*5*	*6*
1	Telephone	0%	0%	0%	0%	18%	0%
2	Mobile Phone Service	100%	100%	100%	0%	73%	100%
3	Post Office	33%	14%	0%	0%	73%	0%

Source: Field Survey March–April 2017 and June–July 2018

The peaceful law and order situation in the Study Area, prevalence of law enforcement agencies and related services is poor. In all zones except Zone 5, the majority of settlements did not have access to a police facility. Police check posts are only present on main Kaghan Highway. Police check posts monitor incoming traffic to tourist areas, to determine purpose of visitors to the valley. **Exhibit 4.140** shows the provision of police facilities by zone, as a percentage.

Exhibit 4.140: Provision of Police Facilities %

No	*Police Facility*	*Zone 1*	*Zone 2*	*Zone 3*	*Zone 4*	*Zone 5*	*Zone 6*
1	Police Station	38%	0%	0%	0%	73%	0%
2	Police Check post	0%	14%	0%	0%	36%	0%

Source: Field Survey March–April 2017 and June–July 2018

Banks and markets are available mainly in Balakot city. Shops are present on main Kaghan Highway. The shops provide for the day to day needs of the local communities or to supply travelers and tourists. For major purchases all settlements in the survey area depends mainly on Balakot city, which is the hub of economic activity in the region. There were one or two shops of basic groceries found in each settlement mostly belonging to household having transportation facility or jeep owners of the respective settlement. **Exhibit 4.141** shows the access to other facilities by zone, including banking and markets, as a percentage.

Exhibit 4.141: Access to Other Facilities %

No	*Other facility*	*Zone 1*	*Zone 2*	*Zone 3*	*Zone 4*	*Zone 5*	*Zone 6*
1	Bank	0%	0%	0%	0%	73%	0%
2	Market	0%	14%	25%	0%	91%	0%

Source: Field Survey March–April 2017 and June–July 2018

Exhibit 4.142 shows the employment within the Study Area. More than 50% of the total employable population is employed while 25% are unemployed. The remaining are students, retired and others (such as labor and small business operators).

Exhibit 4.142: Employment within the Study Area %

No	*Employment Status*	*1*	*2*	*3*	*4*	*5*	*6*	*Overall*
1	Employed	56%	54%	61%	0%	51%	80%	55%
2	Unemployed	19%	30%	25%	0%	26%	10%	25%
3	Student	8%	5%	10%	0%	17%	0%	11%
4	Retired	11%	10%	7%	0%	6%	10%	8%
5	Other	30%	13%	0%	0%	5%	0%	18%

Source: Field Survey March–April 2017 and June–July 2018

Sources of Livelihood

Exhibit 4.143 shows the sources of livelihood as a percentage, by zone in the Study Area. The major source of income for the settlements in Zones 1 to 5 was dependency of its members living in major cities of the country. The local livelihood reported shows main sources are agriculture, wage labor, private and government services, and skilled workers. A number of households have more than one source of income.

Subsistence agriculture, collection of wood, sand for construction, and seasonal services in tourism based hotel industry was the major contributor to the economy. People are also engaged in wood carving, driving, and services in security agencies.

Exhibit 4.143: Sources of Livelihood %

No	*Livelihood Sources*	*1*	2	3	*4*	5	6	*Overall*
1	Private Service	10%	19%	31%	0%	17%	30%	18%
2	Agriculture (Land owner)	13%	19%	8%	0%	43%	5%	25%
3	Agriculture (Wage laborer)	18%	21%	5%	0%	8%	10%	14%
4	Agriculture (Share Cropper)	11%	7%	13%	0%	7%	30%	9%
5	Fishing (Own business)	0%	0%	0%	0%	0%	0%	0%
6	Fishing (Labor)	0%	0%	0%	0%	0%	0%	0%
7	Sediment mining (wage Laborer)	8%	0%	9%	0%	4%	0%	5%
8	Other wage laborer	20%	13%	10%	0%	26%	0%	18%
9	Livestock (owner)	0%	50%	0%	0%	3%	10%	11%
10	Livestock (herder)	0%	15%	0%	0%	0%	0%	5%
11	Business (Hotel/restaurant)	9%	5%	0%	0%	7%	0%	5%
12	Trade/business	11%	5%	8%	0%	15%	5%	11%
13	Skilled workers	8%	28%	8%	0%	12%	5%	14%
14	Skilled artisans	21%	11%	10%	0%	4%	0%	10%
15	Government service (Health)	1%	2%	1%	0%	3%	0%	2%
16	Government service (Education)	7%	5%	5%	0%	7%	5%	6%
17	Government service (Other)	19%	8%	3%	0%	9%	0%	8%
18	Other	15%	0%	0%	0%	4%	0%	8%

Source: Field Survey March–April 2017 and June–July 2018

Household income

Exhibit 4.144 show the distribution of households in surveyed settlements by level of income. More than half of the households earn less than PKR 25,000 per month but more than PKR 10,000. A slight departure is observed in Zone 6, where 50% of the households were earning up to PKR 50,000 per month.

Exhibit 4.144: Household Income Levels by Zones (PKR/month) %

No	*Income Level*	*1*	*2*	*3*	*4*	*5*	*6*	*Total average*
1	Less than 10,000	17%	14%	12%	0%	17%	0%	12
2	10,000 – 25,000	57%	74%	63%	0%	36%	50%	56
3	25,000 - 50,000	19%	11%	26%	0%	20%	50%	25

No	*Income Level*	*1*	*2*	*3*	*4*	*5*	*6*	*Total average*
4	50,000 – 75,000	5%	1%	0%	0%	19%	0%	5
5	More than 75,000	3%	1%	0%	0%	8%	0%	2

Source: Field Survey March–April 2017 and June–July 2018

Exhibit 4.145 shows the average land holding by zone in the Study Area. The average landholding in all settlements ranges from 4 to 7 kanals per household. The urban settlements or settlements near the main Kaghan Road both in Zone 3 and 5 had an average of 3 kanals per household. The maximum landholding was reported as 7.67 kanal per household, found in Zone 2.

Exhibit 4.145: Average Land holding by Zones (Kanal)

Landholding	*1*	*2*	*3*	*4*	*5*	*6*
Average Land holding (Kanal)	3.94	6.71	3.31	-	3.23	5.00

Source: Field Survey March–April 2017 and June–July 2018

Farming

Exhibit 4.146 shows the crops grown by season in the Study Area. The agricultural economy is purely of subsistence in nature. Almost all people own farmlands both as personal property or as share croppers, produce from which is however 100% self-consumed. Rice is produced commercially in Zone 5. The crops grown in the Study Area are season specific. The data in **Exhibit 4.146** shows that maize/corn is the product of summer while wheat is cultivated in winter across the Study Area. Farming is mainly rain fed, with almost no dependence on river water for irrigation.

Exhibit 4.146: Crops Grown by Season Zone-wise

No	*Seasonal Crops*	*1*	*2*	*3*	*4*	*5*	*6*
	Summer						
1	Wheat	Yes	No	Yes	No	Yes	No
2	Maize/Corn	Yes	Yes	Yes	No	Yes	Yes
3	Grass	No	Yes	No	No	No	No
4	Rice	No	No	No	No	Yes	No
5	Other (Vegetables)	Yes	Yes	No	No	Yes	No
	Winter						
1	Wheat	Yes	Yes	Yes	No	Yes	Yes
2	Maize/Corn	Yes	No	Yes	No	No	No
3	Grass	No	No	No	No	No	No
4	Rice	No	No	No	No	No	No
5	Other (Vegetables)	No	No	No	No	Yes	No

Source: Field Survey March–April 2017 and June–July 2018

Exhibit 4.147 shows the proportion of crop sold in the Study Area. As discussed elsewhere, the local agricultural production is mainly for domestic consumption and only maize/corn or vegetable are reported as being sold (mostly in local market or in neighborhood).

Exhibit 4.147: Proportion Sold by Crop by Zone

No	*Nature of Crop*	*1*	*2*	*3*	*4*	*5*	*6*
1	Wheat	0%	0%	0%	0%	0%	0%
2	Maize/Corn	9%	3%	0%	0%	8%	0%
4	Rice	0%	0%	0%	0%	0%	0%
5	Other (Vegetables)	5%	0%	0%	0%	0%	0%

Source: Field Survey March–April 2017 and June–July 2018

Exhibit 4.148 shows the average yield by type of crop in the Study Area. Average yield is reported to be highest in Zone 1 followed by Zone 2 and Zone 5.

Exhibit 4.148: Average Yield by Type of Crop by zone (Mound/Kanal)

No	*Yield Type*	*1*	*2*	*3*	*4*	*5*	*6*
1	Wheat	5.9	3.6	2.3	-	4.3	4.0
2	Maize/Corn	7.0	3.7	2.7	-	4.3	6.0
4	Rice	-	-	-	-	5.0	-
5	Other (Vegetables)	7.8	6.5	-	-	5.0	-

Source: Field Survey March–April 2017 and June–July 2018

Livestock Rearing

As can be seen in **Exhibit 4.143**, more than half of the employed population is engaged in livestock rearing. Trends in livestock rearing were found to be consistent across zones. Most of the animals owned are poultry and cattle. The average value per animal is given in **Exhibit 4.149**. Livestock owners engage herders to rear goats and sheep, whereas poultry, cows and buffalo are reared at home.

Exhibit 4.149: Distribution of Livestock by Animal Type

No	*Livestock Type*	*1*	*2*	*3*	*4*	*5*	*6*	*Total*
1	Bullock/Buffalo	30	42	7	-	923	2	1,004
2	Cow	269	231	54	-	534	80	1,168
3	Goat	493	481	170	-	878	280	2,302
4	Sheep	-	8	-	-	16	-	24
5	Donkey	-	1	6	-	58	-	65
6	Horse	-	-	-	-	-	-	-
7	Camel	-	-	-	-	-	-	-

Source: Field Survey March–April 2017 and June–July 2018

Exhibit 4.150 shows the average value of livestock by type of animal in the Study Area.

Exhibit 4.150: Average Value of Livestock by Type of Animal, PKR

No	*Type of Animal*	*1*	*2*	*3*	*4*	*5*	*6*	*Mean*
1	Bullock/Buffalo	75,714	90,000	95,000	-	131,818	80,000	102,586
2	Cow	52,000	49,286	53,750	-	60,455	65,000	55,032
3	Goat	11,500	12,857	15,500	-	14,300	18,000	13,500
4	Sheep	-	12,000	-	-	22,500	-	19,00
5	Donkey	13,500	13,000	120,000	-	27,500	-	33,750
6	Horse	60,000	-	-	-	150,000	-	105,000

Source: Field Survey March–April 2017 and June–July 2018

Exhibit 4.151 shows the average time spent by livestock by the river-side in the Study Area. The dependency for livestock on Kunhar River was found to small, on average 1.6 hours out of 24 hours in all zones.

Exhibit 4.151: Average time Spent by Livestock by the River-side by Zone (hours/day)

	1	*2*	*3*	*4*	*5*	*6*	*Total*
Average Time (Hours)	0.6	2.8	2.0	-	1.6	-	1.6

Source: Field Survey March–April 2017 and June–July 2018

4.3.4 River-Dependent Socioeconomic Activities

Rural settlement surveys were undertaken in selected settlements with river dependence or within 1 km of Project facilities. Detailed consultations and village profiling were conducted in each settlement to collect data on livelihood and dependency on natural resources including on the Kunhar River for the settlements residing on both sides of the river. The slopes on the right side are steep and there is no access along the river especially from Zone 1 to 3. On the left bank of the river there is a road parallel to the river. This suits people to collect sediment. Even if the same is practiced on right side of the river, the same is transported through local indigenous system of "pulley" through a lifter to the roadside first and then onward transportation to other settlements. River dependent socioeconomic activities are however, limited in the Study Area.

Sediment Mining

Sediment (sand, gravel and cobble) mining is carried out throughout the Study Area. The mineable sediment resource is being extracted to meet small-scale construction demand, involving construction and maintenance of local residential and commercial buildings as well as for roads. Miners in the Balakot area reported that the import of sediment varies from year-to-year depending on the status of construction industry.

The mining techniques are crude, involving use of labor for dredging. No mechanical extraction was observed anywhere in the Study Area except Jagir (Thanda Mor) where sand is extracted through an excavator. The sand and gravel is mined using shovels and spades and is loaded onto animals and vehicles, from where it is transported to the roadside.

Exhibit 4.152 shows the transportation means and their typical capacities. The sediment is then piled up along the road and sold to the trucks that are passing by to collect sand for larger supply orders or in some cases loaded on a jeep and sold in nearby villages. The cable trollies are operated by electric motor (powered by diesel electric generators) or diesel engines. Miners in most cases undertake sand mining on their own lands along the riverbank.

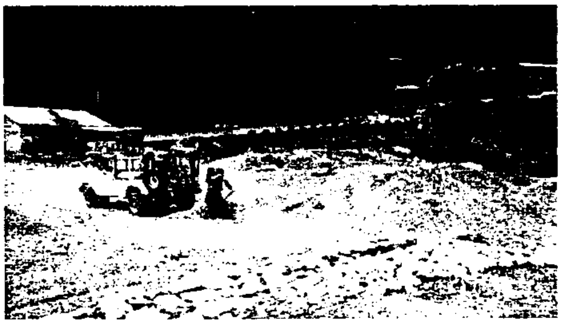
Exhibit 4.152: Modes of Transportation of Sediment

Means	*Capacity (m^3/trip)*
Donkey	0.03
Horse	0.14
Jeep	1.42
Mini-truck	2.83
Tractor Trolley	2.8-4.2
Truck	8.5-11
Cable trolley	0.3

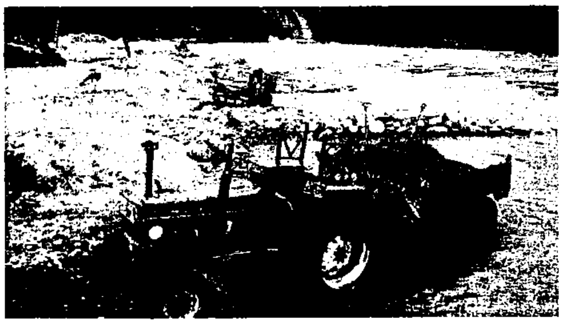
Source: Field Survey March–April 2017 and June–July 2018

Photographs of mining activities are shown in **Exhibit 4.153**.

Exhibit 4.153: Sand Mining Methods



Sand transportation by Jeep



Transporting sand and gravel using tractor trolleys

Sand Mining Trough at Bararkot

Sand mining with excavator

Sand Deposit near Jagir (Tanda Mor)

Chak dam to collect sand near Jalora

The extraction operation 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 are created. The operation continues throughout the year except in the flood season.

The mining operations are of different sizes ranging from 100 m^3/year to 2,080 m^3/year. Small- and medium-scale operations are typically family businesses. Families from nearby villages' set-up the sediment extraction which are usually run by family members. The land on the river bank, in most of the cases, is also owned by the family. However, in some cases it is rented. In most cases the labor is hired locally but at times it is also provided by the family. In this way, earnings from sediment mining operations remain primarily within the local economy. The reported selling price of the sediment varies considerably, from as low as PKR 500/secra to as much as PKR 2,000/secra.[75] To ensure even comparison, the roadside price is considered for the economic analysis.

Exhibit 4.154 summarizes the estimates for sediment mined along the main Kunhar River in the Study Area. Amounts of sediment extracted per km stretch of the river is highest in Zone 5, followed by Zone 4. Of the total sediment mined annually, the majority (98%) is extracted in Zone 5, between the stretch from Shahator Village (2.5 km downstream of Balakot Town) to Dalola Village, located at the upstream end of the reservoir of Patrind HPP.

Based on an analysis of data collected as part of the environmental and social impact assessment (ESIA) of Kohala HPP, sediment extraction is expected to increase as has been observed along other rivers in the basin, including Jhelum and Neelum Rivers, from 2013 to 2016.

Exhibit 4.154: Sand Mining Statistics

	Zone 1	*Zone 2*	*Zone 3*	*Zone 4*	*Zone 5*	***Total***
Number of HH	548	334	161	1500	9038	11569
River stretch (km)	4.2	13.5	4.6	3.5	22.1	47.9
Estimated number of mining businesses (Nos)	20	-	5	40	221	286
Volume extracted annually per business (m^3)	130	-	150	100	2,080	2,460

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[75] A *secra* or *sekra* is equal to 100 cubic feet or about 2.83 cubic meter.

	Zone 1	*Zone 2*	*Zone 3*	*Zone 4*	*Zone 5*	***Total***
Total extracted annually in the zone (m^3)	2,600	0	750	4,000	459,680	467,030
Sand mined m^3/per km stretch of river	619	0	163	1,143	20,800	9,750
Estimated number of persons involved	20	-	15	40	444	519
Percentage of HHs involved in sand mining	4%	0%	9%	3%	5%	4%
Estimate value (million Rs)	4.2	-	1.6	6.2	156.8	168.7
Payment to labor (million Rs)	-	-	2.0	-	18.5	20.5
Total annual income from all sources (million Rs)	158.04	76.88	41.37	607.42	3,809.29	4,693.0
Income as percent of total income	2.63%	0.00%	3.77%	1.03%	4.12%	3.60%

Source: Field Survey March–April 2017 and June–July 2018

The sand mining intensity map is shown in **Exhibit 4.155.**

Fishing

Fishing for self-consumption was observed in the Study Area. Fishing as a business was not observed in any of the six zones except in Zone 5 at Balakot. Even here it was on a small scale to meet the local restaurant clientage. The fishing season lasts between six months through the year, depending on the fish species caught. Seasonal permits for fishing using rods and cast nets are issued by the Tehsil administration or Fisheries and Wildlife Departments at Mansehra. However, most of the fish caught for self-consumption and business is caught without permits as enforcement is very weak. The most common fish species caught include the Alwan Snow Trout, Rainbow Trout and Brown Trout. Fishing activities are shown in **Exhibit 4.156.**

Based on the data collected for this Study, about 88% of the fish is self-consumed whereas the rest is sold commercially. As fishing is carried out illegally, i.e. without obtaining permits from the Fisheries Department, KP, fishermen are reluctant to share information on the fishing activities and volume of fish caught. The statistics presented in **Exhibit 4.157** are based on the analysis of information gathered from the sampled fishermen in the Study Area. During informal discussions with locals it was observed that some people also use illegal practices like blasting and poisoning to catch fish which means fishing is higher than reported.

Based on an analysis of data collected as part of the ESIA of Kohala HPP, fishing pressure is expected to increase as has been observed along other rivers in the basin, including Jhelum and Neelum Rivers, from 2013 to 2017. An increasing trend in fishing pressure was also highlighted by Mohammad Tanvir, Assistant Director, Manshera of the Fisheries Department, KP.

Exhibit 4.155: Sand Mining Intensity

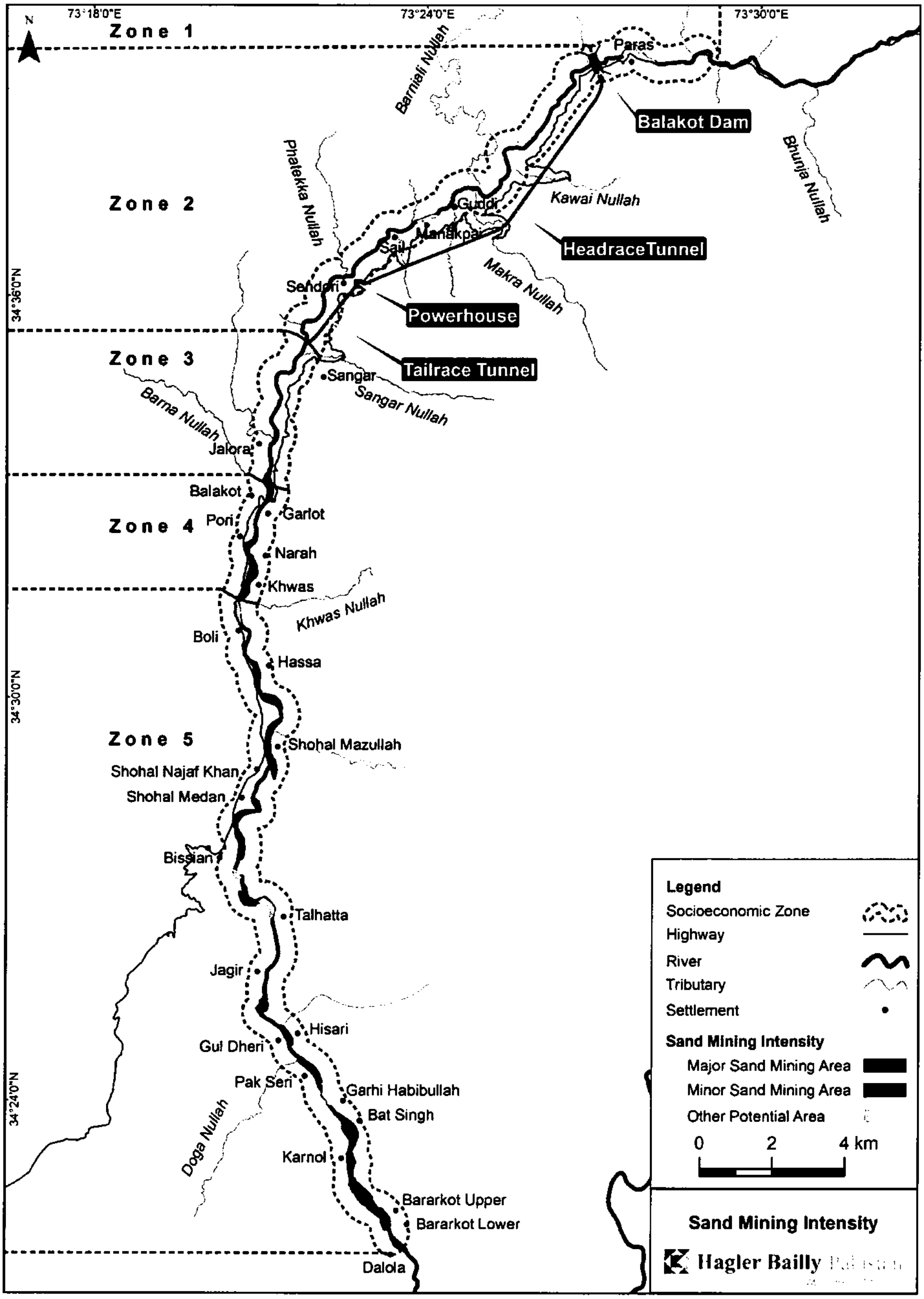
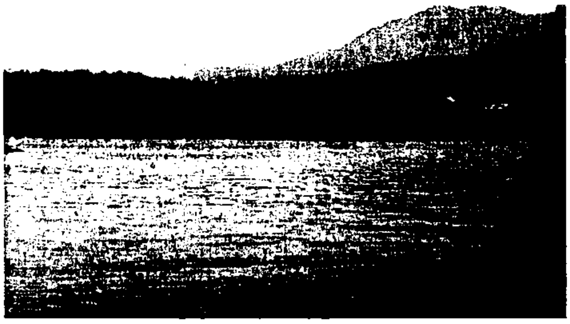
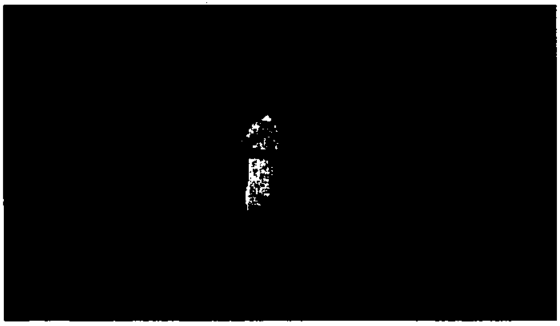


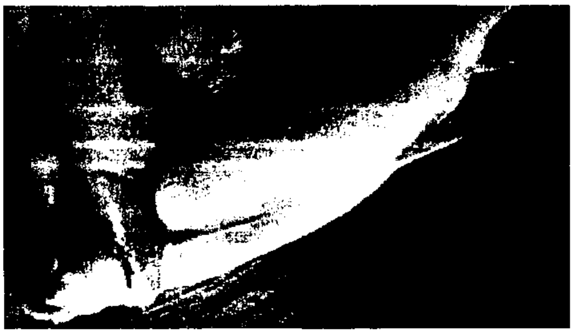
Exhibit 4.156: Fishing


Gill Netting downstream of Bissian


Cast Netting upstream of Bissian


Fishing with Rod at Talhatta


Fishing at Karnol


Alwan Snow Trout Caught at upstream Bissian


Fishing at upstream Garhi Habibullah

Exhibit 4.157: Fishing Statistics

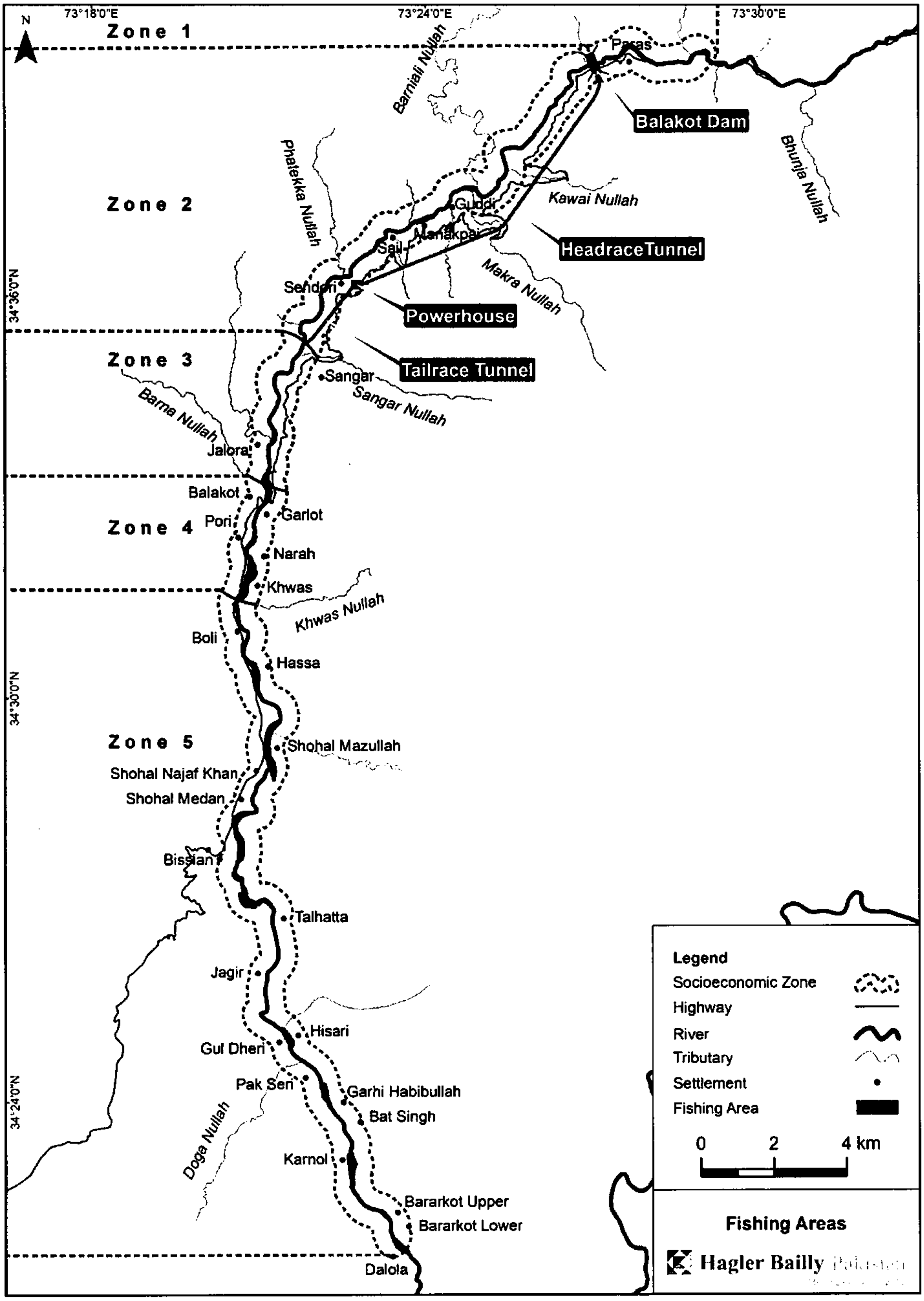
	Zone 1	*Zone 2*	*Zone 3*	*Zone 4*	*Zone 5*	***Total***
Number of HH	548	334	161	1500	9038	11569
Number of fishermen	13	3	4	33	181	234
Total fish catch per year (Maund)	2	2	1	20	51	76
River stretch km	4.2	13.5	4.6	3.5	22.1	47.9
Average fish catch per year per capita, kg	0.1	0.4	0.1	0.1	0.2	0.2
Fish catch kg/per km stretch of river	19.0	5.9	4.3	228.6	92.3	63.0
Self-consumed	100%	100%	100%	80%	85%	88%

	Zone 1	*Zone 2*	*Zone 3*	*Zone 4*	*Zone 5*	***Total***
Percentage of households engaged in fish catching (Entire Zone)	2%	1%	2%	2%	2%	2%
Percentage of households engaged in fish catching (Fishing Settlements)	9%	8%	13%	2%	5%	4%
Estimated total income from fishing (Rs)	-	-	-	88,000	400,400	488,400
Total annual income from all sources (million Rs)	158.04	76.88	41.37	607.42	3,809.29	4,684.6
Income as percent of total income	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%

Source: Field Survey March–April 2017 and June–July 2018

A map showing intensity of fishing on Kunhar River in the Study Area is shown in **Exhibit 4.158.**

Exhibit 4.158: Fishing Areas



Driftwood Used as Fuel

Fuel wood is the main source of energy for domestic cooking and heating. Respondents reported that fuel wood is collected from the farmlands and dead-fallen trees in the forests. There is limited dependence on driftwood collected from the riverbanks as source of fuel wood except in settlements at the peripheries of Balakot where the river flows through more plain areas creating room for such activities.

Tourism and Recreational Activities

Recreational dependence on the river was reportedly low in all the zones. During the survey the respondents did not cite riverside fishing, boating or picnics as a major recreational activity. However, the roadside hotel owners reported that riverside recreation was popular to certain extent among the tourists from other areas.

4.3.5 Profile of the Affected Villages

By the Project execution, four settlements of revenue village Paras; Bela Balseri, Nihan, Rahter and Dhab, one settlement Takool of revenue village Bela Sacha, one settlement Sangar of revenue village Sangar and one settlement Sendori of revenue village Kappi Gali will be affected. All the settlements are included in tehsil Balakot of district Mansehra. The socioeconomic profile is based on the survey carried out in six affected villages; five at the dam site (Bela Balseri, Nihan, Rahter and Dhab) and one at staff colony site (Sanger and Kapi Gali). Socioeconomic data collection could not be conducted in the settlement of Sendori as the ownership status of this settlement is not clear. Land records will be updated in all these settlements before land acquisition and all the affected households (AHs) will be compensated and resettled accordingly.

4.3.6 Socioeconomic Conditions of Affected Households

This section presents socioeconomic information and a profile of affected people based on a survey of all available AHs from six settlements i.e. Bela Balseri, Nihan, Dhab, Rahter, Sangar and Kappi Gali of district Mansehra.

Infrastructure in the Affected Villages

Most of the affected settlements are along the national highway N-15 and linked through unsealed roads. Electricity and communication services are available in all the affected settlements. Schools and health facilities (BHUs) are available within or along the affected villages. Sources of drinking water in all the affected villages is water springs. Communities have installed pipes to bring water to their houses. Services like hospitals, police stations and markets and banks are available in tehsil headquarter Balakot.

Distribution and Demography of Affected Households

As shown in **Exhibit 4.159,** of the total 165 AHs surveyed, 74 households belong to Bela Balseri village, 21 households belong to Nihan village, 5 households belong to Dhab village, 31 households belong to Rahter village, 16 households belong to Sangar village and 18 households belong to Kappi Gali village.

Exhibit 4.159: Village-wise Distribution of Affected Households

Settlement	*Affected Households*	*Parentage*
Bela Balseri	74	*44.8%*
Nihan	21	*12.7%*
Dhab	5	*3.0%*
Rahter	31	*18.8%*
Sangar	16	*9.7%*
Kappi Gali	*18*	*10.9%*
Total	**165**	*100.0%*

Source: Field Survey Mar–Apr 2017 and June–July 2018

Total population of surveyed households is 887 of which 53.2% are male and 46.8 % are female and on average, each household comprises 5.38 members (**Exhibit 4.160**). The female to male ratio of the AHs is 1:0.87.

Exhibit 4.160: Settlement-wise Distribution of surveyed AHs and Sex Ratio

Location	*Affected Households*	*Estimated % of AHs to total HHs of the Village*	*Sex*				*Population*	
			Male	*%*	*Female*	*%*	***Total***	*Average*
Bela Balseri	74	44.8%	201	53.9%	172	46.1%	373	5.04
Nihan	21	12.7%	55	45.8%	65	54.2%	120	5.71
Dhab	5	3.0%	12	41.4%	17	58.6%	29	5.80
Rahter	31	18.8%	90	54.9%	74	45.1%	164	5.29
Sangar	16	9.7%	54	55.7%	43	44.3%	97	6.06
Kappi Gali	18	10.9%	60	57.7%	44	42.3%	104	5.78
Total	**165**		**472**	53.2%	**415**	46.8%	**887**	**5.38**

Source: Field Survey March–April 2017 and June–July 2018

4.3.7 Social Profile of the Affected Households

The major castes of the affected households are Syed (66 %), Akhund Khel (15 %), Gujjar (7 %), Mughal (3 %), Qureshi (2 %) and Awan (2%) as presented in **Exhibit 4.161.**

Exhibit 4.161: Castes of Affected Households

Social Groups/Caste	*No. of HH*	*Percentage*
Syed	108	65.5%
Mughal	5	3.0%

Social Groups/Caste	No. of HH	Percentage
Gujjar	11	6.7%
Awan	3	1.8%
Raja	1	0.6%
Akund khek	25	15.2%
Bhatti	1	0.6%
Qureshi	4	2.4%
Surmi Khel	1	0.6%
Others	6	3.6%
Total	165	100.0%

Source: Field Survey March–April 2017 and June–July 2018

Educational Level and Literacy Rate

The socioeconomic survey conducted in the Project area revealed that the literacy rate among the surveyed population above the age of fifteen years is 72%, which is higher than the overall literacy rate of 50% and 59% of KP and Pakistan, respectively.[76] **Exhibit 4.162** further shows that the literacy rate for males is 83%, which is higher than that for females (59%).

Exhibit 4.162: Literacy Rate of Affected Population

Literacy level	Total Number of Persons		
	Male	Female	Total
Illiterate	77	160	**237**
Literate	369	234	**603**
Total	446	394	**840**
Literacy Ratio %	83%	59%	72%

Source: Field Survey March–April 2017 and June–July 2018

As provided in **Exhibit 4.163**, among literate people 1% are having education from a Madrassah, 24% have studied less than primary, 22% have education up to primary level, 10% have education up to matric level, 7% have education up to intermediate level, 7% have education up to graduate level and less than 1% have other education.

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[76] http://www.sciencedirect.com/science/article/pii/S2405883116300247

Exhibit 4.163: Education Level of Affected Population

Education Level	*Total Number of Persons*			
	Male	*Female*	***Total***	***Percentage***
Illiterate	77	160	**237**	**28.2%**
Madrassah	1	7	**8**	**1.0%**
No or Less than Primary	123	76	**199**	**23.7%**
Primary (Class 5 to Class 9)	106	78	**184**	**21.9%**
Matric (Class 10)	52	33	**85**	**10.1%**
Intermediate (FA/FSc)	40	16	**56**	**6.7%**
Graduate (BA/BSc)	41	20	**61**	**7.3%**
Other	6	4	**10**	**1.2%**
Total	**446**	**394**	**840**	**100.0%**

Source: Field Survey March–April 2017 and June–July 2018

Culture, Religion, Ethnic Minority and Indigenous Structures

No minority, in terms of culture, religion, ethnicity and indigenous household is being affected by the Project.

Gender

Eleven woman-headed households will be affected by the Project. Taking into account the socioeconomic vulnerabilities of the AHs, vulnerable allowance as discussed in Entitlement Matrix (see **Land Acquisition and Resettlement Plan** in **Volume 8**) will be provided to AHs to ensure that they are not marginalized in the process of land acquisition and Project implementation.

Land Ownership and Land Holding Size

As provided in **Exhibit 4.164**, minimum cultivated land of a household is 0.2 kanals and maximum is 4.25 kanals with an average of 1.73 kanals per household. While, minimum uncultivated land of a household is 0.25 kanals and maximum is 5 kanals with an average of 1.33 kanals per household.

Exhibit 4.164: Land Holding Size of Affected Households

Nature of Land	*Minimum (Kanal)*	*Maximum (Kanal)*	*Average (Kanal)*
Cultivated Land	0.2	4.25	1.73
Uncultivated Land	0.25	5	1.33

Source: Field Survey March–April 2017 and June–July 2018

Occupation and Production System

A majority of the working–age population surveyed were without any gainful employment. As shown in **Exhibit 4.165** of the people with gainful employment, about 41% were employed in private sector, about 24% were working as skilled and unskilled labor, almost 18% were employed in public sector, about 24% were doing trade or involved in their own business, almost 11% were generating their income from agriculture and 5% were working as artisans. Out of the total income earning population about 9% are female and 91% are male.

Exhibit 4.165: Occupational Profiles of Affected Population

Livelihood Sector	*No. of Persons*			
	Male	*Female*	*Total*	*% of Total working Population*
Employed in private Sector	32	8	40	18.10
Working as skilled or unskilled laborer	81	9	90	40.72
Employed in government Sector	5	-	5	2.26
Self–Owned trade and business	52	-	52	23.53
Income generating farming	24	-	24	10.86
Self–employed, working as artisans	6	4	10	4.52
Total	**200**	**21**	**221**	100.00
Gender %	**90.5%**	**9.5%**		**100.00**

Source: Field Survey March–April 2017 and June–July 2018

Source of Household Income

During analysis of household income earned from different sources, income from agriculture was also included. Income from fruit trees and consumed crops by the households themselves (in terms of monetary value) was included in agricultural income.

The private and Public sector (Salaried jobs) sector is the main income producing sector which accounts for 53% of the entire income followed by labor (18 %) and business (17 %). Agriculture sector is producing 8% income which also includes self–consumed crops and fruits. While 4% income is coming from other sources like Rent, charity and livestock. The annual income of affected households is presented in **Exhibit 4.166.**

Exhibit 4.166: Annual Income of Affected Households

Livelihood Sector	*Annual Income*	*Percentage*
Salaried	29,218,000	52.6%
Labor	10,033,000	18.1%
Business	9,517,000	17.1%
Farming	4,332,000	7.8%
Other (Rent, Charity and Livestock)	2,442,400	4.4%
Total	**55,542,400**	**100.0%**

Source: Field Survey March–April 2017 and June–July 2018

Average Income and Expenditure

As provided in **Exhibit 4.167** the average income of one household is Pakistani Rupee (PKR) 372,397 per annum and average expenditures of one household are PKR 257,161 per annum. While on average one household is saving PKR 115,237 per annum.

Exhibit 4.167: Income and Expenditures of Affected Households

Income and Expenditures	*Income and Expenditures in PKR/Annum*		
	Minimum	*Maximum*	*Average*
Income	60,000	1,560,000	372,397
Expenditures	24,800	911,000	257,161
Savings	200	1,147,200	115,237

Source: Field Survey March–April 2017 and June–July 2018

Poverty Level

Poverty is usually measured as an index of income inequality. In Pakistan poverty line is PKR 3,030[77] per person per month. Of the surveyed AHs, the proportion of households living under the estimated national poverty line is 13% (19 households) while, households earning more than PKR 10,000 per person per month are also 14% (23 households), which can be considered as higher income level as given in **Exhibit 4.168**.

Exhibit 4.168: Income Level and Percentage of Affected Households Above and Below Poverty Line

Income Level PKR/Person/Month	*Number of HH*	*Percentage*
Up to 3,030 (national poverty line)	19	11.5%
3,030 to 5,000	68	41.2%
5,001 to 10,000	55	33.3%
10,001 and above	23	13.9%
Total	**165**	**100.0%**

Source: Field Survey March–April 2017 and June–July 2018

Housing

Exhibit 4.169 shows that the majority of the houses are having brick built construction with tin roof (semi–*pucca*) (87%) while only one house is *katcha* (made of wood with mud walls) houses.

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[77] <http://www.dawn.com/news/1250694>

Exhibit 4.169: Construction Type of Houses

Village	*Construction Type (No. of Houses)*			
	Pucca	*Semi Pucca*	*Katcha*	***Total***
Bela Balseri	12	62	0	**74**
Nihan	0	21	0	**21**
Dhab	0	5	0	**5**
Rahter	1	29	1	**31**
Sangar	2	14	0	**16**
Kappi Gali	6	12	0	**18**
Total	**21**	**143**	**1**	**165**
Percentage	**12.7%**	**86.7%**	**0.6%**	**100.0%**

Source: Field Survey March–April 2017 and June–July 2018

On average, one house has four rooms, one kitchen and one bathroom. As given in **Exhibit 4.170**, 24% of the houses are small (less than 5 Marla), 58% of the houses are medium (5 Marla–10 Marla) and 30% of the houses are large (more than 10 Marla).

Exhibit 4.170: Number of Houses by Size

Village	*No. of Houses*			
	Small	*Medium*	*Large*	***Total***
Bela Balseri	13	45	16	74
Nihan	2	13	6	21
Dhab	1	4	0	5
Rahter	12	18	1	31
Sangar	1	9	6	16
Kappi Gali	11	6	1	18
Total	**40**	**95**	**30**	**165**
Percentage	**24.2%**	**57.6%**	**18.2%**	**100%**

Source: Field Survey March–April 2017 and June–July 2018

Household Assets

Appliances

Exhibit 4.171 shows the number of households having different home appliances.

Exhibit 4.171: Appliances Owned by Affected Households

Appliances	*No. of Appliances*	*No. of HH*
Television	84	72
Radio	34	32
Refrigerator	29	29
Freezer	17	17
Washing Machine	103	97
Electric Iron	133	122
Electric Fan	238	50
Electric Room Heater	22	20
Electric Water Heater	47	43
Sewing Machine	74	68
Computer	20	15
Generator	4	4

Source: Field Survey March–April 2017 and June–July 2018

Livestock

As provided in the **Exhibit 4.172** type of livestock found in the Project area includes buffaloes, cows, calves, goats, sheep, oxen and chicken. More than 99% of households keep livestock for self–consumption and less than 1% of the households keep livestock for both the purposes like commercial and self–consumption. As most of the people will remain in the same area and most grazing lands will remain available for them, AHs can keep their livestock. There will be no impact on livelihood of AHs regarding livestock due to land acquisition.

Exhibit 4.172: Livestock Owned by Affected Households

Livestock	*No. of Livestock and Use*				
	Self	*Commercial*	*Both*	*Total*	*Percentage*
Buffaloes	11	-	-	**11**	2.8%
Cows	85	-	1	**86**	22.1%
Oxen	2	-	2	**4**	1.0%
Calf	10	-	-	**10**	2.6%
Goats/Sheep	110	-	-	**110**	28.2%
Chickens	169	–	–	**169**	43.3%
Total	**387**	-	**3**	**390**	
Percentage	**99.2%**	**0.0%**	**0.8%**	**100.0%**	

Source: Field Survey March–April 2017 and June–July 2018

Vehicles

As provided in the **Exhibit 4.173** type of vehicles owned by affected households include motorcycles, cars, jeeps, buses, truck and pickup, motorcycles. Some people use cars and jeeps for personal use and some use cars and jeeps for commercial use. While bus, truck and pickups are commercially used.

Exhibit 4.173: Vehicles Owned by Affected Households

Type	*Number of Vehicles*			
	Personal	*Commercial*	*Both*	***Total***
Car	14	-	3	**17**
Motorcycle	6	-	-	**6**
Trucks	-	1	-	**1**
Pick-up	-	1	-	**1**
Other	2	-	-	**2**
Total	**22**	**2**	**3**	**27**

Source: Field Survey March–April 2017 and June–July 2018

Water and Sanitation

The main source of drinking water for affected households is the spring water. Most of the households have installed pipe line from water springs to bring water to their houses however. All the land owners rely on rain water to irrigate their lands.

There is no proper sanitation system in the Project area. Some people discharge their sewerage on the land to the agricultural fields or to the streams. In few cases, soak pits are used for sewerage discharge. All the affected 165 surveyed households have a pit latrine.

Fuel Sources

The fuel sources commonly used by AHs are electricity, fuel wood, liquefied petroleum gas (LPG) as given in **Exhibit 4.174**.

Exhibit 4.174: Fuel Sources used by Affected Households

Fuel Sources	*No. of HHs*			
	Lighting	*Space heating*	*Water heating*	*Cooking*
Electricity	150	16	35	14
Fuel Wood (Gathered)	0	22	22	22
Fuel Wood (Market)	25	94	128	131
LPG	22	11	49	87
Kerosene	1	-	-	-

Source: Field Survey March–April 2017 and June–July 2018

Family Health

Births and Deaths

During the last two years in the affected households 45 live births and 4 still births took place. During last two years a total of 17 persons died in the affected households. Out of total 17 died persons 4 were infants under the age of 2 years, 1 was between the age of 2 to 15 years age, 7 were between the age of 15 to 60 years and 5 persons were above the age of 60 years.

Serious illnesses

The serious illnesses in the AHs in last two years were asthma, cancer, diabetes, heart disease, hepatitis, jaundice, paralysis and tuberculosis (**Exhibit 4.175**). Analysis of the data shows that 47% of the persons that suffered from serious illnesses were treated while 53% were still under treatment.

Exhibit 4.175: Serious Illness and Outcome

Illness	*No. of Persons and Outcome*					
	Treated	*Persisting*	*Disability*	*Lost job or occupation*	*Death*	***Total***
Tuberculosis	2	1	-	-	-	**3**
Hepatitis	-	-	-	-	-	**-**
Asthma	-	2	-	-	-	**2**
Jaundice	-	1	-	-	-	**1**
Tetanus	-	-	-	-	-	**-**
Paralysis	1	-	-	-	-	**1**
Diabetes	1	1	-	-	-	**2**
Cancer	-	1	-	-	-	**1**
Heart disease	3	6	-	-	-	**9**
Typhoid	5	-	-	-	-	**5**
Other	7	9	-	-	-	**16**
Total	**19**	**21**	**0**	**-**	**-**	**40**
Percentage	**47.5%**	**52.5%**	**0.0%**	**0.0%**	**0.0%**	**100.0%**

Source: Field Survey March–April 2017 and June–July 2018

Accidents

Exhibit 4.176 shows the type of accidents that occurred in last two years in AHs.

Exhibit 4.176: Accidents and Outcome

Type of Accident	*No. of Persons and Outcome*						*Percentage*
	Treated	*Persisting*	*Disability*	*Lost Job or Occupation*	*Death*	***Total***	
Fall from height	-	-	-	-	-	-	0%
Snake Bite	-	-	-	-	-	-	0%
Road accident	2	-	-	-	-	**2**	50%
Burns	-	-	-	-	-	-	0%
Electrocution	-	-	-	-	-	-	0%
Accident at work	2	-	-	-	-	**2**	50%
Other	-	-	-	-	-	-	0%
Total	**4**	**-**	**-**	**-**	**-**	**4**	
Percentage	**100%**	**0%**	**0%**	**0%**	**0%**	**100%**	

Source: Field Survey March–April 2017 and June–July 2018

Common Illnesses

As provided in the **Exhibit 4.177** common illnesses reported by the surveyed households were cold and flu, stomach ache and joint aches.

Exhibit 4.177: Common Illness

Common Illness	*Age Group*				*Total*	*% of Common Illness*
	Adult Men	*Adult Women*	*Children (6 to 14)*	*Infants (0 to 5)*		
Cold and flu	110	117	90	72	389	64.19
Diabetes	1	-	1	-	2	0.33
Stomach diseases	9	16	-	-	25	4.13
Skin diseases	22	28	4	1	55	9.08
Breathing problems	2	3	2	1	8	1.32
Joint aches	3	2	-	-	5	0.83
Heart Problem	15	28	-	-	43	7.10
Paralysis	7	6	-	1	14	2.31
Jaundice	1	1	-	-	2	0.33
Tuberculosis	3	2	-	-	5	0.83
Other	-	2	-	-	2	0.33
Total	**190**	**231**	**98**	**87**	**606**	9.24
Percentage	**31.35**	**38.12**	**16.17**	**14.36**	**100.00**	-

Source: Field Survey March–April 2017 and June–July 2018

5. Analysis of Alternatives

A key component in the EIA process is the consideration of alternatives. Most guidelines use terms such as 'reasonable', 'practicable', 'feasible' or 'viable' to define the range of alternatives that should be considered. Essentially there are two types of alternatives:

- incrementally different (modifications) alternatives to the Project; and
- fundamentally (totally) different alternatives to the Project.

Alternatives are essentially, different ways in which the developer can feasibly meet the Project's objectives, for example by carrying out a different type of action, choosing an alternative location or adopting a different technology or design for the project. At the more detailed level, alternatives merge into mitigating measure where specific changes are made to the project design or to methods of construction or operation to avoid, reduce or remedy environmental effects. All EIA systems also require developers to consider mitigation (i.e. measures to avoid, reduce and remedy significant adverse effects).

Alternatives and mitigation therefore cover a spectrum ranging from a high level to very detailed aspects of Project design. The "No Project" scenario must also be considered as the baseline against which the environmental effects of the Project should be considered.

This section presents an analysis of the following alternatives from the perspective of economic and environmental considerations:

1. No project option
2. Alternative options for power generation
3. Environmental flow and management alternatives
4. Options for transportation of equipment to project site

5.1 No Project Option

The No Project alternative will have the following economic and environmental consequences:

- KP and Pakistan are going through an acute power shortage. In KP there is a gap between supply and demand of over 2,600 MW.[1] The proposed Project will contribute to the supply of much needed power to reduce the current gap. Thus in the absence of this project, the gap in power supply and demand will continue to grow.
- Environmentally, this Project will contribute towards improving the air quality as in the long run it will displace fossil fuels used in power generation such as coal and fuel oil which increase the concentrations of pollutants in the air in the

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[1] Pakhtunkhwa Energy Development Organization (PEDO), 2016, Investment Opportunities Hydropower Projects

surrounding areas. The Project will also reduce greenhouse gas emissions in the atmosphere due to this reason.

- The EFlow assessment conducted for the Project (see **Volume 2C** of **EIA**) indicates that under the Business-as-Usual (BAU) management scenario fish populations over a 31 year period are expected to reach a fraction of Present Day levels with Nalbant's Loach and Kashmir Hillstream Loach populations declining to over 50% and 70% of Present Day level, respectively even without the construction of new HPP, given the present level of pressures on the ecosystem related to economic uses of river resources.
- The Wildlife and Fisheries Departments presently have very limited numbers of watchers available to patrol the entire stretch of the river and associated tributaries.
- Illegal fishing is widely prevalent, and unregulated mining of sediment mining is on the increase. In absence of the Project and without a sustainable resource base for protection as envisioned under the Project, the ecology of the Kunhar River runs a high risk of decline corresponding to a BAU management scenario as discussed above.
- Under the BAU management scenario with poor protection as at present, the ecosystem integrity of the river will deteriorate significantly over the next 31 years (**Section 7.2**, *Impact Assessment: Aquatic Ecology*). As discussed in **Section 7** of the **Environmental Flow Assessment Report** in **Volume 2C**, the Project aims to achieve 'net gain' for Nalbant's Loach and Kashmir Hillstream Loach consistent with ADB and IFC guidelines for management of biodiversity when projects are located in Critical Habitats (**Section 4.2.8,** *Habitat Assessment*). A Biodiversity Action Plan (see **Volume 2C** of **EIA**) has been prepared and will be implemented as a part of the Project to achieve this objective.

Therefore, unless an economically and environmentally more viable option can be found, which appears unlikely, the 'no project' option will have a negative impact on the economy as well as on the environment in the Kunhar River.

5.2 Alternative Technologies and Scale for Power Generation

The alternatives to the proposed run-of-the-river (RoR) hydropower project include power generation from LNG/imported natural gas based combined cycle gas turbines (CCGTs), coal fired steam plants, and fuel oil based diesel engines. In addition, other technologies such as nuclear, and wind and solar renewable energy power plants could also be considered as alternatives. An analysis of the life cycle average cost of generation from the competing technologies was carried out to assess the least cost generation alternative of the project.

Exhibit 5.1 illustrates the calculation of life cycle average cost for the competing technologies for power generation in Pakistan. The analysis was carried out at the Brent crude oil price of USD 50/BBL, coal price ex mine of USD 40/ton, and delivered price of

LNG indexed to Brent Crude at USD 9.86/MMBTU[2]. The cost data of alternatives for thermal power generation were taken from recent industry experience in Pakistan.

Exhibit 5.2 shows the comparison of cost of generation from various technology alternatives. Cost of power generation for the proposed large size RoR hydropower project is presently comparable to that for LNG and coal based options based on cost of power generation. Cost of power generation for the large hydropower projects is also lower than that for wind energy and solar PV projects where power generation is intermittent and weather dependent, and requires back up fossil fuel based power generation capacity to maintain supply in the grid. Larger hydropower projects such as Diamer-Basha Dam that have also capacity for water storage can produce power at a slightly lower cost than the smaller RoR hydropower projects. Such large projects, however, generally involve extensive resettlement and technical studies, tend to be delayed for these reasons and can take 7-12 years to complete, and frequently face cost overruns[3]. In addition, investment is difficult to mobilize in Pakistan at present due to risk rating of the country. Given the risk of delays and cost over runs in larger dams, shortage of power in the country, and investment constraints, the Project as a large capacity RoR that can be completed in five years is an acceptable option amongst currently available alternatives in terms of technology and scale of projects.

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[2] MMBTU stands for one million British Thermal Units (BTU). A BTU is a measure of the energy content in fuel. One BTU is equivalent to 1.06 Joules.

[3] Should we build more large dams? The actual costs of hydropower megaproject development, Atif Ansara, Bent Flyvbjergb, Alexander Budzierb, Daniel Lunnc, Energy Policy, Volume 69, June 2014

Exhibit 5.1: Life Cycle Average Cost of Power Generation from the Project Alternatives

Cost Parameters	*Cost Units*	*New Imported and Local Coal Fired Steam*	*CCGT-LNG/Imported Gas*	*Diesel Engine-Fuel Oil*	*Hydel RoR-Medium (50-150 MW)*	*Hydel RoR-Large (>150 MW)*	*Wind*	*Solar*
Assumptions								
Project Life	Years	30	30	25	30	30	20	20
WACC/IRR		17%	15%	15%	14%	14%	16%	17%
Plant Factor		60%	60%	60%	51%	53%	30%	19%
Plant Efficiency		39.50%	60%	44%				
Insurance (% of Capital Cost)		1%	1%	1%	1%	1%	1%	1%
Fuel Price	$/MMBtu	2.46	9.86	8.62	-	-	-	-
Power Plant Capital Cost	$/kW	1,473	826	1,283	2,286[4]	2,180	1,842	1,067
Annualized Capital Cost	$/kW	253	126	199	370	311	311	190
Annual Insurance Cost	$/kW	15	8	13	23	22	18	11
Life Cycle Average Cost								
Capital Cost	Cents/kWh	4.81	2.39	3.78	7.31	6.66	11.68	11.99
O&M Cost	Cents/kWh	1.04	0.66	1.57	0.59	0.68	1.69	1.59
Insurance Cost	Cents/kWh	0.28	0.16	0.24	0.51	0.47	0.69	0.67
Fuel Cost	Cents/kWh	2.12	4.66	6.68	-	-	-	-
Average Cost of Generation	Cents/kWh	8.25	7.88	12.28	8.41	7.80	14.07	14.26[5]

Source: Hagler Bailly Pakistan Estimates

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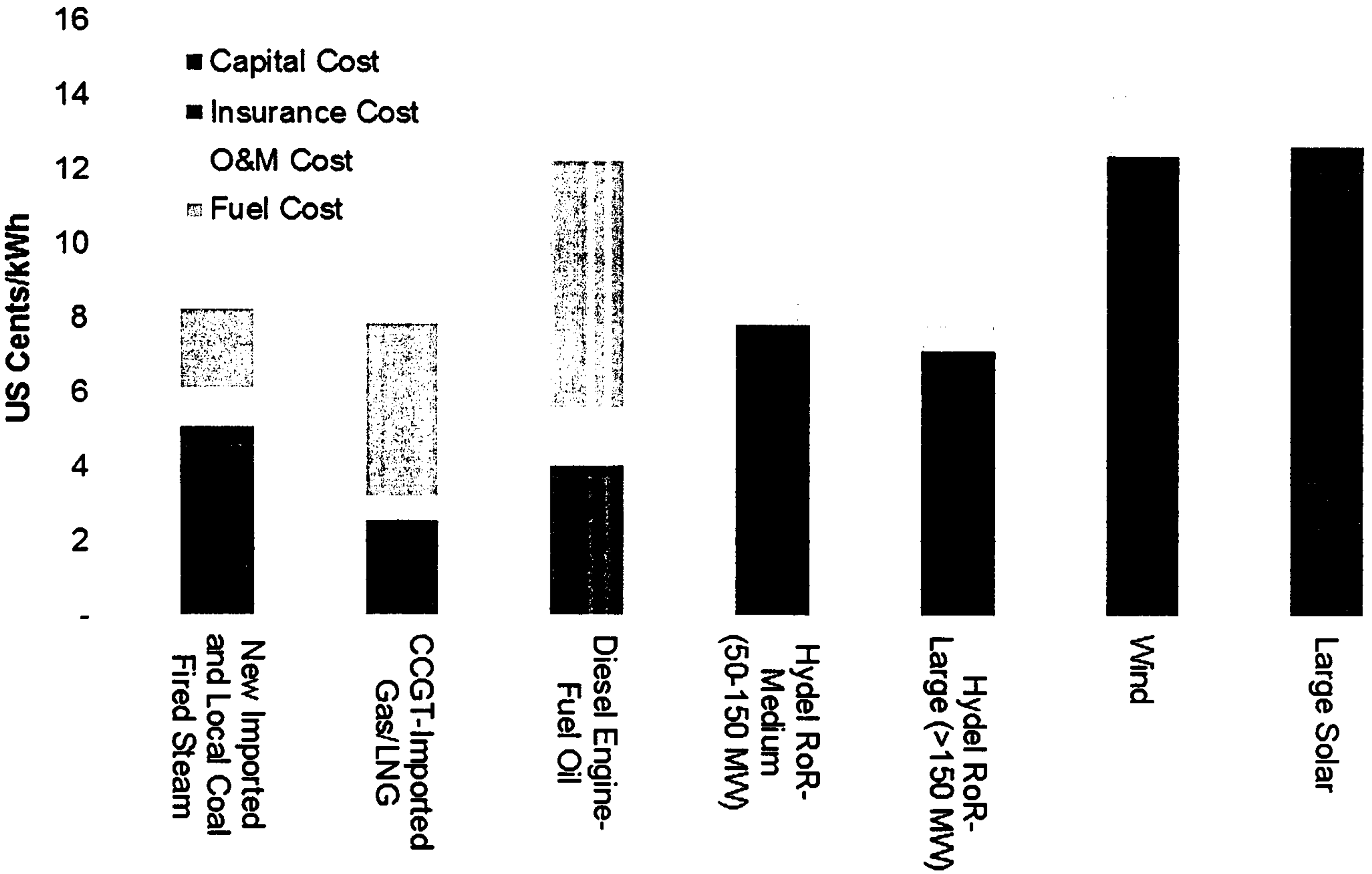
[4] Total investment for a medium scale hydropower project is estimated at $315 million, of which about 70% is for the plant and equipment, corresponding to about $2,200/kW

[5] No project has yet been awarded on this tariff, therefore NEPRA's previously determined levelized tariff of US Cents 17.00/kWh should be considered.

Exhibit 5.2: Comparison of Cost of Power Generation from the Project Alternatives



5.3 Environmental Flow Assessment

Hagler Bailly Pakistan with the support of Southern Waters conducted an EFlow assessment for the Jhelum River upstream and downstream of the proposed dam. The objectives of the EFlow assessment were to assess the implications of alternative operational and management scenarios for the Project on the ecology of the river over the life of the Project. The Downstream Response to Imposed Flow Transformations (DRIFT) decision support system (DSS) developed by Southern Waters was used for EFlow assessment, with special emphasis on impact of fish species of conservation importance. The specialist report on the basis of which these sections have been prepared is presented as **Environmental Flow Assessment for the Balakot Hydropower Development Project** (see **Volume 2C of EIA**) and is referred to as 'EFlow Report' in this section.

5.3.1 EFlow Assessment Process

The DRIFT model used adopts a holistic EFlow assessment approach. An overview of the DRIFT methodology is provided in Appendix A of the EFlow Report. The DRIFT model has been widely applied in South Africa and has been used in Pakistan for EFlow assessment of several hydropower projects in the Jhelum Basin. These include the Kishenganga and Neelum-Jhelum HPPs on the Neelum River, the Gulpur HPP on Poonch River, and KAHPP and KOHPP on the Jhelum River.

5.3.2 Scenarios Assessed

The modelled operational EFlow scenarios, include:

- Baseline hydrology without the Project
- Environmental release of 1.5 m^3/s with baseload operation
- Environmental release of 1.5 m^3/s with peaking operation
- Environmental release of 3.5 m^3/s with baseload operation
- Environmental release of 4.5 m^3/s with baseload operation
- Environmental release of 4.5 m^3/s with peaking operation
- Environmental release of 6.1 m^3/s with baseload operation
- Environmental release of 6.1 m^3/s with peaking operation

Four management scenarios, which represent the predicted river condition in 51 years[6] under different levels of protection/management were considered. The protection levels considered were:

- **Business as Usual Protection (BAU):** increase non-flow-related pressures in line with current trends, i.e. 2017 pressures double in intensity over the next 51 years.

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[6] This is the length of the 3 historical hydrological record that was used in the assessment.

- **Low Protection (LP):** maintain 2017 levels of non-flow-related pressures on the river; i.e., no increase in human-induced catchment pressures over time.
- **Moderate Protection (MP):** reduce 2017 levels of non-flow-related pressures by 50%, i.e., decline in pressures (relative to 2017) over time.
- **High Protection (HP)**: reduce 2017 levels of non-flow-related pressures by 90%, i.e., decline in pressures (relative to 2017) over time[7].

Impact assessment scenarios considered in this assessment, which are a combination of protection and flow scenarios, are presented in **Exhibit 5.3.**

Exhibit 5.3: Impact Assessment Scenarios and IDs

Dam Operation Type		*Baseline*	*Baseload Operation*				*Peaking Operation*		
Environmental Flow m^3/s Release			*1.5)*	*3.5*	*4.5*	*6.1*	*1.5*	*4.5*	*6.1*
Protection Level	Business as Usual (BAU)	BaseBAU	–	B3BAU	–	–	–	–	–
	Low Protection (LP)	BaseLP	–	B3LP	–	–	–	–	–
	Moderate Protection (HP)		–	B3MP	–	–	–	–	–
	High Protection (HP)		B1HP	B3HP	B4HP	B6HP	P1HP	P4HP	P6HP

'– ' scenario was not assessed

5.3.3 Predicted Change in Fish Abundance

Predicted percentage change in abundance or populations of indicator fish species compared to present day populations after construction of the dam are presented in this section. Predictions for the flow dependent indicators change from year to year, depending on variations in flows. The average value over the last 20 years of the 51 year hydrological time series is presented in this report which takes into account natural wet and dry cycles.

5.3.4 Alwan Snow Trout

Predicted change in abundances for the Alwan Snow Trout are presented in **Exhibit 5.4** and illustrated in **Exhibit 5.5**. Key observations are summarized below:

- Upstream of the dam this fish is trapped in the winter season and is unable to migrate down to lower reaches of Kunhar and Jhelum Rivers where the water is slightly warmer. There is a significant loss in population of this fish on account of the stress created by the barrier presented by the dam.
- Downstream of the dam this fish is affected by the low flows. Peaking further downstream has a knock on effect on the population of this fish as it suffers

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[7] Experience in neighboring rivers has shown that it is easier to impose a complete ban on activities such as illegal fishing and mining than it is to reduce these activities by half.

serious losses on account of variations in flows associated with a peaking operation.

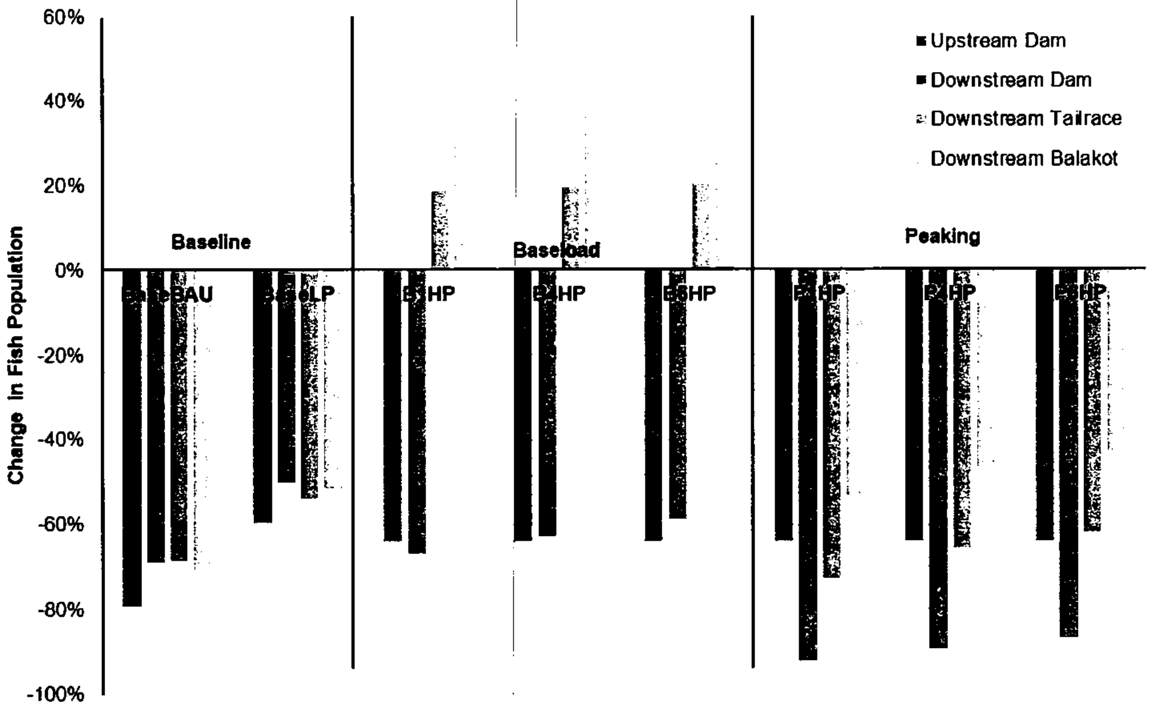
- This fish is able to benefit from a baseload operation and protection, which partially offsets the impact of loss of continuity due to the dam.

Exhibit 5.4: Alwan Snow Trout Predicted Change in Population

All figures are predicted percentage changes in population compared to Present Day over a 51 year period. Red: greater than 70% reduction from Present Day, Orange: 40% to 70% reduction from Present Day, and Green: increase over Present Day

Scenario ID	*Environmental Flow*	*Protection*	*Upstream Dam*	*Downstream Dam*	*Downstream Tailrace*	*Downstream Balakot*
BaseBAU	Baseline hydrology	Business as Usual	-79.2	-68.8	-68.7	-71.2
BaseLP	Baseline hydrology	Low	-59.8	-50.2	-54	-51.6
B3BAU	3.5 m³/s	Business as Usual	-100	-100	-75.6	-73
B3LP	3.5 m³/s	Low	-99.7	-100	-64.9	-54.4
B3MP	3.5 m³/s	Moderate	-75.5	-78	-1.4	17.7
B1HP	1.5 m³/s	High	-64.1	-66.9	18.6	36.9
B3HP	3.5 m³/s	High	-64.1	-64.8	19	37
B4HP	4.5 m³/s	High	-64.1	-62.9	19.5	37.1
B6HP	6.1 m³/s	High	-64.1	-58.8	20.4	37.3
P1HP	1.5 m³/s	High	-64.1	-92.2	-73.0	-53.5
P4HP	4.5 m³/s	High	-64.1	-89.4	-65.8	-46.7
P6HP	6.1 m³/s	High	-64.1	-86.8	-62.1	-43.2

Exhibit 5.5: Alwan Snow Trout Predicted Change in Population



5.3.5 Nalbant's Loach

Predicted abundances for the Nalbant's Loach are presented in **Exhibit 5.6** and graphed in **Exhibit 5.7**. Key observations are summarized below:

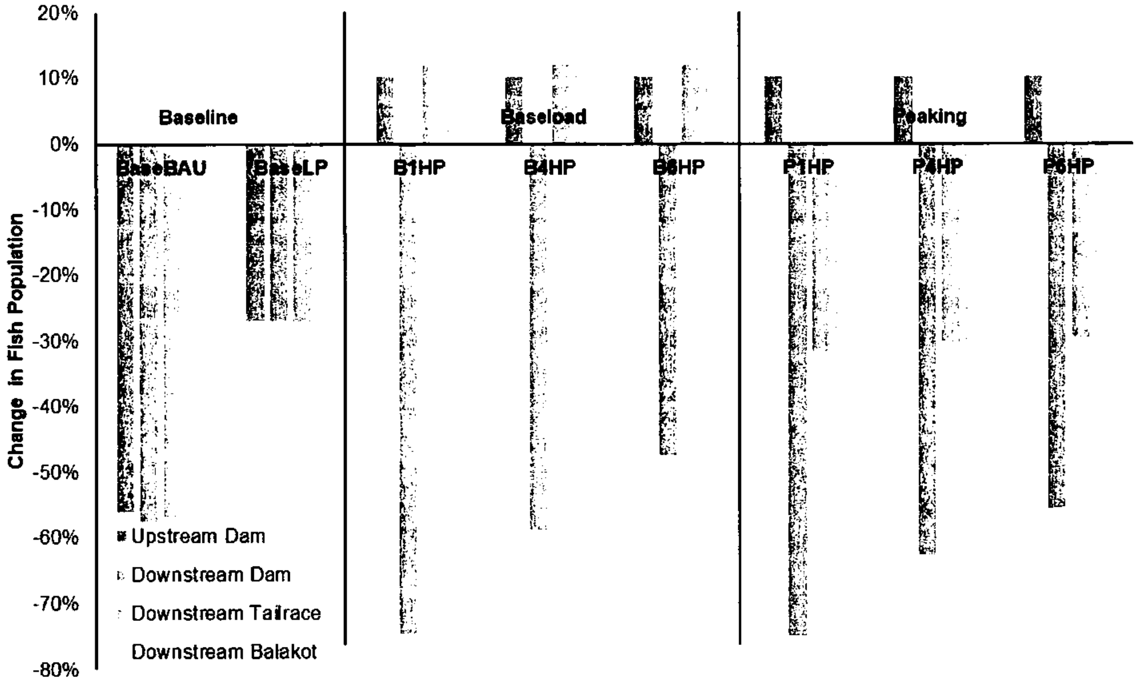
- This is a surface water fish and prefers side channels and tributaries. It is therefore less affected by variations in flow in comparison to the Kashmir Hillstream Loach discussed in the next section.
- This fish is impacted significantly by a peaking operation under which it is subjected to wide variations in habitat availability. The impact, however, much lower in comparison to Alwan Snow Trout which remains in deeper pools in winter and is affected more by changes in velocities generated by peaking, which could dislodge this fish from the pools.

Exhibit 5.6: Nalbant's Loach Predicted Change in Population

All figures are predicted percentage changes in population compared to Present Day over a 51 year period. Red: greater than 70% reduction from Present Day, Orange: 40% to 70% reduction from Present Day, and Green: increase over Present Day

Scenario ID	*Environmental Flow*	*Protection*	*Upstream Dam*	*Downstream Dam*	*Downstream Tailrace*	*Downstream Balakot*
BaseBAU	Baseline hydrology	Business as Usual	-56.2	-57.6	-56.8	-56.9
BaseLP	Baseline hydrology	Low	-26.9	-26.9	-27.1	-27.3
B3BAU	3.5 m³/s	Business as Usual	-56.8	-100	-55.6	-56.1
B3LP	3.5 m³/s	Low	-27.5	-94.6	-25.9	-26.3
B3MP	3.5 m³/s	Moderate	3	-70.4	5.7	5.2
B1HP	1.5 m³/s	High	10.3	-74.7	12	11.7
B3HP	3.5 m³/s	High	10.3	-64	12	11.7
B4HP	4.5 m³/s	High	10.3	-58.8	12	11.7
B6HP	6.1 m³/s	High	10.3	-47.5	12	11.7
P1HP	1.5 m³/s	High	10.3	-75.0	-31.7	-31.8
P4HP	4.5 m³/s	High	10.3	-62.7	-30.3	-30.3
P6HP	6.1 m³/s	High	10.3	-55.5	-29.6	-29.7

Exhibit 5.7: Nalbant's Loach Predicted Change in Population



5.3.6 Kashmir Hillstream Loach

Predicted abundances for the Kashmir Hillstream Loach are presented in **Exhibit 5.8** and graphed in **Exhibit 5.9**. Key observations are summarized below:

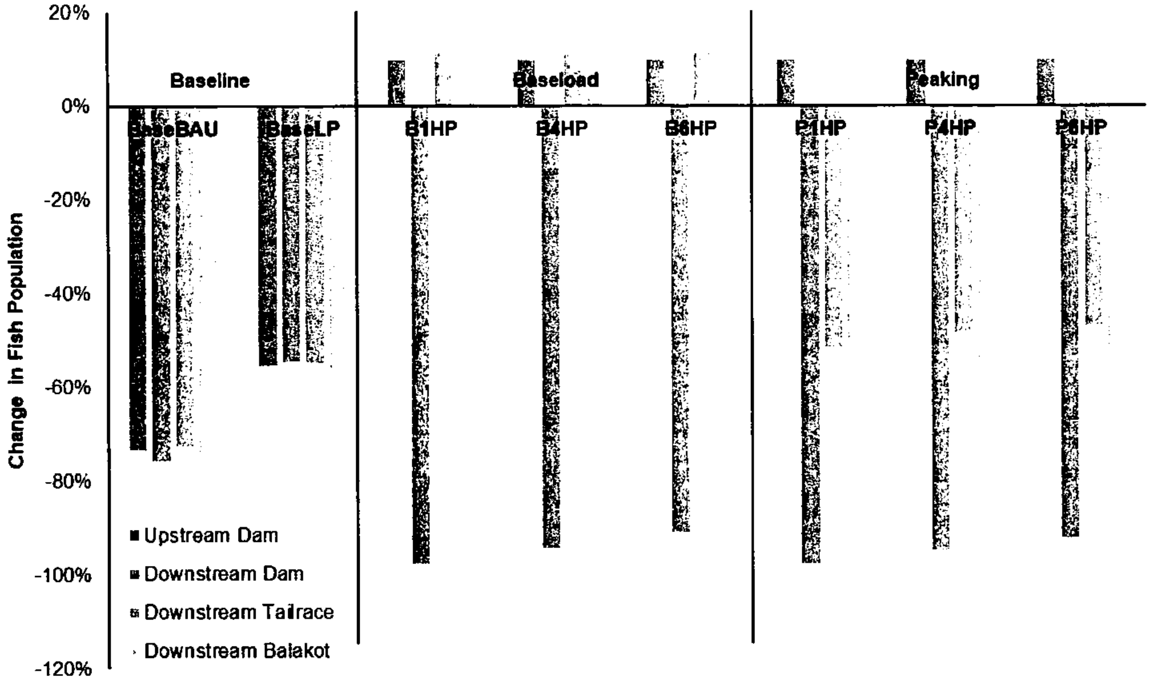
- The fish is sensitive to flow changes and therefore shows a sharp decline in the low flow section downstream of the dam, even with protection in place. Increasing EFlow in the range studied does not significantly increase its population in this segment.
- This fish is non migratory, therefore, under baseload conditions, High Protection improves fish populations downstream of the tailrace.
- Under peaking operation, this fish shows slight gains over the BAU baseline downstream of the tailrace, although these gains are much lower than those under baseload operation.

Exhibit 5.8: Kashmir Hillstream Loach Predicted Change in Population

All figures are predicted percentage changes in population compared to Present Day over a 51 year period. Red: greater than 70% reduction from Present Day, Orange: 40% to 70% reduction from Present Day, and Green: increase over Present Day

Scenario ID	*Environmental Flow*	*Protection*	*Upstream Dam*	*Downstream Dam*	*Downstream Tailrace*	*Downstream Balakot*
BaseBAU	Baseline hydrology	Business as Usual	-73.5	-75.9	-72.8	-73.9
BaseLP	Baseline hydrology	Low	-55.5	-54.8	-55	-56.1
B3BAU	3.5 m³/s	Business as Usual	-75.9	-100	-72.3	-73.3
B3LP	3.5 m³/s	Low	-59.2	-100	-54.4	-55.5
B3MP	3.5 m³/s	Moderate	-2.4	-97.8	2.5	0.8
B1HP	1.5 m³/s	High	10	-97.9	11.9	6.8
B3HP	3.5 m³/s	High	10	-96	11.9	6.8
B4HP	4.5 m³/s	High	10	-94.6	11.9	6.8
B6HP	6.1 m³/s	High	10	-91.3	11.9	6.8
P1HP	1.5 m³/s	High	10	-97.8	-51.8	-58.4
P4HP	4.5 m³/s	High	10	-95	-48.5	-55.2
P6HP	6.1 m³/s	High	10	-92.4	-47	-53.6

Exhibit 5.9: Kashmir Hillstream Loach Predicted Change in Population



5.3.7 Impact on Fish Abundance under Alternative Management and Operational Options

The impacts on fish species will vary with their habitat requirements, migratory behavior and current pressures on the ecosystem.

5.3.8 Impact of Increasing Protection Levels

Exhibit 5.10 shows the impact of variations in protection levels on fish populations. For illustrative purposes, the impacts are shown for the segment downstream of the tailrace under baseload operation where variations in flow will be minimal, in comparison to the baseline. The barrier effect of the dam on the migratory fish, however, will apply. The following is a summary of observations:

- Under the Business-as-Usual (BAU) Scenario, without the dam in place, the decline in fish populations will average at 66% of present day populations due to pressures related to unregulated fishing and sediment mining whereas the decline is predicted at 45% under the Moderate Protection (MP) baseline.
- After the Project is put in place with Moderate Protection (MP), fish populations will improve by an average of about 70% compared to the BAU baseline and 48% compared to the MP baseline. The increase is expected to be highest for the non-migratory Kashmir Hillstream Loach.

- With High Protection (HP), fish populations are predicted to improve by an average of 80% compared to the BAU Scenario. The increase is expected to be highest for the Alwan Snow Trout at close to an 88% increase over the baseline.
- Increasing protection from Moderate Protection to High Protection results in an increase in population by an average of 12%, irrespective of the baseline scenario chosen for comparison.

Exhibit 5.10: Impact of Variation in Protection on Fish Population, Downstream of Tailrace (Baseload Generation with EFlow of 3.5 m^3/s)

Red: greater than 70% reduction from Present Day, Orange: 40% to 70% reduction from Present Day, and Green: increase over Present Day

	Projected Change in Population					
	(% change from Present Day Populations)					
Fish	*Baseline*		*With Project*			
	BAU	*LP*	*B3BAU*	*B3LP*	*B3MP*	*B3HP*
Biophysical Results						
Alwan Snow Trout	-68.7	-54	-75.6	-64.9	-1.4	19.0
Nalbant's Loach	-56.8	-27.1	-55.6	-25.9	5.7	12.0
Kashmir Hillstream Loach	-72.8	-55	-72.3	-54.4	2.5	11.9
Average	**-66.1**	**-45.4**	**-67.8**	**-48.4**	**2.3**	**14.3**
Incremental Gain compared to Business as Usual Baseline, %						
Alwan Snow Trout			-6.9	3.8	67.3	87.7
Nalbant's Loach			1.2	30.9	62.5	68.8
Kashmir Hillstream Loach			0.5	18.4	75.3	84.7
Average			**-1.7**	**17.7**	**68.4**	**80.4**
Incremental Gain compared to Low Protection Baseline, %						
Alwan Snow Trout			-21.6	-10.9	52.6	73.0
Nalbant's Loach			-28.5	1.2	32.8	39.1
Kashmir Hillstream Loach			-17.3	0.6	57.5	66.9
Average			**-22.5**	**-3.0**	**47.6**	**59.7**

5.3.9 Impact of Increasing EFlow

Exhibit 5.11 shows the impact of increasing EFlow on fish species immediately downstream of the d where the impact of lower releases from the dam will be significant. Given the high anthropogenic pressures on the fish, the benefit of EFlow can be realized only if the river is protected. Under BAU the gains due to increasing EFlow are close to 0%. For example, with EFlow of 3.5 m^3/s under BAU all fish indicators show a 100% decline (not shown below, see previous section for BAU results). Therefore, figures in **Exhibit 5.11** are presented for the High Protection scenario. In other words, EFlow releases can be considered of little consequence in absence of protection of the river. The following is a summary of observations:

- The Kashmir Hillstream Loach is most affected by the lower flows in the reach downstream of the dam, and decline is predicted at over 90% for the range of EFlows considered. Increasing EFlow also benefits this fish the least.
- The Alwan Snow Trout benefits from the increased EFlow, however, impact of increasing EFlow on the population of this fish are limited as they are overshadowed by the impact of the barrier to its migration created by the dam.
- The Nalbant's Loach is least affected by lower flows. However, increasing EFlows benefits this fish the most, with loss in population declining by about 27% as EFlow is increased from 1.5 to 6.1 m^{3}s/.

Exhibit 5.11: Impact of Variation in Flow on Fish Population, Downstream of Dam with High Protection

Red: greater than 70% reduction from Present Day, Orange: 40% to 70% reduction from Present Day, and Green: increase over Present Day

Fish	*Change in Population, %*				*Incremental gain, % by increasing Environmental Flow*		
Flow Scenario	*B1HP*	*B3HP*	*B4HP*	*B6HP*	*1.5 to 3.5 m^3/s*	*3.5 to 4.5 m^3/s*	*4.5 to 6.1 m^3/s*
EFlow, m^3/s	1.5	3.5	4.5	6.1			
Alwan Snow Trout	-66.9	-64.8	-62.9	-58.8	2.1	1.9	4.1
Nalbant's Loach	-74.7	-64	-58.8	-47.5	10.7	5.2	11.3
Kashmir Hillstream Loach	-97.9	-96	-94.6	-91.3	1.9	1.4	3.3

5.3.10 Impact of Baseload vs Peaking Generation

Shifting from peaking to baseload operation has a large positive effect on fish populations as shown in **Exhibit 5.12**. In case of baseload operation, the hydrology of the river downstream of the tailrace largely remains close to natural. Comparison is provided for an EFlow of 4.5 m^3/s for illustrative purposes. With High Protection, fish populations can be restored to above present day levels.

Exhibit 5.12: Impact of Baseload vs. Peaking Operation on Fish Population, Downstream of Tailrace

Red: greater than 70% reduction from Present Day, Orange: 40% to 70% reduction from Present Day, and Green: increase over Present Day

	Change in Population, %		*Incremental gain, %*
Fish	*P4HP*	*B4HP*	*Peaking to baseload*
Alwan Snow Trout	-46.7	37.1	84
Nalbant Loach	-30.3	11.7	42
Kashmir Hillstream Loach	-55.2	6.8	62

5.3.11 Net Gain Calculations

Net gain was calculated based on the length of the reach represented by the EFlow site multiplied by the predicted changed in abundance at that particular EFlow site. Distribution of fish populations between the main river and the tributaries was also taken into account, as both the main river and tributaries will benefit from protection (see **Exhibit 5.13**).

Exhibit 5.13: Current Distribution of Fish between River and Tributaries

Fish	*Main River*	*Tributary*
Alwan Snow Trout	70%	30%
Nalbant's Loach	30%	70%
Kashmir Hillstream Loach	100%	0%

As the hydrology of the tributaries will be unchanged, the tributaries will gain from protection only. The estimated impact of protection at EF Site 4 under baseload operation where flows remain unaffected was used as a proxy for impact of protection in tributaries.

The segment of the river upstream of the dam will be impacted by peaking releases from the Sukki Kinari HPP prior to construction of the Project, and fish populations will suffer a high losses in this reach of the river. Following the construction of the Project, the fish that are adapted to a flowing river will not be able to adjust to the non-flow reservoir conditions with a greater depth of water, and will practically be eliminated from the reservoir. Net gain was therefore calculated for the reaches downstream of the dam represented by EF Sites 2, 3 and 4.

The predicted abundances were compared against baselines with two different levels of protection (BAU Protection and Low Protection). These dynamic baselines represent the expected fish abundances in the absence of the Project. Lastly, net gain against Present Day (i.e. static baseline) is also presented.

The resultant net gain under each scenario is summarized in **Exhibit 5.14,** and illustrated in **Exhibit 5.15** and **Exhibit 5.16**. Predictions of DRIFT model are subject to an uncertainty of the order of 15% above and below the predicted mean[8], which is indicated as a line in the graphs.

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[8] Based on results from Kohala Hydropower Plant Environmental Flow Assessment, Technical Report. Southern Waters in Association with Hagler Bailly Pakistan, November 2016

Exhibit 5.14: Summary of Net Gain Calculations for Selected Scenarios

Operation	*Baseload*				*Peaking*		
Environmental Flow (m^3/s)	*1.5*	*3.5*	*4.5*	*6.1*	*1.5*	*4.5*	*6.1*
Scenario ID	*B1HP*	*B3HP*	*B4HP*	*B6HP*	*P1HP*	*P4HP*	*P6HP*
Against Business as Usual Baseline							
Alwan Snow Trout	78.3	78.9	79.5	80.7	32.0	35.8	38.0
Nalbant Loach	59.1	60.4	60.9	62.2	51.0	52.6	53.5
Kashmir Hillstream Loach	42.6	43.3	43.8	45.0	2.1	5.2	7.1
Against Low Protection Baseline							
Alwan Snow Trout	59.6	60.2	60.8	62.0	13.3	17.1	19.3
Nalbant Loach	29.1	30.3	30.9	32.2	20.9	22.6	23.5
Kashmir Hillstream Loach	23.5	24.2	24.8	26.0	-17.0	-13.9	-11.9
Against Present Day							
Alwan Snow Trout	8.3	8.9	9.5	10.7	-38.0	-34.2	-32.0
Nalbant Loach	2.0	3.2	3.8	5.0	-6.2	-4.6	-3.6
Kashmir Hillstream Loach	-32.0	-31.2	-30.7	-29.5	-72.5	-69.4	-67.4

Exhibit 5.15: Net Gain Against BAU Baseline for Selected Scenarios

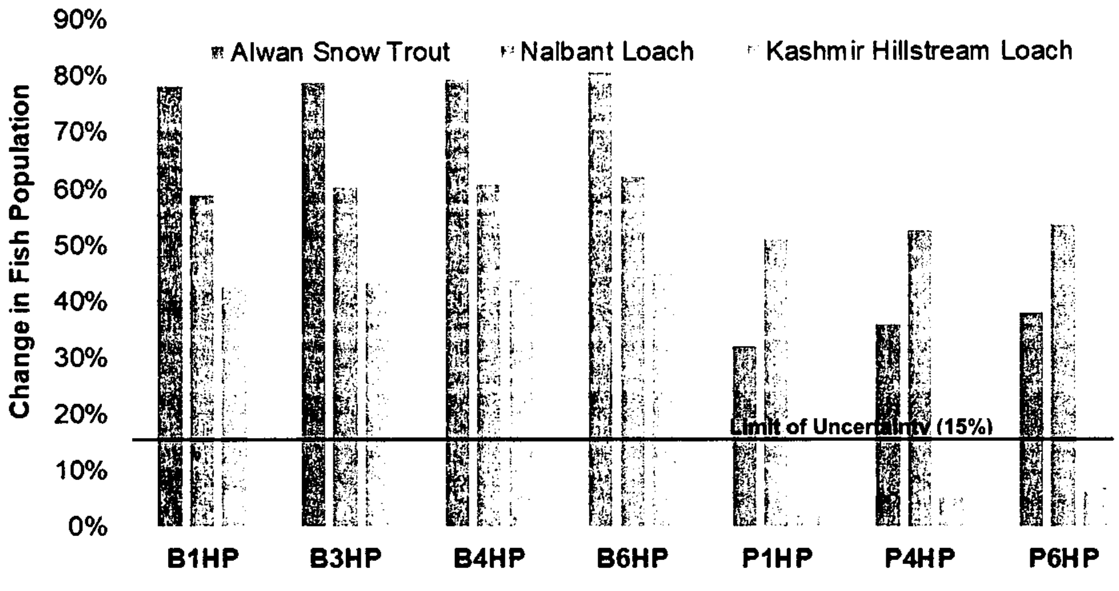
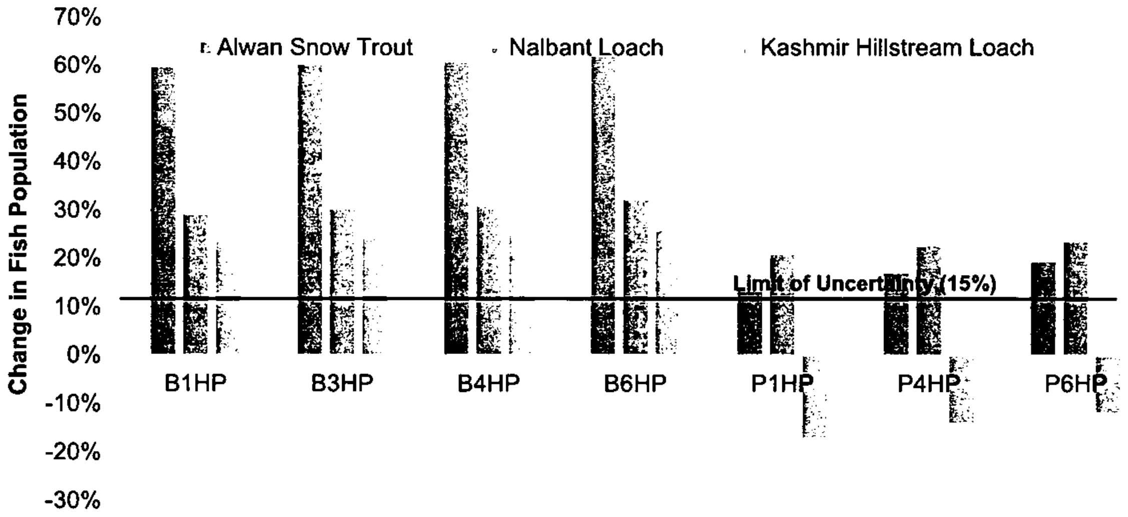


Exhibit 5.16: Net Gain Against Low Protection Baseline for Selected Scenarios



5.3.12 Impact to Power Generation

The following key assumptions are incorporated into the calculation of power loss under the different operational scenarios:

- Impact to power generation was calculated based on the water diverted through the turbines and did not take into account the turbine efficiency at varying flows.
- The operating rules of the Project are detailed in the **Environment Flow Assessment Report for the Balakot Hydropower Development Project** (see **Volume 2C** of the **EIA**), for which the power generation is calculated.
- Baseline power generation (i.e. 0% power loss) is taken as the peaking scenario with EFlow of 1.5 m^3/s as designed
- The Project is designed to produce 1,187 GWh per year in the baseline scenario (see point above) and the price of power is taken as 0.11 $.kWh. No premium is assigned to peaking power generation.
- Recovery from the EFlow turbine is estimated at 20% of the main power house turbine for the same flow of water through the turbine.

Exhibit 5.17: Power Loss Under EFlow Scenarios

Operation	*EFlow (m^3/s)*	*Scenario ID*	*Power Loss*	*Monetary Loss per year, USD Million*
Peaking	1.5	P1	0.0%	-
	4.5	P4	2.1%	$2.78
	6.1	P6	3.5%	$4.59
Baseload	1.5	B1	0.2%	$0.31
	3.5	B3	2.5%	$3.28
	4.5	B4	3.8%	$4,94
	6.1	B6	5.7%	$7.42

Power loss vs net gain is plotted in **Exhibit 5.18** when calculated against the BAU baseline and in **Exhibit 5.19** when calculated against the Low Protection baseline.

Exhibit 5.18: Power Loss vs Net Gain Against Business as Usual Baseline

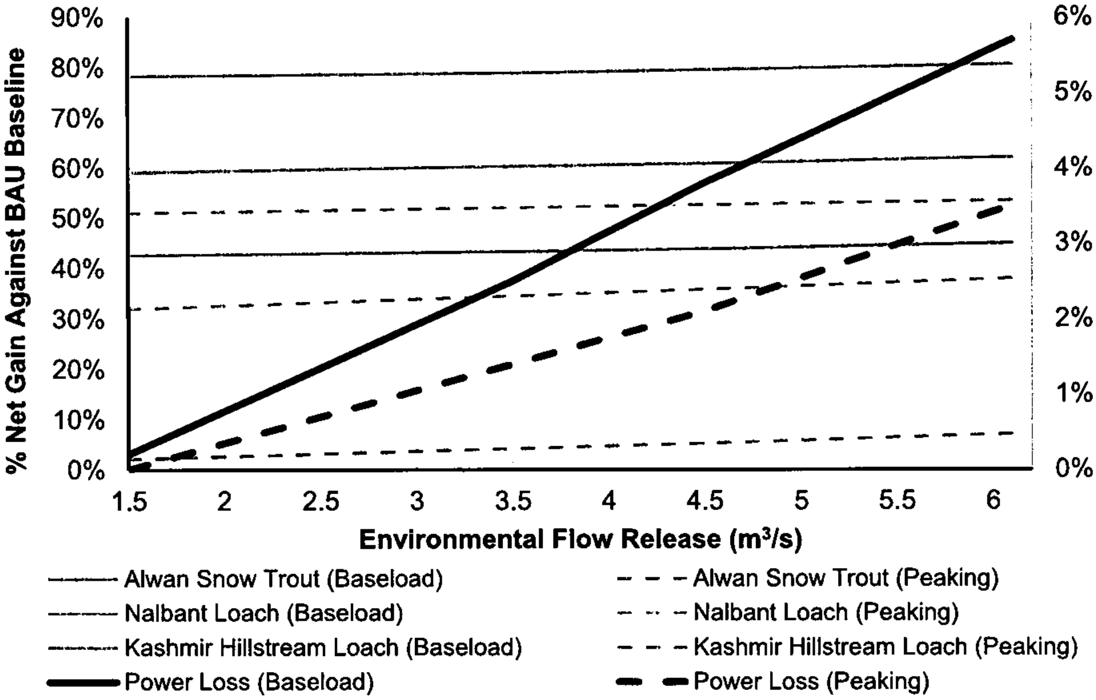
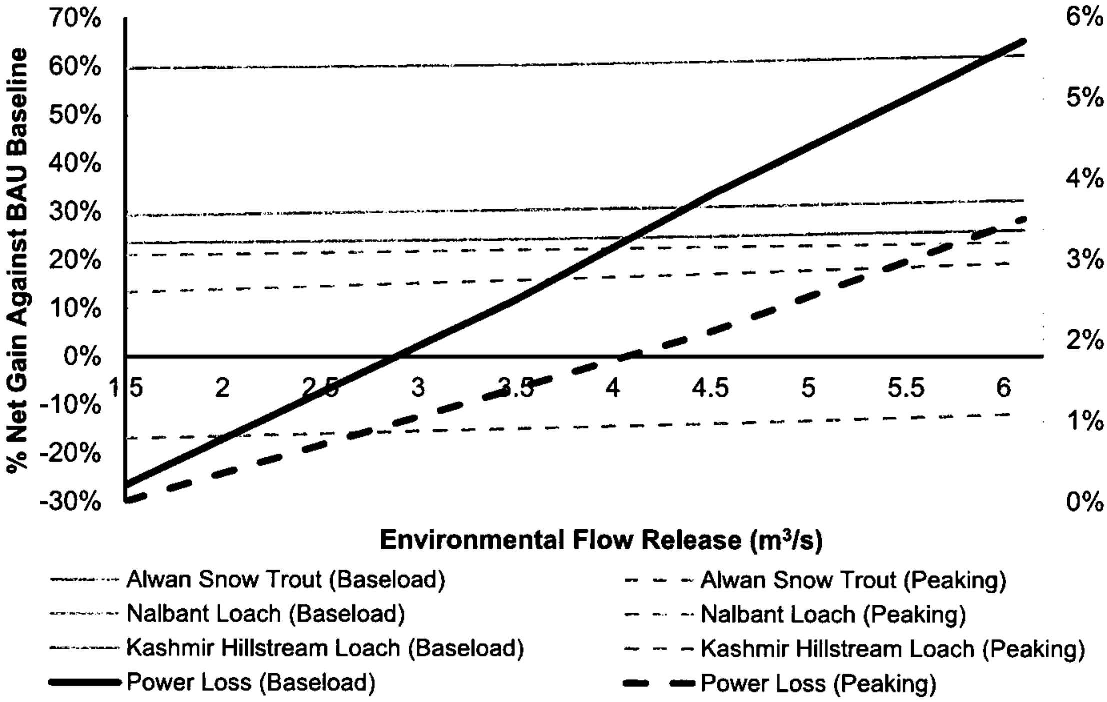


Exhibit 5.19: Power Loss vs Net Gain Against Low Protection Baseline



5.3.13 Conclusions

Two operational scenarios are recommended for consideration of the stakeholders:

- Preferred Case: Baseload operation with an EFlow of 1.5 m^3/s and High Protection (corresponding to scenario B1HP)
- Alternate Case: Peaking operation with an EFlow of 6.1 m^3/s and High Protection (corresponding to scenario P6HP)

With a baseload operation it will be possible to meet the requirement of net gain in population of fish species that trigger Critical Habitat, with a margin for uncertainties in predictions of EFlow modeling of the order of 15% above and below the predicted mean change in populations, and a more conservative baseline of Pro1 level of protection against which net gain is calculated.

With a peaking operation and EFlow release of 6.1 cumec, there will be a loss in power generation of the order of 3.5% compared to the loss under a baseload operation with an EFlow release of 1.5 cumec. While the basic requirement of net gain will be met assuming a BAU Baseline, there will be limited margin for accommodating uncertainties in EFlow modeling predictions. Net gain requirement will not be met assuming a conservative baseline with a Low Protection level of protection.

A peaking operation will produce power to meet the demand on the national power grid during evening peaking hours. Peaking power is presently priced at a premium of about 30% for high end residential and commercial customers with three phase connections. However, power purchase tariff for the generation companies remains at a flat rate, and no premium for peaking power is available to the power producer. This notwithstanding, the power purchaser, Central Power Purchase Agency Guarantee Ltd. (CPPA-G) and system operator, National Power Control Centre (NPCC) of National Transmission and Dispatch Co. Ltd. (NTDCL) under the current framework of Power Purchase Agreement (PPA) retain the right to ask the hydropower producers to operate in peaking mode when technically feasible. Operation on a baseload will therefore require appropriate amendments in the PPA.

Following the approval of EIA and Biodiversity Action Plan by EPA, KP, a baseload operation if opted for will become a legally binding requirement for the Project. Amendments in the PPA will therefore have a policy and legal basis, which will be binding on the power purchaser as well as the electricity regulator, the National Electric Power Regulatory Authority (NEPRA). Further technical studies may be required to design the Project to operate on baseload in view of peaking releases from the Sukki Kinari HPP located upstream of the Project. Obviously, no amendment in standard PPA will be required if a peaking operation is opted for.

The operational configuration selected and agreed upon by the stakeholders, project owner, and the lenders will be presented in the final version of the EIA, along with the justification for the decision.

6. Information Disclosure, Consultation, and Participation

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. This section documents the consultation process for the EIA of the proposed Project and summarizes its results. The consultation process was designed to be consistent with the relevant national legislation and the ADB Guidelines[1] on Information Disclosure, Consultation and Participation.

6.1 Regulatory Requirements

Public consultation is mandated under national environmental law. The Pak-EPA, under Regulation 6 of the IEE-EIA Regulations 2000, has issued a set of guidelines of general applicability and sectoral guidelines indicating specific assessment requirements. These guidelines have been adopted by the EPA KP for use in its jurisdiction. This includes Guidelines for Public Consultation, 1997 (the 'Guidelines'), that are summarized below:

- **Objectives of Public Involvement:** '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:** 'People who may be directly or indirectly affected by a proposal 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 it is good practice to have a very wide definition of who should be involved and to include any person or group who 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'.
- **Mechanism:** 'Provides sufficient relevant information in a form that is easily understood by non-experts (without being simplistic or insulting), allow sufficient time for stakeholders to read, discuss, consider the information and its implications and to present their views, responses should be provided to issues and problems raised or comments made by stakeholders, selection of venues and timings of events should encourage maximum attendance'.

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[1] Asian Development Bank (ADB), Environmental Safeguards: A Good Practice Sourcebook Draft Working Document, December 2012.

- **Timing and Frequency:** Planning for the public consultation program needs to begin at a very early stage; ideally it should commence at the screening stage of the proposal and continue throughout the EIA process.
- **Consultation Tools:** Some specific consultation tools that can be used for conducting consultations include; focus group meetings, needs assessment, semi-structured interviews; village meetings and workshops.
- **Important Considerations:** 'The development of a public involvement program would typically involve consideration of the following issues; objectives of the proposal and the study; identification of stakeholders; identification of appropriate techniques to consult with the stakeholders; identification of approaches to ensure feedback to involved stakeholders; and mechanisms to ensure stakeholders' considerations are taken into account'.

6.2 Lender's Requirements

Information disclosure, consultation and participation are key elements of stakeholder engagement and essential for the successful management of a project's environmental and social impacts. ADB's requirements for community engagement are focused on the engagement of affected people.[2]

Disclosure of relevant information about the proposed project and its potential impacts will help stakeholders to understand the impacts, risks and opportunities of the Project. Relevant information, including that documented in environmental assessment reports, should be provided in a place, language and form that is accessible and understandable to affected people and other stakeholders. This process commences early in the project cycle and continues throughout the life of the project.[3]

6.3 Consultation Methodology

Consultations with the Project stakeholders were undertaken in April, May and June 2017. The main document for distribution to stakeholders during the consultations was the Background Information Document (BID) that informed them about the EIA process and provided a background about the Project. The BID was made available in English (**Appendix M**) and Urdu (**Appendix N**) to suit the language preferences of different stakeholders. Meetings with institutional stakeholders were arranged in Mansehra, Peshawar and Islamabad.

6.3.1 Stakeholders Consulted

Community Stakeholders

Stakeholders are groups or individuals that can affect or take affect from a project's outcome. Affected Communities include population that is likely to be affected by the Project activities. Potential impacts of the Project on the local environment include disturbances and changes to the physical and biological environment, such as, land

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[2] Asian Development Bank (ADB), Environmental Safeguards: A Good Practice Sourcebook Draft Working Document, December 2012.

[3] Ibid

transformation, noise disturbances, and air and water quality issues. These disturbances can result in indirect socioeconomic impacts, such as, physical or economic displacement. These impacts are expected to reduce with the increased distance from the Project facilities. A basin wide study approach was used for the EIA of the Project; therefore 35 rural communities were consulted along the Kunhar River. In addition to the Potentially Affected Communities, nomad communities frequenting the area, local government and local Non-Government Organization (NGO) officials were also consulted.

Exhibit 6.1 lists the community stakeholders consulted. Consultation were conducted in representative number of communities while ensuring that people from various segments of the society participate in the consultation, to ensure proper coverage of possible stakeholder concerns. **Exhibit 6.2** shows location of stakeholders consulted near Project site.

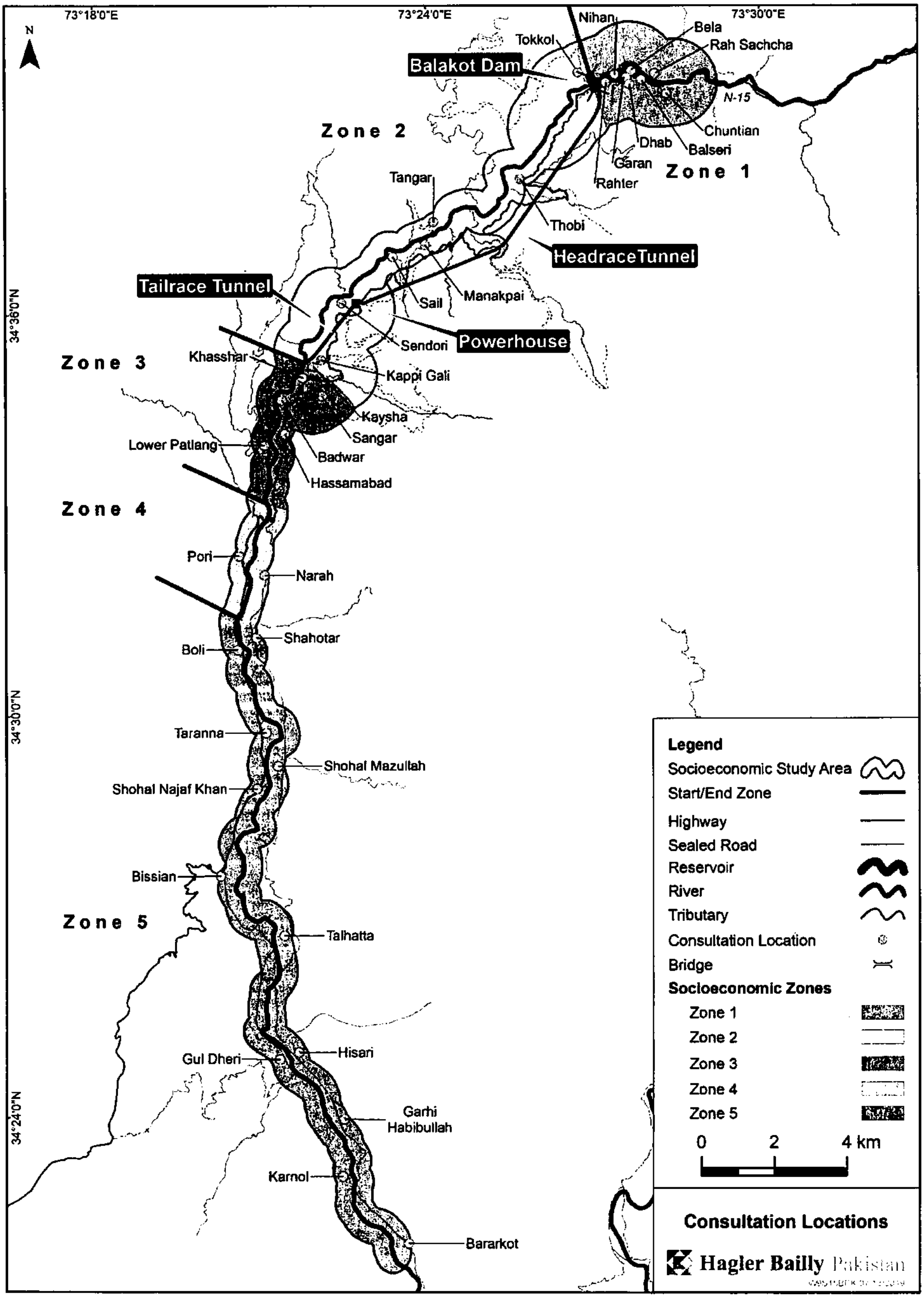
Exhibit 6.1: List of Community Stakeholders Consulted

Zones	*Stakeholders*	*Consultation Group*	*Date Consulted*
1	Balseri	M, F	3-May-17
	Bela	M, F	2-May-17
	Chuntian	M, F	4-May-17
	Dhab	M, F	4-May-17
	Garan	M, F	4-May-17
	Nihan	M, F	2-May-17
	Rah Sachcha	M, F	5-May-17
	Rahter	M, F	3-May-17
2	Kappi Gali	F	6-May-17
	Tokkol	M, F	6-May-17
	Kaysha	M	5-May-17
	Manakpai	M, F	7-May-17
	Sail	M	7-May-17
	Sendori	M, F	8-May-17
	Tangar	F	7-May-17
	Thobi	M, F	5-May-17
3	Badwar	M, F	10-May-17
	Hassamabad	M	9-May-17
	Khasshar	M	9-May-17
	Lower Patlang	M, F	9-May-17
	Sangar	M	9-May-17

Zones	*Stakeholders*	*Consultation Group*	*Date Consulted*
4	Poli	M	19-May-17
	Narah	M	19-May-17
5	Bararkot	F	17-May-17
	Bissian	M	10-May-17
	Boli	M, F	10-May-17
	Garhi Habibullah	M, F	11-May-17
	Gul Dheri	M, F	14-May-17
	Hisari	M, F	10-May-17
	Karnol	M, F	15-May-17
	Shahotar	M, F	10-May-17
	Shohal Mazullah	M, F	18-May-17
	Shohal Najaf Khan	M, F	11-May-17
	Talhatta	M, F	16-May-17

Note: M = Male and F = Female

Exhibit 6.2: Consultation Locations



Institutional Stakeholders

The institutional stakeholders consulted for the Project include relevant government agencies, NGOs and private sector organizations. The list of stakeholders consulted is shown in **Exhibit 6.3**.

Exhibit 6.3: List of Institutional Stakeholders

Stakeholders	*Date Consulted*
Government and Related	
Environmental Protection Agency, Khyber Pakhtunkhwa	April 10, 2017
Forest Department, Khyber Pakhtunkhwa	April 27, 2017
Wildlife Department, Khyber Pakhtunkhwa	April 27, 2017
Fisheries Department, Khyber Pakhtunkhwa	April 27, 2017
Social Welfare Department, Khyber Pakhtunkhwa	May 19, 2017
Kaghan Development Authority	May 22, 2017
Tourism Corporation, Khyber Pakhtunkhwa	June 12, 2017
Revenue Department, Khyber Pakhtunkhwa	July 4, 2017
Deputy Commissioner, Mansehra, Khyber Pakhtunkhwa	July 4, 2017
NGOs	
World Wildlife Fund – Pakistan	April 12, 2017
Himalayan Wildlife Foundation	April 19, 2017
Adventure Time Pakistan	May 2, 2017
Private Sector	
Star Hydropower (Pvt.) Ltd	April 12, 2017
International Finance Corporation (IFC)	May 26, 2017
Educational Institutions	
Archaeology Department, Hazara University	April 27, 2017
Archaeology Department, University of Peshawar	May 30, 2017

6.3.2 Consultations Mechanism

The consultation mechanism for institutional stakeholder is provided below.

Community Consultation

The Potentially Affected Communities (PAC) were visited and consultations were conducted with the community members within their settlements to encourage and facilitate their participation. Representatives, notables and other interested groups from the Potentially Affected Communities were invited. In most of the consultation, women also participated, however, where required, separate consultations were conducted with community women.

Institutional Stakeholder Consultation

Letters to inform experts/institutional stakeholders about the objective of the consultation process and to arrange meetings with the stakeholders were dispatched in advance. A Background Information Document (BID) was enclosed with the letters for the information of the stakeholders.

For institutional consultation, HBP organized meetings in Islamabad, Peshawar, and Mansehra for government departments and agencies, academics and NGOs, and private sector companies. Invitations for the meetings were sent two weeks before the meetings and these were followed up with phone call to ensure maximum participation.

The stakeholders were asked to share their concerns about the Project and Project-related activities along with any recommendations about management and mitigation measures.

6.4 Summary of Consultations

6.4.1 Community Consultation

Exhibit 6.4 summarizes the key concerns emerging from community consultations and explains how each concern is addressed in the EIA. The detailed log of consultations is provided in **Appendix P.** Photographs of the consultation are shown **Exhibit 6.5**.

6.4.2 Institutional Consultation

The key concerns emerging from institutional stakeholder consultations are summarized in **Exhibit 6.6.** The detailed log of consultations is provided in **Appendix P.**

Exhibit 6.4: Summary of Concerns Expressed in Community Consultations

Concerns Expressed by Stakeholders	*How they are Addressed*
Use of natural resources by locals	
Sand mining and fishing sites will be submerged affecting community wellbeing.	A biodiversity Action Plan (BAP) for the Project has been developed to regulate sediment mining and fishing. The Eflow recommended for the Project will increase fish populations downstream of the Project, thereby, increasing fish catch (see **Volume 2C** of the **EIA**).
The locals in the village collect both sand and wood debris from the river. Dam construction would block the downstream flow of the river and limit wood and sand supply.	A biodiversity Action Plan (BAP) for the Project has been developed to regulate sediment mining and fishing. The Eflow recommended for the Project will increase fish populations downstream of the Project, thereby, increasing fish catch (see **Volume 2C** of the **EIA**).
Women said they use the river for a variety of purposes including catching fish, washing clothes, and gathering wood. After construction of the dam, they may not be able to do this.	A biodiversity Action Plan (BAP) for the Project has been developed to regulate sediment mining and fishing. The Eflow recommended for the Project will increase fish populations downstream of the Project, thereby, increasing fish catch (see **Volume 2C** of the **EIA**). There is almost no river water use in the low flow area. There is a chance that springs above the tunnel will dry up during or after the tunneling. A hydrocensus was carried out as part of the EIA above the tunnel alignment. Restoration of water supply is proposed for the settlements where there will be impacts on springs and a budget has been included for this in the EMP.

Concerns Expressed by Stakeholders	*How they are Addressed*
Dam construction would increase water levels and block the river's downstream flow of driftwood that is primarily used as fuel wood by locals. Locals will then cut forest trees, resulting in deforestation.	Based on surveys, a very small number of people in the Study Area use driftwood, therefore, this is not a major impact.
Disturbances due to construction activities	
Land sliding will increase due to tunnels boring and walls of houses will be damaged due vibrations from tunnel boring	Addressed in the mitigation measures in **Section 7**
Environmental issues will increase due to excavation, vehicles, and operation of other heavy machinery	Addressed in the mitigation measures in **Section 7**
The dust from the tunnel boring activity would cause diseases and environmental problems.	Addressed in the mitigation measures in **Section 7**
Traffic increase due to project activity would result in congested roads.	Addressed in the mitigation measures in **Section 7**
Machinery and vehicles used in project activities would cause environmental problems.	Addressed in the mitigation measures in **Section 7**
The dam will lead to increased river temperatures and will disrupt the sewage dilution process of the river.	No change in water flow rate is anticipated in Balakot, the main town downstream of the dam, therefore this impact is not likely to be significant.
Due to catastrophic flood, or breakage of dam, we might suffer, what is the backup plan for our village?	A contingency plan is being developed for such situation.
Water supply from the springs and streams may dry out as result of project construction.	There is almost no river water use in the low flow area. There is a chance that springs above the tunnel will dry up during or after the tunneling. A hydrocensus was carried out as part of the EIA above the tunnel alignment. Restoration of water supply is proposed for the settlements where there will be impacts on springs and a budget has been included for this in the EMP. Addressed in the mitigation measures in **Section 7**
This village has no relevance to the river but is fully dependent on stream water for drinking purpose. Both human and animals are fed through this natural resource, after tunnel formation water table will reduce that affect our drinking water from streams.	Addressed in the mitigation measures in **Section 7**

Concerns Expressed by Stakeholders	*How they are Addressed*
The vibrations created by blasting for tunnels will damage house walls and make land unstable.	Addressed in the mitigation measures in **Section 7**
Project construction activities would deteriorate the natural beauty of the village.	Addressed in the mitigation measures in **Section 7**
Women expressed their fear about the effects of tunnel boring. Their houses can be affected, landslides will increase and there may be more earthquake in their area.	If the houses are affected they will be compensated by the Project.
The link between right and left bank of the river will be broken due to the submergence of the suspension bridges.	Access will be provided wherever it is disturbed.
Loss of agricultural land	
Agricultural land will be affected due to an increase in the water level in reservoir which will affect incomes.	Affected Households will be compensated properly.
Compensation for locals	
We need high priority in employment opportunities in the project activities and no outsider is to be allowed to work in the project unless local human resource is accommodated to the level of local satisfaction.	Priority in jobs and labor will be given to the locals.
Government should provide free electricity to local communities in exchange for their support and cooperation.	There is no such policy in the country.
Appropriate negotiation is required between affected people and government to resettle the affectees of the project.	The resettlement process will be undertaken with full participation of the affected community.
Villagers will not be happy with resettlement. However, if resettlement is necessary then alternative village or houses should be built for them.	Noted.
All the decisions which are related to community land ownership should be displayed in DC office accordingly.	Agreed.
We are requesting for free Chinese and English Language courses for our children so that they may get new opportunities of job according to market demand	The proponents will consider supporting any such effort.
Women quoted the example of payment problems with the developers of Sukki Kinari HPP and that people are not satisfied with the payments that government offered as resettlement cost.	Market prices of affected assets will be provided for this Project.

Concerns Expressed by Stakeholders	*How they are Addressed*
There was a major fear amongst the community that the government will not fulfil their promises in land acquisition case keeping in mind the situation with the Sukki Kinari HPP.	Point noted
Social issues due to movement of labor	
Non–village residents with different cultures will come to the area because of the project and damage the community's culture.	A clause will be added in the contractor's contract documents that they will be confined to their camps and will not breach privacy of local communities.
As we came to know that labor camp is proposed to construct nearby Dhab Village, we don't allow to construct labor camp because it will creates social issues due to increase of in–migration of labor for project construction. Labor camp should be outside from community settlement.	Design of the project is also being reviewed and if it is found possible design will be changed to avoid resettlement.
Our communal forest and other social fabric get destroyed.	A full compensationpackage is beign developed under the Land Acquisition and Resettlment Plan
Social security risk will increase due to increase of in–migration of labor for project construction.	Addressed in the mitigation measures in **Section 7**
Women suggested that the government construct the dam elsewhere and their plans should not affect residential settlements.	Design of the Project is being reviewed and if possible the design will be changed to avoid resettlement. If not, then people will be compensated for resettlement.
Women opposed the construction of the Project because they are concerned about its adverse consequences especially since the negative effects of the earthquake 2005 and floods 2010. They are unhappy about relocation and loss of land, and fruit orchards. They insisted that if they are to be relocated, they want to be provided not only with property but also similar environmental conditions.	A comprehensive resettlement plan has been prepared to relocate and rehabilitate affectees.

Exhibit 6.5: Photographs of Community Consultations

At Balseri

At Bela

At Dhab

At Garan

At Nihan

At Rah Sachcha

At Garan

At Nihan

At Rah Sachcha

At Rahter

At Manakpai

At Sail


At Sendori


At Tangar

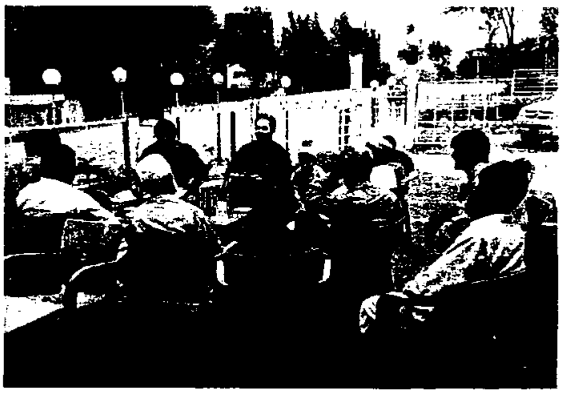

At Thobi


At Badwar

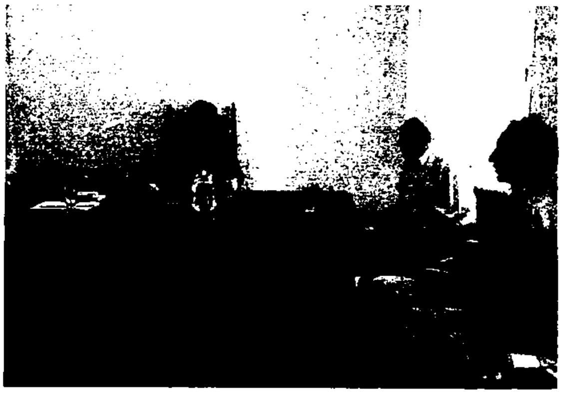

At Hassamabad


At Garhi Habibullah

At Bissian



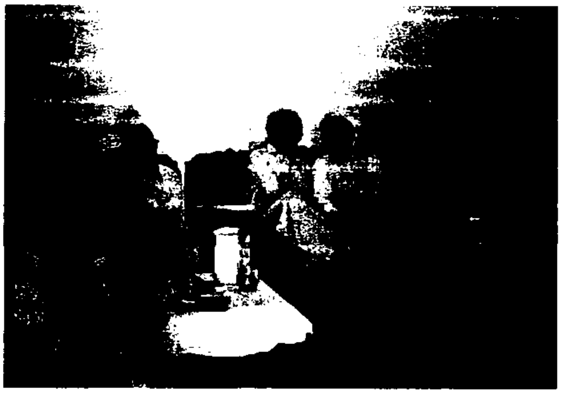
At Boli



At Shohal Mazullah

At Gul Dheri

At Talhatta



At Hisari

At Shahotar

At Karnol

At Bararkot (JK)

At Manakpai

At Gul Dheri

Exhibit 6.6: Summary of Concerns Expressed and Management Measures Recommended

Concerns Expressed by Stakeholders	*How they are Addressed*
Disturbance to the aquatic ecosystem	
The Project will result in disturbance to the existing ecosystem.	Noted. This is the reason for the preparation of a Biodiversity Action Plan (BAP) (see **Volume 2C** of the **EIA**) which addresses these changes and provides measures for mitigating them and restoring or improving the ecosystem.
Removal of trees and deforestation of thick forests	
The presence of thick forests, including Reserve Forests, was highlighted. A key concern is the disturbance to these areas and clearance of forests for the Project.	Mitigation measures during the construction phase will include minimization of disturbance to forest areas and emphasis on finding alternatives to clearing forested areas where possible. Along with this, re-planation of and support to native species as well as prevention of the spread of alien invasive species will be included. During the operational phase mitigation measures will include avoidance of disturbance to forest areas by workers.
The Forest Department, KP is of the opinion that the Project footprint does not include large forested areas, therefore, it is not expected to degrade significant forest habitat. In particular, there is no concern with respect to Reserved Forests as the nearest ones are not located within or adjacent to the Project infrastructure. The habitat is already fragmented due to human activity. The locals have modified the habitat.	Noted. The information regarding Reserved Forests is especially useful for the EIA. The fragmented habitat was observed by the field team carrying out terrestrial ecology surveys. The terrestrial habitat has, therefore, been designated as Modified Habitat under IFC PS6.
The Forest Department is in favor of the Project as it will generate much needed electricity with limited damage to forested areas. Compensatory replantation is recommended for loss of any trees due to Project-related activities. The Forest Department has not decided on the ratio of replantation yet.	Noted. Compensatory re-plantation has been included as a requirement in the EMP in a ratio of 1:10.

Concerns Expressed by Stakeholders	*How they are Addressed*
Downstream impacts and modification of environmental flows	
Operational impacts are a concern for multiple stakeholders including the EPA KP and the other developer in the basin. It is important to know the modification to environmental flows (EFlows) as a result of Project operations. It is also important to know the plans for peaking and flushing including their timing and quantities of water and sediment which will be released. Recommendations included the following: ▶ Communication between developers was emphasized as important by the representative of Star Hydropower (Pvt.) Ltd. ▶ The representative from EPA KP expressed the need to plan for use of fish ladders. This opinion was shared by the representatives of the Fisheries Department. It was noted as important not only use a fish ladder but also to look into ways to improve the efficiency of fish ladders beyond 25-30%.	The environmental flow due to the Project will be determined using holistic environmental flow assessment. The methodology has been explained to the stakeholders and their concerns and opinions about it have been documented. The EFlow assessment is completed and the results have been shared and discussed with the stakeholders. Based on the assessment, an EFlow of 1.5 m^3/s at baseload operation is recommended with High Protection (see **Environmental Flow Assessment Report** in **Volume 2C** of the **EIA**)
The environmental flow agreed upon needs to be maintained.	The EFlow will be maintained as agreed. Monitoring of the environmental flow is part of the monitoring plan in the EMP.
Changes downstream of the dam can result in sites of archaeological importance being affected, especially if there is flooding.	Under the Antiquities Act, 2016 in KP, PEDO needs to be obtain clearance from the Director of Directorate of Archaeology and Museum, KP in accordance with the requirement under the Act to obtain clearance for any major project including hydropower.
A robust impact assessment is required to not only assess the impacts on the Kunhar River but also downstream in the Jhelum River. In particular, the impacts of peaking flows and sediment discharges need to be addressed.	Impacts downstream of Patrind HPP are not within the scope of the EIA of the Project. The major impacts on that part of the Kunhar River and downstream of the confluence, into Jhelum River are due to the Patrind HPP. The impacts downstream of Patrind HPP have been discussed qualitatively, as part of the CIA of the Project, using information from the ESIA of Patrind HPP.

Concerns Expressed by Stakeholders	*How they are Addressed*
The EIA should review the impacts on downstream projects for multiple scenarios, relating to construction activities, failure of cofferdam, accidental release of excavated materials and muck.	These impacts are considered in various sections.
The cumulative impact assessment is required which takes into consideration impacts in the basin on endemic and endangered aquatic species. This includes impacts in the lower Jhelum River as well.	In the case of the CIA, for impacts downstream of the confluence, qualitative assessment using information from the EIA of Patrind HPP has been carried out. The Patrind HPP will have major impacts at and downstream of the confluence, therefore, assessment of these impacts is part of the environmental assessment for Patrind HPP.
The cumulative impact assessment should also review the (provincial/state) transboundary issues relating to ecological, social, legal, and jurisdictional aspects of the project.	The Patrind HPP creates a barrier at the downstream end of the Kunhar River, close to the confluence with Jhelum River. Therefore, downstream of the confluence, the impacts of Patrind HPP are of concern.
The ESIA should take advantage of previous data collection and analyses that may be found in ESIAs and river basin planning documents for other hydropower developments.	Noted. Data from previous work done in the basin has been used, for example, in the ecology baseline.
The overall ESIA process should essentially be impact and risk based assessment.	Noted. The EIA process is an impact and risk based assessment.
Climate Change	
The ESIA analysis may also review the project for impacts and risks on and from climate change.	A climate change risk assessment is included in the EIA.
Spawning grounds	
The spawning grounds for fish fauna will be affected due to changes in flows. As a result native species will be impacted. Most importantly the Alwan Snow Trout, a migratory species and the two endemic species, Nalbant's Loach and Kashmir Hillstream Loach will be affected.	Noted. The presence of these species has been confirmed as part of sampling carried out for the Ecological Baseline of the EIA. A Critical Habitat Assessment, under IFC PS6, in line with that recommended in ADB SPS 2009, was carried out and is presented in the Ecological Baseline. The three fish

Concerns Expressed by Stakeholders	*How they are Addressed*
	species mentioned were taken into consideration. Based on the criteria provided in the Critical Habitat Assessment guidelines, the biodiversity values for which Critical Habitat is determined include the two endemic species, Nalbant's Loach and Kashmir Hillstream Loach. The Project is required to show Net Gain for both species and a BAP (see **Volume 2C** of the **EIA**) has been developed that recommends measures to achieve this.
The use of hatcheries is recommended by the Fisheries Department.	Experimental breeding the Kashmir Hillstream Loach is recommended in the BAP (see **Volume 2C** of the **EIA**).
The ESIA may also develop framework on integrated fish monitoring plan, biodiversity management, sand and gravel mining management.	A monitoring and evaluation framework is included in the BAP developed for this Project. It monitors fish fauna as well as other aspects of the aquatic ecology and environment. Measures to manage biodiversity are a part of the EMP and the BAP. Management of sand and gravel mining is included in the BAP.
Fishing licenses	
Fishing licenses are provided for fishing in the area being occupied by the Project. The development will affect fishing in the area.	Offsets for loss in fish populations are proposed as part of the BAP. Implementation of measures proposed in the BAP will result in increased fish populations elsewhere in Kunhar River.
Submergence of certain areas is a concern	
The submergence of areas due to water level rise and creation of the reservoir is a concern because it will affect both biodiversity (in particular vegetation) and the locals.	Re-plantation of trees is recommended to compensate for the loss of vegetation.

Concerns Expressed by Stakeholders	*How they are Addressed*
The loss of habitat due to submergence is a concern for the Wildlife Department, KP. This will affect the flora and fauna of the riparian zone as well as causing modification of the habitat due to creation of a wetland.	As noted above, re-plantation is recommended as part of the EMP. This will restore habitat lost as a result of submergence by the reservoir.
The Wildlife Department recommends that the reservoir be declared a Protected Area. The Fisheries Department recommends using the reservoir for stocking of fish. However, it is important to prevent the spread of invasive fish fauna. A safe areas for fish within the reservoir is recommended and if access to the reservoir is restricted to the public, the option of pond sharing with the Fisheries Department, KP should be considered.	No native fish species will be able to live in the reservoir as the water temperature will be too low. The stocking of introduced species is not recommended as they adversely affect the populations of native fish species.
Adverse impacts on the local community	
The presence of a colony and camps for workers and laborers will present challenges. These include the regulation of activities to prevent pollution of the environment, proper waste disposal, restrictions on workers partaking in illegal activities especially those damaging to the environment such as exploitation of wildlife and introduction of invasive species.	Strict regulations and the training of workers will be recommended as part of the Environmental Management Plan (EMP) to limit potentially damaging activities including poaching, introduction of alien invasive species and exploitation of wildlife.
The representative from HWF stated that a commitment should be made to provide locals with as many jobs related to the Project as possible. These include technical jobs for which training should be started as soon as possible.	Priority will be given to the affected households/locals in project jobs and labor.
Sediment should be sourced locally and contracts for sediment extraction and provision should be with the locals, not outsiders.	To the extent possible, contracts will be given locally.
There should be an agreement with the government to provide 24 hour electricity daily to the community being affected by the Project.	Noted. However, it is not in the jurisdiction of PEDO.
The maximum benefit of the Project should be to the locals. The resettled people, in particular, should be wealthier with an improved quality of life.	LARP will be planned on the principle that living standards of affected households will remain same after the project implementation.
Under social assessments, the EIA should include analysis on human rights, community benefit sharing, conflicts and security, etc.	These have been convered under the Social and Poverty Analysis Report

Concerns Expressed by Stakeholders	*How they are Addressed*
The ESIA may also develop framework on conflicts & security management plan, livelihood restoration, etc. that would require joint implementation by key stakeholders.	Grievance redressal mechanism and livelihood restoration plan will be included in the EIA
Resettlement is a concern especially as there is commercial infrastructure in the Project area	
All displaced households should be rehabilitated.	All the displaced households will be rehabilitated according to the Land Acquisition and Resettlement Plan (LARP).
Public infrastructure such as Basic Health Units (BHU) should be relocated.	Public infrastructure will be relocated by the project, it is planned in the LARP.
Graves should be managed with the consent of the communities.	Graves management is addressed in the LARP. Either the graves will be shifted or they will be made permanent at their current locations.
The Project should provide special assistance to vulnerable households.	Vulnerable households will receive special assistance and it is included in the entitlement plan of the LARP
Households whose livelihood is affected should be provided with vocational trainings to get benefits from the project.	Vocational trainings is included in the Livelihood Restoration Plan, which is a part of the LARP.
The representative from SHCL highlighted that a market will have to be re-located as a result of the Project, therefore, resettlement is a major and sensitive issue which will need to be addressed carefully.	A land acquisition and resettlement action plan is being developed to address the related impacts.
People who are relocated are likely to move downward based on the trend in this area. This is a positive move from the forest conservation perspective, as it leaves areas higher up free from disturbance.	Noted.
The NGO, HWF, wants to see the quality of life improve for those resettled. Value should be added to their lives. The HWF representative recommended that the new housing provided should be based on comprehensive planning. A sectoral approach should be taken such as that adopted for Islamabad. The infrastructure should be a model for other villages in the Kaghan Valley.	Relocation of houses will be based on the consent of the local communities. Most of the households consulted have opted for cash compensation and self-relocation however, project managed relocation will also be considered in the planning. As part of project managed relocation, all the basic facilities will be provided to the affected peoples. As a policy

Concerns Expressed by Stakeholders	*How they are Addressed*
A town planner should be hired for the work and there should be residential, commercial and amenities plots.	principle, at least pre-project living standards of the affected households will be maintained.
Impacts on terrestrial ecology and species of conservation importance	
Construction phase disturbances area concern for terrestrial wildlife more so than operational phase disturbances. Air and noise pollution, in particular are important to address. The Project is located in areas that have Reserve Forests. Disturbance of these forests will affect the wildlife associated with these forests as well as the activities and resources of the locals that depend on them. The area was highlighted as being 'critical' for wildlife by the representative of the WWF. Species of conservation importance include Taxus spp., Himalayan Grey Langur, Black Bear, Western Tragopan, the Long tailed Tip, Khalij Pheasant, Kokhlas Pheasant. Vulture spp., Common Leopard and ungulates spp. including Ibex, Muntjak Deer, and Grey Goral. The risk of local extinctions was highlighted. Seasonal risks to wildlife are also present because of the presence of altitudinal migrants which descend into areas in and around the Project infrastructure during the winter. The representative from the WWF emphasized that Himalayan biodiversity has a slow growth rate and does not recover rapidly. Recommended mitigation measures for the wildlife included the following: ▶ Timing construction activities to minimize disturbance to wildlife. Preference should be given to constructing during winter when animals are less active. ▶ Strict controls on exploitation of wildlife by Project staff. ▶ Protection of forests upstream of the dam. ▶ Forest targeted restoration and conservation. ▶ Avoiding removal of Taxus spp. ▶ Investments in watershed management programs. ▶ Regular checks on water quality. ▶ Focused studies on Taxus spp., Western Tragopan and Musk Deer.	A Biodiversity Action Plan (BAP) (see **Volume 2C** of the **EIA**) has been prepared to address the challenges associated with the impacts on biodiversity due to the Project. The measures are aimed at achieving net gain depending on the biodiversity, in particular, the species of conservation identified as being impacted by the Project.

Concerns Expressed by Stakeholders	*How they are Addressed*
The Wildlife Department, KP also noted some of the species mentioned above along with the Chakhor. They are especially concerned about the Khalij Pheasant as this is an important area for it. The HWF is interested in contributing towards protection of biodiversity.	
Flushing and Sediment Management	
Flushing will be carried out which will impact the fish fauna of the reservoir. However, it is noted that flushing will be done in the flooding seasons, when flushing is necessary anyways. The schedule for flushing should be shared with the public so that people know about water level changes.	*To be responded following finalization of Feasibility Study*
The analysis of alternatives should cover different approaches to sediment management. This could range from different designs (e.g., dedicated sluicing gates low in the dam vs spillway releases) to different release regimes (e.g., multiple releases in the high-water season vs one or two release periods) to different levels of cooperation and coordination among cascade hydropower operators (e.g., synchronization of releases by upstream and downstream projects to unilateral scheduling of sediment releases).	*To be responded following finalization of Feasibility Study*
Peaking	
The analysis of alternatives should cover different approaches to peaking flows, from run-of-river to two- to four- hour daily peaking discharges.	The analysis of alternatives has covered both baseload and peaking scenarios. The daily discharges covered include five- hours daily peaking discharges
Seasonal limitations on peaking should be considered as well.	This has been taken into consideration. Peaking will only be done from September to April, i.e. the dry season.
Developers are encouraged to consult with relevant authority to discuss the possibility that the Project be operated as a run-of-river project without peaking discharges during the entire year or during key biodiversity periods of the year.	*Responded to be reviewed following finalization of Feasibility Study* An EFlow Assessment (see **Environmental Flow Assessment Report** in **Volume 2C** of the **EIA**) has been carried out for the Project. It has recommended two EFlows including:

Concerns Expressed by Stakeholders	*How they are Addressed*
	▶ An EFlow of 1.5m^3/s with the Project operating at baseload or ▶ An EFlow of 6m^3/s with peaking operations with an associated loss of 3.5% power generation compared to 1.5m^3/s at baseload Both options achieve net gain in biodiversity values for which Critical Habitat is designated provided High Protection is implemented as a non-flow related measure. These options have been presented to the developer, PEDO. The first option of an EFlow of 1.5m^3/s with operation at baseload is recommended.
Water level	
The NGO Adventure Time Pakistan are concerned about changes to the water level due to the Project. The activity of White Water Rafting is carried out only on the Kunhar River in Pakistan, in two areas, one of which is the stretch between Balakot Town and Garhi Habibullah. From the point of view of the sport, a higher water level in this stretch is preferable.	The fluctuation in water levels as a result of peaking will be attenuated due to inflows from the tributaries, therefore, in this stretch the water level is not expected to be significantly impacted.
Impact on tourism	
The impacts on tourism are expected to be positive because of the development of a reservoir. In the Khanpur Dam, for example, activities for children are organized.	The reservoir is likely to be off-limits to the public, however, a section of it may be open for tourism.
The Tourism Corporation, KP (TCKP) stated that there is a lack of data on tourism with the Corporation and only recently their capacity for data collection and other activities has been increased. Therefore, they are in the process of data collection.	Noted.
The TCKP has plans on developing the area for tourism and will propose to donors like the World Bank. If the Project can provide any assistance, that would be welcome.	Noted.

Concerns Expressed by Stakeholders	*How they are Addressed*
Historical value	
The District of Mansehra is rich in history. More than 1,000 sites have been identified in it. This area has been important as a historic trade route and Bhuddist archaeology is important here. The Archaeology Department of Hazara University recommends conducting surveys to determine the archaeological value in the area. If any artifacts of importance are found, excavations can be done. Assessing the area, keeping in view the dam, is important. Any information gained should be shared with the public. The Provincial Antiquities Act has been revised in 2016 and should be taken into consideration.	Under the Antiquities Act, 2016 in KP, PEDO needs to be obtain clearance from the Director of Directorate of Archaeology and Museum, KP in accordance with the requirement under the Act to obtain clearance for any major project including hydropower.
The Archaeology Department, University of Peshawar has no primary or secondary data on the Project area and can, therefore, not comment on the archaeological value of the site.	Noted.
Waste disposal	
Waste generated as a result of the Project should be quantified. This includes the excavated soil and rock material which requires off-site disposal.	This is outside the scope of the EIA. It is being done as part of the feasibility study.
Potential sites for safe disposal of muck should be reviewed for risks of washout, land sliding etc. Consideration of a detailed Muck Disposal Plan during the construction phase is also recommended.	This can only be done when information on the location of these sites is available which is being done as part of the feasibility study.
Jurisdiction of the Kaghan Development Authority (KDA)	*These responses requires review following discussion with PEDO, once the Feasibility Study is finalized*
The Project falls in an area that is entirely within the jurisdiction of the KDA. The KDA supports this move by the Provincial Government of KP to increase energy generation in the province but insists that this should be done in coordination with the KDA.	As part of PEDO's responsibilities outlined in the EMP (**Section 9**, *Environmental Management Plan*), it will, ▶ Support local government in the implementation of infrastructure project and ▶ Support NGOs specializing in development of infrastructure to assist local government.
The KDA has a number of development plans in the area which can be affected by the Project and Project-related impacts. These plans include facilities for sanitation, drainage, waste disposal, garbage collection, firefighting, park development for families and children etc. Project-related	As part of PEDO's responsibilities outlined in the EMP (**Section 9**, *Environmental Management Plan*), it will,

Concerns Expressed by Stakeholders	*How they are Addressed*
impacts can increase commercial activity in the area, thereby, putting pressure on these services. For example, increased activity will result in increased pollution and waste generation. Keeping in view these plans and functions of the KDA, it is important to coordinate with the KDA. The KDA functions as a service provider, building control agency and executing agency for any scheme in the area.	▶ Support local government in the implementation of infrastructure project and ▶ Support NGOs specializing in development of infrastructure to assist local government.
The natural beauty of the area, with all of its flora and fauna are important for the KDA, which is aiming at preserving these as a priority. Therefore, conservation of natural resources is important.	Biodiversity management has been considered as part of the EMP (see **Section 9**, *Environmental Management Plan*) and a BAP (see **Volume 2C** of the **EIA**) has been developed to address impacts on biodiversity.
By legislation, the KDA is the owner of the area and coordination with the KDA is required for public as well as private sector Projects.	As part of PEDO's responsibilities outlined in the EMP (**Section 9**, *Environmental Management Plan*), it will, ▶ Support local government in the implementation of infrastructure project and ▶ Support NGOs specializing in development of infrastructure to assist local government.
It is very important that the KDA be kept up-to-date on all developments and information be shared with the KDA in a timely manner.	As above.
Building the capacity of the KDA is recommended. Specifically the KDA wants to build financial capacity so that it can function more effectively as a service provider.	As above.
Management in Coordination with the Hydropower Industry	
The developers are encouraged to participate in the Hydropower Developers' Working Group, and participate in supporting future activities of the Working Group. This could take the form of participating in Group meetings, direct contributions to various initiatives, as well as participating or even leading certain activities. To that end, the IFC would very much appreciate it if you would provide to us contact information for the Project management.	Noted. Participation of PEDO in the Hydropower Developers' Working Group is recommended in the Biodiversity Action Plan (BAP) (see **Volume 2C** of the **EIA**) for the Project.

Concerns Expressed by Stakeholders	*How they are Addressed*
Non Project-related pressures	
There are numerous non Project-related pressures on wildlife including the following: Habitat loss and fragmentation due to expansion of human settlements Human-wildlife conflict especially with predators like the Common Leopard and Black Bear. After the major earthquake in the area, people have moved to lower elevations resulting in increased habitat for these species. As a result their populations have expanded and they have expanded their range. On the aquatic ecosystem, these pressures include human population growth causing an increase in pollution and effluent discharge into the river. This has resulted in an increase in pH in some areas, making them unsuitable for fish fauna. There is also increased noise pollution from road construction. Abrupt changes in the ecosystem are a concern which can result from climate change, for example.	The BAP will address issues associated with biodiversity management and protection. An increase in the capacity for watch and ward is part of the BAP which will contribute to both aquatic and terrestrial biodiversity protection. A part of the BAP is an M&E plan which will monitor water quality, therefore, pollution levels in the river. A climate change assessment is part of the EIA.
The violations of wildlife laws, including those against aquatic biodiversity, are being enforced by the Wildlife Department.	Noted. Any additional watch and ward system established as part of this Project, under the BAP, will be implemented in coordination with the Wildlife Department, KP
The Fisheries Department, KP has divided the Kunhar River into six zones. Of these, one zone is a sanctuary where no disturbance is allowed and where there are a greater number of fish watchers than in other zones. However, the zonation has changed due to increased pollution as fish are not travelling into areas they previously were. In addition to this, implementation of watch and ward is difficult because more people are visiting these areas as compared to the past.	An M&E plan, which includes data collection on water quality, is part of the BAP developed for this Project. It will collect data to determine if levels of pollution are above acceptable thresholds. Adaptive management is recommended as part of the BAP to address issues associated with unacceptably high levels of pollution.
Release of sewage into river is an existing issue	
The existing issue of sewage being dumped into the river, both from residential discharge and commercial discharge, was highlighted as a key concern. It was emphasized that the Project should not contribute further to this and if possible contribute to its mitigation.	Proper waste disposal procedures will be part of the requirements of the Project both during the construction and operation phases. At this stage options for sewage treatment and reduction of the effluent discharged into the river will be assessed.

Concerns Expressed by Stakeholders	*How they are Addressed*
Lack of data on wildlife	
There is a lack of data on wildlife especially on key species like the Common Leopard and the Indian Palm Civet. The Wildlife Department, KP only has data on game animals and lacks the capacity for data collection. This was also the view of the Fisheries Department concerning fish fauna. In particular, the impacts of pollution on fish fauna are a concern. It was noted by the fisheries Department that the growth of fish has not altered over the past few years and no abnormal growth has been observed. However, this is only based on observation, not based on data collection and research.	Data on wildlife has been collected and reported in the Ecological Baseline for the EIA. This included data collection on vegetation, mammals, birds, herpetofauna, fish fauna, macro-invertebrates. A BAP (see **Volume 2C** of the **EIA**) has been prepared which includes a monitoring and evaluation (M&E) plan to collect data on wildlife that will be impacted by the Project, with a focus on aquatic ecology, mainly fish fauna. The M&E plan also includes data collection water quality and other physical environmental aspects.
The Wildlife Department recommended data collection in extensive detail including on entomology in the area.	Data is being collected for the baseline of the EIA of the Project. Data collection is focused on biodiversity likely to be affected by the Project, not for all biodiversity present in the area. Aquatic insects are being surveyed because they will be impacted. Terrestrial are not being impacted, therefore, they will not be surveyed.
The Fisheries Department recommends weekly monitoring of pH. At the moment the Department only collects data on temperature.	An M&E plan, which includes data collection on water quality, is part of the BAP (see **Volume 2C** of the **EIA**) developed for this Project.
Lack of staff	
The Wildlife Department lacks the staff to effectively implement watch and ward. There is a need to build departmental capacity.	An increase in the number of watchers is recommended under the BAP along with financing for the increased capacity.
Lack of awareness amongst the locals	
There is a lack of awareness amongst the locals about the importance of wildlife and a lack of understanding about the sustainable use and economic benefits of wildlife.	The BAP includes measures to increase awareness amongst the locals regarding the importance of protecting biodiversity and engaging them in conservation activities.

Consultations on Environmental Flow Assessment

Stakeholder consultations were held to discuss the Environmental Flow Assessment carried out for the Project (see **Environmental Flow Assessment Report** in **Volume 2C** of the **EIA**). Two consultations were held. The first one was held before the EFlow Assessment to explain the process to stakeholders and document their views before starting the assessment. The second one was held after the EFlow Assessment to explain discuss the results of the DRIFT DSS. The following stakeholders were invited and attended the consultations:

- Pakhtunkhwa Energy Development Organization (PEDO)
- Asian Development Bank (ADB)
- Khyber Pakhtunkhwa (KP) Environmental Protection Agency
- World Wide Fund for Nature-Pakistan
- KP Wildlife Department
- KP Forest Department
- KP Department of Fisheries
- Department of Environmental Sciences, University of Peshawar
- Directorate General (Extension), Livestock and Dairy Development

The process of EFlow assessment was described, and the results of the EFlow assessment were shared with the participants. The behaviors of different fish species and how they are likely to be impacted by the Project was described. Recommendations for alternatives available for management of the Project operations to minimize the impact on aquatic fauna were presented. Pressures on the river system including fishing and sediment mining, and disposal of urban effluents and solid waste into the river were described. The strategy for management of biodiversity developed for Biodiversity Action Plan (BAP) of the Gulpur HPP and subsequently adopted in the BAP/Management Plan of Karot and Kohala HPPs was described, and it was suggested that the approach that has been tested in implementation of BAP of Gulpur HPP should be adopted. This includes a watch and ward protection of the river, sustainable management of sand and gravel mining, a watershed management program, and research on aquatic biodiversity.

The main concerns expressed by stakeholders and responses to them are provided in **Exhibit 6.7.** Photographs of the consultations are provided in **Exhibit 6.8.** The logs for the consultations are provided in **Appendix Q**. The presentations given are provided in **Appendix R**.

Exhibit 6.7: Summary of Main Concerns Expressed by Stakeholders and Responses

Concerns Expressed by Stakeholders	*How they are Addressed*
What is the ratio of environment to economic weightage in the calculations in DRIFT? How does it work?	DRIFT does not provide a single number for required environmental flow but rather allows stakeholders to make that decision by providing results for each scenario. DRIFT is used as an optimization tool.
What about the 2010 flood? The graphs do not show high flood values.	The 2010 flood did not significantly impact Kunhar River.
Climate Change, new seasons and fluctuations will be considered in DRIFT? In the last 5 years the hydrology of the river seems to have changed.	The climate change models are not reliable. 51 years flow data is used to design dams and climate change models are incorporated in risk assessment to see the effect. Using only last 7 years data for dam design data is not sufficient.
Cumulative impacts of HPPs are a serious concern, how will these be addressed	A cumulative impact assessment is part of the EIA. The approach suggested in the CIA of Kohala HPP is suggested to be followed. The basin wide impacts have been studied at a high level in the IFC sponsored Hydropower Strategy for the Jhelum-Poonch Basin, the second phase of which is to start soon. The stakeholders in KP will be kept informed and will be contacted for participation by IFC in the course of implementation of the second phase of the basin-wide initiative.
Will it be possible to construct a fish ladder?	Given the dam height of the order of over 60 meters, it will not be technically feasible to construct a fish ladder. Genetic studies and physical transport of fish from downstream to upstream of the dam will be recommended of genetic studies show impacts of isolation.

Exhibit 6.8: EFlow Consultations at the PEDO Office, Peshawar

The key conclusions from the consolations were as follows:

- The approach to mitigation and management of cumulative impacts at the basin level was endorsed.
- The institutional and financial model where the government departments supervise and provide legal cover, and independent non-government or private sector qualified organizations are contracted by PEDO to implement the BAP was endorsed.
- Inclusion of environmental costs as Project costs for inclusion in power tariff was accepted.

6.5 Future Consultations

Further consultations to be undertaken as part of the Project EIA process have been outlined in the **Stakeholder Engagement Plan** in **Appendix O**.

The Project management will continue community engagement activities throughout the life of the plant. Visits will be undertaken in all the communities twice or more times in a year, depending on the number of concerns raised under each consultation. Ongoing community engagement activities relevant to the EIA include:

- Ongoing reporting on progress on the implementation of environmental and social management measures identified during the EIA process and recording of comments on the effectiveness of these measures;
- Updating communities about new Project developments and recording comments on these; and,
- Ongoing operation of the grievance redress mechanism (**Stakeholder Engagement Plan** in **Appendix O**).

An overview of Stakeholder Engagement Plan is provided in **Exhibit 6.9.**

Exhibit 6.9: List of Stakeholders and their Relevance for the EIA and the Project

Stakeholder Group	*Stakeholders*	*Engagement Method*	*Frequency*
Regulatory Institutions	Khyber Pakhtunkhwa Environmental Protection Agency (KP EPA)	▶ Face-to-face meetings. ▶ Periodic reports	▶ Annually or earlier, if required
Government Institutions	Fisheries Department, KP Wildlife Department, KP Forest Department, KP Revenue Department, KP Agriculture Department, KP Social Welfare Department, KP	▶ Face-to-face meetings. ▶ Periodic reports	▶ Annually or earlier, if required
Non-Governmental Organizations and Civil Society Organizations	There are a number of NGOs operating in KP. Some of these include: ▶ Sarhad Rural Support Program ▶ Aga Khan Rural Development Program The NGOs working on protection and management of wildlife and natural resources: ▶ World Wide Fund for Nature (WWF) ▶ Himalayan Wildlife Foundation (HWF)	▶ Notification of availability of information on website ▶ Invitation to public events	▶ As and when the information is available or the meeting is held
Communities being relocated	Communities with river-dependent livelihoods and being relocated/resettled	▶ Meetings with the communities ▶ Visit to homes ▶ Group meetings ▶ Sharing of documents in Urdu	On an ongoing basis during resettlement process
Communities within a 500 m buffer of the river	Communities with river-dependent livelihoods	▶ Meetings with the communities ▶ Group meetings	At least once every year
Communities within 1 km of the Project infrastructure	Communities that may be directly impacted by the Project	▶ Meetings with the communities ▶ Group meetings ▶ Sharing of documents in Urdu	At least once every six months

7. Project Impacts 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 section, the potential environmental and social impacts are evaluated. The impacts have been identified based on consideration of the information presented in previous chapters. To avoid unnecessary repetition of supporting information, cross referencing to previous sections is given where necessary. Following the impact assessment, the mitigation measures related to each impact category is presented.

The cross-boundary impacts of the Project on neighboring countries are not expected to be significant and are therefore not discussed below. Details are presented in **Appendix U**.

7.1 Introduction

The general methodology used for impact assessment is described in this section. It describes the process of impact identification and definition, significance rating, mitigation, management and good practice measures.

7.1.1 Impact Identification and Definition

There are several guidelines and textbooks on identification and description of environmental and social impacts. These documents use various tools in an attempt to define a comprehensive and consistent method to capture the potential impacts of a proposed Project. However, it is now widely recognized by EIA practitioners that impact evaluation is not a purely objective and quantitative exercise. It has a subjective element; often based on judgment and values as much as scientific criteria. Recognizing this, a uniform system of impact description is used to enable the reviewers to understand how impacts have been interpreted. The description of each impact will have the following features:

- a definition of the impact using an **impact statement** identifying the Project activity or activities that causes the impact, the pathway or the environmental parameter that is changed by the activity, and the potential receptors of the impact (aspect-pathway-receptor)
- **description of the sensitivity and importance value** of the receiving environment or receptors (based on the stakeholder consultations undertaken)
- **extent of change** associated with the impact
- **rating of the significance** of the impact
- description of appropriate mitigation and management measures and potential effectiveness of the proposed measures

- characterization of the level of uncertainty in the impact assessment

The significance of an impact is determined based on the product of the consequence of the impact and the probability of its occurrence. The consequence of an impact, in turn, is a function primarily of three impact characteristics:

- magnitude
- spatial scale
- timeframe

Magnitude is determined from quantitative or qualitative evaluation of a number of criteria including:

- sensitivity of existing or reasonably foreseeable future receptors
- importance value of existing or reasonably foreseeable future receptors, described using the following:
  - inclusion in government policy
  - level of public concern
  - number of receptors affected
  - intrinsic or perceived value placed on the receiving environment by stakeholders
  - economic value to stakeholders
- severity or degree of change to the receptor due to impact, measured qualitatively or quantitatively, and through comparison with relevant thresholds:
  - legal thresholds—established by law or regulation
  - functional thresholds—if exceeded, the impacts will disrupt the functioning of an ecosystem sufficiently to destroy resources important to the nation or biosphere irreversibly and/or irretrievably
  - normative thresholds—established by social norms, usually at the local or regional level and often tied to social or economic concerns
  - preference thresholds—preferences for individuals, groups or organizations only, as distinct from society at large
  - reputational thresholds—the level of risk a company is willing to take when approaching or exceeding the above thresholds

Spatial scale is another impact characteristic affecting impact consequence. The spatial scale of impacts can range from localized (confined to the proposed Project site) to extensive (national or international extent). They also may vary depending on the component being considered.

The impact **timeframe** is the third principal impact characteristic defining impact consequence and relates to either its duration or its frequency (when the impact is intermittent). Impact duration can range from relatively short (less than four years) to long (beyond the life of the Project). Frequency ranges from high (more than 10 times a year) to low (less than once a year). These timeframes will need to be established for each Project based on its specific characteristics and those of the surrounding environment.

Once the impact consequence is described on the basis of the above impact characteristics, the **probability of impact** occurrence is factored in to derive the overall impact significance. The probability relates to the likelihood of the impact occurring, not the probability that the source of the impact occurs. For example, a continuous Project activity may have an unlikely probability of impact if there are no receptors within the area influenced by that activity.

The **reversibility of each impact** at the end of construction and operation are important, as these impacts may need on-going management after operation. The reversibility of each impact at the end of construction and operation will be noted and described alongside the three primary characteristics of magnitude, spatial scale and duration.

The characteristics are outlined in **Exhibit 7.1.**

Exhibit 7.1: Characteristics Used to Describe Impact

Characteristics	*Sub-components*	*Terms used to describe the impact*
Type		Positive (a benefit), negative (a cost) or neutral
Nature		Biophysical, social, cultural, health or economic Direct, indirect or cumulative
Phase of Project		Construction, operation, decommissioning or post closure
Magnitude	Sensitivity of receptor	High, medium or low capacity to accommodate change High, medium or low conservation importance Vulnerable or threatened Rare, common, unique, endemic
	Importance or value of receptor	High, medium or low concern to some or all stakeholders High, medium or low value to some or all stakeholders (for example, for cultural beliefs) Locally, nationally or internationally important Protected by legislation or policy
	Severity or degree of change to the receptor	Gravity or seriousness of the change to the environment Intensity, influence, power or strength of the change Never, occasionally or always exceeds relevant thresholds
Spatial scale	Area affected by impact - boundaries	Area or Volume covered

Characteristics	Sub-components	Terms used to describe the impact
	at local and regional extents will be different for biophysical and social impacts.	Distribution Local, regional, transboundary or global
Timeframe	Length of time over which an environmental impact occurs or frequency of impact when intermittent	Short term or long term Intermittent (what frequency) or continuous Temporary or permanent Immediate effect (impact experienced immediately after causative project aspect) or delayed effect (effect of the impact is delayed for a period following the causative project aspect)
Probability - likelihood or chance an impact will occur		Definite (impact will occur with high likelihood of probability) Possible (impact may occur but could be influenced by either natural or project related factors) Unlikely (impact unlikely unless specific natural or Project related circumstances occur)
Reversibility/Sustainability		Potential for recovery of the endpoint from a negative impact Reversible or irreversible Sustainability for positive impacts
Effectiveness of management measures (will management measures reduce impact to an acceptable level)		Indication of what could occur in the absence of management measures Effectiveness of proposed measures
Confidence in impact evaluation (degree of certainty in the significance ascribed to the impact)		Scientific uncertainty – limited understanding of ecosystem (or community) and processes governing change Data uncertainty – restrictions introduced by incomplete or incomparable information, or by insufficient measurement techniques Policy uncertainty – unclear or disputed objectives, standards or guidelines

7.1.2 Impact Significance Rating

The impact significance rating process serves two purposes: firstly, it helps to highlight the critical impacts requiring consideration in the approval process; secondly, it serves to show the primary impact characteristics, as defined above, used to evaluate impact significance. The impact significance rating system is presented in **Exhibit 7.2** and described as follows:

- **Part A**: Define impact consequence using the three primary impact characteristics of magnitude, spatial scale and duration.
- **Part B**: Use the matrix to determine a rating for impact consequence based on the definitions identified in Part A; and

- **Part C**: Use the matrix to determine the impact significance rating, which is a function of the impact consequence rating (from Part B) and the probability of occurrence.

Using the matrix, the significance of each described impact is rated.

Exhibit 7.2: Method for Rating the Significance of Impacts

PART A: DEFINING CONSEQUENCE IN TERMS OF MAGNITUDE, DURATION AND SPATIAL SCALE

Use these definitions to define the consequence in Part B

Definition		Criteria	
MAGNITUDE		Negative	Positive
	Major	Large number of receptors affected Receptors highly sensitive and/or are of conservation importance Substantial deterioration, nuisance or harm to receptors expected Relevant thresholds often exceeded Significant public concern expressed during stakeholder consultation Receiving environment has an inherent value to stakeholders	Large number of receptors affected Receptors highly amenable to positive change Receptors likely to experience a big improvement in their situation Relevant positive thresholds often exceeded
	Moderate	Some receptors affected Receptors slightly sensitive and/or of moderate conservation importance Measurable deterioration, nuisance or harm to receptors Relevant thresholds occasionally exceeded Limited public concern expressed during stakeholder consultation Limited value attached to the environment	Some receptors affected Receptors likely to experience some improvement in their situation Relevant positive thresholds occasionally exceeded
	Minor	No or limited receptors within the zone of impact Receptors not sensitive to change Minor deterioration, nuisance or harm to receptors Change not measurable or relevant thresholds never exceeded Stakeholders have not expressed concerns regarding the receiving environment	No or limited receptors affected Receptors not sensitive to change Minor or no improvement in current situation Change not measurable Relevant positive thresholds never exceeded No stakeholder comment expected
TIMEFRAME (determine specific to each Project)		Duration of continuous aspects	Frequency of intermittent aspects
	Short term/ low frequency	Less than 4 years from onset of impact	Occurs less than once a year
	Medium term/ frequency	More than 4 years from onset of impact up to end of life of project (approximately 30 years)	Occurs less than 10 times a year but more than once a year
	Long term/ high frequency	Impact is experienced during and beyond the life of the project (greater than 30 years)	Occurs more than 10 times a year

SPATIAL SCALE (determine specific to each project)		Biophysical	Socio-economic
	Small	Within the project fence line or within 200 m of unfenced facilities	Within the municipality in which the activity occurs
	Intermediate	Within the district in which is the facilities are located	Within the province in which the activity occurs
	Extensive	Beyond the district in which the facilities are located	Beyond the province in which the activity occurs

PART B: DETERMINING CONSEQUENCE RATING

Rate consequence based on definition of magnitude, spatial extent and duration

MAGNITUDE	TIMEFRAME	SPATIAL SCALE		
		Small	Inter-mediate	[redacted]
Minor	Short term / low frequency	Low	Low	Medium
	Medium term / frequency	Low	Low	Medium
	[redacted]	Medium	Medium	Medium
Moderate	Short term / low frequency	Low	Medium	Medium
	Medium term / frequency	Medium	Medium	[redacted]
	[redacted]	Medium	[redacted]	[redacted]
[redacted]	Short term / low frequency	Medium	Medium	[redacted]
	Medium term / frequency	Medium	Medium	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]

PART C: DETERMINING SIGNIFICANCE RATING

Rate significance based on consequence and probability

		CONSEQUENCE		
		Low	Medium	High
PROBABILITY (of exposure to impacts)	[redacted]	Low	Medium	[redacted]
	Possible	Low	Medium	[redacted]
	Unlikely	Low	Low	Medium

7.1.3 Mitigation, Management and Good Practice Measures

Using the matrix, the significance of each described impact is initially rated. This initial rating assumes the management measures inherent in the Project design and described in the Project description (**Section 3**) are in place. For example, if a fuel store has secondary containment, the initial impact rating takes this into account.

Wherever the Project is likely to result in unacceptable impact on the environment, additional mitigation measures are proposed (over and above the inherent design measures included in the Project description). In addition, good practice measures may be proposed however these are unlikely to change the impact significance. In the case of positive impacts, management measures are suggested to optimize the benefits to be gained. Where mitigation measures are required the impact will be rated again to show the residual impact after implementation of management controls.

The following mitigation hierarchy will be utilized in selecting practical mitigation measures for unacceptable impacts as follows (in order of preference):

- avoid the impact wherever possible by removing the cause(s)
- reduce the impact as far as possible by limiting the cause(s)
- ameliorate the impact by protecting the receptor from the cause(s) of the impact
- providing compensatory measures to offset the impact, particularly where an impact is of high significance and none of the above are appropriate.

A rating of impact considering mitigations will be carried out to highlight the effectiveness of proposed management measures designed to mitigate or enhance the impact, and by characterizing the level of confidence or uncertainty in the assessment.

For each of the impacts identified, a table will be filled in **Exhibit 7.3.**

Exhibit 7.3: Impact Assessment Template

Impact 01: Loss of riverine ecosystem due to inundation by Project reservoir								
Applicable Project Phase				*Construction*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Moderate	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	-	High
Mitigation Measures:								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	+	High

7.1.4 Impact Grouping

The impacts in this chapter are grouped as follows:

- **Ecology**
  - 7.2 Aquatic Ecology
  - 7.3 Terrestrial Ecology
- **Physical Environment**
  - 7.4 Ambient Air Quality
  - 7.5 Blasting and Vibration
  - 7. 6 Hydrology and Water Quality
  - 7. 7 Construction Noise
  - 7.8 Soil, Topography, Land Stability
  - 7.9 Aesthetics
  - 7.10 Traffic and Roads
- **Socioeconomic Environment**
  - 7.11 Livelihood and well-being
  - 7.12 Socio-cultural impacts
- **Cross-thematic Aspects**
  - 7.13 Cumulative impact assessment
  - 7.14 Climate change

7.2 Aquatic Ecology

The potential impacts on the ecology and biodiversity of Kunhar River, under the selected environmental flow release and management configuration, are presented below. The methodology for selecting the configuration is presented in **Section 5.3**, *Environmental Flow Assessment.*

An EFlow scenario of 1.5 m^3/s with baseload operation is recommended as the preferred option in the EFlow Assessment Report (see **Volume 2C** of the **EIA**). Under this option there is highest net gain in populations of key fish species with implementation of High Protection. An alternative scenario with an EFlow of 6.1 m^3/s and peaking operation was also considered. However, this is not recommended as it results in loss of power generation as well as a lower net gain, even with High Protection.

Consistent with ADB and IFC Guidelines, the Project was designed to achieve a net gain in biodiversity in view of the location of the Project in a Critical Habitat (**Section 4.2.8,** *Habitat Assessment*). The EFlow with baseload operation is preferable because the impacts on the ecological resources are lower. Given the high anthropogenic pressures on the fish, the benefit of EFlow can be realized only if the river is protected. In other words, EFlow releases can be considered of little consequence in absence of protection of the river. In case of baseload operation the river downstream of the tailrace is not significantly changed and therefore with protection fish populations can be restored to above present day numbers.

The aquatic ecological resources of the Study Area are described in **Section 4.2.6,** *Ecology Baseline: Aquatic Ecology.* The impacts are summarized below:

- Impact 01: Change in ecological integrity of the Kunhar River in the Area of Management following implementation of the Biodiversity Action Plan (BAP) (see **Volume 2C** of the **EIA**).
- Impact 02: Loss of riverine ecosystem due to inundation by Project reservoir.
- Impact 03: Degradation of the river ecosystem in the low flow segment downstream of the Project dam.
- Impact 04: Alteration of the River Ecosystem Downstream of the Tailrace

7.2.1 Change in the Ecological Integrity of Kunhar River through Implementation of the Biodiversity Action Plan

Impact 01: Change in the Ecological Integrity through implementation of the BAP (see **Volume 2C** of the **EIA**)									
Applicable Project Phase				*Construction and Operation*					
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	+	High

Project construction and operation are likely to have a significant negative impact on the ecological integrity in the 40.3 km segment of the river downstream of the Project tailrace to the upstream end of the reservoir of Patrind HPP under Business-as-Usual protection scenario.

According to the EFlow Assessment carried out as part of the Project EIA, (see **Section 5.2** of **the EFlow Assessment Report** in **Volume 2C** of the **EIA**), Project operation with an EFlow of 3.5 m^3/s (which is higher than the recommend EFlow of 1.5 m^3/s) and Business-as-Usual protection, the populations of all three fish species of conservation importance - Nalbant's Loach, Kashmir Hillstream Loach and Alwan Snow Trout – show a decline of more than 70%. However, with the implementation of a Biodiversity Action Plan (BAP) (see **Volume 2C** of the **EIA**), the overall ecological integrity of the Kunhar River within the Area of Management of the BAP is predicted to improve compared to the projected baseline conditions despite Project construction and operation. **Exhibit 7.4** presents the gain/loss in population of key fish species due to the implementation of the BAP with High Protection. Habitat distribution between tributaries and the main river was taken into account in calculating the weighted gain. The assessment consists of operation of Project with an EFlow of 1.5 m^3/s as compared to the Pre-Project Baseline with Business-as-Usual Protection. The key findings are as follows:

- Gains in fish populations are the highest downstream of Balakot where river flow is less affected by the Project, closely followed by gains downstream of the tailrace.

- Native fish populations are adapted to flowing rivers and will not survive in the reservoir created by the dam. The reported decrease is over and above the decrease due to the decline in fish populations under the Business-as-Usual baseline.

Exhibit 7.4: Summary of Net Gain in Abundance of Key Fish Species with Implementation of the BAP, Compared to Pre-Project Baseline with Business-as-Usual Protection

Green = Net Gain, Red= Net Loss

EFlow	*Downstream of Dam*	*Downstream of Tailrace*	*Downstream of Balakot*	*Tributaries*	*Weighted Average Net Gain*
Length (km)	*4.5*	*15.4*	*24.9*	-	*Weighted Sum*
Alwan Snow Trout	1.9	87.3	108.1	107.3	**78.3**
Nalbant's Loach	-17.1	68.8	68.6	68.9	**59.1**
Kashmir Hillstream Loach	-22	84.7	80.7	-	**42.6**

Following construction of the Project and implementation of High Protection, there is a weighted average net gain of 78.3%, 59.1% and 42.6% for the Alwan Snow Trout, Nalbant's Loach, and Kashmir Hillstream Loach respectively compared to that under the Business-as-Usual protection. The BAP includes the recommendation for experimental captive breeding of the Kashmir Hillstream Loach. This is the species that shows the lowest weighted average net gain.

In addition to setting the EFlow at 1.5 m^3/s and High Protection, basin-wide measures, mainly establishment and operation of an Institute for Research in River Ecology (IRRE) and a Watershed Management Program (WMP) have also been included, triggered by the Cumulative Impact Assessment (see **Section 7.13**, *Cumulative Impact Assessment*) and the BAP. The establishment of the IRRE and WMP is subject to approval of associated costs in the tariff by NEPRA.

7.2.2 Loss of Riverine Ecosystem due to Inundation by Project reservoir

Impact 02: Loss of riverine ecosystem due to inundation by Project reservoir

Applicable Project Phase *Construction and Operation*

Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-	High

Mitigation measures:

1. Implementation of the BAP (see **Volume 2C** of the **EIA**) which includes the following:
   a. Subsistence fishing using rods and cast nets with limited weights will be allowed through a permitting system.
   b. Illegal fishing activities will be banned using a watch and ward system. In particular, destructive fishing practices will be prevented to minimize damage to sensitive habitats.
   c. Sediment mining will be regulated to prevent destruction of fish habitat.
   d. Physical transportation of migratory and non-migratory fish from downstream to upstream of the dam if needed to prevent genetic isolation in the long term.
   e. Experimental captive breeding of fish species of conservation importance on which the impacts of the Project are significant, and stocking in river reaches where populations need to be restored.

Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-	High

A segment of the river of length 4.5 km upstream of the Project dam will be inundated by the Project reservoir, where the river will cease to exist. The fish that require riffle habitat such as the Nalbant's Loach and Kashmir Hillstream Loach will not survive in the reservoir. Net gain for these fish species will be achieved by offsetting the loss in its population in the reservoir with the increase in population achieved in other segments of the river through implementation of the BAP. The segment of the river upstream of the reservoir will be impacted by peaking releases from Sukki Kinari HPP. The results of the EFlow Assessment for this segment have not been used to calculate net gain given in **Exhibit 7.4** because of the impact of peaking releases from the Sukki Kinari HPP.

While the ecosystem will change from riverine to lake, a new ecosystem will be created which will support life forms that are adapted to it. Wetland conditions created in the reservoir may also support some resident and migratory birds as has happened in case of Mangla Reservoir.

7.2.3 Degradation of the river ecosystem in the low flow segment downstream of the Project dam

Impact 03: Degradation of the river ecosystem in the low flow segment downstream of the Project dam								
Applicable Project Phase				*Construction and Operation*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-	High
Mitigation measures: 1. Implementation of the BAP. (However, even with an EFlow of 1.5 m³/s and High Protection, the losses in fish populations cannot be mitigated in this river segment. These losses will be offset by gains in other segments of the river).								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-	High

The dam will create a barrier resulting in fragmentation of habitat. The habitat downstream of the dam will be exposed to lower flows due to diversion of the river flow into the power generation tunnels. With an EFlow of 3.5 m^3/s and Business-as-Usual scenario, all species show a decline in population of 100%. With an EFlow of 1.5 m^3/s and High Protection, there will still be a decline in fish populations from the baseline for the three species present in this stretch, however less than 100%. The species that shows gain against the baseline Business-as-Usual scenario in this segment is the Alwan Snow Trout (1.9%). The other two species show a loss. However, the Alwan Snow Trout is also affected by the blockage of connectivity upstream and conditions downstream due to its migratory behavior.

It should be noted that downstream of the dam major impacts include reduction of sediment and water abstraction through diversion which are not relieved due to EFlows.

7.2.4 Alteration of the River Ecosystem Downstream of the Tailrace

Impact 04: Degradation of the River Ecosystem Downstream of the Tailrace								
Applicable Project Phase				*Construction and Operation*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-	High
Mitigation measures: 1. Implementation of the BAP (see **Volume 2C** of the **EIA**) which includes the following: a. Subsistence fishing using rods and cast nets with limited weights will be allowed through a permitting system. b. Illegal fishing activities will be banned using a watch and ward system. In particular, destructive fishing practices will be prevented to minimize damage to sensitive habitats. c. Sand and gravel mining will be regulated to prevent destruction of fish habitat. d. Physical transportation of migratory and non-migratory fish from downstream to upstream of the dam if needed to prevent genetic isolation in the long term. e. Experimental captive breeding of fish species of conservation importance on which the impacts of the Project are significant, and stocking in river reaches where populations need to be restored.								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Moderate	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	+	High

The EFlow Assessment carried out as part of the EIA of the Project concluded that the river habitat downstream of the tailrace tunnel will be affected due to the changes in flow as a result of release of water from the tailrace tunnel (see **Section 5.2** of **the EFlow Assessment Report** in **Volume 2C** of the **EIA**). Under baseload operation with an EFlow of 3.5 m^3/s and Business-as-Usual, the populations of the Alwan Snow Trout, Nalbant's Loach and Kashmir Hillstream Loach show declines in excess of 50%. With peaking operation with an EFlow of 6.1 m^3/s the declines will be similar.

Under baseload operations, the river downstream of the tailrace is not significantly changed and with High Protection (through the implementation of the BAP) fish populations can be restored to above present day numbers. The gain over the baseline Business-as-Usual scenario with an EFlow of 1.5 m^3/s and High Protection is positive for all three species. For the Alwan Snow Trout it is 87.3%, for the Nalbant's Loach it is 68.8% and for the Kashmir Hillstream Loach it is 84.7%.

The baseload scenario downstream of the tailrace and downstream of Balakot Town closely approximates the baseline hydrology. Therefore, increase in protection increases fish abundance in these sections. Downstream of Balakot Town, gain over the baseline Business-as-Usual scenario is 108.1% for the Alwan Snow Trout is, 68.6% for the Nalbant's Loach is and 80.7% for the Kashmir Hillstream Loach.

7.3 Terrestrial Ecology

The Project is a run-of-river hydropower project and will require construction of a dam on the Kunhar River. The Project, with design capacity of 310 MW, will use the water resources of the Kunhar River for power generation.

A map showing the location of the proposed Project facilities is provided in **Section 1** (*Introduction*). The major structures associated with the Project include the dam, powerhouse, the headrace tunnel, tailrace tunnel, surge tank, switch yard, storage yards, labour camps, staff colony, and access roads. A detailed description of the Project is provided in **Section 3** (*Project Description*). A low flow section of a length of about 13.4 km will be created downstream of the dam, between the dam and the tailrace tunnel. The permanent footprint of the proposed Project includes the area that will be acquired for the dam, reservoir, powerhouse, roads and some other facilities. A temporary footprint includes the land that will be required or disturbed due to the facilities that will be developed during the construction phase in the dam, powerhouse and the parts of the stretch of land between Sangar and Paras Village.

The Area of Habitat Loss is defined as the areas that will be occupied due to construction and operation of Project infrastructure.[1] It has been demarcated taking into consideration the footprint of each Project facility and a 50 m zone around each facility, as well as the area that will be submerged under water due to formation of reservoir (**Exhibit 7.5**). The Area of Habitat Loss is estimated at 2.1 km^2.

The Zone of Impact for Terrestrial Ecological Resources (referred to in this section as the Zone of Impact) consists of the Project facilities and a 1 km potential impact zone around these facilities to account for an area in which the ecological resources may be impacted by Project-related disturbances such as sound, light and vibrations during construction and operations (**Exhibit 7.5**).

The Zone of Impact and Area of Habitat Loss include the spoil disposal zones marked 1 to 5 (**Exhibit 7.5**). These are potential spoil disposal zone and are indicative only (see **Section 3.5**). Finalization of which zones will be used and their areas will be done at a later stage. However, as information on the likely ones and the actual areas to be used within each zone is currently unnot available all have been considered as part of the Zone of Impact and Area of Habitat Loss.

The terrestrial ecological resources of the Study Area are described in **Section 4.2.7** (*Ecology Baseline*: *Terrestrial Ecology*). The aspects affecting ecology and biodiversity in the Terrestrial Study Area are discussed below:

- Impact 05: Terrestrial habitat loss caused by construction related activities.
- Impact 06: Decline in abundance and diversity of terrestrial flora and fauna caused by construction related activities.
- Impact 07: Project operation leading to animal disturbance, displacement and decline.

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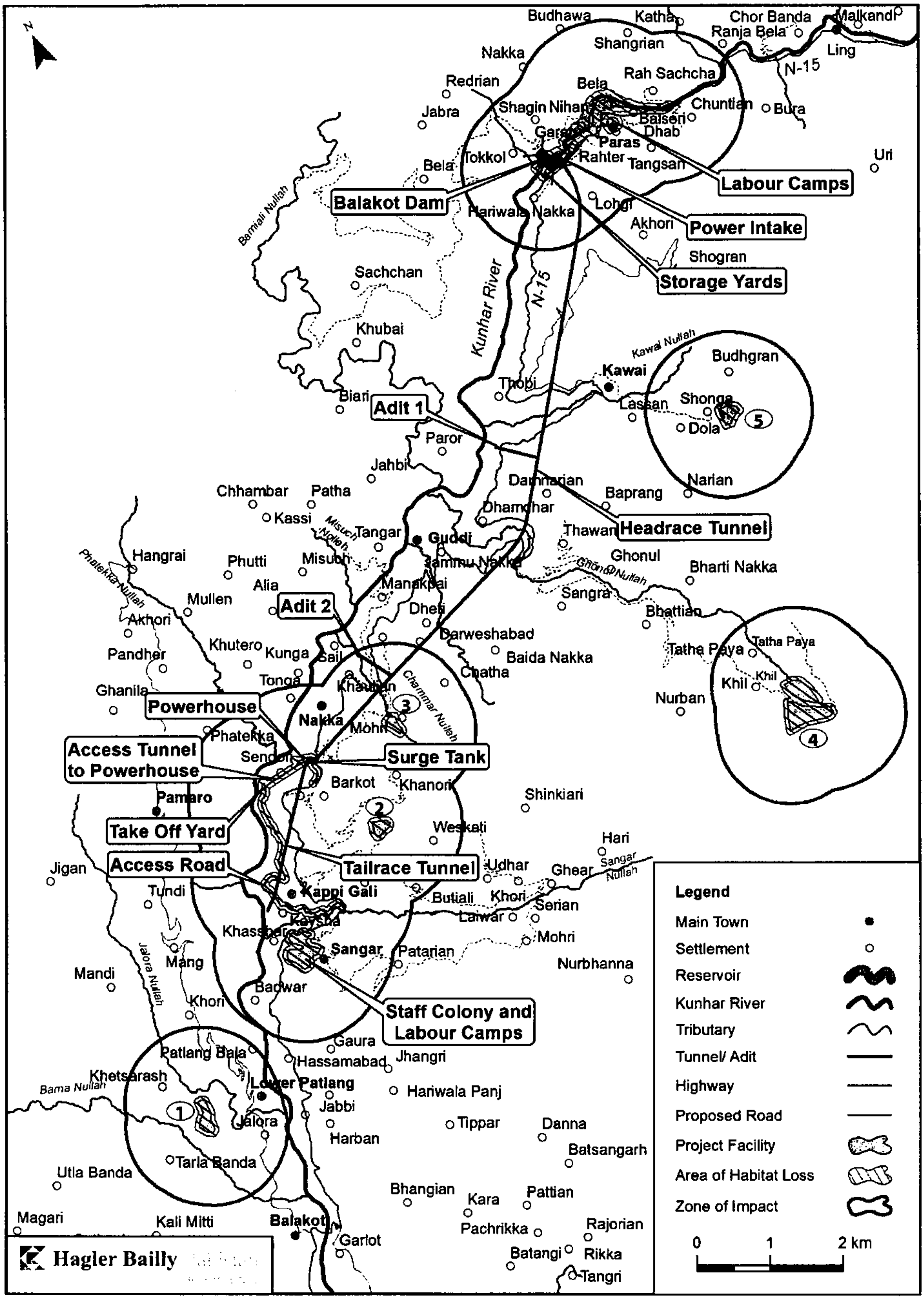
[1] This includes temporary facilities

Exhibit 7.5: Zone of Impact and Area of Habitat Loss



7.3.1 Terrestrial Habitat Loss

Impact 05: Terrestrial habitat loss caused by construction related activities								
Applicable Project Phase				*Construction*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	**Possible**	**Low**	-	High

Mitigation measures:

1. Provide awareness training to staff and contractors on: prevention of injury of animals; identification of likely species found on site; identifications of animal hazards (such as venomous snakes); and what to do if dangerous animals are encountered.
2. Encourage personnel to report sightings of wildlife of conservation importance or incidents of poaching to PEDO.
3. Minimize disturbance to, or movement of, soil and vegetation.
4. Prevent soil damage and erosion.
5. Prevent Alien Invasive Species (AIS) establishment on exposed stored soil (do not store bare soil near known sources of AIS). Invasive species management is recommended based on the risk assessment presented in **Section 4.2.7**, *Description of the Environment*, where the invasive species identified in the Project area have been ranked based on the risk they pose. The habitat most at risk is the Riparian Habitat. The species that are highest risk include Parthenium Weed, Common Weed and Castor Oil Plant (see **Section 4.2.7**, *Description of the Environment*).
6. Train and raise awareness regarding AIS among Project staff and contractors.
7. Retain as much natural vegetation as possible.
8. Solid waste should only be disposed of at designated sites and a Waste Management Plan developed and implemented.
9. Minimize the Project footprint, clearly delineate and restrict access beyond work sites and other areas to be disturbed.
10. Within the quarry and borrow areas, activities will be restricted to areas at a distance from perennial water channels so as to avoid disturbances to them including the risk of siltation.

Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	**Possible**	**Low**	-	High

Site clearance and construction of Project infrastructure such as the powerhouse, dam, and the inlets and outlets of the tunnels will result in immediate and direct modification of land and loss of approximately 1.15 km^2 (75 hectares) of terrestrial habitat leading to loss of plants and displacement of animals in this area. There will be a permanent modification of land within the footprint of specific Project facilities and its ancillaries but the loss will be less severe in the areas that lie adjacent to and immediately outside the Project facilities. In addition, once the Project begins operations, an area of approximately 0.256 km^2 (25.6 hectares) will become submerged due to formation of a reservoir upstream of the dam (**Section 3,** *Project Description*). The submerged terrestrial habitat will be converted into aquatic habitat. The habitat loss and fragmentation resulting from Project infrastructure will lead to displacement of terrestrial species.

Land disturbance due to construction-related activities will lead to a localized reduction in food, shelter and range for mammals, birds and herpetofauna (reptiles and amphibians). Surface stripping will result in the removal of vegetation cover and may cause accidental death of small mammals and reptiles. The more mobile species will be able to move away from the area prior to preliminary earthworks. However, the less mobile species, especially herpetofauna species, will not be able to relocate. Food supplies in the form of seeds, vegetation and prey species will be negatively affected on a localized basis (only within the Project infrastructure facilities and its ancillaries).

The Area of Habitat Loss (total of 2.1 km^2) consists largely of mixed pine and scrub forest and riparian habitat. The dominant plant species in the Forest habitat type (74% by area) include *Pinus wallichiana, Cedrus deodara, Rumex dissectus, Ficus carica* and *Cannabis sativa.* The dominant plant species in the Agricultural Areas habitat type (20% by area) include *Juglans regia, Berberis sp.*, and *Fragaria vesca.* Within the Area of Habitat Loss there is also riparian habitat in which the dominant plant species include *Parthenium hysterophorus. Conyza canadensis* and *Rumex dissectus. Parthenium hysterophorus* is an invasive species and the others are common and widespread plant species in the wider area. The May 2017 Survey identified seven invasive species in both Terrestrial and Riparian Habitat including Cannabis *Cannabis sativa*, Tree-of-heaven *Ailanthus altissima*, Black Locust *Robinia pseudoacacia*, Pink Cheeseweed *Malva parviflora*, Parthenium Weed *Parthenium hysterophorus*, Common Weed *Phragmites karka* and Castor Oil Plant *Ricinus communis.* Some of the plant species found in the Area of Habitat Loss have a socio-economic value for the local communities. Species found in the Agricultural Area habitat type have food value while some of the wild plant species (in the Scrub Forest, Pine Forest habitat types and Riparian habitat type) have a variety of uses including use for their medicinal properties, firewood and grazing of livestock. For example, the species *Cedrus deodara* and *Urtica dioica*, are used for therapeutic application. Plants also have value as firewood and for grazing of livestock. However, all these species are common and abundant in the wider area. Habitat loss caused by construction of Project infrastructure will not have any significant impact on the overall population of these vegetation species though individual plants are likely to suffer harm.

Mammal species observed in this Area of Habitat Loss include the Asiatic Jackal *Canis aureus*, the Red Fox *Vulpes vulpes*, the Indian Crested Porcupine *Hystrix indica*, and the Small Asian Mongoose *Herpestes javanicus.* Abundant bird species observed included the Common Raven *Corvus corax*, the Bank Myna *Acridotheres ginginianus*, the White-cheeked Bulbul *Pycnonotus leucotis*, Black Drongo *Dicrurus macrocercus*, and Great Tit *Parus major.* No vulture species were observed during the May 2017 Survey. The habitats being disturbed are also not considered critical to the breeding, nesting or feeding of vulture species. Abundant herpetofauna included the Agrore Valley Rock Agama *Laudakia agrorensis* and the Asian Garden Lizard *Calotes versicolor.* No flora or fauna species of conservation importance were found or reported from this Area of Habitat Loss. No critical habitat, threatened or unique ecosystem was identified in this area. The habitats found in the Area of Habitat Loss are homogenous and widespread. They hold no significance for the survival of endemic or restricted range species.

Even though there will be irreversible short term harm to some ecological receptors (individuals), the species will not suffer as the area of habitat occupied by the Project infrastructure will be is small. Therefore, the magnitude of impact is considered minor.

7.3.2 Impacts on Biodiversity due to Construction Activities

Impact 06: Decline in abundance and diversity of terrestrial flora and fauna caused by construction related activities.

Applicable Project Phase *Construction*

Initial Impact	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	**Possible**	**Low**	-	High

Mitigation measures:

1. Large flood lights should not be installed outside 50 m of the Project fence.
2. Lights should be directed towards Project facilities and not towards the natural habitats.
3. Regulations for Project staff and contractors to avoid illegal poaching to be incorporated in contract documents.
4. Provide awareness training to staff and contractors on: prevention of injury of animals; identification of likely species found on site; identifications of animal hazards (such as venomous snakes); and what to do if dangerous animals are encountered.
5. Provide adequate knowledge to the workers on relevant government regulations and punishments for illegal poaching and trade in animals and plants.
6. Encourage personnel to report sightings of wildlife of conservation importance or incidents of poaching to PEDO.
7. Enforce speed limits in ecologically sensitive areas if identified.
8. Project staff and contractors to report kills of large mammals particularly designated species of conservation concern.
9. Train and raise awareness regarding AIS among Project staff and contractors.
10. The Contractor shall prepare an Environmental Training Plan for all construction workers: the Plan shall address the following items:
    - All Contractor's employees shall be required to comply with environmental protection procedures and they shall be able to provide evidence that they attended the training sessions detailed in the Plan;
    - The Plan shall educate all construction workers on the following issues but not limited to them: fire arm possession, traffic regulations, illegal logging and collection of non-timber forestry products, non-disturbance of resettlement communities, hunting and fishing restrictions, waste management, erosion control, health and safety issues, all prohibited activities, the Code of Conduct requirements and disciplinary procedures, and general information on the environment in which they will be working and living;
    - Establishment of penalties for those who violate the rules;
    - Proposed methods for conducting the training program, which shall include formal training sessions, posters, data in newsletters, signs in construction and camp areas and 'tool box' meetings.
11. Equipment emitting excessive noise in comparison with other similar equipment will not be allowed to operate.
12. Equipment under use will be regularly maintained, tuned, and provided with mufflers to minimize noise levels.
13. Equipment in poor state of maintenance, particularly without effective noise control will be checked to determine if it can be improved, and replaced with less noisy equipment as soon as practicable.
14. Blowing of horn will be prohibited on all sensitive areas except under emergency conditions.
15. Project staff and contractors to report kills of large mammals particularly designated species of conservation concern.
16. Source goods/materials locally where possible.
17. Minimize disturbance to, or movement of, soil and vegetation.

18. Compensatory trees will be planted. The EPC Contractor will plant a minimum of ten trees for each tree removed in acquired land.
19. PEDO will monitor and maintain the vegetation until it is established.
20. Prevent soil damage and erosion.
21. Prevent AIS establishment on exposed stored soil (do not store bare soil near known sources of AIS).
22. Train and raise awareness regarding AIS among Project staff and contractors. See **Section 4.2.7** of the Ecology Baseline.
23. Solid waste should only be disposed of at designated sites.
24. Implementation of Biodiversity Action Plan.

Residual Impact	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	-	High

Construction of Project infrastructure such as the powerhouse, dam and tunnels will result in disturbance to the floral and faunal species in the Zone of Impact around the Project facilities (**Exhibit 7.5**) due to blasting, noise, vibrations, illumination, and introduction of alien species. Pollution may increase due to vehicles and machinery, spillage of fuels or chemicals, emissions and noise. Increased movement of vehicles will increase the risk of incidences of vehicle collisions with wildlife.

Habitat loss, habitat fragmentation and sensory disturbances may result in a decrease in species abundance and possibly change species diversity within the Zone of Impact. In addition, the spatial and temporal distribution of species will also be affected as a result of loss of habitat integrity due to habitat fragmentation and degradation. Habitat alteration and disturbance may increase the likelihood of spread of alien invasive species such as Parthenium Weed, Castor Oil Plant and Cannabis. The three habitat types (**Section 4.2,** *Ecology Baseline*) found in this Zone of Impact will be affected. The Agricultural Area habitat type was observed to contain the highest diversity of plant species per sampling location while Scrub Forest habitat type had the highest overall species diversity. No terrestrial critical habitat was identified in the Zone of Impact and it does not contain any threatened or unique ecosystem. Moreover, the habitats found in this Area of Habitat Loss are homogenous and widespread. They hold no significance for the survival of endemic or restricted range species.

In addition to direct land disturbance, the site fencing may present a barrier to movement, resulting in habitat fragmentation for small and medium sized mammals as well as the herpetofauna found in the Terrestrial Study Area.

Seed sources for re-establishing plants will remain available from adjacent lands (driven by wind). The areas around the Zone of Impact provide similar habitat to the habitat already existing at the site. Therefore, repopulation by flora and fauna is likely to occur in the areas not occupied by the Project infrastructure, once disturbance associated with construction is stopped.

Rules to regulate hunting exist. However, they are seldom enforced. Improved access to the site as a result of the Project may indirectly increase the incidence of poaching. To prevent further exacerbation of existing impacts and prevent poaching by Project staff and contractors, awareness training will be provided along with information on the penalties for poaching (in terms of the Project's policies and KP wildlife protection laws). Long term impacts are therefore unlikely. By working with local government agencies particularly the KP Fisheries and Wildlife Departments, PEDO can implement measures to enhance conservation in the area. Increase in Project-related traffic may increase the incidence of road animal kills.

Inadequate management and disposal of waste from the construction site and camping locations can lead to deterioration of soil and habitat quality with consequent negative impacts on the flora and fauna.

In addition, the biodiversity may be disturbed due to loss of soil productivity caused by contamination from oil spills and leakages from Project vehicles and machinery, uncontrolled discharge of wastewater, and storm water runoff from the Project site. Soils disturbed due to vegetation stripping and exposure as a result of Project-related construction activities will be more easily eroded by the forces of wind and water. This eroded soil will have lower productivity due to loss of top soil. In addition, the eroded soil may damage the aquatic ecological resources by siltation of the river.

At a local scale, a decrease in biodiversity and ecological function caused by construction-related disturbances is of minor magnitude near the Project facilities. Moreover, because of the homogenous and widespread distribution of species, the area wide impact on biodiversity is also minor.

7.3.3 Impacts on Terrestrial Biodiversity due to Project Operation

Impact 07: Project operation leading to animal disturbance, displacement and decline.								
Applicable Project Phase				*Operations*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	[redacted]	Small	Medium	Possible	Medium	-	High

Mitigation measures:

1. Large flood lights should not be installed outside 50 m of the Project fence.
2. Lights should be directed towards Project facilities and not towards the natural habitats.
3. Provide awareness training to staff and contractors on: prevention of injury of animals; identification of likely species found on site; identifications of animal hazards (such as venomous snakes); and what to do if dangerous animals are encountered.
4. Incorporate regulations for Project staff and contractors to avoid illegal poaching in contract documents.
5. Provide adequate knowledge to the workers on relevant government regulations and punishments for illegal poaching.
6. Encourage personnel to report sightings of wildlife of conservation importance or incidents of poaching to PEDO.
7. Project staff and contractors to report kills of large mammals particularly designated species of conservation concern.
8. Train and raise awareness regarding AIS among Project staff and contractors. See **Section 4.2.7** of the Ecology Baseline.
9. The Contractor shall prepare an Environmental Training Plan for all construction workers. Solid waste should only be disposed of at designated sites.
10. Implementation of Biodiversity Action Plan.

Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Medium	Small	Low	Possible	Low	-	High

The operation of the hydropower plant and associated activities will result in some potential disturbances to species, which may exacerbate the effects of habitat loss and decreased species abundance. In addition, the spatial and temporal distribution of species will also be affected as a result of loss of habitat integrity due to habitat fragmentation and degradation. These disturbances include noise and light. As plant operation will be continuous, the disturbances will also be continuous and affect both diurnal and nocturnal wildlife. The lighting required for operation and safety at the Project site can influence nocturnal foraging behaviors as well as disrupt sleep patterns of crepuscular and nocturnal species. However, considering the fact that no threatened ecosystem or species of conservation importance is reported from the Zone of Impact, the magnitude of this impact is considered minor.

7.4 Ambient Air Quality

The ambient air quality will be affected by the Project activities primarily during the construction phase. In this section, the impacts of construction activities on ambient air quality and the associated air emissions are identified, high risk areas including, nearby receptors and tourist spots are located and suggested mitigation measures are presented.

The baseline air quality is described in **Section 4.1.8** (*Ambient Air Quality*). It shows that, compared to NEQS and IFC-EHS limits, the concentrations of NO_X, NO, NO_2 and SO_2 are low, whereas dust concentrations (PM_{10} and $PM_{2.5}$) are high. Furthermore, emission of particulate matter is a greater concern from construction activities than gaseous pollutants. Therefore, the focus of the impact assessment is on the quantification and mitigation of dust emissions. The main impact is identified below.

Impact 08: Increase in ambient and ground level concentration of air pollutants from construction activities and vehicular movement may cause health impacts to the community.

Applicable Project Phase — *Construction*

	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
Initial Impact Rating	**Moderate**	**Medium Term**	Small	**Medium**	**Possible**	**Medium**	-	High

Mitigation measures:

1. Develop and implement an Air Pollution Control Plan.
2. Prepare a Site Specific Environmental Management Plan (SSEMP) (see **Section 9**, *Environmental Management Plan*) for each construction site that must outline areas to be cleared, vegetated areas to be protected or fenced, solid waste disposal locations, and sprinkling locations. All appropriate measures indicated in Generic Construction Site Environmental Management Plan (CSEMP) in **Section 9** (*Environmental Management Plan*) should be incorporated in the SSEMP.

Fugitive and exhaust emissions from transport vehicles

3. Cover all trucks hauling soil, sand, and other loose materials or require all trucks to maintain at least two feet of freeboard (i.e., the minimum required space between the top of the load and the top of the trailer).
4. Install and maintain all vehicles and machinery with appropriate emission control equipment.
5. Regularly maintain vehicles and equipment to keep emissions in check.
6. Smoke from internal combustion engines should not be visible for more than ten seconds.
7. To the extent possible, use new and low emission equipment and vehicles.
8. Purchase best quality fuel and lubes and where possible use lead free oil and lubes.
9. Sprinkle water on all unsealed roads used by Project vehicles that are within 200 m of any settlement.
10. Cover loads and long-term piles of friable material to reduce fugitive dust emission.
11. Reduce traffic speeds on all unpaved surfaces to 15 miles per hour or less.
12. Paved roads shall be swept frequently if soil material has been carried onto adjacent paved, public thoroughfares from the Project site.
13. Install wheel washers where vehicle exit onto paved road from unpaved.

14. Wheel washing of vehicles leaving the site.
15. Wash vehicles/equipment prior to each trip.
16. Use catalytic converters on vehicles, an emission control device, used to convert harmful pollutants to less harmful pollutants e.g. it converts the nitrogen oxides back into nitrogen and oxygen.
17. Appropriate maintenance of vehicles and machinery.

Fugitive dust emissions from blasting

18. Indicate the limits of a clearing land with highly visible markers.
19. Leave a layer of about 5 m of undisturbed softs above the top of the overburden blasts. This will act as a blanket to contain air blast, dust and fly rock.
20. Sprinkle water on the area where blasting is done to settle down the particulate matter emissions.

Fugitive dust emissions from quarry areas

21. Indicate the limits of a clearing land with highly visible markers.
22. Avoid earth stripping or moving in periods of dry and windy weather.
23. Carry out dust generating activities where maximum protection can be obtained through topography or in areas where prevailing winds will blow dust away from sensitive areas/uses.
24. Water spraying of conveyors/conveyor transfer points, stockpiles and roads.
25. Covering of fine dry loads or spraying of loads prior to exiting the site, and if necessary regular cleaning of public roads in the vicinity of the entrance.

Fugitive dust emissions from concrete batching plants

26. Suspend earthwork operation when wind speed exceeds 20 km/hr. in areas within 500 m of any settlement.
27. The whole process of weighing and mixing would be performed in a fully enclosed environment.
28. The mixers should be equipped with dust collectors.
29. Site the concrete batching plant out of prevailing high winds to minimize dust emissions.
30. The prevailing wind direction should be considered to ensure that bunkers and conveyors are sited in the leeward direction to minimize the effects of the wind.
31. The provision of natural or artificial wind barriers – such as trees, fences and landforms – to help control the emission of dust from the plant should be considered.
32. Batching plants should be sited on land that is not flood prone.
33. Batching plants should be kept as near to natural sinks to minimize emissions to ambient environment.
34. All stacks to be vertical and at least 3 m above ground.

Fugitive dust emissions from aggregate production and handling system

35. Suspend operation when wind speed exceeds 20 km/hr. in areas within 500 m of any settlement.
36. The prevailing wind direction should be considered to ensure that aggregate handling systems located in the leeward direction to minimize the effects of the wind.
37. Sprinkle water on all exposed surfaces, particularly those close and up-wind of settlements.

Wind-blown dust from exposed surfaces such as bare land and waste dumping sites

38. Cover all exposed surfaces, particularly those close and up-wind of settlements.
39. All grading operations on a project should be suspended when winds exceed 20 miles per hour.
40. Minimize disturbance to, or movement of, soil and vegetation.
41. Sprinkle water on all exposed surfaces, particularly those close and up-wind of settlements.
42. Retain as much natural vegetation as possible.

Wind-blown dust from stockpiles of dusty materials such as sand and other minerals

43. On-site dirt piles or other stockpiled PM should be covered, wind breaks installed and water and/or soil stabilizers employed to reduce wind-blown dust emissions.
44. Adequately wet, cover with plastic, or provide with wind shield all stockpiles to reduce dust emission.
45. Sprinkle water on all exposed surfaces, particularly those close and up-wind of settlements.
46. Minimize disturbance to, or movement of, soil and vegetation.
47. Prevent soil damage and erosion.
48. Retain as much natural vegetation as possible.

Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	-	High

7.4.1 Emission Sources

Exhibit 7.6 shows the list of all possible emission sources along with their description.

Exhibit 7.6: Inventory of Emission Sources

Source/Activity	*Zone of Impact*	*Mitigation/Monitoring Measures*
Fugitive and exhaust emissions from transport vehicles Transport emissions include emissions from vehicles moving on roads and from their exhausts. As vehicle moves on the road, due to friction between vehicle's tire and road, the dust particles come in suspension which causes dust (PM_{10} and $PM_{2.5}$) emissions. Exhaust emissions include emissions attributable to engine related processes such as fuel combustion and particles that exit the tailpipe.	**General Guidelines:** ▶ A buffer of 50 meters (m) along the route(s) used by construction vehicles as given in Guidance on the Assessment of Dust from Demolition and Construction document by Institute of Air Quality Management, 2014.[2] **Project Specific Zone:** ▶ Total quarried material to be transported to the required destinations is 250,000 cubic meters (m^3). ▶ Total spoil quantity to be transported to the spoil dumping sites is 1.1 million m^3. ▶ The material will come to the Project site from different areas of Pakistan through N-15. From N-15 the material will go to the construction sites through access roads. ▶ The material generated on-site both as raw material and as waste material will go to their final destination points through site access roads to dam and powerhouse sites, quarry areas and waste dumping sites. ▶ The buffer zone around the transport corridor that includes the N-15 and access roads is provided below. **Additional Assessment Required:** ▶ If additional access roads are required for transport from quarries or to waste disposal sites then receptors within 50 m of the road should be assessed for sensitivity.	▶ Cover all trucks hauling soil, sand, and other loose materials or require all trucks to maintain at least two feet of freeboard (i.e., the minimum required space between the top of the load and the top of the trailer). ▶ Install and maintain all vehicles and machinery with appropriate emission control equipment. ▶ Regularly maintain vehicles and equipment to keep emissions in check. ▶ Smoke from internal combustion engines should not be visible for more than ten seconds. ▶ To the extent possible, use new and low emission equipment and vehicles. ▶ Purchase best quality fuel and lubes and where possible use lead free oil and lubes. ▶ Sprinkle water on all unsealed roads used by Project vehicles that are within 200 m of any settlement. ▶ Cover loads and long-term piles of friable material to reduce fugitive dust emission. ▶ Reduce traffic speeds on all unpaved surfaces to 15 miles per hour or less.

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[2] Guidance on the Assessment of Dust from Demolition and Construction document by Institute of Air Quality Management, 2014. http://www.iaqm.co.uk/text/guidance/construction-dust-2014.pdf

Source/Activity	*Zone of Impact*	*Mitigation/Monitoring Measures*
		▶ Paved roads shall be swept frequently if soil material has been carried onto adjacent paved, public thoroughfares from the Project site. ▶ Install wheel washers where vehicle exit onto paved road from unpaved. ▶ Wheel washing of vehicles leaving the site. ▶ Wash vehicles/equipment prior to each trip. ▶ Use catalytic converters on vehicles, an emission control device, used to convert harmful pollutants to less harmful pollutants e.g. it converts the nitrogen oxides back into nitrogen and oxygen. ▶ Appropriate maintenance of vehicles and machinery.
Fugitive dust emissions from blasting Tunnels, adits and underground powerhouse will be excavated through drilling and blasting. Air quality due to blasting will be degraded near the mouth of these sites where the blasting will be near the surface. Along the length of the tunnel and the underground powerhouse etc. air	**General Guidelines:** A buffer of 200 m from the point of blasting where there is high risk of dust emissions according to the Impact Evaluation of Blasting, 2009.[3] **Project Specific Zone:** This zone for the tunnel and adit mouths are shown below.	▶ Indicate the limits of a clearing land with highly visible markers. ▶ Leave a layer of about 5 m of undisturbed softs above the top of the overburden blasts. This will act as a blanket to contain air blast, dust and fly rock. ▶ Sprinkle water on the area where blasting is done to settle down the particulate matter emissions.

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[3] Impact Evaluation of Blasting, Vlakfontein Opencast Project, 2009 http://www.srk.co.za/files/File/South-Africa/publicDocuments1/Vlakfontien/Appendix%27s/Appendix%20V%20Vibrations%20and%20Blast%20Impact%202010/EIA_Blasting_Vlak_09%20Rev%203.pdf

Source/Activity	*Zone of Impact*	*Mitigation/Monitoring Measures*
quality will not be effected as this is far underground. Blasting may also take place to extract materials at the quarry sites.		
Fugitive dust emissions from quarry areas Quarry areas are used to excavate stones, rocks, sand, gravel and aggregate from ground. This includes stripping of topsoil, blasting of area, crushing and screening of aggregates and loading of excavated material from quarries to stockpiles. Wind erosion from exposed surfaces also leads to dust emissions.	**General Guidelines:** ▶ A buffer of 500 m from the quarry areas where there is high risk of dust emissions as discussed in the Guidelines for Planning Authorities for Quarries and Ancillary Activities, 2004.[4] **Project Specific Zone:** ▶ According to the Feasibility Study, marble and limestone outcrops are exposed along the road while travelling from the proposed dam site to Naran. These exposures can be considered for the development of rock quarry for obtaining coarse aggregates. Samples were collected from marble deposits at Mahandri and limestone deposits at Paras. ▶ In this area, either small existing quarries can be expanded or new rock quarries can be developed for production of coarse aggregates. ▶ The following factors should be considered for selection of the rock quarries: a) It should be located in the close proximity to the power complex; b) Availability of open areas near the quarries to set-up crushing plants and stockpiles for aggregates; c) Good quality and sufficient quantities of rock should be available to meet the Project requirements; d) Favourable topographic conditions for safe quarrying and other operations; and	▶ Indicate the limits of a clearing land with highly visible markers. ▶ Avoid earth stripping or moving in periods of dry and windy weather. ▶ Carry out dust generating activities where maximum protection can be obtained through topography or in areas where prevailing winds will blow dust away from sensitive areas/uses. ▶ Water spraying of conveyors/conveyor transfer points, stockpiles and roads. ▶ Covering of fine dry loads or spraying of loads prior to exiting the site, and if necessary regular cleaning of public roads in the vicinity of the entrance.

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[4] Guidelines for Planning Authorities for Quarries and Ancillary Activities, Department of the Environment, Heritage and Local Government, 2004. http://www.housing.gov.ie/sites/default/files/migrated-files/en/Publications/DevelopmentandHousing/Planning/FileDownLoad%2C1606%2Cen.pdf

Source/Activity	*Zone of Impact*	*Mitigation/Monitoring Measures*
	e) Quarrying operations should not interfere with the construction activities. Total quarried material to be transported to the requried destinations is 250,000 cubic meters (m^3). ▶ Quarries should be located further than 500 m of sensitive receptors such as homes, schools, mosques etc.	
Fugitive dust emissions from concrete batching plants Concrete batching plants are where ingredients such as sand, cement, water and aggregate are mixed to form concrete. This consists of various activities such as storage of raw materials in bunkers and stockpiles, transfer of raw materials by front end loaders, conveyors, hoppers and loading of materials to the trucks.	**General Guidelines:** ▶ A buffer of 100 m between batching plants and sensitive land uses as included in the Recommended Buffer Distances for Industrial Residual Air Emissions, 1990.[5] **Project Specific Zone:** ▶ Location of concrete batching plants are not available in the Feasibility Study. ▶ Batching plants should be located further than 100 m of sensitive receptors such as homes, schools, mosques etc.	▶ Suspend earthwork operation when wind speed exceeds 20 km/hr. in areas within 500 m of any settlement. ▶ The whole process of weighing and mixing would be performed in a fully enclosed environment. ▶ The mixers would all equipped with dust collectors, no dust emission would be expected. ▶ Siting the concrete batching plant out of prevailing high winds minimizing dust emissions. ▶ The prevailing wind direction should be considered to ensure that bunkers and conveyors are sited in the leeward direction to minimize the effects of the wind. ▶ The provision of natural or artificial wind barriers – such as trees, fences and landforms – to help control the emission of dust from the plant should be considered.

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[5] Environmental Guidelines for the Concrete Batching Industry, http://www.epa.vic.gov.au/~/media/Publications/628.pdf

Source/Activity	*Zone of Impact*	*Mitigation/Monitoring Measures*
		▶ Batching plants should be sited on land that is not flood prone.
Fugitive dust emissions from aggregate production and handling system Sand and gravel are typically mined in a moist or wet condition by open pit excavation or dredging. After mining, the materials are transported to the processing plant where the material is dried, screened and crushed which is a source of particulate matter emissions. Typically, the dust associated with aggregate operations consists of particles from exposed soil and rock.	**General Guidelines:** ▶ A buffer of 1000 m between the point of operations and sensitive land uses.[6] **Project Specific Zone:** ▶ Location of quarries are not available in the Feasibility Study. ▶ Fine aggregate production should be minimized and directly extracted where possible. ▶ Final aggregate handling and production systems should be located further than 1000 m of sensitive receptors such as homes, schools, mosques etc. ▶ In case the above is not possible, then homes within this zone should either be temporarily relocated or mitigation measures strictly implemented in this zone.	▶ Suspend operation when wind speed exceeds 20 km/hr. in areas within 500 m of any settlement. ▶ The prevailing wind direction should be considered to ensure that aggregate handling systems located in the leeward direction to minimize the effects of the wind. ▶ Sprinkle water on all exposed surfaces, particularly those close and up-wind of settlements.
Wind-blown dust from exposed surfaces such as bare land and waste dumping sites Waste dumping sites are not themselves an emission source but unloading the waste (dumping) onto dump sites results in dust emissions.	**General Guidelines:** ▶ A buffer of 250 m between waste dumping sites (after completion this site will turn into a landfill site) and residential development as given in IFC-EHS Guidelines Waste Management Facilities, 2007.[7] **Project Specific Zone:** ▶ Final waste dumping sites should be located further than 250 m of sensitive receptors such as homes, schools, mosques etc.	▶ Cover all exposed surfaces, particularly those close and up-wind of settlements. ▶ All grading operations on a project should be suspended when winds exceed 20 miles per hour. ▶ Minimize disturbance to, or movement of, soil and vegetation. ▶ Sprinkle water on all exposed surfaces, particularly those close and up-wind of settlements.

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[6] http://environment.govmu.org/English/Documents/env%20guidelines/29/30Stone.pdf

[7] IFC-EHS Guidelines Waste Management Facilities, 2007, http://www.ifc.org/wps/wcm/connect/1cd72a00488557cfbdf4ff6a6515bb18/Final+-+Waste+Management+Facilities.pdf?MOD=AJPERES

Source/Activity	*Zone of Impact*	*Mitigation/Monitoring Measures*
		▶ Retain as much natural vegetation as possible.
Wind-blown dust from stockpiles of dusty materials such as sand and other minerals Wind erosion erodes the exposed surfaces of stockpiles resulting in dust emissions.	**Project Specific Zone:** Location of stockpile areas are not available in the Feasibility Study.	▶ On-site dirt piles or other stockpiled PM should be covered, wind breaks installed and water and/or soil stabilizers employed to reduce wind-blown dust emissions. ▶ Adequately wet, cover with plastic, or provide with wind shield all stockpiles to reduce dust emission. ▶ Sprinkle water on all exposed surfaces, particularly those close and up-wind of settlements. ▶ Minimize disturbance to, or movement of, soil and vegetation. ▶ Prevent soil damage and erosion. ▶ Retain as much natural vegetation as possible. Additional mitigation measures for stockpiles are discussed in **Section 7.8** *(Soil, Topography and Land Stability)*.

7.4.2 Identification of High Risk Areas

A buffer is provided around each source (called as '*Zone of Impact*') and identified receptors that are within the Zone of Impact and are prone to be affected by the possible increase in pollutant levels due to the construction activities. Identified receptors along with associated risk and proposed air quality sampling locations are presented in **Exhibit 7.7**.The zones are shown in **Exhibit 7.8** to **Exhibit 7.10**.

Exhibit 7.7: Receptors in Risk Areas

Zone of Impact	*Nearby Villages and Affected Receptors*	*Risk*	*Exhibit Reference*
Dam site	None	**Low:** Due to the absence of any sensitive receptor.	**Exhibit 7.8**
Adits mouth	▶ Few houses ▶ One graveyard in Khaulian ▶ One mosque in Khaulian	**High:** Due to the presence of many sensitive receptors and also as the $PM_{2.5}$ levels exceed the NEQS and the PM_{10} levels are very close to the NEQS and leaving very narrow room for construction activities to add up over the baseline levels.	**Exhibit 7.9**
Powerhouse site	▶ Few houses in Dabrian and Sendori villages ▶ Picnic spot near Dabrian		**Exhibit 7.10**
Waste dumping sites	▶ Few houses at waste dumping sites 1 and 3 ▶ None in case of waste dumping sites 2,4 and 5	**High**—at waste dumping sites 1 and 3: Due to the presence of many sensitive receptors and also as the $PM_{2.5}$ levels exceed the NEQS and the PM_{10} levels are very close to the NEQS and leaving very narrow room for construction activities to add up over the baseline levels. **Low**— at waste dumping sites 2,4 and 5: Due to the absence of any sensitive receptor.	**Exhibit 7.11**

Exhibit 7.8: Zone of Impact—Dam Site

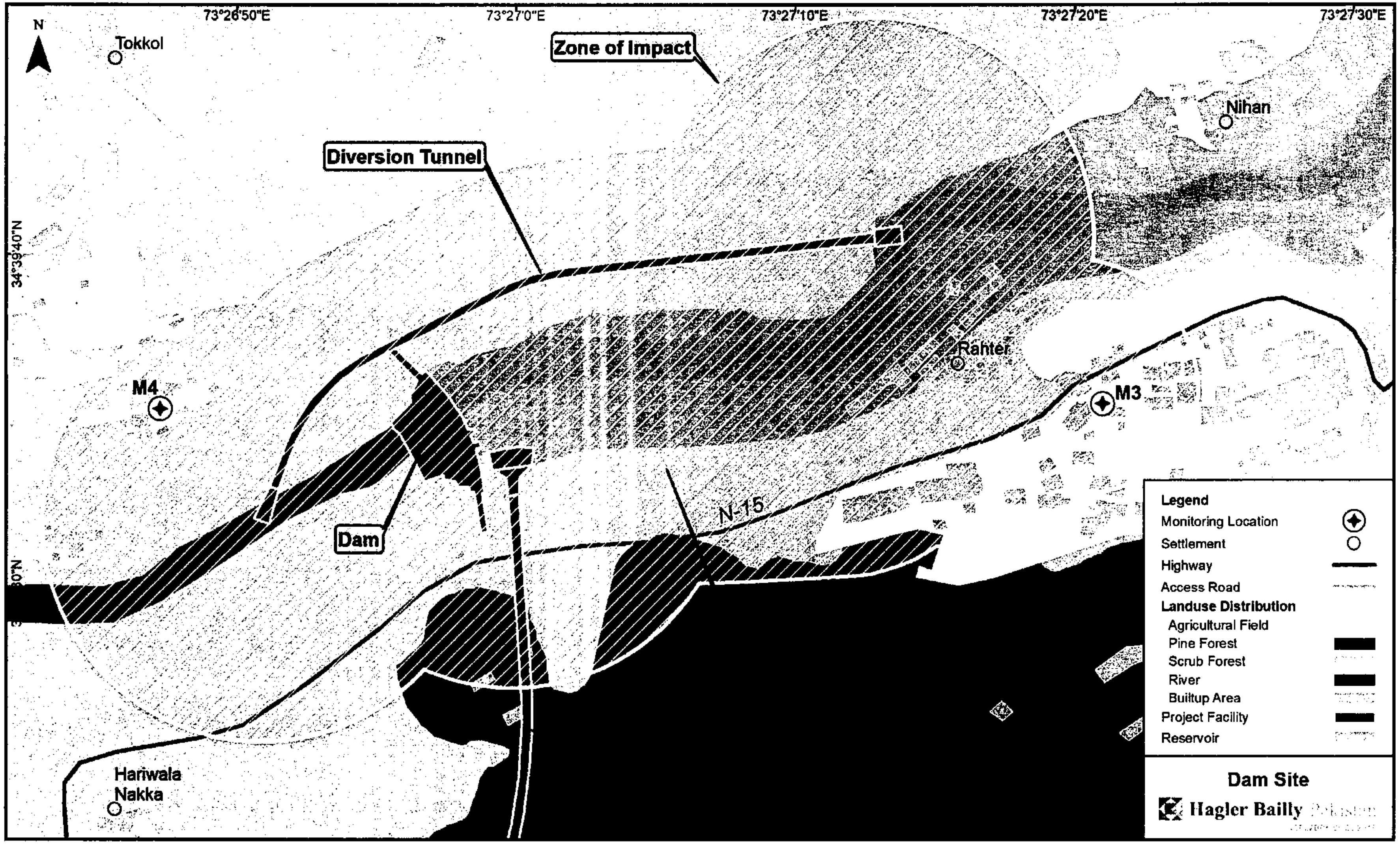


Exhibit 7.9: Zone of Impact—Adits

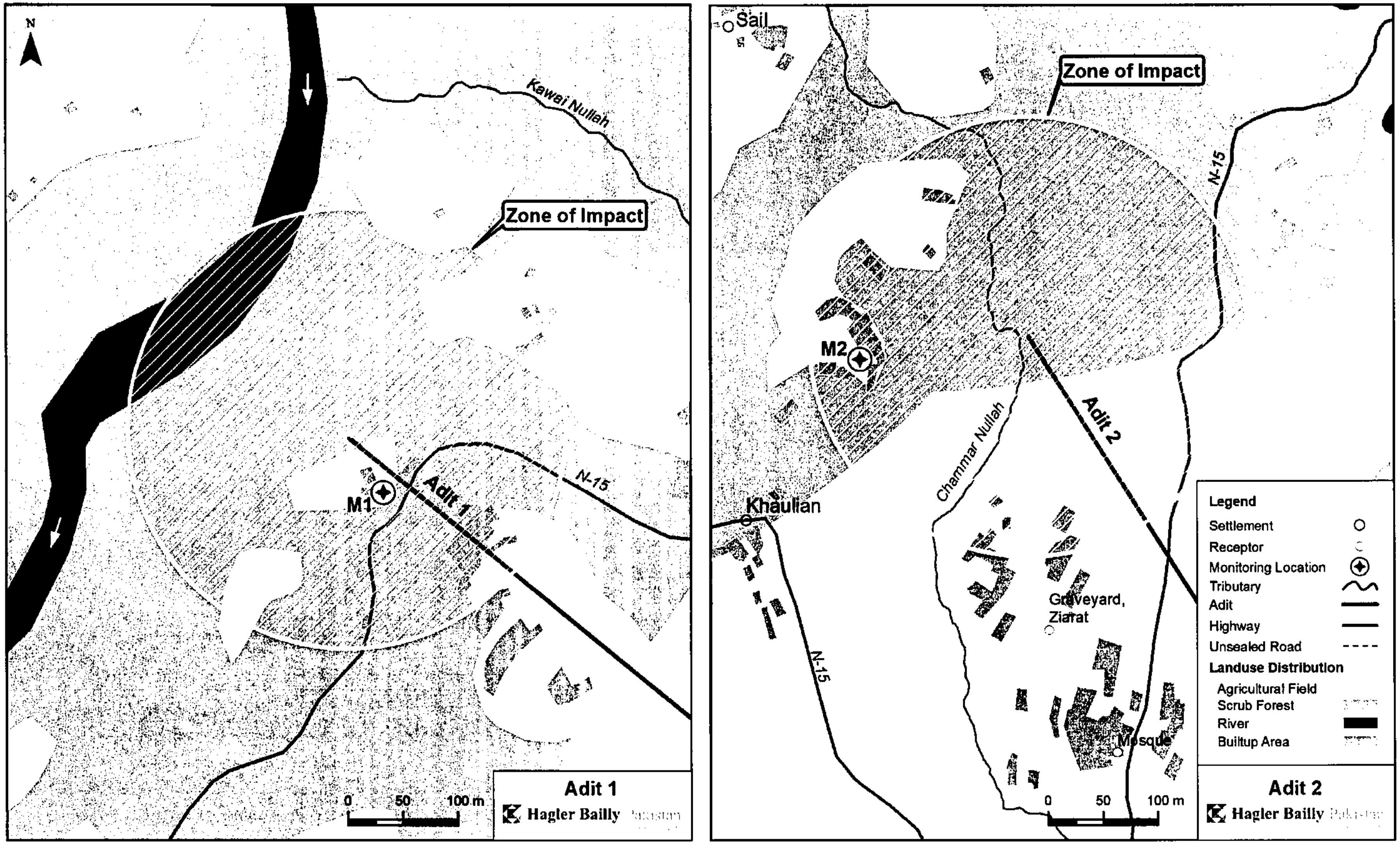


Exhibit 7.10: Zone of Impact—Powerhouse Site

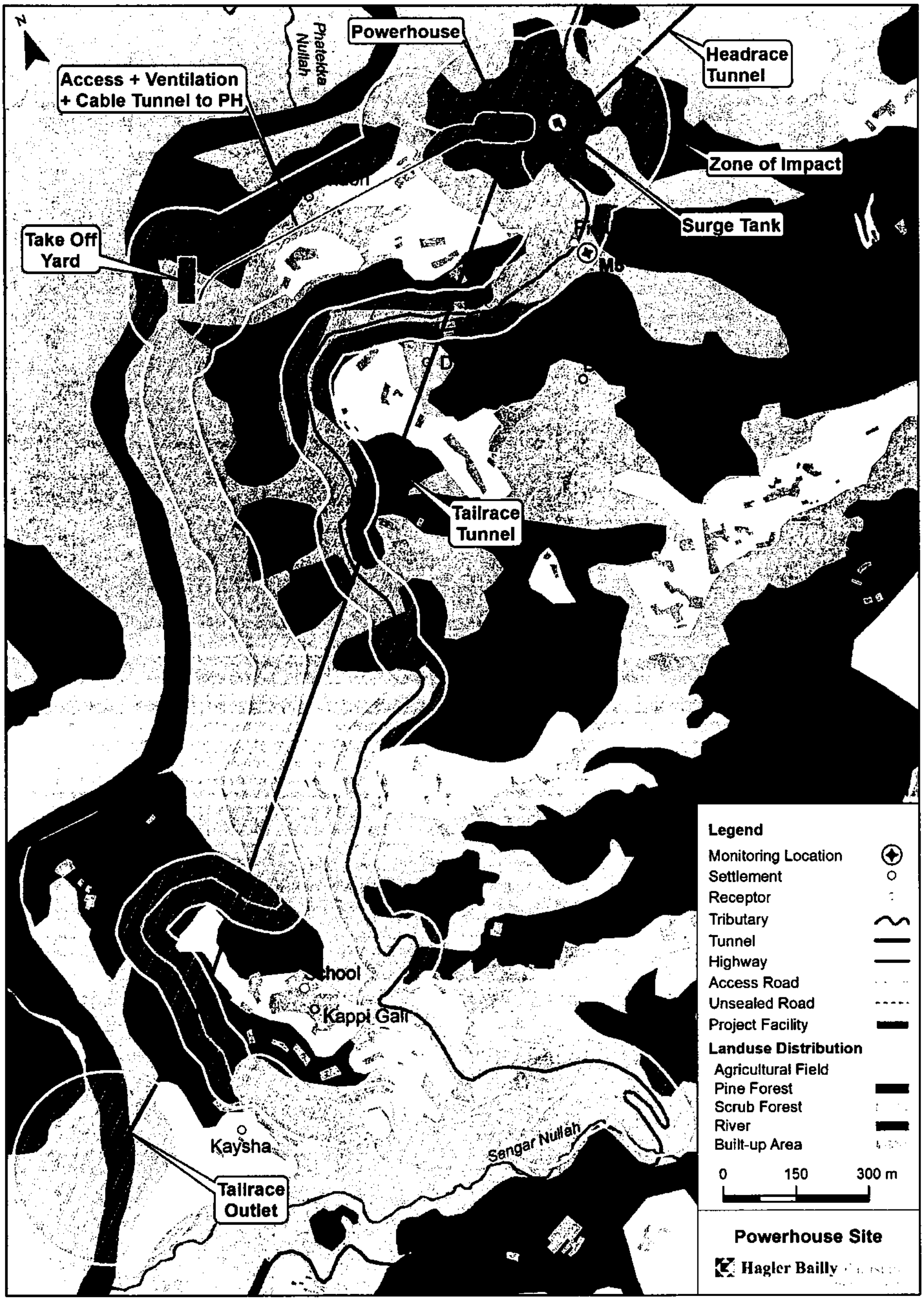
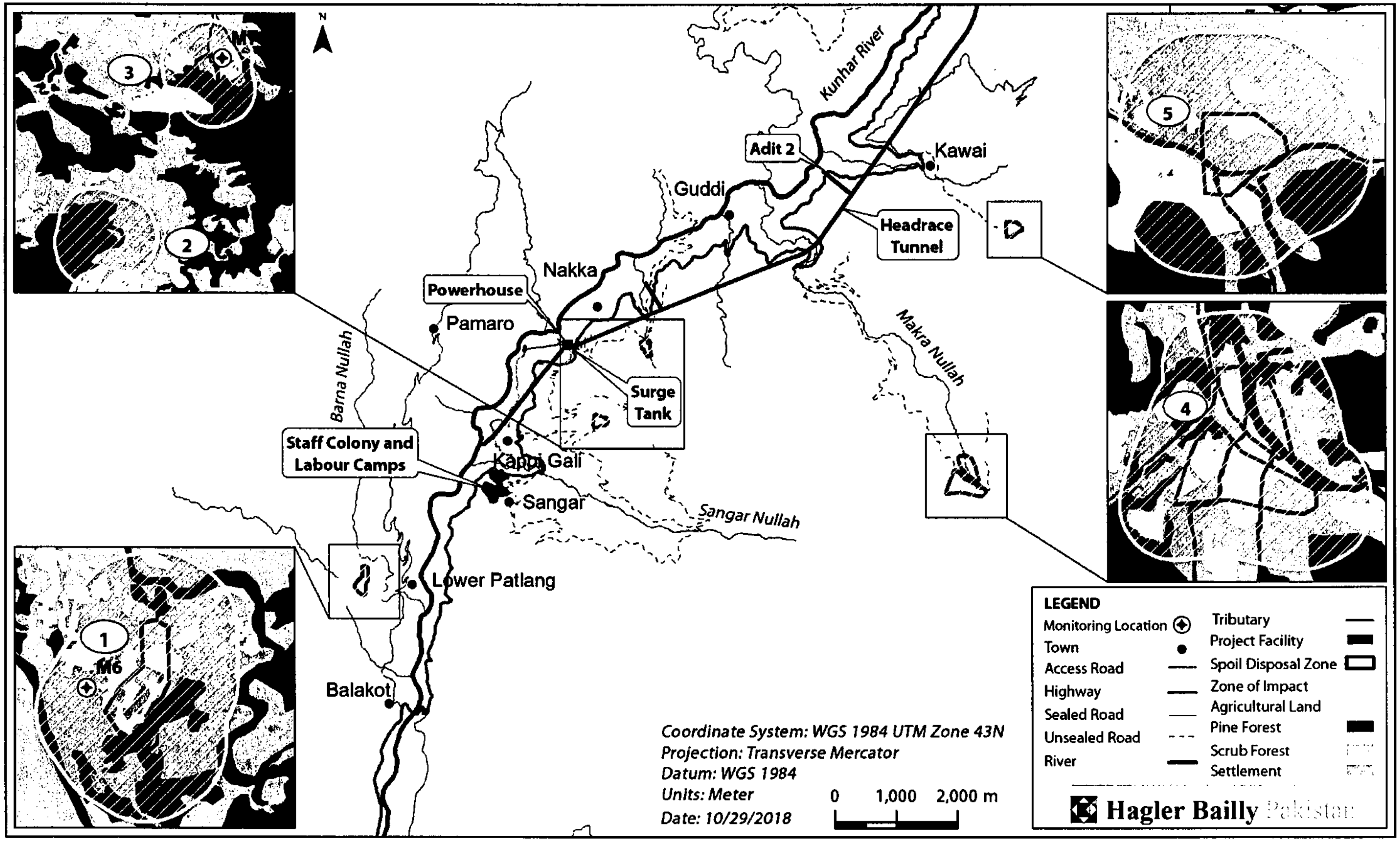


Exhibit 7.11: Zone of Impact—Waste Dumping Sites



7.5 Blasting and Vibration

The major risks of blasting and vibration due to the Project are:

- Impact 09: Vibration from construction activities including blasting may disturb (including annoyance, sleep disturbance, and potential damage to structures) local communities.
- Impact 10: Blasting may pose a health hazard due to flying debris.

Damage to springs from blasting is discussed in the next section.

7.5.1 Vibration from Construction Activities

Impact 09: Vibration from blasting during the construction phase may disturb local communities.

Applicable Project Phase *Construction*

Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Moderate	Medium Term	Intermediate	Medium	Possible	Medium	-	High

Mitigation measures:

1. Develop a Blasting and Explosives Management Plan and Vibration Monitoring Plan.
2. Conduct a pre-construction survey of structures at risk of vibration impacts households.

- In the initial stages, the blasting induced vibration shall be measured as a function of maximum instantaneous charge and distance from the blasting site. This data shall be then used to refine the Blasting Induced Vibration Risk Zones on the basis of the adopted criteria.
- Using, the refined Blasting Induced Vibration Risk Zones maps and the tunnel boring schedule, the Supervision Consultant in consultation with the PEDO and the Construction Contractor, shall identify the houses that will be affected and the impact duration and schedule.
- For the houses that will fall in the Structural Damage Risk Zone, a temporary relocation plan will be developed. An amendment to the Land Acquisition and Resettlement Plan (LARP) (see **Volume 8**) will be commissioned for this purpose. Before start of blasting, all residents of houses in the Structural Damage Risk Zone will be relocated as per the LARP (see **Volume 8**).
- A survey will be undertaken in both zones, to determine the pre-blasting conditions of the buildings. The survey will be commissioned by the Supervision Consultant and will identify and record any existing damage to the structures. The survey will cover the following aspects:
  - Overall condition of the structures, both exterior and interior.
  - Documentation of defects observed in the structure using digital imagery along with notes, measurements and sketches.
  - Documentation of pre-existing cracks using digital imagery along with notes, measurements and sketches.

3. Following completion of the blasting, the survey will be repeated in the Structural Damage Risk Zone to determine the condition of the buildings and verify that they are safe for re-occupation. If the buildings are safe, the residents will be allowed to return to their houses following any necessary damage repairs. If the buildings are damaged beyond repair, compensation will be paid to the owners as per the LARP. If there are any claims or reports of damage in the Cosmetic Damage Risk Zone, the affected house will be surveyed against the pre-Project survey and repairs will be undertaken as appropriate.

4. Following are key mitigation measures for the management of blasting:

- Blasting will be scheduled during the day only.
- Local communities will be informed of blasting timetable in advance and will be provided adequate notice of when blasts are required outside of the planned schedule.
- A Blasting Management Plan will be developed by the Construction Contractor. The Plan will be reviewed and approved by the Supervision Contractor before the initiation of the blasting work.
- Throughout the blasting activity, vibration sensors will be installed at strategic location to monitor the impact of blasting and to ensure that the vibration levels are within the adopted criteria. The monitoring plan will be part of the Blasting Management Plan.
- Unscheduled blasting will be strictly prohibited in any case.

5. Meaningful contact with the community shall be maintained and their grievance shall be attended to in a timely manner. In this regard:

- A meaningful community engagement plan will be developed. The plan will cover identify the affected community; the key contact persons; frequency of engagement; the information to be shared; the responsibilities to manage the plan; and the notice period to be giving to the community for various blasting related generating activities.
- The Grievance Redress Mechanism will be used to record, investigate, and respond to any complaints. Investigation of the complaints will be undertaken by the Supervision Consultant.

6. Develop a Vibration Monitoring Plan that will include monitoring of vibration levels and frequency around the blasting sites. The objectives of the monitoring will be to:

- Ensure that vibration levels in the communities are within the adopted criteria levels;
- Maintain record of vibration to settle any potential conflicts; and
- Monitor changes in the vibration levels due to possible changes in the rock formation and take appropriate corrective actions.

Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	-	High

Sources of vibration includes construction equipment movement, pile driving, compaction, hammering (hydraulic or pneumatic), operation of batching plant and generators. Another source of vibration will be the blasting to be undertaken for tunneling. The propagation of vibration from construction activities are different in nature from the vibration from blasting. The construction activities are undertaken essentially on ground surface and spreads basically as two-dimensional waves. In contrast, the tunneling is undertaken below the surface and spreads in three-dimension. For this reason, the impact of the two is assessed separately.

In the case of ground vibrations, the level of vibration is measured by the Peak Particle Velocity (PPV) with units of millimeters of movement per second. The proposed criteria for damage to buildings are shown in **Exhibit 7.12**. These are derived from British Standard BS 6472 and are German Standards DIN 4150-3:1999.

Exhibit 7.12: Criteria for Structural Damage Due to Vibration

Risk Zone	*PPV Range*
No Damage Likely	PPV < 5 mm/s
Cosmetic damage risk zone	PPV 5 to 15 mm/s
Structural damage risk zone	PPV > 15 mm/s

Vibration Impact of Construction Activities on the Surface

Exhibit 7.13 provides an indication of the approximate vibration levels that may be expected for various vibration sources.

These levels are well below the threshold of any possibility of damage to structures due to vibrations from typical construction activities related to roller, compactors, and movement of construction equipment.

Exhibit 7.13: Approximate Vibration Levels for Various Sources

Activity	*Typical levels of ground vibration*
Vibratory rollers	Up to 1.5 mm/s at distances of 25 m Higher levels could occur at closer distances; however, no damage would be expected for any building at distances greater than approximately 12 m (for a medium to heavy roller)
Hydraulic rock breakers (levels typical of a large rock breaker operating in hard sandstone)	4.50 mm/s at 5 m 1.30 mm/s at 10 m 0.4 mm/s at 20 m 0.10 mm/s at 50 m
Compactor	20 mm/s at distances of approximately 5 m, 2 mm/s at distances of 15 m. at distances greater than 30 m, vibration is usually below 0.3 mm/s
Bulldozers	1 to 2 mm/s at distances of approximately 5 m. at distances greater than 20 m. vibration is usually below 0.32 mm/s
Air track drill	4 to 5 mm/s at a distance of approximately 5 m, and 1.5 mm/s at 10 m. at distances greater than 25 m, vibration is usually below 0.6 mm/s and at 50 m or more, vibration is usually below 0.1 mms
Truck traffic (over normal (smooth) road surfaces)	0.01 to 0.2 mm/s at the footing of buildings located 10 to 20 m from a roadway
Truck traffic (over irregular surfaces)	0.1 to 2.0 mm/s at the footings of buildings located 10 m to 20 m from a roadway

Source: Northern Expressway Environmental Report: Noise and Vibration technical Paper. 2007. http://www.southroad.sa.gov.au/_data/assets/file/0019/13780/Noise_and_Vibration_Technical_Paper.pdf

Vibration Impact of Tunnel Construction

Blasting for construction results in noise as well as ground vibrations that cannot be confined to the site. As blasting is an occasional activity it does not affect the ambient noise limits evaluated, but can be disturbing to local communities with short-term noise exceeding 10 dBA. Single noisy events such as blasting can be audible over a large area.

Although each incident is short term in nature, the repetitiveness of the noise may give rise to complaints if not managed sensitively. The subjective reaction to a single disturbing noise event will depend on the activities being undertaken by the receptor and the manner in which the program for noisy events is communicated to identified receptors. For example, a large noise event at nighttime may give rise to complaints, where at any other time it would be accepted.

The Project will conduct construction blasting consistent with Pakistan and international safety standards. Open pit blasting will be conducted using standard mining industry practices and procedures for securing personnel and equipment. This includes evacuating the blast area to a distance of at least 500 m to avoid any damage from fly rock.

The PPV is directly related to the size of the blast and the distance from the blast—the closer to the blast the greater the vibration. PPV is calculated as follows:

$$PPV = K\,(R/Q^{0.5})^{B},$$

where:

PPV = peak particle velocity (mm/s);

K = site constant (1140)

R = distance to point of concern (m);

Q = maximum instantaneous charge weight (40 kg, see **Exhibit 7.14**);

B = rock properties constant (-1.6).

Exhibit 7.14: Instantaneous Charge Weight Calculation

Parameter	Value	Explanation
Tunnel cross-section (m^2)	65	From design drawings. Headrace tunnel is 8 m by 8.80 m horseshoe shape.
Borehole depth (m)	5	Assumed, based on personal communication with road construction engineer
Rock removed in one blast cycle (m^3)	325	
Rock type	Hard	
Powder factor (kg/m^3)	0.8	For hard rock[8]
Total charge weight (kg)	260	Powder factor x rock removed in one blast
Maximum instantaneous charge weight (kg)	40	Estimated from typical borehole pattern and personal communication with road construction engineer

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[8] Dyno Nobel. Blasting and Explosives Quick Reference Guide. 2010.

A PPV of 15 mm/s is calculated to occur about 95 m from the edge of the blasting source (in all directions) and a PPV of 5 mm/s is calculated to occur about 190 m from the edge of the blasting as shown in **Exhibit 7.15**.

Exhibit 7.15: Calculated PPV as Function of Distance from Blast Site

PPV (mm)	*R (m)*
547.7	10
180.7	20
94.4	30
59.6	40
41.7	50
31.2	60
24.3	70
19.7	80
16.3	90
14.9	95
13.8	100
11.8	110
10.3	120
9.0	130
8.0	140
7.2	150
6.5	160
5.9	170
5.4	180
4.9	190
4.5	200

Extensive blasting will be undertaken during the construction of the headrace tunnels. In **Exhibit 7.16** it can be seen that the headrace tunnel is at a depth of less than these critical distances in certain areas along its length. The depth profile for the construction adits are provided in **Exhibit 7.17** and **Exhibit 7.18**. It can be seen that it is close to the ground level in several locations.

Exhibit 7.16: Depth Profile of the Headrace Tunnel

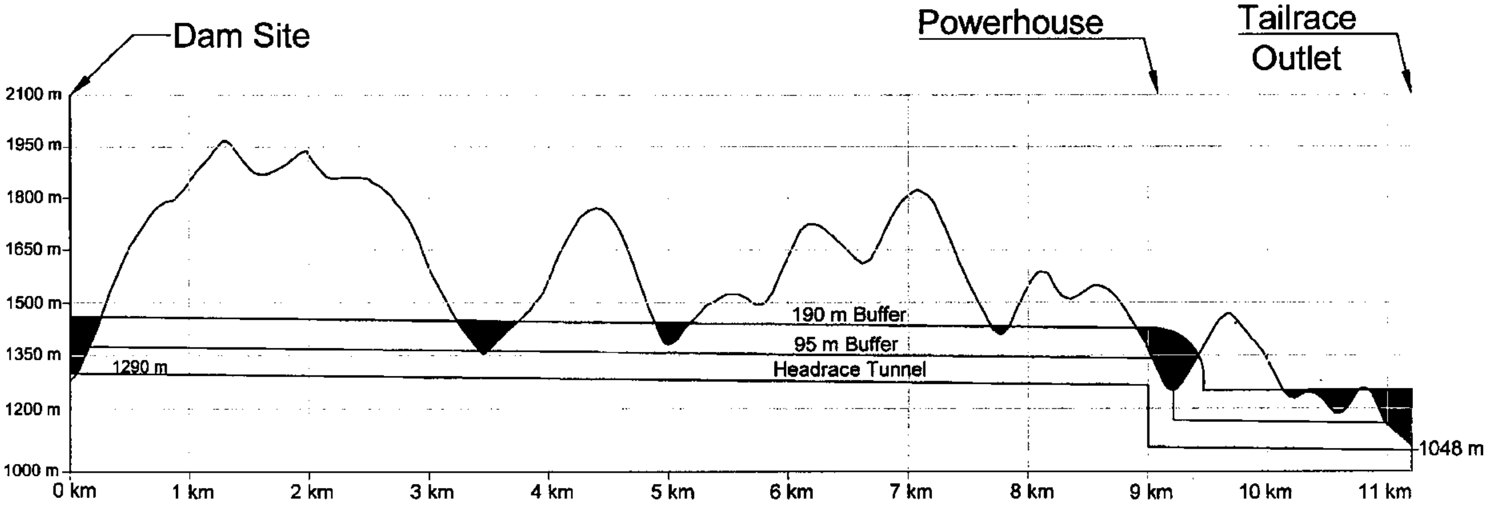


Exhibit 7.17: Depth Profile of Construction Adit 1

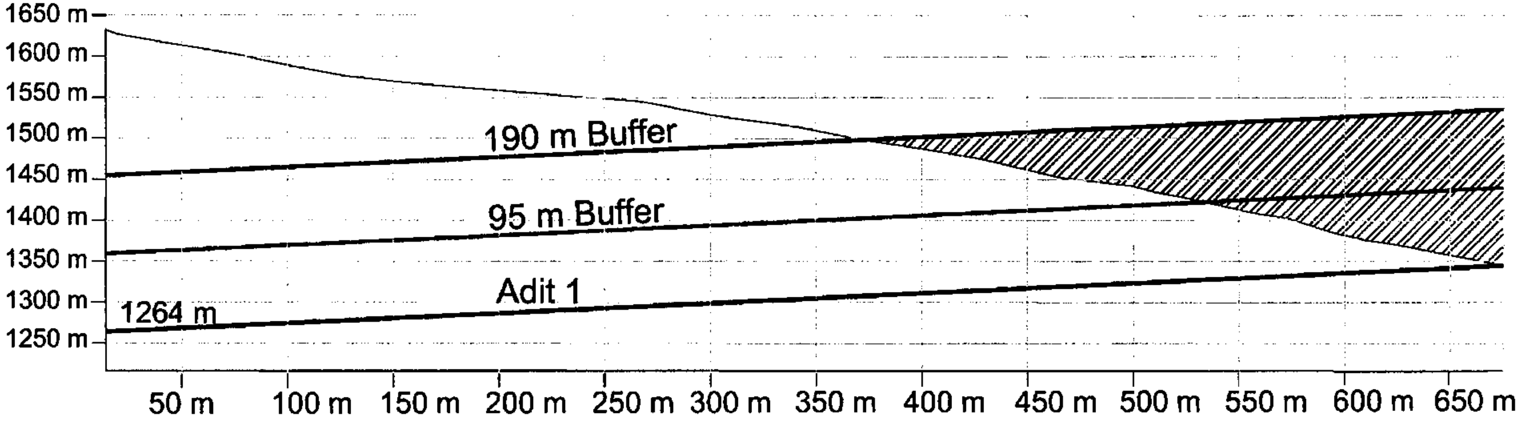
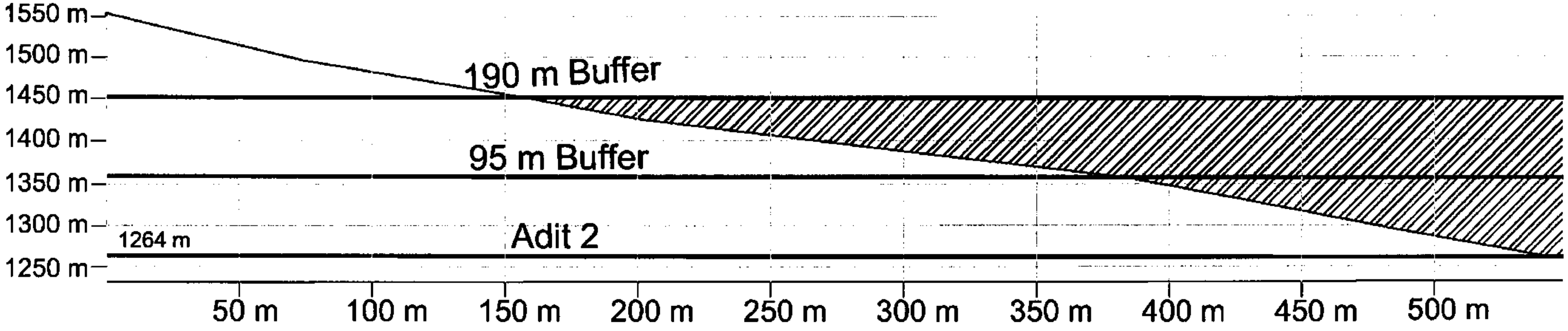


Exhibit 7.18: Depth Profile of Construction Adit 2



The following procedure is proposed for addressing the vibration concerns:

- Identify potential problem areas surrounding the Project sites.
    - The boundaries of risk zones are drawn without taking into consideration the variation in elevation of the terrain. The actual boundaries are likely to be closer to the tunnels.
    - The risk zone boundaries take into considerations, the location of the construction adits and their elevation profiles.
    - The complete lengths of the access tunnels for the powerhouse are included in the Structural Risk Zone.
- Based on the above criteria the total houses identified for preconstruction surveys include:
    - 120 structures of which 13 are within 95 m (structural damage risk zone).
    - The locations of these structures are illustrated in **Exhibit 7.19** and **Exhibit 7.20.**
    - **Appendix S** presents an index of structures within the risk zones, including detailed maps, and coordinates for each structure.

Mitigations Measures

Overall Approach

The PPV is predicted using a semi-empirical model which is the best alternate in the absence of measured field data. Although, there is reasonable confidence in the predicted value, the norm is to measure field data to assess vibration levels. In the initial stages, the blasting induced vibration shall be measured as a function of maximum instantaneous charge and distance from the blasting site. This data shall be then used to refine the Blasting Induced Vibration Risk Zones on the basis of the adopted criteria.

Early during the construction phase, the construction contractor shall develop a detailed tunnel blasting plan as part of the overall construction schedule. The plan shall specify, to a reasonable level of accuracy, the schedule for boring.

Using, the refined Blasting Induced Vibration Risk Zones maps and the tunnel boring schedule, the Supervision Consultant in consultation with the Roads Department and the Construction Contractor, shall identify the houses that will be affected and the impact duration and schedule.

For the houses that will fall in the Structural Damage Risk Zone, a temporary relocation plan will be developed. An amendment to the Land Acquisition and Resettlement Plan (LARP) will be commissioned for this purpose. Before start of blasting, all residents of houses in the Structural Damage Risk Zone will be relocated as per the LARP (see **Volume 8**).

Exhibit 7.19: Vibration Risk Area 1

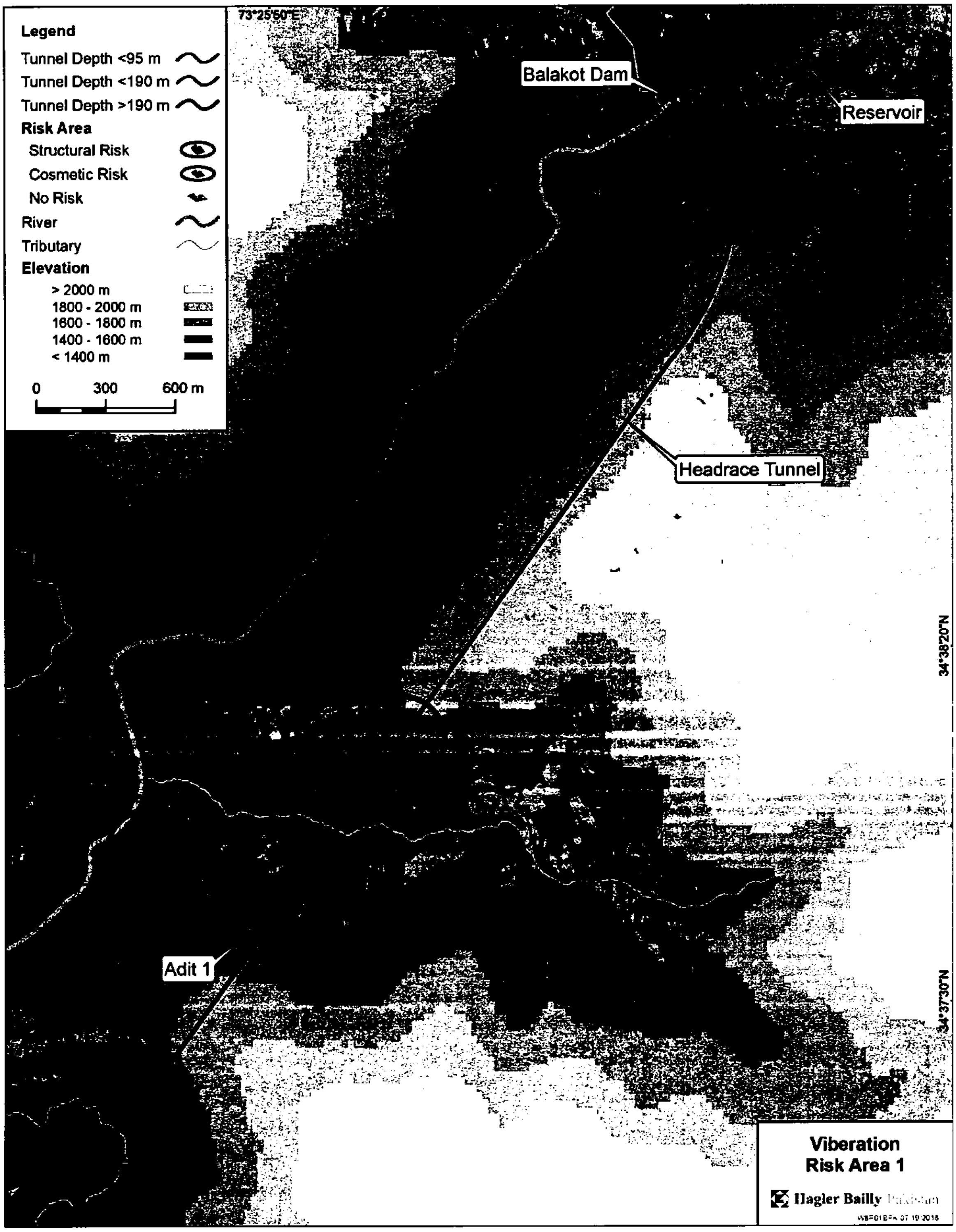
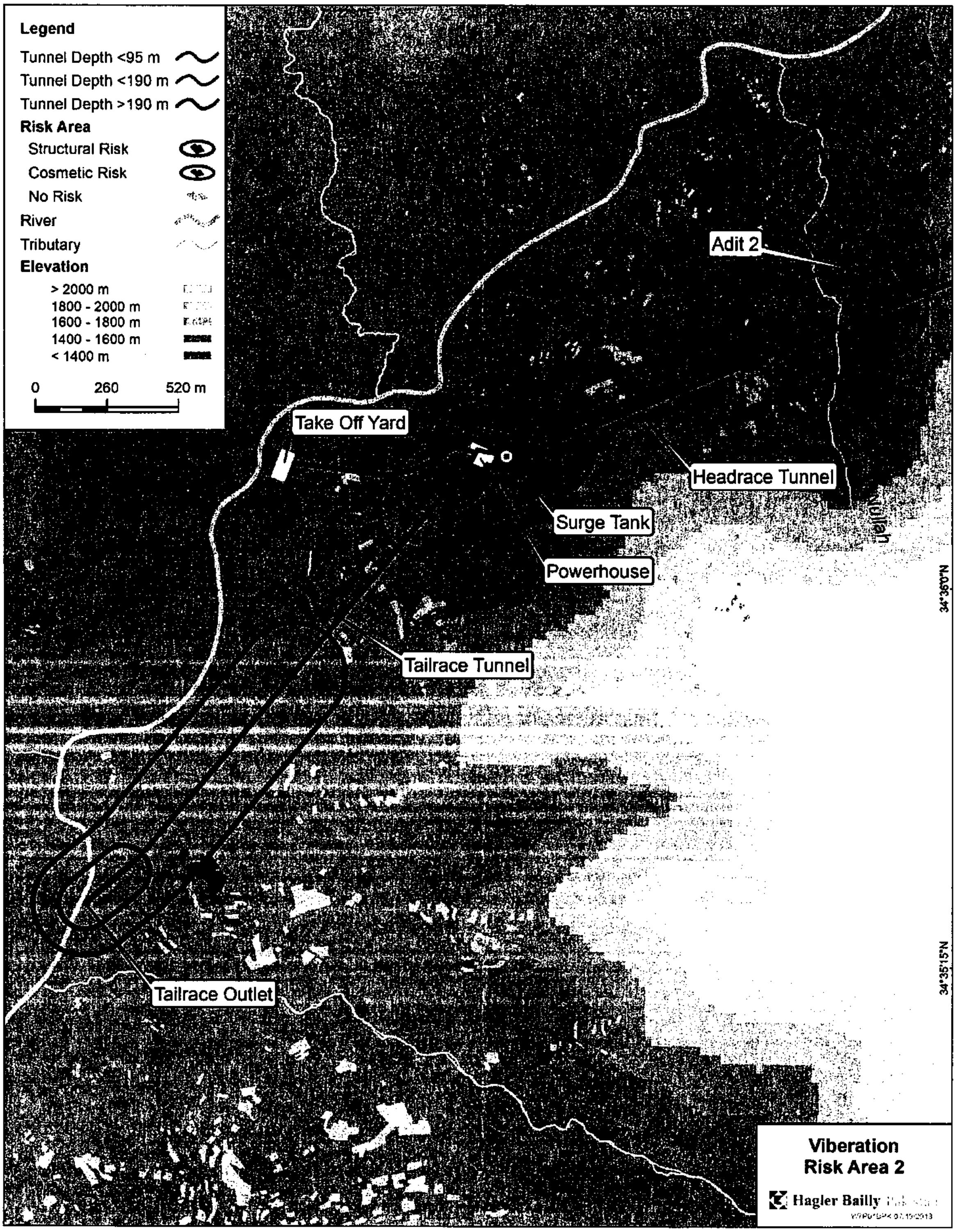


Exhibit 7.20: Vibration Risk Area 2



A survey will be undertaken in both zones, to determine the pre-blasting conditions of the buildings. The survey will be commissioned by the Supervision Consultant and will identify and record any existing damage to the structures. The survey will cover the following aspects:

- Overall condition of the structures, both exterior and interior.
- Documentation of defects observed in the structure using digital imagery along with notes, measurements and sketches.
- Documentation of pre-existing cracks using digital imagery along with notes, measurements and sketches.

The survey will be accompanied with consultations with the affected household to explain the extent and reason for the survey, and the process for reporting any grievances regarding vibration impacts. The households should be provided with materials that summarize the grievance redress process.

Following completion of the blasting, the survey will be repeated in the Structural Damage Risk Zone to determine the condition of the buildings and verify that they are safe for re-occupation. If the buildings are safe, the residents will be allowed to return to their houses following any necessary damage repairs. If the buildings are damaged beyond repair, compensation will be paid to the owners as per the LARP (see **Volume 8**).

If there are any claims or reports of damage in the Cosmetic Damage Risk Zone, the affected house will be surveyed against the pre-Project survey and repairs will be undertaken as appropriate.

Mitigation Plan

Following are key mitigation measures for the management of blasting:

- Blasting will be scheduled during the day only.
- Local communities will be informed of blasting timetable in advance and will be provided adequate notice of when blasts are required outside of the planned schedule.
- A Blasting Management Plan will be developed by the Construction Contractor. The Plan will be reviewed and approved by the Supervision Contractor before the initiation of the blasting work.
- Throughout the blasting activity, vibration sensors will be installed at strategic location to monitor the impact of blasting and to ensure that the vibration levels are within the adopted criteria. The monitoring plan will be part of the Blasting Management Plan.

Unlike other construction activities, it is recognized that the impact of blasting on the community can be significant or can be perceived as significant by the community. It is therefore vital that regular and meaningful contact with the community shall be maintained and their grievance shall be attended to in a timely manner. In this regard:

- A meaningful community engagement plan will be developed. The plan will cover identify the affected community; the key contact persons; frequency of engagement; the information to be shared; the responsibilities to manage the plan;

and the notice period to be giving to the community for various blasting related generating activities.

- The Grievance Redress Mechanism will be used to record, investigate, and respond to any complaints. Investigation of the complaints will be undertaken by the Supervision Consultant.

Vibration Monitoring

Vibration Monitoring Plan will include monitoring of vibration levels and frequency around the blasting sites. The objectives of the monitoring will be to:

- Ensure that vibration levels in the communities are within the adopted criteria levels;
- Maintain record of vibration to settle any potential conflicts; and
- Monitor changes in the vibration levels due to possible changes in the rock formation and take appropriate corrective actions.

Vibration data will be documented, reviewed, and preserved. It will be regularly shared with ADB, PEDO and EPA, KP as part of the monthly progress report.

7.5.2 Fly Rock from Blasting

Fly rock is an unexpected projection of material from the blast site to any area beyond the designated safety area. Fly rock occurs when the amount of explosive energy is greater than that required to break the mass of rock between the blast position and the free face, the excess energy projects the rock debris beyond the safety area. Uncontrolled fly rock from blasting can travel hundreds of meters, with known cases up to 1000 m. This range is for extreme cases where very little blasting control is applied, and is due to over-charging of holes or under-burdening of holes.

Use of large diameter blast holes for small benches, variation in burden due to over break of toe or back crack that results in uneven face, drilling deviation, inadequate burden and too closing spacing are the possible causes of fly rock.

Despite the fact that fly rock consumes only 1% of the explosive energy used in a blast it is more serious in nature than any other damage caused by blasting.

Impact 10: Blasting may pose a health hazard due to flying debris.								
Applicable Project Phase				*Construction*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Moderate	Short Term	Intermediate	High	Possible	Medium	-	High

Mitigation measures:

1. A minimum buffer of 500 m should be provided between the settlements and point of blasting.
2. Leave a layer of about 5 m of undisturbed softs above the top of the overburden blasts. This will act as a blanket to contain air blast, dust and fly rock.
3. Ensure that the holes are correctly collared with respect to the back-break/inclination of the face and also that digging alongside the initiation face well controlled.
4. Inadequate forward displacement of the front row burden arising out of the under charging of these holes will result in fly rock from vertical catering of the rear holes.
5. Where fly rock possess a serious problem, the stemming length should not be less than the hole burden. Also an effective stemming material like crushed angular rock should be used to prevent premature venting of explosion gases through the stemming column.
6. The forward fly rock could be fairly controlled to the commonly used 'inline open loop' pattern. The maximum inter-row delay interval consistent with the absence of cut off helped in minimizing the fly rock formation. As a thumb rule an inter-row delay of 4-8ms/m of burden could be used for this purpose.
7. Adequate care should be taken while connecting the delay devices in the holes/rows and the initiation sequence properly checked before firing to avoid initiation of blast holes out of sequence.
8. Blasts designed on a face length to width ratio in the range of 3 to 4 produces minimum fly rock.

Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	-	High

7.6 Hydrology and Water Quality

The major risks to local hydrology and water quality due to the Project are related to water availability and contamination:

- Impact 11: Alterations of natural passage of springs due to blasting for tunnels may disrupt the water supply for mountain spring users.
- Impact 12: Use of local water resources for construction activities may reduce the water availability for local communities
- Impact 13: Contamination of surface and groundwater due to discharge from the construction activities and sewage from the construction camps may affect agricultural productivity and human health.

7.6.1 Changes to Groundwater Patterns

Impact 11: Alterations of natural passage of springs due to blasting for tunnels may disrupt the water supply for mountain spring users.									
Applicable Project Phase					*Construction*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Moderate	[redacted]	Intermediate	[redacted]	Possible	[redacted]	-	High
Mitigation measures: 1. Record location of the springs especially those in areas proximal to where the underground headrace tunnel will be closer to the ground level (see **Exhibit 7.21** and **Exhibit 7.22**). 2. Monitor flow for located springs and maintain records. 3. Support the community in development of alternate water supply schemes through local NGOs 4. Ensure the availability of water to the communities and the access of the communities to the water resources being used by them is not adversely affected.									
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Medium	Intermediate	Low	Possible	Low	-	High

Heavy construction activities especially the blasting activities for the headrace tunnel (see **Section 7.5** *Blasting and Vibration*) and excavation may cause alterations to the groundwater flow patterns in areas proximal to where the underground headrace tunnel will be close to ground level.

There are numerous settlements on the ridges across which the headrace tunnel will be constructed and those are dependent on the springs for daily water use. These changes will only cause negative impacts when they occur where people or ecological systems are using the water. Areas where the headrace tunnel is proximal to the ground is discussed in **Section 4.1.7** *(Water Resources)*. 6 mountain springs are at high risk out of which 2 springs are used by schools and hospitals. These springs are located in areas where blasting for tunnel construction will be close to the surface are shown in **Exhibit 7.21** and **Exhibit 7.22**. Three springs (2 of which are within the High-Risk area) are used by schools and hospitals (marked as red in the **Exhibit 7.22**). All of these springs should be closely monitored.

Exhibit 7.21: High Risk Areas for Mountain Springs A

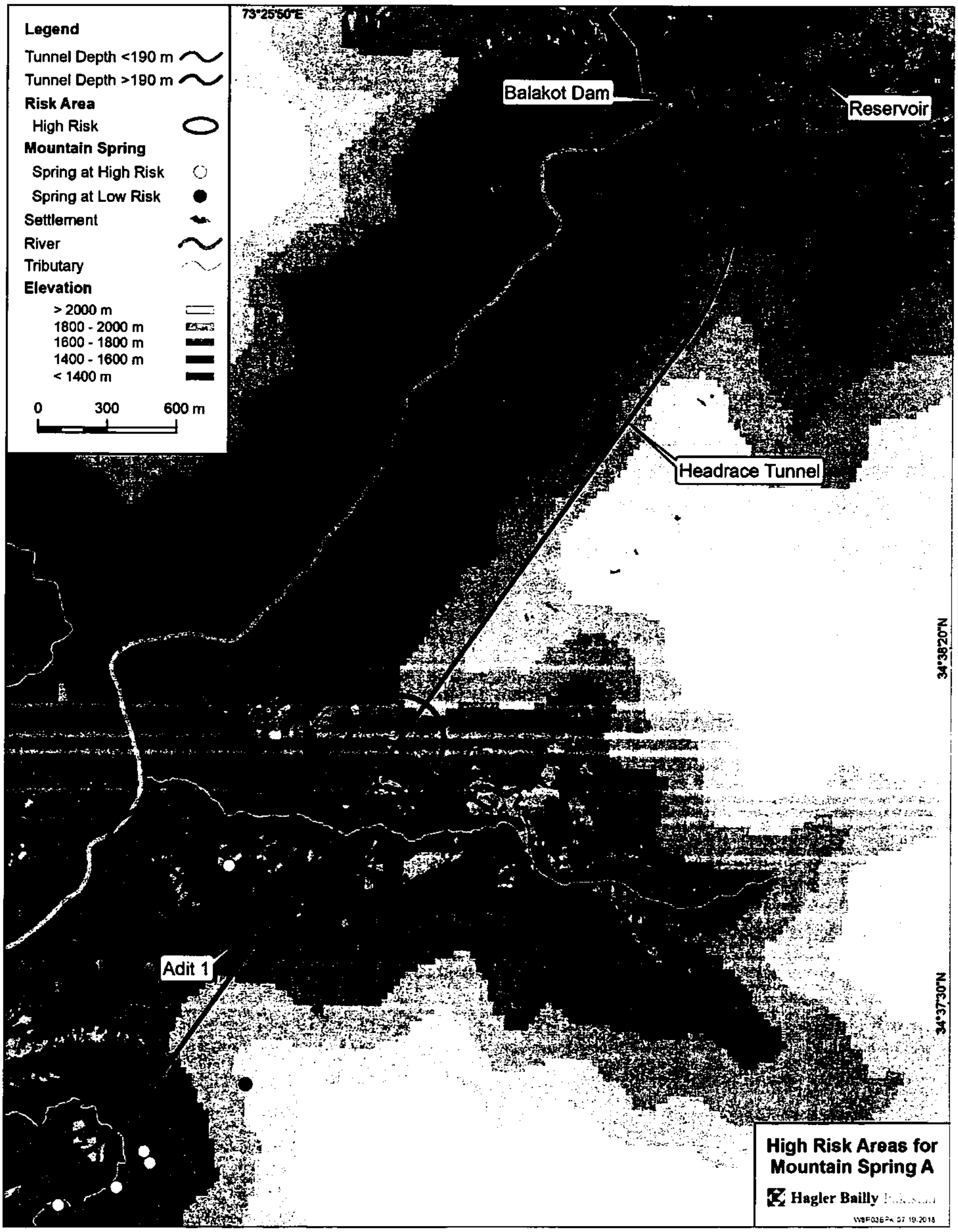
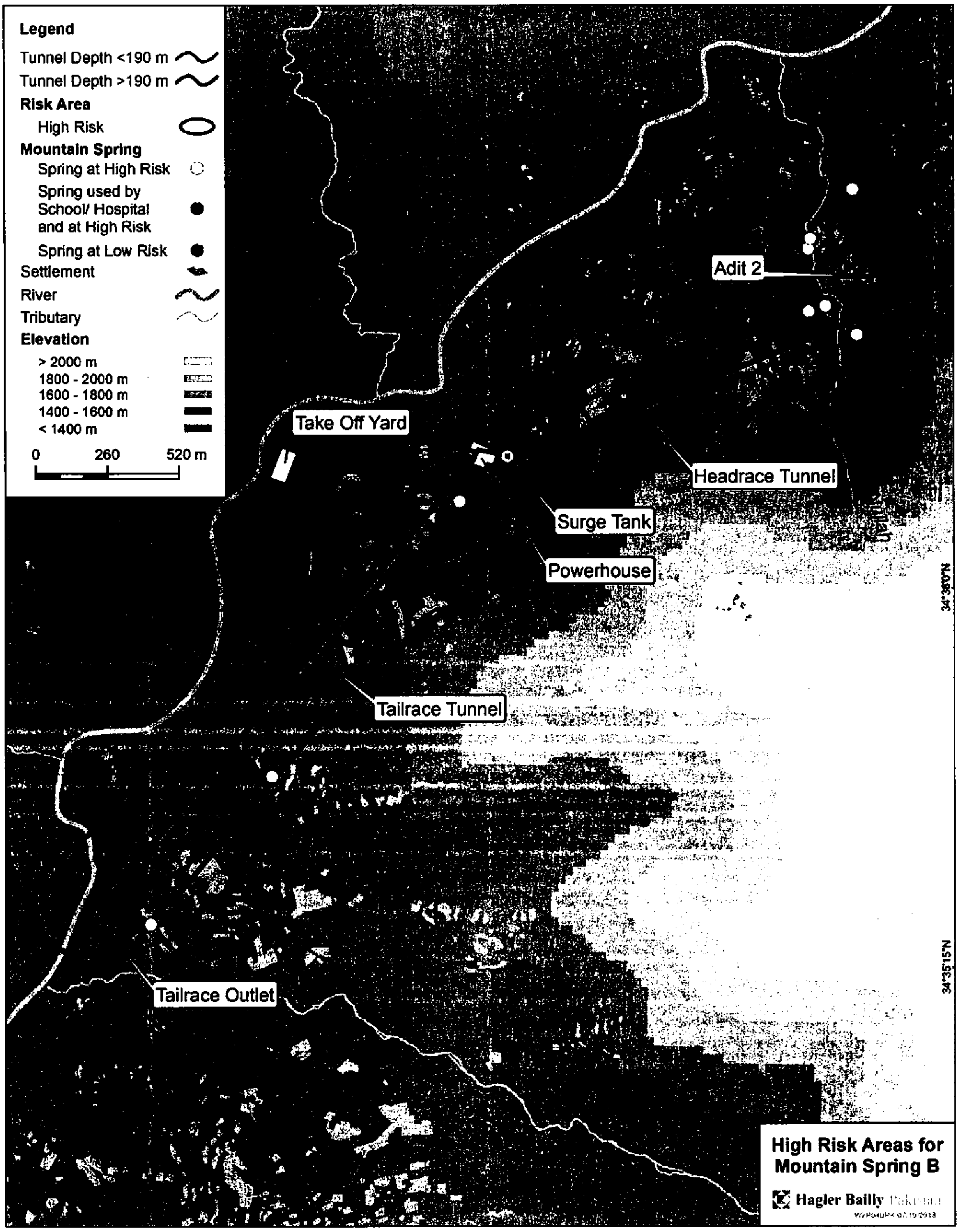


Exhibit 7.22: High Risk Areas for Mountain Springs B



7.6.2 Water Resource Depletion

Impact 12: Use of local water resources for construction activities may reduce the water availability for local communities.								
Applicable Project Phase				*Construction*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Moderate	Short Term	Intermediate	Medium	Possible	Medium	-	High
Mitigation measures: 1. Develop a Water Sourcing and Abstraction Plan. 2. Source water for construction from authorized abstraction sources agreed between the local communities, local government and EPC contractor. 3. Water conservation techniques will be developed and implemented by the EPC contractor. 4. Access of community to water sources shall be kept clear so that the community's ability to meet its water requirements are not compromised. 5. Exercise care while moving heavy machinery to avoid damage or blockage of natural waterways and channels. 6. Maintain records of water usage in all Project activities. 7. Incorporate the above measures in the Construction Site Environmental Management Plan (see **Section 9,** *Environmental Management Plan*).								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Unlikely	Low	-	High

The main source of drinking water in the area is spring water located in the hydro census (see **Section 4.1.7,** *Water Resources*). Water demand for the construction site and camp may take water away from other users if not controlled. Unauthorized abstraction from shallow springs could reduce the yield available or block access for other users, leading to resentment and increasing the risk of hardship.

7.6.3 Contamination of Surface and Groundwater from Construction Activities

Impact 13: Discharge from construction activities can potentially result in the contamination of groundwater and surface water.

Applicable Project Phase *Construction*

Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Moderate	Short Term	Small	Low	Possible	Low	-	High

Mitigation measures:

1. Develop and implement a Water Quality Management Plan.
2. Prepare and implement a Spill Prevention and Response Plan and inducted to the staff for any incident of spill.
3. Provide and use spill prevention trays at refueling locations.
4. The run off from maintenance workshops will be collected by impervious channels and be passed through oil water separators (OWS) before final disposal. The sludge and oil collected at the OWS will be disposed of properly.
5. Build separate impervious pits (with concrete walls and proper shed) at the construction sites for temporary handling and storage of contaminated soil and water if encountered during construction such as sludge from OWS.
6. Keep all fuel storage tanks and lubricating oil drums in secondary containment impervious pits with impervious shed walls.
7. Avoid on-site maintenance of construction vehicles and equipment, as far as possible.
8. Regularly inspect construction vehicles and equipment to detect leakages.
9. Store fuels and lubricants in covered and dyked areas, underlain with impervious lining.
10. Spill control kits (shovels, plastic bags and absorbent materials) will be available near fuel and oil storage areas, vehicle parking, and vehicle maintenance areas as well as at construction sites.
11. Remove contaminated soil from the site and dispose in a manner to ensure protection of water sources.
12. Construct the bottom of any soak pit or septic tank at least 100 meters away from springs and water bores.
13. Maintain records of spills and volume of removed contaminated soil.
14. Maintain record of remedial measures taken.
15. Use silt traps to prevent contamination of river and streams.
16. Incorporate the above measures in the Construction Site Environmental Management Plan (see **Section 9,** *Environmental Management Plan*).

Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Unlikely	Low	-	High

A major risk to water bodies during construction are accidental spills of fuels, lubricants, reagents and other potentially hazardous chemicals.

7.7 Construction Noise

Construction noise is a component of environmental noise associated with construction activities. Construction noise is noise that arises from an activity at a construction site. It includes:

- Noise from operation of construction machinery and equipment for the construction activities including excavation and demolition work, site preparation work, foundations and concrete placement, erection of metal structures, installation of mechanical and electrical equipment and building maintenance or repair work;
- Noise from movement of vehicles within, entering or leaving a construction site; and
- Noise from blasting.

The noise generated through these activities can be categorized as below.

- Airborne noise: Noise that travels through air and caused by general construction and construction traffic.
- Ground borne noise: Noise that is generated through rumbling sound caused by vibration due to impact induced construction activities such as blasting, pile driving and tunneling and movement of heavy transportation such as trucks.
- Air blast noise: Noise generated through blasting, also known as blast overpressure, which is the pressure wave (or pulse) transmitted through the air as the result of an explosion. Air blast may have both acoustic effects in terms of overpressure and vibration effects in terms of airborne and ground borne vibration.

Construction noise emanates from the source and propagates through the atmosphere. There are numerous factors influencing the noise level received at a sensitive receptor including:

- Directivity of the source
- Atmospheric absorption (attenuation is a function of temperature, humidity and frequency within the atmosphere)
- Meteorological influences (attenuation or enhancement due to surface temperature and humidity, vertical temperature profile, wind speed and direction)
- Ground absorption (influence of hard or soft ground types on propagation)
- Topography and structures (attenuation due to intervening buildings and terrain features.

Impact 14: Increase in ambient noise levels due to operation of construction equipment, movement of construction traffic and blasting may create nuisance for nearby communities and visiting tourists.

Applicable Project Phase	*Construction*

Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Moderate	Short Term	Small	Low	**Possible**	**Low**	-	High

Mitigation measures:

1. Develop a Noise and Vibration Control Plan.

Noise generated from construction sites from construction activities

- Select the quietest available plant and equipment that can economically undertake the work required.
- Undertake maintenance of the equipment as simple maintenance can reduce noise levels by as much as 50%. Parts may become loose, creating more noise because of improper operation or scraping against other parts. Grinding noises may also occur as the result of inadequate lubrication.
- Equipment under use will be regularly maintained, tuned, and provided with mufflers to minimize noise levels.
- Use visual alarms in preference to audible alarms.
- Enclose noisy equipment.
- Provide noise attenuation screens, where appropriate.
- Build an enclosure around the noise source so that noise is contained. The enclosure should be free from gaps and made of dense material and be lined with noise-absorbing material like glass or polyester batts.
- Locate noisy equipment behind parking lots or parks.
- Close liaison with the community and regular monitoring of the noise levels in the community are key to successfully implementation of the above mitigation measures. Specifically, inform communities of all major construction activities three days in advance.

Construction noise from traffic

- Fit and maintain appropriate mufflers on earth-moving and other vehicles on the site.
- Mobile plants such as excavators, front-end loaders and other diesel-engine equipment should be fitted with residential class mufflers and other silencing equipment, as applicable.
- Haul roads within the site should have as low a gradient as possible, and paving should be considered if practicable where noise-sensitive receptors are likely to be affected;
- Owners and operators of existing facilities should implement special noise reduction measures, such as erecting purpose-built acoustic barriers, restricting opening hours and maintaining transport vehicle

Construction noise from on-site plant operations and equipment

- All fixed plant at the work sites will be appropriately selected, and where necessary, fitted with silencers, acoustical enclosures and other noise attenuation measures.
- Modify the equipment or the work area to make it quieter by substituting existing equipment with quieter equipment; retro-fitting existing equipment with damping materials, mufflers, or enclosures; erecting barriers; and maintenance.
- Shift to a quieter construction process for example pile driving is very loud as compared to boring which is a much quieter way to do the same work.
- Combine noisy operations to occur in the same time period. The total noise level produced will not be significantly greater than the level produced if the operations were performed separately.

- All plant and equipment should be regularly maintained.
- Move static plant and equipment as far as possible from sensitive boundaries, as work allows. A distance of four times further away lowers the noise by 12 dBA. A reduction of 10 dBA will sound half as loud.
- Sound attenuation measures should be used for plant and equipment such as baffles and specialized mufflers, acoustic enclosures or partial enclosure housings.
- Acoustic barriers need to be designed and purpose built if needed. Vegetated buffer zones can also be planted to mitigate noise from operations using suitably selected native plantings local to the area.
- Reduce workers' exposure to high noise levels by keeping moving workers away from the noise source; restricting access to areas; rotating workers performing noisy tasks; and shutting down noisy equipment when not needed.

Use earplugs to reduce workers' exposure to high noise levels.

Noise generated from the blasting in quarry areas

- Using vibratory piling instead of impact piling.
- Conveyor belts and crushing/screening equipment can be housed to provide acoustic screening.
- It is important that sound-reduction equipment fitted to machinery is used and maintained properly.
- Erect earth mounds around the site boundary can provide acoustic as well as visual screening.
- Soft ground (e.g. grassland and cultivated fields) attenuation can sometimes have a greater impact in reducing noise than barrier attenuation, especially if the ground supports sound absorbing vegetation.

Noise emissions from concrete batching

- Locate noisy equipment away from potential sources of conflict.
- Locate noisy equipment behind sound barriers or sound absorbers – for example, gravel stockpiles or constructed barriers.
- Install silencing devices to all pressure operated equipment.

Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	**Possible**	**Low**	-	High

7.7.1 Existing Conditions

There is no continuous major anthropogenic source of noise in the communities. Intermittent sources include farm equipment and traffic. River noise is only the continuous source present at construction sites of the Project. Noise baseline conditions at the Project construction sites in the villages are between 40 dBA and 60 dBA for daytime and 37 dBA and 53 dBA for nighttime. The detailed noise levels are presented in **Section 4.1.10** (*Noise Levels*).

7.7.2 Criteria for Determining Significance

The World Bank guidelines and NEQS for noise require that the sound level in residential areas should not exceed 55 dBA during the day and 45 dBA during the night as presented in **Exhibit 7.23.** World Bank guidelines also state that noise impacts should not exceed the levels presented in **Exhibit 7.23** or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

Exhibit 7.23: NEQS and IFC Guidelines on Ambient Noise Levels

Specific Environment	*Maximum Allowable Log Equivalent (Hourly Measurements), in dB A*			
	IFC-EHS limit Day (7:00-22:00)	*IFC-EHS limit Night (22:00-7:00)*	*NEQS Day (6:00-22:00)*	*NEQS Night (22:00-6:00)*
Residential, institutional, educational	55	45	55	45
Industrial	75	65	70	70
Commercial	65	55	70	70

7.7.3 Impact Analysis

The analysis presented in this section is based on the approach recommended by Federal Highway Administration of the US Department of Transportation for assessment of construction noise.[9]

Precise prediction of noise due to construction activity at given location at a given time requires the list of all equipment that is operational at the time and the following information regarding each piece of equipment:

- The maximum and minimum noise levels, measured at a reference distance from the equipment, during a work cycle
- The fraction of time it operates at maximum level during a work cycle
- The usage factor, i.e., the number of hours during the day when the equipment is operational
- The distance of the equipment from the receptor
- Potential noise barriers and other topographic features that attenuate the sound.
- Atmospheric conditions—the wind speed and direction, humidity and barometric pressure—also affect the propagation of sound, however, for short distances the effect of these is insignificant compared to other variables.

Construction noise levels at the nearest receptor in the nearby village, located approximately at 350 m from the boundary of construction site, would fluctuate depending on the type, number, distance from receptor, and duration of use of various pieces of construction equipment. In this analysis, first the noise level due to each piece of equipment, which is likely to be used in the construction, is calculated. The peak noise levels of construction equipment mainly used at a typical construction site, are shown in **Exhibit 7.24**. The list includes all equipment except vehicles and some minor pieces of equipment. Using this data, the expected noise level, $L_{eq(8\text{-}hr)}$, is calculated. The predicted noise levels are shown in **Exhibit 7.25**. It shows that the highest equivalent noise level for an 8-hour shift due to a single piece of equipment at a receptor 500 m from the source

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[9] Highway Construction Noise: Measurement, Prediction, and Mitigation, Reagan, J. A. and C. A. Grant, Special Report. US. Department of Transportation, Federal Highway Administration.

will be about 52 dBA. This is under no-mitigation conditions and assuming no attenuation due to ground features.

When more than one piece of equipment are working simultaneously, the noise level at the receptor will increase. Generally speaking, the noise level will increase by 3 dBA due to the first equipment. Increase due to subsequent addition of equipment will gradually decrease from 3 dBA. So if five equipment, each producing 52 dBA at the receptor, are working simultaneously, the resulting noise level will be around 59 dBA. The attenuation due to topographic factors could be up to 5 dBA. Good maintenance of equipment with installation of noise mufflers can reduce the noise by another 5 dBA.

Exhibit 7.24: Construction Equipment Noise Ranges (dBA)

Equipment	*Peak Noise Range at 15.2 m*	*Typical Peak Sound Level in a Work Cycle*[a]	*Typical 'Quieted Equipment' Sound Level*[b]	*Construction Phase*		
				Earthworks	*Structures*	*Installation*
Batching plant	82-86	84	81		Y	
Concrete mixers	76-86	85	82		Y	
Cranes	70-94	83	80		Y	Y
Excavators	74-92	85	82	Y		
Tractors and trolleys	77-94	88	85	Y	Y	Y
Water bowsers	85-93	88	85	Y	Y	Y
Graders	72-92	85	82	Y		
Bulldozers	65-95	80	75	Y		
Paver	87-89	88	80	Y		
Pumps	68-72	76	75	Y	Y	Y
Diesel generators	72-82	78	75	Y	Y	Y
Vibrators	68-82	76	75	Y	Y	
Drilling machines	82-98	90	87		Y	Y
Compressors	74-84	81	71		Y	
Dumpers	77-96	88	83	Y	Y	Y
Road rollers	73-77	75	72	Y		

Sources:Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances. USEPA; Bolt, Beranek, and Newman, 1971.

Notes:

[a] Where typical value is not cited in literature, mean of the peak noise range is assumed

[b] Quieted equipment can be designed with enclosures, mufflers, or other noise-reducing features. Where data is not available, a 3 dB reduction is assumed

It can be seen that some equipment are in compliance with the NEQS and IFC-EHS limits when they are operated on an individual basis. Night time construction activities may exceed the limits for certain construction equipment as shown in **Exhibit 7.25**. It is therefore, predicted that the resultant noise levels at the receptors when the construction work is carried out at a distance of the 350 m from the receptor could be in the range 50-55 dBA. In areas where the baseline noise level is high, say 60 dBA, the increase will be less than 2 dBA and thus barely noticeable. Note that the above statement is valid if there is a continuous non-fluctuating noise source. As the noise levels of construction equipment vary considerably, the community can easily notice the variation. However, the overall noise level, L_{eq}, is likely to be within the predicted limited.

In addition to inherent fluctuation in equipment, the other factors that can increase the noise levels at the community include, simultaneous operation of a very large number of equipment, equipment working in close vicinity of the dwellings, receptors located on elevated area thus eliminating attenuation due to topography, and receptors located downwind of the equipment.

Exhibit 7.25: Predicted Noise Level for Construction Equipment (dBA)

Equipment	*Equivalent Noise Level in an 8-hr Shift at Receptor 250-500 m from Source*	*Individual Compliance*	
		Daytime	*Nighttime*
Batching plant	59	No	No
Concrete mixers	59	No	No
Cranes	54	Yes	No
Excavators	54	Yes	No
Tractors and trolleys	49	Yes	No
Water bowsers	49	Yes	No
Graders	45	Yes	Yes
Bulldozers	45	Yes	Yes
Paver	45	Yes	Yes
Pumps	45	Yes	Yes
Diesel generators	43	Yes	Yes
Vibrators	43	Yes	Yes
Drilling machines	43	Yes	Yes
Compressors	43	Yes	Yes
Dumpers	43	Yes	Yes
Road rollers	43	Yes	Yes

7.7.4 Mitigation

Noise mitigation measures for each construction activity are presented in **Exhibit 7.26.** As the final location of the construction equipment is not known at this stage a safe buffer distance for loud construction activities is also provided in the Exhibit to guide final location of Project construction infrastructure.

Exhibit 7.26: Mitigation Measures for Controlling Noise

Source/Activity	*Zone of Impact*	*Mitigation Measures*
Noise generated from construction sites from construction activities Construction activities include removal of topsoil and overburden, excavation with machinery, drilling and blasting of rock, crushing and screening of aggregates, transport of raw materials and finished products within the site and on public roads, etc.		**Source Mitigation** ▶ Select the quietest available plant and equipment that can economically undertake the work required. ▶ Undertake maintenance of the equipment as simple maintenance can reduce noise levels by as much as 50%. Parts may become loose, creating more noise because of improper operation or scraping against other parts. Grinding noises may also occur as the result of inadequate lubrication. ▶ Equipment under use will be regularly maintained, tuned, and provided with mufflers to minimize noise levels. ▶ Use visual alarms in preference to audible alarms **Pathway Mitigation** ▶ Enclose noisy equipment. ▶ Provide noise attenuation screens, where appropriate. ▶ Building an enclosure around the noise source so that noise is contained. The enclosure should be free from gaps and made of dense material and be lined with noise-absorbing material like glass or polyester batts. ▶ Locate noisy equipment behind parking lots or parks. **Receiver Mitigation** ▶ Close liaison with the community and regular monitoring of the noise levels in the community are key to successfully implementation of the above mitigation measures. Specifically, ▶ Inform communities will of all major construction activities three days in advance, ▶ Discuss noise control measures with the community through informal and formal meetings, and ▶ Implement a complaint registering, tracking and redressal mechanism and undertake on-demand monitoring also in case of any complaints.

Source/Activity	*Zone of Impact*	*Mitigation Measures*
Construction noise from traffic Heavy vehicles on access routes can create disturbing noise entering and exiting the facility. The siting of such facilities need to consider the traffic routes the vehicles will travel, preferably not through built-up residential areas.	The EPA Guidance for the Assessment of Environmental Factors (Separation Distances between Industrial and Sensitive Land Uses) requires that a minimum separation distance of 1,000 metres be provided.[10] Main transport routes to the facility should avoid residential or sensitive use areas.	**Source Mitigation** ▶ Mobile plant such as excavators, front-end loaders and other diesel-engine equipment should be fitted with residential class mufflers and other silencing equipment, as applicable. **Pathway Mitigation** ▶ Haul roads within the site should have as low a gradient as possible, and paving should be considered if practicable where noise-sensitive receptors are likely to be affected; **Receiver Mitigation** ▶ Owners and operators of existing facilities should implement special noise reduction measures, such as erecting purpose-built acoustic barriers, restricting opening hours and maintaining transport vehicle.
Construction noise from on-site plant operations and equipment The extent to which plant and equipment may disturb neighbouring properties will depend on local circumstances and on the nature, level or frequency of the sound emitted, its duration and the time at which it is made.	The EPA Guidance for the Assessment of Environmental Factors (Separation Distances between Industrial and Sensitive Land Uses) requires a minimum separation distance of 1,000 metres.[11]	**Source Mitigation** ▶ All fixed plant at the work sites will be appropriately selected, and where necessary, fitted with silencers, acoustical enclosures and other noise attenuation measures. ▶ Modify the equipment or the work area to make it quieter by substituting existing equipment with quieter equipment; retro-fitting existing equipment with damping materials, mufflers, or enclosures; erecting barriers; and maintenance. ▶ Shift to a quieter construction process for example pile driving is very loud as compared to boring which is a much quieter way to do the same work. ▶ Combine noisy operations to occur in the same time period. The total noise level produced will not be significantly greater than the level produced if the operations were performed separately. ▶ All plant and equipment should be regularly maintained. **Pathway Mitigation**

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[10] Environmental guidelines for construction and demolition, department fo environment and conservation, 2009 http://www.sulo.com.au/wp-content/uploads/2013/07/Environmental_Guidelines_for_Construction_Demolition_Recycling_Facilities_Sep_2009.pdf

[11] Ibid.

Source/Activity	*Zone of Impact*	*Mitigation Measures*
		▶ Move static plant and equipment as far as possible from sensitive boundaries, as work allows. A distance of four times further away lowers the noise by 12 dBA. A reduction of 10 dBA will sound half as loud. ▶ Sound attenuation measures should be used for plant and equipment such as baffles and specialized mufflers, acoustic enclosures or partial enclosure housings. ▶ Acoustic barriers need to be designed and purpose built if needed. Vegetated buffer zones can also be planted to mitigate noise from operations using suitably selected native plantings local to the area. **Receiver Mitigation** ▶ Reduce workers' exposure to high noise levels by keeping moving workers away from the noise source; restricting access to areas; rotating workers performing noisy tasks; and shutting down noisy equipment when not needed. ▶ Use earplugs to reduce workers' exposure to high noise levels.
Audible noise generated from the blasting in quarry areas Blasting (which occurs at quarries, but not in sand and gravel pits) can give rise to vibration, audible noise, flyrock and dust. Nonetheless, vibration transmitted through the ground and pressure waves through the air ("air overpressure") can shake buildings and people and may cause nuisance. Audible noise accompanies overpressure.	A buffer zone of one kilometre (1 km) is to be maintained around existing quarry sites to ensure protection of adjacent areas from quarrying activities in Draft Noise Management Guideline, 1996.[12]	**Source Mitigation** ▶ Using vibratory piling instead of impact piling. ▶ Conveyor belts and crushing/screening equipment can be housed to provide acoustic screening. ▶ It is important that sound-reduction equipment fitted to machinery is used and maintained properly; **Pathway Mitigation** ▶ Erect earth mounds around the site boundary can provide acoustic as well as visual screening. ▶ Soft ground (e.g. grassland and cultivated fields) attenuation can sometimes have a greater impact in reducing noise than barrier attenuation, especially if the ground supports sound absorbing vegetation;

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[12] http://www.legislation.act.gov.au/ni/2002-247/20020404-2973/pdf/2002-247.pdf

Source/Activity	*Zone of Impact*	*Mitigation Measures*
Noise emissions from concrete batching Concrete batching plants are where ingredients such as sand, cement, water and aggregate are mixed to form concrete. This consists of various activities such as storage of raw materials in bunkers and stockpiles, transfer of raw materials by front end loaders, conveyors, hoppers and loading of materials to the trucks.		**Source Mitigation** ▶ Locate noisy equipment away from potential sources of conflict ▶ Locate noisy equipment behind sound barriers or sound absorbers – for example, gravel stockpiles or constructed barriers ▶ Install silencing devices to all pressure operated equipment

7.8 Soil, Topography and Land Stability

The impacts associated with soil topography and land stability are discussed in this section. The detailed description of the geology, land use and soil quality is provided in **Section 4.1.4** (*Geology, Soils and Seismic Hazards*). The impacts are summarized below:

- Impact 15: Contamination of soil as a result of accidental release of solvents, oils and lubricants can degrades soil fertility and agricultural productivity.
- Impact 16: Land clearing, excavation, tunnel boring and other construction activities may loosen the top soil in the Project area resulting in loss of soil, accelerated soil erosion, and landslides, especially in the wet season.
- Impact 17: Increased erosion and sediment load entering river as a consequence of failure of spoil dumping sites.

7.8.1 Soil Quality

<table>
<tr><td colspan="9">Impact 15: Contamination of soil as a result of accidental release of solvents, oils and lubricants can degrades soil fertility and agricultural productivity.</td></tr>
<tr><td colspan="5">Applicable Project Phase</td><td colspan="4"><i>Construction</i></td></tr>
<tr><td rowspan="2">Initial Impact Rating</td><td>Magnitude</td><td>Duration</td><td>Scale</td><td>Consequence</td><td>Probability</td><td>Significance</td><td>+/-</td><td>Confidence</td></tr>
<tr><td>Moderate</td><td>Medium</td><td>Intermediate</td><td>Medium</td><td>Possible</td><td>Medium</td><td>-</td><td>High</td></tr>
<tr><td colspan="9">Mitigation measures:
1. Prepare a Spill Prevention and Response Plan and induct to the staff for any incident of spill.
2. Appropriately mark fuel tanks by content and store in dyked areas with an extra 10% of the storage capacity of the fuel tank. The area will be lined with an impervious base.
3. Install grease traps on the site, wherever needed, to prevent flow of oily water.
4. Spill cleaning kit (shovels, plastic bags and absorbent materials) will be available near fuel and oil storage areas.
5. Carry cleanup kits in all fuel trucks.
6. Fueling should only take place over impermeable surfaces, other hazmats should be stored and used over impermeable surfaces.
7. The bottom of any soak pit or septic tank shall be at least 10 m above the groundwater table. The distance can be reduced, based on the soil properties, if it is established that distance will not result in contamination of groundwater.</td></tr>
<tr><td rowspan="2">Residual Impact Rating</td><td>Magnitude</td><td>Duration</td><td>Scale</td><td>Consequence</td><td>Probability</td><td>Significance</td><td>+/-</td><td>Confidence</td></tr>
<tr><td>Minor</td><td>Medium</td><td>Intermediate</td><td>Low</td><td>Unlikely</td><td>Low</td><td>-</td><td>High</td></tr>
</table>

Oil spills during construction process will result in contamination of soil as well as groundwater. Due to hilly nature of the Project area, soil contamination on the construction site has the potential to travel to surrounding areas and contaminate the soil. Such spills can occur during construction process when tankers will access the area for refueling of excavation and other construction machinery.

Improper handling of oils, lubricants and other such solvents may result during machinery refueling. Storage in areas with no lining and low quality storage containers poses another threat of soil contamination. The impact will be minimized by adopting mitigation measures and extra caution during refueling and machinery maintenance at on site workshops.

7.8.2 Soil Erosion

Impact 16: Land clearing, excavation, tunnel boring and other construction activities may loosen the top soil in the Project area resulting in loss of soil and possible acceleration of soil erosion and land sliding, especially in the wet season.

Applicable Project Phase	*Construction*

Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Moderate	Short Term	Small	Low	[redacted]	**Low**	-	High

Mitigation measures:

1. Develop an Erosion Control Plan.
2. Limit vegetation loss to demarcated construction area.
3. Cover areas such as muck disposal area, batching plant, labor camp and quarry sites after the closure shall with grass and shrubs.
4. Adopt slope stabilization measures such as adequate vertical and horizontal drains, drainage along roadsides, cross drainage and retaining walls.
5. Monitor slope movements around excavation work areas.
6. Salvage, store, and reuse all topsoil at all construction sites.
7. The height of the stockpile will be minimized to the extent possible by increasing the size of the land for the stockpile.
8. Topsoil will be carefully stripped to ensure that it is not mixed with subsoil.
9. The stockpiles will be revegetated to minimize loss of soil quality, minimizing weed infestation, maintaining soil organic matter levels, maintaining soil structure and microbial activity.
10. Topsoil stockpiles will be clearly signposted for easy identification and to avoid any inadvertent losses.
11. The establishment of declared plants on the stockpiles will also be monitored and control programs implemented as required.
12. The topsoil will be treated with temporary soil stabilization and erosion control measures.
13. During removal of topsoil stockpile for restoration of project affected areas, it is preferred that the soil is removed in layers (less than 0.5 m thick) under a gradual process.
14. The top layer will be mixed with the remainder of the stockpile to ensure that living organisms are distributed throughout the topsoil material at the time of final placement. The use of micro-organism inoculates may be necessary to re-establish micro-organisms in topsoil material.
15. Select local species for plantation to restore the biodiversity of the area in consultation with Forest Department after completion of respective activities.

Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	**Possible**	**Low**	-	High

The top cover of soil on the slopes around the Project facilities is mainly sand and fine clay. Any excavation work during the construction activities, whether permanent or temporary, would lead to loss of soil. Excavated material collected during boring of the diversion tunnels will be used for the construction of cofferdam to divert water. Furthermore, construction will require excavation for the powerhouse, tunnels and other project facilities. These activities will result in loss of soil. Erosion of soil can also occur from removal of vegetation cover, runoff from unprotected excavated areas, muck disposal sites and quarry sites. Excavations on slopes would also decrease its stability. Given the topography of the area, unprotected excavations on sloping grounds may lead to landslides, especially during the rainy season. Major landslides will disturb the slopes of the area and may also alter the bed of Kunhar River.

It is expected that moderate level of risk is associated with the type of construction activities that are likely to take place. The current land formation is fairly stable sandstone therefore no major risk 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. The probability of this risk is estimated to be definite due to extensive excavation activities expected for the dam, powerhouse and most importantly the tunnels.

Topsoil from the Project site will be stockpiled for use during the restoration process. As the topsoil will be stockpile for use during the restoration process, it is important that it must retain its advantageous chemical, physical, and biological properties. Generally, the soil is adversely affected during storage if the depth of the stockpile is more than 3 m. Anaerobic conditions are created in the deeper depths, which results in decrease in microbial activity in the stockpiled soil and consequently adversely affect the biological properties. The mitigation measures proposed for ensure the regeneration of biological activity in the topsoil are provided and will be followed.

7.8.3 Spoil Disposal Areas

<table>
<tr><td colspan="9">Impact 17: Failure of spoil dumping sites resulting in increased erosion and sediment load entering river.</td></tr>
<tr><td colspan="3">Applicable Project Phase</td><td colspan="6"><i>Construction and Operation</i></td></tr>
<tr><td rowspan="2">Initial Impact Rating</td><td>Magnitude</td><td>Duration</td><td>Scale</td><td>Consequence</td><td>Probability</td><td>Significance</td><td>+/-</td><td>Confidence</td></tr>
<tr><td>Moderate</td><td>[redacted]</td><td>Intermediate</td><td>[redacted]</td><td>Possible</td><td>[redacted]</td><td>-</td><td>High</td></tr>
</table>

Mitigation measures:

1. Dumping sites should have a flood prevention design for a 20-year flood.
2. The water drainage works consist of the masonry structures, and shall be designed to drain a 5-year rainfall every 10 minutes.
3. Where constructed tailing hold structure will be of galvanized woven wire mesh gabions
4. All the five dumping sites will undergo vegetation restoration works comprising of surface leveling, covering and forest/grass planting or agricultural land rehabilitation
5. Develop a Spoil Disposal Plant that includes the following measures:

- Slope movements will be monitored around excavation work areas.
- Restore to the maximum extent possible the hydrological regime and reinstate natural drainage of the land (including provisions to maintain the water balance of the site and protect from flooding where appropriate)
- Reinstate topsoil (in case it was stripped before construction activities)
- Revegetate sites with suitable native plant species
- Drain spoil piles to prevent the concentration of flow and to prevent rill and gully erosion
- Separate organic material (e.g., roots, stumps) from the dirt fill and store separately. Place this material in long-term, upland storage sites, as it cannot be used for fill.
- Store "clean" material in a short-term disposal site (stockpile) if it will likely be re-used for fill.
- Where feasible, recycle asphalt material in embankments and shoulder backing. Place these materials where they will not enter the stream system. Asphalt that is 5 years old is considered "inert" (that is, all oils washed off).
- Do not add excess unusable material to permanently closed sites.

- Spread material not to be re-used in compacted layers, generally conforming to the local topography. Design the final disposal site reclamation topography to minimize the discharge of concentrated surface water and sediment off the site and into nearby watercourses.
- Cover the compacted surfaces with a 6-inch layer of organic or fine-grained soil, if feasible.
- After placement of the soil layer, track walk the slopes perpendicular to the contour to stabilize the soil until vegetation is established. Track walking creates indentations that trap seed and decrease erosion of the reclaimed surfaces.
- Revegetate the disposal site with a mix of native plant species. Cover the seeded and planted areas with straw compost, mulched with straw at a rate of 1 to 1 ½ tons per acre. Apply jute netting or similar erosion control fabric on slopes greater than 1:2 if site is erosive.
- Locate stockpiles away from drainage lines, at least 10 meters away from natural waterways and where they will be least susceptible to wind erosion.
- Ensure that stockpiles and batters are designed with slopes no greater than 1:2 (vertical\ horizontal).
- Besides these measures, erosion can also be minimized by regular rehabilitation of areas not in use for Project activities during construction. These will include regrading and immediate revegetation (using fast-growing species and different functional groups of plants for keeping soil in place) of slopes to minimize erosion.
- Install erosion and sediment control measures, if possible before construction commences. Identify drainage lines and install control measures to handle predicted storm water and sediment loads generated in the mini-catchment.
- Establish an adequate inspection, maintenance and cleaning program for sediment run-off control structures. Ensure that contingency plans are in place for unusual storm events.
- Continually assess the effectiveness of sediment control measures and make necessary improvements.
- Keep temporary disposal sites out of wetlands, adjacent riparian corridors, and ordinary high-water areas as well as high risk zones, such as 100-year floodplain and unstable slopes.
- Anticipate sufficient storage area with no risk for sediment delivery for piles that may slump. Stress cracks indicate that the pile is at risk of slumping.
- Cover the trucks that will be used for the transportation of spoil material to disposal sites.

Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Moderate	**Medium Term**	**Intermediate**	**Medium**	Unlikely	**Low**	-	High

In the event of failure of a waste dumping site, there can be a danger to downstream communities and sediment can be released into the river impacting the ecology. Sites not revegetated or rehabilitated can be a constant source of fugitive dust emissions due to wind erosion from the surface. Critical mitigation measures listed above ensure spoil units are stable for the coming decades and centuries.

Comparison of Spoil Disposal Zones

Spoil disposal zones under consideration are shown in **Section 3.5**. A comparison of these zones was done as part of the EIA based on the land use within each zone. **Exhibit 7.27** shows the different land uses including habitat types, in each zone.

Exhibit 7.27: Land Use in Spoil Disposal Zones

Disposal Zones	*Area (m^2)*	*Agriculture Land*	*Pine Forest*	*River*	*Settlement*	*Barren Land*
1	60,859	40%	19%	0%	17%	24%
2	37,316	0%	79%	0%	0%	21%

Disposal Zones	Area (m^2)	Agriculture Land	Pine Forest	River	Settlement	Barren Land
3	30,376	0%	35%	12%	0%	52%
4	220,083	41%	4%	15%	0%	39%
5	48,434	25%	0%	10%	2%	63%

The following impacts can be expected:

- The three zones 1, 4 and 5 will have significant socioeconomic impacts as compared to other zones. This is because of the presence of large percentage of settlements associated with physical displacement and agricultural land associated with economic displacement i.e. livelihood. Of the three; Zone 1 will have the highest socioeconomic impact (settlements: 17% and agricultural land: 40%) followed by Zone 4 and Zone 5.
- The two zones 2 and 3 will have significant impact on the ecology as compared to other zones. This is because of the presence of large percentage of forests associated with terrestrial ecology. Of the two; Zone 2 will have the highest impact on ecology as 79% of it is used by forests.
- The three zones 3, 4 and 5 will pose the greatest impact to river ecology as parts of the area in these is stretches of river where spoil can contaminate the water quality, if proper mitigation measures are not taken.

Based on the above discussion, spoil disposal in Zone 3 will have the least impact followed by Zone 2 as land in these zones is not used by the community for settlements or agriculture. However, Zone 2 has 79% Pine Forest and is therefore, important for terrestrial biodiversity.

7.9 Aesthetics

Visual impacts are the effects on people of the changes in available views through intrusion or obstruction and whether important opportunities to enjoy views may be improved or reduced. Visual impact to nearby receptors of the Project include:

- Impact 18: Deterioration of aesthetics and visual amenity of nearby receptors due to construction activities, including vehicular movement on roads, may cause disturbance in aesthetics for tourists, businesses and nearby communities.
- Impact 19: Deterioration of aesthetics and visual amenity of nearby receptors due to low flow in the river may affect the scenic value of the area.
- Impact 20: Permanent change in aesthetics of the area due to the reservoir, dam and powerhouse.

Section 4.1.5 (*Visual Character*) describes the existing visual (aesthetic) character of the site. The area largely consists of mountainous valleys with large trees and bushes of heights greater than 2 m. The mountainous landscape and deep gorges greatly restricts visibility to a maximum of 0.5 to 1.5 km at receptor locations. The area is a popular tourist location (see **Section 4.3.4** *River Dependent Socioeconomic Activities*) due to its aesthetic beauty due to the mountains, forests, rivers and streams.

7.9.1 Degradation of Aesthetic Value of the Area due to Construction Activities

Impact 18: Deterioration of aesthetics and visual amenity of nearby receptors due to construction activities, including vehicular movement on roads, may cause disturbance in aesthetics for tourists, businesses and nearby communities.								
Applicable Project Phase				*Construction*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	**Possible**	**Low**	-	High
Mitigation measures: 1. Minimize disturbance to, or movement of, soil and vegetation. 2. Back fill to original levels. 3. Reshaping to match in with surrounding topography. 4. Reinstate vegetation around construction sites.								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	**Possible**	**Low**	-	High

The construction phase visual impact will be local and temporary. The construction will take place at the powerhouse site and dam site. The activities during construction that will affect the aesthetics of the area include excavation, stacking of material onto stockpiles and dumping at the waste disposal areas. Borrow pits and quarry areas are to be excavated, useful material will be stacked to stockpiles whereas waste and spoils will be dumped to waste disposal areas.

Quarries and borrow areas may leave a permanent scar on the hillsides as once they are opened, will likely to continue to stay in use and as a result change the surrounding landscape. Access roads, tunnel faces[13] and adits will necessitate the clearing of vegetation for their construction. Some of the access roads to construction sites will be entirely new and permanent and some will be reconstructed to accommodate the additional construction traffic load which will also alter the landscape of the area. The tunnel faces and adits during the construction phase will be obvious cuts into the mountainsides, many of which will be likely to be visible to residents, especially those on opposing sides of the valleys. For all of these features during the construction phase there will be an impact on vegetation, as additional areas will be cleared around the feature to provide a working area. These activities will result in the creation of artificial and unnatural features in the landscape. Localized light pollution will also be an issue during construction.

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[13] Working face of tunnels

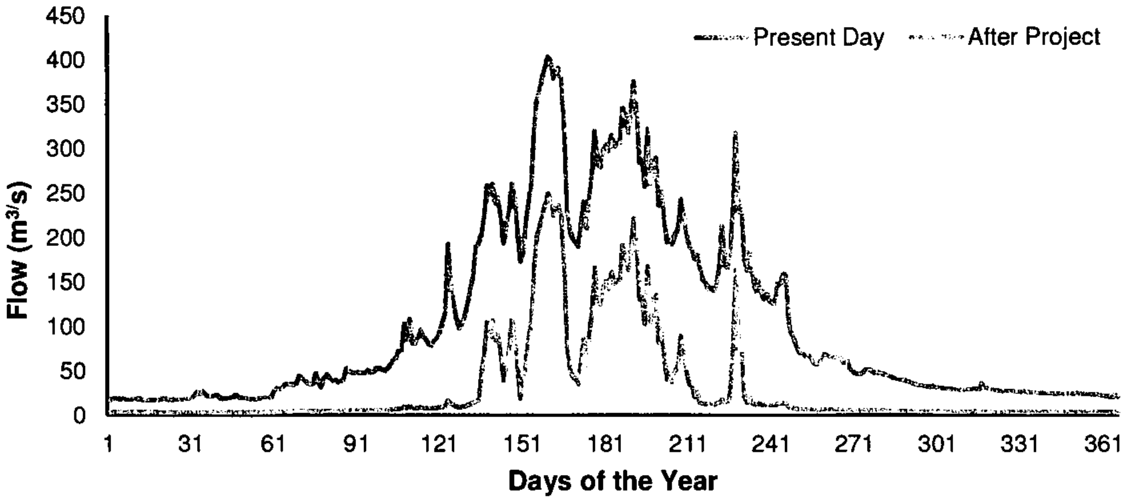
7.9.2 Degradation of Aesthetic Value of the Area due to Low Flow Section

Impact 19: Deterioration of aesthetics and visual amenity of nearby receptors due to low flow in the river may affect the scenic value of the area.								
Applicable Project Phase				*Operation*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Medium	Small	Low	Possible	Low	-	High
Mitigation measures: 1. Ensure environmental flow release.								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Medium	Small	Low	Possible	Low	-	High

The section from the dam to the tailrace will be impacted by water abstraction from the diversion tunnels. The impact will be most visible during the dry season in the winter as only environmental flow will be released downstream of the dam. In the summer overflows from the dam will be released from the spillway. However, even during this season abstraction will be at maximum.

Exhibit 7.28 shows the level of drop in the low flow section[14] for 1960. The minimum 5 day flow during the dry season is presently 17.6 m^3/s[15] which will reduce to 2.9 m^3/s after the Project begins operation. The mean flood peak in the low flow section is 330 m^3/s which will reduce to 174 m^3/s after the Project.

Exhibit 7.28: Comparison of Baseline and Post Project Hydrograph in the Low Flow Section, 1960



The extent of the low flow section is shown in **Exhibit 7.29.** This area has low occupancy and limited use in tourism due to poor access. Therefore, the aesthetic impact due to diversion is expected to be limited.

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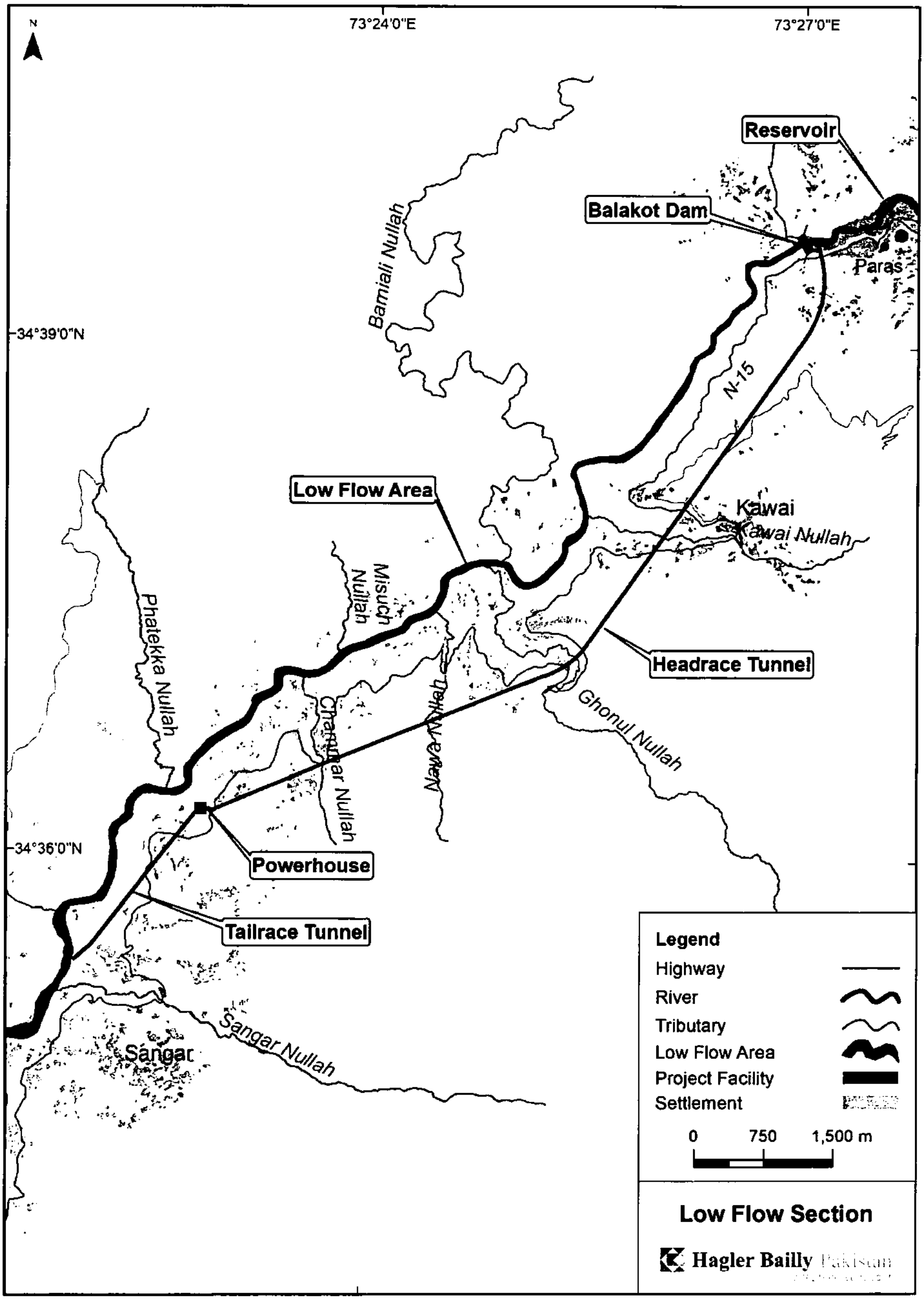
[14] With an EFlow of 1.5 m^3/s

[15] Median value over the 51 year hydrological period.

Exhibit 7.29: Low Flow Section



7.9.3 Permanent Change in Visual Character due to Project Facilities

Impact 20: Permanent impact in aesthetics due to proposed developments.								
Applicable Project Phase				*Operation*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Medium	Small	Low	Possible	Low	-	High
Mitigation measures: 1. Develop and implement a Site Rehabilitation and Landscaping Plan. 2. Use colors that better integrate with the landscape. 3. Disguise elements with vegetation where possible. 4. Retain as much natural vegetation as possible.								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Medium	Small	Low	Possible	Low	-	High

There will be a long term visual impact due to the construction of the dam and powerhouse, and the formation of the reservoir.

The impact due to the reservoir is subjective as it may be argued that a reservoir is visually appealing and the land use is compatible with the surroundings. Natural lakes in the area are popular tourist attractions.

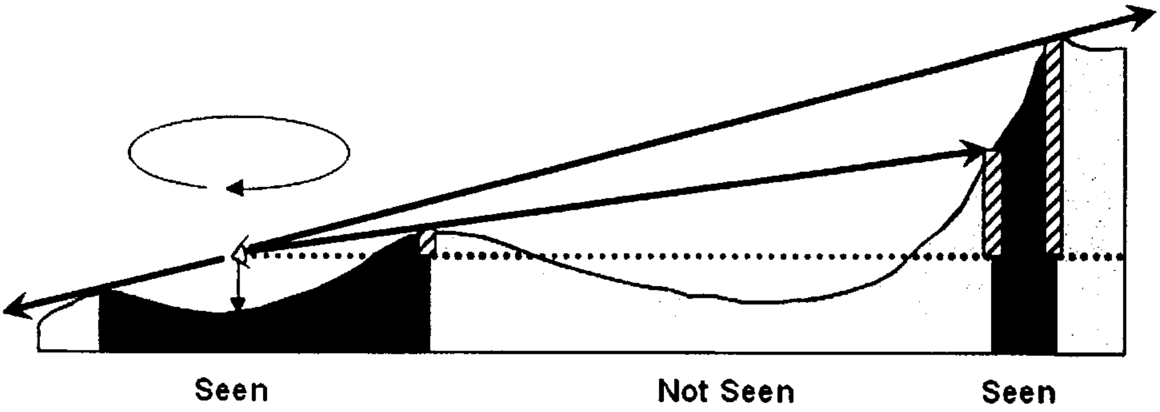
The penstock and powerhouse will be underground limiting its visual impact.

Viewshed of Proposed Project

A viewshed is the geographical area that is visible from a location. It includes all surrounding points that are in line-of-sight with that location. The areas from where the reservoir and powerhouse can be viewed was calculated through Viewshed Analysis Tool (VAT) function of ArcGIS.

The VAT uses the elevation value of each cell of the DEM to determine visibility to or from a particular cell. The VAT calculates all the points that are in line of sight (shown in **Exhibit 7.30**) and excludes all that are blocked by presence of features such as buildings, trees, and hedgerows.

Exhibit 7.30: Graphical Depiction of a Viewshed



For the analysis, a zone of visual influence was taken as 50 meters around the reservoir. This is defined as the extent of potential visibility to or from a specific area or feature. The effect of the canopy layer[16] was not incorporated, therefore, the actual viewsheds will be more limited than those presented.

The villages within 500 m of the reservoir and within the viewshed include: Balseri, Garan, Hariwala Nakka, Rah Sachcha, Shagin, Tangsan, Paras, Chuntian, Dhab, Rahter, Nihan and Tokkol.

The villages within the viewshed but further than 500 m of the reservoir include: Budhawa, Bura, Lohgi, Nakka, Shangrian, Jhabra, Bela, Uri, Chapra, Kashe and Rai Ponian. Of these, the villages Shangrian and Uri are the least Project site visible areas.

A summary of the land use and tourism potential within the 500 m buffer and viewshed of the reservoir and dam is presented in **Exhibit 7.31**. The viewshed of the reservoir and dam is shown in **Exhibit 7.32**.

Exhibit 7.31: Details of the Reservoir and Powerhouse

Parameter	*Forest*	*Agriculture*	*Settlement*	*River*
Land use distribution	74%	14%	8%	4%
Relative occupancy	Low	Medium	High	Nil
Tourism use and potential	Medium	Nil	Nil	Low

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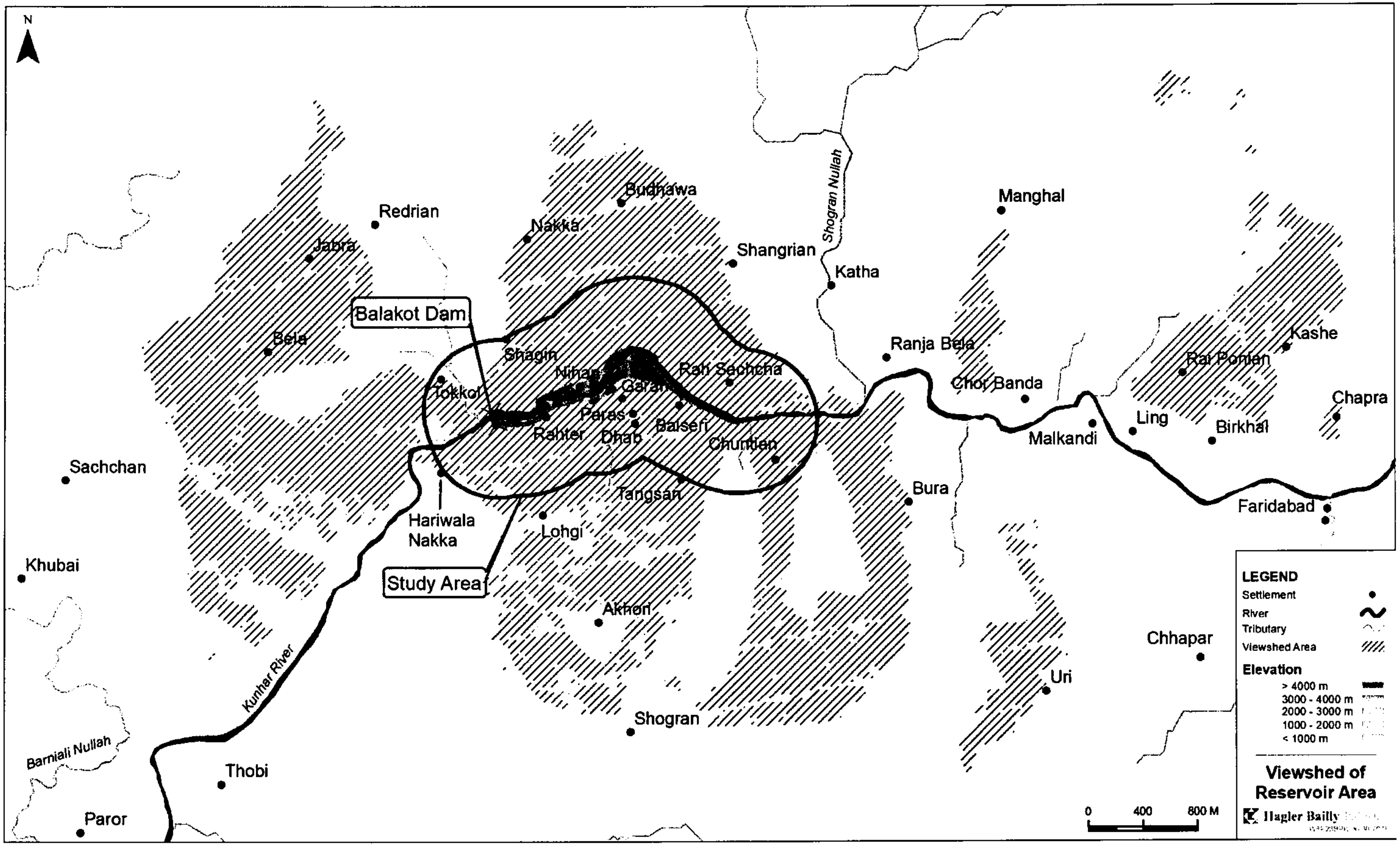
[16] Canopy layer is the uppermost layer of the forest.

Exhibit 7.32: Viewshed of the Reservoir and Dam



7.10 Traffic and Roads

There are three categories of roads that will be used to transport material and equipment to the Project facilities. These are as follows:

7.10.1 Project External Roads

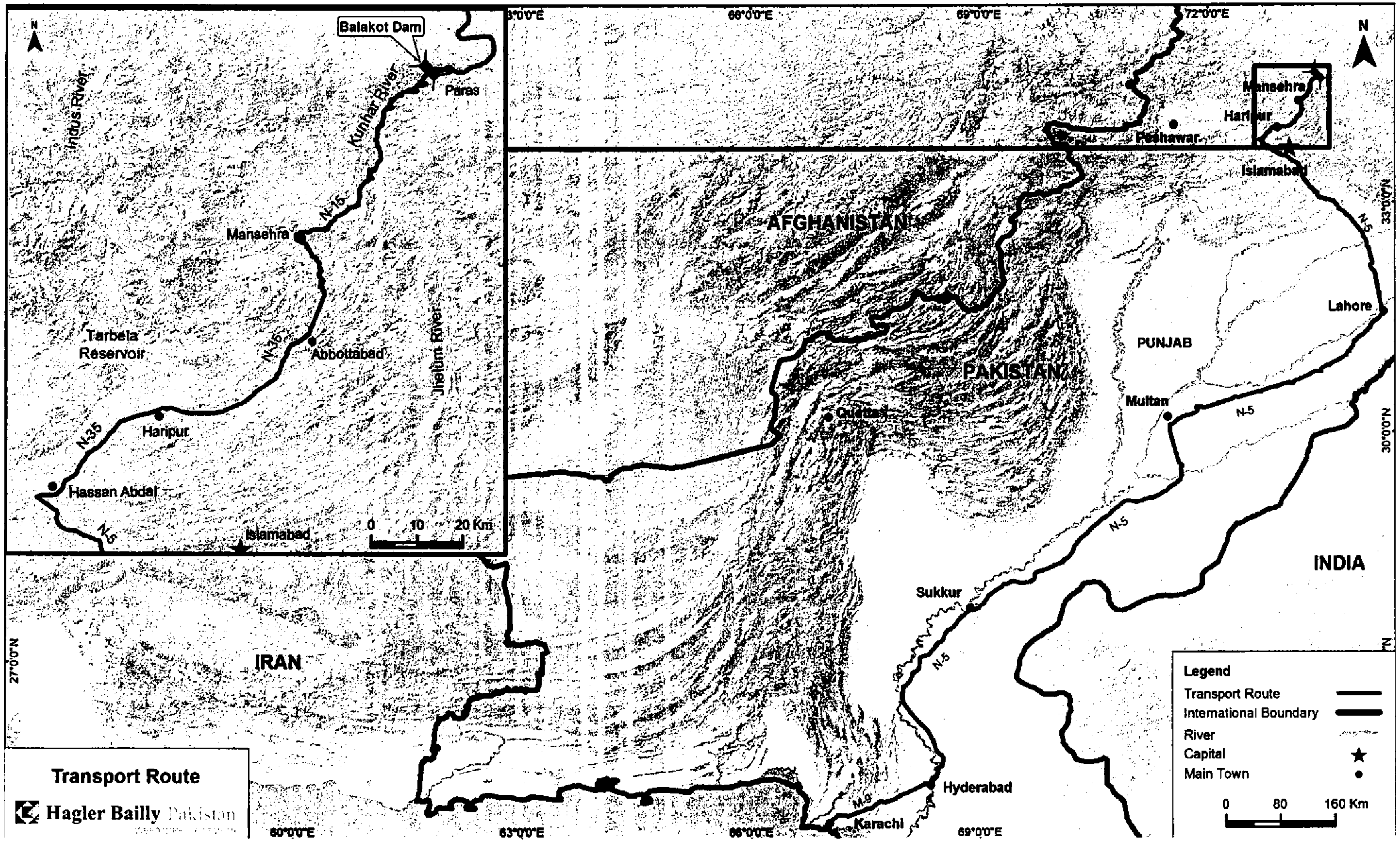
The roads connecting the major cities (Karachi and Islamabad) to the Project site and transporting materials up to the Balakot are called as Project access roads. The construction materials (cement and steel) as required for the construction of Project include:

- **Cement:** It will be required for carrying out construction of the Project structures of the order of million cubic meters. The factories that produces ordinary Portland cement, sulphate resistant cement and low alkali cement and close to the Project site are Maple Leaf Cement at Mianwali, Bestway Cement at Hattar, DG Cement at Kallar Kahar and Lafarge Cement at Kallar Kahar. Of these, the cement factory nearest to the Project is located in Hattar, District Sawabi. White cement is also produced by Anwaar Zaib Cement Factory, located near Karachi and Kohat cement factory located near Kohat. Slag cement is also required by the Project and Pakistan Steel Mills, located near Karachi is the only significant source of producing slag in Pakistan. There are other factories located around Karachi that produces Portland blast-furnace slag cement mainly in accordance with BS 146 include Dadabhoy Cement, Essa Cement, Attock Cement, Zeal Pak Cement, Pakland Cement, Javedan Cement, Thatta Cement, and Star Slag Cement Industry.
- **Steel:** Reinforced steel is required of the order of million tons. A number of re-rolling mills in the country produce reinforcing steel in the form of both plain and deformed bars of tensile strength ranging from 40 kilopound per square inch (ksi) to 60 ksi. There is no factory producing re-rolling reinforcing steel bars in the near vicinity of the Project site. The nearest location from where the reinforcing steel bars of the desired specification are available is Islamabad. Both hot and cold rolled reinforcing steel bars are available from Islamabad in desired quantity. Major source of steel billets for the re-rolling mills is Pakistan Steel Mills located near Karachi. Steel sheets of various thicknesses are also produced by the Pakistan Steel Mills at Karachi, which can be used to fabricate steel formwork. These can also be used for fabricating steel liners and other miscellaneous items required in connection with the construction activities. Alternatively, steel items can be imported from abroad. Most likely source of supply of steel could be neighboring countries such as China and Iran.

The materials and equipment purchased from China will be shipped to Karachi by sea and from Karachi transported by Project access roads to the Project area.

The transport route is shown in **Exhibit 7.33**. The alternative routes are discussed in **Section 5** *(Analysis of Alternatives).*

Exhibit 7.33: Transport Route



Construction Traffic Volume

The traffic due to the Project will be generated during the construction phase of the Project. The construction traffic volume, on the site external roads, will be due to:

- External supplies of construction material and equipment to the powerhouse and dam sited through trucks.
- Movement of construction material from one construction facility to another through trucks.
- Movement of staff among powerhouse and dam site through buses.

The construction generated traffic (**Exhibit 7.34**) will mainly consist of heavy traffic and minor contribution of light traffic due to the Project which was assumed to be 10% of heavy traffic.

Exhibit 7.34: Construction Traffic Volume

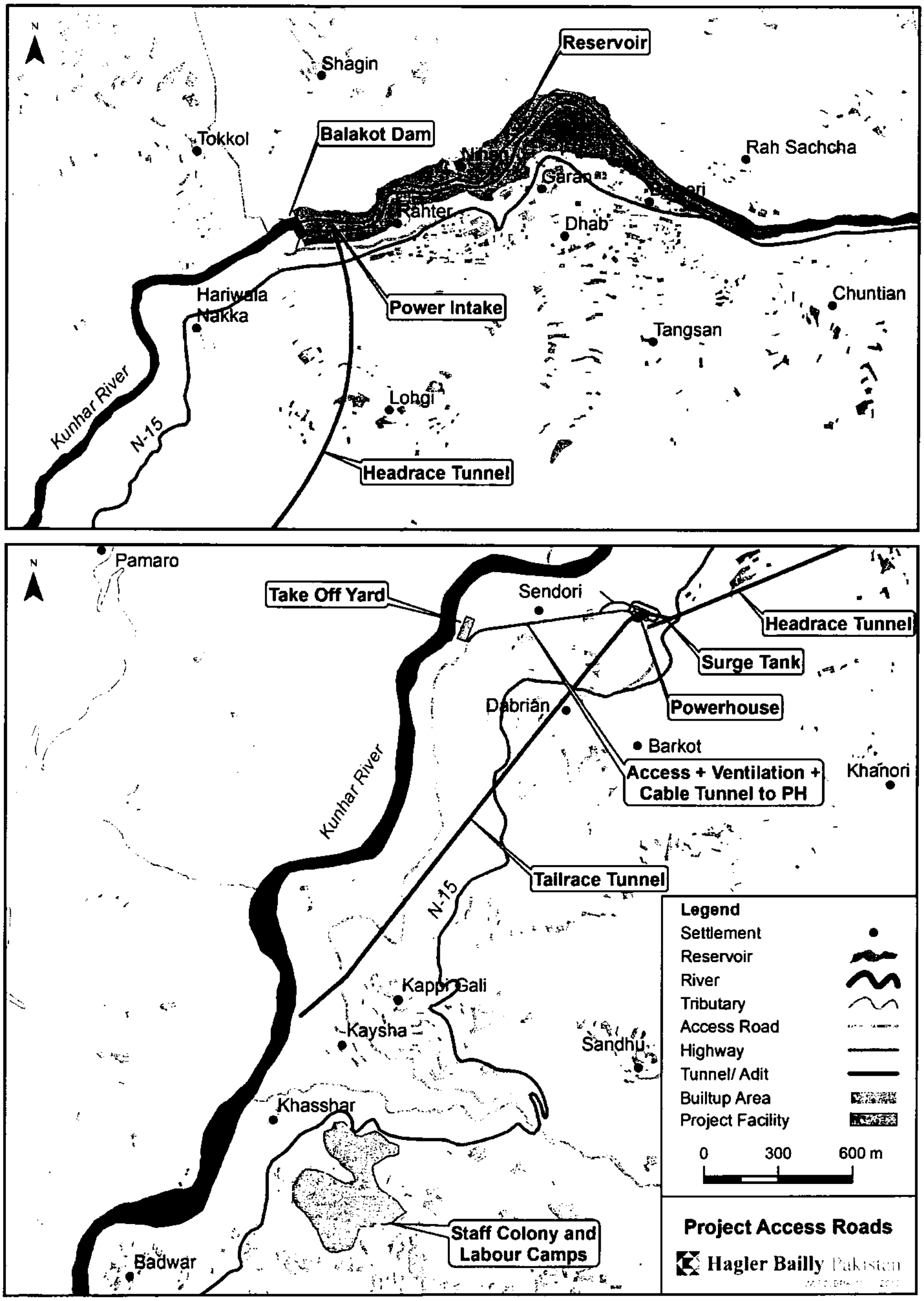
Item	*Amount (m^3)*	*Density (ton/m^3)*	*Total (million tons)*
Quarried material	250,000	2.4	0.6
Spoil material	1,100,000	1.33	1.5
Total			**2.1**

Total external traffic is 2.1 million tons as described above. This will be transported via dump trucks with a capacity of 15-20 tons a 6.5-year period of Project completion. As a worst-case scenario, the capacity of one truck is assumed to be 15 tons and 310 active days are considered. On average, there will be 70 truck trips per day. As a worst case-scenario, 40% peaking factor was used that will result in 98 truck trips per day.

7.10.2 Project Access Roads

The roads connecting the Project access roads to the Project facilities. There are three access roads planned at powerhouse site and one at dam site as shown in **Exhibit 7.35**. These Project access roads made for each specific purpose and originates from N-15. The traffic volume on these roads will be dependent on the total material required and disposed to destined sites and capacity of trucks.

Exhibit 7.35: Site Access Roads



7.10.3 Impact Analysis

The major risks of traffic on existing and proposed roads due to the Project are:

- Impact 21: Improved accessibility due to construction of Project access roads.
- Impact 22: Increase in congestion, due to increased traffic volume will cause delays.
- Impact 23: Increase in traffic volume will deteriorate the air quality.
- Impact 24: Increased risk to community safety due to increased traffic volume during the construction phase near communities.
- Impact 25: Degradation of the pavement due to use by heavy construction traffic.

Accessibility

Impact 21: Improved accessibility due to construction of Project access roads.								
Applicable Project Phase				*Construction*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	+	High
Mitigation measures: 1. Consult communities during final design and location of site access roads. 2. Allow communities use of new site access roads.								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	+	High

Land which is adjacent to roads has greater value due to the accessibility. Mountainous terrain in the area is difficult to traverse and construction of new site access roads will improve connectivity in the area.

Congestion

Impact 22: Increase in congestion, due to increased traffic volume will cause delays.								
Applicable Project Phase				*Construction*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	-	High
Mitigation measures: 1. Develop and implement a Traffic Management Plan. 2. Make roundabouts for the congestion points. 3. Retain as much natural vegetation as possible to reduce the impact of smoke due to vehicles. 4. The vehicles going on the spoil routes and passing through the communities must be completely covered to avoid dust emissions. 5. Strictly implement speed limits and defensive driving policies.								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	-	High

Traffic congestion is a condition that results as road use increases and is characterized by slower speeds, longer trip times, and increased vehicular queueing. There will be a significant congestion problem at Kappi Gali and Dabrian as shown in **Exhibit 7.35**. This is due to the traffic exchange between N-15 and Project access roads. There will be large traffic volume resulting in more vehicles, more time on the road, more idling and more smoke emissions.

Air Pollution

Impact 23: Increase in traffic volume will deteriorate the air quality.								
Applicable Project Phase				*Construction*				
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	**Possible**	**Low**	-	High
Mitigation measures: 1. Keep speeds slow (30 km/hr) on unsealed roads. 2. Sprinkle water on unsealed roads that are used for construction traffic. 3. Retain as much natural vegetation as possible to reduce the impact of smoke due to vehicles. 4. The vehicles going on the spoil routes and passing through the communities must be completely covered to avoid dust emissions. 5. Strictly implement speed limits and defensive driving policies. 6. Promptly and properly repair and maintain roads that are subject to damage by Project activities.								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	**Possible**	**Low**	-	High

The increase in traffic volume will increase environmental pollution (more noise, more emissions and more fuel consumption). It will deteriorate ambient air quality around villages and will result in high noise. As the vehicle will be in queue it continues to result in exhaust emissions and continuous engine generated noise.

There are no settlements located near access road at dam site however, the settlements Dabrian and Kappi Gali will be affected by air and noise pollution generated by Project access roads as shown in **Exhibit 7.35**.

Community Safety

Impact 24: Increased risk to community safety due to increased traffic volume during the construction phase near communities.								
Applicable Project Phase	*Construction*							
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	-	High
Mitigation measures: 1. Develop and implement a Traffic Management Plan. 2. Identify suitable times to transport equipment. 3. Road safety awareness education will also be included during community visits or information sessions, so that communities can be familiarized with common road signs and the types of vehicles and equipment that will be moving through the area. 4. Keep speeds slow (30 km/hr) where there is traffic exchange between roads. 5. Make roundabouts for the congestion points. 6. Designate traffic wardens at roads on the transport route to manage traffic during school hours. 7. Construction traffic will not travel during school starting and ending hours on designated road segments in front of schools on the transport route. 8. Strictly implement speed limits and defensive driving policies. 9. Maintain vehicles especially brakes.								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	-	High

As traffic volume increases the traffic flow becomes unstable and any minor disturbance can lead to major damage. The traffic generated by the Project may worsen the condition of local road surfaces, thereby decreasing road safety for communities. Increased traffic could increase road accidents and injuries, as drivers may be unfamiliar with sharing the roads with trucks, and truck drivers may have difficulty seeing at night. Increase number of vehicles on the road increases the chances of accidents due to any oil leakage going to the Project site. This potential impact would be particularly prevalent during construction, where a higher number of equipment and materials delivery vehicles would be traversing the Project area.

On N-15, congestion can be a problem for locals residing in the settlements; Dabrian and Kappi Gali.

Pavement Condition

Impact 25: Degradation of the pavement due to use by heavy construction traffic.								
Applicable Project Phase	*Construction*							
Initial Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	-	High
Mitigation measures: Promptly and properly repair and maintain roads that are subject to damage by Project activities.								
Residual Impact Rating	Magnitude	Duration	Scale	Consequence	Probability	Significance	+/-	Confidence
	Minor	Short Term	Small	Low	Possible	Low	-	High

7.11 Livelihood and Well-being

During the consultation for the Project the community expressed a need for provision of transparent and merit based employment to the locals and investment in the community infrastructure. Sediment mining was identified as one of the means of livelihood in the area and there was a concern that the Project will result in loss of this resource.

A summary of the possible impacts to the livelihood and well-being of the surrounding communities is as follows:

- Impact 26: Direct, indirect and induced employment at the local levels, resulting in increased prosperity and wellbeing due to higher and stable incomes of people.
- Impact 27: Increase in the stock of skilled human capital due to transfer of knowledge and skill under the Project resulting in enhanced productivity of the local labor.
- Impact 28: Increase in recreational and subsistence fishing due to increase in catch of fish following creation of favorable habitats for the fish in the Kunhar River.
- Impact 29: Loss of income from sediment mining due to change in pattern of sediment deposition following construction of the dam.
- Impact 30: Loss of assets and livelihood as a result of land acquired for the Project.

7.11.1 Employment

Impact 26: Direct, indirect and induced employment at the local levels, resulting in increased prosperity and wellbeing due to higher and stable incomes of people.								
Applicable Project Phase			*Construction and Operation*					
Initial Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Minor			Medium	Possible	Medium	+	High
Enhancement measures: 1. Ensure preferential recruitment of local candidates provided they have the required skills and qualifications. 2. Include an assessment of the contractor's demonstrated commitment to domestic and local procurement and local hiring in the tender evaluation process. 3. Coordinate recruitment efforts related to non-skilled labor, including for non-skilled labor positions required by contractors. **Good practice measures:** 4. Determine what is considered to be 'fair and transparent' in recruitment and in distribution of jobs between different community groups, in consultation with local communities and their leaders.								
Enhanced Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Moderate						+	Medium

In Mansehra District, education levels of the population are generally higher as demonstrated by the literacy level of more than 71% (**Section 4.3.3**, *Socioeconomic Conditions in the Study Area*), compared to KP average of 50% and Pakistan national average of 59%.[17] The skill set of the local community will be developed through vocational institutions and training centers in the Project Area. Presently, around 5% of the local community is dependent on sediment mining and on fishing. Other sources of income include businesses, daily wage labor and employments. During community consultations, some of the women expressed an interest in gaining access to office-based employment opportunities in the project jobs.

The incomes of people employed by the Project are likely to lead to improved nutritional status, better housing, access to education and improvement in overall well-being of their families. Poverty cycles in poor families could be broken if children in the families become better educated and have more livelihood options than their parents had. The Project will provide employment to several persons during the construction and operation phases. The Project will directly and through indirect and induced mechanisms contribute to alleviating poverty and vulnerability in KP, and to prosperity and well-being of the people employed by the Project.

7.11.2 Training and Skill Development

Impact 27: Increase in the stock of skilled human capital due to transfer of knowledge and skill under the Project resulting in enhanced productivity of the local labor.								
Applicable Project Phase			*Construction and Operation*					
Initial Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Minor	[illegible]	Intermediate	Medium	Possible	Medium	+	Low

Enhancement measures:

1. Support a 'vocational training program' to assist local people to qualify for semi-skilled positions focusing on issues such as procurement, involvement of vulnerable groups in Project opportunities and continual professional development of staff.

Good practice measures:

2. Assist local people having practical skills but lacking qualifications to obtain their certificates and thus increase their employment opportunities.
3. Support initiatives promoting a culture of learning in local communities.
4. Plan and implement training program for vulnerable groups to encourage their participation in economic opportunities created by the Project.
5. Assist employees and local communities to improve basic personal financial life skills through training and awareness campaigns, respectively.
6. Consider further training programs to prepare retrenched workers to seek employment in sectors not related to dam construction.

Residual Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Moderate	[illegible]	[illegible]	[illegible]	Possible	[illegible]	+	Low

The Project will result in the training and skill development of local and domestic labor, especially during the construction phase of the Project. Financial and technical investment by foreign companies is generally seen as a positive opportunity for

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[17] http://www.sciencedirect.com/science/article/pii/S2405883116300247 cited on June 2017

developing countries as their technology is usually more advanced compared to locally available technology.

The knowledge and skills acquired by the local community will be of value to the labor-force of the country at national and local levels. The creation and injection of highly trained workers, qualified in multiple skills, into the economy will improve the productivity of the workforce and the benefits will extend to other firms and industries. This impact can therefore stretch to micro- and macro-economic levels.

For enhancement of employment benefits at the local and domestic levels, various training programs will be implemented by PEDO. The training programs will focus on maximization of participation of local community in the construction and operational phases of the Project.

7.11.3 Enhancement of Subsistence and Recreational Fishing

Impact 28: Increase in recreational and subsistence fishing due to increase in catch of fish following creation of favorable habitats for the fish in the Kunhar River.									
Applicable Project Phase				Construction and Operation					
Initial Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Minor			Low	**Possible**	Low	+	High
Mitigation measures: 1. Ensure implementation of the BAP (see **Volume 2C** of the **EIA**).								
Residual Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Minor			Low	**Possible**	Low	+	Medium

Estimates for consumption of fish caught from Study Area are provided in **Section 4.3.4**, (*River Dependent Socioeconomic Activities*). Income from fishing as a percentage of total income across the zones ranges from 0.011% in Zone 5 to negligible, with an average value of 0.010% and maximum level of dependence of 0.011%. Fishing is only carried out for recreational purposes. Some people sell part of their catch, however, income from fishing is an insignificant part of their livelihood. The Fisheries Department, KP issues permits for recreational and subsistence fishing using rods and cast nets. However, bulk of the fishing at present is carried out using prohibited gill nets, a practice that cannot be considered as sustainable. Under the Business-as-Usual scenario with poor protection of the river combined with impacts of the Project (see the **Volume 2C** of the **EIA**) fish of subsistence and recreational value such as Alwan Snow Trout will practically be wiped out in 31 years both upstream and downstream of the dam. However, following implementation of the BAP and High Protection levels (see **Volume 2C** of the **EIA**) populations of these fish will be maintained at levels where it will be possible to support recreational and subsistence fishing.

7.11.4 Sediment Mining

Impact 29: Loss of income from sediment mining due to change in pattern of sediment deposition following construction of the dam.								
Applicable Project Phase				*Operation*				
Initial Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	-	High
Mitigation measures: A Sediment Mining and Management Guidelines will be prepared and implemented as a part of BAP (see **Volume 2C** of the **EIA**), which will identify possible sand and gravel mining spots along the Kunhar River to meet community needs without harming the river ecology.								
Residual Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Minor	Medium	Small	Low	Possible	Low	-	Low

Sediment mining is carried out throughout the length of the main Kunhar River and its tributaries. The mineable sediment resource is being extracted to meet small-scale construction demand, involving construction and maintenance of local residential and commercial buildings as well as roads. Demand for large-scale projects is met through imports from Lawrencepur near Attock about 60 km west of Islamabad and other areas.

Sediment mining will be affected by the Project. The development of the hydropower project will result in changes in flows, including sediment flows, thereby, affecting sediment deposition. Community dependence on sediment mining is significant based on the statistics presented in earlier in **Section 4.3.4** (*River-Dependent Socioeconomic Activities*). The income, as a percentage of total income, ranges from 1.03% to 4.12% in various zones of the river with the average across the zones being 3.6%. A number of persons also depend on daily wages from sediment mining businesses for their livelihoods. Income dependence for sediment mining is of significance.

The total quantity of sediment being mined from the socioeconomic Study Area is estimated at 467,030 m^3 per year. Given a total bed load sediment flow of 2,714,000 m^3/year[18], present demand for sediment is estimated at 17% of the sediment available. The availability of sediment for meeting the demand of the communities is not likely to be an issue for foreseeable future. PEDO as a part of the BAP, will prepare and implement sediment mining management guidelines to minimize the impact of the Project and the extraction of sediment by the community on the river ecology while meeting the requirements of the community.

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[18] Mirza Associates Engineering Services (Pvt.) Ltd. (Lead Consultant), December 2013, Feasibility Study of Balakot Hydropower Development Project, Volume I Main Report for Pakhtunkhwa Hydel Development Organization

7.11.5 Land Acquisition

Impact 30: Loss of assets and livelihood as a result of land acquired for the Project.								
Applicable Project Phase				*Design and Construction*				
Initial Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	-	High
Mitigation Measures: See LARP (**Volume 8**)								
Residual Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Minor	**Medium**	Small	Low	**Possible**	**Low**	-	Low

Land acquired for the Project can potentially have serious effects on the well-being of the community. It is estimated that as about 165 households may have to relocated as a result of the Project. The LARP prepared for the Project identifies the potential social issues and proposes measures to avoid adverse impacts.

7.12 Socio-Cultural Impacts

The Project stakeholders expressed concerns on the potential sociocultural changes that can be induced by the Project including enhancement or possible degradation of social and economic landscape, and hindrance in mobility of the people due to location of Project facilities such as construction camp. Key impacts are listed below and discussed in this section:

- Impact 31: Increase in population due to in-migration of job seekers (in-migrants) leading to pressure on existing social infrastructure and services.
- Impact 32: Disputes over distribution of Project employment within and between Study Area inhabitants and the in-migrants resulting in social unrest.
- Impact 33: Potential social unrest in the Study Area due to conflicting socio-cultural norms amongst the inhabitants and in-migrants.
- Impact 34: Damage to the graveyard.

7.12.1 Pressure on Social Infrastructure and Services

Impact 31: Increase in population due to in-migration of job seekers (in-migrants) leading to pressure on existing social infrastructure and services in the Study Area.								
Applicable Project Phase				*Construction*				
Initial Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Moderate	**Medium**	**Intermediate**	Medium	**Possible**	**Medium**	-	Medium
Good practice measures: 1. Development of a Grievance Redressal Mechanism 2. Encourage local communities to use the grievance procedure for concerns related to deterioration of local services. 3. Support local government in the implementation of infrastructure projects. 4. Support NGOs specializing in development of infrastructure to assist local government.								
Residual Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Minor	**Medium**	**Intermediate**	Low	**Possible**	**Low**	-	Medium

There is a potential for an influx of job seekers in the Study Area due to the jobs created by the Project. Some service providers to the Project may open new offices in Balakot City, which is situated at a distance of about 17 km from the Project site. The potential in-migration in Balakot City due to the Project will be negligible in comparison to the present population of the city. The influx of job seekers will pose pressure on the availability of infrastructure and services, such as those pertaining to education, health care and medication, water and communication in the Project area.

7.12.2 Conflicts Due to Provision of Employment to Outsiders

Impact 32: Disputes over distribution of Project employment within and between Study Area inhabitants and the in-migrants resulting in social unrest.								
Applicable Project Phase			*Construction*					
Initial Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Moderate	Medium	Intermediate	Medium	Possible	Medium	-	High
Good practice measures: 1. Implement PEDO Stakeholder Engagement Plan including: a. maintaining regular communication with local communities and other stakeholders to minimize tensions arising from Project activities; b. maintaining a grievance procedure, and encourage and facilitate stakeholders to use the mechanism to express concerns; and c. providing sufficient resources to the community relations officers to enable them to monitor negative perceptions and associated tensions, and to address them in a timely fashion.								
Residual Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Minor	Short term	Intermediate	Low	Possible	Low	-	Medium

A potential source of conflict is real or perceived unequal access to Project opportunities. Complaints can be expected from local communities residing in the Study Area if the distribution of jobs among local communities is perceived to be unfair. Objections can also be expected if people from outside the Study Area are seen to usurp opportunities created by the Project, as the Study Area inhabitants may consider themselves as the rightful owners to the Project benefits owing to their vicinity to the Project. This increases the need for open communication between PEDO and the various community heads, as well as within the community heads themselves.

7.12.3 Conflicting Socio-Cultural Norms

Impact 33: Potential social unrest in the Study Area due to conflicting socio-cultural norms amongst the inhabitants and in-migrants.								
Applicable Project Phase			*Construction*					
Initial Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Minor	Short term	Small	Low	Possible	Low	-	Medium
Enhancement measures: 1. Refer to measures under Impact 32.								

The influx of job seekers in the Study Area could give rise to ethnic and cultural diversity in the Study Area. There could be cultural conflicts between the in-migrants and the Study Area inhabitants due to their conflicting traditions and norms. The likelihood of this impact is low given that Project facilities are not located in immediate vicinity of local communities and where the facility borders local communities, proper fencing and barriers are provided to avoid unnecessary interaction.

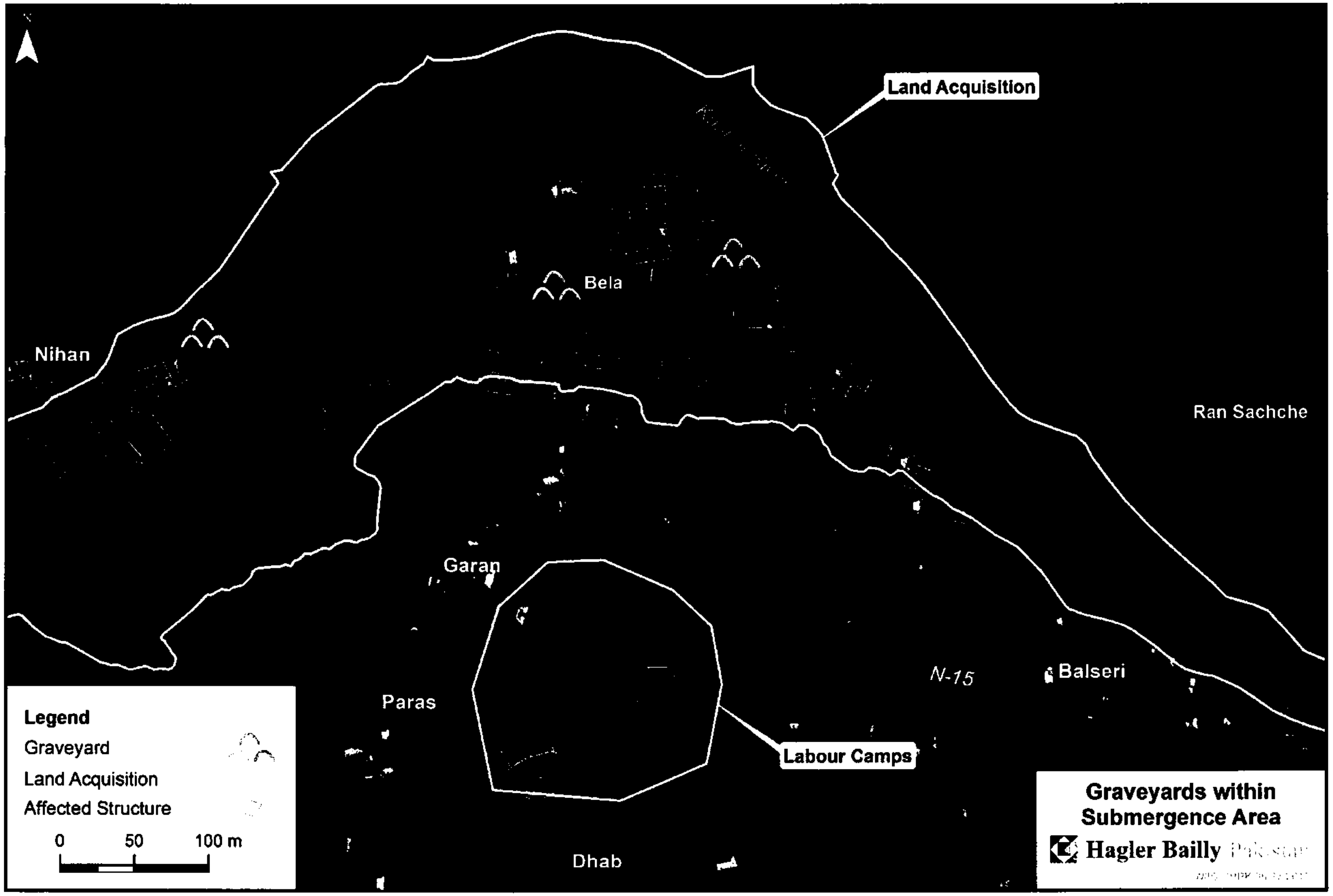
7.12.4 Graveyard Management

Impact 34: Submergence of the graveyards.								
Applicable Project Phase				*Construction*				
Initial Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Moderate	**Medium**	**Intermediate**	**Medium**	**Possible**	**Medium**	-	High
Mitigation measures: 1. Plaster the graves with mud or cement. 2. If relocation of the graveyard cannot be avoided, it shall be managed through the local religious authorities.								
Residual Impact Rating	*Magnitude*	*Duration*	*Scale*	*Consequence*	*Probability*	*Significance*	+ /-	*Confidence*
	Minor	Short term	**Intermediate**	Low	**Possible**	**Low**	-	Medium

Three graveyards have been identified in the area that will be submerged (see **Exhibit 7.36**). Two graveyards are in Bela Balseri and one is in Nihan settlement. Culturally and religiously, a graveyard has a sanctity in the eyes of the people of the area. It is therefore important to handle this aspect recognizing its sensitivity. The hierarchy of measures to manage the graves based on the consultation with the local communities is as:

1. Plaster the graves with mud or cement.
2. If relocation of the graveyard cannot be avoided, it shall be managed through the local religious authorities

Exhibit 7.36: Graveyards in the Project Area



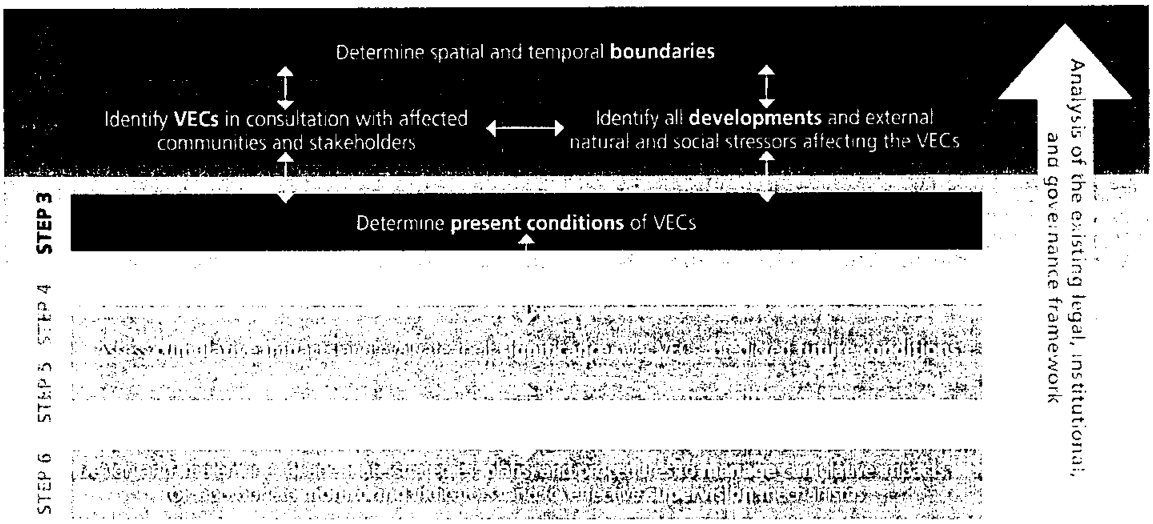
7.13 Cumulative Impact Assessment

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. The overall objectives of cumulative impact assessment (CIA) studies are:

- Ensure that the proposed and likely future developments' cumulative social and environmental impacts and risks to not exceed a threshold that could compromise the sustainability of Valued Environmental and Social Components (VECs)[19];
- Ensure that the proposed and future developments' 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.

The methodology used for the CIA of the Project has been adapted from the guidelines of IFC.[20] The key steps of the study are shown in **Exhibit 7.37** below. Key in the methodology is the identification and mapping of VECs.

Exhibit 7.37: Study Steps



Source: International Finance Corporation. Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. 2014

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[19] The IFC Good Practice Handbook on Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. 2014 defines VECs as environmental and social attributes that are considered to be important in assessing risks; including physical features, habitats, wildlife populations (e.g. biodiversity), ecosystem services, natural processes (e.g., water and nutrient cycles, microclimate), social conditions (e.g. health, economics), or cultural aspects (e.g., traditional spiritual ceremonies).

[20] International Finance Corporation. 2014. Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets

The study area selected for the CIA (CIA Study Area) is shown in **Exhibit 7.38** and includes the entire length of the Kunhar River from Lulusar Lake down to its confluence with the Jhelum River, a total length of 116.3 km. Significant tributaries which are important breeding areas for fish are also included in the CIA Study Area as the tributaries and the main river constitute an integrated and interdependent ecosystem. The temporal scope of the CIA spans a periodBal of 51 years up till the year 2068 corresponding to the period for hydrological daily data is available for the Project location. This accounts for first 5 years of construction of the Project and a further 46 years of its operation. As the results for EFlow modeling show, the fish populations reach equilibrium levels in this time period and the impacts of the Project, management measures, as well as those associated with variations associated with natural hydrological cycles level off. The **Environmental Flow Assessment Report** for the **Balakot Hydropower Development Project** is provided in **Volume 2C** of the **EIA**.

7.13.1 Major Existing, Under Construction and Planned Hydropower Projects on the Kunhar River

There are a number of hydropower projects at different stages of development on the Kunhar River within the CIA Study Area. Furthest downstream, near the Kunhar – Jhelum confluence the Patrind HPP is already constructed and operating. Upstream of the Project, between Kaghan and Naran the Sukki Kinari HPP is presently under construction. Upstream of Naran Town, the Naran HPP and the Batakundi HPP are still at the planning stage. The developments, their planned capacity and current status are shown in **Exhibit 7.39.**

Exhibit 7.38: CIA Study Area

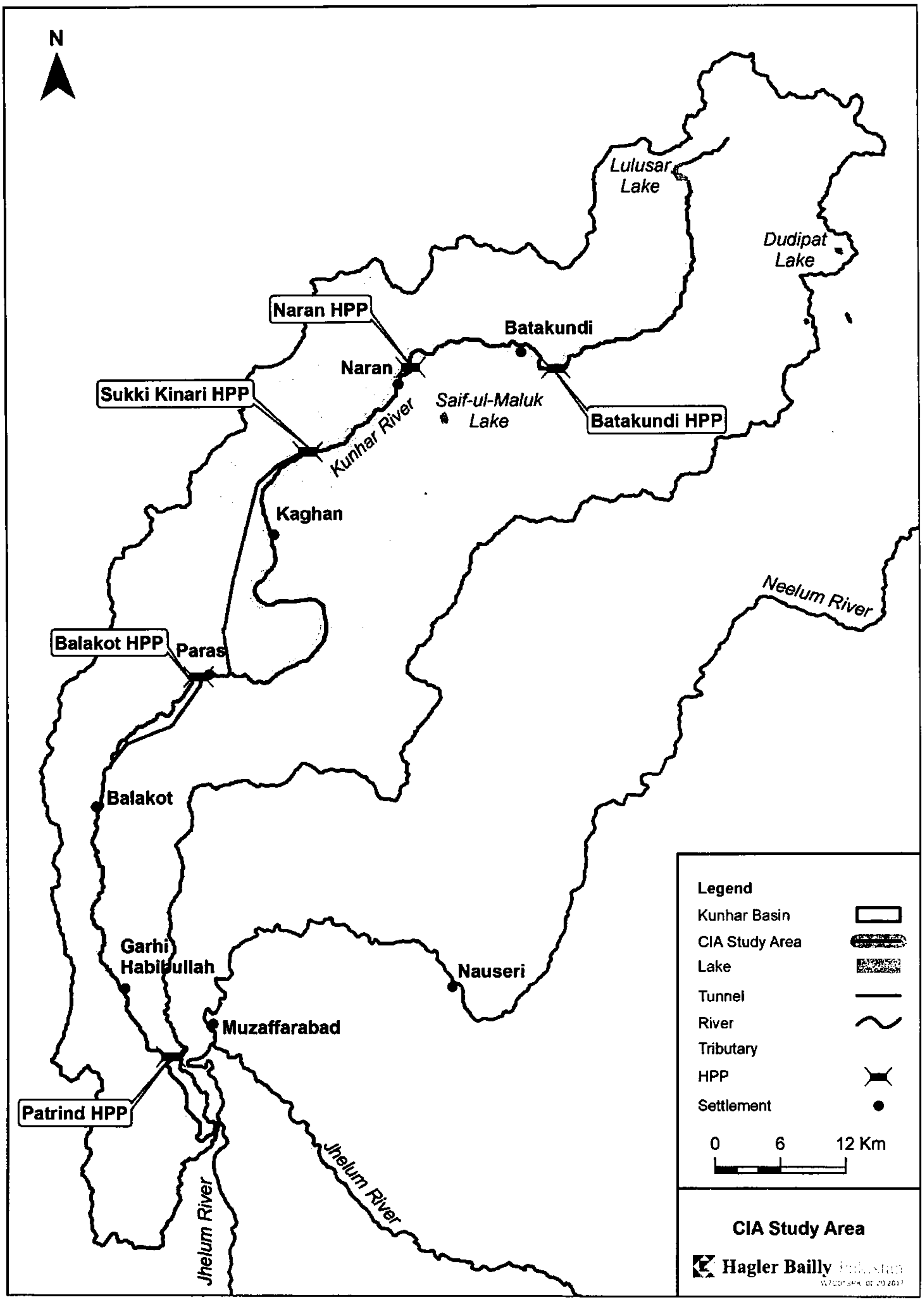
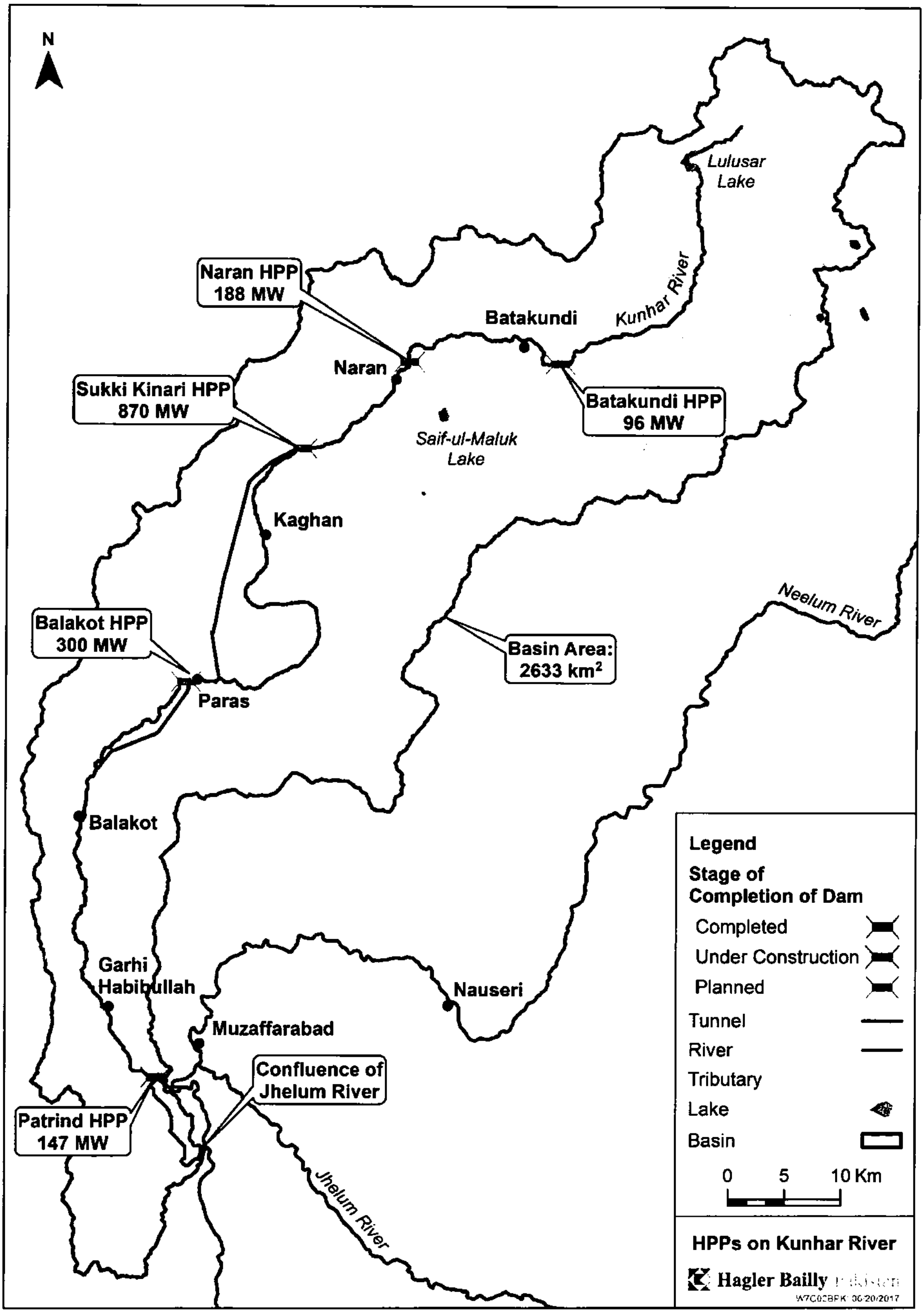


Exhibit 7.39: Locations, Capacities and Status of Major Hydropower Projects on the Kunhar River



7.13.2 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.[21] Ecosystem services are an important class of VECs as the livelihoods of the communities depend on them. Identification of ecosystem services was carried out through a review of the socioeconomic baseline for the Project (see **Section 4.3**, *Socioeconomic Baseline*). The following ecosystem services were identified:

- Provisioning Services: fishing, sand mining, driftwood use as a fuel, domestic uses of river water, and pumping of river water by river-side restaurants; and
- Cultural Services: tourism and recreation.

Fishing: Fishing areas along the main Kunhar River are marked in **Exhibit 4.154** in **Section 4.3.4** (*River-Dependent Socioeconomic Activities*). The fishing season lasts about six months during the summer and seasonal permits for fishing using rods and cast nets are issued by the Fisheries Department, KP. However, the number of permits issued is small and most fishing in the Kunhar River is conducted illegally as enforcement is weak. The creation of barriers and reservoirs along the river will alter river connectivity and habitat, thereby impacting fish populations in the Kunhar River Basin. According to field surveys community dependence on fishing is not significant and only 2% of households in the area engage in fishing. Income from fishing as a percentage of total income in the area is only 0.01%, with the majority of fish catch being self-consumed. Considering the very small contribution of fishing to the CIA Study Area economy, fishing as a socioeconomic activity was not categorized as a priority VEC. This is not related to the ecological importance of certain fish species in the Kunhar River, which is discussed in the next section.

Based on an analysis of data collected as part of the ESIA of Kohala HPP, fishing pressure is expected to increase as has been observed along other rivers in the basin, including Jhelum and Neelum Rivers, from 2013 to 2016. An increasing trend in fishing pressure was also highlighted by Mohammad Tanvir, Assistant Director, Mansehra of the Fisheries Department, KP.

Sediment Mining from River Bed: Sediment (sand, gravel and cobble) mining is carried out in some areas along the length of the main Kunhar River. Surveys for the socioeconomic baseline reported on sand mining activities within the socioeconomic Study Area which extends from 4 km upstream of Paras till Dalola Village. Field surveys showed that 98% of the sediment mined is extracted from the stretch of river between Shahator Village and Dalola Village, downstream of Balakot Town. An improved road network could potentially open up additional areas for sediment mining, as has been the case in other basins in the area. Sediment is mined to meet small-scale construction demand related to the construction and maintenance of local residential and commercial buildings. The sediment is mined manually using shovels and spades and is loaded onto animals, vehicles, or cable trollies, by means of which it is transported to the roadside.

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[21] Ranganathan. J, Raudsepp-Hearne C, Lucas N, Irwin F, Zurek M, Bennet K, Ash N, West P. 2008. Ecosystem Services A Guide for Decision Makers, World Resources Institute

The laborers involved in the sand mining depend on daily wages from this activity for a large part of their income.

The mining operations are of different sizes ranging from 100 m^3/year to 2,080 m^3/year. Small- and medium-scale operations are typically family businesses. Families from nearby villages' set-up sediment extraction operations which are mostly run by family members. In most cases the labor is hired locally but, in some cases, it is also provided by the family. In this way, the earning from the sediment mining operation remains primarily within the local economy. **Exhibit 4.155** in **Section 4.3.4** (*River-Dependent Socioeconomic Activities*) shows the sediment mining areas in the CIA Study Area. The development of the hydropower projects in the Kunhar Basin will result in changes in flows, including sediment flows, thereby, affecting sediment deposition. Community dependence on sediment mining as a percentage of total income is low. Surveys carried out as part of the socioeconomic baseline for the EIA of the Project found that income from sediment mining as a percentage of the total income was 3.6%, although for individual households involved in sand mining the contribution may be much higher, as there are a number of family-owned sand mining businesses. Considering the small contribution of sediment mining to the overall local economy of the area, it was not considered a priority VEC. However, with the expected increase in construction, demand for sediment is expected to grow, therefore, it will become important in future.

Based on an analysis of data collected as part of the ESIA of Kohala HPP, sediment extraction is expected to increase as has been observed along other rivers in the basin, including Jhelum and Neelum Rivers, from 2013 to 2016.

Driftwood: Fuel wood is the main source of energy for domestic cooking and heating. Respondents, interviewed as part of the ESIA of Project reported that fuel wood is collected from a number of sources, including trees growing on farmland, dead and fallen trees in forests, and driftwood along the river, mainly in spring when the water flow increases. Driftwood use as a fuel is likely to be affected by the Project. Dams will trap drift wood in normal flow conditions, which will affect the availability of driftwood downstream of any dam sites. However, there is limited dependence on driftwood collected from the riverbanks as source of fuel wood and community dependence on driftwood was therefore not considered as significant. The use of driftwood as fuel was therefore not considered a priority VEC.

Community use of River Water: River water is not fit for drinking as it carries effluents from settlements located in the catchment of the river. The main sources of water for communities are springs and streams flowing from higher elevations in the valley. There is very limited pumping of water from the river as water is generally available from springs and stream flowing down the valley slopes, and river water use for agriculture is very limited. Community use of river water was therefore not considered a priority VEC.

Recreation and Tourism: Recreational dependence on the river varies greatly from one stretch of the Kunhar River to the other (see **Section 4**, *Socioeconomic Baseline*). Although recreation and tourism is not a major socioeconomic activity in the Project area or further downstream, a large number of tourists do visit the riverside towns of Kaghan and Naran further upstream during the summer. A large number of hotels and restaurants in these areas are located at the riverside, and tourists also undertake river related activities such as fly fishing for trout. Through the provision of accommodation, food and other services local communities in these areas derive a very significant portion of their annual income from recreation and tourism. Recreation and tourism were therefore considered a priority VEC in the CIA.

7.13.3 Priority VECs

Valued Environmental Components (VECs) are defined as "*fundamental elements of the physical, biological or socio–economic environment that are likely to be the most sensitive receptors to the impacts of a proposed project or the cumulative impacts of several projects*".[22] They may include:

- Physical features, habitats, wildlife populations (e.g., biodiversity),
- Ecosystem services (e.g., fishing, timber, food, aesthetic values),
- Natural processes (e.g., water and nutrient cycles, microclimate),
- Social conditions (e.g., health, economics), or
- Cultural aspects (e.g., traditional spiritual ceremonies).[23]

While VECs may be directly or indirectly affected by a specific development, they often are also affected by the cumulative effects of several developments.

Priority VECs have been identified through the Ecosystem Services Review in **Section 7.13.3** (*Priority VECs*) and from ecological studies conducted as part of the EIA. The ecological studies identified two fish species of conservation importance in the Aquatic Study Area (which stretches both upstream and downstream of the Project infrastructure) based on their endemism and restricted range. These include the Nalbant's Loach and Kashmir Hillstream Loach. Because of the presence of these species, river ecology with emphasis on fish fauna was identified as a priority VEC. More detailed information on river ecology can be found in **Section 4.2.6**, (*Aquatic Ecology*).

The biodiversity values identified as important and the ecosystem services considered important were combined to develop a list of prioritized VECs for the purpose of this study. The prioritized VECs for this CIA are:

- River ecology with emphasis on fish fauna
- Recreation and tourism

River ecology was included as a VEC as the survival of fish fauna depends on the integrity of the river ecosystems. Recreation and tourism was included as major changes to the natural environment and aesthetics of the Kaghan and Naran area could result in a drop in tourist numbers, having a major negative impact on the local economy.

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[22] Cadinale, Pablo, and Lorne Greig. 2013."Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets." In *Good Practice Handbook*: International Finance Corporation and ESSA Technologies Ltd

[23] Ibid

7.13.4 Overview of Changes in Flow and Inundation of Habitats

Even though these cascading hydropower projects are not net consumers of water, the timing as well as the allocation of water flow will be modified on the Kunhar River from the Batakundi HPP to the confluence of the Kunhar River with the Jhelum River as follows:

- 19.1 km or 16% of river will be lost as a result of inundation,
- 79.8 km or 69% will be impacted by reduced dry season flows, and
- 17.4 km or 15% will be impacted by peaking flows.

It can be concluded that the cumulative impacts from the operation of all HPPs will cause loss and degradation of riverine aquatic habitat along the entire length of the Kunhar River between the Batakundi reservoir and the Kunhar – Jhelum River confluence, a total length of 89.5 km.

Thus, the potential cumulative impact on river habitat is likely to be significant if not managed or mitigated.

7.13.5 Impact on Fish Fauna

This cumulative assessment is based on the assessment of environmental flows[24] (EFlows) for the Project (see **Section 5**, *Analysis of Alternatives*). The assessment takes into account the prevailing non-flow pressures on the aquatic ecosystem, including selective and non-selective fishing, sediment mining on the river bed, and nutrient enrichment in the river due to effluent disposal from communities and harvesting of riparian vegetation. Four levels of protection were assessed, which are:

- Protection Level BAU = Business as usual, increase non-flow-related pressures in line with 2017 trends, i.e., 2017 pressures double in intensity over the next 51 years.
- Protection Level 1 (Pro 1) = maintain 2017 levels of non-flow-related pressures on the river; i.e., no increase in human-induced catchment pressures over time.
- Protection Level 2 (Pro 2) = reduce 2017 levels of non-flow-related pressures by 50% over the next 5 years and then keep stable at that level for the next 46 years.
- Protection Level 3 (Pro 3) = reduce 2017 levels of non-flow-related pressures by 90% over the next 5 years and then keep stable at that level for the next 46 years.

In the case of each, results obtained from assessment of impacts under various EFlow scenarios for the Project using the DRIFT DSS model were extrapolated to the other HPPs.[25] Three scenarios were assessed in the EFlow assessment for the Project.

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[24] Environmental flows describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems

[25] Modeling of the impacts of an additional four HPPs using DRIFT was outside the scope of this study.

Environmental Management Scenarios

A 'Business as Usual' (BAU) scenario predicts the health of the river ecosystem in the absence of any additional dams (both planned and under construction). However, non-flow pressures discussed above are maintained at Business as Usual levels. It also considers the presence of the already constructed Patrind HPP.

A 'Baseline Management' (BM) scenario predicts the health of the river ecosystem after the construction of all five dams, with the following operational and environmental management measures in place:

- Project will operate with a constant baseload flow and an EFlow of 1.5 m^3/s
- Sukki Kinari HPP, Naran HPP and Batakundi HPP will operate following a peaking regime
- Patrind HPP will continue to operate with a baseload flow, however this has no impact on the Kunhar River as its powerhouse is located on the Jhelum River and the impacts of peaking will occur in the Jhelum River
- Protection Level 3, or Pro 3 level of protection will be implemented in the Project area of management
- Protection Level Business As Usual (BAU) will be implemented in the Patrind HPP, Sukki Kinari HPP, Naran HPP and Batakundi HPP areas of management

An 'Enhanced Management' (EM) scenario predicts the health of the river ecosystem after the construction of all five dams, with the following operational and environmental management measures in place:

- Project, Naran HPP and Batakundi HPP will operate with a constant baseload flow
- Sukki Kinari HPP will operate following a peaking regime
- Patrind HPP will continue to operate with a baseload flow, however this has no impact on the Kunhar River as its powerhouse is located on the Jhelum River and the impacts of peaking will occur in the Jhelum River
- Protection Level 3, or Pro 3 level of protection will be implemented in the areas of management of all HPPs

The estimated likely consequences of the accumulation of these impacts on the Alwan Snow Trout, Nalbant's Loach and Kashmir Hillstream Loach that illustrate the range of impacts on fish fauna are summarized in **Exhibit 7.40**. These impacts have been extrapolated from the results of the EFlow modeling carried out for the Project.

Alwan Snow Trout

BAU Scenario: The Alwan Snow Trout faces heavy selective fishing pressures, which are expected to increase significantly under the business as usual scenario. This is predicted to reduce Alwan Snow Trout populations by around 70% throughout the Kunhar River.

BM Scenario: The expected impact of all dams will result in the complete elimination of the Alwan Snow Trout in most of the Kunhar River. The only exception under this scenario is the stretch between the Project dam to Patrind reservoir, where a 25% decrease compared to current levels is expected. This stretch will continue to support Alwan Snow Trout populations because of the 1.5 m^3/s EFlow from the dam to the powerhouse, and the base flow from the power house to the Patrind reservoir.

EM Scenario: Under Enhanced Management strict protection is applied throughout the river basin and baseload flow is maintained from all dams except Sukki Kinari. However the barrier effect of the dams combined with reduced flows, especially between dams and powerhouses is enough to eliminate the Alwan Snow Trout in most of the river. River sections downstream of the Project dam continue to support fish populations largely due to the dam's EFlow. Other sections or river, such as Sukki Kinari dam to tailrace and Patrind reservoir to the Jhelum confluence retain significantly depleted populations of the Alwan Snow Trout (reduction of 65 to 70%).

Nalbant's Loach

BAU Scenario: The Nalbant's Loach is currently only found downstream of the Sukki Kinari dam site. Under the Business as Usual scenario, the Nalbant's Loach populations reduce by 60% compared to current populations. The Nalbant's Loach is sensitive to pollution, and the growing impact of runoff from human settlements and habitat degradation due to activities such as sand mining will result in the reduced population under BAU.

BM Scenario: The Baseline Management scenario representing the impact of all five dams results in the elimination of the Nalbant's Loach from most stretches of river due to the combined effect of human impacts and changes in hydrology. However, between the Project dam to the tailrace there is a 70% decline, and between Project tailrace to Patrind reservoir there is actually a 10% increase. This increase in the Nalbant's Loach population is a result of this stretch of river retaining sufficient water flow due to the EFlow from the Project dam and baseload flow from the powerhouse, combined with reduced human impacts due to the conservation measures in the Project implemented under BM.

EM Scenario: Under the Enhanced Management scenario, increased protection throughout the river basin result in other stretches retaining some of the Nalbant's Loach population. The stretch between Sukki Kinari dam and its tailrace and Patrind dam and the Jhelum confluence retain 30% of the current population. The Project dam to tailrace and Project tailrace to Patrind reservoir remain unchanged from the BM scenario.

Kashmir Hillstream Loach

BAU Scenario: The Kashmir Hillstream Loach distribution is similar to that of the Nalbant's Loach, and it is only found downstream of the Sukki Kinari dam site. Under the Business as Usual scenario, the Kashmir Hillstream Loach populations will reduce by 70% in all stretches where it is currently found. The Kashmir Hillstream Loach is sensitive to human impacts such as habitat degradation and water pollution, and growing population pressure and its associated impacts will result in the reduced population under BAU.

BM Scenario: Under the Baseline Management scenario changes in hydrology combined with human impacts result in the elimination of the Kashmir Hillstream Loach from most stretches of the Kunhar River. Downstream of Project dam, where an EFlow is maintained, 10% of the existing population will remain. Between the Project tailrace and the Patrind reservoir the combination of EFlow from the dam, baseload flow from the powerhouse and increased protection in this area are expected to result in a 10% increase in the population.

EM Scenario: Increased protection under Enhanced Management results in the Sukki Kinari dam to tailrace and Patrind Dam to confluence sections retaining 10% of the current Kashmir Hillstream Loach populations. The Project dam to tailrace (90% reduction) and Project tailrace to Patrind reservoir (10% increase) sections remain unchanged from the BM scenario.

Exhibit 7.40: Cumulative Impact of Planned HPPs on the Population of Alwan Snow Trout, Nalbant's Loach and Kashmir Hillstream Loach

Green = any increase from present day. White = 0% to -40%. Orange = -40% to -70%. Red = -70% to -100%. Grey is outside the natural range of the fish

			Alwan Snow Trout, %			*Nalbant's Loach, %*			*Kashmir Hillstream Loach, %*		
			BAU	*BM*	*EM*	*BAU*	*BM*	*EM*	*BAU*	*BM*	*EM*
Lulusar Lake to Batakundi Reservoir	River	26.8									
Batakundi reservoir	Submergence	2.8	-70	[illegible]	[illegible]						
Batakundi dam to tailrace	Low Flow	5.1	-70	[illegible]	[illegible]						
Batakundi tailrace to Narran reservoir	Peaking	9.9	-70	[illegible]	[illegible]						
Naran reservoir	Submergence	3.5	-70	[illegible]	[illegible]						
Naran dam to tailrace	Low Flow	5.5	-70	[illegible]	[illegible]						
Naran tailrace to Narran reservoir	Peaking	6	-70	[illegible]	[illegible]						
Sukki Kinari reservoir	Submergence	3.1	-70	[illegible]	[illegible]						
Sukki Kinari dam to tailrace	Low Flow	38.6	-70	[illegible]	-70	-60	[illegible]	-70	-70	-100	-90
Sukki Kinari tailrace to Project reservoir	Peaking	1.5	-70	[illegible]	[illegible]	-60	-100	-100	-70	-100	-100
Project reservoir	Submergence	4.5	-70	[illegible]	[illegible]	-60	[illegible]	[illegible]	-70	-100	-100
Project dam to tailrace	Low Flow	15.4	-70	-25	-25	-60	-70	-70	-70	-90	-90
Project tailrace to Patrind reservoir	Baseload	24.9	-70	-25	-25	-60	10	10	-70	10	10
Patrind reservoir	Submergence	5.2	-70	[illegible]	-65	-60	[illegible]	-100	-70	-100	-100
Patrind dam to Jhelum River Confluence	Low Flow	15.2	-70	[illegible]	-65	-60	[illegible]	-70	-70	-100	-90

Note: BAU: Business as Usual (No protection or construction of additional dams)

BM – Baseline Management

EM – Enhanced Management

7.13.6 Overall Impact on Ecosystem Integrity

This section summarizes the cumulative impact of the proposed HPPs on the overall ecosystem condition and integrity of the Kunhar River and draws from the impact on VECs outlined above. The categories used to describe the Kunhar River's Present Ecological State[26] are based on modification from the natural, with the natural condition seen as the reference condition (see **Exhibit 7.41**). The estimated cumulative impact of the proposed HPPs on overall river and tributary condition is discussed below.

Exhibit 7.41: Definitions of the Present Ecological State (PES) Categories

A	Unmodified, natural	As close as possible to natural conditions.
B	Largely natural	Modified from the original natural condition but not sufficiently to have produced measurable change in the nature and functioning of the ecosystem/community.
C	Moderately modified	Changed from the original condition sufficiently to have measurably altered the nature and functioning of the ecosystem/community, although the difference may not be obvious to a casual observer.
D	Largely modified	Sufficiently altered from the original natural condition for obvious impacts on the nature and functioning of the ecosystem/community to have occurred.
E&F	Completely modified	Important aspects of the original nature and functioning of the ecosystem community are no longer present. The area is heavily negatively impacted by human interventions.

Present Day Situation

At present, sections of Kunhar River upstream of Patrind reservoir are largely natural, and fall within Category B (see **Exhibit 9.5** for category descriptions). Downstream, sections of river between the Patrind reservoir and the Jhelum confluence are already affected by the construction and operation of Patrind dam, and these sections have therefore been placed in Category B/C.

Business-as-Usual Scenario

Under the BAU scenario (i.e. no HPPs, no environmental control measures) it is expected that there will be significant degradation of the entire stretch of river, from Lulusar Lake down to the Jhelum River confluence. This degradation would result from environmental stressors related to growing population pressure, such as increasing water pollution and habitat degradation. It is expected that the upper reaches of the river, close to Naran and upstream, would degrade to Category C/D, whereas the more populated downstream sections would degrade to Category D over time.

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[26] Hagler Bailly Pakistan and Southern Waters. July 2016. Environmental Flow Assessment for Kohala Hydropower Project Volume 3: Environmental Flow Assessment Technical Report. Pakistan.

Impact of Sequential Implementation of HPPs with Baseline Management

The impacts of each additional HPP are discussed below:

1. **Patrind HPP** degrades ecosystem integrity of the river from Patrind dam to Jhelum River confluence to Category E due to reduced water flow.
2. With the addition of **Sukki Kinari HPP** the entire stretch of river from Sukki Kinari reservoir down to the Jhelum confluence degrades to Category E due to a combination of peaking flows, low flows and submergence in different sections of the river.
3. **Project** will inundate an additional 2.8 km of river but will include an EFlow from the dam, a baseload flow from the powerhouse and Pro 3 level protection in the area. As a result the section of river downstream of the Project dam improves from Category E to Category C/D until the tailrace, and the section from the tailrace to Patrind Reservoir improves from Category E to Category B.
4. **Naran HPP** results in the degradation an additional 15 km of river. A stretch of 3.5 km gets inundated and the remaining 11.5 km section from the dam to the tailrace and tailrace to Sukki Kinari reservoir gets degraded to Category E due to low flow and peaking.
5. **Batakundi HPP** affects an additional 17.8 km of river, with 2.8 km inundated, and 15 km degraded to Category E as a result of low flows and peaking.

Enhanced Management Scenario

Under the Enhanced Management scenario, Project, Naran HPP and Batakundi HPP will be operated with a baseload flow, ensuring there is some water flow between their powerhouses and the next reservoir. Also, the entire Kunhar River from Lulusar Lake to the Jhelum confluence will be managed at a Pro 3 protection level, significantly reducing human impacts such as water pollution and habitat degradation. The result of these measures on ecosystem integrity is:

1. Sections of river between all of the dams to their tailrace will improve from Category E to Category C or Category C/D
2. Sections of river between tailraces and reservoirs, where there is now some water flow due to baseload flow will improve from Category E to Category B. The only exception is Sukki Kinari HPP, which will operate using a peaking regime, because of which the section between Sukki Kinari HPP tailrace and Project reservoir will remain at Category E

A score for overall ecosystem integrity in the CIA Study Area was calculated by:

- Assigning the following scores to ecological categories as defined in **Exhibit 7.41:**

Ecological Category F	0%
Ecological Category E	20%
Ecological Category D	40%
Ecological Category C	60%

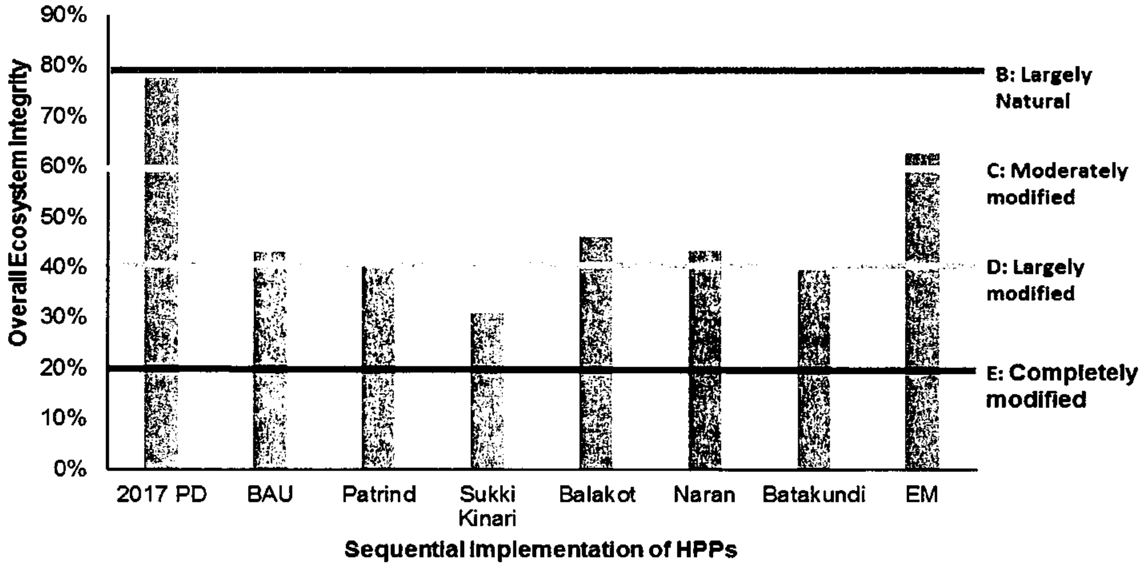
  - ▷ Ecological Category B 80%
  - ▷ Ecological Category A 100%
- Calculating a weighted average score for the CIA Study Area on the basis of the score for ecological integrity in each segment of the river and length of the segment.

Exhibit 7.42 illustrates the calculated changes in overall ecosystem integrity for the CIA Study Area with sequential implementation of the HPPs.

1. Starting with a Present Day score of 78% corresponding to ecosystem integrity of B, the ecosystem integrity deteriorates to D, or a score of about 43% under the BAU scenario without any project. This deterioration is due to poor protection and increasing pressures on the ecosystem from fishing, sediment mining, and deterioration in water quality over time.
2. With Patrind HPP added, the overall score drops to 40%, still within Category D. However with the addition of Sukki Kinari the score reduces further to 31%, which is Category D/E. This reduction is due to the impacts downstream of Sukki Kinari dam.
3. Since Project includes an EFlow, baseload flow and Pro 3 level protection (within the Project area), the addition of this HPP improves the overall ecosystem integrity to a score of 46%, or Category C/D.
4. The addition of Naran HPP brings the score down to 43% and Batakundi HPP brings it further down to 40% or Category D.

Finally, with implementation of the Enhanced Management scenario, the ecosystem integrity can be improved to a score of about 63%, corresponding to an ecological integrity slightly higher than Category C. This is a significant improvement over the BAU and BM scenarios.

Exhibit 7.42: Predicted Ecosystem Integrity in the CIA Study Area with Sequential Implementation of Hydropower Projects



7.13.7 Livelihoods Related to Recreation and Tourism

There is expected to be a significant impact on recreation and tourism in the Kaghan and Naran areas as a result of the construction and operation of Sukki Kinari HPP and Naran HPP. Of the two riverside towns, Naran is the bigger center for recreation and tourism. According to the Tourism Corporation of KP there are currently over 100 hotels operating in and around Naran. Tourism in the area is seasonal, with most tourists visiting during the months of June, July and August. During these months a very significant proportion of local residents work in tourism related activities including the running of hotels and restaurants, labor in hotels and restaurants, provision of transport services, and work as tourist guides. Through the provision of accommodation, food and other services local communities in these areas derive a very significant portion of their annual income from recreation and tourism during the three summer months.

For the most part the construction and operation of Sukki Kinari and Naran HPPs is expected to have a negative impact on tourism in the area. There will be major changes to the present day largely natural environment as a result of access road construction, dam and powerhouse construction, inundation and changes in hydrology (reduced flows, peaking), which will have a detrimental impact on the aesthetics of the area and on activities such as recreational fishing. Dam operation will also create potential safety issues since peaking operations could result in accidents and fatalities as unaware tourists are swept into the river by sudden increases in water flow downstream of powerhouses.

In an area such as Naran with a well-established tourism sector there is a very high dependency on recreation and tourism for income. Any reduction in the number of tourists will have very serious socioeconomic consequences.

Guidelines and mitigations must be prepared as a part of the Sukki Kinari HPP and Naran HPP BAP/BMPs to minimize the impact of the developments on tourism in the area.

7.13.8 Management Strategy and Measures

As defined in **Section 7.13.5** *(Impact on Fish Fauna)*, the following two management scenarios were considered for development of the strategy to manage cumulative impacts:

- Baseline Management
- Enhanced Management

The Baseline Management Scenario

The significant defining aspects and possible outcomes under this scenario are summarized below:

- The Wildlife Department, KP has limited environmental management and monitoring capacity and will rely primarily on the hydropower industry to manage environmental impacts on an individual basis.
- Non-sustainable sand and gravel mining practices will continue resulting in loss of river habitats
- The Minerals Development Department, KP (MDDKP) does not have the policy, means and resources in place to regulate the mining from the river beds.

- The regulatory framework is essentially that of reliance on the environmental regulator, EPA, KP, which has limited monitoring and enforcement capacity in view of the limited number of staff and technical capacity.
- Cities, towns, villages, and residential areas continue to discharge effluents and solid waste into the streams in the CIA Study Area.
- Fishing activities by local communities remain unregulated and continue non-sustainable harvesting practices.

The long term outcome of this scenario in terms of prioritized VECs will be a high level of degradation of the river habitat and ecosystems resulting in substantial and irreversible loss of ecosystem functions and services. Some parts of the river ecosystems protected under the BAP/BMP developed for hydropower projects such as Project will survive and improve due to improved protection and surveillance supported by the projects.

Under this scenario the number of tourists visiting the Kaghan and Naran area is likely to decrease as the area's aesthetics and activities such as recreational fishing are negatively affected.

The Enhanced Management Scenario

Under this scenario, the owners of hydropower projects located within the CIA Study Area would individually and collectively fulfill their environmental and social responsibilities as mandated by law, and manage their corporate and reputational risks. Principal actions and measures recommended for implementation are listed below.

Principal Actions and Measures by the KP Government:

- Preparing guidelines for EIAs for hydropower projects, or adopting accepted best international practices for preparation of EIAs.
- Preparing guidelines for BMP/BAPs, or adopting accepted best international practices for preparation of BMP/BAPs.
- Making preparation of BAP/BMPs mandatory for hydropower developers in the Kunhar Basin.
- Making it a requirement for HPPs to achieve a net gain for key fish species in the Kunhar Basin
- Preparing and implementing guidelines for EFlow assessments, or adopting accepted best international practices for preparation of BAP/BMPs.
- Regulating fishing and sediment mining activities by local communities in collaboration with industry to ensure that sustainable harvesting practices are introduced and established.
- Working with industry to maintain effective watch and ward (patrolling) and regulatory pressure on communities to maintain harvesting at sustainable levels.
- Establishing an institution to conduct research for development of measures to mitigate the impact of hydropower dams on river ecology.
- Establishing a watershed management program to manage water quality in the basin.

Principal Actions and Measures by the Hydropower Industry:

- Designing and operating HPPs to balance power generation benefits and environmental impacts including setting of environmental flows and operating powerhouses at baseload, thereby avoiding peaking operations.
- Preparation and implementation of Biodiversity Action/Management Plans in their respective area of impacts, inclusive of supporting protection, conducting monitoring and evaluation, and adaptive management.
- Maintaining and updating environmental flow assessment models to continuously improve the understanding of ecosystems and to predict the impacts of operations on river ecosystems.
- Setting up detailed hydrology and sediment transport models for prediction of impact of operations on deposition of sediments, and consequentially on ecosystems and ecosystem services.
- Supporting watershed management in the basin to reduce erosion in the catchments and flow of pollutants into the river and tributaries.
- Supporting research and development to mitigate impacts of hydropower projects and to improve environmental management
- Building up environmental management capacity to manage environmental impacts on an individual and collective basis.

The long term outcome of this scenario in terms of river ecosystems and ecosystem services will be maintenance and most likely enhancement of ecosystem functions and services in selected segments of the river, and sustainable livelihoods. Under this scenario there is a likelihood of achieving an increase of about 10% (over the current baseline) in the population of endemic fish species in certain sections of the river.

The transition from the present Baseline Management to this scenario will require extensive and sustained effort over a period of time, and will essentially consist of building upon initiatives that have already been identified and partly tested by the Wildlife Department, KP in other parts of the province. The following management approach is proposed to achieve this transition:

1. An **environmental management framework** consisting of a set of preventive measures and management measures in the CIA Study Area to maintain a balance among:
    a. Maintenance of ecosystem services that are important for local livelihoods and well-being;
    b. Protection of ecosystems and biodiversity, consistent with the policies of the government and commitments made by the country under conventions such as Ramsar and the Convention on Biological Diversity.
2. An **institutional and policy framework** that strengthens key departments in KP and defines the roles, responsibilities and mandates of participating institutions in environmental management of the CIA Study Area.

3. A **financial management framework** that generates and provides funds for environmental management and defines mechanisms for transparent and effective utilization of funds.
4. A **monitoring and evaluation framework** that relies on continuous professional, scientific and independent monitoring of the extent to which the environmental management objectives are being achieved and identifies causes of poor performance or failure.

7.13.9 Institutional Arrangements for Implementation

The suggested roles and responsibilities of identified institutions can be categorized as follows:

- *Leadership and Enforcement:* Ministry of Water and Power and the KP Government
- *Coordination and Management:* Collectively by the industry through a Hydropower Advisory Committee that is recognized by the Ministry of Water and Power and the KP Government, and includes members of the government as well as the community
- *Implementation:* The Wildlife Department, KP and the Fisheries Department, KP
- Capacity Building: WWF, HWF
- *Management Support:* EPA, KP, district administrations, and MDDKP
- *Research:* Pakistan Museum of Natural History, Pakistan Council for Research on Water Resources
- Observation and Management Support: IFC, ADB

7.13.10 Options for Financial Management

It is assumed that actions within the scope of ESIAs for which the projects have independent responsibility will be financed by the projects from their capital and operating budgets as approved by the electricity regulator. The following is an outline of the proposed financial mechanism to support implementation of collective actions proposed in the CIA. These include:

- Administrative costs for the Hydropower Advisory Committee
- Institute for Research on River Ecology
- Watershed Management Program

The proposed financial mechanism consists of:

- A Fund for environmental management titled Kunhar Basin Environmental Management Fund can be set up under the Hydropower Advisory Committee and jointly managed by the industry and the KP government.
- The Advisory Committee will decide on where to use the funds, and how to maintain accountability and transparency.

- Inflows into the Fund can include mandatory and voluntary contributions from the hydropower industry and contributions from donors.

7.13.11 Monitoring and Evaluation

Following the Pressure-State-Response framework, the framework for monitoring of changes in VECs is described in the monitoring and evaluation (M&E) framework included in the BAP of the Project (see **Volume 2C** of the **EIA**). In addition to regular reviews by industry at individual levels and sharing of the results with the stakeholders, the Management Institution should review the M&E reports at least once a year.

7.13.12 Adaptive Management

The framework for adaptive management of cumulative impacts has three components:

1. The first component consists of evaluating the accuracy of the predicted environmental impacts. The corresponding goal is to improve the predictive capability of the models such as those for air quality, hydrodynamics, sedimentation, and water quality, and methods used to identify and quantify project-induced impacts.
2. The second component consists of assessing the effectiveness of the proposed actions and measures.
3. The final component is the modification of actions and measures as needed to ensure that environmental impacts remain within a range that is acceptable to stakeholders.

Suggested indicators and their thresholds for assessing the actual impact of Project are included in the BMP/BAP, which can be expanded to rest of the CIA Study Area. The goal for this component is to implement whatever modifications are needed in actions and measures to keep the levels of observed environmental effects below the thresholds and within the range acceptable to the stakeholders.

The proposed Advisory Committee can advise the Ministry of Water and Power and the KP Government on adaptive management decisions at the basin level following the review of monitoring and evaluation reports.

7.14 Climate Change Risk

A climate change risk assessment carried out in collaboration by Aqualogous, Team Consultants and Hagler Bailly Pakistan, included as part of the Feasibility Study, indicates the following based on analysis of multiple models, as well as literature:

- General potential increase in annual precipitation associated with increase in summer Monsoon precipitation.
- Decrease in winter and spring precipitation.
- Likely increase in the Probable Maximum Flood, based on the Maximum Precipitable Water.

The changes will have consequence on dam operations covered under the scope of the Feasibility Assessment. With respect to environmental impact, i.e. impact on receptors, the following impacts with dam in place, in conjunction with climate change are likely:

- Decreased environmental flow release downstream of the dam, particularly during low flow conditions in winter, based on assessed future green-house gas emissions scenarios and climate change models utilized by the IPCC Fifth Assessment Report (AR5).
- Increase risk of dam failure due to increase in Probable Maximum Precipitable water, and thereby Probable Maximum Flood, under high green-house gas concentration scenarios (representative concentration pathway 8.5) by 2070-2100.

With respect to the risk of decreased environmental flow releases, the design is resilient to climate change, since low level outlets are available and can be utilized to release environmental flow.

In addition, with respect to increase in Probable Maximum Precipitation, based on consultation with dam engineers, the dam is already over designed and an increase of 30-35% in probable maximum precipitation peak, a conservative estimate based on a 30-35% increase in maximum precipitable water, and the dam break risk assessment considers similarly large floods, that are unlikely to cause failure of the dam. Therefore, with respect to environmental impacts on receptors, in alignment with the impact assessment methodology (**Section 7.1**), the dam is resilient to climate change.

7.15 Impact of Transmission Lines

As discussed in **Section 3.7**, NTDC will construct a transmission line to evacuate power from the Project and connect to the main transmission system on the country. The construction of this transmission line is considered an associated facility[27]. Consistent with legislation, NTDC as owner of the transmission line will prepare a separate ESIA and will submit it for approval of Environmental regulator before any work on transmission line can begin.

A preliminary assessment of environmental and social impacts was carried out using ***Google Earth™*** satellite imagery and available geographic information on the wider area in which the transmission line will be located. Given a total length of the transmission line of approximately 720 m, erection of 2 towers is likely to be required. The location of towers can be adjusted in detailed design to minimize risk of land sliding and erosion. There is no reserve forest at the location of the transmission line. Moreover, it can be observed from **Exhibit 3.13 in Section 3** that the proposed transmission line will neither affect any built-up structure or any agricultural land.

The terrestrial biodiversity of the area is similar to the biodiversity in the Terrestrial Study Area for this ESIA. The transmission line will have impacts on terrestrial vegetation and less mobile species, mainly herpetofauna species. It will also disturb habitat of small mammals and ground nesting birds. However, no species of conservation

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[27] Associated facilities are not funded as part of the project (funding may be provided separately by the borrower/client or by third parties), and whose viability and existence depend exclusively on the project and whose goods or services are essential for successful operation of the project.

importance are found in the terrestrial habitat in this area. Construction phase impacts on terrestrial habitats will be temporary and localized, other than the permanent changes they might introduce in the local landscape and land use. Operation phase impacts on terrestrial ecology will be minor, except on avi-fauna. The operation of power lines or transmission lines has been associated with two major negative impacts for avifauna – collision and electrocution.

Based on an initial assessment, the socioeconomic impacts of transmission line are expected to be insignificant as the proposed transmission line will not affect any of the privately-owned assets, and there are no settlements close to the route of the transmission line. No social issues such as conflicts between outsiders and locals are therefore anticipated.

Until the transmission line alignment is finalized it will not be possible to assess the associated environmental or social impacts accurately. Some of the issues that may require detailed examination and the development and implementation of effective mitigation measures are likely to include the following:

- Land acquisition,
- Impacts from influx of workers,
- Impacts on cultural and religious sites,
- Visual impacts,
- Disturbance due to movement of vehicles, construction equipment and materials,
- Noise, dust and air quality,
- Access issues,
- Vegetation clearance,
- Excavation of soil and impacts on surface water,
- Risk of slope instability,
- Disturbance to wildlife,
- Impacts of continuing right of way maintenance.

Exhibit 7.43: Summary of Impacts

ID	Aspect	Impact	Phase	Stage	Magnitude	Timeframe	Spatial Scale	Consequence	Probability	Significance	+/-
1	Aquatic Ecology	Change in the Ecological Integrity through implementation of the BAP (see Volume 2C of the EIA)	C, O	Init	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	+
2	Aquatic Ecology	Loss of riverine ecosystem due to inundation by Project reservoir	C, O	Init	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-
				Res	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-
3	Aquatic Ecology	Degradation of the river ecosystem in the low flow segment downstream of the Project dam	C, O	Init	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-
				Res	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-
4	Aquatic Ecology	Degradation of the River Ecosystem Downstream of the Tailrace	C, O	Init	[redacted]	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	-
				Res	Moderate	[redacted]	Intermediate	[redacted]	[redacted]	[redacted]	+
5	Terrestrial Ecology	Terrestrial habitat loss caused by construction related activities	C	Init	Minor	Short Term	Small	Low	Possible	Low	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
6	Terrestrial Ecology	Decline in abundance and diversity of terrestrial flora and fauna caused by construction related activities.	C	Init	Minor	Short Term	Small	Low	Possible	Low	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
7	Terrestrial Ecology	Project operation leading to animal disturbance, displacement and decline.	O	Init	Minor	[redacted]	Small	Medium	Possible	Medium	-
				Res	Minor	Medium	Small	Low	Possible	Low	-
8	Ambient Air Quality	Increase in ambient and ground level concentration of air pollutants from construction activities and vehicular movement may cause health impacts to the community.	C	Init	Moderate	Medium Term	Small	Medium	Possible	Medium	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
9	Blasting and Vibration	Vibration from blasting during the construction phase may disturb local communities	C	Init	Moderate	Medium Term	Intermediate	Medium	Possible	Medium	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-

ID	*Aspect*	*Impact*	*Phase*	*Stage*	*Magnitude*	*Timeframe*	*Spatial Scale*	*Consequence*	*Probability*	*Significance*	*+/-*
10	Blasting and Vibration	Blasting may pose a health hazard due to flying debris.	C	Init	Moderate	Short Term	Intermediate	High	Possible	Medium	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
11	Hydrology and Water Quality	Alterations of natural passage of springs due to blasting for tunnels may disrupt the water supply for mountain spring users.	C	Init	Moderate	[redacted]	Intermediate	[redacted]	Possible	[redacted]	-
				Res	Minor	Medium	Intermediate	Low	Possible	Low	-
12	Hydrology and Water Quality	Use of local water resources for construction activities may reduce the water availability for local communities.	C	Init	Moderate	Short Term	Intermediate	Medium	Possible	Medium	-
				Res	Minor	Short Term	Small	Low	Unlikely	Low	-
13	Hydrology and Water Quality	Discharge from construction activities can potentially result in the contamination of groundwater and surface water.	C	Init	Moderate	Short Term	Small	Low	Possible	Low	-
				Res	Minor	Short Term	Small	Low	Unlikely	Low	-
14	Construction Noise	Increase in ambient noise levels due to operation of construction equipment, movement of construction traffic and blasting may create nuisance for nearby communities and visiting tourists.	C	Init	Moderate	Short Term	Small	Low	Possible	Low	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
15	Soil, Topography and Land Stability	Contamination of soil as a result of accidental release of solvents, oils and lubricants can degrades soil fertility and agricultural productivity.	C	Init	Moderate	Medium	Intermediate	Medium	Possible	Medium	-
				Res	Minor	Medium	Intermediate	Low	Unlikely	Low	-
16	Soil, Topography and Land Stability	Land clearing, excavation, tunnel boring and other construction activities may loosen the top soil in the Project area resulting in loss of soil and possible acceleration of soil erosion and land sliding, especially in the wet season.	C	Init	Moderate	Short Term	Small	Low	[redacted]	Low	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-

ID	*Aspect*	*Impact*	*Phase*	*Stage*	*Magnitude*	*Timeframe*	*Spatial Scale*	*Consequence*	*Probability*	*Significance*	*+/-*
17	Soil, Topography and Land Stability	Failure of spoil dumping sites resulting in increased erosion and sediment load entering river.	C	Init	**Moderate**	[redacted]	**Intermediate**	[redacted]	Possible	[redacted]	-
				Res	**Moderate**	**Medium Term**	**Intermediate**	**Medium**	Unlikely	Low	-
18	Aesthetics	Deterioration of aesthetics and visual amenity of nearby receptors due to construction activities, including vehicular movement on roads, may cause disturbance in aesthetics for tourists, businesses and nearby communities.	C, O	Init	Minor	Short Term	Small	Low	Possible	Low	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
19	Aesthetics	Deterioration of aesthetics and visual amenity of nearby receptors due to low flow in the river may affect the scenic value of the area.	C	Init	Minor	**Medium**	Small	Low	Possible	Low	-
				Res	Minor	**Medium**	Small	Low	Possible	Low	-
20	Aesthetics	Permanent impact in aesthetics due to proposed developments.	O	Init	Minor	**Medium**	Small	Low	Possible	Low	-
				Res	Minor	**Medium**	Small	Low	Possible	Low	-
21	Traffic and Roads	Improved accessibility due to construction of Project access roads.	C, O	Init	Minor	Short Term	Small	Low	Possible	Low	+
				Res	Minor	Short Term	Small	Low	Possible	Low	+
22	Traffic and Roads	Increase in congestion, due to increased traffic volume will cause delays.	C	Init	Minor	Short Term	Small	Low	Possible	Low	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
23	Traffic and Roads	Increase in traffic volume will deteriorate the air quality.	C	Init	Minor	Short Term	Small	Low	Possible	Low	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
24	Traffic and Roads	Increased risk to community safety due to increased traffic volume during the construction phase near communities.	O	Init	Minor	Short Term	Small	Low	Possible	Low	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-

ID	*Aspect*	*Impact*	*Phase*	*Stage*	*Magnitude*	*Timeframe*	*Spatial Scale*	*Consequence*	*Probability*	*Significance*	*+/-*
25	Traffic and Roads	Degradation of the pavement due to use by heavy construction traffic.	C	Init	Minor	Short Term	Small	Low	Possible	Low	-
				Res	Minor	Short Term	Small	Low	Possible	Low	-
26	Livelihood and Well-being	Direct, indirect and induced employment at the local levels, resulting in increased prosperity and wellbeing due to higher and stable incomes of people.	C, O	Init	Minor			Medium	Possible	Medium	+
				Res	Moderate						+
27	Livelihood and Well-being	Increase in the stock of skilled human capital due to transfer of knowledge and skill under the Project resulting in enhanced productivity of the local labor.	C, O	Init	Minor		Intermediate	Medium	Possible	Medium	+
				Res	Moderate				Possible		+
28	Livelihood and Well-being	Increase in recreational and subsistence fishing due to increase in catch of fish following creation of favorable habitats for the fish in the Kunhar River	C, O	Init	Minor			Low	Possible	Low	+
				Res	Minor			Low	Possible	Low	+
29	Livelihood and Well-being	Loss of income from sediment mining due to change in pattern of sediment deposition following construction of the dam	O	Init							-
				Res	Minor	Medium	Small	Low	Possible	Low	-
30	Livelihood and Well-being	Loss of assets and livelihood as a result of land acquired for the Project	D, C	Init							-
				Res	Minor	Medium	Small	Low	Possible	Low	-
31	Socio-Cultural Impacts	Increase in population due to in-migration of job seekers (in-migrants) leading to pressure on existing social infrastructure and services in the Study Area.	C	Init	Moderate	Medium	Intermediate	Medium	Possible	Medium	-
				Res	Minor	Medium	Intermediate	Low	Possible	Low	-

ID	*Aspect*	*Impact*	*Phase*	*Stage*	*Magnitude*	*Timeframe*	*Spatial Scale*	*Consequence*	*Probability*	*Significance*	*+/-*
32	Socio-Cultural Impacts	Disputes over distribution of Project employment within and between Study Area inhabitants and the in-migrants resulting in social unrest	C	Init	**Moderate**	**Medium**	**Intermediate**	**Medium**	**Possible**	**Medium**	-
				Res	Minor	Short term	**Intermediate**	Low	**Possible**	**Low**	-
33	Socio-Cultural Impacts	Potential social unrest in the Study Area due to conflicting socio-cultural norms amongst the inhabitants and in-migrants.	C	Init	Minor	Short term	Small	Low	**Possible**	**Low**	-
34	Socio-Cultural Impacts	Submergence of the graveyards.	C	Init	**Moderate**	**Medium**	**Intermediate**	**Medium**	**Possible**	**Medium**	-
				Res	Minor	Short term	**Intermediate**	Low	**Possible**	**Low**	-

8. Grievance Redress Mechanism

Timely and effective redress of stakeholder grievances will contribute to bringing sustainability in the operations of a project. In particular, it will help advocate the process of forming and strengthening relationships between project management and the stakeholder community groups and bridge any gaps to create a common understanding, helping the project management to efficiently operate in the area.

To register and resolve the grievances of the community in this process, a Grievance Redress Mechanism (GRM) will be established. The proposed mechanism will be based on two–tear grievance redress committees—at village level and at Project level. The proposed GRM will help achieve the objectives of sustainability by dealing with the environmental and social issues of the Project in a timely manner.

The village–level GRC will be established to engage village–level community members/leaders to participate in the decision–making processes and to have "voices" of the aggrieved person/communities in the grievance redress procedures. This will also enhance local ownership of the Project. Having members based in the village, the village–level GRC will be helpful in resolving the grievances quickly often without going into lengthy documentation. The local participation will further build local capacity in dispute resolution and decision–making and provide leadership support in the implementation of the Project. Cases which are not satisfactorily resolved or affected persons remain aggrieved, the case will then be forwarded to the Project–level GRC as the prime floor for resolution of the grievances.

The purpose of the GRM is to facilitate the resolving of disputes without going into litigation. In this regards, the decision of the Project level GRC will be final within the GRM. However, if any disputant remains dissatisfied with the GRC outcome, the disputant can seek redress from a court of law.

PEDO will be responsible for:

1. Establishing the GRM at each village level and at the project level. The GRM will be established as soon as PC–1 of a project is approved.
2. PMU must ensure that the community is informed of the mechanism to redress complaints.

8.1 Grievance Redress Committees

The Grievance Redress Committees (GRCs) are to ensure accessibility, fairness and independence of the procedures. The GRCs will be established at two–levels:

1. Village GRC, with the scope limited within the village; and
2. Project GRC, covering all the project affected villages.

The composition of the two committees is shown in **Exhibit 8.1**.

Exhibit 8.1: Members of GRC

Organization	*Village GRC*	*Project GRC*
PEDO	Field staff of PMU (PEDO) Chairperson	Representative from PMU (PEDO) Chairperson
Community	One or two elders nominated by the community	One or two elders nominated by the community

8.2 GRC's Scope of Work

The scope of work of the GRC shall include:

1. The village GRC will ensure that all grievances related to social and environmental issues are registered, formally recorded, reviewed, resolved and the concerned person is informed in a timely manner.
2. The Project GRC will monitor the working of the village GRC and will work as a forum for appeal against the decision of the village GRC.
3. GRC will not consider complaints related to the procurements or with any matters pending in the court of law.
4. In resolving the disputes, the GRCs would take into consideration the following:
    - Merit of the complaints/case received for consideration;
    - Evidences to take a decision on the complaint;
    - Witness statements;
    - Plausibility of the case in the light of related project activity;
    - Applicable laws, environmental guidelines of Pakistan, initial environmental examination and environmental review document of the project, and ADB environmental guidelines;
    - Observations made on the field; and
    - Available information on previous complaints of similar nature.

8.3 Approval and Orientation of GRC Members

The GRC members will be selected according to their responsibility and personal integrity. Community members of the village level GRCs will be selected after consultation with the communities. Community members of Project level GRCs will be nominated by the affected community. All GRCs' members will be approved and notified by the Project Director.

All GRC members will attend a training and orientation meeting prior to commencement of their work. The training will be provided by competent technical experts in social/resettlement and environmental management. The training will address the policy aspects, compliance requirements, expectations of the community, and need for rapport and communication with the affected communities, and finally need for independence and transparent views in dealing with grievances.

8.4 Dissemination of GRCs

After notification of all the GRCs information regarding GRCs will be disseminated in all the concerned villages by the Environment and Social Unit of the PMU. Information dissemination will comprise the following;

- List of GRC members including address and contact numbers.
- GRC scope of work.
- Grievance redress procedure.

8.5 Grievance Redress Procedure

Following procedure will be adopted to resolve grievances received by the GRCs. The grievance mechanism will be made public through public consultations by the Environment and Social Unit of PMU and Consultant.

8.5.1 Filing of Grievances to Village GRC

For grievances related to social and environmental safeguards, the aggrieved person (or their authorized representatives) may file a grievance with the village–level GRC in one of the following ways:

1. Submit a written complaint to any member of the village GRC.
2. Given the local cultural context, any aggrieved women may submit complaints to GRCs directly or through the head of the household.

For complaints registration Complaint Registration Forms will be available with the secretary of the village level GRCs and complaints will be registered on Grievance Log.

8.5.2 Hearing and Resolution of the Cases by Village GRC

The procedure for hearing and resolution of the complaint will be as follows:

1. On receipt of a complaint:
    - Secretary of village GRC will log the complaint in a register called Complaint Register.
    - Contact other members of the GRC to conduct a meeting within 10 calendar days of the logging of the complaint.
    - If needed, request the complainant or his representative to meet the Village GRC on the appointed date to discuss his complaint.
    - Prepare all the relevant information and document relevant to the complaint prior to the meeting and provide copies to all members.
2. The GRC will meet on the appointed date during which it may:
    - Deliberate on the nature and circumstances of the complaint;
    - Investigate the complaint based on evidence provided by the complainant;
    - Meet with the complainant and other persons;

  - Visit the site; and
  - Take a decision.

3. If the GRC needs extra time to investigate or deliberate on the complaint, the secretary will inform the complainant of the time when a decision is expected. In any case, all complaints shall be resolved within 30 calendar days of logging.
4. Once the complaint is resolved the secretary will document the decision and prepare full documentation on the process including minutes of meeting, photographs of visits, documents reviewed, and reasons of the decision.
5. The GRC will ensure that the complainant is fully informed of the decision and is also informed about his/her right to appeal to the Project GRC and to the court of law.
6. In case follow–up action is required, the chairperson of the village GRC will ensure that the actions are taken and are documented.

8.5.3 Hearing and Resolution of the Cases by Project GRC

The procedure for hearing and resolution of the complaint by the Project GRC will be as follows:

1. On receipt of a complaint from:

- Secretary of Project GRC will request all the concerned documentation from the secretary of the concerned village GRC.
- Contact other members of the Project GRC to conduct a meeting within 15 calendar days of the logging of the complaint to the Project GRC.
- If needed, request the complainant or his representative to meet the Project GRC on the appointed date and place to discuss his complaint.
- If needed, request the members of the village GRC to meet the Project GRC on the appointed date and place.
- Prepare all the relevant information and document relevant to the complaint prior to the meeting and provide copies to all members.

2. The Project GRC will meet on the appointed date during which it may:
   - Deliberate on the nature and circumstances of the complaint;
   - Investigate the complaint;
   - Meet with the complainant and other persons;
   - Visit the site; and
   - Take a decision.
3. If the GRC needs extra time to investigate or deliberate on the complaint, the secretary will inform the complainant of the time when a decision is expected. In any case, all complaints shall be resolved within 45 calendar days of logging with the Project GRC.

4. Once the complaint is resolved the secretary will document the decision and prepare full documentation on the process including minutes of meeting, photographs of visits, documents reviewed, and reasons of the decision.
5. The GRC will ensure that the complainant is fully informed of the decision and is also informed about his/her right to appeal to the court of law.
6. In case follow–up action is required, the chairperson of the Project GRC will ensure that the actions are taken and are documented.

8.5.4 Maintenance and Evaluation of Data by PMU

The Project Director (PD) PMU will ensure that it receives copies of all complaints, meeting notices, decisions, and documentations related to proceedings of the village and Project GRCs

The PMU will maintain complete record of the complaints in a database or tabular form consisting of the following fields:

- Project name
- Village, union council, tehsil, and district
- Name of complainant
- Nature of complaint like environment (trees cutting, Noise, Dust, Waste, Air–Water–Soil Pollution etc.), social (damage to infrastructure, land, privacy, Favoritism/Nepotism issues, etc), Gender (gender equality, empowerment, privacy etc.) and non–compliance to the Govt. /Donor provided guidelines.
- Date of logging of complaint with village GRC
- Date of first meeting of village GRC
- Information on members attended, number of meetings, meeting with complainant, and site visit.
- Date of decision of village GRC
- Follow–up actions, responsibilities, and completion with dates
- Date of logging of complaint with Project GRC
- Date of first meeting of Project GRC
- Information on members attended, number of meetings, meeting with complainant, and site visit.
- Date of decision of Project GRC
- Follow–up actions, responsibilities, and completion with dates

The PMU will prepare periodic report on the GRM reporting on, for example:

- Number of complaints received and resolved by village GRC, Project GRC and nature of complaint;
- The average time of it took to resolve the complaint; and
- The fraction to complaints that were resolved at the village GRC level.

9. Environmental Management Plan

9.1 Introduction

The Pakhtunkhwa Energy Development Organization (PEDO) intends to construct a 310 megawatt (MW) run-of-river hydropower plant (the "Project") with related infrastructure at Balakot, Mansehra district of Khyber Pakhtunkhwa (KP), Pakistan. The Project called Balakot Hydropower Development Project (BHDP) is located on the Kunhar River about 18.6 km upstream of the town of Balakot.

A feasibility study (FS) of the Project[1] was prepared in 2013. The Asian Development Bank (ADB) is evaluating the Project for financing under its Hydropower Investment Development Program. As part of the evaluation of the Project, ADB has acquired the services of two consultants—Aqualogus - Engenharia e Ambiente, Lda ("Aqualogus") to review and update the FS, and Hagler Bailly Pakistan (Pvt.) Ltd. ("HBP") as Safeguard Consultants to prepare the documents required for ensuring that the project meets the environmental and social safeguards of the ADB, and also conforms to environmental legislation of KP.

9.1.1 Project Location

Exhibit 9.1 shows the location of the Project. The Project is located on the Kunhar River in the Khyber Pakhtunkhwa (KP) province of Pakistan, in the 12 km stretch from Paras to Sangar Village. The dam site (34° 39' 36.510" N, 73° 27' 1.340" E) will be located near the village of Paras in the Mansehra District of KP, about 18.6 km upstream of the town of Balakot. The Powerhouse site (34° 36' 15.143" N, 73° 22' 49.943" E) will be located 8 km upstream of Balakot, near Kappi Gali Village. The headrace tunnel extending approximately 9 km will divert water from the reservoir created by the dam to the powerhouse.

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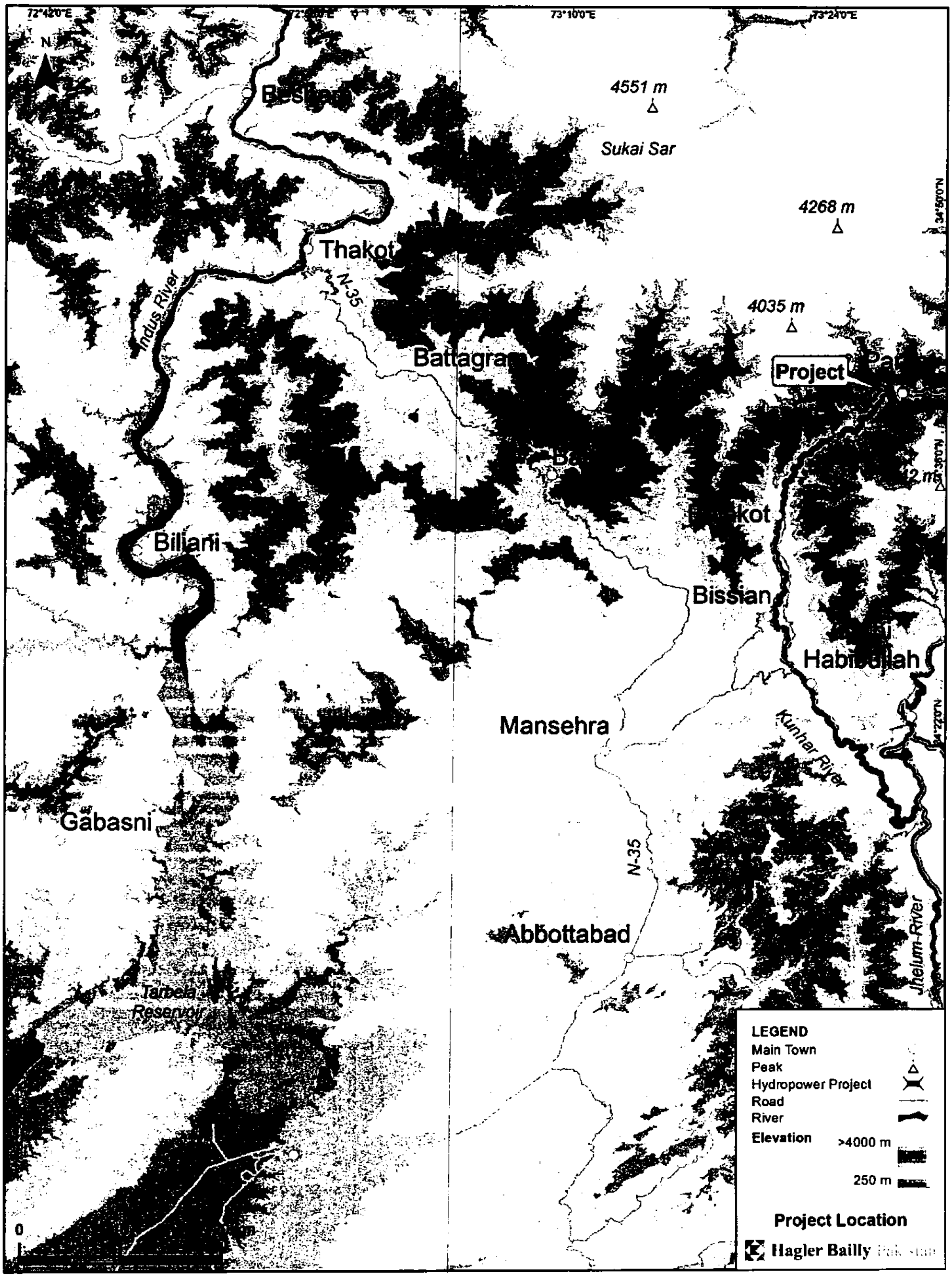
[1] Mirza Associates Engineering Services (Pvt.) Ltd. (Lead Consultant), December 2013, Feasibility Study of Balakot Hydropower Project, Volume I Main Report for Pakhtunkhwa Hydel Development Organization

Exhibit 9.1: Project Location



9.1.2 Introduction to the Environmental Management Plan

The Environmental Management Plan (EMP) summarizes the organizational requirements, management and monitoring plans to ensure that the necessary measures are taken by PEDO to avoid potentially adverse effects and maximize potential benefits of the Project and to operate in conformance with applicable laws and regulations of KP, as well as the policies of international financial organizations such as ADB.

Due to the nature and applicability of the EMP it will also be used for contractual purposes through its inclusion as a part of the bid documents for the EPC contractor who has to adhere to it along with other regulatory requirements. The strict implementation of the EMP and project management's strict enforcement of the adequate construction practices and standards will greatly reduce the negative impacts of the Project.

The EMP presented in this section is a component of the overall Environmental and Social Management System (ESMS), for which a framework is provided in **Section 9.2**.

The EMP is based on the baseline conditions (see **Section 4**, *Description of the Environment*), the impact assessment (see **Section 7**, *Anticipated Environmental Impacts and Mitigation Measures*), and the results of discussions with the stakeholders (see **Section 6**, *Information Disclosure, Consultation, and Participation*). The EMP is prepared for all the identified environmental impacts during design, construction, and operation of various Project activities. The methodology followed for preparing the EMP includes the following:

- Deriving mitigation/protection measures for identified impacts using impact evaluation methodology.
- Rationalizing and combining series of mitigation, compensation and enhancement measures from each identified impacts and risks to prepare overall measures.
- Developing a mechanism for monitoring the proposed mitigation measures.
- Estimating budget requirements for implementation, mitigation and monitoring measures.
- Identifying responsibilities of various agencies involved in the Project for implementation and monitoring of mitigation measures.

Additionally, a Biodiversity Action Plan (BAP) has been prepared for enhancement and conservation of biodiversity of the Kunhar River (see **Volume 2C** of the **EIA**), the implementation of which will involve support from KP Wildlife and Fisheries Departments, and NGOs.

9.2 Environmental and Social Management System

This section describes the framework for the Environmental and Social Management System (ESMS) for the Project.

This section will be revised following discussion with PEDO.

It is the responsibility of each project company affiliated with PEDO's PMU to establish its own ESMS to define the ESHS principles, objectives, and protection measures that ensure the Project does not cause unacceptable impacts. Contractors in turn will adopt the

Project Company's ESMS; however, PEDO PMU retains ultimate responsibility for the EHS performance of all contractors.

The basic elements of the ESMS for the Project are outlined in **Exhibit 9.2** with more detail on each element, and how it applies, given in the following sections. The elements of the ESMS are discussed under the headings of the "plan-do-check-act" business performance improvement cycle. Emergency planning and response and stakeholder engagement are elements of the ESMS that apply to all steps of the "plan-do-check-act" cycle as shown in **Exhibit 9.2**.

9.2.1 Planning Elements

Leadership and Accountability

Policy

The Project is being undertaken in accordance with PEDO's policies. PEDO will periodically review the scope and effectiveness of these policies. The policies will be documented, maintained, implemented and communicated to PEDO employees, contractors, suppliers and the public.

Legal Requirements and Other Obligations

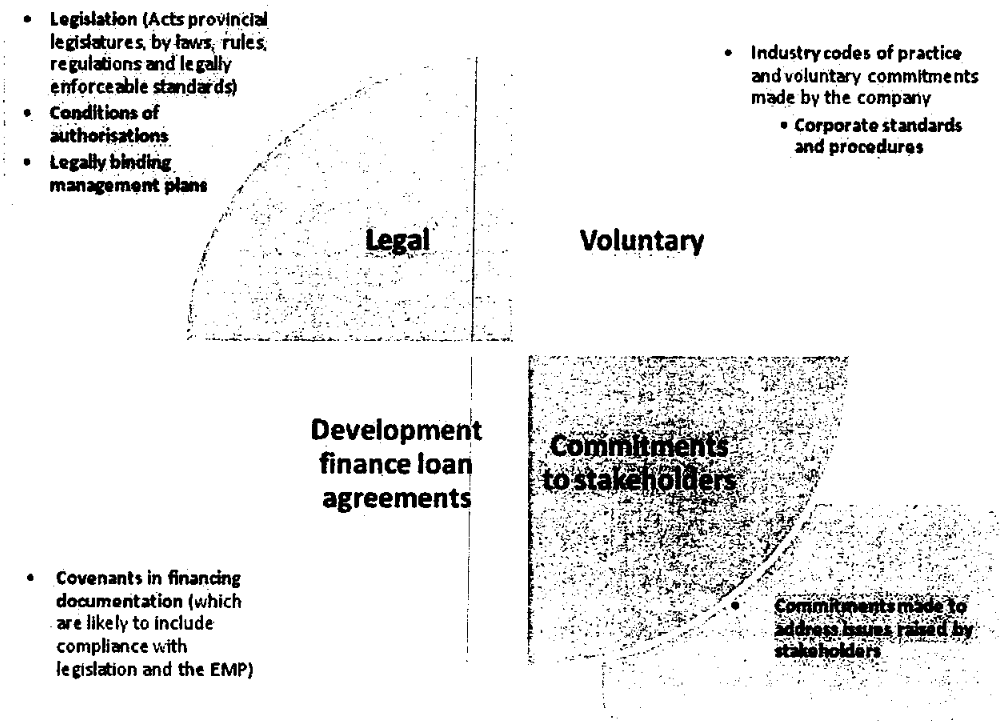
The Project's ESMS takes into account of both legal and other obligations imposed on the Project. The various types of obligations that need to be considered are shown conceptually in **Exhibit 9.3**.

Exhibit 9.2: Elements of the Project ESMS

Steps of the "plan-do-check-act" cycle	Elements of the ESMS for the Project			Elements applying to all steps of the cycle	
	Elements	**Primary function**			
Plan (Chapter 2, *Planning Elements*)	**Leadership and accountability**	Produce and communicate a statement of PEDO commitment to environmental and social management Establish, document, implement, maintain and improve the Project ESMS	⟺	**Stakeholder engagement** An ongoing process, throughout the life of the project. Serves to build and maintain a constructive relationship with communities affected by the Project	**Emergency planning, response and recovery** Maintain emergency response preparedness through the identification of potential environmental emergencies, development of response plans and allocation of response and recovery resources.
	Legal and other requirements	Identify and provide access to legal requirements and other obligations			
	Aspect identification and impact assessment	Identify aspects ("mechanisms" by which project activities impact on the environment) and assess associated impacts throughout the Project life (the EIA falls under this element of the ESMS)	⟺		
	Objectives, targets and plans	Define objectives, targets, criteria and actions for the management of potential impacts (the EMP falls under this element of the ESMS)			
Do (Chapter 3, *Implementation Elements*)	**Roles and responsibility**	Provide sufficient management sponsorship of human and financial resources Establish roles and responsibilities for implementation			
	Contractors, suppliers and vendors	Consider environmental and social impact management and performance in the selection and management of third party services			
	Competence, training and awareness	Make personnel aware of their responsibilities and enable them to be capable and competent in meeting their responsibilities			
	Communication	Maintain internal and external communications to enable effective environmental management	⟺		
	Operational controls and maintenance	Implement operational controls and maintain equipment to uphold environmental performance and compliance and to manage impacts and risks			
	Documentation and record keeping	Control and maintain documents and records associated with environmental and social management			
Check (Chapter 4, *Check Elements*)	**Assessing, correcting and improving performance**	Monitor environmental and social management and performance and take measures to continually improve performance	⟺		
	Non-conformance and incident reporting	Promptly report non-conformances and incidents are promptly reported and take corrective and preventative actions to reduce the likelihood of recurrence			
	EMP and ESMS reporting	Report on compliance with the EMP and ESMS performance to senior management, regulatory authorities and affected communities	⟺		
Act (Chapter 5, *Act Elements*)	**Governance/ management review**	Require site, regional and senior management to review the suitability, adequacy and effectiveness of the ESMS and identify improvement actions to facilitate continuous improvement			
	Management of change	Modify the ESMS in response to changes in the Project and to changes in the organization, personnel, operations and processes	⟺		

⟺ *The arrows show where there is integral relationship between stakeholder engagement and other elements of the ESMS.*

Exhibit 9.3: Types of Obligations Relevant to the ESMS



PEDO will identify, document and maintain a register of legal requirements and other obligations applicable to the Project. It will also:

- manage recurring legal and other obligations (such as inspections, sampling, analysis and reporting);
- track developing legislation and regulations that may apply to operations and activities to anticipate and prepare for compliance;
- inform employees and others working on behalf of the company of existing and emerging obligations that apply to their job responsibilities; and
- consider the register in the setting and review of objectives, targets and plans for management of impacts.

Aspect Identification and Impact Assessment throughout the Project Life

A key element of ESMS is identification of aspects and assessment impacts. The EIA is a part of this element of the ESMS. The impacts identified in the EIA in **Section 7** (*Anticipated Environmental Impacts and Mitigation Measures*) are addressed in this EMP

Procedures will be set up, implemented and maintained for identification of significant environmental aspects and undertaking of impact and risk assessments on an ongoing basis through the Project life. These will address:

- aspects not covered by this EIA;

- any impact arising that was not predicted by the EIA or did not develop as predicted by the EIA; and
- any changes in the Project or new developments arising subsequent to the completion of this EIA.

Objectives, Targets and Plans for Management throughout the Life of the Project

This element of the ESMS pertains to the setting of objectives and targets for environmental and social management, and plans for the achievement of these objectives and targets at corporate and Project levels. The EMP embodies this element of the ESMS at the Project level.

The primary purpose of the EMP is to guide environmental and social management throughout the life of the Project. The core of the EMP is a statement of environmental and social management objectives and associated management measures. The EMP will be supported by other documentation, such as the original Project design and specific management plans and operating procedures.

The preliminary EMP commitments are derived from the following sources:

- inherent design or management measures described in the EIA and Project Feasibility Study;[2]
- mitigation and enhancement measures identified in the EIA, which are required to manage identified impacts; and
- good practice management measures, which may not significantly alter the impact rating but are considered standard industry practice for the management of such impacts.

9.2.2 Implementation (do) Elements

Effective implementation and functioning of the EMP depends on adequate human and financial resources, clearly defined responsibilities for environmental and social management, appropriate training and good communication. An outline of how these features will be managed for the Project is presented below.

Roles and Responsibility

PEDO will define, document and communicate the environmental and social management roles and responsibilities of Project personnel, including contractors, Owners Engineers, and others working on behalf of the company, in all phases of Project implementation from detailed design through to closure, before the start of each phase. Personnel with specific roles and responsibilities will have the authority, and be held accountable for, carrying out these.

The basic roles required to implement the EMP, and establish and maintain the ESMS, are shown in **Exhibit 9.4**. These roles need to be reviewed and incorporated into the organizational structures for the various phases of the Project from detailed design through to closure. A key requirement is for the senior environmental management

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[2] China Water Resources Beifang Investigation, Design and Research Co. Ltd. (BIDR), Revised Technical Report To Updated Feasibility Study, April 2016

professional to report directly to the on-site senior manager (the Operations/General Manager).

Exhibit 9.4: Key Roles for Environmental and Social Management

Roles	*Relevant Responsibilities*
Project Director for the Project Management Unit (PMU) of the Project	▶ Endorse the environmental and social management policy and require it to be communicated to the public ▶ Allocate adequate human and financial resources to enable effective functioning and continual improvement of the ESMS ▶ Establish and maintain a governance system
Project site management and PMU's senior management	**Compliance** ▶ Confirm necessary authorizations (licenses/ permits) have been obtained for the Project ▶ Confirm compliance with legal requirements and other obligations pertaining to environmental and social management ▶ Commit contractors and suppliers to meeting relevant environmental and social obligations by means of specific conditions in the contracts of appointment **Roles and responsibility** ▶ Define, document and communicate environmental and social management roles, responsibilities and authorities ▶ Provide sufficient appropriately trained human resources and adequate financial resources to enable effective functioning and continual improvement of the ESMS ▶ Hold personnel responsible for meeting their assigned responsibilities **Communication and reporting** ▶ Confirm there is adequate ongoing stakeholder engagement ▶ Confirm obligations for reporting to regulatory authorities, development financiers and affected communities are met **Management review** ▶ Provide leadership in the pursuit of environmental and social management ▶ Examine and review the ESMS periodically to determine its suitability, adequacy and effectiveness ▶ Support action to enhance the ESMS and make improvements in environmental and social management performance
Environmental management	**ESMS** ▶ Establish the ESMS, with assistance from the senior management, division managers and community relations managers ▶ Liaise with division managers regarding environmental management roles, responsibilities and authorities throughout operational divisions

Roles	Relevant Responsibilities
	▶ Coordinate monitoring and evaluation activities and confirm corrective actions (an action taken to address a non-conformance) are taken to address incidents and non-conformances (a failure to comply with the Project's ESMS) ▶ Report progress in implementation and functioning of the ESMS to senior management, development financiers, regulatory authorities and stakeholders **EMP** ▶ Keep the EMP up to date and confirm it addresses all relevant environmental and social obligations ▶ Present the EMP in an appropriate format for communication with regulatory authorities and other stakeholders ▶ Present the EMP in an appropriate format for communication with parties responsible for Project execution ▶ Compile EMP compliance reports ▶ "Sign-off" actions in the EMP and non-conformances once they have been completed
Community relations management	▶ Assist the Environmental Management team with ongoing reporting to stakeholders on EMP and supporting management plans, and progress with implementation of management measures ▶ Assist Environmental Manager and division managers with stakeholder communication where awareness and/ or co-operation of stakeholders are required to implement management measures ▶ Manage the community grievance mechanism
Division management (management that oversees certain specified sections in an organization)	▶ Confirm the ESMS and EMP are established, communicated, implemented and maintained in their respective areas ▶ Provide leadership in the pursuit of environmental and social management ▶ Identify ways to improve environmental and social performance through daily monitoring of their activities and evaluating implementation ▶ Review monitoring results, incidents and corrective actions taken ▶ Evaluate adequacy and effectiveness of awareness and skills training programs pertinent to environmental and social management ▶ Maintain internal communication of environmental and social matters between the Environmental Manager, Community Relations Manager and other personnel, and promote environmental and social awareness. ▶ Examples of key responsibilities of specific Division Managers include: ▷ Human resources—Organize in association with the Environment Manager and Community Relations Manager environmental and social related training, maintain linkages between the ESMS and human resources management

Roles	*Relevant Responsibilities*
	systems, as necessary, and manage worker grievance mechanism. ▷ Finance—Track budget/spend data used in implementing and maintaining ESMS in association with the Environment Manager and Community Relations Manager ▷ Purchasing—With the support of environment and community relations teams, assess contractors' and suppliers' environmental and social compliance and control purchase and disposal of hazardous materials ▷ Maintenance—Implement preventive maintenance program for equipment ▷ Health, safety and security—With the support of community relations teams, confirm safeguarding of personnel and property is carried out without adverse impacts on local communities
All personnel and contractors	▶ Work in accordance with the EMP and supporting documents ▶ Report problems or deviations from the ESMS or EMP to division managers and/or environmental managers, as instructed.

PEDO Management can assign part of its responsibilities to Owner's Engineer for construction phase of the Project. All such assignments shall be explicitly included in the contract agreement between PEDO and the Owner's Engineer. Moreover, all associated reporting, documenting, and cost shall also be agreed and written in the contract agreement.

Contractors, Suppliers and Vendors

Environmental and social performance, programs and risk management will be considered in the selection and management of contractors, suppliers and vendors. Contracts will address potential environmental and social liabilities and responsibilities including:

- use of competent, trained staff, including subcontractors;
- consequences for failing to meet obligations;
- monitoring of performance;
- required job-specific, site-specific training;
- compliance with PEDO policies and site standards and applicable legal requirements;
- responsibility for chemicals brought on-site and wastes generated on-site, including closure activities where appropriate; and
- identification of a lead responsible person for both PEDO and the contractor.

Contractors, including their employees and associated subcontractors, will be made aware of the environmental risks, associated controls, procedures and standards relevant to their work on-site. The activities and performance of contractors will be monitored through

Owner Engineer's Environmental & Social Development Cell (ESDC) against the terms of the contracts.

Training

Personnel, including contractors' personnel, working for or on behalf of the Project will receive training to maintain awareness of relevant environmental and social aspects, impacts and risks associated with the Project and corresponding controls. The training will also maintain awareness of the environmental benefits of improved personal performance and the potential consequences of departure from specified procedures. Visitors to Project sites will receive relevant environmental and social awareness training as part of site induction training.

Personnel, including contractors' personnel, will be made aware of the particular environmental and social management responsibilities that apply specifically to their jobs. Training needs analyses will be undertaken and personnel will be given adequate training to meet these responsibilities.

The training program comprises the following elements:

- identification of training needs for all employees specific to their varying responsibilities;
- development of a training plan and schedule to address defined needs;
- verification of training programs to confirm consistency with organizational requirements;
- training of employees and documentation of training received;
- evaluation of training effectiveness; and
- review and modification of training programs, as required.

Personnel with direct responsibility for implementation of the EMP and functioning of the ESMS will have additional training to:

- provide them with the knowledge and skills necessary to perform their work;
- maintain their knowledge of relevant environmental and social obligations; and
- enable them to implement specific measures required under the EMP in a competent and efficient manner.

Training requirements and completed training will be documented. Procedures to evaluate the effectiveness of such training will be implemented.

Communication

To effectively implement environmental and social management, the relevant managers will maintain lines of internal communication and provide information regarding the EMP, ESMS and environmental and social management performance, incidents, best practices, lessons learned and concerns to personnel electronically, on notice boards and/or in newsletters. Such communication will be used to inform the personnel of their individual responsibilities with respect to the ESMS and to raise awareness on specific matters. External stakeholder engagement is discussed in **Section 6** *(Stakeholder Engagement).*

A grievance redress mechanism will be established (**Section 8**, *Grievance Redress Mechanism*) and will provide a means for Project personnel, including contractors' personnel, to anonymously raise environmental and social concerns (this grievance mechanism will be separate from the system dealing with employee grievances that need to be handled by the human resources department).

Operational Controls

Operational controls will be implemented to maintain performance and compliance, and to manage impacts and risks. Operational controls may include:

- administrative controls such as performance standards;
- standard operating procedures and work instructions; and
- engineered controls such as pollution control equipment.

Written operational controls are required where their absence could lead to deviation from environmental obligations or objectives and targets. Written operational controls will be part of the EMP supporting documentation.

The adequacy, suitability, and effectiveness of operational controls will be reviewed regularly.

Documentation on the design basis and operating criteria/limits for equipment having the potential to impact environmental performance will be maintained.

Operating equipment, as well as environmental monitoring and measurement devices, will be maintained consistent with manufacturers' specifications and best management practice to reduce the potential for environmental incidents and adverse environmental impacts.

Documentation and Record Keeping

Elements of the ESMS will be documented and controlled in accordance with a document control system. Records demonstrating compliance with legal requirements and conformance with the ESMS will also be maintained. PEDO will establish, implement and maintain procedures for:

- ESMS document control detailing how the creation, review and updating of various types of documents will be managed and who will be responsible; and
- record identification, storage, protection, retrieval, retention and disposal.

Documentation and record keeping controls will include:

- measures to enable relevant documents (including those of external origin deemed necessary for planning and operation of the ESMS) and records to be readily available and identifiable (labelled, dated and properly filed), legible and protected from damage;
- review, revision and approval of documents for adequacy by authorized personnel at least once a year;

- making current versions of relevant documents available at locations where operations essential to the effective functioning of the ESMS are performed;
- suitably identifying obsolete documents retained for legal and knowledge preservation purposes; and
- identification and segregation of confidential and privileged information.

9.2.3 Check Elements

Checks are required to confirm the existence of an effective ESMS and compliance with the EMP. Checks include monitoring, site inspections and formal audits. Linked to this, measures need to be taken to remedy non-conformances and to continually improve environmental performance. These are also classified as "check" elements of the ESMS.

Assessing, Correcting and Improving Performance

Monitoring Programs

The aim of monitoring programs are to:

- provide measurements of environmental and social impacts of the Project;
- ascertain and demonstrate compliance with conditions of approval and other legislation;
- provide sufficient evidence to address any claims made against the Project in respect of environmental and social matters;
- track performance of the ESMS and progress in the implementation of the EMP;
- track and measure key indicators and other performance measures over time to improve the Project's performance and reduce the likelihood of environmental incidents; and
- inform decision processes for determining management actions.

The monitoring programs cover the physical, biological and social components of the operation and are integrally linked with the assessment criteria stated in the EMP. Where appropriate and possible, the sampling parameters and locations used in the EIA baseline studies have been retained to provide data continuity.

The monitoring program identifies monitoring parameters, sampling locations, sampling frequency and duration and detection limits (where appropriate). It includes control sites, where relevant. The focus and extent of monitoring is commensurate with the risk of impacts occurring, the sensitivity of the surrounding areas and the affected communities' perceptions of risks to their health and environment. For some types of monitoring, thresholds or targets are available, for example the emission and ambient limits. In other cases, the monitoring results will be compared to the baseline data set gathered as part of this EIA. Lastly, where neither thresholds nor baseline data are available, the initial data collection may form the baseline for future data collection.

Data will be documented and interpreted. Temporal and spatial trends in the data will be discerned and compliance with relevant thresholds will be evaluated. Monitoring reports will be produced to meet internal and external reporting requirements. If monitoring results indicate non-conformance with stipulated thresholds or if a significant deteriorating trend is observed, it will be recorded as a non-conformance and handled by the non-conformance and incident procedure.

Preliminary monitoring programs have been prepared and are presented in the EMP. These provide a framework of monitoring to evaluate performance and assist in predicting and managing impacts. In conjunction with the development of supporting documentation for the EMP, detailed monitoring plans, with appropriate sampling protocols where relevant, may need to be developed. These more detailed supporting documents would include the criteria against which the monitoring results will be compared and the actions required if the criteria or thresholds are exceeded. The supporting documents may also cover:

- sample or data collection methods;
- sample handling, storage and preservation;
- sample or data documentation;
- quality control;
- data reliability (calibration of instruments, test equipment, and software and hardware sampling);
- data storage and backup, and data protection;
- interpretation and reporting of results; and
- verification of monitoring information by qualified and experienced external experts.

The frequencies and locations of monitoring may need to be adjusted depending on final Project design and ongoing review of results obtained by the monitoring programs. Therefore, the programs will be reviewed on a regular basis (at least annually) and adjusted, where necessary. Changes to the EMP or obligations register may also result in changes to the monitoring program.

Site Inspections

Site inspections will be undertaken regularly in relevant areas of the Project. The inspections will focus on compliance with the EMP and conformance with the ESMS. The inspections will play an important role in increasing awareness of EMP and ESMS requirements.

Continuous observation and monitoring by site and HSE managers and other responsible parties for compliance with the EMP and conformance with the ESMS will be part of their core responsibilities.

Minor non-conformances will be discussed during the inspection and recorded as a finding in the inspection report. Major non-conformances will be reported as incidents. Inspection results will be disclosed at management meetings.

Formal Audits

Formal audits will be undertaken at planned intervals in accordance with the requirements of PEDO, PEDO's owners and regulatory authorities. Procedures for audits will be established, implemented and maintained. These will cover the audit criteria, scope, frequency and methods, and will address the responsibilities and requirements for planning and conducting audits, reporting results and retaining associated records.

Negative findings arising from an audit will be dealt with in accordance with the non-conformance and incident procedure. Results from audits and evaluations of compliance with legal requirements will be reported to site and senior management and subject to management reviews.

Non-conformances and Incident Reporting

Non-conformances include the following:

- exceedances of relevant thresholds as identified during routine monitoring;
- non-conformances with the requirements of the EMP or supporting documentation identified during an internal inspection;
- non-conformances identified during an audit or by regulatory authorities, including legal non-conformances;
- events, such as spills, resulting in potential or actual environmental harm;
- events that did or could result in injury to staff, visitors to site or surrounding communities; and
- significant complaints or grievances received from any source.

Corrective and preventive actions will be identified and implemented in response to these non-conformances. These actions will address the root cause of the non-conformance and will reduce or prevent repeated non-conformances.

A process will be established for the identification, investigation and tracking of non-conformances, including:

- prioritizing and classifying non-conformances based on the type and severity of the non-conformance;
- recording of non-conformances and the results of corrective and/or preventive actions, including the actions necessary to mitigate or remedy any associated impacts;
- defining results expected from the corrective and/or preventative actions;
- confirming the corrective and/or preventive actions taken to eliminate the causes of the non-conformance are appropriate to the magnitude of problem and commensurate with the impacts encountered;
- reviewing the effectiveness of the corrective and/or preventive actions taken; and
- implementing and recording required changes in the EMP or monitoring program resulting from corrective and preventive action.

Serious non-conformances will be classified as incidents. Incidents will be promptly reported to appropriate management. PEDO will prepare a guideline on:

- the types of incidents reportable to internal management at the site, Project and corporate levels, as well as to regulatory authorities and other external stakeholders; and
- standards to be observed when reporting incidents.

The investigation of incidents and evaluation of effectiveness of existing controls and response actions will be undertaken at a level commensurate with the severity of the incident.

EMP and ESMS Reporting

Progress on compliance with the EMP and functioning of the ESMS (environmental and social performance) will be reported to:

- Project site and PEDO senior management;
- development financiers, if required in terms of the loan agreement;
- regulatory authorities, as required; and
- affected communities and other stakeholders who have an interest in the Project.

9.2.4 Act Elements

Governance/ Management Review

PEDO's senior management will review the EMP and ESMS on a periodic basis to determine its suitability, adequacy and effectiveness. Each management review will initiate a new plan-do-check-act cycle with enhancement of the ESMS and continuous improvements in environmental and social management performance. The management review will cover:

- progress and closure of actions from previous management reviews;
- monitoring programs findings/ the extent to which objectives and targets have been met;
- findings of audits;
- incidents and the status of corrective and/or preventative actions;
- impact and risks assessments;
- changing circumstances, including changes to operations, Pakistan legislation or guidelines, ownership, socio-political circumstances;
- legal compliance and compliance with other obligations;
- stakeholder concerns, requests or complaints;
- adequacy of policies, EMP, monitoring plans, support documents and overall functioning of the ESMS to meet operational and corporate requirements; and
- recommendations for improvement.

Management of Change

Changes to the Project can be expected throughout the life of the Project. These can range from changes to operations and infrastructure, new developments (such as an expansion), changes to personnel and the Company, changes in legislation and changes to the environment of the Project (such as a new settlement established near Project infrastructure). These changes could result in changes to the significance of environmental and social impacts and risks. This may necessitate updates to existing authorizations/ permits, changes to the EMP, which may have to be approved by regulatory authorities, and general changes to the ESMS framework.

A procedure for the management of change will be established and maintained by PEDO. This will:

- observe the corporate owners' requirements for the management of change;
- identify proposed changes that could alter environmental or social impacts and risks and/ or require new authorizations/ permits or changes to existing authorizations/ permits; and
- define the impact and risk assessments appropriate to different types of changes, which need to be undertaken by competent personnel.

Changes will not be made without the required authorizations/permits in place. The measures identified as necessary to mitigate impacts and risks will be implemented. The various elements of the ESMS will be modified as required in response to the change,

A procedure specifically for changes to the policy/s, EMP, monitoring plans and supporting documentation will be established. This will detail:

- how the changes are to be recorded;
- who has responsibility for overseeing changes and checking they do not conflict with any planning conditions or other obligations;
- the process of review and sign off in response to changes; and
- how changes to the EMP should be communicated internally and externally.

9.3 Stakeholder Engagement

Stakeholder engagement provides stakeholders with opportunities to express their views on project risks, impacts and impact mitigation measures and involves appropriate consideration of the views and responses by project management. **Exhibit 9.5** shows that stakeholder engagement applies to each of the steps of the ESMS "plan-do-check-act" cycle and is an integral part of several ESMS elements. The relationship between stakeholder engagement and these elements is explained further in **Exhibit 9.5**.

Exhibit 9.5: General Overview of the Relationship between Stakeholder Engagement and the ESMS elements

Steps of the "plan-do-check-act" cycle
ESMS Elements that Stakeholder Engagement is Integral to

	ESMS Elements	*Role of Stakeholder Engagement*
Plan	EIA	During the EIA, the focus of stakeholder engagement has been the involvement of stakeholders in project-planning and project-approval decision-making processes. It facilitated identification of stakeholder's concerns so they could be addressed in the Project design and/or EMP. It forms the basis for stakeholder engagement throughout the life of the Project.
	EMP	Stakeholders will be involved in the review and approval of the preliminary EMP. Throughout the life of the Project, there should be ongoing reporting to stakeholders on progress in the implementation of the EMP and supporting management plans that are of interest to them. The EMP and supporting management plans may need to be revised in response to stakeholders' concerns.
	SEP	A stakeholder engagement plan is to be developed. It will detail national regulation and good practices on stakeholder engagement, a summary of previous stakeholder engagement undertaken for this Project, required additional consultations, and the structure for future stakeholder engagement.
Do	Communication	Communication with stakeholders will be required to implement some management actions. The communication will be required to raise awareness and/or co-operation of potentially affected communities and other stakeholders. PEDO will determine effective communication methods for making affected communities aware of actions they may need to take to avoid exposure to operation-related hazards and how they can maximize on opportunities resulting from the operation.
Check	Assessing, correcting and improving performance	Participatory monitoring is desirable. This entails involvement of stakeholders, particularly affected communities, in monitoring and verifying information to check that impact mitigation measures are appropriate.
		Grievances will be handled as incidents and managed through the incident procedure to enable the grievance to be received, documented, addressed and results fed back to the complainants. This procedure will protect the confidentiality of the persons raising the complaint, where necessary. The feedback will be easily accessible and understandable to members of the affected community and/or staff.
	Reporting	Stakeholders affected by the Project will be informed of progress in the implementation of the management plans and of the effectiveness of management measures.

PEDO has established an initial program of stakeholder engagement for the Project and this will continue throughout the life of the Project. Currently, this program includes disclosure of information and consultation with stakeholders as part of the EIA process.

When the Project enters the construction phase, and throughout the remaining life of the Project, stakeholder engagement will include:

- a grievance mechanism, for receiving concerns about the Project's environmental and social performance and for facilitating the resolution of the concerns (the grievance mechanism applies to Project stakeholders, including potentially affected communities and Project personnel.
- reporting on the implementation of the EMP and relevant supporting management plans;
- opportunities for stakeholders to respond to the information received; and
- constructive dialogue on environmental and social issues and performance.

The stakeholder engagement process will be documented, including:

- maintenance of a stakeholder database with stakeholder details;
- records of information disclosed to stakeholders;
- records of stakeholder engagements; and
- records of inputs from stakeholders and responses to these.

9.3.1 Emergency Preparedness and Response

The Project will implement and maintain an Emergency Preparedness and Response Plan (EPRP).

Purpose and Applicability

This framework is intended to guide the means by which PEDO and its contractors will ensure that they are prepared for emergency situations and can respond effectively should they arise. For each stage of a project's project life cycle, PEDO and/or contractor will develop and implement an ERPR that meets the requirements of this framework. PEDO will identify the party responsible for preparing the EPRP. It is expected that most emergencies during construction would take place on the site, so the Plan prepared for the construction period would primarily (but not exclusively) address on-site emergencies. During operation, on the other hand, dam failure or other emergencies could cause significant downstream impacts, so the Plan for the operations period would address a combination of on-site and off-site emergencies and actions.

Approach and Activities

EPRPs for new projects will initially be developed based on the Environmental and Social Impact Assessment or other assessment document that identifies on-site and off-site risks during the project life cycle that could result from an accident or other emergency situation, and on a detailed assessment of site activities. The EIA and/or other documents would typically identify specific risk-reduction measures as well, which would become part of the EPRP. EPRPs for existing projects will initially be based on due diligence assessments that evaluate risks of ongoing construction and/or operations, and again will include a detailed assessment of site activities. EPRPs will also be informed by and based upon the best judgment of qualified professionals and the experience gained from ongoing activities. EPRPs will become part of the Project's Environmental Management Plan.

The EPRP will identify various emergency situations that could realistically occur, which could include:

- Fire or explosion
- Road or site traffic accident
- Spills of hazardous materials such as fuels, chemicals, oil, paint, etc.
- Landslides, mudslides, or rockfalls
- Equipment failure
- Earthquakes (primarily during operation)
- Cofferdam failure
- Partial or complete dam failure (impacts of dam break provided as **Appendix T**)
- Floods
- Turbine or blade failure.
- Site lockdown due to breach of security, external attack, or other event.

The EPRP will call for close coordination with local authorities regarding preparing and responding to emergencies that could affect local people or communities. Particularly if there could be serious off-site impacts, EPRPs will describe the coordination process, including PEDO support for community emergency preparedness and response training.

EPRPs will include details for the following elements, which could be different for various types of accidents:

- Organizational and individual responsibilities for both emergency preparedness and for emergency response, which could be very different. This would include roles and responsibilities of responders and decision-makers.
- Measures that need to be taken to prepare for potential emergencies, including equipment, supplies, warning signals, dedicated communication lines, etc.
- Details on how relevant authorities, the public, and third-party emergency response agencies will be informed of potential risks due to emergency situations resulting from project activities, and on agreements that have been reached for cooperative responses to emergencies.
- Contact details of all dedicated and non-dedicated emergency response personnel on the site and personnel who are available off-site.
- Contact details of relevant authorities and third parties who will need to notified for various types of emergencies (nearby residents, landowners, fire brigades, local law enforcement, military, etc.).

- Detailed information on internal and external equipment, personnel, facilities, funding, expert knowledge, and materials that will be required to respond to specific types of emergencies. The EPRP will also need to identify the specialized expertise that may be needed to respond to specific emergencies.
- Procedures for using, inspecting, testing, and maintaining emergency response equipment, which may include equipment under the control of third parties (for example, the local fire brigade or emergency medical teams).
- Clear procedures and protocols for notifications and communications to and within the contractor (if any), local and other authorities, potentially affected people, and other parties.
- Emergency response procedures to be followed, and by whom, for various emergency situations.
- Locations of holding/areas for workers and off-site collection points for others, and conditions under which they would be used.
- Pro forma incident report forms.

The EPRP should call for a root-cause analysis following any emergency or near-emergency situation in order to identify improvements in future preparedness or response. The EPRP, or a separate planning process, should also include measures to ensure business continuity and contingency, including:

- Identifying and making contingency arrangements to exploit replacement supplies or facilities – which could include buildings, electricity, water supplies, equipment and vehicles, fuel, etc. -- to allow business continuity.
- Maintaining backups of critical information, including relevant EPRPs that form the EMP, in a secure but accessible location to ensure continuity or restoration of site activities, including implementation of mitigation measures.

Monitoring, Recordkeeping, and Reporting

The EPRP will describe records that must be kept to document various activities required to maintain emergency preparedness, and the person(s) responsible for maintaining the records. The EPRP will also describe how notice and details of any imminent or actual emergency will be communicated within the contractor (if any), local authorities, potentially affected people, and other parties.

The EPRP will require periodic inspection/monitoring of the Project site(s) and records, with a focus on areas where accidents or other occurrences could lead to emergency situations. The EPRP will need to specify:

- The locations, activities, and records that must be inspected.
- The frequency of inspection.
- The required qualifications of persons who will conduct the monitoring.
- Records that must be kept and the person responsible for keeping the records.

- Special hazards of inspection, including appropriate cross-references to the Occupational Health and Safety Plan for required and recommended risk reduction measures.
- Reports that will be prepared, to whom the reports are to be submitted for review, and the length of time records will be kept. This could include summary reports or detailed technical reports, and could be submitted to company or PEDO management, government agencies, or lenders.

The EPRP will describe how remedial actions will be identified and implemented in the event that monitoring reveals shortcomings in emergency preparedness or in recordkeeping, and how follow-up monitoring will be implemented until the requirements of the EPRP are fully met.

Implementation

The EPRP will identify and describe the responsibilities of all parties, including PEDO, contractors, and competent authorities. The EPRP must also identify the roles and responsibilities of individual positions within PEDO and the contractor. This will include the chain of command for directing response activities in case of various types of emergencies. This should be shown in an organogram that includes as much detail as possible, down to the individual person/position.

Training

The EPRP will identify training requirements for staff and managers of PEDO and/or contractors, including who will be responsible for conducting the training and who must be trained in what skills. Training will also extend to third parties who may be called upon to respond to emergencies. Training will focus on the assigned responsibilities of the trainees in preparing for emergencies and for responding to emergencies if they occur, and will cover technical and administrative skills needed to perform assigned responsibilities. The EPRP will need to provide for emergency preparedness and response training should be closely coordinated with occupational health and safety training. The EPRP should call for at least the following topics to be part of emergency preparedness and response training.

- Providing information necessary for trainees to understand the possible effects of various types of emergencies and an opportunity to contribute effectively, as appropriate, to decisions concerning preparedness and response.
- Providing specific information on appropriate behavior and safety measures to be adopted in case of various types of emergencies.
- The specific responsibilities of the person being trained in case of various types of emergencies.
- Scheduled and unscheduled drills and practice in responding to various types of emergencies, including site evacuation, and procedures to monitor drills closely to verify that staff and managers are aware of their responsibilities and are able to complete them.

Relationship to other Plans

The emergency preparedness and response plan is related to the following plans:

- Spill Prevention and Response Plan.
- Waste Management Plan.
- Blasting and Explosives Control Plan.
- Stakeholder Engagement Plan.
- Dam Safety Review Procedure.
- Site Security Plan.
- Occupational Health and Safety Plan.

Revision

The EPRP will be reviewed by PEDO or the contractor as appropriate, at least annually and whenever there is a significant change in Project or site conditions, or when it is determined that any measure intended to prevent or reduce the probability of emergency situations is or may be insufficient to achieve its purpose. The EPRP will also be reviewed following the root-cause analysis that is completed after any emergency or near-emergency. It will be revised when necessary to update or improve emergency preparedness and response, and when it is determined necessary to ensure compliance with applicable standards and good international industry practice.

9.4 Mitigation and Management Plan

This section summarizes, as the mitigation and management plan, the mitigation measures for the Project as prescribed in the EIA. It divides the responsibilities for implementation of these measures and describes additional management plans that must be developed to facilitate implementation.

9.4.1 Environmental and Social Mitigation

The mitigation plan includes the following:

- **Impact Reference** – this specifies the impact/s for which the mitigation measure is proposed. The impact reference can be used to look up, if required, details on the assessment of the specific impact in **Section 7** (*Anticipated Environmental Impacts and Mitigation Measures*). A summary is provided in **Exhibit 9.6**.
- **Mitigation Measure** – this summarizes the required mitigation measures as given in the above referenced chapter to keep environmental impacts at an acceptable level.
- **Implementation Measure** – these are additional measures that are required for the correct execution of the mitigation measures.
- **Monitoring Indicators** – these are indicators that should be tracked to ensure compliance.

The mitigation plans are given in **Exhibit 9.7** to **Exhibit 9.9.**

Mitigation measures are further divided by responsibility and are presented in the exhibits indicated in the list below. Each table indicates the management unit which the mitigation measure is expected to fall under. This is to facilitate implementation so that managers can locate their responsibilities completely and efficiently.

Design Phase

- Project Design and Construction Planning (**Exhibit 9.10**)

Construction Sites

- Dam Site Construction Manager (**Exhibit 9.11** and **Exhibit 9.12**)
- Powerhouse Site Construction Manager (**Exhibit 9.11** and **Exhibit 9.13**)
- Headrace Tunnel Construction Manager (**Exhibit 9.11** and **Exhibit 9.14**)
- Waste Dump Area Manager (**Exhibit 9.11**)
- Quarry Area Manager (**Exhibit 9.11**)
- Workshop Manager (**Exhibit 9.15**)
- Batching Plant Manager (**Exhibit 9.16**)
- Construction Camp Manager (**Exhibit 9.17**)
- Spoil Disposal Site Manager (**Exhibit 9.18**)

Construction Support

- Transport Fleet Manager (**Exhibit 9.18**)
- Labor Manager (**Exhibit 9.20**)

Other

- Community Liaison Officer (**Exhibit 9.21**)
- Project Environmental Manager (**Exhibit 9.22**)
- PEDO (**Exhibit 9.23**)
- Owner's Engineer (OE) (**Exhibit 9.24**)

A transmission line connecting the Project to the national transmission system is categorized as an Associated Facility (see **Section 3**). NTDC, the owner of the transmission line, will carry out a separate EIA for this transmission line. Mitigation measures described in the EIA of transmission line will be reviewed as part of implementation of EMP.

Exhibit 9.6: Impacts Assessed during the EIA

Impact Reference	*Impact*
1	Improvement of the river ecosystem through implementation of the BAP
2	Loss of riverine ecosystem due to inundation by Project Reservoir.
3	Degradation of the river ecosystem downstream of the dam.
4	Alteration of the river ecosystem downstream of the Tailrace.
5	Terrestrial habitat loss caused by construction related activities.
6	Decline in abundance and diversity of terrestrial flora and fauna caused by construction related activities.
7	Project operation leading to animal disturbance, displacement and decline.
8	Increase in ambient and ground level concentration of air pollutants from construction activities and vehicular movement may cause health impacts to the community.
9	Vibration from blasting during the construction phase may disturb local communities.
10	Blasting may pose a health hazard due to flying debris.
11	Construction activities may be cause alterations to groundwater flow patterns.
12	Use of local water resources for construction activities may reduce the water availability for the local communities.
13	Discharge from construction activities can potentially result in the contamination of soil, groundwater and surface water
14	Increase in ambient noise levels due to operation of construction equipment, movement of construction traffic and blasting may create nuisance for nearby communities and visiting tourists.
15	Contamination of soil as a result of accidental release of solvents, oils and lubricants can degrades soil fertility and agricultural productivity.
16	Land clearing, excavation, tunnel boring and other construction activities may loosen the top soil in the Project area resulting in loss of soil and possible acceleration of soil erosion and land sliding, especially in the wet season.
17	Failure of spoil dumping sites resulting in increased erosion and sediment load entering river.
18	Deterioration of aesthetics and visual amenity due to construction activities.
19	Degradation of aesthetic value of the area due to low flow section.
20	Permanent impact in aesthetics due to proposed developments.
21	Improved accessibility due to construction of Project internal roads.
22	Increase in congestion, due to increased traffic volume will cause delays.
23	Increase in traffic volume will deteriorate the air quality.
24	Increased risk to community safety due to increased traffic volume during the construction phase near communities.
25	Degradation of the pavement due to use by heavy construction traffic.

Impact Reference	*Impact*
26	Direct, indirect and induced employment at the local levels, resulting in increased prosperity and wellbeing due to higher and stable incomes of people.
27	Increase in the stock of skilled human capital due to transfer of knowledge and skill under the Project resulting in enhanced productivity of the local labor.
28	Increase in recreational and subsistence fishing due to increase in catch of fish following creation of favorable habitats for the fish in the Kunhar River.
29	Loss of income from sand and gravel mining due to change in pattern of sediment deposition following construction of the dam.
30	Loss of assets and livelihood as a result of land acquired for the Project.
31	Increase in population due to in-migration of job seekers (in-migrants) leading to pressure on existing social infrastructure and services in the Study Area.
32	Disputes over distribution of Project employment within and between Study Area inhabitants and the in-migrants resulting in social unrest.
33	Potential social unrest in the Study Area due to conflicting socio-cultural norms amongst the inhabitants and in-migrants.
34	Submergence of community graveyards.

Exhibit 9.7: Design Phase Mitigation Plan

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
5	Terrestrial habitat loss caused by construction related activities	▶ Minimize disturbance to, or movement of, soil and vegetation ▶ Minimize project footprint. ▶ Retain as much natural vegetation as possible. ▶ Locate construction facilities based on a knowledge of the soil, slope and vegetation cover of the area to avoid disturbance to the natural environment.	During detailed design	EPC Contractor	Measures included in design documents
6	Decline in abundance and diversity of terrestrial flora and fauna caused by construction related activities.	▶ Locate vehicle yards away from open soils and top soil stockyard ▶ Maximize use of locally-sourced aggregate and borrow material ▶ Minimize contact of non-local aggregate and borrow material with native soil. ▶ Minimize disturbance to, or movement of, soil and vegetation.	During detailed design	EPC Contractor	Measures included in design documents
10	Blasting may pose a health hazard due to flying debris.	▶ A minimum buffer of 500 m should be provided between the settlements and point of blasting.	During detailed design	EPC Contractor	Measures included in design documents
11	Construction activities may be cause alterations to groundwater flow patterns.	▶ Record location of the springs especially those in areas proximal to where the underground headrace tunnel will be closer to the ground level	During detailed design	Supervision Consultant	Record of springs
12	Use of local water resources for construction activities may reduce the water	▶ Prepare a Water Sourcing and Abstraction Plan specifying the source, owner, total yield, current usage, allowable quantity and the duration for which water can be obtained.	During detailed design	EPC Contractor	Agreements between community, government and contractor

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
	availability for the local communities.	▶ To the extent possible avoid, and where unavoidable, minimize the use of water from local sources (springs) for the Project where local abstraction is unavoidable: ▶ Undertake an assessment of the local source identifying its total yield and current usage. If the abstraction from a single source extends three months, the assessment shall be repeated ▶ Fix the allowable quantity to not more than 50% of the available yield (total yield minus current usage) ▶ Enter into a formal agreement with the owner for the water source (or government if it is a public source).			Water Sourcing and Abstraction Plan
14	Increase in ambient noise levels due to operation of construction equipment, movement of construction traffic and blasting may create nuisance for nearby communities and visiting tourists.	▶ Use visual alarms in preference to audible alarms. ▶ Locate noisy equipment behind parking lots, parks or behind sound barriers or sound absorbers – for example, gravel stockpiles or constructed barriers. and away from potential sources of conflict ▶ Using vibratory piling instead of impact piling. ▶ Erect earth mounds around the site boundary can provide acoustic as well as visual screening.	During detailed design	EPC Contractor	Measures included in design documents
17	Failure of spoil dumping sites resulting in increased erosion and sediment load entering river.	▶ Dumping sites should have a flood prevention design for a 20-year flood. ▶ A spoil management plan should be developed as described in **Section 9.4.3** which will implement measures to prevent this.	During detailed design	EPC Contractor	Measures included in design documents
20	Permanent impact in aesthetics due to proposed developments.	▶ Develop and implement a Site Rehabilitation and Landscaping Plan. ▶ Use colors that better integrate with the landscape. ▶ Disguise elements with vegetation where possible.	During detailed design	EPC Contractor	Measures included in design documents

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		▶ Retain as much natural vegetation as possible.			
21	Improved accessibility due to construction of Project internal roads.	▶ Consult communities during final design and location of site access roads.	During detailed design	EPC Contractor	
22	Increase in congestion, due to increased traffic volume will cause delays.	▶ Make roundabouts for the congestion points. ▶ Retain as much natural vegetation as possible to reduce the impact of smoke due to vehicles. ▶ Consult National Highway Authority for implementation of the above measures	During detailed design	EPC Contractor	Measures included in design documents
30	Loss of assets and livelihood as a result of land acquired for the Project.	▶ See LARP (**Volume 8**)	Before construction	PEDO/Land Acquisition Collector	See LARP (**Volume 8**)
34	Submergence of the graveyard.	▶ Plaster the graves with mud or cement. ▶ If relocation of the graveyard cannot be avoided, it shall be managed through the local religious authorities	During detailed design	PEDO	Measures included in LARP
34	Impact of climate change in possible enhancing of flood impacts such as during possible overtopping of spillway	▶ Ensure minimal damage to dam structure from small amount of overtopping of spillway through design.	During detailed design	PEDO	Measures included in Climate Risk Rerport

Exhibit 9.8: Construction Phase Mitigation Plan

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
	Construction Impacts	▶ The site specific environmental management plan (SSEMP) (see **Section 9.5.3**) for each site will outline areas to be cleared, vegetated areas to be protected or fenced, slopes to be stabilized and solid waste disposal locations. ▶ Submit all SSEMP to Owner's Engineer for approval.	At start of construction	Site Managers of EPC	SSEMPs prepared before initiation of construction
1	Improvement of the river ecosystem through implementation of the BAP	▶ Implement the BAP (see **Volume 2C** of the **EIA**)	As given in BAP	As given in BAP	As given in BAP
2	Loss of riverine ecosystem due to inundation by Project Reservoir	▶ Implement the BAP (see **Volume 2C** of the **EIA**)	As given in BAP	As given in BAP	As given in BAP
3	Degradation of the river ecosystem in the low flow segment downstream of the Project dam	▶ Offsets to loss of biodiversity by implementation of the BAP (see **Volume 2C** of the **EIA**).	As given in BAP	As given in BAP	As given in BAP
4	Degradation of the River Ecosystem Downstream of the Tailrace	▶ Implement the BAP (see **Volume 2C** of the **EIA**).	As given in BAP	As given in BAP	As given in BAP
5	Terrestrial habitat loss caused by construction related activities.	▶ Provide awareness training to staff and contractors on: prevention of injury of animals; identification of likely species found on site; identifications of animal hazards (such as venomous snakes); and what to do if dangerous animals are encountered.	During construction	EPC Contractor	SSEMPs prepared before initiation of construction Visual confirmation of replantation

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
		▶ Solid waste should only be disposed of at designated sites and a Waste Management Plan developed and implemented. ▶ Prepare an Environmental Training Plan that contains awareness training to staff and contractors on: prevention of injury of animals; identification of likely species found on site; identifications of animal hazards (such as venomous snakes); and what to do if dangerous animals are encountered. Also see guidelines for the Environmental Training Plan in IR 5. ▶ Encourage personnel to report sightings of wildlife of conservation importance or incidents of poaching to PEDO. ▶ Minimize disturbance to, or movement of, soil and vegetation. ▶ Prevent soil damage and erosion. ▶ Prevent Alien Invasive Species (AIS) establishment on exposed stored soil (do not store bare soil near known sources of AIS). The habitat most at risk is the Riparian Habitat. The species that are highest risk include Parthenium Weed, Common Weed and Castor Oil Plant. ▶ Train and raise awareness regarding AIS among Project staff and contractors. ▶ Retain as much natural vegetation as possible. ▶ Solid waste should only be disposed of at designated sites. ▶ Minimize the project footprint, clearly delineate and restrict access beyond work sites and other areas to be disturbed. ▶ Within the quarry and borrow areas, activities will be restricted to areas at a distance from perennial water			Waste Management Plan Environmental Training Plan

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		channels so as to avoid disturbances to them including the risk of siltation.			
6	Decline in abundance and diversity of terrestrial flora and fauna caused by construction related activities.	▶ Large flood lights should not be installed outside 50 m of the Project fence. ▶ Lights should be directed towards Project facilities and not towards the natural habitats. ▶ Regulations for Project staff and contractors to avoid illegal poaching to be incorporated in contract documents. ▶ Provide awareness training to staff and contractors on: prevention of injury of animals; identification of likely species found on site; identifications of animal hazards (such as venomous snakes); and what to do if dangerous animals are encountered. ▶ Incorporate regulations for Project staff and contractors to avoid illegal poaching in contract documents. ▶ Provide adequate knowledge to the workers on relevant government regulations and punishments for illegal poaching. ▶ Encourage personnel to report sightings of wildlife of conservation importance or incidents of poaching to PEDO. ▶ Project staff and contractors to report kills of large mammals particularly designated species of conservation concern. ▶ Train and raise awareness regarding AIS among Project staff and contractors. ▶ The Contractor shall prepare an Environmental Training Plan for all construction workers: the Plan shall address the following items:	Before and during construction	EPC Contractor	Environmental Training Plan Training Schedule Evidence of trainings and attendance lists Provision of required regulations in contract documents. Evidence of tree planting to required levels and yearly survival records.

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		▶ All Contractor's employees shall be required to comply with environmental protection procedures and they shall be able to provide evidence that they attended the training sessions detailed in the Plan; ▶ The Plan shall educate all construction workers on the following issues but not limited to them: fire arm possession, traffic regulations, illegal logging and collection of non-timber forestry products, non-disturbance of resettlement communities, hunting and fishing restrictions, waste management, erosion control, health and safety issues, all prohibited activities, the Code of Conduct requirements and disciplinary procedures, and general information on the environment in which they will be working and living; ▶ Establishment of penalties for those who violate the rules; ▶ Proposed methods for conducting the training program, which shall include formal training sessions, posters, data in newsletters, signs in construction and camp areas and 'tool box' meetings. ▶ Equipment emitting excessive noise in comparison with other similar equipment will not be allowed to operate. ▶ Equipment under use will be regularly maintained, tuned, and provided with mufflers to minimize noise levels. ▶ Equipment in poor state of maintenance, particularly without effective noise control will be checked to determine if it can be improved, and replaced with less noisy equipment as soon as practicable.			

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
		▶ Blowing of horn will be prohibited on all sensitive areas except under emergency conditions. ▶ Compensatory trees will be planted. The EPC Contractor will plant a minimum of ten trees for each tree removed in acquired land. ▶ PEDO will monitor and maintain the vegetation until it is established. ▶ Implementation of the BAP.			
8	Increase in ambient and ground level concentration of air pollutants from construction activities and vehicular movement may cause health impacts to the community.	▶ Develop and implement an Air Pollution Control Plan ▶ Prepare a site-specific environmental management plan (see **Section 9.5.3**) for each construction site and must outline areas to be cleared, vegetated areas to be protected or fenced, solid waste disposal locations, and sprinkling locations. Fugitive and exhaust emissions from transport vehicles ▶ Cover all trucks hauling soil, sand, and other loose materials or require all trucks to maintain at least two feet of freeboard (i.e., the minimum required space between the top of the load and the top of the trailer). ▶ Install and maintain all vehicles and machinery with appropriate emission control equipment. ▶ Regularly maintain vehicles and equipment to keep emissions in check. ▶ Smoke from internal combustion engines should not be visible for more than ten seconds. ▶ To the extent possible, use new and low emission equipment and vehicles. ▶ Purchase best quality fuel and lubes and where possible use lead free oil and lubes.	Before and during construction	EPC Contractor	SSEMP documents prepared before initiation of construction Air Pollution and Control Plan Continuous observation for non-compliance Vehicle and equipment maintenance logs

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
		▶ Sprinkle water on all unsealed roads used by Project vehicles that are within 200 m of any settlement. ▶ Cover loads and long-term piles of friable material to reduce fugitive dust emission. ▶ Reduce traffic speeds on all unpaved surfaces to 15 miles per hour or less. ▶ Paved roads shall be swept frequently if soil material has been carried onto adjacent paved, public thoroughfares from the Project site. ▶ Install wheel washers where vehicle exit onto paved road from unpaved. ▶ Wheel washing of vehicles leaving the site. ▶ Wash vehicles/equipment prior to each trip. ▶ Use catalytic converters on vehicles, an emission control device, used to convert harmful pollutants to less harmful pollutants e.g. it converts the nitrogen oxides back into nitrogen and oxygen. ▶ Appropriate maintenance of vehicles and machinery. Fugitive dust emissions from blasting ▶ Indicate the limits of a clearing land with highly visible markers. ▶ Leave a layer of about 5 m of undisturbed softs above the top of the overburden blasts. This will act as a blanket to contain air blast, dust and fly rock. ▶ Sprinkle water on the area where blasting is done to settle down the particulate matter emissions. Fugitive dust emissions from quarry areas ▶ Indicate the limits of a clearing land with highly visible markers.			

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		▶ Avoid earth stripping or moving in periods of dry and windy weather. ▶ Carry out dust generating activities where maximum protection can be obtained through topography or in areas where prevailing winds will blow dust away from sensitive areas/uses. ▶ Water spraying of conveyors/conveyor transfer points, stockpiles and roads. ▶ Covering of fine dry loads or spraying of loads prior to exiting the site, and if necessary regular cleaning of public roads in the vicinity of the entrance. Fugitive dust emissions from concrete batching plants ▶ Suspend earthwork operation when wind speed exceeds 20 km/hr. in areas within 500 m of any settlement. ▶ The whole process of weighing and mixing would be performed in a fully enclosed environment. ▶ The mixers would all equipped with dust collectors, no dust emission would be expected. ▶ Siting the concrete batching plant out of prevailing high winds minimizing dust emissions. ▶ The prevailing wind direction should be considered to ensure that bunkers and conveyors are sited in the leeward direction to minimize the effects of the wind. ▶ The provision of natural or artificial wind barriers – such as trees, fences and landforms – to help control the emission of dust from the plant should be considered. ▶ Batching plants should be sited on land that is not flood prone.			

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
		▶ Batching plant should be kept as near to natural sinks to minimize emissions to ambient environment ▶ All stacks to be vertical and at least 3 m above ground Fugitive dust emissions from aggregate production and handling system ▶ Suspend operation when wind speed exceeds 20 km/hr. in areas within 500 m of any settlement. ▶ The prevailing wind direction should be considered to ensure that aggregate handling systems located in the leeward direction to minimize the effects of the wind. ▶ Sprinkle water on all exposed surfaces, particularly those close and up-wind of settlements. Wind-blown dust from exposed surfaces such as bare land and waste dumping sites ▶ Cover all exposed surfaces, particularly those close and up-wind of settlements. ▶ All grading operations on a project should be suspended when winds exceed 20 miles per hour. ▶ Minimize disturbance to, or movement of, soil and vegetation. ▶ Sprinkle water on all exposed surfaces, particularly those close and up-wind of settlements. ▶ Retain as much natural vegetation as possible. Wind-blown dust from stockpiles of dusty materials such as sand and other minerals ▶ On-site dirt piles or other stockpiled PM should be covered, wind breaks installed and water and/or soil stabilizers employed to reduce wind-blown dust emissions.			

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		▶ Adequately wet, cover with plastic, or provide with wind shield all stockpiles to reduce dust emission. ▶ Sprinkle water on all exposed surfaces, particularly those close and up-wind of settlements. ▶ Minimize disturbance to, or movement of, soil and vegetation. ▶ Prevent soil damage and erosion. ▶ Retain as much natural vegetation as possible.			
9	Vibration from blasting during the construction phase may disturb local communities.	▶ Develop a Blasting and Explosives Management Plan and Vibration Monitoring Plan. ▶ Conduct a pre-construction survey of structures at risk of vibration impacts households. ▷ In the initial stages, the blasting induced vibration shall be measured as a function of maximum instantaneous charge and distance from the blasting site. This data shall be then used to refine the Blasting Induced Vibration Risk Zones on the basis of the adopted criteria. ▷ Using, the refined Blasting Induced Vibration Risk Zones maps and the tunnel boring schedule, the Supervision Consultant in consultation with the PEDO and the Construction Contractor, shall identify the houses that will be affected and the impact duration and schedule. ▷ For the houses that will fall in the Structural Damage Risk Zone, a temporary relocation plan will be developed. An amendment to the Land Acquisition and Resettlement Plan (LARP) (see **Volume 8**) will be commissioned for this purpose. Before start of blasting, all residents of houses in the Structural Damage Risk Zone will be relocated as per the LARP.	During Construction	EPC Contractor	Blasting and Explosives Control Plan document Blasting timetable available in nearby villages Results of preconstruction survey Availability of GRM

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		▷ A survey will be undertaken in both zones, to determine the pre-blasting conditions of the buildings. The survey will be commissioned by the Supervision Consultant and will identify and record any existing damage to the structures. The survey will cover the following aspects: o Overall condition of the structures, both exterior and interior. o Documentation of defects observed in the structure using digital imagery along with notes, measurements and sketches. o Documentation of pre-existing cracks using digital imagery along with notes, measurements and sketches. ▶ Following completion of the blasting, the survey will be repeated in the Structural Damage Risk Zone to determine the condition of the buildings and verify that they are safe for re-occupation. If the buildings are safe, the residents will be allowed to return to their houses following any necessary damage repairs. If the buildings are damaged beyond repair, compensation will be paid to the owners as per the LARP (**Volume 8**). If there are any claims or reports of damage in the Cosmetic Damage Risk Zone, the affected house will be surveyed against the pre-Project survey and repairs will be undertaken as appropriate. ▶ Following are key mitigation measures for the management of blasting: ▷ Blasting will be scheduled during the day only. ▷ Local communities will be informed of blasting timetable in advance and will be provided			

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		adequate notice of when blasts are required outside of the planned schedule. ▷ A Blasting Management Plan will be developed by the Construction Contractor. The Plan will be reviewed and approved by the Supervision Contractor before the initiation of the blasting work. ▷ Throughout the blasting activity, vibration sensors will be installed at strategic location to monitor the impact of blasting and to ensure that the vibration levels are within the adopted criteria. The monitoring plan will be part of the Blasting Management Plan. ▷ Unscheduled blasting will be strictly prohibited in any case. ▶ Meaningful contact with the community shall be maintained and their grievance shall be attended to in a timely manner. In this regard: ▷ A meaningful community engagement plan will be developed. The plan will cover identify the affected community; the key contact persons; frequency of engagement; the information to be shared; the responsibilities to manage the plan; and the notice period to be giving to the community for various blasting related generating activities. ▷ The Grievance Redress Mechanism will be used to record, investigate, and respond to any complaints. Investigation of the complaints will be undertaken by the Supervision Consultant. ▶ Develop a Vibration Monitoring Plan that will include monitoring of vibration levels and frequency around the blasting sites. The objectives of the monitoring will be to:			

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
		▷ Ensure that vibration levels in the communities are within the adopted criteria levels; ▷ Maintain record of vibration to settle any potential conflicts; and ▷ Monitor changes in the vibration levels due to possible changes in the rock formation and take appropriate corrective actions.			
10	Blasting may pose a health hazard due to flying debris.	▶ A minimum buffer of 500 m should be provided between the settlements and point of blasting. ▶ Leave a layer of about 5 m of undisturbed softs above the top of the overburden blasts. This will act as a blanket to contain air blast, dust and fly rock. ▶ Ensure that the holes are correctly collared with respect to the back-break/inclination of the face and also that digging alongside the initiation face well controlled. ▶ Inadequate forward displacement of the front row burden arising out of the under charging of these holes will result in fly rock from vertical catering of the rear holes. ▶ Where fly rock possesses a serious problem, the stemming length should not be less than the hole burden. Also, an effective stemming material like crushed angular rock should be used to prevent premature venting of explosion gases through the stemming column. ▶ The forward fly rock could be fairly controlled to the commonly used 'inline open loop' pattern. The maximum inter-row delay interval consistent with the absence of cut off helped in minimizing the fly rock formation. As a thumb rule an inter-row delay of 4-8ms/m of burden could be used for this purpose.	During Construction	EPC Contractor	Blasting and Explosives Control Plan document Blasting timetable available in nearby villages Results of preconstruction survey Availability of GRM

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		▶ Adequate care should be taken while connecting the delay devices in the holes/rows and the initiation sequence properly checked before firing to avoid initiation of blast holes out of sequence. ▶ Blasts designed on a face length to width ratio in the range of 3 to 4 produces minimum fly rock.			
11	Alterations of natural passage of springs due to blasting for tunnels may disrupt the water supply for mountain spring users.	▶ Record location of the springs especially those in areas proximal to where the underground headrace tunnel will be closer to the ground level i.e high risk areas (see **Exhibit 7.20** and **Exhibit 7.21**). ▶ Monitor flow for located springs and maintain records. ▶ Support the community in development of alternate water supply schemes through local NGOs ▶ Ensure the availability of water to the communities and the access of the communities to the water resources being used by them is not adversely affected.	During construction	EPC Contractor	Flow records of identified springs
12	Use of local water resources for construction activities may reduce the water availability for the local communities.	▶ Develop a Water Sourcing and Abstraction Plan ▶ Source water for construction from authorized abstraction sources agreed between the local communities, local government and EPC contractor. ▶ Water conservation techniques will be developed and implemented by the EPC contractor. ▶ Access of community to water sources shall be kept clear so that the community's ability to meet its water requirements are not compromised. ▶ Exercise care while moving heavy machinery to avoid damage or blockage of natural waterways and channels. ▶ Maintain records of water usage in all Project activities.	Before and during construction	EPC Contractor	Agreements documents for water use. Water Sourcing and Abstraction Plan Water use record documents

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		▶ Incorporate the above measures in the Construction Site Environmental Management Plan (see **Volume VI**).			
13	Discharge from construction activities can potentially result in the contamination of soil, groundwater and surface water.	▶ Develop and implement a Water Quality Management Plan ▶ Prepare and implement a Spill Prevention and Response Plan and inducted to the staff for any incident of spill. ▶ Provide and use spill prevention trays at refueling locations ▶ The run off from maintenance workshops will be collected by impervious channels and be passed through oil water separators (OWS) before final disposal. The sludge and oil collected at the OWS will be disposed off properly. ▶ Build separate impervious pits (with concrete walls and proper shed) at the construction sites for temporary handling and storage of contaminated soil and water if encountered during construction such as sludge from OWS. ▶ Keep all fuel storage tanks and lubricating oil drums in secondary containment impervious pits with impervious shed walls. ▶ Avoid on-site maintenance of construction vehicles and equipment, as far as possible. ▶ Regularly inspect construction vehicles and equipment to detect leakages. ▶ Store fuels and lubricants in covered and dyked areas, underlain with impervious lining. ▶ Spill control kits (shovels, plastic bags and absorbent materials) will be available near fuel and oil storage	During Construction	EPC Contractor	Water Quality Management Plan documents Spill Prevention and Response Plan document Visual implementation of mitigation measures such as use of spill prevention trays and proper storage of fuel storage. Record of spills and remedial actions taken

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		areas, vehicle parking, and vehicle maintenance areas as well as at construction sites. ▶ Remove contaminated soil from the site and dispose in a manner to ensure protection of water sources. ▶ Construct the bottom of any soak pit or septic tank at least 100 meters away from springs and water bores. ▶ Maintain records of spills and volume of removed contaminated soil. ▶ Maintain record of remedial measures taken. ▶ Use silt traps to prevent contamination of river and streams. ▶ Incorporate the above measures in the Construction Site Environmental Management Plan (see Volume VI).			
14	Increase in ambient noise levels due to operation of construction equipment, movement of construction traffic and blasting may create nuisance for nearby communities and visiting tourists.	▶ Develop a Noise and Vibration Control Plan Noise generated from construction sites from construction activities ▶ Select the quietest available plant and equipment that can economically undertake the work required. ▶ Undertake maintenance of the equipment as simple maintenance can reduce noise levels by as much as 50%. Parts may become loose, creating more noise because of improper operation or scraping against other parts. Grinding noises may also occur as the result of inadequate lubrication. ▶ Equipment under use will be regularly maintained, tuned, and provided with mufflers to minimize noise levels. ▶ Use visual alarms in preference to audible alarms. ▶ Enclose noisy equipment.	During Construction	EPC Contractor	Noise and Vibration Control Plan document Maintenance record of equipment Records of community meetings regarding noise. Noise level monitoring in nearby communities

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
		▶ Provide noise attenuation screens, where appropriate. ▶ Build an enclosure around the noise source so that noise is contained. The enclosure should be free from gaps and made of dense material and be lined with noise-absorbing material like glass or polyester batts. ▶ Locate noisy equipment behind parking lots or parks. ▶ Close liaison with the community and regular monitoring of the noise levels in the community are key to successfully implementation of the above mitigation measures. Specifically, inform communities of all major construction activities three days in advance. Construction noise from traffic ▶ Fit and maintain appropriate mufflers on earth-moving and other vehicles on the site. ▶ Mobile plants such as excavators, front-end loaders and other diesel-engine equipment should be fitted with residential class mufflers and other silencing equipment, as applicable. ▶ Haul roads within the site should have as low a gradient as possible, and paving should be considered if practicable where noise-sensitive receptors are likely to be affected; ▶ Owners and operators of existing facilities should implement special noise reduction measures, such as erecting purpose-built acoustic barriers, restricting opening hours and maintaining transport vehicle Construction noise from on-site plant operations and equipment ▶ All fixed plant at the work sites will be appropriately selected, and where necessary, fitted with silencers,			

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		acoustical enclosures and other noise attenuation measures. ▶ Modify the equipment or the work area to make it quieter by substituting existing equipment with quieter equipment; retro-fitting existing equipment with damping materials, mufflers, or enclosures; erecting barriers; and maintenance. ▶ Shift to a quieter construction process for example pile driving is very loud as compared to boring which is a much quieter way to do the same work. ▶ Combine noisy operations to occur in the same time period. The total noise level produced will not be significantly greater than the level produced if the operations were performed separately. ▶ All plant and equipment should be regularly maintained. ▶ Move static plant and equipment as far as possible from sensitive boundaries, as work allows. A distance of four times further away lowers the noise by 12 dBA. A reduction of 10 dBA will sound half as loud. ▶ Sound attenuation measures should be used for plant and equipment such as baffles and specialized mufflers, acoustic enclosures or partial enclosure housings. ▶ Acoustic barriers need to be designed and purpose built if needed. Vegetated buffer zones can also be planted to mitigate noise from operations using suitably selected native plantings local to the area. ▶ Reduce workers' exposure to high noise levels by keeping moving workers away from the noise source; restricting access to areas; rotating workers			

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		performing noisy tasks; and shutting down noisy equipment when not needed. ▶ Use earplugs to reduce workers' exposure to high noise levels. Noise generated from the blasting in quarry areas ▶ Using vibratory piling instead of impact piling. ▶ Conveyor belts and crushing/screening equipment can be housed to provide acoustic screening. ▶ It is important that sound-reduction equipment fitted to machinery is used and maintained properly. ▶ Erect earth mounds around the site boundary can provide acoustic as well as visual screening. ▶ Soft ground (e.g. grassland and cultivated fields) attenuation can sometimes have a greater impact in reducing noise than barrier attenuation, especially if the ground supports sound absorbing vegetation. Noise emissions from concrete batching ▶ Locate noisy equipment away from potential sources of conflict. ▶ Locate noisy equipment behind sound barriers or sound absorbers – for example, gravel stockpiles or constructed barriers. ▶ Install silencing devices to all pressure operated equipment.			
15	Contamination of soil as a result of accidental release of solvents, oils and lubricants can degrades soil fertility and agricultural productivity.	▶ Prepare a Spill Prevention and Response Plan and induct to the staff for any incident of spill. ▶ Appropriately mark fuel tanks by content and store in dyked areas with an extra 10% of the storage capacity of the fuel tank. The area will be lined with an impervious base.	During Construction	EPC Contractor	Spill Prevention and Response Plan document Visual verification of conformance

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		▶ Install grease traps on the site, wherever needed, to prevent flow of oily water. ▶ Spill cleaning kit (shovels, plastic bags and absorbent materials) will be available near fuel and oil storage areas. ▶ Carry cleanup kits in all fuel trucks. ▶ Fueling should only take place over impermeable surfaces, other hazmats should be stored and used over impermeable surfaces. ▶ The bottom of any soak pit or septic tank shall be at least 10 m above the groundwater table. The distance can be reduced, based on the soil properties, if it is established that distance will not result in contamination of groundwater.			
16	Land clearing, excavation, tunnel boring and other construction activities may loosen the top soil in the Project area resulting in loss of soil and possible acceleration of soil erosion and land sliding, especially in the wet season.	▶ Develop an Erosion Control Plan. ▶ Limit vegetation loss to demarcated construction area. ▶ Cover areas such as muck disposal area, batching plant, labor camp and quarry sites after the closure shall with grass and shrubs. ▶ Adopt slope stabilization measures such as adequate vertical and horizontal drains, drainage along roadsides, cross drainage and retaining walls. ▶ Monitor slope movements around excavation work areas. ▶ Salvage, store, and reuse all topsoil at all construction sites. ▶ The height of the stockpile will be minimized to the extent possible by increasing the size of the land for the stockpile.	During Construction	EPC Contractor	Erosion Control Plan document

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
		▶ Topsoil will be carefully stripped to ensure that it is not mixed with subsoil. ▶ The stockpiles will be revegetated to minimize loss of soil quality, minimizing weed infestation, maintaining soil organic matter levels, maintaining soil structure and microbial activity. ▶ Topsoil stockpiles will be clearly signposted for easy identification and to avoid any inadvertent losses. ▶ The establishment of declared plants on the stockpiles will also be monitored and control programs implemented as required. ▶ The topsoil will be treated with temporary soil stabilization and erosion control measures. ▶ During removal of topsoil stockpile for restoration of project affected areas, it is preferred that the soil is removed in layers (less than 0.5 m thick) under a gradual process. ▶ The top layer will be mixed with the remainder of the stockpile to ensure that living organisms are distributed throughout the topsoil material at the time of final placement. The use of micro-organism inoculates may be necessary to re-establish micro-organisms in topsoil material. ▶ Select local species for plantation to restore the biodiversity of the area in consultation with Forest Department after completion of respective activities.			
17	Failure of spoil dumping sites resulting in increased erosion and sediment load entering river	▶ Dumping sites should have a flood prevention design for a 20-year flood. ▶ The water drainage works consist of the masonry structures, and shall be designed to drain a 5-year rainfall every 10 minutes.	During construction	EPC Contractor	Spoil Disposal Plan Document

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		▶ Where constructed tailing hold structure will be of galvanized woven wire mesh gabions ▶ All the five dumping sites will undergo vegetation restoration works comprising of surface leveling, covering and forest/grass planting or agricultural land rehabilitation ▶ Develop a Spoil Disposal Plan that includes the following measures: ▷ Slope movements will be monitored around excavation work areas. ▷ Restore to the maximum extent possible the hydrological regime and reinstate natural drainage of the land (including provisions to maintain the water balance of the site and protect from flooding where appropriate) ▷ Reinstate topsoil (in case it was stripped before construction activities) ▷ Revegetate sites with suitable native plant species ▷ Drain spoil piles to prevent the concentration of flow and to prevent rill and gully erosion ▷ Separate organic material (e.g., roots, stumps) from the dirt fill and store separately. Place this material in long-term, upland storage sites, as it cannot be used for fill. ▷ Store “clean” material in a short-term disposal site (stockpile) if it will likely be re-used for fill or shoulder widening projects. ▷ Where feasible, recycle asphalt material in embankments and shoulder backing. Place these materials where they will not enter the stream system. Asphalt that is 5 years old is considered “inert” (that is, all oils washed off).			

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
		▷ Do not add excess unusable material to permanently closed sites. ▷ Spread material not to be re-used in compacted layers, generally conforming to the local topography. Design the final disposal site reclamation topography to minimize the discharge of concentrated surface water and sediment off the site and into nearby watercourses. ▷ Cover the compacted surfaces with a 6-inch layer of organic or fine-grained soil, if feasible. ▷ After placement of the soil layer, track walk the slopes perpendicular to the contour to stabilize the soil until vegetation is established. Track walking creates indentations that trap seed and decrease erosion of the reclaimed surfaces. (See figure on next page.) ▷ Revegetate the disposal site with a mix of native plant species. Cover the seeded and planted areas with straw compost, mulched with straw at a rate of 1 to 1 ½ tons per acre. Apply jute netting or similar erosion control fabric on slopes greater than 1:2 if site is erosive. ▷ Locate stockpiles away from drainage lines, at least 10 metres away from natural waterways and where they will be least susceptible to wind erosion ▷ Ensure that stockpiles and batters are designed with slopes no greater than 1:2 (vertical\ horizontal). ▷ Besides these measures, erosion can also be minimized by regular rehabilitation of areas not in use for Project activities during construction. These will include: Re-grading and immediate re-vegetation (using fast-growing species and			

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		different functional groups of plants for keeping soil in place) of slopes to minimize erosion. ▷ Install erosion and sediment control measures, if possible before construction commences. Identify drainage lines and install control measures to handle predicted storm-water and sediment loads generated in the mini-catchment. ▷ Design and install appropriate erosion and sediment run-off control measures appropriate to site conditions to handle a one-in-two-year storm event (two-year ARI with intensity of six hours), for temporary structures, and a one-in-fifty year storm event, for permanent structures. ▷ Establish an adequate inspection, maintenance and cleaning program for sediment run-off control structures. Ensure that contingency plans are in place for unusual storm events. ▷ Continually assess the effectiveness of sediment control measures and make necessary improvements. ▷ Keep temporary disposal sites out of wetlands, adjacent riparian corridors, and ordinary high-water areas as well as high risk zones, such as 100-year floodplain and unstable slopes. ▷ Anticipate sufficient storage area with no risk for sediment delivery for piles that may slump. Stress cracks indicate that the pile is at risk of slumping. ▷ Cover the trucks that will be used for the transportation of spoikl material to disposal sites. ▷ A spoil management plan should be developed as described in **Section 9.4.3** which will implement measures to prevent this.			

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
18	Deterioration of aesthetics and visual amenity of nearby receptors due to construction activities, including vehicular movement on roads, may cause disturbance in aesthetics for tourists, businesses and nearby communities.	▶ Minimize disturbance to, or movement of, soil and vegetation. ▶ Back fill to original levels. ▶ Reshaping to match in with surrounding topography. ▶ Reinstate vegetation around construction sites.	During detailed design	EPC Contractor	Covers used to disguise equipment, where appropriate.
20	Permanent impact in aesthetics due to proposed developments.	▶ Develop and implement a Site Rehabilitation and Landscaping Plan. ▶ Use colors that better integrate with the landscape. ▶ Disguise elements with vegetation where possible. ▶ Retain as much natural vegetation as possible.	During detailed design	EPC Contractor	Site Rehabilitation and Landscaping Plan
22	Increase in congestion, due to increased traffic volume will cause delays.	▶ Develop and implement a Traffic Managemnet Plan. ▶ Make roundabouts for the congestion points. ▶ Retain as much natural vegetation as possible to reduce the impact of smoke due to vehicles. ▶ The vehicles going on the spoil routes and passing through the communities must be completely covered to avoid dust emissions. ▶ Strictly implement speed limits and defensive driving policies.	During construction	EPC Contractor	Traffic Management Plan
23	Increase in traffic volume will deteriorate the air quality.	▶ Keep speeds slow (30 km/hr) on unsealed roads. ▶ Sprinkle water on unsealed roads that are used for construction traffic.	During construction	EPC Contractor	Traffic Management Plan

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
		▶ Retain as much natural vegetation as possible to reduce the impact of smoke due to vehicles. ▶ The vehicles going on the spoil routes and passing through the communities must be completely covered to avoid dust emissions. ▶ Strictly implement speed limits and defensive driving policies. ▶ Promptly and properly repair and maintain roads that are subject to damage by Project activities.			
24	Increased risk to community safety due to increased traffic volume during the construction phase near communities.	▶ Develop and implement a Traffic Management Plan. ▶ Identify suitable times to transport equipment. ▶ Road safety awareness education will also be included during community visits or information sessions, so that communities can be familiarized with common road signs and the types of vehicles and equipment that will be moving through the area. ▶ Keep speeds slow (30 km/hr) where there is traffic exchange between roads. ▶ Make roundabouts for the congestion points. ▶ Designate traffic wardens at roads on the transport route to manage traffic during school hours. ▶ Construction traffic will not travel during school starting and ending hours on designated road segments in front of schools on the transport route. ▶ Strictly implement speed limits and defensive driving policies. ▶ Maintain vehicles especially brakes.	During construction	EPC Contractor	Traffic Management Plan
25	Degradation of the pavement due to use	Promptly and properly repair and maintain roads that are subject to damage by Project activities.	During construction	EPC Contractor	Number of observations of pavement damage in

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
	by heavy construction traffic				areas with heavy Project-related traffic.
26	Direct, indirect and induced employment at the local levels, resulting in increased prosperity and wellbeing due to higher and stable incomes of people.	**Enhancement measures**: ▶ Ensure preferential recruitment of local candidates provided they have the required skills and qualifications. ▶ Include an assessment of the contractor's demonstrated commitment to domestic and local procurement and local hiring in the tender evaluation process. ▶ Coordinate recruitment efforts related to non-skilled labor, including for non-skilled labor positions required by contractors. **Good practice measures**: ▶ Determine what is considered to be 'fair and transparent' in recruitment and in distribution of jobs between different community groups, in consultation with local communities and their leaders.	During construction	EPC Contractor	Contractual documents Number and ratio of local employees to non-local employees
27	Increase in the stock of skilled human capital due to transfer of knowledge and skill under the Project resulting in enhanced productivity of the local labor.	▶ Support a 'Vocational Training Program' to assist local people to qualify for semi-skilled positions focusing on issues such as procurement, involvement of vulnerable groups in Project opportunities and continual professional development of staff. ▶ Assist local people having practical skills but lacking qualifications to obtain their certificates and thus increase their employment opportunities. ▶ Support initiatives promoting a culture of learning in local communities. ▶ Plan and implement training program for vulnerable groups to encourage their participation in economic opportunities created by the Project.	During construction	EPC Contractor	Vocational Training Program document including annual schedule. Budget allocation for trainings. Documentary evidence including photographs and attendance lists of trainings.

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
		▶ Assist employees and local communities to improve basic personal financial life skills through training and awareness campaigns, respectively. ▶ Consider further training programs to prepare retrenched workers to seek employment in sectors not related to dam construction.			
28	Increase in recreational and subsistence fishing due to increase in catch of fish following creation of favorable habitats for the fish in the Kunhar River.	▶ Implementation of the BAP (see **Volume 2C** of the **EIA**)	As given in BAP	As given in BAP	As given in BAP
29	Loss of income from sand and gravel mining due to change in pattern of sediment deposition following construction of the dam.	▶ Sediment Mining and Management Guidelines are prepared and will be implemented as a part of the BAP, which will identify possible sand and gravel mining spots along the Kunhar River to meet community needs without harming the river ecology.	During construction	EPC Contractor	Sediment Mining and Management Plan document Locations visually earmarked for mining promotion and protection as identified in the Sediment Mining and Management Plan.
30	Loss of assets and livelihood as a result of land acquired for the Project.	▶ See LARP (**Volume 8**)	Before construction	PEDO/Land Acquisition Collector	See LARP (**Volume 8**)
31	Increase in population due to in-migration of job seekers (in-migrants) leading to pressure on existing social infrastructure	▶ Development of a Grievance Redressal Mechanism ▶ Encourage local communities to use the grievance procedure for concerns related to deterioration of local services.	During construction	EPC Contractor	Grievance register and records Influx Management Plan

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
	and services in the Study Area.	▶ Support local government in the implementation of infrastructure projects. ▶ Support NGOs specializing in development of infrastructure to assist local government.			
32	Disputes over distribution of Project employment within and between Study Area inhabitants and the in-migrants resulting in social unrest.	▶ Implement PEDO Stakeholder Engagement Plan including: ▶ maintaining regular communication with local communities and other stakeholders to minimize tensions arising from Project activities; ▶ maintaining a grievance procedure, and encourage and facilitate stakeholders to use the mechanism to express concerns; and ▶ providing sufficient resources to the community relations officers to enable them to monitor negative perceptions and associated tensions, and to address them in a timely fashion..	During construction	EPC Contractor	Stakeholder Engagement Plan Minutes of community and stakeholder consultations Provision in budget for activities.
33	Potential social unrest in the Study Area due to conflicting socio-cultural norms amongst the inhabitants and in-migrants.	▶ Refer to measures under IR 25 (above).		EPC Contractor	
34	Submergence of graveyards.	▶ Plaster the graves with mud or cement. ▶ If relocation of the graveyard cannot be avoided, it shall be managed through the local religious authorities.	Before construction	PEDO	Photographic evidence

Exhibit 9.9: Operation Phase Mitigation Plan

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
1	Improvement of the river ecosystem through implementation of the BAP	▶ Implementation of the BAP (see **Volume 2C** of the **EIA**).	Operation	PEDO	As given in BAP.
2	Loss of riverine ecosystem due to inundation by Project Reservoir	▶ Implementation of the BAP (see **Volume 2C** of the **EIA**).	Operation	PEDO	As given in BAP.
3	Degradation of the river ecosystem in the low flow segment downstream of the Project dam	▶ Implementation of the BAP (see **Volume 2C** of the **EIA**).	Operation	PEDO	As given in BAP.
4	Degradation of the River Ecosystem Downstream of the Tailrace	▶ Implementation of the BAP (see **Volume 2C** of the **EIA**).	Operation	PEDO	As given in BAP.
7	Project operation leading to animal disturbance, displacement and decline.	▶ Large flood lights should not be installed outside 50 m of the Project fence. ▶ Direct lights towards Project facilities and not towards the natural habitats. ▶ Dispose solid waste only at designated sites. ▶ Incorporate regulations for Project staff and contractors to avoid illegal poaching in contract documents. ▶ Encourage personnel to report sightings of wildlife of conservation importance or incidents of poaching to PEDO. ▶ Provide adequate knowledge to the workers on relevant government regulations and punishments for illegal poaching. ▶ Provide awareness training to staff and contractors on: prevention of injury of animals; identification of likely species	Operation	PEDO	As given in BAP.

IR	Impact	Mitigation Measure	When	Responsibility	Monitoring Indicators
		found on site; identifications of animal hazards (such as venomous snakes); and what to do if dangerous animals are encountered. ▶ Implement the BAP (see **Volume 2C** of the **EIA**).			
19	Deterioration of aesthetics and visual amenity of nearby receptors due to low flow in the river may affect the scenic value of the area	▶ Ensure environmental flow release.	Operation	PEDO	Environmental flow release records
21	Improved accessibility due to construction of Project access roads.	▶ Allow communities use of new site access roads.	Operation	PEDO	—
26	Direct, indirect and induced employment at the local levels, resulting in increased prosperity and wellbeing due to higher and stable incomes of people.	**Enhancement measures:** ▶ Ensure preferential recruitment of local candidates provided they have the required skills and qualifications. ▶ Include an assessment of the contractor's demonstrated commitment to domestic and local procurement and local hiring in the tender evaluation process. ▶ Coordinate recruitment efforts related to non-skilled labor, including for non-skilled labor positions required by contractors. **Good practice measures:** ▶ Determine what is considered to be 'fair and transparent' in recruitment and in distribution of jobs between different community groups, in consultation with local communities and their leaders.	Operation	PEDO	Target documents

IR	*Impact*	*Mitigation Measure*	*When*	*Responsibility*	*Monitoring Indicators*
28	Increase in recreational and subsistence fishing due to increase in catch of fish following creation of favorable habitats for the fish in the Kunhar River.	▶ Ensure implementation of the BAP (see **Volume 2C** of the **EIA**).	Operation	PEDO	Interviews with local fishermen and results of monitoring and evaluation as part of the **BAP** (see **Volume C**)
29	Loss of income from sand and gravel mining due to change in pattern of sediment deposition following construction of the dam.	▶ Sediment Mining and Management Guidelines are prepared and will be implemented as a part of the BAP, which will identify possible sand and gravel mining spots along the Kunhar River to meet community needs without harming the river ecology.	Operation	PEDO	Sediment Mining and Management Plan document Locations visually earmarked for mining promotion and protection as identified in the Sediment Mining and Management Plan.

Exhibit 9.10: Design and Construction Planning EMP Responsibilities

Impact Reference	*Mitigation Measures*
5	Minimize project footprint
5	Locate construction facilities based on a knowledge of the soil, slope and vegetation cover of the area to avoid disturbance to the natural environment.
5,6	Minimize disturbance to, or movement of, soil and vegetation.
5,6	Prevent establishment of alien invasive species (AIS) on exposed stored soil (do not store bare soil near known sources of AIS).
5,6	Retain as much natural vegetation as possible.
6	Source goods/materials locally where possible.
12	Source water for construction from authorized abstraction sources agreed between the local communities, local government and EPC contractor.
34	Plaster the graves with mud or cement. If relocation of the graveyard cannot be avoided, it shall be managed through the local religious authorities.
20	Develop and implement a Site Rehabilitation and Landscaping Plan.
22	Make roundabouts for the congestion points.

Exhibit 9.11: General Construction Site Manager EMP Responsibilities

Impact Reference	*Mitigation Measures*
	Site Construction
5, 6, 13, 15, 16, 17	Minimize disturbance to, or movement of, soil and vegetation.
5, 6	Prevent soil damage and erosion.
5,6	Prevent establishment of AIS on exposed stored soil (do not store bare soil near known sources of AIS).
5, 6, 13, 15, 16, 17	Retain as much natural vegetation as possible.
5. 6. 13, 15, 17	Solid waste should only be disposed of at designated sites.
6,7	Large flood lights should not be installed outside 50 m of the Project fence.
6,7	Lights should be directed towards Project facilities and not towards the natural habitats.
8	Water will be sprinkled on all exposed surfaces, particularly those close and up-wind of the settlements.
17	Slope movements will be monitored around excavation work areas.

Impact Reference	*Mitigation Measures*
17	Slope stabilization measures will be adopted such as adequate vertical and horizontal drains, drainage along roadsides, cross drainage and retaining walls.
5, 17	Vegetation loss will be limited to demarcated construction area.
	Resource Use
12	Access of community to water sources shall be kept clear so that the community's ability to meet its water requirements are not compromised.
11, 13	Care will be taken while moving heavy machinery to avoid damage or blockage of natural waterways and channels.
12	Records of water usage will be maintained.
12	Water conservation techniques will be developed and implemented by the EPC contractor.
12	Water for construction will be sourced from authorized abstraction sources agreed between the local communities, local government and EPC contractor.
	Spill Control
13, 15	Spill prevention trays will be provided and used at refueling locations
13, 15	Regular inspections will be carried out to detect leakages in construction vehicles and equipment.
13, 15	Fuels and lubricants will be stored in covered and dyked areas, underlain with impervious lining.
13, 15	Spill control kit (shovels, plastic bags and absorbent materials) will be available near fuel and oil storage areas.
13, 15	Contaminated soil will be removed from the site and disposed in a manner to ensure protection of water sources
13, 15	Emergency plan for spill management will be prepared and inducted to the staff for any incident of spill.
13, 15	The bottom of any soak pit or septic tank will be constructed at least 100 meters away from springs and water bores
13, 15	Record of spills and volume of removed contaminated soil will be maintained.
13, 15	Record of remedial measures taken will be maintained.
	Maintenance
14	Equipment under use will be regularly maintained, tuned, and provided with mufflers to minimize noise levels.
13, 15	On-site maintenance of construction vehicles and equipment will be avoided, as far as possible.
	Noise Control
14	Equipment in poor state of maintenance, particularly without effective noise control will be checked to determine if it can be improved, and replaced with less noisy equipment as soon as practicable.

Impact Reference	*Mitigation Measures*
14	Equipment emitting excessive noise in comparison with other similar equipment will not be allowed to operate.
10	Schedule blasting outside of hours when people are most disturbed by noise (such as at night).
10	Unscheduled blasting will be strictly prohibited in any case.
	Closure and Completion
18, 19	Areas such as muck disposal area, batching plant, labor camp and quarry sites after the closure shall be covered with grass and shrubs.
16	Back fill to original levels.
18, 19, 20	Reshape to match in with surrounding topography.
16	Vegetation reinstatement around the dam site. Trees will be planted to replace those submerged by the reservoir.

Exhibit 9.12: Dam Site Construction Site Manager Additional EMP Responsibilities

Impact Reference	*Mitigation Measure*
	Aesthetics
18, 19	Disguise elements with vegetation where possible.
18, 19	Use colors that integrate with the landscape.
18, 19	Trees will be planted to replace those submerged by the reservoir.
	Blasting and Excavation
16	Indicate the limits of a clearing land with highly visible markers.
8	Leave a layer of about 5 m of undisturbed softs above the top of the overburden blasts. This will act as a blanket to contain air blast, dust and fly rock.
8	Sprinkle water on the area where blasting is done to settle down the particulate matter emissions.

Exhibit 9.13: Powerhouse Site Construction Site Manager Additional EMP Responsibilities

Impact Reference	*Mitigation Measure*
	Blasting
8	Leave a layer of about 5 m of undisturbed softs above the top of the overburden blasts. This will act as a blanket to contain air blast, dust and fly rock.
8	Sprinkle water on the area where blasting is done to settle down the particulate matter emissions.

Exhibit 9.14: Headrace Tunnel Construction Site Manager Additional EMP Responsibilities

Impact Reference	*Mitigation Measure*
	Blasting and Excavation
16	Indicate the limits of a clearing land with highly visible markers.
8	Leave a layer of about 5 m of undisturbed softs above the top of the overburden blasts. This will act as a blanket to contain air blast, dust and fly rock.
8	Sprinkle water on the area where blasting is done to settle down the particulate matter emissions.
9	Blasting will be scheduled during the day only.
9	Local communities will be informed of blasting timetable in advance and will be provided adequate notice of when blasts are required outside of the planned schedule.
9	A Blasting Management Plan will be developed by the Construction Contractor. The Plan will be reviewed and approved by the Supervision Contractor before the initiation of the blasting work.
9	Throughout the blasting activity, vibration sensors will be installed at strategic location to monitor the impact of blasting and to ensure that the vibration levels are within the adopted criteria. The monitoring plan will be part of the Blasting Management Plan.
9	Unscheduled blasting will be strictly prohibited in any case.
10	A minimum buffer of 500 m should be provided between the settlements and point of blasting.
11, 12	Record location of the springs especially those in areas proximal to where the underground headrace tunnel will be closer to the ground level.
11, 12	Monitor flow for located springs and maintain records.

Exhibit 9.15: Workshop Manager EMP Responsibilities

Impact Reference	*Mitigation Measure*
	Pollution Control
5, 7, 13, 15	Solid waste should only be disposed of at designated sites.
6,7	Large flood lights should not be installed outside 50 m of the Project fence.
6,7	Lights should be directed towards Project facilities and not towards the natural habitats.
8	Water will be sprinkled on all exposed surfaces, particularly those close and up-wind of the settlements.
	Resource Use
6	Source goods/materials locally where possible.

Impact Reference	*Mitigation Measure*
13	Care will be taken while moving heavy machinery to avoid damage or blockage of natural waterways and channels.
12	Water conservation techniques will be developed and implemented
	Spill Control
13, 15	Spill prevention trays will be provided and used at refueling locations
13, 15	Regular inspections will be carried out to detect leakages in construction vehicles and equipment.
13, 15	Fuels and lubricants will be stored in covered and dyked areas, underlain with impervious lining.
13, 15	Spill control kit (shovels, plastic bags and absorbent materials) will be available near fuel and oil storage areas.
13, 15	Contaminated soil will be removed from the site and disposed in a manner to ensure protection of water sources
13, 15	Emergency plan for spill management will be prepared and inducted to the staff for any incident of spill.
13, 15	The bottom of any soak pit or septic tank will be constructed at least 100 meters away from springs and water bores
13, 15	Record of spills and volume of removed contaminated soil will be maintained.
13, 15	Record of remedial measures taken will be maintained.
	Maintenance
14	Equipment under use will be regularly maintained, tuned, and provided with mufflers to minimize noise levels.
13, 15	On-site maintenance of construction vehicles and equipment will be avoided, as far as possible.
	Noise Control
14	Equipment in poor state of maintenance, particularly without effective noise control will be checked to determine if it can be improved, and replaced with less noisy equipment as soon as practicable.
14	Equipment emitting excessive noise in comparison with other similar equipment will not be allowed to operate.
14	Schedule blasting outside of hours when people are most disturbed by noise (such as at night).
14	Unscheduled blasting will be strictly prohibited in any case.
	Closure and Completion
17	After closure, areas under use shall be covered with grass and shrubs.
17	Back fill to original levels.

Exhibit 9.16: Batching Plant Manager EMP Responsibilities

Impact Reference	*Mitigation Measure*
	Air Pollution
8	Suspend earthwork operation when wind speed exceeds 20 km/hr. in areas within 500 m of any settlement.
8	The whole process of weighing and mixing would be performed in a fully enclosed environment.
8	The mixers would all equipped with dust collectors, no dust emission would be expected.
8	Siting the concrete batching plant out of prevailing high winds minimizing dust emissions.
8	The prevailing wind direction should be considered to ensure that bunkers and conveyors are sited in the leeward direction to minimize the effects of the wind.
8	The provision of natural or artificial wind barriers – such as trees, fences and landforms – to help control the emission of dust from the plant should be considered.
8	Batching plants should be sited on land that is not flood prone.
8	Suspend operation when wind speed exceeds 20 km/hr. in areas within 500 m of any settlement.
8	The prevailing wind direction should be considered to ensure that aggregate handling systems located in the leeward direction to minimize the effects of the wind.
8	Sprinkle water on all exposed surfaces, particularly those close and up-wind of settlements.
	Noise Control
14	Locate noisy equipment away from potential sources of conflict.
14	Locate noisy equipment behind sound barriers or sound absorbers – for example, gravel stockpiles or constructed barriers.
14	Install silencing devices to all pressure operated equipment.
14	Schedule blasting outside of hours when people are most disturbed by noise (such as at night).
14	Unscheduled blasting will be strictly prohibited in any case.
	Closure and Completion
20	After closure, areas under use shall be covered with grass and shrubs.
20	Back fill to original levels.

Exhibit 9.17: Construction Camp Manager EMP Responsibilities

Impact Reference	*Mitigation Measure*
	Pollution Control
5. 6. 7, 13, 15	Develop and implement a Waste Management Plan
5. 6. 7, 13, 15	Solid waste should only be disposed of at designated sites.
6,7	Large flood lights should not be installed outside 50 m of the Project fence.
6,7	Lights should be directed towards Project facilities and not towards the natural habitats.
8	Water will be sprinkled on all exposed surfaces, particularly those close and up-wind of the settlements.
	Resource Use
6	Source goods/materials locally where possible.
12	Water conservation techniques will be developed and implemented
	Spill Control
13, 15	Spill control kit (shovels, plastic bags and absorbent materials) will be available near fuel and oil storage areas.
13, 15	The bottom of any soak pit or septic tank will be constructed at least 100 meters away from springs and water bores
13, 15	Record of spills and volume of removed contaminated soil will be maintained.
	Maintenance
14	Equipment under use will be regularly maintained, tuned, and provided with mufflers to minimize noise levels.
	Noise Control
14	Equipment in poor state of maintenance, particularly without effective noise control will be checked to determine if it can be improved, and replaced with less noisy equipment as soon as practicable.
14	Equipment emitting excessive noise in comparison with other similar equipment will not be allowed to operate.
	Closure and Completion
17	Construction camp after the closure shall be covered with grass and shrubs.

Exhibit 9.18: Spoil Disposal Site Manager EMP Responsibilities

Impact Reference	*Mitigation Measures*
17	Slope movements will be monitored around excavation work areas.
16, 17	Restore to the maximum extent possible the hydrological regime and reinstate natural drainage of the land (including provisions to maintain the water balance of the site and protect from flooding where appropriate)

Impact Reference	*Mitigation Measures*
16, 17	Reinstate topsoil (in case it was stripped before construction activities)
16, 17	Revegetate sites with suitable native plant species
16, 17	Drain spoil piles to prevent the concentration of flow and to prevent rill and gully erosion
16	Separate organic material (e.g., roots, stumps) from the dirt fill and store separately. Place this material in long-term, upland storage sites, as it cannot be used for fill.
16	Store "clean" material in a short-term disposal site (stockpile) if it will likely be re-used for fill or shoulder widening projects.
16	Where feasible, recycle asphalt material in embankments and shoulder backing. Place these materials where they will not enter the stream system. Asphalt that is 5 years old is considered "inert" (that is, all oils washed off).
16	Do not add excess unusable material to permanently closed sites.
16	Spread material not to be re-used in compacted layers, generally conforming to the local topography. Design the final disposal site reclamation topography to minimize the discharge of concentrated surface water and sediment off the site and into nearby watercourses.
16	Cover the compacted surfaces with a 6-inch layer of organic or fine-grained soil, if feasible.
16	After placement of the soil layer, track walk the slopes perpendicular to the contour to stabilize the soil until vegetation is established. Track walking creates indentations that trap seed and decrease erosion of the reclaimed surfaces. (See figure on next page.)
16	Revegetate the disposal site with a mix of native plant species. Cover the seeded and planted areas with straw compost, mulched with straw at a rate of 1 to 1 ½ tons per acre. Apply jute netting or similar erosion control fabric on slopes greater than 1:2 if site is erosive.
16	Locate stockpiles away from drainage lines, at least 10 meters away from natural waterways and where they will be least susceptible to wind erosion
16	Ensure that stockpiles and batters are designed with slopes no greater than 1:2 (vertical\ horizontal).
16	Besides these measures, erosion can also be minimized by regular rehabilitation of areas not in use for Project activities during construction. These will include: • Re-grading and immediate re-vegetation (using fast-growing species and different functional groups of plants for keeping soil in place) of slopes to minimize erosion,
16	Install erosion and sediment control measures, if possible before construction commences. · Identify drainage lines and install control measures to handle predicted storm-water and sediment loads generated in the mini-catchment.
16	Design and install appropriate erosion and sediment run-off control measures appropriate to site conditions to handle a one-in-two-year storm event (two-year ARI with intensity of six hours), for temporary structures, and a one-in-fifty year storm event, for permanent structures.

Impact Reference	*Mitigation Measures*
16	Establish an adequate inspection, maintenance and cleaning program for sediment run-off control structures. Ensure that contingency plans are in place for unusual storm events.
16	Continually assess the effectiveness of sediment control measures and make necessary improvements.
16	Keep temporary disposal sites out of wetlands, adjacent riparian corridors, and ordinary high water areas as well as high risk zones, such as 100-year floodplain and unstable slopes.
16	Anticipate sufficient storage area with no risk for sediment delivery for piles that may slump. Stress cracks indicate that the pile is at risk of slumping.

Exhibit 9.19: Transport Fleet Manager EMP Responsibilities

Impact Reference	*Mitigation Measures*
	Develop and implement a Traffic Management Plan.
	Community Safety
12	Access of community to water sources shall be kept clear so that the community's ability to meet its water requirements are not compromised.
14	Equipment emitting excessive noise in comparison with other similar equipment will not be allowed to operate.
14	Equipment in poor state of maintenance, particularly without effective noise control will be checked to determine if it can be improved, and replaced with less noisy equipment as soon as practicable.
14	Blowing of horn will be prohibited on all access road except under emergency conditions.
24	Prohibiting use of horns particularly pressure horns, in areas where the group is moving.
14	Equipment under use will be regularly maintained, tuned, and provided with mufflers to minimize noise levels.
24	Keep speeds slow where there is traffic exchange between roads.
24	Make roundabouts for the congestion points.
24	Construction traffic will not travel during school starting and ending hours on designated road segments in front of schools on the transport route
24	Designate traffic wardens at roads on the transport route to manage traffic during important hours
	Pollution Control
8	Cover all trucks hauling soil, sand, and other loose materials or require all trucks to maintain at least two feet of freeboard (i.e., the minimum required space between the top of the load and the top of the trailer).

Impact Reference	*Mitigation Measures*
8	Install and maintain all vehicles and machinery with appropriate emission control equipment.
8	Regularly maintain vehicles and equipment to keep emissions in check.
8	Smoke from internal combustion engines should not be visible for more than ten seconds.
8	To the extent possible, use new and low emission equipment and vehicles.
8	Purchase best quality fuel and lubes and where possible use lead free oil and lubes.
8	Sprinkle water on all unsealed roads used by Project vehicles that are within 200 m of any settlement.
8	Reduce traffic speeds on all unpaved surfaces to 15 miles per hour or less.
8	Paved roads shall be swept frequently if soil material has been carried onto adjacent paved, public thoroughfares from the Project site.
8	Install wheel washers where vehicle exit onto paved road from unpaved.
8	Wheel washing of vehicles leaving the site.
8	Wash vehicles/equipment prior to each trip.
8	Use catalytic converters on vehicles, an emission control device, used to convert harmful pollutants to less harmful pollutants e.g. it converts the nitrogen oxides back into nitrogen and oxygen.
8	Appropriate maintenance of vehicles and machinery.
12, 16	Exercise care while moving heavy machinery to avoid damage or blockage of natural waterways and channels.
14	Fit and maintain appropriate mufflers on earth-moving and other vehicles on the site.
14	Mobile plants such as excavators, front-end loaders and other diesel-engine equipment should be fitted with residential class mufflers and other silencing equipment, as applicable.
14	Haul roads within the site should have as low a gradient as possible, and paving should be considered if practicable where noise-sensitive receptors are likely to be affected;
14	Owners and operators of existing facilities should implement special noise reduction measures, such as erecting purpose-built acoustic barriers, restricting opening hours and maintaining transport vehicle
15	Carry cleanup kits in all fuel trucks.
15	Fueling should only take place over impermeable surfaces, other hazmats should be stored and used over impermeable surfaces.
22	Make roundabouts for the congestion points.
23	Retain as much natural vegetation as possible to reduce the impact of smoke due to vehicles.
24	The vehicles going on the spoil routes and passing through the communities must be completely covered to avoid dust emissions.

Impact Reference	*Mitigation Measures*
24	Strictly implement speed limits and defensive driving policies.
24	Keep speeds slow (30 km/hr) on unsealed roads.
24	Sprinkle water on unsealed roads that are used for construction traffic.
24	Retain as much natural vegetation as possible to reduce the impact of smoke due to vehicles.
24	The vehicles going on the spoil routes and passing through the communities must be completely covered to avoid dust emissions.
24	Road safety awareness education will also be included during community visits or information sessions, so that communities can be familiarized with common road signs and the types of vehicles and equipment that will be moving through the area.
24	Make roundabouts for the congestion points.
24	Construction traffic will not travel during school starting and ending hours on designated road segments in front of schools on the transport route.
24	Maintain vehicles especially brakes.
24	Promptly and properly repair and maintain roads that are subject to damage by Project activities.

Exhibit 9.20: Labor Manager EMP Responsibilities

Impact Reference	*Mitigation Measures*
	Health and Safety
14	Reduce workers' exposure to high noise levels by keeping moving workers away from the noise source; restricting access to areas; rotating workers performing noisy tasks; and shutting down noisy equipment when not needed.
14	Use earplugs to reduce workers' exposure to high noise levels.
	Community Employment
26, 27	Ensure preferential recruitment of local candidates provided they have the required skills and qualifications.
26, 27	Include an assessment of the contractor's demonstrated commitment to domestic and local procurement and local hiring in the tender evaluation process.
26, 27	Determine what is considered to be 'fair and transparent' in recruitment and in distribution of jobs between different community groups, in consultation with local communities and their leaders.
26, 27	Support a 'vocational training program' to assist local people to qualify for semi-skilled positions focusing on issues such as procurement, involvement of vulnerable groups in Project opportunities and continual professional development of staff.
26, 27	Assist local people having practical skills but lacking qualifications to obtain their certificates and thus increase their employment opportunities.

Exhibit 9.21: Community Liaison Officer EMP Responsibilities

Impact Reference	*Mitigation Measures*
	Community Water Supply
12	Water for construction will be sourced from authorized abstraction sources agreed between the local communities, local government and EPC contractor.
12	Access of community to water sources shall be kept clear so that the community's ability to meet its water requirements are not compromised.
12	Support the community in development of alternate water supply schemes through local NGOs
12	Ensure the availability of water to the communities and the access of the communities to the water resources being used by them is not adversely affected.
14	Close liaison with the community and regular monitoring of the noise levels in the community are key to successfully implementation of the above mitigation measures. Specifically: The communities will be informed of all major construction activities at three days in advance. Noise control measures will be discussed with the community through informal and formal meetings.
	Construction Noise
14	A complaint registering, tracking and redressal mechanism will be implemented.
14	Noise levels will be monitored regularly in the community in order to take timely corrective measures, if needed.
14	Inform local communities of blasting timetable in advance and provide adequate notice of when blasts are required outside of the planned schedule.
	Grievance Procedure
14, 24	Encourage local communities to use the grievance procedure for concerns related to deterioration of local services and environment (including noise)
14, 24	Provide support for implementation of the PEDO Stakeholder Engagement Plan by:
14, 24	a. maintaining regular communication with local communities and other stakeholders to minimize tensions arising from Project activities;
14, 24	b. maintaining a grievance procedure, and encourage and facilitate stakeholders to use the mechanism to express concerns; and
14, 24	c. providing sufficient resources to the community relations officers to enable them to monitor negative perceptions and associated tensions, and to address them in a timely fashion.
	Training and Recruitment
26	Coordinate recruitment efforts related to non-skilled labor, including for non-skilled labor positions required by contractors.
27	Support initiatives promoting a culture of learning in local communities.
27	Plan and implement training program for vulnerable groups to encourage their participation in economic opportunities created by the Project.
27	Assist employees and local communities to improve basic personal financial life skills through training and awareness campaigns, respectively.

Impact Reference	*Mitigation Measures*
27	Consider further training programs to prepare retrenched workers to seek employment in sectors not related to dam construction.
	Graveyard Land Acquisition
34	Plaster the graves with mud or cement.
34	If relocation of the graveyard cannot be avoided, it shall be managed through the local religious authorities.

Exhibit 9.22: Project Environmental Manager EMP Responsibilities

Impact Reference	*Mitigation Measures*
	Community Water Supply
12	Water for construction will be sourced from authorized abstraction sources agreed between the local communities, local government and EPC contractor.
	Poaching and Wildlife
5,6,7	Encourage personnel to report sightings of wildlife of conservation importance or incidents of poaching to PEDO.
6	Project staff and contractors to report kills of large mammals particularly designated species of conservation concern.
6,7	Regulations for Project staff and contractors to avoid illegal poaching to be incorporated in contract documents.
6,7	Provide adequate knowledge to the workers on relevant government regulations and punishments for illegal poaching.
	Awareness Trainings
5,6, 7	Train and raise awareness regarding AIS among Project staff and contractors.
6,7	Provide awareness training to staff and contractors on: prevention of injury of animals; identification of likely species found on site; identifications of animal hazards (such as venomous snakes); and what to do if dangerous animals are encountered.

Exhibit 9.23: PEDO's EMP Responsibilities

Impact Reference	*Mitigation Measures*
	Ecology
1, 2, 3,4,6,7	Implementation of the BAP (see **Volume 2C** of the **EIA**)
	Community
29, 30, 31, 32, 33, 34	Implement PEDO Stakeholder Engagement Plan, which includes the grievance procedure.

Impact Reference	*Mitigation Measures*
29	A Sediment Mining and Management Guidelines will be prepared and implemented as a part of BAP, which will identify possible sand and gravel mining spots along the Kunhar River to meet community needs without harming the river ecology.
24	Support local government in the implementation of infrastructure projects.
24	Support NGOs specializing in development of infrastructure to assist local government.

Exhibit 9.24: Owner's Engineer EMP Responsibilities

Impact Reference	*Mitigation Measures*
7	Solid waste should only be disposed of at designated sites.
11	Monitoring records of local springs within 1 km downstream of Dam Site
11, 12	Maintain records of water release to downstream of river at Dam Site
3, 4	Ensure release of environmental flow of the river in dry seasons.
17	Develop and implement an emergency response plan.

9.4.2 Specific Environment Management Plans

Nineteen specific management plans that are to be developed to facilitate the implementation of the mitigation measures are detailed in **Exhibit 9.25**. Additional plans may be developed on discretion to further facilitate other areas of mitigation.

It should be noted that these plans (and other required mitigation measures not included within these plans) will be operationalized via Site Specific Environmental Management Plans (SSEMP) that are discussed in detail in **Section 9.5.3**. All construction sites must have a SSEMP prepared by the EPC Contractor and approved by PEDO before any major construction activity is started on the site.

Some of the required plans that have been developed as part of the EIA are described in the following sections.

Exhibit 9.25: Supporting Plans

No.	*Title*	*Description and Requirements*	*Responsibility*
1	Air Pollution Control Plan	The plan will incorporate mitigation measures described under IR 8 in **Exhibit 9.8.**	EPC Contractor
2	Biodiversity Action Plan	The Study Area for the Project falls in Critical Habitat as defined in the IFC PS6 due to the presence of the endemic and restricted range species the Nalbant's Loach and Kashmir Hillstream Loach. The Project is required to	As given in BAP

No.	*Title*	*Description and Requirements*	*Responsibility*
		achieve a 'Net Gain' in the population of both species to comply with PS6. There is an increasing threat to river ecology and fish fauna due to increasing levels of illegal fishing and unregulated sand mining in the Project area. The EFlow assessment of the Project (see **Volume 2C** of the **EIA**) recommended an environmental flow of 1.5 m^3/s downstream of the dam, and implementation of strict protection measures and management measures to control illegal fishing and regulate sand mining. A Biodiversity Action Plan (BAP) has been prepared as a part of the EIA to ensure that the protection measures as assumed in the EFlow assessment are implemented to protect fish fauna in general and Nalbant's Loach and Kashmir Hillstream Loach, in particular, such that achievement of Net Gain in the populations of these two species is achieved. In addition, management measures triggered by the CIA of the Project and included in the BAP are establishment of an Institute for Research on River Ecology and a Watershed Management Program (WMP). Together, these are aimed at improving conditions for both aquatic and terrestrial ecology derived from research and development in areas such as captive breeding and restocking, genetic studies, improvements in water quality, afforestation, land use management, amongst others. The complete plan is presented in the **BAP** in **Volume 2C**.	
3	Blasting and Explosives Control Plan	The plan will be developed using mitigation measures described under IR 9 and 10 in **Exhibit 9.8.**	EPC Contractor Headrace Tunnel Construction Manager Quarry Area Manager
4	Construction Site Environmental Management Plan	The plan will incorporate mitigation measures for the site.	EPC Contractor All managers for construction sites
5	Emergency Preparedness and Response Plan	This plan will identify emergency situations such as fires, landslides, earthquakes, coffer dam failure etc. that could realistically occur and detail the response that is required.	PEDO

No.	*Title*	*Description and Requirements*	*Responsibility*
6	Environmental Training Plan	This plan will sensitize Project employees on environmental aspects and will incorporate mitigation measures described under IR 5 and, 6 in **Exhibit 9.8.**	Labor Manager Project Environmental Manager
7	Surface Run Off and Erosion Control Plan	The plan will contain mitigation measures listed under IR 16 in **Exhibit 9.8.**	EPC Contractor
8	Spoil Disposal Plan	Major measures for safe spoil disposal are included in the Project design. The plan will contain these Project design features and additional mitigation measures as listed under IR 17 in **Exhibit 9.8.**	EPC Contractor Disposal Site Manager
9	Noise and Vibration Control Plan	An important feature of effective noise control is regular monitoring in effected communities and a complaint registering and redressal mechanism. Key measures presented in IR 14 in **Exhibit 9.8** should be incorporated in the plan.	Community Liaison Officer
10	Occupational Health and Safety	This plan should seek to meet guidelines followed by ADB, specifically those laid down in the IFC's General EHS Guidelines on Occupational Health and Safety.	Labor Manager
11	Reservoir Clearing Plan	This plan should ensure maximum utilization of cleared material by local communities and limit clearing to where required.	Community Liaison Officer EPC Contractor
12	Sediment Mining and Management Plan	This plan will be based on the guidelines presented in the BAP in **Volume 2C**.	PEDO
13	Site Rehabilitation and Landscaping Plan	The plan will contain measures listed under IR 18 and 20 in **Exhibit 9.8.**	EPC Contractor
14	Spill Prevention and Response Plan	The plan will contain measures listed under IR 13 and 15 in **Exhibit 9.8.**	EPC Contractor
15	Traffic Management Plan	The plan will contain measures listed under IR 22, 23, 24 in **Exhibit 9.8.**	Transport Fleet Manager
16	Vocational Training Plan	The plan will outline the 'vocational training program' to assist local people to qualify for semi-skilled positions focusing on issues such as procurement, involvement of vulnerable groups in Project opportunities and continual professional development of staff.	PEDO

No.	Title	Description and Requirements	Responsibility
17	Waste Management Plan	A waste management plan is the written record of what must be done to achieve the goals you have set for managing construction waste. Where subcontractors have sole responsibility for their waste, they should complete their own waste management plan. Each site should have its own waste management plan.	All construction site managers especially Construction Camp Manager
18	Water Sourcing and Abstraction Plan	The plan will contain measures listed under IR 12 in both **Exhibit 9.7** and **Exhibit 9.8**.	EPC Contractor
19	Worker Accommodation Management Plan	This plan can draw upon the IFC publication *Workers' accommodation: processes and standards, A guidance note by IFC and the EBRD.p*	Labor Manager Construction Camp Managers

9.4.3 Frameworks for Spoil and Quarry Management Plans

The exact location of quarry and spoil disposal areas will require technical and engineering studies which will be conducted at the detailed engineering stage. Proposed locations for spoil diposal areas are shown in **Section 3.4.4** and a comparison of the impacts of these locations is provided in **Section 7.8.3**. This section provides frameworks for preparation of the Spoil and Quarry Management Plans. These plans will be prepared for each of the spoil disposal and quarry areas prior to commencement of quarrying and spoil disposal operations in the construction phase.

Spoil Management Plans

This section provides the framework for development of the Spoil Management Plan (SMP) including purpose of the plan, mitigation hierarchy, and guidelines for on-site management.

A SMP will be prepared prior to commencement of any tunnelling works and other works that may generate spoil. The SMP will incorporate detailed information on the handling of spoil generated during construction. It should be consistent with the Traffic Management Plan to allow for ready access to spoil and spoil disposal areas and to avoid disturbance to the non-Project related traffic.

Purpose

The purpose of the SMP is to:

- identify environmental management issues associated with sourcing, handling, transportation, stockpiling, disposal and reuse of spoil material; and
- document and describe the systems and procedures developed to mitigate environmental impacts specifically to:
  - Minimise spoil removal and associated impacts on stakeholders, community and the environment;
  - Maximise the beneficial reuse of spoil material from the Project; and

  - ▷ Address the Project wide objective to provide certainty of delivery by managing spoil in a manner that avoids impacts on construction activities and timing

Mitigation Heirarchy

Where feasible and reasonable, spoil should be managed according to the following hierarchy:

- Minimisation of spoil generation through design and management
- Reuse of spoil within the Project
- Beneficial reuse of spoil outside the Project for environmental and community works
- Beneficial reuse of spoil outside the Project for site levelling, development or rehabilitation
- Disposal of spoil outside the Project for non-beneficial uses (landfilling)

On-site Management

On-site management includes management of stockpiling sites, spoil transport, spoil tracking and spoil testing for re-use.

Stockpiles

On site management of spoil material stockpiling sites involves planning for stockpiling including selection of stockpiling sites, their accessibility to the road network, management of stockpiles to minimize wind and water erosion, management of stockpiles to minimize dust from exposed surfaces and management of noise and dust during loading and unloading.

The stockpile sites need to:

- Have ready access to the road network
- Be located on levelled land where possible
- Not affect land use of adjacent properties
- Be located in areas so that the erosion control measures can be implemented
- Be located in areas so that flooding does not result in runoff
- Be located in areas such that they do not result in the disturbance of species of conservation importance
- Be positioned in areas where there is minimal visual, noise and vibration impacts anticipated on nearby residents
- Be located within the Project approved boundary
- Be located in areas such that they do not affect cultural heritage
- Ensure land care and avoid loss of habitat and spread of invasive plant species

- Avoid flooding of trees and waterlogging of soils
- Have contaminated materials stockpiled separately
- Have erosion and sedimentation controls in place
- Be subjected to regular inspection

Spoil transport

The following need to considered for spoil transport:

- Spoil transport/haulage routes should be identified, assessed and if necessary upgraded
- Haulage routes should be assessed and if necessary upgraded
- The routes should be selected to minimize impacts on sensitive receptors including people, ecology and the landscape
- Transport should be undertaken with minimization of noise and dust

Spoil tracking

A spoil tracking system should be developed which should include fields such as:

- Date
- Docket Number
- Haulage Company (if other than EPC Contractor)
- Material Classification
- Quantity in Tonnes to be Transported
- Truck Identification Number
- Location of Spoil Generation Site
- Location of Spoil Receival Site

Spoil Testing

It is necessary to determine if the waste material is hazardous or non-hazardous and whether or not it requires any special treatment before disposal or re-use. Spoil testing before re-use is important to answer questions such as the following:

- Are manufactured chemicals or process residues present?
- Are sulfidic ores or soil present?
- Are naturally occurring asbestos soils present?
- Is there any other waste present?

Quarry Management Plans

Quarrying involves the removal, haulage, processing, stockpiling, and distribution of rock products. Planning a site for quarrying must take account of geological, environmental, and engineering parameters. Rehabilitation and post quarry land use options must also be considered in planning and developing a quarry.

The framework for the Quarry Management Plan (QMP) includes its environmental objectives, major activities, key management areas, rehabilitation and site selection guidelines.

Environmental Objectives

Environmental objectives of the QMP are to:

- Protect water quality
- Reduce potential for erosion and sedimentation
- Protect the general amenity of the site and surrounding area
- Protect the acoustic environment and surrounding residences to minimize disturbance to people
- Protect air quality
- Ensure land care and avoid loss of habitat and spread of invasive plant species
- Minimize waste and control waste disposal
- Avoid complaints from the community

Major Activities

The major activities of the QMP include:

- demarcation of the area to be quarried;
- an indication of final contours and floor levels including the proposals for the coordination of final levels of adjoining land;
- proposed ultimate drainage of quarried lands and include any water consents that it may be necessary to obtain;
- an indication of the period over which quarrying will continue, and of staged development
- provision for the disposal and/or stockpiling of overburden, waste and quarried material, including the area to be used for stockpiling;
- areas for stockpiling topsoil (where applicable);
- provision for screening unsightly features from public view and fencing dangerous or potentially dangerous features;
- description of methods to be employed to prevent contamination of air or natural water and to comply with the noise and vibration provisions of these rules;
- description of methods to be employed to maintain impact of sensitive ecological resources as identified in the EIA within acceptable limits:
- an indication of the route by which quarried material is to be removed from the lot;

- provision for the progressive restoration of the lot such that the land will be left in such condition that is suitable for the establishment of those uses to which that land may subsequently be put; and
- description of methods to be employed to avoid, remediate or mitigate any adverse effects of quarrying operations on identified significant places and areas

Key Management Areas

The following are key management areas:

- Noise Management
- Stormwater Management
- Air Quality Management
- Traffic Management
- Blasting Management
- Landcare Management
- Oil, Grease, Fuel and Chemical Management
- Ecological Management (if resources of concern exist as identified in ecological baseline in the EIA or Biodiversity Management Plan)
- Community Relations Management
- Waste Management
- Rehabilitation Management

Rehabilitation

Rehabilitation is an essential component of quarry planning and development. Good planning prior to the commencement of quarrying greatly assists in the management of environmental impacts and provides for efficient operations.

The principal objectives of rehabilitation and landscaping at the proposed quarry will be:

- To reduce the potential for erosion
- To protect and enhance visual screening
- To protect the general amenity of the area both during and subsequent to extractive operations
- To ensure a safe and stable landform
- To ensure self-sustaining vegetation
- To protect and enhance the wildlife habitat of the site
- To improve and maintain habitats in buffer areas surrounding the quarry
- To ensure a sustainable post extraction land use

Site Selection Guidelines

The location of the quarry and processing plant needs to be done to maximize noise and dust attenuation as well as visual impact. Careful site selection will:

- reduce the potential environmental impacts and consequently, the need for impact mitigation and ongoing management measures
- reduce levels of public controversy
- avoid potential delays in the approval process.

Principles of site selection for quarry proposals consideration must be given to whether:

- the land use is permissible
- environmentally sensitive areas are avoided
- the use is compatible with nearby land uses
- initial site investigations indicate the site is fundamentally suitable for a quarry or not

The following steps are recommended for site selection:

- Describing the socio-environmental conditions of each site and identifying potential impacts;
- Constructing a comparative matrix to evaluate relative site characteristics with respect to physical, ecological, socioeconomic factors; and
- Selecting the most suitable site based on the above factors and with the stakeholder participation.

Details of the factors that need to be considered for the physical, ecological and socioeconomic environment are as follows:

Physical Environment

- accessibility by heavy transport vehicles
- being, or having the potential to be, well drained;
- resulting in minimal soil loss and erosion;
- not degrading water quality in waterways and aquifers;
- stable enough to attenuate noise and vibration levels;
- screened to minimize dust pollution;
- being restorable to a suitable condition.

Key questions include the following:

- Are the rainfall patterns or prevailing wind directions likely to cause management difficulties?

- Are the local climatic conditions (e.g. air movement, rainfall) in combination with the topography likely to result in microclimatic conditions which will adversely increase impacts on the community?
- Are there any site constraints which make on-site water management difficult (including both process water and stormwater)?
- Are there risks of surface water pollution because of the proximity or pathways to waterbodies?
- Can any required separation distances from waterbodies under any existing legislation or guidelines be complied with?
- Are there risks of groundwater pollution because of shallow or rising groundwater tables, or proximity to groundwater recharge areas, or areas with a high vulnerability to pollution?
- Is the site susceptible to flooding?
- Are there any topographic or geological characteristics which will cause difficulties in managing impacts (subsidence, slippage, seismic)?
- Are the soils highly erodible? Identify any potential sediment management problems?
- Are there existing soils problems e.g. contaminated soils, acid sulfate or saline soils?
- Can the standard and capacity of the road network accommodate traffic likely to be generated by the proposal?
- Can truck traffic avoid residential areas, hospitals, schools and commercial areas?
- If inadequacies exist, can the road network or traffic management be changed to minimise any impacts particularly on residential areas?

Ecology

- maintenance of the quality, structure and functioning of important natural and sensitive ecosystems;
- minimizing impacts on species populations and biodiversity

Key questions include the following:

- Is there sufficient separation from environmentally sensitive areas such as national parks, nature reserves, wetlands, protection zones?
- Can clearing of natural vegetation be avoided?
- Can clearing of vegetation of high significance be avoided e.g. vegetation used for visual screening, riparian vegetation, vegetation used as corridors for the movement of fauna?
- Are threatened flora or fauna species, populations and ecological communities or their habitats liked to be affected?

Socioeconomic Environment

- Community infrastructure
- public goods and services
- aquifers used by local communities
- recreation
- community activities
- aesthetics
- quality of life
- open space and community amenity

Key questions include the following:

- Is the proposal likely to be compatible with surrounding existing or proposed land uses, particularly any residential, special uses (such as schools, hospitals, community buildings) and any sites of outstanding natural or environmental value?
- Is there likely to be a problem in meeting sustained compliance with dust, noise or water quality requirements due to the proximity and nature of nearby land uses?
- Is the proposal likely to pose health risks?
- Is the proposal likely to affect the heritage of significance?
- Is the site highly visible?
- Will there be significant visual impacts?

9.5 Implementation Plan

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. An outline of how these features will be managed for the Project is presented below.

9.5.1 Contractual Requirements

PEDO will ensure that:

1. EMP is included in the bidding package for the EPC Contractor;
2. During the bid evaluation the environmental performance of the bidders are taken into consideration;
3. Environmental costs are included in the financial bid of the bidders;
4. The environmental requirements are included in the contract of the selected EPC Contractor. Any conditions of the environmental clearance from the KP EPA and any subsequent licenses and approvals from KP EPA are also included in the environmental requirements for the contractors.

5. The contract of the of the selected EPC Contractor provides for withholding payment for completion of specific works until E&S requirements for those works have been implemented satisfactorily, and penalties for unsatisfactory performance

9.5.2 Design

The approving authority for the detailed design will:

- Ensure that all environmental aspects are communicated to the EPC;
- The detailed design includes the environmental design;

9.5.3 Site Specific Environmental Management Plans

EPC's Contractor's managers during the construction phase will operationalize their responsibilities described in **Section 9.4** (*Mitigation and Management Plan*) by developing Site Specific Environmental Management Plans (SSEMP). These will be applied to the actual site where construction activities will occur. Ideally, the preparation of the SSEMP must occur before the contractor is given access to the project site. However, it can be prepared after the access is given but certainly *before* the initiation of site clearance and any major site construction or erection work. At a minimum the following sites should have an SSEMP prepared:

- Dam Site
- Powerhouse Site
- Headrace Tunnel site
- Tailrace Tunnel site
- Waste Dump Areas
- Quarry Areas
- Workshops
- Batching Plants
- Labour Camp

Some of these sites, such as the headrace tunnel may require multiple SSEMPs to cover the entire spatial extent of the development.

All contract documents must include the requirement that SSEMPs be prepared by the contractor and reviewed by PEDO and OE and approved by ADB prior to commencement of construction activities.

Preparing an SSEMP

This section explains the following steps that should be followed while developing an SSEMP:

- Definition of boundaries
- Identification of environmental values and sensitive receptors of the site and its surrounds

- Definition of construction activities
- Assignment of environmental management measures
- Preparation of site plans
- Preparation of environment work plans

Definition of Boundaries

For megaprojects with multiple construction sites, such as a hydropower scheme, there will be a number of SSEMPs for each site. A hydropower scheme would need to have SSEMPs covering works at the dam site, the powerhouse, the switchyard, the downstream channel, headrace and tailrace tunnels, the intake structures, quarries that supply aggregate, the waste disposal areas, contractor's camps, equipment yards, workers' accommodations, etc. Generally, areas falling under the jurisdiction of a construction manager should have a separate SEMP.

Identification of Sensitive Receptors

Once the boundaries of a site to be covered by a SSEMP have been defined, the sensitive receptors surrounding the site and the environmental values of the area need to be confirmed.

Areas that can be considered sensitive receptors include

- Forested area
- Water bodies
- Communities (including schools, hospitals, homes)
- Agricultural areas

The physical, ecological and socioeconomic baselines in the **Section 4**, *Description of the Environment* provide the necessary details. The information is best presented as an overlay on the detailed engineering drawings or maps for the project.

Construction and Associated Mitigation Activities

A schedule of works for the project will have been prepared during the detailed design phase. It is important to understand what the various phases of work are for each site, as different phases will include different activities and thus different environmental management requirements. In this simplified example, the construction of a bridge across a river could have the following schedule of works:

- Site surveying, vegetation clearance
- Site establishment
- Soil stripping and earth movement
- Bridge construction
- Grading approaches
- Surfacing
- Painting and finishing structures

- Landscaping and signage

The planning of the environmental management requirements for the bridge must ensure that the necessary environmental management activities take place at the right time. For example, the site survey should markup areas of vegetation to be removed, trees that must be saved, and the locations of any species of importance. Soil stripping will need to be accompanied by the introduction of erosion-control measures to prevent sediment from entering the river. The concrete pouring and filling of the bridge abutments will require a large number of vehicle movements, so it may be necessary to develop a traffic management plan to ensure that the vehicles don't disrupt traffic on existing roads. If there are sensitive receptors nearby, there may be a requirement to limit working hours that will require a change in the work schedule. These measures are easy to plan for, but very hard to introduce once the project has started. This, again, emphasizes the need for effective planning of the environmental management measures.

Section 9.4 (*Mitigation and Management Plan*) provides a list of required mitigation measures that must be incorporated into the relevant SSEMPs.

Site Plan

A site plan must cover the extent of the construction activity and should contain:

- Location and nature of planned work;
- Locations of sensitive receptors; and
- Locations of required mitigation activities.

Other important features may include:

- Indication of North, and scale;
- Existing and planned supporting infrastructure (e.g., access roads, water supplies, electricity supplies, etc.);
- Contours; and
- Drainage systems.

Work Plan

The completed SSEMP provides details of all the environmental management requirements for all stages of the construction process. For individual work teams responsible for only a small part of the overall construction work, it can be hard to understand what is required for their particular work components. For example, the work team responsible for stripping soil for the construction areas are not going to be interested in the requirements for pouring concrete for footings and foundations. However, it is essential that the soil stripping team know exactly what to clear, what to leave, and where to put stockpiles of soil for later use.

When different work activities are required at different times or at different locations, environmental work plans can be prepared. These are similar to the work method statements often produced for major construction projects.

9.5.4 Site Inspection

Site inspections will be undertaken regularly in relevant areas of the Project. The inspections will focus on compliance with the EMP. The inspections will play an important role in increasing awareness of EMP.

Minor non-conformances will be discussed during the inspection and recorded as a finding in the inspection report. Major non-conformances will be reported as incidents. Inspection results will be disclosed at management meetings.

9.5.5 Non-conformance and Incidents

Non-conformances include the following:

- exceedances of relevant thresholds as identified during routine monitoring;
- non-conformances with the requirements of the EMP or supporting documentation identified during an internal inspection;
- non-conformances identified during an audit or by regulatory authorities;
- events, such as spills, resulting in potential or actual environmental harm;
- events that did or could result in injury to staff, visitors to site or surrounding communities; and
- significant complaints or grievances received from any source.

Corrective and preventive actions will be identified and implemented in response to these non-conformances. These actions will address the root cause of the non-conformance and will reduce or prevent repeated non-conformances.

A process will be established for the identification, investigation and tracking of non-conformances, including:

- prioritizing and classifying non-conformances based on the type and severity of the non-conformance;
- recording of non-conformances and the results of corrective and/or preventive actions, including the actions necessary to mitigate or remedy any associated impacts;
- defining results expected from the corrective and/or preventative actions;
- confirming the corrective and/or preventive actions taken to eliminate the causes of the non-conformance are appropriate to the magnitude of problem and commensurate with the impacts encountered;
- reviewing the effectiveness of the corrective and/or preventive actions taken; and
- implementing and recording required changes in the EMP or monitoring programme resulting from corrective and preventive action.

Serious non-conformances will be classified as incidents. Incidents will be promptly reported to appropriate management. A guideline will be prepared on:

- the types of incidents reportable to internal management at the site, Project and corporate levels, as well as to regulatory authorities and other external stakeholders; and
- standards to be observed when reporting incidents.

During construction, environmental monitoring will ensure the protection of air and noise pollution, community relations, and safety provisions. During operation, emissions, air, noise, and waste water quality monitoring and greenbelt development around the plant will be important parameter of the monitoring program.

The monitoring requirement can only be fulfilled by maintaining the proper documentation records of the findings. Daily checklists, weekly reports and monthly audit will be taken in accordance with construction management plan. Based on the EIA approval a scheduled audit will be conducted by the PEDO and reports will be shared with the regulatory authority and funding agency if required.

9.5.6 Audits

Formal audits will be undertaken at planned intervals in accordance with the requirements of client and regulatory authorities. Procedures for audits will be established, implemented and maintained. These will cover the audit criteria, scope, frequency and methods, and will address the responsibilities and requirements for planning and conducting audits, reporting results and retaining associated records.

Any negative findings arising from an audit will be treated an incident and dealt with in accordance with the non-conformance and incident procedure. Results from audits and evaluations of compliance with legal requirements will be reported to site and senior management and subject to management reviews. Usually environmental regulatory authorities require a quarterly audit report for large scale projects.

The following audits will be carried out for:

- Labor
- Health and Safety
- Environment

9.6 Monitoring Plan

Monitoring of environmental components and mitigation measures during implementation and operation stages is a key component of the EMP to safeguard the protection of environment. The objectives of the monitoring are to:

- manage environmental issues arising from construction works through closely monitoring evidence for implementation of the mitigation measures and environmental compliance; and
- monitor changes in the environment during various stages of the Project life cycle with respect to baseline conditions.

A monitoring mechanism is developed for identified impact and includes:

- location of the monitoring (near the Project activity, sensitive receptors or within the Project influence area);
- means of monitoring, i.e. parameters of monitoring and methods of monitoring (visual inspection, consultations, interviews, surveys, field measurements, or sampling and analysis); and
- frequency of monitoring (daily, weekly, monthly, seasonally, annually or during implementation of a particular activity).

Monitoring program will include regular monitoring of construction and commissioning activities for their compliance with the environmental requirements as per relevant standards, specifications and EMP. The purpose of such monitoring is to assess the performance of the undertaken mitigation measures and to immediately formulate additional mitigation measures and/or modify the existing ones aimed at meeting the environmental compliance as appropriate during construction.

The monitoring program will be coupled with a series of supporting procedures, yet to be developed, covering:

- sample or data collection;
- sample handling, sample storage and preservation;
- sample or data documentation;
- quality control;
- data reliability (calibration of instruments, test equipment, and software and hardware sampling);
- data storage and backup, and data protection;
- interpretation and reporting of results; and
- verification of monitoring information by qualified and experienced external experts.

9.6.1 Specific Monitoring Plan

Environmental monitoring and reporting plan for the construction and operation phases are provided in **Exhibit 9.22**. Moreover, each supporting plan (as described in **Section 9.4**) includes monitoring and documentation requirements; the same is also true of the SSEMP (as described in **Section 9.5.3**). Therefore, the monitoring plan will also contain requirements of these additional plans once they have been developed.

Monitoring framework for biodiversity is presented in **Section 9** (*Monitoring and Evaluation Framework*) in the BAP in **Volume 2C**.

9.6.2 Documentation and Reporting

Monitoring elements of the EMP will be documented and controlled in accordance with a document control system by the OE and communicated to PEDO. Records demonstrating compliance with legal requirements and conformance with the EMP will also be maintained. PEDO through its OE will supervise, establish, implement and maintain procedures.

Documentation and record keeping controls will include:

- measures to enable relevant documents and records to be readily available and identifiable (labeled, dated and properly filed), legible and protected from damage;
- review, revision and approval of documents for adequacy by authorized personnel at least once a year;
- establishment of the electronic document control version as the 'authorized version';
- making current versions of relevant documents available at locations where operations essential to the effective functioning;
- suitably identifying obsolete documents retained for legal and knowledge preservation purposes; and
- identification and segregation of confidential and privileged information.

Monitoring data will be documented and analyzed to determine temporal and spatial trends and confirm compliance with relevant thresholds. Monitoring reports will be produced to meet internal and external reporting requirements. If monitoring results indicate non-conformance with stipulated thresholds or if a significant deteriorating trend is observed, it will be recorded as a non-conformance and handled by the non-conformance and incident procedure. The following reports will be produced:

- Based on reports provided by the Construction Contractor as listed in **Exhibit 9.26**, quarterly and annual reports will be reviewed by OE/PEDO for monitoring of the physical and social environment and shared with the KP-EPA.
- Reports for biological environment will be produced under the frameworks provided in the BAP.
- Monitoring of NTDC's implementation of mitigation measures as described in the EIA of transmission lines will be carried out as part of the monitoring activities of the EMP.

Exhibit 9.26: Environmental Monitoring Program for Construction and Operation

Aspect	*Type of monitoring*	*Frequency of Monitoring*	*Location/s*	*Reporting Frequency*	*Monitoring and implementation Responsibility*	*Report Preparation Responsibility*	*Report Receiving Authority*
Construction Phase							
Soil Quality	Visual inspection for any oil and lubricant spills and leakages in the construction area and presence of oil in the drains at the construction site	Daily	Construction area and drains at the construction site	Monthly report during construction	EPC Contractor, OE, PEDO	EPC Contractor	PEDO, OE and EPA, KP
Soil Erosion	Visual inspection of soil erosion and land sliding, especially in the wet season	Once a month in dry season. Once a week in wet season.	Construction sites, rehabilitated areas and water release points	Monthly report during construction	EPC Contractor, OE, PEDO	EPC Contractor	PEDO, OE and EPA, KP
Waste Disposal	Inspection of waste disposal areas and channels	Weekly	Waste disposal sites,	Quarterly report during construction	EPC Contractor, OE, PEDO	EPC Contractor	PEDO, OE and EPA, KP
Water Resource Depletion	Record of water used and source of water supply for construction, sprinkling and camp	Daily	Construction sites, truck filling points and water tanks at camp.	Quarterly report during construction	EPC Contractor, OE, PEDO	EPC Contractor	PEDO and EPA, KP
Community Water Supplies	Monitor flow for springs identified as at risk from tailrace construction.	Monthly	Identified springs in communities.	Quarterly report during construction	EPC Contractor, OE, PEDO	EPC Contractor	PEDO and EPA, KP
Fugitive Dust Emissions	Air quality sampling at social receptors in case any complaints regarding excessive particulate matter in ambient air are received.	As required, in case complaints are received	Social receptors	Report as required, in case complaints are received	EPC Contractor, OE, PEDO	EPC Contractor	PEDO and EPA, KP

Aspect	*Type of monitoring*	*Frequency of Monitoring*	*Location/s*	*Reporting Frequency*	*Monitoring and implementation Responsibility*	*Report Preparation Responsibility*	*Report Receiving Authority*
Vehicular and Machinery Exhaust Emissions	Visual checks of exhaust emissions from vehicles and batching plant machinery to ensure excess pollutants are not being released	Monthly	Construction sites and batching plant location	Quarterly	EPC Contractor, OE, PEDO	EPC Contractor	PEDO and EPA, KP
Noise Nuisance	Monitoring of the noise levels in the nearest communities against the baseline noise conditions	Once a month and when a complaint is received	Nearest settlements or area for which complaint is received	Quarterly	EPC Contractor, OE, PEDO	EPC Contractor	PEDO and EPA, KP
Traffic	Random speed checks and inspections and investigations in case of complaints by community	Once a month and in case complaints are received	Different location and different time	Quarterly	EPC Contractor, OE, PEDO	EPC Contractor	PEDO and EPA, KP
Distribution of Project Employment	When complaint is received or an issue observed	When a complaint is received	Construction site, camp and nearby villages	Monthly	EPC Contractor, OE, PEDO	EPC Contractor	PEDO and EPA, KP
Social Unrest due to Conflicting Social Norms	When complaint is received or an issue observed	When a complaint is received	Construction site, camp and nearby villages	Monthly	EPC Contractor, OE, PEDO	EPC Contractor	PEDO and EPA, KP
Operation Phase							
Waste Disposal	Inspection of waste disposal areas and channels	Weekly	Dam and Powerhouse sites	Quarterly report	O&M Contractor	O&M	PEDO, and EPA, KP
Environmental Flow	Continuous record of downstream release into river by dam	Continuous	Dam site	Quarterly report	O&M Contractor	O&M	PEDO, and EPA, KP
Biodiversity Action Plan	As described in BAP	As described in BAP	As described in BAP	As described in BAP	As described in BAP	As described in BAP	As described in BAP

Aspect	*Type of monitoring*	*Frequency of Monitoring*	*Location/s*	*Reporting Frequency*	*Monitoring and implementation Responsibility*	*Report Preparation Responsibility*	*Report Receiving Authority*
		Monitoring to start at least one year before start of construction the BAP is to be initiated before financial close					

9.7 Roles and Responsibilities of Key Staff

To be effective, this EMP must be viewed as a tool reflecting to the contractors and sub-contractors' overall commitment to environmental protection. This must start at the most senior levels in the organization. Contractor management must provide strong and visible leadership to promote a culture in which all employees share a commitment to environmental awareness and protection. The following are commitments to be achieved by the highest position in Pakistan from PEDO:

- Putting environmental matters high on the agenda of meetings;
- Highlighting the importance of environmental issues in relation to the HSE considerations in business decisions and communication with stakeholders;
- Evaluating environmental aspects, before final decisions are reached;
- 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;
- Immediately and visibly responding and being involved in investigating incidents or other abnormal events related to environmental and HS issues;
- Seeking internal and external views on environmental issues; and recognizing their achievement.

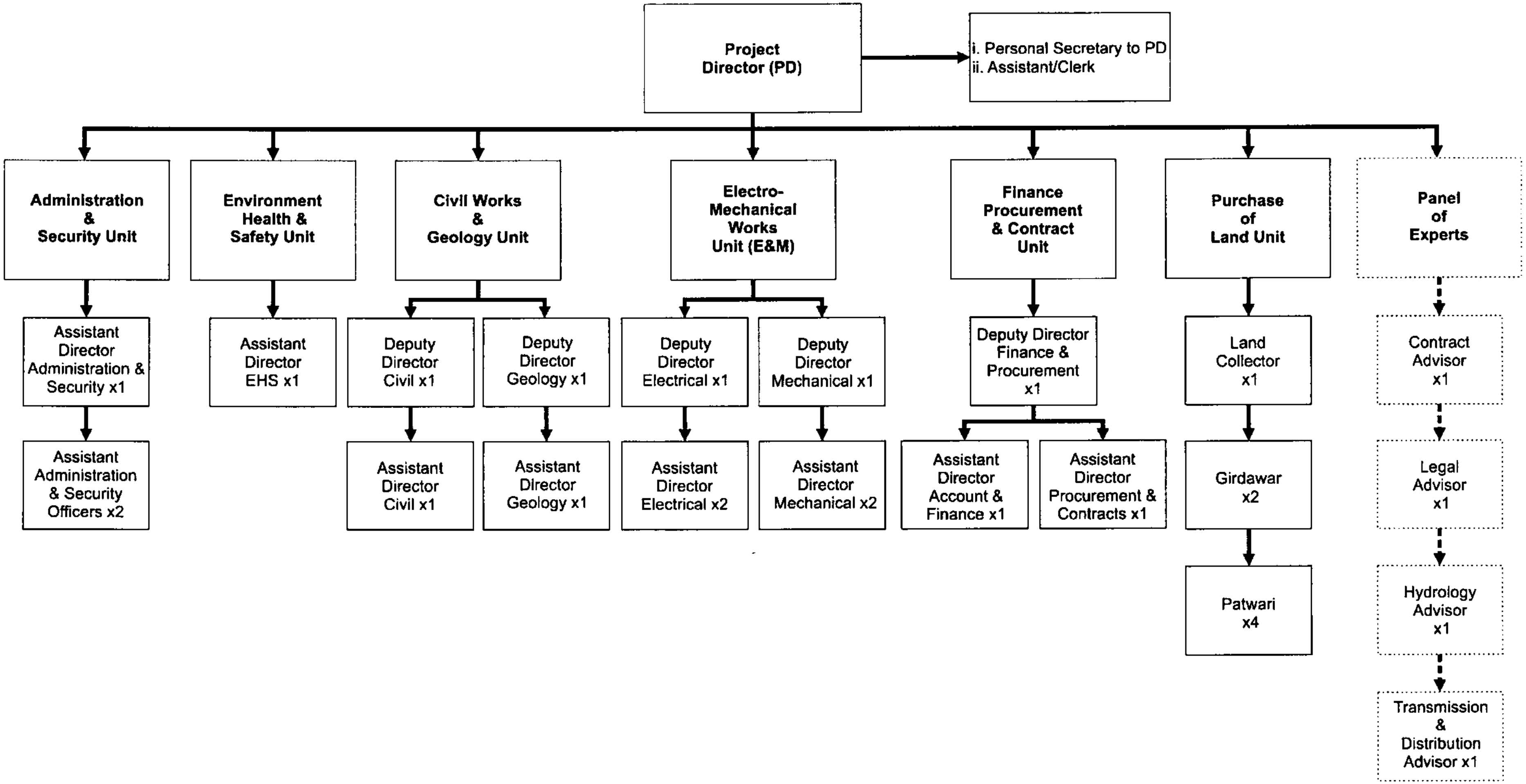
The organizational setup of PEDO for implementation of the EMP is provided in **Exhibit 9.27**. Key roles and responsibilities are described below.

9.7.1 PEDO

With overall responsibility for the Project, PEDO will:

- Prepare the ESMS and implement the ESMS and EMP.
- Minimize any impact the Project may have on the environment through preparation of this EIA (as being carried out in the design stage).
- Appoint responsible contractors who will comply with this EIA.
- Approve environmentally safe materials for use on site in accordance with the EIA.
- Ensure all relevant parties receive a copy of the approved EIA and that it is incorporated into all contractual documentation.
- Obtain the relevant environmental permits, consents and authorizations prior to commencing site works.
- Comply with all requirements of EPA, KP and obtain NOCs related to the Project.

Exhibit 9.27: Organizational Setup of PEDO for EMP Implementation



9.7.2 Owner's Engineer

Hiring an owner's engineer (OE) in the power industry is a practice which is considered a standard since the last two decades.[3] The OE is a person or, more appropriately, a team of experts that serves as an independent advocate for the owner. The OE plays a supporting but a very critical role as he is the technically trained eyes and ears of the project proponents in the field. It is expected that an OE will also be hired for the Project construction and commissioning phases. The specific roles and responsibilities of the OE will be defined in their contract. Typically, there are several important environmental roles that the OE can undertake on behalf of PEDO.

In general, following types of tasks can be assigned to the OE:

- Prepare technical specifications for design of environmental element
- Approval of technical design developed by the EPC Contractor of environmental elements of the Project
- Review and Approval of SSEMP
- Environmental Monitoring
- Review of the environmental monitoring reports and data produced by EPC

Some role for the OE is suggested in this document. However, prior to commencement of construction a formal agreement will be reached between PEDO and the OE on the latter's environmental role and responsibility.

9.7.3 Construction Contractor

The EPC or Construction Contractor will prepare a 'Construction Management Plan' (CMP) demonstrating the manner in which they will comply with the requirements of mitigation measures proposed in the EMP. After completion of the Construction Contractor's contract, PEDO will be in charge of the operation and maintenance of the Project and will be responsible for compliance with the monitoring plan during operations. The Construction Contractor's general responsibilities will be to:

- Ensure the implementation of the EIA/EMP throughout construction works by all contractor personnel and subcontractors.
- Ensure that adequate resources are available to implement the requirements of this EMP.
- Undertake quarterly environmental audits and report to PEDO on regular basis.
- To coordinate with PEDO for all correspondence to EPA, KP.
- Prepare a comprehensive legislation list and ensure compliance to these legislations.

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[3] http://www.powermag.com/who-needs-an-owners-engineer/

9.7.4 Sub-Contractors

Any Sub Contractor hired directly or indirectly by the Construction Contractor to carry out Project related tasks will be designated as a sub-contractor. It will be the responsibility of those sub-contractors, whose activities have at least one interface with identified key environmental aspects, to comply with the EIA at all times. They must also designate sufficient competent resources to ensure all Sub-Contractor personnel receive the required training. Sub-contractors directly in charge of activities shall be registered and approved. Registration documentation will be provided to PEDO prior to commencement of any activities. Sub-contractors will be expected to demonstrate a proactive behavior towards environmental concerns. It will be their responsibility to provide information requested by PEDO with regard to their scope of activities and to demonstrate compliance with the applicable environmental requirements.

9.7.5 PEDO Personnel

This section to be finalized following discussion with PEDO.

Project Director

The Project Director (PD) will manage and superintend all office and site activities for the implementation of the Project. In relation to the EIA and implementation of ESMS and EMP, the PD's responsibilities will include:

- Overall responsibility for ensuring implementation of the EMP in compliance of all legal matters regarding the Project.
- Development and establishment of adequate Environmental, Safety and Quality Management teams, who will ensure the development, communication and implementation of this EIA across the entire Project, including all activities being undertaken by subcontractors and suppliers working on the site, and all personnel visiting the site.
- Ensure that the sub-contractor has hired an environmental team to address environmental requirements in accordance with the EIA.
- Develop and establish an organization structure adequate to oversee the whole of the works, including overseeing the appointment of an appropriate qualified HSE Manager and Environmental Manager.
- Ensure that adequate resources are available to implement the requirements of this EIA.
- Ensure the EIA is reviewed regularly to correspond with on-going construction activities.
- Coordinate with government agencies and bodies regularly to discuss the Project's construction environmental issues and requirements.
- Attend regular meetings with Manager EHS and CSR in order to discuss the site's environmental issues and requirements.

Deputy Director – Civil

- Taking primary responsibility for all activities on site, including those undertaken by direct or indirectly employed personnel or agencies.
- Ensuring the issue of suitable procedures for the definition of working methods and site regulations that take into consideration the requirements within the EIA.
- Ensuring that construction and erection works are performed in respect of the EIA requirements.
- Attending regular meetings in order to discuss the site's environmental issues and requirements.

Assistant Director EHS

The Assistant Director EHS manages and supervises the Project activities relating to health, safety and environment. The Assistant Director EHS will be responsible for:

- The overall responsibility for the development and implementation of the Project HSE policy/philosophy.
- Coordinating weekly HSE meetings, during which any environmental issues will be discussed and minuted.
- Reviewing and ensuring the implementation of Contingency and Emergency Response Procedure.
- Providing specialized HSE input into engineering, construction and contracts, ensuring requirements are properly integrated into project planning, design criteria, construction plans and specifications and contracts
- Supporting/leading incident investigations as per project procedure and report to all concerned. Follow up and review the corrective and preventive action taken, and close-out the incidences.
- Conducting HSE inspections of project construction activities and monitoring compliance with requirements including contractual commitments, permits and projects HSE plan and other applicable HSE requirements and ensure that the Project HSE inspection plan is implemented.
- Ensuring that all internal as well as external incidents and complaints are appropriately resolved with all applicable forms and records duly filled and maintained.
- Coordinating and organizing regular meetings with the Project Director, Construction Manager and Environmental Manager in order to discuss the site's HSE issues and requirements.
- Coordinating the environmental activities with the higher management time to time.
- Coordinating with the EPA, KP, other regulatory authorities and stakeholders on environmental issues related to construction of the Project.

- Monitoring construction activities and performance to ensure compliance with the EIA and effectiveness of control measures adopted.
- Ensuring that no works are carried out outside the construction corridor as defined in the EIA, especially within the protected areas (e.g. forests).
- Ensuring the issue and updating of the Project's environmental plans.
- Coordinating Project document review activities from an environmental standpoint, assuring that the execution of these activities is compatible with development of the Project and reporting any discrepancies between the environmental requirements and other Project objectives to the Head Hydro Power and CEO.
- Supplying essential information for the preparation of the environmental control plan for construction.
- Updating EPA, KP regularly on construction information.
- Coordinate the development of environmental monitoring data relevant to construction activities.
- Performing environmental checks and monthly internal audits of onsite activities, in coordination with the HSE Manager.
- Supporting the higher management in relations with the governmental agencies and with the EPA, KP on environmental matters.
- Implementing the environmental requirements of the project management system including inspection and reporting.
- Monitoring construction activities and performance to ensure compliance with the Construction Management Plan and effectiveness of control measures adopted.
- Developing and implementing of the environmental training program.
- Conducting staff environmental training, inductions and Tool Box Talks (TBT).
- Communicate with internal and external parties as required.
- Coordinating daily and weekly site inspections and approving the associated environmental inspection report.
- Reviewing daily and weekly checklists to ensure that appropriate recording of site activities and observations.
- Preparing of the monthly environmental reports, quarterly performance reports and incident reports.
- Reporting of any environmental incidents to the higher management.
- Ensuring that major environmental incidents are reported to EPA, KP within a maximum of 3 days.
- Participating in environmental management reviews.
- Reviewing environmental monitoring data.

- Raise non-conformance and issue CAPs reports in coordination with the EHS Manager (PEDO).
- Ascertaining that effective measures and relevant actions are undertaken to avoid or minimize adverse environmental impacts.
- Attending regular meetings with the PD and staff that reports to the Assistant Director EHS in order to discuss the site's environmental issues and requirements.
- Ensuring that all internal as well as external environmental incidents, emergencies and complaints are appropriately resolved with all applicable forms and records duly filled and maintained.
- Regular reviewing of environmental plans and procedures to assess compliance and recommend revisions, where required.
- Review reports provided by the Construction Contractor and submit periodic reports to EPA, KP.
- Review BAP reports and submit to Management Committee for BAP and to EPA, KP.

9.8 Change Management and Document Control

It is possible that some changes in Project design will be required at the time of Project implementation. These can include changes to

- Operations and infrastructure,
- New developments (such as an expansion),
- Personnel and the Company,
- Legislation, and
- Project baseline environmental conditions (such as a new settlement established near Project infrastructure).

These changes could result in changes to the significance of environmental and social impacts and risks. This may necessitate updates to existing authorizations/ permits, changes to the ESMS, which may have to be approved by regulatory authorities, and general changes to the ESMS framework.

This section describes the mechanism that will be in place to manage changes that might affect the project's environmental impacts. The Change Management System recognizes three orders of changes:

First Order: A first order change is one that leads to a significant departure from the project and consequently requires a reassessment of the environmental impacts. A new environmental assessment will be conducted and a revised ESIA or IEE for updates will be submitted to the Punjab EPA for a first-order change in the project.

Second Order: A second order change is one that may result in different project impacts, although the overall magnitude of project impacts would be similar to those assessed in this report. The required action for such changes is to reassess the impact of the activity on the environment and report it to the Punjab EPA.

Third Order: A third-order change or uncertainty is one that is of little consequence to the ESIA and IEE findings. In case such a change is made, the only action necessary will be to make the required changes in the EMMP (Construction or Operations) to reflect how the change has been dealt with.

Changes will not be made without the required authorizations/ permits in place. The measures identified as necessary to mitigate impacts and risks will be implemented. The various elements of the ESMS will be modified as required in response to the change.

A procedure specifically for changes to the policy/s, ESMS, underlying management plans and supporting documentation will be established. This will detail:

- how the changes are to be recorded;
- who has responsibility for overseeing changes and checking that they do not conflict with any planning conditions or other obligations;
- the process of review and sign off in response to changes; and
- how changes to the ESMS and underlying and associated plans should be communicated internally and externally.

9.9 Cost Estimate

Cost estimate for EMP implementation is presented in **Exhibit 9.28**. It is separated into cost to be borne by PEDO and EPC Contractor. The EPC Contractor will provide the cost of other items.

The cost estimates for control measures and some of the mitigation measures that were already part of the design are not included in the EMP.

In addition to the cost estimate for EMP implementation estimated land acquisition and resettlement cost is USD 13,514,184. Breakdown of the land acquisition and resettlement cost cost is provided in the LARP[4] of the BHDP.

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[4] Hagler Bailly Pakistan, Balakot Hydropower Development Project Land Acquisition and Resettlement Plan, June 2019.

Exhibit 9.28: Summary of Cost Estimates for EMP (USD) to be borne by PEDO and EPC Contractor

No	*Item*	*Note*	*Construction Phase*			*Operation Phase (Annual)*
			Capital	*Recurring (Annual)*	*Total (years) 6.5*	
1	**Biodiversity Action Plan**		**388,343**	**340,761**	**2,603,290**	**340,761**
1.1	Protection		114,238	40,533	377,703	40,533
1.3	Monitoring and Evaluation of Protection		125,000	76,740	623,810	76,740
1.4	Implementation of the IRRE	Subject to approval by NEPRA	21,792	23,822	176,635	23,822
1.5	Implementation of the WMP	Subject to approval by NEPRA	127,313	169,666	1,230,142	169,666
1.6	Monitoring and Evaluation of the IRRE and WMP	Subject to approval by NEPRA	–	30,000	195,000	30,000
2	**Implementation of Stakeholders Engagement Plan**		–	**208,190**	**1,353,235**	**208,190**
3	**Environmental & Social Mitigation Measures**			**310,780**	**2,286,990**	**192,640**
3.1	Salaries and benefits		–	310,780	1,786,990	192,640
3.2	EHS Training, Laboratory Fees and out of pocket expenses				500,000	
4	**External monitoring**	For the construction phase this is lump sum cost for the services for 6.5 years, based on 18 visits. For the operation phase this is the annual cost based on 2 visits per year	–	–	284,460	31,610
5	**Instrumental monitoring and sampling**		**8,380**	**700**	**12,930**	**9,080**

No	*Item*	*Note*	*Construction Phase*			*Operation Phase (Annual)*
			Capital	*Recurring (Annual)*	*Total (years) 6.5*	
5.1	Monitoring of vehicles for emissions and noise*		–	700	4,550	700
5.2	Monitoring of ambient noise levels		2,190		2,190	2,190
5.3	Monitoring of ambient dust levels		6,190		6,190	6,190
6	**Mitigation Measures**		**2,185,265**	–	**2,185,265**	–
6.1	Compensation for trees	To be determined in consultation with Forest Department	1,223,965	–	1,223,965	–
6.2	Tree plantation cost	To be determined in consultation with Forest Department	822,420	–	822,420	–
6.3	Springs and water resources		138,880	–	138,880	–
	Total (1+2+3+4+5+6)		**2,581,988**	**860,431**	**8,726,170**	**782,281**

*Unit rate for monitoring of vehicles for emissions and noise is assumed as PKR 5,000.

The annual cost is calculated by multiplying unit rate with the number of trucks used for the Project. Calculation is as follows:

Monitoring of vehicles for emissions and noise = 50 USD

Number of truck trips for the Project = 70 (Section 7.10)

Number of trips per truck = 5 (assumed)

Number of trucks = 70 /5 = 14 trucks

10. Conclusion and Recommendation

PEDO has proposed the 300 MW Balakot Hydropower Development Project (BHDP) or Balakot Hydropower Project (BAHPP) on the Kunhar River about 18.6 kilometer (km) upstream of the town of Balakot in KP. This Project was evaluated in this report by HBP and its associated team experts for environmental and social impacts. The proposed design and construction activities were assessed against the laws of KP, the GoP policies and ADB Guidelines. Mitigation and management measures were recommended and made part of the Project design.

Environmentally, the most important aspect of the Project is the cumulative impact of the proposed Project and other hydropower projects in the Jhelum Basin on the aquatic biodiversity of the Basin, including the fish fauna, macro-invertebrates, periphyton biomass, and riparian vegetation. Two species of fish are of conservation importance, namely the Nalbant's Loach and Kashmir Hillstream Loach, both of which are endemic and restricted range species.

Cumulative impact assessment was carried out following the methodology adapted from the guidelines of the IFC. The study area for the assessment included the Kunhar River from Lulusar Lake downstream to the top of the confluence of the Kunhar River and Jhelum River. In addition to the existing Patrind HPP, the other four proposed projects on the Kunhar River, including the Project, were included in the assessment.

The Biodiversity Action Plan (BAP) for Balakot Hydropower Development Project[1] identified fish fauna as a priority biodiversity value. The Discrete Management Unit (DMU) for the Project falls in Critical Habitat as defined in the IFC PS6 mainly due to presence of the two endemic and restricted range species, the Nalbant's Loach and Kashmir Hillstream Loach. The Project is required to achieve a 'net gain' in the population of these two species to comply with PS6. River ecology and fish fauna in the Study Area was also determined to be a priority biodiversity value.

A Biodiversity Action Plan (BAP) has been prepared as a part of the EIA to ensure that the protection measures as described in the EFlow assessment are implemented to protect fish fauna in general and the Nalbant's Loach and Kashmir Hillstream Loach, in particular, such that achievement in net gain in the populations of these two species is achieved.

Socially, the most important aspect is resettlement. 165 household are likely to lose their land and residences. A resettlement action plan has been prepared separately to undertake the resettlement in a fair and open manner and to minimize social or economic impacts. The basic principles used for resettlement are derived from Pakistani laws and ADB's SPS 2009 so that the livelihoods and standards of living for all affected households are improved or at least restored.

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[1] Hagler Bailly Pakistan (HBP), July 2017. Draft Report of the Biodiversity Action Plan for the 300 megawatt (MW) Balakot Hydropower Development Project for the Asian Development Bank (ADB).

All the affected households losing any asset will be compensated according to the replacement cost. Every Project Affected Person (PAP) losing their livelihood resources or places of income generation as a result of Project interventions will be supported with income and livelihood restoration assistance. Moreover, eligible PAPs will also receive resettlement allowances like relocation allowance, vulnerability allowance, severe impact allowance etc. The Resettlement Action Plan also provides a grievance redress mechanism and a monitoring and evaluation system.

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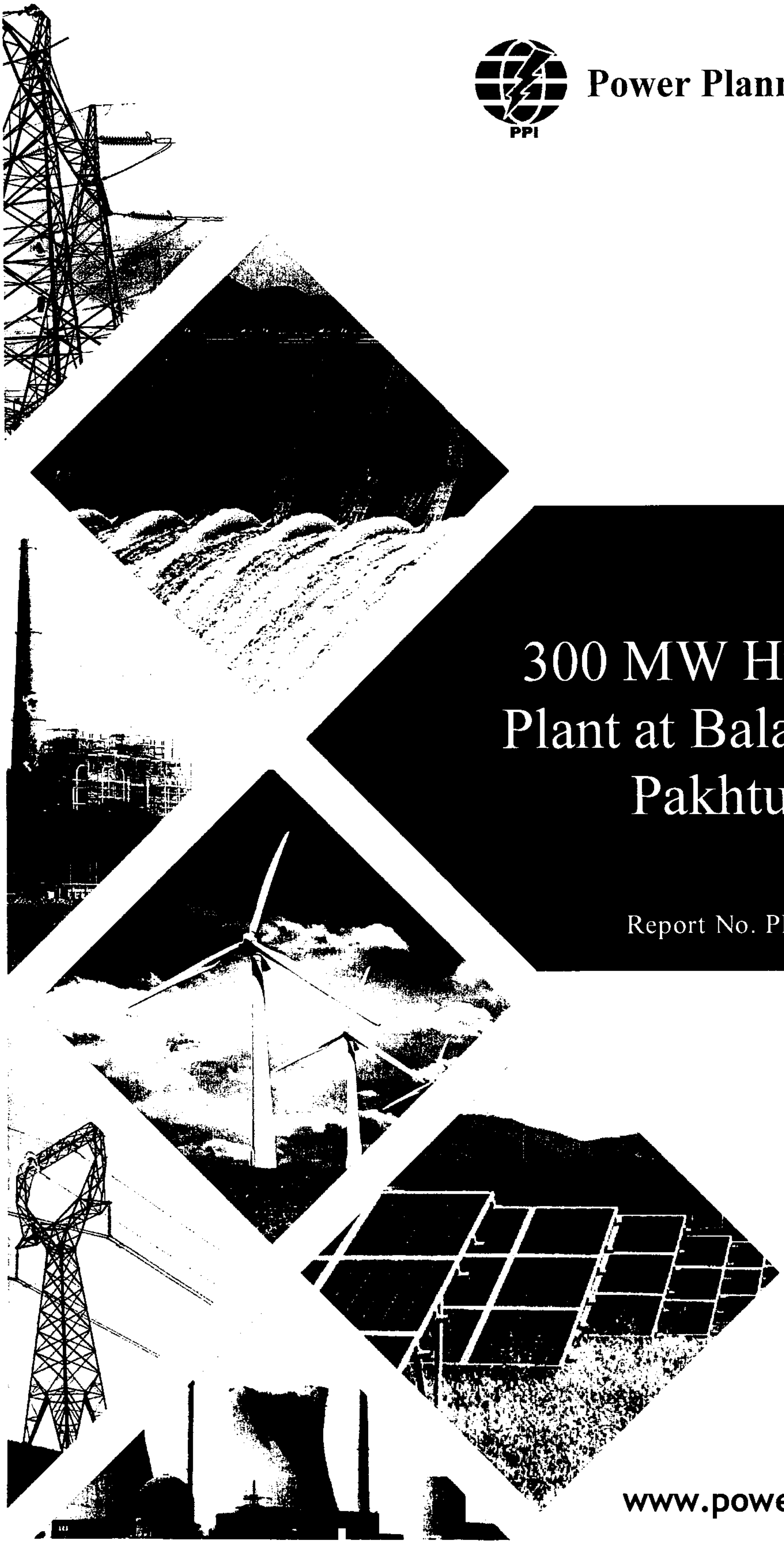

300 MW Hydro Power Plant at Balakot, Khyber Pakhtunkhwa

Report No. PPI-283.1 Draft/18

www.powerplannersint.com

Interconnection Study of 300 MW HydroPower Plant

at Balakot, Khyber Pakhtunkhwa

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Executive Summary

- The Draft Report of 300 MW Hydro Power Plant at Balakot, KPK referred to as Balakot HPP, is submitted herewith. The installed capacity of the plant would comprise of three generating units of 100 MW each, among which two will be at 500 kV and one unit will be at 132 kV. These three units would deliver a maximum net power of 300 MW to the grid.
- The study objective, approach and methodology have been described and the plant's data received from the Client is validated.
- As per the scheme proposed, the power plant will be connected at two different voltage levels supplying the power to NTDC at 500 kV level and to PESCO at 132 kV level. The following scheme of interconnection is proposed:
    - Due to the location and power capacity of Balakot HPP, the most feasible interconnection scheme would be looping in-out Balakot HPP 500/132kV grid station at the 500 kV single circuit between Sukhi Kinari and Maira Switching Station. The looping distance is about 2 km. The conductor used will be Bunting/High capacity conductor.
    - The interconnection at 132 kV level would be looping in-out at the 132 kV single circuit of Balakot to Manshera-N. The looping distance is about 10 km and the conductor used will be Rail.
    - An interconnecting transformer of 500/132 kV of 120 MVA is also proposed to ensure the reliability.
    - It is also proposed that the existing 132 kV Single circuit between Balakot and Mansehra to be re-conductored from Lynx to Rail.

  A few approximate sketches for the proposed scheme of interconnection are shown in Appendix-A.
- In view of planned COD of Balakot HPP in December 2027, the above proposed interconnection scheme has been assessed for steady state conditions through detailed load flow studies, short circuit analysis and stability criterion for September 2028 for maximum hydel power dispatches in the grid during summer.

- Steady state analysis by load flows, short circuit and stability criterion reveals that proposed scheme is adequate to export 300 MW output from the plant under normal and contingency conditions.
- Since the plant operates throughout the year, detailed analysis for Balakot HPP has also been carried out for off-peak load conditions of year 2028.
- In an extended term scenario, September 2030 has been studied to evaluate the performance of the proposed interconnection scheme. The system conditions of normal and N-1 contingency have been examined for all scenarios to meet the reliability criteria. Additionally, short circuit analysis has also been carried out for a complete check of the system.
- The short circuit levels of the Balakot HPP 500 kV are 16.30 kA and 12.51 kA for 3-phase and 1-phase faults, respectively, in the year 2030. Therefore, industry standard switchgear of a short circuit rating of 50 kA would be sufficient for installation at 500 kV switchyard of Balakot HPP. The short circuit levels of the Balakot HPP 132 kV are 15.82 kA and 12.00 kA for 3-phase and 1-phase faults, respectively, in the year 2030. Therefore, industry standard switchgear of a short circuit rating of 40 kA would be sufficient for installation at 132 kV switchyard of Balakot HPP. There are no violations of the power rating of the equipment in the vicinity of Balakot HPP in the event of fault conditions.
- The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability has been tested for the worst cases, i.e. three phase fault right on the 500 kV and 132 kV bus bar of Balakot HPP substations followed by trip of a single circuit from Balakot HPP for fault clearing of 5 cycles (100 ms), as understood to be the normal fault clearing time of 500 kV and 132 kV protection system. Also 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 system is stable for all the tested fault conditions.

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1. Introduction

1.1. Background

Balakot HPP, near Balakot, in KPK is embedded in the distribution network of NTDC and PESCO. The electricity generated from this project would be supplied to the grid station of NTDC through 500 kV Switching Station Maira available in the vicinity of this project, and through 132 kV grid Balakot and Manshera. A general idea of the grid stations in the vicinity of the plant can be viewed in Sketch-1 attached in Appendix - A.

Balakot HPP aims to install three 100 MW units with the aim of exporting 300 MW power to the grid throughout the year. The project is expected to start commercial operation by the end of 2027. The electricity generated from this project would be supplied to the grid system of NTDC and PESCO through 500kV and 132 kV grids available in the vicinity of this project. The location of Balakot HPP can be seen in Sketch-2 attached in Appendix - A.

1.2. Objectives

The overall objective of the Study is to evolve an interconnection scheme between Balakot HPP and national grid station, for stable and reliable evacuation of 300 MW 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 500 kV and 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 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 Balakot 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	0.8 Lagging; 0.90 Leading

Short Circuit:

500 kV Substation Equipment Rating of 50 kA and132 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

There will be two generating units at Balakot HPP 500 kV and one at Balakot HPP 132 kV. As per the data provided by the client following data has been modeled:

2.1. Balakot HPP Data

Installed capacity of power plant = 3 x 100 = 300 MW

Auxillary Load = 3 MW (Assumed 1%)=

Net Power Delivered 300 MW

Power factor = 0.85 lagging, 0.95 leading

Inertia Constant = 4 MW-sec/MVA

Generating Voltage = 18 kV

GSU Transformer 500/18 kV Rating = 130 MVA

Interconnecting Transformer 500/132 kV Rating = 120 MVA

2.2. Network Data

The 500 kV network in the area near Balakot HPP, as shown in Sketches in Appendix-A.

3. Study Approach and Methodology

3.1. Understanding the Problem

Balakot HPP would like to install Hydro power generation with the aim of exporting a maximum of 300 MW supply to the grid throughout the year. The site of proposed project is located at a distance of about 18 km from the 500 kV Sukhi Kinari G/S and 114 km from 500 kV Chakothi G/S. The 132 kV G/S of Balakot HPP is located at a distance of about 10 km from Balakot 132 kV G/S. The proposed Power Project is going to be embedded in the transmission network of NTDC and PESCO through these nearest available 500kV and 132 kV network.

The adequacy of these 500 kV and 132 kV networks in and around the proposed site of Balakot 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 month of September 2028 has been selected for the study because it represents the peak load conditions after the COD, December 2027, of Balakot 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 off peak scenario has also been completely analyzed for the system, considering maximum thermal dispatches and a reduced power demand in the system.
- Load flow and short circuit studies have also been performed for September 2030 to gauge the performance of the proposed plant in an extended term scenario.
- 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 scheme 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.
- The relevant equipment for the proposed technically feasible scheme has been determined.
- Finally, the most technically feasible interconnection scheme has been recommended.

4. Development of Interconnection Scheme

4.1. The Existing Network

Electrically, the nearest proposed substations to Balakot HPP would be Shuki Kinari HPP and Maira 500 kV Switching Station. The overall 500 kV network in that area without Balakot HPP is shown in Sketch-1 in Appendix-A, which comprises of a Direct 500 kV S/C from Sukhi Kinari to Maira 500 kV Substation. Other proposed Hydropower plants in the vicinity are:

- Suki Kinari
- Azad Pattan
- Chakothi
- Kohala
- Mahal
- Karot

The power from these hydropower projects will be delivered to Maira 500 kV Switching Stataion. This power is then sent towards load centers of Lahore and Islamabad.

The PESCO network in the vicinity is being fed from 220 kV Mansehra-New substation and Patrind HPP is also providing power to the local area network.

4.2. The Interconnection Scheme of Balakot HPP

As per the scheme proposed, the power plant will be connected at two different voltage levels supplying the power to NTDC at 500 kV level and to PESCO at 132 kV level. The following scheme of interconnection is proposed:

- The most feasible interconnection scheme would be looping in-out Balakot HPP 500/132kV grid station at the 500 kV single circuit between Sukhi Kinari and Maira Switching Station. The looping distance is about 2 km. The conductor used will be Bunting/High capacity conductor.
- The interconnection at 132 kV level would be looping in-out at the 132 kV single circuit of Balakot to Manshera-N. The looping distance is about 10 km and the conductor used will be Rail.
- An interconnecting transformer of 500/132 kV of 120 MVA is also proposed to ensure the reliability.

A few approximate sketches for the proposed scheme of interconnection are shown in Appendix-A.

5. Detailed Load Flow Studies

The base cases have been developed for the peak conditions of September 2028 using the network data of NTDC and PESCO available with PPI. The peak loads of the year 2025 for PESCO have been modeled as per the latest PMS Demand forecast as provided by NTDC. Detailed load flow studies have been carried out for Peak September 2028, Off-Peak September 2028 and future case September 2030.

5.1. Peak Load Case September 2028

The peak load case for September 2028 has been studied in detail both, without and with Balakot HPP.

5.1.1. Without Balakot Hydro Power Plant

The results of load flow for this base case are plotted in Exhibit 0.0 of Appendix-B. The system plotted in this Exhibit shows 500 kV and 132 kV network in the vicinity of Balakot HPP including the substations of Balakot, Sukhi Kinari and Maira S/S.

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 – B as follows:

Exhibit-0.1	Suki-Kinari to Chakothi 500 KV Single Circuit Out
Exhibit-0.2	Chakothi to Maira-S/S 500 KV Single Circuit Out
Exhibit-0.3	Maira-S/S to Azad Pattan 500 KV Single Circuit Out
Exhibit-0.4	Kohala to Azad Pattan 500 KV Single Circuit Out
Exhibit-0.5	Suki-Kinari to Kohala 500 KV Single Circuit Out

5.1.2. With Balakot Hydro Power Plant

The results of load flow with Balakot HPP interconnected as per proposed scheme are shown for each case. 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.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – B as follows:

Exhibit-1.1	Suki-Kinari to Balakot HPP 500 KV Single Circuit Out
Exhibit-1.2	Balakot HPP to Chakothi 500 KV Single Circuit Out
Exhibit-1.3	Chakothi to Maira-S/S 500 KV Single Circuit Out
Exhibit-1.4	Azad Pattan to Maira-S/S 500 KV Single Circuit Out
Exhibit-1.5	Kohala to Azad Pattan 500 KV Single Circuit Out
Exhibit-1.6	Suki-Kinari to Kohala 500 KV Single Circuit Out
Exhibit-1.7	Balakot HPP 500/132 KV Single Transformer Out
Exhibit-1.8	Balakot_132 to Balakot 132 KV Single Circuit Out
Exhibit-1.9	Balakot_132 to Mansehra-New 132 KV Single Circuit Out
Exhibit-1.10	Balakot to Muzafarabad 132 KV Single Circuit Out
Exhibit-1.11	Balakot to Mansehra-New 132 KV Single Circuit Out
Exhibit-1.12	Patrind to Balakot 132 KV Single Circuit Out

It must be noted that to provide the maximum power to PESCO network, it is proposed that the existing 132 kV single circuit transmission line must be re-conductored from Lynx to Rail. Beside this the interconnecting transformer 500/132 kV at Balakot Hydropower Project has the nominal rating of 120 MVA. It has been seen that in some contingencies the power flow at the interconnecting transformer exceeds its rated value. Therefore, it is proposed that an overcurrent protection must be installed at the interconnecting transformer such that, when the power flow increases its 110 % (i.e. 132 MVA) over load capacity, the transformer must trip.

Exhibit – 1.6 indicated that the flow at interconnecting transformer is about 130 MW, however considering the 10 % overload margin it seems acceptable. Therefore, we find that power flows on the circuits are 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 500 kV and 132 kV circuits under normal and contingency conditions.

5.2. Off-Peak Load Case September 2028

The scenario of Balakot HPP with maximum thermal dispatches and only 80% loads has been studied. The results of load flows with Balakot HPP under normal conditions have been plotted in Exhibit 2.0 in Appendix-B.

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 500 kV and 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – B as follows:

Exhibit-2.1	Suki-Kinari to Balakot HPP 500 KV Single Circuit Out
Exhibit-2.2	Balakot HPP to Chakothi 500 KV Single Circuit Out
Exhibit-2.3	Chakothi to Maira-S/S 500 KV Single Circuit Out
Exhibit-2.4	Azad Pattan to Maira-S/S 500 KV Single Circuit Out
Exhibit-2.5	Kohala to Azad Pattan 500 KV Single Circuit Out
Exhibit-2.6	Suki-Kinari to Kohala 500 KV Single Circuit Out
Exhibit-2.7	Balakot HPP 500/132 KV Single Transformer Out
Exhibit-2.8	Balakot_132 to Balakot 132 KV Single Circuit Out
Exhibit-2.9	Balakot_132 to Mansehra-New 132 KV Single Circuit Out
Exhibit-2.10	Balakot to Muzafarabad 132 KV Single Circuit Out
Exhibit-2.11	Balakot to Mansehra-New 132 KV Single Circuit Out
Exhibit-2.12	Patrind to Balakot 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 500 kV and 132 kV circuits under normal and contingency conditions.

5.3. Peak Load Case 2030: Extended Term Scenario

We have also studied the future scenario of September 2030 to assess the impact of the plant in the extended term of its installation as per NTDC requirement.

Exhibit 3.0 shows the normal case of 2030 of the region with Balakot HPP. 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.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – B as follows:

Exhibit-3.1	Suki-Kinari to Balakot HPP 500 KV Single Circuit Out

Exhibit-3.2	Balakot HPP to Mahal 500 KV Single Circuit Out
Exhibit-3.3	Mahal to Maira-S/S 500 KV Single Circuit Out
Exhibit-3.3a	Mahal to Maira-S/S 500 KV Single Circuit Out
Exhibit-3.4	Azad Pattan to Maira-S/S 500 KV Single Circuit Out
Exhibit-3.5	Kohala to Azad Pattan 500 KV Single Circuit Out
Exhibit-3.6	Suki-Kinari to Kohala 500 KV Single Circuit Out
Exhibit-3.7	Balakot HPP 500/132 KV Single Transformer Out
Exhibit-3.8	Balakot_132 to Balakot 132 KV Single Circuit Out
Exhibit-3.9	Mansehra-New to Balakot_132 132 KV Single Circuit Out
Exhibit-3.10	Muzafarabad to Balakot 132 KV Single Circuit Out
Exhibit-3.11	Mansehra to Balakot 132 KV Single Circuit Out
Exhibit-3.12	Patrind to Balakot 132 KV Single Circuit Out

In the contingency case of Exhibit – 3.3 i.e. Mahal to Maira 500 kV circuit the power of hydro power plants start to flow towards 132 kV grid stations via 500/132 kV Balakot HPP proposed transformer and causes overloading. Even though the proposed transformer accommodates 110% overload capacity, the power flow in this case is about 163 MW therefore, the interconnecting transformer is also tripped in this scenario. This scenario has been plotted in Exhibit 3.3a.

After the cross tripping of this case 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 500 kV and 132 kV circuits under normal and contingency conditions.

We find that there are no capacity constraints in the proposed connectivity scheme even in the up-coming years i.e. 2030.

5.4. Conclusion of Load Flow Analysis

From the analysis discussed above, we conclude that the proposed interconnection scheme with all the proposed reinforcements and the protection schemes is adequate to evacuate the maximum 300 MW spillover power of Balakot HPP under normal and contingency conditions after fulfilling the above mentioned cross tripping requirement. It serves as an efficient energy source towards sustaining the voltage profile of the surrounding area.

6. Short Circuit Analysis

6.1. 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 year 2030 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.

6.2. Fault Current Calculations with Balakot HPP Year 2030

Fault currents have been calculated for the electrical interconnection of proposed scheme. Fault types applied are three phase and single-phase at the 500 kV and 132 kV bus bar of Balakot HPP itself and other bus bars of the 500 kV and 132 kV substations in the electrical vicinity of Balakot HPP. The graphic results are shown in Exhibit 4.0.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 500 kV and 132 kV bus bars of the network in the electrical vicinity of Balakot HPP and the bus bars of Balakot HPP itself are placed in Appendix-C. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.1.

Table-6.1
Maximum Short Circuit Levels with Balakot HPP

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Balakot HPP 500kV	16.30	12.51
Balakot_132 132 kV	15.82	12.00
Balakot 132 kV	16.88	12.49
Suki Kinari 500 kV	16.61	15.37
Kohala 500 kV	29.81	27.44
Neelam Jehlum 500kV	27.38	25.19
Azad Pattan 500kV	27.54	20.58
Mahal 500kV	20.15	14.77
Chakothi Hattian 500kV	15.15	12.26
Maira-S/S 500kV	39.04	30.83
ISBD-N 500kV	41.46	29.87
Karot 500kV	35.01	28.47
Gujranwala 500kV	42.80	26.71

6.3. Conclusion of Short Circuit Analysis

The short circuit analysis results show that for the proposed scheme of interconnection of Balakot HPP with Chakothi and Sukhi Kinari 500 kV substations, we don't find any violations of short circuit ratings of the already installed equipment on the 500 kV bus bars in the vicinity of the plant due to fault current contributions from Balakot HPP. Therefore industry standard switchgear of the short circuit rating of 50 kA for 500 kV G/S and 40 kA for 132 kV G/S 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 & Methodology

7.1.1. Dynamic Models

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
Stabilizer	STAB2A
Inertia Constant	H = 4.0 kWs/kVA

Power System Stabilizer has also been proposed to be installed for the smooth and stable operation of the power plant.

7.1.2. System Conditions

The month of September 2028 has been selected for the study because it represents the peak load season after the COD of Balakot Hydro Power Project and thus the loading on the lines in the vicinity of Balakot HPP will be maximum, allowing us to judge the full impact of the plant.

The proposed Balakot 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-D. 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 nine 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

Three phase faults are considered as the worst disturbance in the system. We have considered 3-phase fault in the closest vicinity of Balakot HPP i.e. right at the 500 kV and 132 kV bus bars of Balakot HPP substation, cleared in 5 cycles, as normal clearing time i.e. 100 ms, followed by a permanent trip of a 500 kV and 132 kV single circuits emanating from Balakot HPP. 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 - September 2028

7.2.1. Fault at 500 kV Balakot HPP

We applied three-phase fault on Balakot HPP 500 kV bus bar, cleared fault in 5 cycles (100 ms) followed by trip of a 500 kV single circuit from Balakot HPP to Chakothi. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows:

Fig. 1.1 Bus Voltages

The bus voltages of 500 kV bus bars of Balakot HPP, Chakothi and Sukhi Kinari; 132 kV bus bars of Balakot HPP and Balakot; 18 kV bus bar of Balakot HPP are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 1.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 1.3 MW/MVAR Output of Generators of Balakot HPP

The MW/MVAR output of Balakot HPP gets back to the pre-fault output quickly after fast damping of the oscillations in its output.

Fig. 1.4 Speed and Mechanical power of Generators at Balakot HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 1.5 Power Flow on Balakot HPP to Sukhi Kinari 500 kV Single Circuit

Followed by clearing of fault, the tripping of a 500 kV single circuit from Balakot HPP to Chakothi causes this entire power to flow on the intact second 500 kV circuit from Balakot HPP to Sukhi Kinari. This causes significant loading on this line. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 1.6 **Rotor Angles**

The rotor angles of the generators of Balakot HPP, Chakothi, Sukhi Kinari, Azad Pattan, Kohala are plotted relative to machines at Guddu-new 500 kV. The results show that the rotor angle of Balakot HPP gets back after the first swing and damps down quickly. Similarly, the rotor angles of other machines swing very little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.2. Fault at 500 kV Balakot HPP (Stuck Breaker)

We applied single-phase fault on Balakot HPP 500 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of a 500 kV single circuit from Balakot HPP to Chakothi. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows:

Fig. 2.1 **Bus Voltages**

The bus voltages of 500 kV bus bars of Balakot HPP, Chakothi and Sukhi Kinari; 132 kV bus bars of Balakot HPP and Balakot; 18 kV bus bar of Balakot HPP are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 2.2 **Frequency**

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 2.3 **MW/MVAR Output of Generators of Balakot HPP**

The MW/MVAR output of Balakot HPP gets back to the pre-fault output quickly after fast damping of the oscillations in its output.

Fig. 2.4 **Speed and Mechanical power of Generators at Balakot HPP**

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 2.5 **Power Flow on Balakot HPP to Sukhi Kinari 500 kV Single Circuit**

Followed by clearing of fault, the tripping of a 500 kV single circuit from Balakot HPP to Chakothi causes this entire power to flow on the intact second 500 kV circuit. This causes significant loading on this line i.e. from Balakot HPP to Sukhi Kinari. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 2.6 **Rotor Angles**

The rotor angles of the generators of Balakot HPP, Chakothi, Sukhi Kinari, Azad Pattan, Kohala are plotted relative to machines at Guddu-new 500 kV. The results show that the rotor angle of Balakot HPP gets back after the first swing and damps down quickly. Similarly, the rotor angles of other machines swing very little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.3. Fault at Balakot HPP 500 kV

We applied three-phase fault on Balakot HPP 500 kV bus bar, cleared fault in 5 cycles (100 ms) followed by trip of a 500 kV single circuit from Balakot HPP to Sukhi Kinari. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows:

Fig. 3.1 **Bus Voltages**

The bus voltages of 500 kV bus bars of Balakot HPP, Chakothi and Sukhi Kinari; 132 kV bus bars of Balakot HPP and Balakot; 18 kV bus bar of Balakot HPP are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 3.2 **Frequency**

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 3.3 **MW/MVAR Output of Generators of Balakot HPP**

The MW/MVAR output of Balakot HPP gets back to the pre-fault output quickly after fast damping of the oscillations in its output.

Fig. 3.4 **Speed and Mechanical power of Generators at Balakot HPP**

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 3.5 **Power Flow on Balakot HPP to Chakothi 500 kV Single Circuit**

Followed by clearing of fault, the tripping of a 500 kV single circuit from Balakot HPP to Sukhi Kinari causes this entire power to flow on the intact second 500 kV circuit. This causes significant loading on this line. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 3.6 Rotor Angles

The rotor angles of the generators of Balakot HPP, Chakothi, Sukhi Kinari, Azad Pattan, Kohala are plotted relative to machines at Guddu-new 500 kV. The results show that the rotor angle of Balakot HPP gets back after the first swing and damps down quickly. Similarly, the rotor angles of other machines swing very little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.4. Fault at Balakot HPP 500 kV

We applied single-phase fault on Balakot HPP 500 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of a 500 kV single circuit from Balakot HPP to Sukhi Kinari. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows:

Fig. 4.1 Bus Voltages

The bus voltages of 500 kV bus bars of Balakot HPP, Chakothi and Sukhi Kinari; 132 kV bus bars of Balakot HPP and Balakot; 18 kV bus bar of Balakot HPP are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 4.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 4.3 MW/MVAR Output of Generators of Balakot HPP

The MW/MVAR output of Balakot HPP gets back to the pre-fault output quickly after fast damping of the oscillations in its output.

Fig. 4.4 Speed and Mechanical power of Generators at Balakot HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 4.5 Power Flow on Balakot HPP to Chakothi 500 kV Single Circuit

Followed by clearing of fault, the tripping of a 500 kV single circuit from Balakot HPP to Sukhi Kinari causes this entire power to flow on the intact second 500 kV circuit. This causes significant loading on this line. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 4.6 Rotor Angles

The rotor angles of the generators of Balakot HPP, Chakothi, Sukhi Kinari, Azad Pattan, Kohala are plotted relative to machines at Guddu-new 500 kV. The results show that the rotor angle of Balakot HPP gets back after the first swing and damps down quickly. Similarly, the rotor angles of other machines swing very little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.5. Fault at Balakot 132 kV

We applied three-phase fault on Balakot HPP 132 kV bus bar, cleared fault in 5 cycles (100 ms) followed by trip of a 132 kV single circuit from Balakot HPP to Balakot. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows:

Fig. 5.1 Bus Voltages

The bus voltages of 500 kV bus bars of Balakot HPP, Chakothi and Sukhi Kinari; 132 kV bus bars of Balakot HPP and Balakot; 18 kV bus bar of Balakot HPP are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 5.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 5.3 MW/MVAR Output of Generators of Balakot HPP

The MW/MVAR output of Balakot HPP gets back to the pre-fault output quickly after fast damping of the oscillations in its output.

Fig. 5.4 Speed and Mechanical power of Generators at Balakot HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 5.5 Power Flow on Balakot HPP to Manshera-N 132 kV Single Circuit

Followed by clearing of fault, the tripping of a 132 kV single circuit from Balakot HPP to Balakot causes this entire power to flow on the intact second 132 kV circuit. This causes significant loading on this line. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 5.6 **Rotor Angles**

The rotor angles of the generators of Balakot HPP, Chakothi, Sukhi Kinari, Azad Pattan, Kohala are plotted relative to machines at Guddu-new 500 kV. The results show that the rotor angle of Balakot HPP gets back after the first swing and damps down quickly. Similarly, the rotor angles of other machines swing very little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.6. Fault at Balakot 132 kV (Stuck Breaker)

We applied single-phase fault on Balakot HPP 132 kV bus bar, cleared fault in 9 cycles (100 ms) followed by trip of a 132 kV single circuit from Balakot HPP to Balakot. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows:

Fig. 6.1 **Bus Voltages**

The bus voltages of 500 kV bus bars of Balakot HPP, Chakothi and Sukhi Kinari; 132 kV bus bars of Balakot HPP and Balakot; 18 kV bus bar of Balakot HPP are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 6.2 **Frequency**

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 6.3 **MW/MVAR Output of Generators of Balakot HPP**

The MW/MVAR output of Balakot HPP gets back to the pre-fault output quickly after fast damping of the oscillations in its output.

Fig. 6.4 **Speed and Mechanical power of Generators at Balakot HPP**

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 6.5 **Power Flow on Balakot HPP to Mansehra-N 132 kV Single Circuit**

Followed by clearing of fault, the tripping of a 132 kV single circuit from Balakot HPP to Balakot causes this entire power to flow on the intact second 132 kV circuit. This causes significant loading on this line. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 6.6 **Rotor Angles**

The rotor angles of the generators of Balakot HPP, Chakothi, Sukhi Kinari, Azad Pattan, Kohala are plotted relative to machines at Guddu-new 500 kV. The results show that the rotor angle of Balakot HPP gets back after the first swing and damps down quickly. Similarly, the rotor angles of other machines swing very little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.3. Conclusion of Dynamic Stability Analysis

The results of dynamic stability carried out for September 2028 shows that the system is very strong and stable for the proposed scheme for the severest possible faults of 500 kV and 132 kV systems near to Balakot HPP under all events of disturbances. Therefore there is no problem of dynamic stability for interconnection of Balakot HPP; it fulfills all the criteria of dynamic stability. The presence of stabilizer (STAB2A) also helps damp oscillations after fault conditions and ensures a stable system.

8. Conclusions

- As per the scheme proposed, the power plant will be connected at two different voltage levels supplying the power to NTDC at 500 kV level and to PESCO at 132 kV level. The following scheme of interconnection is proposed:
    - Due to the location and power capacity of Balakot HPP, the most feasible interconnection scheme would be looping in-out Balakot HPP 500/132kV grid station at the 500 kV single circuit between Sukhi Kinari and Maira Switching Station. The looping distance is about 2 km. The conductor used will be Bunting/High capacity conductor.
    - The interconnection at 132 kV level would be looping in-out at the 132 kV single circuit of Balakot to Manshera-N. The looping distance is about 10 km and the conductor used will be Rail.
    - An interconnecting transformer of 500/132 kV of 120 MVA is also proposed to ensure the reliability.
    - It is also proposed that the existing 132 kV Single circuit between Balakot and Mansehra to be re-conductored from Lynx to Rail.

  A few approximate sketches for the proposed scheme of interconnection are shown in Appendix-A.

- In view of planned COD of Balakot HPP in December 2027, the above proposed interconnection scheme has been assessed for steady state conditions through detailed load flow studies, short circuit analysis and stability criterion for September 2028 for maximum hydel power dispatches in the grid during summer.

- Steady state analysis by load flows, short circuit and stability criterion reveals that proposed scheme is adequate to export 300 MW output from the plant under normal and contingency conditions.

- Since the plant operates throughout the year, detailed analysis for Balakot HPP has also been carried out for off-peak load conditions of year 2028.

- In an extended term scenario, September 2030 has been studied to evaluate the performance of the proposed interconnection scheme. The system conditions of normal and N-1 contingency have been examined for all scenarios to meet the reliability criteria. Additionally, short circuit analysis has also been carried out for a complete check of the system.

- The short circuit levels of the Balakot HPP 500 kV are 16.30 kA and 12.51 kA for 3-phase and 1-phase faults, respectively, in the year 2030. Therefore, industry standard switchgear of a short circuit rating of 50 kA would be sufficient for installation at 500 kV switchyard of Balakot HPP. The short circuit levels of the Balakot HPP 132 kV are 15.82 kA and 12.00 kA for 3-phase and 1-phase faults, respectively, in the year 2030. Therefore, industry standard switchgear of a short circuit rating of 40 kA would be sufficient for installation at 132 kV switchyard of Balakot HPP. There are no violations of the power rating of the equipment in the vicinity of Balakot HPP in the event of fault conditions.
- The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability has been tested for the worst cases, i.e. three phase fault right on the 500 kV and 132 kV bus bar of Balakot HPP substations followed by trip of a single circuit from Balakot HPP for fault clearing of 5 cycles (100 ms), as understood to be the normal fault clearing time of 500 kV and 132 kV protection system. Also 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 system is stable for all the tested fault conditions.