GOVERNMENT OF KHYBER PAKHTUNKHWA
PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION
(PEDO)

GENERATION LICENSE APPLICATION

FOR

157 MW MADYAN HYDROPOWER PROJECT
DISTRICT SWAT

October 2020

Copy

307-PEDO House, 38/B-2 Phase-V Hayatabad, Peshawar, Pakistan.
Tel: +92-91-9217329, Fax: +92-91-9217340

P E D O

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

Government of Khyber Pakhtunkhwa

PEDO House, Plot No. 38, Sector B/2, Phase 5, Hayatabad, Peshawar

No. 06 / PEDO / CE-WB / 01
Dated, Peshawar the: 13/10/2020

To

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

Subject: **Application for Grant of Generation Licence**

Dear Sir,

1. I, Mustafa Kammal Khan, Project Director Madyan Hydropower Project (157MW), being the duly authorised representative of PEDO by virtue of Authority Letter dated October 06, 2020 hereby apply to the National Electric Power Regulatory Authority (NEPRA) for the grant of a Generation Licence to PEDO for 157 MW Madyan Hydropower Project, pursuant to the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

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

3. A crossed cheque no. 38815097 dated 13/10/2020 in the name of NEPRA, sum of Rupees Nine Hundred Thirty Four Thousand Seven Hundred and Twenty Only, being the non-refundable licence application fee, calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, is also attached herewith.

Mustafa Kammal Khan
Project Director
Madyan HPP

CC:
1. Chief Executive Officer CPPA – G, Islamabad.
2. PS to Secretary Energy & Power Department, Govt. of Khyber Pakhtunkhwa, Peshawar.
3. PS to CEO, PEDO, Peshawar.

Project Director
Madyan HPP

Payee's Account Only

Cheque No 38815097

THE BANK OF KHYBER
PHASE V HAYATABAD ~~BRANCH~~ (0083)SECTOR B1 PH-V
HAYATABAD PESHAWAR

A/C 01495009

Date 13 10 2020

Pay NEPRA or bearer

Rupees Nine Hundred Thirty Four Thousand Seven Hundred & Twenty only —

PKR 934,720/=

PK64 KHYB 0083 0000 0149 5009

PROJECT DIRECTOR PURCHASE OF LAND & PM

Accountant
PMO World Bank Projects
PEDO Peshawar

Drawing & Disbursing Officer (DDO)
PMO World Bank Projects
PEDO Peshawar

Please do not write below this line.

⑈38815097⑈06100831:0083000001495009⑈000⑈

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

Name of Company: Pakhtunkhwa Energy Development Organization (PEDO)
Capacity: 157MW
Prepared/Updated on: 09-10-2020

Regulation	Information/Documents Required	Compliance		Remarks
		Yes	No.	
3(1)	Authorization from Board Resolution / Power of Attorney	Yes		Attached
3(3)	Application fee (including Indexation)	Yes		Crossed Cheque attached
3(4)	Three copies of Application	Yes		Provided
3(5)(a)(i)	Certificate of incorporation		No	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(5)(a)(ii)	Memorandum and articles of association	Yes		PEDO is a public sector organization constituted under SHYDO Act 1993.
3(5)(a)(iii)	Annual Return statements or in lieu thereof	Yes		Attached
3(5)(b)	Profile of experience of the applicant its management, staff and its members in power sector.	Yes		Attached
3(5)(c)	CVs of applicant's Senior Management and Technical professionals	Yes		CVs provided
3(5)(d)(i)	Cash balance & bank certificates		No	PEDO is a public sector organization constituted under SHYDO Act 1993 and therefore, it is not required
3(5)(d)(ii)	Expression of interest to provide credit or financing along with sources and details thereof	Yes		The scheme will be financed in the ratio of 80:20 by World Bank (IDA / IBRD) and ADP/HDF respectively.
3(5)(d)(iii)	Latest financial statements	Yes		Attached
3(5)(d)(iv)	Employment records of Engineers & Technical Staff	Yes		CVs provided
3(5)(d)(v)	Profile of Sub-contractors		No	Works contract has not yet been awarded
3(5)(d)(vi)	Verified references w.r.t. experience of the Applicant and its sub-Contractors		No	Works contract has not been awarded yet.
3(5)(e)	Encumbrances on assets			N/A
3(5)(f)	Technical and financial proposal for Operation, maintenance, planning and development of the generation facility.			Project feasibility has been completed (report attached),Works contract will be awarded in 2020-21 while Plant O&M will be done by PEDO through its own staff.
3(5)(g)(a)	Type of Technology	hydro power		Feasibility report provided

3(5)(h)	Feasibility Report	Yes		Provided
3(5)(i)	Prospectus	Yes		Provided

Cont'd....P/2.

Schedule III				
1.	Location (location maps, site maps) land	District Swat		Provided
2.	Plant: run of river, storage, weir	Run of the River		Provided
3.	Head: Minimum, maximum			Gross Head-154.4m Net Head-138.2m
4.	Technology: Francis, Pelton, etc. Size, number of units.	Francis turbine		Three units (52.43 MW)
5.	Tunnel (if proposed): length, diameter			Length: 11.8km Diameter 7m
6.	ESSA (Environmental and Social Soundness Assessment)	Yes		Provided
7.	Detailed feasibility report	Yes		Provided
8.	Resettlement issues			The potential resettlement issues will be taken care of in the project LARP
9.	Consents	Yes		Consent from NTDC has been sought vide letter attached to the application
10.	Infrastructure development	Yes		Included in the project feasibility report.
11.	Interconnection with National Grid Co. distance and name of nearest grid, voltage level (single line diagram)	Yes		The interconnection scheme for the power dispersal from Madyan Hydropower Plant would be through 220 Kv transmission Line as Loop-in, Loop-out arrangement to the 220 kV transmission line of Gorkin Matiltan HPP in Swat Area.
12.	Project cost, information regarding sources and amounts of equity and debt.	Yes		Project development cost is USD: 498.64 million.
13.	Project schedule, expected life			Project implementation period period:84 months (including DLP), Project life 30 years, which can be extended to 50 years.
14.	Peaking/base load operation			No peaking

15.	Plant characteristics: generation voltage, power factor, frequency, automatic generation control, ramping rate, control metering and instrumentation			Generating Voltage -11 KV Frequency --50 Hz Power Factor - 0.85 Automatic Generation Control --No Ramping Rate -10 minutes Alternative Fuel -No Auxiliary Consumption 1.57 MW (1% of installed capacity) Time required to Synchronise -5 minutes
16.	System studies load flow, short circuit, stability	Yes		Subsequent to the NTDC consent, load flow study will be conducted under the arrangement stated above
17.	Training and development	Yes		Project development include trainings and capacity building programs.

MINUTES OF THE MEETING

SUBJECT: - MINUTES OF THE 50TH MEETING OF THE PEDO BOARD OF DIRECTORS HELD ON SEPTEMBER 3, 2020.

The 50th meeting of PEDO Board of Directors was held on September 03, 2020 under the Chairmanship of Mr. Nisar Muhammad Khan, Chairman PEDO Board of Directors. List of participants is at **Annex-I**.

2. The meeting started with the recitation of few verses from the Holy Quran. The Chairman welcomed the newly appointed member PEDO Board Mr. Haque Nawaz and expressed the hope that he will make useful contribution to the overall development of the Organization in view of his professional experience. CEO PEDO then presented the following agenda items for discussion in the meeting:

Agenda Item#	Subject
50-01	APPROVAL / CONFIRMATION OF MINUTES OF 49TH MEETING OF THE PEDO BOARD OF DIRECTORS
50-02	DISCUSSION ON THE AGE LIMIT OF PDs FOR PEDO PROJECTS
50-03	APPROVAL OF RECOMMENDATIONS FOR APPOINTMENT OF PROJECT DIRECTORS FOR VARIOUS PEDO PROJECTS
50-04	APPROVAL TO AUTHORIZE CEO PEDO TO SIGN AND SUBMIT THE TARIFF PETITIONS TO NEPRA FOR GABRAL-KALAM AND MADYAN HPPs
50-05	APPROVAL OF TECHNICAL EVALUATION REPORT FOR HIRING OF CONTRACTOR FOR THE PROJECT "ACCESS TO CLEAN ENERGY PROGRAM FOR CONSTRUCTION OF 672 MINI MICRO HYDRO POWER PROJECTS ON RIVER/TRIBUTRAIES AND CANAL" FINANCED BY ADB.
50-06	DISCUSSION ON THE LATEST IMPLEMENTATION STATUS OF MHPs PROJECT (COMPLETED, OPERATIVE, COST INVOLVED AND ISSUES, IF ANY).
50-07	APPROVAL FOR AMENDMENT NO.5 IN THE CONSULTANCY SERVICES AGREEMENT FOR 356 MHPs
50-08	APPROVAL FOR EXTENSION IN CONTRACT AGREEMENT OF CONTRACTOR FOR THE MINI MICRO HYDEL ON CANALS.

50-09	DISCUSSION ON THE INSPECTION REPORT OF PEDO INSPECTION TEAM REGARDING RANOLIA HPP
50-010	DISCUSSION ON THE IMPLEMENTATION STATUS OF THE DECISIONS TAKEN DURING 44TH & 45TH BOD MEETINGS REGARDING SOLARISATION PROJECTS OF MOSQUES AND SCHOOLS

AGENDA ITEM NO. 50-001

APPROVAL / CONFIRMATION OF MINUTES OF 49TH MEETING OF THE PEDO BOARD OF DIRECTORS

3. CEO PEDO informed the forum that the draft minutes of the 49th Board meeting were circulated amongst the Board members for their inputs. The inputs received from Mr. Abdul Siddique have been duly incorporated in the draft minutes. The draft minutes were presented to the forum for confirmation/approval.

DECISION:

4. The Board of Directors resolved to confirm and approve the minutes of the 49th PEDO Board meeting.

AGENDA ITEM NO. 50-002:

DISCUSSION ON THE AGE LIMIT OF PDs FOR PEDO PROJECTS

5. CEO PEDO informed the forum that during the 12th PEDO Board meeting held on 25th March, 2016 the age limit for Project Directors was approved as 65 years which was reduced to 63 years later on during the 37th Board meeting while finalizing advertisement for five (05) posts of PDs. However, in view of World Bank reservations regarding the upper age limit, the PEDO Board decided to re-advertise the positions of PDs by keeping the maximum age limit of 55 years. CEO PEDO informed the forum that in response a very limited number of applicants could be shortlisted for interview due to their less specific relevant experience of hydel projects which is possessed only by employees of WAPDA at Federal level and Irrigation Department at Provincial level. As a result the management could have a very thin pool of candidates available for final selection as compared to skilled professionals which could have been available in case the age limit was 63 years. CEO PEDO further highlighted that clause 9.6 (ii) of Chapter 9 of the Manual for Development Projects 2019 of Planning Commission and Guidelines for appointment

AGENDA ITEM NO. 50-004:

APPROVAL TO AUTHORIZE CEO PEDO TO SIGN AND SUBMIT THE TARIFF PETITIONS TO NEPRA FOR GABRAL-KALAM AND MADYAN HPPs.

24. CEO PEDO informed the forum that as part of the KP Hydropower & Renewable Development Program financed by Work Bank, PEDO has been undertaking construction of 88 MW Gabral Kalam and 157 MW Madyan HPPs. He stated that Consultants for the projects are in the hiring stage. After approval of the PC-I for the projects by PDWP, the same was submitted to CDWP for approval. During the Pre-CDWP meeting, the PC-I was returned with the direction that the sponsors will apply for feasibility stage tariff as per ECNEC decision for all subprojects of hydro power projects. In pursuance to the Pre-CDWP decision, an individual Consultant was hired as per the Word Bank guidelines for obtaining the feasibility stage tariffs for both the HPPs. The case was submitted to NEPRA by the authorized officer of PEDO. In response, NEPRA has directed to re-submit the case along with resolution of PEDO BoD for signatory of the subject tariff petitions.

25. CEO PEDO solicited approval of the Board to authorize him or his nominee for submission of the tariff petitions to NEPRA and to grant of Generation Licence for Gabral Kalam and Madyan HPPs.

26. Responding to the query raised by Engr. Arbab Khudadad Khan regarding selection of sites, CEO PEDO informed that detailed feasibility has been done afresh and there is no change in the sites conditions. Moreover the process of land acquisition will be initiated shortly. The forum was also informed that the feasibility stage tariffs for Gabral-Kalam and Madyan HPPs are 7.726 cents per KWH and 7.639 cent per KWH respectively.

DECISION:

27. After due deliberation, the forum unanimously resolved to authorize CEO PEDO or his nominee for submission of the tariff petitions to NEPRA and grant of Generation Licence for Gabral Kalam and Madyan HPPs. It was however decided that the Board may be kept informed about further development in this regard.

3.	Sahil Builders (Contractor) and ABKT (NGO)	**Package-I** LOT- 4 (Kohistan)	**Non-Responsive**	–
		Package-I LOT- 5(Batagram)	**Non-Responsive**	–

30. Approval of the forum was solicited to the technical evaluation recommended by the MC and to allow PD MMHPPs opening of financial bids of the qualified bidders as per details contained in the table above.

31. While discussing the matter, the forum expressed its concern about delay in the bidding process and hiring of Management Consultant. PD MMHPPs responded that time was consumed in hiring of Management consultant, evaluation process of bids and addressing grievances of some of the firms. Secretary Energy & Power observed that the process of evaluation at the Committee level was completed in May, 2020 while it is being brought to the Board after three months. He stated that the issue should have been submitted to the Board earlier. CEO PEDO responded that it could not be placed before the Board earlier due to Covid-19 pandemic and other long list of important agenda items awaiting approval of the Board. Regarding delay in processing the case, CEO PEDO clarified that there will be no financial loss to the government and with no escalation charges as no such clause exist in the documents.

32. Mr. Abdul Siddique pointed out that as per the contract agreement; the consultant has to review the feasibility and preparation of the tendering documents. On the contrary, the pre-qualification was done before arrival of the consultants. He highlighted that two year has already been lapsed out the total contract period of 48 months. He further stated that the Consultant agreement is not clear whether payment shall be made on man-months basis or work done. CEO PEDO explained that for hydropower projects including MMHPPs, man-months system is being followed.

33. Project Director MMHPPs said that preparation of feasibility and design comes under the responsibilities of the contractors. He also clarified that pre-qualification was done by the PEDO PMU itself as it was feared that arrival of the consultants would take time.

34. The Board members also highlighted the following points:

i. Reasons of halting the pre-qualification process initiated in October, 2017;

Annex-I

1.	Mr. Nisar Muhammad Khan	In Chair
2.	Muhammad Zubair Secretary to Govt. of Khyber Pakhtunkhwa Energy & Power Department.	Member
3.	Engr. Muhammad Naeem Khan	CEO/ Secretary to PEDO Board
4.	Mr. Abdul Siddique	Member
5.	Engr. Arbab Khudadad Khan	Member
6.	Dr. Hassan Nasir	Member
7.	Engr. Bakht Zaman	Member
8.	Syed Mussawer Shah	Member
9.	Mr. Haque Nawaz	Member
10.	Engr. Maqsood Anwar Pervaiz, President Khyber Pakhtunkhwa Chamber of Commerce Industries, Peshawar	Member
11.	Mr. Nasrullah Additional Secretary Home & Tribal Affairs Department (Representative of Secretary Home)	Member
12.	Mr. Taj Muhammad Director Private Power	To assist CEO PEDO
13.	Dr. Shahid Ali Karim Dir (Finance & Admin), PEDO	For presenting relevant agenda
14.	Engr. Muhammad Luqman PD 356 Mini/Micro HPPs	For presenting relevant agenda

PEDO

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

Government of Khyber Pakhtunkhwa

No. 04 / PEDO / CE-WB / 01
Dated, Peshawar the: 6/10/2020

To

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

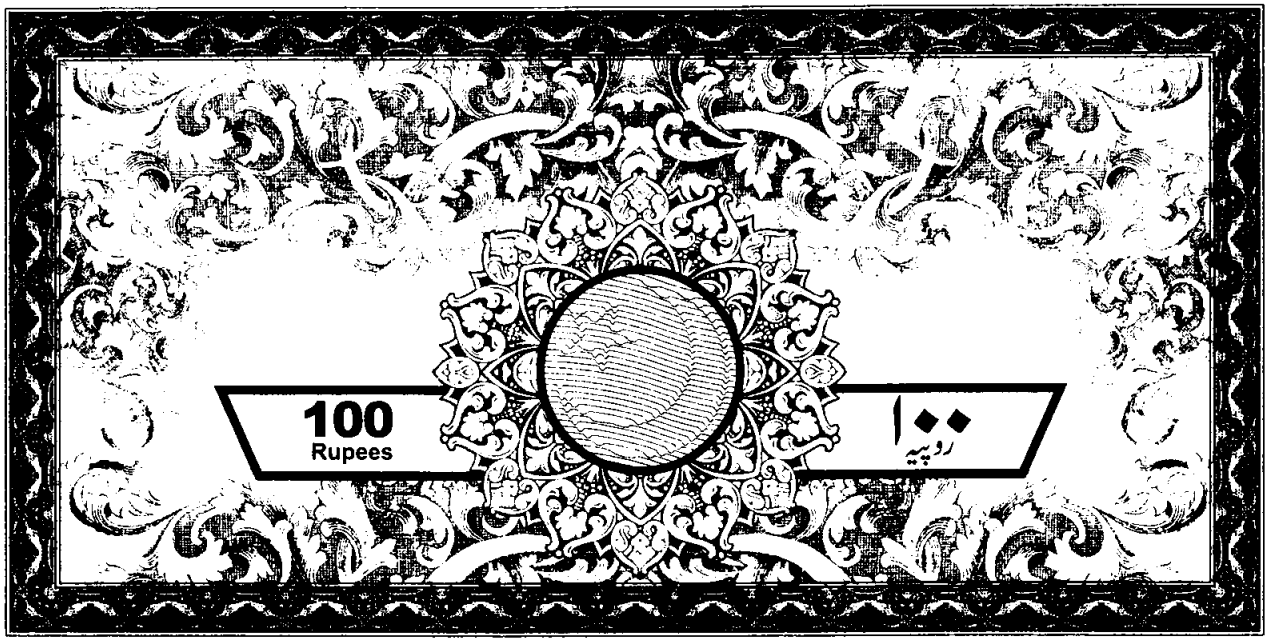
Subject: **AUTHORITY LETTER**

Mr. Mustafa Kammal khan S/O, Muhammad Ayaz Khan Bearing CNIC No. 173011-679845-9 is hereby appointed as Authorized Representative of the Pakhtunkhwa Energy Development Organization (PEDO), for the purpose of filing an application for Generation License for Madyan Hydropower Project (157 MW). He is also authorized to attend any meeting(s) and discussions related to the determination of tariff and to provide any information & documents needed in this regard.

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

6/10/2020
Muhammad Naeem
Chief Executive Officer
PEDO, Peshawar

E858483



BEFORE THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY

AFFIDAVIT

I, **Mustafa Kammal Khan** , Project Director Madyan Hydropower Project (157MW), being duly Authorized Representative of Pakhtunkhwa Energy Development Organization (PEDO), hereby solemnly affirm and declare that the contents of the accompanying Generation License dated October 13, 2020, including all supporting documents 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.

Dated: October 13, 2020

Mustafa Kammal Khan
Project Director
157MW Madyan HPP

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 Pakhtunkhwa Energy Development Organization (PEDO) Madyan Hydropower Project (157MW)

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 Madyan Power Plant
    - General Layout of entire Madyan Power Plant
    - Interconnection Arrangements with National Grid

Plant Details

1. General Information

- Name of Applicant: Pakhtunkhwa Energy Development Organization (PEDO) , Madyan Hydropower Project

- Address of the registered office: PEDO House, 38-B2, Phase-5, Hayatabad, Peshawar
- Plant Location : Madyan, District Swat, Khyber Pakhtunkhwa
- Type of Facility: Run of the River Hydropower Project

Plant Configuration

- Capacity of the Power Plant: (157MW)
- Type of Technology: High Head Hydropower (154m)
- Number of Units / Capacity - : Three units (3x 52.43 MW)
- Power Plant Make and Model –Francis turbine and Generators
- Commissioning Date ---- January 31, 2028

Fuel Details

- Type of Fuel: Hydropower Project
- Fuel (Imported / Indigenous): N/A
- Fuel Supplier: N/A

- **Emission values**

- SOx ---------- N/A
- NOx ---------- N/A
- CO ---------- N/A
- PM10 ---------- N/A

- Installed Capacity: **157**MW

2. Derated Capacity: No Derating as compared to ISO

3. Expected Life of the Facility ---------- 30 years

7. Operation Record ----------New Plant to be commissioned by January 31, 2028

4. Plant Characteristics

- Generating Voltage ---------- 11 KV
- Frequency ---------- 50 Hz
- Power Factor ---------- 0.85
- Automatic Generation Control ---------- No
- Ramping Rate ---------- 10 minutes
- Alternative Fuel ----------No
- Auxiliary Consumption ----------1.57 MW (1% of installed capacity)

Time required to Synchronise ---------- 5 minutes

SCHEDULE – II

The Net Capacity of the Licensee's Generation Facility

- Gross Installed Capacity of the Plant (ISO) ---------- 157 MW
- De-rated Capacity of the Plant ---------- 157 MW
- Auxiliary Consumption of the Plant ---------- 1.57 MW
- Net Capacity of the Plant ---------- 155.43 MW
- Construction Period ---------- 84 months
- Expected date of Commercial Operation of the Plant – January 31, 2028

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 Agreements or Grid Code

Interconnection Arrangement with National Grid for Power Dispersal of the Plant

The interconnection scheme for the Power dispersal from Madyan Hydropower Plant would be through 220KV transmission Line as Loop-in, Loop-out arrangement to the proposed 220KV Transmission Line of Gorkin Matiltan HPP in Swat Area.

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION (PEDO)

1. INTRODUCTION

The Khyber Pakhtunkhwa (KP) 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 6000MW 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 ofhydel 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 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 comprising Twelve (12) members under the Chairman governs affairs of PEDO. Following are the members of the PEDO Board of Directors as of date followed by organizational structure of the PEDO on the next page.

Chairman

Nisar Muhammad

Members include

1-	Secretary Energy & Power	2-	Secretary Finance Department
3-	Secretary Home Department	4-	Engr. Bakht Zaman
5-	Engr. Muhammad Jabbar Khan	6-	Abdul Siddique
7-	Arbab Khudadad Khan	8-	Syed Mussawar Shah
9.	Haq Nawaz	10.	Engr. Maqsood Anwar Pervaiz
11-	Hassan Nasir	12-	Chief Executive Officer PEDO

PEDO ORGANOGRAM

[redacted]

CHIEF EXECUTIVE OFFICER (CEO) (MP-1/Market Based Package)

- General Manager Admin/ Finance (B-21)
  - Consultant/Legal / Finance Expert (B-19)
  - Sr. Managers (B-19)
    - Senior Manager (P&F) (B-19)
      - Manager (Hydrology)
        - 2Nos. Asstt. Manager Civil/Hyg
      - Manager (Geology)
        - 2Nos. Asstt. Manager (Civil)
      - Manager (Civil)
        - 2Nos. Asstt. Manager Civil/Elect
      - Manager (Elect)
- General Manager (Hydel) (B-21)
  - Chief Engineer (Dev) (B-20)
    - Senior Manager (PP) (B-19)
      - Manager (PP)
        - 2Nos. Asstt. Manager PP/Civil
      - Resident Engs. (Project Specific) (B-
    - Senior Manager (O&C) (B-19)
      - Manager (OC&R)
        - 3Nos. Asstt. Manager OC&R/Elc.(B
  - Chief Engineer (O&C) (B-20)
    - Senior Manager (Admn/Finance) (B-19)
      - Manager Admn (B-
        - 5Nos. Asstt. Manager Admn/Transport/ Legal/Training /PRO (B-17)
      - 2Nos. Asstt. Manager
- General Manager (Thermal) (B-21)
  - Chief Engineer RFO & Gas (B-20)
    - Senior Manager (Plants) (B-19)
      - Resident Engineers (B-18)
    - Senior Manager (Rentals) (B-19)
      - Manager Boilers (B-18)
- General Manager (ARE) (B-21)
  - Chief Engineer Solar (B-20)
    - Senior Manager (Fuels) (B-19)
      - Manager Coal /CWS (B-18)
  - Chief Engineer Wind (B-20)
    - Senior Manager Planning (B-19)
      - Manager Bio-Mass (B-18)
- General Manager (Distribution) (B-21)
  - Chief Engineer D&DSM (B-20)
    - Senior Manager Transmission (STG) (B-19)
      - Manager Tariff (B-18)
    - Senior Manager Distribution (B-19)
      - Manager Industries (B-18)
      - Manager Collection (B-18)

New Creations

Existing Posts

Note: I. Organogram is showing posts up to Asstt. Managers only. II. The PMUs/PDs under independent PC-I/PC-II will fall under respective General Managers.
III. The existing posts of Director Finance/Admn will continue as Sr. Manager Finance/Admn for the Hydel Wing of PEDO. IV. The Existing Ministerial Staff of the Hydel Wing of PEDO will also continue with same nomenclature.
V. The grades has been prepared according to the hierarchy of Posts. VI. Supporting staff with the new GMs is shown in the Budget Working Paper.

iv. 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 6000MW 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.

2. PEDO PROJECTS

As tabulated, following are PEDO's projects at various stages.

Projects under Feasibility/Detail Design Studies

S/No	Name of Project	District	Capacity (MW)
1	Gabral Kalam HPP	Swat	88
2	Madian HPP	Swat	157
3	Kari Muskhur HPP	Chitral	495
4	Torecamp- Goduber HPP	Chitral	409
5	356 MHPPs	All Districts of KPK	34.74
6	Access to Clean Energy Canal (10 MHPPs)	Charsadda / Mardan	81 KW

Projects with Completed Feasibility

S/No	Name of Project	District	Potential (MW)
1	Patrak-Shringal HPP	Dir	22.0
2	Nandihar HPP	Batagram	12.3
3	Arkari Gol HPP	Chitral	99.0
4	Istaro Boni HPP	Chitral	72.0
5	Mujigram-Shaghore HPP	Chitral	64.3
6	Naran Dam HPP	Mansehra	188.0
7	Balakot HPP	Mansehra	300.0
8	Sharmai HPP	Dir	150.0
9	Shushgai HPP	Chitral	144.0
10	Shogosin HPP	Chitral	132.0
11	Gahrait-Swir Lasht HPP	Chitral	377.0
12	Toren More Kari HPP	Chitral	350.0

S/No	Name of Project	District	Potential (MW)
13	Laspur Marigram HPP	Chitral	230.0
14	Barikot Patrak HPP	Dir	47.0
15	ShigoKach HPP	Dir	102.0
16	Ghor Band HPP	Shangla	20.8
17	Batakundi HPP	Mansehra	96.0
18	Jameshill More Lasht	Chitral	260.0

Under Construction Hydropower Projects

S/No	Name of Project	District	Capacity (MW)
1	Lawi HPP	Chitral	69
2	Koto HPP	Dir (Lower)	40.8
3	Karora HPP	Shangla	11.8
4	Jabori HPP	Mansehra	10.2
5	Balakot HPP	Mansehra	300
6	Gorkin-Matilthan HPP	Swat	84

Solar and Other Under Construction Projects

S/No	Project Name	Capacity
1	Electrification of 100 Villages through Solar Alternate Energy, Phase-I	300 Watt each (2900 Solar Units)
2	Solarization of Chief Minister's Secretariat/Chief Minister's House	400 KWatt (Estimated)
3	Solarization of Civil Secretariat (Remaining Departments of Civil Secretariat)	400 KWatt (Estimated)
	Solarization Schools & Health Facilities	600 Watt per Class
5	Solar Electrification of 4000 Masajid in Khyber Pakhtunkhwa	2.6 KWatt (2000 Masajid)
		1.6 KWatt (2000 Masajid)
6	Solar Electrification of 440 in PK-10 & PK-11 in District Peshawar.	2.7 KWatt each (440 Masajid)
7	Electrification of Un-Electrified Villages through Solar/Alternate Energy, Phase-II (Additional 1000 SHS)	200 Watt each (1000 Solar Units)
8	Solarization of Administration Headquarters Offices in Charsadda (Feasibility)	N/A

S/No	Project Name	Capacity
9	356-Mini Micro HPP	34.74
10	Access to Clean Energy (Streams)	37.41
11	Access to Clean Energy (Canals)	15.72

Recently Completed Projects

S/No	Project Name	MW
1	Ranolia HPP Dubair District Kohistan	17
2	Daral Khwar Hydropower Project	36.6MW
3	Machai HPP	2.6
4	Electrification of Un-Electrified Villages through Solar/Alternate Energy, Phase-II.	200 Watt each (2750 Solar Units)

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PEDO

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION
Government of Khyber Pakhtunkhwa

No. 44-47 / PEDO / PD (MHP)
Dated Peshawar the July 13, 2020

To

Director General,
Environmental Protection Agency,
Peshawar, Govt. of KP

Subject: **ENVIRONMENT IMPACT ASSESSMENT (EIA) REPORT OF 157 MW MADYAN HYDROPOWER PROJECT, DISTRICT SWAT FOR ENVIRONMENTAL APPROVAL.**

The Pakhtunkhwa Energy Development Organization (PEDO) intends to construct a 157 MW run-of-river hydropower plant at Madyan, in Swat District of Khyber Pakhtunkhwa (KP), Pakistan. The Project site is located on the Swat River about 2 km upstream of the town of Madyan.

As per schedule (1) of IEE/EIA regulations 2000, Environmental Impact Assessment (EIA) report needs to be submitted for Environmental approval to Environmental Protection Agency (EPA), Govt. of KP.

Therefore, enclosed please find herewith ten hard copies of EIA report, two soft copies of EIA report (CDs), Challan receipt of Bank of Khyber for EIA processing fee in original and schedule four filled and duly signed by the undersigned for further necessary actions at your end please.

Acting Project Director
Madyan Hydropower Project,
PEDO, Peshawar

Cc:-

i. PS to Secretary, E&P, Peshawar
ii. PS to CEO, PEDO, Peshawar
iii. Mr. Muhammad Saqib, Program Incharge, World Bank

Received 13/7/20

Acting Project Director
Madyan Hydropower Project,
PEDO, Peshawar

38/B2, Phase-V, Hayatabad, Peshawar, Pakistan. Tel: 9217004, Fax 9217464

P E D O

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

Government of Khyber Pakhtunkhwa

No. 02 / PEDO / CE-WB / 01
Dated, Peshawar the: 04 / 09 / 2020

To,

Managing Director,
National Transmission & Dispatch Company Limited (NTDCL),
Lahore.

Subject: **ISSUANCE OF CONSENT FOR POWER EVACUATION FROM WORLD BANK PROJECTS OF 88MW GABRAL-KALAM HPP & 157MW MADYAN HPP – DISTRICT SWAT**

Dear Sir,

The Government of Khyber Pakhtunkhwa under the loan of World Bank is executing two (2) projects namely 88MW Gabral-Kalam HPP and 157MW Madyan HPP in District Swat to overcome the shortfall of electricity and promote cheap hydel electricity to reduce the burden of electricity charges on the people of Pakistan. The construction on both the projects will be starting soon.

PEDO has already filed feasibility stage tariff with NEPRA. NEPRA has observed that case for Generation License of both the above-mentioned projects be processed prior to approval of the Feasibility Stage Tariff.

Keeping in view the above, we intend to apply for Generation License for both the subject projects for which the issuance of Consent / N.O.C. for power evacuation from your good office is desired as the power evacuation voltage level is 220KV.

We further assure that PEDO will execute the following as part of the projects scope of work:

i. Preparation of detailed design for interconnection with the existing networks
ii. Load flow, short circuit and stability studies
iii. Submission of load flow studies to concerned quarters for approval
iv. Metering station at both the projects and telemetering with NPCC Islamabad as per NEPRA code
v. Signing of tariff agreement with CPPA-G according to the policy laid down by the Government of Pakistan

In light of the above and keeping in view the national importance of the subject projects, NTDC is requested to issue consent for Power Evacuation for both the projects as these projects have already been included in IGCEP 2047 so that the case for Generation License with NEPRA be taken up.

Syed Shah Hussain
Chief Engineer / Head PMO
World Bank Projects

CC:

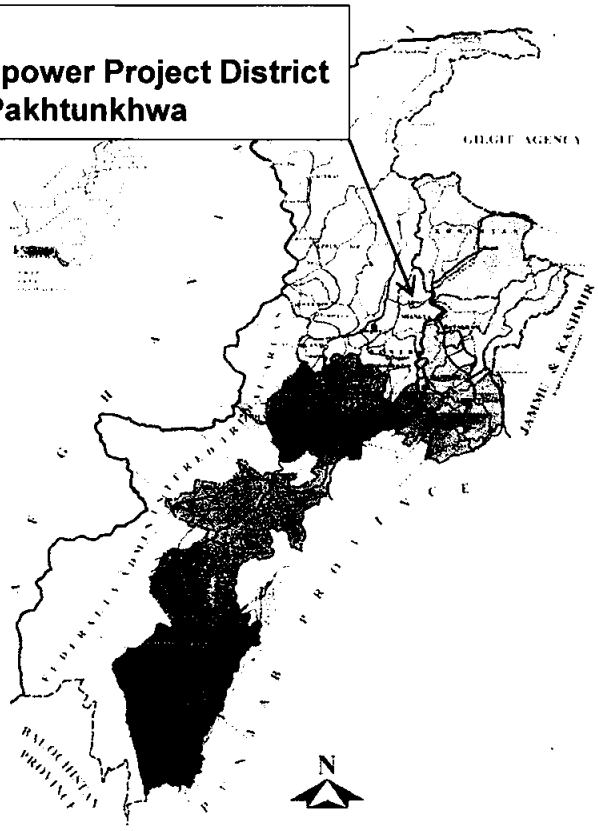
1. Project Director – 157MW Madyan HPP, PEDO, Peshawar
2. Project Director – 88MW Gabral-Kalam HPP, PEDO, Peshawar
3. PS to Secretary Energy & Power Department, Govt. of Khyber Pakhtunkhwa, Peshawar
4. PS to CEO, PEDO, Peshawar

Syed Shah Hussain
Chief Engineer / Head PMO
World Bank Projects

PROJECT INTRDODUCTION

The project area is located in the Swat District, north of Madyan Town. Madyan Town is located at a distance of approximately 200 km from Peshawar, the capital of Khyber Pakhtunkhwa and 60 km from Mingora, the district headquarters of Swat Valley. The project area is accessible from Peshawar and Islamabad via Motorway (M1) and National Highway (N-95). Swat Expressway is also under-construction which will significantly reduce the travel time from Peshawar to Chakdara whereas further same route of N-95 will be followed. At the moment Swat Motorway is operational only for light traffic vehicle.

Location Map:
Madyan Hydropower Project District
Swat Khyber Pakhtunkhwa



The proposed weir site of the Madyan HPP is located on the Swat River some 14 km north of Madyan town and the powerhouse just 1.2 km upstream where the approximately 35 km long V-shaped gorge section of the Swat River ends and continues further as a river with wide flood plains.

Location Coordinates are as Under;

Latitude: 35° 09' 25" N
Longitude: 72° 32' 02" E

PROJECT HISTORY

To explore and develop the hydropower potential on provincial level, the Government of the then NWFP (now Khyber Pakhtunkhwa Province) created Small Hydel Development Organization (SHYDO) in 1986-87 which was later on converted to Sarhad Hydel Development Organization (SHYDO), under the SHYDO Act 1993. After the change of province name, the name of SHYDO was changed to PHYDO i.e. Pakhtunkhwa Hydel Development Organisation which further renamed to PEDO(Pakhtunkhwa Energy Development Organization) which could implement power project up to 50MW only. However, as result of 18th amendment in the constitution of Pakistan in year 2011, the provincial governments were allowed to develop electricity above 50 MW also in their jurisdictions.

Comprehensive studies for the assessment of the hydropower potential of the Swat catchment area were carried out between 1990 and 1995 and updated in 2006 by the so called Cascade Study (MAES, Mirza Associates Engineering Services (PVT) Ltd) proposing the development of a cascade of the following five hydropower plants on the Swat Valley:

- Matiltan, 84 MW
- Gabral-Kalam, 101 MW
- Kalam-Asrit, 197 MW
- Asrit-Kedam, 209 MW
- **Madian, 157 MW**

PROJECT OBJECTIVE

Primary objective of the Project is to generate 157MW hydropower; with mean annual energy production of 765.5 GWh.

PROJECT COMPONENTS

For diversion of part of the river flow for power generation a concrete weir of 19 m height (above riverbed) is proposed at Kedam village. In the central part of the weir structure a spillway with 3 tainter gates is proposed discharging into a stilling basin where the excess hydraulic energy is dissipated. At the weir structure two flushing outlets are provided to evacuate sediments that may deposit in front of the power intake proposed on the left side of the weir. The weir structure is designed to withstand safely floods up to a return period of 10,000 years and the design earthquake without major damages.

For diversion of the Swat River during construction of the weir, stilling basin and power intake, conventional diversion works are designed. The diversion works consist of a conventional upstream rock fill cofferdam sealed by jet grouting, a downstream cofferdam and a diversion tunnel. The existing Madyan-Kalam road needs to be relocated over a length of approximately 250 m at the weir site.

The headrace tunnel starts at the power intake and has a length of 11.8 km. Its alignment was selected for conventional drill and blast excavation method nearly parallel to the Swat River. Three adits are planned to ensure tunnel construction within a reasonable period. The desanding facilities are arranged 2.1 km downstream of the weir and consist of three desanding caverns with the corresponding ducts and gates for evacuation of sediments.

At the downstream end of the low pressure headrace tunnel a surge tank is proposed to limit pressure rise in the headrace tunnel and ensure the required flexibility of the hydropower plant in operation. A vertical pressure shaft leads the flow to the elevation of the three Francis turbine units proposed in an underground powerhouse. The steel lined pressure tunnel and manifolds are kept short to achieve an economic design. Transformer and Switchyard are proposed underground as well in a cavern parallel and at 30 m distance from the powerhouse cavern. From the powerhouse cavern a short tailrace tunnel releases the flow back into Swat River.

Since the major works of the Madyan Hydropower Project are underground, the environmental and socio-economic impact (including the required resettlement) of the Project is minor and is largely related to dumping of excavation material at sites which are presently cultivated.

ENVIRONMENTAL ASPECT OF THE PROJECT.

Detailed Environmental and Social Impact Assessment Report is also a part of Feasibility Report. The Construction of Madyan hydropower project (157 MW) will have positive impacts on the local socio-economic base and physical environment. Major findings of the environmental impact assessment studies are describe below.

Beneficial Impacts

The direct benefits of the project will be 157 MW of electrical power and on average, 742.5 GWh of electrical energy per year.

The proposed hydropower project exploits a renewable energy source. It will not deplete Pakistan's reserves of natural resources; at the same time, it will ease the nation's dependence on imported fossil fuels.

The operation of the power plant will not produce harmful gases. Indeed, the

hydropower scheme will be credited with displacing the emission of just over 152,633 tons of CO2 per year that would otherwise be released into the environment by a Combined Cycle Gas Turbine Thermal Power Plant. For CO2 reduction, carbon credits can be claimed as compensation which is estimated to be Rs. 905.98 million for 20 years period.

The construction of project will take about 5 years. During this period, it will provide direct employment and career opportunities for several hundred persons of the local community.

After dumping of spoil materials, low lying areas will be rehabilitated and waste land will be reclaimed for agriculture activities.

The initiation of the project will improve the foreign exchange condition in the country.

Addition of 157 MW of cheap electricity into the National Grid will significantly reduce the ongoing energy crises in the country.

Project Adverse Impacts

Consumption of land resources will be the major adverse impact of the Madyan Hydropower Project (157MW).

Project implementation will need acquisition of a total 39.438 ha land (state land farmland, wasteland). Out of this total, 36.638 ha will be acquired on permanent basis and the remaining 2.800 ha on lease for 5 years.

Only 15 houses with a total of 176 persons will be directly affected by the Project. 2 of these houses will be affected by reservoir impounding, 8 due to their location in areas to be utilised for dumping of excavated material, 3 in the vicinity of the diversion works; 1 due to relocation of the road at the weir site and 1 due to the proposed access road to the weir site along the left bank of the Swat River.

Only 176 persons will be directly affected because parts of their farmland/ wasteland/ river bed will be acquired permanently or temporarily for project implementation.

A land area of 36.638ha will be acquired permanently and 2.8 ha will be acquired temporarily.

A total of 1,423 trees will be felled. Thereof, 950 are fruit trees and 473 are firewood and timber trees.

During construction, traffic on Madyan Kalam road will be affected at weir site.

EXECUTING AND FINANCIAL AGENCIES

Executing Agency (EA) for implementation of the Project is Pakhtunkhwa Energy Development Organization (PEDO) of KP Province headed by Chief Executive Officer, PEDO. The Authorized Representative of EA is the Project Director, Madyan Hydropower Project (PEDO).

The scheme will be financed in the ratio of 80:20 by World Bank (IDA / IBRD) and ADP/HDF respectively. The ADP No. for this project for the FY 2020-21 is 575.

PROJECT IMPLEMENTATION ARRANGEMENTS

Executing Agency : Pakhtunkhwa Energy Development Organization (PEDO)

SALIENT FEATURES

Following are the key parameters of the Project.

Hydrological Features at Weir Site:		
Catchment Area	2,403	km^2
Mean Annual Flow	118.5	m^3/s
Diversion Flood	656	m^3/s
HQ1,000	1,450	m^3/s
HQ10,000	2,002	m^3/s
Reservoir:		
Total Volume	480,000	m^3
Normal Reservoir Operation Level	1494.0	m SoP
Max. Operation Level	1994.5	m SoP
Weir Structure:		
Crest Level of Weir	1496.0	m SoP
Max. Weir Height	18.0	m above river bed
Length of Weir Crest	77.0	m
Invert of Flushing Outlet	1477.0	m SoP
Spillway:		
Level of Spillway Crest	1482.5	m SoP
Number of Tainter Gates	3	
Width of Gate	7.6	m
Height of Gate	12.0	m
Desander:		
Design Discharge	129	m^3/s
Design Particle Diameter	0.2	mm
Number of settling chambers	3	
Effective length of chamber	206.0	m w/o transition
Width of chamber	13.7	m
Average depth of chamber	16.8	m
Low-pressure Headrace Tunnel:		
Length	11.8	km
Net Diameter	7.00	m
Max. Flow velocity	3.35	m/s
Surge Tank:		
Diameter	21.0	m
Height	69.0	m
Pressure Shaft and High-Pressure Tunnel:		
Total length (shaft & tunnel)	180.3	m

Length of vertical shaft	120.8	m
Diameter	5.8	m conrete lined
Flow velocity	4.88	m/s
Diameter	5.4	m steel lined
Flow velocity	5.63	m/s
Steel lining	20 - 28	mm
Powerhouse:		
No. of units	3	Vertical Francis
Installed Capacity	3 x 60.8	MW
Available Capacity (ex transformer 3 units in operation)	3 x 52.43	MW
Max. Turbine Design Discharge	43.0	m^3/s
Cavern Width	20.0	m
Cavern Length	70.0	m
Turbine Setting	1336	m SoP
Electomechanical Equipment:		
No of Transformers	9	
Type of GIS Switchyard	SF6	
Voltage	220	kV
Tailrace Tunnel:		
Total length (w/ manifold)	93.6	m
Diameter	7.3	m
Diameter of manifold	4.2	m conrete lined
Flow velocity	3.08	m/s
Additional Project Parameters:		
Mean Annual Energy	767.5	GWh
Annual Energy available for Sale	742.5	GWh
Plant Factor	0.56	

PEDO Amended Act 2019
Final Copy

EXTRAORDINARY

REGISTERED NO. P.111

GOVERNMENT

GAZETTE

North.West Frontier Province

Published by Authority

PESHAWAR, WEDNESDAY, 24TH FEBRUARY, 1993.

PROVINCIAL ASSEMBLY SECRETARIAT,
NORTH.WEST FRONTIER PROVINCE

.....

NOTIFICATION

24th FEBRUARY, 1993.

No. PA/NWFP/Legis/93/4866. ~~The~~ Sarhad Hydel Development Organizatior Bill, 1993, having been passed by the Provincial Assembly of the North-Wes Frontier Province on the 14th February, 1993 and assented to by the Governor of the North-West Frontier Province on the 22nd February, 1993 is hereby published as ar Act of the Provincial Legislature of North-West Frontier Province.

THE SARHAD HYDEL DEVELOPMENT ORGANIZATION ACT, 1993.

N.W.F.P. ACT NO. 1 OF 1993

[First published after having received the assent of the Governor of the North-West Frontier Province in the Gazette of North-West Frontier Province (Extraordinary), dated the 24th February, 1993].

Further to amend the Pakhtunkhwa Hydel Development Organization Act, 1993 (Khyber Pakhtunkhwa Act No. 1 of 1993) for the purposes hereinafter appearing;

Preamble WHEREAS it is expedient further to amend the Pakhtunkhwa Hydel Development Organization Act, 1993 (Khyber Pakhtunkhwa Act No. 1 of 1993) for the purposes hereinafter appearing;

It is hereby enacted as follows:-

CHAPTER I
Preliminary

Short title, and Commencement.

1. (1) This Act may be called the Khyber Pakhtunkhwa Energy Development Organization (Amendment) Act, 2019. **PEDO (Amendments) Act, 2019**

(2) It extends to the whole of the Khyber Pakhtunkhwa province **PHYDO (Amendments) Act, 2013**

(3) It shall come into force at once.

Definitions

2. In this Act, unless there is anything repugnant in the subject or context:-

(i) "Authority" means the Water and Power Development Authority established under the Pakistan Water and Power Development Authority Act, 1958 (W.P. Act XXXI of 1958);

(ii) "Board" means the Board of Directors of the Pakhtunkhwa Energy Development Organization; **PEDO (Amendments) Act, 2014**

(iii) "Chairman" means the Chairman of the Energy Apex Committee or Board or Executive Committee or investment Committee, as the case may be;";

(iii-a) "Energy Apex Committee" means the Energy Apex Committee constituted under section 3-A of this Act;"; and

(iv) "Federal Government" means the Government of Islamic Republic of Pakistan;

(v) "Government" means the Government of the Khyber Pakhtunkhwa Province; **PHYDO (Amendments) Act, 2013**

(vi) "land" includes benefits to arise out of land, and things attached to the earth or permanently fastened to anything attached to the earth;

(vii) "local body" means a Local Council Constituted under the North-West Frontier Province Local Government Ordinance, 1979 (N.W.F.P. Ord. No. IV or 1979);

(viii) "Chief Executive Officer" means the Chief Executive Officer of the Pakhtunkhwa Energy Development Organization; **PEDO (Amendments) Act, 2014**

(ix) "member" means a member of the Board;

(x) "Organization" means the Pakhtunkhwa Energy Development Organization established under section 3; **PEDO (Amendments) Act, 2014**

(xi) "Officer" means an officer of the Organization including the Chief Executive Officer;

(xii) "power" includes hydraulic power, electrical energy, steam, gas, "thermal generation, alternative renewable sources of energy".

(xiii) "prescribed" means prescribed by rules and regulations;

(xiv) "Province" means the Khyber Pakhtunkhwa Province;

(xv) "regulations" means regulations framed under this Act;

(xvi) "rules" means rules made under this Act;

(xvii) "section" means a section of this Act, and

(xviii) "Scheduled Bank" means a Bank for the time being included in list of Banks maintained under sub-section (1) of section 37 of the State Bank of Pakistan Act, 1956 (XXXIII of 1956).

CHAPTER II
Constitution of Energy Apex Committee

3. (1) There shall be established an Organization to be Known as the Pakhtunkhwa Energy Development Organization **Establishment of Organization** **PEDO (Amendments) Act 2014**

(2) The Organization shall be a body corporate having power to acquire, hold and sell property, both movable and immovable, shall have perpetual succession and a common seal and shall by the said name sue and be sued. **PHYDO (Amendments) Act 2013**

(3) The head office of the Organization shall be at Peshawar

3-A (1) The Government shall constitute an Energy Apex Committee to provide policy guide line to the Board. **Constitution of Apex Committee** **PEDO (Amendments) Act 2014**

(2) The Energy Apex Committee shall be headed by the Chief Minister, Khyber Pakhtunkhwa and shall consist of such other persons as the Government may determine.

(3) The meeting of the Energy Apex Committee shall be held in such a manner as may be prescribed.

4. (1) Subject to the provisions of section 3-A of this Act, the powers, functions and management of the **Board of Directors** **PEDO (Amendment)**

Organization shall vest in a Board constituted Under this section. **Act, 2014**

(2) The Board shall have a Chairman to be appointed by Government for a period of three years from amongst the persons having at least twenty years experience in the field of energy and power or industries or financial sector, in such a manner and on such terms and conditions as the Government may determine.

(3) The other members of the Board shall be as under:

i.	Secretary to Government, Energy and Power Department;	**Member**
ii.	Secretary to Government, Finance Department;	**Member**
iii.	Secretary to Government, Home and Tribal Affairs Department;	**Member**
iv.	President, Khyber Pakhtunkhwa Chamber of Commerce and Industries;	**Member**
v.	Seven persons to be appointed by Government for a period of three years from amongst the persons having at least ten years experience in the field of energy and power or industries or financial sector; and	**Members**
vi.	Chief Executive Officer.	**Member/Secretary**

(4) The Powers, functions and management of the Organization shall vest in a Board constituted Under sub section (2) **PEDO (Amendments) Act, 2014**

(5) The Chairman and members at clause (v) may at any time resign from his office by writing under his hand to Government.

(6) Government may remove, the chairman and members at clause (v) before the expiry of their term on the ground of misconduct or of being incapable of properly performing the duties of his office by reason of physical or mental incapacity:

Provide that before removing the Chairman and members at clause (v), as the case may be, Government shall give them an opportunity of being heard in person.".

4 A. Executive Committee-(1) There shall be an Executive Committee consisting of:- **PEDO (Amendment) Act 2014**

i.	the Minister for Energy and Power;	Chairman
ii.	the Additional Chief Secretary to Government;	Member
iii.	the Secretary to Govt., Finance Deptt.	Member
iv.	the Secretary to Govt., Energy & Power Deptt.	Member
v.	the Chief Executive Officer of the Organization.	Member

(2) The Executive Committee shall perform such functions as may be delegated to it by the Board from time to time.

5. **(1)** Government shall appoint the Chief Executive Officer of the Organization from amongst the persons having expertise in the field of energy and power sector on such terms and conditions as the Government may determined. **Chief Executive Officer** **PEDO (Amendments) Act, 2014**

(2) The Chief Executive Officer shall be the Chief Executive of the Organization and shall be responsible for its day to day administration and management. He shall also be responsible to carry out and implement the orders and decisions of the Board.

(3) The term of office of the Chief Executive Officer shall be four years. On expiry of his term of office, the Chief Executive Officer shall be eligible for re-appointment for a subsequent term or terms or for such shorter term as Government may determine in consultation with the Board.

(4) The Chief Executive Officer may, at any time, resign from his office and by virtue of his resignation, he shall cease to be member of the Board. Or if he resigns from the membership of the Board, he shall cease to be the Chief Executive Officer;

Provided that his resignation in either case shall not take effect until accepted by Government.

6. Deleted. **PEDO (Amendments) Act, 2014**

7. (1) The Board may employ such experts, advisers, consultants and other officers, as it considers necessary for the efficient performance of functions of the Organization, on such terms and conditions as may be determined by the Board. **Other officers.**

(2) The Chief Executive Officer, in case of emergency, may appoint such experts, advisers, consultants and other officers as may be considered necessary;

Provided that every appointment made under this sub-section shall be reported to the Board without un-necessary delay and shall not continue beyond six months unless approved by the Board.

PEDO (Amendments) Act, 2014

8. Government may, by Notification, remove the Chief Executive Officer.

Removal of Chief Executive Officer.

(a) If he refuses or fails to discharge or becomes, in the opinion of Government, incapable of discharging his responsibilities under this Act; or

PEDO (Amendments) Act, 2014

(b) if he has been declared insolvent; or

(c) if he has been declared to be disqualified for the employment, or has been dismissed from, the service of Pakistan, or has been convicted of an offence involving moral turpitude; or

(d) if he has knowingly acquired or continued to hold without the permission in writing of Government, directly or indirectly or through a partner, any share or interest in any contract or employment with, or on behalf of, the Organization or in any land or property which, in his knowledge, is likely to benefit or has benefited as a result of the operation of the Organization.

9. (1) The Board shall meet at least once in every six months in such manner and at such time and place as may be prescribed by the Chairman:

Meeting of the Board

PHYDO (Amendments) Act 2013

(2) The Chairman, or in his absence, a member authorized by him to preside over the meeting and three other members shall be present to constitute a quorum at meeting of the Board.

PHYDO (Amendments) Act 2013

CHAPTER III
Power and duties of the Organization

General powers and duties of the Organization and framing of schemes

10. (1) Subject to any other law for the time being in force, the Organization shall prepare, for the approval of Government, a comprehensive plan for the development and utilization of the power and energy resources of the Province. The Organization may also undertake such other schemes as Government may direct.

(2) Without prejudice to the provisions of sub-section (1), the Organization may frame a scheme or schemes for the Province or any part thereof providing for all or any of the following matters, namely:-

(i) the generation, transmission and distribution of power;

(ii) the construction, maintenance and operation of power houses, grids and microgrids, transmission and distribution lines specially in the remote mountainous areas of the Province.

(3) Every scheme prepared by the Organization under sub-sections (1) and (2) shall be processed in accordance with Government procedures or instructions, which may be issued to the Organization from time to time. The Organization will submit to the Government periodical reviews and other reports required by it.

(4) Government may sanction or may refuse to sanction or may return for reconsideration or further examination any scheme submitted to it under sub-section (3), or may call for such further details or information about any such scheme as it may consider necessary.

(5) The Organization will act as adviser to the Government on all matters regarding issuance of licenses and joint ventures in the power sector.

(6) The Chairman may request the Government to provide assistance for the efficient functioning of the organization.

11. The Organization, if it considers necessary or expedient for carrying out the purposes of this Act, may:- **Survey and experiments.**

(a) cause studies, pre-feasibility studies, detailed feasibility studies, surveys experiments of technical research to be made, or

(b) contribute towards the cost of any such studies surveys, experiments or technical research made by any other agency.

12. Consequent upon the winding up of the Small Hydel Development Organization under section 12 of the Sarhad Hydel Development Organization Ordinance, 1992 (NWFP Ordinance II of 1992), having since been repeated with effect from the 3rd June, 1992, all officers, servants and other employees of the aforesaid Organization transferred to the Organization established under the repealed Ordinance shall be officers, servants and employees of the Organization established under this Act and shall continue to work on the same terms and conditions as applicable to them immediately before the commencement of this Act. **Winding up of the Hydel Development Organization and transfer of assets liability.**

13 (1) Subject to the provisions of any other law for the time being in force, the Organization. **Control over power houses, grids and transmission and distribution lines.**

(i) shall have control over the operation of all power houses, grids, transmission and distribution lines in the Province constructed by, or transferred to, the Organization, including such ancillary works as may be considered necessary for their proper operation;

(ii) may make recommendations to Government for prescribing standards for the maintenance of power houses, grids, micro-grids and transmission and distribution lines of the Organization; and

(iii) may make recommendations to Government for promoting simplification of methods of charge for supplies of electricity and standardization of the system of supply.

(2) Before the Organization exercises any control under clause (i) of sub-section (1), the area over which and the extent to which control is intended to be exercised shall be agreed to and notified by Government in the official Gazette.

Organization to have powers and obligations of licensee under Electricity Act, 1910.

14. The Organization shall, for the purposes of the Electricity Act, 1910, be deemed to be a licensee and shall have all the powers and discharge all the obligations of a licensee under the said Act:

Provided that nothing in sections 3 to 11, sub-sections (2) and (3) of section 21 and sections 22, 23 and 27 of the said Act, or in clauses I to XII of the Schedule to the said Act, relating to the duties and obligations of a licensee shall apply to the Organization.

Powers regarding certain matters

15. (1) The Organization may take such measures and exercise such powers as it considers necessary or expedient for carrying out the purposes of this Act.

(2) Without prejudice to the generality of the powers conferred by the preceding sections and the provisions of sub-section (1), the Organization may, in the prescribed manner and subject to the provisions of this Act.

(a) undertake any work, incur any expenditure, procure plant, machinery and materials required for its use and enter into and perform all such contracts as it may consider necessary or expedient to carry out the purposes of this Act:

(b) acquire by purchase, lease, exchange or otherwise and dispose of by sale, lease, exchange or otherwise, any immoveable property or any interest in such property;

(c) place wires, poles, wall brackets, stays, apparatus and appliances for the transmission of electricity or for the transmission of telegraphic or telephone communications necessary for the proper execution of a scheme;

(d) undertake any anti-corrosion operations;

(e) restrict or prohibit by general or special Order, the clearing and breaking up of land in the catchments area of any river;

(f) 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 things necessary and incidental with power produced or generated by or through the Organization; and". **PEDO (Amendments) Act, 2014**

(g) seek and obtain advice and assistance in the preparation or execution of a scheme from any local body or agency of the Government, and such local body or agency shall give the advice and assistance so sought to the best of its ability, knowledge and judgment;

Provided that the Organization shall pay the cost of such advice and assistance, if the giving of such advice and assistance entails additional expenditure to the local body or the agency concerned.

(3) The acquisition of any land or any interest in land for the Organization under this section, or for any scheme under this Act, shall be deemed to be an acquisition for a public purpose within the meaning of the land acquisition Act, 1894, and the provisions of the said Act shall apply to all such proceedings.

16. The Chairman or any person authorized by him in writing may enter upon and survey any land, erect pillars for the determination of intended lines of works, make boring and excavations and do all other acts which may be necessary for the preparation of any scheme. **Right of entry.**

Provided that when the affected land does not vest in the Organization the power conferred by this sub-section shall be exercised to such manner as to cause the least interference with, and the least damage to the rights of the owner thereof.

17. A scheme framed and sanctioned under this Act may be amended or modified by the Board at any time, but if a material change is made in the scheme and its cost or the revised cost exceeds the sanctioning limit of the Organization, then sanction of Government shall be obtained afresh. **Sanction of Government.**

18 (1) As soon as any scheme has been carried out by the Organization or at a later date, the Board may arrange by a written agreement with a local body or other agency within whose jurisdiction any particular area covered by the scheme lies, to take over and maintain any of the works and services in that area. If the Board fails to obtain the assent of such a local body or other agency, it may refer the matter to Government, and Government may give such directions to the local body or other agency as it may deem fit. **Arrangement with local body or other agency.**

"(2) The Organization, with the prior approval of the Board, shall have the power to hand over power generation scheme or the part of the power plant of a multi-purpose scheme, having capacity not exceeding 2 MW, carried out by it, to any agency of Government, local body, community base organization, non-governmental organization or local community, as the case may be, in the best public interest, on such terms and conditions, as deemed appropriate by the Board.". **PEDO (Amendment) Act, 2019**

CHAPTER IV
Establishment

19. (1) The Board may from time to time employ directly or by induction, transfer, deputation or by absorption from Federal or other Provincial Governments, semi-autonomous and autonomous bodies, such officers and servants, as it may consider necessary for the efficient performance of its functions, on such terms and conditions as it may deem fit; **Employment of Officers and servants.**

Provided that the terms and conditions of service of any such person as aforesaid shall not be varied by the Board to his disadvantage.

(2) Appointment and promotion of officers and employees upto and including BPS-16 shall be made by the Chief Executive Officer in the prescribed manner. Appointments and promotions in BPS-17 and above shall be **PEDO (Amendments) Act, 2014**

made by the Board in the prescribed manner.

20. Deleted. **SHYDO (Amendment) Act, 1996**

21. (1) The Chairman, member, Chief Executive Officer, officers and servants of the Board or the Organization shall, when acting or purporting to act in pursuance of any of the provisions of this Act be deemed to be public servants within the meaning of section 21 of the Pakistan Penal Code. **Immunity** **PEDO (Amendments) Act, 2014**

(2) No suit, prosecution or other legal proceedings shall lie against the Chairman, Chief Executive Officer, members or officers and servants in respect of anything done or intended to be done, in good faith under this Act.

22. The Board may, by general or special order, delegate to the Executive Committee, the Chief Executive Officer, a member or any officer of the Organization any of its Powers, duties or functions under this Act, subject to such conditions as it may think fit to impose. **Delegation of Powers** **PEDO (Amendments) Act 2014**

CHAPTER V
Reports and Statements

23. (1) The Board shall submit to the Provincial Assembly, as soon as possible after the end of every financial year but before the last day of October next following, a report on the conduct of the affairs of the Organization for the year including an analysis of its physical activities and financial achievements for discussion. **Submission of yearly reports and returns, etc.**

(2) Provincial Assembly may require the Board to Furnish with –

i) any return, statement, estimate, statistics or other information regarding any matter under the control of the Organization; or

ii) a report on any such matter; or

iii) a copy of any document in the charge of the Board;

and the Board shall comply with such requisition.

CHAPTER VI
Finance

Fund

24. (1) There shall be a fund to be known as the Organization Fund vested in the Organization which shall be utilized by it to meet changes in connection with its functions under this Act, including the payment of salaries and other remunerations to the Chief Executive Officer, officers, servants and employees.

PEDO (Amendments) Act, 2014

(2) The fund shall consist of :-

(a) grants made by Government including the Federal Government;

(b) loans obtained from Government including the Federal Government;

(c) grants made by local bodies as required by Government;

(d) sale proceeds of bonds issued under the authority of Government;

(e) loans obtained by the Organization from commercial banks or any other source;

(f) foreign loans, grants or any other financial assistance obtained; and

(g) all other sums received by the Organization;

(3) The Organization may keep money in the Khyber Bank or any scheduled bank or a National Saving Centre, through an Investment Committee;

PHYDO (Amendments) Act 2013

(4) Nothing in sub-section (3) shall be deemed to preclude the Organization from investing any such moneys which are not required for immediate expenditure in any of the securities described in section 20 of the Trust Act, 1882 (Act No. II of 1882), or placing them in a fixed deposit with the Khyber Bank or any schedule bank or a National Saving Centre, through an Investment Committee;

PHYDO (Amendments) Act 2013

(5). the Board will endeavor to promote private sector in the generation, transmission and distribution of power. For this purpose it may sponsor, promote or join private limited companies.

(6) The Board may also permit the Organization **SHYDO (Amendment) Act, 1996**

a. to join, promote, sponsor or incorporate public limited companies or

b. to join other stationary or corporate bodies, involved in the generation, transmission and distribution of power.

24 A. Investment Committee – (1) there shall be an Investment Committee consisting of the following members; **PEDO (Amendments) Act 2014**

(i) Chief Executive Officer of the Organization **Chairman**

(ii) Additional Secretary Finance Deptt. **Member**

(iii) General manager, Administration and Finance, Pakhtunkhwa Energy Development Organization; **Member**

(iv) Assistant Director Budget and Finance Pakhtunkhwa Energy Development Organization **Member"; and**

(v) a representative of Energy and Power Department not below the rank of Deputy Secretary. **Member".**

(2) The Investment Committee shall have the power to invest the surplus fund in a manner as it may deemed fit".

25. The Organization shall be deemed to be a local authority under the Local Authorities Loans Act, 1914, for the purpose of borrowing money under the said Act, and the making and execution of any scheme under this Act shall be deemed to be a work which such authority is legally authorized to carry out. **Organization to be deemed a local authority.**

26. The Liability of Government to the creditors of the Organization shall be limited to the extent of grants made by it and the loans raised by the Organization with the sanction of Government. **Limited liability**

27. The rates at which the Organization shall sell power shall be so fixed as to provide for meeting the operation costs, investment costs and depreciation of assets, the redemption at due time of loans other than those covered by depreciation, the payment of any taxes and a reasonable return on investment or the **Rates for sale of Power**

rates approved by Government.

28. The Organization shall maintain complete and accurate books of accounts in such form as may be prescribed by it ;

Provided that separate accounts shall be maintained for all schemes and transactions relating to power.

Maintenance of Accounts.

29. In the month of January each year, the Organization shall submit to Government for approval a budget of receipts and expenditure in respect of the next financial year.

Annual Budget

PHYDO (Amendments) Act 2013

30 (1) The accounts of the Organization shall be audited by Chartered Accountants within the meaning of the Chartered Accountants Ordinance, 1961 (Ord. X of 1961), appointed by the Board on such remunerations as it may deem fit.

Audit.

(2) Notwithstanding the provisions of sub-section (1), the Auditor General may, on the request of Government, cause to be audited the accounts of the Organization.

CHAPTER VII
Rules and Regulations

"31. Power to make rules. For the purposes of carrying into effect The provisions of this Act, the Board may frame such rules as it considers necessary or expedient".

SHYDO (Amendment) Act, 1996

32 The Sarhad Hydel Development Organization Ordinance, 1993 (N.W.FP. Ordinance No. I of 1993) is hereby repealed.

Repeal

BY ORDER OF THE SPEAKER,
PROVINCIAL ASSEMBLY OF KHYBER PAKHTUNKHWA

AMANULLAH
Secretary
Provincial Assembly of Khyber Pakhtunkhwa

GOVERNMENT OF KHYBER PAKHTUNKHWA
ENERGY & POWER DEPARTMENT

1st Floor, Block A, Wali Khan, Multiplex, Civil Secretariat, Peshawar
Tel: 091-9223625, Fax No: 091-9223624

No. SO (Power-I)E&P/4-21/Appt: CEO PEDO/2018/Vol-II 96/97
Dated Peshawar the, 15-05-2019

To

The Chief Executive Officer,
Pakhtunkhwa Energy Development Organization,
Peshawar.

Subject: - **NOTIFICATION.**

Dear Sir,

I am directed to refer to the subject noted above and to enclose herewith a copy of Notification No. PA/Khyber Pakhtunkhwa/Bills-29/2019/14100, dated 04-04-2019 alongwith its enclosures received from the Provincial Assembly Secretariat, Khyber Pakhtunkhwa for information, record and necessary action, please.

Yours faithfully,

15/05/19

(Rangeen Khan)
Section Officer (Power-I)

Encl: As Above.
Endst: of Even No. & Date.

Copy forwarded for information to the:-

PS to Secretary Energy & Power Department.

Diary No. 3009 Dated 21-05-2019
Office of the Chief Executive Officer,
PEDO

Section Officer (Power-I)

FOR THE EXTRAORDINARY GAZETTE ISSUE OF THE KHYBER PAKHTUNKHWA

PROVINCIAL ASSEMBLY SECRETARIAT KHYBER PAKHTUNKHWA

NOTIFICATION

Dated Peshawar, the 4/04/2019.

No.PA/Khyber Pakhtunkhwa/Bills-29/2019/ 14200 The Khyber Pakhtunkhwa Energy Development Organization (Amendment) Bill, 2019 having been passed by the Provincial Assembly of Khyber Pakhtunkhwa on 27th March, 2019 and assented to by the Governor of the Khyber Pakhtunkhwa on 1st April 2019 is hereby published as an Act of the Provincial Legislature of the Khyber Pakhtunkhwa.

THE KHYBER PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION (AMENDMENT) ACT, 2019.
(KHYBER PAKHTUNKHWA ACT NO. XVI OF 2019)

(First published after having received the assent of the Governor of the Khyber Pakhtunkhwa in the Gazette of the Khyber Pakhtunkhwa. (Extraordinary), dated the 4 /04/2019).

(Here print as in the accompaniment).

SECRETARY,
Provincial Assembly of Khyber Pakhtunkhwa.

No. and date (as per notification above).

A copy of the above notification with the accompaniment is forwarded to the Manager, Government Stationery and Printing Department, Peshawar, with the request to publish the same in the extraordinary issue of the Khyber Pakhtunkhwa Government Gazette of today's date and distribute copies thereof immediately in accordance with the list given overleaf.

Proof should be sent to this Secretariat before publication.

SECRETARY,
Provincial Assembly of Khyber Pakhtunkhwa

E.No. PA/Khyber Pakhtunkhwa /Bills-29/2019/ 14101-08 Dated 4 /04/2019

A copy of the above is forwarded to:-

1. The Principal Secretary to Governor, Khyber Pakhtunkhwa.
2. The Secretary to Government of Khyber Pakhtunkhwa, Law Department.
3. The Secretary to Government of Khyber Pakhtunkhwa, Energy and Power Department.
4. The Director Information, Khyber Pakhtunkhwa.
5. The Director I.T/ Special Secretary Provincial Assembly of Khyber Pakhtunkhwa.

SECRETARY,
Provincial Assembly of Khyber Pakhtunkhwa

LIST OF COPIES TO BE DISTRIBUTED

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2.	The Secretary to Government of Khyber Pakhtunkhwa Law, Parliamentary Affairs and Human Rights Department.	5
3.	The Secretary to Government of Khyber Pakhtunkhwa, Energy and Power Department.	5

AN
ACT

further to amend the Pakhtunkhwa Energy Development Organization Act, 1993.

WHEREAS it is expedient further to amend the Pakhtunkhwa Energy Development Organization Act, 1993 (Khyber Pakhtunkhwa Act No. I of 1993), for the purposes hereinafter appearing;

It is hereby enacted as follows:

1. Short title and commencement.---(1) This Act may be called the Pakhtunkhwa Energy Development Organization (Amendment) Act, 2019.

(2) It shall come into force at once.

Asstt. Legal Drafter
Govt. of Khyber Pakhtunkhwa
Law Department
Peshawar

Amendment of section 18 of the Khyber Pakhtunkhwa Act No. I of 1993.---In the Pakhtunkhwa Energy Development Organization Act, 1993 (Khyber Pakhtunkhwa Act No. I of 1993), in section 18, for sub-section (2), the following shall be substituted, namely:

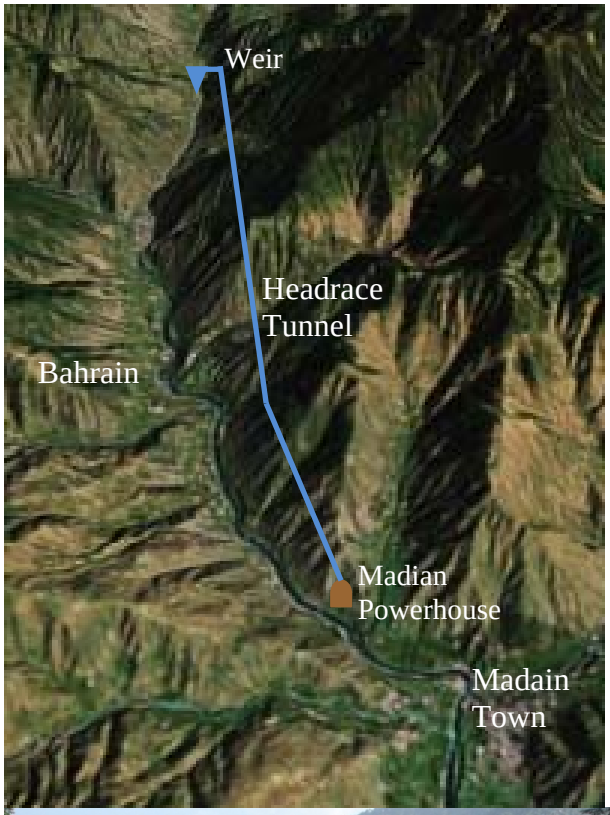
"(2) The Organization, with the prior approval of the Board, shall have the power to hand over power generation scheme or the part of the power plant of a multi-purpose scheme, having capacity not exceeding 2 MW, carried out by it, to any agency of Government, local body, community base organization, non-governmental organization or local community, as the case may be, in the best public interest, on such terms and conditions, as deemed appropriate by the Board.".

BY ORDER OF MR. SPEAKER
PROVINCIAL ASSEMBLY OF KHYBER PAKHTUNKHWA

(NASRULLAH KHAN KHATTAK)
Secretary
Provincial Assembly of Khyber Pakhtunkhwa

MADIAN
HYDRO POWER LIMITED

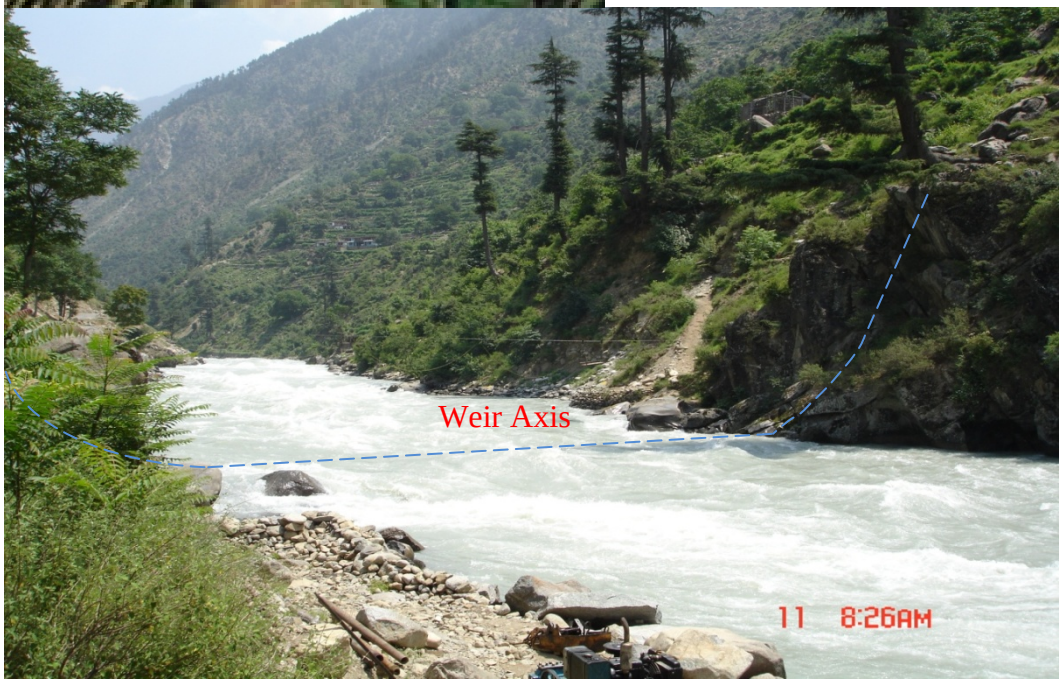
Feasibility Study for the Madian Hydropower Project



VOLUME I

EXECUTIVE SUMMARY

PROJECT SUMMARY



EXECUTIVE SUMMARY

0. Executive Summary

0.1 Introduction

The Ghulam Faruque Group has submitted an Expression of Interest to the Private Power & Infrastructure Board (PPIB) of the Ministry of Water & Power, Islamabad, for the development of the Madian Hydropower Plant in the Upper Swat Valley, on Swat River 60 km north of the town of Mingora. The Contract for conducting a bankable Feasibility Study was awarded to the German Consultant Fichtner GmbH to assess the technical, economic and environmental viability of the Project. Fichtner appointed Pakistan Engineering Service (PES), a local sub-consultant to assist in the elaboration of the feasibility study.

Comprehensive studies for the assessment of the hydropower potential of the Swat catchment area were carried out between 1990 and 1995 and updated in 2006 by the so called Cascade Study (MAES, Mirza Associates Engineering Services (PVT) Ltd) proposing the development of a cascade of the following five hydropower plants on the Swat Valley:

- Matiltan, 84 MW
- Gabral-Kalam, 101 MW
- Kalam-Asrit, 197 MW
- Asrit-Kedam, 209 MW
- **Madian, 148 MW (subject of this feasibility study)**

The project area is located in the Swat District, north of Madian Town. Madian Town is located at a distance of approximately 200 km from Peshawar, the capital of NWFP and 60 km from Mingora, the district headquarters of Swat Valley.

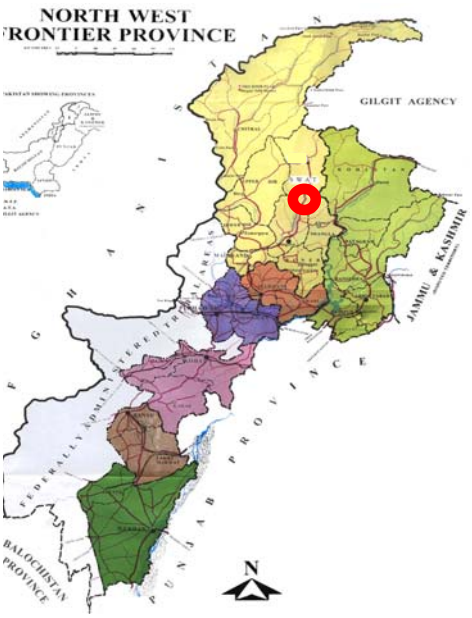


Figure 0.1
Map of Northwest Frontier Province (NWFP)

0.2 General Description of the Project Layout

The project concept is based on diversion of part of the flow of Swat River by means of a diversion weir and further through a system of power tunnels to the powerhouse where the water is returned to the Swat River some 14 km further downstream. By this concept some 154 m head can be obtained for power generation which permit a maximum available capacity ex generator of 157.3 MW and a mean annual energy generation of 767.5 GWh at a project cost of 371.9 million US$.

Table 0.1 shows the salient features of Project components.

Hydrological Features at Weir Site:		
Catchment Area	2,403	km²
Mean Annual Flow	118.5	m³/s
Diversion Design Flood	656	m³/s
$HQ_{1,000}$	1,450	m³/s
$HQ_{10,000}$	2,002	m³/s
Reservoir:		
Total Volume	480,000	m³
Normal Reservoir Operation Level	1494.0	m SoP
Max. Operation Level	1494.5	m SoP
Weir Structure:		
Crest Level of Weir	1496.0	m SoP
Max. Weir Height	18.0	m above river bed
Length of Weir Crest	77.0	m
Invert of Flushing Outlet	1477.0	m SoP
Spillway:		
Level of Spillway Crest	1482.5	m SoP
Number of Tainter Gates	3	
Width of Gate	7.6	m
Height of Gate	12	m
Desander:		
Design Discharge	129.0	m³/s
Design Particle Diameter	0.20	mm
Number of settling chambers	3	
Effective length of chamber	206.0	m w/o transition
Width of chamber	13.7	m
Average depth of chamber	16.8	m
Low-pressure Headrace Tunnel:		
Length	11.80	km
Net Diameter	7.00	m
Max. Flow velocity	3.35	m/s

Surge Tank:		
Diameter:	21.00	m
Height:	69.0	m
Pressure Shaft and High-Pressure Tunnel:		
Total length (shaft & tunnel)	180.3	m
Length of vertical shaft	120.8	m
Diameter	5.80	concrete lined
Flow velocity	4.88	m/s
Diameter	5.40	steel lined
Flow velocity	5.63	m/s
Steel lining	20 – 28	mm
Powerhouse:		
No. of units	3	Vertical Francis
Installed Capacity	3 x 60.8	MW
Available Capacity (ex transformer 3 units in operation)	3 x 52.43	MW
Max. Turbine Design Discharge	43.0	m^3/s
Cavern Width	20.0	m
Cavern Length	70.0	m
Turbine Setting	1336.0	m asl (SoP)
Electromechanical Equipment:		
No of Transformers	9	
Type of GIS Switchyard	SF6	
Voltage	220	KV
Tailrace Tunnel:		
Total length (w/ manifold)	93.6	m
Diameter	7.30	m
Diameter of manifold	4.20	concrete lined
Flow velocity	3.08	m/s
Additional Project Parameters:		
Mean Annual Energy Generation	767.5	GWh
Plant Factor	0.56	
Estimated Construction Costs	366,163	million US $
Total Project Costs	371.907	million US $

Table 0.1 : Salient Features of Project Components

0.3 Hydrological Conditions / Power Generation

The catchment area of Swat River at the weir site is 2,403 km^2. At the site of the Power House downstream of Kedam gauging station the catchment area is 2,842 km^2. For the assessment of the benefits from power generation, simulation of plant operation was carried out based on 47 years of historical daily river flow data (period 1961-2007 records of Kalam gauging station). Figure 0.2 below shows the flow duration curve and the annual pattern of flow of Swat River at the proposed weir site.

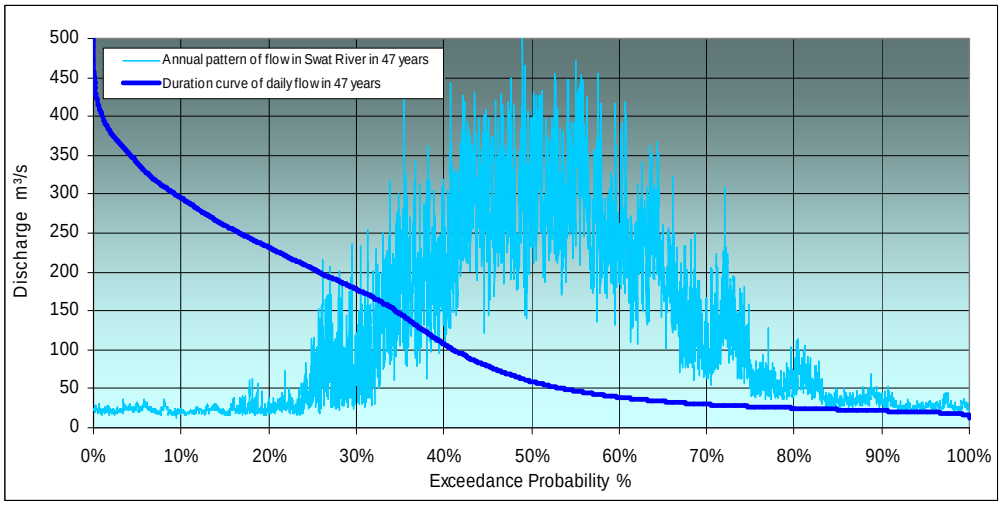


Figure 0.2: Weir Site, Flow Duration Curve

The simulation of Madian HPP operation reveals that the annual energy generation may vary between 688.4 and 851.9 GWh with an average of 767.5 GWh.

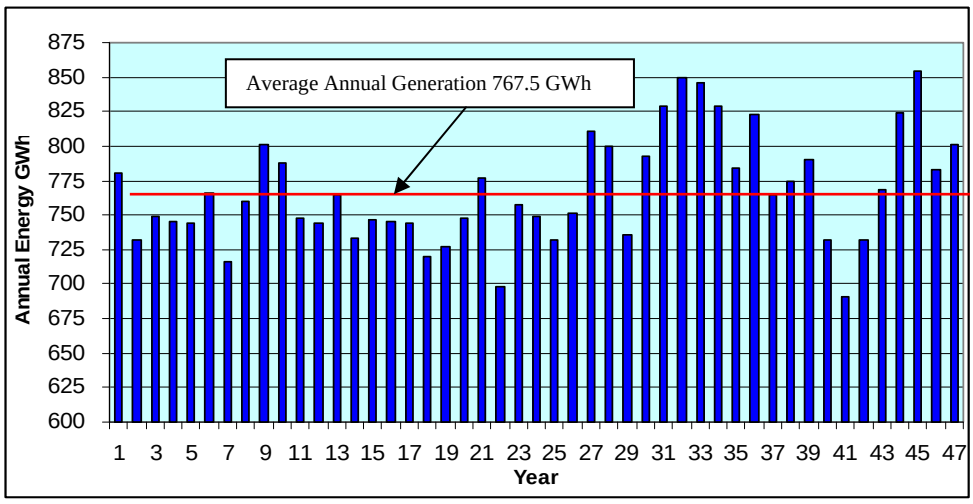


Figure 0.3: Variation of Annual Energy Generation of the Proposed Madian HPP

0.4 Cost Estimation

The project costs were estimated by the Consultant based on his experience in coordination with the Project Sponsor as the basis for the present Feasibility Study. The reference date applied to the present feasibility study is June 30th 2008, which corresponds to the end of the fiscal year 2008.

June 30th 2008 1 US$ = 67.98 Rps. (PAK)

Table 0.2: Basic Exchange Rate for Local to Foreign Currency

There is a large number of hydropower projects under development in Pakistan which provide a reasonable orientation for the plausibility of the calculated unit rates. The Consultant collected and analysed unit rates of civil works of hydropower projects that are to a reasonable extent similar in type and size to the Madian HPP. Based on the unit rates established in the Consultants unit cost data base and the detailed Bill of Quantity of the Project, the costs of the civil works were estimated as given in Table 0.3.

COST CATEGORY	Charges	Local 1000 US$	Foreign 1000 US$	Total 1000 US$	% of Total
CIVIL COSTS		78.998	106.361	185.359	50,6%
CONTINGENCIES	10,00%	7.900	10.636	18.536	5,1%
INDIRECT COST	25,00%	21.724	29.249	50.974	13,9%
ENGINEERING / ADMINISTRATION	6,00%	6.517	8.775	15.292	4,2%
SUBTOTAL CIVIL COSTS		115.139	155.022	270.161	73,8%
STEEL STRUCUTRE EQUIPMENT		4.735	7.209	11.944	3,3%
CONTINGENCIES	7,50%	355	541	896	0,2%
IMPORT CHARGES & FEES	7,00%	542	0	542	0,1%
ENGINEERING	3,00%	153	232	385	0,1%
SUBTOTAL STEEL STRUCTURE EQUIPMENT		5.786	7.982	13.768	3,8%
ELETRO-MECHANICAL EQUIPMENT		3.270	22.890	26.160	7,1%
CONTINGENCIES	7,50%	245	1.717	1.962	0,5%
IMPORT CHARGES & FEES	7,00%	1.722	0	1.722	0,5%
ENGINEERING	3,00%	105	738	844	0,2%
SUBTOTAL ELECTRO-MECH. EQUIPMENT		5.343	25.345	30.689	8,4%
ELECTRICAL EQUIPMENTS		5.492	38.447	43.940	12,0%
CONTINGENCIES	7,50%	412	2.884	3.295	0,9%
IMPORT CHARGES & FEES	7,00%	2.893	0	2.893	0,8%
ENGINEERING	3,00%	177	1.240	1.417	0,4%
SUBTOTAL ELECTRICAL EQUIPMENT		8.975	42.571	51.545	14,1%
SUBTOTAL w/o ENGINEERING		128.290	219.934	348.224	95,1%
SUBTOTAL		**135.243**	**230.920**	**366.163**	**100,0%**
EIA MITIGATION AND RESETTLEMENT		2.134	0	2.134	0,6%
OWNERS OWN COST	1,00%	1.301	2.309	3.610	1,0%
TOTAL		**138.678**	**233.229**	**371.907**	**101,6%**

Table 0.3 : Summary of costs of the Madian Hydropower Project at level of prices June 30, 2008

0.5 Social and Environmental Impact Assessment

Following national and international requirements, an Environmental Impact Assessment (EIA) and a Resettlement Action Plan (RAP) were prepared for the Madian Hydropower Project, both as stand alone report which form Volume VI of the Feasibility Study Report:

Construction Phase
From the findings of the study as summarised above it can be concluded that a significant negative impact only results from the deposition of excavated material. The amount of excavated material affects several environmental aspects as there are traffic, air quality, noise, landscape, terrestrial fauna and flora etc. Regarding these aspects, however, mitigation measures are possible. Concerning socio-economic aspects, the impacts of the Project are locally and regionally positive.

Operational Phase
During to operational phase no high negative impacts will occur. Main focus in the assessment is given on the ecology of the Swat River. It can be stated that the river ecology will be subject to certain changes. A 1.5 km long river reach will be converted into a lake (reservoir), in the downstream located 13 km long river reach the discharge will be reduced with all its consequences for the ecology. Regarding water-borne vector diseases, the Project may cause medium impacts. For all other aspects during the operational phase the impacts of the Project will be low negative or even nil.

Land Acquisition
Project implementation will need acquisition of a total 39.438 ha land (state land, farmland, wasteland). Out of this total, 36.638 ha will be acquired on permanent basis and the remaining 2.800 ha on lease for 5 years.

Affected Houses
Only 15 houses with a total of 176 persons will be directly affected by the Project. With reference to the type of construction all houses are category C houses except 1 which is of category B. (Type B Houses: Masonry in cement mortar, timber roof; Type C Houses: Stone in mud mortar with timber roof)

Affected Persons
Only 176 persons will be directly affected because parts of their farmland/wasteland/river bed will be acquired permanently or temporarily for project implementation. The Resettlement Plan is elaborated in accordance with World Bank/IFC policy guidelines.

Affected Trees
A total of 1,423 trees will be felled. Thereof, 950 are fruit trees and 473 are firewood and timber trees.

For the Madian Hydropower Project the aspects of both extent of population displacement and loss of land, particularly farmland, are not significant. Also, the affected persons, without any exception, have readily and willingly opted for cash compensation as they all intend to start business ventures by using this cash. It is hard to find replacement land in the project area. Besides, “land-for-land” strategy, according to World Bank/IFC practice, has remained a difficult policy to implement. The strategy for income restoration of affected persons, therefore, should be based on training programmes in terms of small business, computer skills, health care technology and education.

The resettlement budget consists of costs for permanent land acquisition, temporary land acquisition, compensation for lost assets including houses and trees and costs to be increased on hiring resettlement expertise. The replacement cost of land is based on current market prices. The market value was assessed on the basis of recent transactions and consultation with the affected persons and other community members. Total resettlement cost is estimated as Rs. 129.385 million.

Within the project cycle, the implementation schedule, covering a period of 5 years plus the pre-project period, provides the time frame for commencement and completion of the resettlement activities. These activities include community consultants, site demarcation, resettlement training workshop, payment of compensation grievance redress, taking over of land and other assets, construction work, return of temporarily acquired land and monitoring and evaluation.

0.6 Further Steps for Project Implementation

Project implementation consists of the three following main stages:

- Stage I: Pre-Construction Activities/Tendering
- Stage II: Construction Works
- Stage III: Commissioning, Testing and Training

The implementation schedule was prepared with the assumption that the Project will be implemented as a turnkey project (EPC-Contract). Thus, the detailed design engineering will be carried out under the responsibility of the general contractor and will not be part of the pre-tender process.

After the approval of the Feasibility Study by PPIB and POE, the preparation of tender documents is scheduled to start. During or even ahead of the preparation of the tender documents some additional technical activities are required such as hydraulic model tests in particular of the weir structure with power intake and flushing structure.

The preparation of the tender documents consists mainly of the preparation of general and particular (technical) specifications of all project components, the preparation of the tender documents, pre-qualification of contractors and manufacturers, floating of tenders, evaluation of bids and finally the contract negotiations with the contractor and the contract negotiations for the power purchase agreement (PPA). A period of 24 months needs to be considered for these activities which shall be completed by early 2011. The turbine-generator units need be ordered as soon as possible after the contract has been signed, as a period of 24 months shall be considered for the designing and manufacturing of the units. Erection is expected to take a period of approximately 12 to 18 months for all three units. The design and manufacturing of the hydraulic steel structures for weir, intake, desander caverns, surge tank and powerhouse will be carried out more or less simultaneously to that of the turbine generator units in a 12 months period. 18 month are considered for design and manufacturing the remaining electrical equipment. After the award of contract, the mobilization and site installation is considered to be done within a three months period. Detailed design engineering and preparation of the construction design drawings will commence together with the mobilisation of the contractor and will accompany the construction works till completion.

The preliminary implementation period of Madian Hydropower Project which covers a total period of 102 month, can be summarized as follows:

- **Phase I: Pre-Construction Activities**

Start: first quarter of the year 2007
Period: 48 month
End: first quarter of the year 2011

- **Phase II: Construction Work**

Start: first quarter of the year 2011
Period: 54 month
End: end of second quarter of the year 2015

- **Phase III: Testing and Commissioning**

Start: first quarter of the year 2015
Period: 4 month
End: end of second quarter of the year 2015

- **Commercial Operation of the Plant: mid 2015**

The above given period for construction and implementation of the Project is a so-called minimum requirement and based on the assumption that an experienced and qualified contractor executes the works without being affected by any type of political destabilization or other security relevant incidents which have occurred in the project area in the past years.

0.7 Project Costs and Project Benefits

The construction costs of the Project amount to US$ 366.2 million. Adding environmental and owner's cost, total project costs amount to US$ 371.9 million. An estimated 63% of the total cost is incurred in foreign and 37% in local currency. Including financing fees and interest during construction, total financing requirements are estimated at US$ 438.4 million. The Reference Date for this cost estimate is June 30, 2008.

Item	US$ '000
Civil Works	270,161
Steel structure equipment	13,768
Electro-mechanical equipment	30,689
Electrical equipment	51,545
Subtotal construction cost	**366,163**
EIA mitigation and resettlement	2,134
Subtotal with EIA cost	**368,297**
Owner's cost	3,610
Total project cost	**371,907**
Interest during construction	58,354
Financing fees	8,098
Subtotal financing cost	66,453
Total financing requirements	**438,359**

Table 0.4 : Project cost at Reference Date

The project requires a levelized tariff of 8.92 US cents/kWh to provide the investor with a return on equity of 20% which reflects the risks associated with the project. Since the CPP matches the debt service profile, the project has a healthy cash flow during the loan term with an average debt service coverage ratio of 1.56. The financial internal rate of return of the project at the proposed tariff is 13.5%. The uncertainty of future price developments and the associated financial risk make it necessary to provide for tariff adjustments once the final project costs and financing parameters are known.

Item	Unit	Parameter
Contracted capacity	MW	157.3
Annual generation (considering scheduled outages)	GWh	742.5
Project cost	US$'000	371.9
Total financing requirements	US$'000	438.4
EIRR	%	15.8
Economic NPV	US$'000	182.7
Economic B/C ratio	-	1.66
Levelized tariff	USc/kWh	8.92
EPP	USc/kWh	3.03
CPP (levelized)	USc/kWh	5.89
CPP - First year	US$/kW/m	38.29
CPP - after debt service	US$/kW/m	5.22
Share of CPP	% of lev. tariff	66%
FIRR		13.5%
NPV (at disc rate 12%)	US$ '000	80,841
Return on Equity (ROE)	%	20.0%
Min. DSCR	-	1.27
Max. DSCR	-	1.76

Table 0.5 : Summary of results

0.8 Conclusions and Recommendations

The Madian HPP is a run-of river hydropower project based on the concept of diverting flow from Swat River near Kedam village and exploiting the gradient of the Swat River of 11 m per km on average over a 13 km long river reach. By this concept some 154 m head can be obtained for power generation which permit a maximum available capacity ex transformer of 157.3 MW and a mean annual energy generation of 767 GWh at a project cost of 371.9 million US$.

The design of alternative project layouts and the finally preferred alternative for the Madian HPP were elaborated considering site specific conditions derived from the detailed geotechnical field and laboratory investigations as well as the topographic survey. The Project and its components were optimized applying unit rates which were verified with local and international market prices and rates of similar projects under development.

The Consultant analysed the economic feasibility of the project in comparison with alternative thermal power generation and determined the Economic Internal Rate of Return of the Project being 15.8 % and the Benefit Cost ratio of 1.66. The Consultant conducted a sensitivity and risk analysis which verified that the Madian HPP is economically feasible even under adverse conditions such as higher investment cost and unfavourable hydrological conditions.

In the financial analysis the Consultant considered the legal and institutional framework for development of hydropower projects by private investors in Pakistan which is in the process of being established. Pursuant to NEPRA's Tariff Standards and Procedure Rules a model for calculation of the power tariff was developed that permits the licensee to recover the costs incurred for power generation as well as provide a reasonable rate of return on the investment which reflects the risks assumed by the investor.

The present Feasibility Study of the Madian Hydropower Project serves to answer three key questions:

(1) **Technical Feasibility**:
Is the project technically feasible under consideration of the prevailing hydrological, topographic, geological, infrastructure, environmental and socio-economic boundary conditions?

(2) **Economic Feasibility**:
Is the project beneficial for the economy of Pakistan?

(3) **Financial Viability**:
Is the project profitable for the investor?

The three above stipulated aspects have been analysed at the required level of detail in this Feasibility Study. The first two questions can be clearly answered with: Yes, Madian Hydropower Project is feasible and it is worth to continue developing the Project till implementation.

Concluding statements regarding the third question can be given only when the Project Sponsor and the Power Purchaser have reached on the respective agreements. The potential that such an agreement can be beneficial for both parties has been demonstrated in this Feasibility Study.

PROJECT SUMMARY

1. Introduction

The Ghulam Faruque Group has submitted an Expression of Interest to the Private Power & Infrastructure Board (PPIB) of the Ministry of Water & Power, Islamabad, for the development of the Madian Hydropower Plant in the Upper Swat Valley, on Swat River 60 km north of the town of Mingora. The Contract for conducting a bankable Feasibility Study was awarded to the German Consultant Fichtner GmbH to assess the technical, economic and environmental viability of the Project. Fichtner appointed Pakistan Engineering Service (PES), a local sub-consultant to assist in the elaboration of the feasibility study.

1.1 Scope of Work

The scope of the study is in brief as follows:

Phase I: Pre-Feasibility Study

- To review the previous work which had been done,
- To obtain any data deemed relevant by the Consultant,
- To assess the site conditions,
- To identify and compare any alternatives,
- To prepare a new topographic survey of the project area.
- To establish the long term hydrological basis for the Project.
- To produce a preliminary geological/geo-technical model of the Project.
- To carry out preliminary engineering studies comprising the power potential and determination of design capacity.
- To prepare preliminary layouts and designs, cost estimates, a financial / economic assessment together with a tariff calculation,

Phase II Feasibility Study of the Preferred Alternative

- To define the controlling topographic, hydrologic, sedimentological and geotechnical parameters for the design of the project,
- To carry out detailed geological mapping and detailed ground investigations, comprising seismic refraction, sub-surface drillings, investigation pits and laboratory tests.
- To review and optimize the layout and design of the selected alternative.
- To assess the Project in the context of the cascade scheme.
- To make an environmental and social impact assessment,
- To prepare a detailed cost estimate and calculate the total construction / implementation costs.
- To carry out a risk analysis indicating the technical, economical and financial viability of the proposed scheme, and
- To evaluate the financial and economic characteristics, and determine the tariff.

Phase III

- To present the draft Bankable Feasibility Study to the POE and PPIB.
- To review and complete the final Bankable Feasibility Study.

1.2 Previous Works

Comprehensive studies for assessment of the hydropower potential of the Swat catchment area were carried out between 1990 and 1995 and updated in 2006 by the so called Cascade Study (MAES, Mirza Associates Engineering Services (PVT) Ltd) proposing the development a cascade of five hydropower plants on the Swat Valley:

- Matiltan, 84 MW
- Gabral – Kalam, 101 MW
- Kalam-Asrit, 197 MW
- Asrit-Kedam, 209 MW
- Madian, 148 MW (subject of this feasibility study)

1.3 Objectives of the Feasibility Study Report

During Phase I of the Feasibility Study, layout alternatives of the Madian Hydropower Project were identified and studied on comparative basis. At the beginning of Phase II – Feasibility Study the Private Power & Infrastructure Board (PPIB) established the boundary conditions for the co-ordinated development of the hydropower projects on Swat River, the Asrit-Kedam and the downstream located Madian Hydropower Project (HPP).

The selected project concept of Madian HPP was adjusted to these boundary conditions and the preferred project layout designed at feasibility level. In accordance with the Terms of Reference for this Feasibility Study a design of the Madian Hydropower Project has been developed according to international best practice ensuring a reliable, sustainable and economical design of structures and equipment which complies with the best international hydroelectric engineering practice.

This Feasibility Report consists of the following seven volumes:

Volume I: Executive Summary

Volume II: Main Report (this Report)

Volume III: Report on Geology and Geological Field Investigations

Volume IV: Hydro-Meteorological Data Base

Volume V: Report on Topographic Survey

Volume VI: Environmental Impact Assessment Study and Resettlement Action Plan

Volume VII: Drawing Album

2. Location of Project and Integrated Development

2.1 General

The project area is located in the Swat District, north of Madian Town. Madian Town is located at a distance of approximately 200 km from Peshawar, the capital of NWFP and 60 km from Mingora, the district headquarters of Swat Valley.

Swat is one of the twelve districts constituting the NWFP of Pakistan. The highest administrative authority is the Deputy Commissioner / District Coordination Officer, who is assisted by three Assistant Commissioners for Alpuri, Daggar and Swat Sub-Divisions.

2.2 Project Area and Integrated Development

The Private Power & Infrastructure Board (PPIB) issued licenses to private investors for development of hydropower projects on Swat River and supervises the coordinated development of the projects. At present the hydropower projects Kalam – Asrit, Asrit – Kedam and Madian along Swat River are under development in parallel whereas work on the Gabral – Kalam Hydropower Project (HPP) was suspended.

The proposed weir site of Madian HPP is located on the Swat River some 14 km and the powerhouse just 1.2 km north of Madian town where the approximately 35 km long V-shaped gorge section of the Swat River ends.

On 12th September 2007 PPIB clarified the boundary conditions for the co-ordinated development of the Madian HPP and the upstream located Asrit-Kedam HPP. The corresponding normal reservoir operation (NOL) level for the Madian HPP is 1494.4 m asl (SoP).

Based on a NOL of 1494 and the minimum water level at the selected power outlet some 1.2 km north of Madian town of 1339.6 m asl, a maximum gross head of 154.4 m is available for power generation.

2.3 General Description of the Project Layout

The project concept is based on diversion of part of the flow from Swat River by means of a diversion weir and further through a system of power tunnels to the powerhouse where the water is returned to the Swat River some 14 km further downstream.

The mean annual river flow of Swat River is 118.5 m³/s at the selected weir site. River flow varies considerable around the year characterized by a high flow period (May to September) and low flow period (December to March).

In an average hydrological year such as e.g. the year 1995, daily river flow varied between 18.5 and 447.6 m³/s around the mean value of 118.5 m³/s.

Diversion of river flow is arranged by means of a 19 m high concrete weir structure upstream of the confluence with Kedam Nullah (stream). In the central part of the weir structure a spillway with 3 tainter gates is arranged discharging into a concrete stilling basin. At the left bank adjacent to the power intake two flushing outlets are foreseen to evacuate sediments that may deposit in front of the power intake.

During the high flow season in summer the sediment concentration in the river flow increases and may reach up to 4000 g/m³ in an average year. The suspended sediments consist largely of clay and silt fractions, however, it consists in addition of some 25 % of fine sand including quartz minerals.
At the moment it cannot be assumed with sufficient reliability that the upstream located hydropower projects are in operation when the Madian HPP is commissioned. Therefore, the Project Sponsor in co-ordination with PPIB decided to develop the Madian HPP as stand-alone run-of river project with its own independent desanding facilities.

For diversion of the Swat River during construction of the weir with stilling basin and power intake, conventional diversion works are designed. The diversion works consist of a conventional upstream rock fill cofferdam sealed by jet grouting, a bore pile wall downstream cofferdam to be transformed in the stilling basin end sill and a diversion tunnel. The existing Madian-Kalam road will be relocated over a length of approximately 250 m

The headrace tunnel starts at the power intake and has a length of 11.8 km. Its alignment was selected for conventional drill and blast excavation method nearly parallel to the Swat River. Three adits are planned to ensure tunnel construction within a reasonable period. The desanding facilities are arranged 2.1 km downstream of the weir and consist of three desanding caverns with the corresponding ducts and gates for evacuation of sediments.

At the downstream end of the low pressure headrace tunnel a surge tank is designed to limit pressure rise in the headrace tunnel and ensure the required flexibility of the hydropower plant in operation. A vertical pressure shaft leads the flow to the elevation of the three Francis turbine units arranged in an underground powerhouse. The steel lined pressure tunnel and manifolds are kept short to achieve an economic design. Transformer and Switchyard are arranged underground as well in a cavern parallel and at 30 m distance from the powerhouse cavern. From the powerhouse cavern a short tailrace tunnel releases the flow back to Swat River. Table 2.1 presents the salient features of the Madian Hydropower Project.

Hydrological Features at Weir Site:		
Catchment Area	2,403	km²
Mean Annual Flow	118.5	m³/s
Diversion Flood	656	m³/s
$HQ_{1,000}$	1,450	m³/s
$HQ_{10,000}$	2,002	m³/s
Reservoir:		
Total Volume	480,000	m³
Normal Reservoir Operation Level	1494.0	m SoP
Max. Operation Level	1994.5	m SoP
Weir Structure:		
Crest Level of Weir	1496.0	m SoP
Max. Weir Height	18.0	m above river bed
Length of Weir Crest	77.0	m
Invert of Flushing Outlet	1477.0	m SoP
Spillway:		
Level of Spillway Crest	1482.5	m SoP
Number of Tainter Gates	3	
Width of Gate	7.6	m
Height of Gate	12	m
Desander:		
Design Discharge	129.0	m³/s
Design Particle Diameter	0.20	mm
Number of settling chambers	3	
Effective length of chamber	206.0	m w/o transition
Width of chamber	13.7	m
Average depth of chamber	16.8	m
Low-pressure Headrace Tunnel:		
Length	11.80	km
Net Diameter	7.00	m
Max. Flow velocity	3.35	m/s
Surge Tank:		
Diameter:	21.00	m
Height:	69.0	m
Pressure Shaft and High-Pressure Tunnel:		
Total length (shaft & tunnel)	180.3	m
Length of vertical shaft	120.8	m
Diameter	5.80	concrete lined
Flow velocity	4.88	m/s
Diameter	5.40	steel lined
Flow velocity	5.63	m/s
Steel lining	20 – 28	mm

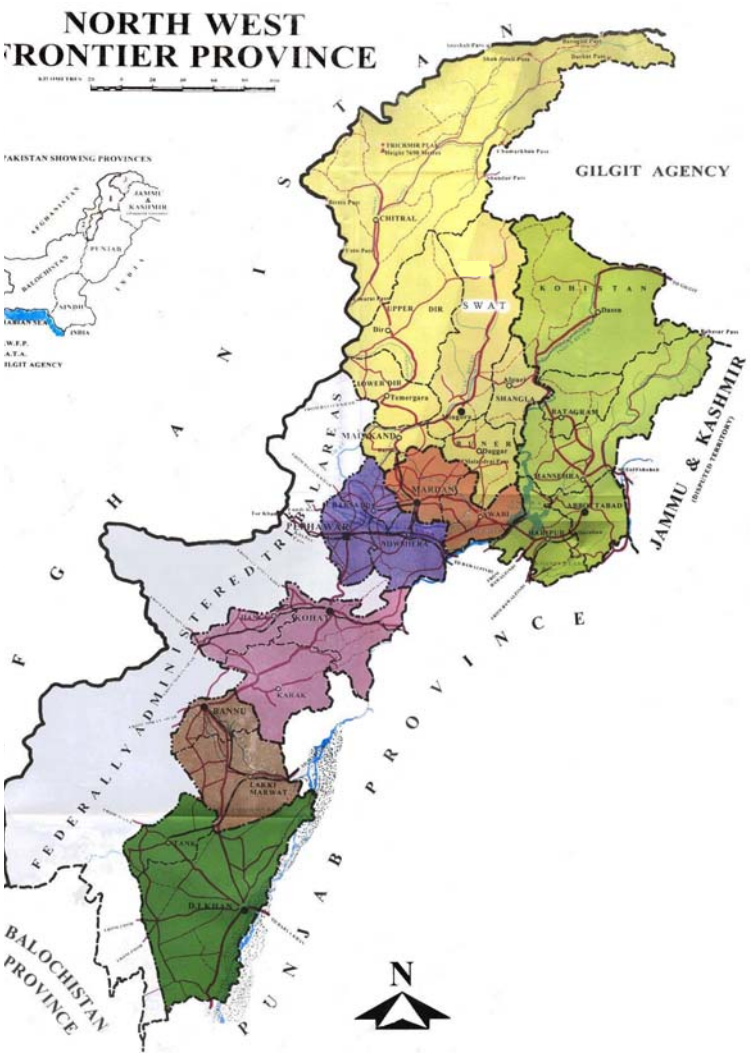
Powerhouse:		
No. of units	3	Vertical Francis
Installed Capacity	3 x 60.8	MW
Available Capacity (ex transformer 3 units in operation)	3 x 52.43	MW
Max. Turbine Design Discharge	43.0	m³/s
Cavern Width	20.0	m
Cavern Length	70.0	m
Turbine Setting	1336.0	m asl (SoP)
Electromechanical Equipment:		
No of Transformers	9	
Type of GIS Switchyard	SF6	
Voltage	220	KV
Tailrace Tunnel:		
Total length (w/ manifold)	93.6	m
Diameter	7.30	m
Diameter of manifold	4.20	concrete lined
Flow velocity	3.08	m/s
Additional Project Parameters:		
Mean Annual Energy	767.5	GWh
Plant Factor	0.56	
Estimated Construction Costs	366,163	1000 US $

Table 2.1 Salient Features of Project Components

3. Physical Conditions for Project Development

3.1 Location of Project Area

The Madian Hydropower Project (HPP) is located in the north of Northwest Frontier Province (NWFP) of Pakistan. The Province is surrounded by Northern Areas of Pakistan in the North, Kashmir in the East, Punjab Province of Pakistan in the Southeast, Balochistan Province in the Southwest and Afghanistan in the West, see Figure 3.1.



The area of the project is located in the Swat District, somewhat north of Madian Town, the tail of the national grid on the Swat River.

3.2 Hydrology and Sedimentation

Hydrologic information relevant for the hydropower project area and available in the Swat valley includes Kalam and Chakdara on the Swat River. Both stations are operated by Surface Water Hydrology Project (SWHP). Additional hydrological stations were installed by the Project Sponsor Madian Hydro Power Ltd. on the Swat River in 2006 at Kedam and Ramet on Swat River close to the weir site.

Code	Station	River	Coordinates		Catchment Area (km^2)	Elevation (m asl)	Record	
			Lat	Long			Start	End
35724502	Kalam	Swat	352810	723540	2,012	1921	1961	2007
35722503	Ramet	Swat	351640	723550	2,365	1585	2006	2008
35722504	Kedam Nullah	Kedam	351505	723508	55	1541	2006	2008
35722505	Kedam	Swat	351455	723505	2,529	1500	2006	2008
35726002	Chakdara	Swat	352915	723545	5,776	1951	1992	2006

Table 3.1: Hydrological Stations

Precipitation Regime

The precipitation regime in the Swat Valley is dominated by the occurrence of eastward moving extra tropical zones of low pressure, known locally as Western Disturbances, which bring humidity to the Swat catchment from the Atlantic Ocean and the Mediterranean Sea.

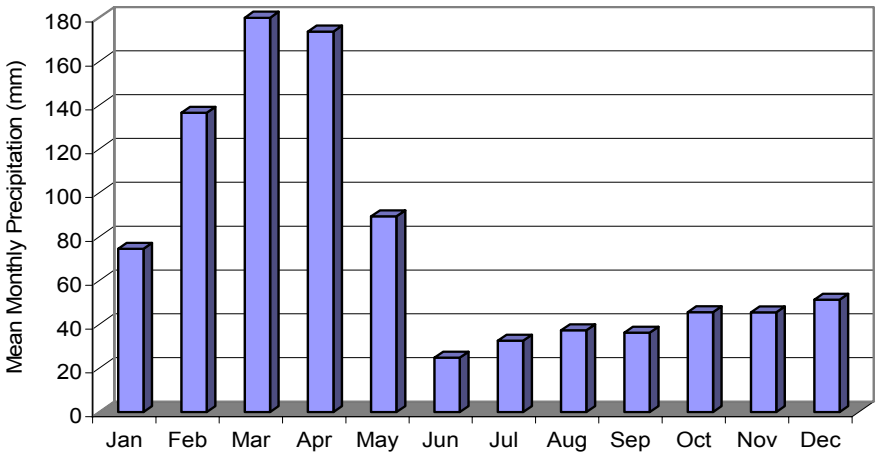


Figure 3.2: Kalam, Monthly Precipitation (1963-2006)

Temperature Regime

The Flows in upper Swat River are mostly snowmelt generated. It can be expected that largest flows occur during the summer period since precipitation in the winter season is largely in the form of snow. A combination of large precipitation in winter followed by high temperatures in summer, produce floods and large base flows.

The weir site is located downstream of the gauging station Ramet. The catchment area at the weir site is 2,403 km^2. At the site of the Power House downstream of Kedam gauging station the catchment area is 2,842 km^2, compared to 2,529 km^2 at Kedam.

Period	Flows (m^3/s)	
	Weir	**Power House**
Jan	23.57	28.52
Feb	21.61	26.26
Mar	27.17	32.40
Apr	78.72	88.35
May	191.70	234.14
Jun	298.38	431.69
Jul	302.92	440.34
Aug	227.33	291.51
Sep	128.84	143.36
Oct	57.45	65.07
Nov	36.40	42.56
Dec	27.81	33.21
Annual	**118.49**	**154.78**

Table 3.2: Mean Monthly Flows at Weir Site and Power House

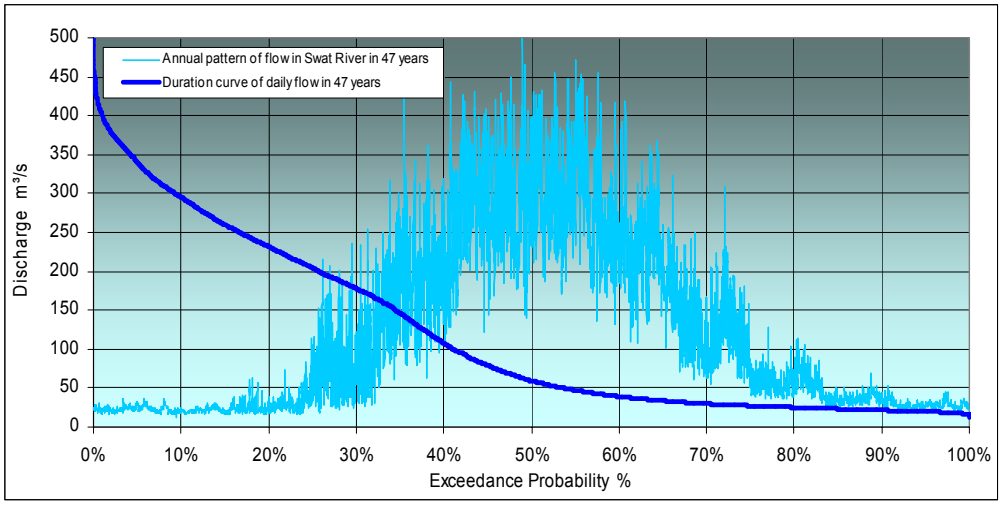


Figure 3.7: Weir Site, Flow Duration Curve

Maximum annual floods in the Upper Swat catchment have been recorded for the last 46 years at Kalam (1961-2006). The recorded maximum floods have a regular pattern and occur between May and July. The maximum floods recorded at Kalam are originated by snowmelt.

In September 1992 a large and deep low pressure front moved from the Indian Ocean and reached the north of Pakistan. At the same time, a Western Disturbance moved to the east, across the Swat and Upper Indus catchments. The run-off was the largest recorded at Kalam.

The event of 1992 demonstrated that rainfall can produce a significantly larger amount of run-off than snowmelt in the Upper Swat catchment and consequently may affect the site of the hydropower project. For a complete analysis of maximum floods in the Swat catchment, both floods of snowmelt and rainfall origin were analyzed.

3.2.1 Design Floods

Table 3.3 shows the maximum values determined in the flood analysis
.

Return Period	Maximum Floods (m^3/s)	
	Weir Site	Power H
2	445	502
5	530	596
10	587	659
20	656	731
50	712	796
100	860	1,065
1,000	1,450	1,785
10,000	2,002	2,405

Table 3.3: Design Floods for Madian Weir and Powerhouse Sites

From the results of the flood studies, it is concluded that the floods from snowmelt origin are relevant for the short periods of return, while for the larger periods of return, the floods estimated with the precipitation run-off model are more critical.

3.2.2 Suspended Sediment

For estimation of suspended sediments, series of data on sediment concentrations are available from the sites at Kalam, Kedam and Ramet. The relation between river flow and sediment transport for the gauging stations at Kalam and Kedam is shown in Figure 3.4. The solid curve in Figure 3.4 represents the mean rate of suspended sediment transport, while the dashed line represents a high estimate relevant for the required capacity of the desanding facilities.

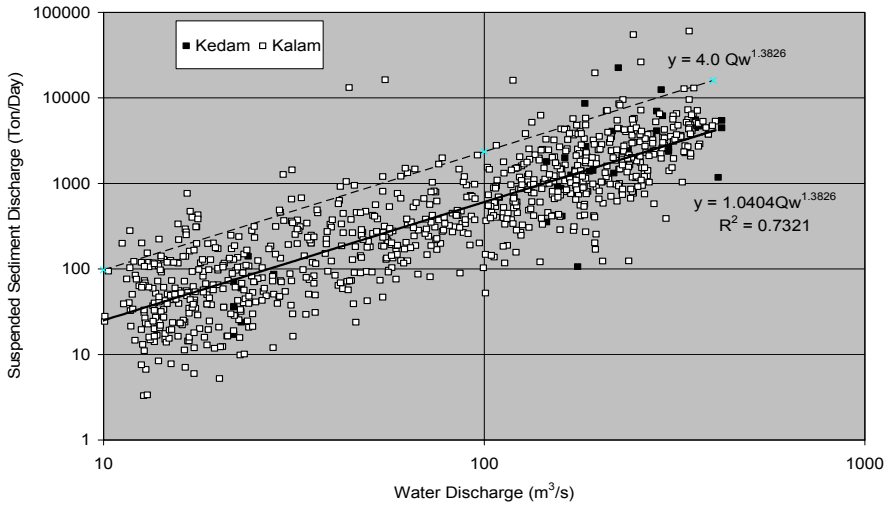


Figure 3.4: Suspended Sediment Concentration versus River flow at Swat River

3.3 Topography

This chapter summarizes the methodology applied, activities carried out and results obtained in the topographic survey for the Madian Hydropower Project which are presented in detail in Volume V of this Feasibility Report.

3.3.1 Scope of Work

Survey work sets the standard to which accurate and meaningful engineering designs can be achieved. It is important that all survey work of a project is carried out systematically and accurately in one uniform system of co-ordinates and elevations. A comprehensive topographic survey program was setup and executed by qualified subcontractors.

- Setup a project trigonometric network with a system of benchmarks
- Digital satellite based survey of the project area (DGPS) including the survey of benchmarks of the System of Pakistan (SoP) and Ground control Points (GCP)
- Terrestrial topographic survey of the area of the major project components such as
  - Weir site and reservoir area
  - Powerhouse and switchyard area
  - Area of adits for headrace tunnel construction and adjacent sites for dumping excess construction material
- Terrestrial topographic survey of river cross sections
  - In the reservoir area
  - upstream and downstream of weir site
  - upstream and downstream of powerhouse site
- Terrestrial topographic survey of lines of geophysical survey
- Terrestrial topographic survey of bore hole locations

The project area has a north-south extension from Madian town to Kedam village, i.e. from powerhouse site to the upstream boundary of the reservoir of approximately 15 km length. The large distance in combination with difficult conditions to access the steep and high valley of the Swat River with numerous deep cut in tributaries (nullahs) made a conventional terrestrial survey of the entire project area practically impossible. Therefore, the Consultant applied a combined approach comprising of a satellite imaginary based DGPS survey of the entire project area and conventional terrestrial survey of the area of the main project structures.

The terrestrial survey commenced in the early stage of the pre-feasibility study on 21.03.2007. The terrestrial survey work was carried out by a local sub-contractor in assistance with the Consultants topographer.

Traverse Survey
For horizontal and vertical reference of the terrestrial topographic survey for the Madian HPP closed loop traverse surveys were conducted. The traverse

survey started and ended at SoP BM Madian and followed the Madian - Kalam Road towards Khaluli.

- Closed loop traverse survey connecting the SoP-Benchmarks Madian and Khaluli (July/August 2007)
- Closed loop traverse survey covering all permanent benchmarks and connection all terrestrial surveyed areas within the project area. The traverse started and ended at SoP BM Madian (March/April 2008).

The terrestrial survey works comprised the following areas:

Weir Site/Reservoir Area:

- 45 river cross sections covering the weir site, the reservoir area and the river reach downstream of the weir site including Kedam gauging station and Kedam bridge
- 20 hectares of survey covering the following permanent project components
  - Weir, reservoir area
  - upstream and downstream cofferdams
  - diversion tunnel including intake and outlet
  - power intake

Power House Site:

- 26 river cross-sections between powerhouse sites and Madian town
- 53 hectares of survey covering the following permanent project components
  - surge tank
  - pressure shaft
  - powerhouse and power outlet
  - camp area and dumping site

Headrace Tunnel / Construction Adits:

- 2 hectares at access to desander caverns, area of tunnel portal of adit No. 1 and adjacent dumping site
- 15 hectares at area of tunnel portal of adit No. 2 and adjacent dumping areas
- 4 hectares at tunnel portal adit No. 3 and adjacent dumping areas
- Survey of side valleys to support the alignment and the design of the headrace tunnel;

Altogether 71 River cross sections of the Swat River were surveyed in two survey campaigns in March/April 2007 and in March 2008. The locations and spacing of the river cross-sections were carefully selected to meet the requirements of the corresponding hydraulic analysis.

Madian HPP Benchmarks – Trigonometric Network

For the Madian HPP a triangulation network based on SoP-coordinates was established in the project area. The system comprises of 8 concrete monuments covering the Swat valley between Madian and Kedam and including the SoP Benchmark Madian. All concrete monuments were tied to the SoP system based on the traverse between SoP BM Madian and Khaluli

and the corresponding surveyed closed loop traverse. The construction of the concrete monuments was carried according to the standards of SoP.

Figure 3.5: DGPS-Survey of SoP-Benchmarks in Swat Area at Madian (left) and Kalam in February 2008.

3.3.2 Results of Topographic Survey

The Consultant elaborated a Digital Terrain Model (DTM) of the entire project area in close cooperation with his German subcontractor TRIGIS. The DTM covers the town of Madian in the south and extends approx. 5 km north of the weir site. The extent of the DTM is as follows:

Area covered: 107.005 km²
Extension SW – NE 20.009 km

The locations and elevations of points of geotechnical investigations such as seismic refraction survey (SRS) and electric resistivity survey (ERS) lines were surveyed by the Consultant's sub-contractor T&M using a total station. Altogether 5950 m of survey lines comprising of hundreds of points were recorded in the field.

For the area of the major structural components of the Madian HPP a standard terrestrial topographic survey was conducted by the Consultant's sub-contractor T&M. With regard to published SoP elevations the closed loop survey achieved the following values indicating a deviation of 0.01 m as shown below:

Benchmark:	SBM Madian	–	SBM Khaluli
Recorded Elevation	1349.88 m		1643.98 m
SoP published Elevation	1349.88 m		1643.97 m

It can be concluded that the accuracy achieved meets the requirements of a bankable feasibility study.

3.4 Geology and Seismology

Upon completion of the pre-feasibility study of the Madian HPP the Consultant elaborated a comprehensive field investigation program, prepared the corresponding contract documents and initiated contract negotiation with pre-qualified contractors in July/August 2007.

3.4.1 Program for Geotechnical Field Investigations

As a brief summary the scope of work conducted for the Feasibility Study of the Madian HPP comprises the following activities:

- Description and assessment of regional geology and tectonics
- Analysis of historic seismic activities, assessment of satellite images and assessment of seismic hazard risks
- Elaborate, conduct & supervise a geotechnical field investigation program, adjust it to the site and design specific requirements consisting of
  - Seismic Refraction Survey (SRS) and Electric Resistivity Survey (ERS); interpret results for design purposes
  - Core drilling at 16 bore holes in total, permeability testing, installation of piezometers for ground water table monitoring and interpret results for design purposes.
  - Geological Mapping including joint orientation measurements, scan line surveys etc.
- Elaborate, conduct, supervise a comprehensive program for Laboratory analysis and interpret results for design purposes,

The locations of boreholes for core drilling were defined for those spots where detailed knowledge on the surface of the rock, its strength, jointing, weathering and permeability are of utmost importance for the project design

At the weir site the Consultant defined a total of 8 boreholes, at the powerhouse a total of 5 boreholes and along the headrace tunnel alignment a total of 3 boreholes in the vicinity of the foreseen construction adits:

The data gathered from the individual boreholes were recorded in special bore-logs supplemented by photos of the core boxes, statistics on joint characteristics, weathering of joints, assessment of fragmentation of rock (in terms of RQD) and its permeability. Water pressure tests were carried out in nearly all bore holes and in a total of 11 boreholes piezometers were installed for a continued monitoring of the groundwater tables.

The geophysical survey represents together with the geological site reconnaissance the first step of geotechnical field investigation activities before start of core drilling. At the weir site the Consultant defined a total of 10 seismic refraction survey lines, at the powerhouse a total of 7 seismic refraction and 5 electric resistivity survey lines.

Sr. No.	Hole No.	Location	Coordinates		Depth (m)	Packer Test	Piezometer Instalation
			East (m)	North (m)			
1	MWD1	Weir site/R. Abut.	3,160,764	1,228,188	30	5	x *
2	MWD 1A	Weir site/R. Abut.	3,160,783	1,228,180	45	5	-
3	MWD 2	Weir site/River	3,160,811	1,228,163	40	5	x
4	MWD 3	Weir site/River	3,160,823	1,228,156	40	5	-
5	MWD 4	Weie Site/River/Intake	3,160,858	1,228,159	40	5	-
6	MWD 5A	Intake	3,160,916	1,228,139	70	3	x
7	MWD 5	Weir Left Abutment	3,160,868	1,228,123	45	5	x
8	MWD 6	Stilling Basin Right Bank	3,160,798	1,228,105	20	-	-
9	MSD 1	Surge Tank	3,156,268	1,217,509	90	7	x
10	MPTD 2	Pressure Shaft	3,156,257	1,217,466	150	3	-
11	MPCD 3	Ph Cavern	3,156,179	1,217,412	150	7	x
12	MPD 5	Open air PH	3,156,049	1,217,375	40	5	x
13	MPD 7	Power Outlet	3,156,012	1,217,329	15	-	-
14	MWA 1A	Desander Cavern / Adit 1	3,159,858	1,226,217	120	3	x
15	MWA 2	Darolai Nullah / Adit 2	3,158,332	1,223,988	85	3	x
16	MWA 3	Ain Nullah / Adit 3	3,156,709	1,220,650	95	-	x

Table 3.4: Summary of Borehole Location, Depth, Type & Quantity of Testing
x * existing piezometer of borehole DDH-8 used instead

The Consultant defined the number and type of laboratory tests to ensure that the required input data is at disposal for the feasibility design of all major structural components of the Project. Among others the total intact rock laboratory testing program at CMTL comprised of the following tests:

- 50 unit weight, porosity and Point Load Tests of intact rock;
- 27 & 10 uniaxial compression tests w/o & with strain measurements for Young's modulus and Poisson's ratio determination
- 10 petrographic analyses.

3.4.2 Geology of the Project Area

Tectonic Setting

The geology of the study area in Kohistan in North Pakistan is dominated by continental collision tectonics where three of the world's greatest and most active mountain ranges merge: the Himalayas, the Karakoram, and the Hindukush. With the Indian plate moving northward, a complex pattern of thrust and wrench faults has been developing. Several fault structures have been identified in the area in the northern vicinity of the project area.

Lithology

The project area is situated in the mid-western part of the Kohistan Tectonic Zone and consists entirely of (igneous) plutonic rocks. The rather uniform rock type at the site is a medium-grained slightly foliated gabbro, classified as Norite, a rock mainly composed of ortho-pyroxenes and basic feldspars.

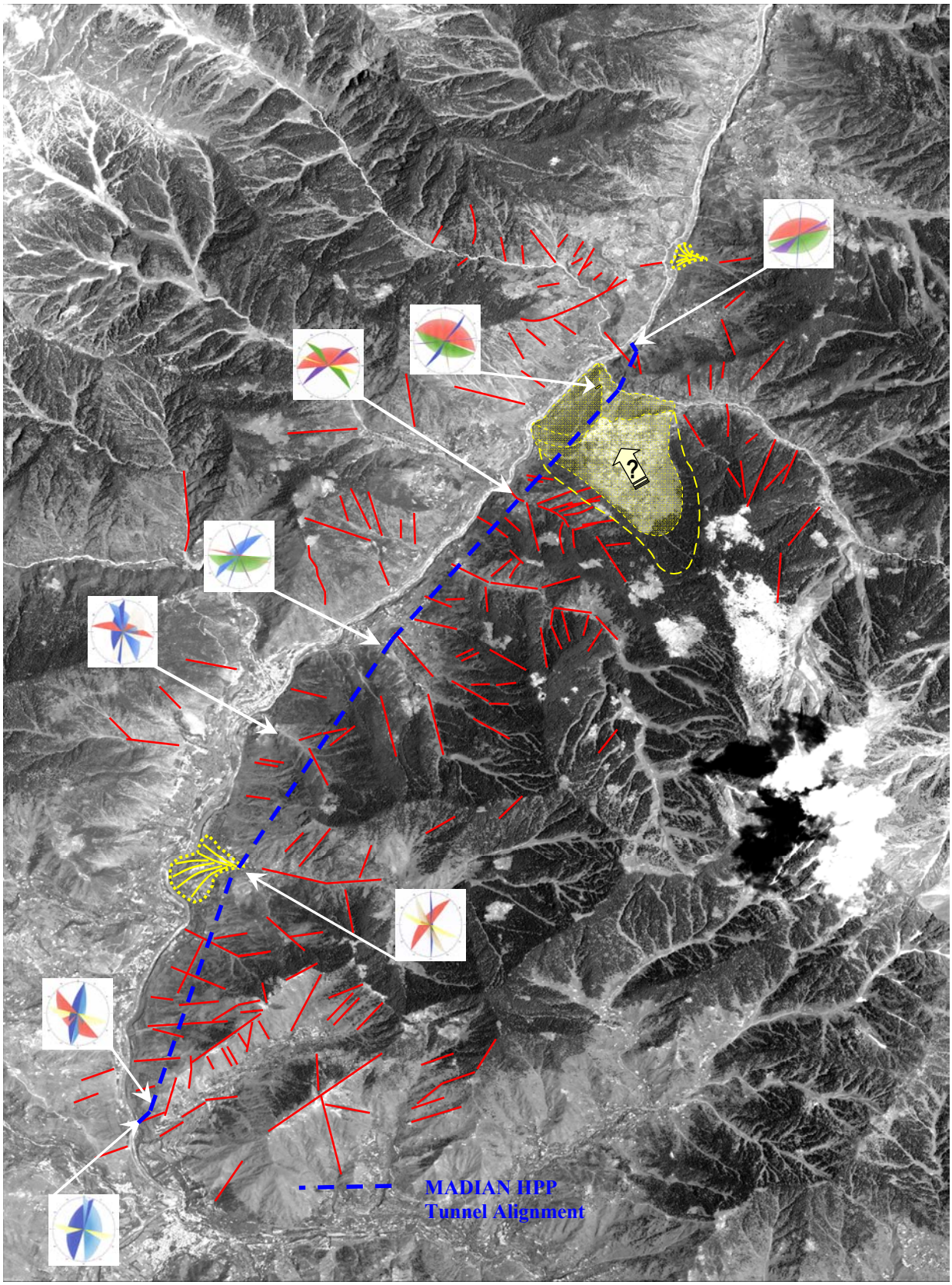


Figure 3.6: CARTHOSAT image of the study area with interpreation of fractures, a potential big old rockslide at Gornai village and some quaternary sediment bodies. The inserts of wing diagrams show the local predominance of joints and their intersections.

The Consultant proposes parameters for the Maximum Credible Earthquake (MCE) as safety level and the Operating Basis Design Earthquake (OBE) as serviceability level for the Madian Hydropower Project in Pakistan. Both earthquakes are selected according to established international standards, described in the ICOLD Bulletin 72 *"Selecting Seismic Parameters for Large Dams"* (ICOLD 1989).

The resulting value for horizontal peak ground acceleration at the Madian Hydropower Project site is 0.48 g for MCE. For OBE, a value of 0.26 g for the annual probability of exceedance of 1 / 475 is recommended. The proposed seismic design parameters are judged to be appropriate conservative for the Madian Hydropower Project site.

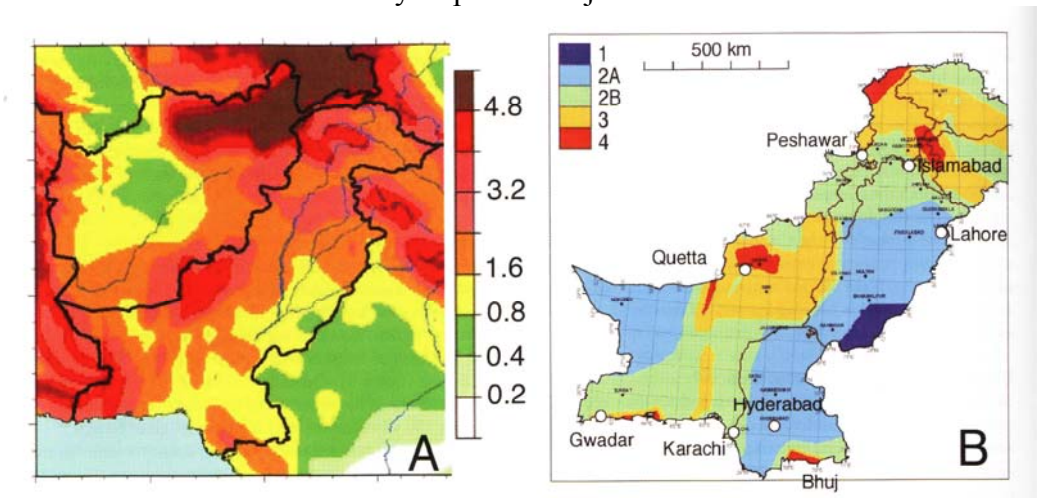


Figure 3.7: GSHAP hazard map of Pakistan, colour scale indicates peak ground acceleration (m/s^2) with 10% probabilistic exceedance within 50 years (Giardini et al. 1999); (B) recently revised hazard map after 2005 earthquake from working group on Pakistan Hazard 2006, 4 is most hazardous, 1 - least hazardous (Bilham et al. 2007)

3.4.3 Results of Geotechnical Site Investigation

The geological mapping of the project covered an area of 19.8km^2 including

- Geological boundaries between bedrock and overburden;
- Areas of sheared and fractured bedrock were marked in the maps;
- Major shear zones were delineated;
- Geometry of rock discontinuities determined by scan line survey, marking joint strike, dip and features such as joint roughness;
- Bedrock wall strength assessed by use of Schmidt Hammer.

The total number of measured joint orientations considered in the present analysis is 845. In addition 258 joint measurements were evaluated from the joint scan-line survey at rock outcrops.

Altogether 16 boreholes with cumulative 1139 m were core-drilled; the deepest borehole attained 150 m depth. The data assembled is

- Drilling-operation observations, e.g., water losses
- Amount of core recovery
- Rock Quality Designation (RQD)
- Degree of weathering
- Joint spacing and Joint properties and fillings
- Groundwater levels
- Water pressure tests (Lugeon)

The groundwater tables have been measuring from the beginning of drilling operation on daily basis. After installation of piezometers the water levels were monitored on a regular basis. No extraordinary high external water pressure is to be expected.

3.4.4 Results of Laboratory Testing Program

Testing was executed according to the established testing program and the given technical specifications for this Feasibility Study of

- Rock core samples from bore holes
- Rock lump samples from potential quarry and weir site
- Sand samples from potential borrow pit
- Soil samples
- Water samples from bore holes

Testing of Concrete Aggregates

According to the limited availability of natural concrete aggregates at the project site and in view of the abundance of excavation material from tunnel and cavern excavation, the Consultant conducted sampling at project site of:

- Rock lump samples from the area close to the proposed rock quarry;
- Core samples from selected bore holes;
- Sand samples from the proposed borrow area at Kalam.

Rock samples were tested with regard to their compressive strength and abrasion (Los Angeles Test) as well on their potential alkali silica reaction.

Results of Petrographic Analysis

With the objective to obtain information on the mineralogical composition of rock material and concrete aggregates, the Consultant instructed execution of the following complete petrographic analyses:

Rock core and lump samples	No. 8
Fine aggregate (sand) sample	No. 1
Sample of joint coating material	No. 1

3.4.5 Engineering Geological Assessment

The geological mapping campaign and the geotechnical site investigations have revealed that in general the engineering geologiocal conditions are favorable for the construction of the Madian Hydropower Plant. Considering all factors, the prevailing rock of the project site can be classified as >good< in terms of Bieniawski's (1989) rock mass classification system, except for faults and shear zones.

Concrete Gravity Weir

The favourable morphology of the valley and the apparently outcropping rock on the left bank were the basis for this selection besides design requirements for the power intake and flushing structure. The riverbed is covered by river deposits of different size ranging from boulders to gravel and sand. The thickness of this loose alluvial material the same Quaternary sediments as on the right bank of Swat River have been encountered in boreholes. According to borehole MWD3, a maximum thickness of theses sediments of 30 m can be expected. The Norite rock below should not create any foundation problem nor from its strength (rock class B to C can be estimated) neither from its permeability. Grouting of the rock mass below the weir foundation will not be necessary except for the few first meters below the contact of alluvium and rock.

Reservoir Area

The extension of the reservoir area is limited to a length of 1.46 km. The sub-ground of the reservoir area is entirely formed by Norite rock with a cover of Quaternary and fluvial deposits. In any kind of artificial lake the hazard of landslides moving into the reservoir has to be assessed. Due to the limited extension and water depth of the reservoir at Madian HPP weir this hazard is minor.

Desander Caverns

The site of the caverns was investigated by one borehole, 130 m deep, and by the mapping of two rock outcrops along the nearby Ashkon Nullah. At the depth of interest for the construction of the desander caverns (100 to 130 m) the rock thus is in good condition. RMR is calculated to be 60 to 80 indicating a rock class of A to B. A total of 114 individual joint orientations were recorded on the right bank of Ashkon Nullah. The favourable orientation of the desander cavern longitudinal axis is thus found at an orientation of 30° (NNE - SSW) which should prevent the possible formation of voluminous rock wedges. The bolt support for desander caverns is evaluated by limit equilibrium wedge analyses and cross-checked by precedent experience collected in double logarithmic diagrams of rock quality and excavation span e.g. by Barton and Grimstad.

Headrace Tunnel

The headrace tunnel has a length of 11.8 km and internal diameter of 7.0 meters. It will be excavated along the left bank slope of Swat River between the intake area near Kedam Nullah and the surge tank near Kalaga Nullah.

The rock overburden along the tunnel alignment varies between 55 m (Ashkon Nullah, Station 2+500) and 440 m at Station 7+000 as shown in the geological profile of the headrace tunnel (see Annex A-6 of Volume III). The tunnel alignment was investigated at the planned three construction adit locations by boreholes MWA1A, MWA2 and MWA3 and in addition by boreholes MWD5 at the power intake and MSD1 at the surge tank axis. Based on the geological mapping and supported by the core drilling at five bore holes the expected headrace tunnel rock quality for the total length of 11,800 m length was defined as follows:

- 1,500 m of very good and good rock (class A, B) in Section 1,
- 900 m of fair rock (class C, D) in Section 1
- 2,800 m of fair rock (class C, D) in Section 2
- 2,750 m of very good and good rock (class A, B) in sections 3 and 4
- 3,300 m of fair rock (class C, D) in Sections 5 and 6.
- 550 m of poor to very poor rock in different sections (class E, F).

Surge Tank

The surge tank will be arranged at the end of the headrace tunnel, some 50 m upstream of the transition to the pressure shaft; it will have an excavated diameter of approximately 23 m and a depth of 78 m. The geological conditions for the surge tank have been investigated with a 90 m deep borehole (MSD1) and three seismic refraction lines. Even in greater depth, where the core quality of other bore holes uses to show improved rock mass characteristics, the rock quality is poor to very poor. The fracturing and jointing is classified as high.

Underground Powerhouse and Transformer Caverns

The powerhouse will be constructed in an underground cavern, about 70 m long, 20 m wide and 36 m high. The powerhouse will be located on the left bank of Swat River some 1.2 km upstream of Madian town. The cavern powerhouse and the surface powerhouse site were investigated by three bore holes, namely MCD3, MPD5 and MPD7.

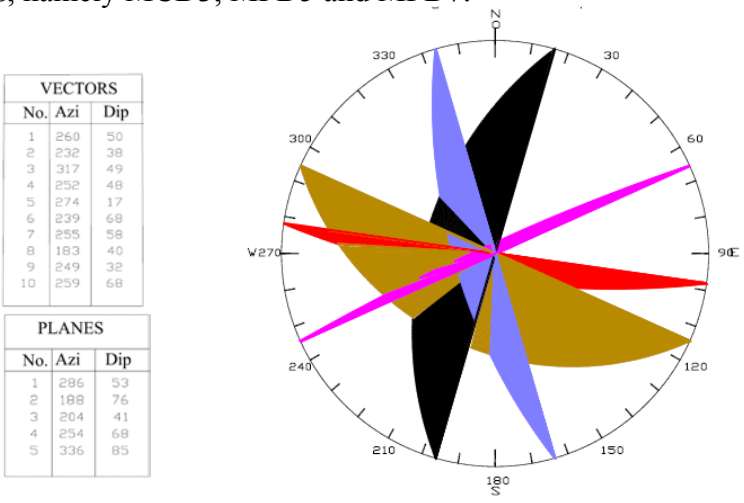


Fig. 3.8: Wing diagram of the predominant joint planes and their intersections of all joints measured in the powerhouse and the surge tank areas; dashed line: axis of cavern.

The total overburden above the powerhouse cavern will be about 100 m, 13 m of which have been cored as colluvial soil in borehole MPCD3. From 30 m depth on, the situation improves with another bad zone occurring between 38 and 42 m depth. From here on to the end at 125 m depth, the rock can be classified as fair to good meaning rock class C to B. Water pressure tests undertaken between 100 and 125 m depth provided Lugeon values between 2.0 and 9.4 which means that the rock mass is almost tight.

Major construction materials required for the Madian HPP are cement and aggregates, reinforcement steel (including mesh/mattresses) for concrete and shotcrete fabrication for all major structures including the lining of underground works. In addition slope and riverbed protection works require the use of riprap, gabion mesh and gabion fill material as well as geotextiles as non-mineral filter. According to the limited availability of natural concrete aggregate at the project site and in view of the abundance of excavation material from tunnel and cavern excavation, the concept for the use of concrete aggregates is as follows:

a) Initial phase: open a rock quarry at weir site and use crushed rock
obtain sand from existing borrow area at Kalam

b) Main phase: select and crush tunnel excavation material
obtain sand from existing borrow area at Kalam

In accordance with the selected concept of applying crushed rock from tunnel and cavern excavation and sand from the borrow area at Kalam as concrete aggregates the Consultant conducted sampling as follows:

a) Rock lump samples from the area close to the proposed rock quarry
b) Core samples from bore holes along the headrace tunnel
c) Sand samples were taken from Kalam borrow area

Rock strength and abrasion resistance proved to be adequate by carrying out tests of the unconfined compressive strength and conducting Los Angeles tests, respectively. The petrographic analysis and accelerated mortar bar tests confirmed that no alkali reaction of aggregates was observed and ordinary Portland cement can be used for concrete fabrication in combination with the proposed aggregates.

From the geological and engineering geological point of view the Madian HP Project is feasible. The foundation of the weir and the intake structures should not face a major problem. The headrace tunnel runs along the selected alignment largely in sound rock of class B to C. The section between Gornai Nullah and the Desander Cavern remains questionable and requires investigation and reconfirmation during the next planning stage.

3.5 Access to Site, Transport and Communication

3.5.1 General Aspects

In Pakistan a well-established aviation network is operated. The main airports are Karachi, Lahore, Islamabad, Quetta and Peshawar; they are national as well as internationally connected. The closest airport to Madian is at Peshawar, some 200 km distant from Madian.

The main seaport of Pakistan is Karachi on the Arabian Sea. It handles the bulk of the countries in- and export. A further seaport in Gwadar, Balochistan equally on the Arabian Sea is under construction. Pakistan has a well-developed road and railway network, serving all areas of its economy. The railway station situated nearest to the project area is Dargai, located some 120 km away from Madian.

The major electro-mechanical, electrical and heavy steel structure equipment components will be imported and can be expected to arrive at Karachi Port. From Karachi the equipment shall be transported to the project area located north of Madian Town, District Swat of NWFP. There are two general modes of transport which can be adopted for moving the equipment to the project area entirely by road or by rail from Karachi to Nowshera or Dargai, and further on road. From Karachi the trucks will reach Dargai and from Dargai onwards the trucks will move to the project area along the Dargai – Mingora - Madian section of the road.

Alternative I: from Karachi to Batkhela (shortest connection): = 1521 km
Alternative II: from Karachi to Batkhela via Motorway = 1695 km

The journey from Batkhela to Madian would be common along the same route for both alternatives.

Distance from Batkhela to Madian = 119 km

Several examinations of the road conditions were conducted by the Consultant which indicate that serious difficulties are to be expected under prevailing transport conditions. The present road conditions are not good in some sections. There exist some narrow passages with roads in town centres along the way between Dargai and Madian, which may cause severe problems for transport of large and heavy equipment. Two bridges do not meet this criterion with an estimated carrying capacity below 30 tonnes, namely Ghari Pia Bridge (cracked abutment) and the Baily Bridge at Madian. The management of the National Highway Authority (NHA) informed the Consultant and the Project Sponsor on request that the road from Mingora to Kalam will be upgraded to a National Highway (7.3 m wide asphalt paved road) in the following years, however, no anticipated date of completion of these road works could be given.

3.5.2 Requirements for Transport of Equipment

The feasibility of transporting construction equipment with large dimension and heavy weight may govern the selection of construction methods, in particular in case of the long headrace tunnel and thereby its design. The minimum width of several bridges of 3.5 m represents a constraint to transport and requires particular attention.

Tunnel Excavation Equipment
Condition for the potential application of a Tunnel Boring Machine (TBM) is that transport of the equipment to site is technically feasible at reasonable cost. The Consultant inquired the relevant information for transport of a TBM to the Madian HPP site and progress of work with leading TBM manufacturers. For the particular conditions to construct an approximately 12 km long headrace tunnel with an excavated tunnel diameter of 7.0 to 8.0 m , the overall weight of a such a TBM would be in the order of 600 to 700 t. For the estimated excavated tunnel diameter the main dimensions of the heaviest and largest single piece would be:

Width / Height	3.6 m
Weight	60 – 70 tonnes

Earth Moving Equipment
Standard earth moving equipment will comprise bulldozers, excavators, front loader and trucks. The standard type would be a D6 (or equivalent) with an operating weight of 18 to 21 tonnes and a width including the blade of 3.36 m. The standard excavator could be a Cat 320D (or equivalent) with a width of 3.00 m which does not represent a difficulty for transport.

Transport Requirements for Permanent Equipment
The transportation of heavy permanent electro-mechanical and steel structure equipment to the site is an aspect which may govern design aspects in developing the Madian HPP.

Electro-Mechanical Equipment
With regard to the spiral casing, sufficient free overall width or height cannot be obtained. Therefore, the spiral casing needs to be transported divided in segments and erection-welded at site.

Electrical Equipment
The heaviest component to be transported to the site of a hydropower project is in most cases the 3-phase transformer. Alternatively single-phase transformer may be used instead. A 3-phase transformer would weigh more than 65 tonnes without oil. The alternative single-phase transformer weighs 28 tonnes without oil. Transport of the 3-phase transformer represents a major difficulty with regard to the carrying capacity and clear width of at least three of the existing bridges in the area of the city of Madian. Transport of the 3-phase transformer becomes feasible only in case that two existing bridges will be replaced by bridges with sufficient width, radii in their approaches and sufficient carrying capacity.

Hydraulic Steel Structure Equipment

Referring to the feasibility design the dimensions of the major equipment components are the spillway radial tainter gate with the dimensions H x W = 12.0 x 7.6 m and a distance between gate to trunion point of 14 m. In view of the prevailing limitations as regards in particular the width of the bridges in the area of Madian town, Bahrain and Kedam, the tender documents should specify that all large steel-structure equipment components need to be assembled at site and the contractor must do the corresponding provisions in the design and preparation of its camp.

Some of the roads in Swat District are not designed for transportation of heavy equipment. Certain road improvement work is under progress. Road conditions in Swat District would be conducive for transportation of heavy equipment with the exception of some bridges in the area of Madian town.

The Consultant recommends giving priority to transportation of equipment by road, in particular for the large pieces of construction and permanent equipment due to limitations in the available width along the railroad. The transportation by railway can be used for bulk material which can easily be unloaded from railway wagons and re-loaded on trucks. The final decision on the mode of transport between Karachi and Nowshera remains with the EPC Contractors.

As mentioned above the following bridges represent bottlenecks for transport of heavy and bulky equipment due to their maximum clear width of 3.5 m and estimated carrying capacity not exceeding 30 tonnes:

Ghari Pia Bridge	Cracked Abutment	(lack of capacity)
Madian Sadar Bazaar Bridge	Clear width 3.5 m	(limited width)
Bailey Bridge outside Madian	Clear width 3.5 m	(width & capacity)*

It would be advantageous for development of the Madian HPP if rehabilitation of the mentioned narrow or damaged bridges will be executed by National Highway Authority (NHA) before construction of the Madian HPP starts.

These above mentioned constraints have the following consequences:

1. According to present conditions at three bridges as regards both their clear width and their carrying capacity, TBM tunnel construction technique cannot be applied.

2. Single-Phase transformer shall be used instead of 3-phase transformers due to the limited capacity of the existing bridges.

Certain road improvement and maintenance in the area between powerhouse site and dam site of the Madian HPP is included in the present feasibility study and the corresponding Bill of Quantities (BoQ).

4. Civil Engineering Design

4.1 General

The feasibility layout and design for the Madian Hydropower Project comprises the following main components:

- Concrete weir structure with gated spillway and flushing structure
- Power intake on left bank adjacent to weir structure with raking machine
- Desanding facilities
- Power waterways consisting of headrace tunnel, pressure shaft, pressure tunnel, manifold, tailrace and power outlet
- Powerhouse with switchyard / transformer cavern
- Diversion works consisting of upstream and downstream cofferdam and diversion tunnel
- Access roads, permanent and temporary camps
- Dumping sites for deposition of surplus excavation material

4.2 Design Criteria

For the feasibility design the following hydraulic and civil design criteria have been established in co-ordination with the Project Sponsor:

4.2.1 Design Floods

In view of the size of the weir structure and consequences of potential failure the following design floods are considered adequate as a conservative approach in accordance with the recommendations of ICOLD-Bulletin 82: "*Selection of Design Flood – Current Methods*".

Design Flood: $HQ_{1,000} = 1450$ m³/s with one gate malfunctioning and normal freeboard (1.5 m)

Safety Check Flood $HQ_{10,000} = 2002$ m³/s all gates open and minimum freeboard (1.0 m)

The powerhouse shall be operational up to the powerhouse design flood which is defined as the flood with a return period of 1000 years

Design Flood: HQ1,000 = 1,785 m³/s

Recommended Max.Operation Flood HQ 100 = 1,065 m³/s

The estimated construction period for the weir including stilling basin and power intake is 3 years. In accordance with common design practice a flood with a return period of 20 years is selected as diversion design flood:

Diversion Design Flood Weir $HQ_{20} = 656$ m³/s

4.2.2 Hydraulic Design of Desanding Facilities

Settling basins are required if the river flow contains high concentrations of suspended sediment which may cause severe damage to the turbine runners.

Design Grain Diameter: Critical Sediment Grain Size,
grain size to be removed to 95 per cent or more
- Head 20 - 50 m D = 0.30 mm
- Head 50 - 100 m D = 0.25 mm
- Head 100 - 300 m D = 0.20 mm

4.3 Design of the Weir Structure

The weir axis was selected according to the prevailing geological, topographic and design boundary conditions. The normal operation water level of 1494 m asl is based on the definition of PPIB to ensure the coordinated development of the Madian HPP and the upstream located Asrit-Kedam HPP on Swat River. The concrete weir structure across the Swat River has a crest length of approximately 65 m and a height above riverbed of 19 m. The spillway is equipped with three hydraulically operated tainter gates.

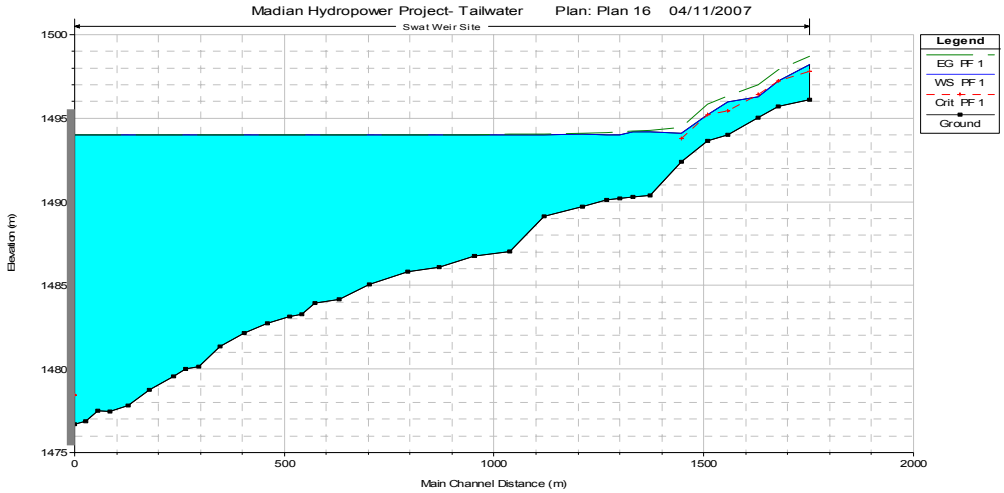


Figure 4.1 Profile through the Madian HPP Reservoir

The most left bank tainter gate is equipped with a fish belly flap on top for fine regulation of the flow and for flushing of floating debris. The inclined weir ogee is followed by a stilling basin at its end.

Max. water level	1,494	m asl (SoP)
Total storage volume	480,000	m^3
Length of the reservoir	1.46	km

Maximum reservoir level:	1494.5 m asl
Spillway crest elevation:	1482.5 m asl
Maximum head	12.0 m

The ogee crest structure is designed applying WES standard profile as defined by the Hydraulic Design Charts. The thickness of piers was selected to be 3.0 m to safely transfer forces in the main dam body. The dimensions of the spillway gates were selected as follows:

Number of Gates	3
Width x Height	7.6 x 12.0 m

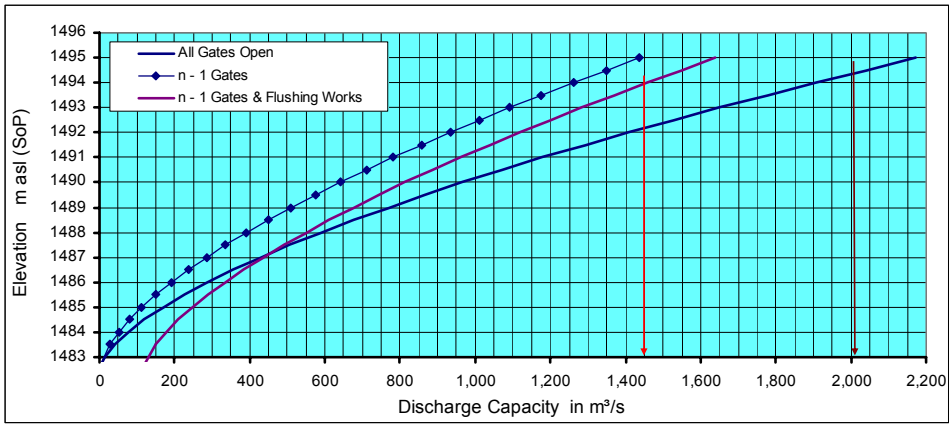


Figure 4.2: Discharge Capacity of the spillway of the Madian HPP Weir

In the event of the Safety Check Flood $HQ_{10,000}$ = 2002 m³/s at the required minimum freeboard of 1.0 m is the discharge capacity is sufficient for all 3 spillway gates being fully open

Spillway Discharge 2069 m³/s > 2002 m³/s

The hydraulic conditions from spillway crest to the stilling basin were determined for discharges between HQ_2 and $HQ_{10,000}$, i.e. 445 to 2002 m^3/s. As the result the stilling basin with the following dimensions was selected:

Invert of stilling basin	1472.0 m asl
Width of stilling basin	28.8 m
Elevation of river bed d/s	1476.1 m asl
Length of stilling basin	54.0 m

In order to maintain the power intake free of sediments, in particular of bed load that may accumulate upstream of the weir structure, a flushing structure is arranged in the left part of the weir structure close to the power intake. The flushing (or sluicing) gates discharge into a chute separated from the stilling basin to allow for its maintenance and repair while the stilling basin is in operation. The invert of the flushing ducts is arranged at riverbed level. To achieve a safe and optimized structural layout at low costs as regards in particular quantities of concrete and reinforcement, structural analyses computations were carried out for consideration of soil loads, water pressure and seismic loads including the dimension of the bore piles for

- Overturning of the Weir body
- Sliding of the Weir Structure
- Uplift of Weir Structure and Stilling Basin

4.4 Design of Diversion Works

The Consultant designed conventional river diversion works with the following components:

Weir Structure

1. Upstream rock fill cofferdam with sealing
2. Downstream cofferdam constructed on bore pile wall
3. Diversion tunnel on left river bank

Powerhouse / Power Outlet

1. Gabion cofferdam with sealing (PVC sealing)

In accordance with common design practice and the hydraulic design criteria a design flood for river diversion during construction with a return period of 20 years is selected resulting in the following discharge values:

Diversion Design Flood	Weir	HQ20 = 656 m³/s
Diversion Design Flood	Powerhouse	HQ20 = 731 m³/s

Therefore, the crest elevation of the upstream cofferdam is limited to elevation 1496.0 m asl. The following dimensions of the diversion works were defined:

Diversion Tunnel D-shaped	Width =	8.0 m
	Height =	9.2 m
	Length =	275.0 m

4.5 Conceptual Design of Power Waterways

The project concept consists of the following major components:

a) Power intake on left bank of Swat River
b) Desander basins, No. 3
c) Headrace tunnel, 11.8 km long
d) Surge tank
e) Vertical pressure shaft
f) Horizontal pressure tunnel
g) Manifold
h) Powerhouse
i) Tailrace and Power outlet

The Consultant developed a tunnel alignment for conventional drill and blast excavation method in a such a way that the rock cover shall not be less than approximately 50 m, in particular in the area of nullahs (depressions where perennial streams form in the rainy season).

In view of the length of the headrace tunnel of almost 12 km, conventional tunnel construction would need to proceed in parallel in several tunnel stretches. Aiming on an economic feasible construction period, a total

number of 4 tunnel reaches with a maximum length of 3.6 km was defined. The location of the construction adits was defined taking into account the following criteria:

Headrace Tunnel	TBM Feasibility m	D&B Feasibility m
Reach 1		2,474
Reach 2		2,680
Reach 3		3,802
Reach 4		2,934
Total HR-Tunnel Length	11,893	11,890
Adit at Surge Tank	201	150
Constr. Adit No. 1		280
Constr. Adit No. 2		380
Constr. Adit No. 3		250
Total Adit Length	201	1,060

Table 4.1 Length of Headrace tunnel for TBM and Conventional Excavation

The headrace tunnel alignment was eventually defined as the result of a trade-off between additional costs resulting from extra headrace tunnel length and the cost of extra length of the construction adits.

As an alternative to the project layout proposed in the pre-feasibility study a layout with underground powerhouse was elaborated. The additional costs for the underground powerhouse (compared to an open air powerhouse), transformer and switchyard cavern and the required access and cable tunnel are almost compensated by the savings in the steel lining for the high pressure tunnel, excavation and slope protection works. The comparison of costs indicates that the design concept with underground powerhouses requires slightly higher investment costs compared to the concept with an open air powerhouse. The difference in cost between the two powerhouse alternatives is minor so that from the economical point of view both alternatives can be considered equivalent. Preference to an alternative can be made taking into account the following aspects such as:

- Risks during construction and operation (vandalism, terrorism, extraordinary floods, earth slides etc.);
- Costs during operation (maintenance, access etc.);
- Environmental and socio-economic impact.

4.5.1 Optimization of Installed Capacity

Optimization of the Madian HPP means to determine the waterway design discharge and respective installed capacity for which development of the project results in the economically most favourable configuration.

For optimization of hydropower projects commonly the following optimization criteria are applied:

a) Maximum Internal Rate of Return on investments (IRR); or minimum specific cost of generation in US c /kWh
b) Maximum Net Benefit.

From the prospective of a private project developer the preferred optimization criterion is that which provides the maximum rate of return on investment. All relevant project related costs and benefits are expressed in terms of their present value referring to the same date to be comparable.

By means of the Consultant's hydropower optimization program HPC (Hydropower Costing) the design of the project components and the corresponding elaboration of the bill of quantities, costing and simulation of annual energy generation was performed. This procedure was applied to powerhouse design discharges in the range from 100 to 180 m³/s with 10 m³/s increments.

Optimization of Design Discharge - Base Case

Power Revenues	0,07	US$ / kWh		**Cost Fact :**		**1**	-			
O&M Cost	1,5	%		Net Head :		133	m			
Interest Rate	10,00	%		Forced Outage :		1	d	(Full Operation)		
Life Time	60	Years		Increm. Discharge		10	m³/s			
Construc. Period	4	Years		CRF		0,10033	-			
Design Discharge	m³/s	100	110	120	130	140	150	160	170	180
Original Cost	US$	246,001	261,45	275,334	291,087	302,922	317,756	335,263	345,929	364,996
Orig. Ann. Energy	GWh	644,00	687,45	724,48	762,76	799,11	832,92	860,00	889,20	911,09
Installed Capacity	MW	120	133	145	157	168	180	192	203	215
Proj. Cost (Funct.)	Mill US$	249,057	261,389	274,331	287,915	302,171	317,133	332,836	349,316	366,613
Energy Reduction	GWh	2,850	3,134	3,419	3,704	3,989	4,274	4,559	4,844	5,129
Ann. En. (incl.Red.)	GWh	641,150	684,316	721,061	759,056	795,121	828,646	855,441	884,356	905,961
Ann. En. (Function)	GWh	640,765	683,193	723,012	760,221	794,821	826,811	856,192	882,964	907,127
Accum. Factor	-	1,16	1,16	1,16	1,16	1,16	1,16	1,16	1,16	1,16
Present Value Cost	Mill US$	288,968	303,276	318,293	334,053	350,594	367,954	386,173	405,294	425,363
Annual Benefits	Mill US$	44,854	47,824	50,611	53,215	55,637	57,877	59,933	61,807	63,499
Annual O&M Cost	Mill US$	3,736	3,921	4,115	4,319	4,533	4,757	4,993	5,240	5,499
Annual (B-O&M)	Mill US$	41,118	43,903	46,496	48,897	51,105	53,120	54,941	56,568	58,000
Present Value Bene	Mill US$	409,827	437,585	463,431	487,361	509,370	529,453	547,605	563,820	578,092
PV(B-C)	Mill US$	120,859	134,309	145,138	153,308	158,776	161,500	161,432	158,525	152,729
Cost / kWh	US$ / kWh	0,0511	0,0503	0,0499	0,0498	0,0500	0,0504	0,0511	0,0520	0,0531
Cost / kW	US$ / kW	2408	2280	2195	2128	2087	2044	2011	1997	1978
CRF	-	0,142	0,145	0,146	0,146	0,146	0,144	0,142	0,140	0,136
1/ CRF	-	7,028	6,908	6,846	6,832	6,860	6,927	7,029	7,165	7,334
O'B (auxilliary Val.)	-	7,028	6,908	6,846	6,832	6,860	6,927	7,029	7,165	7,334
IRR	%	14,224	14,472	14,604	14,633	14,573	14,432	14,222	13,952	13,629

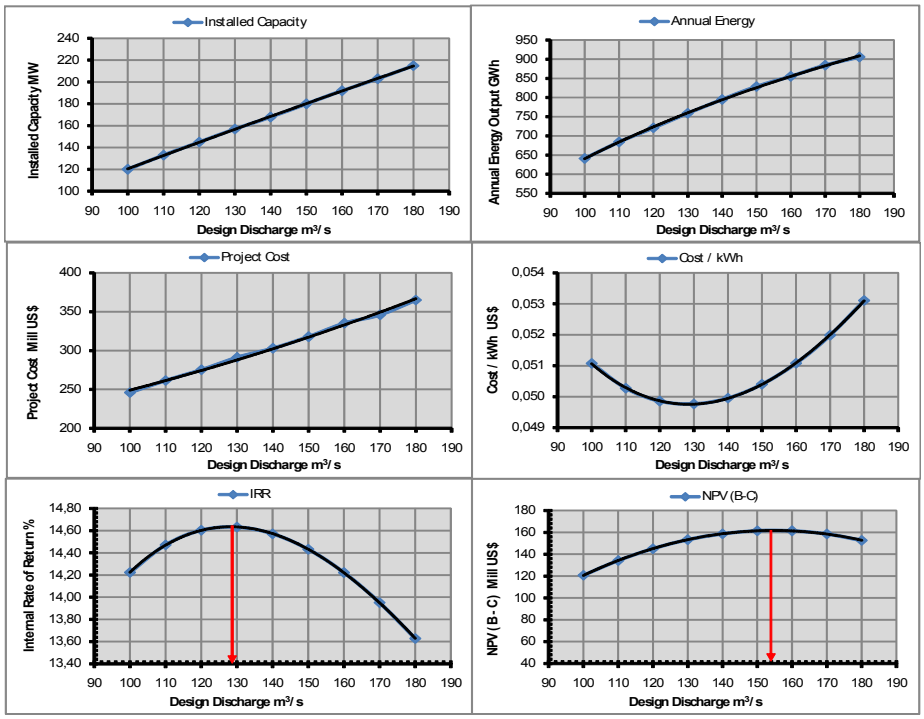


Table 4.2 Optimization of the Installed Capacity for Madian HPP

A flat rate tariff of 0.07 US $ / kWh was applied to the assessment of energy generation related benefits for determination of the annual benefits. The simulation of reservoir operation and powerhouse operation was based on series of 10-daily river discharges.

Based on the above described approach and an optimum power waterway design discharge of 129 m^3/s was obtained for the highest rate of return. The Consultant established alternative combinations of the number and capacity of turbine units and optimized the combination of rated turbine discharges of reasonable combinations of number and size of units in a way to maximize the annual energy generation simulating run-of-river operation based on daily river flow data. The corresponding optimum alternative combinations of number and rated discharge of turbine units are:

ALT 1:	3 units of identical size:	3 x 43 m^3/s
ALT 2:	2 large units and 1 small unit	2x50.5 + 1 x 28.0 m^3/s
ALT 3:	2 large units and 2 small units	2x41.0 + 2 x 23.5 m^3/s

As the next step the Consultant elaborated a project design for the three above alternative concepts applying the design and hydropower project assessment tool HPC and the corresponding cost estimation. The assessment of benefits from hydropower plant operation (run-of river) was carried out based on 46 years of daily river flow data.

The highest annual energy generation can be achieved by 2 large and 2 small units (ALT 3) which permit operation at high turbine efficiency during most of the time. The alternative with 3 identical units represents the least cost solution compared to any other alternative.

The alternatives with 3 turbine units (ALT 1 and ALT 2) are equivalent as regards their economic key parameters with a minor advantage for the concept with turbine units of identical size. In co-ordination with the Project Sponsor, the Consultant proposes the installation of 3 Francis units of identical size, i.e. ALT1. This recommendation can be considered conservative. The present analysis is based on the simulation of run-of-river operation. At times of extremely low river flow, the available flow might me not sufficient to operate a Francis unit safely on continuous basis at all time. However, with consideration of pondage operation, daily power generation can be maintained and an approximate additional annual power generation of 12 GWh achieved.

Based on the analysis the Consultant recommends installation of three identical turbine units with the installed capacity of 3 x 60.8 MW (ex turbine). For the assumed turbine characteristics this discharge corresponds to an optimum available capacity (ex transformer) of 3 x 52.43 = 157.3 MW for the Madian HPP. In view of the merits of the optional application of pondage operation, the Consultant makes the corresponding provisions in the feasibility design of the weir and intake structures to enable pondage operation between elevation 1494 and 1492 asl.

4.5.2 Optimization of Power Waterway Dimensions

As part of the overall project optimization, the dimensions of the power waterway conduit system are optimized applying the relevant economic parameters. The hydraulic design of the power waterway system is based on the following basic parameters and dimensions:

Rated Turbine Discharge:	3 x 43 m³/s
Full Supply Level	1494.0 m asl
Max./Min. Operation Level	1494.5 / 1492.0 m asl
Max./Min. Tailwater Level	1346.0 / 1339.6 m asl

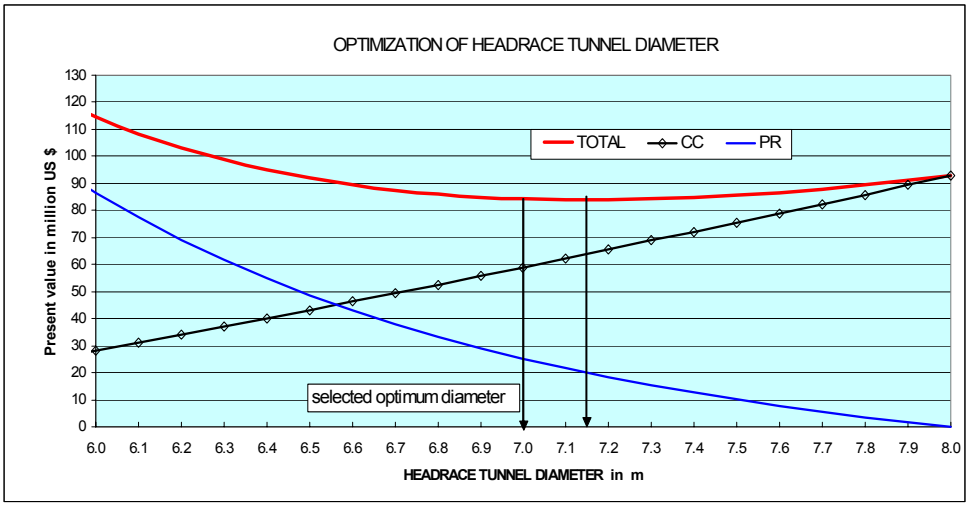


Figure 4.3: Optimization of Headrace / Tailrace Tunnel Diameter – Base Case

As indicated in Figure 4.3 the optimum headrace tunnel diameter is 7.15 m. A range of diameters from 6.95 to 7.40 m exists without a significant variation of the optimization criterion. With the aim to minimize investment cost for a headrace tunnel diameter of 7.0 m was selected.

For selection of optimum diameters of the short pressure shaft / tunnel an empirical approach was applied. The optimum diameter of the concrete lined part of the vertical pressure shaft results in a diameter of 5.8 m. In its lower third the shaft is steel lined. Starting from the steel lined section the conduit diameter reduces to 5.4 m. The corresponding design flow velocities coincide well with prototype data of a number of similar hydropower plants.

4.6 Hydraulic Design of Power Waterway System

4.6.1 Headrace Tunnel and Surge Tank

The first section of the headrace tunnel with an internal diameter of 7.0 m is arranged from the power intake to the desander caverns (situated some 2.1 km downstream of the power intake). The second section starts downstream of the desander caverns and proceeds to the surge tank.

At the surge tank a maintenance gate is arranged to close the headrace tunnel during times of maintenance and inspection of the pressure shaft and manifold system without the need to empty and re-fill the entire headrace tunnel (0.36 million m³ water).

In accordance with common design practice and the hydraulic design criteria, the cross sectional area of the cylindrical surge tank is selected 70 % larger than the THOMA-Criterion (actual safety factor 1.7) to ensure adequate stability of plant operation. For load acceptance of the turbine units and subsequent full load rejection the following scenarios and load cases were considered:

LC-UP1) Load acceptance from partial load, not exceeding 50 % total load increase; subsequent full load rejection;

LC-UP2) Load acceptance of two units after synchronization; subsequent full load rejection;

LCDP1) Full load acceptance of one turbine followed by another turbine after a certain time interval; this interval is to be adjusted to detect the most unfavourable moment;

LCDP2) Load reduction by 50 per cent and subsequent complete load acceptance.

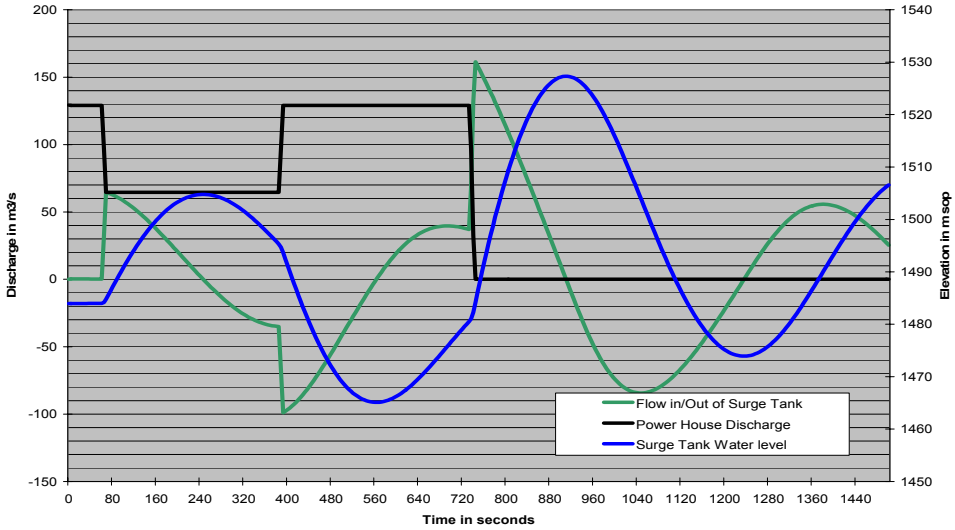


Figure 4.4: Surge Tank: Combined Load Case–Maximum Upsurge

4.6.2 Pressure Shaft, Pressure Tunnel and Manifold

For ease of construction by means of the raise boring method the 5.8 m diameter pressure shaft is designed vertical. In view of the expected internal tunnel pressure and the rock mass characteristics in the pressure shaft area, concrete lining is required. In view of the internal pressure (transient analysis) steel lining is required in the lower third of the pressure shaft only. The two vertical bends of 90 degrees are arranged applying a radius of 17.4 m (R = 3.0 x D) thus representing a good compromise between economic design and low head losses. In the lower part the pressure shaft is steel lined

and has an internal diameter of 5.4 m. The lining thickness increases from 20 to 28 mm towards the powerhouse cavern. The 10 m long horizontal steel lined pressure tunnel connects the pressure shaft with the manifold system. The internal diameter of the steel lined pressure tunnel is 5.4 m. At the end of the pressure tunnel consecutively three manifolds branch off the main tunnel at an angle of 55 degrees. Each manifold has the internal diameter of 3.0 m including the confusor arranged as transition to the safety butterfly flap of 2.5 m nominal diameter. A straight alignment is provided towards the turbines over a length of at least 10 times the conduit diameter.

The head losses of the waterways are in the order of 14.7 m for operation under rated conditions as shown in Table 4.3.

Underground Powerhouse , Section through Unit No. 2

Reach No.	Length [m]	Area [m²]	Perimeter [m]	Diameter [m]	Roughness [mm]	local head loss coefficient	Description of local head loss	Flow velocity	Head loss [m]
Intake	68.00	12.57	12.57	4.00	0.60	0.330	inlet loss, trahrack etc.	3.42	0.330
Headrace	1997.00	38.48	21.99	7.00	0.60	0.111	various bends	3.35	1.984
Desander inlet	33.50	12.57	12.57	4.00	0.60	0.000		3.42	0.065
Desander	256.00	173.04	46.63	14.84	0.60	0.000	Dividing flow & bend 55°	0.25	0.001
Desander Outlet	112.00	12.57	12.57	4.00	0.60	0.860	R/D=3	3.42	0.732
Headrace	9401.00	38.48	21.99	7.00	0.60	0.035	surge tank	3.35	9.062
Pressure Shaft	111.47	26.42	18.22	5.80	0.60	0.369	2 x bend 90°, R/D = 3	4.88	0.732
High Pressure Tunne	66.65	22.90	16.96	5.40	0.10	0.000		5.63	0.184
Manifold	55.80	7.07	9.42	3.00	0.10	0.040	dividing flow 55 °	6.08	0.431
Turbine inlet	6.60	5.73	8.48	2.70	0.10	0.050	confusor, butterfly valve	7.51	0.216
Draft tube extension	53.80	13.85	13.19	4.20	0.60	0.570	combining flow 55°	3.10	0.361
Tailrace Tunnel	84.02	41.85	22.93	7.30	0.60	1.100	outlet, gate slots	3.08	0.598
							Head loss hl =		14.697
							hl = N x 10^{-6} x Q^2		883.158

* draft tube loss is included in turbine efficiency

Table 4.3 Head Loss Characteristics of Waterways, Underground Powerhouse

For verification of pressure conditions along the power waterways, a transient analysis was carried out based on the method of characteristics. The load cases considered in this transient analysis are similar as to the hydraulic design of the surge tank

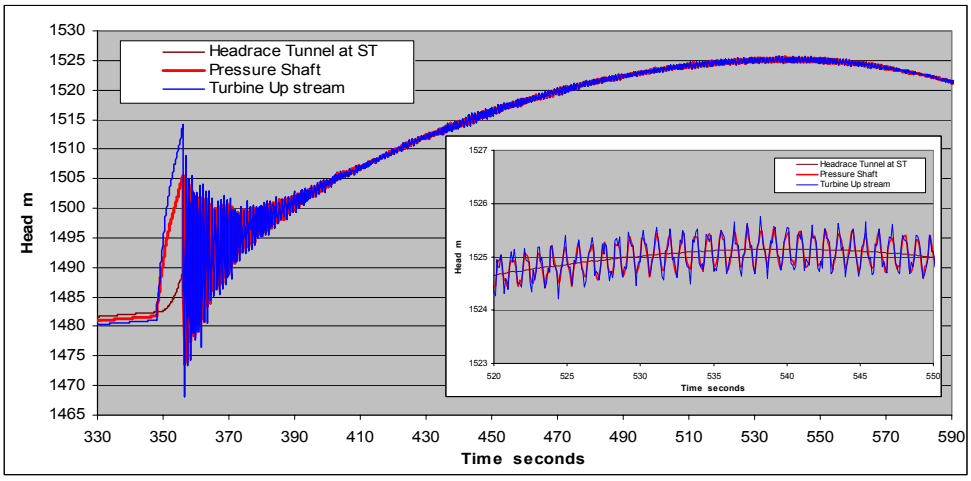


Figure 4.5 Fluctuation of Head in the Upstream Waterway System after Full Load Rejection of 3 units

The hydrodynamic pressure rise as the consequence of transient phenomena is limited to 23 % of static head in the headrace tunnel. In this case a maximum head of 1530 m applies to the headrace tunnel design equivalent to 8 bar of internal water pressure as the design parameter.

4.7 Hydraulic Design of the Desander System

Sediments in suspension will unavoidably result in a certain wear and tear, in particular at the turbine runner. The extent of the abrasion depends largely on the concentration, size and mineralogical characteristics of the sediment particles etc. This abrasion and the resulting need for overhaul and replacement of runners cannot be avoided. Desanding facilities are arranged to control or better say to reduce the frequency of the required change and overhaul of turbine runners.

During the high flow season the Swat River has the potential to transport large quantities of sediments in suspension as well as bed load. Sediment concentrations of up to 10,000 ppm have been recorded in Swat river. From the petrographic analysis of rock and sand samples it can be assumed that quartz minerals may make up to 10 % of the suspended sediments.

The topographical and geological conditions make the arrangement of open air desanding basins impossible in the case of the Madian HPP due to the narrow valley and steep valley slopes. For this reason, underground desanding facilities are arranged for the Madian HPP. The Consultant analysed the existing desander types and flushing systems and elaborated a modified Bieri – desander flushing system. The desanding works consist of three 206 m long desander caverns. Manifold systems branch off the headrace tunnel upstream and downstream to the headrace tunnel. The Consultant determined the required dimensions for the long basin desander applying his program DESANDER which is based on the theoretical approaches of CAMP and SARIKAYA. The results of the design and thus the key parameters of the desander caverns are given in Table 4.4

Desander:		
Design discharge	129	m³/s
Number of settling chambers	3	
Effective length of chamber	206	m (without transition)
Width of chamber	13.7	m
Average depth of chamber	16	m
Mean velocity	0.2	m/s
Grain size to be excluded	0.20	mm

Table 4.4 Technical Key Parameters of the Desander Works

Particle Diameter mm	Settling velocity mm/s	Rate of Removal %
0.40	58.0	100.0%
0.20	22.0	98.0%
0.15	15.0	82.0%
0.10	9.0	56.0%
0.06	3.5	22.0%
0.02	0.4	0.0%

Table 4.5 Rates of Removal of Suspended Sediments at the Desander Caverns

Approximately 98 % of the sediments are removed from the water sediment mix at the desander works of the sediment fraction of the design particle diameter of 0.2 mm. For fractions with larger particle size the removal rate approaches 100 % and for particles of 0.1 mm diameter the removal rate is still above 50 %. Table 4.5 demonstrates that the selected desander design is adequate.

4.8 Powerhouse and Tailrace

The proposed underground powerhouse is a conventional cavern structure for three identical Francis units with vertical axis of 60.8 MW installed turbine capacity and a runner diameter of 2.22 m. Within the powerhouse the main inlet butterfly valve of nominal diameter of D = 2.5 m is arranged immediately upstream of each turbine unit. After passing through the turbines, the water is discharged via the draft tube extension into the common tailrace tunnel and from there to the outlet bay. Each draft tube can be closed by a draft tube flap gate for maintenance or repair of a turbine unit. The distance between the turbine unit centre lines is 15.15 m.

The tentative dimensions of the powerhouse cavern are as follows:

Width	20.0 m	Length	73.5 m
Height	35.0 m at draft tube, (31.0 m at valve floor)		

On both lateral walls of the cavern crane beams of reinforced concrete are arranged anchored to the rock for the overhead travelling crane. A single service and erection bay is provided in the northern part of the cavern at elevation 1345.45 m. For access to the powerhouse cavern and further to the transformers cavern a common access tunnel is provided of 5.5 m diameter.

The No. 10 single phase transformers are arranged in a small cavern which is arranged at 30 m distance from the powerhouse cavern. Aiming on a high reliability it was decided to consider a SF6 gas insulated switchyard arranged underground adjacent to the transformer cavern. The transformer cavern is approximately 9.0 m wide, 7.4 m high and 64 m long whereas the switchyard cavern is 13.7 m in width and 10.5 m in height. The turbine setting is defined according to the requirements to prevent cavitation at the turbine units at elevation 1336.0 m asl based on the minimum tailwater level of 1339.6 m asl for the selected turbine and the prevailing hydraulic conditions.

The turbine draft tube extensions form a manifold system that joins into a single tailrace tunnel of 93 m length and 7.3 m diameter. At its end a power outlet structure at the left bank of the Swat River is arranged. The elevation of the invert at the outlet structure is selected at elevation 1336.0 m asl. The working and access platform are arranged at elevation 1355.0 m asl safely above the above the maximum flood water levels of Swat River.

5. Design of Electro-Mechanical Equipment

5.1 General

The mechanical equipment and main mechanical auxiliaries in the powerhouse consists of following items:

- three vertical shaft single-stage Francis-turbines including hydraulic/electronic turbine governors
- butterfly valve in front of each turbine with auxiliaries

Auxiliary mechanical systems such as:

- cooling water system
- drainage and dewatering system
- ventilation and air conditioning system
- oil treatment plant
- compressed air system
- mechanical and welding workshop
- three sets of draft-tube flap gates
- powerhouse-overhead travelling bridge crane
- fire fighting system

5.2 Design Criteria

For the feasibility design the hydraulic and civil design criteria have been established in coordination with the Project Sponsor.

Sediment and grain size analysis:
Silt and sediments of finer fractions may pass the turbine units with a sediment concentration of up to 4000 ppm. The petrographic analysis of rock and sand samples revealed a possible maximum content of quartz minerals of 10 %. The chemical analysis of the sediments and their hardness is recommended to be performed in the tender design phase that particular design features such as special coatings or extreme wear resistant materials can be chosen based upon the results of this analysis.

Hydrological and hydraulic conditions:
On the basis of the available hydrological data and the assumed operation regimes, the expected maximum peak capacity is presently assumed to be some 157 MW. During the present feasibility study phase the number and size of the turbines was optimised. The significant variation of flow in Swat River in combination with the run-off river operation concept results in the selection of three Francis units of identical size (3 x 52.43 MW rated output capacity). During the high flow season for more than 4 to 5 months each year the turbine units will run continuously under full load. During the low flow period of 4 months only one turbine unit will be operated mostly under part-load operation conditions.

5.3 Selection of Turbines

The net head and discharge are such that only vertical axis Francis turbines can be considered. The outlet structure of the turbine tailrace spills into the riverbed at riverbed level of 1339.6 m asl. For the present turbine layout we defined the setting of the turbine at level 1336.0 m asl, which gives enough safety for overload conditions.

Characteristics	Unit	Intake/ Powerhouse
PMF	m asl	1494.5
FSL (Full Supply Level)	m asl	1494.0
MSL (Minimum Supply Level)	m asl	1492.0
TWL_{min} (Tailwater Level Minimum)	m asl	1339.6
TWL (at 129 m^3/s)	m asl	1341.1
TWL_{max} (Tailwater Level Maximum at PMF)	m asl	1346.0
H_{gross} (range)	m	146 – 154
h_l (1 unit operation / 43 m^3/s)	m	2.2
h_l (3 unit operation / 129 m^3/s)	m	14.7
H_{net} (1 unit operation / 43 m^3/s)	m	151.7
H_{net} (3 unit operation / 129 m^3/s)	m	138.2
Q_{avail} (inflow)	m³/s	10 - 400
Q_{turb} (maximum design discharge)	m³/s	43

Table 5.1: Main hydraulic data of turbine layout

The units are supposed to be operated mainly as run-off-river plant. The turbine is selected to operate continuously under part load conditions The primary operation mode for this run-off-river plant will be level regulation.

Characteristic	Unit	Data
Type	-	Francis
Number of Units	-	3
P at maximum design Q	MW	54.3
H rated	m	139
Q maximum design	m^3/s	3 x 43
Runner diameter	mm	2220
Setting	m asl	1336.0
Rated speed	rpm	333
P overload at rated head	MW	55.4
P max. (one unit operational only)	MW	60.8

Table 5.1: Main parameters of turbine layout (capacity given ex turbine unit)

It remains to discuss, clarify and specify in the tender documents the configuration and integration of the Madian HPP into the existing grid and the extent of the required black-start capability. In the present feasibility design provision are made for black-start and isolated grid operation.

5.4 Design of Francis-Turbine Equipment

The spiral-case of welded construction serves as inlet-structure to the radial oriented stay- and guide-vanes, which convey the incoming water from axial to rotational flow.

The guide-vanes made of stainless steel and optionally covered with hard-ceramics permit the regulation of the incoming-flow. The guide-vane stems are supported by one lower and two upper self lubricating bearings, which can be adjusted, exchanged and maintained without dismantling head cover or bottom ring. The turbine is controlled by an electronic governor, which transforms each electronic signal into a hydraulic action to be executed by the hydraulic governor. For maintenance- and commissioning purposes the governor can be operated from the local control panel of the electronic governor, but under normal operation it is remote-controlled from the control room in the powerhouse or from each other place to be designated.

Particularly the long lasting conditions of part-load operation have to be considered seriously and the runner shall be designed to allow a continuous, fail-safe operation without increased vibration, noise and draft tube pressure pulsations as well a free of cavitation operation.

The runner is a weld construction of high alloy steel made of pre-fabricated cast or forged blades and rings. Depending on the results of the chemical analysis and hardness of the suspended sediment the advantages of a hard or soft-coating of the runner have to be evaluated in the tender design. The runner is bolted to the turbine-flange. Multi-stage labyrinth rings reduce the losses of water.

The draft-tube cone made of ordinary steel is bolted on its upstream side to the runner cone and welded downstream to the draft tube.

5.5 Powerhouse Outlet / Draft Tube Flap Gate

Three sets of draft tube flap gates are foreseen for repair and maintenance of the draft-tube and the turbine. For safety reasons and to protect the outlet structure from inundation and silting, flap gates for each unit are supplied. Each flap gates is operated by means of a hydraulic hoist, which is installed above the housing of the flap gate.

Clear width of flap gate	app. 5.5 m
Clear height	App. 2.5 m
Max tailwater level	1346.0 m asl
Sill elevation	1327.9 m asl
Operation	Open/Close under balanced no-flow condition
Hoist	Oil-hydraulic hoist drive
Flap normal operation speed	0.3 m/min

Table 5.2: Main data of draft tube flap gates

5.6 Main Inlet Valve

In front of each turbine, one butterfly-valve is installed as emergency- and repair shutdown-valve of the turbine. The butterfly valve type was selected since the alternative spherical valve type results according to common experience in significantly higher equipment costs and requires larger dimensions for access facilities and capacity of lifting equipment.

Characteristic	Unit	D1 (b)
Number of Units	-	3
Nominal diameter DN	mm	2500
Nominal pressure PN	bar	20

Table 5.3: Main data of main inlet butterfly valves

The opening of the valve is effectuated by means of one or two hydraulic pistons, the closing by means of a counterweight, which closes the valve under all flow conditions.

5.7 Main Lifting Equipment

The required total maximum lifting capacity of the EOT powerhouse crane is determined by the generator rotor which will weigh around 180 tons. The weight of all other pieces of equipment to be handled by the main hook will be much less than 100 tons. An auxiliary hook of 10 tons capacity will be provided on the crane and will run along the main bridge beam; this will be used for handling smaller equipment and for normal maintenance work such as runner removal, etc. The present proposed capacity of the crane should be reviewed during the tender stage when the suppliers confirm the actual weight of the generator rotors.

During the installation of the turbine embedded parts, a lifting capacity of roughly 25 tons will be required for assembly of the draft tube and spiral case. The temporary construction crane will be available for this work. Details of this temporary lifting facility will be given in the civil works specifications of the tender documents. The required total maximum lifting capacity of the EOT crane is supposed to be around 10 tons for installation and assembly of the switchyard and transformer components. The present proposed capacity of the crane should be reviewed during the tender stage.

For maintenance and operation of the entire power plant facilities a mobile crane will serve to handle equipment on the various sites. The lifting capacity is estimated to be around 20 tons with a jib of 10m. Within the design phase the lifting capacity has to be adapted to the maximum load of equipment to be handled and the required effective working area.

5.8 Mini-hydro Francis Turbine for Ecological Release

The applicable turbine is selected according to the head and discharge available. The unit will use the ecological flow which is to be released at Madian HPP weir site to the downstream river reach. The available head and discharge (per definition) are almost constant over the 365 days per year except during operation of the flushing facilities. The unit is supposed to be continuously operated as run-off-river plant.

A standardized horizontal Francis turbine is the most economical solution under such conditions. For the low head application and the discharge many manufacturers offer standardized skid mounted units, which are delivered workshop tested to the power plant. The runner will be directly coupled to the synchronous low-voltage generator, which is connected to the local medium voltage grid available at the intake. The unit is fully automatically controlled from the central control room. In the following Table 5.4 the basic characteristics of the selected turbine are given:

Characteristic	Unit	Data
Type	-	Horizontal Francis
Number of Units	-	1
P rated	kW	510
H rated	m	15.8
Q rated	m^3/s	3.6
Runner diameter	mm	650
Setting	m asl	1478
Rated speed	rpm	600
P max.	kW	540

Table 5.4: Main data of auxiliary turbine

Immediately upstream of the turbine a butterfly-valve is installed as emergency- and repair shutdown-valve of the turbine with a nominal diameter of 800 mm, operated by a hydraulic servomotor.

6. Design of Electrical Equipment

This chapter summarizes the feasibility design of the electrical equipment of the Madian HPP to be installed at the major project structures such as powerhouse, weir/power intake and desander caverns. The design concept is based on the assumption to interconnect the Madian HPP to a 220 kV high voltage transmission line at the switchyard as informed by PPIB in a meeting in September 2008. The single line diagram 220/11/0.4 kV is included in Volume 7, Plate 60.

Main Supply Scheme at Power Cavern

The applied connection scheme between the generators and their respective step-up transformers will be of conventional arrangement, with generator circuit-breaker and with tap-off to the excitation transformers and to the unit auxiliary transformer. As step-up transformers, three banks each of three single-phase units will be foreseen (plus one spare single-phase unit) and located in the power cavern in dedicated transformer rooms. The transformer terminals will be suitable for connection of isolated single-phase bus ducts on the 13.8 kV side. The 230 kV terminals will be equipped with bushings for connection of 220 kV power cables to the 220 kV GIS switchgear located in the power cavern as well (separate room).

The 220 kV GIS switchgear will comprise a double bus bar scheme, ensuring reliability and flexibility during normal and also during exceptional operating conditions. Two 220 kV power cable connections will lead out of the switchyard cavern through a cable tunnel up to a 220 kV terminal gantry with surge arresters provided for the 220 kV public grid overhead line side. The 220 kV gantry will be located close to the cable tunnel outlet structure.

The study considers the existing Madian conventional open-air type 220 kV switchyard located on a appropriate terrain in a distance of about 2 km from the Madian HEP and considers a double 220 kV overhead line (using suspension type intermediate towers, if necessary) up to the 220 kV terminal gantry close to the HEP power outlet structure (not part of the Madian HPP and not detailed further in this Study).

Auxiliary Supply Scheme at Power Cavern

Under normal condition supply of auxiliary power will be through one of the two 100% unit auxiliary transformers feeding the 400 V station service board. Alternatively station auxiliaries (about 50% of total auxiliaries) may be fed from the synchronous emergency diesel generator set, in case of complete power failure (also used in case of black-start).

For normal starting of a turbine-generator unit, the feeding of the 400 V station service board and all station auxiliaries will be effected by using the 220 kV grid supply through the unit step-up transformer and the unit auxiliary transformer, while the generator circuit-breaker is open. UPS systems will comprise the 2 x 100% redundant 110 VDC-, 24 VDC-, 48 VDC-, 400 V safe AC-systems and one emergency diesel system.

6.1 Electrical Equipment within the Power Cavern

6.1.1 Main Generating Equipment

The closed-cycle air-cooled generators will be equipped with air-water heat exchangers, connected to the plant cooling water system. For all load conditions maximum air temperature will be limited to 40°C. The power and speed of the generators are dictated by the turbine, with its calculated output at the shaft coupling at design heads and design flow. Considering the respective turbine power output, a typical generator efficiency of approx. 98% and a power factor of 0.85 (which allows the generation of the necessary reactive power for voltage regulation at the 220 kV grid).

All windings of stator and rotor will be provided with a class „F“ insulation system. As the long-term performance of the insulation system is affected by the maximum operating temperature of the windings, the rated output of the generators will be related to a temperature rise to class „B“ insulation. The rated generator voltage will be considered with 13.8 kV, which is a typical standard voltage and appropriate for generators of this size. However, for optimization of the generator and bus bar design, the final selection may be left open to the supplier.

Turbine power			
			Remarks:
P_{rated}	MW	54.3	3 units running at maximum design discharge (at full capacity nominal). Minimum power delivered to each generator at class B temperature rise!
P_{max}	MW	60.8	Only 1 unit is running. Maximum power delivered to a (each) generator at class F temperature rise!
Nominal speed	rpm	333.3	
Rated frequency	Hz	50	
Generator power			
Generator efficiency	%	98.0	
nominal power factor	-	0.85	
P_{S_rated}	**MVA**	**63**	Minimum power each generator at class B temperature rise must be able to deliver!
P_{S_max}	**MVA**	**70**	Maximum power a (each) generator at class F temperature rise must be able to deliver!

Table 6.1: Design Parameter for Generator Design

For the dimensioning of the civil layout the following generator dimensions were estimated:

- Rotor diameter approx. 4000 mm
- Outer stator diameter approx. 6100 mm
- Shaft length approx. 5000 mm
- Weight of complete rotor approx. 152 tons

Due to the limitations of transport dimensions and weights, the stator housings will be divided and delivered in sections and the winding at the joints will be completed on site. The rotor will be assembled completely at site, including stacking of the rotor rim and fixing of the poles.

6.1.2 Step-Up Transformers

Due to the transportation weight restrictions, single-phase transformers are considered in this stage of the project. The rating of each oil-immersed closed single-phase transformer will be 24 $^{1}/_{3}$ MVA (corresponding to 73 MVA for the three-phase transformer bank). The detailed requirements of the on-load tap-changer will be investigated in the tender design stage once corresponding load-flow studies for the grid and the power plant are available. Because of the indoor location in the power cavern, the cooling-type of the transformers will be OFWF (oil forced cooling / water forced re-cooling). Each transformer bank of three single-phase transformers will be installed in a separate cavern-cell with concrete partition walls for fire protection. One spare single-phase transformer will be provided and stored in a separate cavern-cell adjacent to the active transformers. This arrangement allows the replacement of any transformer in a short time.

• Number of single-phase transformers	9 + 1 (spare)
• Type	single-phase, two windings
• Rated bank output of 3 single-phase transformers	73 MVA
• Frequency	50 Hz
• Type of cooling	OFWF
• Rated voltage:	
• High voltage winding	230/√3 kV
• Low voltage winding	13.8 kV
• Rated power frequency withstand voltage (rms value)	460 kV
• Rated lighting impulse withstand voltage (peak) BIL	1050 kV
• Type of tap changer	on-load tap-changer
• Range of tapping	± 12 x 1.25% = ± 15%

Table 6.2: Design Parameter of Single Phase Transformers

6.1.3 Unit Auxiliary Transformers: 13.8/0.42 kV

Two three-phase transformers will be provided for auxiliary power supply from the generator bus ducts of unit No. 1 and 3. The rating of each dry-type (cast-resin) transformer will be 1250 kVA, where each transformer will be suitable to feed the total auxiliary power demand in the power cavern. The voltage ratio will be 13.8 / 0.42 kV.

6.1.4 220 kV GIS Switchgear

A 220 kV SF_6 gas-insulated switchgear (GIS) will be installed in a separated room in extension of the transformer cavern. The switchgear scheme includes a double bus bar system to ensure reliability and flexibility during normal and during exceptional operating conditions. The switchgear will consist of six bays. The technical characteristics of the GIS will be as follows:

• Insulation medium	SF_6
• Maximum operation voltage	245 kV
• Rated power frequency withstand voltage (rms value), across open switching device and/or isolating distance, at minimum operating gas-pressure	460 kV
• Rated power frequency withstand voltage (rms value), phase to phase and phase to earth, at minimum operating gas-pressure	530 kV
• Rated lighting impulse withstand voltage (peak), phase to phase and phase to earth, at minimum operating gas-pressure	1050 kV
• Rated short-circuit breaking current	25 kA for 1 second
• Rated bus bar current	1000 A
• Rated current for generator, line and coupling bay	630 A / 1000 A / 1000 A

Table 6.3: Design Parameter of 220 kV GIS Switchgear

6.1.5 220 kV XLPE Cables

The connection between the HV terminals of the step-up transformers and the corresponding feeders in the GIS will be executed with 220 kV XLPE copper cables.

• Maximum operation voltage	245 kV
• Rated voltage (Uo/U)	127/220 kV
• Short duration power frequency withstand voltage (rms value)	460 kV
• Rated lighting impulse withstand voltage (peak)	1050 kV
• Rated power per 3-phase cable system	190 MVA

Table 6.4: Design Parameter of 220 kV XLPR Cable

6.1.6 Auxiliary Electrical Equipment

400 V AC Auxiliary Power Supply

The auxiliary power requirements of each unit will be provided through the three unit auxiliary boards, each one fed from the main distribution board. The 400 V main distribution board itself will be fed either from the two unit auxiliary transformers, rated 1250 kVA each and connected to the generator bus system of unit No. 1 and 3.

UPS Systems

UPS systems will comprise the 2 x 100% redundant 110 VDC-, 24 VDC-, 48 VDC-, 400 V safe AC-systems and one emergency diesel system as follows:

Diesel Generator Set

The 400 V emergency diesel-generator set will be required to provide the necessary emergency and black-start power supply. The unit will start and build-up voltage automatically within 15 sec. Shut-down of the diesel engines will be by means of fuel shut-off solenoid. As a result from preliminary estimations of the essential loads to be supplied by the diesel generator set, a rated output of 630 kVA will be sufficient.

Electrical Protection Systems

All electrical protection systems will be of the digital (numerical) type and will comprise the following sub-systems:

- Generator Protection System
- Step-Up Transformer Protection
- Station Service Transformer Protection
- 220 kV GIS Switchgear Protection

11 kV Switchgear

Protection comprises 3-phase over-current- and earth-fault relays in the incoming feeders. The over-current relay will be of the inverse-time type with instantaneous tripping set at a high level. The relays will be installed in the relay compartment of the 11 kV panels.

400 V Switchgear

Protection of the 400 V system will be provided by magnetic thermal trip units mounted on the circuit-breakers. In the case of fuse isolators combined with contactors only thermal overload protection will be required. Under-voltage relays on each bus bar will supply the criteria for the automatic change-over device for the different supply sources.

Fire Detection System

A decentralised fire alarm system with detection and release function will be provided for the entire power station and the corresponding galleries. The system will consist of one central unit (main fire alarm panel) supervising the sub-units located in the different areas of the cavern.

Fire Fighting Systems
The necessity of fire-fighting systems for sites such as oil tanks, cable ways, cable spreading room and the main control room will be defined in the tender design phase of the Project.

Electrical Workshop and Laboratory
A suitable equipped workshop and laboratory for maintenance and repair of the electric and electronic equipment will be located in the power cavern.

Control and Monitoring System
For reliable, efficient and safe operation of the power station a monitoring and control system will be provided suitable for supervisory, control and monitoring of each individual unit as well as common equipment in the power cavern, desander cavern and weir site / power intake. A modular, screen-prompted control system will be used, with references documented for relevant power stations. Provisions will be made to adapt the DCS for future remote monitoring from a remote grid dispatch centre.

Telephone System
The entire power station will be equipped with a telephone system consisting of a main exchange. This system will take over the internal and external telephone traffic of the power station area. The system will enable the telephone communication for at least 40 internal subscribes and 5 external lines via OPGW.

6.2 Main Electrical Equipment outside the Power Cavern

Power Supply at Weir Site
The power supply at the weir site, including the weir control building and the power intake, will be connected through an 11 kV transmission line (loop-in) to the local 11 kV grid.

The following equipment will be foreseen at weir site:

- One 11 kV switchgear with two feeders
- One auxiliary transformer 11/0,42 kV, 630 kVA
- One 400 V main distribution and sub-distribution boards
- Two 100% UPS systems, battery backed-up
- One synchronous hydraulic turbine-generator approx. 650 kVA at 400 V
- One synchronous 400 V emergency diesel generator set 150 kVA
- One satellite DCS

220 kV Terminal Gantry
A 220 kV terminal gantry will be located close to the cable tunnel outlet structure. It will consist of a lattice steel construction, to which the public grid 220 kV overhead lines will be connected on the external side and the 220 kV XLPE cable will be connected on the internal side.

7. Design of Hydraulic Steel Structure Equipment

7.1 General

The design for the Madian Hydropower Project comprises the following main components, which include hydraulic steel structure equipment:

- Concrete weir structure with gated spillway
- Power intake with raking machine and flushing structure
- Desander with gates at inlet and outlet
- Power waterways
- Tailrace and outlet structure
- Diversion tunnel

The gated spillway equipment includes:
- Three radial segment gates (7.6m x 12.0 m) with hydraulic drives
- One radial gate will be equipped with a flap gate (7.6m x 2.5m)
- Set of stop log for maintenance (7.6m x 12.0 m)
- Gantry crane with capacity 50/10 t;

The power intake facilities include:
- One stop log set (5.9m x 7.5m) at intake entrance
- Three trash racks (5.9m x 7.5m)
- One cleaning machine with hoisting facilities
- Three intake roller gate (W x H = 3.2m x 4.0m)
- One set of maintenance stop log (3.2m x 4.0m)

The flushing facilities located between spillway and power intake consist of:
- two roller gates (2m x 3m)
- One set of maintenance stop logs (2m x 3m) in front and behind
- Steel lining (length of 25 m) of the flushing channel / bottom surface

The three desander caverns are equipped with:
- three slide gates (3.2m x 4m) upstream of the desander cavern
- three slide gates (3.2m x 4m) downstream of the desander cavern
- desanding device with auxiliaries
- six sluice valves DN500 for sediment flushing

The power waterways will include these HSS equipment:
- one sliding gate (5.5m x 5.8m) for inspection & maintenance of pressure shaft and surge tank
- pressure shaft steel (5.4 m) lining starting from elevation 1375 m asl
- three manifolds before main inlet valve

The outlet structure at the end of the tailrace will be equipped with a bulkhead gate (W x H = 6.1m x 7.3m). The diversion tunnel will be locked after construction of the weir by means stop logs (8.0m x 9.5m).

7.2 Spillway

Radial Spillway Gates

The gated spillway consists of three radial gates for the spillway bays, one of them with hinged flaps on the top for fine regulation of the reservoir level and for spilling of floating debris. The radial gates are used for flood control and discharge of excess water. Operation control must be possible locally from the Local Control Room and remote from the Main Control Room. The gates shall have self closing tendency.

Basic data and design criteria of the radial gates are:

Clear width of one spillway bay opening	7.6 m
Gate height (approx.)	12.0 m
Freeboard	0.50 m
Clear width of flap gate	7.6 m
Flap height (approx.)	2.5 m
Sill elevation	1482.5 m asl
Gate sill in max. raised position	1495.5 m asl
Max Reservoir Level	1494.5 m asl
Crest elevation of the piers	1496.0 m asl
Max. operation load:	All hydraulic loads, dead weights and friction loads
Hoist	Oil-hydraulic
Gate and flap normal operation speed	0.3 m/min
Gate opening speed	0.3 m/min

Table 7.1: Basic data and design criteria of the radial gates

In the left spillway bay a radial gate will be installed with integrated flap gate on top next to the flushing outlet. It shall be a torsion-rigid box type. Two servomotors connected to the gate arms shall operate each spillway gate. The hydraulic power units will be located on the spillway piers, in a common control room, together with the local control boards.

Stop log for Maintenance

In order to enable in situ maintenance work at the radial gates and to enhance erection, one set of stop logs for the spillway, to be installed upstream of the radial gates, is provided. The stop logs will be installed with the gantry crane.

Gantry Crane

One gantry crane with an approximate lifting capacity 50/10 tons will be installed to serve the spillway. The final capacity of the crane shall be coordinated with the design of the spillway radial gates and stop logs in the tender design stage. The crane will be able to travel to the unloading platform located beside the spillway structure. The gantry cranes will serve to install the spillway stop logs and to assemble and erect the spillway radial gates with flaps.

7.3 Equipment of Power Intake

Stop logs

To dewater the individual bays of the intake structure for maintenance of the trash rack and the intake roller gate, stop logs can be installed upstream of the trash rack and immediately downstream of the fixed wheel roller gates. These stop logs will be stored at deck level 1496 m asl. Setting of these two stop logs permits maintenance/inspection at one gate or trash rack while flow and power plant operation may proceed via the remaining inflow sections. All stop log elements shall have the same shape and dimensions.

Trash rack

The trash rack screen consists of 3 identical elements covering the inlet area with a clear width of 5.9 m and a clear height of 7.5 each (total area of 3 x 44.25 m^2) each split in three segments. The trash rack panels will be supported by means of a pre-caste concrete beam of fish belly shape. The design has to provide vibration-free performance and minimal head loss. A clear spacing between screen bars of 75 mm was selected and will be re-confirmed in the detailed design in co-operation with the turbine manufacturer.

Trash rack Cleaning Machine

The rake cleaning machine will be a movable portal raking machine with operator cabin and container for the removed trash. The main characteristics of the raking machine are as follows:

Roller Gate

The intake gates located downstream of the trash rack serve as emergency closure devices in case of failures or damages of downstream structures in the desander or waterways, extraordinary pressure difference at the trash rack etc. All gate controls and hydraulic motors will be housed in a control building at the intake deck level.

Design data of roller gate:

Type	Fixed Roller Gate
Number of gates	3
Clear width of opening	3.2 m
Clear height of opening	4.0 m
Sill elevation	1483.0 m asl
Max Reservoir Level	1494.5 m asl
Crest of the piers	1496.0 m asl
Operation	Open against max. differential head Close at max. flow
Max. operation load:	All dead weights and friction loads
Seal position:	upstream
Maximum allowable leakage	0.1 l/m of seal/sec

Operating mechanism:	Hydraulic Hoist

Table 7.2: Basic data and design criteria of the roller gates at power intake

Flushing Gates

The flushing structure is located left of the gated spillway in extension of the power intake structure. The two sliding gates 2 m wide and 3 m high are operated intermittently to flush the sand and gravel which may deposit in front of the power intake into the tailrace when required. The gates will seal upstream and have ballast for gravity closure against flow with adequate factors of safety against hydraulic forces and friction. Control will be by a hydraulic servomotor set operating at deck level and coupled to the gate via steel linkage rods. The concrete structure of the flushing channel is subject to extraordinary wear and tear during flushing operation. Therefore it is planned to cover the entire flushing channel by a steel lining of 20 mm thickness. The steel lining starts at the pier nose and will ends after the downstream stop log.

Stop log

To have access to the flushing gate for maintenance purposes under any operating conditions, stop logs will be installed upstream and downstream of the flushing gates (2 bulkhead gates upstream and 1 downstream).

7.4 Desander

The civil design provides a single headrace tunnel and three underground desander caverns. From the headrace tunnel 3 manifolds branch of upstream and downstream of the caverns.

Suspended sediments (sand and silt) transported by Swat River and entering the headwork of the Madian HPP will unavoidably result in a certain wear and tear. The extent of the abrasion depends largely on the concentration, size and mineralogical characteristics of the sediment particles on one hand and the turbine type and runner speed on the other. This abrasion and the resulting need for overhaul and replacement of runners cannot be avoided, however, the frequency of repair works can be reduced by arrangement of desanding facilities.

The Consultant selected a conceptual design of the desander basins which permits continuous operation of the power plant by means of intermittent (or if required continuous) flushing of the desander basin based on a modified so called “Bieri”-Desander Design (Switzerland) applying elements of the recently developed so called “4-S” Design (Norway). Hydropneumatic valves seal the desander basins against the flushing duct and are opened periodically when required. The discharge in the flushing ducts is controlled by the flushing gates situated at the junction to the central flushing tunnel. In the flushing tunnel the water-sediment mixture continues by free flow and enters Swat River close to the confluence with Ashkon Nullah.

The desanding caverns as well as the flushing tunnels shall be concrete lined. The pump/compressor system for the rubber hose sealing system with

accessories and control devices will be installed in a common control room together with the panels of the sluice valves.
For inspection and maintenance of each desander cavern gates are provided in the upstream and downstream manifolds 3.2 m wide and 4 m high. This concept ensures inspection and maintenance of a single desander cavern without suspending power plant operation and emptying the entire pressure tunnel. The sliding gates including all accessories and control cubicles are located in a gate chamber near the desander cavern which is connected by a gallery to the downstream access tunnel. The gate has ballast for gravity closure under balanced water conditions with adequate factors of safety against hydraulic forces and friction.

Sluice Valve
The sluice valves are installed at the outlet of the flushing ducts of the desander caverns just upstream of the junction with the flushing tunnel. When the desanding basin is filled to a certain level with sediments, the flushing procedure will be initiated. Simultaneously, the sluice valves are opened to flush the sediment to the flushing tunnel and return the flow to Swat River. Their design and corrosion protection must be proved to resist wear and tear under these adverse operating conditions of heavy suspended water and the high flow velocities during flushing.

7.5 Power Waterways

The bulkhead is located at the surge tank and serves as maintenance gate to dewater the pressure shaft between surge tank and powerhouse. The gate is only operated under no flow condition, when the turbines are at standstill.

The pressure shaft is split into a concrete lined section of nominal internal diameter of 5.8 m starting at the surge tank and a steel lined part to the high pressure side. The steel liner of nominal internal diameter of 5.4 m starts at a level of approx. 1375 m asl and comprises of the following sections:

The bifurcations will have an optimized shape to minimize head losses and an internal reinforcing structure. The splitting of bifurcation for site installation will be made depending on the size of construction and tunnel excavation. Three pipelines will be site-erected and installed with an internal diameter of 3.0 m including the required bends to the upstream conical pipe of the butterfly valves with nominal internal diameter of 2.5 m. The design pressure will be 20 bar.

In order to close the diversion tunnel intake once the construction of the weir is accomplished and to plug the intersection with the headrace tunnel with concrete, one set of stop logs (concrete and/or steel) will be provided.

Diversion tunnel inlet dimensions (W x H):	8.0 x 9.2 m
Sill elevation:	1478.0 m asl
Design water level:	1494.5 m asl

8. Power and Energy Potential

8.1 Methodology and Basic Parameters

For the design of the Project the following design water levels are defined:

Normal Operation Level:		1494.0 m asl
Minimum Operation Water Level:		1492.0 m asl *
Maximum Reservoir Level:		1494.5 m asl **
Powerhouse Design Discharge	Q =	129.0 m³/s
Maximum Gross Head	H_{max} =	154.4 m
Minimum Gross Head	H_{min} =	146.0 m

* In case active storage is provided for temporary additional releases not considered in the present comparison

**in the event of the design flood a surcharge of 0.5 m may establish.

Simulation of hydropower plant operation and the corresponding energy calculations were based on daily flow data of the available records of 47 years of Kedam gauging station.

The calculation of the available gross head for power generation takes into account the head pond level at Madian weir site and the tailwater level at the power outlet. The net head was determined reducing the head losses of the power waterway system from the gross head applying the head loss characteristics. The available power and energy generation were simulated applying the corresponding efficiency curves for the turbine units and the generator. The transformer efficiency was assumed constant in this study.
For the power waterway system a head loss of 14.7 m was determined at maximum turbine design discharge at all 3 units at rated head. For discharges smaller than the maximum design discharge, the head loss can be estimated applying the following relationship based on the assumption of an even distribution of flow through the 3 turbine units:

$$h_l = 883.158 \times 10^{-6} \times Q^2$$

where h_l = head loss in m
Q = powerhouse discharge in m³/s

Accordingly head losses are

at rated conditions	Q = 129 m³/s	14.7 m*
at a discharge of	Q = 86 m³/s	6.5 m*
at a discharge of	Q = 50 m³/s	2.2 m

* even distribution of flow at all three units

Based on the corresponding optimization of the number and size of turbines (see Section 4.10), the following arrangement of turbine units was selected:

ALT 1 3 identical units (Base Case) 3 x 43 m³/s

In the result of this optimization and the corresponding electro-mechanical design the following key parameters were considered in the simulation of hydropower plant operation and the corresponding estimation of annual energy generation. The optimum powerhouse design discharge for the Madian Hydropower Project was determined to be 129 m^3/s.

E&M key parameters:

Maximum Design Discharge:	43.0 m³/s
Minimum Unit Design Discharge	17.2 m³/s
Rated Discharge	39.0 m³/s
Maximum Design Head:	151.7 m
Maximum Power*:	58.5 MW
Power* at Maximum Design Discharge:	3 x 52.43 MW
Power* at Rated Discharge:	3 x 48.4 MW
Maximum turbine efficiency:	94.5 %

* Power ex transformer

Turbine efficiency was assumed as given in Figure 8.1, typical generator and transformer efficiencies (constant 0.99) were assumed correspondingly.

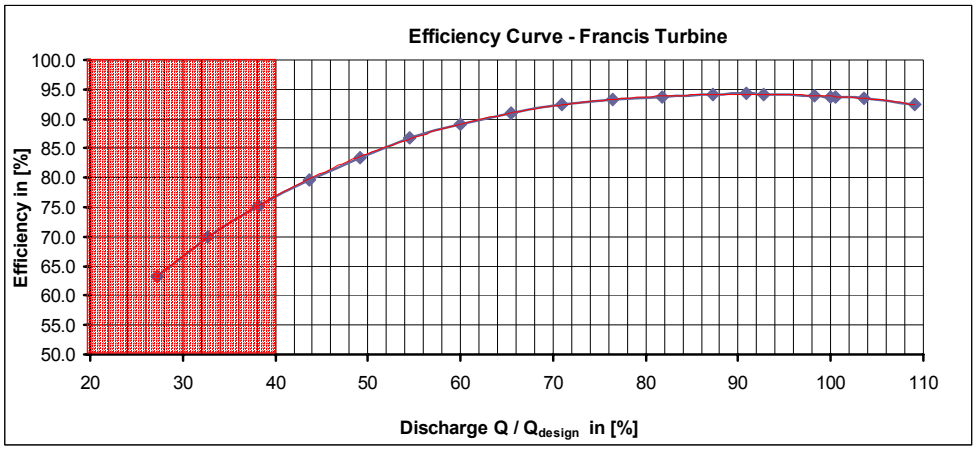


Figure 8.1: Turbine Efficiency as a Function of Turbine Discharge

For the defined Normal reservoir Operation Level (NOL) of 1494 m the weir structure has a height of 19 m above river bed and creates a reservoir with a length of approximately 1.46 km. The total volume of the reservoir would be 0.48 million m³. Regular pondage operation is not foreseen, however, at times of extremely low river flow a certain pondage may be allowed to ensure operation of a single unit for a limited number of hours.

Transients may be caused by the future operation of the immediately upstream located Asrit Kedam HPP (presently in development) from unforeseen changes in the mode of operation which need to be compensated at the Madian weir site. Therefore, a reservoir with a certain storage capacity is of advantage at Madian HPP weir site to guarantee and improve conditions for turbine operation (and turbine efficiency) at times of extremely low river flow.

8.2 Simulation of Annual Energy Generation

For the assessment of the benefits from power generation, simulation of plant operation was carried out based on 47 years of historical daily river flow data (period 1961-2007) based on records of Kalam gauging station.

The simulation of Madian HPP operation reveals that the annual energy generation may vary between 688.4 and 851.9 GWh (see Table 8.1) with an average of 767.5 GWh, i.e. annual energy generation varies between 89.7 and 111.0 % of the mean annual generation.

Year Month	Min Peak En GWh	Mean Peak En GWh	Max Peak En GWh	Percent of Annual Generation
Jan	0.00	14.08	26.47	1.83%
Feb	0.00	8.53	23.64	1.11%
Mar	5.58	20.99	49.61	2.74%
Apr	41.61	67.73	101.16	8.82%
May	96.14	113.92	116.63	14.84%
Jun	111.40	112.11	112.81	14.61%
July	115.05	115.82	116.53	15.09%
Aug	113.97	116.26	116.75	15.15%
Sep	60.08	94.64	112.87	12.33%
Oct	38.23	50.78	77.45	6.62%
Nov	23.17	30.77	47.21	4.01%
Dec	12.07	21.89	33.50	2.85%
Total	688.41	767.52	851.88	100.00%
			May - September	72.02%
			November - March	12.54%

Table 8.1: Minimum, Average and Maximum Monthly and Annual Energy Generation - Simulation Period of 47 years of RoR Plant Operation

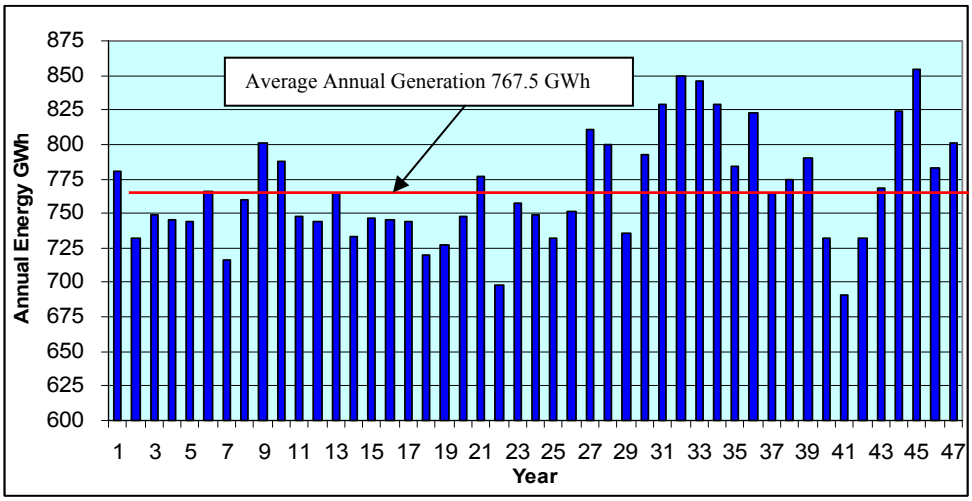


Figure 8.2: Variation of Annual Energy Generation of the Proposed Madian HPP

Figure 8.2 demonstrate that energy generation is nearly the same in the period from May to August when about 60 % of annual energy generation is realized at full load conditions, i.e. during 33 % of time 60 % of annual

energy would be produced. During this period the available power would be in general above 150 MW.

RoR Month	Max Daily Energy GWh	Min Daily Energy GWh	Mean monthly Energy GWh	Max Daily Power MW	Min Daily Power MW	Mean Monthly Power MW
Jan	1.05	0.75	25.96	43.6	31.4	34.9
Feb	1.05	0.54	23.64	43.9	22.6	35.2
Mar	2.52	0.97	49.61	105.0	40.2	66.7
Apr	3.78	2.01	96.74	157.3	83.7	134.4
May	3.77	3.75	116.55	156.9	156.3	156.6
Jun	3.76	3.70	111.91	156.8	154.2	155.4
July	3.74	3.70	115.29	155.7	154.3	155.0
Aug	3.78	3.71	116.29	157.3	154.5	156.3
Sep	3.77	2.11	97.32	157.3	87.8	135.2
Oct	2.55	1.05	48.97	106.3	43.7	65.8
Nov	1.05	0.69	25.18	43.8	28.8	35.0
Dec	0.89	0.72	24.42	37.2	29.8	32.8
Total Annual Energy Generation			851.88	GWh in a wet hydrological year (2005)		
RoR Month	Max Daily Energy GWh	Min Daily Energy GWh	Mean monthly Energy GWh	Max Daily Power MW	Min Daily Power MW	Mean Monthly Power MW
Jan	0.00	0.00	0.00	0.0	0.0	0.0
Feb	0.00	0.00	0.00	0.0	0.0	0.0
Mar	1.09	0.00	16.70	45.5	0.0	22.5
Apr	2.95	0.88	51.96	122.8	36.8	72.2
May	3.78	3.25	115.28	157.3	135.5	154.9
Jun	3.76	3.75	112.61	156.8	156.1	156.4
July	3.77	3.75	116.44	156.9	156.1	156.5
Aug	3.77	3.76	116.75	157.2	156.5	156.9
Sep	3.77	1.62	77.35	157.3	67.7	107.4
Oct	1.80	1.06	42.68	75.1	44.2	57.4
Nov	1.34	0.60	26.57	56.0	25.2	36.9
Dec	0.64	0.00	12.07	26.5	0.0	16.2
Total Annual Energy Generation			688.41	GWh in a dry hydrological year (2001)		
RoR Month	Max Daily Energy GWh	Min Daily Energy GWh	Mean monthly Energy GWh	Max Daily Power MW	Min Daily Power MW	Mean Monthly Power MW
Jan	0.65	0.51	17.76	27.0	21.4	23.9
Feb	0.78	0.50	17.68	32.4	20.7	26.3
Mar	1.32	0.00	20.61	55.1	0.0	27.7
Apr	3.78	0.92	62.61	157.4	38.5	87.0
May	3.77	3.30	115.68	157.3	137.3	155.5
Jun	3.75	3.72	112.04	156.2	155.0	155.6
July	3.74	3.70	115.41	155.8	154.4	155.1
Aug	3.76	3.74	116.10	156.6	155.7	156.0
Sep	3.77	2.57	94.23	157.2	107.0	130.9
Oct	2.62	1.28	55.44	109.0	53.4	74.5
Nov	1.31	0.84	31.63	54.6	35.0	43.9
Dec	0.85	0.62	22.90	35.2	25.8	30.8
Total Annual Energy Generation			782.10	GWh in a mean hydrological year (1995)		

Table 8.2: Variation of Power and Energy Generation with time for hydrological wet, dry and average year of plant operation

During the period from December to March energy generation is low and amounts to 8.0 % of annual energy generation in a dry year, 14.1 % on average and 17.5 % in a wet year. For run-of-river operation the power plant is assumed operational when the river flow available for power generation is

equal or above 40 % of the maximum turbine design discharge (44 % of rated discharge), i.e. higher than 17.2 m³/s.
Simulation of power plant operation reveals that the power plant could not be operated during 4 days in March as the consequence of low river flow in a mean hydrological year, such as e.g. 1995 (99.0 % plant availability). For a wet hydrological year such as the year 2005, plant operation simulation shows that power generation could continuously proceed around the year. If power plant operation is permitted with a limited draw down (up to 2 m) on the basis of e.g. two periods of operating the power plant for 3 to 5 hours per day, power generation can be maintained each day of the year.

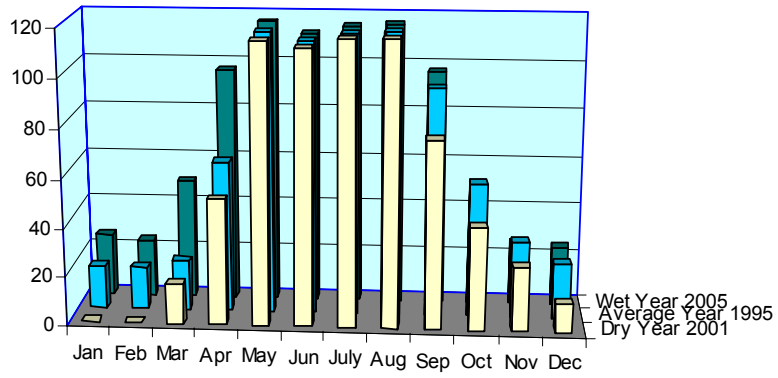


Figure 8.3: Annual Energy Generation of the Proposed Madian HPP

8.3 Interpretation of Results and Recommendations

The maximum available power of the Madian Hydropower Project is 157.3 MW (ex transformer). The available power of a single turbine unit in operation at maximum design discharge (43 m³/s) is 57.5 MW.

In the present simulation of operation of the Madian HPP, no pondage operation is considered at times of low river flow. By means of pondage operation in a dry year such as 2001, annual energy generation may be lifted from 688.3 GWh to 709.9 GWh or even 717.0 GWh, which is an increase by 3 to 4 % with little additional investment. According to the simulation of power plant operation based on daily river flow data of 47 years (period 1961-2007), the application of the concept of pondage operation was found to be advantageous.

8.4 Plant Simulation for the Economic and Financial Analysis

In co-ordination with the Project Sponsor and based on the official Draft Power Purchase Agreement (DPPA), common operation conditions shall be

applied for the economic and financial analysis of the Madian Hydropower Project. Accordingly provisions are made for unforced (scheduled) outages and forced (unscheduled) outages.
According to the DPPA the following assumptions are made:

Unforced Outages	20.00 days/year (480 hours/year)
Forced Outages	5.54 days/year (133 hours/year)

The Consultant considered that unforced outages are scheduled for the low flow period when river flow and energy production would be low, e.g. in the month of February. The Consultant considers that forced outages may rarely occur in the low flow season. Therefore, 5 days of forced outages is assumed in the high flow season and 0.54 days in the low flow season.

These assumptions result in reduction of the theoretically possible annual power generation by 25.2 GWh to 742.5 GWh as indicated in Table 8.3. The corresponding reduction of the annual energy generation is adjusted in the months of February and August.

Month	Energy Generation GWh
Jan	14.1
Feb	2.3
Mar	21.0
Apr	67.7
May	113.9
Jun	112.1
July	115.8
Aug	97.51
Sep	94.6
Oct	50.8
Nov	30.8
Dec	21.9
Total	742.5

Table 8.3: Mean Annual Energy Generation - Simulating 47 Years of Plant Operation with Provisions for Scheduled and Forced Outages

9. Bill of Quantities and Cost Estimates

9.1 General

This report summarizes selected key parameters for the estimation of costs of the Madian Hydropower Project and the cost estimate itself for all its major components. Basic costs of labour, material, consumables and equipment were inquired, unit costs calculated and compared with unit rates of hydropower projects of similar size and type presently under development in Pakistan. The cost estimate includes the following main plant components and cost elements:

- land acquisition
- land clearing and access;
- mobilisation cost and site infrastructure;
- surveys and investigations (e.g. hydraulic model tests);
- civil works:
- material disposal sites;
- manufacturing, transport erection, installation, testing and commissioning of:
  - hydraulic steel structures,
  - electro-mechanical and electrical equipment,
- environmental and social impact mitigation costs;
- taxes and import duties;
- administration and legal costs;
- engineering and supervision costs;
- finance and insurance;
- Sponsor's costs prior to commercial operation; etc.

9.2 Basis of Cost Estimation

The following assumptions were made by the Consultant based on his experience in coordination with the Project Sponsor as the basis for the present Feasibility Study:

June 30th 2007	**1 US$ = 60.63 Rps. (PAK)***
June 30th 2008	**1 US$ = 67.98 Rps. (PAK)**

* defined in coordination with client (November 2007)

Table 9.1: Basic Exchange Rate for Local to Foreign Currency

All costs will be expressed in the foreign currency US$. Local market prices and rates will be converted to foreign currency applying the exchange rate of the Central Bank of Pakistan at the selected reference dates. In co-ordination with the Project Sponsor the reference date applied to the present

feasibility study is June 30th 2008, which corresponds to the end of the fiscal year 2008.

9.3 Estimation of Direct Project Costs

The direct costs of a hydropower project are commonly estimated separated for the following major components based on the major items/elements.

a) Civil works;
b) Hydraulic steel structure equipment;
c) Electro-mechanical and
d) Electrical equipment;

9.3.1 Estimation of Civil Costs

The cost estimates shall be prepared on the basis of representative unit rates for the various construction activities and the respective quantities.

The Consultant followed the following approach:

1. Collect basic costs of materials, fuel, energy, consumables, labour, equipment etc ex factory and at site (cost of transport).
2. Calculate unit rates for relevant items of civil works for application to the BoQ;
3. Collect unit rates used in feasibility studies and tendering of Hydropower Projects of similar type and magnitude;
4. Compare, analyse and conclude on most appropriate unit rates for application to the BoQ of the Madian HPP.

The financial cost of labour rate were obtained from basic salaries used for different categories of labours on projects near Swat NWFP as shown in National Statistical Bulletin issued by the Federal Government of Pakistan and calculated and up-dated with the exchange rate based on 30th June 2007.

There is a large number of hydropower projects under development in Pakistan which provide a reasonable orientation for the plausibility of the calculated unit rates. The Consultant collected and analysed unit rates of civil works of the following hydropower projects to a reasonable extent similar in type and size to the Madian HPP:

1.) Malakand-III,
2.) Patrind HPP
3.) Golen Gol HPP
4.) Diamer Basha Dam Project
5.) Dubeer Khawar HPP
6.) Khan Khawar HPP

Since the units rates presented in the BoQ of the six above projects refer to different reference dates, they were escalated to the level of

June 30, 2007 applying an appropriate inflation rate per annum on local and foreign currency rates and the corresponding currency exchange rate of the Central Bank of Pakistan.
Based on the unit rates established in the Consultants unit cost data base and the detailed Bill of Quantity of the Project, the cost of the civil works was estimated as given in Table 9.2

MADIAN HYDROPOWER PROJECT	COST IN (USx1000)		COST IN Million US $
	LOCAL	FOREIGN	TOTAL
DIVERSION WORKS	**4.201,2**	**4.588,5**	**8,790**
U/S coffer Dam	920,2	746,2	1,666
D/s Coffer Dam	239,2	185,6	0,425
Diversion Tunnel	3.041,8	3.656,7	6,699
CONCRETE WEIR	**5.895,3**	**7.088,0**	**12,983**
Main Weir Body	4.530,6	3.990,4	8,521
Foundation Treatment (Borepiling)	722,9	2.313,2	3,036
Grouting	641,8	784,4	1,426
RESERVOIR PROTECTION WORKS	**1.771,9**	**869,2**	**2,641**
HEADRACE	**47.015,0**	**66.565,4**	**113,580**
Intake	933,2	912,1	1,845
Tunnel	45.495,8	64.814,5	110,310
Construction adits	586,0	838,8	1,425
Desander Cavern	**9.974,6**	**14.730,5**	**24,705**
Caverns	9.632,6	14.211,2	23,844
Construction adits	341,9	519,3	0,861
PRESSURE SHAFT / TUNNEL	**823,5**	**1.152,7**	**1,976**
Pressure Shaft	339,4	486,3	0,826
Pressure Tunnel	155,4	227,0	0,382
Manifolds	328,7	439,4	0,768
TAILRACE TUNNEL	**1.582,8**	**1.838,2**	**3,421**
Draft tube Extension & Tailrace Tunnel	1.006,6	1.310,7	2,317
Tailrace tunnel & Power Outlet	576,2	527,5	1,104
SURGE TANK	2.482,1	3.487,9	**5,970**
POWERHOUSE CAVERN, TRANSFORMER & SWITCHYARD GALLERY	**4.762,8**	**5.817,1**	**10,580**
Powerhouse Cavern	3.206,1	3.709,6	6.915,7
Transformer & Switchyard Cavern	603,8	732,3	1.336,1
Cable Tunnel	203,8	286,2	490,0
Access Tunnel	749,1	1.089,1	1.838,2
ACCESS ROADS & BRIDGES	489	224	**0,713**
TOTAL	**78.997,8**	**106.361,4**	**185.359,2**

Table 9.2: Costs of Civil Works of Madian Hydropower Project

9.3.2 Estimation of Costs of Hydraulic Steel Structure Equipment

The cost estimate of the hydraulic steel structure equipment for the Madian HPP is based on tender costs of hydropower projects of similar type and magnitude worldwide.

No.	DESCRIPTION	UNIT RATE Local US$	Foreign US$	Total US$
1	Diversion Tunnel Intake Stoplogs	302,400	100,800	403,200
2	Spillway Gates and Stopglogs	452,484	3,167,391	3,619,875
3	Flushing Outlet - Steel Liner and Gates	317,835	476,753	794,588
4	Power Intake, Gates, Stoplogs, Raking Machine	466,298	1,398,895	1,865,194
5	Desander gates	1,027,688	1,027,688	2,055,375
6	Headrace Tunnel Maintenance Gate	36,094	252,656	288,750
7	Pressure Shaft/Tunnel Steel Liner	1,884,157	332,498	2,216,655
8	Powerhouse	55,420	387,942	443,363
9	Tailrace Outlet	192,938	64,313	257,250
	SUBTOTAL	4,735,314	7,208,935	**11,944,249**

Table 9.3: Cost of Hydraulic Steel Structure Equipment for the Madian HPP

9.3.3 Estimation of Costs of Electro-mechanical Equipment

The equipment costs were estimated based on recent tender prices of projects of similar type of equipment from qualified manufacturers on the basis of equipment lists broken down into CIF prices, transportation to site, erection and commissioning

No.	DESCRIPTION	UNIT	QUANTITY	UNIT RATE Local US$	Foreign US$	Total US$
1	Turbines	Lumpsum	1	1.872.687	13.108.807	14.981.493
2	Butterfly valve, D=2.5m	Lumpsum	1	382.592	2.678.143	3.060.735
3	Cooling Water System	Lumpsum	1	166.461	1.165.227	1.331.688
4	Drainage and Dewatering System	Lumpsum	1	69.359	485.511	554.870
5a	Low Pressure Compressed Air System	Lumpsum	1	26.356	184.494	210.851
5b	Low Pressure Compressed Air System	Lumpsum	1	33.781	236.469	270.251
6	Air Conditionning and Ventilation System	Lumpsum	1	188.779	1.321.452	1.510.231
7	Oil Treatment Plant	Lumpsum	1	16.579	116.053	132.632
8	Mechanical Workshop Equipment	Lumpsum	1	31.905	223.335	255.240
9	EOT Crane Powerhouse 210 t	Lumpsum	1	118.134	826.935	945.069
9	Elevator	Lumpsum	1	33.281	232.967	266.248
10	Fire Fighting System	Lumpsum	1	99.575	697.022	796.597
11	Auxiliary Francis unit - 520kW	Lumpsum	1	150.799	1.055.592	1.206.390
	Subtotal			3.190.287	22.332.008	**25.522.295**
	-Miscellaneous items	%	2,5			638.057
	TOTAL	in	US$			**26.160.353**

Table 9.4: Cost of Electro-mechanical Equipment for the Madian HPP

9.3.4 Estimation of Costs of Electrical Equipment

The equipment costs were estimated based on recent tender prices of projects with similar type of equipment as above.

No.	DESCRIPTION	UNIT	QUANTITY	UNIT RATE Local US$	Foreign US$	Total US$
1	Synchronous generators 63 kVA, 333 r	Lumpsum	1	2.525.473	17.678.311	20.203.784
2	Step-up transformer 230/13.8 kV	Lumpsum	1	882.853	6.179.969	7.062.822
3	220 kV SF6 Switchyard	Lumpsum	1	742.180	5.195.259	5.937.438
4	220 kV Terminal Gantry & Auxil.	Lumpsum	1	76.431	535.017	611.448
5	13.8 kV generator busbars & auxil.	Lumpsum	1	353.368	2.473.575	2.826.943
6	Protection Systems	Lumpsum	1	261.487	1.830.407	2.091.894
7	Control and Monitoring System	Lumpsum	1	332.464	2.327.247	2.659.711
8	Electrical Equipment at Dam Site	Lumpsum	1	171.090	1.197.629	1.368.718
9	El. Equipment at Desander Cavern	Lumpsum	1	92.523	647.664	740.188
10	Emergency Diesel 630 kVA	Lumpsum	1	54.576	382.031	436.607
	Subtotal					**43.939.553**
	-Miscellaneous items	%	0			0
		in	US$			**43.939.553**

Table 9.5: Cost of Electrical Equipment for the Madian HPP

9.4 Estimation of Indirect Project Costs and Contingencies

Consideration of Indirect Costs and Contingencies
As common practice in bankable feasibility studies, the concept of indirect costs is applied to civil costs and includes preparation of the construction sites, camp installation, site administration, bonds, insurances and contractor's profits. Indirect costs are taken to 25 % of the direct cost.

The costs related to land acquisition, compensation payments and resettlement were determined to amount to

RAP Cost: 129.395 million Rupees equivalent to 2.134 million USD

A provision for Contingencies is required irrespective of the level of planning, to account for some element of uncertainty which will still remain in the estimation of quantities and costs. For the feasibility study of the Madian HPP the provisions given in Table 9.6 were applied.

Consideration of Import Charges
The Consultant inquired the extent of import charges which would apply for import of electro-mechanical, electrical and particular hydraulic steel structure equipment to be adequately considered in the estimation of costs. In total 7.0 % of import charges are therefore applied to the above mentioned imported equipment and considered in the Bill of Quantities and the estimation of costs to account for import and related charges.

9.5 Estimation of Costs for Project Development

Estimate for Cost of Engineering and Administration
The cost of all required activities for Engineering and Administration, setting up the legal and institutional framework of the Project is estimated applying a percentage of the total project cost. Assuming the provision of services for tender design, assistance in the tender process and supervision of construction, erection and commissioning by a leading international consultant, an estimate of 6 % of cost of civil works and 3 % hydraulic steel structure, electro-mechanical and electrical equipment works is made.

Estimate for Cost of Client's Own Costs
The cost of all related expenditures of the Client in the course of developing the Project is estimated applying a percentage of the total cost of the project. As a common approach an estimate of 1.0 % of the total project cost is made taking into account the requirements of legal support for negotiation of the Power Purchase Agreement (PPA) and other related activities in the volatile North Western Frontier Province of Pakistan.

9.6 Total Construction Cost and Basic Project Cost

As discussed in the previous sections the total project cost is calculated applying provisions for indirect costs, contingencies, import charges, engineering and administration and client's own costs.

Cost item	(%)
Indirect civil costs (% of direct civil costs)	25
Contingencies (% of direct + indirect costs)	
- civil	10.0
- electro-mechanical	7.5
- electrical	7.5
Engineering and administration	6.0 / 3.0
Client's own costs	1.0

Table 9.6 : Indirect Costs and Contingencies

COST CATEGORY	Charges	Local 1000 US$	Foreign 1000 US$	Total 1000 US$	% of Total
CIVIL COSTS		78.998	106.361	185.359	50,6%
CONTINGENCIES	10,00%	7.900	10.636	18.536	5,1%
INDIRECT COST	25,00%	21.724	29.249	50.974	13,9%
ENGINEERING / ADMINISTRATION	6,00%	6.517	8.775	15.292	4,2%
SUBTOTAL CIVIL COSTS		115.139	155.022	270.161	73,8%
STEEL STRUCUTRE EQUIPMENT		4.735	7.209	11.944	3,3%
CONTINGENCIES	7,50%	355	541	896	0,2%
IMPORT CHARGES & FEES	7,00%	542	0	542	0,1%
ENGINEERING	3,00%	153	232	385	0,1%
SUBTOTAL STEEL STRUCTURE EQUIPMENT		5.786	7.982	13.768	3,8%
ELETRO-MECHANICAL EQUIPMENT		3.270	22.890	26.160	7,1%
CONTINGENCIES	7,50%	245	1.717	1.962	0,5%
IMPORT CHARGES & FEES	7,00%	1.722	0	1.722	0,5%
ENGINEERING	3,00%	105	738	844	0,2%
SUBTOTAL ELECTRO-MECH. EQUIPMENT		5.343	25.345	30.689	8,4%
ELECTRICAL EQUIPMENTS		5.492	38.447	43.940	12,0%
CONTINGENCIES	7,50%	412	2.884	3.295	0,9%
IMPORT CHARGES & FEES	7,00%	2.893	0	2.893	0,8%
ENGINEERING	3,00%	177	1.240	1.417	0,4%
SUBTOTAL ELECTRICAL EQUIPMENT		8.975	42.571	51.545	14,1%
SUBTOTAL w/o ENGINEERING		128.290	219.934	348.224	95,1%
SUBTOTAL		**135.243**	**230.920**	**366.163**	**100,0%**
EIA MITIGATION AND RESETTLEMENT		2.134	0	2.134	0,6%
OWNERS OWN COST	1,00%	1.301	2.309	3.610	1,0%
TOTAL		**138.678**	**233.229**	**371.907**	**101,6%**

Table 9.7 : Summary of cost of the Madian Hydropower Project at level of prices 30. June 2008

9.7 Operation, Maintenance and Repair Costs

The Consultant assessed the operating costs for the project based on the technical data elaborated within the scope of previous tasks. These costs will be divided into:

- maintenance costs for all productive assets;
- operation costs;
- personnel costs, including expenses for technical staff required to supervise and to operate the system;
- training costs;
- Administration costs associated with the project, including such cost items as office costs, insurance, equipment and materials.

Recurrent annual fixed costs for operation, maintenance and repairs (OMR) during the period of operation were calculated as a percentage of the initial investment costs.

The following percentages were applied:

- Civil structures : 0.5%,
- Electro-mechanical equipment, including hydraulic steel structures : 2.0%

According to common experience in the operation of hydropower plants and in view of the assumed concession period of 30 years, an overhaul of equipment (electro-mechanical, electrical and hydraulic steel structure) will be assumed as follows:

a) Electrical control and protection equipment after 15-20 years of operation (16.6 % of electrical equipment cost);

b) Electro-mechanical equipment components after 20-25 years of operation; (15 % of electro-mechanical equipment cost);

c) Hydraulic Steel structure equipment components (and valves) after 30 years (end of concession period) of operation.

This overhaul does not form part of the annual OMR cost.

10. Social and Environmental Impact Assessment

Following national and international requirements, an Environmental Impact Assessment (EIA) and a Resettlement Action Plan (RAP) have to be prepared for the Madian Hydropower Project. In order to fulfil this demand two reports have been written, both as stand alone report which form Volume VI of the Feasibility Study Report:

- Feasibility Study: Environmental Impact Assessment (EIA);
- Feasibility Study: Resettlement Action Plan (RAP).

10.1 ENVIRONMENTAL IMPACT ASSESSMENT STUDY

Herewith, the Environmental Impact Assessment to the Madian HPP is presented assessing the environmental impacts of the project and presenting an Environmental Management Plan (EMP). For transparent presentation and evaluation, a tabulated evaluation procedure has been applied. On the basis of a points scale, the severity of the particular environmental impact together with its general trend - that is negative or positive - is described.

10.1.1 Legal and Institutional Framework

Pakistan Environmental Protection Act (PEPA-1997) provides guidance for the protection, conservation, rehabilitation and improvement of the environment, for the prevention and control of pollution and for promotion of sustainable development. Aim of this EIA study is to bring the Project in line with following international guidelines:

- OP/BP 4.01 + Annexes '*Environmental Assessment';*
- OP/BP 4.04 '*Natural Habitats*';
- Environmental Assessment Sourcebook Vol. II, Sectoral Guidelines of the World Bank (Chapter 8 "Dams and Reservoirs");
- Pollution Prevention and Abatement Handbook 1998;
- Environmental, Health, and Safety Guidelines replacing Part III of the Pollution Prevention and Abatement Handbook 1998;
- International Finance Corporation (IFC) Environmental, Health and Safety Guidelines;
- Report of the World Commission on Dams (WCD);
- Large Dams, Learning from the Past, Looking at the Future (IUCN and The World Bank; Workshop Proceedings Gland, Switzerland, April 11-12, 1997);
- Equator Principles of private donor banks.

EIA and RAP of Madian Hydropower Project will be filed with NWFP EPA Peshawar for their approval. Because it will be a private financed project the Private Power and Infrastructure Board (PPIB) is also involved in the development of the Project.

10.1.2 Baseline Conditions

The investigation area covers the Swat valley from upstream of the weir site including the future reservoir to the power house site.

The Swat River
The Swat River starts from Kalam town in the valley at the confluence of Ushu River and Gabral River. The native fish fauna of these waters, prior to the introduction of trout, was *Schizothorax species* and *Orienus species*, locally known as Swati fish. Also *Noemacheilus* species occurred. The introduction of trout (*Salmo trutta fario/brown trout and Oncorlrynchus mykiss/rainbow trout*) started in 1961. Consequently, the trout population has been established, which has replaced the indigenous fish breeds.

Terrestrial Fauna and Flora
The Flora of the region is characteristic for a dry temperature and can be assessed to be rich. Sixty-five species of trees and shrubs belonging to the Dicot families exist. Over the last 50 years the number of animal species has been decreased dramatically. A lot of species are endangered by the destruction of habitats.

Health Aspects in Project Area
HIV is currently not a dominant epidemic in the adult population of Pakistan. Children mostly suffer from acute respiratory infection, asthma and pneumonia.

10.1.3 Significant Environmental Impacts

Table 10-1: Ranking of environmental impacts during the construction and operation phase of the proposed Madian Hydropower Project

CONSTRUCTION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Land acquisition and use	■	Land acquisition and use will be compensated. For this purpose a Resettlement Action Plan as a stand alone report was developed that will be adopted when final design has been fixed.
Excavated material	■ ■ ■	Dumping of the excavated material is a big challenge of the Project. Because it is a run-of-river design with a long headrace tunnel a lot of material will be excavated. Dumping of this material has impacts on many issues as air quality, noise aspects, traffic, landscape, flora and fauna, tourist activities etc. Some of the material will be reused as concrete aggregates, for gabions and slope protection.
Traffic	■ ■	Needless truck movements will be avoided by proper truck management; dumping sites are selected close to the adits on the left river bank helping to reduce transportation routes. Near powerhouse conveyors may be used for transport of excavation material. Transport of excavated material through the City of Bahrein will be avoided. However, construction material and machines coming from Madian to the weir site have to cross the cities of Madian and Bahrain. Together with other projects going on in the region this will sum up to a considerable amount of traffic during construction.

CONSTRUCTION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Air quality	■ ■	The measures in order to reduce the traffic are suitable to reduce the negative impact on air quality (see traffic above). In addition, water shall be sprayed continuously to reduce dust emissions of construction activities.
Noise aspects (on public)	■ ■	The measures in order to reduce the traffic are suitable to reduce the noise impact on the public (see traffic above)
Ecology of Swat River	■	Only a short river section (about 240 m) will be diverted during the construction of the weir structure. Other parts remain untouched except for a short period when the coffer dams in the river will be closed. A certain sediment run off might occur during this time period.
Terrestrial fauna and flora	■ ■	Large areas for dumping the excavation material will be necessary. The area of the reservoir will be flooded and terrestrial habitats will disappear.
National parks, wildlife sanctuaries and other protected areas	O	No national parks or other protected land are located within the Project area.
Historical and cultural sites	O	No historical and cultural sites are located within the Project area. If archaeological remnants are found the construction work will be ceased immediately and the relevant authority will be informed.
Landscape	■ ■	Increased truck traffic and dust emission will influence the overall picture of the landscape.
Health and Safety of Workers	■	Proper workers' camp will be provided to the workers. A Health and Safety Plan for the construction period will be developed and implemented by the construction contractor. Training of workers will be performed regularly.
Solid and liquid wastes	■	Around 400 workers in peak periods will generate significant amounts of liquid and solid wastes. The liquid sanitation waste water will be treated at workers' camp site
Socio-economy	✦ ✦✦	Around 400 workers (skilled and unskilled) will find employment during the construction period in peak times. In addition, related services (hotels, shops selling articles for the daily life etc.) will benefit from the Project. Because of the very conservative social structures of population committed to principles of Islamic Shariah HIV/AIDS does not play any role and the adverse effects on the local community will be very limited.
Tourism	■	The construction activities will affect tourist activities in the Swat valley. However, hotel managers do not expect severe negative impacts on the number of tourists, whose number has already decreased because of the political situation. There is the hope that projects like Madian HPP will bring more stability to the region.

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
O	=	nil
✦	=	locally positive
✦✦	=	regionally positive

OPERATION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Microclimate and GHG	■	The effect on the microclimatic conditions will be minimal due to the small size of the reservoir surface. Most of the organic materials as trees, shrubs etc. will be removed before filling the reservoir. This reduces the generation of green house gases to a minimum.
Swat River ecology	See discussion	There will be a minimum water release also during the dry season (ecological flow). Due to this Project and when looking on the other hydropower projects in the Swat Valley in development the Swat River itself will undergo major alterations. It will be converted from a white water river to a cascade of headponds with river reaches where less water will flow than before. Very limited knowledge is available about the ecological features of the river, therefore no overall assessment is given.
Terrestrial fauna and flora	■	The reservoir represents a migration obstacle for big mammals. However, most of bigger animals have been disappeared since decade due to high population pressure (e.g. hunting).
Landscape	■	The character of the landscape down in the valley will be changed. A section of a fast flowing white water river will be converted into a lake.
Seismic aspects	■	The project will be designed to withstand the max. credible earthquake (MCE) without major damages and OBE-1 without damages.
Substations	■	Concerning EMF there will be no negative impacts on workers' health coming up. The handling of SF6 has to be done very carefully considering the presented guidelines
Deposits from desander	■	The sand of the desander will be flushed regularly during times of high water. In winter time flushing will not be required.
Water-related vector diseases	■ ■	There might be an increase of water-related diseases after constructing the planned reservoirs in the Swat valley. In order to manage these health problems, a concerted action of all HPPs owners/operators together with relevant regional and national health authorities will be necessary. This has still to be agreed.
<u>Socio-economic aspects:</u> Employment	✦ ✦✦	The effect on employment of people during operational period will be limited. Some skilled and unskilled workers will find jobs during operation of Madian HPP.
Tourist activities	O	The angler attitude will change from white water fishing to fishing in a lake with other species as before. Other tourist activities will not be affected except for the landscape has changed. Overall it is assumed that the number of tourists will not decrease.
Water supply downstream the weir site	■	The operation of the Project will not affect irrigation downstream of the weir. Farmer use other water sources such as tributaries and wells. Those households downstream the weir which use presently water from Swat River as drinking water source. They will be provided with clean drinking water as long as they are not connected to a drinking water system such as under development in Bahrain village.

The Swat valley topography, with its Swat River, offers possibilities for the development of a number of hydropower projects in a cascade system. At present, there are four hydropower projects proposed on the Gabral-Swat River system. These projects are Gabral-Kalam, Kalam-Asrit, Asrit-Kedam, and Kedam-Madian. This may amplify the environmental impacts of the individual HPPs. The development of the Daral-Khwar HPP located between weir and powerhouse site of the Madian HPP includes the installation of a drinking water supply and sewerage system with treatment plant. This will help to improve the water quality of the Swat River.

10.1.4 Environmental Management Plan

An environmental management and monitoring programme is pursued during construction stage and operation stage of the Project to protect and provide safeguards for a continuing healthy environment in the project area. After the Project becomes operational the Plant Manager with the assistance of staff on behalf of Madian Hydropower Ltd. will be overall in charge and responsible for management and monitoring of the hydropower project. The purpose of mitigation measures is to manage the Project in a manner that minimises adverse impacts and maximises secondary benefits.

Construction Phase
From the findings of the study as summarised above it can be concluded that a significant negative impact only results from the deposition of excavated material. The amount of the excavation material can not be mitigated. On the other hand, this kind of HPP reduces considerably the size of the reservoir that would have been much bigger in the case of a dam with storage for daily peaking operation. The amount of excavated material affects many environmental aspects as there are traffic, air quality, noise, landscape, terrestrial fauna and flora etc. Regarding these aspects, however, mitigation measures are possible. Concerning socio-economic aspects, the impacts of the Project are locally and regionally positive.

Operational Phase
During to operational phase no high negative impacts will occur. Main focus in the assessment is given on the ecology of the Swat River. Consequently a general final assessment of the extent of the impact could not be given. Even without exact knowledge it can be stated that the river ecology will be subject to certain changes. A 1.5 km long river reach will be converted into a lake (reservoir), in the downstream located 13 km long river reach the discharge will be reduced with all its consequences for the ecology. Regarding water-borne vector diseases, the Project may cause medium impacts. For all other aspects during operational phase the impacts of the Project will be low negative or even nil.

10.2 RESETTLEMENT ACTION PLAN

The objective of this report on Land Acquisition and the Resettlement Plan is to describe involuntary resettlement impacts and mitigation measures of Madian Hydropower Project according to World Bank/IFC resettlement criteria and guidelines. Madian HPP will require permanent and temporary land acquisition. Permanent land will mainly be needed for the reservoir area, for permanent access roads and for the dumping sites of excavated material. This causes the main impact of the Project related to land acquisition issues.

The Consultants' team consisted of three ESIA specialists who visited the project area in April and June 2008 to collect data on the project layout and its impacts on environmental and socio-economic aspects. All collected data are based on the status of the feasibility design of June 2008. For changes coming up in further stages of Project development (e.g. need for additional access roads, extension of dumping areas etc.) 15% of the total costs are added for contingencies.

Community consultations, especially with affected persons including owners of lands, houses, trees were performed to assess community response to the proposed Project. Interviews were held with officials of the government departments, the representative of the only NGO, and other resource persons.

10.2.1 Legal and Institutional Framework

Under Pakistan Environmental Protection Act 1997, environmental protection agencies at federal and provincial levels are functional. Besides, National Environmental Quality Standards (NEQS) are applicable country-wide. Draft National Resettlement Policy 2002 has yet to be approved for implementation.

The Land Acquisition Act (LAA 1894) with amendments is used as the core legal document. However, its legal process often takes too long because of legal formalities and courts interventions. Instead, it would be preferable to go for direct negotiations with owners of land and other assets affected by the Project. This methodology minimises the subsequent grievances as the decisions with the affected persons have to be made in consensus.

World Bank/IFC policies address losses of land, assets and resources which people suffer as a result of development projects. For operations requiring involuntary resettlement, resettlement planning is an integral part of the project design. These policies require compensation for lost assets at replacement costs to both titled and non-titled landholders.

10.2.2 Baseline Data

Besides some hamlets consisting of one or two houses, there are seven villages/ towns in the project area with a current (2008) population of 44,900 and average size of 8.3 persons per household. The literacy ratio within the project area is 20.5%, male 43.1% and female 13.5%. Main diseases are diarrhoea and malaria. Children mostly suffer from respiratory infections. No cases of HIV/AIDS have been reported. Health facilities in terms of availability of doctors, basic health units and trained birth attendants are very limited.

HIV is not currently a dominant epidemic in the adult population of Pakistan.
The water supply for drinking purposes obtained from the Swat River and springs does not meet WHO Guidelines in terms of bacteriological quality. With absence of a solid waste disposal system/ human excreta, the sanitation conditions are inadequate. Farming and livestock rearing are major occupations in the project area, followed by forestry and construction labour. Villagers also depend on off-farm income sources, like work opportunities in down country and even abroad, particularly in Saudi Arabia/ Gulf states.

10.2.3 Results of Resettlement Survey

Land Acquisition
Project implementation will need acquisition of a total 39.438 ha land (state land, farmland, wasteland). Out of this total, 36.638 ha will be acquired on permanent basis and the remaining 2.800 ha on lease for 5 years.

Affected Houses
Only 15 houses with a total of 176 persons will be directly affected by the Project. 2 of these houses will be affected by reservoir impounding, 8 due to their location in areas to be utilised for dumping of excavated material, 3 in the vicinity of the diversion works, 1 due to relocation of the road at the weir site and 1 due to the proposed access road to the weir site along the left bank of the Swat River. With reference to the type of construction all houses are category C houses except 1 which is of category B. (Type B Houses: Masonry in cement mortar, timber roof; Type C Houses: Stone in mud mortar with timber roof)

Affected Persons
Only 176 persons will be directly affected because parts of their farmland/ wasteland/ river bed will be acquired permanently or temporarily for project implementation. A land area of 36.638ha will be acquired permanently and 2.8 ha will be acquired temporarily. The Resettlement Plan is elaborated in accordance with World Bank/IFC policy guidelines.

Affected Trees
A total of 1,423 trees will be felled. Thereof, 950 are fruit trees and 473 are firewood and timber trees.

The RAP Report has considered all options available for physical resettlement of the population displaced as a result of development projects like Madian HPP. These options include no resettlement, on-site resettlement, partial resettlement, resettlement to multiple/ nearby sites, resettlement to margins of developed areas, and resettlement to distant sites.

10.2.4 Income Restoration Programmes

In the case of Madian Hydropower Project the aspects of both extent of population displacement and loss of land, particularly farmland, are not significant. Also, the affected persons, without any exception, have readily and willingly opted for cash compensation as they all intend to start business ventures by using this cash. It is hard to find replacement land in the project area. Besides, “land-for-land” strategy, according to World Bank/IFC practice, has remained a difficult policy to implement. The strategy for income restoration of affected persons, therefore,

should be based on training programmes in terms of small business, computer skills, health care technology and education.

10.2.5 Institutional Arrangements

The project sponsor, Madian Hydro Power Limited (MHPL) will establish an administrative unit, the Environmental and Resettlement Cell (ERC) consisting of two members: an environmental specialist and a resettlement specialist. The cell will help overcome lack of institutional mechanisms for environmental/ resettlement planning, implementation, monitoring and evaluation, which MHPL not yet possesses in implementing the EMP and RAP. Thus, MHPL, as implementing agency, will have to depend on external technical support for implementing the environmental and resettlement related activities. For this purpose it will need two implementation Consultants (Environmental and Resettlement Specialists) to provide technical assistance in environment and resettlement planning, implementation, monitoring and evaluation.

The Environment and Resettlement Cell (ERC) will update the data on land and affected persons. Furthermore, it will assess the amount of compensation and prepare a requisition to be submitted to DRO Swat for initiating the process of land acquisition. DRO Swat is formally responsible for acquiring the identified lands from the respective land owners and for paying compensation money to the affected persons, according to the procedure laid down in the Land Acquisition Act 1894, or as decided by MHPL through direct negotiations with the village community.

The resettlement budget consists of costs for permanent land acquisition, temporary land acquisition, compensation for lost assets including houses and trees and costs to be increased on hiring resettlement expertise. The replacement cost of land is based on current market prices. The market value was assessed on the basis of recent transactions and consultation with the affected persons and other community members. Total resettlement cost is estimated as Rs. 129.385 million.

Within the project cycle, the implementation schedule, covering a period of 5 years plus pre-project period, provides the time frame for commencement and completion of the resettlement activities. These activities include community consultants, site demarcation, resettlement training workshop, payment of compensation grievance redress, taking over of land and other assets, construction work, return of temporarily acquired land and monitoring and evaluation.

11. Project Implementation

The duration of the individual construction activities, and of the project as a whole, shall be made considering the logistics for construction, i.e. taking into account the design in conjunction with the corresponding construction methods and construction equipment. The present section, addresses the aspects of the construction planning in the required detail:

11.1 Construction Planning

Once the project layout and dimensions of the main structures are defined, a detailed construction and implementation schedule for the project is prepared on the basis of construction planning (the logistics of constructing the project), construction scheduling (how long it will take), and construction methods (how it will be done).

For construction of the headrace tunnel by conventional drill and blast excavation method, three temporary and two permanent access tunnels (adits) will have to be constructed. The distance between weir and power house is approximately 13 km. The project's civil works in general can be roughly divided to be three mostly independent construction sites:

1. weir site incl. river diversion
2. headrace tunnel incl. desander caverns and surge tank
3. power house, transformer caverns, penstock and tailrace

With the objective to minimize the time required for construction in an economically reasonable way, work will proceed at the three major construction sites in parallel. For the site transports river crossings and temporary access roads will have to be constructed. For the permanent maintenance access to the desander caverns a permanent bridge and road to the relevant adit has to be built.

11.1.1 River Diversion and Weir Construction

For river diversion at the Weir Site a diversion tunnel of approx. 290 m length will be established. The tunnel can be sealed by stop logs at the intake portal. After finishing the weir construction the diversion tunnel will be closed, the coffer dams removed and a concrete plug installed after setting the stop logs at the intake to seal the Diversion Tunnel towards the Headrace Tunnel. The upstream river closure will be established by a rock-fill cofferdam with an adequate sealing to reduce ground water flow into the construction pit.

The construction scheduling for the weir site works is governed by the seasonal variation by the flow of Swat River. The diversion tunnel will be started immediately after first mobilization and establishing the road from Kedam bridge to the downstream portal.

Year	Season	Construction Activity	
1	low flow high flow	access road to d/s portal and portal, excavation right side moraine, bore pile sealing wall right side (1.), diversion tunnel excavation and rock support and concrete works	relocation of Kedam road, u/s portal, bore pile wall at right side of construction pit (3.)
2	low flow	u/s coffer dam 1st stage, cut-off wall, coffer dam 2nd stage	d/s coffer dam 1st stage, bore pile cut-off wall (4.), d/s coffer dam 2nd stage
	high flow	excavation of construction pit, construction pit drainage	completion of bore pile sealing wall (1.), bore pile weir support (2.)
3	low flow high flow	concreting: weir body, stilling basin slab and end sill, wing walls, piers, lateral intake, flushing section	embedded parts and steel lining, bridge, stop logs at intake, flushing gates)
4	low flow	closing weir and lateral intake by stop logs, removal of u/s and d/s coffer dams	erection of main gates and remaining steel structures), plug for diversion tunnel, completing headrace tunnel, portal and transition structure, external works
	high flow		
5	low flow high flow	finalizing external works, testing and commissioning	

Table 11.1 Construction Sequence at Weir Site

11.1.2 Underground Excavation and Rock Support

The main parts of the underground excavation works are:

- Diversion Tunnel
- Headrace Tunnel
- Desander Caverns
- Surge Tank
- Pressure Shaft and Tunnel
- Power House, Transformer/Switchgear Cavern
- Tailrace Tunnel

Since the deployment of a Tunnel Boring Machine (TBM) is not feasible in respect of transport conditions, traditional drill and blast method will applied. The tunnel and cavern excavation cycle will be: drilling - blasting - mucking / loading - transport / dumping - shotcrete - rock bolts. The biggest portion of the underground works is the excavation of the 11.5 km long headrace tunnel and Desander Caverns.

These structures cover about **85 %** of the total excavation volume. The main objective of the project planning is time and cost minimization.

The Headrace Tunnel will be sub-divided into 4 sections. With this division in construction sections, it will be possible to work simultaneously at minimum at six fronts basically independently from each other. Taking into account the other locations for rock excavation it is envisaged to mobilize a total of eight sets of underground excavation equipment for tunnels and chambers. By shifting these sets within the critical pass, it will be possible to minimize the underground excavation and rock support works to a net period of less than two years.

Surge Tank and Power House Area
These structures comprise of various shapes and rather large dimensions. The construction sequence is determined by access facilities and technical requirement. E. g. the pressure shaft requires access from top and bottom, the surge tank shall be drilled from top to bottom and excavated from bottom to top (raise boring), and the tunnels should be excavated against the slope due to expected groundwater conditions in the power house area.

11.1.3 Progress Estimation

The progress for tunnel excavation and rock support is estimated for each tunnel section and respective rock quality in accordance with the geological profiles and required rock support measures.

Rock Support / Rock Class	Progress [m/d]	remarks
B / II	5.5	full face, 3 m advance
C / III	4.5	full face, 2.2 m advance
D / IV	3.2	roof & bench, 2.5 m advance
E / V	2.2	roof & bench, 1.5 m advance

Table 11.2: Excavation and Rock Support Progress for Headrace Tunnel

Table 11.3 shows the anticipated progress for the caverns taking into account the reported rock quality, shape of structures and adjacent structures such as ventilation, access tunnels etc. for the power house cavern.

Structure	Rock Class	Progress [m³/d]
Desander Caverns	III	230
Surge Tank	IV	180
Power House, Transformer Cavern	III	180

Table 11.3: Excavation and Rock Support Progress for Cavern Construction

11.1.4 Underground Concrete Works

The main underground concrete structures are:

- Tunnel Lining
- Desander Cavern, Manifold and Transition Structures
- Surge Tank Concrete Lining and Structures
- Power House Equipment Foundations and other Structures

Similar to the excavation volumes for this project, the major concrete quantities were estimated for the concrete lining for the Headrace Tunnel etc. for consideration in the estimation of the required time for execution.

Headrace and Tailrace Tunnel Lining

Following the tunnel excavation and rock support works the concrete tunnel lining will be the subsequent critical path of the civil works. It is envisaged to work on four locations simultaneously with four sets of equipment to achieve a reasonable progress. There are suitable special hydraulically operated slip form and conventional formwork tunnel lining machines available on the market, so the works can be performed continuously in a highly automated system. Coordination is required for concrete production, e. g. for desander caverns. If sufficient capacity for batching is installed, there will be no negative impact on the general progress. For this concept the critical path for the civil works will be tunnel excavation and concrete tunnel lining resulting to a total period of approx. 4 years after mobilization.

Concrete works in the caverns can start as soon as access to the construction sites is clear. For access the access tunnel to power house and tailrace tunnel can be used. Close coordination with turbine and equipment suppliers is essential due to embedded parts and first and second stage concrete during erection/installation of equipment. For feasibility study purposes sufficient time is considered in the construction schedule according to the consultants' professional experience.

11.2 Further Steps for Project Implementation

The implementation of the project is distinguished in three main stages:

- Stage I: Pre - Construction Activities
- Stage II: Construction Works
- Stage III: Commissioning, Testing and Training

The implementation schedule was prepared with the assumption that the Project will be implemented as a turnkey project (EPC-Contract). Thus, the detailed design engineering will be carried out under the responsibility of the general contractor and will not be part of the pre-tender process.

11.2.1 Stage I - Pre-Construction Activities

The Pre-Construction Activities, extend over an estimated period of 36 months. The corresponding activities are subdivided in two parts, i.e.:

a) Feasibility Study
b) Tendering and Contracting

The presently contracted engineering services for the development of the Madian Hydropower Project are structured in the following three stages:

- Phase I: Identification and comparison of project alternatives. Preparation of Pre-Feasibility Study.
- Phase II: Optimisation of preferred alternative. Preparation of Draft Feasibility Study.
- Phase III: Project review by POE and PPIB. Preparation of Final Feasibility Study.

The Feasibility Study was originally planned for a period of 18 months. As the consequence of the Force Majeure situation in the project area in the period from October 2007 to January 2008 the period for completion of the feasibility study is extended to 21 months. Phase I and II of the Feasibility Study are completed with the submission of this feasibility report. The review of the Feasibility Report by the various institutions including the Private Power and Infrastructure Board (PPIB) and their Panel of Experts, the due consideration of their remarks by the Consultant and the final approval of the Feasibility Study Report will form part of Phase III of the Project which is expected to continue till January 2009.

11.2.1.1 Tendering and Contracting

After the approval of the Feasibility Study by PPIB and POE, the preparation of tender documents is scheduled to start. During or even ahead of the preparation of the tender documents some additional technical activities are required such as hydraulic model tests in particular of the weir structure with power intake and flushing structure.

The preparation of the tender documents consists mainly of the preparation of general and particular (technical) specifications of all project components, the preparation of the tender documents, pre-qualification of contractors and manufacturers, floating of tenders, evaluation of bids and finally the contract negotiations with the contractor and the contract negotiations for the power purchase agreement (PPA). A minimum period of 24 months needs to be considered for these activities which shall be completed by early 2011.

11.2.2 Phase II - Construction Works

The construction schedule was elaborated assuming that the execution of works will be assigned to an experienced contractor with sufficient resources in terms of experience staff, adequate machinery and equipment. Further more it was assumed, that the works particularly the tunnelling works will not be interrupted during the winter period due to climatic conditions at the project site. However under extreme condition as observed in December 2007 and January 2008, the climatic conditions may cause a certain delay in execution of the works.

The turbine-generator units need be ordered as soon as possible after the contract has been signed, as a period of 24 months shall be considered for the designing and manufacturing of the units. Erection is expected to take a period of approximately 12 to 18 months for all three units. The design and manufacturing of the hydraulic steel structures for weir, intake, desander caverns, surge tank and powerhouse will be carried out more or less simultaneously to that of the turbine generator units in a 12 months period. 18 month are considered for design and manufacturing the remaining electrical equipment. After the award of contract, the mobilization and site installation is considered to be done within a three months period. Detailed design engineering and preparation of the construction design drawings will commence together with the mobilisation of the contractor and will accompany the construction works till completion.

The preliminary implementation period of Madian Hydropower Project which goes over a total period of 102 month, can be summarized as follows:

- **Phase I: Pre-Construction Activities**
  Start: first quarter of the year 2007
  Period: 48 month
  End: first quarter of the year 2011

- **Phase II: Construction Work**
  Start: first quarter of the year 2011
  Period: 54 month
  End: end of second quarter of the year 2015

- **Phase III: Testing and Commissioning**
  Start: first quarter of the year 2015
  Period: 4 month
  End: end of second quarter of the year 2015

- **Commercial Operation of the Plant: mid 2015**

The above given period for construction and implementation of the Project is a so-called minimum requirement and based on the assumption that an experienced and qualified contractor executes the works without being affected by any type of political destabilization or other security relevant incidents which have occurred in the project area in the past years.

12. Economic and Financial Analysis

The economic and financial analysis of the Madian Hydropower Project serves to answer two key questions:

(1) Economic analysis: Is the project beneficial for the economy of Pakistan?
(2) Financial analysis: Is the project profitable for the investor?

Economic and financial analyses use a similar approach to answer these questions but differ in their concepts of determining project costs and benefits.

(a) Direct and indirect effects: While the financial analysis deals only with the costs and benefits incurred by the investor, the economic analysis also includes indirect costs and benefits which are caused by the project but incurred, or enjoyed, by third parties.

(b) Valuation of benefits: The direct benefits of Madian HPP are the additional capacity and energy provided by the project. From the investor's point of view, as reflected in the financial analysis, the value of these benefits is equal to the revenues from the sales of capacity and energy.
From the economy's point of view, as reflected in the economic analysis, these benefits are equal to the cost of the most economically attractive alternative project which would produce the same output.

(c) Pricing of costs and benefits: The economic analysis should consider the true costs and benefits of the project to the economy. Market prices, as used in the financial analysis, do not always reflect the true economic costs because government interventions into the market process through price controls, taxes, duties, subsidies etc., as well as monopolistic practices result in distorted prices of labour, materials, capital, land etc. Therefore market prices need to be converted into economic prices.

12.1 Project Costs and Project Benefits

The construction costs of the Project amount to US$ 366.2 million. Adding environmental and owner's cost, total project costs amount to US$ 371.9 million. An estimated 63% of the total cost is incurred in foreign and 37% in local currency. Including financing fees and interest during construction, total financing requirements are estimated at US$ 438.4 million.

The Reference Date for this cost estimate is July 1, 2008. Since then, prices for relevant inputs have increased, and are expected to increase further during the construction period. Over the past 2-3 years, rising demand in the construction sector in general and in the power sector in particular has led to drastic increases in prices for steel, cement and other raw materials.

During the following years, equipment prices may be expected to increase at lower rates, but it is unknown when the prices will stabilize or even drop.

Item	US$ '000
Civil Works	270,161
Steel structure equipment	13,768
Electro-mechanical equipment	30,689
Electrical equipment	51,545
Subtotal construction cost	**366,163**
EIA mitigation and resettlement	2,134
Subtotal with EIA cost	**368,297**
Owner's cost	3,610
Total project cost	**371,907**
Interest during construction	58,354
Financing fees	8,098
Subtotal financing cost	66,453
Total financing requirements	**438,359**

Table 12-1: Project cost at Reference Date

The National Electric Power Regulatory Authority (NEPRA) has developed a mechanism for adjustment of the tariff ("tariff re-opener") at later stages of project development: at the EPC stage, when the EPC contract has been concluded, and/or at the COD stage, when final costs, including interest during construction, are known.

12.1.1 Project Benefit – Power and Energy Output

As described in more detail in Section 8, Madian HPP is capable of generating 767.5 GWh in an average mean year, 688.4 GWh in an average dry year, and 851.9 GWh in an average wet year.

Taking the maximum possible forced and scheduled outages (according to Draft Power Purchase Agreement) into consideration, average annual generation of Madian HPP is estimated at 742.5 MW in a mean year, 669.7 in a dry year and 826.9 in a wet year. The contracted capacity of Madian HPP is assumed to be 157.3 MW. Over the 12 months of the year, the capacity of the plant varies considerably. In January, the capacity may be as low as 23.9 MW in an average year, 0 MW in a dry year, and 34.9 MW in a wet year. The project cannot provide capacity with a certain degree of reliability ("firm capacity").

12.2 Economic Analysis

The economic analysis of Madian HPP is carried out as a conventional cost-benefit analysis, where the costs of the hydropower project are compared with its benefits. The costs of the project comprise all costs incurred during implementation and subsequent operation of the project, i.e. investment costs, reinvestment costs and operation and maintenance costs.

The benefits of the project are equivalent to the avoided costs of thermal generation, because without the project the equivalent power and energy would have to be provided by thermal power plants within the grid.

Most of WAPDA's plants are run on indigenous gas and furnace oil. With increasing shortage of gas, furnace oil is the most widely used fuel. It is therefore assumed that energy from Madian HPP is used to substitute furnace oil. Furthermore, hydro generation prevents greenhouse gas emissions which would otherwise result from thermal generation. Therefore the avoided cost of CO_2 emissions has to be considered explicitly in the economic analysis of Madian HPP.

12.2.1 Parameters and Assumptions

The economic analysis is based on the following parameters / assumptions:

General

The evaluation period is 30 years, equivalent to the concession period. According to the Policy for Power Generation Projects 2002 (§37), the evaluation of hydropower projects is based on a discount rate of 12%. A Standard conversion factor of 0.9 is used to convert the market prices for local goods and services to economic shadow prices.

Madian HPP

Annual energy generation is 742.5 GWh in a mean year (base case), 669.7 GWh in a dry year and 826.9 GWh in a wet year (sensitivity cases). The economic project cost at the Reference Date thus amount to US$ 353.4 million as compared to the financial project cost of US$ 371.9 million. Civil works are assumed to have a lifetime of 60 years; thus at the end of the evaluation period a residual value of 50% is considered. For steel structures, electromechanical and electrical equipment an economic lifetime of 30 years is considered in the present analysis. The economic operation and maintenance costs are determined by applying the SCF of 0.9 to the financial O&M costs resulting in US$ 2.94 million. The water use charge is not considered in the economic analysis.

Thermal alternative

Considering WAPDA's plant mix, the thermal alternative is assumed to be a combined cycle plant capable of dual-firing with natural gas and furnace oil. Fixed operation and maintenance costs are part of the capacity costs of the thermal alternative which are not considered in this analysis. Variable O&M costs of a CC plant are assumed to be 0.3 US cents/kWh.

Item	Unit	Base case	Sensitivity
General parameters			
Evaluation period	Years	30	-
Discount rate	%	10%	8%, 12%
Standard conversion factor	-	0.9	-
Madian HPP			
Installed capacity	MW	157.3	
Firm capacity	MW	0	
Average annual energy	GWh	742.5	dry 669.7/wet 826.9 (-10%/+11%)
Economic investment cost	US$ million	353.4	+10%/+20%/-10%
Economic lifetime civil works	Years	60	
Economic lifetime equipment	Years	30	
O&M costs	US$ million	2.94	
Water use charge	Rs./kWh	n.a.	
Thermal alternative			
Type of plant	-	Comb.Cycle	
Variable O&M costs	USc/kWh	0.3	
Type of fuel	-	furnace oil	100% local gas / 100% internat.gas / 60% FO:40% gas
Fuel price	US$/GJ	13.5	3.2 / 9.0 / 9.4
Fuel cost	USc/kWh	9.7	2.3 / 6.5 / 6.8
Cost of CO_2	US$/ton	10	
Specific CO_2 cost	USc/kWh	0.6	0.4 / 0.4 / 0.5

Table 12-3: Parameters and assumptions for economic analysis

12.2.2 Results

Based on these assumptions, Madian HPP has an EIRR of 15.8%. The EIRR indicates the actual profit rate of the total investment outlay. Thus, the economic analysis confirms that Madian HPP is economically feasible.

Economic indicator	Value
EIRR	15.8
NPV (US$ '000)	182,666
B/C ratio	1.66

Table 12-4: Results of economic analysis

Sensitivity Analysis

The sensitivity analysis serves to test the effects of changes in key parameters used in the economic evaluation. The following parameters are tested in the sensitivity analysis:

- Change in investment cost.
- Change in energy generation.
- Change in fuel cost.
- Change in discount rate.

Madian HPP is still economically feasible under adverse conditions for all discount rates from 8% to 12%. The most important parameter for economic project feasibility is the fuel price. When the energy from Madian is compared to a mix of gas/furnace-oil generated energy, the project has an EIRR of 11.8% and a B/C ratio of 1.19 at a discount rate of 10%, while it is

no longer feasible at a discount rate of 12%. When the energy generation from Madian is assumed to replace gas-generated energy at low local gas prices, then EIRR drops to 4.0% and B/C ratio to 0.48.

12.3 Financial Analysis

The financial analysis of Madian HPP serves to assess the financial performance of the project over the concession period. Project profitability is usually measured by the Financial Internal Rate of Return (FIRR) and the Net Present Value (NPV). For the calculation of FIRR and NPV it is sufficient to compare the project costs with the revenues in a simple cash flow analysis.

In order to capture all aspects of financial performance it is necessary to set up a financial model which:

- establishes the financing plan for the project,
- projects revenues and costs, based on the plant operation, and
- generates a complete set of financial statements of the project company over the concession period.

The financial statements comprise profit and loss account, sources and applications of funds, cash flow statement, and the balance sheet. All financial statements together provide a concise picture of the financial performance of the project company and allow quantifying the risks associated with the project.

- The profit and loss account compares operating revenues and operating costs, calculates the profit for the year, and determines how much of the profit is distributed; dividend payments depend on the profit as well as the available cash as determined in the cash flow statement.

- The cash flow statement synchronizes the cash outflow with the cash inflow. In addition to costs and revenues, the cash flow shows inflows from loans and equity and outflows for debt service and dividends.

- The sources and applications of funds statement synchronizes the sources of funds with the applications of funds and serves to assess the liquidity of the project company. This statement provides similar information as the cash flow statement, but inflows and outflows are arranged in a slightly different way. The resulting net cash flow is identical in both statements.

- The balance sheet describes the development of assets and liabilities of the project and shows the financial position of the project company at the end of each year.

The financial model for the Madian HPP is set up on a quarterly basis over the construction period and on a semi-annual basis over the operation

period. The model is used to derive the tariff which covers the costs of the project and provides the project company with a reasonable profit.

12.3.1 Parameters and Assumptions

Further to the project cost and project output described in section 12.1, the financial analysis is based on the following parameters and assumptions:

Construction is assumed to start on January 1, 2011. Commercial operations date is assumed to be after 54 months of construction, on July 1, 2015. The concession period of 30 years ends on June 30, 2045. The price base for cost estimation and tariff calculation ("Reference Date") is July 1, 2008, and the exchange rate at the reference date is 67.98 Rs./US$. The discount rate for calculation of the levelized tariff is 10%. Assets are depreciated over the concession period on a straight line basis over 30 years. At the end of the concession period, the civil works will still have a residual technical lifetime of 30 years. The project company will be completely exempted from the payment of income tax. However, dividend payments will be subject to a withholding tax of 7.5%.

The parameters and assumptions are summarized in Table 12-.

Item	Unit	Parameter	
Contracted Capacity	MW	157.3	
Net Electrical Output	GWh	742.5	
Time schedule			
Construction period	Months	54	
Start of construction	Date	1 Jan 2011	
Commercial operations date (COD)	Date	1 July 2015	
Concession period	Years	30	
Prices			
Discount rate for levelized cost calculation	%	10%	
Price base	Date	30 June 2008	
Exchange rate 30 June 2008	Rs./US$	67.98	
Depreciation			
Civil works	Years	30	
Steel structure/E&M/electrical equipment	Years	30	
Environmental cost	Years	10	
Owner's cost	Years	30	
Commercial data			
Accounts receivable (revenues)	Days	45	
Accounts payable (O&M cost)	Days	45	
Inventory	Months	1	
Interest on overdraft	% p.a.	10%	
Interest earned on accounts	% p.a.	5%	
Income tax	%	0%	
Withholding tax on dividends	%	7.5%	
Funding			
Debt:equity	%	80:20	
Target ROE	%	20%	
Loan conditions:		Debt 1	Debt 2
Repayment period (excl. grace p.)	Years	10	10
Grace period (= construction)	Years	4.75	4.75
Interest during construction	% p.a.	8%	8%
Interest	% p.a.	8%	8%
Up-front fee (one-off)	%	1%	1%
Commitment fee on outstanding bal.	% p.a.	0.50%	0.50%

Table 12-5: Parameters and assumptions for financial analysis

The debt : equity ratio is assumed to be 80 : 20. There may be two loans, one for the foreign currency component, one for the local currency component. Both loans are assumed to have an interest of 8%, a grace period equal to the construction period, and a repayment period (excluding the grace period) of 10 years.

With project costs of US$ 371.9 million and additional financing costs of US$ 66.5 million, total financing requirements amount to US$ 438.4 million. These are assumed to be financed with 20% equity (US$ 87.7 million) and 80% debt (US$ 350.7 million), as shown in the table below.

Uses of Funds	000 US$	Sources of Funds	000 US$
Construction cost	366,163	Equity (20%)	87,672
Environmental cost	2,134	Debt 1	219,922
Owner's cost	3,610	Debt 2	130,766
Subtotal project cost	371,907	Total debt (80%)	350,688
Financing cost	66,453		
Total uses	**438,359**	**Total sources**	**438,359**

Table 12-6: Funding of project cost

12.3.2 Tariff Structure

Pursuant to NEPRA's Tariff Standards and Procedure Rules a power tariff should allow the licensee to recover the costs incurred for power generation as well as provide a reasonable rate of return on the investment which reflects the risks assumed by the investor. The structure of the tariff to be paid for power and energy from Madian HPP has not been determined. The Draft Standardized Hydro Power Purchase Agreement (PPA) refers to a capacity price to be paid for the tested capacity and an energy price to be paid for the net electrical output. Further details on tariff components, payment mechanism and indexation shall be regulated in a Schedule attached to the Standardized PPA which, however, is not available yet. The tariff calculation for Madian HPP is based on the information provided in the Policy for Power Generation Projects 2002 and the PPA schedule on tariff, indexation and adjustment of a recent hydropower project.

According to the Power Policy:

- the hydropower tariff has two parts: a Capacity Purchase Price (CPP) in Rs./kW/month and an Energy Purchase Price (EPP) in Rs./kWh;
- there may be a limit to the share of the CPP in the overall tariff; considering the low energy-related costs of hydropower projects, the CPP will be approximately 60% to 66%, and the EPP 40% to 34% of the levelized tariff;

In accordance with these rules, the Reference Tariff for Madian HPP:

- is based on the project cost at the Reference Date June 30, 2008.
- comprises a CPP in US$/kW/month and an EPP in US cents/kWh.
- The debt-related component of the CPP matches the debt service and thus is reduced to Zero after the loans have been repaid.
- The non-debt related CPP component (ROE and Fixed O&M) and the EPP are constant over the term of the PPA.

12.3.3 Results

The Madian HPP Project has a levelized tariff of 8.92 US cents/kWh at a discount rate of 10%. The EPP is 3.03 US cents/kWh, thereof 2.81 US cents/kWh for variable O&M costs and 0.22 US cents/kWh for the water use charge. The CPP declines from 38.29 US$/kW/month in the first year to 5.22 US$/kW/month after the loans have been repaid. Of this non-debt-related CPP, the equity related component amounts to 3.66 US$/kW/month and the Fixed O&M component to 1.56 US$/kW/month.

Tariff Component	Unit	Tariff
Levelized tariff	USc/kWh	8.92
EPP (34%)	USc/kWh	3.03
CPP (66%)	USc/kWh	5.89
EPP	USc/kWh	3.03
Variable O&M	USc/kWh	2.81
Water use charge	USc/kWh	0.22
CPP – First year	US$/kW/m	38.29
CPP – after debt service	US$/kW/m	5.22
Return on equity	US$/kW/m	3.66
Fixed O&M	US$/kW/m	1.56

Table 12-7: Reference Tariff

Figure 12-1 below shows the development of the reference tariff over the 30 year term. The CPP which is expressed in US$/kW/month has been converted to US cents/kWh for this purpose.

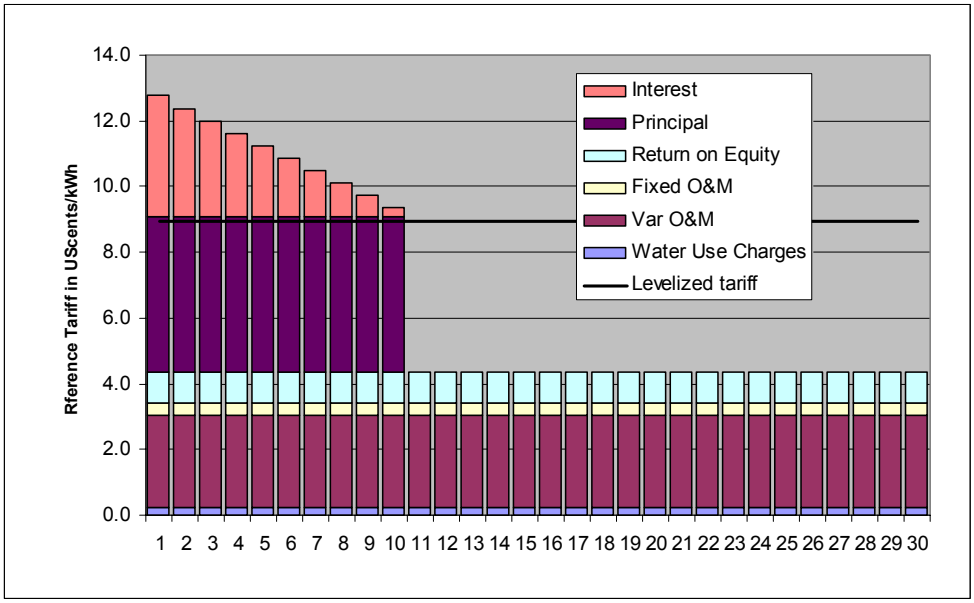


Figure 12-1: Development of Reference Tariff

The tariff as determined above is sufficient to cover the debt service, the fixed and variable O&M cost and water use charge and to provide the investor with a return on equity of 20% before the deduction of the dividend withholding tax and 18.9% after tax. The FIRR is 13.5%, and the NPV at a discount rate of 10% is US$ 80.9 million. The project has an average debt service coverage ratio (DSCR) of 1.56, which is acceptable to lenders. The minimum DSCR of 1.27 occurs only in the first half year of operation.

Financial indicator	Value
Financial Internal Rate of Return (FIRR)	13.5%
NPV (at discount rate 10%) US$ '000	80,867
Return on Equity (ROE)	20.0%
Min. DSCR	1.27
Max. DSCR	1.76
Average DSCR	1.56

Table 12-8: Financial indicators

Risk and Sensitivity Analysis

The key parameters with an impact on the project results are the investment cost, the project output in terms of energy, and the financing conditions. Changes of these parameters are tested in the sensitivity analysis:

Investment cost

Increases in the investment cost may arise due to under-estimation of quantities or increases in real prices. A cost overrun of +20% as well as a corresponding cost reduction by 20% are considered in the sensitivity analysis. When the investment costs change before the tariff has been fixed, the tariff will be adjusted accordingly either at the EPC stage or the COD stage, so that the financial performance of the project will not be affected.

The table below shows the project tariff for changes in the investment cost by +20% and -20%.**Fehler! Verweisquelle konnte nicht gefunden werden.** Since the capacity costs have a high share in the tariff, the tariff changes almost at the same rate as the investment costs.

Case	Unit	Base Case	Cost Increase by 20%	Cost Decrease by 20%
Sensitivity parameter				
Project cost	US$ '000	371,907	446,288	297,525
Change	% of Base Case	100%	120%	80%
Impact on tariff				
Levelized tariff	USc/kWh	8.92	10.57	7.27
Change	% of Base Case	100%	119%	81%
EPP	USc/kWh	3.03	3.59	2.47
CPP – First year	US$/kW/m	38.29	45.61	30.97
CPP – after debt service	US$/kW/m	5.22	5.92	4.52

Table 12-9: Sensitivity analysis: Tariff at different investment cost

Energy

The Reference Tariff is based on the hydrology of a mean year. For the purpose of the sensitivity analysis the effect of changes in energy generation is tested, assuming a decrease in generation by 10% (equivalent to the generation in an average dry year) and also an increase in generation by 11% (equivalent to the generation in an average wet year). The table below shows the results of the analysis. The levelized tariff increases by 10% when the energy generation is reduced by 10%.

Case	Unit	Base Case	Energy Decrease by 10% (dry year)	Energy Increase by 11% (wet year)
Sensitivity parameter				
Annual energy generation	GWh p.a.	742.5	669.7	826.9
Change	% of Base Case	100%	90%	111%
Impact on tariff				
Levelized tariff	USc/kWh	8.92	9.86	8.04
Change	% of Base Case	100%	110%	90%
EPP	USc/kWh	3.03	3.35	2.73
CPP – First year	US$/kW/m	38.29	38.23	38.37
CPP – after debt service	US$/kW/m	5.22	5.16	5.30

Table 12-10: Sensitivity analysis: Tariff at different energy generation

Combined impact of increases cost and reduced energy generation
When a 20% increase in investment cost coincides with a 10% decrease in energy generation, the levelized tariff increases to 11.7 USc/kWh, as shown in the table below.

Case	Unit	Base Case	Cost +20% Energy -10%
Levelized tariff	USc/kWh	8.92	11.69
Change	% of Base Case	100%	131%
EPP	USc/kWh	3.03	3.97
CPP – First year	US$/kW/m	38.29	45.55
CPP – after debt service	US$/kW/m	5.22	5.87

Table 12-11: Sensitivity analysis: Tariff at +20% cost and -10% generation

Financing conditions
The financing conditions affect the tariff at which the project is financially feasible in two ways: a change in the interest rate affects the interest during construction as well as the debt service during operation, and a change in the loan term affects the profile of the debt service. The table below shows the project tariff for alternative interest rates and loan terms. An increase in the interest rate by 2%-points increases the levelized tariff by 0.7 US cents/-kWh, and an equivalent decrease reduces the tariff by 0.7 US cents/kWh. An extension of the loan term tends to reduce the tariff. The adjustment of the tariff to the actual financing conditions at financial close ensures that the financial performance of the project is not affected.

Case	Unit	Base Case	Higher interest	Lower interest	Longer term	Longer term
Sensitivity parameter						
Interest rate	% pa.	8%	10%	6%	8%	8%
Loan term	years	10	10	10	15	20
Impact on tariff						
Levelized tariff	USc/kWh	8.92	9.62	8.26	8.82	8.74
Change	% of Ref.	100%	108%	93%	99%	98%
EPP	USc/kWh	3.03	3.27	2.80	2.99	2.97
CPP – First year	US$/kW/m	38.29	42.94	33.94	32.34	29.39
CPP – after debt service	US$/kW/m	5.22	4.86	5.56	5.34	5.42

Table 12-12: Sensitivity analysis: Tariff at different financing conditions

12.4 Summary and Conclusions

The Madian HPP project has total costs of US$ 371.9 million in prices at the Reference Date June 30, 2008. Total financing requirements including interest during construction and financing fees amount to US$ 438.4 million, thereof US$ 87.7 million (20%) financed with equity and US$ 350.7 million (80%) financed by debt.

The project requires a levelized tariff of 8.92 US cents/kWh to provide the investor with a return on equity of 20% which reflects the risks associated with the project. Since the CPP matches the debt service profile, the project has a healthy cash flow during the loan term with an average debt service coverage ratio of 1.56. The financial internal rate of return of the project at the proposed tariff is 13.5%. The uncertainty of future price developments and the associated financial risk make it necessary to provide for tariff adjustments once the final project costs and financing parameters are known.

Item	Unit	Parameter
Contracted capacity	MW	157.3
Annual generation	GWh	742.5
Project cost	US$'000	371.9
Total financing requirements	US$'000	438.4
EIRR	%	15.8
Economic NPV	US$'000	182.7
Economic B/C ratio	-	1.66
Levelized tariff	USc/kWh	8.92
EPP	USc/kWh	3.03
CPP (levelized)	USc/kWh	5.89
CPP - First year	US$/kW/m	38.29
CPP - after debt service	US$/kW/m	5.22
Share of CPP	% of lev. tariff	66%
FIRR		13.5%
NPV (at disc rate 12%)	US$ '000	80,841
Return on Equity (ROE)	%	20.0%
Min. DSCR	-	1.27
Max. DSCR	-	1.76

Table 12-13: Summary of results

13. Conclusions and Recommendations

The Madian HPP is a run-of river hydropower project based on the concept of diverting flow from Swat River near Kedam village and exploiting the gradient of the Swat River of 11 m per km on average over a 13 km long river reach. By this concept some 154 m head can be obtained for power generation which permit an installed capacity of 3 x 60.8 MW, a maximum available capacity ex generator of 157.3 MW and a mean annual energy generation of 767.5 GWh at a project cost of 371.9 million US$. The present Feasibility Study of the Madian Hydropower Project serves to answer three key questions:

(1) **Technical Feasibility**:
Is the project technically feasible under consideration of the prevailing hydrological, topographic, geological, infrastructure, environmental and socio-economic boundary conditions?

(2) **Economic Feasibility**:
Is the project beneficial for the economy of Pakistan?

(3) **Financial Viability**:
Is the project profitable for the investor?

The three above stipulated aspects have been analysed at the required level of detail in this Feasibility Study. The first two questions can be clearly answered with: Yes, Madian Hydropower Project is feasible and it is worth to continue developing the Project till implementation.

Concluding statements regarding the third question can be given only when the Project Sponsor and the Power Purchaser have reach on the respective agreements. The potential that such an agreement can be beneficial for both parties has been demonstrated in this Feasibility Study.

13.1 Summary of Results of Feasibility Study

In accordance with the requirements of a bankable feasibility study and the corresponding terms of reference the Consultant conducted comprehensive field investigations comprising:

- Supplementary hydro-meteorological survey and field studies
- Detailed topographic survey of the project area
- Comprehensive geotechnical field and laboratory investigation program
- Study of conditions to access the project area
- Environmental Impact Assessment Study and Resettlement Action Plan in accordance with international standards

The design of alternative project layouts and the finally preferred alternative for the Madian HPP were elaborated based on the site specific conditions

derived from the detailed geotechnical field and laboratory investigations as well as the topographic survey.

The Project and its components were optimized applying unit rates which were verified with local and international market prices and rates of similar projects under development.

The Consultant analysed the economic feasibility of the project in comparison with alternative thermal power generation and determined the Economic Internal Rate of Return of the Project being 15.8 % and the Benefit Cost ratio of 1.66.

The Consultant conducted a sensitivity and risk analysis which verified that the Madian HPP is economically feasible even under adverse conditions such as higher investment costs and unfavourable hydrological conditions.

In the financial analysis the Consultant considered the legal and institutional framework for development of hydropower projects by private investors in Pakistan which is in the process of being established. Pursuant to NEPRA's Tariff Standards and Procedure Rules a model for calculation of the power tariff was developed that permits the licensee to recover the costs incurred for power generation as well as provide a reasonable rate of return on the investment which reflects the risks assumed by the investor.

13.2 Recommendations – Project Implementation

For Project implementation, the following major activities are considered:

- Stage I: Pre - Construction Activities: 48 months
- Stage I.1: Feasibility Study
- Stage I.2: Tender Design, Pre-qualification and Contracts
- Stage II.: Construction Works, Commissioning, Testing/Training: 54 months
- Stage I: Commercial Operation of the Plant: mid 2015

The construction schedule is based on en estimated overall construction period of 4 years and 6 months. The critical path of construction works is defined by the excavation and lining of the 11.8 km long headrace tunnel.

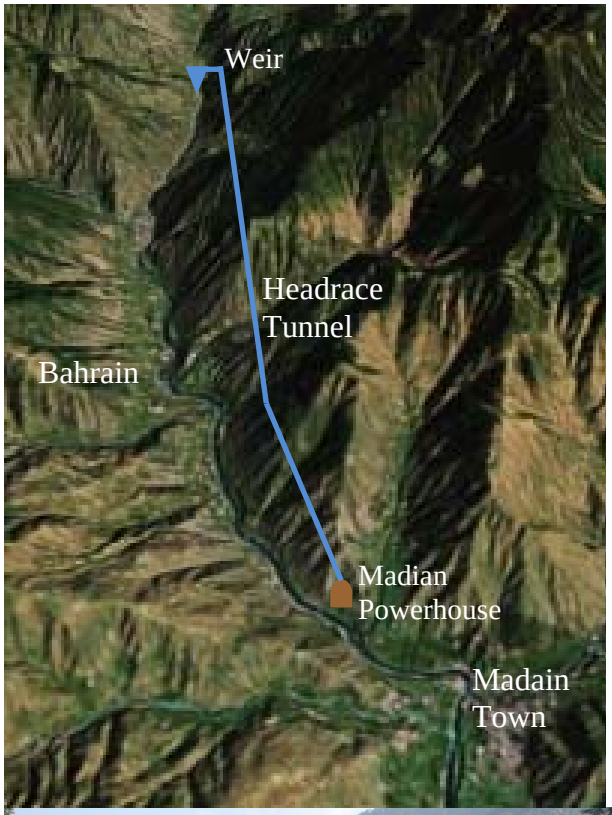
Annex A-1-1: Photo Documentation of Access to Project Site

Photo 1: Madian Sadar Bazaar Bridge (3.5 m wide)

Photo 2: Temporary Baily Bridge at Northern Outskirt of Madian Town (3.5 m wide)

MADIAN
HYDRO POWER LIMITED

Feasibility Study for the Madian Hydropower Project



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ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

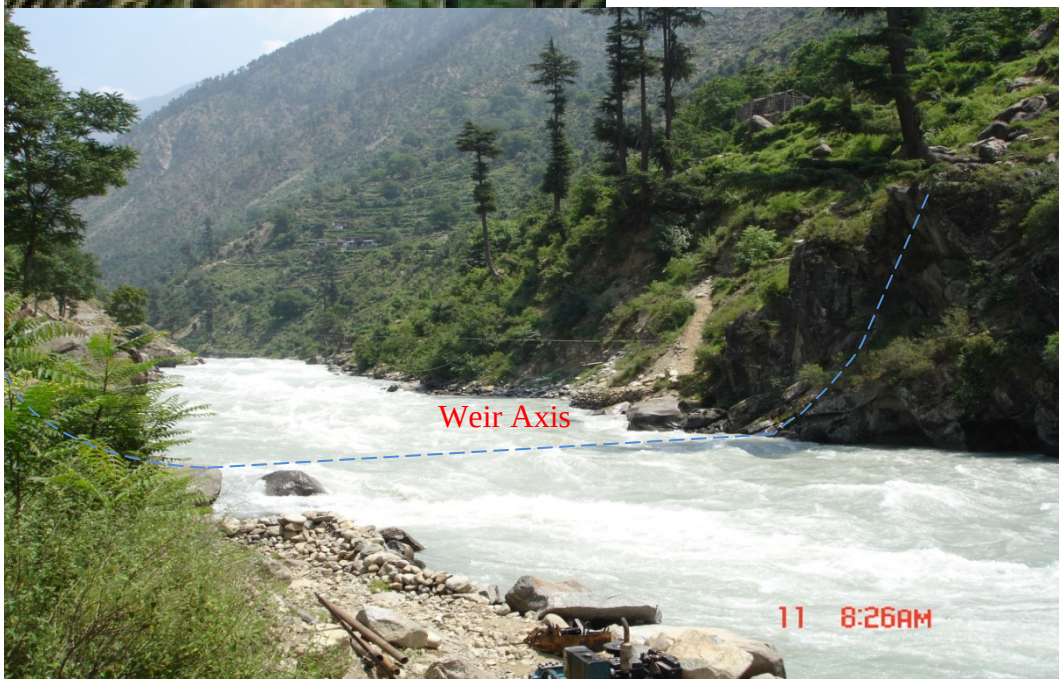

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Table of Contents

Abbreviations

µT	Micro Tesla
A	Ampere
AC	Alternative currencies
AIDS	Acquired immunodeficiency syndrome
asl	Above sea level
B	Magnetic flux density
BAT	Best available Technique
bcm	Billion cubic metre
CC	Construction Contractor
CEMAGREF	Agricultural and Environmental Engineering Research Institute of France
CIGRE	Council on large Electric Systems
DIN	Deutsches Institut für Normung
E	Electric field strength
EIA	Environmental Impact Assessment
ELF	Extremely low frequency
EMF	Electric and Magnetic Field(s)
EMP	Environmental Management Plan
EN	European Norm
EPA	Environmental Protection Agency
EPFI	Equator Principles Financial Institution
f	frequency
GHG	Green House Gases
GHz	Giga Hertz
GIS	Geographic Information System
GTZ	German Society for Technical Cooperation (Gesellschaft für Technische Zusammenarbeit)
GWh	Gigawatt hour
H	Magnetic field strength
ha	hectare
HPP	Hydropower Plant
Hz	Hertz
Ic	Contact Current
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ICOLD	International Commission on Large Dams
IEC	International Electro technical Commission
IEE	Initial Environmental Examination
IFC	International Finance Corporation
INRC	International Non-Ionizing Radiation Committee
IRPA	International Radiation Protection Association
ISO	International Standard Organisation
IUCN	International Union for Conservation of Nature (World Conservation Union)
IUNC	International Union for Conservation of Nature and Natural Resources
kg	kilogramme
KIDP	Kalam Integrated Development Programme

km	Kilometre
KTZ	Kohistan Tectonic Zone
kV	Kilo Volt
l	litre
LAA	Land Acquisition Act (1894)
m	metre
m^2	square metre
m^3	cubic metre
mA	milli Ampere
MAES	Mirza Associates Engineering Services
MCE	Maximum Credible Earthquake
MHz	Mega Hertz
MKT	Main Karakoram Thrust
MMT	Main Mantle Thrust
MQan	Mean annual flow in m^3/sec
MQeco	Mean monthly ecological flow in m^3/sec
MQmo	Mean monthly flow in m^3/sec
MW	Mega Watt
NCS	National conservation strategy
NEQS	National Environmental Quality Standards
NGO	Non-Government Organisation
NIR	Non-ionizing radiation
NWFP	Northwest Frontier Province
OP/BP	Operational Policies/Bank Procedures
P-EPA	Pakistan Environmental Protection Agency
PEPA-1997	Pakistan Environmental Protection Act 1997
PH	Public health
PME	Powered mechanical equipment
PPIB	Private Power and Infrastructure Board
PTDC	Pakistan Tourism Development
PVT	Pressure, Volume, Temperature
RAP	Resettlement Action Plan
rms	Radiation Monitoring System
Rps	Pakistan Rupees
S	Power density
SA	Specific absorption
SAR	Search And Rescue
sec	Seconds
SHYDO	Sarhad Hydel Development Organisation
SIA	Security Industry Association
SoP	Survey of Pakistan
UNEP	United Nations Environment Programme
USSR	Soviet Union / Union of Soviet Socialist Republics
UV	Ultra violet
V	Volt
VDE	Association of German Electrical Engineers
W	Watt
WCD	World commission on dams
WHO	World Health Organisation

0

Executive Summary

0 EXECUTIVE SUMMARY

0.1 SCOPE OF WORK AND METHODOLOGY

In Pakistan, there is an increasing demand for power recently outstripping the supply of electricity. By 2010 demand is expected to exceed supply by approximately 5,500 MW. To close this gap different possibilities for power generation are investigated and many projects have been identified including hydropower projects.

One of this identified hydropower projects is the Madian HPP. Following national and international requirements, an Environmental Impact Assessment (EIA) and a Resettlement Action Plan (RAP) have to be prepared for this Project. In order to fulfil this demand two reports have been written, both as stand alone reports:

- Feasibility Study for the Madian Hydropower Project: Environmental Impact Assessment (EIA);
- Feasibility Study for the Madian Hydropower Project: Resettlement Action Plan (RAP).

Herewith, the Environmental Impact Assessment to the Madian HPP is presented assessing the environmental impacts of the project and presenting an Environmental Management Plan (EMP). The preparation of the EIA was guided by the 'Guidelines for the Preparation and Review of Environmental Reports' (Government of Pakistan, November 1997) and follows the principle to ensure environmentally sound and sustainable development and that no body is made worse of as a result of the Project.

For transparent presentation and evaluation, a tabulated evaluation procedure has been applied. On the basis of a points scale, the severity of the particular environmental impact together with its general trend - that is negative or positive - is described. The evaluation scale applied is as follows:

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
O	=	nil
✦	=	locally positive
✦✦	=	regionally positive

0.2 LEGAL AND INSTITUTIONAL FRAMEWORK

Covering all sectors of economy, Pakistan Environmental Protection Act (PEPA-1997) provides guidance for the protection, conservation, rehabilitation and improvement of the environment, for the prevention and control of pollution and for promotion of sustainable development.

According to national and international guidelines, the Madian Hydropower Project with an estimated generation of 157 MW is requiring the preparation of an Environmental Impact Assessment (EIA) and of a Resettlement Action Plan (RAP)

Aim of this EIA study is to bring the Project in line with following international guidelines:

- OP/BP 4.01 + Annexes '*Environmental Assessment';*
- OP/BP 4.04 '*Natural Habitats*';
- Environmental Assessment Sourcebook Vol. II, Sectoral Guidelines of the World Bank (Chapter 8 "Dams and Reservoirs");
- Pollution Prevention and Abatement Handbook 1998;
- Environmental, Health, and Safety Guidelines replacing Part III of the Pollution Prevention and Abatement Handbook 1998;
- International Finance Corporation (IFC) Environmental, Health and Safety Guidelines;
- Report of the World Commission on Dams (WCD);
- Large Dams, Learning from the Past, Looking at the Future (IUCN and The World Bank; Workshop Proceedings Gland, Switzerland, April 11-12, 1997);
- Equator Principles of private donor banks.

EIA and RAP of Madian Hydropower Project will be filed with NWFP EPA Peshawar for their approval. Because it will be a private financed project the Private Power and Infrastructure Board (PPIB) is also involved in the development of the Project who will review all social and environmental assessments reports pf power projects sponsored by private sector.

An update of the EIA shall be made after the overall feasibility of the Project is confirmed and decision is made to start the implementation of the Project.

0.3 PROJECT DESCRIPTION

Madian Hydropower Project is planned to generate a power of approx. 157 MW. The proposed project area is located in the North West Frontier Province, on the Swat River between Madian town and Kedam village. It includes the 1.5 km long reservoir upstream the weir and the 13 km long river section between the weir and the power house.

The Madian Hydropower Project consists of following main structural components:

- Concrete weir construction, height 19 m above riverbed;
- Reservoir upstream the weir, length 1.46 km;
- Headrace (pressure) tunnel, 11.8 km, net diameter 7 m;
- Three underground desander caverns;
- Underground powerhouse with surge tank;
- Underground GIS substation 220 kV;
- One permanent new bridge crossing the Swat River;
- 3.8 km of permanent new access roads;
- Relocation of the Madian-Kalam road at the weir for 250 m;
- Two temporary bridges crossing the Swat River;
- several sites to dump excavation material;

The headrace pressure tunnel is located parallel to the Swat River along its left bank with a length of about 11.8 km. In order to achieve a reasonable construction time by conventional drill and blast method, construction of the headrace tunnel is planned to start from 4 construction adits in parallel. The adits along the headrace tunnel were selected to divide the tunnel into four parts of almost equal length. These adits are located on the left bank of the Swat River.

Overall approximately 1.15 Mill m³ of excavated material will be generated which including a bulking factor of 15 % results in a corresponding capacity of dumping sites of 1.35 Mill m³. From this quantity about 150,000 m³ can be deducted for use as gabion fill and concrete aggregates and another 150,000 m³ as riprap for slope protection in the reservoir area upstream of the weir. That means that around 1,050,000 m³ of mostly rocky material have to be dumped.

0.4 BASELINE CONDITIONS

Location and Investigation Area

The Madian HPP is located in the north of Northwest Frontier Province of Pakistan (Map 0-1).

Map 0-1: Location of Madian Hydropower Project

The investigation area covers the Swat valley upstream of the weir site including the future reservoir and the reach of the Swat River from the weir to the power house site. The investigated area includes also the slopes of the valley where cultivated land might be affected by flooding and by construction activities such as adits for headrace tunnel construction and areas for dumping of excavation material.

Climate

The climatic conditions in the project area are typical for high altitude regions. The mean monthly temperature varies from its lowest value of -6.1°C in January to the highest temperature in June with +26.3°C in June at Kalam meteorological station located some 30 km upstream of the project area at elevation 1921 m. At the weir site temperatures are about 3 to 4 degree higher.

Topography

In the northern part of Pakistan, the Hindu Kush Mountains converge with the Karakoram Range, a part of the Himalayan mountain system. These ranges have a large number of peaks ranging from 6,000 m to 8,611 m above the sea level. In the southern foots of the Hindu Kush mountain lies the Swat Valley having peaks up to 6,300 m asl running from north to south. The valley is a part of the Kabul River catchment, which ultimately drains into Indus River near Attock bridge.

Geology
The project area is situated in the middle-western part of the Kohistan Tectonic Zone and comprises plutonic igneous rocks. The predominant rock type at the site is a medium-grained slightly foliated gabbroic rock, classified as Norite. This rock type is in intrusive contact with another plutonic igneous rock called Diorite. The contact between the two rock types passes almost midway between Kedam and Mankial. Minor rock types in the area include Amphibolites, Pegmatites and fine grained basic dykes. None of them are in significant large proportions to affect the mechanical strength of rocks in the site area.

The Swat River
The Swat River flows in the area upstream of the town of Madian in a narrow U-shaped valley. The Swat River starts from Kalam town in the valley at the confluence of Ushu River and Gabral River. A number of villages and small towns are located in the Swat valley among them Kalam, Bahrain, Madian and Mingora. After flowing over a length of 250 km, Swat River ultimately joins Kabul River near Charsada town of North Western Frontier Province. The native fish fauna of these waters, prior to the introduction of trout, was *Schizothorax species* and *Orienus species*, locally known as Swati fish. Also *Noemacheilus* species occurred. The introduction of trout (*Salmo trutta fario/brown trout and Oncorlrynchus mykiss/rainbow trout*) started in 1961. Since then trout is regularly reared in the Government hatchery at Madian and released in these waters. Consequently, the trout population has been established, which has replaced the indigenous fish breeds more or less totally.

It has to be stated that the information given above are based on interviews with the Fishery Department in Madian and with local residents. There are no actual exact scientific data available, neither about fish species living in the Swat River nor about diatoms, benthic macroinvertebrates, phytoplancton etc.

Terrestrial Fauna and Flora
The Flora of the region is characteristic for a dry temperature and can be assessed to be rich. Sixty-five species of trees and shrubs exist which belong to the Dicot families.

The total forest area of Kalam is 23,976 ha. From this, 6,223 ha are commercial and 17,753 ha are non-commercial forests. It can be classified to be a dry temperate forest. Presently, the forests are under the administrative control of the Kalam Integrated Development Programme (KIDP). Several factors put pressure on the existence of the forest. The most severe impacts arise from cutting of trees as firewood.

Over the last 50 years the number of animal species has been decreased dramatically. A lot of species are endangered by the destruction of habitats. The entire area is widespread populated and heavily influenced by human activities including housing, agriculture, hunting, tourism like fishing and creating of tourist infrastructure etc. Overall, the ecological value of this part of the mountains is nowadays very limited.

Reserves and Protected Areas, Historical and Cultural Sites
In the investigation area no Wildlife Reserves or other protected areas exist. The same is valid for historical and cultural sites.

Landscape
The part of the Swat valley that is foreseen as potential reservoir, can be classified to be "attractive" (number 3 in five level scale). The upper part of the Swat valley, that is steeper, can be assessed to be "very attractive".

Seismic situation
The site area in particular and the upper Swat River region in general do not show any significant cluster of epicentre. The recorded epicentres are generally less than 3 in magnitude. However, the region is commonly affected by seismic events occurring in the Hindu Kush seismic zone, that occurs some 200 km NW of the site area.

Traffic
At present there is a significant heavy truck traffic prevailing in Madian and Bahrein crossing along the main road (Madian-Kalam). Trucks can advance slowly in the rather densely populated urban areas, in particular when two trucks have to pass each other in the urban centres.

Social Structure
Swat has a predominantly rural population. It is inhabited by Yousafzail Pathans, Mians, Kohistanis, Gujars and Pirachas. The Pashto speaking Yousafzai Pathans are the direct descendants of Aghans of Ghazni. The Gujar and Kohistanis speak their own dialects of Gujar, Garwi. Torwali and Kohistanis inhabit the mountainous areas up to the north. The Kohistanis are settled in and around Kalam, Ushu, Utror and Gabral valleys. The nomadic Gujars also form a substantial part of the population in the northern areas of the district.

The urban population has a fair number of Pirachas who have migrated over the past 100 years and assimilated themselves in the local population speaking Pashto. They dominate the local commerce and trade. Swat has a small minority population consisting of Sikhs, Hindus, and Christians.

The clans of the different sub-tribes associated with the former ruling families and the other clans are different in prestige. The artisans, carpenters, blacksmiths and musicians belong to landless clans which do not enjoy a high status. Dehqans (farmer), dependant on the landowners, are working for the landowner clans and get usually a share of 33% of the harvest. The mutual dependence of landowners and dehqans is still in place. The big landowners normally belong to the former ruling families.

Health Aspects in Project Area

HIV is currently not a dominant epidemic in the adult population of Pakistan. No cases of HIV/AIDS in the investigation area have been reported. Children mostly suffer from acute respiratory infection, asthma and pneumonia. Vaccinations are carried out in Bahrain town against measles, cholera and polio. The project area of Madian Hydropower Project, however, is known to consist of conservative population committed to principles of Islamic Shariah. HIV/AIDS, therefore, does not play any role in the society as far as it is known at present.

0.5 SIGNIFICANT ENVIRONMENTAL IMPACTS

Construction Phase

The extent of impacts during the construction and operational phase is summarised in the following two tables:

CONSTRUCTION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Land acquisition and use	■	Land acquisition and use will be compensated. For this purpose a Resettlement Action Plan as a stand alone report was developed that will be adopted when final design has been fixed.
Excavated material	■ ■ ■	Dumping of the excavated material is a big challenge of the Project. Because it is a run-of-river design with a long headrace tunnel a lot of material will be excavated. Dumping of this material has impacts on many issues as air quality, noise aspects, traffic, landscape, flora and fauna, tourist activities etc. Some of the material will be reused as concrete aggregates, for gabions and slope protection.
Traffic	■ ■	Needless truck movements will be avoided by proper truck management; dumping sites are selected close to the adits on the left river bank helping to reduce transportation routes. Near powerhouse conveyors may be used for transport of excavation material. Transport of excavated material through the City of Bahrein will be avoided. However, construction material and machines coming from Madian to the weir site have to cross the cities of Madian and Bahrein. Together with other projects going on in the region this will sum up to a considerable amount of traffic during construction.
Air quality	■ ■	The measures in order to reduce the traffic are suitable to reduce the negative impact on air quality (see traffic above). In addition, water shall be sprayed continuously to reduce dust emissions of construction activities.
Noise aspects (on public)	■ ■	The measures in order to reduce the traffic are suitable to reduce the noise impact on the public (see traffic above)
Ecology of Swat River	■	Only a short river section (about 240 m) will be diverted during the construction of the weir structure. Other parts remain untouched except for a short period when the coffer dams in the river will be closed. A certain sediment run off might occur during this time period.
Terrestrial fauna and flora	■ ■	Large areas for dumping the excavation material will be necessary. The area of the reservoir will be flooded and terrestrial habitats will disappear.
National parks, wildlife sanctuaries and other protected areas	O	No national parks or other protected land are located within the Project area.
Historical and cultural sites	O	No historical and cultural sites are located within the Project area. If archaeological remnants are found the construction work will be ceased immediately and the relevant archaeological authority will be informed.
Landscape	■ ■	Increased truck traffic and dust emission will influence the overall picture of the landscape.

CONSTRUCTION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Health and Safety of Workers	■	Proper workers' camp will be provided to the workers. A Health and Safety Plan for the construction period will be developed and implemented by the construction contractor. Training of workers will be performed regularly.
Solid and liquid wastes	■	Around 400 workers in peak periods will generate significant amounts of liquid and solid wastes. The liquid sanitation waste water will be treated at workers' camp site; proper dumping of solid waste will be the responsibility of the contractor.
Socio-economy	✦ ✦✦	Around 400 workers (skilled and unskilled) will find employment during the construction period in peak times. In addition, related services (hotels, shops selling articles for the daily life etc.) will benefit from the Project. Because of the very conservative social structures of population committed to principles of Islamic Shariah HIV/AIDS does not play any role and the adverse effects on the local community will be very limited.
Tourism	■	The construction activities will affect tourist activities in the Swat valley. However, hotel managers do not expect severe negative impacts on the number of tourists, whose number has already decreased because of the political situation. There is the hope that projects like Madian HPP will bring more stability to the region.
Resettlement actions	■	Following the positive statements given by the affected people and under precondition that the RAP is implemented appropriately, the impact caused by necessary resettlement actions is assessed to be low.

Table 0-1: Ranking of environmental impacts during the construction phase for the proposed Madian Hydropower Project under consideration of the proposed mitigation measures

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

It has to be pointed out that specific biomass removal measures of the inundated area will not be necessary because only a very small number of trees are growing in the reservoir area. Some 20 trees are growing near the weir site, which will be cut down during construction of the weir.

OPERATION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Microclimate and GHG	✦ ✦✦	The effect on the microclimatic conditions will be minimal due to the small size of the reservoir surface. Most of the organic materials as trees, shrubs etc. will be removed before filling the reservoir. Compared to conventional thermal power generation significant reduction of CO2 emission will be achieved.
Swat River ecology	See discussion	As a matter of fact, the weir will act as an insurmountable barrier to migrating fishes causing fragmentation of fish populations. There will be a minimum water release also during the dry season (ecological flow). Due to this Project and when looking on the other hydropower projects in the Swat Valley in development the Swat River itself will undergo major alterations. It will be converted from a white water river to a cascade of headponds with river reaches in between where less water will flow than before. Very limited knowledge is available about the ecological features of the river, therefore no overall assessment is given. Please refer to Chapter 5.2.2.
Terrestrial fauna and flora	■	The reservoir represents a migration obstacle for big mammals. However, most of bigger animals have been disappeared since decade due to high population pressure (e.g. hunting).
Landscape	■	The character of the landscape down in the valley will be changed. A section of a fast flowing white water river will be converted into a lake.
Seismic aspects	■	The project will be designed to withstand the max. credible earthquake (MCE) without major damages and OBE-1 without damages.
Substations	■	Concerning EMF there will be no negative impacts on workers' health coming up. The handling of SF6 has to be done very carefully considering the presented guidelines outlined in Chapter 12.5.1.
Deposits from desander	■	The sand of the desander will be flushed regularly during times of high water. In winter time flushing will not be required.
Water-related vector diseases	■ ■	There might be an increase of water-related diseases after constructing the planned reservoirs in the Swat valley. In order to manage these health problems, a concerted action of all HPPs owners/operators together with relevant regional and national health authorities will be necessary. This has still to be agreed.
<u>Socio-economic aspects:</u> Employment	✦ ✦✦	The effect on employment of people during operational period will be limited. Some skilled and unskilled workers will find jobs during operation of Madian HPP.
Tourist activities	o	The angler attitude will change from white water fishing to fishing in a lake with other species as before. Other tourist activities will not be affected except for the landscape has changed. Overall it is assumed that the number of tourists will not decrease.

OPERATION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Water supply downstream the weir site	■	The operation stage of the Project will not affect irrigation between the weir and the power house because the tributary steams/nullahs and springs are used for irrigation downstream of the weir. Downstream the power house there will be no alterations of the Swat River flow. Those households/hotels downstream the weir which use presently water from Swat River as drinking water, will be provided with clean drinking water as long s they are not connected to a drinking water system.

Table 0-2: Ranking of environmental impacts during the operational phase for the proposed Madian Hydropower Project under consideration of the proposed mitigation measures

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

0.6 ANALYSIS OF ALTERNATIVES

No Project Option

At present, there is an increasing demand for power nowadays outstripping supply of electricity in Pakistan. This disproportion results in many power failures and intentionally disconnecting large parts of towns from power supply, e.g. in Lahore nearly every day. By 2010 the demand is expected to exceed supply by approximately 5,500 MW. Adequate power supply, however, is a key to achieve growth targets of a country resulting in higher welfare of its population in general. Thus, the 'no project option' is not a realistic scenery, if Pakistan shall be supplied with enough power to meet the demand.

Gas fired power plant

Gas-fired power plants have some advantages compared to hydropower projects: in the case of gas fired plants investment costs per kW are less, energy can be provided much faster and the location can be selected to have limited environmental and social impacts. But the disadvantages like the lack of appropriate gas supply, uncertainty in development of variable O&M (fuel) costs and loss of autonomy in primary energy supply may not to be underestimated. Finally, it is the Government's decision on what power supply policy to rely on, in Pakistan as well as in other countries

0.7 INTERFACE WITH OTHER PROJECTS

The Swat valley topography, with its Swat River, offers possibilities for the development of different hydropower projects in a cascade system. At present, there are four hydropower projects proposed on the Gabral-Swat River system. These projects are Gabral-Kalam, Kalam-Asrit, Asrit-Kedam, and Kedam-Madian. This may amplify environmental impacts of the HPPs.

The development of the Daral-Khwar HPP at Bahrein village (located between Madian HPP weir and powerhouse site) includes the installation of a drinking water supply and sewerage system with treatment plant. This will help to improve the water quality of the Swat River.

The upgrade of the Madian-Kelam road to a national highway (presently in progress) will bring more traffic into the Swat valley but it also facilitates access for tourism and improves conditions for transport of permanent and construction equipment for the implementation of the Madian HPP and other hydropower Projects in the Swat valley.

0.8 ENVIRONMENTAL MANAGEMENT PLAN

An environmental management and monitoring programme is pursued during construction stage and operation stage of the Project to protect and provide safeguards for a continuing healthy environment in the project area. After the Project becomes operational the Plant Manager with the assistance of staff on behalf of Madian Hydropower Ltd. will be overall in charge and responsible for management and monitoring of the hydropower project.

The purpose of mitigation measures is to manage the Project in a manner that minimises adverse impacts and maximises secondary benefits. It is a planning step that evolves naturally from the process of identifying and assessing potential impacts. Mitigation is best conducted throughout the planning process when it is usually more effective and changes can be made at the least cost. Mitigation is the process of making a project more compatible with its environment.

This Environmental Management Plan (EMP) was developed based on the status of the feasibility design of June 2008. After finalising the technical feasibility study this EMP shall be updated and then added to the tender documents of the Madian HPP. The construction contractor shall implement the measures as outlined for the construction phase, and the operator/owner shall implement the measures as outlined for the operation phase.

In general, there are two options for operation of hydropower projects: Run-of-river and peaking operation mode. Peaking operation requires larger reservoirs compared to run-of-river operation. Such storage would result in additional negative socio-economic impacts which can be avoided by developing the Project as run-of-river power plant.

Daily peaking operation mode would require up to 1,500,000 m^3 active storage, whereas the selected run-of-river power plant has a max. reservoir storage of only 480,000 m^3.

Other design measures to mitigate environmental impacts of the Project have been to arrange the location of the powerhouse away from Madian town instead building it right at the town border as foreseen in the cascade study /1/. Another measure was not to involve Kedam Kalam and Bara Dar tributaries near the weir site as inflow to the reservoir.

The management plan focuses on two issues:

First the development of a Resettlement Action Plan to compensate loss of land and for relocation. This plan is given in a stand-alone report. The measures sum up to about 2 Mill. US$.

Second, it is recommended to perform a regular construction site audit to supervise the implementation of the mitigation and monitoring measures during the construction phase.

0.9 PUBLIC CONSULTATIONS

The Consultant along with representatives of the Project Sponsors undertook the process of informing community representatives and affected households about the Project and its impacts. Three field trips were conducted in April, Mai and June 2008. The consultation process was conducted during the socio-economic survey preparing the affected community regarding land acquisition, helping to counter the rumours, preventing unnecessary distress, and bringing clarity on issues that might be raised by the affected persons. The process also includes the preparation of an introductory and information brochure in Urdu about the Project, its location and main impacts. A detailed listing of people interviewed and discussed is given in the Resettlement Action Plan (RAP) to the Project in Annex 13.1.2.

Before project appraisal, the Sponsor with the help of the Implementation Consultant will prepare and conduct an Information and Community Consultation Programme in Madian.

Participation of project affected people and of the community during the project cycle will be ensured through their involvement in a committee for redress of grievances. This will ensure satisfactory settlement of any issue regarding affected land, houses, crops etc.

0.10 GAPS OF DATA AND RECOMMENDATIONS

There is a lack of knowledge concerning the ecological 'features' of the Swat River. No exact data about the fish fauna are available and a total lack of knowledge concerning benthic macro-invertebrates, diatoms, phytoplankton etc. has to be stated. That fact makes it very difficult to assess the impacts of the Project on the ecology of the Swat River.

It is reported that by artificial introduction of trouts into the Swat River the species that formerly lived in the river are extinct. However, this is reported only and no scientific data are available. From the experience of the author of this report it is very likely that there are remnants of original fish species left. Also no knowledge is available whether there are endemic fish species living in the river or not.

Therefore, it is recommended to perform a scientific investigation at least concerning fish population in the river.

In addition, it is recommended to develop a general Catchment Management Program containing landscape management measures for planting of trees, creating of ecological valuable habitats etc. aiming, among others, at the control of erosion and consequent sedimentation of the reservoir. To develop or even to implement such a plan, however, is beyond this EIA for a single run-off river hydropower project. It is understood as a general task for all hydropower projects in the catchment area in order to maintain their sustainability and to minimise their ecological impacts.

0.11 SUMMARY OF FINDINGS

Construction Phase

From the findings of the study as summarised above it can be concluded that a significant negative impact results only from the deposition of excavated material during the construction phase. The amount of the excavation material can not be mitigated. It is a result of the prevailing topographic conditions and the need to construct a long headrace tunnel for development of a run-of-river hydropower plant to generate power. On the other hand, this kind of HPP reduces considerably the size of the reservoir that would have been much bigger in the case of a dam with storage for daily peaking operation or seasonal flow regulation.

The amount of excavated material affects several environmental aspects as there are traffic, air quality, noise, landscape, terrestrial fauna and flora etc. Regarding these aspects, however, mitigation measures are possible. As a consequence the project's impact on these aspects can be assessed to be medium. Further aspects are judged to be low negative or nil. Concerning socio-economic aspects, the impacts of the Project are locally and regionally positive. These impacts are limited to the 4.5 year long construction phase.

Operational Phase

During the operational phase no high negative impacts will occur. Focus is given in the assessment on the ecology of the Swat River. However, the knowledge of the biology in the river is very limited. Consequently a general final assessment of the extent of the impact could not be given. Even without exact knowledge it can be stated that the river ecology will be subject to certain changes. A river reach of 1.5 km length will be converted into a lake (reservoir), downstream in a river reach of 13 km length the discharge will be reduced with all its consequences for the ecology, despite the fact that a minimum flow is released as 'ecological flow'.

The environmental implications as discussed above are unavoidable and not to mitigate when constructing hydropower plants. Decision makers have to weigh between these impacts on the environment and the need for generation of power and the impacts of alternative (thermal) facilities for generation.

Regarding water-borne vector diseases, the Project may cause medium impacts. For all other aspects during operational phase the impacts of the Project will be low negative or even nil.

1

Scope of Work and Methodology

1 SCOPE OF WORK AND METHODOLOGY

1.1 INTRODUCTION

In Pakistan, there is an increasing demand for power recently outstripping the supply of electricity. By 2010 demand is expected to exceed supply by approximately 5,500 MW. To close this gap different possibilities for power generation are investigated and many projects have been identified including hydropower projects.

Thus, Shy do/GTZ investigated the hydropower development potential in Swat Valley in 1994 /3/. They came up with three hydropower stations at the Swat River. These findings have been further developed by Mira Company /4/ that proposed five hydropower stations. One at Ushu River, the most upstream part of Swat River, one at Gabral River, a tributary of Swat River, and three at the Swat River itself (Map 7-1). One possible dam site was identified to be approx. 20 km north of the City of Madian, about 225 km north of Peshawar. This represents the most downstream weir site following the Mirza study.

Taking up this proposal, a consortium consisting of Cherat Cement Ltd. and Shirazi Investments Ltd., both of Karachi, were awarded the License to develop this Project. It is planned to generate approximately 157 MW and 767 GWh per year, respectively.

1.2 SCOPE OF THE STUDY

Following national and international requirements, an Environmental Impact Assessment (EIA) and a Resettlement Action Plan (RAP) have to be prepared for the Madian HPP. In order to fulfil this demand two reports have been written, both as stand alone reports:

- Feasibility Study for the Madian Hydropower Project: Environmental Impact Assessment (EIA);
- Feasibility Study for the Madian Hydropower Project: Resettlement Action Plan (RAP).

Herewith, the Environmental Impact Assessment to the Madian HPP is presented. In this assessment, the overall impacts of the Madian Power Plant Project and essentially effects on the ecology are considered and assessed. In addition, an Environmental Management Plan containing mitigation, compensation and monitoring measures has been developed.

The extent of impacts is judged against the REPORT OF THE WORLD COMMISSION ON DAMS, published in 2000, involving World Banks Operational Policies on Environmental and Social Safeguards. The report also considers specific national requirements on an EIA. The preparation of the report takes also into consideration the Terms of Reference to the Project.

The preparation of the EIA was guided by the 'Guidelines for the Preparation and Review of Environmental Reports' (Government of Pakistan, November 1997) and follows the principle to ensure environmentally sound and sustainable development and that no body is made worse of as a result of the Project.

1.3 PROCEDURE AND STRUCTURE OF THE INVESTIGATION

The preparation of this EIA is based on field trips to the investigation area, on interviews with people living in the investigation area, on discussions with relevant authorities and NGOs and on the

- Feasibility Study for the Madian Hydropower Project,
  Report on Preferred Project Alternative,
  FICHTNER Company, Stuttgart, March 2008.

The time schedules for the field trips (in April, May and in June 2008) and the interviewed authorities and NGOs can be found in Chapter 12.1 of this Report.

1.4 METHOD ADOPTED FOR PRESENTING AND EVALUATING THE RESULTS OF THE INVESTIGATIONS

The description and evaluation of the environmental impacts of the proposed Madian Hydropower Plant (HPP) Project are presented in Chapter 5 "Significant Environmental Impacts". This Chapter includes also proposed mitigation and compensation measures. For better overview, these and additional measures are listed in a tabular form in Chapter 8.3 "Mitigation / Compensation Activities".

Special attention has been paid to the fact that a huge amount of excavated material has to be dumped in the vicinity of a rather populated area (Chapter 5.1.2): A special discussion is given to the aspect of changes of Swat River ecology and the question of "how much is adequate" concerning the ecological flow released at the weir site (Chapter 5.2.2).

The final discussion and the concluding evaluation of the investigation results follow in Chapter 11 "Summary of Findings". For transparent presentation and evaluation, a tabulated evaluation procedure has been applied. On the basis of a points scale, the severity of the particular environmental impact together with its general trend - that is negative or positive - is described.

The evaluation scale applied is as follows:

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
O	=	nil
✦	=	locally positive
✦✦	=	regionally positive

1.5 THE STUDY TEAM

The study team was formed by local experts (based in Lahore) and guided by FICHTNER's

Senior Health, Safety and Environment (HSE) Expert Dr. Hans G. Back.

The local team consisted of:

Dr. Mohammad Nawaz Tariq
Chief Environmental Engineer in the function as team leader of the local team

Mukhtar Tahir
Senior Environmental Expert

Naeem Akhtar
Senior Environmental Expert

2

Legal and Institutional Framework

2 LEGAL AND INSTITUTIONAL FRAMEWORK

2.1 NATIONAL LEGISLATION

Covering all sectors of economy, Pakistan Environmental Protection Act (PEPA-1997) provides guidance for the protection, conservation, rehabilitation and improvement of the environment, for the prevention and control of pollution and for promotion of sustainable development. At present, under PEPA-1997, Pakistan Environmental Protection Agency (P-EPA) is functional at federal level. Similarly provincial Environmental Protection Agencies (EPA) in every province of the country are also functional. For control and management of gaseous emissions and industrial/ municipal effluents, National Environmental Quality Standards (NEQS) have been framed and are applicable countrywide. These and other legislative instruments are briefly discussed below:

2.1.1 National Environmental Quality Standard (NEQS)

In order to control environmental pollution, the Government of Pakistan has laid down National Environmental Quality Standards (NEQS) for municipal and industrial liquid effluents, industrial gaseous emissions, motor vehicle exhaust and noise. The NEQS were first promulgated in 1993 and were amended in 1995 and 2000. These standards specify maximum allowable concentrations of pollutants for:

- Municipal and liquid industrial effluents discharged to inland waters, sewage treatment facilities, and the sea;
- Gaseous emissions from industrial sources; and
- Gaseous emissions from vehicle exhaust and noise emission from vehicles.

2.1.2 Forest Act 1927/ NWFP Forest Ordinance 2002

The Forest Act 1927 (and later amendments), establishes the right of the government to designate areas for reserved forest, village forest and protected forest, and may acquire such areas for prohibiting or restricting the public use of the resources or other activities. NWFP Forest Ordinance 2002 has the objectives of protection, conservation, management and sustainable development of forests as well as promotion of the economic, social and ecological well-being of the local people.

2.1.3 Sarhad National Conservation Strategy 1996/ 2004

Pakistan Environmental Protection Act 1997 is the basis of environmental legislation and provides the framework for the implementation of the National Conservation Strategy (NCS) issued in 1991 by the Government of Pakistan in collaboration with IUCN. North Western Frontier Province (N.W.F.P) initiated the Sarhad Provincial Conservation Strategy in 1992 for completion in 1996; it was reviewed in 2004. This document has the goal to secure the economic, social and ecological well being of the people of NWFP through the conservation and sustainable development of the province's natural resources.

2.1.4 Other Environmental Legislation Requiring Consideration

In addition to the key environmental policies and legislation identified above, the following legislative instruments may be relevant to the Madian Hydropower Project:

- The West Pakistan Water and Power Development Authority Act 1958
- Pakistan Penal Code, 1860
- Local Government Ordinance of 2001
- Regulation of Mines and Oil Fields and Mineral Development Act, 1948
- Motor Vehicles Ordinance, 1965
- Factories Act, 1934
- Highways Safety Ordinance of 2000
- Explosives Act, 1884
- Environmental Tribunal Rules of 1999
- West Pakistan Goat Restriction Rules, 1961; and
- Wildlife Act of 1975.

2.1.5 Workplace Safety

Pakistan regulations concerning workplace safety provide a safe and healthy working environment including adequate steps to prevent accidents and injury to health arising out of or associated with or occurring in the course of work, by minimizing, so far as it is reasonably practicable, the causes of hazards inherent in the working environment. Further, regulations ensure that all personnel receive regular and recorded health and safety training and that systems are established to detect, avoid or respond to potential threats to workplace safety. The regulations provide clean bathrooms, access to potable water, and, if appropriate, sanitary facilities for food storage for all personnel. They further assure to meet the basic needs of the personnel for clean, safe dormitory facilities as well as adequate lightning, ventilation, fire safety equipment, emergency exists, emergency lights and fire alarms etc. Limit values of noise at workplaces are fixed at 85 dB(A).

2.1.6 Categorisation of Project

Pakistan Environmental Protection Agency issued in August 2002 policy and procedures for filing, review and approval of environmental assessment for the development of projects relating to various sectors of national economy. This document includes Schedules A, B and C defining projects in terms of requirements of IEE and EIA.

Schedule A defines projects which require an EIA. It deals with a list of major projects which have the potential to affect a large number of people. The impact of such projects may be irreversible and could lead to significant changes in land use and in the social, physical and biological environment. The section of Schedule A relating to the energy sector is reproduced below:

Energy Sector – Schedule A

- Energy Sector: Hydroelectric power generation over 50 MW.

Schedule B defines projects which require an IEE. It deals with projects where the range of environmental issues is comparatively narrow and issues can be understood and managed through less extensive analysis. The section of Schedule B relating to energy sector is reproduced below.

Energy Sector – Schedule B

- Energy Sector: Hydroelectric power generation less than 50 MW.

Schedule C combines everything not included in Schedules A and B.
An illustrative example given in Schedule C includes the following:

- Projects promoting energy efficiency.

Madian Hydropower Project has an estimated generation of 157 MW. Consequently, the preparation of an Environmental Impact Assessment (EIA) and of a Resettlement Action Plan (RAP) is required under Schedule A. This is in agreement with international used guidelines as derived from World Bank (see Chapter 2.2).

2.2 INTERNATIONAL GUIDELINES

2.2.1 World Bank / IFC

The World Bank Operational Policy 4.01 (Environmental Assessment) is guiding the content of this EIA to the feasibility study of the Madian HPP.
Aim of this EIA study is to bring the Project in line with:

- OP/BP 4.01 + Annexes '*Environmental Assessment'*
- OP/BP 4.04 '*Natural Habitats*'
- Environmental Assessment Sourcebook Vol. II, Sectoral Guidelines of the World Bank (Chapter 8 "Dams and Reservoirs").
- Pollution Prevention and Abatement Handbook 1998
- Environmental, Health, and Safety Guidelines replacing Part III of the Pollution Prevention and Abatement Handbook 1998
- International Finance Corporation (IFC) Environmental, Health and Safety Guidelines.

A full EIA will be initiated and prepared after the overall feasibility of the Project is confirmed and decision is made to start the implementation of the Project.

2.2.2 World Commission on Dams (WCD)

The EIA to the feasibility study to the Madian Hydropower Project is also guided by the 'Report of the World Commission on Dams (WCD)' and by findings of a workshop on 'Large Dams, Learning from the Past, Looking at the Future' (IUCN and The World Bank; Workshop Proceedings Gland, Switzerland, April 11-12, 1997).

2.2.3 Equator Principles

The environmental policy of many private donor banks follows the so called "Equator Principles". In financing private projects, these Equator Principles Financial Institutions (EPFIs) demand to encounter social and environmental issues during development of projects.

Thus, negative impacts on project-affected ecosystems and communities should be avoided where possible, and if these impacts are unavoidable, they should be reduced, mitigated and/or compensated for appropriately. The methods to reach these goals follow mainly the World Bank/IFC Guidelines as outlined in Chapter 2.2.1

2.3 INSTITUTIONAL FRAMEWORK

EIA and RAP for the Madian Hydropower Project will be filed with NWFP EPA Peshawar for their approval. Because it will be a private financed project the Private Power and Infrastructure Board (PPIB) is involved in the development of the Project.

The Private Power and Infrastructure Board (PPIB) was founded in 1994 to facilitate private sector investors in matters concerning establishing power projects and related infrastructure. PPIB is governed by a Board which is headed by the Federal Minister of Water and Power with the PPIB Managing Director as Member. Chairman of the Water and Power Development Authority is one of the Board members which are drawn from the Federal Ministries as well as from the Private Sector. All feasibility study reports including social and environmental assessment reports of power projects sponsored by the private sector are subject to review by a Panel of Experts appointed by PPIB.

3

Project Description

3 PROJECT DESCRIPTION

The Madian Hydropower Project is planned to provide a power of approx. 157 MW. The proposed project area is located on the Swat River between Madian town and Kedam village. It includes the 1.5 km long reservoir upstream the weir and the 13 km long river section between the weir and the power house (see Map 4-2 and Map 12-1).

Based on the proposed layout of the upstream located Asrit-Kedam HPP, the topographic and in particular the geological conditions prevailing in the area upstream of Kedam village a single feasible site could be identified for construction of the weir and power intake for the Madian HPP. Two alternative sites were identified and studied for the arrangement of an open air powerhouse or the outlet of an underground powerhouse located some 1.1 and 1.5 km upstream of the road bridge over Swat River at Madian town. The corresponding layouts (PH1 and PH2) were assessed regarding the respective power potential, geological conditions, civil design and costs as well as the environmental and socio-economic impact of their development. The social and environmental impact of the layout alternatives PH1 and PH2 studied in the Pre-Feasibility Study is summarised as follows:

a) Powerhouse PH1

- Powerhouse and switchyard are located outside of Madian Town and will have minor impact on settlements and agricultural land.
- The surge tank and the lower tunnel portal are located in an unsettled area and no agricultural land is affected.
- Access to the surge tank and the lower tunnel portal has to pass through the settled areas in the vicinity of Madian Town which may create some disturbance during construction, but improves the access to the upper areas of Baranwai in the future.

b) Powerhouse PH2

- Powerhouse and switchyard are located in the direct vicinity of Madian Town and will have major impact on settlements and agricultural land.
- The surge tank and the lower tunnel portal are located in the boundary areas of settlements and cultivated land.
- Access to the surge tank and the lower tunnel portal has to pass through the settled areas in the vicinity of Madian Town which may create some disturbance during construction, but improves the access to the upper areas of Baranwai in the future.

In the course of the study it became obvious, that the PH1 Layout alternative is environmentally and socio-economically more friendly and economically more attractive than PH2. The impacts of the PH2 powerhouse on settlements and agricultural land have to be rated as major, not only during the construction period but also during the operation of the plant. Therefore, development of the Madian HPP on feasibility level was based on Layout Alternative PH1.

The Madian Hydropower Project consists of the following main components (detailed location is shown in Map 12-2 to Map 12-5):

- Concrete weir construction, height 21 m above riverbed;
- Reservoir upstream the weir, length 1.46 km;
- Headrace (pressure) tunnel, 11.8 km, net diameter 7 m;
- Three underground desander caverns;
- Underground powerhouse with surge tank;
- Underground GIS substation 220 kV;
- One permanent new bridge crossing the Swat River;
- 3.8 km of permanent new access roads (partly as track already existing);
- Relocation of the Madian-Kalam road at the weir for 250 m;
- Two temporary bridges crossing the Swat River;
- several sites to dump excavation material;

The pressure tunnel is located along the left bank of Swat River having a length of about 11.8 km. In order to achieve a reasonable construction time by conventional drill and blast method, construction of the headrace tunnel is planned to start from 4 construction adits in parallel. The adits along the headrace tunnel were selected to divide the tunnel into four parts of similar length. These adits are located on the left bank of the Swat River.

	Location	**Structure**	**Area (m²)**
Weir Site	located upstream of Kedam Town	Excavation weir site Diversion structure Power intake	WS1=10,437 m² WS2=23,291 m²
Adit 1a / 1b	located upstream of Ashkon Nullah	Desander Pressure tunnel Part 1 Connection tunnels	A1=12,595 m²
Adit 2	located downstream of Darolai Nullah	Pressure tunnel Part 2 Access tunnel	A2=31,266 m²
Adit 3	located downstream of Ain Nullah	Pressure tunnel Part 3 Access tunnel	A3a=16,703 m² A3b=21,737 m² A3c=17,227 m²
Power House Site	located upstream of Madian Town	Pressure tunnel Part 4 Surge tank Power house Transformer cavern Access tunnel	PH=52,745 m²

Tab. 3-1: Structures and associated dumping site areas (see Map 12-1 to Map 12-5). All data are given as design stands in June 2008 and shall be revised when final design has been elaborated.

Overall approximately 1.15 Mill m³ of excavated material will be generated which including a bulking factor of 15 % results in a corresponding capacity of dumping sites of 1.35 Mill m³. From this quantity about 150,000 m³ can be deducted for use as gabion fill and concrete aggregates and another 150,000 m³ as riprap for slope protection in the reservoir area upstream of the weir. That means that around 1,050,000 m³ of mostly rocky material have to be dumped. (see Tab. 3-1).

The powerhouse site is located on the left bank of the Swat River approximately 1.2 km upstream of the road bridge at the northern extent of the town of Madian. At the weir site, the river bed has an elevation of about 1,477 m asl (SoP) and at the powerhouse sites an elevation of about 1,339 m asl (SoP).

During operation, the water level of the reservoir will be controlled by the spillway gates at elevation 1,494 m asl as shown in Fig. 3-1. The inlet of the headrace tunnel will be kept free of sediments with the help of the flushing outlets, arranged at the weir structure to flush sediments through the same when necessary. A 0.5 MW auxiliary turbine will be arranged using part of the ecological flow to generate power to feed into the existing 11 kV line from Madian to Kalam (Fig. 3-2).

For the anticipated run-of-river operation of the Madian Hydropower Project, the reservoir level remains constant at elevation 1,494 m asl (SoP) throughout the year. At periods of extremely low river flow pondage operation may be permitted and limited to a maximum draw down of 2.0 m to elevation 1,492 m. From the total storage capacity of 0.48 million m^3 a volume of 126,000 m^3 would be available for pondage operation. This storage capacity has been selected to improve conditions for turbine operation (and turbine efficiency) at times of extremely low river flow thus ensuring that the selected turbine units might be operated intermittently under acceptable operation conditions at times of extremely low river flow.

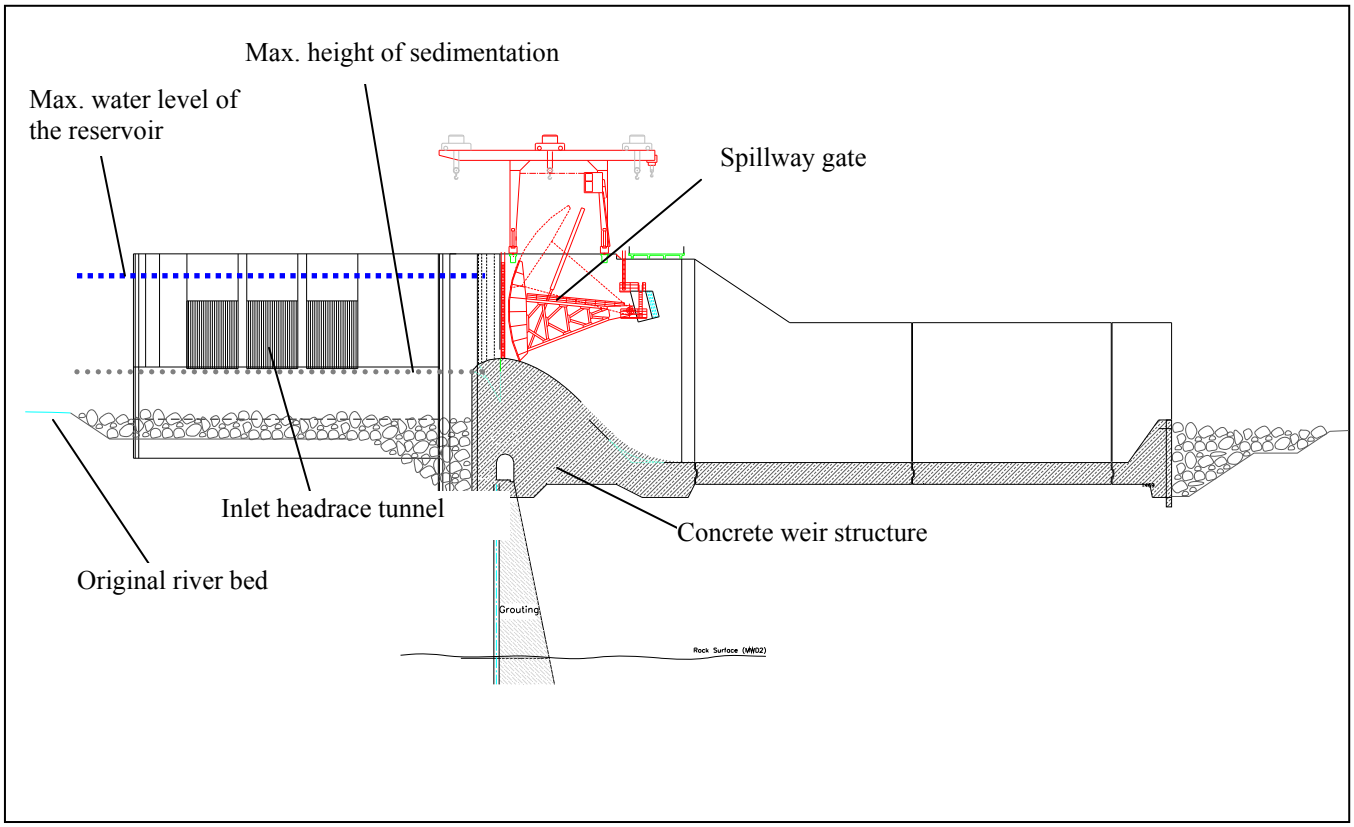


Fig. 3-1: Cross-section of weir structure

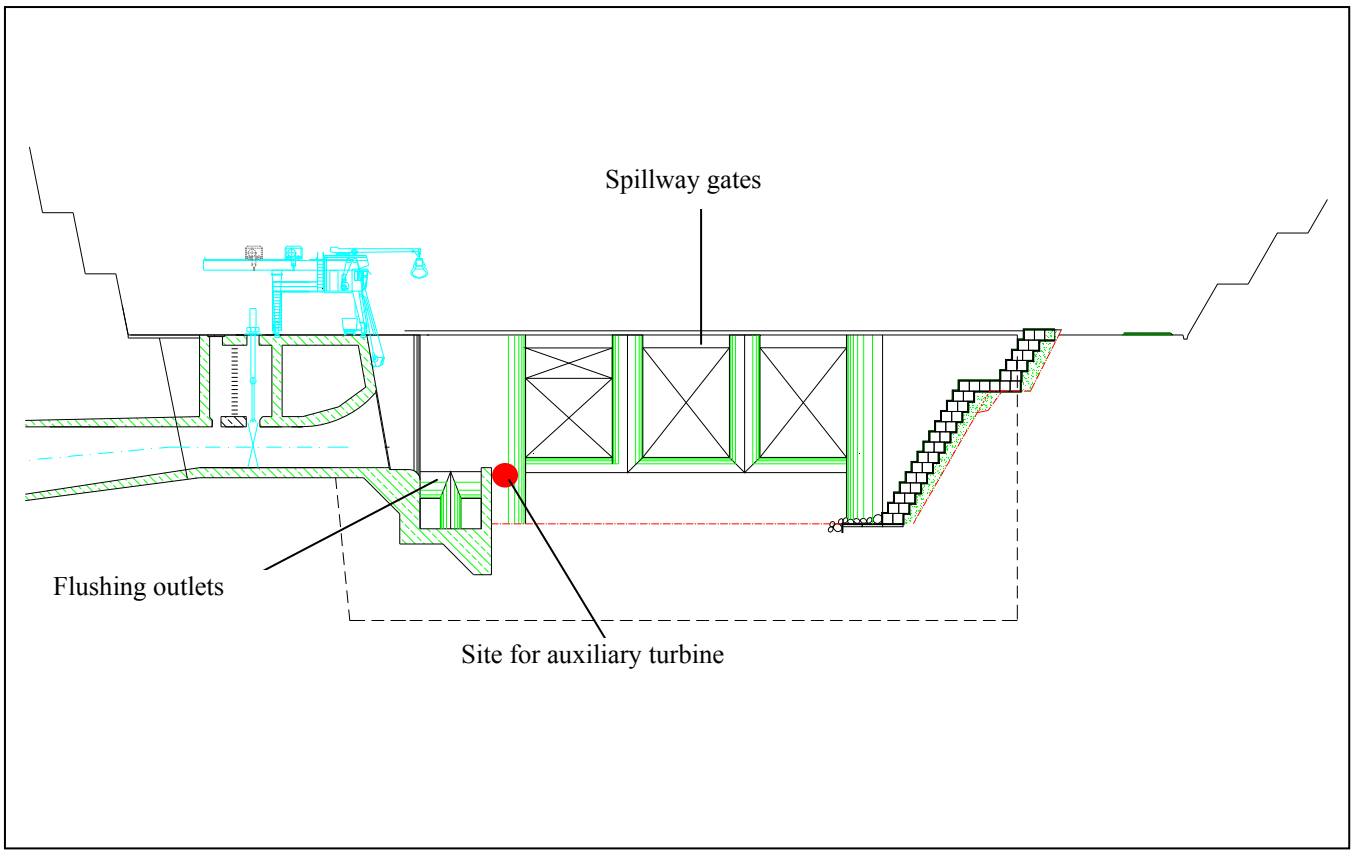


Fig. 3-2: Weir structure seen from upstream of weir site

4

Baseline Data

4 BASELINE CONDITIONS

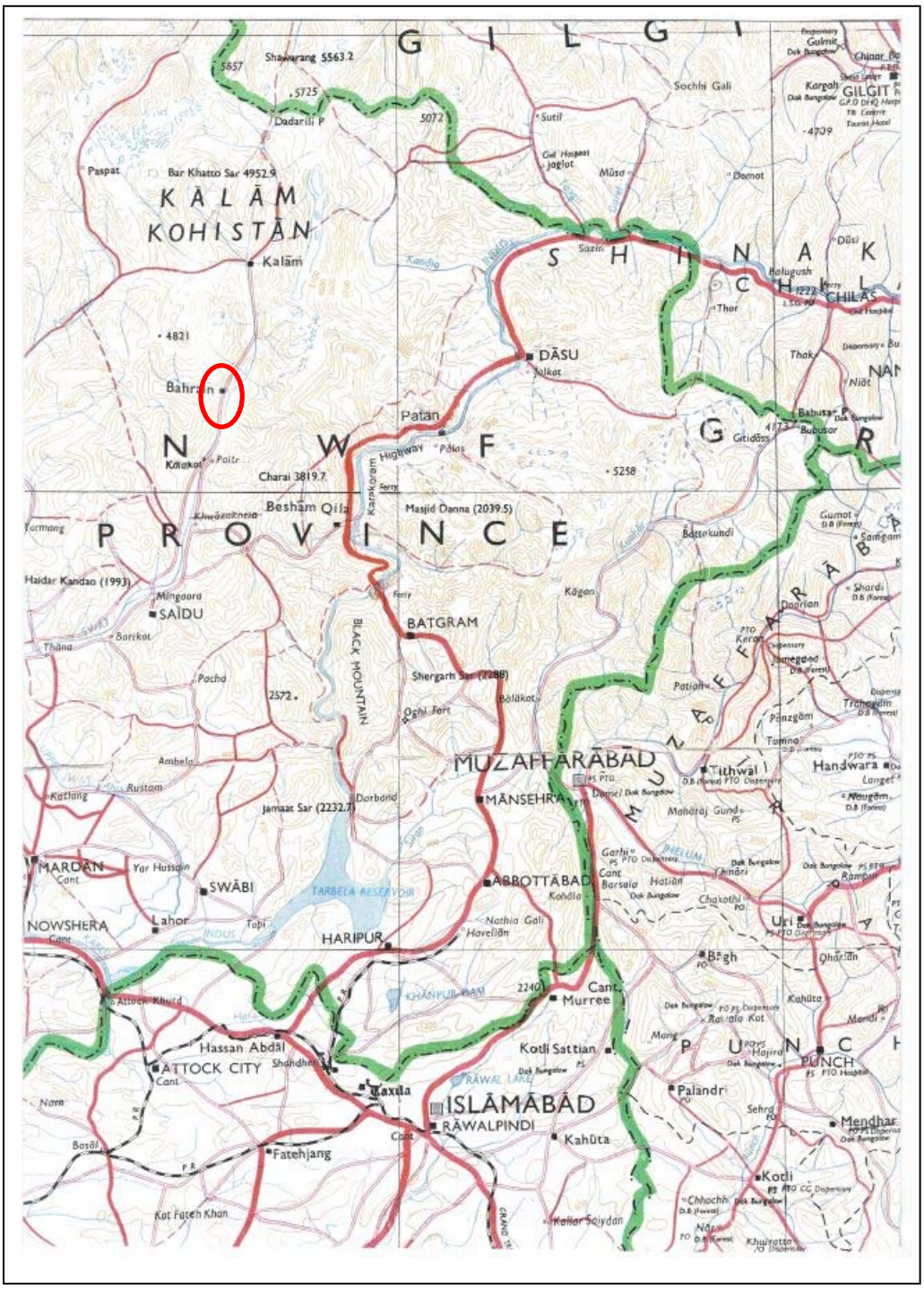
4.1 ENVIRONMENT

4.1.1 Location and Investigation Area

The Madian HPP is located in the north of Northwest Frontier Province of Pakistan (Map 4-1). The Province is surrounded by Northern Areas of Pakistan in the North, Kashmir in the East, Punjab Province of Pakistan in the Southeast, Balochistan Province in the Southwest and Afghanistan in the West. The project area is part of the Swat District north of Madian Town. Madian is located about 200 km north of Peshawar, the Capital of NWFP and 60 km from Mingora, the district headquarter of Swat Valley.

Map 4-1: Location of Madian Hydropower Project

The investigation area covers the Swat valley upstream of the weir site including the future reservoir and the reach of the Swat River from the weir to the power house site (Map 4-2, Map 12-1). The investigated area includes also the slopes of the valley were cultivated land might be affected by flooding and by construction activities such as adits for headrace tunnel construction and areas for dumping of excavation material.



Map 4-2: Investigation Area around Bahrein located about 270 km North of Islamabad

4.1.2 Climate

The climatic conditions in the project area are typical for high altitude regions. The hydrological station at Kalam is located some 30 km upstream of the proposed weir site at an elevation of 1,921 m asl. The measurements of temperature and precipitation have been recorded for more than 40 years. The mean monthly temperature varies from its lowest value of -6.1°C in January to the highest temperature in June with +26.3°C in June. In January 2008, an extremely low temperature of -18°C was recorded. Fig. 4-1 shows the variation of the mean monthly temperature during the year.

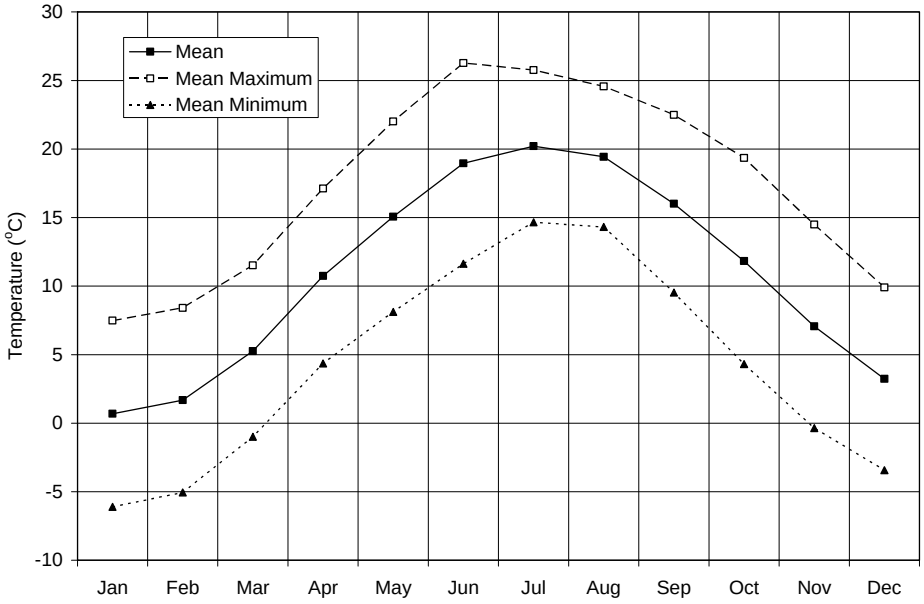


Fig. 4-1: Temperature Regime at Kalam Meteorological Station

Since the proposed weir site is located at an elevation of 1,480 m asl, more than 440 m below the Hydrological Station in Kalam, the mean temperatures can be assumed to be about 3-4°C higher than those recorded at Kalam.

The precipitation in the Swat Valley is dominated by the occurrence of eastward moving extra tropical zones of low pressure, also known locally as Western Disturbances. The Western Disturbances are more frequently and intense during the months between January and May and they provoke the largest amount of precipitation over the Swat Valley. During the summer season the precipitation on the region decreases. The monthly precipitation recorded at the Hydrological Station at Kalam is given in Fig. 4-2.

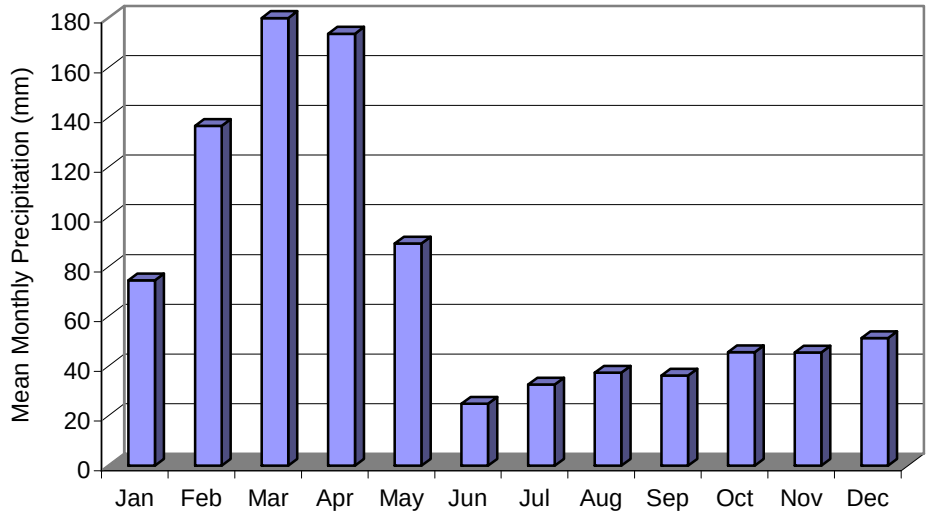


Fig. 4-2: Kalam, Mean Monthly Precipitation (1963-2006)

4.1.3 Topography

In the northern part of Pakistan, the Hindu Kush Mountains converge with the Karakoram Range, a part of the Himalayan mountain system. These ranges have a large number of peaks ranging from 6,000 m to 8,611 m above the sea level. In the southern foots of the Hindu Kush mountain lies the Swat Valley having peaks up to 6,300 m asl running from north to south. The valley is a part of the Kabul River catchment, which ultimately drains into Indus River near Attock bridge.

The Swat River flows in the area upstream of the town of Madian in a narrow U-shaped valley. Further downstream the river valley is wide and becomes wider and flat up to Amandara. Panjkora River joins with the Swat River near Amandara and the valley remains narrow up to Munda. From Amandara to Kalangai, the Swat River flows with a steep gradient.

Gabral and Ushu River join at Kalam forming the river Swat. The Gabral River flows in a long valley and has a narrow catchment. The upper north east part, above 3,000 m asl, is heavily covered with glaciers. In the glaciated part, the Gabral River flows from north-west to south-east. The river changes its direction near Utror Village and starts to flow in east direction up to Kalam.

The Gabral River with a length of about 62 km has a gradient of more than 2% to 3%. The slope of the Swat River slightly reduces from Kalam to Kedam. From Isrit to Kedam the river slope is approximately 17 m per km whereas the slope reduces to approximately 12 m/km in the reservoir area and 11 m/km further downstream up to the powerhouse outlet. The small tributaries joining the main river have average river gradients from 7% to 14%.

4.1.4 Geology

The proposed weir and powerhouse site for the Madian Hydropower Project involves a segment of the Swat River between Kedam in the north and Madian in the south being part of the Kohistan Tectonic Zone. The proposed headrace tunnel connecting the intake at Kedam with the powerhouse at Madian traverses across and beneath the eastern valley slopes of the Swat River.

Geologically the Kohistan Tectonic Zone comprises predominantly plutonic igneous rocks ranging from Gabbros, through Diorites-Granodiorites to Granites. Two other lithology types include:

- Metamorphosed volcanic and sedimentary rocks, which are mainly exposed along and immediately south of the Shyok Suture (Chitral-Ghizer-Hunza region), and locally in Kalam-Dir area, and

- Ultramafic-mafic plutonic rocks and Amphibolites occupying the southern part of Kohistan along the Indus Suture.

The project area is situated in the middle-western part of the Kohistan Tectonic Zone and comprises plutonic igneous rocks. The predominant rock type at the site is a medium-grained slightly foliated gabbroic rock, classified as Norite. This rock type is in intrusive contact with another plutonic igneous rock called Diorite. The contact between the two rock types passes almost midway between Kedam and Mankial. Minor rock types in the area include Amphibolites, Pegmatites and fine grained basic dykes. None of them are in significant large proportions to affect the mechanical strength of rocks in the project area.

4.1.5 The Swat River

The Swat River with its numerous tributaries imparts the scenic beauty of the Swat valley. The Swat River starts from Kalam town in the valley at the confluence of Ushu River and Gabral River. After flowing over a length of 250 km, Swat River ultimately joins Kabul River near Charsada town of North Western Frontier Province. Through two canals water is diverted from Swat River. The Upper Swat Canal irrigates plains of Peshawar south of Malakand. The Lower Swat Canal is used for hydropower generation at Jabban and Dargai powerhouses.

The weir site is located at Kedam village where the catchment area is 2,403 km^2, compared to 2,365 km^2 at the upstream located project gauging station Ramet. At the site of the powerhouse the catchment area is 2,842 km^2, compared to 2,529 km^2 at Kedam.

The flow regime of the Swat River is characterized by a low flow season from November to March and a high flow snow melt season from May to September with a mean annual river flow is 118. 5 m^3/s as indicated in Table 4.1.

Period	Flows (m^3/s)	
	Weir	**Power House**
Jan	23.57	28.52
Feb	21.61	26.26
Mar	27.17	32.40
Apr	78.72	88.35
May	191.70	234.14
Jun	298.38	431.69
Jul	302.92	440.34
Aug	227.33	291.51
Sep	128.84	143.36
Oct	57.45	65.07
Nov	36.40	42.56
Dec	27.81	33.21
Annual	118.49	154.78

Table 4.1: Mean Monthly Flows at Weir Site and Power House

Compared to other catchment areas in Pakistan the sediment yield of the Swat River at Madian HPP weir site is rather low as indicated in table 4.2.

Period	Sediment Transport (Ton)	
	Mean	**High**
Jan	2,573	9,991
Feb	2,095	8,135
Mar	3,163	12,283
Apr	13,088	50,829
May	51,361	199,462
Jun	115,199	447,376
Jul	122,822	476,980
Aug	68,950	267,769
Sep	24,966	96,954
Oct	8,339	32,385
Nov	4,410	17,127
Dec	3,196	12,411
Total	420,162	1,631,703

Table 4.2: **Weir Site, Suspended Sediment Transport**

Streams (Khawar/ Nullah) and springs contribute flow to the Swat River joining it from left and right banks. Water supply for irrigating farmland and for drinking purposes is obtained largely from these streams and springs instead of the Swat River which would require pumping to the areas located at higher elevation. Hotels and other commercial entities located along the Swat River bank along Mingora – Kalam road obtain water for drinking purposes from nearby springs and streams and not from Swat River – except two hotels downstream of Bahrein.

Just downstream of the Madian HPP weir site two major streams join Swat River, Kedam Nullah from the right bank and Gornai Nullah from the left bank. The operation of the Madian Hydropower Project will require diversion of flow from Swat River to the power waterway system seeking maximum hydropower output.

The native fish fauna of these waters, prior to the introduction of trout, was *Schizothorax species* and *Orienus species*, locally known as Swati fish. Also *Noemacheilus* species occurred. The introduction of trout (*Salmo trutta fario/brown trout and Oncorlrynchus mykiss/rainbow trout*) started in 1961. Since then trout is regularly reared in the Government hatchery at Madian and released in these waters. Consequently, the trout population has been established, which has replaced the indigenous fish breeds more or less totally.

Large scaled commercial fishing does not exist in the area. Only a number of locals and some owners of restaurants are going for fishes from the Swat River. Fishes caught by the local people is mainly consumed in the households, but not representing a regular part of food. Instead, the region is better known for sport fishing. Swat valley is an angler's paradise for tourists, which contributes to some extent directly and indirectly to the local economy. The control of fishing is exercised by the Provincial Fisheries Department under the provisions of the N.W.F.P. fishery rules. Swat River, together with its tributaries and lakes is supervised by fisheries watchers. Fishing licenses are valid for one day, one week or one month. The season is in winter time from October to March.

It has to be stated that all information given above are only based on interviews with the Fishery Department in Madian and with residents. There are no actual exact scientific data available, neither about fish species living in the Swat River nor about diatoms, benthic macroinvertebrates, phytoplancton etc.

4.1.6 Terrestrial Flora and Fauna, Protected Areas

Flora

The Flora of the region is characteristic for a dry temperature and can be assessed to be rich. Sixty-five species of trees and shrubs exist which belong to the Dicot families. Also, up to nineteen species of mushrooms can be found in the region, some of them harvested for sale. Algae in rivers subdivides in twelve species belonging to the Chlorophycae family. They represent an important part of phytoplankton. Furthermore, aquatic algae of twenty nine genera with multiple species are also found, as well as aquatic rooted plants.

Pastures

The pastures are distinguished in different types. *Valley bottom pasture land* is located at an elevation of 1,830 m to 2,500 m, below the forest zone and grazed in winter and spring. *Forest grazing lands*, from 2,500 m to 3,000 m asl. are grazing grounds in the forest zone. They are used for grazing during seasonal migrations from valley bottom lands to alpine pastures in early summer and in

autumn during the reverse migration. *Sub-alpine pastures* are to be found between 2,500 m and 3,000 m. The condition of the valley bottom pasture up to the sub-alpine grazing land is generally poor due to heavy grazing over extended periods of time. *High alpine pastures* are located above the dense forest areas at an altitude of 2,700 m to 4,200 m asl. These are the important fodder sources for the livestock of the Kalam population and the migratory herdsmen. An extensive grazing takes place for a short duration, due to the cold climate during the winter season.

No management of grazing lands is being practiced in this area. Thus, an increasing problem of overgrazing exists, which results in erosion. This effect is enforced due to the introduction of potato as cash crop. A considerable share of the pastures has been converted into potato fields leading to reduced grazing grounds and forage.

Forest

The total forest area of Kalam is 23,976 ha. From this, 6,223 ha are commercial and 17,753 ha are non-commercial forests. It can be classified to be a dry temperate forest. Within this forest type, several sub-types can be recognized, starting from Dry oak forest (*Quercus ilex*) at the lowest elevation of about 1,830 m. With rising elevations it grades into Dry deodar (*Cedrus deodra*), Dry fir *(Abies pindrow),* Spruce (*Picea smithiana*), Kail (*Pinus excelsa*) forests and then into alpine pastures. Presently, the forests are under the administrative control of the Kalam Integrated Development Programme (KIDP).

Wood is mostly used as fire wood and as construction material. Due to the absence of alternative energy sources, wood is required for heating and cooking. It is sold in the markets or people collect it in the surrounding forests. With regard to construction activities an agreement makes possible that the inhabitants and right holders of Kalam have the concession to claim a maximum of 350 trees per year for building purposes.

Several factors put pressure on the existence of the forest. The most severe impacts arise from collecting the wood for fuel. Although it is not allowed to cut trees for heating, it is done illegally in an extensive manner. From this practice especially oak and deodar trees are affected. In addition, *Parratia indigofera* and other shrubs are collected as firewood.

Fauna

In 1987 a wildlife survey in the N.W.F.P. was performed which was updated in 1993. The survey comprises important species of the mammals and avifauna detected in the area. The group of the mammals is represented by Rhesus monkey, Wolf, Jackal, Brown and Black bear and, beside others, Leopard cat and Common leopard. Furthermore, Sparrow hawk, Wood cock and Paddy bird can be found. Information on the vertebrate or on the invertebrate fauna in the region is scanty. Among the reptiles, the only species of snakes likely to occur is *Aqkistrodan himalavansus.* It is one of the ten poisonous snakes in Pakistan.

The lizard *Agama tuberculata* may be found as a commonly representative of rocky areas and crevices. Among the amphibians, *Bufo himalayanus. Rana cyanrophlyctis* and *Rana breviceps* are likely to exist in the area.

The N.W.F.P. Wildlife Protection, Preservation, Conservation and Management Act of 1975 covers the project area. However, its implementation is hampered by many administrative and socio-economic factors. Over the last 50 years the number of animal species has been decreased dramatically. On the one hand, growing tourism in addition with the offer of hotels and pensions has led to this decline. With only three hotels in Kalam in the 1980's, the number has increased up to more than 100 nowadays. On the other hand the human population is expanding. This has put great pressure on the natural resources of the area, particularly on the forests and on the wildlife. A lot of species are endangered by the destruction of habitats, by unrestricted hunting and by poaching. Immediate and effective conservation measures are needed to save the wildlife in the project area.

Reserves and Protected Areas

The general existence of sanctuaries in the district of Swat is scarce. Only five small and one bigger wildlife reserves are registered. They are distinguished in three different types defined as game reserves, community game reserves and game reserves and proposed national park. The biggest of them is located in the north-east sector of the district and has the meaning of a game reserve and proposed national park. It is confined to the north and east by the administrative border of Gilgit and Kohistan. In southern direction it is bounded near to the village of Kalam, while in the west the upper watershed and glacier of the river Gabral border the reserve. Despite of the nearness to Kalam the project area is not directly touched by the sanctuary.

Summarizing, the entire area is widespread populated and heavily influenced by human activities including housing, agriculture, hunting, tourism like fishing and creating of tourist infrastructure etc. These activities have changed the ecology of the investigation area dramatically within the last decades. Consequently, no big mammals are occurring in the area at present and when animals intrude they are hunted immediately. Even the occurrence of birds, like birds of prey, is very limited. Overall, the ecological value of this part of the mountains is nowadays very limited.

4.1.7 Historical and Cultural Sites

The area under investigation shows no important historical or cultural sites. There are no archaeological remains, only small mosques or graveyards are an essential part of the villages. The graves are mostly located in areas near the family home and not in central graveyards.

4.1.8 Landscape

The Swat valley is predominated by the Swat River representing a natural white water that is changing its character dramatically between dry (winter) and glacier and snowmelt (summer) season. The valley is characterised by forested slopes, by agricultural terraces and high mountains in the background (Photo 12-1, Photo 12-2, Photo 12-3).

For assessment of the value of the landscape, the following landscape-scaling system developed and used by FICHTNER for years has been adopted:

Value	Quality of Landscape
1	Highest quality
2	Very attractive
3	Attractive
4	Ordinary
5	Poor

According to this scaling-system, the lower part of the Swat valley that is foreseen as potential reservoir, can be classified to be “Attractive” (Value 3) as confirmed also by the photographic documentation (Chapter 12.2). This assessment is done in comparison with other landscapes occurring in Pakistan (for example: the high Himalayan mountains would be classified to be of “Highest quality”). The upper part of the Swat valley, that is steeper, can be assessed to be “Very attractive”.

However, it has to be kept in mind that the evaluation of the visual quality of the landscape is always depending on the observer, which means that this classification never is free of subjective decisions. Such kind of evaluation always requests a certain margin within the results might be settled.

4.1.9 Seismic Situation

The project site is situated in Swat Kohistan, which is part of the Kohistan Tectonic Zone (KTZ). The KTZ is a ~ 60 km wide, over 300 km long stretch of mainly plutonic igneous rocks, with subordinate metamorphosed volcanic and sedimentary rocks. The zone has been recognized as a crust of an ancient island arc, which was entrapped between the collided tectonics plates of India and Eurasia in Late Cretaceous (90-58 millions years ago). The northern and southern boundaries of the zone are, therefore, suture zones marked by regional fault structures called Shyok Suture [Main Karakoram Thrust (MKT)] and Indus Suture [Main Mantle Thrust (MMT)].

The project area is situated in the middle-western part of the KTZ, away from the two regional faults bounding the zone. The southern fault, the MMT, passes in an east-west orientation from Mingora (42 km from Madian) while the northern boundary fault (MKT) passes through Shandur Pass area (Chitral), 80-100 km from Kedam.

Several fault structures, however, have been recognised in the area in the northern vicinity of the project area, especially around Kalam. In this area two sets of faults have been recognized. A set of older faults with thrust/ reverse-fault geometry occurs north of Kalam. In this area, at least four such faults with a general east-west direction have been recognised. The second set of faults is oriented north-south and is characterised by a vertical attitude and strike-slip sense of movement.

These N-S oriented steep faults cut across the older set of E-W thrust faults. One such steep NNW-SSE directed fault follows the Kalam - Mankial segment of the Swat River and thus extends within 5 km of the site area. The neotectonic activity associated with these fault structures needs careful assessment. Considering that some segments of the Swat River follow these fault structures, neotectonic activity associated with these faults cannot be ruled out.

In terms of recent seismicity, the site area in particular and the upper Swat River region in general do not show any significant cluster of epicentres. The recorded epicentres are generally less than 3 in magnitude. However, the region is commonly affected by seismic events occurring in the Hindukush seismic zone, that occurs some 200 km NW of the site area.

4.1.10 Traffic Situation

All transport from Madian to Kalam has to pass the main road of Bahrein. Presently, there are construction activities on the way to upgrade the road Madian-Kalam to a "National Highway" with a standard width of 7.3 m.

From the field visits it became obvious that the impact from traffic is already high, especially in the towns of Madian and Bahrein. In Bahrein the main road is the only road that makes it possible to cross the city either by food, with cars or trucks (see Photo 12-4). At present, even without implementation of any of the hydropower projects or other planned infrastructure measures (see Chapter 7), the traffic shows sometimes a chaotic picture when e.g. two large trucks pass each other (Photo 12-5). It often takes minutes until the "passing action" has been terminated. For pedestrians this situation is also very uncomfortable.
In order to have some hard facts about the traffic situation, FICHTNER performed a traffic census at 12th and 13th of May, 2008 at the southern entry of the City of Bahrein (see Table 4.3).

The results are showing that in average a basic load of 81 vehicle movements (covering both directions) per hour prevails. Taking into account that the cars are moving slowly and trucks have to pass each other in the main street by stop and go, at peak times there is already a constant traffic flow on the main road today in the urban centres. In addition, this census does not give an idea about the number of pedestrians using the main road.

Date	Madian to Bahrein		Bahrein to Madian	
	Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles
12th of May 08	215	25	195	27
13th of May 08	230	37	210	33

Tab. 4-3: Traffic census of light and heavy vehicles on May 12th (7:00 to 13:00) and 13th (13:00 to 19:00) of May 2008; the census did not cover motorbikes.

4.1.11 Social Structure

Swat has a predominantly rural population. It is inhabited by Yousafzail Pathans, Mians, Kohistanis, Gujars and Pirachas. The Pashto speaking Yousafzai Pathans are the direct descendants of Aghans of Ghazni. The Gujar and Kohistanis speak their own dialects of Gujar, Garwi. Torwali and Kohistanis inhabit the mountainous areas up to the north. The Kohistanis are settled in and around Kalam, Ushu, Utror and Gabral valleys. The nomadic Gujars also form a substantial part of the population in the northern areas of the district. In the harsh winter months almost half the population migrates to the warmer southern plains to work as shepherds and tenants in farms till the weather permits them to return to their abode. In summers herdsmen with flock of sheep head towards the area in search of pasture lands.

The urban population has a fair number of Pirachas who have migrated over the past 100 years and assimilated themselves in the local population speaking Pashto. They dominate the local commerce and trade. They have considerable stake in the local silk industry, construction and transport sectors. Swat has a small minority population consisting of Sikhs, Hindus, and Christians.

The clans of the different sub-tribes associated with the former ruling families and the other clans are different in prestige. The artisans, carpenters, blacksmiths and musicians belong to landless clans which do not enjoy a high status. Dehqans (farmer), dependant on the landowners, are working for the landowner clans and get usually a share of 33% of the harvest. The mutual dependence of landowners and dehqans is still in place. The big landowners normally belong to the former ruling families.

4.1.12 Health Aspects in Project Area

The total number of human settlements in the project area is 7. There are no Basic Health Units in the Project area except in Bahrein town. People from human settlements/villages of the project area normally visit the health centre in Bahrain town. In case of severe diseases, patients are brought to Mingora. Main diseases are diarrhoea, dysentery, hepatitis C, and malaria. No cases of HIV/AIDS in the investigation area have been reported. Children mostly suffer from acute respiratory infection, asthma and pneumonia. Vaccinations are carried out in Bahrain town against measles, cholera and polio.

HIV is currently not a dominant epidemic in the adult population of Pakistan. However, the number of cases is growing. Low awareness of HIV/AIDS in Pakistan, very high drug use and lack of acceptance of non-marital sex in the society has allowed the AIDS epidemic to take hold in Pakistan. AIDS may yet become a major health issue. National AIDS Programme's latest figures show that over 4,000 HIV cases have so far (2008) been reported since 1986. Overall prevalence of HIV infections in adults aged 15 to 49 is 0.1%. Officials say that the majority of cases go un-reported due to social taboos about sex and victims fears of discrimination.

The project area of Madian Hydropower Project, however, is known to consist of conservative population committed to principles of Islamic Shariah. HIV/AIDS, therefore, does not play any role in the society as far as it is known at present.

Health Facility	No. of Villages where Health Facility is Available
BHU	2
Doctor/ Hakeem	2
LHV	-
TBA	7

BHU: Basic Health Unit, LHV: Lady Health Visitor, TBA: Trained Birth Attendant

Table 4.4: Health Institutions in the Project Area

5

Significant Environmental Impacts

5 SIGNIFICANT ENVIRONMENTAL IMPACTS

5.1 CONSTRUCTION PHASE

5.1.1 Land Acquisition and Use

The impacts on land use described below are based on the stage of the feasibility design of June 2008 (see RAP). There might come up some minor changes in the design e.g. concerning final figures on quantities of excavation material, adjustments of dumping sites or routing of access roads. However, this will not cause major changes regarding content and costs outlined in the RAP. The costs for such changes in the design are covered by a provision of 15 % of the total expenditures in the Resettlement Action Plan (RAP).

For construction of the Madian Hydropower Project, 36.6 ha of riverbed, farmland and wasteland have to be acquired for permanent use. Temporary land acquisition comprises the workers camp at weir and powerhouse site at areas close to Adit A1, A2, and A3 (around 2.8 ha). For construction activities 15 households have actually to be relocated displacing a total of 176 persons.

Land acquisition and relocation activities were minimised by applying a run-of-river mode project concept instead of provisions for daily peaking operation which would require a 3 times bigger reservoir. Also, the location of the power house well outside of Madian has reduced the need for relocation. All land acquisition (permanent and temporary) and relocation necessities will be compensated by implementing a Resettlement Action Plan that is prepared for the Project as a stand alone report following national and international requirements as derived e.g. from The World Bank/IFC.

Conclusion for construction period

As usual for hydropower projects, permanent and temporary land acquisition represents one of the major impacts. Due to the nature of such projects this is unavoidable. In Madian HPP the need for land acquisition was minimised as far as possible and in order to mitigate and to compensate remaining impacts a Resettlement Action Plan was developed. Mindful of the fact, that none of the affected people complained about the project but that the compensation money for land acquisition and for relocation measures as well would be appreciated and considering the fact that only 176 people have to be relocated, the impact of the Project on land acquisition and use is assessed to be low.

Extent of impact* on land acquisition and use *under consideration of implementation of the associated RAP	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.2 Excavated Material

The development of the Madian Hydropower Project affects areas near Kedam village for construction of the weir and the appurtenant structures, the reservoir as well as the powerhouse located some 1.3 km north of Madian Town (see Map 12-1). It includes the 13 km long river section between the weir and the power house. The headrace tunnel is located parallel to the Swat River at the left bank with a length of about 11.8 km. In order to achieve a reasonable construction time by conventional drill and blast method, construction of the headrace tunnel is planned to start from 4 construction adits in parallel. The adits along the headrace tunnel were selected to divide the tunnel into four parts of almost equal length. These adits are located on the left bank of the Swat River. To avoid long transport from the adits to the dumping sites, dumping locations in close vicinity to the adits have been selected.

The estimated volumes of excavation material for all major structures are given in the Table 5-1 below:

Access areas/ Location	**Structures**	**Excavation Volume [m^3]**	**Required Land Area [m^2]**
Weir Site	Excavation Weir Site		
	Diversion Structures	137,180	33,728
	Power Intake		
Adit 1a / 1b	Desander Structure		
	Pressure Tunnel part 1		
	Connection tunnels	382,431	12,595
	Access tunnels		
	Desander flushing		
Adit 2	Pressure Tunnel part 2	148,772	31,266
	Access tunnel		
Adit 3	Pressure Tunnel part 3	209,535	55,667
	Access tunnel		
Power House Site	Pressure Tunnel part 4		
	Surge Tank		
	Power House	274,952	52,745
	Transformer Cavern		
	Connection tunnels		
	Access tunnels		
Total		**1,152,871**	**186,001**

Tab. 5-1: Dumping of excavated material

The total excavation volume is calculated to be some 1,153,000 m^3. For the calculation of the tunnel volumes, an average lining of 0.62 m according to the

rock quality is used. The excavation material is placed on the dumping sites in layers as semi-compacted fill. Each layer will be compacted before adding a new layer. This method allows dumping the material with an average density of 85% of the former in-built density of the material. Therefore, a bulking factor of 0.85 is used for the calculation of the necessary capacity of the dumping sites of 1,356,319 m^3.

From this amount about 150,000 m³ can be reused for gabions and concrete aggregate and another 150,000 m³ will be used for slope protection in the reservoir area upstream of the weir. That means that around 1,050,000 m³ of mostly excavated material has to be dumped.

Conclusion for construction period

Dumping of this large amount of excavated material is one of the biggest challenges of the project from an environmental point of view. The amount of excavated material is governed by the design concept as a run-of-river hydropower project with a low weir structure and a long headrace tunnel. Beside re-use of excavation material as fill for gabions, to use them as riprap for slope protection and as concrete aggregates, no measures are possible to minimise the amount of material to be dumped. Only side effects related to the transport of excavation material can be mitigated and are described in the Chapters 5.1.3, 5.1.4 and 5.1.5.

This issue will significantly affect different aspects such as land acquisition, use of terrestrial habitats, traffic, noise, air quality and tourist activities. Thus, the impact of dumping excavated material on several environmental aspects has to be evaluated as being high although a certain percentage of the area used for dumping of excavation material can be re-cultivated removing the thin layer of fertile soil prior to dumping the excavation material and placing it on top thereafter.

Extent of impact of excavated material	■ ■ ■ = high negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.3 Traffic Aspects and Access

It will be necessary to construct 3.8 km new permanent access roads (status of feasibility design July 2008, land acquisition for it is not covered in detail by RAP but a provision of 15% of total cost is made). This comprises access to weir site on the left river bank and access to the power house site (see Map 12-1). The location and alignment of temporary access roads will be finally decided by the construction contractor in coordination with the project developer and his supervising engineer.

As mentioned before, one of the main impacts on the environment during the construction period will be the need to dump more than 1 Mill. m³ of material resulting from the excavation of the headrace tunnel and other underground structures. This impact includes the transport of this material to the specified dumping sites. Overall more than 1.0 million m³ excavation material will have to be transported being equivalent to about 170,000 truck loads. Consequently, the main focus was given to reduce the transport of excavation material along the Madian - Kalam road as far as possible, which would also positively affect aspects as noise and air quality, especially in town/villages like Bahrein and Madian. Following mitigation measures have been adopted to reach this goal:

- Instead of transporting rock material out of the valley south of Madian town, dumping sites were selected as close as possible to the tunnel construction adits, weir site and powerhouse site (see Chapter 5.1.2, Map 12-1 to Map 12-5);
- The dumping sites are selected on the left Swat River bank in order to avoid transport crossing the river;
- No transport of a large amount of excavation material through Bahrain;
- Use of conveyors where economically feasible;
- Re-use as construction material as much as possible on site;
- Producing of concrete on site;
- Proper transport management to reduce truck movements;
- Transportation of material is allowed only during daytime (from 6.00 am to 6.00 pm);
- Speed limit of trucks crossing populated areas.

<u>Conclusion for construction period</u>
The passage of trucks carrying excavation material through Bahrein to dumping sites shall be largely avoided. Short transportation ways from the site of excavation to the dumping site are selected. Construction equipment will have to be transported to the weir site coming from Madian.

Extent of impact* on traffic *under consideration of mitigation measures (see EMP)	■ ■ = medium negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.4 Air Quality

There are no data available about air quality in the Swat valley. But from the site visits it became obvious that the air quality is already negatively influenced in the town of Madian and Bahrain by the truck traffic along the main road up to Kalam. The situation will become more serious when the upgrading the Madian-Kalam road to a national highway will be completed. In addition, when starting the construction of other hydropower projects, air quality will drop more due to the increased truck traffic for transport of construction and permanent equipment to the respective projects sites.

Having this in mind, efforts are made to reduce the truck traffic as possible. In addition proper regular maintenance of trucks will also help to reduce the emissions. Mitigation measures are given in Chapters 5.1.3 and 8.3.2

Beside exhausts of trucks an impact on air quality will arise from dust emission during construction activities. This can be mitigated by spraying the trucks frequently with water and/or using cover sheets during the dry season.

Conclusion for construction period

Considering all ongoing activities in the region the air quality has to be considered to be of low to medium quality at peak times of traffic. Big efforts have been undertaken to reduce truck movements, especially as regards transport of excavation material, but there will remain the need of transporting the excavation material to dumping sites. In addition, construction material has to be brought in along the main road crossing Madian and Bahrein. This is unavoidable. Therefore, the additional impact on air quality caused by the Project is assessed to be medium negative during construction activities.

Extent of impact* on air quality *under consideration of mitigation measures (see EMP)	■ ■ = medium negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.5 Noise Aspects (Public)

There are no data available about noise level in the Swat valley. But in Chapter 4.1.10 the author of this EIA presents some data obtained from a traffic census performed on 12th and 13th of May, 2008, at the southern entry of the City of Bahrein. As it can be seen 81 car movements (heavy and light cars) per hour took place on average (covering both directions), resulting in more than one movement per minute. Taking into account the road situation this traffic is moving sometimes very slowly with long stop and go times (Photo 12-5).

This present situation is more serious when trucks cross the city transporting road construction material for the ongoing upgrading of the Madian-Kalam road to a National Highway. In addition, when starting the construction of other hydropower projects, the noise level will also rise.

In order not to increase the actual prevailing traffic by the development of the Madian HPP, major efforts have been undertaken to reduce truck movements. Mitigation measures are given in Chapters 5.1.3 and 8.3.2.

Noise from construction activities will also come up by blasting, by piling activities etc. This might affect some houses nearby the tunnel construction adits and the weir site. Mitigation measures are given within the EMP (Chapter 8.3.2), but a higher noise level due to the construction activities during day time will be unavoidable.

<u>Conclusion for construction period</u>

In order not to increase the noise level more than absolutely necessary, efforts have been undertaken to reduce truck movements in the cities to the necessary minimum. Thus, no excavated material will be transported through Bahrein for dumping. Only construction material and equipment has to be carried to the weir site and Adit 1 crossing Bahrein. This is unavoidable and will last the whole construction period. The additional impact of noise for the population living in the project area is assessed to be medium negative.

Extent of impact* of noise (on public) *under consideration of mitigation measures (see EMP)	■ ■ = medium negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.6 Ecology of Swat River

During the construction period the ecology of the Swat River is mainly influenced from activities near the weir site. Here, the river has to be diverted through a tunnel during construction of weir and power intake. The second point of construction activities near the Swat riverbed is the power outlet located some 100 m downstream of the underground powerhouse and 1.2 km upstream of Madian town.

At both sites, weir site and power outlet, the river will only be influenced marginally by drilling, blasting and excavation activities. As it is shown in Fig. 5-1 the construction pit will be protected by small cofferdams enclosing the working area for weir construction. The phases of construction at the weir site are as follows: (i) erection of 'working dams', (ii) excavation of the diversion tunnel, (iii) erection of cofferdams, (iv) construction of the weir, (v) removal of cofferdams and plugging the diversion tunnel. Only during the time of construction of the upstream cofferdam some increased sediment run-of will take place for 1-2 weeks until the Swat River water is flowing through the diversion tunnel. Mitigation measures in addition to the described construction design are not possible and not necessary.

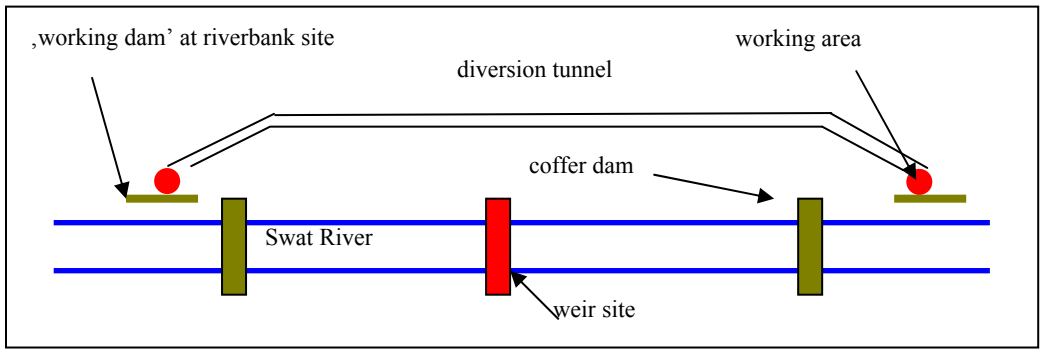


Fig. 5-1: Construction scheme for drilling of the diversion tunnel

<u>Conclusion for construction period</u>

During the construction period a short section of the Swat River will be diverted through a tunnel at the future weir site. The affected part of the Swat River (about 230 m) will be drained and partly excavated during the construction period. During about 1-2 weeks an increased sediment run-off might take place during river closure. Further mitigation measures as described in the working scheme are not possible and not necessary. The impact on the ecology of the Swat River is assessed to be low during the construction period.

Extent of impact on ecology of Swat River	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.7 Terrestrial Fauna and Flora

The terrestrial flora and fauna in terms of forests and pastures discussed in Section 4.1.5 will not be under impact due to project construction. These biological entities do not fall within the area of influence of the project construction because they are located at altitudes higher than the location of the project components.

As discussed in Chapter 4.1.6, terrestrial fauna and flora is already heavily influenced by human activities. A large part of the valley slopes covered with overburden and slope wash has been covered be terraces by local farmers. Major impact will be the destruction of terrestrial land by flooding at the reservoir site and by dumping of excavated material. Selection of dumping site was based on the criterion that the terrain must not be too steep to ensure the stability of dumping sites. However, all land with moderate slopes has been cultivated already. For this reason the selected dumping sites consist mainly of cultivated land, in some cases covered with fruit trees. It will last decades until trees and other groves will be replaced in the same quality as before. However, this land does not present areas of specific ecological value neither for plants nor for animals.

In the reservoir area only a very small number of trees are growing, thus a specific biomass removal measures of the inundated area will not be necessary. Near the weir site some 20 trees are growing which will be cut down during construction.

In order to restore the land at dumping sites as far as possible, the surface soil layer will be removed and laid down aside before filling up with excavated material. After dumping the overburden the soil will be brought back and spread over the dumping area. The overburden will be filled in semi compacted (see Chapter 5.1.2), that means, the retention capability of water will be improved much by this method.

Conclusion for construction period

About 37 ha of terrestrial land will be used either by flooding or by dumping of excavated material. The loss of terrestrial land in the area of the reservoir is limited but unavoidable. For restoration of dumping sites the original surface soil layer will be reused to cover the surface of the dumping sites, however it will last a number of years if ever until a situation will be reached again that can be compared with the actual one. The impact of the construction activities on terrestrial fauna and flora is assessed to be medium mainly due to the large areas needed for dumping the excavated material.

Extent of impact* on terrestrial fauna and flora *under consideration of mitigation measures (see EMP)	■ ■ = medium negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.8 National Parks, Wildlife Sanctuaries and other Protected Areas

There are no national parks or other protected areas under the influence of the Project. The wildlife habitats/sanctuaries in the form of forest cover are located at altitudes higher than the location of the project components.

Conclusion for construction period

An impact of the Project on national parks or other protected areas does not take place during construction of Madian HPP.

Extent of impact on National Parks, Wildlife Sanctuaries and other Protected Areas	O= nil

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
O	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.9 Historical and Cultural Sites, Archaeological Remnants

From discussions with the tourist department and with people living in the area it became obvious, that no historical and cultural sites as well exist in the area that might be affected by the Project.

If any archaeological remnants will be found during construction (e.g. by excavation activities), the work will be ceased immediately and the responsible archaeological authority will be informed.

Conclusion for construction period

There are no sites of historical or cultural interest in the investigation area.

Extent of impact* on historical and cultural sites *under consideration of mitigation measures (see EMP)	O = nil

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
O	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.10 Landscape

During the construction period a massive increase in traffic volume will be caused by truck movements at least in some areas. Dust emissions will be unavoidable and the construction activities at the proposed weir site, tunnel adits and the dumping sites will optically affect the landscape during construction. There is no mitigation possible except for spraying construction sites in dry season to reduce at least the dust emissions.

Conclusion for construction period

The extent of impact on the landscape is assessed to be medium. However, evaluation of visual impacts is always dependent on the observer, which means it is subjective in nature. This type of impact can be assessed differently by different individuals.

Extent of impact on Landscape	■ ■ = medium negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.11 Health and Safety Aspects of Workers

The worker's camps will be provided with proper sanitary installations. Clean drinking water will be placed at worker's disposal in a sufficient quantity at all sites where construction activities take place. A sufficient number of portable chemical toilets will be erected nearby main construction zones.

Workers are exposed to considerable noise levels when constructing a weir, tunnel etc. Main sources of noise will be blasting, piling and operation of heavy construction equipment, several of them often running at the same time.

The maximum allowed noise level according to national legislation is 85 dB(A). Monitoring of noise levels shall take place during the regular construction site audits. Where the noise level is exceeded ear protecting devices shall be handed out to the workers. Warning signs shall be erected.

Tunnel excavation and weir construction represent always a risk for workers to be affected by physical injuries. Therefore, the Construction Contractor (CC) shall develop and implement a Health and Safety Plan for the construction activities. In addition, national Health and Safety regulations (Chapter 2.1.5) require a permanent and regularly training of the workers concerning health and safety issues.

The CC shall provide sufficient medical care to the workers. The corresponding provisions will be made in the tender documents.

Conclusion for construction period

If all precaution measures are implemented and a regular construction site audit with measurements of noise levels are implemented, the impact on worker's health regarding noise burden is assessed to be low.

Extent of impact* on health and safety of workers *under consideration of mitigation measures (see EMP)	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.12 Solid and Liquid Wastes

During the construction phase up to 400 workers may live in two temporary worker's camp sites at peak periods generating solid and liquid wastes in a considerable amount.

The construction of a temporary sewage treatment plant will be part of the worker camp site installations and will be specified in the tender documents. The CC will also be responsible for the erection of a sufficient number of mobile toilets at the different on-site working places. The sewage of these mobile toilets will then be transported to the sewage plant on camp sites and treated adequately. The treated water will be discharged into the Swat River. No direct discharges of untreated waste water shall be allowed.

The solid waste generated during construction activities will be collected on site and sent to an adequate and authorized landfill. Burning of waste is explicitly not allowed.

On site storage of fuel, engine oil and lubricants has to be done in locked and sealed tanks and on sealed areas, having bunds of a capacity of 110 % of the total storage capacity. Proper maintenance of all machines and trucks will avoid losses of oil that could pollute soil and groundwater. Dealing with oily products as oil changes in machines shall only be done on sealed areas.

Conclusion for construction period

Up to 400 workers in peak periods will generate a lot of liquid and solid wastes. The liquid sanitation waste water will be treated at worker's camp site. The Contractor will be obliged to dump solid construction and sanitation wastes in a proper manner. A regular construction site audit will ensure that the mitigation measures will be executed to the greatest extent possible. The impact of solid and liquid waste on the environment can then be assessed to be low.

Extent of impact* of solid and liquid wastes *under consideration of mitigation measures (see EMP)	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.13 Socio-economic Aspects

It is anticipated that up to 400 workers, both skilled and unskilled workers, will be employed during the peak construction activities. This work will comprise preparation of the weir site, construction work, erection of buildings, excavation and erection of foundations, excavation of access and headrace tunnels, etc. Major parts of the project will employ local manpower and will have a direct positive impact on the local job market. During the construction period of about 4.5 years the demand of food grain and commodities will increase. Moreover, as new jobs become available in the area, the out migration of the labour force will be reduced enabling the men to stay at home and find work. Thus the project will have major effect on the local economy, employment and income as the local market will provide food, clothing and consumable items for the project workforce.

It is expected that on average about 250 people will live in the worker's camp during the construction phase.

Positive socio-economic impacts during the construction phase will include:

- generation of direct employment opportunities;
- stimulation of the local economy by increased spending on local goods and services;
- increased scope for attracting related services and other industries of the area and subsequent impacts on local employment levels and economic activity.
- Partial use of the presently non-saturated accommodation capacity of the existing hotels in Madian and Bahrein

No specific estimates can be made within the scope of this EIA of the financial extent of such benefits.

During the construction phase of the hydropower project, a mass inflow of outside workers and heavy machinery can disturb the local socio-political and socio-cultural life. The Project might have effects on the life style of the people during the construction stage.

Potential negative socio-economic impacts during construction period include:

- an influx of migrant workers;
- pressure on local public services, including health and education;
- pressure on the local commercial services;
- saturation of the local housing markets.

These possible negative impacts will be minimised by employing local people where possible, those who are already living in the nearby communities and already using the communities` educational, hospital and other facilities. Most of the migrant workers will live in the worker camp; the facilities provided by the contractor for its employees will be put at workers` disposal, like medical

care etc. From that, it is indicated that the Project is unlikely to have any major adverse socio-economic effects on the local community.

No cases of HIV/AIDS in the investigation area have been reported. The project area of Madian Hydropower Project is known to consist of conservative population committed to principles of Islamic Shariah. HIV/AIDS, therefore, does not play any role in the society as far as it is known at present. Workers from outside have to submit to these traditions, thus the HIV/AIDS problem will hardly play any role.

Conclusion for construction period

The project will most probably be of substantial economic benefit and increase the employment opportunities during the construction phase. It is indicated that the Project is unlikely to have any adverse socio-economic effects on the local community, on district or regional levels. Negative influence of migrant workers on the society incl. spreading of HIV will hardly occur and the risk is assessed to be very low.

Extent of impact on the socio-economy	✦ = locally positive ✦✦ = regionally positive

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.14 Tourist Aspects

The Swat valley offers a popular tourist attraction to the country. An extensive tourist infrastructure in form of large number of hotels, guesthouses and restaurants exist in the project area towns of Bahrein and Madian according to local standards. Such tourist infrastructure becomes operational in the summer months from beginning of June to end of August. Tourists from in-country and abroad use these towns as stop-overs before they travel further on to Kalam to enjoy the beautiful landscape and the famous lakes Sufaid, Condol, Paryen and Izmiz situated near Utror.

It has to be stated that because of the instable political situation the number of tourists was stagnant and decreasing, respectively, in the last years. According to interviews of hotel owners and managers (e.g. Hotel Marina) it is not expected by them that the construction will affect the tourism activities negatively.

Conclusion for construction period

Of course, the construction activities will affect tourist activities in the Swat valley. However, hotel managers do not expect severe negative impacts on the number of tourists, whose number is already decreased because of the political situation. There is the hope that projects like Madian HPP will bring more stability to the region. Mitigation measures are hardly possible except for the general efforts not to increase the traffic in Bahrein more than absolutely necessary (see Chapter 5.1.3).

Extent of impact on tourism	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.1.15 Resettlement Action Plan

A resettlement action Plan has been prepared as a stand-alone report. This plan comes up with following survey results:

The Project implementation will need acquisition of a total 39.438 ha land (state land, farmland, wasteland). Out of this total, 36.638 ha will be acquired on permanent basis and the remaining 2.800 ha on lease for 5 years.

15 houses with a total of 176 persons will be directly affected by the Project. 2 of these houses will be affected by reservoir impounding, 8 due to their location in areas to be utilised for dumping of excavated material, 3 in the vicinity of the diversion works, 1 due to relocation of the road at the weir site and 1 due to the proposed access road to the weir site along the left bank of the Swat River.

A total of 1,423 trees will be cut. Thereof, 950 are fruit trees and 473 are firewood and timber trees.

In order to compensate the losses all necessary measures are described in detail in the related Resettlement Action Plan (RAP).

Conclusion for construction period

Following the positive statements given by the affected people and under precondition that the RAP is implemented appropriately, the impact caused by necessary resettlement actions is assessed to be low.

Extent of impact* of resettlement actions * under consideration of the appropriate implementation of the Resettlement Action Plan (RAP)	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.2 OPERATIONAL PHASE

5.2.1 Microclimate and Emissions of Green House Gases

Because of the small surface of the reservoir (max. 64,000 m^2) the changes in the microclimate will be very limited.

All freshwater systems, whether they are natural or man-made, emit greenhouse gases (GHG) due to decomposition of organic material. This means that lakes, rivers, estuaries, wetlands, seasonally flooded zones and reservoirs emit GHG. In general, in cool and temperate regions, GHG emissions from reservoirs are higher just after impoundment, but decline within the first years to reach levels similar to those of natural lakes, if properly managed.

If the inundated land is heavily wooded and not sufficiently cleared prior to flooding, decomposition will deplete oxygen levels in the water. This affects quality of life and may result in fish kills. Products of anaerobic decomposition include also hydrogen sulphide, which corrodes dam turbines and is noxious to aquatic organisms. Also methane will be generated which represents a very effective greenhouse gas. The reservoir area of the Madian reservoir is barely covered by vegetation with exception of a few shrubs and cultivation of a few terraces on the left river bank.

Madian Hydropower Project will in fact contribute towards improvement of air quality at National and International levels. According to an estimate, an oil-fired steam unit would produce Depending on the plan efficiency between 0.7-0.9 tonnes of Carbon Dioxide for each MWh of energy generated. The mean annual energy output of Madian Hydropower Project is 767 GWh and when it is connected to the national grid it will reduce Carbon Dioxide emission (GHG) in air by 530-680 tonnes annually.

<u>Conclusion for operational phase</u>

The effect on the microclimatic conditions will be minimal. Most of the few organic materials as tress, shrubs etc. will be removed before filling the reservoir. This reduces the generation of green house gases to a minimum. Compared with oil or coal fired power plants the emission of CO_2 can be neglected.

Extent of impact* on microclimate and of green house gases *compared to conventional thermal power plants	✦	= locally positive
	✦✦	= regionally positive

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.2.2 Swat River Ecology

It can not be ignored that the character of the Swat River will be changed to a great extent, especially if the other hydropower projects planned upstream are taken into account. A long reach of river will be converted from a white water river into a series of head ponds with lake characteristic. For example, the power outlet of the Asrit-Kedam HPP is located just some 300 m upstream of the beginning of the Madian Hydropower Reservoir. Within first years reservoir sedimentation will take place in particular in the upstream part of the reservoirs and new river beds with different characteristics than before may be created.

As outlined in Chapter 4.1.5, it is reported that the original fish fauna is mostly extinct because of introduction of trouts for angler purposes. These trouts are farmed and introduced artificially. However, no actual scientific data about the Swat River ecology is available like data on possible remnants of original fish species, composition of diatom species or benthic macroinvertebrates.

After implementing the Project, the weir will act as an insurmountable barrier to migrating fishes causing fragmentation of fish populations. The character of fish species will change from fishes living in rapid white waters to fish species being typical for standing water bodies in the reservoir area. In the river reach between weir and power outlet the river flow is reduced. It can be assumed that the fish farmers will adapt to the new situation and breed also this kind of fish species for introducing them into the reservoirs.

At the power intake a trash rack will be installed with a distance of 7.5 cm clear width between the bars. The flow speed at the trash rack is about 1 m/sec, which does not represent a threat for fishes like trouts who can escape easily such a current.

Ecological flow

There is a growing demand worldwide to conserve the ecological health and functioning of rivers for the benefit of people and biodiversity. It is widely recognised that any artificial alteration to a river flow regime will change the river ecosystem. IUCN states that an "environmental flow" is the water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits where there are competing water uses and where flows are regulated.

There is no simple figure than can be given for the environmental flow requirements of river ecosystems. The ecological flow depends on many factors determining the ecology of a river. All elements of a flow regime, including floods, medium and low flows are important. Thus, any changes in the flow regime will influence the river ecosystem in some way. Consequently, if the aim is to maintain a pristine natural river ecosystem, the environmental flow will have to be very close to the natural flow regime /5/.

As mentioned above it is not possible to give a unified standard for ecological flow in general. Consequently, there exists also no uniform Pakistani Standard.

Some models are using the average of the minimum daily flows of each year. $^1/_3$ of this average represents the minimum ecological flow. Other studies taking 10% of the yearly average flow as an absolutely minimum release. Percentages of the mean annual flow are specified that provide different quality habitats for fish e.g. 10% for poor quality (survival), 30% for moderate habitat (satisfactory) and 60% for excellent habitat. Other studies show that 10 % of the mean annual flow offer only "poor" habitat conditions, 30 % would be "fair" and 40 % or more is "good" /5, 6, 7, 8, 9, 10/.

According to the opinion of the author of this report it would be desirable if PPIB would set generally binding ecological flow standards for the development of hydropower projects along the Swat River, in particular in view of that the Madian HPP is the most downstream located projects of four run-of river hydropower schemes on Swat River.

Section 4.1.5 describes the ecological value of Swat River. The requirements of water for irrigation of crop land and for drinking purposes are met by the small tributaries and springs joining the river from left and right banks. The ecological minimum flow requirements are those of aquatic flora and fauna.

For the determination of the mean monthly ecological flow, a formula representing a function of the available mean monthly discharges and the mean annual discharges was used as presented below:

$$MQeco = \{(0.0651 * MQmo + 2)/100\} * MQan$$

Where = MQeco = mean monthly ecological flow in m^3/s
MQmo = mean monthly flow in m^3/s
MQan = mean annual flow in m^3/s

This formula has the charm that the alterations of seasonal flows are reflected. The resulting minimum flow is below the minimum ecological flows as discussed above. This formula was developed by CEMAGREF, Agricultural and Environmental Engineering Research Institute of France and was already applied to the feasibility study of the Gabral-Kalam Hydropower Project. The formula is also recommended by the International Association of Small Hydropower. The resulting monthly average values are given in table Tab. 5-2.

In the original project concept the flow of Kedam Nullah and Bara Dar (Gornai Nullah) was foreseen to be diverted into the reservoir and used for power generation. This concept was omitted and the flow of these two tributaries is considered as part of the ecological release at the weir. This procedure was presented in the pre-feasibility study /2/ of the Madian Hydropower Project and has been accepted by PPIB and their Panel of Experts.

Period	Discharge (m^3/s)					
	Swat River at Weir	Required Ecological Flow*	Contribution of Tributaries			Required Release
			Kedam Kalam	Bara Dar	Total	
Jan	23.57	**4.19**	0.31	0.47	0.78	**3.41**
Feb	21.61	**4.04**	0.38	0.57	0.95	**3.09**
Mar	27.17	**4.47**	0.96	1.45	2.41	**2.06**
Apr	78.72	**8.44**	3.44	5.19	8.63	**Surplus Spill**
May	191.70	**17.16**	7.85	11.86	19.71	**Surplus Spill**
Jun	298.38	**25.39**	8.24	12.45	20.69	**Surplus Spill**
Jul	302.92	**25.74**	4.58	6.93	11.51	**Surplus Spill**
Aug	227.33	**19.91**	2.58	3.89	6.47	**Surplus Spill**
Sep	128.84	**12.31**	1.13	1.71	2.84	**9.47**
Oct	57.45	**6.80**	0.99	1.49	2.48	**4.32**
Nov	36.40	**5.18**	0.62	0.93	1.55	**3.63**
Dec	27.81	**4.51**	0.38	0.57	0.95	**3.56**

Tab. 5-2: Ecological discharge requirements downstream of the Madian Weir
*Excluding contribution of Kedam, Kalam and Bara Dar

Conclusion for operational phase

Unfortunately, there are only few data available about the fish fauna in the Swat valley and no data could be obtained about the occurrence of diatoms, benthic macroinvertebrates, phytoplancton etc. in the Swat River itself. Thus ecological knowledge of the water body is very poor and the impact cannot be assessed from a scientific point of view. That is why the extent of impact is not given as a 'figure', but one has to refer to the discussion given above.

Despite the gap of knowledge, it has to be stated that there will be major alterations in the ecology of the Swat River, especially if taking into account the development of three more hydropower projects upstream. Decision makers have to weigh up between impacts on the environment and the need for generation of power and by issuing the license to potential developers this decision was made.

Extent of impact on Swat River ecology	See discussion above

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.2.3 Terrestrial Fauna and Flora

The terrestrial flora and fauna of forests and pastures will not be impacted during the operation phase of the Project. Migration of big terrestrial mammals will be interfered by creating the reservoir representing an obstacle that can not be cleared. However, it has to be kept in mind that big animals have disappeared in most of the Swat valley especially around Bahrein due to high population pressure (see Chapter 4.1.6).

Conclusion for operational phase

There are no mitigation measures during operation phase possible. The extent of impact on terrestrial fauna and flora is assessed to be low.

Extent of impact on terrestrial fauna and flora	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.2.4 Landscape

The actual appearance of the Swat valley north of Bahrein will be changed. The fast flowing white water of the Swat River will partly be converted into a lake upstream of the weir. Downstream of the weir much less water will form the future Swat River. This can be assessed, dependent on the attitude of the observer, from positive up to negative.

The assessment given below takes into consideration that the landscape is not considered to be 'very attractive' as the highest mountains in the Himalayan Range. The extent of impact given below does not take into account the other hydropower projects upstream that will cause changes in appearance in the full course of the Swat River. The present assessment is restricted to the Madian HPP itself.

Conclusion for operational phase

The overall appearance of the landscape with its mountains will not be changed by the landscape, but the character of the landscape near the riverbed in the valley. It has to be pointed out, that evaluation of visual impacts is always dependent on the observer, which means it is subjective in nature. This type of impact can be assessed differently by different individuals. The author of this EIA assesses the impact on the landscape to be low.

Extent of impact on landscape	■ = low

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.2.5 Seismic Aspects

Seismic risks of the Project area were assessed by the Consultant by means of a comprehensive Seismic Hazard Study and their due consideration in the feasibility design. In the structural design of the individual components of the Madian Hydropower Project the corresponding seismic risks are taken into consideration in terms of design loads and their corresponding safety factors in accordance with international standards (according to ICOLD Bulletin 72 *"Selecting Seismic Parameters for Large Dams"*, 1989). The resulting value for horizontal peak ground acceleration at the Madian Hydropower Project site is 0.48 g for the Maximum Credible Earthquake (MCE). For the Design Earthquake (OBE-1), values of 0.26 g for annual probabilities of exceedance of 1 / 475 are recommended.

In view of the fact that most of the structural components of the Madian HPP are underground works where no differential movements take place between the structure and the surrounding rock mass, the seismic risk regarding the Project's design is rather limited. For the structures with high rock coverage and circular or nearly circular shapes the impact is negligible.

In the feasibility design the consideration of seismic risks applies in particular to the stability calculations of the weir structure, slope stability in the reservoir and the design of the spillway gates among others.

Conclusion for operational phase

The actual seismic situation prevailing in the project area is considered in the design to the Project.

Extent of impact* caused by seismic events *under consideration of mitigation measures	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.2.6 SF_6 Gas Insulated Substation

The underground substation will be a SF_6 gas insulated 220 kV substation. SF_6 is a very strong greenhouse gas and has to be handled very carefully. In Annex 12.5.1 some considerations about the effects and the handling of SF_6 gas are given. The substation shall be fitted with detectors indicating any SF_6 leak.

Concerning electric and magnetic fields internationally used limit values are discussed in Annexes 12.5.2. It has to be pointed out that in case of this substation no problems will come up concerning electric and magnetic fields (EMF) related to health effects. The Annexes are given for general information. The discussed limit values might be of relevance for overhead transmission lines and open air substations with 220 or more kV. Oil pits beneath the transformers (9 operating + 1 standby) will collect leaking oil if any, and through a drainage system the oil, if any, will be collected in a central storage room fitted with an oil separator.

Conclusion for operational phase

Concerning EMF there will be no negative impacts on workers'health come up. The handling of SF_6 has to be done very carefully considering the presented guidelines as outlined in Chapter 12.5.1.

Extent of impact* of substation (SF_6 and EMF) *under consideration of mitigation measures	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.2.7 Deposits from Desander

The sand of the desander will be flushed regularly during periods of high river flow. That means that there will be a no or very little run-off of sediments in the river in the low flow period similar as it is naturally. It is to be considered that during the high flow season a large part of river flow with the natural concentration of suspended sediments will pass the weir structure. In winter time no flushing is required because of low river flow which is nearly free of sediments.

Conclusion for Operational Phase

Extent of impact by deposits from desander	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.2.8 Water-related Vector Diseases

The investigation area was surveyed for prevalence of water related and other diseases in April 2008. Diseases related to water-borne infections like diarrhoeal diseases were reported by about 50% of the interviewees, particularly children. This is attributed to the present lack of safe drinking water supply in the project area. Furthermore, the sanitation facilities assessed in terms of sanitary based wastewater and solid waste management including human excreta disposal are not satisfactory. The creation of relatively slow moving water in the form of impounding the Swat River upstream the weir structure is likely to promote disease vector's breeding in which case preventive measures would need to be taken. The mosquito *Anopheles*, for example, the transmitter of malaria has its breeding habitat in stagnant water and hence the new reservoir will be a potential new habitat for this disease vector.

The problem of water-related vector diseases is an issue that can not be seen isolated for the Madian HPP. There are actual cases of malaria in Swat valley and the situation might become worse after implementing HPPs with its reservoirs. Solving this problem, however, can not be issue of the owner/operator of the power plants alone.

Conclusion for operational phase

There might be an increase of water-related diseases during the operation period of the Madian HPP in the Swat valley. In order to manage these health problems, a concerted action of all HPP owners/operators together with relevant regional and national health authorities will be necessary.

Extent of impact* regarding water-related vector diseases *mitigation measures have still to be agreed with all involved parties	■ ■ = medium negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.2.9 Socio-economic Aspects

Employment

The employment opportunities available during the operation phase of the Project will be limited to a number of technicians / skilled workers like engineers. For unskilled people some job opportunities will be created as guards, for simple maintenance purposes etc.

Conclusion for operational phase

The effect on employment of local people during operational period will slightly be positive.

Extent of impact on employment	✦ = locally positive ✦ ✦ = regionally positive

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

Tourist Activities

The region is well known for sport fishing. Swat valley is an angler's paradise for tourists, contributing directly and indirectly to the local economy. The control of fishing is exercised by the provincial Fisheries Department under the provisions of fishing rules. Swat River, its tributaries and lakes are supervised by fishing watchers. Fishing licenses are valid for one day, one week or one month. Fishing season is from 10th of October to 9th of March of the year. The main tourist season is, however, from June to August as mentioned above.

The deterioration of the river water quality creates stress on the aquatic flora and fauna. The fish population will be affected from the changing conditions. Also, the migration of water insects, crustaceans and fishes is hampered by reduction in water flow of the river, and by physical barriers, especially during spawning time.

Fishes like trouts are introduced artificially to the Swat River, thus the weir represents no problem for the trout population. In the area of the reservoir angler will find another opportunities for catching fishes adapted to the character of a lake. The fish farms will adapt to this situation by breeding fishes typical for lakes.

Conclusion for operational phase

The angler attitude will change from white water fishing only to fishing in the river and in a lake. Other tourist activities will not be affected except for the fact that the landscape will be slightly changed by realisation of the Project. Overall it is assessed that the number of tourists will not decrease, in particular in the main tourist season from June to August. Maybe some tourists will not use this area anymore for white water fishing, but other tourists will visit the valley instead. Specific mitigation measures are not required to implement.

Extent of impact on tourist activities	O = nil

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
O	=	nil
✦	=	locally positive
✦✦	=	regionally positive

5.2.10 Water Supply downstream the Weir Site

The water of the Swat River within the area under investigation is not directly used for irrigation because of its high river banks. The elevation of Swat River flow is lower than that of the adjacent cultivated terraces. Instead, the tributary steams/nullahs and springs (Photo 12-16), existing in the vicinity of such farmlands and flowing into the Swat River on the left and right banks are used for irrigation downstream of the weir.

It was reported that two hotels are using water from the Swat River as drinking water resources. According to the water analysis (see Annex 12.4) this is critical because of the actual content of E. coli. This situation will be worsened when the discharge is reduced in the river bed after implementation of the project despite the fact that a minimum ‘ecological’ flow is maintained. In this context it is referred to the Daral Khwar Hydropower Plant Project that also includes the implementation of a water treatment and supply component for Bahrein town. The same project is also going for installation of a sewerage system with an associated treatment plant, which will improve the river water quality situation in future. In addition, more and more hotels are switching to a sanitation pit system for waste water instead of flushing waste water directly and untreated to the Swat River (e.g. Marina Hotel).

Downstream the power house there will be no alterations of the Swat River flow.

Conclusion for operational phase

The operation of the Project will not affect irrigation downstream of the weir because other water resources than the Swat River water are used by the farmers. After installation of Daral Khwar Hydropower Plant Project water quality of Swat River will be improved and more households will be connected to a drinking water supply system.

Extent of impact* on water supply downstream the weir site *under consideration of mitigation measures	■ = low negative

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

6

Analysis of Alternatives

6 ANALYSIS OF ALTERNATIVES

6.1 NO PROJECT OPTION

At present, there is an increasing demand for power nowadays outstripping supply of electricity in Pakistan. This disproportion results in many power failures and load shedding (intentional alternating disconnection of parts of cities from power supply), e.g. in Lahore each day for several hours. By 2010 the demand is expected to exceed supply by approximately 5,500 MW. Adequate power supply, however, is a key to achieve growth targets of a country resulting in higher welfare of its population in general. Thus, the 'no project option' is not a realistic scenario, if Pakistan shall be supplied with sufficient and sustainable power to meet the demand.

6.2 GAS FIRED POWER PLANT

From the environmental point of view only a gas fired power plant could be an alternative to this hydropower Project. Therefore, a short discussion of this alternative is given in this section.

It can be assumed that the construction of a gas fired power plant will sum up to around US$ 590 per installed kW (investment cost) using an open cycle plant, and to around US$ 720 per installed kW using a combined cycle system in Pakistan. In case of a hydropower project, the investment costs usually vary between US$ 1,200 to 2,000 per installed kW depending on size and complexity of the project. The construction time of a gas fired plant would last 24 to 30 months after contracting; however, for the construction of a hydropower project a period of 3 to 5 or even more years might elapse before power generation will start. This means, power would be available to the population much earlier in case of the construction of a gas-fired power plant by less investment cost than for a dam project. Moreover, it would be easier to find an adequate construction site for a gas-fired plant where no resettlement activities would be necessary. The plant could further be constructed closer to the demand centres and interconnection points (e.g. close to the big cities), what would also reduce the length of transmission line systems. The impacts of the plant on the ecology, besides the production of greenhouse gas CO_2, could be restricted to an absolute minimum.

But also disadvantages of gas-fired power plants shall be quoted such as the need of long gas pipelines and the dependence on gas delivery from outside the country and the uncertainty as regards the development of gas prices on the world market. The significantly higher operation (fuel) and maintenance cost of a thermal power plant may govern the decision to develop sustainable hydropower based generating capacity and attract private investors provided the government establishes the corresponding legal framework.

In Pakistan around 40% of energy is actually generated using gas. According to the 'The Pakistan Oil and Gas Report' the gas consumption in 2006 was 409bcm, 329bcm produced in Pakistan and 80bcm imported. In 2011 the

consumption will be 620bcm, 487bcm produced in the country and 142bcm imported. This fact results in a certain dependence on neighbouring countries and the gas reserves are not endless. In addition, the costs of a gas pipeline and for the fired gas must also be taken into the overall consideration.

The technical life span of a hydropower plant is assumed to be significantly longer than that of a gas-fired plant, however, due to e.g. sedimentation effects in reservoirs of hydropower plants adverse impacts on the operational conditions and lifetime might occur.

Summarizing, gas-fired power plants have some advantages compared to hydropower projects, but the disadvantages like the lack of appropriate gas supply and loss of autonomy in primary energy supply may not to be underestimated. Finally, it is the Government's decision on what power supply policy to rely on, in Pakistan as well as in other countries.

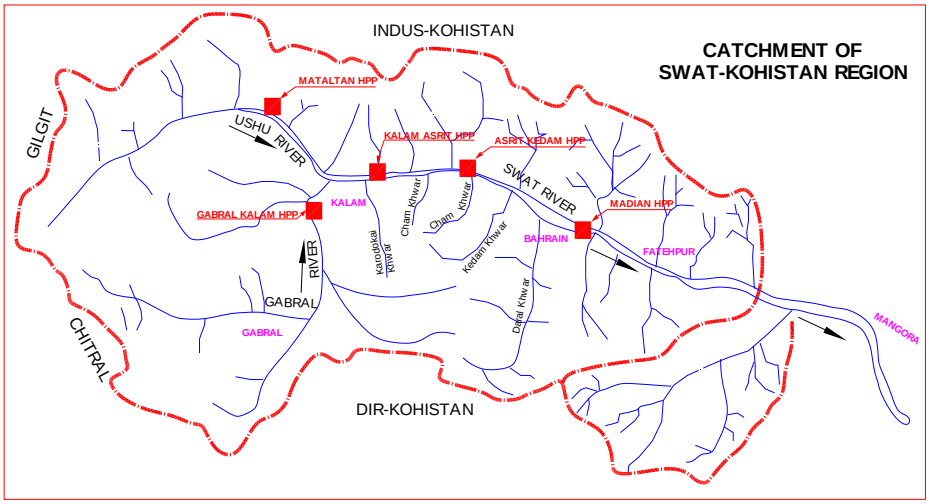
7

Interface with other Projects

7 INTERFERENCE WITH OTHER PROJECTS

7.1 DAM PROJECTS UPSTREAM MADIAN HPP

The topographic conditions in the Swat valley, with its Swat River, offers opportunities for the development of several hydropower projects, e.g. in a cascade system. At present, licenses have been issued by the Pakistani governmental institutions for the development of four hydropower projects proposed on the Gabral-Swat River system. These projects are Gabral-Kalam, Kalam-Asrit, Asrit-Kedam, and Kedam-Madian. The last one, Madian Hydropower Project, is the topic of the study of this EIA Report.



Map 7-1: Planned Hydropower Plants in Catchment of Swat-Kohistan Region

The map above shows that large parts of the Swat River valley could be affected by the development of hydropower plants. The river may be converted in a series of head ponds and significant parts of its natural flow are diverted from the riverbed over almost the entire length of the river bed.

7.2 DARAL-KHWAR HYDROPOWER PROJECT

This project is located in a right bank tributary of the Swat River that joins the Swat River at Bahrein town (between Madian HPP weir and powerhouse site).

The project includes the construction of

- access roads;
- a water supply system;
- a sewerage system and treatment plant;
- electricity supply and distribution system.

After implementation of Daral-Khwar project the water quality of the Swat River downstream Bahrein will be improved and more households will be supplied with proper drinking water. In addition, much less untreated waste water will enter the Swat River. Thus this project will help to mitigate negative impacts of Madian HPP concerning the fact that the concentration of E. coli, found in the river water (Annex 12.4), would increase when river flow would be reduced due to diversion of part of the flow for power generation. As discussed above it was reported that two hotels are using Swat River water as drinking water (see Chapter 5.2.10).

7.3 IMPROVEMENT OF MADIAN-KALAM ROAD

It is planned to upgrade the Madian-Kalam road to a National Highway. This is on the one hand of advantage in terms of transporting heavy construction machines to the planned hydropower plant sites. On the other hand, during the presently ongoing construction process, it brings more traffic to the cities of Madian and Bahrein (see Chapter 5.1.3).

8

Environmental Management Plan

8 ENVIRONMENTAL MANAGEMENT PLAN

8.1 INTRODUCTION

An environmental management and monitoring programme is pursued during the construction and operation stage of the Project to protect and provide safeguards for a continuing healthy environment in the project area. After the Project becomes operational, the Plant Manager with the assistance of staff on behalf of Madian Hydropower Ltd. will be overall in charge and responsible for management and monitoring of the hydropower project.

The purpose of mitigation measures is to manage the Project in a manner that minimises adverse impacts and maximises secondary benefits. It is a planning step that evolves naturally from the process of identifying and assessing potential impacts. Mitigation is best conducted throughout the planning process when it is usually more effective and changes can be made at least cost. Mitigation is the process of making a project more compatible with its environment.

8.2 IMPLEMENTATION OF MEASURES

The presented Environmental Management Plan (EMP) was developed at the status of the feasibility design of June 2008. This EMP shall be updated in the tender design stage and then added to the tender documents for the construction of Madian HPP. The construction contractor shall implement the measures as outlined for the construction phase, the operator/owner shall implement the measures as outlined for the operation phase.

8.3 MITIGATION / COMPENSATION ACTIVITIES

8.3.1 General Mitigation Activities during Pre-Design Phase

In general, there are two options for operation of hydropower projects: Run-of-river mode and peaking operation mode. Peaking operation mode requires larger reservoirs compared to run-of-river operation. Such storage would result in additional negative socio-economic impacts which can be avoided by developing the Project as a run-of-river power plant. For example, daily peaking operation mode would require approximately 1,500,000 m^3 active storage, whereas the selected run-of-river power plant has a max. reservoir storage of only 480,000 m^3.

Other design measures to mitigate environmental impacts of the Project have been to arrange the location of the power house away from Madian town instead building it right at the town border, as foreseen as foreseen in the cascade study /1/, and not to involve Kedam Kalam and Bara Dar tributaries as inflow to the reservoir.

8.3.2 Construction Phase

			Cost		Institutional Responsibility		Comments (e.g. secondary impacts)
Phase	**Issue**	**Mitigating Measure**	**Install**	**Operate**	**Install**	**Operate**	
C O N S T R U C T I O N	Land acquisition and use	Compensation measures as outlined in Resettlement Action Plan	129,285,000 RS (about 2 Mill. USD)		Project Developer		See stand alone report RAP to the Project
	Traffic aspects (to be continued)	• Use of selected dumping sites; • Dumping sites at the left river bank have been preferred; • No transport of rock material through towns (Bahrain, Madian); • Use of conveyors where economically feasible; • Use of excavation material for construction as much as possible; • Producing of concrete on site; • Proper transport management to reduce truck movements; • Truck movements are allowed only during daytime (from 6.00 am to 6.00 pm). • Reduced speed when trucks cross villages.		Included in the construction budget		CC	

			Cost		Institutional Responsibility		Comments (e.g. secondary impacts)
Phase	**Issue**	**Mitigating Measure**	**Install**	**Operate**	**Install**	**Operate**	
C O N S T R U C T I O N	Traffic aspects (continued)	▪ Contractor will adhere to its established practices of posting warning signs and managing traffic to protect the travelling public and the workers. • In case of overweight material during transportation, it might be necessary to reinforce some of the weaker roads and/or bridges.		Included in the construction budget		CC	
	Air quality and noise aspects (public)	• See traffic aspects; • Routine service and maintenance of vehicles and machines to reduce engine emissions; • Spraying of construction sites incl. non paved access roads with water especially during dry season		Included in the construction budget		CC	
	Terrestrial fauna and flora	• In order to prepare selected dumping sites the surface soil layer shall be removed and laid down aside. After dumping the excavation material, the fertile soil shall be brought back and spread over the dumping area.		Included in the construction budget		CC	This will allow rehabilitating the dumping sites at least to some extent.

			Cost		Institutional Responsibility		Comments (e.g. secondary impacts)
Phase	**Issue**	**Mitigating Measure**	**Install**	**Operate**	**Install**	**Operate**	
C O N S T R U C T I O N	Archaeological sites	• If archaeological remnants are found the work shall be ceased immediately and the responsible archaeo-logical authority shall be informed.		unknown		CC	
	Health and safety aspects of workers (to be continued)	• Development and Implementation of a Health and Safety Plan for construction phase; • The staff/workers shall be trained regularly.		Included in contractor's site installations	CC	CC	
		• Workers will be provided with necessary safety tools such as helmets, working shoes, dust filter and ear defenders. • Site workers will be accommodated in proper campsites including appropriate sanitation (drinking water!) facilities; • No worker camps will be permitted outside the provided areas		Included in contractor's site installations		CC	

			Cost		Institutional Responsibility		Comments (e.g. secondary impacts)
Phase	**Issue**	**Mitigating Measure**	**Install**	**Operate**	**Install**	**Operate**	
C O N S T R U C T I O N	Health ands aspects of workers (continued)	• A sufficient number of portable chemical toilets will be erected nearby main construction zones; • Sufficient medical care facilities are provided to the workers (to be defined within the Health and Safety Plan).	Included in contractor's site installations	Included in contractor's site installations	CC	CC	
	Health and safety aspects of workers (noise aspects) (to be continued)	▪ Supply of the workers with ear defenders. In zones where 85 dB(A) are exceeded the workers shall wear ear protection devices ▪ Powered mechanical equipment (PME) like bulldozer, air compressor, concrete pumps, excavator, concrete mixer etc. shall only be used with low sound power whenever possible. ▪ The building machinery and other equipment shall be well-maintained and serviced regularly during construction works		Included in the construction budget		CC	

			Cost		Institutional Responsibility		Comments (e.g. secondary impacts)
Phase	**Issue**	**Mitigating Measure**	**Install**	**Operate**	**Install**	**Operate**	
C O N S T R U C T I O N	Health and safety aspects of workers (noise aspects) (continued)	▪ The building machinery being in intermittent use shall be shut down or throttled to a minimum. • Silencers or mufflers on construction equipment shall be used		Included in the construction budget		CC	
	Solid and liquid wastes	• A temporary waste water treatment plant at worker's camp sites shall be installed. • Proper disposal	Included in contractor's site installations	Included in contractor's site installations	CC	CC	
		• The camp sites and surrounds will be kept in a tidy and clean manner. Adequate number of rubbish bins for general litters and rubbish will be provided; • Regular waste/rubbish collection will be part of the camp requirements; Proper disposal of solid waste will be the responsibility of the contractor • Handling of oily products incl. maintenance of construction machines shall only be done in sealed and bounded areas		Included in contractor's site installations		CC	

8.3.3 Operational Phase

			Cost		Institutional Responsibility		Comments (e.g. secondary impacts)
Phase	**Issue**	**Mitigating Measure**	**Install**	**Operate**	**Install**	**Operate**	
O P E R A T I O N	Microclimate and emissions of Green House Gases	• Before filling the reservoir all trees and bushes shall be cut and taken out of the area	Included in the construction budget		CC		
	Swat River ecology	• A minimum 'ecological flow' is released also during dry season		Included in power tariff		Owner/Operator	
	Seismic aspects	• The project will be designed to withstand the max. credible earthquake (MCE) without major damages and OBE-1 without damages.	Included in the construction budget		CC		
	SF_6/EMF	• SF_6 leak detectors shall be installed • Oil pit beneath the transformers will be installed	Included in the construction budget		CC		
	Water related vector diseases	• A concerted programme between operators/ owners of all intended HPPs in Swat valley together wit health authorities shall be implemented	unknown	unknown	Health authorities	Health authorities	Co-financed by the Project Owner and Operator
	Water supply downstream weir site	• Households/Hotels using Swat River water as drinking water shall be provided with clean drinking water, as long as they are not connected to a drinking water supply system		250 USD per month		Operator/Owner	Among others the connection of households to a water supply system is issue of the Daral-Khwar HPP Project (see Chapter 7.2)

8.4 MONITORING ACTIVITIES

8.4.1 Construction Phase

						Cost		Responsibility		Comments
Phase	**What** *Parameter is to be monitored?*	**Where** *Is the parameter to be monitored?*	**How** *Is the parameter to be monitored/ type of monitoring equipment?*	**When** *is the parameter to be monitored-frequency of measurement or continuous?*	**Why** *is the parameter to be monitored (optional)?*	**Install**	**Operate**	**Install**	**Operate**	
CONSTRUCTION	Noise	At construction sites	Noise measuring device	During construction period	To ensure that national standard (85 dB(A) is not exceeded	10,000 USD for 2 noise measuring devices	Partly two employees of CC	CC	CC	
	Mitigation measures during construction period	At construction and dumping sites and along access roads	Perform a regular construction site audit	Quarterly during construction period	To ensure compliance with the mitigation measures		30,000 USD per year		Project Developer	Audit shall be performed by an independent third party

8.4.2 Operational Phase

						Cost		Responsibility		Comments
Phase	**What** *parameter is to be monitored?*	**Where** *is the parameter to be monitored?*	**How** *is the parameter to be monitored/ type of monitoring equipment?*	**When** *is the parameter to be monitored- frequency of measurement or continuous?*	**Why** *is the parameter to be monitored (optional)?*	**Install**	**Operate**	**Install**	**Operate**	
O P E R A T I O N	Weir stability, movements, water losses	At weir structure	sensors, visual inspections	regularly	To ensure weir safety	Included in construction costs	Included in operation and maintenance costs	CC	Owner/ Operator	
	E. coli	Swat River downstream the weir		monthly	To provide information for users of water of the Swat River		2,500 USD/ year		Operator	

8.5 TRAINING REQUIREMENTS

A regular training of workers concerning health and safety aspects shall be performed according to the Health and Safety plan developed by the construction contractor for the construction phase.

9

Public Consultations

9 PUBLIC CONSULTATIONS

The Consultant along with representatives of the Project Sponsors undertook the process of informing community representatives and affected households about the Project and its impacts. Three field trips were conducted in April, Mai and June 2008. The consultation process was conducted during the social survey preparing the affected community regarding land acquisition, helping to counter the rumours, preventing unnecessary distress, and bringing clarity on issues that might be raised by the affected persons. The process also includes the preparation of an introductory and information brochure in Urdu about the Project, its location and main impacts. A detailed listing of people interviewed and discussed is given in the Resettlement Action Plan (RAP) to the Project in Annex 13.1.2.

Before project appraisal, the Sponsor with the help of the Implementation Consultant shall prepare and conduct an Information and Community Consultation Programme in Madian.

Participation of project affected people and of the community during the project cycle will be ensured through their involvement in a committee for redress of grievances. This will ensure satisfactory settlement of any issue regarding affected land, houses, crops etc.

10

Gaps of Data

10 GAPS OF DATA AND RECOMMENDATION

There is a lack of knowledge concerning the ecological 'features' of the Swat River. No exact data are available about the fish fauna and a total lack of knowledge has to be stated concerning benthic macro-invertebrates, diatoms, phytoplankton etc. That fact makes it very difficult to assess the impacts of the Project on the ecology of the Swat River.

It is reported that by artificial introduction of trout into the Swat River all species that formerly lived in the river are extinct. However, this is only reported but no scientific data are available. From the experience of the author of this report it is very likely that there are remnants of original fish species left. Also no knowledge is available whether there are endemic fish species living in the river or not.

Therefore, it is recommended to perform a scientific investigation at least concerning fish population in the river in the tender design stage. This can be done by electro-fishing without having negative impacts on the caught fishes.

In addition, it is recommended to develop a general Catchment Management Program containing landscape management measures for planting of trees, creating of ecological valuable habitats etc. aimed, among others, at reducing of erosion and consequent sedimentation of the reservoir. To develop or even to implement of such a plan, however, is beyond this EIA. It is understood as a general measure for the entire catchment area in order to maintain their sustainability and to minimise ecological impacts.

11

Summary of Findings

11 SUMMARY OF FINDINGS

The extent of impacts during the construction and operational phase is summarised in the following two tables:

CONSTRUCTION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Land acquisition and use	■	Land acquisition and use will be compensated. For this purpose a Resettlement Action Plan as a stand alone report was developed that will be adopted when final design has been fixed.
Excavated material	■ ■ ■	Dumping of the excavated material is a big challenge of the Project. Because it is a run-of-river design with a long headrace tunnel a lot of material will be excavated. Dumping of this material has impacts on many issues as air quality, noise aspects, traffic, landscape, flora and fauna, tourist activities etc. Some of the material will be reused as concrete aggregates, for gabions and slope protection.
Traffic	■ ■	Needless truck movements will be avoided by proper truck management; dumping sites are selected close to the adits on the left river bank helping to reduce transportation routes. Near powerhouse conveyors may be used for transport of excavation material. Transport of excavated material through the City of Bahrein will be avoided. However, construction material and machines coming from Madian to the weir site have to cross the cities of Madian and Bahrein. Together with other projects going on in the region this will sum up to a considerable amount of traffic during construction.
Air quality	■ ■	The measures in order to reduce the traffic are suitable to reduce the negative impact on air quality (see traffic above). In addition, water shall be sprayed continuously to reduce dust emissions of construction activities.
Noise aspects (on public)	■ ■	The measures in order to reduce the traffic are suitable to reduce the noise impact on the public (see traffic above)
Ecology of Swat River	■	Only a short river section (about 240 m) will be diverted during the construction of the weir structure. Other parts remain untouched except for a short period when the coffer dams in the river will be closed. A certain sediment run off might occur during this time period.
Terrestrial fauna and flora	■ ■	Large areas for dumping the excavation material will be necessary. The area of the reservoir will be flooded and terrestrial habitats will disappear.
National parks, wildlife sanctuaries and other protected areas	O	No national parks or other protected land are located within the Project area.
Historical and cultural sites	O	No historical and cultural sites are located within the Project area. If archaeological remnants are found the construction work will be ceased immediately and the relevant archaeological authority will be informed.
Landscape	■ ■	Increased truck traffic and dust emission will influence the overall picture of the landscape.

CONSTRUCTION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Health and Safety of Workers	■	Proper workers' camp will be provided to the workers. A Health and Safety Plan for the construction period will be developed and implemented by the construction contractor. Training of workers will be performed regularly.
Solid and liquid wastes	■	Around 400 workers in peak periods will generate significant amounts of liquid and solid wastes. The liquid sanitation waste water will be treated at workers' camp site; proper dumping of solid waste will be the responsibility of the contractor.
Socio-economy	✦ ✦✦	Around 400 workers (skilled and unskilled) will find employment during the construction period in peak times. In addition, related services (hotels, shops selling articles for the daily life etc.) will benefit from the Project. Because of the very conservative social structures of population committed to principles of Islamic Shariah HIV/AIDS does not play any role and the adverse effects on the local community will be very limited.
Tourism	■	The construction activities will affect tourist activities in the Swat valley. However, hotel managers do not expect severe negative impacts on the number of tourists, whose number has already decreased because of the political situation. There is the hope that projects like Madian HPP will bring more stability to the region.
Resettlement actions	■	Following the positive statements given by the affected people and under precondition that the RAP is implemented appropriately, the impact caused by necessary resettlement actions is assessed to be low.

Table 11-1: Ranking of environmental impacts during the construction phase for the proposed Madian Hydropower Project under consideration of the proposed mitigation measures

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

It has to be pointed out that specific biomass removal measures of the inundated area will not be necessary because only a very small number of trees are growing in the reservoir area. Near the weir site, some 20 trees are growing, which will be cut down during construction of the weir.

OPERATION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Microclimate and GHG	✦ ✦✦	The effect on the microclimatic conditions will be minimal due to the small size of the reservoir surface. Most of the organic materials as trees, shrubs etc. will be removed before filling the reservoir. Compared to conventional thermal power generation significant reduction of CO2 emission will be achieved.
Swat River ecology	See discussion	As a matter of fact, the weir will act as an insurmountable barrier to migrating fishes causing fragmentation of fish populations. In the river reach between weir and power outlet the river flow is reduced. There will be a minimum water release also during the dry season (ecological flow). Due to this Project and when looking on the other hydropower projects in the Swat Valley in development the Swat River itself will undergo major alterations. It will be converted from a white water river to a cascade of headponds with river reaches in between where less water will flow than before. Very limited knowledge is available about the ecological features of the river; therefore no overall assessment is given. Please refer to Chapter 5.2.2.
Terrestrial fauna and flora	■	The reservoir represents a migration obstacle for big mammals. However, most of bigger animals have been disappeared since decade due to high population pressure (e.g. hunting).
Landscape	■	The character of the landscape down in the valley will be changed. A section of a fast flowing white water river will be converted into a lake.
Seismic aspects	■	The project will be designed to withstand the max. credible earthquake (MCE) without major damages and OBE-1 without damages.
Substations	■	Concerning EMF there will be no negative impacts on workers' health coming up. The handling of SF6 has to be done very carefully considering the presented guidelines outlined in Chapter 12.5.1.
Deposits from desander	■	The sand of the desander will be flushed regularly during times of high water. In winter time flushing will not be required.
Water-related vector diseases	■ ■	There might be an increase of water-related diseases after constructing the planned reservoirs in the Swat valley. In order to manage these health problems, a concerted action of all HPPs owners/operators together with relevant regional and national health authorities will be necessary. This has still to be agreed.
<u>Socio-economic aspects:</u> Employment	✦ ✦✦	The effect on employment of people during operational period will be limited. Some skilled and unskilled workers will find jobs during operation of Madian HPP.
Tourist activities	O	The angler attitude will change from white water fishing to fishing in a lake with other species as before. Other tourist activities will not be affected except for the landscape has changed. Overall it is assumed that the number of tourists will not decrease.

OPERATION PHASE		
Impact on/of	**Extent of impact**	**Comment**
Water supply downstream the weir site	■	The operation stage of the Project will not affect irrigation between the weir and the power house because the tributary steams/nullahs and springs are used for irrigation downstream of the weir. Downstream the power house there will be no alterations of the Swat River flow. Those households/hotels downstream the weir which use presently water from Swat River as drinking water, will be provided with clean drinking water as long s they are not connected to a drinking water system.

Table 11-2: Ranking of environmental impacts during the operational phase for the proposed Madian Hydropower Project under consideration of the proposed mitigation measures

Extent of impact:

■ ■ ■	=	high negative
■ ■	=	medium negative
■	=	low negative
o	=	nil
✦	=	locally positive
✦✦	=	regionally positive

Construction Phase

From the findings of the study as summarised above it can be seen that the high negative impact only results from dumping the excavated material during the construction phase. The amount of the excavated material can not be mitigated. It is a result of the prevailing topographic conditions and the need to construct a long headrace tunnel for development of a run-of-river hydropower plant to generate power. On the other hand, this kind of HPP reduces considerably the size of the reservoir that would have been much bigger in the case of a dam with storage for daily peaking operation.

The amount of excavated material affects many other environmental aspects as there are traffic, air quality, noise, landscape, terrestrial fauna and flora etc. Regarding these aspects, however, mitigation measures are possible. As a Consequence the project's impact on these aspects can be assessed to be medium. Further aspects are judged to be low negative or nil. Concerning socio-economic aspects, the impacts of the Project are locally and regionally positive. All these impacts are limited to the construction phase that will last about 4.5 years.

Operational Phase

During the operational phase no high negative impacts will occur. Main focus in the assessment is given on the ecology of the Swat River. However, the knowledge of the biology in the river is very limited. Consequently a general final assessment of the extent of the impact could not be given. But also without exact knowledge, it has to be stated that the actual ecology of the river will be changed considerably. A 1.5 km long reach of the Swat River will be converted into a lake (reservoir), in the subsequent 13 km long river reach flow

will be significantly reduced with all its consequences for the ecology, despite the fact that a minimum flow is released as 'ecological flow'.
This assessment will be amplified when the Swat River is subjected to the intended development of several additional hydropower plants. Because the environmental implications as discussed above are unavoidable and not to mitigate when constructing hydropower plants, decision makers have to weigh up between these impacts on the environment and the need for generation of power.

Regarding water-related vector diseases, the Project will cause medium impacts as long as there is no concerted programme established between all HPP's of the swat valley and the health authorities. For all other aspects during operational phase the impacts of the Project will be low negative or even positive.