POWER

Packages Power Pvt Ltd.

Schedule I

(Regulation 3(1))

FORM OF APPLICATION

The Registrar
National Electric Power Regulatory Authority
2nd Floor, OFP Building,
Sector G-5/2,
Islamabad

Subject: Application for a Generation License of Packages Power (Pvt.) Limited

I, Mr. Abdus Samad Goraya, Chief Executive Officer, being the duly authorized representative of Packages Power Pvt. Limited by virtue of BOARD RESOLUTION/POWER OF ATTORNEY dated Jan 26, 2018, hereby apply to the National Electric Power Regulatory Authority for the grant of a Generation License to the Packages power Private Limited pursuant to section 15 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

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

A PAY ORDER in the sum of Rupees 155,688/-, being the non-refundable license application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, is also attached herewith.

Date: May 3, 2018

PACKAGES POWER LIMITED LAHORE

ASGoraya

Mr. Abdus Samad Goraya

Designation CEO

Packages Power (Pvt.) Limited

Shahrah-E-Roomi, P.O. Amer Sidhu, Lahore-54760, Pakistan.
Ph: (042) 35811191-94, 35811541-46 Fax: (042) 35811195, 35820147.

Check List

For Examination of License Application of New Generation Facility (HYDEL)

Name of Company	Packages Power Private Limited
Power Generation Capacity	2.45MW
Prepared/Updated on	28-05-2018
Application	The Application is being filed pursuant to NEPRA (Application and Modification Procedure) Regulations 1999

Regulation No	Information/Document Required	Compliance/Remarks
3(1)	An Application for Generation License shall be made in the form specified in Schedule 1 to these rules. Authorization from Board of Directors Resolution / Power of Attorney	The Application is as per Format of Schedule 1. Authorization of Board of Directors (BOD) is attached with the application at **Annexure A (1).** Affidavit by the CEO is also attached at **Annexure A (2).**
3(3)	The Registrar shall not receive the application unless it is accompanied with the correct amount of application fee. (including indexation)	A pay order (B.C. No.: 3610869) amounting to PKR 152,448/- and a pay order (B.C. No.: 3729466) amounting to PKR 3,240/- in favor of NEPRA is attached with the Application in a separate sealed envelope.
3(4)	The Application for Generation License shall be submitted in triplicate	Three copies of the Application for the Generation License with supporting documents are hereby submitted.
3(5)(a)(i)	Copy of Certificate of incorporation	Certificate of Incorporation with SECP is attached with this Application as **Annexure B.**
3(5)(a)(ii)	Certified Copies of Memorandum and articles of association	Copy of Memorandum and Articles of Association attached with this Application as **Annexure C** and **Annexure D** respectively.
3(5)(a)(iii)	Copies of Last Filed Annual Return of the company	Annual Return of the company attached with this application as **Annexure E.**

3(5)(h)	Feasibility Report	Attached with this application at **Annexure J.**
3(5)(i)	Prospectus	Requisite information is available in Feasibility Report and attached at **Annexure J.**

Schedule III
Regulation 3(6) C, New Generation Facilities (HYDEL)

1	Location, Maps, Site Maps, Land	This raw site is located on BRBD Link Canal at RD 509+712 in District Kasur and nearly 50 km away from Lahore. The site is accessible by Ferozepur Road Lahore to Kasur Khem Karan Road which leads straight to Bambanwala Ravi Bedian Depalpur (BRBD) canal. The site is within 3.5 Km from Kasur City and easily accessible. Project location map is provided in **Drawing No. BRBD-HEPP-FS-1.1.**
2	Plant: Run of the River, Storage and Weir	Packages HPP is of Run of the River type as there is no water storage facility on canal.
3	Head: Minimum, Maximum	Min: Net Head 5.69 m Max: Net Head 7.38 m
4	Technology: Francis, Pelton, etc. size, number of units	Kaplan Turbine, 01 unit Bevel Gear Bulb Type Double Regulated Unit of 2.88 MVA Nominal Capacity.
5	Tunnel (if proposed): length, diameter	Tunnel is not required for Kasur HPP.

6	ESSA (Environmental & Social Soundness Assessment)	Three sets of the IEE Report duly approved by Punjab EPA submitted and attached herewith. ESSA is not applicable for this project.
7	Detailed feasibility Report	Three sets of Feasibility Report are attached herewith.
8	Resettlement issues	No such issues have been confronted as there is no population or house structure on project site.
9	Consents	• Initial Environmental Examination (IEE) got approved from EPA Punjab. Attached with this Application. • Remaining consents shall also be obtained as per Project Development Schedule.
10	Infrastructure Development	Provision for residential colony and roads, etc. has been included in the project Feasibility Report.
11	Interconnection with national grid company, length of transmission line(s)	Requisite Interconnection Study already conducted and attached herewith. Kasur 132/11 KV is the nearest LESCO Grid Station located at a distance of 06 km from the Power Plant.
12	Project Cost, information regarding sources and amounts of equity and debt	Total Project Cost: PKR 761.50 Million Debt Portion: 70% Equity Portion: 30%

13	Project Schedule, expected life	Major activities in Project Schedule include Feasibility Study and approval, Generation License, Issuance of LOS, EPC Design, EPC tendering, financing arrangements, financial close, construction, testing, commissioning and COD. Project time line of major activities are provided in **Annexure J, Section 10 Table 10.1** and **Figure 10.1.** Total Construction period will be 22 months and expected life is 30 Years.
14	Peaking/base load operation	The plant is of base load operation type as there is no Water storage facility on the BRBD canal.
15	Plant characteristics: generation voltage, power factor, frequency, automatic generation control, ramping rate, control metering and instrumentation	Generation Voltage: 11KV Transmission Voltage: 11KV Power Factor: 0.85 Frequency: 50 Hz For more details please refer to **Annexure J.**
16	System studies load flow, Short circuit, stability	System Studies such as Load Flow, Short Circuit & Dynamic Stability Analysis already conducted and three sets of the full report attached herewith.
17	Training and development	Training of E&M Staff will be arranged before COD of the Plant by the EPC Contractor and Turbine manufacturer.

1. BRIEF DESCRIPTION OF PROJECT

1.1 Background of The Project

Pursuant to "Punjab Power Generation Policy 2006 (Revised in 2009)", the Punjab Power Development Board (PPDB) invited expression of interest through advertisement dated May 30, 2016 for the development of 5 raw sites with the last date of submission of Statement of Qualification (SOQ) as June 30, 2016. On the basis of prequalification documents submitted by private firms/consortium, PPDB issued a Letter of Interest (LOI) to M/s Packages Private Limited on September 28, 2016 for the development of Hydropower Project on BRBD Link Canal utilizing the potential available at fall structure at RD 509+712.

Packages Limited has gained the right to develop this plant for which Packages Limited has incorporated a project specific SPV firm in the name of Packages Power Private Limited (PPPL). The feasibility study has been prepared by M/s AIPEL that demonstrate the technical and financial viability of the project.

1.2 Grounds for Application

Under the "Regulation of Generation, Transmission and Distribution of Electric Power Act (XL of 1997), hereinafter referred to as the NEPRA Act, and the rules and regulations framed thereunder, a Generation License is required to be obtained from the National Electric Power Regulatory Authority (NEPRA) for operation of an electric power generation facility. Pursuant to it, **Packages Power (Pvt.) Limited** (the "Company") intends to obtain a Generation License for its 2.45 MW Kasur Hydropower project having generation facility on BRBD Link Canal at Kasur, Punjab province.

1.3 Details Of The Applicant And Project Sponsor

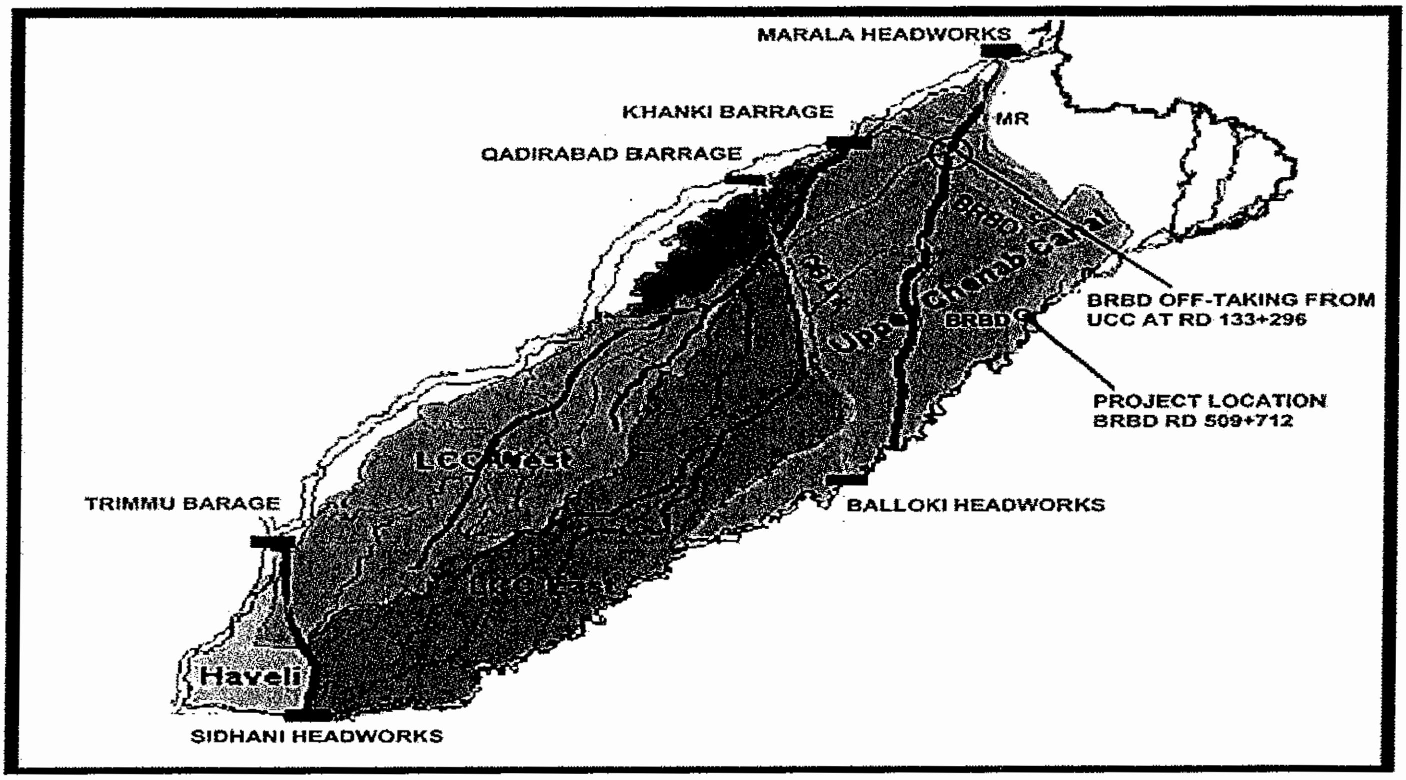
DETAILS OF THE APPLICANT	PACKAGES POWER (PVT.) LIMITED Shahrah-e-Roomi, 45760, Lahore Phone: 042-35811541-46, Fax:042-3583511191
Location of the Project	Kasur, Punjab
Project Sponsors	Major sponsors/shareholders is M/s Packages Limited
Representative of Packages Power (Pvt.) Limited	Abdus Samad Goraya

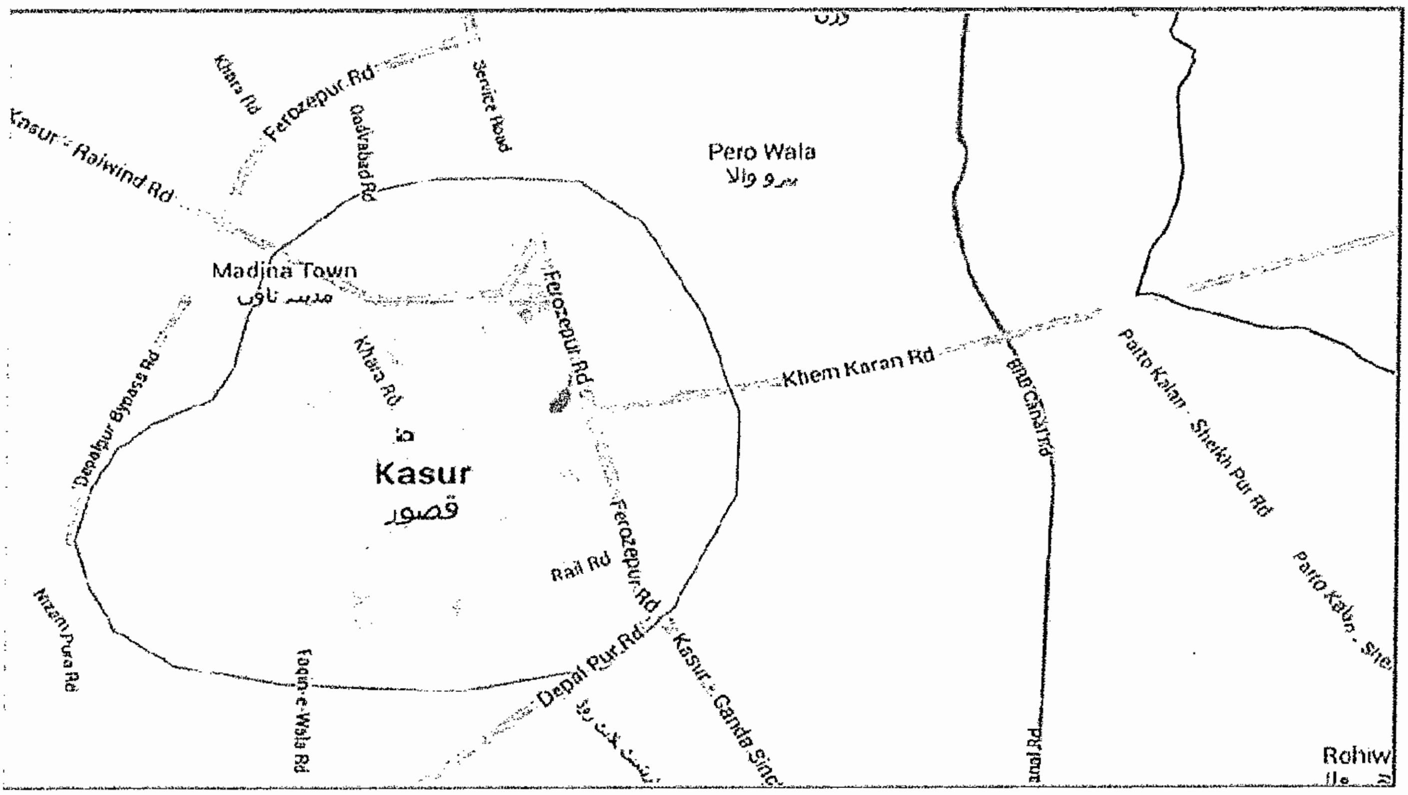
ASG

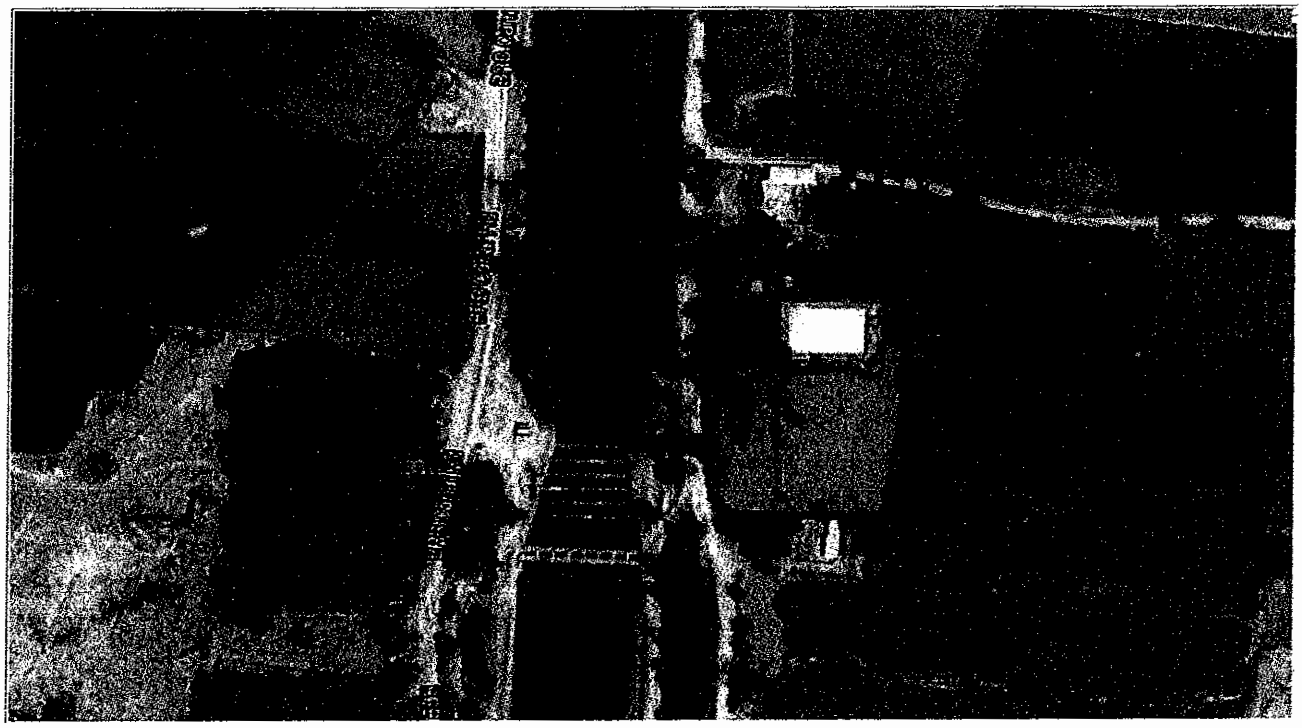
1.4 SALIENT FEATURES OF THE FACILITY

Project Name	Kasur Hydropower Project	
Sponsor	Packages Power Private Limited	
Location	RD 510+600, District Kasur, Punjab	
River System	BRBD Link Canal	
Current Status of Project	Feasibility Submitted and approved by PPDB Initial Environmental Examination Study is approved by EPA Punjab Letter from LESCO that all comments are incorporated and final report is vetted.	
Key Design Parameters	Design Discharge	50 Cumecs
	Gross Head	5.87 m
	Net Head	5.77 m
Power & Energy	Installed Capacity	2.45 MW
	Total Annual Energy	10.73 GWh
	Net Annual Plant Factor	50.02%
Estimated cost of the project	PKR 761.50 million including IDC	
Debt/Equity Proportion	70% : 30%	
Average cost of generation	8.005 Rs./KWh	
Project Construction Duration	22 Months	
-Project Major Components	Powerhouse (Located at RD 510+600)	
	Power House	01 Bevel Gear Bulb Type Double Regulated Unit
		20 Tons OH Crane
		Generator Room, Loading Bay etc, switchyard
	Access Road + O&M Accommodation + Spillway (equipped with Radial Gates) & all auxiliary electromechanical equipment's	

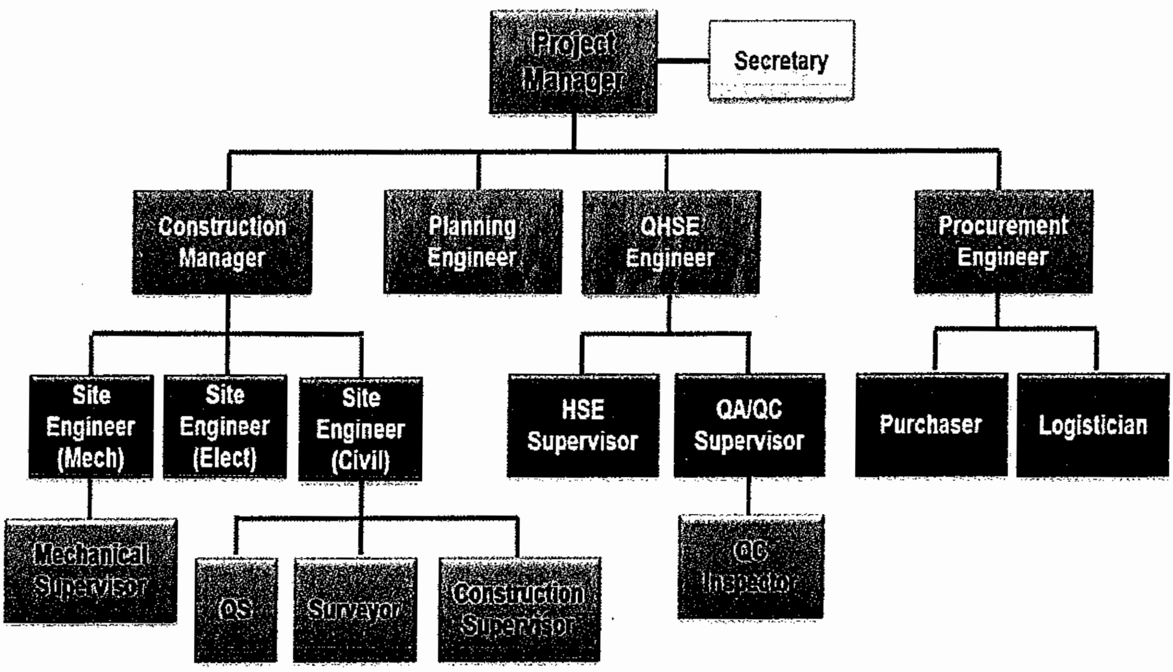
1.5 Location and Maps







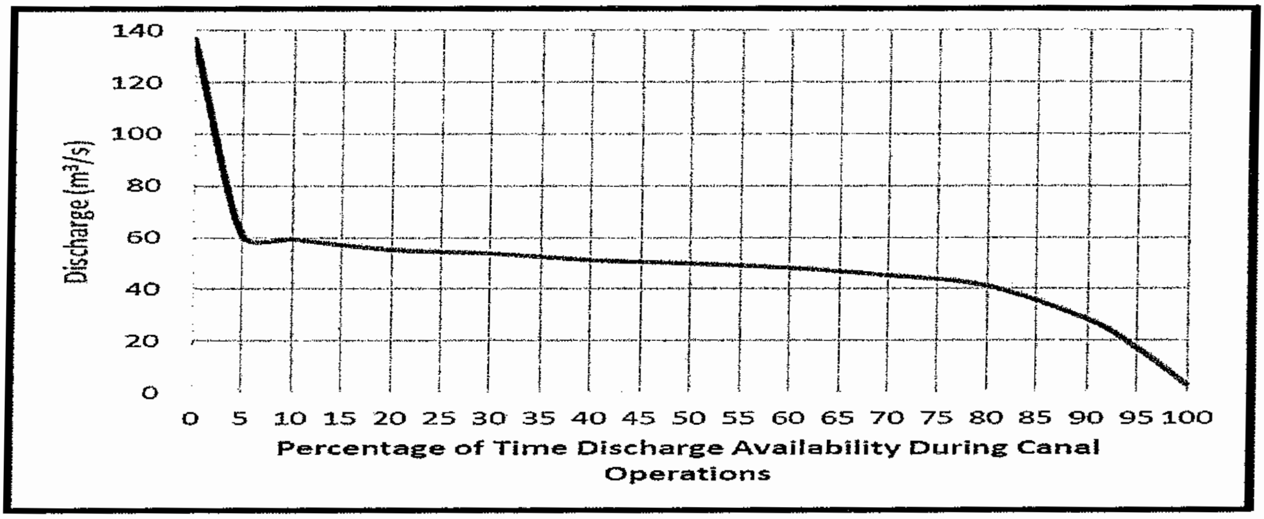
1.6 ORGANIZATIONAL CHART



2. TYPE, TECHNOLOGY, MODEL, TECHNICAL DETAILS AND DESIGN OF THE FACILITIES

2.1 Design of the Facilities

Flow duration curve for 2.45 MW Hydropower project is provided in below figure. The discharge of 35 m^3/s, 40 m3/s, 45 m3/s and 50 m3/s during canal operations at RD 509+712 of BRBD Link Canal is available for a duration of 85.1%, 80.4%, 70.7% and 49.5% of the time respectively during canal operations.



2.2 Powerhouse Equipment

Preliminary mechanical equipment has been selected to suit the project location and tentative size of the powerhouse. Both the basic design of the equipment and the requirements of IEC has been taken into account. At this stage, preliminary data from the supplier from the European Origin is also obtained and considered for technical parameters and cost estimation. During detail design stage, the data of selected supplier will enable to furnish a comprehensive study for final selection of all equipment.

2.3 Turbine Selection

The type, geometry and dimension of the turbine will be fundamentally conditioned by various criterions such as:

- Net head
- Range of discharges through the turbines
- Turbine rotational speed
- Cavitation problems
- Cost

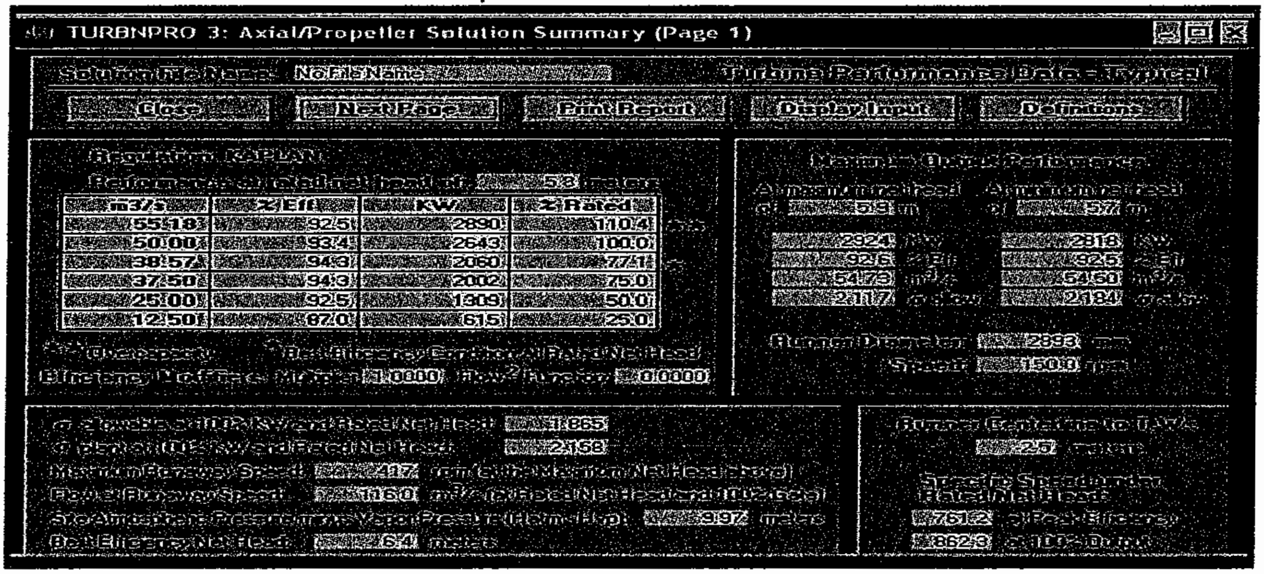
Considering operating net head of 5.77 m, rated flow of 50 m3/sec with the availability of monthly net flows, only Kaplan type of turbines are most suited. Kaplan Horizontal Pit Type Unit, Bulb Type or Bevel Gear Bulb Type could be considered depending on the suitability of the plant, economic benefits and different manufacturers. In order to provide an appropriate option, a comparison was made between Kaplan Bulb Type and Kaplan Pit Type units and ultimately it was concluded that bulb type is a compact solution with minimum civil components and smaller size of the powerhouse. Therefore, bulb type unit is selected for onward study. Main characteristics of bulb type unit are mentioned below:

- High speed generator
- Short installation time
- Compact power house structure
- LV (Low Volt) Application of 400 or 690V

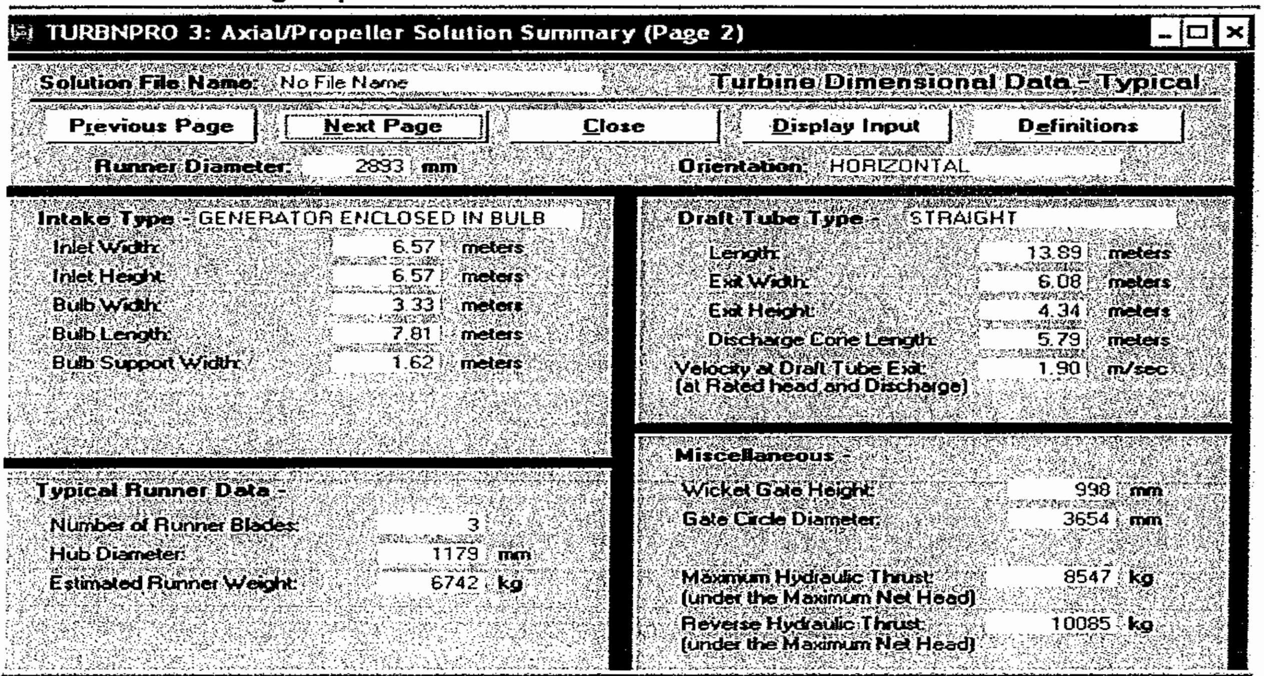
Turbnpro and solid edge softwares have been used while calculating the main characteristics of turbine. Meanwhile a comparison between one and two units is also provided in Table below.

Parameters	Unit	No of units	
		1	2
Q design/rated	m3/s	50	26
H rated	m	5.77	5.77
P rated power (Turbine output per unit)	KW	2924	1404
Runner diameter	mm	2893	2038
Rated speed	rpm	150	214
Specific speed (Ns)	rpm	761	768
Estimated Runner weight	Kg	6742	2430
Turbine Inlet width x height (WxH)	m	6.57x6.57	4.63x4.63
No. of runner blades	Nos	3	3
Bulb width x length x bulb support width	m	3.33x7.81x1.62	2.34x5.54x1.14
Bulb			
Draft tube total Length (L)	m	13.89	9.78
Draft tube outlet width x height (WxH)	m	6.08x4.34	4.28x3.06

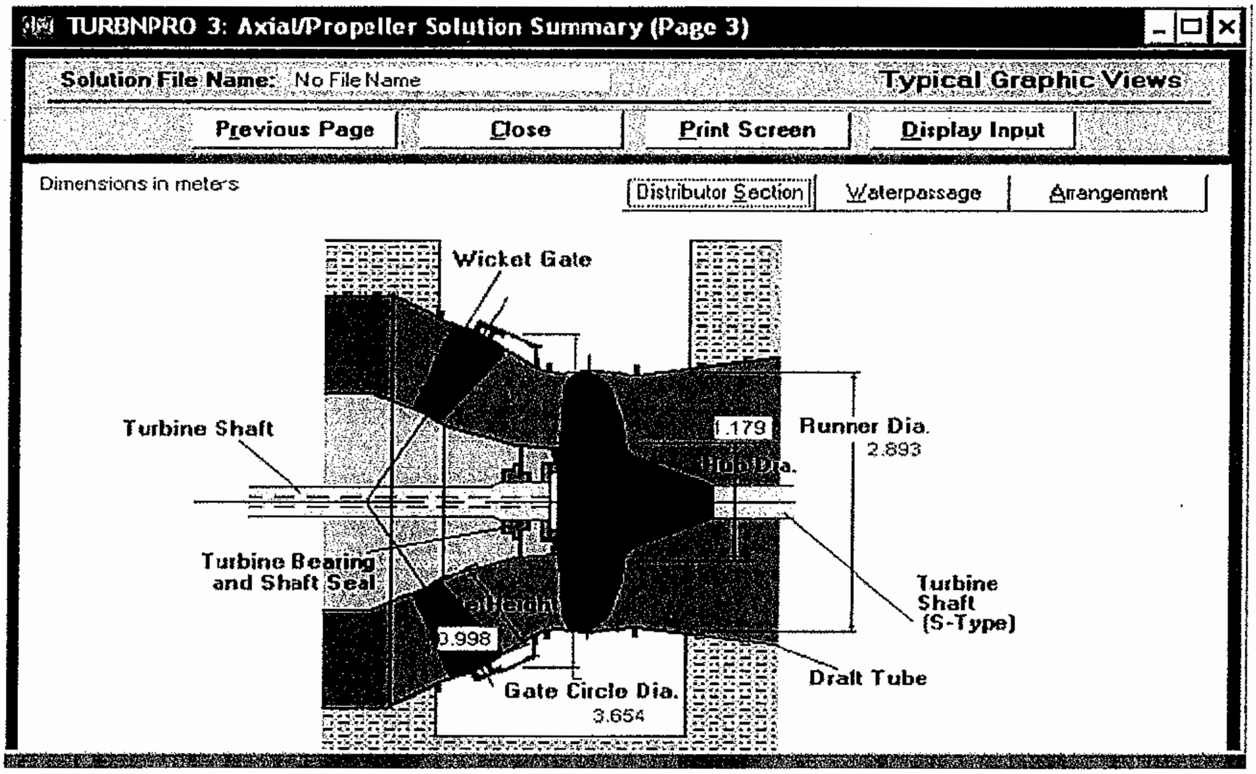
2.4 Turbine Performance and Input data



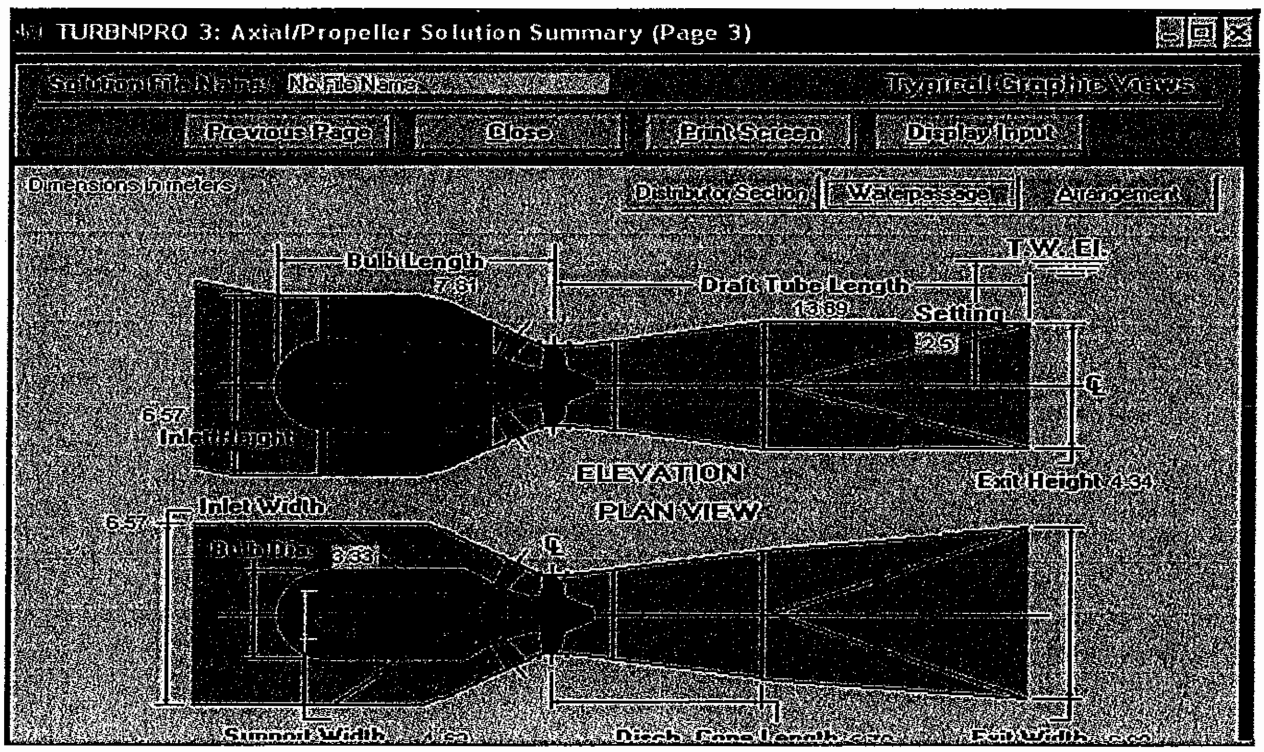
2.5 Turbine Design Input



2.6 Turbine Dimensional Data



2.7 Turbine Dimensional Data



2.8 Salient Features of Generator

Salient features of the generators are as follows

No of units	01
Nominal capacity	2.88MVA
No of poles	40
Generation voltage	11kV
Power facto	0.85
Nominal speed	150 rpm
Runaway speed	417 rpm
Insulation class	F
Temperature rise class	B
Ambient temperature	50Co
Protection class	IP44
Efficiency	97%
Cooling of stator and rotor	Air-cooled, self-ventilated, with Air/water heat exchangers.
Excitation system	Static type
Excitation voltage	Static, 220 V DC
Range of voltage variation	+/- 5 %
Range of frequency variation	+/- 3%
Stator winding Connection	Y, Neutral Grounded through resistance
Cooling	Closed Circuit, air cooled
Transient reactance Xd'	To be determined by the manufacturer
Sub transient reactance	To be determined by the manufacturer
Bearings	Guide & Thrust bearings
Braking system	Mechanical/Electrical
Firefighting system	Automatic CO2 system

2.9 Automatic Voltage Regulator (AVR)

The control of generator voltage shall be affected by comparing continuously the generated voltage with a reliable reference voltage. Adjustment of the reference voltage set point shall be performed locally by a switch on the AVR front, or remotely by a voltage signal. Adjustment range of the AVR shall be 80% to 120% of the generator rated voltage. The AVR shall respond quickly and accurately to any fluctuation in generator load including sudden application or throw-off of load. The static accuracy shall lie within the range of ± 0.5% of the set value of the generator. The generator voltage shall be maintained at or below 110% of rated value with the generator disconnected and at maximum over-speed.

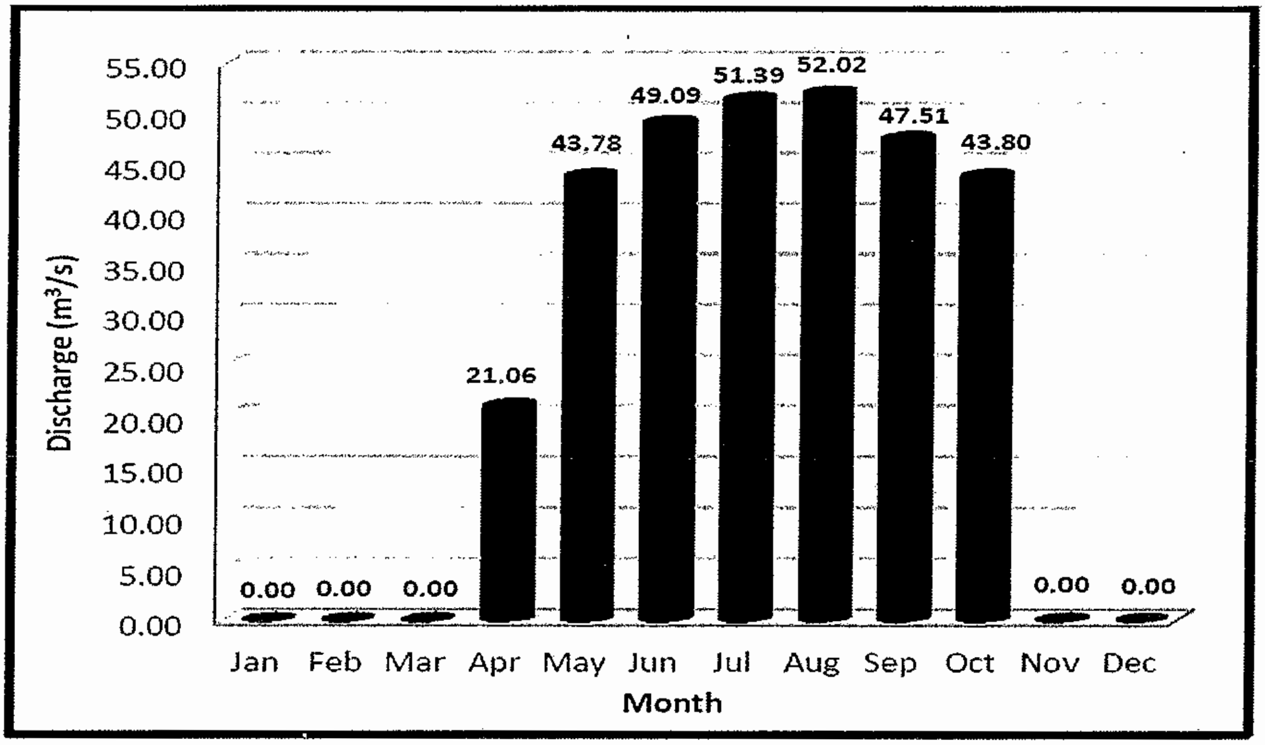
The AVR shall include a power swing stabilizer unit with adjustable parameters. The AVR shall include a separate manual voltage regulator consisting of electronic circuit for constant excitation current control. The constant current regulator (CCR) shall be for use during energizing of transmission line and when the AVR is out of order for some reason. The AVR and CCR shall be realized as two physically separated and independent acting electronic circuits.

3. FUEL TYPE OF THE PROPOSED PROJECT

2.45 MW Kasur hydropower project is a renewable energy project and its fuel is canal water. Below is the description of hydrology.

3.1 Hydrology

The hydrological data of Bambawali Ravi Bedian Canal (BRBD) at RD 509+000 is unavailable as discharge is not being observed at RD 509+000. Accordingly, the hydrological data of RD 434+000 for the period 2000 to 2016 (17-Years) have been analyzed as there is no distributary/outlet between RD 434+000 & RD 534+000. The hydrological data at RD 434+000 is presented in feasibility study report which is attached in Annexure J. BRBD is a non-perennial canal due to which the discharge in this canal is only available from April to October every year. According to the hydrological data, the mean monthly discharges vary from 21.06 m^3/s to 52.02 m^3/s from April to October. The mean monthly discharges are elaborated through below Figure. The average annual discharge is 25.72 m^3/s.



4. Emissions Control System

Hydropower project normally has the lowest greenhouse gas emissions for power generation. Since Hydropower plants do not use fuel, power generation does not produce any sort of hazardous emissions.

The following mitigation measures will be implemented at the proposed construction site during construction to control the emission of particulate matter:

- Water will be sprinkled daily or when there is obvious dust problem on all exposed surfaces to suppress emission of dust. Frequency of sprinkling will be kept such that the dust remains under control, particularly when wind is blowing towards the community.
- Dust emission from soil piles and aggregate storage stockpiles will be reduced by covering the piles, for example with tarpaulin or thick plastic sheet, to prevent emission.
- Construction material that is susceptible to dust generation will be transported only in securely covered trucks to prevent dust emission.

5. COOLING WATER SYSTEM

5.1 COOLING WATER SYSTEM

The generator for the project shall be air cooled and self-ventilated by axial or radial ventilation through the rotor itself acting as a fan. The air will be re-cooled by air/water heat exchangers situated outside the stator housing. Through this design a closed air loop system inside the generator pit is achieved thus avoiding pollution through atmospheric impurities. The water-cooling systems for the generator will be split into two independent systems:

- One for the oil circuits for the bearings of generator and turbine and
- One for the air/water cooling of the generator and the unit step-up transformers

The generators shall be protected by an electrical heating system to prevent them from damages during periods of standstill. To avoid water condensation during long no operative periods of the machine, heating elements shall be installed in the air circuit and in the excitation cubicles. These elements shall be connected to the 400/230 V A.C., 50 Hz power source, via contactors.

5.2 COOLING SYSTEM OF TRANSFORMER

It is proposed to use the oil natural & air forced cooling system (ONAF) for the transformer. The air fans will be controlled from thermal detectors within the transformer tank Reserve fans in the cooling system shall be provided so that failure of two fans will not shut down the transformer. The number of fans shall be selected by the manufacturer. Structural details of the civil engineering design shall take into consideration a good airflow to the transformer location, so that no accumulation of high temperature air volume takes place.

5.3 INFRASTRUCTURE

All infrastructure e.g., road, sewerage, water supply, electric supply, gas etc. already exist in the project area. The project is an environmental friendly site. There will be not wastewater and solid waste because the Hydropower technology is itself environmental friendly and sustainable which use the water resource for production of energy.

6. ENVIRONMENTAL & SOCIAL SOUNDNESS ASSESSMENT (ESSA)

Keeping in view, all the findings of Initial Environmental Examination study, and through general observation and desktop study, and understanding of the activities and processes involved in the project, environmental impacts have been anticipated. Weather describes an impact as having both spatial and temporal impacts, which can be described as the change in an environmental parameter over a specified period and within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been initiated. A hydropower project doubtlessly causes substantial landscape changes i.e creation of artificial reservoirs, and occurrence of waste dumps, power lines, access roads and also the use of the water resource characteristics are changes, local people possibilities to use the rivers might be deteriorate.

The expected impacts from the project are mostly insignificant and others are of limited nature. In this regard possible improvements and mitigation measures have been taken and at the site where these activities related to this plant happen, there is proper collection of waste and its disposal, and there is no need of the artificial reservoir, because on canal, power plant is constructed. The study also shows that there will be no exploitation and consequential depletion of the local natural resources.

The general approach to Environmental Management Plan for the Project, for the operational phase of the Project has been presented, along with an outline plan for the Project Environmental Management Plans (EMPs). Site specific and practically suitable mitigation measures are recommended to mitigate the impacts

6.1 Green technology

The technology used in the proposed project is categorized under clean and efficient which will eventually improve the quality of local environment and promote sustainable use of natural resources.

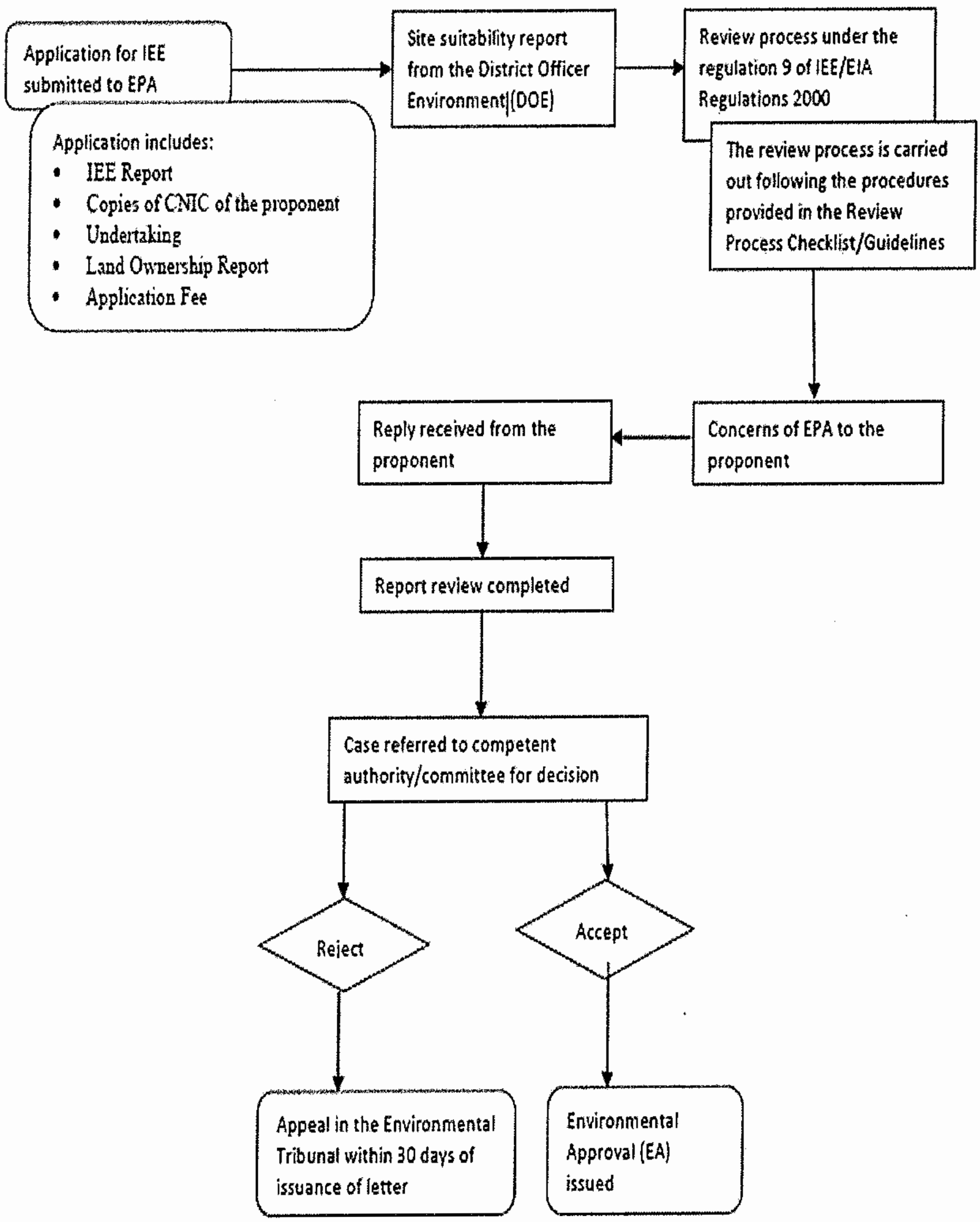
6.2 Proposed Monitoring:

Monitoring at the proposed site has been conducted for ambient air, noise, water and the reports demonstrated that results are within the limits prescribed by PEQS (2016). The detail of these parameters is present in baseline study of project and lab reports are attached herewith this IEE report attached in Annexure L.

PACKAGES POWER LIMITED * LAHORE

6.3 IEE Flow Chart

Additionally, a detailed IEE process flow chart is presented below is captioned.



7. SAFETY & EMERGENCY PLAN

7.1 Fire Protection

A complete central automatic carbon dioxide fire extinguishing system is proposed for the protection of single generator. It is recommended to keep trolley mounted CO2 Cylinders of 10 & 25 kg capacity to protect any equipment from fire hazards at various areas of the power plant e.g. the machine room, control room, and Auxiliary equipment room, 11kV panel hall etc. Similarly, sufficient number of foaming liquid Cylinders shall also be provided. The actual No of CO2 Cylinders shall be determined at the final design stage.

7.2 FIRE PROTECTION FOR TRANSFORMER

Transformers shall be installed outside of the power house building, so that the most favorable solution for this type of protection will be the water sprinkle system. An adequate tank reserve of pressurized water is needed for this purpose. AC/DC driven pumps of suitable capacity should be included to keep the dimensions of the storage tank economically small. An adequate volume of the oil reception basin underneath transformer is required. Gravel shall cover the surface of oil receipt. The require dimensions shall be evaluated at the final design.

7.3 Protections

In order to ensure reliable function of the Generator, Transformer and Transmission line, following protections shall be included

7.3.1 GENERATORS & TUBUNES

- Stator turn to turn fault
- Loss of excitation
- Time over current
- Temperature (thermo detector)

Negative sequence current

- Loss of input (Anti-motoring)
- Loss of synchronism
- Backup over current
- Bearing temperature high
- Unit over speed
- Governor oil pressure low

7.3.2 STEP-UP TRANSFORMERS

- Winding temperature high (for hot spot)
- Oil temperature and level control
- Buchholz protection
- Three phase over current protection as back up device.
- Restricted ground fault protection
- Differential over current
- Oil level and temperature indications

7.3.3 11 KV TRANSMISSION LINE

- Over current protection
- Earth fault protection
- Breaker failure protection

The necessary protections for generators, power transformers and transmission line shall be finalized at the final design stage.

7.4 EMERGENCY DIESEL GENERATOR SET

It is proposed to incorporate a stand-by diesel generator set of suitable capacity (100kVA) fully able to supply to auxiliaries of the unit during the time of a black start. However, the rating of the D.G set shall be finalized at the time of final design keeping in view the actual auxiliary load requirements of the unit plus 15% of this load as a safety margin.

8. CONTROL METERING, INSTRUMENTATION & PROTECTION

8.1 The Existing and Ongoing Network

The nearest existing LESCO interconnection facilities at the time of commissioning of Kasur Hydro Power Project would be as follows:

- 132 KV Kasur substation
- 132 KV Kasur-New substation

There are multiple feeding points in the vicinity which provides reliability and voltage support to the system. All substations provide a strong 220 KV and 500 kV network around the proposed plant.

The schemes of interconnection of Packages

The interconnection scheme would be 6 km 11 kV double circuit to 132 kV Kasur G/S from proposed Packages Power Plant using Osprey conductor. One circuit is to be connected to Kasur 132 /11 kV T-1 and the other is to be connected to Kasur 132/11 kV T-2.

The proposed scheme will require the following equipment at 11 kV switchgear of packages PP.

- One breaker panels of 11 kV for connecting One generating units
- Two 11 kV breaker/line lays need to be added with 11 kV Bus Bar of packages PP.

Packages Power Pvt Ltd.

Date: 2[illegible]st June, 2018

The Registrar
National Electric Power Regulatory Authority
2nd Floor, OFP Building,
Sector G-5/2, Islamabad

Attention: Mr. Iftikhar Ali Khan, Director Registrar Office

Subject: Application of Package Power (Pvt) Limited for grant of Generation License in respect of 2.45 MW Kasur Hydropower Project District Kasur

This is in continuation of our earlier letter dated 8th Jun 2018 **(Annex-I)** and telephonic conversation on June 14th, 2018 with DG Licenses Mr. Imtiaz Baloch, it is intimated that Punjab Power Development Board (PPDP) has issued Letter of Interest (LOI) to M/s Packages Private Limited on September 28, 2016 for the development of 2.45 MW Hydropower Project on BRBD Link Canal Kasur. In its pursuance, while submitting the feasibility study of the project, M/S Packages Power (Pvt) Limited has given an undertaking to develop the project by opting Up-front tariff determined by NEPRA for small hydel power projects up to 25MW installed capacity. M/S Package Power (Pvt) Limited requested LESCO to provide consent for procurement of power.

The Customer Service Directorate LESCO has provided consent for procurement of power vide letter No 5694-98 dated 06.04.2018 **(Annex-II)**, whereas the extended date for option for accepting Upfront Tariff by small hydro power projects expired on 27th March 2018. This is because of the reasons, M/S Package Power (Pvt) Limited could not apply to NEPRA; for opting acceptance of Upfront Tariff, as intended previously, while submitting feasibility study to the PPDB for approval.

The GoP has now amended NEPRA Act, 1997 which encourages the power producers to sell power to the BPC through bilateral agreements by using wheeling of power facilities of the related distribution company. Therefore, M/S Packages Power Pvt. Limited intends to sell the electricity generated by 2.45 MW Kasur Hydropower Project to Bulleh Shah Packaging (Pvt.) Limited (The Bulk Power Consumer) by using distribution facilities of LESCO against wheeling charges approved by the authority; abiding by terms and provision of NEPRA (Wheeling of Electric Power) Regulations 2016. The letter of consent by BPC to purchase generated electricity is attached at **Annex-III**.

We are currently in a process of applying to LESCO for use of its distribution facilities in Kasur area for the purpose of supply of electricity generated by 2.45 MW Kasur Hydropower Project to Bulleh Shah Packaging (Pvt.) Limited under NEPRA (Wheeling of Electric Power) Regulations 2016.

Based upon the above understanding, please process our aforementioned application for grant of Generation License.

AS Goraya

A. Samad Goraya
Chief Executive
Packages Power (Pvt.) Limited

Shahrah-E-Roomi, P.O. Amer Sidhu, Lahore-54760, Pakistan.
Ph: (042) 35811191-94, 35811541-46 Fax: (042) 35811195, 35820147.

Annexure A (1): Authorization of Board of Directors

PACKAGES POWER (PRIVATE) LIMITED

TRUE COPY OF THE BOARD RESOLUTION OF PACKAGES POWER (PRIVATE) LIMITED DATED 26 JANUARY 2018

Authorization to execute and sign singly all documents and applications to National Electric Power Regulatory Authority (NEPRA), Lahore Electric Supply Company (LESCO), Punjab Power Development Board (PPDB) and any other regulatory authority

Mr. Abdus Samad Goraya, Chief Executive Officer of the Company, apprised the Board that in respect of the Hydel projects being undertaken by the Company, it is required to submit various documents and applications to the National Electric Power Regulatory Authority (NEPRA), Lahore Electric Supply Company (LESCO), Punjab Power Development Board (PPDB), Pakhtunkhwa Energy Development Organization (PEDO) and any other Regulatory Authority.

The Board considered the matter and **RESOLVED THAT** the Chief Executive Officer of the Company be and is hereby authorized singly to execute all documents and applications to the National Electric Power Regulatory Authority (NEPRA), Lahore Electric Supply Company (LESCO), Punjab Power Development Board (PPDB), Pakhtunkhwa Energy Development Organization (PEDO) and any other Regulatory Authority in relation to hydel projects being undertaken by the Company.

SPECIMEN:

A S Goraya

ABDUS SAMAD GORAYA

Packages Power (Private) Limited

Certified true copy

Company Secretary

Registered Office:
4th FLOOR, THE FORUM, SUITE NO. 416-422, G-20, BLOCK 9, KHAYABAN-E-JAMI, CLIFTON, KARACHI – 75600, PAKISTAN
PH: (021) 35378650-52, 35874047-49, 35831618, 35833011. FAX: (021) 35860251

Head office:
SHAHRAH-E-ROOMI, P.O. AMER SIDHU, LAHORE-54760, PAKISTAN
PH: (042) 35811191-94, 35811541-46 FAX: (042) 35811195, 35820147

PACKAGES POWER LIMITED LAHORE POWER

POWER

Packages Power Pvt Ltd.

Resolution of Board of Directors of

Packages Power (Pvt.) Limited

In the 6th Board meeting held on Jan 26, 2018, the following resolution was passed by the Board members unanimously, extract of resolution is given below

1. RESOLVED that the draft 'Application for Grant of Generation License for 2.45 MW Hydropower project at Kasur Canal, Punjab' is hereby approved for submission to the National Electric Power Regulatory Authority (NEPRA);
2. RESOLVED that [Abdus Samad Goraya], [CEO] , is hereby given the mandate and authorized to sign and submit to National Electric Power Regulatory Authority (NEPRA) or to its authorized nominee, for and behalf of the company and to proceed with and make any correction and amendment, if required, in finalizing the Application for Grant of Generation License for 2.45 MW Hydropower project, BRBD link canal RD 510+600 District Kasur, Punjab, as per draft attached with the request for approval paper, prior to its submission to NEPRA;
3. RESOLVED that [Mr. Abdus Samad Goraya] is hereby authorized to sign the Application for Grant of Generation License for 2.45 MW Hydropower project, District BRBD link canal District Kasur Punjab, for and on behalf of the Company; and
4. RESOLVED that these Board Resolutions shall remain in full force and effect until an amending resolution shall be passed by the Board.

- Certified to be true copy of the Board Resolution passed through circulation

AS Goraya

PACKAGES POWER LIMITED LAHORE

Shahrah-E-Roomi, P.O. Amer Sidhu, Lahore-54760, Pakistan.

A022446

SECP

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

COMPANY REGISTRATION OFFICE, KARACHI

CERTIFICATE OF INCORPORATION

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

Corporate Universal Identification No. 0102957

I hereby certify that PACKAGES POWER (PVT.) LIMITED is this day incorporated under the Companies Ordinance, 1984 (XLVII of 1984) and that the company is limited by shares.

Given under my hand at Karachi this Twentieth day of October, Two Thousand and Sixteen.

Incorporation fee Rs. 401,000/= only

(Zia ul Rasheed Abbasi)
Joint Registrar of Companies
Karachi

PACKAGES POWER LIMITED * LAHORE * POWER

Annexure C : Memorandum of Association

PACKAGES POWER LIMITED * LAHORE *

THE COMPANIES ORDINANCE, 1984
(Company Limited by Shares)

MEMORANDUM OF ASSOCIATION
OF
PACKAGES POWER (PRIVATE) LIMITED

I. NAME

The name of the Company is Packages Power (Private) Limited (the "**Company**").

II. REGISTERED OFFICE

The registered office of the Company will be situated in the Province of Sindh, Pakistan.

III. OBJECTS

The objects for which the Company is established are to undertake any or all of the following:

1. To carry on the business of establishing, operating and managing electric power generating projects and transmission systems for the generation and supply of electric power, in any manner that may be deemed necessary and expedient by the Company, including but not restricted to setting up of thermal power plants, wind power plants, hydroelectric power plants, solar power plants, biomass power plants, biogas power plants, other renewable energy plants and to manufacture, assemble, acquire and supply all necessary power stations, transmission systems, control systems, cables, wires, lines, accumulators, lamps and works to generate, accumulate, distribute and supply electricity to customers, both public and private, including but not limited to villages, cities, towns, streets, docks, markets, theatres, buildings, industries, plants, utilities and places, both public and private, and for all other purposes for which energy can be utilized or is required, subject to permission from the relevant authority/NEPRA.

2. To acquire, manufacture, produce, use, sell and supply electricity for lighting, heating or power purposes and to deal with, manufacture and render saleable all residual products obtained in the production of electric power subject to permission from the relevant authority/NEPRA.

3. To enter into any arrangements with the Government of Pakistan, Provincial Governments, the Alternative Energy Development Board or its successors-in-interest, Private Power & Infrastructure Board or any other Federal or Provincial department, operating under Ministry of Water & Power or any autonomous/semi -autonomous body and or with private sector power consumers/buyers for the purpose of providing, generating and distributing power and energy, if any or any other provincial or local government or with any supreme, national, municipal or local authority, autonomous region if any or with any person, and at any place where the Company may have interest that may seem conducive to the Company's objects, or any of them in any mode and to obtain from such government or authority, or other persons any right, privilege and concession which the Company may think is desirable to obtain and to carry out, exercise and comply with any such arrangement, right, privilege and concession.

4. To purchase or otherwise acquire, generate, sell, supply, market, distribute and transmit electric energy and perform services, operations and maintenance related thereto and to provide operations and maintenance services to any other power company in the business of generation, distribution and transmission of electric power or do all such other things as may be deemed incidental or conducive to the attainment of the said objects or convenient or advantageous in connection therewith, subject to permission from the relevant authority/NEPRA.

5. To locate, establish, construct, equip, operate, use, manage and maintain hydroelectric power plant, power grid station, transforming, switching, conversion, and transmission facilities, grid stations, cables, overhead lines, sub-stations, switching stations, tunnels, cable bridges, link boxes, heat pumps, plant and equipment for combined heat and power schemes, offices, computer centers, shops, dispensing machines for pre-payment cards and other devices, showrooms, depots, factories, workshops, plants, printing facilities, warehouses and other storage facilities, subject to permission from the relevant authority/NEPRA.

6. To carry on all or any of the businesses of wholesalers, retailers, traders, importers, exporters, suppliers, distributors, designers, developers, manufacturers, installer, filters, testers, repairers, maintainers, contractors, constructors, operators, users, inspectors, reconditioners, improvers, alterers, protectors, removers, hirers, replacers, importers and exporters of and dealers in, electrical appliances, systems, products and services used for energy conservation, equipment, machinery, materials and installations, including but not limited to cables, wires, meters, pylons, tracks, rails, pipelines and any other plant, apparatus equipment, systems and things incidental to the efficient generation, procurement, transformation, supply and distribution of electricity.

7. To undertake the business of consultants, and to grant rights or privileges in respect of, or otherwise deal with all or any part of the property and rights including engineering, designs, intellectual and tangible property, and to establish laboratories, research and development centers to perform such research and development as the Company may deem advisable or feasible, and to expend money or experimenting upon and testing and improving or securing any processes, patent or protecting any invention or inventions which the Company may acquire or propose to acquire or deal with.

8. To ascertain the tariff for bulk supply that will secure recovery of operating costs, interest charges and depreciation of assets, redemption at due time of loans, expansion projects, payment of taxes, and return on investment, to quote the tariff to bulk purchasers of electrical power, and to prefer petition to the appropriate authority for approval of the schedule of tariff and of adjustments or increases in its bulk supply tariff, where desirable or necessary.

9. To construct, own, purchase, acquire, take on lease, build, erect, install, establish, operate, manage and maintain plants, laboratories, equipment, apparatus and other facilities for the generation, transmission, sale and distribution of electrical energy and its allied parts, equipment and resources.

10. To import, buy, own, install or otherwise procure plants, machineries and other equipment and to forge machine parts in the Company's workshop or to take on rental plants, machineries and other equipment for the purposes for which the Company is established and/or dispose of such plants, machineries and spare parts which have becomes obsolete or worn out.

11. To pay all costs, charges and expenses, if any, incidental to the promotion, formation, registration and establishment of the Company.

12. To acquire or undertake the whole or any part of the business, goodwill, and assets of any person, firm or company carrying on or proposing to carry on any of the business which the Company is authorized to carry on and as part of the consideration for such acquisition to undertake all or any of the liabilities of such person, firm or company, or to acquire an interest in, amalgamate with, or enter into partnership or into any arrangement for sharing profits, or for cooperation, or for mutual assistance with any such person, firm or company, or for subsidising or otherwise assisting any such person, firm or company, and to give or accept, by way of consideration for any of the acts or things aforesaid or property acquired, any shares, debentures, debenture stock or securities that may be agreed upon, and to hold and retain, or sell, mortgage, and deal with any shares, debentures, or debenture stock so received.

13. To acquire, purchase, take on lease, hire, exchange, sell transfer, convey or dispose of any moveable and immovable property rights and privileges on such terms and conditions as the Company may think necessary or convenient for the purposes of its business, and to manage, construct, repair, develop, mortgage, charge, sell, turn to account, grant licences, options and rights and privileges in respect of or otherwise deal with all or any part of the property and rights of the Company necessary or convenient for the purposes of the business of the Company.

14. To enter into agreement(s) with any individual, firm, co-operative or other society, company, corporate body, Government or local authority or other legal entity necessary or expedient for the purpose of carrying on the business of the Company.

15. To purchase or otherwise acquire become interested in, deal in and with, invest in, hold, sell, mortgage, pledge or otherwise dispose of, turn to account or realize upon, all forms of securities, including stocks, bonds, debentures, notes, evidences of indebtedness, securities of any nature or form convertible into all exchangeable for other securities of any nature or forms, certificates of interest, participation certificates, voting trust certificates and certificates evidencing shares of or interest in trusts and trusts estates or associations, certificates of trust of beneficial interests in trust, mortgages and other instruments, securities and rights but not to act as an investment company.

16. To institute, participate or promote commercial, mercantile and industrial enterprises and operations directly or indirectly related to power sector or otherwise.

17. To supply to any transmission and distribution companies, governmental or autonomous bodies, cities, towns, villages, communities and the inhabitants thereof, corporations, partnerships, individuals, places of amusement or exhibitions, or any two or more of either or same with water, light, heat, gas and/or electric power and to do any and all things incidental, necessary, and/or proper in furtherance of and/or in connection with the foregoing objects and purposes.

18. To subscribe for, take, purchase, or otherwise acquire, hold, sell and dispose of, shares, debentures, debenture stocks, bonds, obligations or securities issued or guaranteed by any other company constituted or carrying on business in any part of the world, and debentures, debenture stocks, bonds obligations or securities issued or guaranteed by any government or authority, municipal, local or otherwise, in any part of the world, but not to act as an investment company.

19. To remunerate any person, firm or company rendering services to the Company either by cash payment or by the allotment to him or them of shares or other securities of the Company credited as paid up in full as may be thought expedient.

20. To buy, take on lease, sell, exchange or otherwise acquire and to construct, lay, maintain and operate facilities and other conveyers for the transportation/supply of electric power and other substances.

21. To buy, sell, manufacture, store, repair, alter, improve, exchange, hire, import, export and deal in all factories, works, plant machinery, tools, utensils, aircrafts, vehicles, appliances, apparatus, products, materials, substances, articles and things capable of being used in any business which this Company is competent to carry on or required by any customers of or persons dealing with the Company or commonly dealt with by persons engaged in any such business or which may seem capable of being profitably dealt with in connection therewith and to manufacture, experiment with, render marketable and deal in all products of residue and by-products incidental to or obtained in any of the businesses carried on by the Company.

22. To purchase, take on lease or tenancy or in exchange, hire, take options over or otherwise acquire for any estate or interest whatsoever and to hold, develop, work, cultivate, deal with, dispose of and turn to account concession, grants, decrees, licenses, privileges, claims, options, property (movable or immovable), or rights or powers of any kind which may appear to be necessary or convenient for any business of the Company or for purposes of investment or re-investment and to purchase, charter, hire, build or otherwise acquire vehicles of any or every sort or description and to use the same for carriage of merchandise or passengers of all kinds and to carry on the business of owners of trucks, lorries, motor-cars and aircraft in all or any of their respective branches.

23. To construct and provide or otherwise acquire, whether by purchase, lease or otherwise, residential accommodation for persons engaged in the business of the Company.

24. To appropriate any part or parts of the property of the Company for the purposes of, and to build offices find other places of business.

25. To promote and form other companies for undertaking any business in accordance with the law and to take or otherwise acquire, hold shares, debentures or other securities of any such company and to subsidize or otherwise assist any such company.

26. To obtain all powers and authorities necessary to carry out or extend any of the objects herein including any other business which is permissible under the laws of land.

27. To take or otherwise acquire and hold shares, stock, debentures, debenture stock and/or to acquire and undertake the whole or any part of the business, property or liabilities of any other company having objects altogether or in part similar to those of this Company or carrying on any business capable of being conducted so as directly or indirectly to benefit this Company.

28. To enter into any agreement or any arrangement for sharing profits, union of interest, co-operation, joint-ventures, reciprocal concessions, or otherwise with any individual, firm co-operative or other company, association, corporate body, research and education institutions, affiliates, Government or local authority or other legal entity whether national or not, as may be necessary or expedient for the purpose of carrying on any business of the Company.

29. To open, close and operate bank accounts of the Company with any bank or banks and to draw, make, accept, endorse, discount, execute and issue promissory notes, bills of exchange, bills of lading, warrants, debentures and other negotiable or transferable instruments and do any banking transactions which may be deemed appropriate in the best interest of the Company.

30. To borrow money and to receive the proceeds of loans and to secure payment of money in such manner as the Company may decide is necessary for realization of the purposes mentioned above and in particular by:

   (i) the issue of perpetual or redeemable and convertible or nonconvertible PTCs, TFC s and like instruments and finances under the interest free system such as finances by purchase of movable and immovable properties, securities and instruments with buy back agreements including sukuks and other Islamic modes of financing instruments, debentures or debenture stock (perpetual or otherwise), bonds, promissory notes, bills of exchange and such other securities;

   (ii) furnishing undertakings and guaranteeing the performance by the Company or any other person or company of any obligation undertaken by the Company or any other persons or company as the case may be, depositing securities, shares and documents of title;

   (iii) hypothecating, charging and mortgaging all or any of the properties and assets (both present and future, movable and immovable) of the Company and creating pledge, liens or any other security, on any part of the property or assets of the Company (both present and future) such properties on the condition that such transactions shall not effect the performance of the Company; and

   (iv) appointing attorneys, counsels and giving them powers and authority for executing documents, registering documents, selling and managing the properties, undertaking any business of the Company and furnishing and creating such other securities as may be considered expedient; and for the purposes aforesaid, or otherwise, execute, complete and deliver agreements and such other documents as may be required;

31. To guarantee the payment of money and the performance of contracts of engagement of the Company and to secure the payment of money and the performance of any contracts or engagements entered into by the Company and to discharge any debt or any obligations of or binding upon the Company by a mortgage or charge upon all or any part of the undertaking, property and rights of the Company (either present or future or both), or by the creation or issue of bonds debentures stocks, pledges, liens or any other securities or by any other means.

32. To guarantee the payment of money unsecured or secured by or payable under or in respect of promissory notes, bonds, debentures, debenture stock (perpetual or otherwise), contracts, mortgages, charges, obligations, instruments and securities of the Company and generally to guarantee or become sureties for the performance of any contracts or obligations concerning the business of this Company.

33. To draw, make, accept, endorse. seal, execute, negotiate, purchase, hold and dispose of cheques, promissory notes, bills of exchange, drafts, charter parties, bills of lading, warrants and other negotiable documents and contracts, deeds and other instruments and to cancel and vary such instruments, relating to the business of the Company.

34. To apply for purchase or otherwise acquire and protect and renew in any part of the world any patent, patent rights, brevets d'invention trademarks, designs, licences, concessions, and the like, conferring any exclusive or non-exclusive or limited right to their use, or any secret or other information as to any invention which may seem capable of being used for any of the purposes of the Company, or the acquisition of which may seem calculated directly or indirectly to benefit the Company, and to use, exercise, develop or grant licences in respect of, or otherwise turn to account the property, rights or information so acquired, and to expend money in experimenting upon, testing or improving such patents, inventions or rights, and to sell any patent rights or privileges belonging to the Company, or which may be acquired by it, or any interest in the same, and to grant licences for the use and practice of the same or any of them and to let or allow to be used or to otherwise deal with any inventions, patents or privileges in which the Company may be interested, and to do all such acts and things as may be deemed expedient for turning to account any inventions, patents and privileges in which the Company may be interested.

35. To establish and operate provident funds, gratuity or any other retiring benefits for the employees and to establish and support or aid any schools and any educational, scientific, literary, religious or charitable institutions or trade societies whether such societies be solely connected with the trade carried on by the Company or not, and any club or other establishment calculated to advance the interests of the Company or its employees.

36. To subscribe money for any national, charitable, benevolent, public, general or useful object or for any exhibition.

37. To provide services to any business or concern that the Company may find convenient or advantageous and to do any kind of commercial and agency business.

38. To transact or carry on all kinds of agency, commission and contract business in particular in relation to industry and to act as agents of any person, firm, company, Government or local authorities, but to not act as managing agent.

39. To accept stock or shares in, debentures, mortgage-debentures or other securities of any other company in payment or part payment for any services rendered or for any sale made to or debt owing from any such company.

40. To improve, develop, sell, exchange, take on lease, mortgage, pledge, hypothecate, assign, transfer, dispose of turn to account or otherwise deal with, all or any part of the present and future property, assets, equipment, immovable and movable, corporeal or incorporeal, tangible or intangible and any right, title and interest therein of the Company, including rights, licence, privileges, concessions, easements and franchises as may seem expedient.

41. To payout of the funds of the Company all expenses of and incidental to the formation, registration, advertisement of the Company and the issue and subscription of the share or loan capital including brokerage and/or commission for obtaining applications for or placing of shares or any debentures, debenture stock and other securities of the Company and also all expenses relating to the issue of any circular or notice and the printing, stamping and circulating of proxies and forms to be filled up by the members of the Company.

42. To pay for rights or property acquired by the Company and to remunerate any person or company whether by cash payment or by the allotment of shares, debentures or other securities of the Company as fully paid up.

43. To adopt such means of making known the business, services and products of the Company as may seem expedient and in particular by undertaking seminars, training and demonstration programs and by advertising in the press, media and internet by circulars and by purchase and exhibition of works of art or interests, by publication of books and periodicals and by granting prizes, rewards and donations.

44. To establish and maintain or procure the establishment and maintenance of any contributory or non-contributory pension or superannuation funds for the benefit of and give or procure the giving of donations, gratuities, pensions, allowances or emoluments to any persons who are or were at any time in the employment or service of the Company, and also to establish and subsidize and subscribe to any institutions, associations, clubs or funds calculated to be for the benefit of or to advance the interests and wellbeing of the Company or of any such other company as aforesaid and do any of the matters aforesaid, either alone or in conjunction with any such other company as aforesaid.

45. To open branches, liaison offices, register the Company and to undertake all or any of the business of the Company in any part of the world and to become a member of various associations and trade bodies whether, in Pakistan or abroad.

46. To apply for and obtain necessary consents, permissions and licences from any Government, State, Local and other national or international authorities for enabling the Company to carry any of its objects into effect or for extending any of the powers of the Company or for effecting any modification of the constitution of the Company or for any other purpose which may seem expedient, and to oppose any proceedings or applications which may seem cancelled, directly or indirectly to prejudice the interests of the Company

47. To enter into arrangements with any Government or authorities, central, provincial, municipal, local or otherwise, public or quasi-public bodies or with any natural persons and legal entities, in any place where the Company may have interests that may seem conducive to the objects of the Company or any of them or to obtain from such Government, authorities or persons, any rights, privileges and concessions which the Company may think fit to obtain and to carry out exercise and comply therewith for the purposes of the Company.

48. To adopt such means of making known the products of the Company as may seem expedient, including, in particular, by advertisement in the press, circulars, purchase and exhibitions of work of art or interests, publication of books and periodicals.

49. To insure the property, assets and employees of the Company in any manner deemed fit by the Company, and to create any reserve fund, sinking fund, insurance fund, or any other special fund whether for depreciation or for repairing, insuring, improving, extending or maintaining any of the property of the Company or for any other purpose conducive to the interests of the Company.

50. To invest the surplus monies of the Company, not immediately required, in any manner as may from time to time be determined and to hold or otherwise deal with such investment made.

51. To advance money or give credit to such persons or companies, with or without security, and on such terms as the Company may approve, in particular to customers and others having dealings with the Company.

52. To import, export, buy, sell, own, install and/or rent machinery and other equipment, goods, materials, raw materials and spare parts required for or in connection with the business of the Company.

53. To enter into partnership or other joint venture or co-operation with any person or company or other legal entity, local or foreign, carrying on or engaged in any business or transaction which this company is authorized to carry on or engage in, or otherwise assist any such person or company or legal entity and/or to buy, purchase wholly or partially the shareholding or enter into a collaboration arrangement with any other power generating company or business concern, on such terms which are best for the company.

54. To receive, declare and distribute profits and to capitalize such portion of the profits of the Company as are not distributed among shareholders of the Company, in the form of dividends, and as the Company may think fit, and to issue bonus shares, as fully paid up in favor of the shareholders of the Company.

55. To file any documents required to be filed under law, and to pay any fees, charges, expenses, rents, taxes, duties and other dues payable in connection with the business or operation of the Company.

56. To amalgamate, consolidate, or merge, with a view to affecting a union of interests, either in whole or in part, with or into any other companies, associations, firms or persons carrying on any trade or business of a similar nature to that which the Company is authorized to carry on.

57. To improve, manage, develop, grant, rights or privileges in respect of or otherwise deal with, all or any part of the property.

58. To accept, buy, sell, market, supply, transfer (including transfer of actionable claims) or deliver any and every kind of moveable property for such price and subject to such terms, conditions and warranties as the Company may think fit.

59. To sell, improve, manage, develop, exchange, mortgage, enfranchise, dispose of, turn to account, or otherwise deal with, all or any part of the property, assets or undertaking of the Company for such consideration as the Company may think fit, and in particular for shares, debentures, or other securities of any other company whether or not having objects altogether or in part similar to those of this Company.

60. To guarantee the performance of contracts, agreements, obligations or discharge of any debt of the Company or on behalf of its any associate/ sister concern company or person in relation to the payment of any financial facility including but not limited to loans, advances, letters of credit or other obligations through creation of any or all types of mortgages, charges, pledges, hypothecations, on execution of the usual banking documents or instruments or otherwise encumbrance on any or all of the movable and immovable properties of the Company, either present or future or both and issuance of any other securities or sureties by any other means in favour of banks, Non-Banking Finance Companies (NBFCs) or any financial institutions and to borrow money for purpose of the Company on such terms and conditions as may be considered proper.

61. To settle disputes by negotiation, conciliation, mediation, arbitration, litigation or other means and to enter into compromise with creditors, members and any other persons in respect of any difference or dispute with them.

62. To develop and/or transfer technology and to acquire or pass on technical know-how.

63. To train personnel and workers, both in Pakistan and abroad, to obtain technical proficiency in various specialties connected with the business of the Company.

64. To carry on any other trade or business which can be advantageously carried on in connection with or ancillary to any of the businesses.

65. To distribute among the members of the Company, in specie, any property of the Company of whatever nature, or any proceeds of sale or disposal of any property of the Company, so that no distribution amounting to a reduction of capital be made except with the sanction (if any) for the time being required by law, in the case of winding up of the Company.

66. To generate and sell carbon credits and enter into agreements and/or required arrangements with the interested parties for the sale of the same.

67. It is, hereby, undertaken that the Company shall not engage in banking business or Forex, illegal brokerage, or any business of investment company or non-banking finance company or insurance or leasing or business of managing agency or in any unlawful business and that nothing contained in the object clauses shall be so construed to entitle it to engage in such business directly or indirectly and the Company shall not launch multi-level marketing (MLM), Pyramid and Ponzi schemes.

68. Notwithstanding anything stated in any object clause, the Company shall obtain such other approval or license from the competent authority, as may be required under any law for the time being in force, to undertake a particular business.

IV. LIABILITY

The Liability of the members is limited.

V. SHARE CAPITAL

The Authorized Share Capital of the Company shall be Rs.50,000,000/- (Pakistani Rupees Fifty Million only) divided into 5,000,000 (Five Million) Ordinary Shares of Rs. 10/- (Pakistani Rupees Ten only) each with powers to the Company from time to time shall have power to increase or reduce or consolidate or sub-divide the shares into higher or lower denominations as may be for the time being provided by the Articles of Association of the Company.

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

Name & Surname (Present & Former) in full (in Block Letters)	Father's/Husband's Name in full	Nationality with any former Nationality	C.N.I.C. No.	Occupation	Residential address in full	Number of shares taken by each subscriber	Signature
ADI JEHANGIR CAWASJI	Jehangir Nadir Shah Cawasji	Pakistani	42000-0524360-9	Professional Manager	66-B, South Circular Avenue, D.H.A. Phase-2, Karachi-75500	(1) One	Adi J. Cawasji
ABDUS SAMAD GORAYA	Mohammad Bashir Goraya	Pakistani	35202-1095663-1	Professional Manager	House No.372, Sector A-1, Township, Lahore	(1) One	ASGoraya
SAJJAD IFTIKHAR	Mr. Qazi Iftikhar-Un-Nabi	Pakistani	35202-9162960-1	Professional Manager	House No.84-D Punjab Govt.Co-Operative Society Phase -2, College Road, Lahore	(1) One	
MOHAMMAD FAISAL HANIF	Mohammad Hanif Niaz	Pakistani	35202-3033480-5	Professional Manager	House No.175-C, Block 'C' Faisal Town, Lahore	(1) One	
PACKAGES LIMITED Through its authorized representative :	N/A	A public listed limited liability company incorporated under the Companies Ordinance, 1984		Business	Shahrah-e-Roomi, P.O. Amer Sidhu, Lahore	(2,499,996) Two Million Four Hundred Ninety Nine Thousand Nine Hundred Ninety Six	
BILAL NAEEM	Khawaja Naeem Ejaz	Pakistani	35200-8839566-1	Professional Manager	House No.113/2, Block F, Model Town, Lahore		Bilal Naeem
				Total number of Shares taken		(2,500,000) Two Million Five Hundred Thousand	

Dated this 4th day of October 2016

Witness to the above signatures: Nisar Ahmed
Father's name: Aziz Ahmed
Occupation: Service
Nationality: Pakistani
C.N.I.C. number: 42101-1586299-1
Full address: 1-A-9/7, Nazimabad, Karachi-76500

Company Registration Office Karachi
Securities and Exchange Commission of Pakistan

Certified to be True Copy
Deputy Registrar of Companies

THE COMPANIES ORDINANCE, 1984
(Company Limited by Shares)

ARTICLES OF ASSOCIATION

OF

PACKAGES POWER (PRIVATE) LIMITED

1. The regulations contained in Table "A" in the First Schedule to The Companies Ordinance, 1984 shall not apply to the Company except in so far as the same are expressly made applicable by the said Ordinance, or these Articles. The regulation for management of the Company, and for the observance thereof by the members of the Company, and their representatives shall, subject as aforesaid and to any exercise of the statutory power of the Company in reference to the repeal or alteration of or addition to its regulations by Special Resolution as prescribed by the said Ordinance; be such as are contained in these Articles.

INTERPRETATION

2. In the interpretation of these Articles the following expressions shall have the following meanings, unless repugnant to or inconsistent with the subject Articles.

2.1: "The Ordinance" means the Companies Ordinance, 1984, or any statutory modification or re-enactment thereof for time being in force in Pakistan;

2.2: "Board" means a Board of the Directors, elected by the shareholders, to act on their behalf in the management of the Company affairs;

2.3: "The Company" or "This Company" means **Packages Power (Private) Limited;**

2.4: "The Directors" means the Directors and Alternate Directors for the time being of the Company, or as the case may be, the Directors and Alternate Directors assembled at a Board;

2.5: "Dividend" includes bonus shares;

2.6: "Month" means a calendar month;

2.7: "The Office" means the Registered Office for the time being of the Company;

2.8: "Persons" includes corporation as well as individuals;

2.9: "The Register" means the Register of members to be kept pursuant to the Ordinance;

2.10: "In Writing" means written or printed or partly written and partly printed or lithographed or typewritten or other substitute for writing;

2.11: Words importing singular number include the plural number and vice versa;

2.12: Words importing masculine gender include the feminine gender;

2.13: Subject as aforesaid any words or expressions defined in the Ordinance; shall except where the subject or context forbids bear the same meaning in these Articles.

Company Registration Office Karachi
Securities and Exchange Commission of Pakistan

PRIVATE COMPANY

3. The Company is "Private Company" within the meaning of sub section 2(1) (28) of the Ordinance and accordingly:

    (1) No invitation shall be issued to the public to subscribe for any share of the Company.

    (2) The numbers of the members of the Company (exclusive of persons in the employment of the Company), shall be limited to fifty, provided that for the purpose of this provision, where two or more persons hold one or more shares in the company jointly, they shall be treated as single member; and

    (3) The right to transfer shares of the Company is restricted in manner and to the extent herein appearing.

BUSINESS

4. The company is entitled to commence business from the date of its incorporation. The business of the company shall include all or any of the objects enumerated in the Memorandum of Association. The business of the company shall be carried out at such place or places anywhere in Pakistan or elsewhere as the directors may deem proper or advisable from time to time.

SHARES AND CAPITAL

5. The authorised share capital of the Company is Rs. 50,000,000 (Rupees Fifty Million Only) divided into 5,000,000 (Five Million) ordinary shares of Rs. 10/- (Rupees Ten Only) each with powers of the Company to increase or reduce the same and to divide the shares into several classes.

6. The shares shall be under the control of the Board of Directors who may allot or otherwise dispose off the same to such persons, on such terms and conditions and at such times, as the Board of Directors think fit. Shares may also be allotted in consideration other than cash.

7. Fully paid shares shall be allotted to all subscribers in the first instance and the Company shall not be bound to recognize any equitable, contingent, future or partial claim to or interest in a share on the part of any person other than the registered share holder, save as herein provided or saves as ordered by some Court of competent jurisdiction.

8. The certificate of title to shares shall be issued under the seal of the Company.

9. Every member shall be entitled to one certificate for the shares registered in his name, or at the discretion of the directors to several certificates, each for one or more of such shares.

TRANSFER AND TRANSMISSION OF SHARES

10. Every person whose name is entered as a member in the Register of Members shall without payment, be entitled to a certificate under the common seal of the Company specifying the shares held by several persons. The Company shall not be bound to issue more than one certificate and delivery of a share certificate to any one of several joint holders shall be sufficient delivery to all.

11. The directors may decline to register any transfer of shares to transferee of whom they do not approve and shall be bound to show any reasons for exercising their discretion subject to the provisions of Section 77 and 78 of the Ordinance.

12. No share can be mortgaged, pledged, sold, hypothecated, transferred or disposed off by any member to a non-member without the previous sanction of the Board of Directors.

13. The legal heirs, executors or administrators of a deceased holder shall be the only persons to be recognised by the directors as having title to the shares. In case of shares registered in the name of two or more holders, the survivors and the executors of the deceased shall be the only persons to be recognised by the company as having any title to the shares.

BORROWING POWERS

14. Subject to the provision of the Ordinance, the Directors may from time to time at their absolute discretion raise or borrow any sum, or sums of money for the purpose of the company from banks, firms or companies, particularly a person holding the office of the director, and may secure the payment of money in such manner and upon such terms, and conditions in all respects as they think fit particularly by the issue of debentures of the company or by making, drawing, accepting or endorsing on behalf of the company any promissory note or bills of exchange or giving or issuing any other security of the Company.

15. Debentures and other securities may be made assignable free from any equities between the Company and the persons to whom the same may be issued.

16. Any debentures or other security may be issued at a discount, premium or otherwise and with any special privilege as to redemption, surrender, drawing, allotment of shares, attending and voting at general meeting of the Company or subject to compliance of the provisions of the Ordinance.

RESERVES

17. The directors may from time to time before recommending any dividend set aside out of the profit of the company such sums as they think fit as a reserve for redemption of debentures or to meet contingencies for equalization of or for special dividends or for rebuilding, repairing, restoring replacing, improving, maintaining or altering any of the property of the Company or for such other purpose as the directors may in their absolute discretion think conducive to the interest of the Company.

GENERAL MEETINGS

18. A General meeting, to be called annual general meeting shall be held, in accordance with the provisions of section 158, within eighteen months from the date of incorporation of the Company and thereafter once at least in every year within a period of four months following the close of its financial year and not more than fifteen months after the holding of its last preceding annual general meeting as may be determined by the directors.

19. The directors may, whenever, they think fit, call an extra ordinary general meeting, and extra ordinary general meetings shall also be called on such requisition, or in default, may be called by such requisitionists, as is provided by section 159 of the Ordinance.

NOTICE AND PROCEEDINGS OF GENERAL MEETING

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

21. All business shall be deemed special that is transacted at an extraordinary general meeting, and also all that is transacted at annual general meeting with the exception of declaring dividend, the consideration of the accounts, balance sheet and the reports of the directors and auditors, the election of the directors, the appointment of, and the fixing of the remuneration of, the auditors.

QUORUM

22. No business shall be transacted at any general meeting unless a quorum of members is present at that time when the meeting proceeds to business; save as herein otherwise provided, members having twenty-five percent of the voting power present in person or through proxy and two members personally present will be quorum of the Company's meeting.

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

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

25. The Chairman may, with the consent of any meeting at which the quorum is present (and shall if so directed by the meeting), adjourn the meeting from time to time but no business shall be transacted at any adjourned meeting other than the business left unfinished at the meeting from which the adjournment took place. When the meeting is adjourned for ten days or more, notice of the adjourned meeting shall be given as in the case of an original meeting. Save as aforesaid, it shall not be necessary to give any notice of an adjournment. of the business to be transacted at an adjourned meeting.

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

27. A poll may be demanded only in accordance with the provisions of section 167 of the Ordinance.

28. If a poll is duly demanded, it shall be taken in accordance with the manner laid down in section 168 of the Ordinance and the result of the poll shall be deemed to be the resolution of the meeting at which the poll was demanded.

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

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

VOTES OF MEMBERS

31. Subject to any rights or restrictions for the time being attached to any class or classes of shares, on a show of hands every member present in person shall have one vote except for election of Directors in which case, the provisions of section 178 of the Ordinance shall apply. On a poll every member shall have voting rights as laid down in section 160 of the Ordinance.

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

33. On a poll votes may be given either personally or by proxy.

34. (1) The instrument appointing a proxy shall be in writing under the hand of the appointer or of his attorney duly authorized in writing. A proxy must be a member.

(2) The instrument appointing a proxy and the power of attorney or other authority (if any) under which it is signed, or a notarially certified copy of that power or authority, shall be deposited at the registered office of the company not less than forty-eight hours before the time for holding the meeting at which the person named in the instrument proposes to vote and in default the instrument of proxy shall not be treated as valid.

35. An instrument appointing a proxy may be in the following form, or a form, as near thereto as may be:-

PACKAGES POWER (PRIVATE) LIMITED

I..................................of......................................in the district of ....being a member of the**PACKAGESPOWER (PRIVATE) LIMITED** hereby appoint.................. of .... as my proxy to vote for me and on may behalf at the (annual, extraordinary, as the case may be) general meeting of the company, to be held on the .... day of .... and at any adjournment thereof.

DIRECTORS

36. The number of directors shall not be less than two. The following persons shall be the first directors of the Company **and shall hold the office upto the date of the First Annual General Meeting unless a casual vacancy occurred that shall be filled in by the Board in accordance with the provisions of the Ordinance.**

1. **Mr. Adi Jehangir Cawasji**
2. **Mr. Abdus Samad Goraya**
3. **Mr. Sajjad Iftikhar**
4. **Mr. Mohammad Faisal Hanif**

37. The remuneration of the directors shall from time to time be determined by the Company in general meeting subject to the provisions of the Ordinance.

38. Save as provided in Section 187 of the Ordinance, no person shall be appointed as a director unless he is a member of the Company.

POWERS AND DUTIES OF DIRECTORS

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

40. The directors shall appoint a chief executive in accordance with the provisions of sections 198 and 199 of the Ordinance.

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

42. The directors shall cause minutes to be made in books provided for the purpose:-

(a) of all appointments of officers made by the directors;

(b) of the names of the directors present at each meeting of the directors and of any committee of the directors;

(c) of all resolutions and proceedings at all meetings of the company and of the directors and of committees of directors.

DISQUALIFICATION OF DIRECTORS

43. No person shall become the director of a company if he suffers from any of the disabilities or disqualifications mentioned in section 187 of the Ordinance and, if already a director, shall cease to hold such office from the date he so becomes disqualified or disabled.

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

PROCEEDINGS OF DIRECTORS

44. The directors may meet together for the dispatch of business, adjourn and otherwise regulate their meetings, as they think fit. Questions arising at any meeting shall be decided by a majority of votes. In case of an equality of votes, the chairman shall have and exercise a second or casting vote. A director may, and the secretary on the requisition of a director shall, at any time, summon a meeting of directors. It shall not be necessary to give notice of a meeting of directors to any director for the time being absent from Pakistan.

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

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

FILLING OF VACANCIES

47. At the first annual general meeting of the company, all the directors shall stand retired from office, and directors shall be elected in their place in accordance with section 178 of the Ordinance for a term of three years.

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

49. The directors shall comply with the provisions of sections 174 to 178 and sections 180 and 184 of the Ordinance relating to the election of directors and matters ancillary thereto.

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

51. The company may remove a director but only in accordance with the provisions of the Ordinance.

DIVIDENDS AND RESERVE

52. The company in general meeting may declare dividends but no dividend shall exceed the amount recommended by the directors. No dividends shall be paid otherwise than out of the profits of the Company.

THE SEAL

53. The directors shall provide for the safe custody of the seal and the seal shall not be affixed to any instrument except by the authority of a resolution of the board of directors or by a committee of directors authorized in that behalf by the directors and the presence of at least two directors; and those two directors shall sign every instrument to which the seal of the company is so affixed in their presence.

ACCOUNTS

54. The directors shall cause to be kept proper books of account as required under section 230 of the Ordinance.

55. The books of account shall be kept at the registered office of the company or at such other place as the directors shall think fit and shall be open to inspection by the directors during business hours.

56. The directors shall be required by sections 233 and 236 of the Ordinance, cause to be prepared and to be laid before the company in general meeting such profit and loss accounts or income and expenditure accounts and balance sheets duly audited and reports as are referred to in those sections.

AUDIT

57. Once at least in every year the accounts of the Company shall be audited and the correctness of profit and loss accounts or income and expenditure accounts and balance sheet ascertained by an auditor or auditors and the provisions of the Ordinance in regard to audit and the appointment and qualification of auditors shall be observed.

58. Auditors shall be appointed and their duties regulated in accordance with sections 252 to 255 of the Ordinance.

WINDING UP

59. If the company is wound up, whether voluntarily or otherwise the liquidator may, with the sanction of a special resolution, divide amongst the contributories in specie or kind, the whole or any part of the assets and liabilities of the company, subject to the section 421 and other provisions of the Ordinance as may be applicable.

INDEMNITY

60. Every director and other officer or servant of the company shall be indemnified by the company against, and it shall be the duty of the directors to pay out of the funds of the company, all costs, losses and expenses which any such officer or servant may incur or become liable to by reason of any contract entered into or thing done by such officer or servant as such in any way in the discharge of the duties of such officer or servant including traveling expenses.

61. No director or other officer of the company shall be liable for the acts, receipts, neglect or default of any other director or officer or for joining in any receipt or other act for conformity or for any loss or expenses happening to the company through the insufficiency or deficiency of title to any property acquired by order of the directors for or on behalf of the company or for the insufficiency or deficiency of any security or investment in or upon which any of the money of the company shall be invested or for any loss or damage arising from bankruptcy, insolvency or tortuous act of any person with whom any money, securities or effects shall be deposited or for any loss occasioned by any error of judgment or oversight on his part or for any other loss, damage or misfortune whatever which shall happen in the execution of his office or in relation thereto unless the same happens through his dishonesty.

NOTICES

62. (1) A notice may be given by the company to any member either personally or by sending it by post to him to his registered address or (if he has no registered address in Pakistan) to the address, if any, within Pakistan supplied by him to the company for the giving of notices to him.

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

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

ARBITRATION

64. Whenever any difference arises between the company on the one hand and any of the members, their executors, administrators or assignees on the other hand touching the intent or construction or the incidence or consequences of these presents, or of the statute or touching any thing then or thereafter done, executed, omitted, or suffered in pursuance of these presents or of the statute or touching breach or alleged breach or otherwise relating to the premises, or to any statute effecting the company, or to any of the affairs of the company, including the fixing of the fair value of the shares of the company, every such difference shall be referred to the decision of an arbitrator to be appointed by the parties in difference or if they cannot agree upon a single arbitrator to the decision of two arbitrators of whom one shall be appointed by each of the parties in difference or any umpire to be appointed by the two arbitrators.

DISPUTE RESOLUTION

65. In the event that a dispute, claim or controversy arises between the Company, its management or its shareholders, or between shareholders inter-se, or the directors inter-se, all steps shall be taken to settle the dispute and resolve the issue through mediation by an accredited mediator before taking recourse to formal dispute resolution such as arbitration or litigation.

SECRECY CLAUSE

66. Every director, manager, member of the committee, officer, servant, accountant or other person employed in the business of the Company shall if so require by the directors before entering upon his duties, sign a declaration pledging to observe a strict secrecy respecting all transactions of the company with the customers and the state of accounts with individuals, matters relating thereto and shall by such declaration pledge himself not to reveal any of the matters which come to his knowledge in the discharge of his duties except when required to do so by the directors or by a Court of Law and except so far as may be necessary in order to comply with any of the provisions in these presents contained.

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

Name & Surname (Present & Former) in full (in Block Letters)	Father's/Husband's Name in full	Nationality with any former Nationality	C.N.I.C. No.	Occupation	Residential address in full	Number of shares taken by each subscriber	Signature
ADI JEHANGIR CAWASJI	Jehangir Nadir Shah Cawasji	Pakistani	42000-0524360-9	Professional Manager	66-B, South Circular Avenue, D.H.A. Phase-2, Karachi-75500	(1) One	Adi J. Cawasji
ABDUS SAMAD GORAYA	Mohammad Bashir Goraya	Pakistani	35202-1095663-1	Professional Manager	House No.372, Sector A-1, Township, Lahore	(1) One	ASGoraya
SAJJAD IFTIKHAR	Mr. Qazi Iftikhar-Un-Nabi	Pakistani	35202-9162960-1	Professional Manager	House No.84-D Punjab Govt.Co-Operative Society Phase -2, College Road, Lahore	(1) One	
MOHAMMAD FAISAL HANIF	Mohammad Hanif Niaz	Pakistani	35202-3033480-5	Professional Manager	House No.175-C, Block 'C' Faisal Town, Lahore	(1) One	Faisal Hanif
PACKAGES LIMITED Through its authorized representative :	N/A	A public listed limited liability company incorporated under the Companies Ordinance, 1984		Business	Shahrah-e-Roomi, P.O. Amer Sidhu, Lahore	(2,499,996) Two Million Four Hundred Ninety Nine Thousand Nine Hundred Ninety Six	
BILAL NAEEM	Khawaja Naeem Ejaz	Pakistani	35200-8839566-1	Professional Manager	House No.113/2, Block F, Model Town, Lahore		Bnaeem
				Total number of Shares taken		(2,500,000) Two Million Five Hundred Thousand	

Dated this 4th day of October 2016

Witness to the above signatures:	Nisar Ahmed
Father's name:	Aziz Ahmed
Occupation:	Service
Nationality:	Pakistani
C.N.I.C. number:	42101-1586299-1
Full address:	1-A 9/7, Nazimabad, Karachi-76500

Company Registration Office Karachi Securities and Exchange Commission of Pakistan

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Deputy Registrar of Companies

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Annexure J : Feasibility Study

Volume 1	**Chapter-1**	**Executive Summary**
	Chapter-2	**Topographic Survey**
	Chapter-3	**Hydrology**
	Chapter-4	**Geotechnical and Geological Study**
	Chapter-5	**Alternative Studies**
	Chapter-6	**Project Layout Description**
	Chapter-7	**Hydro-Mechanical Equipment**
	Chapter-8	**Electrical Equipment**
	Chapter-9	**Power Potential and Energy**
	Chapter-10	**Construction Planning & Management**
	Chapter-11	**Undertaking**
Volume 2	Drawings	
Volume 3	Initial Environmental Examination	

List of Acronyms

Abbreviations

PPPL	Packages Power Private Limited
AP	Affected Persons
BHU	Basic Health Unit
CCPP	Combined Cycle Power Plant
CO	Carbon Mono Oxide
ED	Energy Department
EPA	Environmental Protection Agency
EIRR	Economic Internal Rate of Return
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESMP	Environmental and Social Management Plan
ESHS	Environmental Social Health and Safety
EPC	Engineering Procurement and Construction
ER	Environmental Report
GT	Grand Trunk
GWH	Giga Watt Hour
GENCO	Generation Company
GW	Ground Water
IEE	Initial Environmental Examination
IPP	Independent Power Producer
KV	Kilo Volt
KAPCO	KotAddu Power Company
KESC	Karachi Electric Supply Corporation
LCC	Lower Chenab Canal
LPG	Liquefied Petroleum Gas
LOI	Letter of Intent
LAA	Land Acquisition Act
MAF	Million Acre Feet
MW	Mega Watt
NSL	Natural Surface Level
NEQS	National Environmental Quality Standards
NO_x	Nitrogen Oxides
NOC	No Objection Certificate
NESPAK	National Engineering Services Pakistan
NGO	Non-Government Organization
NPO	No Project Option
O&M	Operation and Maintenance
PEPA	Pakistan Environmental Protection Agency
PPDB	Punjab Power Development Board
PEPCO	Pakistan Electric Power Company

PAEC	Pakistan Atomic Energy Commission
PSHA	Probabilistic Seismic hazard Assessment
PAP	Project Affected Persons
PPE	Personal Protective Equipment
ROW	Right of Way
SO_x	Sulphur Oxides
SW	Surface Water
TPL	Trident Power GR (Pvt.) Ltd.
WAPDA	Water and Power Development Authority
WAA	Water Apportionment Accord
WHO	World Health Organization
PPDB	Punjab Power Development Board
LESCO	Lahore Electric Supply Company
NEPRA	National Electric Power Regulatory Authority

Weights and Measures

km	Kilometer
ft	Feet/Foot
m^3	Cubic meter
ft^3	Cubic feet
sec	Seconds
m	Meter
mm	Millimeter
°C	Degree centigrade
dB	decibels
Cusecs	Cubic feet per seconds
Cumecs	Cubic meter per second

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CONTENTS

1.1 INTRODUCTION

Allah has blessed Pakistan with a tremendous hydel potential of more than 60,000 MW. However, only 15% of the hydroelectric potential has been harnessed so far. The remaining untapped potential, if properly exploited, can effectively meet Pakistan's ever-increasing demand for electricity in a cost-effective way.

High head sites exist in hilly areas and Low head hydropower sites are located at barrages, and small falls in large rivers and artificial canals which can be utilized to develop energy. All these low head hydropower projects have very little or no negative impact on the environment and social life in the area. The most significant feature of all these projects is that they are practically emission-free and help to curb global warming, since they replace thermal power in the power supply systems. In addition country will save lot of foreign exchange by reducing import of costly fuel by utilizing environmental friendly Hydel energy.

During the last two & half decades more thermal power stations have been added to the system than development of hydel power stations, which resulted in increase in power tariff. To achieve target of meeting power demand at an affordable cost of generation, the installation of new hydel power plants is important and necessary. From this point of view, Punjab Power Development Board (PPDB) (a subsidiary of Punjab Energy Department), was established by the Government of Punjab to invite private sponsors for the development of low head hydropower projects in Punjab and fully assist them in all matters of project implementation. This chapter includes the summary of necessary studies done for the evaluation of available power and energy potential of the Kasur Hydropower Project.

1.2 BACKGROUND AND INTRODUCTION

Pursuant to "Punjab Power Generation Policy 2006 (Revised in 2009)", the Punjab Power Development Board (PPDB) invited expression of interest through advertisement dated May 30th, 2016 for the development of 5 raw sites with the last date of submission of Statement of Qualification (SOQ) as June 30, 2016. On the basis of prequalification documents submitted by private firms/consortium, PPDB issued a Letter of Interest (LOI) to M/s Packages Private Limited on September 28, 2016 for the development of Hydropower Project on BRBD Link Canal utilizing the potential available at fall structure at RD 509+712.

Packages Limited has gained the right to develop this plant and this feasibility study forms the initial part of this development. Packages Limited has incorporated a project specific SPV firm in the name of **Packages Power Private Limited (PPPL).**

The feasibility study has been prepared by M/s AIPEL and sets out to demonstrate the technical and financial viability of the project. The Sponsor engaged M/s AIPEL in November 2016 for the preparation and submission of feasibility study and Initial Environmental Examination (IEE).

The report is presented in 3 volumes:

Volume I: Main Report

The main report presents an assessment of the technical and financial viability of the project under the following headings:

- Section 1 is the introduction and presents the background and summary of the project
- Section 2 describes the topographic data collection
- Section 3 considers aspects of hydrology and sedimentation.
- Section 4 reviews the geological and geotechnical setting of the project
- Section 5 looks at the alternative powerhouse sites and presents an assessment of the sites and concluding with the selection of the site chosen for development.
- Section 6 provides a brief description of project layout and summarizes the proposed civil engineering works
- Section 7 summarizes the proposed mechanical equipment
- Section 8 summarizes the proposed electrical equipment
- Section 9 summarizes the optimization of the scheme parameters & presents

the development of the power and energy model

- Section 10 considers the construction schedule
- Section 11 develops the cost estimate
- Section 12 presents the financial assessment of the project.

Volume II: Drawings

- Topographic Surveys
- Project Alternatives
- Civil Components
- Mechanical Components
- Electrical Works
- Care & Handling of Water

Volume III: Initial Environmental Examination

- IEE discusses the environmental and social impacts of the proposed works including the following
- PROJECT INFORMATION
- Legal and Administrative Framework Policy
- Baseline Conditions
- Site monitoring & Laboratory Testing
- Environmental Impacts & Mitigation Measures
- Public Consultation
- Environmental Management Plan
- Conclusions & Recommendations

1.3 LOCATION & ACCESS TO THE PROJECT SITE

1.3.1. ACCESS BY ROAD

This raw site is located on BRBD Link Canal at RD 509+712 in District Kasur and nearly 50 km away from Lahore. The site is accessible by Ferozepur Road Lahore to Kasur Khem Karan Road which leads straight to Bambanwala Ravi Bedian Depalpur

(BRBD) canal. The site is within 3.5 Km from Kasur City and easily accessible. Project location map is provided in Drawing No. **BRBD-HEPP-FS-1.1.**

1.3.2. ACCESS BY RAIL

The Project area is located in District Kasur of Punjab Province. The nearest railway station is Kasur Railway Station, however, the closest standard dry port & railway station where the facilities of loading and unloading of heavy equipment is possible is Lahore railway station.

1.3.3. ACCESS BY AIR

International Airports in the nearest facility to the project area is Allama Iqbal International Airport in Lahore about 70 Km from the project site.

1.4 PREVIOUS STUDIES

1.4.1. STUDY BY WAPDA-GTZ (1992)

In 1992, WAPDA in association with GTZ, prepared an inventory of potential sites on canals, and barrages for hydropower development in Pakistan. The report assessed the power and energy estimates for various low head hydel power sites which identified the fall at the BRBD Link Canal at RD 509+712 as a potential site.

1.4.2. STUDY BY TARAKAI ENERGY (Pvt.) Ltd.

This site was advertised by PPDB in the year 2011 and a prefeasibility study was also conducted by Tarakai Energy (Pvt.) Ltd wherein it was proposed that the hydropower plant within main canal is a preferred option, however, the canal being a non-perennial was not considered seriously for onward study.

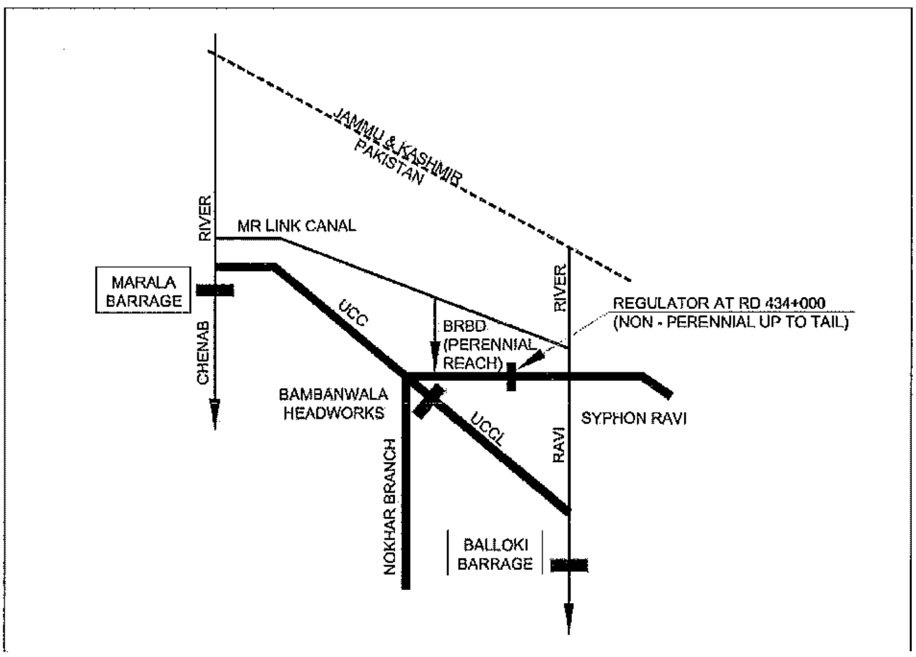
1.5 NEED FOR AN UPDATED STUDY

The earlier study was an inception report addressing the technical suitability of the project and plant alternatives only. A comprehensive study on power potential and energy and consequent benefits was not conducted. However, the current study is conducted on the basis of historical flows and it is concluded that a power plant of capacity 2.45 MW can be developed utilizing the available potential at RD 509+712 of BRBD Link Canal. A detailed financial assessment is also carried out considering the available flows and sensitivity analysis.

1.6 EXISTING SITE CONDITIONS

It is proposed to develop the hydropower plant utilizing the available head and discharge at RD 509+712 of BRBD Link Canal in District Kasur. Bambanwala-Ravi-Bedian-Depalpur (BRBD) Link Canal is a branch canal off-taking from RD 133+296 of Upper Chenab Main Canal. It is perennial up to regulator at RD 434+000 and non-perennial from RD 434+000 to its tail. Canal schematic diagram is provided in **Figure 1.1** and detailed canal network plan is discussed in Chapter 3 of this study.

Figure 1.1: Schematic Diagram

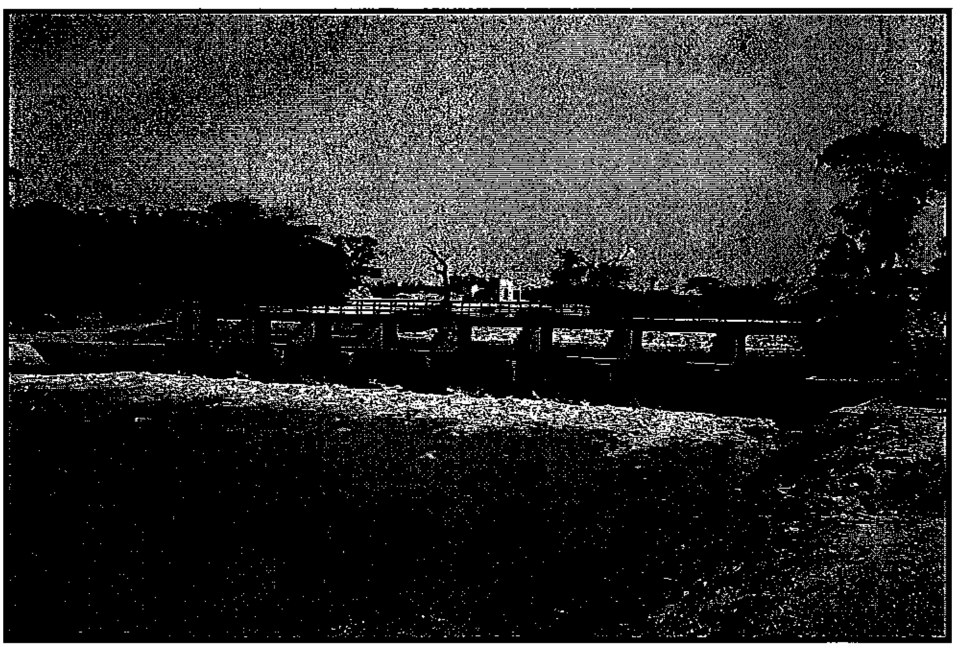


1.6.1. FALL STRUCTURE AT RD 509+712 OF BRBD LINK CANAL

Fall at RD 509+712 of BRBD Link Canal is an un-gated structure having width of 85 feet and gross head of 19.27 feet. It is a simple *Stepped Type Fall Structure* consisting of a series of vertical drops in the form of steps at gradual intervals. It is provided with brick walls at each of the drops. The bed of the canal within the fall is protected by rubble masonry with surface finishing by rich cement mortar (1:3). The salient features of fall structure are provided below and the photograph of the fall are shown in **Figures 1.2.**

- Upstream Full Supply Level = 673.72 ft.
- Downstream Full Supply Level = 654.45 ft.
- Upstream Bed Level = 666.72 ft.
- Downstream Bed Level = 647.45 ft.
- No. of Bays = 1 No.
- Width of Bay = 85 ft.
- Discharge = 2280 cusecs.

Figure 1.2: D/S View of Fall Structure at RD 509+712



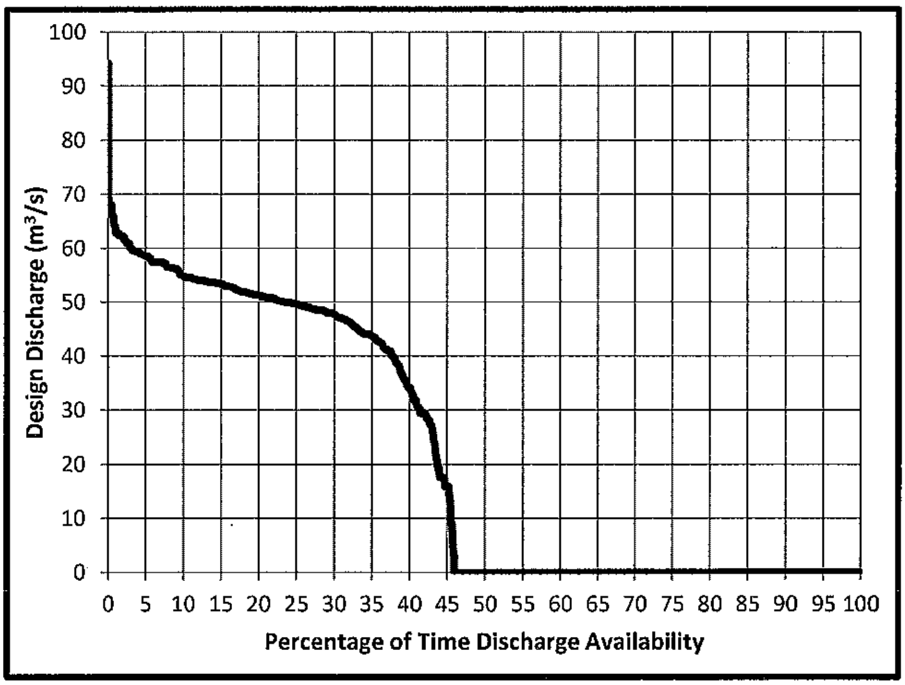
1.7 HYDROLOGY AND DISCHARGE OPTIMIZATION

The average daily discharge data of BRBD Link Canal at RD 434+000 was collected from the office of Executive Engineer, Depalpur Circle of Punjab Irrigation

Department. The discharge observation is not being carried out at RD 509+712, however, there is no outlet between RD 434+000 and RD 509+712.

Flow duration curve has been developed using average daily discharge data for a period of 2000-2016 in order to estimate the availability of water for power generation. Flow Duration curve is provided as **Figure 1.3** and it is noticeable that the discharge of 35 m^3/s, 40 m^3/s, 45 m^3/s and 50 m^3/s are available for duration of 39.6%, 37.8%, 33.2% and 23.6% of the time respectively. BRBD Link Canal is non-perennial within the reach of RD 434+000 to its tail and the flow duration curve demonstrates the availability of water during canal operations only.

Figure 1.3: Flow Duration Curve



With power and energy values, benefits and costs have been estimated for design discharges ranging from 35 m^3/s to 55 m^3/s. Three scenarios have been analyzed to check the sensitivity of selected capacity. These three scenarios are base case option, increased cost and reduced flows.

Base Case Scenario

For this scenario, benefits and costs have been calculated for the selected range of design discharge from 35 m^3/s to 55 m^3/s. The summary of analysis is presented in **Table – 1.1**.

Table - 1.1: Base Case - Normal Cost

Design Discharge (m^3/s)	Power (MW)	Annual Energy (GWh)	Plant Factor (%)	Project Cost (million Rs.)	Cost/kWh (Rs.)	Benefit/ Cost	NPV (million US$)
35	1.86	8.62	52.90	615.41	9.214	1.078	0.059
40	2.08	9.59	52.63	631.19	8.488	1.156	0.121
45	2.30	10.40	51.62	648.71	8.050	1.209	0.166
50	2.45	10.73	50.02	668.17	8.005	1.223	0.183
55	2.66	10.73	46.05	692.18	8.285	1.181	0.154

Increased Cost Scenario

Similar to above scenario, benefits and costs have been calculated for the selected range of design discharge from 35 m^3/s to 55 m^3/s and the summary of analysis is presented in **Table - 1.2**.

Table - 1.2: 10% Increased Cost

Design Discharge (m^3/s)	Power (MW)	Annual Energy (GWh)	Plant Factor (%)	Project Cost (million Rs.)	Cost/kWh (Rs.)	Benefit/ Cost	NPV (million US$)
35	1.86	8.62	53.01	676.95	10.135	0.980	-0.016
40	2.08	9.59	52.70	694.31	9.337	1.051	0.044
45	2.30	10.40	51.73	713.58	8.855	1.099	0.087
50	2.45	10.73	50.02	734.99	8.798	1.112	0.101
55	2.66	10.73	46.78	761.39	9.102	1.073	0.069

Reduced Flows Scenario

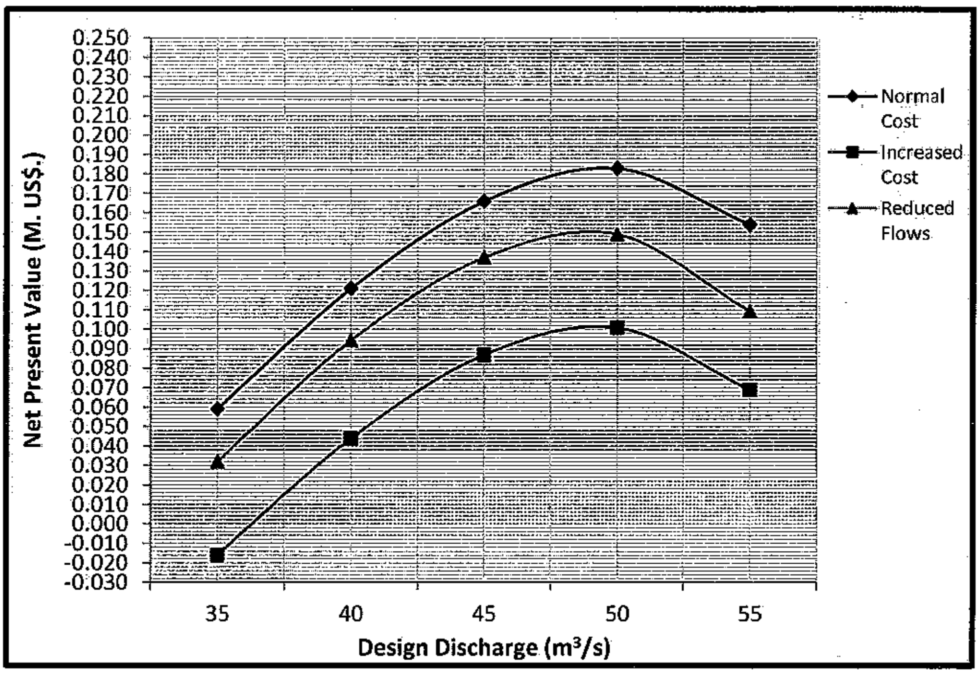
For reduced flows, benefits and costs have been calculated for the selected range of design discharge from 35 m^3/s to 55 m^3/s and the summary of analysis is presented in **Table - 1.3**.

Table - 1.3: 10% Reduced Flows

Design Discharge	Power	Annual Energy	Plant Factor	Project Cost	Cost/kWh	Benefit/ Cost	NPV
(m^3/s)	(MW)	(GWh)	(%)	(million Rs.)	(Rs.)		(million US$)
35	1.86	8.55	52.47	615.41	9.489	1.029	0.032
40	2.08	9.49	52.08	631.19	8.783	1.104	0.094
45	2.30	10.03	49.78	648.71	8.347	1.159	0.137
50	2.45	10.13	47.20	668.17	8.219	1.178	0.149
55	2.66	10.13	43.47	692.18	8.518	1.126	0.109

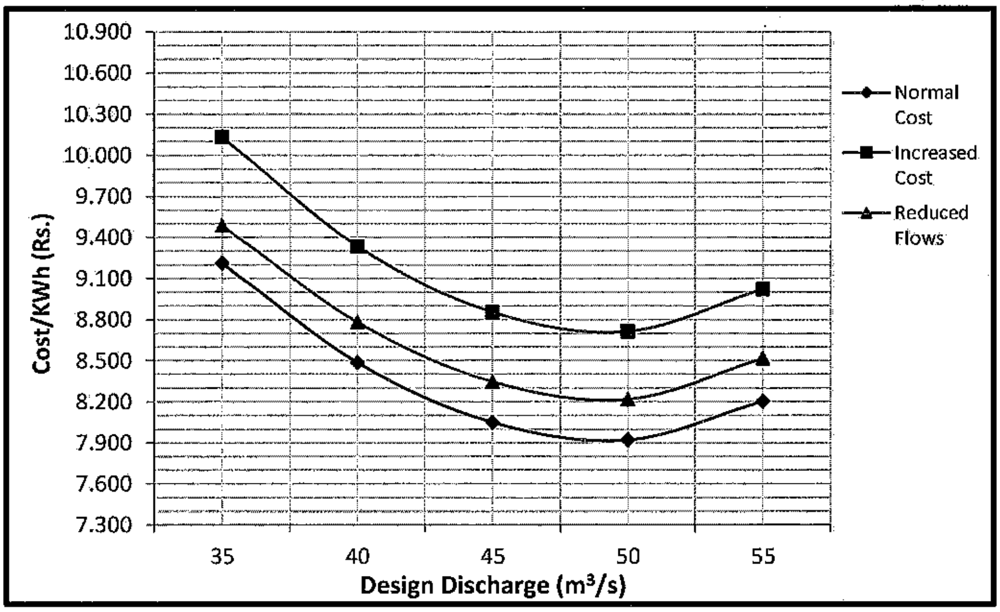
The above results of the analysis indicate that for all the three scenarios, cost per KWh is minimum, B/C ratio and NPV is maximum for a design discharge of 50 m^3/s and it corresponds to a capacity of 2.45 MW. NPV vs discharge curves are drawn for all the three scenarios and is presented in **Figure - 1.4**. It indicates that for all the three scenarios, NPV increases for a discharge upto 50 m^3/s and decreases with increase in discharge.

Figure - 1.4: NPV vs Design Discharge Curve



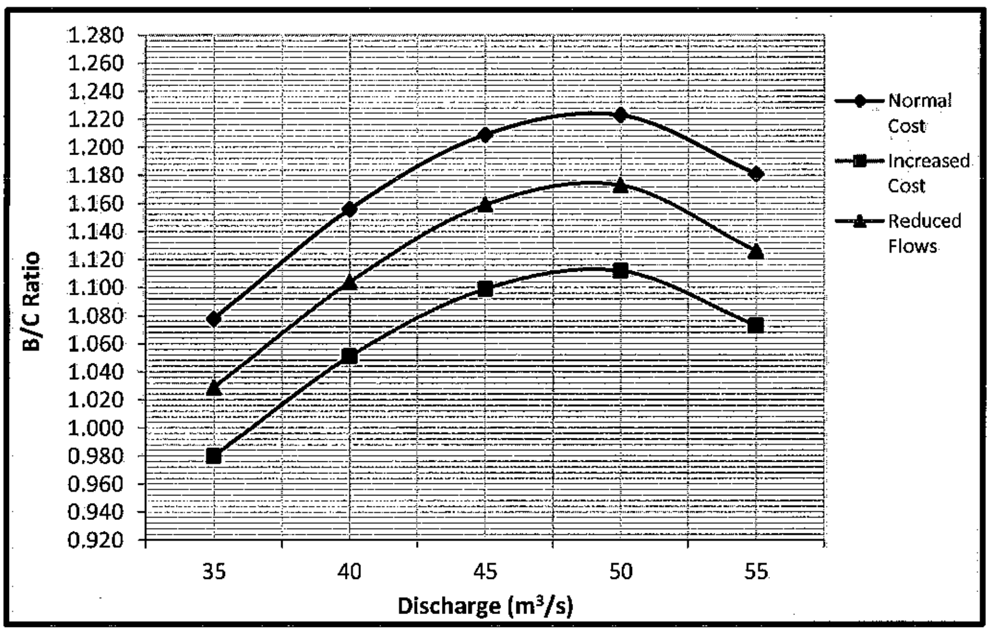
Similarly, the unit cost vs discharge curves are drawn for above mentioned three scenarios and are presented in **Figure - 1.5**. The graph indicates that unit cost for all the three scenarios decreases to minimum and then it increases again. The analysis for all the three scenarios indicates that unit cost/KWh is minimum for the design discharge of 50 m^3/s.

Figure - 1.5: Cost/kWh vs Design Discharge Curve



B/C ratio has also been checked for various discharges. The B/C ratio vs discharge curves are drawn for said three scenarios and is presented in **Figure - 1.6**.

Figure - 1.6: B/C Ratio vs Design Discharge Curve



The graph indicates that B/C ratio increases to maximum for a discharge of 50 m^3/s and then it decreases for higher discharge. All the three scenarios indicate that B/C ratio is maximum at design discharge of 50 m^3/s.

1.8 POWER AND ENERGY CALCULATIONS

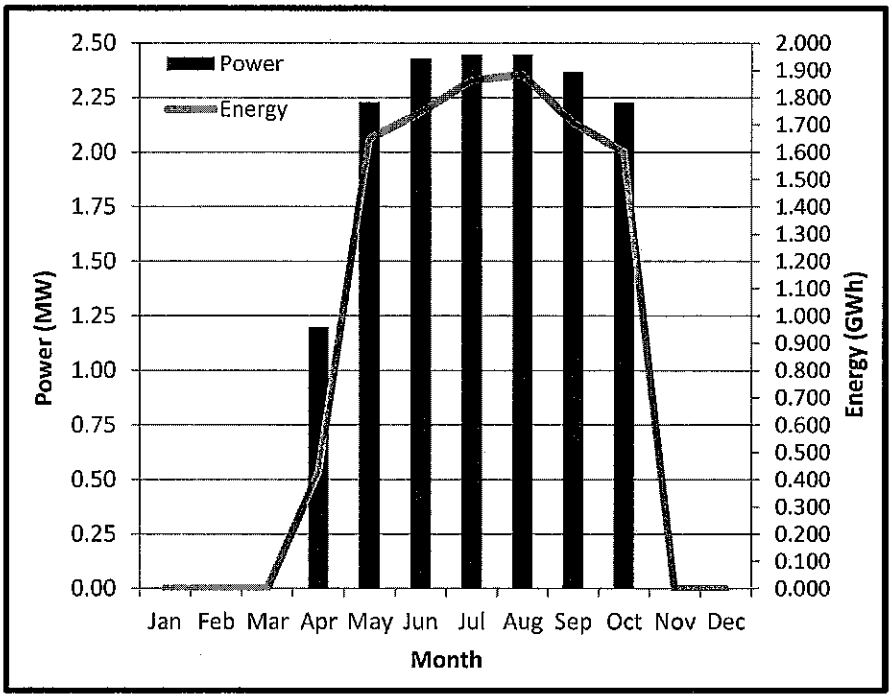
For selected design discharge of 50 m^3/s (1766 ft^3/s) and net head of 5.77 m, the installed capacity would be 2.45 MW (comprising of 01 Unit of 2.45 MW), with average mean annual energy of 10.88 GWh. The plant factor has been estimated as 50.75% which is based on net plant capacity and net deliverable energy.

Design Discharge = **50 m^3/s**
Gross Head = **5.87 m**
Net Head = **5.77 m**
No. of Turbines = **01**
Combined Efficiency = **86.50%**
Plant Installed Capacity (Gross) = **2.45 MW**
Net Plant Installed Capacity = **2.42 MW**
Annual Energy (Gross) = **10.73 GWh**
Auxiliary Consumption @ 1% = **0.1073 GWh**
Net Deliverable Energy = **10.62 GWh**
Plant Factor = **50.02%**

The estimated mean monthly power and energy is presented in **Figure - 1.7.** In July and August, installed capacity of 2.45 MW would be available. In remaining months from April to October, the power varies from 1.20 MW to 2.37 MW.

The energy is directly proportional to volume of water available for power generation. The monthly energy generation varies between 0.429 GWh to 1.885 GWh.

Figure - 1.7: Mean Monthly Power & Energy



1.9 GEOTECHNICAL AND GEOLOGICAL STUDY

- Groundwater was encountered at 4 m depth in the boreholes drilled up to a maximum depth of 20 m below NSL.
- The top surface comprises Clayey Silt/Silty Clay/Lean Clay (Soft to Very Stiff) up to a depth of 7.0 m below NSL. The material is underlain by Sandy Silt/ Silty Sand (Very Soft to Very Stiff, Dense to Very Dense) up to a maximum investigated depth of 20 m depth below NSL.
- The analysis of the bearing capacity has been carried out for a depth of foundation 2.0 m below NSL. The allowable bearing capacity for the mat foundation is evaluated for 50 mm settlement which is 1.2 tsf.
- If any soft and loose material encountered, at foundation excavation level, during construction, then it should be further excavated and replaced with suitable granular material in proper compaction.

1.10 PROJECT ALTERNATIVES

Considering the site layout situation, only possible alternative options have been considered. The best option is to construct the powerhouse alongwith splillway within main canal, however, following three options have been considered in the light of above discussions:

Alternative 1: Construction of power plant within Main Canal alongwith Spillway

Alternative 2: Construction of power plant in diversion canal

Alternative 3: Construction of powerhouse with Flap Gate option

It is concluded from the analysis that Alternative I whereby the powerhouse and spillway within the same axis is proposed within main canal at RD 510+600, is the most economical and viable solution and, therefore recommended for onward study. An illustrative plan of this alternative is provided in Drawing No. **BRBD-HEPP-FS-2.1.** The canal banks shall be raised on both sides from RD 509+712 up to the powerhouse which will allow the utilization of available head at RD 510+600 for power generation. In this scenario, the canal will follow its original regime and there will be minimum disturbance to the hydrological behavior of the canal. The main canal shall be diverted temporarily during canal closure and coffer dams shall be constructed on upstream and downstream of the proposed powerhouse at the confluence of diversion and main canal. Therefore, construction works of the power plant can be executed independently without disturbing the canal operations. An auxiliary spillway catering the same discharge capacity is proposed alongside the powerhouse within the main canal in order to safely manage the canal operations during emergency shutdown of the power plant. The Hydropower Project utilizes a net head of 18.9 ft. The discharge shall be regulated by the spillway gates and power generating unit will be double regulated with much better efficiency.

Operations of the canal will not be disturbed during construction and after the commissioning of the proposed power plant. The Sponsor is responsible to take care of all the structures and reach of the canal during the construction and operations of powerhouse.

1.11 SELECTION OF TURBINE

(DOUBLE REGULATED BULB TYPE UNIT)

As per the available net head of 5.77 m and design discharge of 50 Cumecs, it is recommended to install one (01) Bulb Type Unit. Major parameters of selected unit are mentioned in **Table-1.4.** During detailed engineering, the manufacturer's technical specifications and shop drawings shall be considered for final selection of the units.

Table 1.4: Turbine Parameters

Design or Rated Net head	5.77 m
Design or Rated Discharge	50 m^3/s
Rated turbine output	2924 KW
Specific Speed under Rated Net Head	761.2 Ns
Wicket Gate Height / Diameter	988 mm / 3654 mm
Unit Speed	150 rpm
Runner Diameter	2.83 m
Number of runner blades	3
Runner weight	6742 kg
Inlet height	6.57 m
Exit Height	6.57 m
Hydraulic thrust	8547 Kg
Number of units	1
Plant Installed capacity	2.45 MW
Average Energy Production	10.62 GWh

1.12 CONSTRUCTION PLANNING & MANAGEMENT

The Kasur Hydropower Project is planned to be constructed in a period of 22 months. This includes Civil, Electro-mechanical, Transmission and Interconnection works from installation to commissioning. Special consideration should be given to the critical tasks related to the canal closure and schedule delivery of Turbines, Generators & other E&M equipment to site. Activity Schedule and Construction Planning drawings are provided in Volume II as **BRBD-HEPP-FS-1.8 & BRBD-HEPP-FS-2.4** respectively.

1.13 INITIAL ENVIRONMENTAL EXAMINATION

A detailed assessment and monitoring about environmental examination is provided in Volume III of this study whereby it is concluded that Kasur Hydropower Plant is an environment friendly project. A detailed discussions about the project salient features, baselines conditions, legal & administrative framework policy, and environmental management plan and mitigation measures has been conducted during the environmental study and the requisite deliverables furnished accordingly. It has minimal environmental impacts. There are no resettlement requirements and the entire reach of the project is vacant for any development activity. It is believed that this project will furnish long time economic and social benefits to the residents of the area and, will also create employment opportunities. The proposed Hydropower Project is unlikely to cause any significant, lasting impact on the social, physical and biological environment of the area, provided that the proposed activities are carried out in accordance with recommendations of IEE report, and the mitigation measures included in the IEE are completely and effectively implemented. The proposed Kasur Hydropower Project is environmental friendly and is recommended for implementation.

1.14 CONCLUSIONS

- The construction of the Power Plant in within main canal at RD 510+600 along with spillway provides us maximum power and energy. It is technically more viable and preferred option with simpler construction methodology. Therefore, it is recommended for onward study and development of the project.

- The installed capacity of the Power Plant is 2.45 MW and mean annual energy is 10.62 GWh. The electricity shall be sold to National Grid.

- The Project is economically feasible and has the capacity to offset adverse change in variable and generate economic benefits. It offers good return for diverting scarce resources.

- This can be developed in accordance to **NEPRA's upfront tariff**.

CONTENTS

2.1. GENERAL

This chapter contains documentation on surveying and mapping. The scope covered surveying and mapping of proposed locations of various components of the hydropower plant including the topographic details of existing fall structure. M/s Aipel in association with Myco Survey (Pvt) Ltd. was mobilized on the project site on 21st December, 2016 and field work was completed on 26th December, 2016.

2.1.1. SCOPE OF WORK

The Scope of Work is described here under:

- Establishment of horizontal and vertical control points to acquire field survey data in digital format.
- Fixation of permanent monuments.
- Detailed topographic survey of project site to acquire spot levels of ground for generation of contours and ground details including all natural and man-made land features and both banks of canal etc.
- Surveying BRBD Link Canal at RD 509+712 (fall structure) as the designated locations, starting from 1.2 km downstream (up to Syphon at RD 513+500) of the fall structure to its about 600 m upstream. To the extent practical, cross sections were surveyed to upstream and downstream of the fall structure. Reconnaissance was carried out within the reach of the proposed project.
- Processing field data and producing topographic maps of project site showing all above mentioned features on scale of 1:1000 on eight topographic sheets with contour interval of 0.3 m (1 ft).

2.2. ACCESS TO SITE

2.2.1. ROAD NETWORK

This raw site is located on BRBD Link Canal at RD 509+712 in District Kasur and nearly 50 km away from Lahore. The site is accessible by Ferozepur Road Lahore to Kasur Khem Karan Road which leads straight to Bambanwala Ravi Bedian Depalpur

(BRBD) canal. The site is within 3.5 Km from Kasur City and easily accessible. Project location map is provided in Drawing No. **BRBD-HEPP-FS-1.1.**

2.2.2. RAILWAYS NETWORK

The Project area is located in District Kasur of Punjab Province. The nearest railway station is Kasur Railway Station, however, the closest standard dry port & railway station where the facilities of loading and unloading of heavy equipment is possible is Lahore railway station.

2.2.3. AIRPORT AND AIR LINK

International Airports in the nearest facility to the project area is Allama Iqbal International Airport in Lahore about 70 Km from the project site.

2.3. EQUIPMENT LIST

The following calibrated survey instrument was used for carrying out the topographic survey. The calibration certificate of survey instrument is provided in **Annexure-2.1.**

Sr. No	Name	Make	Model	Serial #
1	Total Station	Sokkia	610	26115

2.4. HORIZONTAL AND VERTICAL CONTROL POINTS

2.4.1. REFERENCE DATUM

Global Positioning System (GPS) was used to establish reference control points CP1, CP2, CP3 & CP4. GPS observation and measurement is capable of reading to a horizontal and vertical accuracy of at least ± 1m. Following are the coordinates and elevations of four survey stations used for this task:

Table 2.1: Survey Control Points

Control Point	Easting (m)	Northing (m)	Elevation (m)
CP1	452588.286	3441889.299	206.263
CP2	452545.276	3441888.806	206.513
CP3	452551.486	3440751.661	200.772
CP4	452577.165	3440751.426	201.002

2.4.2. UNITS OF MEASUREMENT

The measurement units used in survey and mapping work is feet.

2.4.3. FIXATION OF PERMANENT CONTROL MONUMENTS

The surveyors established four (04) vertical control points i.e. Control Points CP1, CP2, CP3 & CP4 in the areas of interest to acquire field survey data in digital format for its processing by using appropriate computer software to produce computer aided mapping of various components of the project. The permanent control points were fixed at safe and stable locations by using concrete block of 6" X 6" and 3'3" length.

2.5. DATA PROCESSING

2.5.1. LAYOUT PLAN

Electronic total stations used for topographic survey had electronic data recording facility and same were used for acquiring bulk of the field data. The data were computer processed to create computer aided mapping produced at the desired scale.

2.5.2. CONTOURS DEVELOPMENT

The contours were generated at 0.3 m (1 ft.) interval from the file acquired from Total Station data. The topographic survey sheets are attached as Drawing No. **BRBD-HEPP-FS-1.5** (07 Sheets) of Volume II.

2.5.3. LONGITUDINAL SECTION

Longitudinal section of the canal is generated and attached as Drawing No. **BRBD-HEPP-FS-1.7** of Volume II.

2.5.4. X-SECTIONS

The cross sections of BRBD Link Canal are generated on 100m interval of the surveyed area. The cross sections are attached as Drawing No. **BRBD-HEPP-FS-1.6** (12 Sheets) of Volume II.

2.6. SITE PHOTOGRAPHS

Figure 2.1: Control Points CP1 & CP2

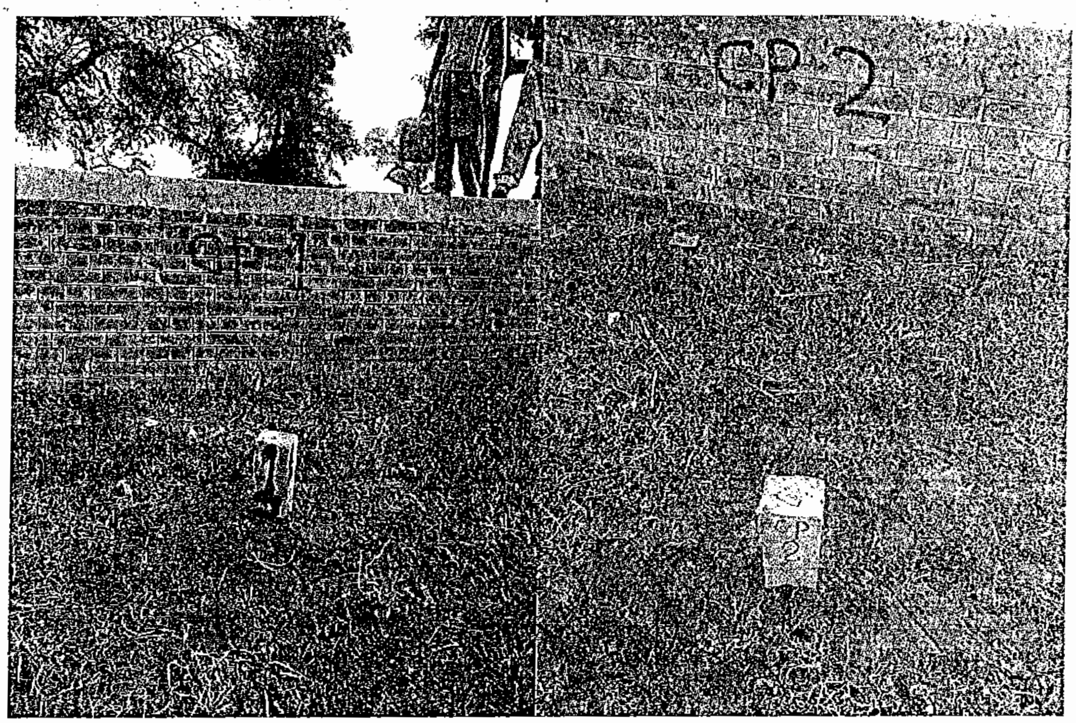


Figure 2.2: Control Points CP3 & CP4

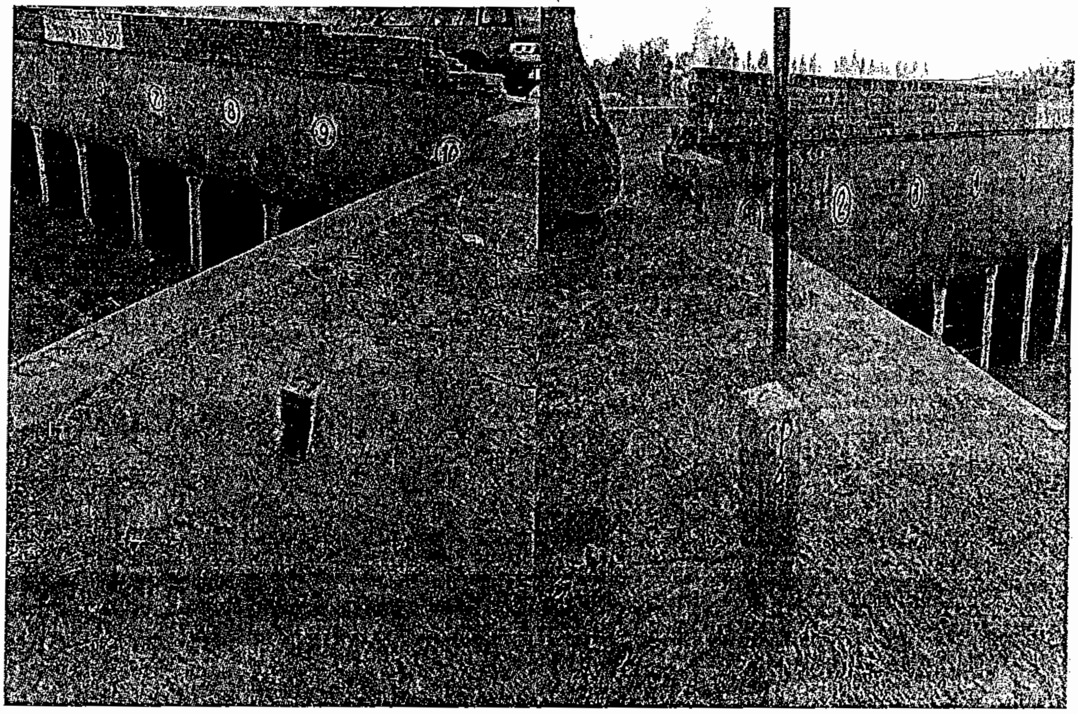


Figure 2.3: U/S View of Fall Structure at RD 509+712

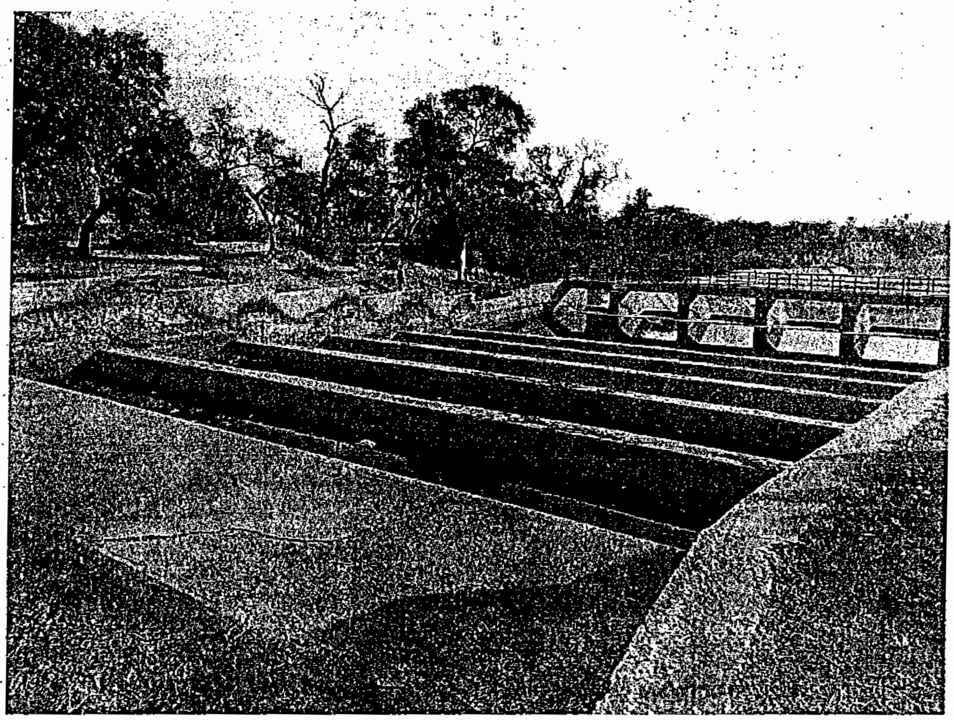


Figure 2.4: D/S View of Fall Structure at RD 509+712

Figure 2.5: D/S View of Canal from Fall Structure at RD 509+712

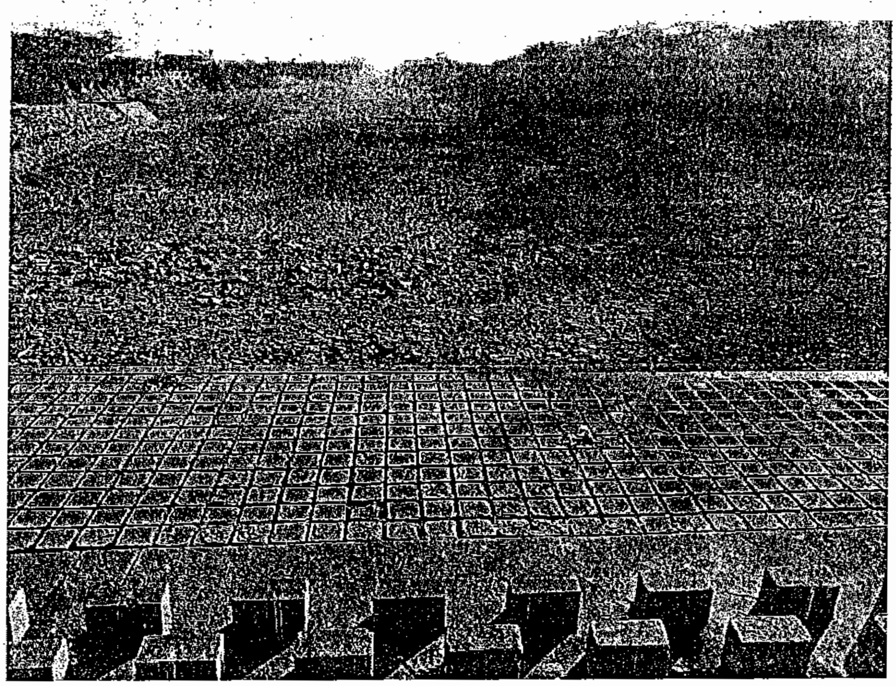


Figure 2.6: Syphon at BRBD Link Canal at RD 513+500

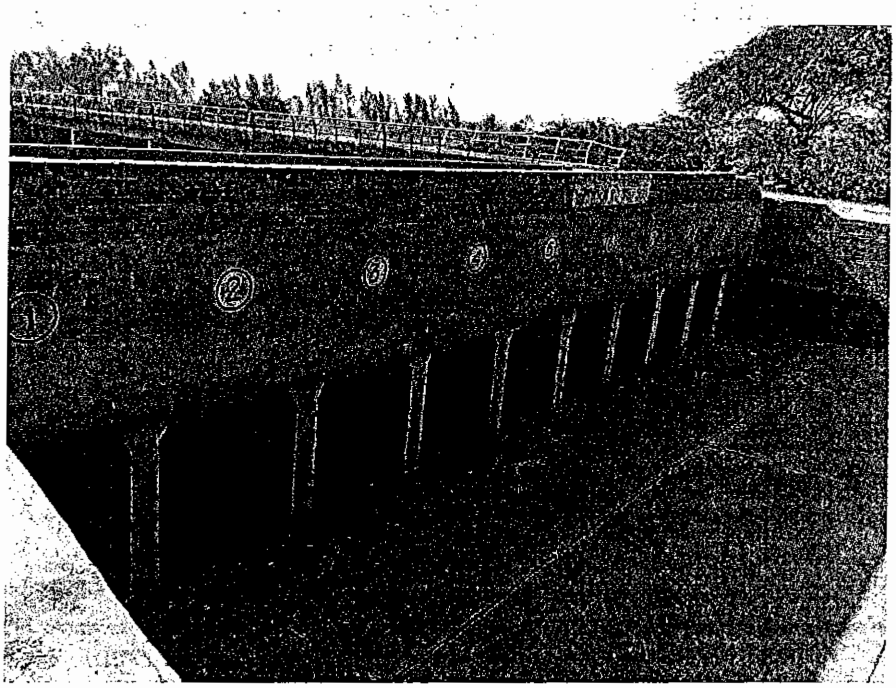
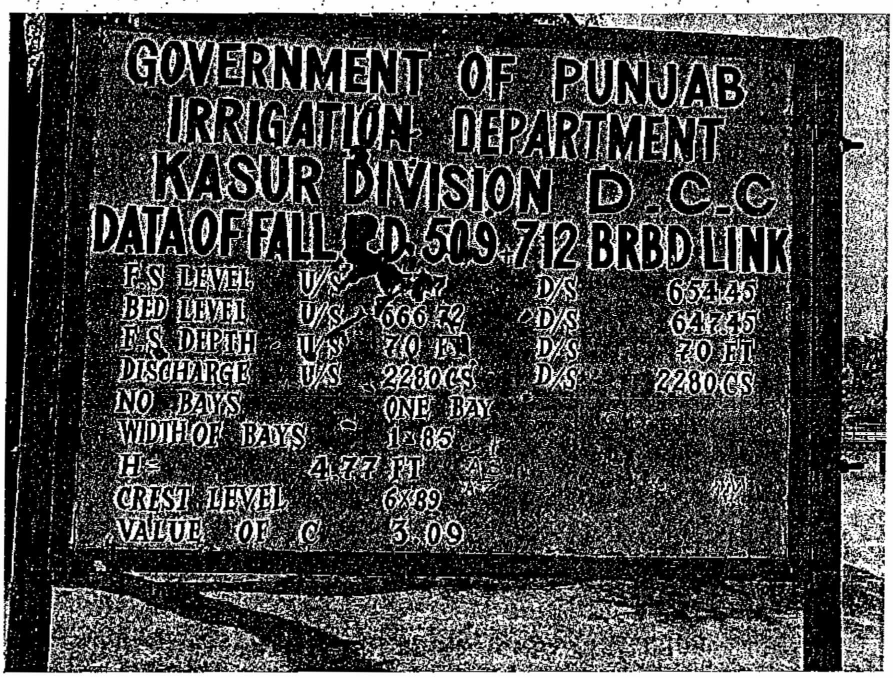


Figure 2.7: Data of Fall Structure at RD 509+712



CONTENTS

3.1. GENERAL

This chapter comprises of the analysis of available hydrological and meteorological data relevant for the estimation of flows available for power generation at RD 509+712 on BRBD Link Canal, District Kasur. A brief account of Marala Headworks and BRBD Link Canal with related irrigation network is also discussed in order to provide comprehensive information to the reader. The project area is accessible by Ferozepur Road Lahore to Kasur-Khem Karan Road which leads straight to Bambanwala Ravi Bedian Depalpur (BRBD) Link Canal.

3.2. MARALA HEADWORKS & CANAL SYSTEM

Marala Headworks on Chenab River is the first Barrage on entry of the River into Pakistan. The Barrage lies in District Sialkot and is located 25 Km in the northeast of Sialkot city.

The old Marala Weir was constructed in 1905-12 to feed Upper Chenab Canal with discharge capacity of 467 cumecs (16,500 cusecs). Later on in 1956, Marala Ravi Link Canal of 623 cumecs was constructed and the weir remodeled to supplement water supplies in the river Ravi. The capacity of the old weir was 19825 cumecs (700,000 cusecs) with upstream pond level at RL 246.28 m. The weir experienced the highest flood at Marala with discharge of 31,152 cumecs (1,100,000 cusecs) on 26.08.1957. The left and right guide bunds were allowed to breach resulting in catastrophic inundation of cropped lands and built-up properties.

The construction of new barrage is part of the Indus Basin Project completed in 1965-68. With the construction of Barrage, the old Marala Weir was abandoned in 1968. The new Barrage is located at 335.28 m downstream of the old weir. The Barrage length is 1363 m with 66 No. bays including 13 nos. under sluices on the left side and 07 nos. on the Right side. The designed discharge capacity of the Barrage is 31,149 cumecs (1,100,000 cusecs). Upper Chenab Canal (UCC) of 467 cumecs (16,500 cusecs) and Marala Ravi link canal of 623 cumecs (22,000 cusecs) off-take on its Left Bank.

The existing Barrage experienced an exceptionally high flood of 23,933.5 cumecs (845,090 cusecs) on 10-09-1992 and attained flood height of 248.10 m (814 ft.) at Barrage crest. In order to improve performance of the off taking canals, the pond level for New Barrage was raised by four feet. The level was thus fixed at 247.49 m (812.00 ft). This reduced the approach velocity and considerably reduced the erosion of belas.

3.2.1. UPPER CHENAB CANAL

Two major canals originate at the Marala headworks i.e. Marala-Ravi (MR) Link Canal and the Upper Chenab Canal (UCC). The Upper Chenab Canal (UCC) serves the districts of Sialkot, Gujranwala and Sheikhupura and outfalls in the River Ravi at the right flank of Balloki Headwoks for augmenting the flow of Lower Bari Doab Canal (LBDC). The Upper Chenab Canal (UCC) commands the majority of the area between the Marala Ravi and Qadirabad-Balloki Link Canals and a small area below the Qadirabad-Balloki Link Canal along the river Ravi. The area is popularly termed as the Upper Rechna Doab.

The UCC has been operating in the Upper Rechna Doab area since 1915. There is no off take from UCC to its tail up to RD 133+296 where Bambanwala Trifurcation Structure is also located. Nokhar Branch, BRBD Link Canal (formerly known as Raya Branch) and Lower Chenab Canal Lower (LCCL) off take from this trifurcation structure. Canal network plan of Rechna Doab area is provided in **Figure 3.1**. Canal data of UCC at RD 133+296 is provided in **Figure 3.2.** Two hydropower projects i.e., 13.8 MW Nandipur and 13.2 MW Chichoki on RD 44+000 and 220+200 of UCCL are already in operation whereas another two hydropower plants are under construction by Project Management Unit (PPMU) of Punjab Energy Department, Government of Punjab.

Figure 3.1: Rechna Doab Canal Network Plan

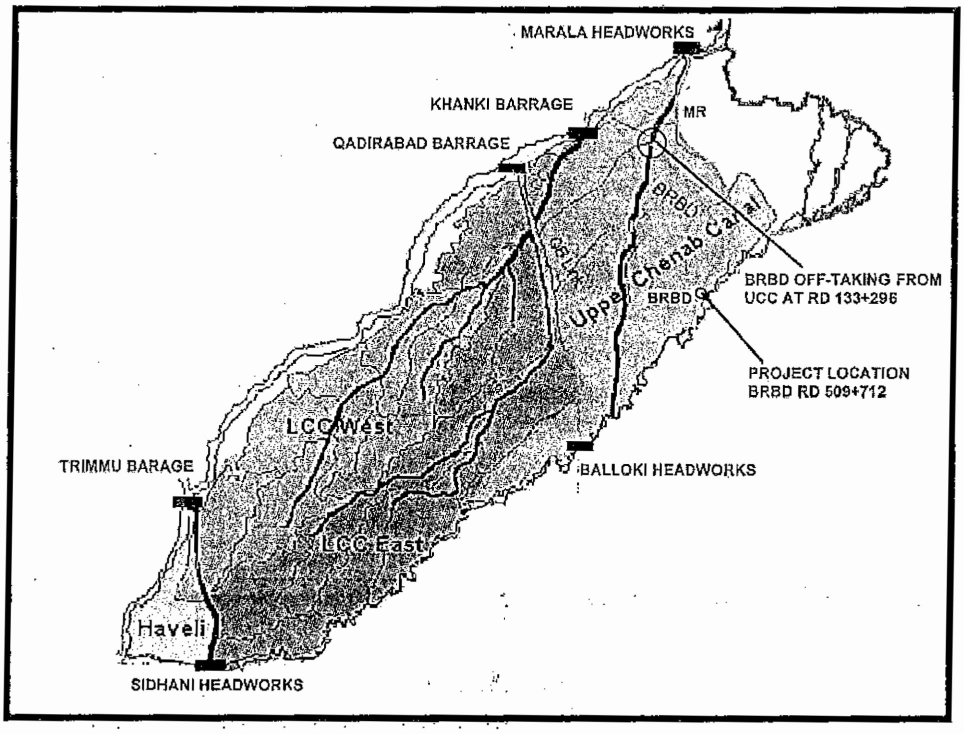
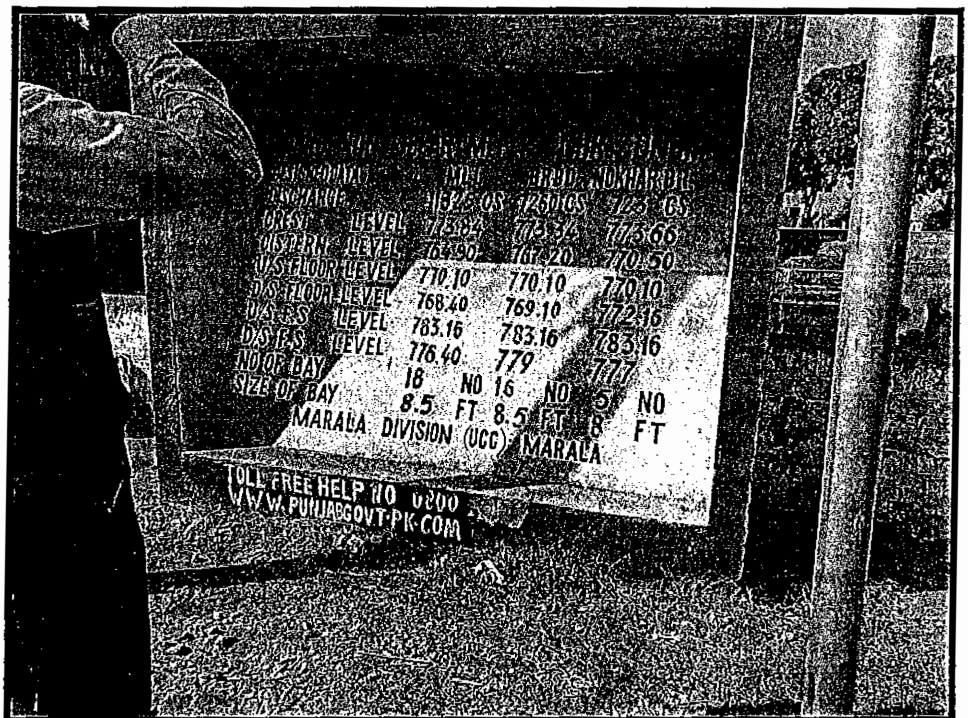


Figure 3.2: UCC Trifurcation Data at RD 133+296

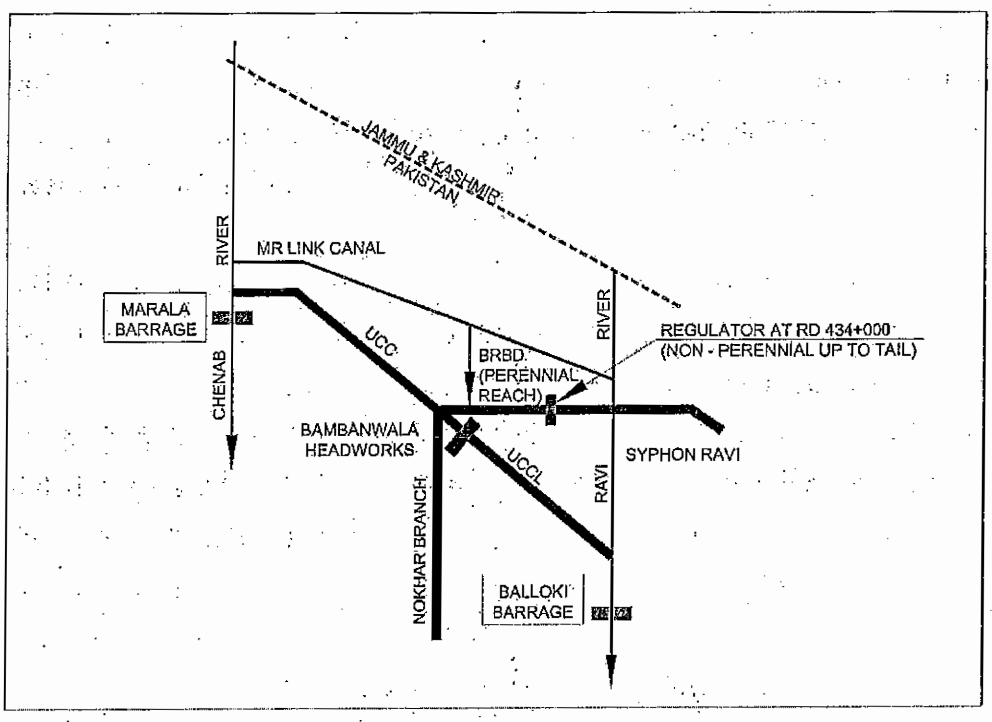


3.2.2. BAMBANWALA-RAVI-BEDIAN-DEPALPUR (BRBD) LINK CANAL

Bambanwala-Ravi-Bedian-Depalpur (BRBD) Link Canal, a branch canal off-taking from RD 133+296 of Upper Chenab Main Canal transmits its larger volume of water to the Eastern Punjab areas. BRBD Link Canal was rehabilitated in 1948 to carry additional flows towards the Eastern Punjab area. It is widened at Banbanwala, crossed the river Ravi through the Siphon and carried water to Bedian and Depalpur Canals. Hence, a new name Bambanwala-Ravi-Bedian-Depalpur (BRBD) Link Canal was given to Raya Branch.

The BRBD Link Canal is perennial up to regulator at RD 434+000 and non-perennial from RD 434+000 to its tail. It receives supplies through the UCC at RD 133+296 and is further fed through sub-link canal off the MR Link canal at about RD 183+680. Total length of BRBD Link Canal is nearly 164 Km. It carries a flow of 118 Cumecs at its head and gets additional 57 Cumecs from MR Link Canal. BRBD Link Canal irrigates 0.194 million hectares of the Upper Rechna Doab area through a network of distributaries, minors and watercourses before conveying water to the eastern Punjab areas. Canal schematic diagram is provided in **Figure 3.3**.

Figure 3.3: Schematic Diagram



3.2.3. FALL STRUCTURE AT RD 509+712 OF BRBD LINK CANAL

Fall at RD 509+712 of BRBD Link Canal is an un-gated structure having width of 85 feet and gross head of 19.27 feet. It is a simple *Stepped Type Fall Structure* consisting of a series of vertical drops in the form of steps at gradual intervals. It is suitable for the canals where the slopping ground is very long and having very high upstream level as compared to downstream. These two levels are connected by providing vertical steps or drops as shown in **Figure 3.4** of a typical diagram of such fall structures.

Fall structure at RD 509+712 is provided with brick walls at each of the drops. The bed of the canal within the fall is protected by rubble masonry with surface finishing by rich cement mortar (1:3). The salient features of fall structure are provided below and the photographs of the fall are shown in **Figures 3.5, 3.6, 3.7** and **3.8.**

- Upstream Full Supply Level = 673.72 ft.
- Downstream Full Supply Level = 654.45 ft.
- Upstream Bed Level = 666.72 ft.
- Downstream Bed Level = 647.45 ft.
- No. of Bays = 1 No.
- Width of Bay = 85 ft.
- Discharge = 2280 cusecs.

Figure 3.4: Typical Stepped Type Fall Structure

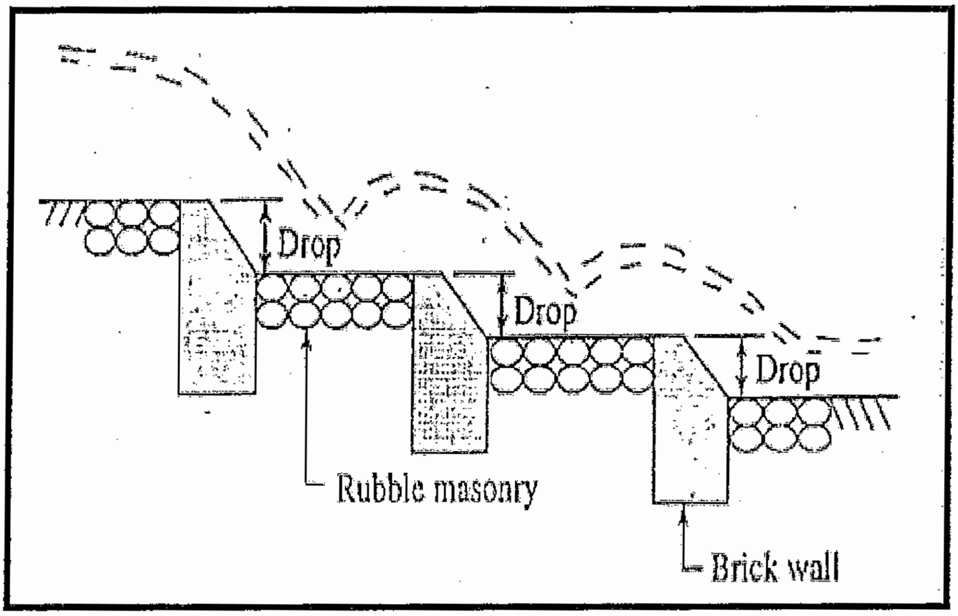


Figure 3.5: Fall Structure Data at RD 509+ 712

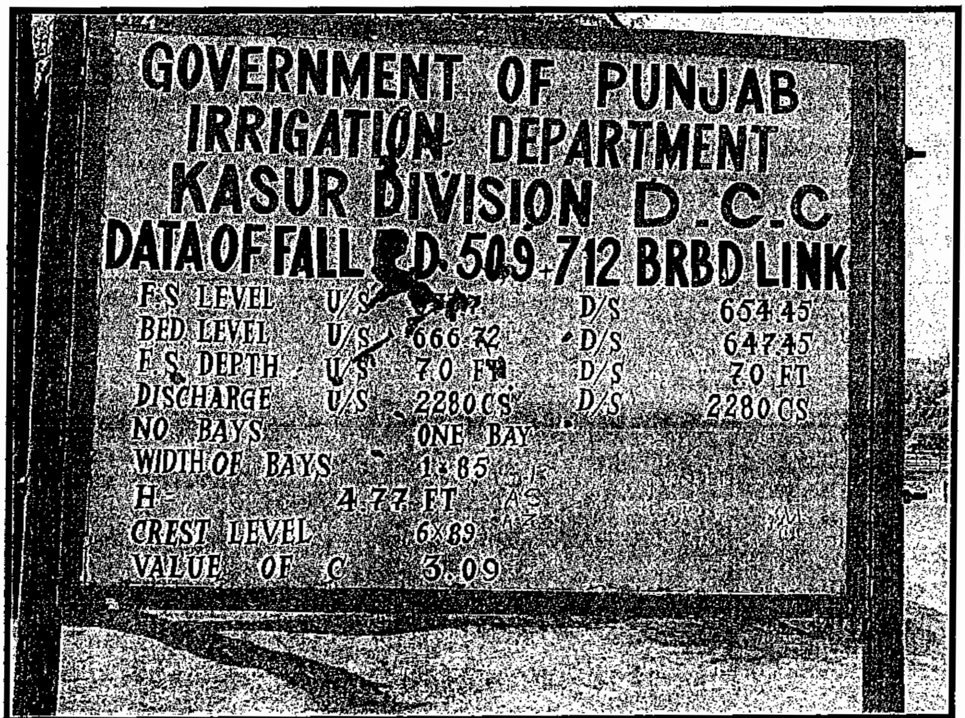


Figure 3.6: Fall Structure at RD 509+712

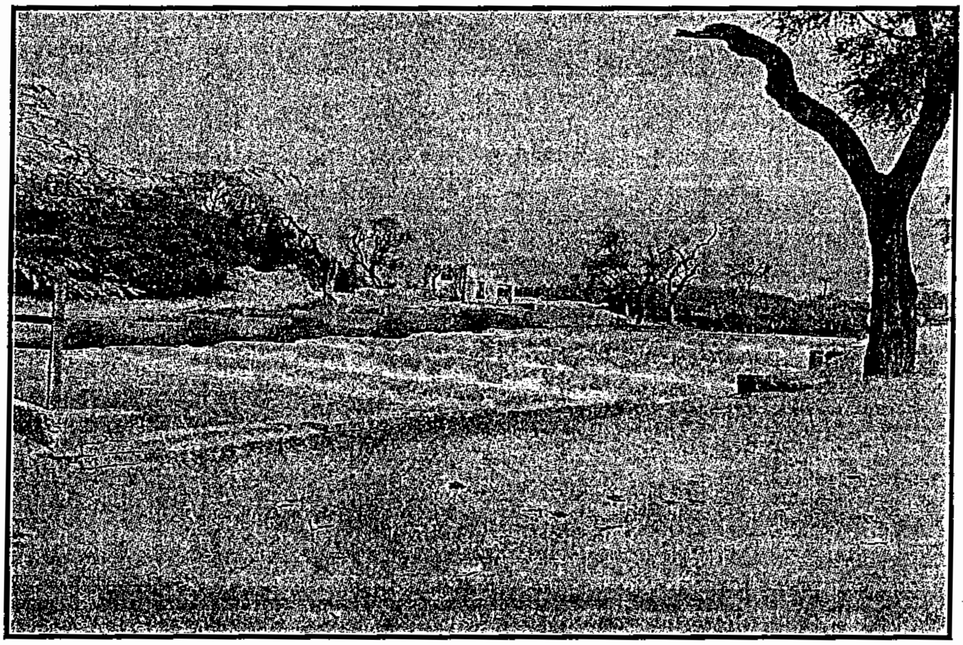


Figure 3.7: D/S View of Fall Structure at RD 509+712

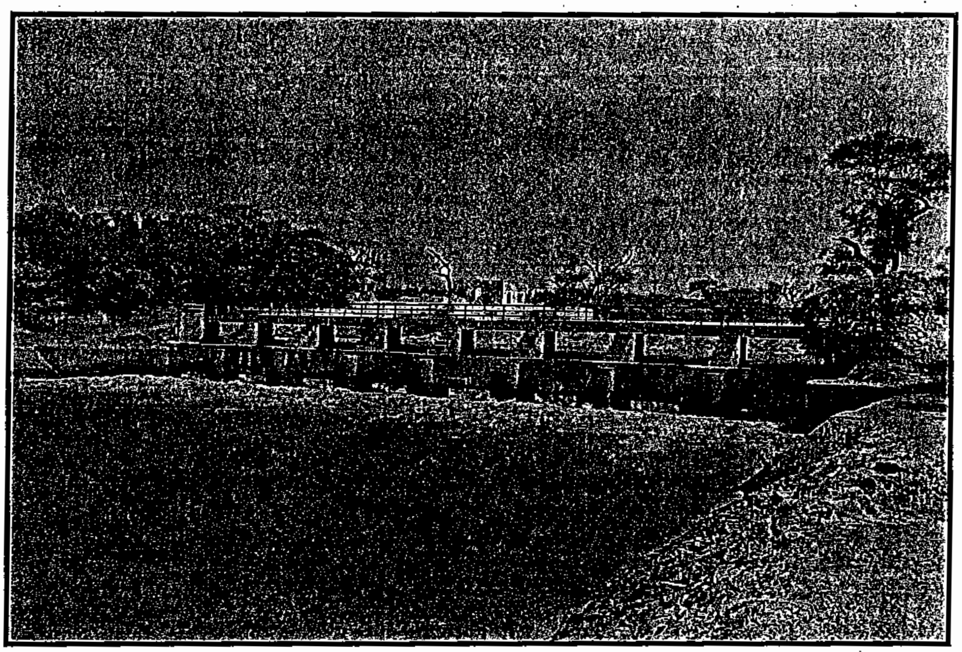
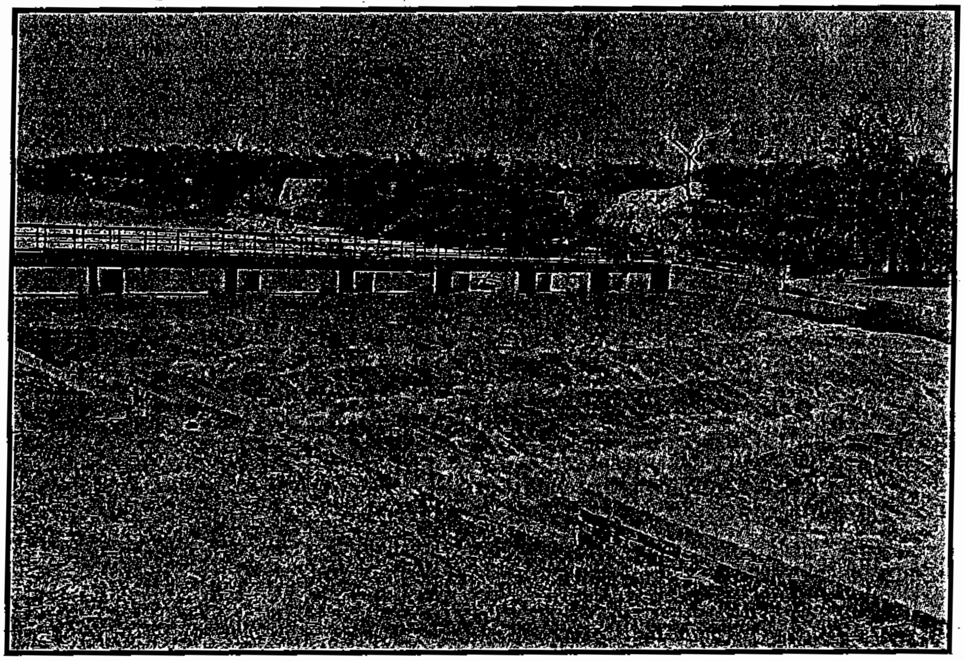


Figure 3.8: U/S View of Fall Structure at RD 509+712



3.3. METEOROLOGICAL DATA and ANALYSIS

3.3.1. DATA COLLECTION

Meteorological data (Temperature, Rainfall, Humidity and Wind Speed) for Lahore meteorological station being the closest was analyzed for a period of last ten years (2006-2015).

3.3.2. DATA ANALYSIS

The country has four distinct climate seasons. April, May and June are extremely hot and dry months. July, August and September are hot and humid with intensive heat and scattered rainfall. The cool and dry period starts at the beginning of October and continues through November. December, January and February are the coldest months of the year. Due to the diversity of the climate, a large variety of crops is grown to support the agricultural economy. The same is experienced at the project site and shall not affect the construction schedule of the project. However, Moonsoon season in July and August affects the area whereas March and April being the spring season are very pleasant months.

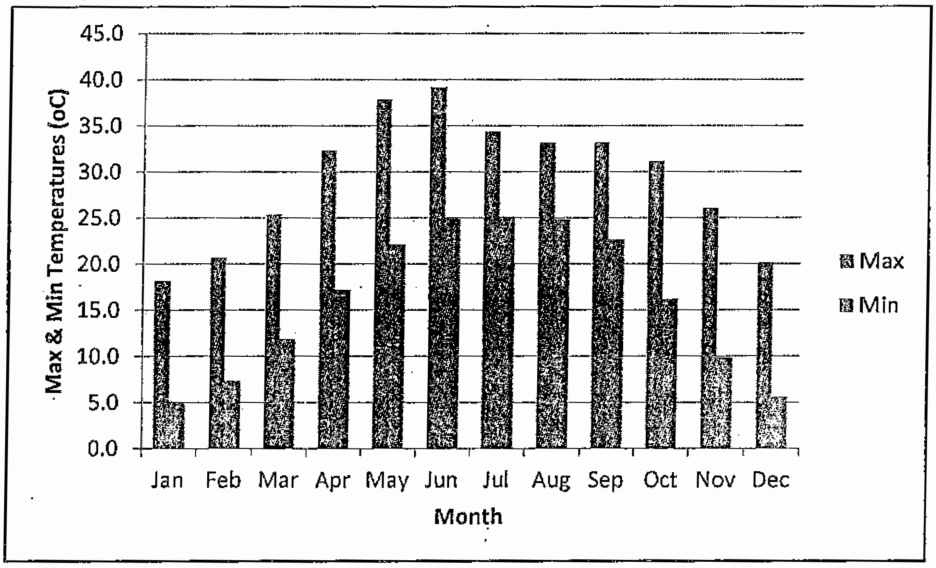
3.3.3. TEMPERATURE

The mean daily temperature ranges from (June being the hottest month) 30°C to 32°C in the summer season (May to July) and 11°C to 13°C in winter season (January and December). Mean monthly temperature in June rises to a highest value of 32.1°C and falls to the lowest value of 11.6°C in January. June and July are the hottest months in summer season. December and January are the coldest months in winter season. The monthly averages of minimum, maximum and mean daily temperatures are given in Table 3.1 and shown graphically in **Figure 3.9** which shows the mean monthly maximum and mean monthly minimum temperature at Lahore.

Table 3.1: Mean Monthly Temperature at Lahore

Month	Daily Temperature (°C)		
	Max	Min	Mean
Jan	18.2	5.1	11.7
Feb	20.7	7.4	14.1
Mar	25.4	11.9	18.7
Apr	32.4	17.2	24.8
May	37.9	22.1	30.0
Jun	39.2	25.0	32.1
Jul	34.4	25.2	29.8
Aug	33.2	24.8	29.0
Sep	33.2	22.6	27.9
Oct	31.2	16.2	23.7
Nov	26.1	9.9	18.0
Dec	20.2	5.6	12.9

Figure 3.9: Mean Monthly Maximum & minimum Temperature at Lahore



3.3.4. RAINFALL

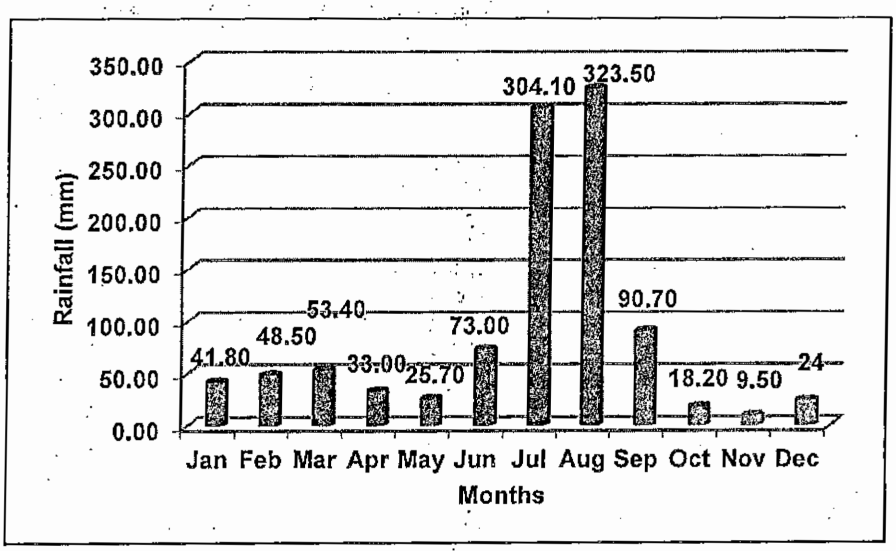
In Pakistan the mean annual rainfall ranges from 4 to 30 inches in the lower Indus region to the northern foot hills. Only a small proportion of this annual rainfall makes any direct or useful contribution to irrigation water supplies. According to World Bank Consultants' report, the figure ranges from 1 to 17 inches. The rest is either converted to Direct Runoff or becomes a part of the ground water while a small proportion is lost by evaporation. According to estimation the present direct contribution to the crops is 9 MAF / Annum. Daily rainfall data for Lahore was collected and processed for monthly and annual rainfall basis.

Mean monthly rainfall and the number of rainy days for Lahore are given in Table 3.2. The mean annual rainfall of the area is about 1045 mm (41 inches). The maximum rainfall occurs during the months of July, August and September, which is about 70% of the annual rainfall. Precipitation in the project area is characterized by the monsoon season. Most of the rainfall occurs during the monsoon season (May to October). Winter rains generally occur during the months of January, February and March. Table 3.2 shows that April, May, October and November are normally the months of least precipitation.

Table-3.2: Average Monthly Rainfall in Lahore (mm)

Month	Mean Monthly Rainfall (mm)	Rainy Days (No.)
Jan	41.80	5
Feb	48.50	5.7
Mar	53.40	7.3
Apr	33.00	6.1
May	25.70	5.8
Jun	73.00	7.7
Jul	304.10	15.1
Aug	323.50	14.2
Sep	90.70	6.8
Oct	18.20	2.2
Nov	9.50	1.6
Dec	24	3.3
Annual	**1045.4**	**80.8**

Figure 3.10: Average Annual Rainfall (mm)



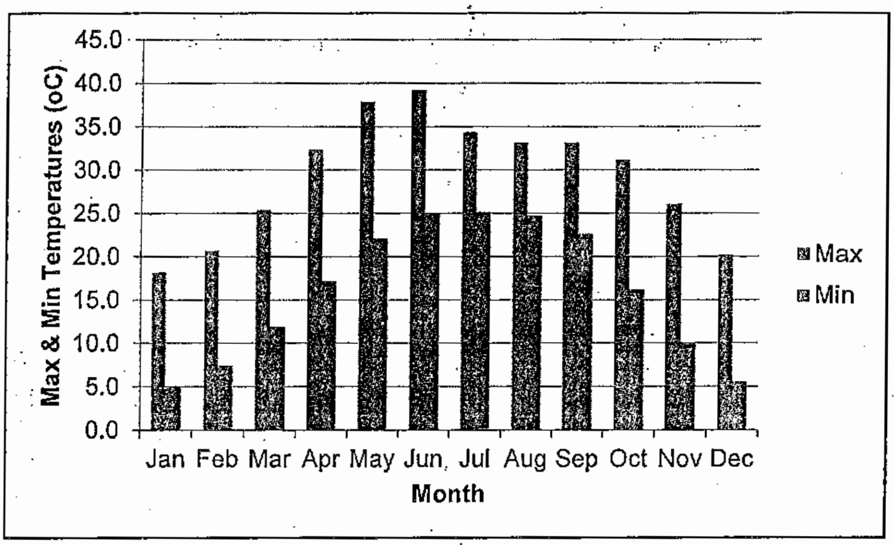
3.3.5. WIND SPEED

The mean wind speed at synoptic hours in knots is given in Table 3.3. and graphically presented in **Figure 3.11**. The data reveals that at 00:00 hours, the wind speeds are generally lower while higher wind speed are recorded at 03:00 and 12:00 hours. During summers wind speeds are generally higher than the wind speeds in winters.

Table-3.3: Mean Monthly Wind Speed in Lahore

Month	Mean Monthly Wind Speed (Knots)		
	00:00	03:00	12:00
Jan	0.4	0.3	0.8
Feb	0.8	0.6	1.8
Mar	0.9	0.9	2
Apr	1	1	1.9
May	0.9	1.4	2
Jun	1.1	1.7	2
Jul	1.4	1.2	1.5
Aug	1.1	0.7	1.1
Sep	0.6	0.7	1.3
Oct	0.4	0.3	0.4
Nov	0.1	0.2	0.2
Dec	0.3	0.2	0.3

Figure 3.11: Mean Monthly Maximum & Minimum Wind Speed at Lahore



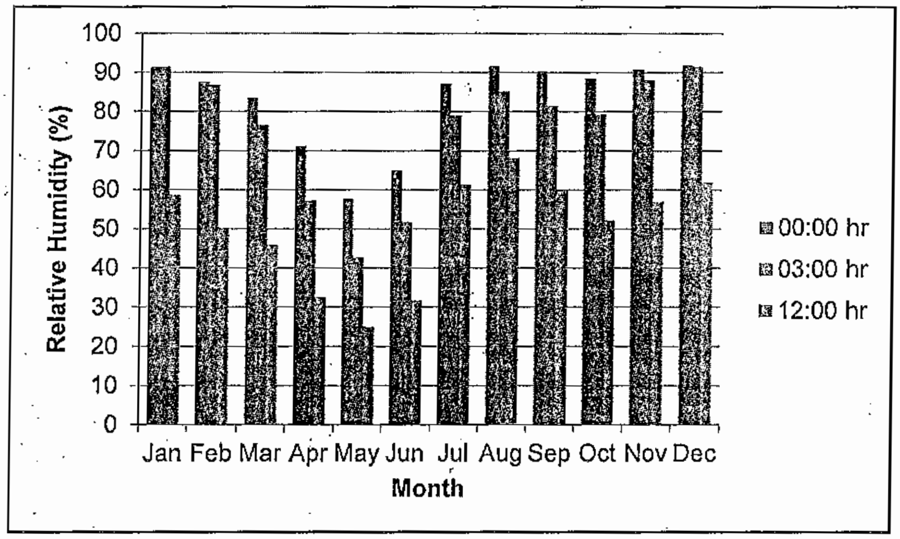
3.3.6. RELATIVE HUMIDITY

The relative humidity data at 00:00, 03:00 and 12:00 hours are available. Mean monthly relative humidity is given in Table 3.4. At 00:00 hr the relative humidity varies from lowest value of 58% in May to highest value of 92% in December. At 12:00 hr the lowest value is 24.9 % in May to highest value of 68 % in August.

Table-3.4: Mean Monthly Humidity

Month	Relative Humidity (%)		
	00:00	03:00	12:00
Jan	91.3	91.5	58.6
Feb	87.5	86.8	49.9
Mar	83.5	76.5	45.8
Apr	71.2	57.2	32.6
May	57.7	42.7	24.9
Jun	65	51.8	31.7
Jul	87.1	79	61.3
Aug	91.7	85.2	68.1
Sep	90.4	81.5	60.1
Oct	88.5	79.3	52.3
Nov	90.9	88.1	56.9
Dec	92	91.5	61.9

Figure 3.12: Relative Humidity (%)



3.4. HYDROLOGY

3.4.1. DISCHARGE DATA COLLECTION

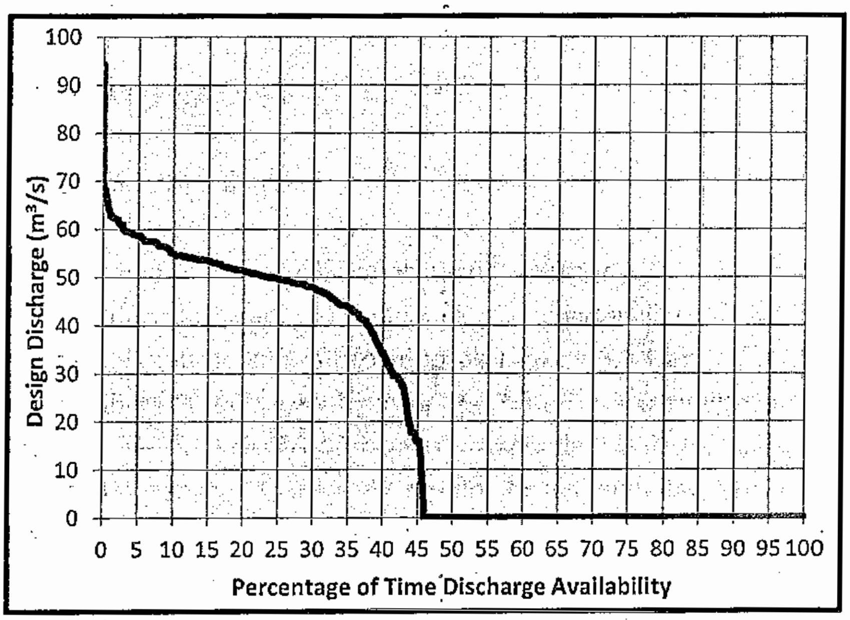
The average daily discharge data of BRBD Link Canal at RD 434+000 was collected from the office of Executive Engineer, Depalpur Circle of Punjab Irrigation Department. The discharge observation is not being carried out at RD 509+712, however, there is no outlet between RD 434+000 and RD 509+712. Furthermore, the losses between this reach are also negligible and not considered. Therefore, the same data is considered for discharge calculation at RD 509+712. The Discharge data is provided as **Annexure-3.1** with this chapter.

3.4.2. FLOW DATA ANALYSIS

3.4.2.1. Flow Duration Curve

Flow duration curve has been developed using average daily discharge data for a period of 2000-2016 in order to estimate the availability of water for power generation. Flow Duration curve is provided as **Figure 3.13** and it is noticeable that the discharge of 35 m^3/s, 40 m^3/s, 45 m^3/s and 50 m^3/s are available for duration of 39.6%, 37.8%, 33.2% and 23.6% of the time respectively. BRBD Link Canal is non-perennial within the reach of RD 434+000 to its tail and the flow duration curve demonstrates the availability of water throughout the year. The selected plant capacity is 50 Cumecs and the details of discharge optimization are furnished in Chapter 9 of this study.

Figure 3.13: Flow Duration Curve



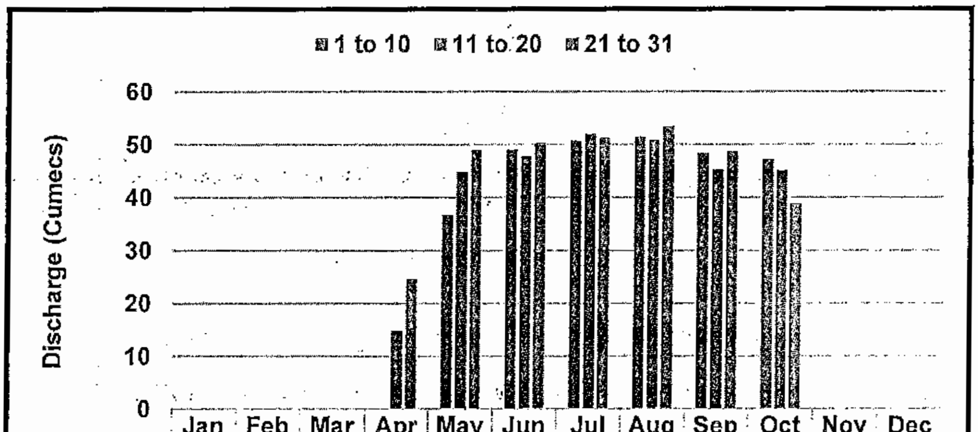
3.4.2.2. Availability of Flows for Power Generation

Average 10-Daily discharge and the mean monthly discharge data is processed on the basis of daily discharge data. **Figure 3.14** shows the availability of 10-Daily discharges whereby it is evident that the canal flows during the months of May to

August are very steady and ranges between 45 to 50 Cumecs. Canal remains in operations from mid of April to end of October.

Similarly, mean monthly discharge is provided in **Figure 3.15** and it is observed that discharge of 50 Cumecs is available during July and August and remains above 40 Cumecs during May to October. Maximum, average and minimum discharge from the year 2000 to 2016 is provided in **Figure 3.16. It** is noticeable that it remains up to 45 Cumecs (1600 Cusecs).

Figure 3.14: Average 10-Daily Discharge



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 to 10	0	0	0	0	36.81	49.06	50.8	51.56	48.4	47.28	0	0
11 to 20	0	0	0	14.92	44.92	47.79	52.03	50.93	45.4	45.14	0	0
21 to 31	0	0	0	24.73	49.07	50.42	51.35	53.43	48.72	38.98	0	0

Figure 3.15: Mean Monthly Discharge

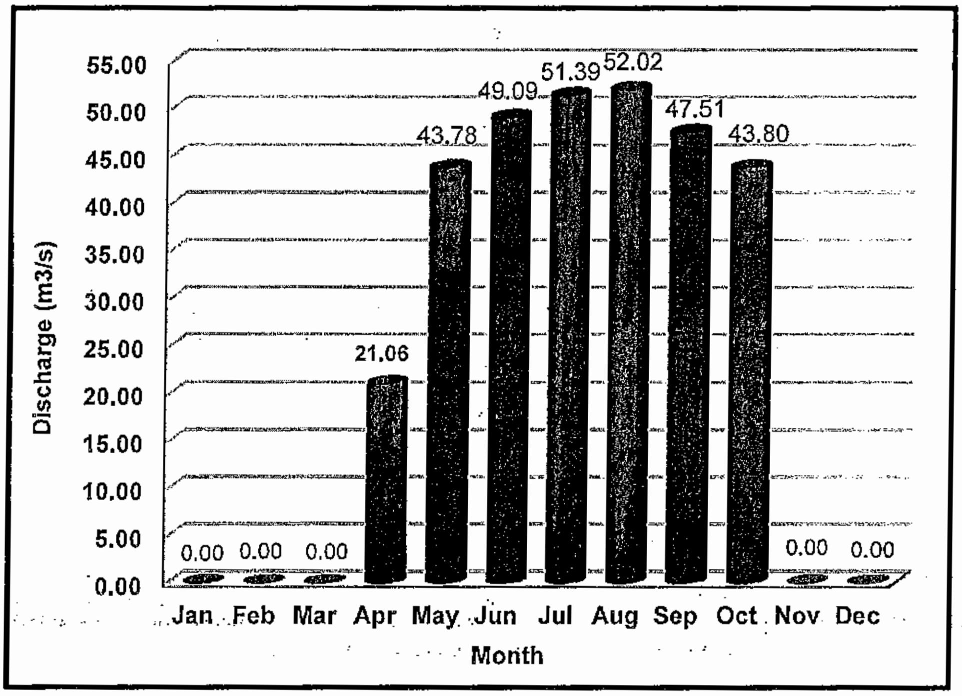
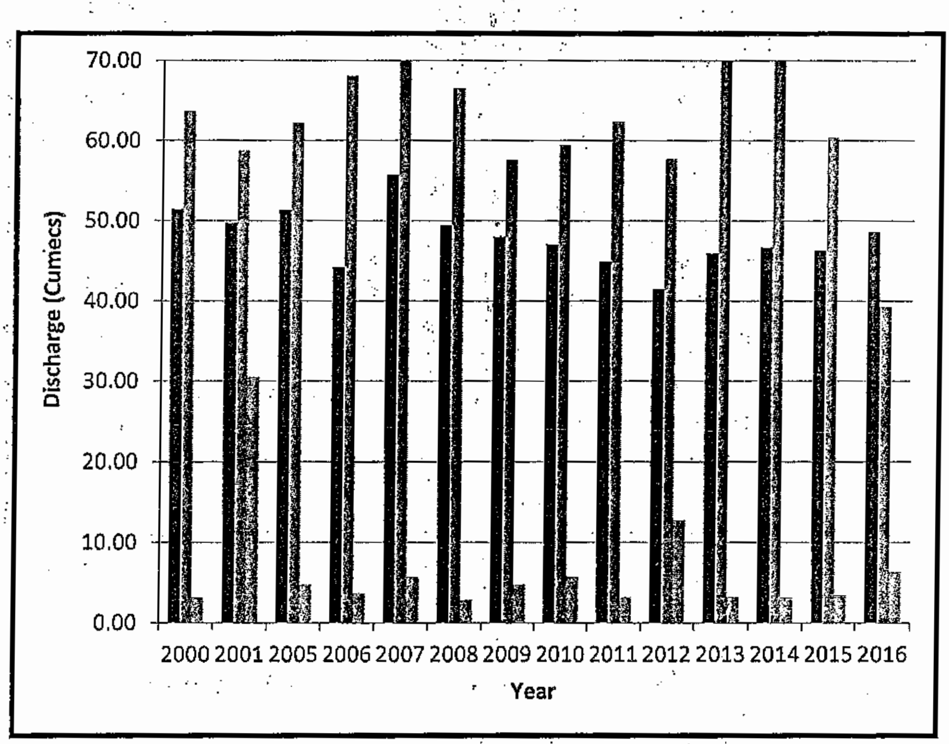


Figure 3.16: Average, Maximum & Minimum Discharge



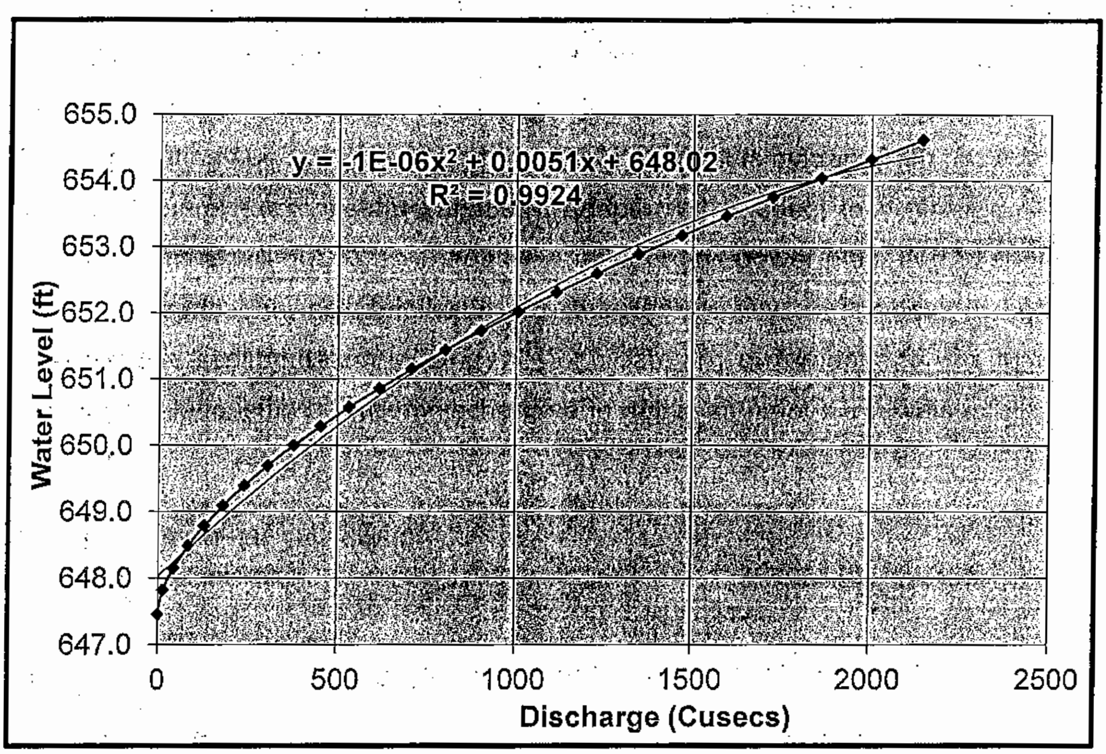
3.4.3. DISCHARGE RATING CURVE

Discharge rating curve at RD 509+712 is obtained by the correlation between the gauges and discharges observed at RD 434+000. Meanwhile, the reduced levels and the hydraulic data of the fall structure at RD 509+712 has also been considered for the accuracy of the relationship. The same relationship is considering for the estimation of daily power and energy against subsequent daily discharges. Discharge rating curve is provided in **Figure 3.17** and it is evident from the available curve that there is a constant variation in depth with respect to discharge. It also shows that there will not be any negative impact on the power plant due to sediment loads. The sediments are smaller in size and that is why a very smooth curve is furnished and sedimentation loading will not create any disturbance for the turbines. The stage relationship between discharge and depth at various intervals is obtained as follows:

$Y = -1E\text{-}06x^2 + 0.0051x + 648.02$

$R^2 = 0.9924$

Figure 3.17: Discharge Rating Curve



3.5. SEDIMENT

3.5.1. GENERAL

Sediment data is needed for low head hydropower development for the following analysis:

- Estimation of the useful life of power channels
- Investigation of sedimentation processes upstream/downstream of the powerhouse
- Design of intake structures if any
- Useful life of turbine runner blades

For canals in Punjab, the total sediment load constitutes the main parameter to determine dead storage requirements and also to estimate the useful life of the project. The canals are maintained and cleaned during the canal closure on regular basis. BRBD Link Canal being a non-perennial canal remains closed for nearly 5 to 6 months of the year. Therefore, sedimentation deposits in BRBD Link Canal is also minimized. Meanwhile, the said project at RD 509+712 is also located on the tail side of the canal and it has its own advantage that expected sedimentation is minimized. Secondly, the turbine runner blades are provided special coating techniques which reduces the erosion affects caused due to expected sedimentation. In general, low head hydropower plants are safe from sedimentation if the canal is maintained and cleaned on regular basis and turbine runner blades have been treated with the requisite coatings.

3.5.2. SEDIMENT DATA

Sediment samples on daily basis are observed at Marala Headworks by Punjab Irrigation Department. Daily concentration data has been collected and applied for estimation of daily sediment load for Upper Chenab Canal & subsequently for BRBD Link Canal at RD 509+712. A 2.6 Million Tones sediment load has been computed at the desired location from the measured concentration at barrage. It has been assumed that the concentration will remain unchanged throughout the canal length. Annual sediment load is provided in Table 3.5 below & **Figure 3.18.**

Mean monthly sediment load has also been calculated and given below in **Figure 3.19.**

Table 3.5: Annual Sediment Load (Tons)

Year	Sediment Load (Tons)
2003	2825258.181
2004	2401835.587
2005	2602604.789
2006	2662893.887
2007	2637164.016
2008	2668452.044
2009	2333128.111
2010	2263065.127
2011	2516771.539
2012	2466540.514
2013	2774359.75
2014	2663619.568
2015	2473251.268
Average	**2,560,688.03**

Figure 3.18: Annual Sediment Load (Tons)

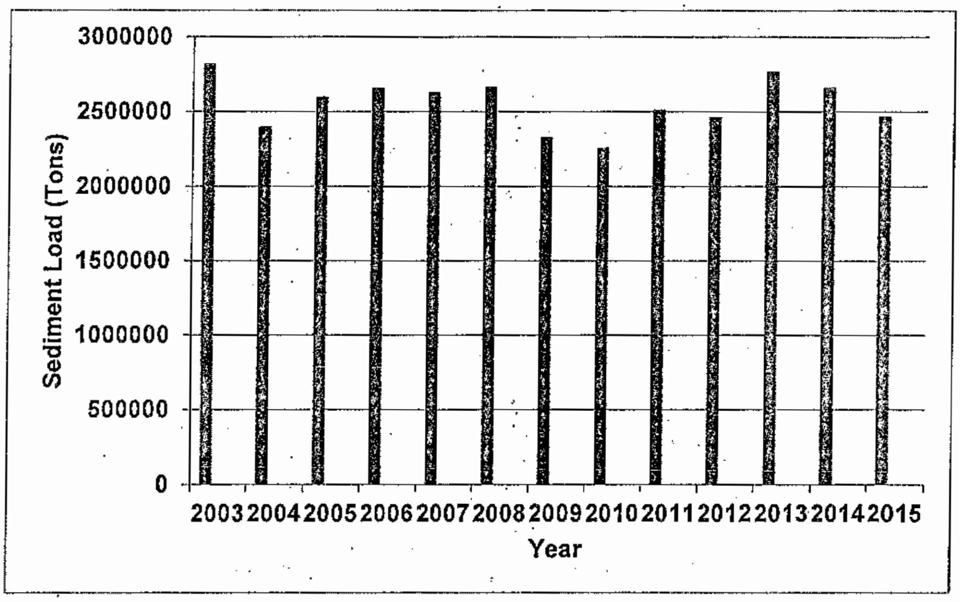
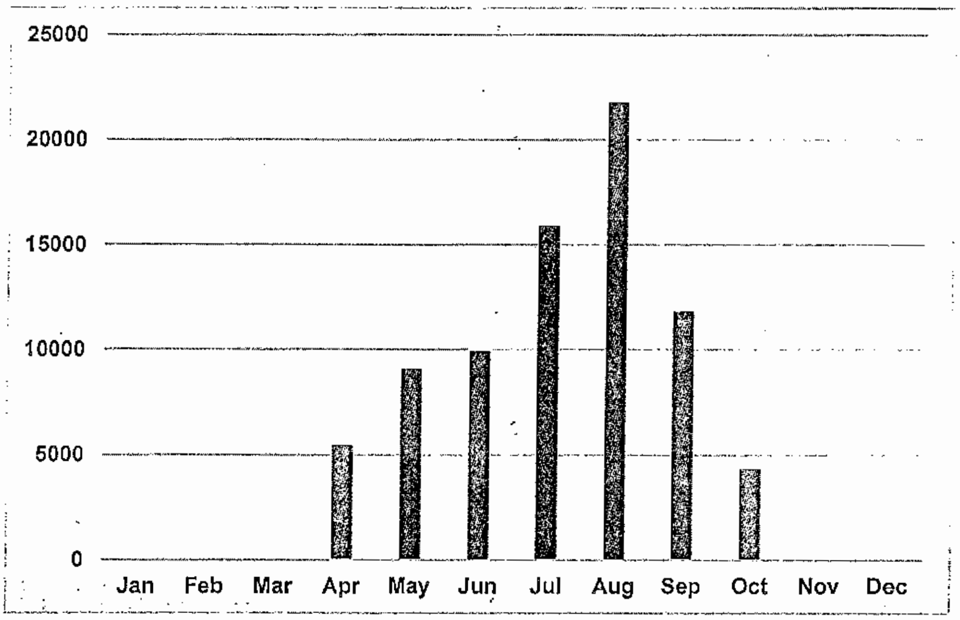


Figure 3.19: Mean Monthly Sediment Load (Tons)



The data indicates that there is no quartz or hard mineral/material which may damage to turbines hence there will be no negative impact due to sediment load. Further, owing to the very low head, abrasion effects at the turbine runner are caused by suspended load but it will also have very negligible affects as the sediment particles are very fine. The maximum tolerable concentration value shall be provided by the turbine manufacturer.

From the measured sediment data it can be observed BRBD Link Canal carries 96% sediment particles which are finer than 0.055 mm. For such situations of low head turbines the sedimentation affect is insignificant. The life of low head turbines (Kaplan Bulb) is long as compared to Francis and Pelton Turbines which are used in medium and high head projects. Renala hydropower project is an example which is in operation since 1925 with the oldest turbines in the country. However the manufacturer would be asked to adopt further precautionary measures/special material to avoid abrasion of turbines.

Table 3.6: Calculated Daily sediment load at RD 509+712 (Tones)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1						10739.4	16132.9	22520.4	12507.6	6391.35		
2					8850.8	10739.4	16550.8	23096.5	12507.6	3742.69		
3					10223.5	10739.4	16132.9	21952	12840.1	4572.75		
4					9698.5	10739.4	16132.9	21952	12507.6	6231.89		
5					9958.9	10739.4	16973.6	21383.6	13509.3	5306.14		
6					9958.9	10739.4	16132.9	21383.6	13509.3	3742.69		
7					9958.9	10739.4	16973.6	22520.4	13509.3	3478.79		
8					9958.9	10739.4	16132.9	22520.4	13509.3	6231.89		
9					9958.9	10739.4	16132.9	21952	14190.4	6391.35		
10					10223.5	10739.4	16132.9	21952	9970.1	6551.86		
11					10488.1	11017.3	16550.8	21952	13509.3	6391.35		
12					10488.1	11017.3	16550.8	21383.6	13509.3	4430.93		
13					10223.5	10739.4	16550.8	22520.4	13509.3	4716.81		
14					10223.5	10739.4	16132.9	21952	9970.1	4572.75		
15				5212.41	9958.9	11017.3	16132.9	22520.4	9068.5	4290.23		
16				5809.23	9958.9	10739.4	16132.9	22520.4	9665.6	4151.7		
17				6719.37	9958.9	10461.5	17829.7	23096.5	13509.3	4151.7		
18				6543.32	8724.8	10739.4	16132.9	23096.5	13509.3	4151.7		
19				7218.75	8610	10461.5	16550.8	23096.5	13509.3	4430.93		
20				6543.32	8850.8	10461.5	16550.8	22520.4	13509.3	4430.93		
21				6369.79	9958.9	10461.5	16973.6	23096.5	13509.3	4430.93		
22				5855.43	9958.9	10739.4	16132.9	23096.5	13172.6	4572.75		
23				6196.26	10223.5	10739.4	15303.4	23096.5	13172.6	3610.74		
24				6719.37	10488.1	10739.4	14492.1	23096.5	13172.6	3877.93		
25				6897.87	10223.5	10739.4	13694.8	23096.5	13509.3	5762.4		
26				6894.16	10223.5	10739.4	16132.9	21952	13848.8	5917.45		
27				6369.79	10223.5	11017.3	15303.4	23096.5	13848.8	5762.4		
28				6543.32	10223.5	11299.4	15303.4	22520.4	13509.3	5762.4		
29				6719.37	10223.5	11299.4	14492.1	19556.6	13509.3	5917.45		
30				6719.37	10223.5	11017.3	14492.1	20271.3	13509.3	5917.45		
31					8962.1		15303.4	21952		5306.14		

3.6. CONCLUSIONS

The following is concluded on the basis of above discussions:

- The upstream level should be kept constant at designed full supply level.
- Design Discharge for the power plant is considered as 50 Cumecs after discharge optimization and the details are furnished in Power & Energy (Chapter 9).
- The data indicates that there is no quartz or hard mineral/material which may damage to turbines hence there will be no negative impact due to sediment load. The sediment consists of very fine particles which have very insignificant impact on Kaplan runner blades. Anyhow, the manufacturer is recommended to adopt protective coating.

Annexure 3.1: Daily Discharge Data

Daily Discharge (2000)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1						50.26	53.62	60.91	57.36	62.35		
2						47.44	53.62	59.50	57.36	33.85		
3						48.58	53.62	59.50	57.36	30.67		
4						44.01	53.62	59.50	57.36	25.81		
5						34.86	53.62	59.50	57.36	69.07		
6						44.01	15.89	57.49	58.73	69.07		
7						54.29	27.57	57.49	58.73	69.07		
8						54.29	38.52	59.50	58.73	69.07		
9						47.15	38.52	59.50	58.73	30.45		
10						52.21	38.52	59.50	57.36	17.68		
11						54.29	41.03	59.50	57.36	24.21		
12						46.44	47.15	60.91	57.36	27.35		
13						39.01	47.15	60.91	57.36	3.64		
14						30.80	55.36	63.75	57.36			
15						30.80	53.62	60.91	57.36	65.93		
16						36.29	53.62	60.91	57.36	62.79		
17						41.55	53.62	60.91	57.36	62.79		
18						36.29	53.62	60.91	57.36	62.79		
19						46.46	53.62	60.91	57.36	62.79		
20						32.72	51.98	60.91	57.36	62.79		
21						42.86	51.98	60.91	57.36	25.81		
22						42.86	53.62	60.91	57.36	48.35		
23						45.72	53.62	60.91	57.36			
24						42.86	53.62	60.91	53.59			
25						44.01	53.62	60.91	55.59			
26						51.49	56.44	60.91	55.59			
27						54.95	53.62	60.91	53.40			
28						51.44	53.62	60.91	53.40			
29						54.29	59.26	57.66	53.40			
30							59.26	57.66	55.59			
31							59.26	59.50				
						44.90	**49.86**	**60.16**	**56.84**	**46.97**		

Daily Discharge (2001)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1							56.44					
2							56.44					
3							56.44					
4							56.44					
5							56.44					
6							56.44					
7							56.44					
8							56.44					
9							56.44					
10							56.44					
11							56.44					
12						37.29	56.44					
13						37.15	56.44					
14						37.15	56.44					
15						40.01	56.44					
16						40.01	58.55					
17						40.01	58.55					
18						52.64	58.55					
19						50.26	56.44					
20						46.46	58.55					
21						44.01	57.42					
22						46.46	58.55					
23						50.26	58.55					
24						45.23	58.55					
25						30.80	45.88					
26						39.01	43.46					
27						34.29	43.46					
28						33.58	54.26					
29						33.58	53.14					
30						34.29	58.55					
31												
						40.66	**55.63**					

Daily Discharge (2005)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1						54.29	46.25	51.54				
2						46.84	46.25	51.54				
3						46.84	57.42	54.06				
4							58.67	54.06				
5							56.27	51.54				
6						48.01	50.09	51.54				
7						48.12	51.33	51.54				
8						62.87	59.12	62.33				
9						61.81	59.12	62.33				
10						62.87		58.90				
11							21.39	58.90				
12						4.77	56.27	56.49				
13							56.27	56.49				
14							56.27	56.49				
15						24.60	56.27	56.49				
16						28.95	57.40	56.49				
17						34.58	56.27	52.81				
18						42.86	56.27	52.81				
19						45.49	56.27	52.81				
20						46.84	53.84	52.81				
21						45.49	53.84	52.81				
22						46.84	53.84	52.81				
23						46.84	53.84	54.06				
24						51.98	53.84	54.06				
25						46.84	53.84	54.06				
26						46.84	56.27	54.06				
27						49.44	51.33	54.06				
28						46.84	53.84	54.06				
29						46.84	51.33	54.06				
30						46.84	51.33	54.06				
31							51.33	49.01				
						45.38	**53.19**	**54.49**				

Daily Discharge (2006)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1					20.74	51.98	62.08	18.50		19.84		
2					29.42	54.52	57.42	32.95		19.84		
3					29.42	54.52	57.42	43.80		29.23		
4					29.42	44.18	57.42	46.44		8.95		
5					29.42	49.44	57.42	50.43		13.28		
6					29.42	40.12	57.42	61.28		8.95		
7					29.42	41.49	57.42	57.66		18.12		
8					29.42	44.18	57.42	68.11		29.23		
9					29.42	41.49	57.42	68.11		63.73		
10					29.42	37.72	57.42	68.11		65.02		
11					34.21	34.63	57.42	68.11		67.66		
12					42.72	54.29	57.42	68.11		51.27		
13					42.72	54.29	57.42	68.11		13.28		
14					42.72	54.29	57.42	56.49		35.41		
15					42.72	58.15	53.84	52.81		47.69		
16					39.92	61.44	52.60	38.45		58.65		
17				30.67	42.72	61.44	55.00	35.73		41.95		
18				15.76	42.72	56.98	52.60	32.95		44.24		
19				17.42	49.81	61.44	52.60	35.73		19.84		
20				19.11	49.81	62.87	52.60	34.37		35.16		
21				19.11	49.81	46.84	57.42	35.73		33.28		
22				17.42	49.81	36.03	48.82	68.11				
23				17.42	49.81	40.38	46.25	68.11				
24				17.42	50.90	54.52	43.63	68.11				
25				19.11	50.90	62.87	46.25	68.11				
26				19.11	50.90	62.87	46.25	68.11				
27				31.85	53.51	62.87	57.42	68.11				
28				31.85	54.84	62.87	57.42	68.11				
29				31.85	54.84	62.87	22.83	68.11				
30				22.45	54.84	62.87	38.29	58.90				
31					54.84		21.36	32.95				
				22.18	**41.63**	**52.48**	**52.06**	**54.15**		**34.51**		

Daily Discharge (2007)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1					28.33	64.15	48.82	58.90	52.12			
2					26.48	64.15	38.29	61.28	54.47			
3					34.21	64.15	38.29	56.49	53.10			
4					28.33	64.15	53.84	61.28	24.80			
5					41.30	62.87	58.67	61.28	53.10			
6					56.13	62.87	58.67	62.33	53.10			
7					48.22	62.87	58.67	61.28	57.36			
8					52.95	64.15	62.08	62.33	60.09			
9					52.95	64.15	62.08	62.33	60.09			
10					52.95	0.00	62.08	62.33	60.09			
11					52.95	56.98	62.08	62.33	60.09			
12					52.95	51.98	62.08	62.33	60.09			
13					52.95	49.44	56.27	62.33	60.09			
14					58.66	56.98	52.60	62.33	60.09			
15					58.66	54.52	58.67	61.28	58.73			
16					53.63	46.84	53.84	59.50	56.00			
17					53.63	51.98	56.44	54.06	56.00			
18					53.63	69.72	56.44	58.90	54.47			
19					59.87	94.30	52.20	62.33	54.47			
20					63.63	58.58	56.44	56.49	52.12			
21					5.88	61.44	62.08	58.90	54.47			
22					64.72	58.58	62.08	62.33	56.79			
23					66.05	59.41	53.84	58.90	52.12			
24					66.05	59.41	62.08	62.33	57.36			
25				22.29	66.05	61.44	62.08	62.33	57.36			
26				28.66	66.05	61.44	62.08	62.33	57.36			
27				31.85	66.05	58.58	62.08	62.33	54.63			
28				38.22	66.05	58.58	62.08	62.33	54.63			
29				38.22	66.05	49.44	56.27	62.33	54.63			
30					66.05	34.29	58.67	58.90	54.63			
31					66.05		58.67	58.90				
				31.85	**53.14**	**57.58**	**57.11**	**60.76**	**55.15**			

Daily Discharge (2008)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1					34.21	51.44	59.26	59.50	57.36			
2					34.21	51.44	59.26	59.50	57.36			
3					34.21	51.44	59.26	59.50	57.36			
4					44.13	51.44	59.26	59.50	57.36			
5					44.13	54.01	47.77	59.50	57.36			
6					39.92	54.01	49.69	47.31	57.36			
7					44.13	54.01	47.13	43.57	50.01			
8					47.07	54.01	47.13	43.57				
9					44.13	54.01	47.13	43.57				
10					44.13	55.92	47.13	43.57				
11					44.13	54.01	47.13	43.57				
12					44.13	36.01	47.13	43.57	57.36			
13					44.13	40.61	59.26	49.89				
14					44.13	48.46	59.26					
15					44.13	62.87	59.26	38.45				
16					44.13	67.15	59.26	59.50				
17					47.07	64.29	59.26	59.50				
18					50.01	58.47	59.26	59.50				
19					50.01	51.66	59.26	54.82				
20					48.22	52.98	59.26	54.82	57.36			
21					50.01	51.66	43.40	54.82	57.36			
22					52.95	51.66	44.61	46.07	57.36			
23					52.95	51.66	44.61	46.07				
24					52.95	51.66	45.88	46.07				
25				3.18	52.95	51.66	44.61	48.62				
26				15.92	52.95	49.66	32.82	47.31				
27				15.92	52.95	58.15	38.29	47.31				
28				15.92	52.95	58.15	42.13	47.31				
29				25.76	52.95	60.01	57.42	47.31				
30				27.42	52.95	60.01	57.42	59.50				
31					52.95		59.26	59.50				
				17.36	**46.77**	**53.75**	**51.67**	**51.09**	**56.69**			

Daily Discharge (2009)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1					31.27	54.29	57.42			48.85		
2					34.21	51.98	57.42			48.85		
3					35.66	53.49	57.42			48.85		
4					37.10	46.84	57.42			46.50		
5					38.86	49.44	47.13			46.50		
6					45.48	51.98				49.42		
7					45.48	54.52				49.42		
8					48.22	53.26	24.30			50.61		
9					48.22	54.52	28.59			59.65		
10					50.01	54.52	43.91			59.65		
11					52.22	54.52	41.82			59.65		
12					53.51	57.15	42.84			59.65		
13					53.51	58.15	44.42			59.65		
14					56.13	58.15	45.49			59.65		
15					53.51	58.15	43.94			51.80		
16					56,13	58.15	46.02					
17					56.13	43.38	44.42					
18					53.51	41.61	44.42					
19					53.51	41.43	43.91					
20					50.90	52.18	47.13					
21					52.22	48.81	57.42					
22					52.22	48.81	57.42					
23					52.22	48.81	57.42					
24					53.51	48.81	57.42					
25					54.98	48.81	57.42					
26				7.07	55.07	49.38	57.42					
27				29.04	55.07	58.15	57.42					
28				31.62	55.07	58.15	57.42					
29				41.75	55.07	58.15	46.02					
30				37.04	55.07	58.15	46.02					
31					55.90		47.66					
				29.31	**50.00**	**52.46**	**48.87**			**53.25**		

Daily Discharge (2010)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1					29.42	44.18	44.95	53.83	51.90	53.47		
2					29.42	46.84	44.95	51.00	49.17	53.47		
3					29.42	51.44	44.95	51.00	50.92	53.47		
4					29.42	54.52	46.02	54.06	51.90	54.88		
5					29.42	57.15	59.26	54.06	51.90	54.88		
6					29.42	57.15	59.26	51.00	51.90	59.65		
7					29.42	57.15	59.26	49.01	51.90	56.51		
8					29.42	30.38	50.79	51.54	51.90	56.51		
9					29.42	57.15	50.79	51.54	51.90	56.80		
10					29.42	57.15	50.79	54.06	51.90	59.65		
11					32.74	34.63	50.79	54.06	47.75	57.96		
12					34.21	38.78	50.79	54.06	47.75	58.52		
13					35.66	36.03	50.79	54.06	47.75	58.52		
14					38.25	38.78	50.79	54.06	47.75	58.52		
15					31.27	36.03	50.79	54.06	47.80	58.52		
16					28.33	41.49	50.79	54.06	47.80	36.51		
17					31.27	41.49	50.79	54.06	47.80	33.37		
18					35.66	38.78	50.79	54.06	47.80	30.23		
19					38.25	57.15	50.79	54.06	49.69	27.03		
20					35.66	57.15	50.79	54.06	51.90	39.59		
21					39.92	57.15	50.79	54.06	51.90	51.46		
22					42.28	57.15	50.79	54.06	51.90	54.32		
23					39.92	57.15	50.79	54.06	51.90	47.09		
24					39.92	57.15	50.79	54.06	51.90	45.59		
25					44.13	60.01	50.79	54.06	51.90	47.09		
26					44.13	60.01	50.79	54.06	51.90	30.23		
27					44.13	44.46	53.62	54.06	51.90	30.23		
28					44.13	44.46	53.62	54.06	51.90			
29					42.72	44.46	50.79	54.06	49.17			
30				31.85	41.30	45.52	50.79	54.06	46.52			
31							52.35	54.06				
				31.85	**35.27**	**48.70**	**51.13**	**53.43**	**50.33**	**49.04**		

Daily Discharge (2011)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1					22.27	54.52	50.40	51.96	40.95	48.76		
2					28.33	56.98	50.40	51.96	40.95	48.76		
3					35.66	54.52	50.40	51.96	27.32	49.48		
4					28.33	54.52	42.33	49.92	27.32	52.37		
5					25.33	54.52	42.33	49.92	41.19	52.37		
6					34.21	54.52	43.34	50.60	41.19	52.37		
7					35.66	54.52	47.97	53.32	49.41	52.37		
8					39.92	54.52	47.97	53.32	52.75	52.37		
9					42.72	54.52	51.05	42.50	40.97	52.37		
10					48.22	54.52	51.05	42.50	40.97	52.37		
11					50.90	54.52	51.05	42.50	40.97	47.09		
12					50.90	54.52	51.05	54.71	40.97	30.23		
13					50.90	54.52	48.20	42.50	40.97	44.08		
14					53.51	54.52	48.20	30.12	40.97	33.37		
15					53.51	54.52	51.75	28.33	40.97	3.52		
16					53.51	54.52	51.75	14.17	49.17	10.42		
17					53.51	50.98	50.40		27.32	27.03		
18					53.51	51.41	51.75		27.32			
19					53.51	51.26	51.75	28.33	27.32			
20					56.13	51.26	49.72	32.95	40.97			
21					56.13	51.26	49.04	32.95	40.97			
22					56.13	51.26	49.04	32.95	40.97			
23					56.13	51.26	49.04	47.91	37.01			
24					53.51	51.26	49.04	48.56	40.97			
25				15.92	53.51	51.26	51.05	46.58	40.97			
26				15.92	53.51	51.26	50.40	53.32	44.91			
27				15.92	53.51	51.04	50.40	53.32	46.82			
28				15.92	53.51	51.04	50.40	54.71	44.91			
29					64.84	51.04	50.40	42.50	44.91			
30				24.11	58.84	51.04	51.75	42.50	42.42			
31							51.75	46.58				
				17.56	**47.67**	**53.05**	**49.52**	**43.91**	**40.16**	**41.73**		

Daily Discharge (2012)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1					41.60	17.15	55.03	54.54	49.69	51.46		
2					25.33	21.63	55.03	54.54	50.67	50.23		
3					28.33	21.63	53.62	54.54	50.42	50.23		
4					41.19	26.60	55.03	54.54	50.42	50.23		
5					41.19	28.58	53.62	54.54	49.69	50.23		
6					41.19	28.58	55.03	54.54	49.69	52.87		
7					41.19	28.58	55.03	54.54	49.69	51.46		
8					41.19	28.58	55.03	57.77	49.69	50.23		
9					41.19	28.58	53.62	54.54	53.40	50.23		
10					41.19	28.58	56.44	54.54	53.40	50.23		
11					17.65	28.58	56.44	54.54	53.40	48.26		
12					17.65	28.58	55.03	55.98	53.40	41.10		
13					17.65	38.78	56.44	53.83	49.44	30.23		
14					17.65	27.52	56.44	54.54	49.44	17.61		
15					17.65	41.49	55.03	54.54	52.12	23.77		
16					17.65	46.84	55.03	54.54	32.78			
17				15.70	17.65	44.18	53.62	54.54	32.78			
18				15.92	17.65	44.18	53.62	54.54	35.51			
19				15.92	17.65	44.18	53.62	54.54	42.23			
20				15.92	17.65	47.35	53.62	53.83	49.66			
21				15.92	17.65	51.44	53.62	49.27	49.66			
22				15.92	17.65	51.44	53.62	49.27	49.17			
23				15.92	17.65	51.44	53.62	49.27	49.17			
24				15.92	17.65	54.29	53.62	49.27	49.17			
25				15.92	17.65	51.44	53.62	49.27	49.17			
26				14.33	17.65	54.29	53.62	49.27	49.17			
27				14.33	17.65	54.29	53.62	44.31	49.17			
28				20.80	17.65	54.29	54.32	49.27	49.17			
29				27.42	17.65	54.29	54.32	53.83	49.17			
30				30.67	17.65	54.29	54.32	51.54	44.77			
31					17.65		54.32	47.46				
				17.90	**24.33**	**39.39**	**54.48**	**52.78**	**48.18**	**44.56**		

Daily Discharge (2013)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1					29.42	50.72	45.12	49.24	31.77			
2					29.42	51.44	43.82	46.58	49.17			
3					29.42	44.18	43.82	49.24	55.48			
4					29.42	47.04	43.82	50.60	55.48			
5					34.21	47.04	45.46	46.58	52.17			
6					34.21	47.04	45.46	43.38	53.70			
7					34.21	51.44	45.46	45.30	53.70			
8					34.21	51.44	45.46	47.91	52.36			
9					35.69	51.44	45.46	47.91	48.78			
10					38.83	51.44	46.39	53.32	32.81			
11					42.72	51.44	43.82	46.58	37.01			
12					42.72	44.18	43.20	45.30	39.99			
13					42.72	49.44	50.88	48.56	42.42			
14					44.13	44.18	49.21	51.25	39.99			
15					44.13	46.84	54.15	51.96	35.21			
16				15.92	44.13	51.44	54.15	47.91	37.94			
17				15.92	44.13	51.44	54.15	53.32	54.11			
18				15.92	44.13	45.72	58.55	39.24	47.47			
19				15.92	44.13	47.66	58.55	22.64	49.41			
20				17.42	47.75	50.35	58.55	3.17	44.28			
21				15.92	45.48	50.35	58.55		43.05			
22				15.92	45.48	50.35	52.71		43.68			
23				20.80	50.07	49.66	47.07		43.68			
24				22.10	50.07	49.66	37.64		43.68			
25				24.11	47.10	46.32	41.31		43.68			
26				27.42	47.10	43.49	49.04		43.68			
27				31.85	52.95	43.49	51.75		42.58			
28				31.85	52.95	43.49	45.12		43.05			
29				31.85	52.95	43.49	45.12		43.05			
30				28.69	52.95	45.69	46.39		43.05			
31					52.95		47.72					
				22.11	**42.57**	**48.06**	**48.32**	**44.50**	**44.88**			

Daily Discharge (2014)												
DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1						48.58	47.97	49.92	41.57	30.23		
2						48.58	47.97	49.92	44.47	30.23		
3						48.58	47.97	49.92	48.13	36.51		
4						48.58	47.97	49.92	48.13	39.59		
5						48.58	47.97	50.49	34.44	41.10		
6						48.58	47.97	51.00	14.94	41.10		
7						48.58	47.97	51.68	16.39	39.59		
8						48.58	47.97	51.68	9.07	39.59		
9					29.42	48.58	47.97	51.68	12.02	42.60		
10					29.42	48.58	47.97	51.68	9.07	51.62		
11					29.42	48.58	47.97	51.68	20.68	51.62		
12					29.42	48.58	47.97	51.00	12.02	53.09		
13					37.92	48.58	47.97	51.00	8.17	53.09		
14					44.13	48.58	47.97	49.92	9.07	53.09		
15				6.37	44.13	48.58	47.97	49.92	9.07	56.80		
16				15.92	44.13	48.58	47.97	49.92	9.07	57.89		
17				15.92	49.40	48.58	47.97	49.92		56.80		
18				12.74	50.01	48.58	47.97	49.92		55.92		
19				3.57	51.48	48.58	47.97	48.56		55.92		
20					51.48	48.58	47.97	49.92		55.92		
21					53.69	48.58	47.97	49.92		54.57		
22					53.69	48.58	47.97	49.92				
23					53.69	48.58	48.65	49.92				
24					53.40	48.58	49.04	49.92				
25					53.69	48.58	49.04	49.92				
26					50.01	48.58	49.04	49.92				
27					50.01	48.58	49.04	49.92				
28					50.01	48.58	49.72	49.92		36.51		
29					50.01	48.58	49.72	49.92		30.23		
30					50.01	48.58	49.72	49.92		30.23		
31					50.01		49.72	46.21				
				10.90	**46.03**	**48.58**	**48.36**	**50.16**	**21.64**	**45.58**		

Daily Discharge (2015)

DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1					29.42	48.81	51.39	52.90	51.00	52.71		
2					29.42	46.86	51.39	52.90	51.00	53.37		
3					35.30	48.52	51.39	51.59	51.00	54.22		
4					35.30	48.52	50.09	51.59	53.54	54.22		
5					35.30	49.35	48.73	47.57	55.86	53.37		
6					37.10	49.35	48.73	47.57	51.00	52.71		
7					39.39	48.52	48.73	50.29	51.00	53.37		
8					41.19	48.52	48.73	50.80	49.74	53.37		
9					44.13	48.52	48.73	52.90	49.74	54.22		
10					44.13	47.98	48.73	51.59	43.24	53.37		
11					46.01	43.83	48.73	50.29	37.94	53.37		
12					46.01	45.23	52.68	48.93	36.58	52.71		
13					47.10	47.98	4.99	50.29	36.58	52.71		
14					48.75	47.98	50.85	42.95	40.65	52.71		
15					45.75	49.35	48.73	39.35	44.55	52.71		
16					50.01	47.98	52.68	42.50	44.55	14.07		
17					50.01	47.98	53.98	46.75	47.17			
18					50.01	47.98	52.68	50.29	48.48			
19					49.28	49.35	47.38	51.59	47.17			
20					50.90	49.35	50.09	51.08	42.42			
21					49.54	49.35	48.23	50.29	40.65			
22				19.11	48.22	48.78	51.39	50.29	45.86			
23				19.11	48.22	48.78	52.18	57.94	49.17			
24				19.11	49.54	50.72	51.39	60.46	49.17			
25				31.85	49.54	53.35	48.73	54.20	49.17			
26				31.85	48.22	50.72	52.68	54.20	49.17			
27				31.85	49.54	50.72	55.31	52.90	49.17			
28				31.85	48.75	47.98	57.71	52.90	49.17			
29				31.85	49.40	45.23	51.39	52.90	51.90			
30				31.85	49.95	50.72	50.85	39.35	47.17			
31					50.25		50.85	44.03				
				27.60	**45.02**	**48.61**	**49.36**	**50.10**	**47.13**	**50.83**		

Daily Discharge (2016)

DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1					44.63	52.04	49.98	36.52	51.90	40.19		
2					44.63	51.01	50.99	30.83	55.86	40.19		
3					44.63	50.35	51.78	30.83	51.00	40.47		
4					45.16	50.24	50.62	24.90	48.48	41.10		
5					46.57	50.24	49.75	24.90	48.48	43.61		
6					46.57	49.04	49.75	36.52	47.17	56.17		
7					45.16	49.04	50.06	33.71	49.93	56.17		
8					45.16	49.04	50.62	38.50	49.88	56.17		
9					45.16	49.04	50.62	39.32	49.93	56.17		
10					45.16	49.52	52.01	39.78	49.93	56.17		
11					45.42	49.58	50.82	39.78	49.93	52.71		
12					44.13	49.58	51.84	45.67	49.93	49.70		
13					58.84	49.58	51.84	44.11	49.93	49.70		
14					58.84	50.18	51.27	47.77	47.39	46.72		
15					58.84	50.18	51.70	48.79	49.93	46.72		
16				7.07	58.84	50.18	50.23	52.61	49.93			
17				20.80	58.84	50.18	53.42	53.38	49.93			
18				19.14	58.84	50.89	51.22	53.04	51.57			
19				19.14	46.57	49.75	51.22	53.04	49.63			
20				27.99	58.84	49.86	51.22	53.04	49.63			
21				26.56	58.84	49.35	49.92	53.46	48.57			
22				27.99	52.28	48.75	50.99	53.46	48.57			
23				27.99	50.66	48.75	50.99	53.46	48.57			
24				34.65	50.81	50.41	49.47	51.31	48.57			
25				42.64	52.28	50.09	51.44	51.31	48.57			
26				42.64	52.25	51.49	50.65	54.43	48.57			
27				44.59	52.25	50.89	50.65	52.90	48.48			
28				44.59	52.34	51.41	50.65	42.50	44.44			
29				44.59	52.34	52.49	50.65	48.16	26.91			
30				48.31	54.04	51.78	41.99	53.83	26.91			
31					56.19		36.37	53.83				
				31.91	**51.13**	**50.16**	**50.15**	**45.02**	**47.95**	**48.80**		

CONTENTS

4.1. GENERAL

Kasur Hydropower Project is proposed at RD 509+712 of Bambanwala-Ravi-Bedian-Depalpur (BRBD) Link Canal in District Kasur. BRBD Link Canal off-takes from RD 133+296 of Upper Chenab Canal (UCC). It is perennial from its head up to RD 434+000 and becomes non-perennial from regulator at RD 434+000 to its tail. The project area is accessible by Ferozepur Road Lahore to Kasur-Khem Karan Road which leads straight to BRBD Link Canal.

M/s Pacific Engineering & Geotechnical Services (PEGS), Lahore, was engaged to carry out subsurface soil investigations at the proposed site for designing of appropriate foundations of the project.

Geotechnical investigations were conducted through one exploratory boring of 20 meter deep below the existing bed level. The fieldwork was commenced in February 2017. This report presents an account of the geotechnical investigations carried out for the proposed site. Detailed geotechnical investigations shall be carried out during the detailed engineering and construction stage of the project.

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

4.2. PURPOSE AND SCOPE OF WORK

The primary objective of these investigations is to determine the appropriate parameters for the design of foundations significantly the foundation of structures under beneath the turbine unit and the gated spillway proposed within main canal within the same axis of the proposed powerhouse. For this purpose the following aspects were determined / evaluated:

- Sub surface stratigraphy within the limits of exploratory borings.
- Geotechnical characteristics of the subsurface materials (strata) encountered.
- Evaluation of subsoil parameters, recommendation for appropriate type of

foundations and allowable bearing capacity for use in the design of foundations.

All field and laboratory data is presented under Appendices to this report.

4.3. GEOTECNICAL INVESTIGATIONS

4.3.1. GEOLOGY AND SEISMICITY OF THE AREA

The Project site is located in Punjab, which is a plain of alluvial material as well as rocks at deeper depth.

Probabilistic Seismic Hazard Assessment (PSHA) recently carried out for revision of seismic provisions of the Building Code of Pakistan, shows that the site area falls in Zone 2A. Therefore, the project structures should be designed to cater for the requirements of Zone 2A of the Building Code of Pakistan (2007). Geological Map of Punjab and Seismic Map of Pakistan is provided in drawings **BRBD-HEPP-FS-1.4 & BRBD-HEPP-FS-1.2** respectively. It is recommended that the project structures should be designed to withstand a horizontal peak ground acceleration of 0.08 to 0.16g. The table of PGA values regarding the seismic zones is as under:

Seismic Zones	PGA Value
1	0.05 to 0.08 g
2A	0.08 to 0.16 g
2B	0.16 to 0.24 g
3	0.24 to 0.32 g
4	>0.32 g

4.3.2. CURRENT USE OF THE PROJECT AREA

The project site currently consists of an open area having no population within project reach. The major activity in this area is agriculture. Most of the project area comprises of level or nearly level plains formed by thick alluvial deposits brought down by rivers, generally comprising of silty sand trace clay layer overlying fine to coarse grained sand layer overlying fine to coarse grained sand with trace of concretions.

4.3.3. TOPOGRAPHY OF THE PROJECT AREA

Topographically the site area is generally plain. Powerhouse alongwith Spillway is proposed within the main canal at RD 510+600.

4.3.4. EXPLORATION METHODOLOGY

4.3.4.1. EXPLORATORY BORINGS AND SAMPLING

The drilling of borehole was carried out in February 2017 during the canal closure. The borehole location map is provided as Drawing No. **BRBD-HEPP-FS-2.4**. The borings were advanced using manually operated post-hole auger and light percussion techniques. Representative disturbed samples were recovered using Standard Penetration Test (SPT) split spoon sampler in accordance with ASTM D1586. The SPT's were conducted at intervals of 3 ft to 5 ft within the depths investigated.

Detailed description of the subsurface soils encountered and the depth at which samples were taken is given in the borehole logs. Soil descriptions on the boring logs are a compilation of field and laboratory testing data. The stratification lines represent the approximate boundary between soil types and transitions may be assumed gradual.

4.3.4.2. LABORATORY TESTING

Selected representative subsurface soil samples were tested at the Geotechnical Engineering Laboratory of the Civil Engineering Department, University of Engineering and Technology, Lahore in order to determine various geotechnical characteristics. Following tests were conducted and the results are attached as **Annexure 4.2**:

- Grain size analysis
- Hydrometer Analysis
- Bulk & Dry Density
- Natural moisture content
- Atterberg limits

- Direct Shear test
- Chloride and sulphate contents, total dissolved solids and pH value of water samples.

Summaries of laboratory test results is presented in Table 1 (for soil samples). The laboratory test results sheets are included as **Annexure 4.2.**

Table 4.1: SUMMARY OF LABORATORY TEST RESULTS

BH No.	Sample No.	Depth (m)	Particle Size Distribution			Atterberg Limits			NMC	Bulk Density	pH	SO_4^{--}	Cl^-	TDS	Direct Shear		Symbol
			Gravel (%)	Sand (%)	Silt & Clay (%)	LL (%)	PL (%)	PI	%	KN/m³		PPM	PPM	PPM	c (kPa)	f (deg)	ASTM D2487
BH-1	SPT-2	2	0	70	30			NP									SP-SM
	UDS-01	3.5	0	12	88	29	20	9	18.8	19.1					5.8	21	CL
	SPT-08	8	0	89	11			NP									SP
	SPT-14	14	0	92	8			NP									SP
	SPT-20	20	0	95	5			NP									SM
	W.S	4									6.9	195	168	941			

4.3.4.3. DISCUSSION ON LABORATORY TEST RESULTS

- Using grain size analyses and Atterberg limits, soils were classified according to ASTM D 2487. The fine grained soils have been classified as silt/sandy silt (ML). The non-cohesive strata consist of sand with variable percentage of silt contents classified as SM, SP-SM and SP.
- Natural moisture content (NMC) is 18.8 and in-situ bulk density 19.1 kN/m³.
- Direct shear tests were performed on samples remoulded to density close to the expected in-situ density. The angle of internal friction (□) value is found 21° with cohesion 5.8 kPa.
- Atterberg Limits tests are performed but all the samples are non-plastic except one.

4.3.5. GROUND CONDITIONS AND ENGINEERING PROPERTIES

4.3.5.1. GROUND CONDITIONS

The ground conditions consist of the following general conditions summarized in Table: 4.1.

Table 4.1: Ground Conditions

Borehole Number	Top Depth (m)	Bottom Depth (m)	Thickness (m)	Description Title	Description
BH-1	0.00	3.00	3.00	SANDY CLAYEY SILT	BrownishGrey, Firm, Sandy Clayey Silt, Low to Medium Plastic
BH-1	3.00	6.00	3.00	LEAN CLAY	Brownish Grey, Soft to Stiff, Lean Clay, Low Plasticity
BH-1	6.00	8.00	2.00	CLAYEY SILT	BrownishGrey, Soft to very Stiff, Clayey Silt, Low to Medium Plastic
BH-1	8.00	12.00	2.60	SILTY SAND	Grey, Medium Dense, Silty Sand, Trace Mica
BH-1	10.60	20.00	9.40	SILTY SAND	Grey, Dense to Very Dense, Silty Sand, Trace Mica

The detail of Lithology of the material encountered is further elaborated in the Borehole logs attached as **Annexure 4.1**.

A surface layer of fine grained soil comprising non plastic silt/sandy silt is present at the site. Its thickness is to a maximum of 12.0 ft. This layer is followed by fine sand with variable silt contents. The type and thickness of soil layers indicate typical alluvial deposits in Punjab.

Based on SPT blows, the cohesive soils exist in soft to firm state and non-cohesive soils in loose to very dense state. At the time of these investigations during February 2017, the average depth of the ground water table (GWT) in the borehole was observed as 4 meter. Basic subsurface soil design parameters for use in the geotechnical design of foundations have been derived from field/laboratory testing, latest literature and using expert judgment and are presented in the following table:

Description of Parameter	Value
Bulk unit weight, KN/m^3	16
Average SPT blows for raft	12
Angle of internal friction, deg	30

4.3.5.2. GROUNDWATER

The Groundwater was encountered at 4 m depth in the boreholes drilled up to a maximum depth of 20 m below NSL.

4.3.6. GEOTECHNICAL DESIGN PARAMETERS

4.3.6.1. SUMMARY OF DESIGN PARAMETERS

The Table 4.2 summarizes the recommended Layer thicknesses used in parameters selection and design recommendation evaluated.

Table 4.2: Summary of Design Parameters

Material Type	Depth below NSL	Bulk Density/Submerged Density ρb	Coefficient of Volume Compressibility m_v	Angle of Internal Friction phi	Cohesion C	Young's Modulus E
	(m)	(g/cm^3)	(cm^2/kg)	degree	Kg/cm^2	MPa
Clayey Silt/Silty Clay/Lean Clay	0.0-7.0	1.65	0.012	-	0.28	1.0
Sandy Silt/Silty Sand	7.0-20.0	1.80	-	32	-	7

4.3.6.2. DISCUSSION ON DESIGN PARAMETERS

The design parameters have been evaluated considering results of field geotechnical investigation, laboratory testing and experience in the similar ground. The ground condition reveals mostly Clayey Silt/Silty Clay/Lean Clay in the upper crust.

4.3.6.3. FOUNDATIONS

4.3.6.3.1. FOUNDATION DESIGN REQUIREMENTS

The foundations of a structure should meet the following minimum design criteria:

i. It should be safe against shear failure of the supporting ground. A factor of safety of 3.0 is generally adopted for this purpose.

ii. It should not settle excessively under the service loads. Limit of 25 mm is put on the total settlement of isolated footings and 50 mm for a raft. Structures such as solid reinforced concrete foundations supporting smokestacks and towers can tolerate larger settlements up to 12 inch (Ref: EM 1110-1-1904).

iii. The foundations must stay safe under tensile, lateral, moment and earthquake loadings.

4.3.6.3.2. PROPOSED STRUCTURES

The proposed structure is expected to be of medium to heavy loading. The proposed powerhouse will be supported on a mat foundation along the cross section of the channel. The powerhouse foundations are expected to be bear the heavier loads due to the loading of equipment & machinery. The other structure is Spillway which will also have a mat foundation but at relatively lesser depth than that of powerhouse.

4.3.6.3.3. DESIGN OF FOUNDATIONS

The evaluation of the bearing capacity of the foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of foundation 2.0 m below NSL. The allowable bearing capacity for the mat foundation is evaluated for 50 mm settlement.

Keeping in view the subsurface soil conditions discussed earlier, type of structure, raft foundations or piles are recommended to support the silos and RC isolated/strip for one to two storied buildings.

RAFT

The footings should always be placed on the natural competent ground. We recommend to place rafts at a depth not less than 6 ft below the existing bed level.

Allowable bearing capacity analysis has been performed and based on these analysis, an allowable bearing capacity of 1.20 tsf against 50 mm settlement is recommended. Modulus of subgrade reaction for this pressure is estimated as 57 kcf. For any other order of permissible settlement, allowable bearing pressure can be adjusted accordingly by linear interpolation.

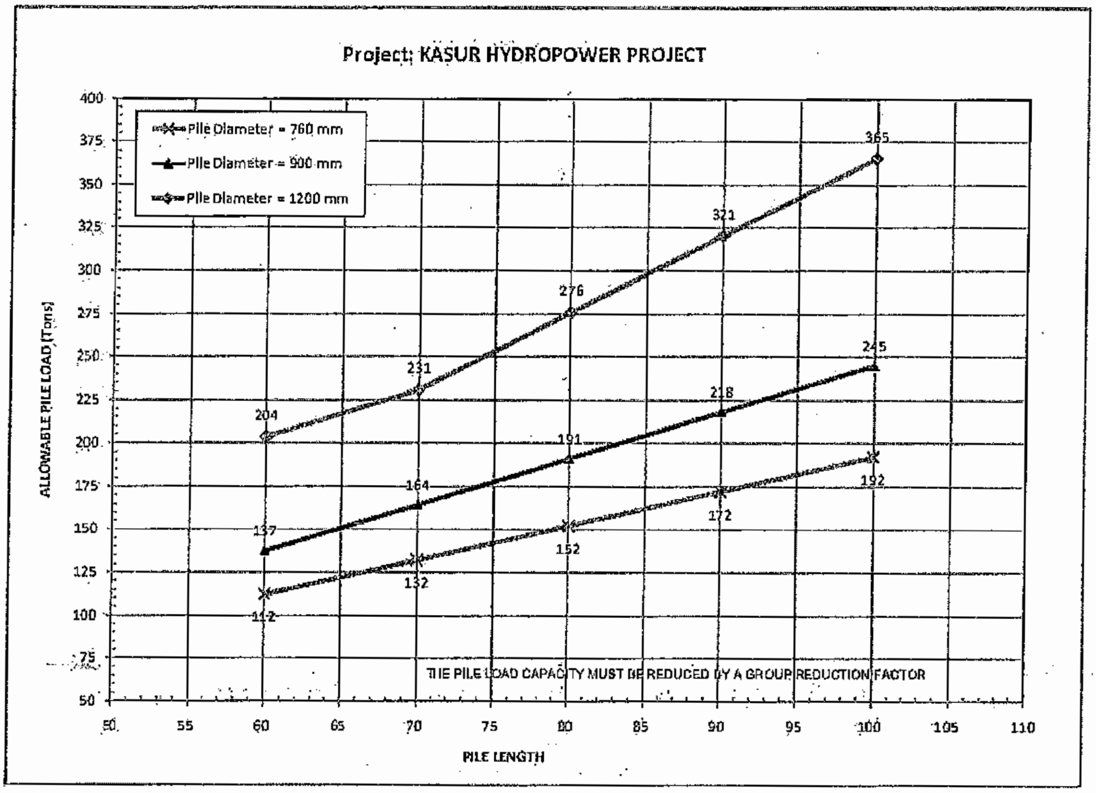
PILES

Pile capacity analysis has been performed for pile diameter 760 mm, 900 mm and 1200 mm and length from 60 ft to 100 ft. Figure 4.1 presents the allowable capacity curves for the piles.

The load carrying capacity of the pile must be confirmed by subjecting at least one pile, to full-scale compressive load test. The minimum test load for this purpose should be 2.5 times the pile design load. The design of the piles must be adjusted as per the findings of the ultimate load test. The load carrying capacity should be reduced for the group effect, depending upon spacing between the piles as tabulated below:

Spacing	Efficiency (%)
2.5d	0.67
3d	70
4d	77.5
5d	85
6d	92.5
7d	100

Figure 4.1: Allowable Bearing Capacity for Piles



Above recommendation is based on the preliminary results being furnished at the feasibility stage. Considering the project requirements, the detailed assessment regarding the type of foundations shall be conducted during detailed engineering and the foundation parameters shall be finalized in accordance to structural requirements, detailed geotechnical investigations and applicable standards.

4.3.6.4. MODULUS OF SUB-GRADE REACTION

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

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

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

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

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

4.3.6.5. PLACEMENT OF GRANULAR FILL

The availability of the sound ground must be confirmed before placement of the foundation pad. An experienced engineer should confirm the soundness of the excavation base. The excavated surface must be proof compacted to at least 95% of the Modified AASHTO Dry Density before placement of foundation.

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

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

4.3.6.6. LATERAL EARTH PRESSURE

4.3.6.6.1. STATIC EARTH PRESSURE COEFFICIENTS

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

Coefficient of active earth pressure:

$$Ka = \frac{(1 - sin\emptyset')}{(1 + Sin\emptyset')}$$

Coefficient of earth pressure at rest:

$$Ko = (1 - Sin\ \emptyset')$$

Coefficient of passive earth pressure:

$$Kp = \frac{(1 + sin\emptyset')}{(1 - Sin\emptyset')}$$

Where,

ϕ' = Effective angle of internal friction of backfill soil. The effective angle of friction of typical sandy soils available in alluvial planes of Punjab may be used as 30 degree.

4.3.6.6.2. DYNAMIC EARTH PRESSURE COEFFICIENTS

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

4.3.6.7. EARTHWORKS AND ROAD WORKS

4.3.6.7.1. GROUND PREPARATION

The top soil at site mostly belongs to vegetative material. Initial site preparation will require removal of such contaminated/vegetative topsoil.

4.3.6.7.2. EXCAVATION

Apparently, the proposed construction does not involve deep excavation. The excavation required for the construction of foundation can be made without provision of any supporting system. The provision of dewatering must be kept in the scope of work of construction due to possibility of shallow ground water table.

4.3.7. CONSTRAINTS AND RISKS

4.3.7.1. PREPARATION OF FOUNDATION SUBGRADE

Prior to start the construction of shallow foundation, the subgrade should be proof rolled to 95% Modified Proctor density obtained as per ASTM D1557 and immediately after proof rolling, the subgrade should be covered with 3-inch layer of lean concrete. In case any soft or loose pocket of subgrade soil is encountered at footing levels, it must be replaced with well compacted granular material.

4.3.7.2. DAMP PROOFING AND SURFACE DRAINAGE

Principle constraints include following:

- Proper paving should be provided along the periphery of the structure.
- All the backfilling of the foundation above concrete pad should be done with cohesive material to avoid seepage of water in the foundation base.
- Adequate water proofing/damp proofing shall be provided for the structure. To avoid problem regarding moisture, it is recommended to adopt water-reducing admixtures in concrete, also cementations coatings should be provided to avoid moisture movement through the concrete.

4.3.7.3. TYPE OF CEMENT

The chemical tests (Sulphate, Chloride and Organic Matter Content) performed on site soil and water samples reveal that salt concentration is in low proportions. Chemical analysis of the water sample indicate that the concentration of injurious Sulphate salt as 196 ppm. As per ACI Committee Report and Concrete Manual of USBR, the upper limit of SO_4 content for use of Ordinary Portland Cement (OPC) is 150 ppm in water. Hence Sulphate Resisting Cement should be used in the construction works in contact with as well as below the ground to protect steel from corrosion, ensure minimum rebar cover of the order of about 75 mm (3") along with some appropriate coating to the reinforcement. Therefore, it is recommended to use Ordinary Portland Cement in all the construction in contact with soil.

4.3.7.4. CONTAMINATED LAND

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

4.3.7.5. QUALITY CONTROL

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

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

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

4.4. LIMITATIONS OF REPORT

The following are the limitations of this report:

- The analyses, conclusions and recommendations contained in this report are based on site conditions, as they existed at the time of field investigations and further on the assumption that the exploratory borings are representative of the subsurface conditions throughout the site.

- The number of borings and their depth & spacing were chosen in such a way as to decrease the possibility of undiscovered abnormalities. However, the nature and extent of variations may not become evident until the course of construction. It is recommended that experienced personnel should supervise operations involving earthwork and foundation construction.

- If there is a substantial lapse of time between submission of this report and the start of work at the site and conditions have changed due either to natural causes or to construction operation at or adjacent to site, we urge that we be promptly informed and retained to review our report to determine the applicability of the conclusions and recommendations, considering the changed conditions and / or time lapse.

4.5. CONCLUSIONS

The following is concluded on the basis of above discussions:

- Groundwater was encountered at 4 m depth in the boreholes drilled up to a maximum depth of 20 m below NSL.

- The top surface comprises Clayey Silt/Silty Clay/Lean Clay (Soft to Very Stiff) up to a depth of 7.0 m below NSL. The material is underlain by Sandy Silt/ Silty Sand (Very Soft to Very Stiff, Dense to Very Dense) up to a maximum investigated depth of 20 m depth below NSL.

- The analysis of the bearing capacity has been carried out for a depth of foundation 2.0 m below NSL. The allowable bearing capacity for the mat foundation is evaluated for 50 mm settlement which is 1.2 tsf.

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

KASUR HYDROPOWER PROJECT

SUBSURFACE EXPLORATION LOG

FIELD DATA

BH No. BH-01
Sheet No. 01 OF

Job No.	3838	Ground Elevation:	-	Geologist / Engineer:	M. Naeem
Project:	Kasur HPP	Client:	Packages Power (Pvt.) Ltd.	Consultant:	AIPEL
Location:		Type of Boring:	Light Percussion	Date Start:	2/12/2017
Ground Water Depth:	4.0 m	Drilling Fluid:	Bentonite	Date Completed:	2/13/2017

Depth (m)	Sample No.	USCS	DESCRIPTION OF MATERIALS	Casing Data		SPT No. of Blows						Sample Length (cm)
				Total Length	Project Length	6"	3"	3"	3"	3"	Blows per Ft. (N)	
1.0	SPT-1		Brownish grey, medium dense, silty sand to poorly graded sand			2	2	2	2	3	10	
2.0	SPT-2					3	2	3	3	4	12	34
3.0	SPT-3					3	3	3	2	3	11	36
4.0	SPT-4		Light brown, silty clay			5	3	3	4	5	15	40
5.0	SPT-5		Brownish grey, dense, silty sand to poorly graded sand			7	4	5	5	7	21	
6.0	SPT-6					5	4	4	4	5	17	35
7.0	SPT-7					7	5	6	5	7	23	38
8.0	SPT-8					10	6	7	7	6	26	40
9.0	SPT-9					9	4	6	7	7	24	32
10.0	SPT-10					13	8	9	7	8	32	41

NFP: No further penetration R: Refusal

KASUR HYDROPOWER PROJECT

SUBSURFACE EXPLORATION LOG

FIELD DATA

BH No.	BH-01	Sheet No.	02 OF 02
Job No.	3838	Ground Elevation:	-
Geologist / Engineer:	M. Naeem	Project:	Kasur HPP
Client:	Packages Limited	Consultant:	AIPEL
Location:		Type of Boring:	Light Percussion
Date Start:	2/12/2017	Ground Water Depth:	4.0 m
Drilling Fluid:	Bentonite	Date Completed:	2/13/2017

Depth (ft.)	Sample No.	USCS	DESCRIPTION OF MATERIALS	Casing Data		SPT No. of Blows						Sample Length (cm)	Remarks
				Total Length	Project Length	6"	3"	3"	3"	3"	Blows per Ft. (N)		
11.0	SPT-11		Brownish grey, dense, silty sand to poorly graded sand			3	2	2	2	3	9	41	
12.0	SPT-12					5	2	3	3	3	11	38	
13.0	SPT-13					6	3	4	5	6	18	40	
14.0	SPT-14					11	6	8	8	9	31	38	
15.0	SPT-15					15	8	9	11	10	38	31	
16.0	SPT-16					10	8	8	9	10	35	30	
17.0	SPT-17					12	7	7	8	8	30	28	
18.0	SPT-18					15	8	12	11	13	44	27	
19.0	SPT-19					19	11	10	13	13	47	30	
20.0	SPT-20					17	9	9	12	13	43	33	

University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

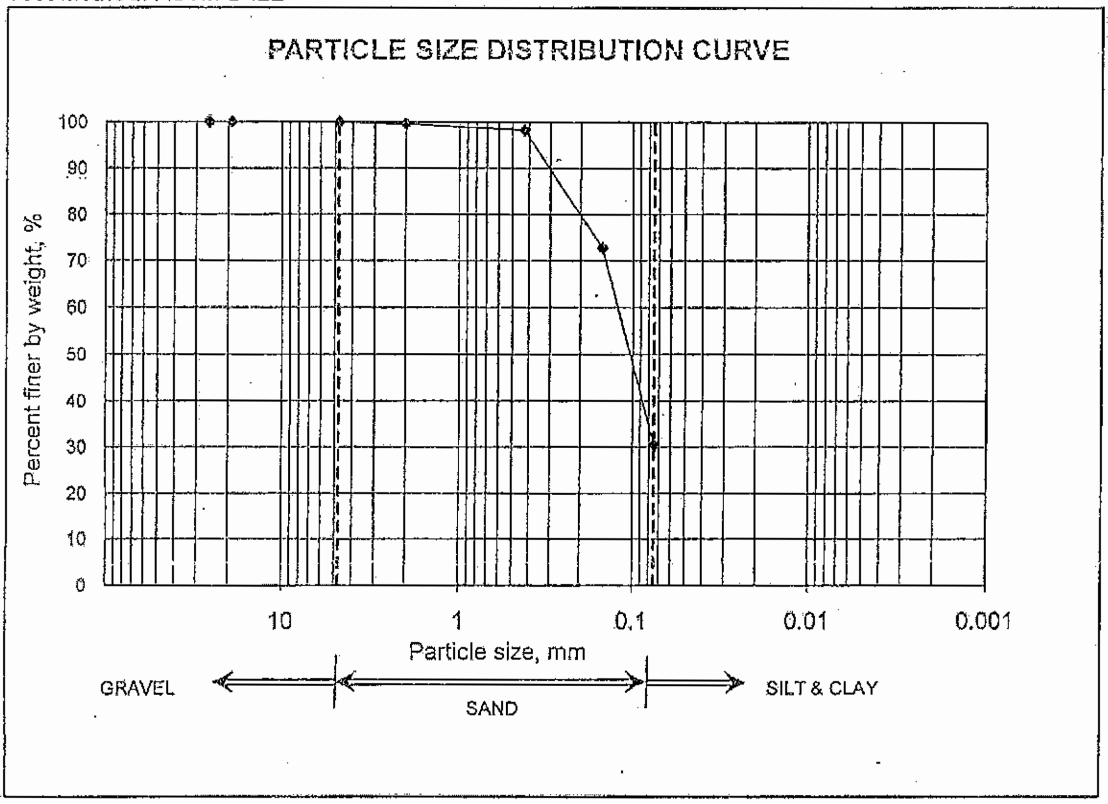
PARTICLE SIZE DISTRIBUTION

Project: Kasur HPP

Client: Pacific Engineering & Geotechnical Services

BH/TP No.	BH-1	Gravel =	0 %
Depth (m):	2.0	Sand =	70 %
		Silt & Clay =	30 %

Test Method: ASTM D422



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Department of Civil Engineering
Geotechnical Engineering Laboratory

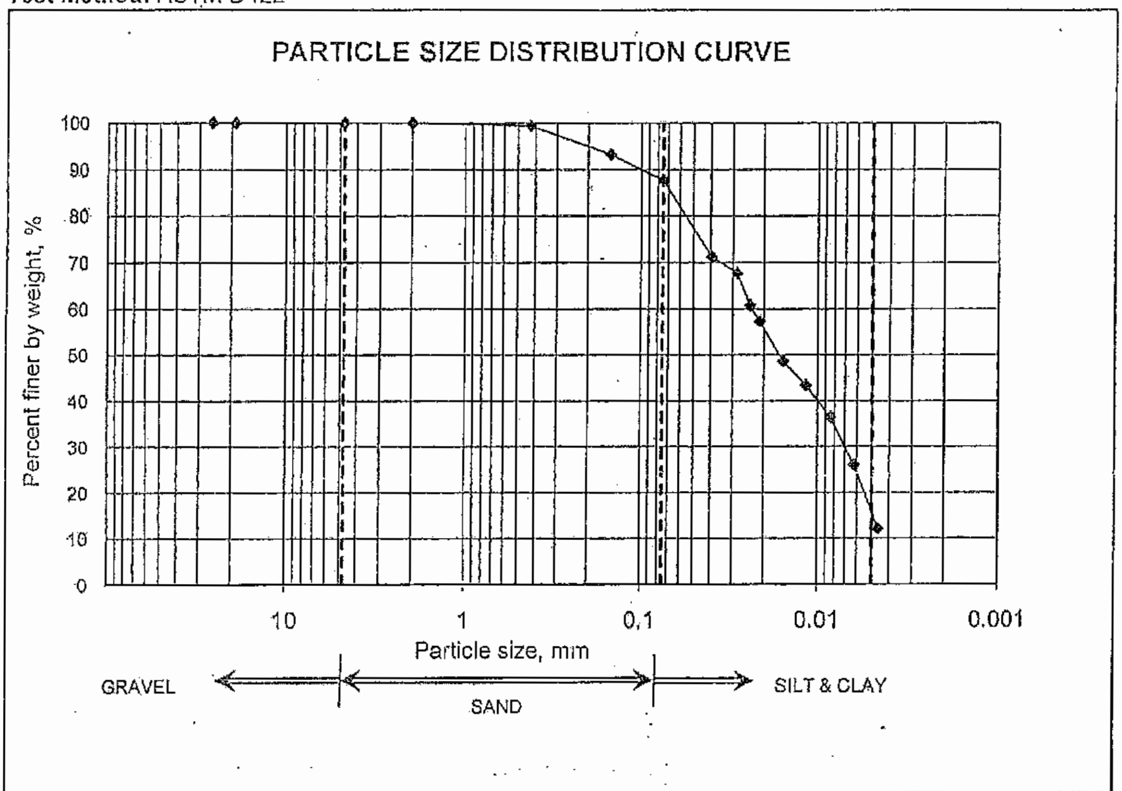
PARTICLE SIZE DISTRIBUTION

Project: Kasur HPP

Client: Pacific Engineering & Geotechnical Services

BH/TP No.	BH-1	GRAVEL (> 4.75 mm) =	0 %
Sample No.	UDS-1	SAND (< 4.75 mm) =	12 %
Depth (m)	3.5	SILT (< 0.075 mm) =	74 %
		CLAY (< 0.005 mm) =	14 %

Test Method: ASTM D422



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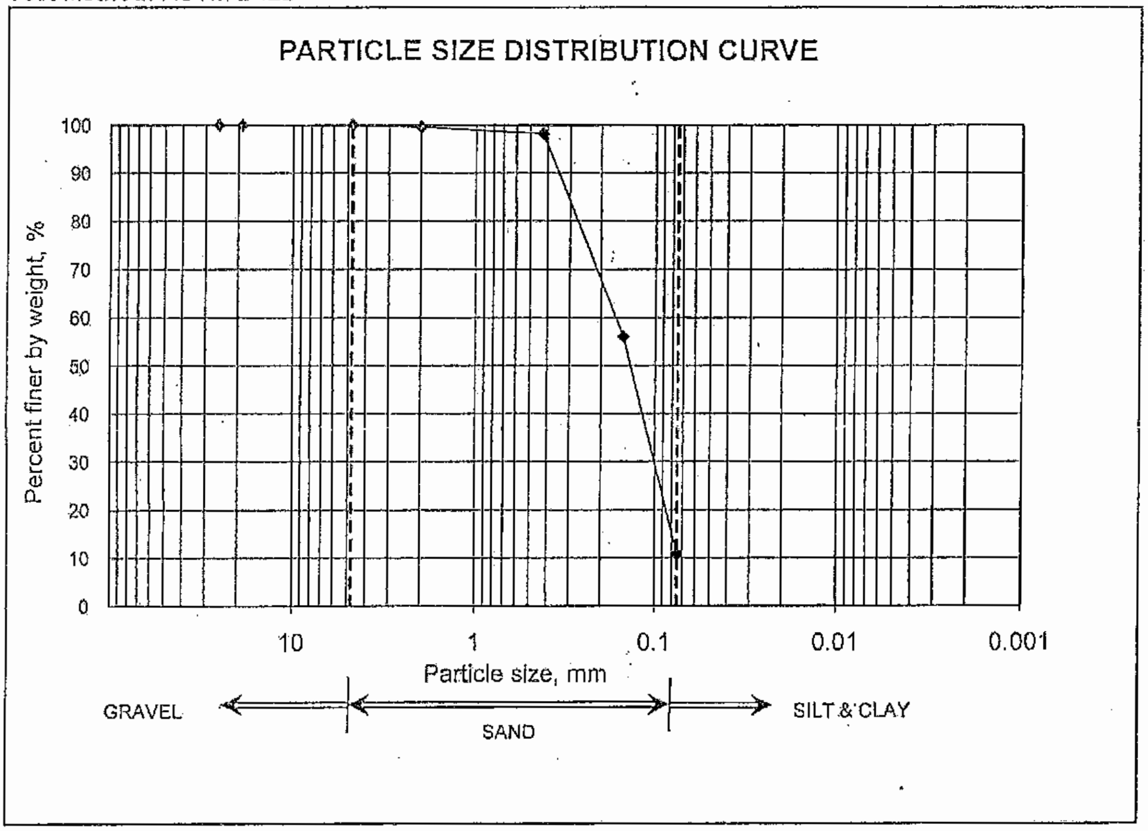
PARTICLE SIZE DISTRIBUTION

Project: Kasur HPP

Client: Pacific Engineering & Geotechnical Services

BH/TP No.	BH-1	Gravel =	0 %
Depth (m):	8.0	Sand =	89 %
		Silt & Clay =	11 %

Test Method: ASTM D422



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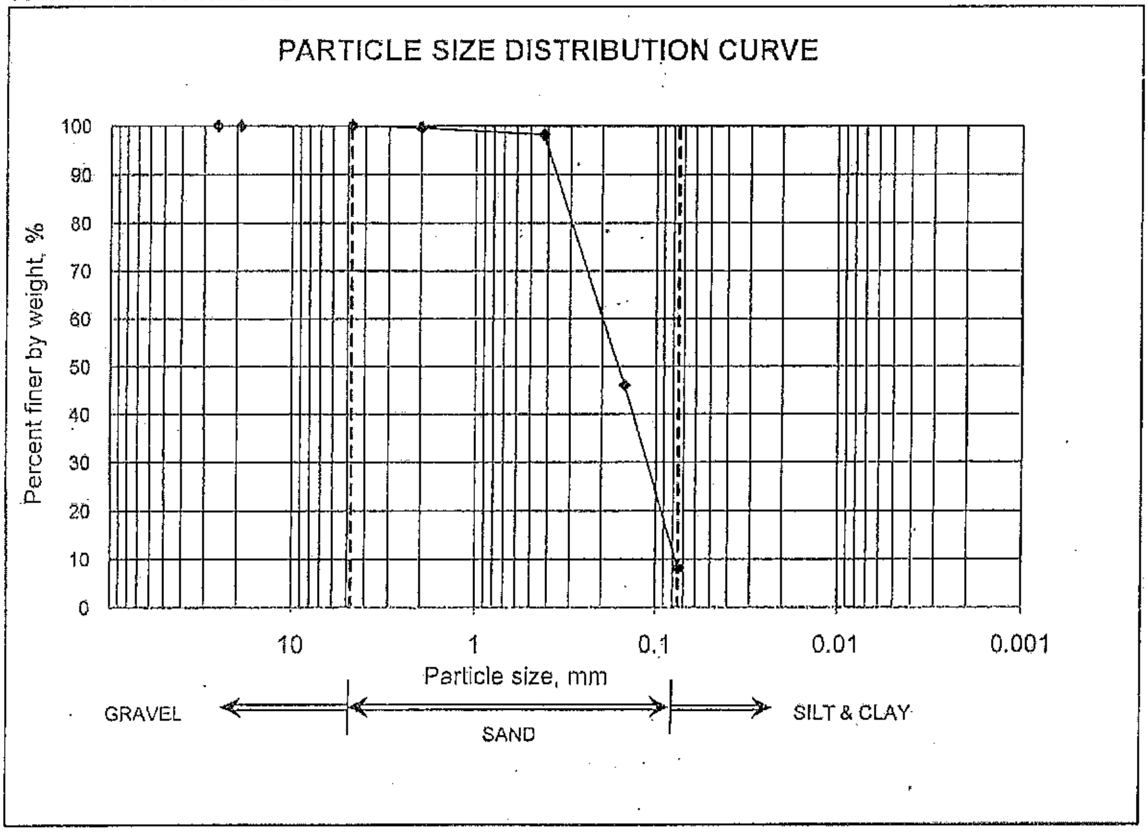
PARTICLE SIZE DISTRIBUTION

Project: Kasur HPP

Client: Pacific Engineering & Geotechnical Services

BH/TP No.	BH-1	Gravel =	0 %
Depth (m):	14.0	Sand =	92 %
		Silt & Clay =	8 %

Test Method: ASTM D422



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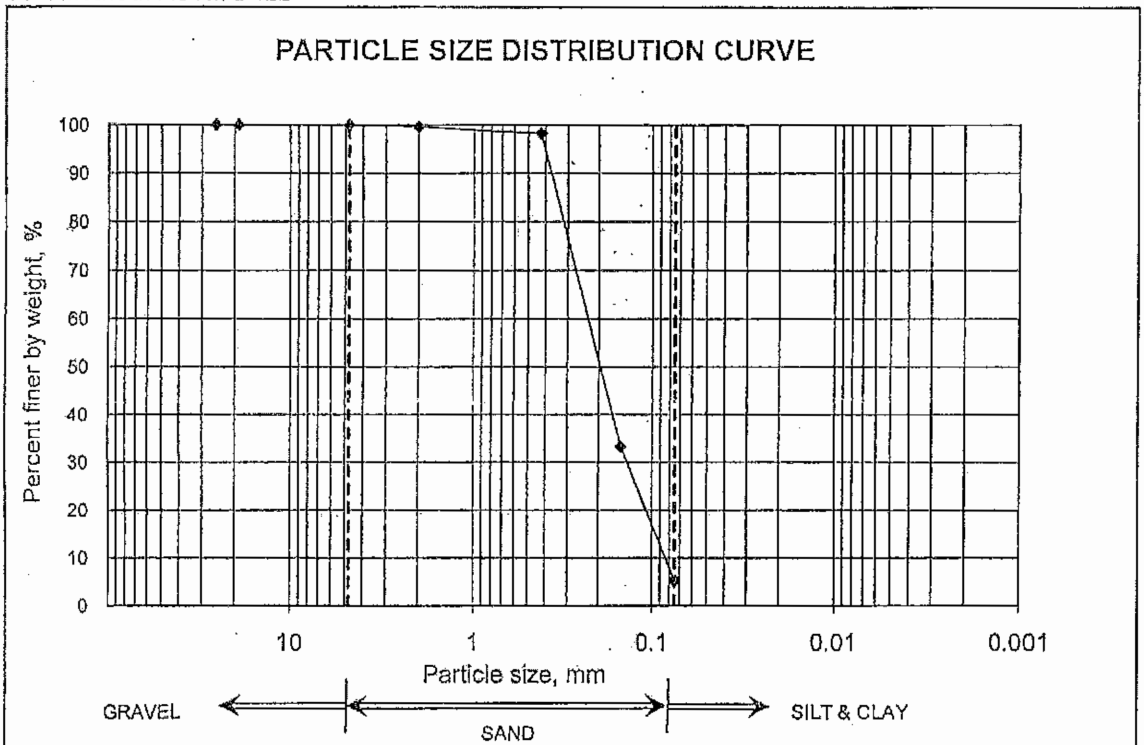
PARTICLE SIZE DISTRIBUTION

Project: Kasur HPP

Client: Pacific Engineering & Geotechnical Services

BH/TP No.	BH-1	**Gravel =**	0 %
Depth (m):	20.0	**Sand =**	95 %
		Silt & Clay =	5 %

Test Method: ASTM D422



Prepared by:

Checked by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

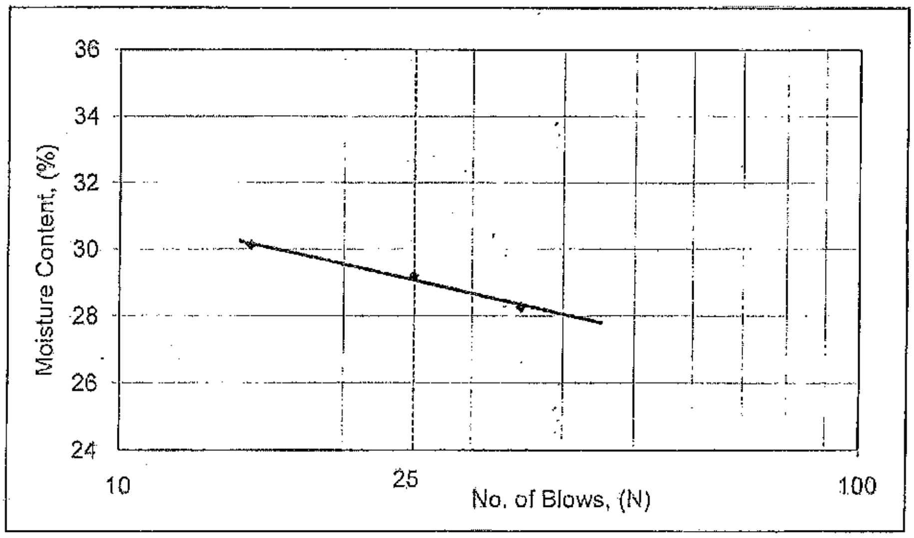
ATTERBERG LIMITS

Project: Kasur HPP

Client: Pacific Engineering & Geotechnical Services

		Blows	w (%)
BH/TP No.	BH-1	15	30.12
Sample No.	UDS-1	25	29.20
Depth (m):	3.5	35	28.26

Test Method: ASTM D4318



Liquid Limit (%)	=	29
Plastic Limit (%)	=	20
Plasticity Index	=	9

Prepared by:

Checked by:

CONTENTS

5.1. GENERAL

This chapter describes the possible schemes for the development of hydropower plant utilizing the potential of fall structure at RD 509+712 of BRBD Link Canal, District Kasur. The project area is accessible by Ferozepur Road Lahore to Kasur-Khem Karan Road which leads straight to Bambanwala Ravi Bedian Depalpur (BRBD) Link Canal. Alternatives study is conducted on the basis of the following:

- Topographic surveying
- Existing site conditions
- Geotechnical & geological study
- Historic data of discharge

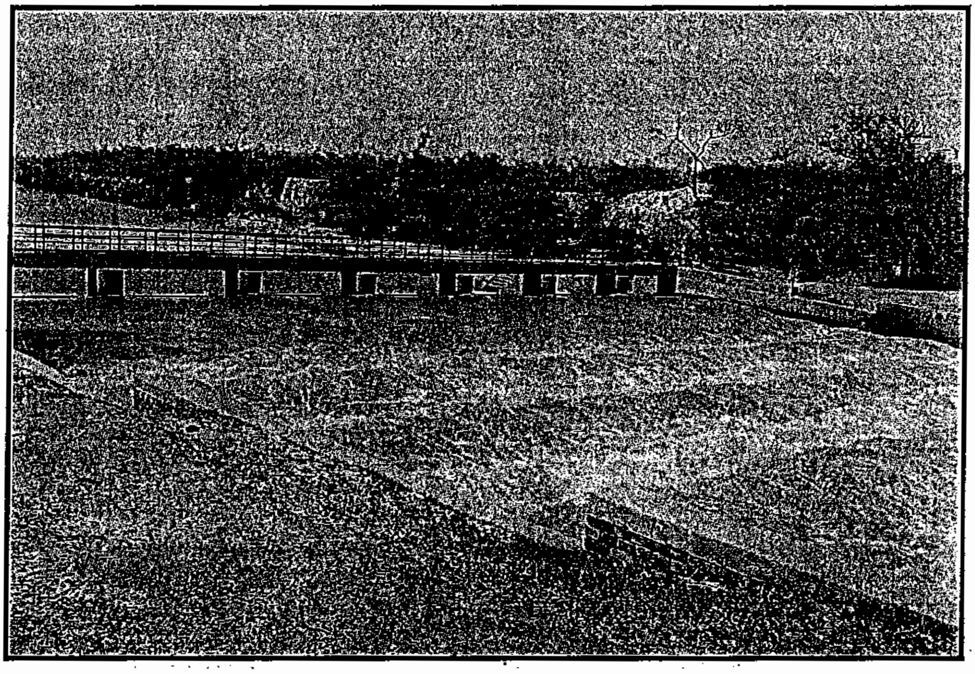
5.2. EXISTING SITE CONDITIONS

Topographically the site area is generally plain. The location of proposed powerhouse lies within the non-perennial reach of the canal as BRBD Link Canal is non-perennial from regulator at RD 434+000 to its tail.

Kasur Hydropower Project involves the development of hydropower plant utilizing the energy and power potential of fall at RD 509+712. Fall at RD 509+712 of BRBD Link Canal is an ungated and stepped type fall structure as shown in **Figure 5.1**. The salient features of fall structure are as under:

- Upstream Full Supply Level = 673.72 ft.
- Downstream Full Supply Level = 654.45 ft.
- Upstream Bed Level = 666.72 ft.
- Downstream Bed Level = 647.45 ft.
- No. of Bays = 1 No.
- Width of Bay = 85 ft.
- Discharge = 2280 cusecs

Figure 5.1: Fall Structure Data at RD 509+ 712



5.2. GEOLOGICAL & GEOTECHNICAL STUDY

The project site is located in Punjab, which is a plain of alluvial material as well as rocks at deeper depth. Probabilistic Seismic Hazard Assessment (PSHA) recently carried out for revision of seismic provisions of the Building Code of Pakistan, shows that the site area falls in Zone 2A. It is therefore, recommended that the project structures should be designed to cater for the requirements of Zone 2A of Building Code of Pakistan (2007).The top surface comprises Clayey Silts and Clay/Lean Clay (Soft to Very Stiff) up to a depth of 7.0 m below NSL. The material is underlain by Sandy Silt/ Silty Sand (Very Soft to Very Stiff, Dense to Very Dense) up to a maximum investigated depth of 20 m below NSL. Groundwater is encountered at 4 m depth in the borehole drilled up to a maximum depth of 20 m below NSL.

5.3. PROJECT ALTERNATIVES STUDY

The main consideration during planning has been that the hydropower scheme should not disturb the irrigation system by all means. Therefore, only those layout options have been considered which have the flexibility to accommodate the planned project. The following criterion has been adopted while conceiving the alternative layouts:

- The identified layouts should be within the selected reach and do not interfere with the irrigation system.
- Both irrigation system and power generation system could be operated simultaneously without any disturbance
- Environmental and social impacts.
- Climatic and hydrological conditions.
- Identification of powerhouse to gain maximum head and corresponding power potential.
- The alternative with short water way and maximum head is preferred.
- The project plan is furnished considering the topographic and geological features of the project area and should involve the easier construction methodology.
- The selected alternative should involve the minimum resettlement issues.
- The existing/planned scheme(s) of the irrigation system should not be affected by the identified layout.
- Minimum or preferably no land acquisition. The government-owned land has been preferred over the private owned land.
- Minimum construction period with optimum utilization of the annual canal closure period
- Minimum head loss for maximizing the power potential

Considering the site layout situation, only possible alternative options have been considered. The best option is to construct the powerhouse alongwith splillway within main canal, however, following three options have been considered in the light of above discussions:

Alternative 1: Construction of power plant within Main Canal alongwith Spillway

Alternative 2: Construction of power plant in diversion canal

Alternative 3: Construction of powerhouse with Flap Gate option

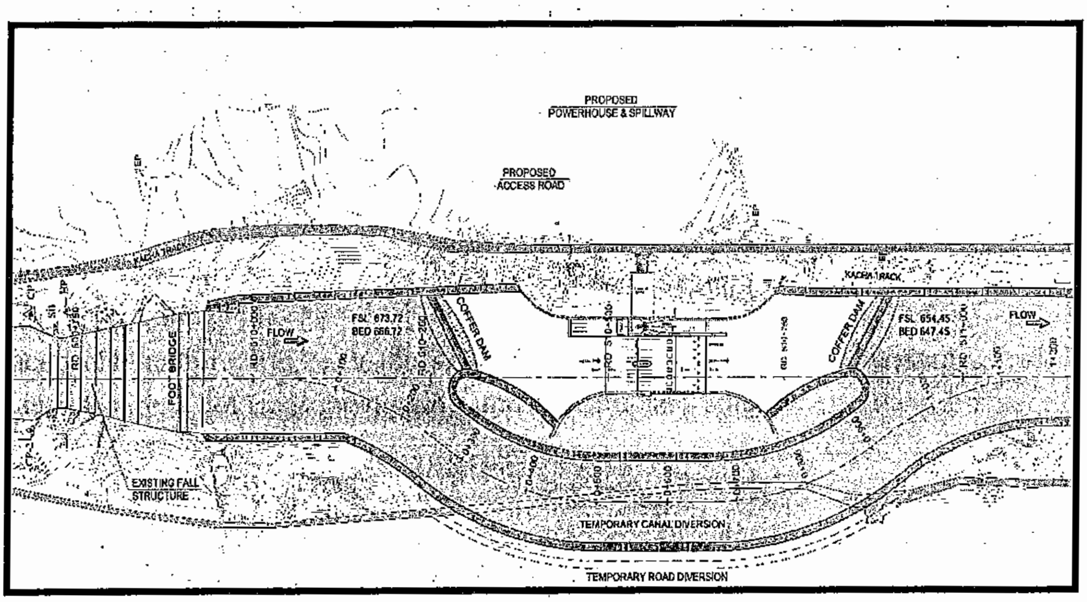
5.3.1. ALTERNATE PROJECT LAYOUT-I

(CONSTRUCTION OF POWERHOUSE WITHIN MAIN CANAL ALONGWITH SPILLWAY AT RD 510+600)

It is proposed that powerhouse should be constructed within the main canal at RD 510+600 and an illustrative plan of this alternative is provided **Figure 5.2** and Drawing No. **BRBD-HEPP-FS-2.1.** The canal banks shall be raised on both sides from RD 509+712 up to the powerhouse which will allow the utilization of available head at RD 510+600 for power generation. In this scenario, the canal will follow its original regime and there will be minimum disturbance to the hydrological behavior of the canal. The main canal shall be diverted temporarily during canal closure and coffer dams shall be constructed on upstream and downstream of the proposed powerhouse at the confluence of diversion and main canal. Therefore, construction works of the power plant can be executed independently without disturbing the canal operations. An auxiliary spillway catering the same discharge capacity is proposed alongside the powerhouse within the main canal in order to safely manage the canal operations during emergency shutdown of the power plant. Powerhouse can be placed either on right side or left side within the main canal and the same shall be finalized during detailed engineering and construction stage with mutual consent of Punjab Irrigation Department.

The Hydropower Project utilizes a net head of 18.9 ft. The discharge shall be regulated by the spillway gates and power generating unit will be double regulated with much better efficiency.

Figure 5.2: Alternative 1



5.3.1.1. ADVANTAGES

- Canal operations will remain smooth during construction and after construction.
- There will be no change in canal design.
- Construction cost is less than alternative-II & III.
- Construction schedule is less than alternative II and saves cost.
- This alternative offers minimum head loss.
- Canal will follow its original regime and offer maximum flexibility during canal operations as compared to other alternatives.

5.3.1.2. DISADVANTAGES

- The main canal shall require temporary diversion. However, the temporary diversion shall be designed to safely pass the design discharge of the canal.

5.3.2. ALTERNATE PROJECT LAYOUT - II

(CONSTRUCTION OF POWERHOUSE WITHIN DIVERSION CANAL)

This option is provided here for discussion only and does not seem viable for implementation. The powerhouse can be constructed in permanent diversion channel. By this option the spillway shall be constructed within main canal. During construction, very careful and precise planning is required as the construction activities shall be executed within main canal as well as diversion canal. The canal operations shall also be very difficult during construction and operations of the plant. This option is not considered onward.

5.3.2.1. DISADVANTAGES

- Extensive care and handling of water is required during the construction of power plant.
- Project cost is much higher than alternative-I & III.
- Construction time will be more than alternative-I & III.
- It involves very complex construction methodology and difficult canal and plant operations.
- There will be serious sediment problems.
- It requires permanent land acquisition.

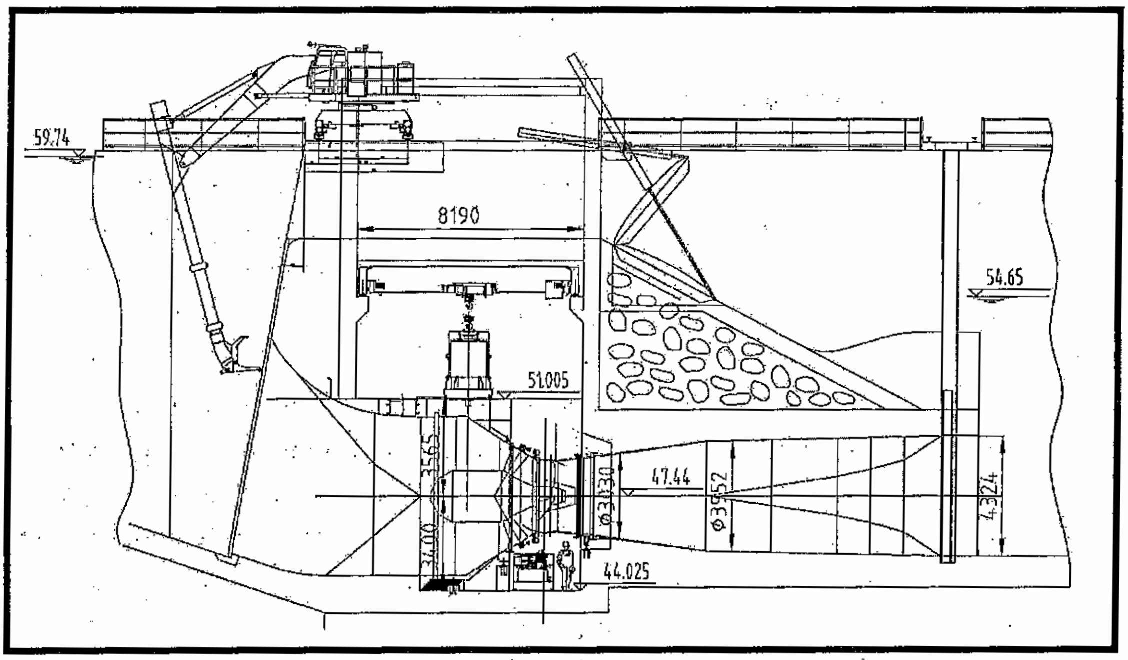
- Project in this alternative is on the verge of financial and economic viability.

5.3.3. ALTERNATE PROJECT LAYOUT - III

(POWERHOUSE WITHIN MAIN CANAL HAVING KAPLAN UNITS WITH FLAP GATES)

This option involves the provision of overtopped flap gates. Here, the flap gates can be regulated as an alternative to the spillway and will automatically be operated during emergency shut down of the turbine. The flap gates will also become automatically operative in case of excessive discharge within canal. A longitudinal section of the proposed alternative is provided as **Figure 5.3**. This is a very simple option as it provides maximum flexibility during construction of the powerhouse as well as canal operations after the commissioning of the plant. The canal will also remain in its original hydraulic regime and will not be subject to any hydraulic interference or disturbance. This is a very interesting and technical viable option but it involves higher costs of electromechanical works. It has a drawback that it has not yet been practiced anywhere in Punjab up till now. Therefore, it is provided here for discussion only and it is suggested that during detailed engineering and with the consent of Punjab Irrigation Department, this option should be discussed in detail.

Figure 5.3: Alternative III with Overtopped Flap Gates



5.3.3.1. ADVANTAGES

- Canal operations will remain smooth during construction and after construction.
- There will be no change in canal design.
- Construction schedule is less than alternative I & II.
- This alternative offers minimum head loss.
- Canal will follow its original regime and offer flexibility during canal operations.
- Very simple construction methodology.

5.3.3.2. DISADVANTAGES

- The only disadvantage is that the canal shall require temporary diversion. However, the temporary diversion shall be designed to safely pass the design discharge of the canal.
- This alternative has not yet been implemented in Pakistan up till now.
- It involves higher cost of electromechanical works.

5.4. CONCLUSIONS

It is concluded from the above discussions that Alternative I whereby the powerhouse and spillway within the same axis is proposed within main canal at RD 510+600, is the most economical and viable solution and, therefore recommended for onward study.

Operations of the canal will not be disturbed during construction and after the commissioning of the proposed power plant. The Sponsor is responsible to take care of all the structures and reach of the canal during the construction and operations of powerhouse.

CONTENTS

6.1. GENERAL

BRBD Link Canal off-takes from Upper Chenab Canal Main at RD 133+296 whereby it is perennial up to RD 434+000. It becomes non-perennial from RD 434+000 to its tail. The site for the installation of Kasur Hydropower Project is proposed at RD 509+712. The site is accessible by Ferozepur Road Lahore to Kasur Khem Karan Road which leads straight to Bambanwala Ravi Bedian Depalpur (BRBD) canal. The site is within 3.5 Km from Kasur City and easily accessible. This chapter provides a brief description of layout of Kasur Hydropower Project.

6.2. PROJECT LAYOUT

After conducting the project alternatives study, it is suggested that the hydropower plant should be developed at RD 510+600. The project has been planned within the main canal as shown on Drawing No. **BRBD-HEPP-FS-1.3**. The Hydropower Project utilizes a net head of 5.77 m available at the fall structure at RD 509+712. It is proposed that the main canal shall be temporarily diverted on right side during construction period and the powerhouse along with a Spillway shall be constructed at RD 510+600. The available head at RD 509+712 shall be shifted at RD 510+600 after canal filling and the raising of canal embankments. The discharge shall be regulated by the spillway gates and power generating unit as it will regulate with much better efficiency.

6.2.1. POWERHOUSE AND SPILLWAY

The powerhouse structure consists of an intake and main service building to accommodate loading bay and control room. The intake of water from the head race to a single turbo-generator unit has a single bay. The span of the bays is 7 m. A single bulb type unit is considered for power generation. The powerhouse will be constructed in an open pit. The bottom elevation of the pit would be 189.90 m. On the left side of powerhouse, a loading bay and at downstream of loading bay area, transformer platform is provided.

The powerhouse will be constructed in RCC. The piers will rise above from the walls of the 4 bays resting on a mat slab acting as raft. This foundation slab will also provide support to the three turbo-generator units.

The elevation of loading bay is 201.82 m. The bottom elevation of the roof slab of powerhouse is 213.04 m. Powerhouse foundations at elevation 194.16 m has been designed to accommodate the turbine unit and draft tube.

The hydraulic gates / stoplogs provided on the upstream side of the powerhouse intake will facilitate closing of flow for inspection purpose, if and when required.

In order to prevent the entry of tree branches, bushes and other floating material into the turbines bays, a trashrack arrangement has been provided on the upstream of the stoplogs.

The downstream end of the four bay will be gated by providing stoplogs to regulate the flow to power plant. Details are provided in Drawing No. **BRBD-HEPP-FS-3.4, BRBD-HEPP-FS-3.5 & BRBD-HEPP-FS-3.3.**

A 20 ton bridge Crane shall be installed in the powerhouse. A double storey office building has been provided on left side of powerhouse containing store, O&M staff room, R.E room, Battery and Control room.

The cross-section of access road to powerhouse is shown on Drawing No. **BRBD-HEPP-FS-4.2.**

Spillway is proposed within the main canal and within the same axis of powerhouse. It is equipped with Radial gates for ease of canal operations after commissioning of the plant. The spillway can be constructed either on right side or the left side within the main canal and the same shall be discussed during detailed engineering and construction stage after mutual consent from Punjab Irrigation Department.

6.2.2. CANAL IMROVEMENT WORKS

BRBD Link canal at this reach is designed for a discharge of nearly 63 Cumecs. The upstream of the powerhouse shall require improvement in terms of raising of canal bed and embankments up to RD 510+600. The canal bed shall be raised naturally during the canal operations and the available head at RD 509+712 could be efficiently and effectively be shifted at RD 510+600. Accordingly, it is proposed that the canal embankments shall be raised up to 4 feet which also include the free board. A 3 feet stone apron at canal bed adjoining the side slopes shall be provided which will provide stability to the proposed stone pitching of 1' provided on the side slopes. The existing canal cross sections are provided in Drawing No. BRBD-HEPP-FS-1.6. It is emphasized that the canal operations shall not be disturbed during construction and operations of the powerhouse.

6.2.3. DEWATERING SYSTEM

<u>During Construction:</u>
The boreholes drilled by M/s Pacific Engineering & Geotechnical Services indicate the ground water table is at a depth of about 4 m from the ground surface. The foundation elevation of the pit of the powerhouse is 194.16 m. It has been estimated that to facilitate the construction of the powerhouse, existing ground water table will have to be lowered by about 7 to 8 m, therefore, it has been worked out that 24 Nos. pumps of 0.75 cusec capacity each, can achieve this objective by running 10 hours daily in 30 days. The dewatering plan is provided in drawing No.**BRBD-HEPP-FS-3.9.**

<u>During Plant Operations</u>
The powerhouse is provided with adequate dewatering system so that dewatering could be done from the draft tube whenever required. Dewatering pumps with dewatering sumps are provided within the powerhouse.

6.2.4. ACCOMODATION FOR O&M STAFF

Suitable office and residential accommodation for operation and maintenance staff of the project will be constructed in the allocated area, as shown on the Drawing No **BRBD-HEPP-FS-4.1**.

CONTENTS

7.1. GENERAL

This chapter presents a general description of the design criteria and the actual design / selection of major mechanical equipment and systems forming part of Kasur Hydropower Project. It also covers the characteristics of these equipment and various factors used to establish the sizes and configurations of such type of equipment etc.

The construction of Kasur Hydropower project in connection with the already existing canal system requires special arrangements in order to avoid interruption of the water flow needed for the irrigation during the period of construction and operation. Some alternatives regarding the location of the powerhouse have been analyzed while considering site, environment and erection conditions. The necessary measures during the time of execution of the civil works and during erection time of the electro-mechanical equipment are described in other chapters of this study. The fall structure of BRBD Link Canal at RD 509+712 can be used for a total annual power generation of about 10.88 GWh using the available potential.

The head-flow measurements during the last many decades as well as the definition of an acceptable range regarding the installation level of the units are decisive for the selection of type of turbines, number, size and speed of the units. The low head turbines run at relatively low speed so, considering the turbine output, the speed shall be transformed by different type of speed increaser, fitting to the provided options, to reach the usable synchronous speed of a generator.

All hydro mechanical equipment has to be designed for an operation under worst conditions regarding the water quality. Especially during flood periods, the content of sand and other solid components in the water require high quality of material and paint coatings and special devices to protect sealings, bearings, filters and the cooling systems.

All items of the different equipment are specified in sufficient detail to ensure that they function as an integral part of the relevant concrete structures and provide a higher degree of operational security and reliability. Moreover, it enables simple, convenient and secure control and indication of all relevant equipment and provides a high degree of corrosion protection to all the underwater parts of the turbine.

7.2. CODES AND STANDARDS

The design will conform to the applicable portions of the following codes and standards:

- DIN - Deutsche Industrial Normen.
- EN - European Standard.
- IEC - International Electro technical Commission.
- ISO - International Organization for Standardization.
- FEM - Federation European de la Mauntention.
- ASTM - American Society for Testing and Materials.
- ACSE - Americans Society for Civil Engineers. Manuals and Reports on Engineering Practice No. 79-Steel Penstocks, 1993.
- CMAA - Crane Manufacturers Association of America.
- ABMA - Americans Bearing Manufactures Association.
- AGMA - Americans Gear Manufactures Association.
- NEC - National Electric Code.
- NEI - National Elevator Industry, Inc.
- NFPA - National Fire Protection Association.
- PPI - Plastic Pipe Institute.
- SSPC - Steel Structures Painting Council.
- FM - Factory Mutual Engineering and Research Corporation.
- IAPMO - International Association of Plumbing and Mechanical Officials

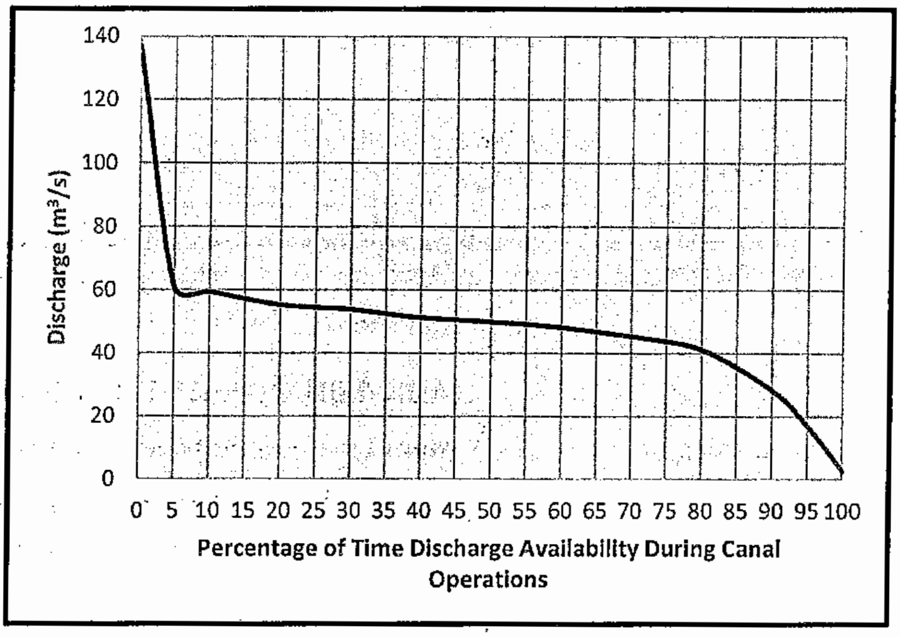
7.3. IRRIGATION REQUIREMENTS

The main purpose of BRBD Link Canal is the continuous feeding of irrigation outlets with a guaranteed quantity of water. The discharge through the canal must remain nearly unchanged, also if one or some turbine units come to an unexpected standstill. In case of a sudden load rejection, the flow should be controlled with the aid of the turbine runner blades (no-load free discharge) as long as the remote controlled gates, installed in the spillway are opened to meet the water requirements for irrigation. This procedure of regulation of the discharge should be achieved without additional gates in the draft tube. The increase of the speed during no-load free discharge operation must be hold as low as possible by controlling the gate vane mechanism and runner blades only.

7.4. DISCHARGE AND NET HEAD

Flow duration curve is provided in **Figure 7.1**. The discharge of 35 m^3/s, 40 m^3/s, 45 m^3/s and 50 m^3/s during canal operations at RD 509+712 of BRBD Link Canal is available for a duration of 85.1%, 80.4%, 70.7% and 49.5% of the time respectively during canal operations.

Figure 7.1: Flow Duration Curve



7.5. POWERHOUSE EQUIPMENT

Preliminary mechanical equipment has been selected to suit the project location and tentative size of the powerhouse. Both the basic design of the equipment and the requirements of IEC has been taken into account. At this stage, preliminary data from the supplier from the European Origin is also obtained and considered for technical parameters and cost estimation. During detail design stage, the data of selected supplier will enable to furnish a comprehensive study for final selection of all equipment.

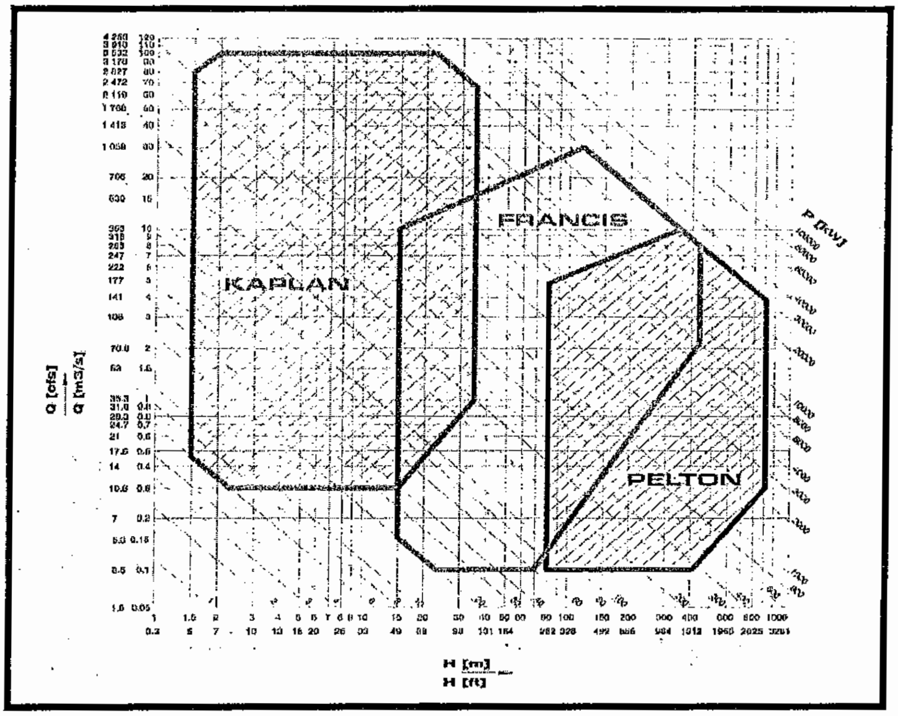
7.5.1. TURBINE SELECTION

The type, geometry and dimension of the turbine will be fundamentally conditioned by various criterions such as:

- Net head
- Range of discharges through the turbines
- Turbine rotational speed
- Cavitation problems
- Cost

Among the above criterion net head and discharge are the basic ones, while others support them. Basic criteria adopted while selection of turbines is presented in **Figure 7.2** below:

FIGURE 7.2: TURBINE SELECTION CHART



The total maximum discharge for all turbines is limited to Q_{total} = 50 m^3/s with a rated net head of H_n = 5.77 m. As far as a harmless operation is possible, the minimum discharge with one unit in operation should go down to Q_{min} = 15 m^3/s with a maximum net head of H_{netmax} = 6.62 m. The upstream water level remains constant. Two alternatives each with one and two units were compared in order to find the most economical solution.

Basic data for both options is as under:

Maximum total discharge Q		= 50 m^3/s
Alternative A	$H_{netrated}$	= 5.77 m
Alternative B	$H_{netrated}$	= 5.77 m

Maximum net head if one unit in operation with full discharge:

Alternative A	$H_{net\ max}$	= 6.72 m
Alternative B	H_{netmax}	= 6. 72 m

Considering operating net head of 5.77 m, rated flow of 50 m^3/sec with the availability of monthly net flows, only Kaplan type of turbines are most suited for above mentioned head and flows. Here, Kaplan Horizontal Pit Type Unit, Bulb Type or Bevel Gear Bulb Type could be considered depending on the suitability of the plant, economic benefits and different manufacturers. In order to provide an appropriate option, a comparison was made between Kaplan Bulb Type and Kaplan Pit Type units and ultimately it was concluded that bulb type is a compact solution with minimum civil components and smaller size of the powerhouse. Therefore, bulb type unit is selected for onward study.

7.5.2. KAPLAN BULB TYPE UNIT *(DOUBLE REGULATED)*

Main characteristics of bulb type unit are mentioned below:

- High speed generator
- Short installation time
- Compact power house structure
- LV (Low Volt) Application of 400 or 690V

Turbnpro and solid edge softwares have been used while calculating the main characteristics of turbine. Meanwhile a comparison between one and two units is also provided in **Table 7.1** below. The orientation in both the options is horizontal and generator is enclosed in bulb.

Table-7.1 Comparison Table for different No. of Units

Parameters	Unit	No of units	
		1	2
Q design/rated	m^3/s	50	26
H rated	m	5.77	5.77
P rated power (Turbine output per unit)	KW	2924	1404
Runner diameter	mm	2893	2038
Rated speed	rpm	150	214
Specific speed (Ns)	rpm	761	768
Estimated Runner weight	Kg	6742	2430
Turbine Inlet width x height (WxH)	m	6.57x6.57	4.63x4.63
No. of runner blades	Nos	3	3
Bulb width x length x bulb support width	m	3.33x7.81x1.62	2.34x5.54x1.14
Bulb			
Draft tube total Length (L)	m	13.89	9.78
Draft tube outlet width x height (WxH)	m	6.08x4.34	4.28x3.06

The above comparison shows the difference in technical parameters against one and two bulb type units. It is important to mention here that Kasur Hydropower Plant lies within the non-perennial reach of BRBD Link Canal. Therefore, the plant will remain stopped for nearly five months of the year. It is emphasized that the project development cost should be reduced to as low as is technically and practically possible by adopting value added engineering and without compromising on requisite quality standards. The manufacturer / supplier from the European origin was considered at the feasibility stage and special consideration was given to the supplier's recommendations and technical and commercial offer. With the recommendation of the manufacturer and considering the plant development cost, net annual benefits and benefits to cost ratio it is recommended that one bulb type unit is suitable under the circumstances and the following information is generated considering a single unit. Basic performance data of the bulb type as obtained from the software is provided in **Figure 7.3.** Accordingly, the turbine design data, dimensional data and efficiency chart is provided in **Figures 7.4, 7.5 & 7.6** respectively. It is a double regulated turbine providing higher efficiency. Furthermore, the double regulation allows, at any time, for the adaptation of the runner and guide vanes coupling to any head or discharge variation.

Figure 7.3: Turbine Performance & Input Data

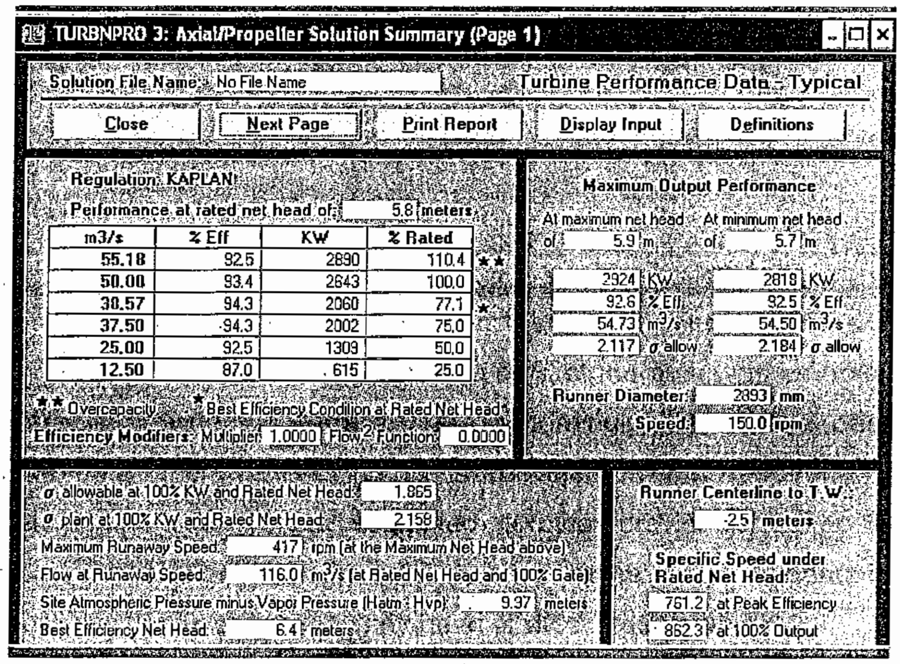


Figure 7.4: Turbine Design Input

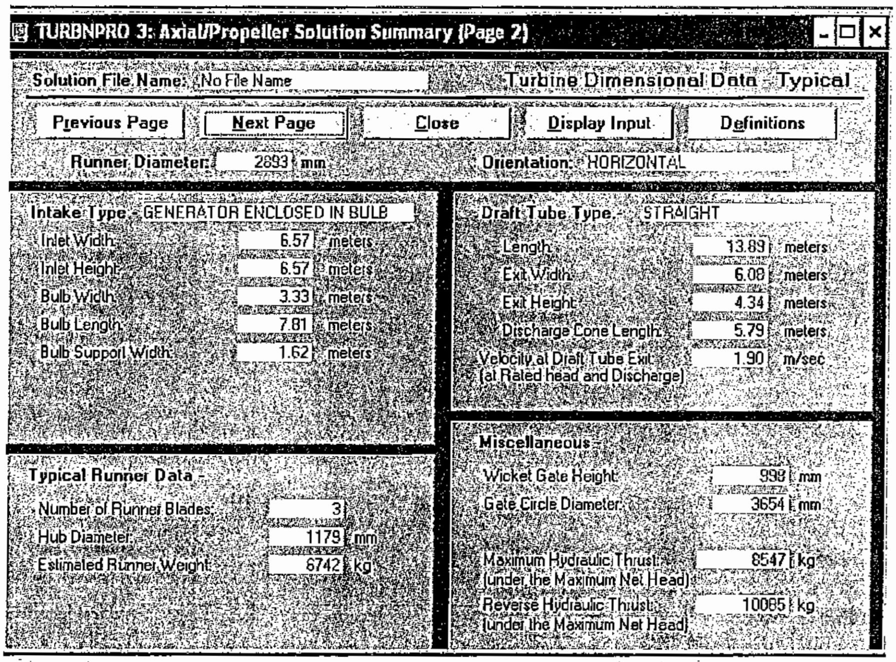


Figure 7.5 (a): Turbine Dimensional Data

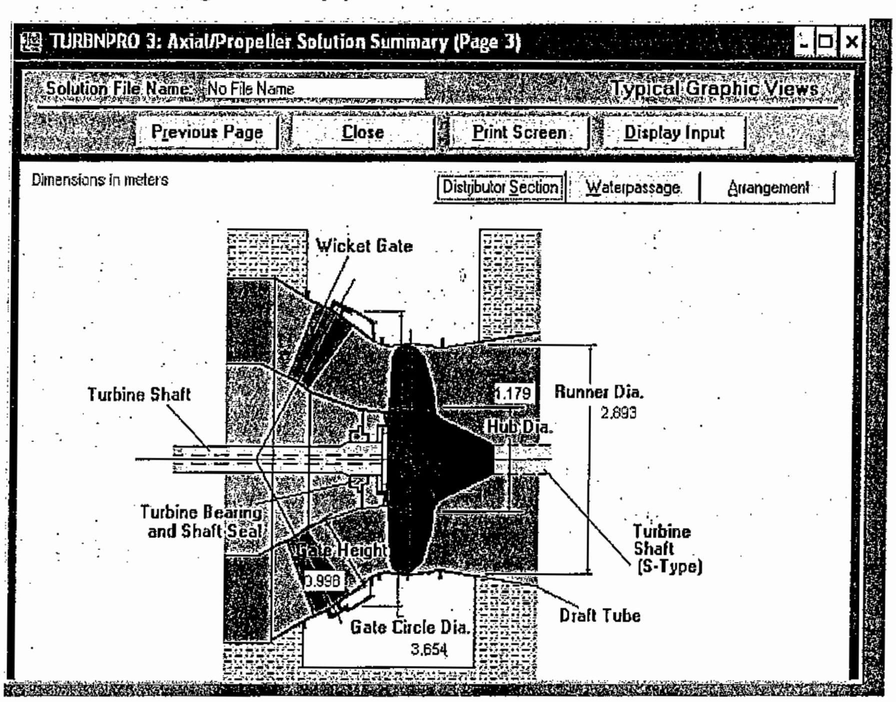


Figure 7.5 (b): Turbine Dimensional Data

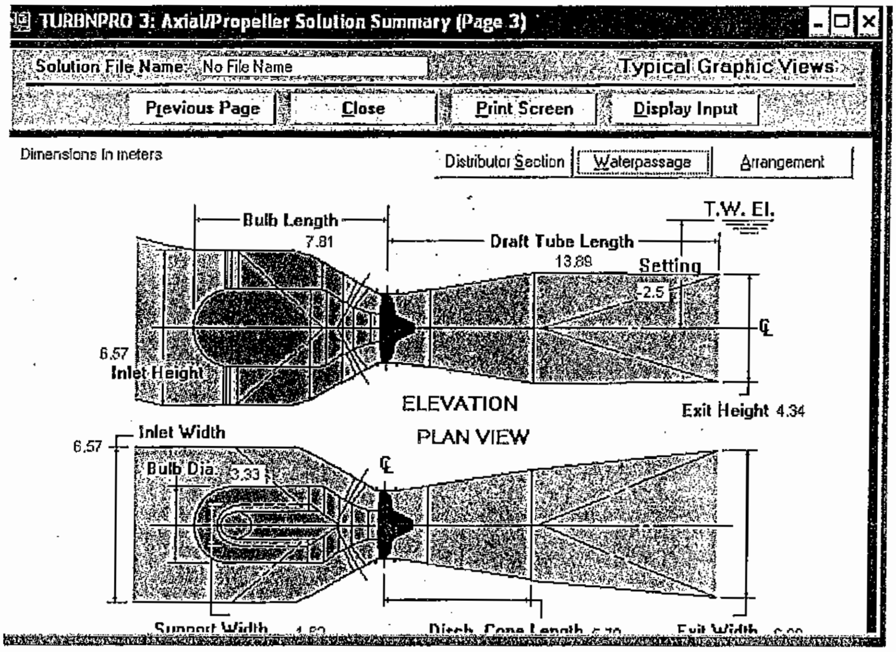
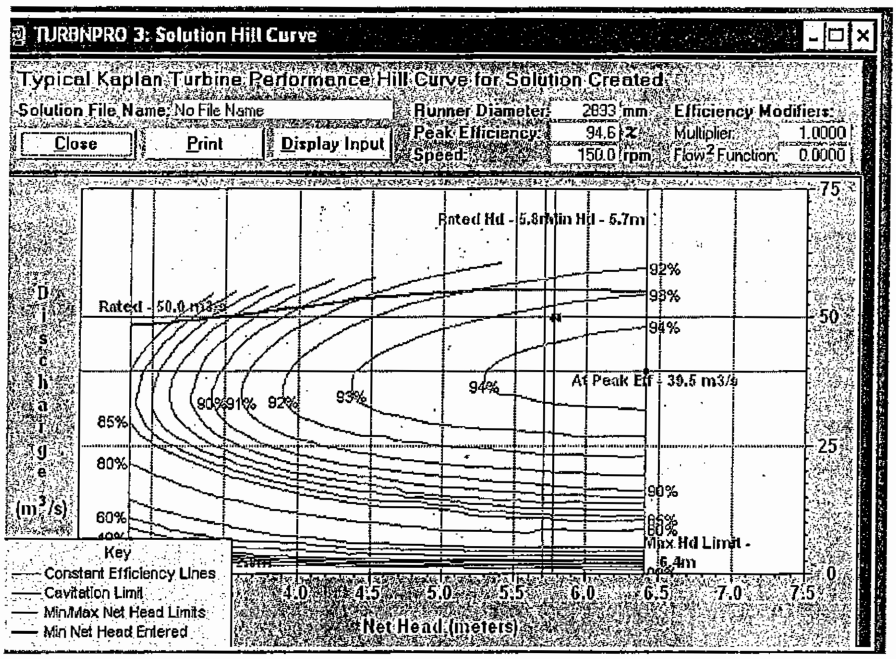


Figure 7.6: Turbine Efficiency



7.5.3. TURBINE RATING

The design or rated net head of the powerhouse has been determined from the gross head curves as detailed in Chapter 3 against mean daily flows for the years 2006-2016. The gross head at this site varies from 5.77 m to 6.72 m over a range of 0 to 100% of time exceedance for the curves. However, a design head of minimum 5.77 m has been selected after considering requisite headless across the waterways. Furthermore, in order to make use of maximum available discharge, the plant design discharge of 50 m^3/s is considered (details of discharge optimization provided in chapter 9 of this study).

7.6. SCOPE OF SUPPLY

7.6.1. TURBINE

Proposed unit consists of the following components:

A Kaplan bulb type unit is the one having a runner with three, four, five or six blades in which the water passes through the runner in an axial direction with respect to the shaft. Here, the selected unit has three runner blades. The pitch of the blades may be fixed or movable. Principal components consist of a water supply case, wicket gates, a runner and a draft tube. Three runner blades are radial oriented on the hub and without an outer rim. The runner blades have a slight curvature and cause relatively low flow losses. This allows for higher flow velocities without great loss of efficiency. Accordingly, the runner diameter becomes relatively small and the rotational speed more than two times higher than a Francis turbine for the corresponding head and discharge. Accordingly, the generator dimensions also become comparatively smaller and cheaper. The comparatively high efficiencies at partial loads and the ability of overloading is obtained by a coordinated regulation of the guide vanes and the runner blades to obtain optimal efficiency for all operations.

The proposed unit have the following main components:

- scroll casing and stay ring
- guide apparatus
- covers
- runner
- runner blade servomotor

- regulating mechanism of the runner blades
- co-operation of regulating the runner blades and guide vanes
- turbine shaft
- turbine bearing
- shaft sleeve and seal box
- runner chamber
- draft tube

7.6.2. DESIGN OF TURBINE UNITS

7.6.2.1. Basic Data

Kaplan bulb turbines selected for the Powerhouse will operate under the following conditions of discharge, head and tailrace level:

7.6.2.2. Discharge

Design or Rated Discharge/unit	50 m^3/s
Minimum Discharge	15 m^3/s

7.6.2.3. Headrace and Tailrace Levels

Power Channel(FSL) level (u/s)	205.42 m
Power Channel(FSL) level (d/s)	199.52 m

7.6.2.4. Turbine Setting

The turbines of the powerhouse are set at 2.5 m below the tailrace level.

7.6.2.5. Head Loss and Rated Head

The maximum gross head with one unit in operation for this Powerhouse would be 5.87 m, whereas, the waterways head loss is assumed as 1% of the gross head. Therefore, the design or rated net head will be 5.7m.

7.6.2.6. Synchronous Speed

The turbine speed is selected as 150 rpm and will be stepped up to generator synchronous speed of 750 rpm through a speed increasing gears may be of epicycle design.

7.6.2.7. Efficiency

The turbine full gate and gear efficiencies will be 91.5% and 98% respectively. The characteristics of the selected Kaplan turbines for are summarised hereunder:

Table 7.2: Characteristics of the selected Turbines

Design or Rated Net head	5.77 m
Design or Rated Discharge	50 m^3/s
Rated turbine output	2924 KW
Specific Speed under Rated Net Head	761.2 Ns
Wicket Gate Height / Diameter	988 mm / 3654 mm
Unit Speed	150 rpm
Runner Diameter	2.83 m
Number of runner blades	3
Runner weight	6742 kg
Inlet height	6.57 m
Exit Height	6.57 m
Hydraulic thrust	8547 Kg
Number of units	1
Plant Installed capacity	2.45 MW
Average Energy Production	10.88 Gwh

7.6.2.8. Materials

The materials standards as are normally used for turbine parts are mentioned hereunder in Table 7.3.

Table 7.3: Turbine Material Standards

Item No.	Part	Material Designation
1	Runner	Cr13Ni4Mo
2	Draft tube liner	A283GrC
3	Discharge ring	A283GrC
4	Spiral Case	A516Gr70
5	Stay Ring	A516Gr70
6	Shaft	A668classD
7	Guide vanes	Cr13 Ni4 Mo
8	Regulating ring	A283GrC
9	Links	A668classD
10	Servomotor cylinder	G485-275
11	Servomotor piston	A283GrC
12	Guide bearing pad	G485-275
13	Guide bearing white metal	B23-83
14	Rotating wearing rings	S41500 ASTM
15	Governor accumulator	A515Gr70

7.6.2.9. Turbine Governors

Digital governors with PID characteristics and based on programmable logic controller (PLC) are proposed for three units within the bulb. The digital governors will be suitable for network (grid) and isolated operation and will have the following function and properties:

- Automatic frequency and speed (signal from PT and shaft gear) control
- Automatic load control
- Headrace level measurement and control
- Tailrace level measurement
- Manual and auto mode
- Turbine start and stop sequence
- Permanent speed drop adjustable between 0-10%
- Black start operation

The Contractor shall supply all instruments, cabling etc. for the measurement of the above quantities/values.

7.6.3. RUNNER

With three adjustable blades of stainless steel, hub of cast steel and a runner top hub of steel bolted to the runner. The bearings of the runner blade-trunnions must of self-lubricating type. The machined and completely assembled runner must be dynamically balanced.

7.6.4. RUNNER SERVOMOTOR

The servomotor should preferably be located outside the runner hub and should be connected via operating rod, lever and links with the runner blades. The servomotor should be installed accessible from outside in a lantern between the gearbox and the runner or outside the gearbox. The low speed gearbox shaft shall be in case of a bevel-gear directly coupled to the turbine runner (if recommended by the manufacturer).

The servomotor for the turbine equipped with a planet gear can be built in the runner hub. The feedback device should be incorporated but accessible from outside.

7.6.5. SHAFT

As far as the bulb turbine is concerned no separate turbine shaft will be provided. For the turbine coupled with a planet gear a separate intermediate shaft will be installed between turbine runner and the low speed axis of the planet gear.

7.6.6. SHAFT SEAL

The shaft seal for the turbine with planet gear should be provided close to the runner hub but renewable and accessible from the pit side.

7.6.7. BEARINGS

Guide and thrust bearing are parts of the gear box and should be lubricated from the pressure oil system of the gear box. For the coupling with the planet gear a further guide bearing close to the runner becomes necessary.

7.6.8. FLYWHEEL AND BRAKE SYSTEM

The Flywheel mounted on the high speed gear shaft should be combined with breaking system acting if 30% of the normal speed will be achieved.

The generator support structure of the turbine as part of the turbine supply shall be designed to surround the flywheel, the coupling and the breaking system. The brake shall be controlled by oil of the governor oil pressure system.

7.6.9. TURBINE CASING

It comprises the turbine pit structure, made of fabricated mild steel. The transmission of forces and torques shall be provided via thrust piers, wall rings and welded on studs. The gear box and other auxiliaries in the upstream part of the pit structure must remain easily accessible from above. A flange connection has to be provided to the outer distributor ring as well as the steel lining from square to the circular of the intake.

7.6.10. WICKET GATE MECHANISM

Wicket gates made of stainless steel with integrally cast outer stems. Inner wicket gate bushings for the support in stainless steel bolts of the inner distributor ring. A safety device has to be provided in the connection between the gate operating ring and the wicket gate stems in order to avoid a damages of the wicket gates if solid material gets squeezed between two or more wicket gates. The security device should be self-adjusting after reopening of the gate vane mechanism. The wicket gates should have at least up to an opening of 10 % of the full open position closing tendency.

7.6.2. OPERATING RING

It should be fabricated of plate steel should be supported by self-lubricating guides. All bearings for the connection between operating ring and wicket gate stems have to be of self-lubricating type.

7.6.11. GATE SERVOMOTOR

It should consist of a cylinder of cast steel and the piston for the connection with the operating ring. The servomotor should be designed for action in one direction with oil of the governor at the lowest operating pressure.

7.6.12. CLOSING WEIGHT

It is made of plate steel or cast iron and must be heavy enough to close the turbine under the worst condition. The necessary wheels have to be provided to guide the rope of the closing weight considering the inclined axis of the wicket gate ring.

7.6.13. RUNNER THROAT RING

It surrounds the runner, should be split in two parts to enable the dismantling of the runner blades. The inner surface must be spherically machined.

The upstream end is connected to the outer distributor ring the downstream end via the dismantling flange with the embedded draft tube liner.

7.6.14. DISMANTLING FLANGE

Between the runner throat ring and the draft tube liner a dismantling flange has to be provided. It should be welded of plate steel and designed to enable a easy dismantling of the runner throat ring.

7.6.15. DRAFT TUBE LINER

It is made of plate steel with anchors for the embedding in the first stage concrete. The total length of the conical part of the draft up to a distance from the centerline of the runner of approx. 2.1 time the runner diameter should be lined. Screws and nuts connecting structures of the water passage should be made of stainless steel.

7.6.16. GOVERNOR

The governor should be suitable to control the system as well in parallel operation with the network as in an isolated network.

The governor system should comprise:

- digital electronic controller with speed sensing equipment
- oil pressure supply and control unit
- instruments for remote indication and control of the turbine
- water level remote control

7.6.17. DIGITAL ELECTRONIC CONTROLLER

The electronic controller has to be designed as standard card rack for the installation in the main control board. Nevertheless the installation should be such that a manipulation by incompetent people will be avoided. Necessary adjustments and indications must be recognized from outside.

The modules have to be interconnected by a bus and should allow an easy modification of the configuration and parameters considering the requirements of the power station operating program. Each module must be identified by an address that the microprocessor can locate it and check it's function within the governing loop. The operation sequence must be shown step by step on a LCD display. To assure a proper operation of the controller an equalizer of the voltage supply has to be installed.

The speed sensing shall be provided via a toothed wheel with at least two pickups or other approved systems.

7.6. OIL PRESSURE SUPPLY AND CONTROL UNIT

Each unit should be located independent of its electronic control at any suitable place as close as possible to the servomotors of the turbine. An intermediate connection of the oil pressure systems of the power station should be provided in order to allow the use of each system for the control of different turbines in cases of fault or maintenance.

Each unit consists of following main components:

- oil sump tank with a panel for mounting calves and control equipment
- pilot valve for gate control
- control valve for the breaking system
- emergency shutdown valve
- pressure accumulator
- two pumps with motor

- all necessary filters, air valves, piping and fittings

At least the following control and safety equipment should be provided for local an remote indication:

- controller of oil pressure and oil level
- controller of pump operation
- one safety valve for the accumulator
- oil level indicator

7.7. INSTRUMENTS FOR REMOTE INDICATION AND CONTROL OF THE TURBINE

Following instruments are foreseen:

- Pressure gauges in the gearbox and the bearing lubrication pipe
- Oil level indication with contacts
- Thermometer with contacts in the oil circuit
- Mechanical-hydraulic over speed safety device

7.8. WATER LEVEL REMOTE CONTROL

The headwater will be measured upstream the trash rack and downstream the power house controlling the optimum relation between runner blades and gate vanes. A possibility should be provided to control the spillway discharge considering the requirements of the irrigation.

7.9. COOLING WATER SYSTEM

The cooling water will be taken from the canal. It shall be filtered by two reversible strainers to exclude particles of a size of 1 mm maximum. One strainer is standby and will go automatically in operation if the pressure drop of the second strainer becomes too high.

The pressure of the cooling water will be increased by two cooling water pumps in order to reach the necessary pressure used in the system. Special filters to clean from 100 micron sized particles shall be provided in the pipes feeding the cooling of the sealings.

7.10. DRAINAGE EQUIPMENT

One main sump pit will be provided for the dewatering of the power house. It should be joined with the dewatering points in front of and behind the turbines by pipes of synthetic material as far as they can be embedded in the first stage concrete. Pipes remaining in contact with air have to be galvanized.

The drainage system mainly should include:

Two stationary installed submersible pumps with motors of squirrel cage type for 380V, three-phase, 50 Hz., each suitable to empty the waterway of one turbine within three hours if intake and draft tube are closed with STOPLOGS.

- Two float control switches
- Two non-return valves
- Two hand operated gate valves

All pipes and bifurcations up to the outlet approximately two meters above the highest tail water level.

7.11. SPARE PARTS

At least the following spare parts are suggested to be provided.

7.11.1. TURBINE

- two wicket gate bushings of each type
- two set wicket gate breaking safety device
- one sealing ring for the shaft sealing

7.11.2. GOVERNOR

- one set of magnets of each type
- one pressure switch
- one set of gaskets
- two set of filter insets
- one pilot valve
- two position indicators
- one set of electronic cards for the digital governor

7.11.3. SPEED INCREASER

- one set of all sealings

7.12. HYDRAULIC STEEL STRUCTURES

7.12.1. GENERAL

This section gives general information and guidelines used for the feasibility design of the hydro-mechanical equipment of Kasur Powerhouse. The equipment which will be required comprises of:

Mechanical equipment, comprising:

- ▶ Turbines and Governors
- ▶ Powerhouse Bridge Crane
- ▶ Cooling and Dewatering Systems
- ▶ Auxiliary Equipment
- ▶ Draft Tube Gates

Hydraulic Steel Structures, comprising:

- ▶ Power Intake stoplog Gates complete with hoisting gantry and Trashracks
- ▶ Stoplogs to close the d/s ends of 4 draft tubes
- ▶ Spillway gates, hoisting system and its auxiliary equipments

7.12.2. TRASHRACKS

Trash racks will be provided at the intake of the turbine. It will be located on the upstream of the stoplogs. To minimize vortices and potential vibration of the structural steel vertical strips and the horizontal stiffeners of the trash rack, it will be manufactured into different sections and placed over each other within the guide channels at the upstream of the bulkhead gate.

The trash racks will be designed and fabricated with structure steel plate and flat bar. The frame of the racks will be fabricated with steel plate and racks structure will be made of flat bars. The structure steel plate will be 20 mm thick whereas flat bar will be 12 mm.

Each openings of the rack will be 125x150 mm. The racks will be installed in inclined direction at an angle of 8 degree (approx.) for the purpose of easy cleaning. One set of trashrack inclined at 15^0 are proposed at the entrance of each power intake. The trashrack main dimension and design will be as stipulated in the following table:

Number of trashrack sets	1
Free opening between the bars,	135 mm
Trashrack inclination	15 °
Net width	4m
Height	8m
Design water velocity	≤1m/s

7.12.3. INTAKE STOPLOGS

Provision will be made to install the stoplogs upstream to each intake to carry out inspection or repair of each turbine and its associated parts. At power intake structure 7.2 m wide and 7.8 m high stoplog shall be provided.

Each stoplogs section will be of welded steel construction with downstream skin plate reinforced with horizontal and vertical girders. Each stoplog will be fitted with wedged type bottom seals and J-type side seals.

Slots for the operation of the stop logs, fixing of guide channels and other embedded metal work will be provided in the pier upstream of intake. One set of Stoplog for will consist of four sections.

Guide shoes will be provided at top and bottom of each side of the stop log section to engage the guides embedded in the concrete. The stoplogs will be designed to be handled during operation with lifting beam and mobile or monorails.

The structural parts of the stoplogs will be designed and fabricated in accordance with criteria specified in ASTM, TGSP, DIN, AISC, AWSD 1.1 and SSPC standards.

7.12.4. OUTLET STOLOGS

Draft Tube outlet stoplogs width x height (7.2 m x 5.2 m) are provided with an electric hoist below the cantilever beam extending downstream side of the powerhouse building. Size of the Intake and outlet stoplogs will be confirmed during design stage.

The structural parts of the stoplogs will be designed and fabricated in accordance with criteria specified in ASTM, ASTM, TGSP, DIN, AISC, AWSD 1.1 and SSPC standards.

7.12.5. REGULATION

Provision will be made for gated spillway which needs an operator to open the gate for diverting the excess water flow. This will take some time for operating the gate during which the water level would rise on the upstream side of powerhouse. A suitable arrangement shall be made such that in case of load rejection, the excess water is diverted when water level reaches maximum permissible limit by regulated spillway. Turbine shall be double regulated and shall be synchronized with the spillway gates through PLC SCADA system. During emergency shut downs the spillway gates shall be automatically regulated and operated in accordance to the regulation of turbine and stoplogs.

7.12.6. GRAPPLING BEAM

One grappling beam, designed to be handled by the mobile crane.

7.12.7. CAVITATION

Cavitation guarantees should base on the IEC-Standard Publication 609. Beside normal operating conditions with the provided unit running the following conditions have to be considered if one unit only is in operation:

H(m)	5.77 m
Q(m3/s)	50

7.12.8. REGULATION

In case of sudden load rejection, the speed increase should not exceed 25% of the rated speed. The pressure rise should be limited to 30%. The maximum speed rise should be guaranteed for 100%, 75%, 50% and 25% load rejection. The runaway speed should not exceed 2.5 times the rated speed.

7.12.9. HYDRAULIC POWER PACKS

The hydraulic power packs suitable for parallel operation (grid and isolated loads) are proposed for the hydraulic control of the Kaplan turbines which work under the command of the digital governors. The hydraulic power packs will comprise of all instruments such as pilot valve, actuators, distribution valves, two (2) pumps of gear or screw type with motors, sump tank with oil capacity not less than 30 litres, filter, oil level indicator, pressure switches, alarms and indications and any other instruments as would be necessary for safe operation of the turbines in the parallel mode as briefly described hereinabove.

7.12.10. POWERHOUSE BRIDGE CRANE

A 20 ton pendent operated bridge crane with separate wheel drives for longitudinal travel of the bridge and cross travel of trolley, is proposed considering runner and shaft weight. The crane will consist of travelling rails for full length of the power station with all embedded anchors, sole plates, cleats etc. The crane shall be designed in accordance with the CMAA or FEM standards.

7.13. MISCELLANEOUS AUXILIARY MECHANICAL SYSTEM

Kasur Hydropower Station is to be provided with all mechanical auxiliary systems required for reliable operation of a modern hydropower station. The mechanical auxiliaries envisaged for the feasibility-level design of the power station comprise:

- Unit cooling water system.
- Drainage and dewatering system.
- Heating, ventilating and air-conditioning system.
- Station water services.
- Fire protection system.
- Compressed air system.
- Oil handling system.
- Workshop Equipment.

7.13.1. UNIT COOLING WATER SYSTEM

Cooling water system is required to dissipate the heat energy produced during the operation of the Turbine shaft as well as the Generators. The cooling water temperature is to be about 20°C.

A simple cooling system is proposed wherein the cooling water is directly taken from draft tube or from upstream intake. This cooling water will be discharged into the tailrace after completion of the cooling process. This system does not require any additional equipment except the circulating pumps, filters and interconnecting piping.

The main source of heat is the generator losses. At maximum 1.67 MW turbine shaft power per unit, the generator efficiency is about 96% with a dissipated heat of 204 kW. With a maximum cooling water temperature of +20°C and a temperature difference of 10°C between in and outflow of the cooling water, 1 l/s can carry away about 42 kW of heat.

Total required quantity of water will be about 20 l/sec including auxiliary services for power station, final demand shall be determined during detail design.

The water through the turbines contains besides sediments, smaller trash and organic matters, the total amount of the latter is, however, unknown. The sediment content will hardly do any harm in ordinary cooling water systems provided the water velocity is sufficient high to transport the sediments but below the velocity casing severe wear. Filter housing, cooler heads equalizing basins, instruments etc. might however represent a problem if the sediments are allowed to settle.

Another alternative will be studied during design stage of providing cooling water from a tube well installed outside powerhouse.

The service water supply for the shaft seal shall be provided by the domestic water supply system and standby supply shall be provided from cooling water supply system.

7.13.2. DRAINAGE SYSTEM

All power station drain water is to be collected in a drainage sump from where it will be pumped out to the tailrace. Two submersible pumps with a capacity of 15 L/s each are proposed for this purpose. Each pump will serve as standby of the other in such a way that the average running hours of both pumps will remain the same throughout the operational life.

7.13.3. DEWATERING SYSTEM

Dewatering of the units is required on the following occasions:

- Whenever any of the unit is stopped due to low discharge.
- During scheduled maintenance.
- Break down of one or both units.

For this purpose, a separate pumping system is proposed in the drainage and dewatering pit along with necessary equipment i.e. valves, interconnecting pipes etc. to ensure efficient dewatering of the units.The details will be worked out during design stage.

7.13.4. FIRE ALARM AND PROTECTION SYSTEM

The following locations in the power plant shall be monitored by a fire alarm and detection system:

The power plant hall:

- The control room, switch room and auxiliary equipment room of the power plant.
- Electrical gallery housing control cubicles adjacent to the machine hall.

Detection system shall be based on ionic smoke detector and heat rate of rise detectors, distributed in the relevant protected rooms of the power plant, in accordance with the manufacturer's recommendation. Detectors shall be connected to a central alarm and detection panel on which visual and audible alarm facilities shall be provided. Alarm shall be made inside and outside the power plant through flashing lights and siren.

- In the main power house and in the switchgear room portable dry powder containers shall be arranged. In total 5 such containers, 8 kg each shall be supplied.

- There shall be no other firefighting system arranged.

7.13.5. COMPRESSED AIR SYSTEM

Dual Air cooled service air compressor with a receiver is to provide service air for the power station. Following equipment will draw air from the service air receiver tank:

- Generator breaks
- Turbine maintenance seals
- Workshop hand tools.

7.13.6. OIL HANDLING SYSTEM

A centralized oil handling and purification system has been provided in the power station. The system will include two oil storage tanks; one for the storage of clean oil and the other for dirty oil along with the piping system for supply of clean oil to the designated unit.

7.13.7. WORKSHOP EQUIPMENT

A standard workshop with the facilities of the basic machine tools and machining operations is provided to enable the staff for in-house maintenance of the whole power station. This workshop includes the following equipment:

- Vertical Drilling machine.
- Horizontal turntable with equipment for welding and thermal coating.
- Horizontal precision lathe.
- Hand Tools, i.e. air blower, hand drill machine and electric hammer.
- Different tool kits.
- Steel work benches.
- Steel storage cabinets and racks.
- Manually operated trolley.

The above mentioned will be further investigated during detail design stage.

7.14. HEATING, VENTILATION AND AIR CONDITIONING SYSTEM

7.14.1. GENERAL

Main sources of heating load are electrical and mechanical equipment that give rise to indoor temperature. To maintain the indoor temperature at acceptable levels in accordance with the requirements of the occupants, electrical and mechanical equipment, Heating, Ventilating and Air Conditioning system is recommended.

The super structure of the plant shall be ventilated all the time and will not be cooled or heated except in cases where:

- Temperatures are required to protect the plant equipment from freezing or excessive high temperature.
- Water condensation or moisture will cause damage to the equipment.

Heat exchangers will use the raw water to cool the air. The water will be pumped from tail water and cleaned by using twin strainers and filters up to the required limit. The chillers and pumps shall be installed in modules for economical operation and to avoid complete failure of the system. The system is to be equipped with Automatic Controls for better and economical working.

Winter heating is normally not required as the equipment generate sufficient heat. In certain areas, such as administrative areas, control room and relay room, duct mounted electric resistance heaters will be used for winter heating.

The current Handbook of Fundamentals from the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) should be used as reference for designing the HVAC system in the power plant.

7.14.2. GENERAL SYSTEM DESCRIPTION

The HVAC system for the power station shall be designed during the final design phase; however, the following main outlines have been suggested:

7.14.2.1. MACHINE HALL

The machine halls of the power station shall have a forced ventilation system using electrical heating of the circulating air during winter time and water based cooling during the hottest summer periods. Simple air circulation shall be ensured through axial flow fans installed at appropriate places at turbine floor.

7.14.2.2. OFFICE AND CONTROL ROOM BUILDING

The power station administrative and control building shall have a forced ventilation system, with equipment controlling the air temperature and the humidity. Toilets, kitchen etc. shall have separate exhaust air systems.

7.14.2.3. DESIGN CRITERIA

The HVAC system shall be designed by targeting the following objectives:

- To maintain the indoor temperature at a predetermined level.
- To provide clean air to air conditioned space by the filtration of re-circulated and outside (fresh) air.
- To pressurize the building so as to prevent the infiltration of uncontrolled outside air.
- To provide general winter heating in some areas such as control room, administration areas, workshops etc., by adding heat to the indoor environment.
- To recover heat dissipated by the equipment in winter, and to use it for space heating where possible.

CONTENTS

8.1. GENERAL

This chapter covers selection of the electrical equipment for 2.45 MW Kasur Hydropower Scheme and its planning for installation in powerhouse building, 11-kV indoor switchyard and 11Kv transmission line to connect the power plant to the national grid system through Kasur Grid Station situated at nearly 06 Km from the powerhouse site. This study shall provide the basis for the cost estimates and will provide preliminary engineering for the final design.

The maximum electrical output of newly proposed Kasur Hydro Power Project is 2.45 MW generated by a single generating unit that shall be directly coupled to a horizontal Kaplan blub type Turbine at the rated speed of 150 rpm. This generator speed corresponds to a runaway speed of 417 rpm. Flywheel effect can also be incorporated to obtain high natural inertial constant. The generator shall be able to run at 10% continuous overload without exceeding the temperature limits of class F.

The power plant shall be connected to the nearest 132 kV Kasur Grid station located at 06 Km from the power plant by means of double circuit 11Kv transmission line (using osprey conductor). Additional equipments required are to install two No 11kV metal clad switch gears at the 11kV side of 132kV Kasur Grid station.

8.2. CODES AND STANDARDS

All electrical equipment is proposed to comply with the latest IEC standards. In case of non-existence of relevant IEC standards, BS or equivalent standards shall be applied. Whenever available relevant WAPDA standards and codes are also to be respected. WAPDA standards require an impulse withstand voltage of 650 kV for the 132 kV systems. This value corresponds to the higher alternative of IEC standard No.71, which defines two alternatives for the lightning impulse withstands voltage of 550 kV and 650 kV. WAPDA standard in accordance with IEC therefore has to be taken into consideration. For the 11 and 33 kV system, 95 kV and 170 kV respectively will have to be applied as Impulse Withstand Voltage.

WAPDA standard minimum short circuit level for 132 KV is 40 kA. The corresponding values of short circuit level are 12.5 kA for 11 kV and 16 kA for 33kV equipment.

8.3. MAIN COMPONENTS

The main Electrical components required for a complete Hydropower station are as under:

- Generator with its Excitation, Automatic voltage regulator, Earthing arrangement and local control panel.
- Generator Circuit Breaker.
- Step up and Step down transformers.
- Control and Protection equipment.
- Medium and Low voltage switchgear.
- DC supplies along with DC/AC converters.
- Cables (Medium voltage, low voltage and control).
- Plant vide Grounding/ Earthing along with Lightning Protection.
- Interior and Exterior Lighting.
- Telecommunication and Station Control System.
- 11 kV overhead lines.
- Emergency Diesel Generator Set.

Each of these components is described below, giving as much technical specifications as are needed at this stage of Feasibility. Detailed specifications will be required once actual execution of the project is decided.

8.3.1. GENERATOR

Salient features of the generators are as follows:

No of units	:	01
Nominal capacity		2.88MVA
No of poles		40
Generation voltage		11kV
Power factor		0.85

Nominal speed	150rpm
Runaway speed	417rpm
Insulation class	F
Temperature rise class	B
Ambient temperature	50C^0
Protection class	IP44
Efficiency	97%
Cooling of stator and rotor	Air-cooled, self-ventilated, with Air/water heat exchangers.
Excitation system	Static type
Excitation voltage	Static, 220 V DC
Range of voltage variation	+/- 5 %
Range of frequency variation	+/- 3%
Stator winding Connection	Y, Neutral Grounded through resistance.
Cooling	Closed Circuit, air cooled
Transient reactance Xd'	To be determined by the manufacturer
Sub transient reactance	To be determined by the manufacturer
Bearings	Guide & Thrust bearings
Braking system	Mechanical/Electrical
Firefighting system	Automatic CO2 system

8.3.1.1. DESIGN

The design of the generator is determined by the construction, layout and speed of the turbine. The choice of a horizontal shaft Kaplan (Bulb Type) turbine defines a horizontal generator and upper guide and thrust bearing and lower guide bearing. The bearings shall be self-lubricating. The frame and the foundation will have to carry the weight of the turbine and the generator as well as to take over the stresses caused by the dynamic forces produced during short circuit conditions on the generator side as well as the stresses caused by seismic activities.

The nominal voltage of the generator has been chosen as 11 kV which is appropriate for this size of the Generators and standard WAPDA system. The generators are capable to run at 10% continuous overload without exceeding the temperature limits of class F insulation.

The power factor of the machines are proposed to be 0.85 which is the common practice of WAPDA and is considered to meet the requirements of the reactive power generation at the end of the 11 Kv transmission line with a length of approximately 06 KM.

8.3.1.2. STATOR

The stator frame shall have welded steel rings on both sides, which will transmit all dynamic and static forces through supporting feet to the base plates into the foundations. For proper and effective cooling, the stator core shall be divided by radial air gaps for airflow through the core. The winding shall be designed in such a way that the generated waveform is as close to sine wave as much as possible.

The stator winding shall be made of bar or coil winding system with F class insulation of continuous tape impregnated with synthetic resin applied in vacuum and subsequently cured. The coils must be provided with a necessary anti-corona protection at the end of the slot sections.

For the selected parameters of the generator, conventional stator design, as recommended by the manufacturer shall be the best option. However this shall conform to the following

Insulation class	:	F
Stator Air temp in	:	$40C^0$
Max allowable rise-stator temp		$90K^0$

8.3.1.3. TEMPERATURE DETECTORS

Appropriate No of temperature detectors shall be located around the periphery in the stator coil bars, at different depths in order to detect the temperature of the stator windings.

8.3.1.4. ROTOR

The rotor structure supporting the pole pieces built up of steel lamination shall be of steel plates or with a central cast steel/fabricated spider, equipped with field and damper windings. The poles shall be laminated and provided with a damper winding for the required operating stability. Any method of securing the poles to the rotor body shall depend on the stresses by the centrifugal force that is developed at the runaway speed. The construction should however, be optimized by the successful bidder during manufacture of the generator and be subject to quality control by the project supervision. The insulation class of the pole windings has to be "F" but for extended insulation life the generators would be rated at class "B" temperature rises. Damper bars of copper shall be braced into ring segments at both ends of the rotor.

The output, runaway speed and the required flywheel effect largely determine the construction of the rotor. The rotor dimensions are a function of the speed “n” in revolutions per sec, the capacity P in MVA, the desired inertia (WR2) in [tm]2 and construction factors. The most appropriate design consists of solid forging with thick steel plates welded together to a solid body. The construction should, however, be optimized by the successful bidder during manufacturing of the generator and be subjected to quality control.

The poles shall be laminated and shall be provided with damper windings for the required operational stability if applicable for the construction. The poles are to be connected to the rotor in such a way that they can be easily taken off to facilitate transportation.

8.3.1.5. BEARINGS AND BRAKES

The generator will be of conventional design with combined thrust and guide bearing. The thrust bearing should therefore be designed to with stand the hydraulic thrust during operation as well as it must be capable to absorb the dynamic forces of a short-circuit conditions.

Brakes will be provided to ensure a quick standstill of the rotor after normal shut-down and to hold the rotor against slow rotation due to turbine leakage, as well as in cases of emergency, such as bearing failure or electrical faults, with the objective to avoid outbreak of fire.

8.3.1.6. EXCITATION SYSTEM

Two types of excitation systems are generally in use for generator excitation.

- Static excitation
- Rotary excitation

Former type has certain advantages such as quick in operation and full reversible excitation voltage is possible. Hence for this hydro power scheme static type of excitation is proposed.

Static excitation with excitation transformer, controlled rectifier and the automatic voltage controller has the advantage of providing quick response, being able to deliver full reversible excitation voltage. Therefore the proposed Kasur Powerhouse shall have a Static excitation system.

Static excitation with excitation transformer, controlled rectifier and the automatic voltage controller. The controlled DC current is supplied to the field winding through carbon brushes and slip rings. Static excitation provides fast response to the changes in generator output voltages. Full reverse excitation voltage is possible, so that de-excitation can be done in short time. Excitation transformer shall be connected directly to the generator output for supplying power to a controlled rectifier bridge. Station batteries can be used for initial buildup of the voltage in case of a Black start up. Under normal conditions, 0.4 kV bus will be energized in order to enable field flashing. Excitation power shall be taken from the generator itself, through a branch-off from the generator terminal bus-bars and supplied to the excitation rectifier through the excitation transformer. The excitation system shall be independent of any outside power supply except short-time external supply for voltage builds up (field flashing). The excitation system shall have built-in protection and supervision equipment. All fault signals shall be displayed on the AVR front panel.

The excitation transformer shall be installed in a self-supported steel plate cubicle. The excitation transformer shall be a cooled and of dry insulated type using non-flammable Class B insulating.

8.3.1.7. AUTOMATIC VOLTAGE REGULATOR

The control of generator voltage shall be affected by comparing continuously the generated voltage with a reliable reference voltage. Adjustment of the reference voltage set point shall be performed locally by a switch on the AVR front, or remotely by a voltage signal. Adjustment range of the AVR shall be 80% to 120% of the generator rated voltage. The AVR shall respond quickly and accurately to any fluctuation in generator load including sudden application or throw-off of load. The static accuracy shall lie within the range of ± 0.5% of the set value of the generator. The generator voltage shall be maintained at or below 110% of rated value with the generator disconnected and at maximum over-speed.

Over- and under-excitation limiters shall be included. The under-excitation limit shall match the static and dynamic stability curve for the generator. The AVR shall include adjustable voltage droop compensation for both active and reactive load with setting range 0 – 20% of rated current, and frequency compensation adjustable in the range 0 – 5%.

The AVR shall include a power swing stabilizer unit with adjustable parameters. The AVR shall include a separate manual voltage regulator consisting of electronic circuit for constant excitation current control. The constant current regulator (CCR) shall be for use during energizing of transmission line and when the AVR is out of order for some reason. The AVR and CCR shall be realized as two physically separated and independent acting electronic circuits.

The set point adjustment range shall correspond to 0 – 100% of rated excitation current. Change over from AVR to CCR shall take place automatically by failure of the AVR.

Provision for manual The CCR shall have provision for local and remote adjustment of an excitation current reference setting changeover from AVR to CCR and vice versa shall be included. The changeover shall take place without the change of excitation voltage with aid of a balancing circuit.

8.3.1.8. COOLING SYSTEM

The generator shall be air cooled and self-ventilated by axial or radial ventilation through the rotor itself acting as a fan. The air will be re-cooled by air/water heat exchangers situated outside the stator housing. Through this design a closed air loop system inside the generator pit is achieved thus avoiding pollution through atmospheric impurities. The water-cooling systems for the generator will be split into two independent systems:

- One for the oil circuits for the bearings of generator and turbine and
- One for the air/water cooling of the generator and the unit step-up transformers

The generators shall be protected by an electrical heating system to prevent them from damages during periods of standstill. To avoid water condensation during long no operative periods of the machine, heating elements shall be installed in the air circuit and in the excitation cubicles. These elements shall be connected to the 400/230 V A.C., 50 Hz power source, via contactors.

8.3.1.9. FIRE PROTECTION

A complete central automatic carbon dioxide fire extinguishing system is proposed for the protection of single generator. It is recommended to keep trolley mounted CO2 Cylinders of 10 & 25 kg capacity to protect any equipment from fire hazards at various areas of the power plant e.g. the machine room, control room, and Auxiliary equipment room, 11kV panel hall etc. Similarly, sufficient number of foaming liquid Cylinders shall also be provided. The actual No of CO2 Cylinders shall be determined at the final design stage.

8.3.2. MATCHING TRANSFORMER

The generator shall be connected to an 11/11kV matching transformer. The matching transformer shall be capable to absorb the system faults and shall protect the generator from the direct impacts of these faults. The switchyard scheme is shown in single line diagram as Drawing No. **BRBD-HEPP-FS-5.2** of Volume II.

8.3.2.1. TRANSFORMER RATING

Based on the determined data and information, the matching transformer shall have the following typical characteristics:

No of Transformers	01
Nominal rating	3.0 MVA
Type	3- phase, oil –immersed, out door
High voltage side	11 KV
Max voltage	12kV
Low Voltage side	11 KV
Voltage variation	+-5%
Tap Changer	Off circuit
Frequency	50Hz
Temperature rise	55 - 65 deg. C
Vector group	Dyn11
Impedance	7% (approx)
Cooling type	ONAF

8.3.2.2. COOLING SYSTEM OF TRANSFORMER

It is proposed to use the oil natural & air forced cooling system (ONAF) for the transformer. The air fans will be controlled from thermal detectors within the transformer tank Reserve fans in the cooling system shall be provided so that failure of two fans will not shut down the transformer. The number of fans shall be selected by the manufacturer. Structural details of the civil engineering design shall take into consideration a good airflow to the transformer location, so that no accumulation of high temperature air volume takes place.

8.3.2.3. FIRE PROTECTION FOR TRANSFORMER

Transformers shall be installed outside of the power house building, so that the most favorable solution for this type of protection will be the water sprinkle system. An adequate tank reserve of pressurized water is needed for this purpose. AC/DC driven pumps of suitable capacity should be included to keep the dimensions of the storage tank economically small. An adequate volume of the oil reception basin underneath transformer is required. Gravel shall cover the surface of oil receipt. The require dimensions shall be evaluated at the final design.

8.3.2.4. AUXILIARY TRANSFORMERS

Two No Auxiliary transformers of capacity 200KVA (one standby) shall supply the electrical power to the auxiliary equipments of two generating units and for the station services. Each transformer can be connected to 11 KV bus through 11KV breaker.

Oil filled distribution type transformers with a capacity of 200KVA, 11KV/0.4kV, have been selected based on the required capacity of load in the plant. Natural air circulation cooling has been chosen due to the operational safety. The insulation material shall be self-extinguishing and varnish shall prevent any spreading of fire. The units shall be installed close to the space where the power is needed. The ratings and characteristics of the auxiliary transformers will be as follows:

No. of transformers	2 Nos (one stand by)
Rated Capacity	200KVA
Transformation voltage	11kV/0.4KV
Insulation class	H

8.3.2.5. SWITCHGEAR SYSTEM

The transformers shall be connected to 11Kv bus bar via 11 kV switch gear system, which consists of medium voltage circuit breakers, medium voltage disconnecting switches and the corresponding metering and protection equipments.

8.3.3. 11 KV SWITCHGEAR

11kV metal.clad switchgear Panel (indoor type) shall be used. The switchgear shall have all necessary instruments & accessories including Vacuum type Circuit Breaker (VCB).

VCBs are preferred due to very fast switching and quick arc quenching process. These breakers are almost maintenance free. The current/voltage transformer (CT/PT) shall be used for metering and protection duties. The main data for the circuit breaker is:

Nominal voltage	11Kv
Maximum voltage	12Kv
BIL	95Kv
Rated short circuit current	31.5KA
Rated current of bus bar and circuit	630AMPS
Min Rated continuous current of circuit breakers	630AMPS

8.3.4. CABLES

The cables shall be used to connect the generators with the transformers, switchgears, transmission feeders and auxiliary transformers. Special cables shall be used for specific jobs such as control, measurement and protection. Specific use of these cables is described as under:

8.3.4.1. POWER CABLES

The power cables to be used between the generators, transformers and their respective 11kVswitchgears shall be as per IEC/WAPDA standards. Actual quantity/Length of 11kv cable cables shall be decided at the final design.

Technical data of 11kVcable is as follows:

Nominal Voltage	11kV
Maximum voltage	12kV
Type of Insulation	XLPE
Single core/ Multi core	Single
Armored / Unarmored	Armored

Material of Conductor	Aluminum/copper
Short Circuit Current	13.12kAmps, 18.35kAmps for 3 secs
Power Frequency Withstand Voltage	28Kv
Lightning Impulse Withstand Voltage	95Kv
Contineous withstand temperature	90 Deg C
Short circuit with stand	250 Deg C

8.3.4.2. CONTROL CABLES

Control cables are used for protection, instrumentation, control and communications. These shall be of stranded copper conductors or armored cables. These cables shall be standard product of a reputed manufacturer with a proven track record. The construction of the cables will be in compliance with the specified requirements and the related IEC Standards. Control cables will be laid in perforated steel trays or at the bottom of concrete trenches. The cable trays shall be mounted on the floor underneath the local control area, to have short connections between the different control panels, distribution boards, equipments and other auxiliary installations.

8.3.5. TRANSMISSIOM SYSTEM

The powerhouse is proposed to connect to 132Kv Kasur Grid station which is at a distance of ONLY 06 Km from the Kasur powerhouse site. Double circuit 11Kv transmission line with Osperay conductor shall be sufficient to disperse the power generated by the power plant to the national grid. Additional arrangement at 132kV Kasur grid station is to install two No 11Kv metal clad switch gears at 11kV side of the said grid. The size and type of conductor selected is extensively used in WAPDA distribution system. Main parameters of the line are as follows:

Line voltage	11kV
Interconnection	Direct connection with the 11Kv side of the 132kV Kasur grid station

Line length	06kM
Type of line	Double circuit
Conductor	Osprey
Type of Pole	HT lattice Structure or PC pole extensively used in WAPDA
Type of insulators	Standard disc & pin type

8.3.6. CONTROL, PROTECTION AND INSTRUMENTATION EQUIPMENT

8.3.6.1. INSTRUMENTATION & CONTROL

Indicating, measuring and control instruments have been considered necessary for the major components of Power House .For monitoring and control of the over all power plant a sophisticated SCADA System is recommended. The transducers shall be installed where necessary. All indications shall be visible in the main control room.
The control of the single unit shall be local and remote, able for auto or manual selection. It is necessary to provide a separate control desk and mimic panel that shall be located in the main control room and include the most important remote control functions. Because of standard practice, a control voltage of 220 V DC is preferred. The contractor shall design and prepare the requisite diagrams and layouts as a part of construction drawings during the implementation stage.

8.3.6.2. PROTECTIONS

In order to ensure reliable function of the Generator, Transformer and Transmission line, following protections shall be included:

8.3.6.2.1. GENERATORS&TUBUNES

- Stator turn to turn fault
- Loss of excitation
- Time over current
- Temperature (thermo detector)

- Negative sequence current
- Loss of input(Anti-motoring)
- Loss of synchronism
- Backup over current
- Bearing temperature high
- Unit over speed
- Governor oil pressure low

8.3.6.2.2. STEP-UP TRANSFORMERS

- Winding temperature high (for hot spot)
- Oil temperature and level control
- Buchholz protection
- Three phase over current protection as back up device.
- Restricted ground fault protection
- Differential over current
- Oil level and temperature indications

8.3.6.2.3. 11 KV TRANSMISSION LINE

- Over current protection
- Earth fault protection
- Breaker failure protection

However the necessary protections for generators, power transformers and transmission line shall be finalized at the final design stage.

8.3.7. MISCELLANEOUS ELECTRICAL EQUIPMENT

8.3.7.1. LIGHTING AND SMALL POWER

The main categories of illumination are the outdoor and indoor. Efficient equipment shall be installed to ensure safety, security and proper operation of the plant. There are different areas to be illuminated in the Power Plant. For important areas requiring extensive illumination; a central control system shall be used from the main control room.

8.3.7.2. OUTDOOR LIGHTING

Following areas need outdoor illumination during night only:

- Trash rack deck
- Power channel surface on the head race
- Access roads to the powerhouse with reduced intensity.

8.3.7.3. INDOOR LIGHTING

11KV panel hall, machine hall and all the rooms, unit areas shall be illuminated with the intensity that is required by IEC and other international standards.

There shall be switchboards at different locations to feed the lighting and small power outlets. The final design shall indicate the required numbers. In addition, emergency lighting shall be provided, separately connected to the 220 V batteries upon failure of the AC supplies.

The machine hall shall be equipped on both long walls with a chain of fluorescent lamps of suitable intensity. During maintenance and repair jobs on one of the units, portable illumination shall be used.

8.3.7.4. STATION BATTERIES SYSTEM

The purpose of the station battery system is to provide a safe and reliable supply of power to all primary functions. The system is almost independent of all other power supply systems and ensures reliable execution of the control functions, both for selected normal operation and during possible fault conditions. DC batteries shall be installed in the powerhouse for protection, emergency power, alarms and indications. The battery installations proposed for Kasur Hydropower Project is as follows:

Two sets of 220 V batteries shall serve the whole power station. The batteries shall have their own battery charger. Under normal conditions, DC supply shall be obtained through an AC to DC rectifier/converter and in case of failure of AC supplies; DC batteries shall automatically safe guard the DC system .Ah capacity of battery shall be finalized at the final design stage.

8.3.7.5. EMERGENCY DIESEL GENERATOR SET

It is proposed to incorporate a stand-by diesel generator set of suitable capacity (100kVA) fully able to supply to auxiliaries of the unit during the time of a black start. However the rating of the D.G set shall be finalized at the time of final design keeping in view the actual auxiliary load requirements of the unit plus 15% of this load as a safety margin.

8.3.7.6. TELECOMMUNICATION

8.3.7.6.1. POWERHOUSE COMMUNICATION

Within and outside the area of the powerhouse an appropriate communication system is needed. This will make it possible to communicate the operational instructions to concerned sections.

A digital telephone network (intercom system) is to be installed in the powerhouse to cover the entire plant (powerhouse, intake and the places). Each generating unit will include at least one telephone per floor. All the crane control sites should be connected to this system, and the working and depositing areas will be made reachable by this communication system.

Furthermore, it is recommended that the powerhouse shall remain under visualization by the manufacture in his office. This will also allow remote visualization of the powerhouse by the plant operator anywhere. For this reason, internet facility shall be provided within the powerhouse site.

8.3.7.6.2. EXTERNAL COMMUNICATION

For communication with the load dispatch center, it is recommended to use a PLC system likewise being practiced by WAPDA whereby its communications between powerhouses and the load dispatch center are connected through a system of power line carrier. If possible a local telephone connection is also recommended for communication between the power plant and the load dispatch center.

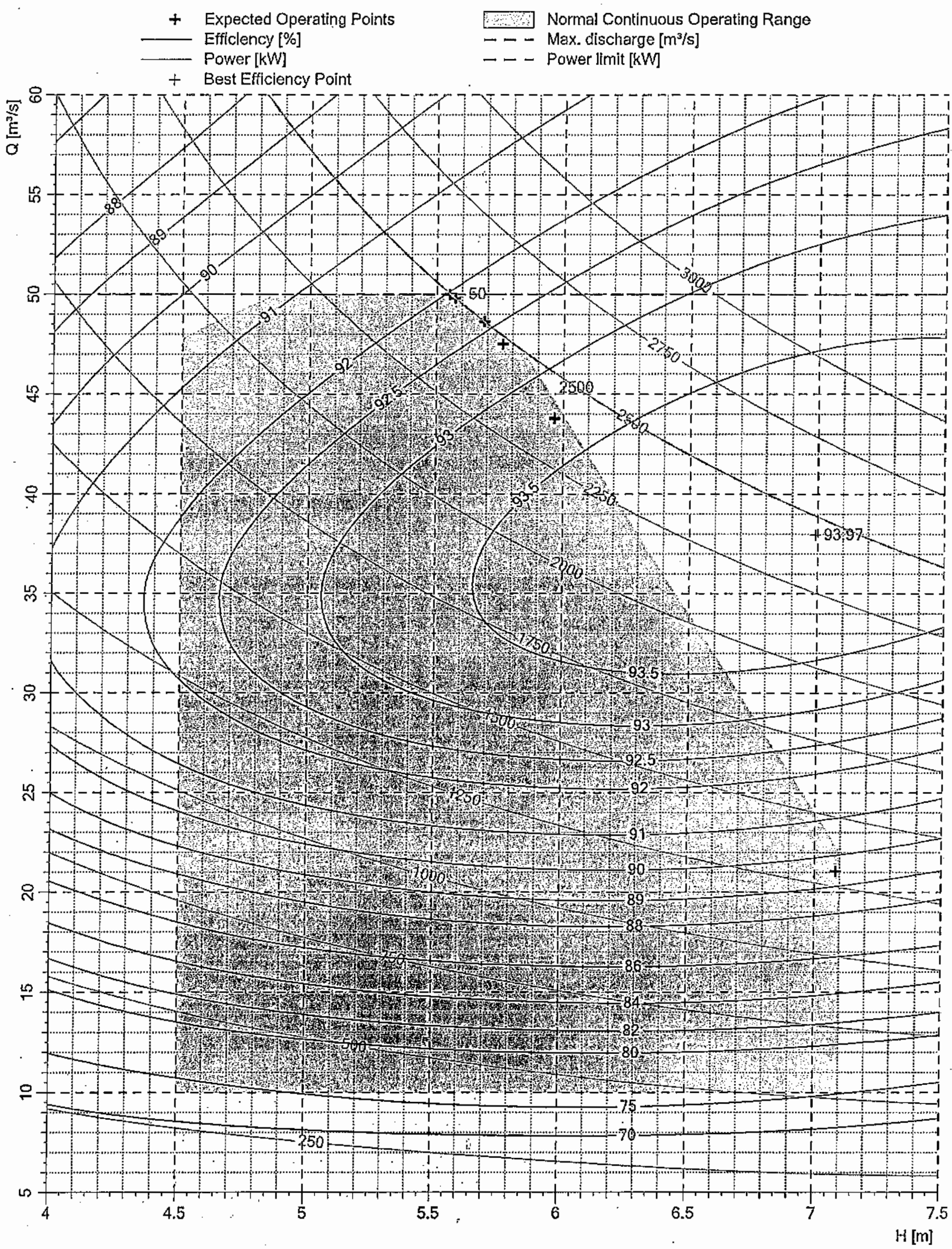
The PLC system will give the possibility for voice and signal transmission on the 132 kV line between the remote powerhouse and grid station at the receiving end. In view of a successful operation of this HPP, a complete communication system shall be developed. Within the area of the powerhouse and outside, such as switchyard, machine hall, control room etc an intercom telephone system should be provided where local communication is required. Telecommunication channel may be provided between LDC and Kasur power station by using an extra pair from the power carrier facilities available in the nearby 132kV grid station which is 06 Km away from the powerhouse if possible. One No telephone line from local telephone company such as PTCL is also recommended in the control room and in the offices for communication with outside the project area.

8.3.7.7. GROUNDING SYSTEM

Metallic parts of all the electrical equipment in or around the powerhouse shall be connected to the grounding system for safety of the personnel and equipment. It shall use stranded bare copper conductor in the concrete floor slabs. Ground rods shall be driven in soil surrounding the powerhouse. The number of electrodes shall be determined during the final design stage, keeping in view the soil resistivity and touch/step voltage .The grounding grid shall be capable to sustain without damage heavy currents during short-circuits for specified time. The contractor shall carryout the necessary measurements to determine the ground and ground water resistivity to be used for the calculations and the design. The actual cross-section of the earthing conductors will be defined in the earthing system calculation. All equipment associated with the plant including reinforcement steel and embedded steelwork will be bonded to the earthing electrodes by adequately dimensioned conductors. Surge arresters and transformer neutrals will be directly connected to the main earthing conductor and /or particular earthing rods. The entire earthing system will have an earthing resistance of approx 0.5 ohms.

Kasur_2017

Expected Prototype Hillchart



	D_1	= 2.600	[m]	ρ	= 998.7	[kg/m³]	Prep.		Date
	Site El. Ref	= R.C.L.	[-]	g	= 9.79300	[m/s²]		C. Morper	20-February-2017
	Site El.	= 194.50	[m]	B*	= 9.80	[m]	Sig.		Dwg.
	n	= 205.00	[rpm]	Re_{D1}	= 68.802E6	[-]			2017 0023

1.0 GENERAL

Energy losses caused by entrances, bends, gates, valves, piers, etc., are conventionally called "local losses". In many situations they are more important than the losses due to conduit friction.

A convenient way of expressing the local losses in flow is:

$h_l = K (V^2/2g)$

where;

h_l = head loss in meters
K = dimensionless coefficient
V = designated reference velocity m/s
g = acceleration due to gravity m/s^2

1.1 Friction Head Losses (Boundary Losses)

Head losses are commonly classified as boundary losses and form losses. The boundary losses are those arising from shear forces between the fluid and the boundary materials. In addition, the cross-sectional shapes are significant to boundary losses because they affect the ratio of the flow area to the wetted perimeter.

Friction Losses are usually determined by formulas which have a long background of use. The Manning's formula is of fundamental importance.

Manning's Formula: $$H_F = n^2 \frac{V^2 L}{R^{4/3}}$$

Other accepted formulae are:

Darcey – Weisbach Formula: $$H_F = \frac{fLV^2}{2gD}$$

Hazen – Williams Formula: $$H_F = \frac{6.87L}{D^{1.165}}\left(\frac{V}{C}\right)^{1.85}$$

Manning's formula has been used to determine the friction head losses for all channels.

1.2 Local Head Losses (Form Losses)

Between intake and exit, flow encounters a variety of shape configurations in the flow passageway such as changes in section from rectangular to circular, partial obstacles, branches, bends, slots, expansions, the contractions. These impose losses in addition to those resulting from frictional resistance. Form losses are the result of fully developed turbulence and thus can be expressed in the general form:

$$H_L = K_e \frac{V^2}{2g}$$

where:

K_e	=	coefficient of form loss
H_L	=	form loss

2.0 ESTIMATION OF HEAD LOSSES

The head losses computed for approach channel has been estimated as 0.027 m due friction loss and 0.0125 m due to trashrack, friction, entrance and loss due to stop log slot at intake for design discharge of 50 m^3/s.

A. Losses in Approach Channel

Friction Loss

Design Discharge	Q_D	50	m^3/s
Flow Area	A	249.5	m^2
Wetted Perimeter	P	121.0	m
Flow Velocity	V	0.81	m/s
Mannings "n"	n	0.020	
Hydraulic Radius	R	2.06	m
Length of Channel	L	271	m

$$h_f = n^2 \frac{V^2 L}{R^{4/3}}$$

Friction Loss	h_f	**0.027**	**m**

B. Intake Losses

Trashrack Loss

Width of rack bars	t	12	mm
Clearance between rack bars	b	135	mm
Angle of bars with horizontal	α	78°	
Coefficient	K	1.67	

$$h_{l,ra} = K\left(\frac{t}{b}\right)^{4/3} \frac{v_{bars}^2}{2g} \sin\alpha$$

Trashrack Loss	$h_{l,ra}$	**0.007**	**m**

Friction Loss

Velocity Coefficient	k	66.67	
Average hydraulic radius	R	1.54	m
Length of entrance flume	l	3	m

$$h_{l,f} = \frac{v^2}{k^2 R^{4/3}} l$$

Friction Loss	$h_{l,f}$	**0.001**	**m**

Entrance Loss

Entrance velocity	v_{eT}	0.9	m/s
Coefficient for entrance losses		0.10	

$$h_{l,e} = \varsigma_e \frac{v^2}{2g}$$

Entrance loss	$h_{l,e}$	**0.0041**	m

Stoplog Slot Loss

Velocity before the slot	v_{in}	0.9	m/s
Coefficient (stoplog slot)	β_s	0.94	
Weisbach coefficient (stoplog slots)	α_s	0.94	

$$h_{l,s} = 1.2 \frac{v^2}{2g} \left[(1-\beta)^2 + \left(\frac{1-\alpha}{\alpha} \right)^2 \right]$$

Head loss at stoplog slot	**0.0004**	m

C. Draft Tube Outlet Losses

Draft tube outlet losses has been taken as 1% of total head	**0.0587**	m
Total Losses	**0.098**	m
	(Approx.) 0.1	m

CONTENTS

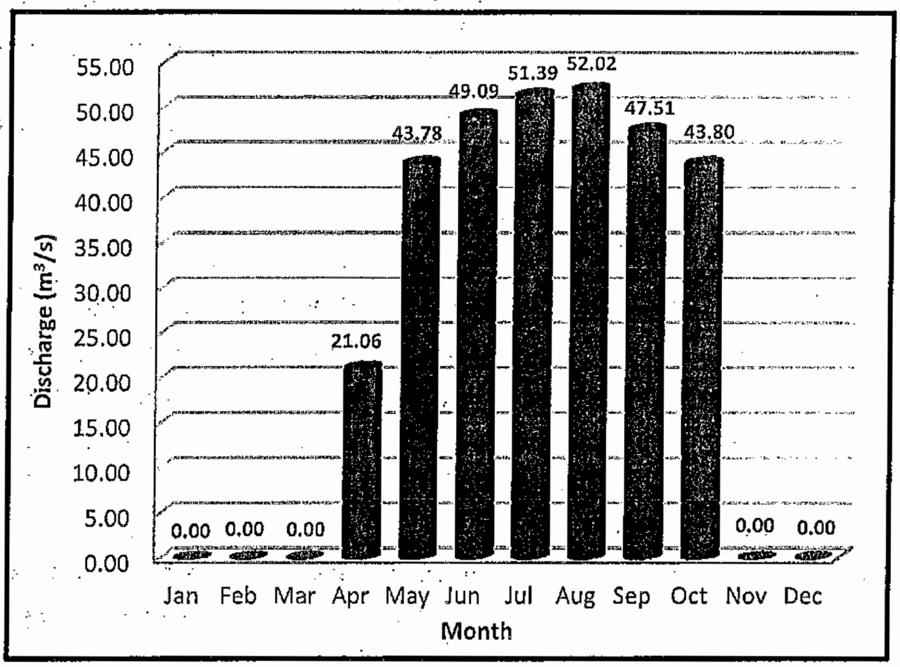
9.1 GENERAL

This chapter presents a summary of the power and energy potential estimates for the Kasur Hydropower Project. For this, the power and energy optimization studies have been carried out by selecting design discharges ranging from 35 m³/s to 55 m³/s with an interval of 5 m³/s.

9.2 HYDROLOGY

The hydrological data of Bambawali Ravi Bedian Canal (BRBD) at RD 509+000 is unavailable as discharge is not being observed at RD 509+000. Accordingly, the hydrological data of RD 434+000 for the period 2000 to 2016 (17-Years) have been analyzed as there is no distributary/outlet between RD 434+000 & RD 534+000. The hydrological data at RD 434+000 is presented in Chapter-3 of this feasibility study report. BRBD is a non-perennial canal due to which the discharge in this canal is only available from April to October every year. According to the hydrological data, the mean monthly discharges vary from 21.06 m³/s to 52.02 m³/s from April to October. The mean monthly discharges are indicated in **Figure - 9.1.** The average annual discharge is 25.72 m³/s.

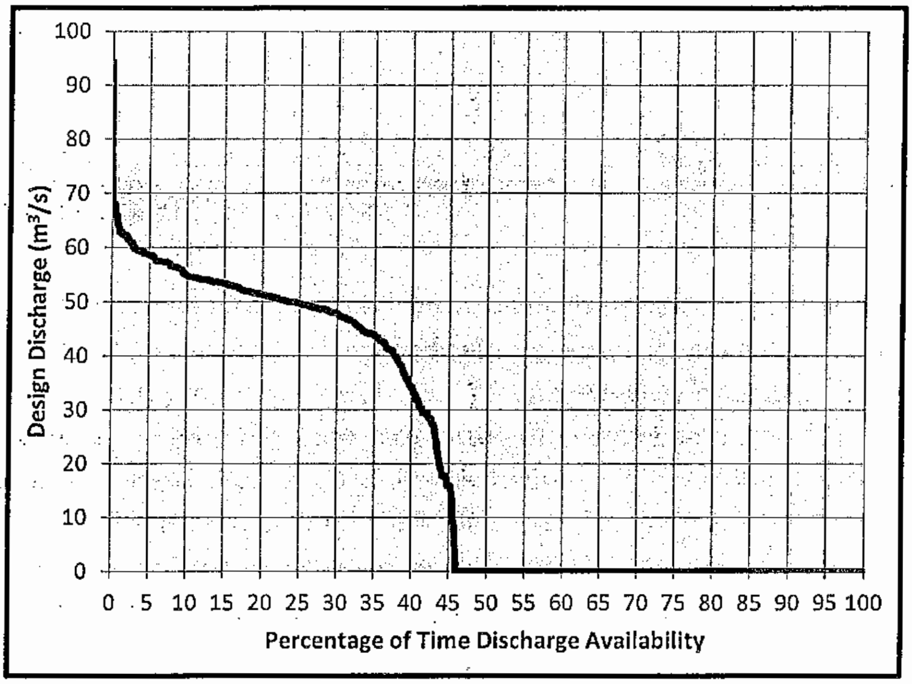
Figure - 9.1: Estimated Mean Monthly Discharges



9.3 OPTIMIZATION STUDIES

The optimization procedure involves first to estimate power and energy benefits for each design discharge of the hydropower project. The benefits of the project consider the energy produced as well as to the firm capacity available. The optimum installed capacity is the one which maximizes the difference between benefits and costs. According to the **Figure – 9.2**, the discharge of 35 m^3/s, 40 m^3/s, 45 m^3/s and 50 m^3/s are available for duration of 85.1%, 80.4%, 70.7% and 49.5% of the time respectively. The optimum discharge would be the one at which generation cost i.e. cost per kWh is minimum and the NPV is maximum.

Figure - 9.2: Flow Duration Curve



9.3.1. HEAD

The difference of Upstream Water Level and Downstream Water level provide the gross head. The head has been calculated with constant upstream water level i.e. 673.72 ft. (205.25 m) and maximum downstream water level as 654.45 ft. (199.38 m). A constant head loss of 0.1 m has been taken up. This shall be investigated further during detailed design when the turbine manufacturer has been selected. The net head varies from 5.77 m to 6.72 m. Head loss calculation is provided as **Annexure 9.2.**

9.3.2. EFFICIENCIES

The variations in the efficiencies of generating units due to change of net heads have not been considered. **Table - 9.1** shows the efficiency coefficient of various components of power plant:

Table - 9.1: Efficiency Coefficient of Various Components of Power Plant

Component	Efficiency
Turbine	91 %
Generator	97 %
Transformer	98 %
Overall	86.50%

9.3.3. POWER AND ENERGY ESTIMATION

Power and energy has been estimated for various design discharges. The design discharge ranges from 35 m^3/s to 55 m^3/s and output has been calculated at intervals of 5 m^3/s. The estimation of power and energy for various design discharges is presented as **Annexure 9-1** and summarized in **Table - 9.2.**

Table - 9.2: Estimation of Power & Energy for various Design Discharges

Design Discharge	Power	Annual Energy	Plant Factor
(m^3/s)	(MW)	(GWh)	(%)
35	1.86	8.62	52.90
40	2.08	9.59	52.63
45	2.30	10.40	51.62
50	2.45	10.73	50.02
55	2.66	10.73	46.05

9.3.4. PROJECT BENEFITS

Capacity and energy benefits for each design discharge have been estimated and added up to get the total benefits. The difference of benefits to cost of hydropower scheme for a particular discharge is compared with that of other discharges.

The aim of the project sizing is to recommend a robust and stable solution for the so-called optimum installed capacity of the project. For the respective design discharges, monthly power and energy have been estimated. With the derived capacity and energy cost, total benefits for each design discharge have been estimated in a spread sheet. For each design discharge, net benefit and generated unit cost have been compared to get the optimum design discharge.

9.3.5. COST ESTIMATION

For the selected alternative, cost estimation have been carried out by a computer programme for design discharges ranging from 35 to 55 m^3/s with interval of 5 m^3/s.

The cost estimates include the cost for Preliminary works, Civil works, E&M equipment, Hydraulic Steel Structures, transportation and erection charges. Engineering and Supervision charges, contingencies and project administration expenses have been added to prepare the project base cost. Interest during construction is added to the base cost for estimating total project cost. The cost estimates have been made for each discharge scenarios. A comparison of cost estimates for design discharges ranging from 35 to 55 m^3/s with interval of 5 m^3/s has been made and is presented in **Table - 9.3.**

Table - 9.3: Comparison of Estimated Cost

Sr. No.	Discharge (m^3/s)	Cost (million US$)
1	35	5.86
2	40	6.01
3	45	6.18
4	50	6.36
5	55	6.59

9.4 CAPACITY OPTIMIZATION

With power and energy values, benefits and costs have been estimated for design discharges ranging from 35 m^3/s to 55 m^3/s. Three scenarios have been analyzed to check the sensitivity of selected capacity. These three scenarios are base case option, increased cost and reduced flows.

Base Case Scenario

For this scenario, benefits and costs have been calculated for the selected range of design discharge from 35 m^3/s to 55 m^3/s. The summary of analysis is presented in **Table - 9.4.**

Table - 9.4: Base Case - Normal Cost

Design Discharge (m³/s)	Power (MW)	Annual Energy (GWh)	Plant Factor (%)	Project Cost (million Rs.)	Cost/kWh (Rs.)	Benefit/ Cost	NPV (million US$)
35	1.86	8.62	52.90	615.41	9.214	1.078	0.059
40	2.08	9.59	52.63	631.19	8.488	1.156	0.121
45	2.30	10.40	51.62	648.71	8.050	1.209	0.166
50	2.45	10.73	50.02	668.17	8.005	1.223	0.183
55	2.66	10.73	46.05	692.18	8.285	1.181	0.154

Increased Cost Scenario

Similar to above scenario, benefits and costs have been calculated for the selected range of design discharge from 35 m³/s to 55 m³/s and the summary of analysis is presented in **Table - 9.5.**

Table - 9.5: 10% Increased Cost

Design Discharge (m³/s)	Power (MW)	Annual Energy (GWh)	Plant Factor (%)	Project Cost (million Rs.)	Cost/kWh (Rs.)	Benefit/ Cost	NPV (million US$)
35	1.86	8.62	53.01	676.95	10.135	0.980	-0.016
40	2.08	9.59	52.70	694.31	9.337	1.051	0.044
45	2.30	10.40	51.73	713.58	8.855	1.099	0.087
50	2.45	10.73	50.02	734.99	8.798	1.112	0.101
55	2.66	10.73	46.78	761.39	9.102	1.073	0.069

Reduced Flows Scenario

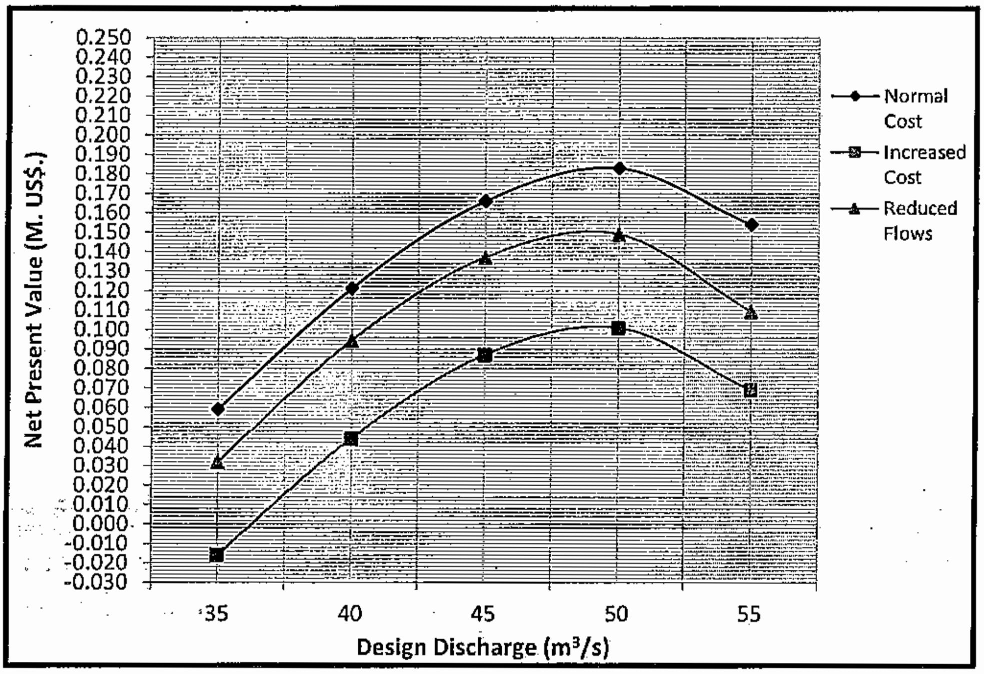
For reduced flows, benefits and costs have been calculated for the selected range of design discharge from 35 m³/s to 55 m³/s and the summary of analysis is presented in **Table - 9.6.**

Table - 9.6: 10% Reduced Flows

Design Discharge (m³/s)	Power (MW)	Annual Energy (GWh)	Plant Factor (%)	Project Cost (million Rs.)	Cost/kWh (Rs.)	Benefit/ Cost	NPV (million US$)
35	1.86	8.55	52.47	615.41	9.489	1.029	0.032
40	2.08	9.49	52.08	631.19	8.783	1.104	0.094
45	2.30	10.03	49.78	648.71	8.347	1.159	0.137
50	2.45	10.13	47.20	668.17	8.219	1.173	0.149
55	2.66	10.13	43.47	692.18	8.518	1.126	0.109

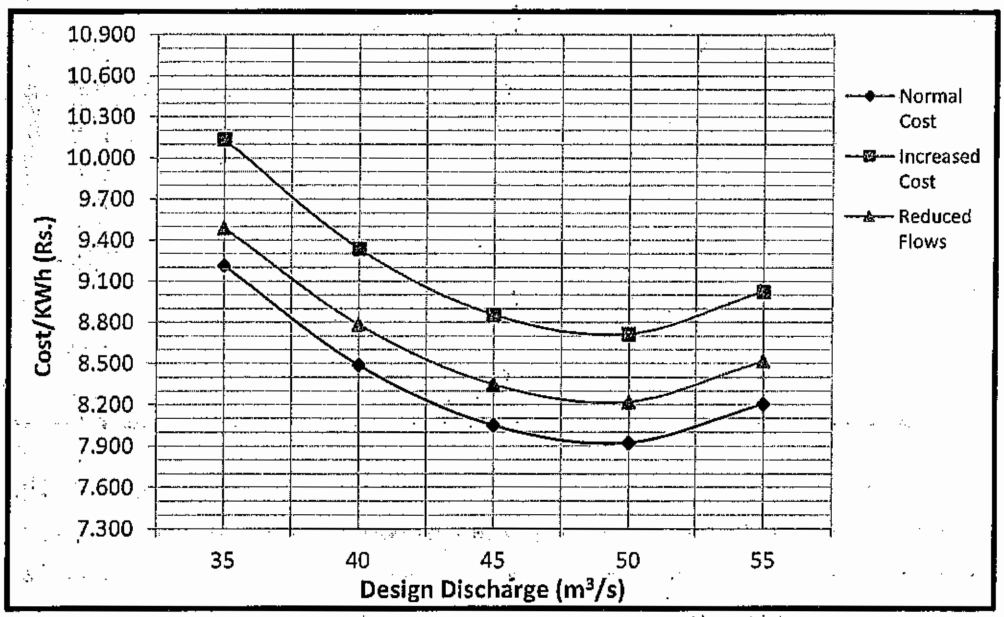
The above results of the analysis indicate that for all the three scenarios, cost per KWh is minimum, B/C ratio and NPV is maximum for a design discharge of 50 m³/s and it corresponds to a capacity of 2.45 MW. NPV vs discharge curves are drawn for all the three scenarios and is presented in **Figure - 9.3.** It indicates that for all the three scenarios, NPV increases for a discharge upto 50 m^3/s and decreases with increase in discharge.

Figure - 9.3: NPV vs Design Discharge Curve



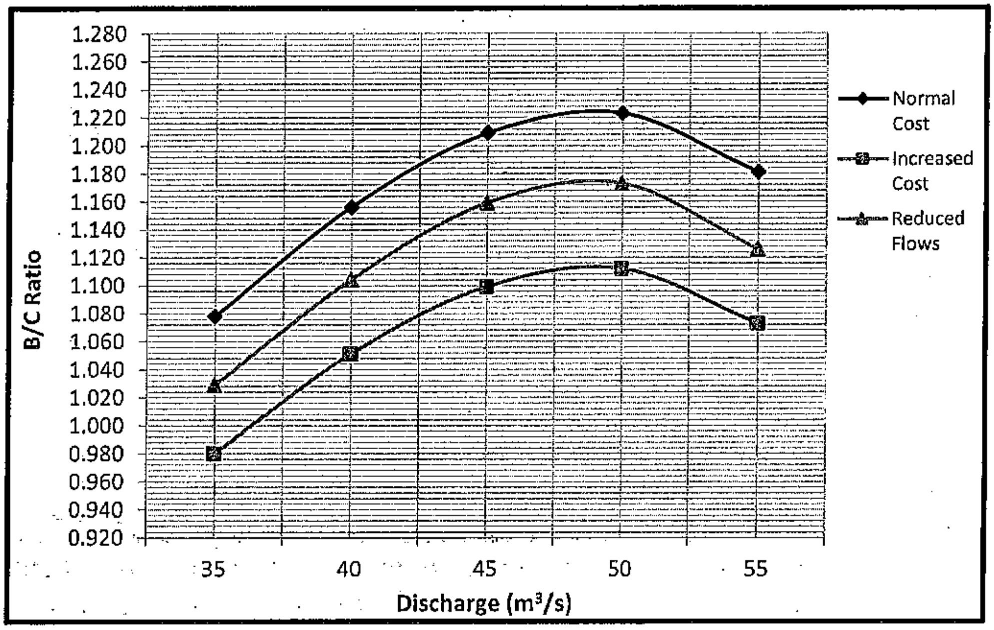
Similarly, the unit cost vs discharge curves are drawn for above mentioned three scenarios and are presented in **Figure - 9.4**. The graph indicates that unit cost for all the three scenarios decreases to minimum and then it increases again. The analysis for all the three scenarios indicates that unit cost/KWh is minimum for the design discharge of 50 m^3/s.

Figure - 9.4: Cost/kWh vs Design Discharge Curve



B/C ratio has also been checked for various discharges. The B/C ratio vs discharge curves are drawn for said three scenarios and is presented in **Figure - 9.5**.

Figure - 9.5: B/C Ratio vs Design Discharge Curve



The graph indicates that B/C ratio increases to maximum for a discharge of 50 m^3/s and then it decreases for higher discharge. All the three scenarios indicate that B/C ratio is maximum at design discharge of 50 m^3/s.

9.5 SELECTED CAPACITY

From all the three scenarios presented in **Table - 9.4 to 9.6**, it can be concluded that NPV is in maximum range for a design discharge of 50 m^3/s. From the analysis, it can be inferred that the project would provide maximum net benefits when discharge is 50 m^3/s. The 2.45 MW installed capacity for a design discharge of 50 m^3/s would be optimum.

From all the three scenarios, the base case scenario has the highest NPV at design discharge of 50 m^3/s and 2.45 MW installed capacity. It is, therefore, can be concluded that the project with base case scenario is very much required as it provide maximum NPV values.

The change of mode of operation or increase in cost or change in flow pattern shall naturally affect power and energy output and consequently the project benefit and unit cost scenario, but shall not change the optimum design discharge.

9.6 POWER AND ENERGY CALCULATIONS

For selected design discharge of 50 m^3/s (1766 ft^3/s) and net head of 5.77 m, the installed capacity would be 2.45 MW (comprising of 01 Unit of 2.45 MW), with mean annual energy of 10.73 GWh (gross). The plant factor has been estimated as 50.02% which is based on net plant capacity and net deliverable energy.

The daily power and energy is presented as **Annexure 9-1.** The following formulas have been used for the estimation of power and energy:

Power

$$P = \eta \times g \times Q \times H / 1000.$$

Where,

P is the Power (MW).
Q is design discharge Q_d (m^3/s).
H is net head (m).
η is the combined efficiencies of turbine, generator and transformer.
g is the acceleration due to gravity (9.81 m/s^2).

Energy

$$Energy = P \times t / 10^6.$$

Where,

E is energy in (GWh).
P is Power in (MW).
t is time in hours in a day.

Plant Factor

$$pf = (E / (P \times 8.760)) \times 100.$$

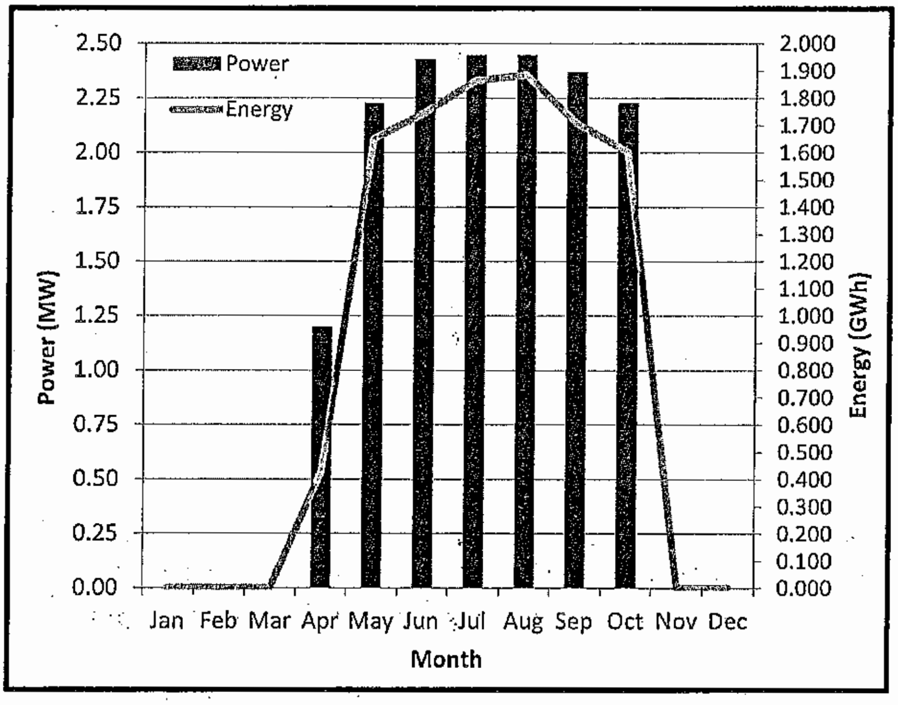
Where,

pf is the Plant Factor (%).
E is the mean annual energy (GWh).
P is the installed capacity (MW).

The estimated mean monthly power and energy is presented in **Figure - 9.6.** In July and August, installed capacity of 2.45 MW would be available. In remaining months from April to October, the power varies from 1.20 MW to 2.37 MW.

The energy is directly proportional to volume of water available for power generation. The monthly energy generation varies between 0.429 GWh to 1.808 GWh.

Figure - 9.6: Mean Monthly Power & Energy



Annexure 9-1

Design Discharge = **50 m³/s**

Gross Head = **5.87 m**

Net Head = **5.77 m**

No. of Turbines = **01**

Combined Efficiency = **86.50%**

Plant Installed Capacity (Gross) = **2.45 MW**

Net Plant Installed Capacity = **2.42 MW**

Annual Energy (Gross) = **10.73 GWh**

Auxiliary Consumption @ 1% = **0.1073 GWh**

Net Deliverable Energy = **10.62 GWh**

Plant Factor = **50.02%**

M	Days	Discharge	Net Head	Turbine Flow	Power (MW)	Energy
		m³/sec	m	Unit 1	Unit 1	GWh
JANUARY	1	0.00	0.00	0.00	0.00	0.000
	2	0.00	0.00	0.00	0.00	0.000
	3	0.00	0.00	0.00	0.00	0.000
	4	0.00	0.00	0.00	0.00	0.000
	5	0.00	0.00	0.00	0.00	0.000
	6	0.00	0.00	0.00	0.00	0.000
	7	0.00	0.00	0.00	0.00	0.000
	8	0.00	0.00	0.00	0.00	0.000
	9	0.00	0.00	0.00	0.00	0.000
	10	0.00	0.00	0.00	0.00	0.000
	11	0.00	0.00	0.00	0.00	0.000
	12	0.00	0.00	0.00	0.00	0.000
	13	0.00	0.00	0.00	0.00	0.000
	14	0.00	0.00	0.00	0.00	0.000
	15	0.00	0.00	0.00	0.00	0.000
	16	0.00	0.00	0.00	0.00	0.000
	17	0.00	0.00	0.00	0.00	0.000
	18	0.00	0.00	0.00	0.00	0.000
	19	0.00	0.00	0.00	0.00	0.000
	20	0.00	0.00	0.00	0.00	0.000
	21	0.00	0.00	0.00	0.00	0.000
	22	0.00	0.00	0.00	0.00	0.000
	23	0.00	0.00	0.00	0.00	0.000
	24	0.00	0.00	0.00	0.00	0.000
	25	0.00	0.00	0.00	0.00	0.000
	26	0.00	0.00	0.00	0.00	0.000

	27	0.00	0.00	0.00	0.00	0.000
	28	0.00	0.00	0.00	0.00	0.000
	29	0.00	0.00	0.00	0.00	0.000
	30	0.00	0.00	0.00	0.00	0.000
	31	0.00	0.00	0.00	0.00	0.000
FEBRUARY	32	0.00	0.00	0.00	0.00	0.000
	33	0.00	0.00	0.00	0.00	0.000
	34	0.00	0.00	0.00	0.00	0.000
	35	0.00	0.00	0.00	0.00	0.000
	36	0.00	0.00	0.00	0.00	0.000
	37	0.00	0.00	0.00	0.00	0.000
	38	0.00	0.00	0.00	0.00	0.000
	39	0.00	0.00	0.00	0.00	0.000
	40	0.00	0.00	0.00	0.00	0.000
	41	0.00	0.00	0.00	0.00	0.000
	42	0.00	0.00	0.00	0.00	0.000
	43	0.00	0.00	0.00	0.00	0.000
	44	0.00	0.00	0.00	0.00	0.000
	45	0.00	0.00	0.00	0.00	0.000
	46	0.00	0.00	0.00	0.00	0.000
	47	0.00	0.00	0.00	0.00	0.000
	48	0.00	0.00	0.00	0.00	0.000
	49	0.00	0.00	0.00	0.00	0.000
	50	0.00	0.00	0.00	0.00	0.000
	51	0.00	0.00	0.00	0.00	0.000
	52	0.00	0.00	0.00	0.00	0.000
	53	0.00	0.00	0.00	0.00	0.000
	54	0.00	0.00	0.00	0.00	0.000
	55	0.00	0.00	0.00	0.00	0.000
	56	0.00	0.00	0.00	0.00	0.000
	57	0.00	0.00	0.00	0.00	0.000
	58	0.00	0.00	0.00	0.00	0.000
	59	0.00	0.00	0.00	0.00	0.000
MARCH	60	0.00	0.00	0.00	0.00	0.000
	61	0.00	0.00	0.00	0.00	0.000
	62	0.00	0.00	0.00	0.00	0.000
	63	0.00	0.00	0.00	0.00	0.000
	64	0.00	0.00	0.00	0.00	0.000
	65	0.00	0.00	0.00	0.00	0.000
	66	0.00	0.00	0.00	0.00	0.000
	67	0.00	0.00	0.00	0.00	0.000
	68	0.00	0.00	0.00	0.00	0.000
	69	0.00	0.00	0.00	0.00	0.000
	70	0.00	0.00	0.00	0.00	0.000

	71	0.00	0.00	0.00	0.00	0.000
	72	0.00	0.00	0.00	0.00	0.000
	73	0.00	0.00	0.00	0.00	0.000
	74	0.00	0.00	0.00	0.00	0.000
	75	0.00	0.00	0.00	0.00	0.000
	76	0.00	0.00	0.00	0.00	0.000
	77	0.00	0.00	0.00	0.00	0.000
	78	0.00	0.00	0.00	0.00	0.000
	79	0.00	0.00	0.00	0.00	0.000
	80	0.00	0.00	0.00	0.00	0.000
	81	0.00	0.00	0.00	0.00	0.000
	82	0.00	0.00	0.00	0.00	0.000
	83	0.00	0.00	0.00	0.00	0.000
	84	0.00	0.00	0.00	0.00	0.000
	85	0.00	0.00	0.00	0.00	0.000
	86	0.00	0.00	0.00	0.00	0.000
	87	0.00	0.00	0.00	0.00	0.000
	88	0.00	0.00	0.00	0.00	0.000
	89	0.00	0.00	0.00	0.00	0.000
	90	0.00	0.00	0.00	0.00	0.000
APRIL	91	0.00	0.00	0.00	0.00	0.000
	92	0.00	0.00	0.00	0.00	0.000
	93	0.00	0.00	0.00	0.00	0.000
	94	0.00	0.00	0.00	0.00	0.000
	95	0.00	0.00	0.00	0.00	0.000
	96	0.00	0.00	0.00	0.00	0.000
	97	0.00	0.00	0.00	0.00	0.000
	98	0.00	0.00	0.00	0.00	0.000
	99	0.00	0.00	0.00	0.00	0.000
	100	0.00	0.00	0.00	0.00	0.000
	101	0.00	0.00	0.00	0.00	0.000
	102	0.00	0.00	0.00	0.00	0.000
	103	0.00	0.00	0.00	0.00	0.000
	104	0.00	0.00	0.00	0.00	0.000
	105	6.37	7.38	0.00	0.00	0.000
	106	12.97	7.07	0.00	0.00	0.000
	107	19.80	6.78	19.80	1.14	0.027
	108	15.90	6.94	15.90	0.94	0.022
	109	14.39	7.00	14.39	0.86	0.021
	110	20.11	6.76	20.11	1.15	0.028
	111	19.38	6.79	19.38	1.12	0.027
	112	19.27	6.80	19.27	1.11	0.027
	113	20.25	6.76	20.25	1.16	0.028
	114	21.84	6.70	21.84	1.24	0.030

	115	21.88	6.69	21.88	1.24	0.030
	116	22.55	6.67	22.55	1.28	0.031
	117	27.47	6.49	27.47	1.51	0.036
	118	29.18	6.43	29.18	1.59	0.038
	119	34.16	6.28	34.16	1.82	0.044
	120	31.38	6.36	31.38	1.69	0.041
MAY	121	31.13	6.37	31.13	1.68	0.040
	122	31.09	6.37	31.09	1.68	0.040
	123	33.63	6.30	33.63	1.80	0.043
	124	34.78	6.26	34.78	1.85	0.044
	125	36.57	6.21	36.57	1.93	0.046
	126	39.37	6.14	39.37	2.05	0.049
	127	39.23	6.14	39.23	2.04	0.049
	128	40.88	6.10	40.88	2.12	0.051
	129	40.22	6.12	40.22	2.09	0.050
	130	41.17	6.09	41.17	2.13	0.051
	131	40.76	6.10	40.76	2.11	0.051
	132	41.67	6.08	41.67	2.15	0.052
	133	44.01	6.03	44.01	2.25	0.054
	134	46.08	5.99	46.08	2.34	0.056
	135	44.94	6.01	44.94	2.29	0.055
	136	44.58	6.02	44.58	2.28	0.055
	137	45.85	5.99	45.85	2.33	0.056
	138	46.34	5.98	46.34	2.35	0.056
	139	46.73	5.97	46.73	2.37	0.057
	140	48.27	5.80	48.27	2.37	0.057
	141	43.56	6.04	43.56	2.23	0.054
	142	48.68	5.79	48.68	2.39	0.057
	143	48.85	5.79	48.85	2.40	0.058
	144	48.94	5.79	48.94	2.40	0.058
	145	49.34	5.78	49.34	2.42	0.058
	146	48.90	5.79	48.90	2.40	0.058
	147	49.79	5.77	49.79	2.44	0.059
	148	49.84	5.77	49.84	2.44	0.059
	149	50.80	5.75	50.00	2.44	0.059
	150	50.33	5.76	50.33	2.46	0.059
	151	50.76	5.76	50.00	2.44	0.059
JUNE	152	49.42	5.78	49.42	2.42	0.058
	153	49.21	5.78	49.21	2.41	0.058
	154	49.09	5.78	49.09	2.41	0.058
	155	48.39	5.80	48.39	2.38	0.057
	156	48.84	5.79	48.84	2.40	0.058
	157	48.86	5.79	48.86	2.40	0.058
	158	50.24	5.76	50.24	2.46	0.059

	159	49.52	5.78	49.52	2.43	0.058
	160	50.84	5.90	50.00	2.50	0.060
	161	46.23	5.98	46.23	2.35	0.056
	162	47.13	5.97	47.13	2.39	0.057
	163	42.67	6.06	42.67	2.19	0.053
	164	46.43	5.98	46.43	2.36	0.057
	165	45.97	5.99	45.97	2.34	0.056
	166	46.86	5.97	46.86	2.38	0.057
	167	48.56	5.79	48.56	2.39	0.057
	168	48.00	5.80	48.00	2.36	0.057
	169	49.01	5.93	49.01	2.47	0.059
	170	52.79	5.72	50.00	2.43	0.058
	171	50.47	5.76	50.47	2.47	0.059
	172	49.90	5.77	49.90	2.44	0.059
	173	49.11	5.78	49.11	2.41	0.058
	174	49.91	5.77	49.91	2.44	0.059
	175	51.18	5.75	50.00	2.44	0.059
	176	50.53	5.76	50.53	2.47	0.059
	177	51.47	5.74	50.00	2.44	0.058
	178	51.42	5.75	50.00	2.44	0.059
	179	50.77	5.76	50.00	2.44	0.059
	180	50.34	5.76	50.34	2.46	0.059
	181	49.54	5.78	49.54	2.43	0.058
JULY	182	52.05	5.74	50.00	2.43	0.058
	183	50.95	5.75	50.00	2.44	0.059
	184	51.70	5.74	50.00	2.44	0.058
	185	52.33	5.73	50.00	2.43	0.058
	186	51.74	5.74	50.00	2.44	0.058
	187	49.06	5.78	49.06	2.41	0.058
	188	50.23	5.76	50.23	2.46	0.059
	189	49.40	5.78	49.40	2.42	0.058
	190	49.82	5.77	49.82	2.44	0.059
	191	50.68	5.76	50.00	2.44	0.059
	192	48.35	5.80	48.35	2.38	0.057
	193	51.56	5.74	50.00	2.44	0.058
	194	49.17	5.78	49.17	2.41	0.058
	195	52.68	5.73	50.00	2.43	0.058
	196	53.01	5.72	50.00	2.43	0.058
	197	53.14	5.72	50.00	2.43	0.058
	198	53.42	5.72	50.00	2.43	0.058
	199	53.41	5.72	50.00	2.43	0.058
	200	52.54	5.73	50.00	2.43	0.058
	201	52.98	5.72	50.00	2.43	0.058
	202	52.98	5.72	50.00	2.43	0.058

	203	52.53	5.73	50.00	2.43	0.058
	204	51.46	5.74	50.00	2.44	0.058
	205	51.14	5.75	50.00	2.44	0.059
	206	50.69	5.76	50.00	2.44	0.059
	207	50.78	5.76	50.00	2.44	0.059
	208	52.00	5.74	50.00	2.43	0.058
	209	53.02	5.72	50.00	2.43	0.058
	210	49.90	5.77	49.90	2.44	0.059
	211	51.10	5.75	50.00	2.44	0.059
	212	49.28	5.78	49.28	2.42	0.058
AUGUST	213	49.85	5.77	49.85	2.44	0.059
	214	50.21	5.76	50.21	2.46	0.059
	215	51.04	5.75	50.00	2.44	0.059
	216	51.36	5.75	50.00	2.44	0.059
	217	50.86	5.75	50.00	2.44	0.059
	218	51.21	5.75	50.00	2.44	0.059
	219	50.78	5.76	50.00	2.44	0.059
	220	53.95	5.71	50.00	2.42	0.058
	221	53.02	5.72	50.00	2.43	0.058
	222	53.32	5.72	50.00	2.43	0.058
	223	52.65	5.73	50.00	2.43	0.058
	224	53.92	5.71	50.00	2.42	0.058
	225	53.51	5.71	50.00	2.42	0.058
	226	51.79	5.74	50.00	2.44	0.058
	227	49.74	5.77	49.74	2.44	0.058
	228	49.21	5.78	49.21	2.41	0.058
	229	52.27	5.73	50.00	2.43	0.058
	230	51.47	5.74	50.00	2.44	0.058
	231	48.28	5.80	48.28	2.38	0.057
	232	46.45	5.98	46.45	2.36	0.057
	233	50.28	5.76	50.28	2.46	0.059
	234	52.74	5.73	50.00	2.43	0.058
	235	54.60	5.70	50.00	2.42	0.058
	236	55.01	5.69	50.00	2.42	0.058
	237	54.49	5.70	50.00	2.42	0.058
	238	55.27	5.69	50.00	2.41	0.058
	239	54.56	5.70	50.00	2.42	0.058
	240	54.19	5.71	50.00	2.42	0.058
	241	53.71	5.71	50.00	2.42	0.058
	242	52.75	5.73	50.00	2.43	0.058
	243	50.18	5.76	50.18	2.45	0.059
SEPTEMBER	244	48.56	5.79	48.56	2.39	0.057
	245	51.05	5.75	50.00	2.44	0.059
	246	50.21	5.76	50.21	2.46	0.059

	247	47.48	5.96	47.48	2.40	0.058
	248	50.16	5.77	50.16	2.45	0.059
	249	47.88	5.95	47.88	2.42	0.058
	250	48.81	5.79	48.81	2.40	0.058
	251	48.24	5.95	48.24	2.43	0.058
	252	47.29	5.96	47.29	2.39	0.057
	253	44.31	6.02	44.31	2.27	0.054
	254	45.02	6.01	45.02	2.30	0.055
	255	45.55	6.00	45.55	2.32	0.056
	256	43.63	6.04	43.63	2.24	0.054
	257	43.63	6.04	43.63	2.24	0.054
	258	43.97	5.88	43.97	2.19	0.053
	259	42.73	6.06	42.73	2.20	0.053
	260	46.56	5.98	46.56	2.36	0.057
	261	46.25	5.98	46.25	2.35	0.056
	262	47.16	5.97	47.16	2.39	0.057
	263	49.52	5.78	49.52	2.43	0.058
	264	49.33	5.78	49.33	2.42	0.058
	265	50.18	5.76	50.18	2.45	0.059
	266	48.62	5.79	48.62	2.39	0.057
	267	49.30	5.78	49.30	2.42	0.058
	268	49.55	5.78	49.55	2.43	0.058
	269	50.04	5.77	50.04	2.45	0.059
	270	49.52	5.78	49.52	2.43	0.058
	271	48.83	5.79	48.83	2.40	0.058
	272	46.64	5.98	46.64	2.37	0.057
	273	45.13	6.01	45.13	2.30	0.055
	274	45.32	6.00	45.32	2.31	0.055
	275	42.09	6.07	42.09	2.17	0.052
	276	43.68	6.04	43.68	2.24	0.054
	277	41.52	6.09	41.52	2.14	0.051
	278	47.16	5.97	47.16	2.39	0.057
	279	49.15	5.78	49.15	2.41	0.058
	280	49.56	5.78	49.56	2.43	0.058
	281	50.80	5.90	50.00	2.50	0.060
OCTOBER	282	51.80	5.74	50.00	2.44	0.058
	283	51.75	5.74	50.00	2.44	0.058
	284	51.39	5.75	50.00	2.44	0.059
	285	47.07	5.97	47.07	2.38	0.057
	286	40.55	6.11	40.55	2.10	0.050
	287	44.64	6.02	44.64	2.28	0.055
	288	45.27	6.00	45.27	2.31	0.055
	289	40.06	6.12	40.06	2.08	0.050
	290	44.39	6.02	44.39	2.27	0.054

	291	48.30	5.80	48.30	2.38	0.057
	292	41.40	6.09	41.40	2.14	0.051
	293	48.37	5.80	48.37	2.38	0.057
	294	41.28	6.09	41.28	2.13	0.051
	295	51.33	5.75	50.00	2.44	0.059
	296	47.09	5.97	47.09	2.38	0.057
	297	45.59	6.00	45.59	2.32	0.056
	298	47.09	5.97	47.09	2.38	0.057
	299	30.23	6.40	30.23	1.64	0.039
	300	30.23	6.40	30.23	1.64	0.039
	301	36.51	6.21	36.51	1.93	0.046
	302	30.23	6.40	30.23	1.64	0.039
	303	30.23	6.40	30.23	1.64	0.039
	304	0.00	0.00	0.00	0.00	0.000
NOVEMBER	305	0.00	0.00	0.00	0.00	0.000
	306	0.00	0.00	0.00	0.00	0.000
	307	0.00	0.00	0.00	0.00	0.000
	308	0.00	0.00	0.00	0.00	0.000
	309	0.00	0.00	0.00	0.00	0.000
	310	0.00	0.00	0.00	0.00	0.000
	311	0.00	0.00	0.00	0.00	0.000
	312	0.00	0.00	0.00	0.00	0.000
	313	0.00	0.00	0.00	0.00	0.000
	314	0.00	0.00	0.00	0.00	0.000
	315	0.00	0.00	0.00	0.00	0.000
	316	0.00	0.00	0.00	0.00	0.000
	317	0.00	0.00	0.00	0.00	0.000
	318	0.00	0.00	0.00	0.00	0.000
	319	0.00	0.00	0.00	0.00	0.000
	320	0.00	0.00	0.00	0.00	0.000
	321	0.00	0.00	0.00	0.00	0.000
	322	0.00	0.00	0.00	0.00	0.000
	323	0.00	0.00	0.00	0.00	0.000
	324	0.00	0.00	0.00	0.00	0.000
	325	0.00	0.00	0.00	0.00	0.000
	326	0.00	0.00	0.00	0.00	0.000
	327	0.00	0.00	0.00	0.00	0.000
	328	0.00	0.00	0.00	0.00	0.000
	329	0.00	0.00	0.00	0.00	0.000
	330	0.00	0.00	0.00	0.00	0.000
	331	0.00	0.00	0.00	0.00	0.000
	332	0.00	0.00	0.00	0.00	0.000
	333	0.00	0.00	0.00	0.00	0.000
	334	0.00	0.00	0.00	0.00	0.000

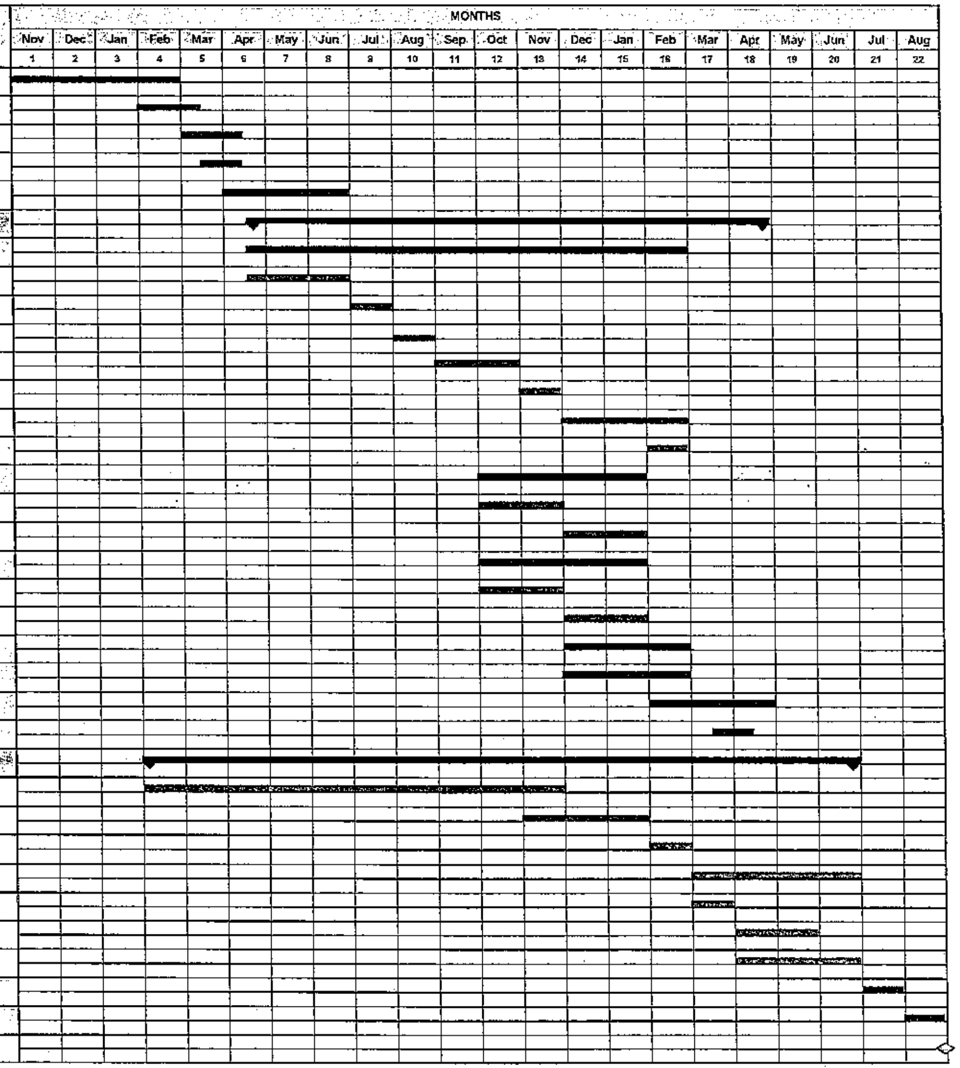
DECEMBER	335	0.00	0.00	0.00	0.00	0.000
	336	0.00	0.00	0.00	0.00	0.000
	337	0.00	0.00	0.00	0.00	0.000
	338	0.00	0.00	0.00	0.00	0.000
	339	0.00	0.00	0.00	0.00	0.000
	340	0.00	0.00	0.00	0.00	0.000
	341	0.00	0.00	0.00	0.00	0.000
	342	0.00	0.00	0.00	0.00	0.000
	343	0.00	0.00	0.00	0.00	0.000
	344	0.00	0.00	0.00	0.00	0.000
	345	0.00	0.00	0.00	0.00	0.000
	346	0.00	0.00	0.00	0.00	0.000
	347	0.00	0.00	0.00	0.00	0.000
	348	0.00	0.00	0.00	0.00	0.000
	349	0.00	0.00	0.00	0.00	0.000
	350	0.00	0.00	0.00	0.00	0.000
	351	0.00	0.00	0.00	0.00	0.000
	352	0.00	0.00	0.00	0.00	0.000
	353	0.00	0.00	0.00	0.00	0.000
	354	0.00	0.00	0.00	0.00	0.000
	355	0.00	0.00	0.00	0.00	0.000
	356	0.00	0.00	0.00	0.00	0.000
	357	0.00	0.00	0.00	0.00	0.000
	358	0.00	0.00	0.00	0.00	0.000
	359	0.00	0.00	0.00	0.00	0.000
	360	0.00	0.00	0.00	0.00	0.000
	361	0.00	0.00	0.00	0.00	0.000
	362	0.00	0.00	0.00	0.00	0.000
	363	0.00	0.00	0.00	0.00	0.000
	364	0.00	0.00	0.00	0.00	0.000
	365	0.00	0.00	0.00	0.00	0.000
	TOTAL (GWh)					10.73

Figure - 10.1

KASUR HYDROPOWER PROJECT

ACTIVITY SCHEDULE

ACTIVITY	Period (Months)
INVESTIGATIONS & DETAIL DESIGN BY EPC CONTRACTOR	4
MOBILIZATION / SITE INSTALLATIONS	1.5
EXCAVATION OF TEMPORARY DIVERSION CHANNEL	1.5
CONSTRUCTION OF U/S AND D/S COFFER DAM	1
CONSTRUCTION OF O&M STAFF RESIDENTIAL COLONY	3
CIVIL WORKS	
POWERHOUSE & SPILLWAY	11
Excavation 1st Stage	2.5
Installation of Dewatering System	1
Excavation 2nd Stage	1
Concreting of Powerhouse and Spillway Foundations	2
Installation of Embedded Parts	1
Concreting of Powerhouse and Spillway Superstructure	3
Backfilling around Powerhouse & Spillway Structures	1
UPSTREAM TRANSITION	4
Excavation and Compaction	2
Concreting of Foundation Slab & Retaining Walls	2
DOWNSTREAM TRANSITION	4
Excavation and Compaction	2
Concreting of Foundation Slab & Retaining Walls	2
UPSTREAM CANAL PROTECTION WORKS	3
DOWNSTREAM CANAL PROTECTION WORKS	3
SWITCHYARD CONSTRUCTION	3
REMOVAL OF U/S AND D/S COFFER DAM	1
E&M WORKS	
Manufacturing of Turbine, Generator, Other E&M Equipment and Spillway Gates	10
Delivery at Site	3
Erection of Powerhouse Crane	1
Installation of Turbine, Generator and Other E&M Equipment	4
Installation of Spillway Gates & Hoisting System	1
Installation of Switchyard Equipment	2
Transmission and Interconnection Works	3
TESTING AND COMMISSIONING	1
REMOVAL OF DEFECTS AND MISC WORKS	1
PROJECT COMPLETION / COMMERCIAL OPERATION	



10.1 GENERAL

This chapter briefly describes the construction planning and management of the project. Based on the project scope, construction material quantities, sequence of activities and their dependence on the hydrological conditions, the Kasur Hydropower Project is planned to be implemented in 22 months including 04 months for detailed engineering design.

The activity schedule is presented in **Figure – 10.1**, showing the duration and sequence of activities spanning the entire period of 22 months. The schedule indicates major construction stage activities and is based on the assumption that the project shall be awarded to a qualified constructor on EPC basis having similar experience in the construction of hydraulic structures and powerhouses and with the experience in the design, manufacture or procurement of hydropower generating equipment.

10.2 CONSTRUCTION PLANNING

The Kasur Hydropower Project is planned to be constructed in a period of 22 months. This includes Civil, Electro-mechanical, Transmission and Interconnection works from installation to commissioning. The pre-construction activities shall precede the construction activities of the Kasur Hydropower Project.

These include:

- Submission of Feasibility Study and Approval by PPDB.
- Approval of Tariff and Power Generation Certificate by NEPRA.
- Issuance of NOC by the Punjab, EPA.
- Appointment of Project Implementation Consultant.
- Acquisition of Land.
- Tender Design, Documents and Tendering.
- Award of EPC Contract.

Major activities to be undertaken and estimated time to be dedicated for each of these are elaborated in **Table – 10.1** as under:

Table – 10.1: Time Line of Major Activities

Sr. #	Activity	Days
1.	Investigations and Detailed Design by EPC Contractor	120
2.	Mobilization / Site Installations	45
3.	Construction of O&M Staff Residential Colony	90
4.	Excavation of Temporary Diversion Channel	45
5.	Construction of Upstream and Downstream Coffer Dams	30
6.	Excavation of Powerhouse and Spillway Foundations	135
7.	Concreting of Powerhouse and Spillway Foundations	60
8.	Concreting of Powerhouse and Spillway Superstructure	90
9.	Manufacturing of Turbine, Generator, other E&M Equipment and Spillway Gates	300
10.	Delivery at site	90
11.	Installation of Turbine, Generator & other E&M Equipment	120
12.	Transmission & Interconnection Works	90
13.	Testing and Commissioning	30

The dedicated time of 22 months for the above listed activities is to be staggered, shared and distributed in such a way that the project works are executed, completed and commissioned within the period of 22 months. This task is to be achieved through the construction management. Experience shows that valuable time is lost due to poor construction planning. In some cases, the construction plant idles due to lack of essential spares. In other cases, the material delivery is not well timed to allow uninterrupted execution of site works. Important considerations for timely completion of the project are:

- Assess requirements of construction material, skill and number of construction workers and types of tools and plants.
- Arrange logistic supports for an efficient supply chain.
- Minimize idling of plant and resources through critical paths.
- Maximize work output by keeping the plant and resources at optimum level of performance and operation.
- Anticipate problems and analyse them for their likely time impacts.
- Suggest contingent plans and means to ward off problematic situation.

10.2.1 Suggested Methodology

It is assumed that one EPC Contractor would execute the entire Civil, E&M and Structural Steel works. Single source EPC Contract has many advantages over split scope contracts. The EPC Contractor may, however, engage sub-contractors for specialized jobs that include supply of materials, powerhouse electrification etc.

The site works shall be executed in accordance with the construction management plan. The construction activities include care and handling of water, bulk excavation and disposal, concrete mixing and placing and structural steel works. For preparation of quality concrete, batching plant shall be used. The construction schedule shall be coordinated with the local irrigation authorities to avoid disruption to the canal flows for irrigation purposes.

Working conditions at the project site are expected to be excellent. Care and handling of water in the excavated area may be a construction hazard for which extra resources would be needed.

10.2.2 Construction Means

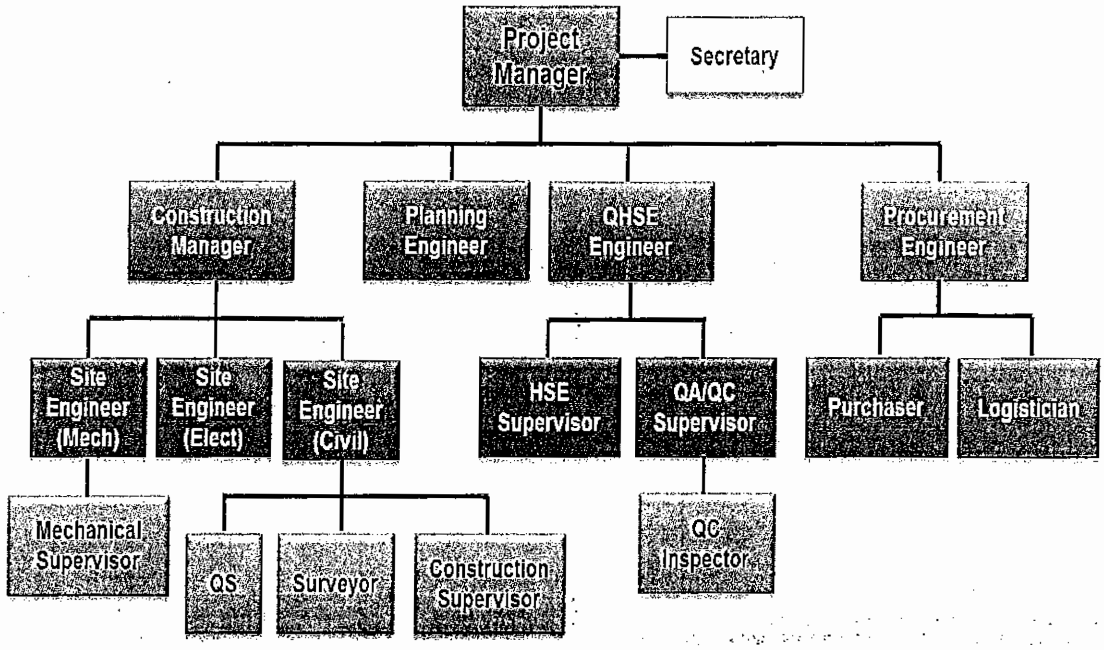
For all works, conventional construction methods shall be applied. Surface excavations require conventional earth moving equipment only. The construction work shall start with the excavation of temporary diversion channel on the right side of the canal. The majority of the work force shall be local, with site laborers and semi-skilled labor available from the project area and skilled labor also coming from the region as well as from other parts of the Country.

Foreign experts shall be hired for special tasks, especially that associated with installation and testing of major E&M equipment (if necessary).

10.3 PROJECT ORGANIZATION

The construction of the project could be conveniently managed with an efficient, professional and dedicated managerial team. The project organization proposed for successful execution of the project is given in **Figure - 10.1**.

Figure - 10.1 Project Organization



The above staff shall have the roles and responsibilities as under:

- The overall responsibility of the management of the entire project organization shall rest with an experienced professional, who has extensive exposure on successfully handling the project related issues. He shall act in the capacity of Project Manager. He shall be assisted by Construction Manager, Planning Engineer, QHSE Engineer and Procurement Engineer.

- The Construction Manager shall deal with the day to day construction issue and ensure compliance with the design and specification codes. He would maintain close liaison with the Irrigation Department and monitor the quality and site productivity. The Construction manager shall have extensive experience on construction related problems with a capacity to make a sound judgement for quick decision making.

- The Procurement Engineer is a direct assistant to Project Manager, who shall assist him in preparation of an inventory of material for smooth execution of works at site. He shall also be responsible for preparation of supply/delivery orders of all kind of materials, spares, tools etc. at site.

- The QHSE Engineer is also a direct assistant to the Project Manager, who shall assist him in resolving day to day problems regarding safety, quality and environmental hazards at site.

- The Planning Engineer is also a direct assistant to the Project Manager for scheduling the site activities and preparation of monthly progress reports.

- Down the line of organizational hierarchy are the site engineers each for Civil and E&M works. The site engineers shall be responsible for execution of works in accordance with the specifications and schedule of progress. The site engineers shall be assisted by construction supervisors.

10.4 SEQUENCE AND SCHEDULE OF ACTIVITIES

10.4.1 Investigations & Detail Design

The detailed engineering design, drawings and related investigations shall be the responsibility of EPC Contractor. About 04 months have been envisaged for additional investigations, working out the plant size and final layout for review and approval by the sponsor and PPDB. Side by side the contractor shall move for procurement of Turbines, Generators & other E&M equipment.

10.4.2 Mobilization / Site Installations

The first important stage in the construction planning is the site installations. It mainly deals with the mobilization of all plant and equipment required for the various construction items, construction of camp & offices, electric and water supplies to offices and equipment, erection of repair and maintenance workshops, stores for spare parts and materials, administration office, concrete mixing and aggregate processing plant, steel yard, fuel storage stores, etc.

These items shall be erected and operated by the EPC Contractor. The area for these items should be as close as possible to the construction site and organized in such a way that no disturbance to the construction activities occurs. The estimated time for mobilization / site installations is 1.5 month.

10.4.3 Temporary Diversion Channel

Construction of temporary diversion channel shall be initiated as soon as possible during the canal closure period. Once the temporary diversion channel is excavated, the upstream and downstream cofferdams shall be constructed during the same canal closure period. This shall allow construction activities of the powerhouse and spillway to commence. The excavation of temporary diversion channel is estimated to be completed in 1.5 months.

10.4.4 Powerhouse and Spillway

Upon enclosing the powerhouse and spillway site, a time dense activity program must be carried out to excavate and install dewatering system. On completion of excavation, the steel reinforced base concrete shall be poured and subsequent concrete works shall be completed leaving spaces for second stage concreting which shall be placed during installation of embedded part for turbine/draft tube/stoplogs.

The superstructure shall be accordingly completed in accordance with the planned sequence. The draft tube liner and turbine embedded part shall be available for installation during the second stage concreting. The powerhouse and spillway substructure and superstructure does not require unusual construction techniques or methods for reinforced concrete construction.

The powerhouse roof shall be constructed alongwith the installation of powerhouse crane, which can be used for turbine, generator and installation of other E&M equipment. Backfilling around powerhouse and spillway shall be done upon completion of upstream and downstream retaining walls. All these activities related to powerhouse and spillway construction shall require 10 months. The finishing works of Powerhouse and Spillway shall be completed parallel to testing and commissioning of the plant.

Upon completion of spillway alongwith gates, canal flows shall be diverted toward the powerhouse & spillway after removal of upstream & downstream coffer dams. Flows through the turbine shall be stopped by placing stoplogs upstream and downstream.

10.4.5 Upstream & Downstream Transitions

Construction of upstream & downstream transitions shall be taken up alongside the construction of powerhouse. The excavation and compaction shall consume 2 months followed by concreting of foundation slab and walls in 2 months.

10.4.6 Canal Protection works U/s & D/s of Powerhouse

To avoid disruption of the irrigation supplies from the BRBD after the construction of the project, it is planned to carryout protective measures of bed and both banks of the canal by placing stone apron and raising both banks of the canal upstream and downstream of the canal. Utmost efforts shall have to be made to complete the work before the end of canal closure period.

10.4.7 Procurement and Installation of Major E&M Equipment

The scheduling and procurement of major equipment shall be the responsibility of the EPC contractor. Procurement of major equipment requires careful planning so that installation can be finished prior to desire commissioning date.

a. Turbine, Generator & Other E&M Equipment

The critical items are the procurement of turbine and generator which needs to be planned carefully to avoid delay in the project. The process of procuring hydropower turbine, generator and other E&M equipment shall take about 10 months, whereas, about 04 months shall be required for installation of these equipment.

b. Switchyard Equipment

In parallel of procurement of E&M equipment for powerhouse, switch yard equipment shall be procured. The transmission and interconnection works shall require 03 months. However, the transmission line shall be constructed by Power Purchaser.

The switchyard equipment is not a critical task. The equipment can be easily procured from the local market. Installation shall require no more than 02 months.

c. Spillway Gates

Installation of gates is also not a critical path of supply for construction completion. Once the spillway civil works are completed, the embedded parts installed, the gates shall be installed. Testing of gates shall be conducted parallel to turbine testing. The fabrication of the gates needs to be started parallel with civil construction.

10.4.8 Testing and Commissioning

Testing and commissioning includes testing of all equipment and facilities, operational test of electromechanical equipment under load conditions (both dry and wet condition) and safety tests. The activities require 01 month after erection of the E&M equipment.

10.4.9 Miscellaneous Works

The miscellaneous works include rectification of punch list items (if any), dumping of the excavated earthfill and landscaping works. The excavated material can be spread on the canal banks and tracks throughout along the Project area to strengthen them, filling of low lying areas and landscaping of the Project area.

10.5 CONCLUSION

- Based on the project scope, construction quantities, sequence of activities and their dependence on canal closure, the total construction period of 22 months is estimated.

- It should be noted that construction of temporary diversion channel must be finished before mid of April to use the closing time for diverting the main canal and to start powerhouse and spillway construction.

- Special consideration should be given to the critical tasks related to the canal closure and schedule delivery of Turbine, Generator & other E&M equipment to site.

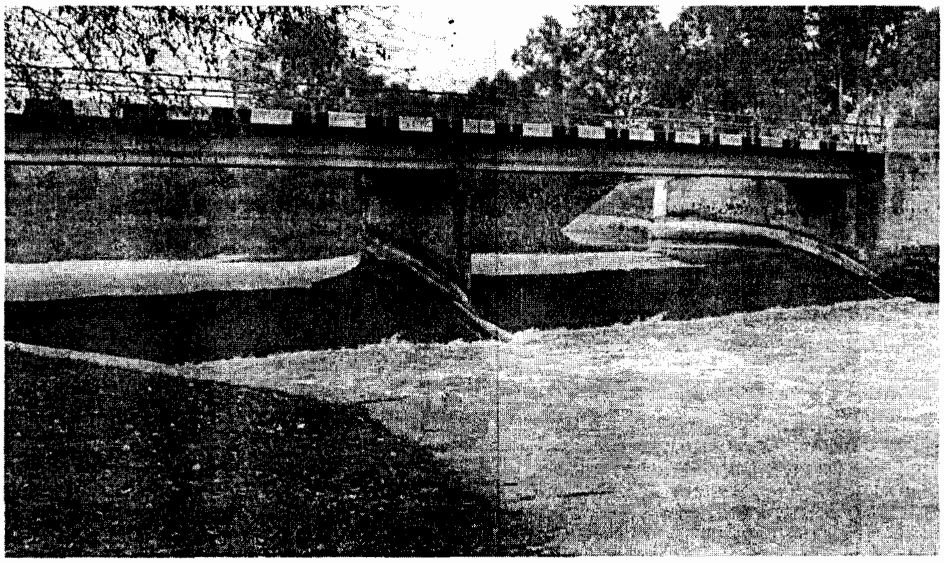
Report No. PPI-265.3-Final/17

PPI

INTERCONNECTION STUDY

For

2.45 MW Kasur Hydro-Power Project by M/s Packages Power (Pvt.) Limited, District Kasur, Punjab



Final Report
(October 2017)

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Executive Summary

- The Final Report of 2.45 MW Kasur Hydropower Project by M/s Packages Power (Pvt.) Limited, referred to as Packages-PP, is submitted herewith. The maximum net power of the plant would be 2.4255 MW.
- The latest generation, transmission plan and load forecast of NTDC has been used for the study, attached in Appendix – A.
- The study objective, approach and methodology have been described and the plant's data received from the client is validated.
- The latest system data of LESCO was obtained from LESCO PMU department during meeting held at their office.
- The interconnection study of Packages-PP to evacuate its maximum power of 2.4255 MW is envisaged and studied in detail for M/s Packages Power (Pvt.) Limited.
- Due to the location of Packages-PP, the most feasible interconnection scheme would be 6 km 11 kV double circuit to Kasur grid station from the proposed Packages-PP on Osprey conductor. The up-coming chapters discuss in detail the location and interconnection of the Packages-PP. A few approximate sketches are shown in Appendix-B.

  The proposed scheme will require the following equipment at 11 kV switchgear of Packages-PP:

  - One breaker panels of 11 kV for connecting One Generating Units
  - Two 11 kV breaker/line bays need to be added with 11 kV Bus Bar of Packages-PP.
- In view of planned COD, of the Packages-PP in October 2019, the above proposed interconnection scheme has been assessed for steady state conditions through detailed load flow studies, short circuit analysis and stability criterion for January 2020 for maximum thermal power dispatches in the grid during winter.
- Detailed load flow studies have been carried out for the peak load conditions of January 2020 for the schemes considered under normal and N-1 contingency conditions to meet the reliability criteria. Load flow studies have also been carried out for summer scenario as well, the high-water season, its detail analysis has also been carried out for September 2020.

- In an extended term scenario, September 2022 has been studied to evaluate the performance of the proposed interconnection scheme. The system conditions of normal and N-1 contingency have been examined for all scenarios to meet the reliability criteria. All the study scenarios were agreed with LESCO in the kickoff meeting. Along with it, short circuit and dynamic stability analysis have been carried out for a complete check of the system.
- The short circuit level of the Packages-PP 11 kV is 7.13 kA and 6.97 kA for 3-phase and 1-phase faults respectively for the year 2022. Therefore, industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at 11 kV switchyard of Packages-PP taking care of any future generation additions and system reinforcements in its electrical vicinity and also fulfill the NEPRA Grid Code requirements specified for 11 kV switchgears. There are no violations of exceeding the rating of the equipment in the vicinity of Packages-PP due to contribution of fault current from it.
- The power and energy loss calculations have also been done for the plant.
- The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability check for the worst case of three phase fault right on the 11 kV bus bar of Packages-PP substation followed by the final trip of 11 kV circuits emanating from this substation, has been performed for fault clearing within 9 cycles (180 ms). The system is found strong enough to stay stable and recovered with fast damping. The stability of system for far end faults of 3-phase has also been checked. The proposed scheme successfully passed the dynamic stability checks for near and far-end faults.
- The proposed scheme of interconnection has no technical constraints or problems, it meets all the criteria of reliability and stability under steady state load flow, short circuit currents and dynamic/transient conditions; and is therefore recommended to be adopted.

Report Contents

Appendices

Appendix –A: Generation, Transmission Plan, Load Forecast of NTDC and PMS of LESCO for Chapter – 4

Appendix –B: Maps & Sketches

Appendix –C: Plotted Results of Load Flow for Chapter – 5

Appendix –D: Results of Short Circuit Calculations for Chapter – 6

Appendix –E: Plotted Results of Stability Analysis for Chapter – 7

Appendix –F: Generator Data and Dynamic Data for Stability

1. Introduction

1.1. BACKGROUND

The proposed project is Packages-PP to be located at RD. 509+712 on BRBD Link Canal, District Kasur, Punjab situated in the concession area of Lahore Electricity Supply Company (LESCO). The location of Packages-PP is shown in Appendix-B. The net output planned to be generated from the site is about 2.4255 MW of electrical power. The project is expected to start commercial operation by the October 2019. The electricity generated from this project would be supplied to the grid system of LESCO through the 132 kV Kasur grid station available in the vicinity of this project.

1.2. OBJECTIVES

The overall objective of the Study is to develop an interconnection scheme between Packages-PP and LESCO network, for stable and reliable evacuation of 2.4255 MW of electrical power generated from this plant, fulfilling N-1 reliability criteria. The specific objectives are:

1. To develop schemes of interconnections at 11 kV of which right of way (ROW) and space at the terminal substations would be available.
2. To determine the performance of interconnection scheme during steady state conditions of system, normal and N-1 contingency, through load-flow analysis.
3. To check if the contribution of fault current from this new plant increases the fault levels at the adjoining substations at 11 kV and 132 kV voltage levels to be within the rating of equipment of these substations, and also determine the short circuit ratings of the proposed equipment of the substation at Packages-PP.
4. To check if the interconnection withstands dynamic stability criteria of post fault recovery with good damping after 3-phase faults on the system.

1.3. PLANNING CRITERIA

The planning criteria required to be fulfilled by the proposed interconnection is as follows:

Steady State:

Voltage	± 5 %, Normal Operating Condition ± 10 %, Contingency Conditions
Frequency	50 Hz, Continuous, ± 1% variation steady state 49.4 - 50.5 Hz, Short Time
Power Factor	0.85 Lagging; 0.9 Leading

Dynamic/Transient:

The system should revert to normal condition after dying out of transients without losing synchronism with good damping.

- For 132 kV and above, the total normal fault clearing time from the instant of initiation of fault current to the complete interruption of current, including the relay time and breaker interruption time to isolate the faulted element, is equal to 100 ms (5 cycles).

- For 11 kV the total normal fault clearing time from the instant of initiation of fault current to the complete interruption of current, including the relay time and breaker interruption time to isolate the faulted element, is equal to 180 ms (9 cycles).

2. Assumptions of Data

The number of new generating units at Packages-PP will be one. As per the data provided by the client following data has been modeled

2.1. PACKAGES-PP DATA

Generator data:

Number of Generating Units	= 1
Normal rating of generating units	= 2.45 MW
Maximum generating capacity	= 1 x 2.45 = 2.45 MW
Power factor	= 0.85 lagging/leading
MVA capacity	= 2.92 MVA
Inertia Constant	= 1.7980 MW-sec/MVA
Generating Voltage	= 6.3 kV

Generator Step-up Transformer Data:

Voltage Ratio	= 6.3/11 kV
GSU Percent Impedance	= 4 % at rated MVA

2.2. NETWORK DATA

The 132 kV network in the area near Packages-PP are as shown in Sketches in Appendix-B. The latest Generation Expansion Plan and Load Forecast of NTDC has been used as shown in Appendix-A. The network of LESCO in the vicinity of Packages-PP was verified during site visit held on 11th April 2017 by PPI engineers. A meeting was held on 27th April 2017 with LESCO PMU Department to discuss the interconnection scheme and study scenarios. Latest plans of LESCO were also obtained in the meeting. Further the interconnection scheme of Packages-PP was verified during site visit held on 16th August 2017 by LESCO PMU Department and PPI engineers.

3. Study Approach and Methodology

3.1. UNDERSTANDING OF THE PROBLEM

Packages-PP of 2.4255 MW is going to be a low head hydropower project embedded in the distribution network of LESCO. The site of proposed project is located at a distance of about 6 km from the 132 kV Kasur G/S.

The interconnection scheme would be 6 km 11 kV double circuit to 132 kV Kasur G/S from proposed Packages-PP using Osprey conductor. One circuit is to be connected to Kasur 132/11 kV T-1 and the other is to be connected to Kasur 132/11 kV T-2.

3.2. APPROACH TO THE PROBLEM

The consultant has applied the following approaches to the problem:

- A base case network model has been prepared for the year 2020, comprising all 500kV, 220kV and 132 kV system, envisaging the load forecast, the generation additions and transmission expansions for that year particularly in LESCO.
- Month of January 2020 has been selected for the study of the base case because it represents the maximum thermal dispatch conditions and we can judge the maximum impact of the plant on the network in these conditions.
- Interconnection schemes without any physical constraints, like right of way or availability of space in the terminal substations, have been identified.
- Performed technical system studies for peak load conditions to confirm technical feasibility of the interconnection schemes. It is found that the scheme has been subjected to standard analysis like load flow, short circuit, and transient stability study to check the strength of the machines and the interconnection scheme under disturbed conditions.
- Determine the relevant equipment for the proposed technically feasible scheme.
- Recommend the technically most feasible scheme of interconnection.

4. Development of Schemes of Interconnection

4.1 THE EXISTING AND ONGOING NETWORK

The nearest existing LESCO interconnection facilities at the time of commissioning of Kasur Hydro Power Project would be as follows:

- 132 kV Kasur Substation
- 132 kV Kasur-New Substation

The existing 132 kV network available around the 132/11 kV grid station is shown in Sketch-1 & 2 in Appendix-B. There are multiple feeding points in the vicinity which provides reliability and voltage support to the system. All these substations provide a strong 220 kV and 500 kV network around the proposed plant. A strong system helps in stable operation of a power plant.

4.2 THE SCHEMES OF INTERCONNECTION OF PACKAGES-PP

The interconnection scheme would be 6 km 11 kV double circuit to 132 kV Kasur G/S from proposed Packages-PP using Osprey conductor. One circuit is to be connected to Kasur 132/11 kV T-1 and the other is to be connected to Kasur 132/11 kV T-2.

The proposed scheme will require the following equipment at 11 kV switchgear of Packages-PP:

- One breaker panels of 11 kV for connecting One Generating Units
- Two 11 kV breaker/line bays need to be added with 11 kV Bus Bar of Packages-PP.

5. Detailed Load Flow Studies

A base case has been developed for the peak load of January 2020, which represents maximum thermal condition and will allow us to judge the maximum impact of Packages-PP on the LESCO network, using the network data supplied/authorized by LESCO/NTDC.

5.1 BASE CASE JANUARY 2020, WITHOUT PACKAGES-PP

The results of load flow analysis without Packages-PP have been plotted under normal conditions in Exhibit 0.0 in Appendix-C. The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % off the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit 0.1	Khudian to Kasur 132 kV Single Circuit Out
Exhibit 0.2	Kasur-N to Kasur 132 kV Single Circuit Out
Exhibit 0.3	Raiwind to Kasur 132 kV Single Circuit Out
Exhibit 0.4	Kasur to Lulliani 132 kV Single Circuit Out
Exhibit 0.5	Raiwind III to Raiwind 132 kV Single Circuit Out

The load flow results show that there are no capacity constraints in the area surrounding and the voltage rating of the bus bars remain within their limits.

5.2 PEAK LOAD CASE JANUARY 2020: WITH PACKAGES-PP

The scenario of Packages-PP after the COD of the plant when it starts exporting 2.4255 MW to the LESCO network has been studied. The results of load flows with Packages-PP under normal conditions have been plotted in Exhibit 1.0 in Appendix-C.

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % off the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit 1.1	Package-PP to Kasur T-1 11 kV Single Circuit Out
Exhibit 1.2	Khudian to Kasur 132 kV Single Circuit Out
Exhibit 1.3	Kasur-N to Kasur 132 kV Single Circuit Out
Exhibit 1.4	Raiwind to Kasur 132 kV Single Circuit Out
Exhibit 1.5	Kasur to Lulliani 132 kV Single Circuit Out
Exhibit 1.6	Raiwind III to Raiwind 132 kV Single Circuit Out

We find that power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 10 % off the nominal for contingency conditions' criteria. We find no capacity constraints on 132 kV circuits under normal and contingency conditions.

5.3 PEAK LOAD CASE SEPTEMBER 2020: WITH PACKAGES-PP

The scenario of Packages-PP during the summer season, for the month of September with maximum hydel dispatches, has been studied. The results of load flows with Packages-PP under normal conditions have been plotted in Exhibit 2.0 in Appendix-C.

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % off the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit 2.1	Package-PP to Kasur T-1 11 kV Single Circuit Out
Exhibit 2.2	Khudian to Kasur 132 kV Single Circuit Out
Exhibit 2.3	Kasur-N to Kasur 132 kV Single Circuit Out

Exhibit 2.4 Raiwind to Kasur 132 kV Single Circuit Out

Exhibit 2.5 Lulliani to Kasur 132 kV Single Circuit Out

Exhibit 2.6 Raiwind III to Raiwind 132 kV Single Circuit Out

We find that power flows on the circuits are well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 10 % of the nominal for contingency conditions' criteria.

5.4 PEAK LOAD CASE SEPTEMBER 2022: EXTENDED TERM SCENARIO

The future scenario of Packages-PP during the summer season has been studied. The results of load flows with Packages-PP under normal conditions have been plotted in Exhibit 3.0 in Appendix-C.

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % off the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit 3.1 Package-PP to Kasur T-1 11 kV Single Circuit Out

Exhibit 3.2 Khudian to Kasur 132 kV Single Circuit Out

Exhibit 3.3 Kasur-N to Kasur 132 kV Single Circuit Out

Exhibit 3.4 Raiwind to Kasur 132 kV Single Circuit Out

Exhibit 3.5 Kasur to Kasur-II 132 kV Single Circuit Out

Exhibit 3.6 Raiwind III to Raiwind 132 kV Single Circuit Out

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 10 % off the nominal for contingency conditions' criteria.

We find that there are no capacity constraints in the proposed connectivity scheme even in the up-coming years i.e. 2022.

5.5 POWER AND ENERGY LOSS CALCULATIONS

5.5.1 NORMAL CASE (EXHIBIT 1.0)

Power Loss

$$Power\ Loss = \frac{Power\ Sent - Power\ Delivered}{Total\ Power}$$

$$\text{Power Loss} = \frac{2.4255 - 2.4065}{2.4255}$$

% Power Loss = 0.78%

Energy Loss

$$Energy\ Loss = \frac{Energy\ Sent - Actual\ Energy\ Received}{Energy\ Sent\ at\ Installed\ Capacity}$$

$Actual\ Energy\ Received$ = 0.5002 (plant factor) x 2.4065 MW x 8760 hrs

$Actual\ Energy\ Received$ = 10544.68 MWh

$Energy\ Sent\ at\ Installed\ Capacity$ = 0.5002 (plant factor) x 2.4255MW x 8760 hrs

$Energy\ Sent\ at\ Installed\ Capacity$ = 10627.94 MWh

$$\text{Energy Loss} = \frac{10627.94 - 10544.68}{10627.94}$$

% Energy Loss = 0.78%

5.5.2 CONTINGENCY CASE (EXHIBIT 1.0A)

Power Loss

$$Power\ Loss = \frac{Power\ Sent - Power\ Delivered}{Total\ Power}$$

$$\text{Power Loss} = \frac{2.4254 - 2.3907}{2.4254}$$

% Power Loss = 1.43 %

Energy Loss

$$Energy\ Loss = \frac{Energy\ Sent - Actual\ Energy\ Received}{Energy\ Sent\ at\ Installed\ Capacity}$$

$Actual\ Energy\ Received$ = 0.5002 (plant factor) x 2.3907 MW x 8760 hrs

$Actual\ Energy\ Received$ = 10475.45 MWh

$Energy\ Sent\ at\ Installed\ Capacity$ = 0.5002 (plant factor) x 2.4254 MW x 8760 hrs

$Energy\ Sent\ at\ Installed\ Capacity$ = 10627.50 MWh

$$\text{Energy Loss} = \frac{10627.50 - 10475.45}{10627.50}$$

% Energy Loss = 1.43 %

5.6 CONCLUSION OF LOAD FLOW ANALYSIS

From the analysis discussed above, we conclude that the proposed interconnection schemes are adequate to evacuate the maximum 2.4255 MW power from Packages-PP under normal and contingency conditions in January 2020 cases.

It was found that in 2020 all the contingency conditions the surrounding circuits remain within the rated capacity. Also the bus bar voltages were well within the permissible limits in all the contingency events.

The scenario of September 2020 and 2022 was also evaluated and found to be stable under normal and contingency cases.

6. <u>Short Circuit Analysis</u>

6.1. METHODOLOGY AND ASSUMPTIONS

The methodology of IEC 909 has been applied in all short circuit analyses in this report for which provision is available in the PSS/E software used for these studies. The maximum fault currents have been calculated with the following assumptions under IEC 909:

- Set tap ratios to unity
- Set line charging to zero
- Set shunts to zero in positive sequence
- Desired voltage magnitude at bus bars set equal to 1.10 P.U. i.e. 10 % higher than nominal, which is the maximum permissible voltage under contingency condition.

For evaluation of maximum short circuit levels we have assumed contribution in the fault currents from all the installed generation capacity of hydel, thermal and nuclear plants in the system in the year 2020 and 2022 i.e. all the generating units have been assumed on-bar in fault calculation's simulations.

The assumptions about the generator and the transformers data are the same as mentioned in Chapter.2 of this report.

6.2. FAULT CURRENT CALCULATIONS WITHOUT PACKAGES-PP

In order to assess the short circuit strength of the network of 132 kV and 11 kV without Packages-PP for the grid of LESCO/NTDC in the vicinity of the site of the plant, fault currents have been calculated for balanced three-phase and unbalanced single-phase short circuit conditions. These levels will not only give us the idea of the fault levels of Kasur G/S and other grid stations in the vicinity without Packages-PP but would also help us determine how much the contribution of fault current from Packages-PP later on may add to the existing levels.

The results are attached in Appendix – D.

The short circuit levels have been represented graphically on the bus bars of 132 kV and 11 kV which are shown in the Exhibit 4.0 attached in Appendix-D.

The fault currents in the Exhibit are given in polar coordinates i.e. the magnitude and the angle of the current. The total fault current is shown below the bus bar.

The tabular output of the short circuit calculations is also attached in Appendix-D for the 132 kV and 11 kV bus bars of our interest i.e. the substations connecting in the 132 kV and 11 kV circuits lying close to Packages-PP. The total maximum fault currents for 3-phase and 1-phase short circuit at these substations are summarized in Table 6.1. We see that the maximum fault currents do not exceed the short circuit ratings of the equipment at these 132 kV substations which normally are 20 kA, 25 kA or 31.5 kA for older substations and 40 kA for new substations.

Table 6.1
Maximum Short Circuit Levels without Packages-PP

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Kasur T-1 11 kV	17.82	18.02
Kasur T-2 11 kV	17.82	18.02
Kasur 132 kV	15.20	10.16
Kasur-N 132 kV	14.93	9.95
Khudian 132 kV	13.96	9.22
Lulliani 132 kV	8.84	5.65
Raiwind 132 kV	15.43	10.70
Raiwand III 132 kV	17.97	13.15
Packages 132 kV	10.00	6.49
H.Teri 132 kV	16.81	12.20
Master 132kV	16.38	11.93
Indus 132 kV	17.45	13.02

6.3. MAXIMUM FAULT CURRENT CALCULATIONS WITH PACKAGES-PP

The fault currents have been calculated for the electrical interconnection of proposed scheme for the Year 2020. Fault types applied are three phase and single-phase at the 11 kV bus bar of Packages-PP itself and other bus bars of the 132 kV and 11 kV substations in the electrical vicinity of Packages-PP. The graphic results are shown in Exhibit 4.1.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV and 11 kV bus bars of the network in the electrical vicinity of Packages-PP are placed in Appendix-C. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.2

Table 6.2
Maximum Short Circuit Levels with Packages-PP- Year 2020

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Packages PP 11 kV	7.02	4.86
Kasur T-1 11 kV	17.82	18.02
Kasur T-2 11 kV	17.82	18.02
Kasur 132 kV	15.20	10.16
Kasur-N 132 kV	14.93	9.95
Khudian 132 kV	13.96	9.22
Lulliani 132 kV	8.84	5.65
Raiwind 132 kV	15.43	10.70
Raiwand III 132 kV	17.97	13.15
Packages 132 kV	10.00	6.49
H.Teri 132 kV	16.81	12.20
Master 132kV	16.38	11.93
Indus 132 kV	17.45	13.02

The short circuit level at Packages-PP 11 kV bus bar is 7.02 kA and 4.86 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at the 11 kV substation of Packages-PP. It would provide large margin for any future increase in short circuit levels due to future generation additions and network reinforcements in this area.

6.4. MINIMUM FAULT CURRENT CALCULATIONS WITH PACKAGES-PP

The minimum fault currents have been calculated for minimum dispatch of power in the grid system for the electrical interconnection of proposed scheme for the Year 2020. Fault types applied are three phase and single-phase at the 11 kV bus bar of

Packages-PP itself and other bus bars of the 132 kV and 11 kV substations in the electrical vicinity of Packages-PP. The graphic results are shown in Exhibit 4.2.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV and 11 kV bus bars of the network in the electrical vicinity of Packages-PP are placed in Appendix-D. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.3.

Table 6.3
Minimum Short Circuit Levels with Packages-PP- Year 2020

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Packages PP 11 kV	6.05	4.19
Kasur T-1 11 kV	15.36	15.55
Kasur T-2 11 kV	15.36	15.55
Kasur 132 kV	12.59	8.52
Kasur-N 132 kV	12.38	8.35
Khudian 132 kV	11.56	7.70
Lulliani 132 kV	7.47	4.82
Raiwind 132 kV	12.81	9.00
Raiwand III 132 kV	14.84	11.02
Packages 132 kV	8.42	5.51
H.Teri 132 kV	13.94	10.26
Master 132kV	13.59	10.04
Indus 132 kV	14.45	10.93

6.5. MAXIMUM FAULT CURRENT CALCULATIONS WITH PACKAGES-PP: FUTURE SCENERIO

The fault currents have been calculated for the electrical interconnection of proposed scheme for the future year 2022. Fault types applied are three phase and single-phase at the 11 kV bus bar of Packages-PP itself and other bus bars of the 132 kV and 11 kV substations in the electrical vicinity of Packages-PP. The graphic results are shown in Exhibit 4.3.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV and 11 kV bus bars of the network in the electrical vicinity of Packages-PP and the 11 kV bus bars of Packages-PP are placed in Appendix-D. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.4

Table 6.4
Maximum Short Circuit Levels with Packages-PP- Year 2022

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Packages PP 11 kV	7.13	6.97
Kasur T-1 11 kV	18.24	18.83
Kasur T-2 11 kV	18.24	18.83
Kasur 132 kV	17.31	12.02
Kasur-N 132 kV	17.03	11.82
Khudian 132 kV	15.18	10.05
Lulliani 132 kV	9.26	5.95
Raiwind 132 kV	17.05	11.96
Raiwand III 132 kV	19.46	14.45
Packages 132 kV	10.85	7.16
H.Teri 132 kV	17.68	12.97
Master 132kV	17.37	12.79
Indus 132 kV	18.37	13.87

6.6. CONCLUSION OF SHORT CIRCUIT ANALYSIS

The short circuit analysis results show that for the proposed scheme of interconnection of Packages-PP Feeder, we don't find any violations of short circuit ratings of the already installed equipment on the 132 kV and 11 kV equipment of substations in the vicinity of Packages-PP due to fault current contributions from this plant under three-phase faults as well as single phase faults.

The short circuit level at Packages-PP 11 kV bus bar is 7.13 kA and 6.97 kA for 3-phase and 1-phase faults respectively for 2020 and 7.02 kA and 4.86 kA for 3-phase and 1-phase faults respectively for 2022. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at 11 kV substation of Packages-PP taking care of any future generation additions in its electrical vicinity.

7. Dynamic Stability Analysis

7.1 ASSUMPTIONS & METHODOLOGY

7.1.1 Dynamic Models

The assumptions about the generator and its parameters are the same as mentioned in Chapter-2 of this report.

We have employed the generic dynamic models available in the PSS/E model library for dynamic modeling of the generator, exciter and the governor as follows;

Generator	GENSAL
Excitation System	EXST1
Speed Governing System	HYGOV

7.1.2 System Conditions

We have used the system conditions of January 2020, which represents the maximum thermal dispatch condition. Most of the generators in LESCO power system in the vicinity of Packages-PP would be running nearly at their full output.

We have carried out the Dynamic Stability analysis for Packages-PP with the proposed interconnection scheme. All the power plants of WAPDA /NTDC from Tarbela to Hub have been dynamically represented in the simulation model.

7.1.3 Presentation of Results

The plotted results of the simulation runs are placed in Appendix-E. Each simulation is run for its first one second for the steady state conditions of the system prior to fault or disturbance. This is to establish that the pre fault/disturbance conditions of the network under study were smooth and steady. Post fault recovery has been monitored for nine seconds. Usually all the transients due to non-linearity die out within 2-3 seconds after disturbance is cleared from the system.

7.1.4 Worst Fault Cases

Three phase faults are considered as the worst disturbances in the system. Normally we apply 3 phase fault on the bus bar of the power plant, followed by tripping of a circuit emanating from that bus, and trip one of the generators of the plant and / or trip one of the inter-bus transformers if there are two voltage levels in the switching station of the plant. Also we apply 3-phase fault at bus bars at far end of the interconnection of the plant and trip circuit or transformer as the case may be. The fault clearing time of 11 kV breakers has been assumed 9 cycles as the switchgear of the medium voltages are slow.

7.2 DYNAMIC STABILITY SIMULATIONS' RESULTS

7.2.1 Three-Phase Fault at 11 kV Packages-PP

We applied three-phase fault on Packages-PP 11 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of 11 kV circuit between Packages-PP and Kasur-T2 11 kV. We monitored different parameters for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows;

Fig. 1.1 Bus Voltages

The bus voltages of 11 kV bus bar of Packages-PP, Kasur-T1, Kasur-T2 and 132 kV substations of Kasur, Kasur-New and Khudian are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 1.2 Frequency

We see that the system frequency recovers its normal condition quickly after fault clearance.

Fig. 1.3 MW/MVAR Output of Generators of Packages-PP

The pre-fault output of a generator at Packages-PP was 2.4255 MW and it gets back to the same output quickly after fast damping of the oscillations in its output.

Fig. 1.4 Speed and mechanical power of Generators at Packages-PP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 1.5 MW/MVAR Flow on Packages-PP to Kasur-T1 11 kV circuit

Followed by clearing of fault, the trip of the 11 kV circuit from Packages-PP to Kasur-T2 11 kV circuit caused the entire output of 2.4255 MW to flow through the intact circuit of 11 kV between Packages-PP to Kasur-T1 11 kV. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 1.6 Rotor Angles

The rotor angles of the generators of Packages-PP, Reshma-PP, Saphire, Orient-P and Nishat-P are plotted relative to machines at Tarbela. The results show that the rotor angle of Packages-PP recovers its normal condition after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is stable and very strong in damping the post fault oscillations.

7.2.2 Three-Phase Fault at 11 kV Kasur-T1

We applied three-phase fault on Kasur-T1 11 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of 11 kV circuit between Packages-PP and Kasur-T1 11 kV. We monitored different parameters for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows;

Fig. 2.1 Bus Voltages

The bus voltages of 11 kV bus bar of Kasur-T1, Packages-PP, Kasur-T2 and 132 kV substations of Kasur, Kasur-New and Khudian are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 2.2 Frequency

We see that the system frequency recovers its normal condition quickly after fault clearance.

Fig. 2.3 MW/MVAR Output of Generators of Packages-PP

The pre-fault output of a generator at Packages-PP was 2.4255 MW and it gets back to the same output quickly after fast damping of the oscillations in its output.

Fig. 2.4 Speed and mechanical power of Generators at Packages-PP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 2.5 MW/MVAR Flow on Packages-PP to Kasur-T2 11 kV circuit

Followed by clearing of fault, the trip of the 11 kV circuit from Packages-PP to Kasur-T1 11 kV circuit caused the entire output of 2.4255 MW to flow through the intact circuit of 11 kV between Packages-PP to Kasur-T2 11 kV. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 2.6 Rotor Angles

The rotor angles of the generators of Packages-PP, Reshma-PP, Saphire, Orient-P and Nishat-P are plotted relative to machines at Tarbela. The results show that the rotor angle of Packages-PP recovers its normal condition after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is stable and very strong in damping the post fault oscillations.

7.2.3 Three-Phase Fault at 11 kV Kasur-T2

We applied three-phase fault on Kasur-T2 11 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of 11 kV circuit between Packages-PP and Kasur-T2 11 kV. We monitored different parameters for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows;

Fig. 3.1 Bus Voltages

The bus voltages of 11 kV bus bar of Kasur-T2, Packages-PP, Kasur-T1 and 132 kV substations of Kasur, Kasur-New and Khudian are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 3.2 Frequency

We see that the system frequency recovers its normal condition quickly after fault clearance.

Fig. 3.3 MW/MVAR Output of Generators of Packages-PP

The pre-fault output of a generator at Packages-PP was 2.4255 MW and it gets back to the same output quickly after fast damping of the oscillations in its output.

Fig. 3.4 Speed and mechanical power of Generators at Packages-PP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 3.5 MW/MVAR Flow on Packages-PP to Kasur-T1 11 kV circuit

Followed by clearing of fault, the trip of the 11 kV circuit from Packages-PP to Kasur-T2 11 kV circuit caused the entire output of 2.4255 MW to flow through the intact circuit of 11 kV between Packages-PP to Kasur-T1 11 kV. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 3.6 Rotor Angles

The rotor angles of the generators of Packages-PP, Reshma-PP, Saphire, Orient-P and Nishat-P are plotted relative to machines at Tarbela. The results show that the rotor angle of Packages-PP recovers its normal condition after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is stable and very strong in damping the post fault oscillations.

7.2.4 Three-Phase Fault at 132 kV Kasur

We applied three-phase fault on Kasur 132 kV bus bar, cleared fault in 5 cycles (100 ms) followed by trip of 132 kV circuit between Kasur and Khudian grid stations. We monitored different parameters for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows;

Fig. 4.1 Bus Voltages

The bus voltages of 11 kV bus bar of Packages-PP, Kasur-T1 and 132 kV substations of Kasur, Kasur-New, Khudian and Raiwind are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 4.2 Frequency

We see that the system frequency recovers its normal condition quickly after fault clearance.

Fig. 4.3 MW/MVAR Output of Generators of Packages-PP

The pre-fault output of a generator at Packages-PP was 2.4255 MW and it gets back to the same output quickly after fast damping of the oscillations in its output.

Fig. 4.4 Speed and mechanical power of Generators at Packages-PP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 4.5 MW/MVAR Flow on Kasur to Khudain 132 kV circuit

Followed by clearing of fault, the trip of the 132 kV circuit from Kasur to Khudian 132 kV circuit caused the entire output to flow through the intact circuit of 132 kV between Kasur to Khudian 132 kV second circuit. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 4.6 Rotor Angles

The rotor angles of the generators of Packages-PP, Reshma-PP, Saphire, Orient-P and Nishat-P are plotted relative to machines at Tarbela. The results show that the rotor angle of Packages-PP recovers its normal condition after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is stable and very strong in damping the post fault oscillations.

7.2.5 Three-Phase Fault at 132 kV Kasur (Stuck Breaker)

We applied three-phase fault on Kasur 132 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of 132 kV circuit between Kasur and Khudian grid stations. We monitored different parameters for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows;

Fig. 5.1 Bus Voltages

The bus voltages of 11 kV bus bar of Packages-PP, Kasur-T1 and 132 kV substations of Kasur, Kasur-New, Khudian and Raiwind are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 5.2 Frequency

We see that the system frequency recovers its normal condition quickly after fault clearance.

Fig. 5.3 MW/MVAR Output of Generators of Packages-PP

The pre-fault output of a generator at Packages-PP was 2.4255 MW and it gets back to the same output quickly after fast damping of the oscillations in its output.

Fig. 5.4 Speed and mechanical power of Generators at Packages-PP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 5.5 MW/MVAR Flow on Kasur to Khudain 132 kV circuit

Followed by clearing of fault, the trip of the 132 kV circuit from Kasur to Khudian 132 kV circuit caused the entire output to flow through the intact circuit of 132 kV between Kasur to Khudian 132 kV second circuit. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 5.6 Rotor Angles

The rotor angles of the generators of Packages-PP, Reshma-PP, Saphire, Orient-P and Nishat-P are plotted relative to machines at Tarbela. The results show that the rotor angle of Packages-PP recovers its normal condition after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is stable and very strong in damping the post fault oscillations.

7.3 CONCLUSION OF DYNAMIC STABILITY ANALYSIS

The results of dynamic stability show that the system is very strong and stable for the proposed schemes for the severest possible faults of 11 kV systems near Packages-PP. Therefore there is no problem of dynamic stability for interconnection of Packages-PP; it fulfills all the criteria of dynamic stability.

8. Conclusions

- ❖ The study objective, approach and methodology have been described and the plant's data received from the client is validated.
- ❖ The latest system data of LESCO was obtained from LESCO PMU department during meeting held at their office.
- ❖ The interconnection study of Packages-PP to evacuate its maximum power of 2.4255 MW is envisaged and studied in detail for M/s Packages Power (Pvt.) Limited.
- ❖ Due to the location of Packages-PP, the most feasible interconnection scheme would be 6 km 11 kV double circuit to Kasur grid station from the proposed Packages-PP on Osprey conductor. The up-coming chapters discuss in detail the location and interconnection of the Packages-PP. A few approximate sketches are shown in Appendix-B.

  The proposed scheme will require the following equipment at 11 kV switchgear of Packages-PP:

  - One breaker panels of 11 kV for connecting One Generating Units
  - Two 11 kV breaker/line bays need to be added with 11 kV Bus Bar of Packages-PP.
- ❖ In view of planned COD, of the Packages-PP in October 2019, the above proposed interconnection scheme has been assessed for steady state conditions through detailed load flow studies, short circuit analysis and stability criterion for January 2020 for maximum thermal power dispatches in the grid during winter.
- ❖ Detailed load flow studies have been carried out for the peak load conditions of January 2020 for the schemes considered under normal and N-1 contingency conditions to meet the reliability criteria. Load flow studies have also been carried out for summer scenario as well, the high-water season, its detail analysis has also been carried out for September 2020.
- ❖ In an extended term scenario, September 2022 has been studied to evaluate the performance of the proposed interconnection scheme. The system conditions of normal and N-1 contingency have been examined for all scenarios to meet the reliability criteria. All the study scenarios were agreed with LESCO in the kickoff

meeting. Along with it, short circuit and dynamic stability analysis have been carried out for a complete check of the system.

- The short circuit level of the Packages-PP 11 kV is 7.13 kA and 6.97 kA for 3-phase and 1-phase faults respectively for the year 2022. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at 11 kV switchyard of Packages-PP taking care of any future generation additions and system reinforcements in its electrical vicinity and also fulfill the NEPRA Grid Code requirements specified for 11 kV switchgears. There are no violations of exceeding the rating of the equipment in the vicinity of Packages-PP due to contribution of fault current from it.
- The power and energy loss calculations have also been done for the plant.
- The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability check for the worst case of three phase fault right on the 11 kV bus bar of Packages-PP substation followed by the final trip of 11 kV circuits emanating from this substation, has been performed for fault clearing within 9 cycles (180 ms). The system is found strong enough to stay stable and recovered with fast damping. The stability of system for far end faults of 3-phase has also been checked. The proposed scheme successfully passed the dynamic stability checks for near and far-end faults.
- The proposed scheme of interconnection has no technical constraints or problems, it meets all the criteria of reliability and stability under steady state load flow, short circuit currents and dynamic/transient conditions; and is therefore recommended to be adopted.

Annexure L : Initial Environmental Examination

EXECUTIVE SUMMARY

INTRODUCTION

This executive summary presents an overview of the main findings of the Initial Environmental Examination (IEE) report for installation of 2.45 MW Hydropower Plant at Bambawali-Ravi-Bedian Canal (BRB) at RD 509+712 within main Link canal in Kasur. Packages Power Energy (Pvt.) Limited is the private investor in Punjab Power Development Board (PPDB) under Power Generation Policy, 2006.The project aims to generate electricity, hydroelectricity has a higher value than base power and a much higher value compared to intermittent energy sources.

Punjab Irrigation Department along Packages is committed to abide by all applicable legal and regulatory requirements and shall orient for continual improvement including prevention of pollution by establishing and monitoring of its quality and environmental objectives. The Chief Executive and management are committed to communicate and maintain this policy at all levels of the company and achieve continual improvement through teamwork.

SALIENT FEATURE OF PROJECT

Title and Location of Project:

Kasur Hydropower Project of 2.45 MW involves the development of hydropower plant utilizing the energy and power potential of fall at RD 509+712. The salient features of fall structure are as under:

- Upstream Full Supply Level = 673.72 ft.
- Downstream Full Supply Level = 654.45 ft.
- Upstream Bed Level = 666.72 ft.
- Downstream Bed Level = 647.45 ft.
- No. of Bays = 1 No.

- Width of Bay = 85 ft.
- Discharge = 2280 cusecs.

Name of Proponent:

Packages Power (Pvt.) Limited is the proponent for 2.45 MW Hydropower Plant at Bambawali-Ravi-Bedian Canal (BRB).

Environmental Consultants

An Initial Environmental Examination (IEE) report has been prepared to identify and predict the significant environmental impacts likely to arise from the commencement of the project along with environmental impact statement followed by delineation of appropriate Environmental Management Plan and Environmental Monitoring Plan to check the implementation of the EMP. Proponent of 2.45 MW Hydropower Plant has decided to conduct IEE study through Environmental Consultants, AIPEL 204-Eden Heights, Jail Road Lahore

0301-4276787 & 0303 9683522
info@aipel.com.pk, ecosphiron@gmail.com

A Brief Outline of Proposal

Packages Power Energy (Pvt.) Limited, located in Lahore as well as in Kasur, is intending to install Hydropower Plant at Bambawali-Ravi-Bedian Canal(BRBD) at RD 509+712 within main Link canal. This plant generates electricity, serving Kasur city and it is a source of low-cost renewable energy. This plant generates electricity, serving Kasur city and it is a source of low-cost renewable energy. Hydropower can be generated wherever a flow of water descends from a higher level to a lower level.

The Major Impacts & Recommended Mitigation Measures

Keeping in view, all the findings of the baseline study, and through general observation and desktop study, and understanding of the activities and processes involved in the project, environmental impacts have been anticipated. Following impact assessment methodology; i.e. defining the criteria for evaluation of the impacts, identification of mitigation measures (all possible options), evaluation of the residual impacts and identification of the monitoring requirements, adequate and effective mitigation measures have been proposed for all power house construction and operation related likely environmental impacts of the project. These mitigation measures have been proposed in order of attempts to eliminate or minimize the impact, provide some compensation or rehabilitate the environment by some means.

Weather describes an impact as having both spatial and temporal impacts, which can be described as the change in an environmental parameter over a specified period and within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been initiated. A hydropower project doubtlessly cause substantial landscape changes i.e creation of artificial reservoirs, and occurrence of waste dumps, power lines, access roads and also the use of the water resource characteristics are changes, local people possibilities to use the rivers might be deteriorate.

The expected impacts from the project are mostly insignificant and others are of limited nature. In this regard possible improvements and mitigation measures have been taken and at the site where these activities related to this plant happen, there is proper collection of waste and its disposal, and there is no need of the artificial reservoir, because on canal, power plant is constructed. The study also shows that there will be no exploitation and consequential depletion of the local natural resources.

The general approach to Environmental Management Plan for the Project, for the operational phase of the Project has been presented, along with an outline plan for the

Project Environmental Management Plans (EMPs). Site specific and practically suitable mitigation measures are recommended to mitigate the impacts.

Proposed Monitoring:

Monitoring at the proposed site has been conducted for ambient air, noise, water and the reports demonstrated that results are within the limits prescribed by PEQS (2016). The detail of these parameters is present in baseline study of project and lab reports are attached herewith this IEE report as annexure.

Conclusion

The Initial Environmental Examination (IEE) contains description of the project, description of the environmental baselines, potential environmental impacts and suggested mitigation measures. An implementation mechanism for mitigation measures in the form of an Environmental Management Plan is included in the study.

While the objectives of this study have been to describe the project and its environmental impact, it also identifies adverse environmental factors associated with the project. Appropriate mitigation measures as explained in the environmental study should reduce, if not eliminate, these impacts so that these are within acceptable limits.

It is further concluded that all potential environmental concerns associated with the project have been adequately addressed, and no further study is required in this context.

The main key persons involved in finalizing IEE report are following;

Ms. Ayesha Siddiqua	**Ms. Shakeela Rani**	**Ms. Yusra Mahfooz**
Environmentalist	Environmentalist	Environmentalist

For the Proponent

I have reviewed the project IEE report and found the contents to be valid and true to the best of my knowledge and belief.

Abdus Samad Goraya
(Chief Executive)
Packages Power Energy (Pvt.) Limited

LIST OF ANNEXURE

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

1.1 Purpose of report and identification of the project:

Punjab Government has introduced its Power Generation Policy, 2006 and has also established Punjab Power Development Board (PPDB) for its implementation. Punjab Power Development Board will provide One Window Facility to the Private Investors for development of project based on any technology like Hydel, Thermal, Wind, Solar and Biomass. Private Investors are invited to invest in the Power Project to meet the energy shortage in the Province. Under this policy, Packages Power Energy (Pvt.) Limited, located in Lahore as well as in Kasur, is intending to install Hydropower Plant at Bambawali-Ravi-Bedian *Canal* (BRBD) at RD 509+712 within main Link canal. This plant generates electricity, serving Kasur city and it is a source of low-cost renewable energy.

Hydropower is a flexible source of electricity since stations can be ramped up and down very quickly to adapt to changing energy demands. Hydro turbines have a start-up time of the order of a few minutes. It takes around 60 to 90 seconds to bring a unit from cold start-up to full load; this is much shorter than for gas turbines or steam plants Power generation can also be decreased quickly when there is a surplus power generation. Hence the limited capacity of hydropower units is not generally used to produce base power except for vacating the flood pool or meeting downstream needs. Instead, it serves as backup for non-hydro generators. A hydroelectric generating station emits 100 times less Greenhouse Gases (GHG) than a coal-fired station.

This report intends to provide satisfactory mitigation measures to avoid/eliminate any chance of adverse environmental impact on the socio-cultural, economic and environmental components. This report also intends to fulfill the regulatory requirements set under Punjab Environmental Protection Act (Amended 2012) 1997 and its consequent legislative framework for IEE/EIA including the IEE/EIA Regulations 2000 and the guidelines drafted for IEE and EIA under numerous sectorial heads. The entire set of legislative framework requires any new development project to undergo an IEE or EIA based on the categorization of the project under Schedule I and/or Schedule II.

1.2 Identification of Proponent

Contact Person: Abdus Samad Goraya

Contact Number: 0092 (042) 35811191-94, 35811541-46

Address of the Contact Person: House # 372, Mohalla sector A-1 Township Lahore.

Designation: Chief Executive, Packages Power (Pvt.) Ltd.

1.3 Environmental Consultants

The Initial Environmental Examination (IEE) has been carried out by aptly skilled and duly qualified group of professionals working for the consulting Services namely M/s AIPEL. The consulting team can be approached through the following contact details:

AIPEL

204-Eden Heights, Jail Road Lahore

0092 423 5786823, 0092 0302 4592324, 0092 0301 4276787

info@aipel.com.pk, ecosphiron@gmail.com

1.4 Nature and Size of Project

Irrigation Department in sponsorship with Packages Power (Pvt.) limited is planning to install a 2.45 MW Hydropower Plant at Bambawali-Ravi-Bedian Canal (BRB) at RD 509+712 within main Link canal in Kasur. The Project is planned within main canal. Kasur Hydropower Project utilizes a net head of 5.77 m. The hydropower plant is conceived considering the fall structure at RD 509+712 of BRBD Link Canal whereby the available net head of 5.77 m and plant designed for a discharge of 62 Cumecs is considered for the development of this hydropower scheme. BRBD is a non-perennial canal due to which the discharge in this canal is only available from April to October every year. According to the hydrological data, the mean monthly discharges vary from 21.06 m^3 /s to 52.02 m^3 /s from April to October.

The project aims to generate electricity, hydroelectricity has a higher value than base power and a much higher value compared to intermittent energy sources. Hydropower is electrical energy produced through the power of moving water. In modern technology, hydropower moves turbines that pass on their energy to a generator which then produces electric power. Hydropower is a type of renewable energy, and once the power plant is constructed it produces little to no waste. It is a flexible source of electricity since stations can be ramped up and down very quickly to adapt to changing energy demands. Since hydroelectric dams do not use fuel, power generation does not produce carbon dioxide.

An efficient disposal system for domestic wastewater is present. The nature of wastewater will be domestic only. This is further explained under Environmental Impacts and Mitigation Measures as the proposed project will be small project. For domestic wastewater septic tank is present at project site. Solid waste during construction phase will be reused in construction activities while there will be no solid waste during operational phase. Adequate firefighting arrangements will be provided at power house at certain location to deal with any case of emergency.

1.5 Eco-Friendly Features of the Project

1.5.1 Green technology

The technology used in the proposed project is categorized under clean and efficient which will eventually improve the quality of local environment and promote sustainable use of natural resources.

1.5.2 Power House Pollution (Clean Energy project)

Power system mainly contains three parts namely generation, transmission and distribution. Generation means how to generate electricity from the available source and there are various methods to generate electricity but in this article we only focused on generation of electricity by the means of hydro or water (hydro power plant). A generating station which utilizes the potential energy of water at a high level for the generation of electrical energy is known as hydro-electric power station. Power plant is defined as the place where power is generated from a given source, so here the source is hydro that's why we called it hydro power plant. In hydro power plant gravitational force of fluid water used to run the turbine which is coupled with electric generator to produce electricity. This power plant plays an important role to protect our fossil fuel which is limited, because the generated electricity in hydro power station is the use of water which is renewable source of energy and available in lots of amount without any cost. In 2015 hydropower generated 16.6% of the world's total electricity and 70% of all renewable electricity, and was expected to increase about 3.1% each year for the next 25 years.

Clean and renewable hydropower is among the best solutions in the fight against climate change. The main advantages offered by the Hydropower Plant can be listed as follows:

- Clean power generation
- No production of greenhouse gases (ex: CO_2)
- No air polluting gases (NOx, SOx).
- Reduces global warming effect.

1.6 Location

The proposed project is to be located at district Kasur. The project site is surrounded by:

East: Agriculture land

West: Open land

North: Agriculture land

South: Open land

Based on the current land use of the proposed project, the said project is not located in an ecologically sensitive area.

Figure 1.1: Project Site

1.7 Extent/scope of IEE Study

This IEE report has been conducted in accordance with the requirements of PEPA, 1997 (amended 2012), IEE/EIA regulations 2000 as well as section 2.3 of the guidelines for the perpetration and review of environmental reports, November 1997/2000. This IEE report presents screening of potential environmental impacts of the proposed construction and operational phase and presents the necessary mitigation measures to eliminate or reduce the negative impacts to an acceptable level. The report provides an Environmental Management and Monitoring Plan and the institutional requirements for the implementation of this plan. The IEE process followed all the complementary stages described in the guidelines for IEE/EIA preparation and review. A brief flowchart exhibiting the different stages involved is in Figure 1.2

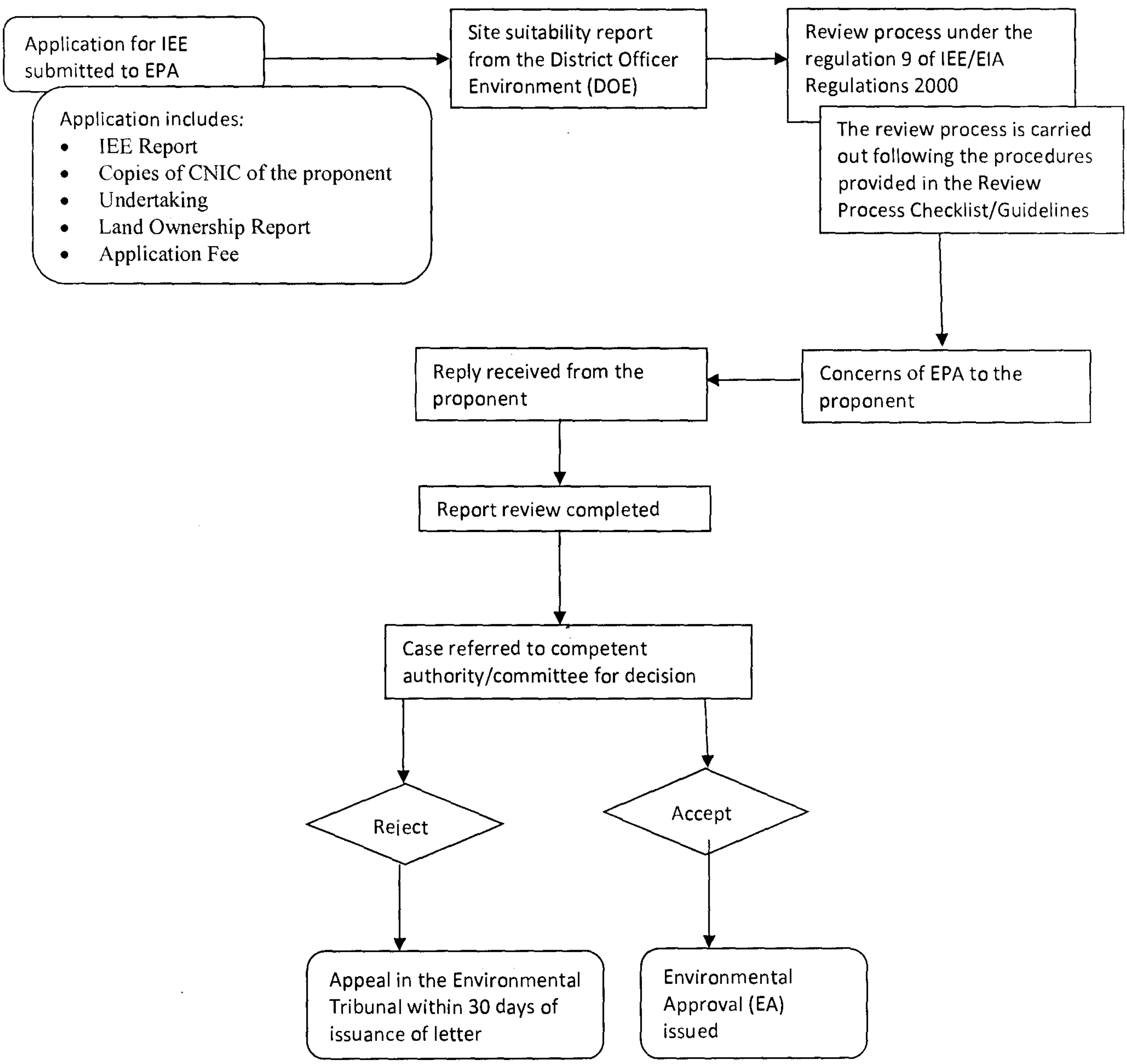


Fig 1.1: The IEE process flow chart

The format of this IEE covers the followings:

1.8 Structure of the Report

IEE report comprises following chapters:

Chapter 1: Introduction (A description of the project, proponent and consultants, the need for the project and the report and method of preparing it).

Chapter 2: Project Description (Full description of the relevant parts of the project and summary of project inputs and outputs).

Chapter 3: Policy, statutory, and institutional Framework (A description of the pertinent national & provincial legislations, regulations and policies that are relevant and applicable to the project and a demonstration of how the project conforms to these aspects).

Chapter 4: Description of the environment (Description of project area's existing physical, biological and socio-economic condition, including geomorphology and soils, water resources, air quality, flora, fauna and demography).

Chapter 5: Project Impacts and mitigations (Presents an assessment of the project's impacts, suggested mitigation measures on the Physical, Biological and Socioeconomic environment, residual impacts and the monitoring requirements).

Chapter 6: Environmental Management Plan (Provides Environmental Management Plan& Environmental Monitoring Plan for the construction &operational phase of the project).

Chapter 7: Conclusions & Recommendations (Concludes the IEE report with a few recommendations to conduct the project in environment-friendly manner).

CHAPTER 2: DESCRIPTION OF THE PROJECT

2.1 Type and Category of Project

According to projects categorization for environmental assessment studies, the proposed project that is Hydropower project falls under the B (I) category of projects mentioned in Schedule I for Initial Environmental Examination (IEE) i.e. "Hydroelectric Power Generation less than 100 MW". This report is required to fulfill the legal requirements set under section 12 of the Punjab Environmental Protection Act, 1997 (Amended 2012). This section of the study renders a detailed account of the project and its salient features, such as location and various phases. Inputs and discharges relevant to different phases of the project, such as electricity & materials etc. have also been examined as a response to possible environmental concerns.

2.2Mission

Punjab Irrigation Department mission is to provide superior value to its customers with distributed, flexible, efficient, and environmentally advanced energy solutions which enable a global transition to a more sustainable and modern energy infrastructure.

- Endeavor to be the lowest cost producer.
- Consistently maintain a high standard of customer service.
- Continue to invest in human resource through training, development and promotions from within whenever possible in order to meet future expansion needs.
- Adhere to the principles of health, safety and environment (HSE) and best practices in order to ensure sustainable development

2.3 Objectives of the Project:

- It is one of the cheapest renewable sources of energy.
- To reduce the adverse impact on the environment.

- The possibility of energy storage in a reservoir permits to manage the production in the best economic interests, to store energy during off-peak hours and to release it during peak hours.
- hydro plants are well adapted to decentralized energy production in remote area and easily adjustable to local energy demand ·
- hydraulic power permits very secure regulation techniques, that permits to guaranty high quality of current in comparison of others sources like wind energy where rapid unpredictable fluctuations are present

2.4 Alternatives Considerations

Different alternatives considered for the project which are listed as follow:

2.4.1 Alternative 1- No Project Option

The current power production in Pakistan is about 24,906 MW and the demand supply gap is around 4000 to 5000 MW for the year 2014/15 resulting in load shedding of almost 6 to 8 hours a day in urban centers of Pakistan and even more in rural areas. This gap is increasing annually and causing a great economic loss to the country apart from the human suffering due to regular power outages. There have started many thermal, coals, nuclear and renewable power generation projects to fill the demand gap. Government is working itself along with its power development companies to reduce the power shortage. So, No Project Option if exercised shall deprived Pakistan 2.5 MW power which can be generated from the cheapest source. In the light of the above situation No Project Option (NPO) is not acceptable for this project.

2.4.2 Alternative 2- Project Layout Alternatives

The main consideration during planning has been that the hydropower scheme should not disturb the proposed and approved layout and design of the new hydropower plant at

BRB canal Kasur. Therefore, only those layout options have been considered which have the flexibility to accommodate the planned project. The following criterion has been adopted while conceiving the alternative layout

The identified layouts are within the selected reach and do not interfere with the irrigation system. Both irrigation system and power generation system could be operated simultaneously without any disturbance.

Environmental and social impacts

Climatic and hydrological conditions

The alternative with short water way and maximum head is preferred

The project plan is furnish considering the topographic and geological features of the project area and should involve the easier construction methodology

The selected alternative should involve the minimum resettlement issues

The existing/planned schemes of the irrigation system should not be affected by the identified layout

Minimum or preferably no land acquisition. The government owned land has been preferred over the private owned land

Minimum construction period with optimum utilization of the non-perineal canal closure period

Minimum head loss for maximizing the power potential

2.4.3 Alternative 3 - Construction of powerhouse at RD 509+712within main canal along with spillway

It is proposed that powerhouse should be constructed within the main canal. The canal banks shall be raised on both sides from RD 509+712 up to the powerhouse. In this scenario, the canal will follow its original regime and there will be minimum disturbance to the hydrological behavior of the canal. The main canal shall be diverted temporarily during canal closure and coffer dams shall be constructed on upstream and downstream of the proposed powerhouse at the confluence of diversion and main canal. Therefore, construction works of the power plant can be executed independently without disturbing the canal operations. An auxiliary spillway catering the same discharge capacity is proposed alongside the powerhouse within the main canal in order to safely manage the canal operations during emergency shutdown of the power plant.

The Hydropower Project utilizes a net head of 18.9 ft. The discharge shall be regulated by the spillway gates and power generating unit as it will regulate with much better efficiency.

Advantages

- Canal operations will remain smooth during construction of power house and flow of water during operational phase.
- The construction works can be executed independently without disturbing the canal operations.
- There will be no change in barrage design.
- Construction cost is lesser than alternative-II.
- Construction schedule is less than alternative II and saves cost.
- This alternative offers minimum head loss.

Disadvantages

- The main canal shall require temporary diversion. However, the temporary diversion shall be designed to safely pass the design discharge of the canal.

ALTERNATE PROJECT LAYOUT - II

2.4.4 (CONSTRUCTION OF POWERHOUSE WITHIN DIVERSION CANAL)

The power house is proposed in diversion canal downstream of the existing fall. The spillway shall be constructed within main canal. This option involves very complex construction methodology and difficult canal and plant operations. Layout plan of alternative –II is provided as AIPEL-HHP- AL-02.

Advantages

- This alternative does not offer any significant advantage except the availability of Govt. owned land therefore, not discussed.

Disadvantages

- Extensive care and handling of water is required during the construction of power plant.
- Project cost is much higher than alternative-I.
- Construction time will be more than alternative-I.
- It involves very complex construction methodology and difficult canal and plant operations.
- There will be serious sediment problems.
- Project in this alternative is on the verge of financial and economic viability.

Conclusion

In the light of above discussions, it is concluded that Alternative I whereby the powerhouse and spillway within the same axis is proposed within main canal at RD510+600. The same option is considered for onward study. It is concluded from the above discussions that Alternative I is the most economical and viable solution and, therefore recommended for onward study and development. Operations of the canal will not be disturbed during construction and after the commissioning of the proposed power plant. The Sponsor is responsible to take care of all the structures and reach of the canal during the construction and operations of powerhouse.

2.5 Location Plan/Map

The project site is located in District kasur at **BRBD link canal.** Location map of proposed Hydropower project site is shown in Fig 2.1

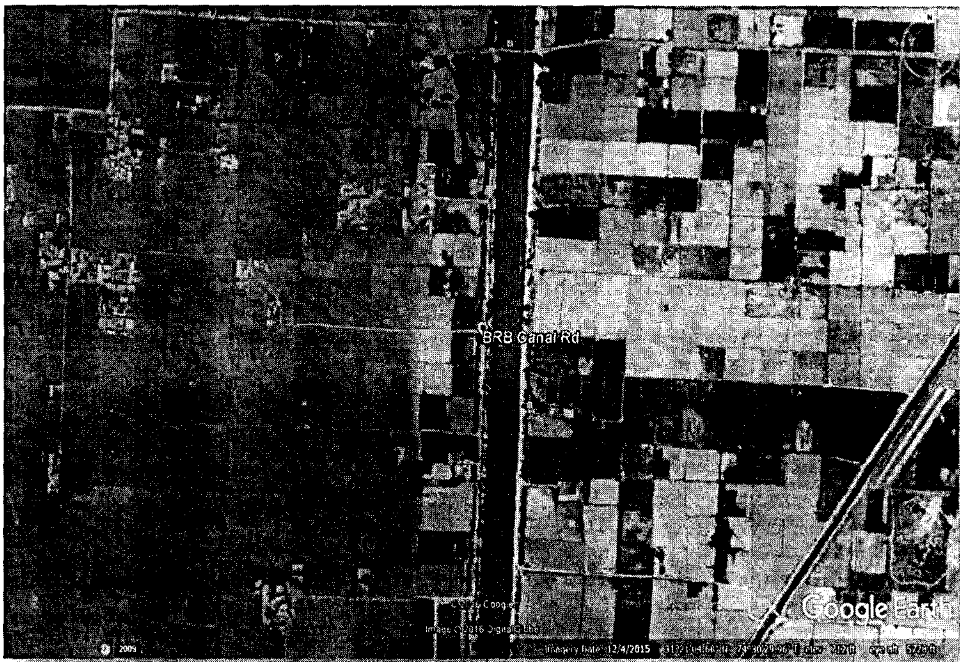


Fig 2.1: Google Map of Project Site

Land use on the site

At present, most of the Project area is agriculture in nature which is located in the nearby suburbs of Kasur border. The area consisted of some bushes, grass and trees in the surrounding at some distance from the project site. The Hydropower plant is located on BRBD link canal. The proposed project area has agriculture on its sides, while Road is in front of the project site.

2.6 Road Access

All HPP structures under consideration require access using permanent or temporary roads. The site is within 3.5 Km from Kasur City and easily accessible from main road.

2.7 Vegetation Feature on the site

Project site is surrounded by agricultural land (grain crops and vegetables) with large vegetation including trees like *Neem, Eucalyptus (Safida), Bhaira, Harrar, Dhair and Moosri*, Shrub, herbs (medicinal plants) and weeds. The dominant shrub species are *prosopisglandulosa (Mesquite), Calotropisprocera (Akk)* etc. Among weeds, *Pohli, Piazi, Khandiari* are more commonly species in crops. Many trees are found in the surrounding of the project area. Therefore there is no adverse impact on the flora. There is no Reserve Forest in the 5 km radius.

2.8 Cost and Magnitude of operation and Associated Activities

The proposed project will produce 2.45 MW of electricity. And its cost is 5 million approximately. The land is of irrigation department land and Packages Power (Pvt.) Limited is private investor to installed hydropower plant on the BRBD Link canal for Kasur city. The hydropower plant is conceived considering the fall structure at RD 509+712 of BRBD Link Canal whereby the available net head of 5.77 m and plant design for a discharge of 62 Cumecs is considered for the development of this hydropower scheme.

2.9 Proposed Schedule of Implementation

Project implementation schedule drive on the basis of calculated quantities of works to be done and duration that is required to design, fabrication, supply and installation of major project components. It is estimated that the completion of construction phase of entire project will be started after getting environmental approval from EPA, Punjab.

Activities involved are:

- Land acquisition

Land is owned by Punjab Irrigation Department (BRBD link Canal) and Packages Power Private Limited is private investor for energy production

- Lay out plan of project (attached herewith this IEE report)
- Leveling of land
- Construction of Power House

  The generator room is the main feature of the powerhouse about which other areas are grouped. The height of the generator room is governed by the maximum clearance height required for dismantling and/or moving major items of equipment. The elevation of the turbine room floor establishes so as to provide a minimum roof thickness of 4 feet for a semi-spiral concrete case. In establishing the distance between the generator and turbine room floors, the size of equipment to be handled in the turbine room, the head room between platforms in the turbine pit, and the generator room floor construction is considered.
- All finishing work of the entire plant will be furnished after last step.
- Time by Time Management & Maintenance
  - Monitors and records equipment parameters such as temperatures, pressures, vibrations, leakage current, dissolved gas analysis, etc.
  - Tests periodically and/or when problems are suspected, such as double testing, vibration testing, infrared scanning, and so forth

- Continuously analyzes operator-gathered data
- Water storage (reservoir) and the water conductor system— intake, headrace tunnel, surge shaft, emergency valves and pressure shafts, penstock, and main inlet valves—comprise the vital organs of a hydropower plant will be checked regularly
- Periodically maintain unit auxiliary, station auxiliary and station service transformer
- Check station batteries and battery chargers
- Regularly inspect cable ducts for proper ventilation/heat dissipation.

2.10 IEE Report Process

The study team reviewed the Project site with the aim to determine the likely impacts of the project on the environmental and socio-economic conditions of the area. All the necessary elements of the project were reviewed and compared with the existing conditions in the vicinity of the Project Area. The IEE report identifies the adverse environmental impacts due to the construction and operational activities of the project and also suggests proper measures for their mitigation, as described in Environmental Management Plan (EMP).

No fresh water bodies are known to exist in the vicinity of the project area; therefore there will not be any deterioration of surface water quality. During the construction vehicles and machinery will be employed. These will generate some dust and smoke temporarily which will definitely stop on completion of the construction work. The potential negative impacts during construction and operational stage of the project will be mitigated to an acceptable level. Comparison of potential adverse and beneficial impacts of the project shows that project will prove to be beneficial for the inhabitants of the area. Hence the proposed project will prove to be beneficial and also increase the socio economic status of the nearby inhabitants, and will contribute in the overall economy of the country.

Necessary mitigation measures are recommended in the report to make the proposed project Environment Friendly. Environmental Management Plan identifies monitoring needs and implementation on Environmental Management Plan is also recommended. The IEE concludes that the proposed project have indicated that there are no significant environmental impacts associated with the construction and operation phase of the project, if the anticipated impacts are properly mitigated; therefore, no further IEE study is required.

2.11 Description of the project

The project is Hydropower Plant at Bambawali-Ravi-Bedian Canal (BRBD) within main Link canal in district Kasur. This plant generates electricity, serving Kasur city and it is a source of low-cost renewable energy. Hydropower can be generated wherever a flow of water descends from a higher level to a lower level. The difference between the two water surface elevations is referred to as head. Head can exist in nature, for instance when a stream runs down a steep hillside or when a sharp change in elevation creates a waterfall in a river. However, head can also be created artificially by constructing a weir or dam; the dam creates a barrier to water flow, raising the upstream water level to the desired elevation. As a result of elevation differences gravitational potential energy is stored in the water; this energy can be exploited by installing turbines and generators. Water flow moves the turbine blades, thereby converting water's potential energy into kinetic energy. The turbine rotation forces the generator rotator to spin around the stator thereby converting kinetic energy first to mechanical energy, and then to electrical energy.

There are four parts of a typical hydropower plant which are:

2.12 Canal/Water reservoirs

A large quantity of water is stored in reservoir. The height and depth of the stored water determines how much electricity can be generated. Raises the water level of the river to create falling water, also controls the flow of water. The reservoir that is formed is, in effect, stored energy. In case of small hydro such as run-off water of canal is installed on running water and does not use water stored in reservoirs

2.12.1 Turbine

The force of falling water pushing against the turbine's blades causes the turbine to spin. A water turbine is much like a windmill, except the energy is provided by falling water instead of wind. The turbine converts the kinetic energy of falling water into mechanical energy.

2.12.2 Generator

Connected to the turbine by shafts and possibly gears so when the turbine spins it causes the generator to spin also, converts the mechanical energy from the turbine into electric energy. Generators in hydropower plants work just like the generators in other types of power plants.

2.12.3 Transmission lines

Conduct electricity from the hydropower plant to homes and business.

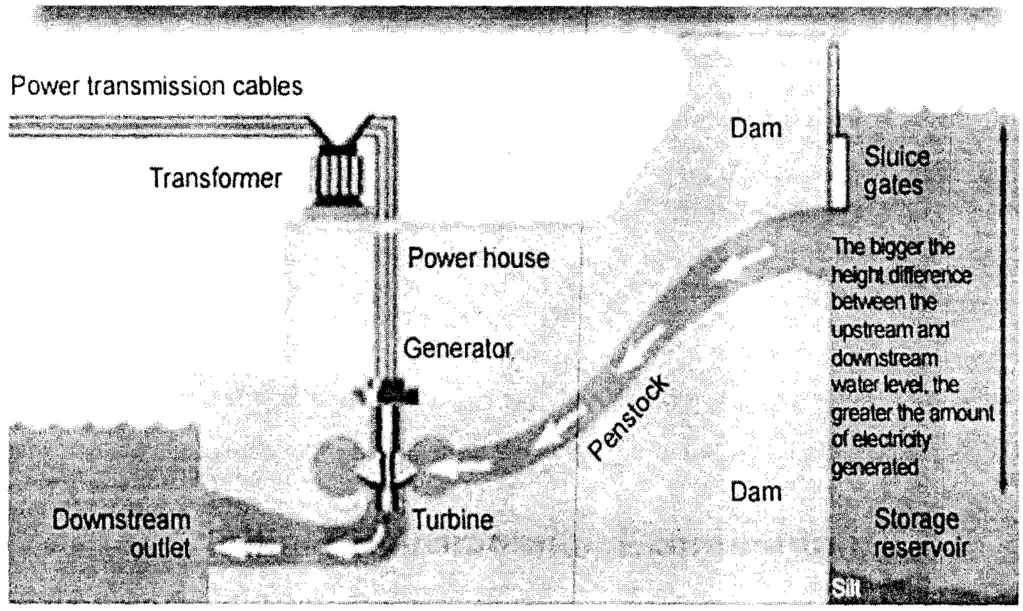


Fig 2.2: Process of Hydropower Plant

2.13 Water Requirement

The drinking water requirement for the workers during construction will be fulfilled by hand pump installed near project location. While the hydrological data of RD 434+000 for the period 2000 to 2016 (17-Years) have been analyzed. BRBD is a non-perennial canal due to which the discharge in this canal is only available from April to October every year. According to the hydrological data, the mean monthly discharges vary from 21.06 m^3 /s to 52.02 m^3 /s from April to October.

2.14 Solid Waste Management

Estimated quantity of solid waste during construction phase is varied. The reason being, solid waste will have excavation material as major part of its overall composition. However, the earth material (iron, mud etc.) during construction phase will be reused within the site eventually leaving zero waste due to excavation activities. There will be no process solid waste produced in operational phase of the project. However, solid waste generated due to human activities of 8-10 persons will be 1-2 kg/WEEK which will be disposed of using the current solid waste management and disposal services. Additional disposal bins will be provided to accommodate the additional waste.

2.15 Wastewater Generation and Disposal

There will be no wastewater production in the process or as effluent, this particular feature of the project makes it sustainable endeavor. The domestic wastewater during construction phase will be no issue as the sanitary facilities are already present at the existing plant site. A septic tank is already present at project site for the treatment of domestic wastewater.

2.16 Monitoring System:

CCR system will be used to monitor the plant. The water fall, pressure etc will be monitored at every point. For additional monitoring, cameras will be installed.

2.17 Energy Demand

There is as such no need of the energy for the project.

2.18 Manpower Required

The man power during construction phase will be approximately 40-45 and operational stages will be approximately 50 persons. Thus the project is source of employment for economic development activities of the area.

2.19 Safety Measures

Emergency exits at plant site have already been planned. Firefighting equipment including Water and Mud Fire Extinguishers will be installed outside every room and alarm system created for emergency situation in the power house of hydropower project.

Adequate trainings including HSE training will be provided to staff to tackle any critical situation.

2.20 Emergency preparedness plan

General

There are many types of emergency events that could affect dams. Whenever people live in areas that could be impacted by a potential or actual flood caused by the failure or operation of a dam, there is a potential for loss of life and damage to property. The purpose of these Guidelines is to encourage comprehensive and consistent emergency action planning to protect lives and reduce property damage. This document provides guidance for the licensee and the emergency management authorities who work together to respond to dam safety emergencies. An Emergency Action Plan (EAP) is a formal document that identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life. The EAP describes actions the licensee will take to moderate or alleviate a problem at the dam, as well as what actions the licensee, in coordination with emergency management authorities, should take to respond to incidents or emergencies related to the dam. It presents procedures and information to assist the licensee in issuing early warning and notification messages to responsible downstream emergency management authorities. The EAP also contains inundation maps to assist the licensee and emergency management authorities by identifying critical infrastructure and population-at-risk sites that may require protective measures, warning and evacuation planning. The EAP must clearly define the responsibilities of all those involved in managing the incident and how those responsibilities should be coordinated.

Hydropower stations can pose significant safety risks to those who work in them, but there is no excuse for injury or death in our workplaces. Developers, owners and operators of hydropower plants all need to make a strong commitment to workplace health and safety. Some of the hazards at hydropower stations differ from those at thermal power stations or commercial installations. Hydropower stations typically have limited access and no natural lighting. Lower floors are often below the outside water level, and many are underground.

a) **Designing safety into hydropower stations**

When designing and implementing a new hydropower scheme, or when upgrading an existing station, we need to carefully consider the required standard of workplace health and safety, and the scope of work necessary to achieve that standard. This means understanding the relevant legislation, building codes and the requirements of the insurer. We also need to be clear about how responsibilities are shared between all the parties involved – the designer, developer, owner, contractors, and so on. But while standards, codes and guides are a good starting point, the final solution needs to be tailored to the particular circumstances and level of risk at the station in question. Safety systems for hydropower plants can be complex and sophisticated, but simple systems can also be robust – it all depends on the specific requirements of the facility in question.

b) **Planning ahead to control risks**

A general approach taken to minimize workplace risks involves planning ahead to prevent workplace accidents, injuries and illnesses. We do this by ensuring that systems of work are safe and that equipment is properly maintained. Employees must receive health and safety information, training and appropriate supervision.

This approach is usually expressed through a hierarchy of controls:

ELIMINATE

Hazards should be eliminated where possible
or if this is not possible...

SUBSTITUTE

Hazards should be substituted with lower risk types
or if this is not practical...

ISOLATE

Hazards should be isolated from personnel
or if this is not practical...

ENGINEERING CONTROLS

Provide additional or upgraded plant
to help control the risk
or if this is not practical...

ADMINISTRATION

Provide policies, procedures, work practices
and training to reduce exposure to risk
or if this is not practical...

PPE

As a last resort, provide personal
protective equipment to help
minimise the risks to personnel.

c) Safety upgrades for older hydropower stations

Typically, new hydropower stations are well designed and comply with appropriate safety standards and local building codes. Larger hydropower stations can have safety systems as complex and thorough as those in modern multi-floor commercial buildings. However, older plants were often designed with little regard to safety, and now need urgent attention to comply with modern workplace health and safety standards.

While safety facilities are readily incorporated into new hydropower schemes, they may be more difficult to retro-fit into existing stations. The scope of work will need to take into account the interfaces with existing facilities and the tailoring required to suit the specific site and location.

d) Station evacuation

Whatever the nature of the crisis, people must be able to get out of a hydropower station safely. All stations should have at least two independent ways to exit. If one route becomes inaccessible, an alternative emergency escape route should always be available. Adequate lighting is essential for emergency escapes. The primary consideration should be to provide safety facilities to get personnel out of a hydropower station safely *before* conditions inside become dangerous. The second consideration should be providing facilities to get people out safely *after* conditions become dangerous. Only then do we think about safety facilities to prevent damage to the plant itself.

e) Flood protection

Hydropower stations can and do flood. Failure of drainage pumps can lead to a slow increase in the water level and eventual flooding of the station. Alternatively, a plant failure and leakage that drainage pumps cannot manage can cause rapid flooding of the station. This makes water-level, flood and evacuation alarms an absolute necessity. Flood protection schemes can be implemented to automatically close intake gates or hilltop valves and keep turbines operating to attempt to drain the headworks and penstocks of water to control flooding, and to automatically stop the hydro plant before the water levels become critical.

f) Fire and smoke control

We need to detect fires as early as possible, prevent them from spreading, alert all personnel, and provide safe and well-lit means of evacuation as soon as possible. Smoke control and ventilation are also extremely important. Fire will rapidly fill a hydro station with thick, black, acrid smoke, which is often a far greater hazard to personnel than the fire itself, as it obscures vision (preventing occupants from finding safe escape routes, as well as hindering search and rescue operations). It can also asphyxiate or poison people well before the temperature of the fire or smoke causes injury.

A holistic fire protection system needs to attend to the full range of passive measures (e.g. fire-rated construction materials and methods), active measures (e.g. sprinklers, venting, fire-fighting equipment) and operational measures (e.g. plans, systems and training for fire prevention and response).

g) Emergency and crisis management

Safety at hydro stations involves more than simply having the correct equipment or hardware present at the site. It involves an ongoing commitment by the owner, management, operator and employees to provide and maintain a safe and healthy work environment.

2.21 Emissions Control System

Hydro normally has the lowest greenhouse gas emissions for power generation .Since Hydropower plants do not use fuel, power generation does not produce any sort of hazardous emissions.

2.22 Restoration and Rehabilitation Plan

Said project is surrounded in an open and agricultural land where the structure is already constructed. There is no population and sensitive area. Flora and agricultural land is present away from the project location even wild flora like kekar is also not present at project site and also there is also no fauna and any type of endangered species present near project site.

So there will be no harm for any type of vegetation and fauna. And thus the project is totally environmental friendly. The Hydropower project will staff more people for proper maintenance of proposed project under skilled supervision of the site supervisor. Regular maintenance can increase the life expectancy of such project considerably. If and when the end of life time period of the project comes, safety measures will be adopted.

2.23 Government Approvals

The project area is owned by Punjab Irrigation Department. Other concerned NOC's will obtain after getting approval from EPA. However, copy of LOI for the Hydropower plant is attached herewith.

CHPTER NO 3: STATUTORY REQUIREMENTS

3.1 General

Sustainable development and green economy is a concept that has emerged over the past decades to describe a new framework aimed at economic and social development while maintaining the long term integrity of the ecological system and environmental resources. The principal of sustainable development is in the process of being incorporated into the national policy and legislation through various statutory instruments. This chapter describes the current legal responsibilities of the proponent in context of environmental and sustainable development, and the institutions that exist in the country that may influence the environmental management of the project.

This section deals with the current policy as well as legal and administrative framework related to carrying out of Initial Environmental Examination (IEE) of the project. An efficient and effective organizational structure is essential for successful implementation of the mitigation measures identified for the project. Like other projects, the project, before its implementation, is required to go through an Environmental Assessment, in accordance with the provisions of the Punjab Environmental Protection (Amendment) Act 2012.

3.2 Existing Legislation and Legal Framework

The Federal Ministry of Environment was responsible authority for policy making on environmental protection in Pakistan but after 18th Amendment in the Constitution, the Provincial Governments have taken over the subject of Environment. This IEE study has been carried out in the light of the policy guidelines of the Preparation of IEE/EIA Reports under the procedures and practices formulated by the Pak EPA and adopted by the Punjab Environmental Protection Agency (EPA).

3.3 Institutional Setup

3.3.1 Environmental Protection Councils

The Punjab Environmental Protection Council (PEPC) is the apex decision-making body of Punjab. It has been developed under the provision of Punjab Environmental Protection (Amendment) Act 2012. It is headed by Chief Minister of Punjab with other members. The purpose of IEE is basically to obtain Environmental Approval from the Environmental Protection Agency (EPA), Punjab in compliance with Pakistan Environmental Protection Act (PEPA) - 1997, now having been replaced by Punjab Environment Protection (Amendment) Act 2012.

3.3.2 Environmental Protection Agencies

Pak EPA has been established at the Federal level and EPAs are established at Provincial level also. In Punjab an independent Environmental Protection Agency is constituted headed by the Director General.

3.3.3 Environment Protection Department, Punjab

The Punjab Government has established Environment Protection Department (EPD) administratively controlled by the Secretary, Government of Punjab. The EPD has its independent Minister. According to the provisions of the Punjab Environmental Protection (Amendment) Act, 2012, EPD has a significant role in policy making and implementation of the environmental laws in the Punjab Province.

3.3.4 Relevant Legal / Institutional Framework

The applicable laws for the environmental study of the project are briefly given below. The proponent of the project will abide by the applicable laws and regulations.

A number of laws have been promulgated by the Government of the Pakistan to deal with the environmental and social aspects related to the implementation of various development projects in the country. In 1983, the Government of Pakistan issued an

Environmental Protection Ordinance (EPO) that was replaced by the PEPA, 1997, through an Act of Parliament. According to the 18th Amendment in Constitution, the PEPA 1997 has been confined to Federal Area and provinces have been allowed to formulate their own environmental legislation in the subject of environment.

Under the PEP Act, it is mandatory to carry out IEE or EIA for all development projects. The Pak EPA has also framed guidelines for environmental assessment of projects in various developmental sectors, According to PEPA 1997; the National Environmental Quality Standards (NEQS) were established for effluents discharges and gaseous emissions of various Municipal and Industrial sources. The latest revision of NEQS as carried out in year 2000.

Provincial Environmental Protection Departments are also working on the formulation and enforcement of environmental statutes and by-laws. The Pak EPA has issued several policies guidelines and adopted measures for streamlining the environmental assessment. Though, the need for environmental screening and assessment has received some weight during the recent past, strict implementation of the NEQS is still a dream to be realized. The applicable laws for the environmental study of the Project are briefly described below:

3.4 Pakistan Environmental Protection Order (PEPO) 1983

In 1983, the Government of Pakistan issued an Environmental Protection Ordinance (EPO) 1983. It was the first legislation promulgated for the protection of environment. According to PEPO, 1983 it was necessary to carry out IEE / EIA for all development projects, but there were no IEE / EIA regulations under that ordinance.

3.5 Punjab Environmental Protection (Amendment) Act 2012

Section 12 of the Punjab Environmental Protection (Amendment) Act 2012 makes it mandatory for the proponent of a project to file with the Environmental Protection

Agency either an Initial Environmental Examination (IEE) or Initial Environmental Examination (IEE), as the case may be, in respect of the project.

As per definition given in the Punjab Environmental Protection (Amendment) Act 2012, Initial Environmental Examination (IEE) means an environmental study comprising collection of data, prediction of qualitative and quantitative impacts, comparison of alternatives, evaluation of preventive, mitigatory, and compensatory measures, formulation of environmental management & training plans & monitoring arrangements, and framing of recommendations and such other components as may be prescribed. The provision of Section 12 has been incorporated "as it is" in the new Punjab Environmental Protection (Amendment) Act, 2012.

3.6 National Environmental Policy 2005

Government of Pakistan has notified National Environmental Policy 2005, for different projects/aspects in which guidelines/priorities have been given to undertake/commence the projects having significant environmental impacts.

The National Environmental Policy (2005) provides a framework for addressing the environmental issues (particularly pollution of fresh water bodies and coastal waters, air pollution, lack of proper waste management, deforestation, loss of bio diversity, desertification etc.) confronting Pakistan. It recognizes the goals and objectives of the Pakistan National Conservation Strategy (PNCS, 1992), National Environmental Action Plans, and other existing environment related national policies, strategies, and action plans. It also provides broad guidelines to the Federal Government, Provincial Governments, federally administrated territories and local governments to address their environmental concerns and to ensure effective management of their environmental resources.

3.7 Review of IEE / EIA Regulations 2000

The Pak EPA has issued Review of the Initial Environmental Examination and Environmental Impact Assessment Regulations 2000, to review the Initial Environmental Examination (IEE) / Environment Impact Assessment (EIA) reports. Categorization of the projects for IEE and EIA is one of the main components of the Regulations. Projects have been classified on the basis of expected degree of adverse environmental impacts. Projects type listed in Schedule I are designated as potentially less adverse effect, schedule I projects require an IEE and projects given in schedule II require EIA to be conducted.

Salient features of the Regulations are listed below:

- Categories of project requiring IEE and EIA are issued through two schedules attached with the regulations.
- A fee depending on the cost of the project has been imposed for the review of IEE and EIA.
- The submittal is to be accompanied by an application in prescribed format included as Schedule IV of the Regulation.
- The EPA is required to issue conformation of compliance within 15 days of receipt of request and complete documentation.
- The IEE / EIA approval for construction of the project will be valid for three years from date of accord.

3.8 Guidelines for the Preparation of IEE/EIA Reports

The Pak EPA has also framed Guidelines for the Preparation of IEE / EIA of projects in various developmental sectors.

3.9 The Punjab Local Government Ordinance, 2001

Schedules 4 and 8 of this Ordinance pertain to environmental pollution. There are not withstanding any specific provisions, every local government may perform functions conferred by or under the Punjab Local Government Ordinance, 2001, and in performance of such functions may exercise such powers, which are necessary and appropriate. Under the ordinance, the local councils are authorized to restrict projects causing pollution to air, water or land. They may also initiate schemes for improving the environment.

3.10 Pakistan Penal Code, 1860

This defines the penalties for violations concerning pollution of air, water bodies and land. Sections 272 and 273 of this Act deal with the adulteration of food or drink. Noise pollution has been covered in section 268, which defines and recognizes noise as a public nuisance. "A person is guilty of a public nuisance who does any act or is guilty of an illegal omission which causes any common injury, danger of annoyance to the public or the people in general who dwell or occupy property in the vicinity, or which must necessarily cause injury, obstruction, danger or annoyance to persons who may have occasion to use any public right".

3.11 The Land Acquisition Act, 1894

The Land Acquisition Act (1894) deals with the acquisition of private properties for public purposes. There are 55 sections in this Act mainly dealing with area notification, surveys, acquisition, compensation, apportionment awards, disputes resolution, penalties and exemptions.

Although quite old, this act laid out the legal basis for any property affected by a project and for compensating the effected owners of the land.

3.12 Labor Laws

Construction and operational activities during the course of construction may affect occupational health of workers. Employers are required to abide by labor laws in respect of their own employees and also to ensure that contractors to follow the relevant labor laws and rules relating to safety of the workforce and creating a healthy working environment. The proponents shall ensure that the labor force engaged at the project site is not exposed to any danger by monitoring the contractor's work frequently.

3.13 Power Generation Policy, 2006

Under Power Generation Policy, 2002 announced by Government of Pakistan, Punjab Government has introduced its Power Generation Policy, 2006 and has also established Punjab Power Development Board (PPDB) for its implementation. Punjab Power Development Board will provide One Window Facility to the Private Investors for development of project based on any technology like Hydel, Thermal, Wind, Solar and Biomass. Private Investors are invited to invest in the Power Project to meet the energy shortage in the Province.

CHAPTER 4: DESCRIPTION OF ENVIRONMENT

4.1 General

The existing environment around the site of project has been studied with respect to physical, ecological and socio-economic resources. The existing information to establish a database for the IEE of the project was collected from different departments, review of previous studies and through the site visits carried in out in the project area.

4.2 Physical environment

The study examines the physical resources, topography, soil, climate, surface and ground water and geology of not only the project site but also the city as whole to assess whether the project under review can or does impact on any of these parameters. The description of physical environment of Kasur city and the project site is present in the following sub sections.

4.2.1 Geological Formation

The soil of the Kasur belongs to the typical alluvium of the Indo-Gangetic plains. The majority of the soils are loamy or sandy loam consisting of soil crust of different depths. Hardly any profile characteristics are observed; soluble soils are present in considerable amounts. The lower layer consists of kankar nodules. The soils have generally an alkaline reaction and are adequately supplied by phosphorus and potash, but are deficient in organic matter and nitrogen. Geologically the alluvium is divided into khaddar, i.e., the newer alluvium of sandy generally light colored and of less concretionary composition; and Bhangar, i.e., the older alluvium of the more clayey composition, generally of dark appearance and full of kankar. The soil differs in consistency from drift sand to loam and from fin silt to stiff clay. A few occasional pebble beds are also present. Layers of kankar in the Indo-Gangetic alluvium of the district are also observed.

4.2.2 Climate

Kasur's climate is a local steppe climate. There is little rainfall throughout the year. The Climate of Kasur is tropical. Except of few months of summer, Kasur is a suitable place to live.

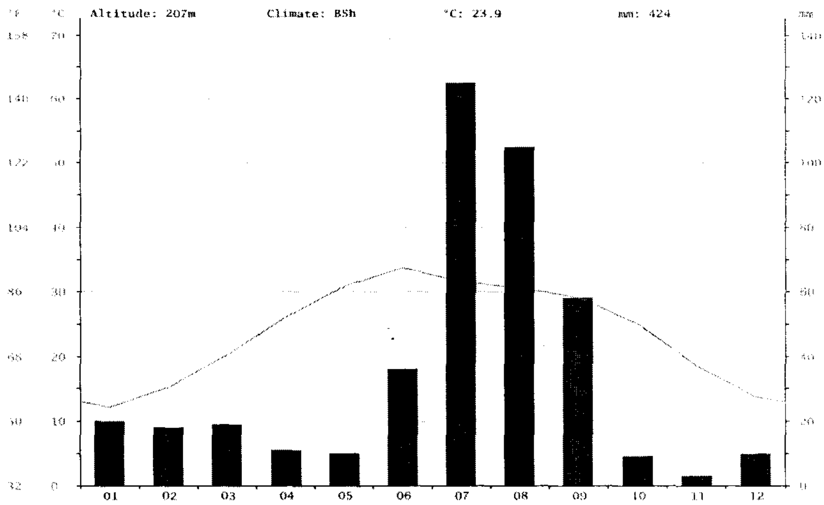


Figure 4.1: Climate Graph of Kasur

The people of Kasur have to experience extremes of temperature. The summers are really hot and the winters are very cold. There are three main seasons in Kasur, namely, summer, winter and rainy season. During the summers Kasur experiences heat waves.

Table: 4.1: Seasons in Kasur

Weather	Months
Autumn	Oct – Nov
Winter	Nov – Feb
Spring	Feb – Apr

Summer	Apr – Sep
Monsoon	July – Sep

4.2.3 Temperature

Kasur weather is hot and humid. The city experiences an extreme climate during the months of May, June and July, when the city witnesses summer season. The temperature in Kasur ranges between 40°C to 45°C, during the summer months. Kasur experiences winters during the months of December, January and February. The temperature during this season varies between 5°C to 8°C. Given below are the maximum and minimum temperatures of Kasur throughout the year:

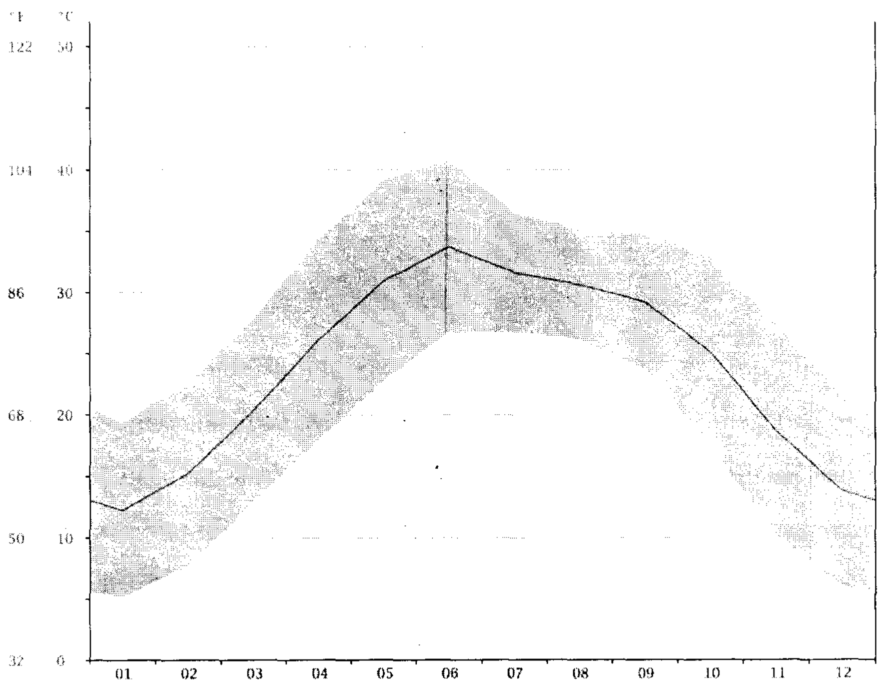


Figure 4.2: Average Annual Temperatures in Kasur

4.2.4 Rainfall

Kasur has a distinct rainy season, during which the weather is very humid. The rainiest months of the year are July and August, with June and September also gets some rain. During the rest of the year, barely any rain falls in Kasur.About 424 mm of precipitation falls annually. Precipitation is the lowest in November, with an average of 3 mm. The greatest amount of precipitation occurs in July, with an average of 125 mm.

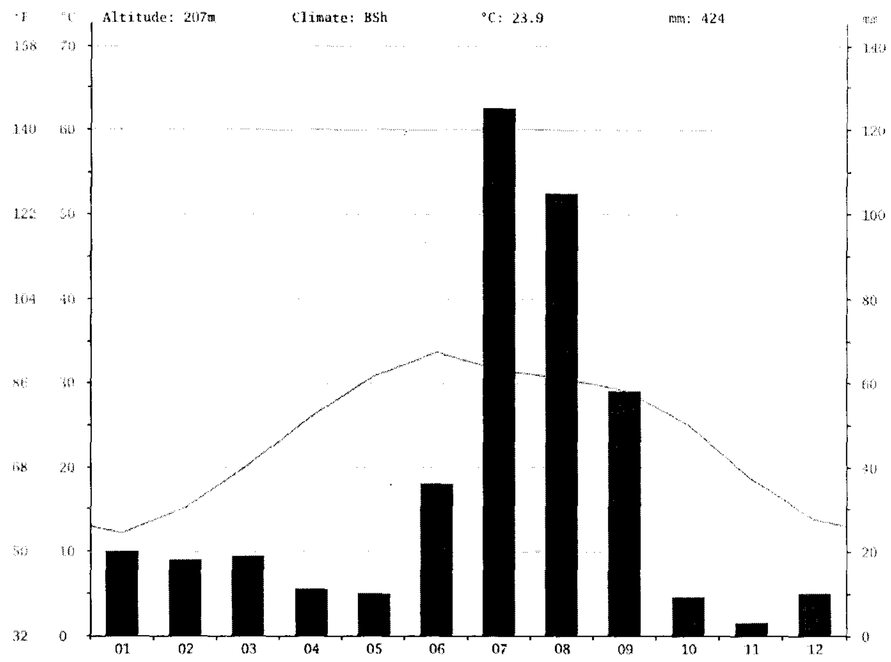


Figure 4.3: Average Yearly Precipitation in Kasur

4.2.5 Wind Direction

The Kasur region experiences westerly and north westerly winds during the winter and spring seasons, known usually as the dry stable times of year and southerly and south easterly winds during summer and monsoons. Wind speeds are low during winter picking up during spring season and peaking during the summer months.

4.2.6 Ambient Air Quality

Atmospheric pollution particularly in urban area has a strong impact upon daily life. Its economic growth and rising energy consumption are causing the increase in air pollution. The main sources of the air pollution are motor vehicles and industrial activities. SO_2, NO_2, CO_2, CO, O_3 and Particulate Matter (PM) are investigated as the pollution indicators.

The overall air quality in the study area is of moderate nature. Dust particles along with oxides of nitrogen, sulphur and carbon are the major causes of air pollution in the ambient air quality.

It was however observed during the visit that environment of the project area is clean as the area is far away from the city Centre.

4.2.7 Water Resources

4.2.7.1 Surface Water

There are no surface water resources other than BRBD link Canal on which the proposed project is constructed. Which is non perennial the flow of water is only between April to October.

4.2.7.2 Drinking Water Quality

WASA (Water and Sanitation Agency) is providing drinking water to the residents of Kasur. WASA claims the quality of water conform to the Drinking Water Standards. The increase in population will have direct impact on the water sector for meeting the domestic, industrial and agricultural needs. Pakistan has now essentially exhausted its available water resources and is on the verge of becoming a water deficit country. The quality of water supplies in many cities of Pakistan is deteriorating fast. Over pumping of groundwater due to extended drought has affected the water quality adversely. Hand pump is installed on project site for drinking water purpose. There is no other source like WASA water supply on project site.

4.2.8 Noise Level

There are many a large, medium and small industries which are still working within city premises. Industrial activity and vehicular emissions are causing excessive noise in the city. The affluent areas of Kasur are quieter than rest of the city; the noise level in these areas is still far higher than the standards set by the World Health Organization and the Pak-EPA. Noise pollution in the city is on the rise with most residents complaining that the noise is becoming a public nuisance. At project site through canopy noise level of generators controlled.

4.3 Ecological environment

Kasur is enriched with the presence of natural flora and fauna, although with the growing population and development activities, the presence of the same has been somewhat affected. There are no significant or well-shaped trees and shrubs on the project site as the site is located in plane land within the premises of project area.

4.3.1 Flora

Trees, also called the 'lungs' of the earth, are important for the restoration of the eco-system. People can benefit immensely from their survival and existence. Trees have also been a source of medicine for thousands of years and a refuge for various species of birds. Several species of the trees in Kasur are being used in medicine and provide excess raw material for Indian ayurvedics. Trees such as Neem, Bhaira, Harrar, Dhair and Moosri have great medicinal value and can be grown easily in the city. Many trees are found in the surrounding of the project area. Therefore there is no adverse impact on the flora. There is no Reserve Forest in the 5 km radius. No threatened or endangered species and no medicinal plants are present in the project area.

4.3.2 Fauna

With an increase in the rate of urbanization, the ecology of Kasur has been considerably affected and population of birds in Kasur has reduced to just 85 including the resident and migratory ones. Some birds and few animals like Buffaloes, cows, goats, donkeys, hen, rats, cats, dogs are present in the vicinity. Some reptiles like lizards are also present. No threatened or endangered species are found in the project site. Similarly no wildlife is present.

4.4 Socio economic

Social change is the consequence of almost any intrusion into the community life of any society. The intrusion can be in the form of any developmental projects or non-specific, less tangible forms such as increased exposure to other cultures, technological changes and so on. The social change that results from intrusion into community life can also be beneficial, but can have undesirable or negative outcomes. Even that change in the long run may have positive effect on the social wellbeing of a community. Social Impact Assessment is a methodology used for examining social change due to external sources, especially specific developmental projects, but also government policies, technological changes and social processes or anything that has a social impact.

The objectives of the given study are outlined as follow:

- To carry out the assessment of social impact.
- Acquire socio-economic data to evaluate and identify the project interventions.
- Assess needs of community related environmental concerns.

- To assess adverse and beneficial socio-economic and health impacts of the activity.
- To suggest remedial measures and solutions to improve socio-economic conditions.
- To analyze socio economic conditions of community, with special reference to environment and conservation of natural resources

4.4.1 Study Population

The target population was comprised of households around the project site which was a small village of Kasur.

Study Size

Therefore, approximately a total of 15 households of different socio-economic conditions were surveyed and their heads of households were our main respondents.

Study Instrument

Data collection tool was questionnaire; it was a 20- items based semi structured questionnaire.

4.4.2 Sampling Procedure for Questionnaire

4.4.2.1 Procedure

Before filling the questionnaire respondents were fully assured that their data will not be disclosed. They were told about the purpose of study. They were also told if they have any problem to understand the questions in questionnaire can ask.

4.4.2.2 Statistics Measures

After preparing the questionnaire, field surveys were conducted at 26-02-2017. The data selected from questionnaire was analyzed by using SPSS version 16. The data collected with the help of questionnaire was analyzed in SPSS to get the descriptions of current study. A part of questionnaire has been adopted from SF-36, a standard question to evaluate physic-social-health status.

4.4.2.3 Study Areas

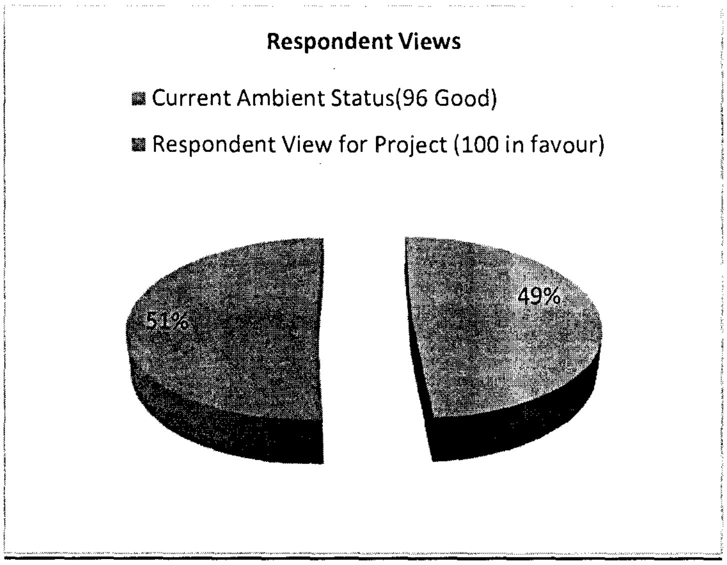
Somehow at surrounding and nearer village was visited for socio-economic aspects. Detail of these sited are discussed below. These areas were surveyed by team of experts as per requirement of socioeconomic survey for Initial Environmental Examination Report of Hydropower Project.

4.4.2.4 Description of Tables:

In the following table, only frequency and percentage has been measured (by SPSS) of those parameters which are probably present in maximum quantity.

Sr. #	Variables	Frequency	Percent (%)
1	Name & Address	-	-
2	Date	-	-
3	Address & CNIC	-	-
4	Age	89 (above 30 years)	89%
5	Education	93 (under metric)	92.8
6	Occupation	96 (Private jobs)	95.9
7	Marital Status	99 (married)	99
8	If married then no. of children	87 (> 4)	86.7
9	Total Family members	90 (< 5)	90
11	No. of earning members in family	88 (< 3)	88
12	Total income	97 (> 25 PKR)	96.3
13	Source of income	99 (Private jobs)	99

Table 4.2: Socioeconomic Questionnaire



4.4: Respondent View about Project

4.5 Quality of life

No residential area is present near the project site; therefore, individuals and workers from neighboring areas were interviewed. The individual assessed from the neighboring communities of the project area were involved in agricultural practices and private jobs in nearby industries. Most of the people work in the shops or small units. Neighboring community inhabitants involved in different occupations were asked about their monthly income but most of them hesitated to tell and stated that they earn just enough to fulfill their basic demands. Regarding the project, almost all of the interviewed members were in favor of the project as it does not involve any chemical manufacturing or pollution causing operational activities which generate pollution. Data was also collected to assess the health status of the community members at the project site. Complaints about different diseases were also recorded during the study.

The diseases prevalent in the community were stomach disorders, fatigue, joint pain, diabetes and arthritis. But it was also observed that all these disease are commonly due to improper diet and water contamination.

4.4.1 Health facilities

The city of Kasur in Punjab Province of Pakistan is served by a number of private and government hospitals offering world class medical facilities. The rural and urban areas are served by various other medical centers and dispensaries offering modern medical facilities. The hospitals, dispensaries and medical centers in Kasur aim to provide the citizens best medical facilities and prevention from contagious and other harmful diseases. There is no health facility or any dispensary near the project area.

4.4.2 Transportation and Communication

Kasur is one of the most accessible cities of Pakistan and the only unique city of Pakistan where you can find Public and private Transport, 24 hrs a day and 7 days in a week.To fulfill the remaining needs of transport there are thousands of rickshaws and taxis which run on compressed natural gas to reduce pollution in the city and of course about 75 percent of the residents have their own conveyances. Public transport is not available inthe project area. Private transport is used by staff and workers and officials used their own conveyance.

4.4.3 Industrial Activities

Kasur trade and industries thrives on certain large-scale industries such as steel, textile, carpet and IT industries. Kasur is known as the industrial belt of Pakistan contributing the largest share in the GDP of the country. The city is home to 20% of Pakistan industrial producers; manufactures include textiles, rubber, iron, and steel. Handicrafts, especially gold and silver work, also flourish. The project area is present in a plain area and is surrounded by agricultural land.

4.4.4 Water Supply

The project will have an independent water supply system comprising storage tank of sufficient capacity. Water will be supplied to office and works through motor pump.

4.4.5 Telephone Facilities

Landline and Cellular telephone facilities are present in the project area.

4.5 Lab reports analysis

4.5.1 Ambient Air Quality Monitoring

Ambient Air Quality was monitored for the parameters according to Punjab Environmental Quality Standards (PEQS) 2016 i.e. Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Nitrogen Oxide (NO), Nitrogen Dioxide (NO_2) and Particulate Matters (PM_{10}), Ozone (O_3), Carbon Dioxide (CO_2), Volatile Organic Compounds (VOC's), Humidity (%), Suspended Particulate Matters (SPM) and Humidity of ambient air at proposed site of 2.49 MW Hydropower Plant atBambawali-Ravi-Bedian Canal (BRB) at RD 510+600 within main Link canal in Kasur. This monitoring is carried out under standard time of monitoring i.e. 24 hrs. Monitoring reports are attached herewith Annexure

4.5.2 Ground Water Analysis

Ground water analysis was done for the parameters according to Punjab Environmental Quality Standards (PEQS) 2016 i.e. Alkalinity, Calcium, Carbonates, Total Coliform, Conductivity, Hardness as $CaCO_3$, Magnesium, Odor, pH, Sulfate, Sodium, Taste, Turbidity, Nitrogen/Nitrates, Lead and Mercury of the water samples collected from the proposed site of 2.49 MW Hydropower Plant at Bambawali-Ravi-Bedian Canal (BRB) at RD 510+600 within main Link canal in Kasur.. Results are obtained by ESPAK Laboratory are attached herewith Annexure.

4.5.3Noise Monitoring

Monitoring of was done according to Punjab Environmental Quality Standards (PEQS) 2016 for proposed site of 2.49 MW Hydropower Plant at Bambawali-Ravi-Bedian Canal (BRB) at RD 510+600 within main Link canal in Kasur.. Results are obtained by ESPAK Laboratory are attached herewith Annexure.

4.6 Conclusion

Comparison of potential adverse and beneficial impacts of the project shows that project will prove to be beneficial for the inhabitants of the Kasur city. The project will provide job opportunities for the local inhabitants as well as provide climate-friendly energy source, generating power without producing air pollution or toxic by-products. Hence improve their socio-economic status. Employment opportunities generated by the project include workers, helpers and guards. The overall socio-economic impact of the project is interpreted in relation to the existing environmental conditions.

The project, overall, does not have adverse impacts on the existing environment and people with due implantation of the mitigation measures, there will be very insignificant adverse impacts on the socio-economic environment. The project has more beneficial impacts on the socio-economic environment than adverse impacts. In conclusion, it can be said that overall the project would have positive impacts on the socio-economic status of the workers the neighboring community inhabitants, because it is a green project and release less amount of GHGs because fuel is not used in the process.

CHAPTER 5 : ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

5.1 General

This chapter discourses the potential environmental and social impacts of the project activities, predicts the magnitude of the impact, assesses significance, identifies the mitigation measures to minimize the adverse environmental impacts and evaluates the residual impact of the project, if any. Environmental impacts of a project are driven out using numerous factors and parameters, due to which it is necessary to evolve Environmental Management Plan (EMP) to develop the mitigation measures. The assessment via these parameters is necessary in the study area for comparative analysis in comparison with that area where there is no activity has been introduced

5.2 Impact assessment methodology

5.2.1 Screening of Impacts

Based on general observation and through the guidelines issued by Pak-EPA, and setting some criteria scale, significant impacts were screened out from the insignificant impacts. Impact checklists filled for this purpose (for impacts associated with construction and operation phases of the project), have been annexed with this report.

This step refers to the description; quantitatively (where possible) or qualitatively, of the anticipated impacts of the project

5.2.2 Identification of mitigation measures

It is determined that the predicted impact is significant when compared with the criteria for determining the significance, suitable mitigations measures are then accordingly identified. These measures can be classified into following categories:

- Minimizing impacts by limiting the degree or magnitude of the activities. For example, minimizing dust emission by reducing the vehicular traffic.

- Rectifying the impacts by repairing, rehabilitating, or restoring the affected environment.
- Compensating for the impacts by replacing or providing the substitute resources or environment.

5.2.3 Evaluation of the residual impacts

Incorporation of suggested mitigation measures reduce the environmental impacts of the project and bring it within the acceptable limits. This step refers to the identification of the anticipated remaining impacts after mitigation measures have been applied.

5.2.4 Identification of monitoring requirements

The last step in the assessment process is the identification of minimum monitoring requirements. The scope and frequency of monitoring depends on the residual impacts. The purpose of the monitoring is to confirm that the impact is within the prescribed limits and to provide timely information if unacceptable impact is taking place.

5.3 Impacts associated with site selection

The land is of irrigation department land, where on BRBD link canal only hydropower plant is constructed. The land is open land. And there is no community and human settlement within 2km of the site. There is no endangered species of fauna flora within a 2 km radius of the site. There is no ecologically sensitive or declared protected area (PA) like forest, fish hatcheries, Territorial Waters, wildlife or game reserves, any structure of socio- cultural significance (historical or archaeological site or religious structures; Masjid, temples, etc.) within 10 km of the selected site

It can be concluded in view of these reasons that the hydropower plant project is totally environmental friendly.

5.4 Impact during design phase (Power House)

At the design phase, no considerable impact will occur on land, soil, topography, ground water, and on people of the area. Design of the power plant will adhere to all standard technical requirements in order to avoid adverse impacts on environment and human health.

5.4.1 Mitigation Measures at Design Phase

At design phase special attention should be given to the design of the power plant has been designed in such a way as to cause minimum disruption and deterioration of environment and surroundings.

5.5 Anticipated potential environmental impacts (construction phase of Power House)

Characterization is done on the basis of significance, probability and prevalence of the potential impacts in the surrounding environment. Primarily, anticipated impacts have been categorized as direct, indirect and induced. These groups of impacts can be further broken down according to their nature into:

- Positive and negative impact;
- Minor, major and moderate impact;
- Local and widespread impact;
- Temporary and permanent impact;
- Short and long term impact; and
- Reversible and Irreversible impact

5.5.1 Notion of Significance

Evaluation of impacts will be based on determining the significance of impacts as well as characteristics of impacts. Indicators considered for determining the significance include: predicted increase in the acceptable level (established standard e.g., PEQS and duration) in relation to key species life cycle and requirement for population maintenance, geographical extent of an effect, assimilative capacity of environmental attributes. The criteria used to define the significance of impacts in terms of low, moderate and severe impact are as follows:

- **Negligible/No Impact:**

The impact, which has unapparent and negligible influence on natural and socio-economic environment

- **Low Adverse Impact:**

The impact which has a slight influence on the natural and socio-economic environment

- **Moderate Adverse Impact:**

The impact which can be eliminated/ mitigated after applying the appropriate mitigation measures

- **Severe Adverse Impact:**

The impact, which can be partially/ but not fully mitigated by applying the mitigation measure.

- **Positive/Beneficial Impact:**

The impact, which improve/enhance the natural and socio-economic environment

5.6 Impacts associated with the construction phase

As project area is far from the community and biological life, so, there are rare impacts on the environmental and socio-economic conditions. Moreover, possible impacts associated with the construction activities of the project are discussed in this section.

The impacts that are discussed are following:

- Construction Noise
- Dust Emission during Construction
- Vegetation Loss
- Water Pollution
- Health and Safety of Workers
- Access to road
- Power transmission lines
- Reservoir sedimentation

5.6.1 CONSTRUCTION NOISE

During construction phase, the noise shall generally be generated from vehicular movement sand and aggregate processing, concrete mixing & excavation machinery. Depending upon the equipment used and its distance from the receptor, the community will not be exposed to intermittent and variable noise level. Noise level is measured as ambient noise which is defined as background noise that is always present.

Potential Issues

The potential noise related issues during the construction may cause disturbance to the surrounding areas of the project due to construction machinery operation on the project site and the noise related issues during the construction cause disturbance but as such there is no community residing around the project area so, the impacts regarding noise will be on minimal / negligible level.

Impact Analysis

The potential sources of significant noise during the construction period include the construction machinery and construction related traffic and it also includes installation of machinery. Precise prediction of noise due to construction activities and installation of machinery activities at given location at given time requires the list of all equipment that is operational at the time and the following information regarding each piece of equipment:

- The maximum and minimum noise level, measured at reference distance from the equipment, during a work cycle
- Fraction of time it operates at maximum level during a work cycle
- The usage factor, i.e. the number of hours during the day when the equipment is operational
- Distance of equipment from the receptor
- Potential noise barrier and other topographical features that attenuate the sound
- Atmospheric condition, the wind speed and direction, humidity and barometric pressure, also affect the propagation of sound. However for short distances the effect of these is insufficient compared to other variables.

Mitigation

The strategy to minimize the noise in the community within acceptable limits should be based on the followings:

- Reduce equipment noise at source.
- Minimize construction related vehicular noise.
- Make sure the movement of transportation vehicles should be confined only in the day. The movement of vehicle should be restricted during night time.
- It will confirm that construction equipment and vehicles should be equipped with mufflers to effectively decrease generation of noise.
- Providing construction workers with suitable hearing protection like ear cap, or ear muffs and training them in their use.

The proposed strategy should be implemented through the following specific measure:

Reduce Equipment Noise at source

Based on the above survey, equipment emitting excessive noise in comparison to other similar equipment should not be allowed to operate. Equipment underuse should be regularly maintained, tuned and provided with mufflers to minimize noise level. Equipment in poor state of maintenance, particularly without noise control should be checked to determine if it can be improved, replaced with less noisy equipment as soon as practicable.

Traffic noise

- Blowing of horns will be prohibited on the access road to the hydropower plant site and at the site.
- It will be ensured that all such vehicles are properly tuned and maintained in good working conditions and have quality mufflers installed in order to reduce vehicular noise.

Residual Impacts

No irreversible noise impact is expected from the construction activities at the site of project. It is possible that occasionally there will be accidences of the significance criteria during the construction. This may happen if for example the numbers of construction machineries are deployed close to community. This will cause a nuisance to the community, but in case of this project there is no residential activity within 2 km around the project area although this project is likely to last for short period.

Monitoring Requirements

Although the Proposed Project is away from the residential area but the issue related to the noise will not be taken for granted, to mitigate the impacts that can arise due to noise a complete monitoring plan will be developed. Monitoring will be carried out regularly.

5.6.2 Dust emission during construction

Dust emission from construction sites of proposed project during construction of hydropower plant. In case where they reach the receptor, the dust is considered as nuisance as it may disturb soil property and affect the visibility.

Potential Issues

Particulate matter emitted during construction activities can result in deterioration of ambient air quality in the vicinity, and be the nuisance for the community and workers.

Impact Analysis

Potential sources of particulate matter emission during construction activities include truck dumping, halting vehicle movement on unpaved road, combination of liquid fuel in equipment and vehicles. Earthwork and concrete mixing and batching will also yield minute quantities of PM. The quantity of dust that will be generated on a particular day will depend on the magnitude and nature of activity and the atmospheric conditions prevailing on the day.

A wide variety of options exist to control emission from the construction site. The most effective means of reducing the dust emission is wet suppression. Water exposed surface and the soil to keep soil moist at all times can reduce the total dust emission from the project by as much as 75 %.

Mitigation

The following mitigation measures will be implemented at the proposed site construction site during construction to control the emission of particulate matter:

- Water will be sprinkled daily or when there is obvious dust problem on all exposed surfaces to suppress emission of dust. Frequency of sprinkling will be kept such that the dust remains under control, particularly when wind is blowing towards the community.

- Dust emission from soil piles and aggregate storage stockpiles will be reduced by covering the piles, for example with tarpaulin or thick plastic sheet, to prevent emission.
- Construction material that is susceptible to dust generation will be transported only in securely covered trucks to prevent dust emission.

Monitoring Requirement

In the view of the likelihood of residual impacts, the following monitoring measures will be undertaken:

- Dust emission from the construction activities will be visually monitored.
- The community in the residential area and the nearby areas will be actively consulted. Their feedback will form a key mean for monitoring the impacts of dust emissions.

5.6.3 Vegetation loss

The project area is surrounded by an open land. In the surrounding of power plant there is no vegetation cover. Even wild plants are far away from the project site. The power house will be constructed only on BRBD link canal. (Pictures attached here in Annexure). So there is no possibility of vegetation loss.

5.6.4 Water pollution

Potential Issues

Water will be required for the construction camp utilization and for construction purpose. Sources of water pollution on project site include diesel and oil and lubricants; and construction debris and dirt. Pollutants on construction sites can also leach into the groundwater.

Impact Analysis

Sources of water pollution on project sites include diesel and oil, solvents, cleaners and other harmful chemicals; and construction debris and dirt. Pollutants on construction sites can also leach into the groundwater.

Mitigation

Based on discussion above, the following mitigation measures are proposed:

- Special care should be taken when handling oil, solid waste and hazardous waste to entirely avoid any accidental spills and leakages.

5.6.5 Health and safety of workers

Health and safety impacts of the project on workers and communities in the area of influence of the project will be reasonably managed. During construction phase, minor and severe injuries to workers due to machine operation and earthwork may occur but if managed properly, this impact can be mitigated.

Mitigation

- All reasonable precautions will be taken for the safety of employees and equipment will be operated by competent persons.
- Construction activities would be carried out under the supervision of a suitably experienced person.
- Necessary safety gear will be provided to all employees and proper supervision will ensure that the gears are worn at all times.

- First aid kits and other necessary equipment are kept available at Project Site along with a list of emergency phone numbers to be contacted in case of any emergency or accidents.
- Adequate sanitary facilities, potable water, and garbage bins will be provided. Safety rules and regulations will be implemented during construction.
- All workers will be required to wear protective gear and equipment that conforms to safety standards. Security of the project site will be imposed at all times.

5.6.6 Access to road

- New access roads to hydroelectric dams can induce major land use changes—accelerated erosion, and other environmental problems. The environmental impacts of access roads can greatly exceed those of the reservoir.

Mitigation

- New access roads could be sited in corridors that incur the least environmental and social damage. Road engineering should ensure drainage to protect waterways and minimize erosion. Environmental rules for contractors (including penalties for noncompliance) should cover construction camp siting, gravel extraction, waste disposal, water pollution, worker behavior and other good practices for construction.

5.6.7 Power Transmission Lines

Power transmission line right-of-ways can reduce and fragment forests; indirectly, they can increase deforestation by improving physical access.

Mitigation

Fauna and flora of any type is not present at project site. The site is an open land thus project is clean and environmental friendly from all aspects.

Monthly audit will be carried out to check the power lines, to ensure smooth supply of electricity to citizens of Kasur.

5.6.8 Reservoir Sedimentation

Over time, reservoir sedimentation reduces live storage and power generation to a degree that could also lower the projects' long-term prospects for renewable energy over the long term.

Mitigation

Effectively implemented watershed management can minimize sedimentation and extend the reservoir's useful physical life by controlling road construction, mining, agriculture, and other land use in the upper catchment area. For this reason, protected areas are sometimes established in upper catchments to reduce sediment flows into reservoirs. Other sediment management techniques for hydroelectric reservoirs include installing upstream check structures, protecting dam outlets, flushing the reservoir, removing sediment mechanically, and increasing dam height, if physically and economically feasible.

5.7 Environmental impacts as associated with operational activities

The environmental and socio-economic impacts related with the operation phase of the Proposed Project are discussed in this section. The impacts that are discussed are the following:

IMPACTS OF OPERATIONAL PHASE

The anticipated impacts related to the proposed project have been studied for operational stage and is discussed as follows:

5.7.1 Emissions of Greenhouse gases

In comparison to other hydropower plant production sources, such as fossil fuels or nuclear, the hydropower produces relatively small or negligible amount of GHGs which could contribute towards global warming. No greenhouse gases shall be emitted.

Mitigation measures

Since GHGs shall not be emitted from power house so no mitigation is required.

5.7.2 Air Quality

During operational phase air pollution is expected to be very limited, and the main sources shall be from vehicles/dust from maintenance traffic on unpaved roads and increased traffic due to movement of workforce.

Mitigation

A few mitigation measures such as proper vehicle tuning and road maintenance etc, are available to limit influx of traffic movements resulting from improved road infrastructure

5.7.3 Noise

Power station shall be the major source of noise pollution during operation phase. This noise shall mainly be generated in the power station only through operation of electrical and mechanical equipment. Further the increased access as a consequence of the road improvements may generate some additional traffic which could also impact on the existing noise levels in project area. Therefore appropriate noise reduction measures shall be taken to reduce the generation of any noise level.

- **Mitigation**

There will be prohibition on the use of horns in the scheme. Plantation along the roads will act as a noise barrier. Acoustics measure shall be taken care in power house construction for noise reduction, therefore noise level shall not exceed the limiting values as desired by National and International level. Mitigation measures for noise impacts on workers shall include standard occupational health and safety practices such as ear protection.

CHAPTER 6: ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

6.1 Background:

The purpose of developing this Environmental Management and Monitoring Plan (EMMP) is to provide a dynamic guideline to the concerned stakeholders to define details of who, what, where and when environmental management and mitigation measures are to be implemented besides providing the contractors and proponents better on-site environmental management control over the life of the project which is located at the Kasur. The said project is installation of 2.45 MW Hydropower Plant at Bambawali-Ravi-Bedian Canal (BRB) at RD 509+712 within main Link canal in Kasur. The scope of this Environmental Management and Monitoring Plan includes the activities during operational. However, to ensure the compatibility of the Environmental Management and Monitoring plan in accordance with the changing socio-cultural, economic and environmental factors, it would be used as a dynamic tool which means that the EMMP would undergo necessary modifications to keep catering to the changing environmental needs of the project.

Table 6.1 Users of EMMP

Sr. #	EMMP Elements	End Users
1	Background	All stakeholders – internal and external Approval or consent authority e.g. EPA Punjab
2	Environmental Management	The management and supervisory staff of Packages Limited. EPA Punjab
3	Implementation	The management and supervisory staff of Packages Limited EPA Punjab
4	Monitor and review	The management and supervisory staff of Packages Limited

		and EPA Punjab

6.2 Purpose and Objective of EMMP

The purpose of the EMMP is to provide **a** framework for the implementation of the mitigation and monitoring measures which were identified in **Chapter 5**.

Based on this purpose, the key objectives of the EMMP are to:

- Facilitate the implementation of the identified mitigation and monitoring measures from the assessment;
- Define the responsibilities of the project proponent and contractor, and provide a means of effective communication of environmental issues between them;
- Identify parameters in order to ensure the effectiveness of the mitigation and monitoring measures;
- Provide **a** mechanism for taking timely action in the face of unanticipated environmental situations; and,
- Identify training requirements at various levels.

6.3 Management Approach:

The overall responsibility for compliance with the environmental management plan rests with the project proponent.

6.4 Institutional Responsibilities:

Following functionaries are involved in the implementation of EMP.

- Project Proponent
- HSE/ Project Manager
- In-Charge Administration
- Supervisor of Project

- Environmental Engineer

6.5 Environmental Management and Monitoring Plan Structure and Responsibility

The Table further explains the Environmental management and Monitoring plan.

Table 6.2 Environmental Management and Monitoring Plan

Sr. #	Positions	Significance	Stage	Environmental Responsibilities
1	Proponent / Owner	Critical	Construction/ Operations	Oversee Environmental Policy and EMMP Serve as primary contact to the regulatory authorities Commit resources to achieve environmental objectives
2	All Employees	Critical	Construction/ Operation	Attend training and understand their roles in the implementation of EMMP Understand the Environmental Policy / Objectives and act accordingly Participate in the review of EMMP Coordinate with the responsible authorities within the project to report any noncompliance to their Environmental Policy
3	Operational Supervisor	Critical	Construction/ Operational	Understand the environmental policy of the project Operate in accordance with the environmental policy. Ensure all machineries /equipment are in good conditions

				Ensure health and safety of the workers during construction phase Ensure safe transportation of good/materials to and from the project site
4	Maintenance Manager	Critical	Construction/ Operation	Understand the environmental policy of the project Operate in accordance with the environmental policy Ensure all machineries /equipment are in good conditions Ensure health and safety of the workers during operational phase Provides health, safety and environmental awareness trainings to the staff
5	Administrative Person Deal with Environment Issues	Critical	Construction/ Operational	Understand the environmental policy of the project Operate in accordance with the environmental policy Ensure all machineries /equipment are in good conditions Ensure health and safety of workers during operational phase Receive health, safety and environmental awareness trainings Prepare and maintain accidents/environmental risk records Timely coordination with the responsible

				authority

6.6 Environmental Management Plan

Packages Private Limited believes in sustainable resource management which is why it has developed a comprehensive Environmental Management and Monitoring Plan for its construction and operational phase.

Table 6.3 Environmental Management and Monitoring Plan

Sr. #	Environmental Element	Mitigation Measures to be taken during	
		Construction Phase	**Operational Phase**
1	Sewage	There will be only domestic wastewater during construction phase. Wastewater of construction will be reused in construction practices like making construction material or sprinkling on dust etc.	Residential area for workers will be constructed (mentioned in map) with proper disposal of wastewater.
2	Civil water supply	It shall be ensured that no activity tempers with the civil water supply system in the area, if any.	It shall be ensured that no activity tempers with the civil water supply system in the area, if any.
3	Solid waste	Solid waste from construction phase (iron, mud etc) will be reused in construction making	During operational phase, there will be only domestic solid waste No solid waste will be produced by the process operation.

		material. Domestic solid waste will be collected by sanitary workers according to their guidelines.	
5	Noise	In order to avoid the nuisance of noise the project maintenance manager shall ensure the all vehicles, equipment, machineries used during construction phase are in good working condition. The working hours of the project construction activities shall be limited to day time only i.e. 08 in the morning till 05 in the evening. Generators, if used during construction phase, shall be kept under canopy to avoid generation of unwanted noise.	Noise suppression canopy will be installed over the turbine to reduce the noise pollution. The noise will be generated but it will be within the limits set by PEQS.
6	Gaseous emissions and particulate	The electricity generator to run various construction machineries	During operational phase, the hydropower plants do not use fuel, so power generation does not produce carbon dioxide. Hydropower normally

	matters / dust generation	and equipment will produce gaseous emissions and particulate matters. Therefore, the generators will only run during shutdown of power supply from WAPDA grid. Construction materials e.g. sand and clay will be transported to the construction site under cover to avoid any fugitive dust.	has the negligible life cycle greenhouse gas emissions for power generation.
7	Traffic related problems	Traffic management will be done to avoid traffic stampede/congestion. Parking on the main roads and/or blocking public accessibility will be discouraged.	Enough space for car parking will be provided to avoid random vehicle parking on roads. Although vehicles frequency will be negligible at project site.
8	Trash burning	No trash burning will be allowed in or outside the project site.	Trash burning will be discouraged within the premises of the Hydropower plant.
9	Dust	The construction materials with potential to create dust issues will be kept	The proposed project is planned in such a way to minimize generation of dust. Green belts will be watered to avoid the issues of desertification and

		under cover. Sprinkling of water will be conducted to avoid dust generation.	soil erosion.
10	Environment quality enhancement measures	Hydropower plant is itself an environmental friendly project.	Hydropower is clean, renewable and non-polluting energy resource with high conversion energy efficiency.
11	Staff for environmental management plan	Special staff will be recruited to implement this Environmental Management Plan on regular basis.	Special staff will be recruited to implement this Environmental Management Plan on regular basis. Administration will be responsible for establishment of successful implementation of EMMP.
12	Protection of surface water quality	Surface water quality will not be deteriorated during construction phase of hydropower plant as there will be no water in canal during construction	During operational phase, no construction will be carried out which deteriorate the surface water quality of canal.

6.7 Environmental Monitoring Plan

Environmental monitoring is being followed and will be strictly undertaken in accordance with the requirements of the environmental authority (EPA, Punjab) to ensure compliance to the Punjab Environmental Quality Standards (PEQS) as and when required. Proponent has decided to spend 0.1 million PKR annually for sake of Environmental Budget.

Environmental monitoring is including parameters that are mentioned in the Environmental Approval accorded by the Environmental Protection Agency, Punjab for getting approval under section 12.

6.8 Institutional Arrangement

Administration under the supervision of the maintenance manager provides report directly to the proponent. The administration consists of skilled personnel with expertise in health, environment and safety issues. Roles and responsibilities for the implementation of EMMP are further explained earlier under the head Roles and Responsibilities.

6.9 Reporting

The proponent aims to provide timely, relevant and appropriately presented information to the concerned government authorities, local community surrounding the proposed project site on the environmental, health and safety performance of the project. The commitment would be met by record keeping and presenting it to the concerned authorities as and when required.

6.10 Staff Training

Staff training is important parameter that needs to be fulfilled adequately in order to ensure the successful implementation of environmental objectives. Keeping this fact under consideration, Packages Private Limited ensures that the employees, contractors and workers receive appropriate environmental awareness training. Staff training is being conducted on regular basis and it will be obtained through a variety of methods including training sessions, formal/informal meetings and discussion and formal presentations. Environmental awareness training would take place at various stages of the persons concerned with the proposed project. This would occur at the induction of any new employee/contractor/workers and will be made a regular on-site feature. Records of training content and attendance will be maintained.

Packages Private Limited requires the persons involved during operational phase to be aware of following responsibilities and equipment, maintenance detail:

- Their roles and responsibilities (including environmental incident reporting)
- The environmental impacts (potential and actual) of their activities during operation
- Natural hazards such as earth quake and floods etc.
- The potential consequence of poor environmental performance
- Site emergency plans and their execution procedures

Table 6.4 Persons involved during constructional and operational phase to be aware of following responsibilities and equipment, maintenance detail

#	Description	Responsibility	Who will be involved	Outcomes
1	Air Quality	Administration	All employees	Better understanding of the health impacts associated with air pollution Develop a monitoring and reporting system for air pollution. Nevertheless Hydropower project is clean and nonpolluting energy resource. Third party involvement especially EPA approved labs will be decided under potentially harmful circumstances
2	SWM	Administration	Staff	The staff will be trained to follow the principles of keep the environment neat and clean Improved understating regarding health

				impacts associated with unplanned waste management A monitoring and reporting system that would enable the supervisor to keep control of all unnecessary scattering
3	Wastewater	Administration	Employees but specific attention to the staff	There will be no wastewater because at the site workers will use water only for sake of drinking purpose because only day time excavating activity will be done during construction phase. The operational process is closed loop and does not produce any wastewater.
4	Noise	Administration	All employee	Monitoring and reporting system for noise related issues if detected Appropriate measures would be identified and implemented Guidance to the employee on adopting good practices for noise and any other practice that otherwise could lead to environmental nuisance. During operation, noise suppression canopy will be installed over the turbine to reduce the noise pollution.
5	Firefighting	Administration	All employee	Improved understanding of keeping a tab on all potential threats that could lead to fire hazards. Understanding on how to use the

				firefighting equipment Understanding regarding emergency exits and use of fire point
6	Landscaping	Administration	Staff	At the project site there will be the need for proper managing of waste during construction phase and during operational phase the siltation soil used in agricultural fields.
7	Accidental Spills	Administration	All staff	Improved understanding regarding how to react during minor and major spills according to the measures identified

6.11 Environmental Audits and Reviews

Packages Private Limited will ensure conducting environmental audits to assess compliance with the conditions set under the environmental legislation and those mentioned by the EPA, Punjab during grant of Environmental Approvals. The objective of the environmental audit and review is to monitor and report both compliance and non-compliance with the statutes, EMMP and the conditions set under Environmental Approval. This would be done for the operational phase of the proposed project under the supervision of the administration.

6.12 Public Consultation

Social survey was held with the surroundings from the project area at Kasur. The social survey was held to come to know about the project has opportunities for surrounding people as well as will bring new income opportunities for the surrounding community ultimately helping in the reduction of poverty in the area to a greater extent. The questionnaires filled during public consultation have been attached in Annexures.

Emphasis was placed on community awareness and perception about the proposed project. This was an important component of the entire study as social assessments are complementary part of environmental assessment. By and large, the people of the project area are well aware of the project and can well anticipate the activities that would entail once the project enters its operational phase. All of the respondents who participated in the public consultation process welcomed the project considering it beneficial both economically and socially. According to their point of views, the project fulfills their energy requirements and providing small income generating opportunities. People foresee this project as a positive precursor that would give rise to employment opportunities as well as their energy requirements. No opposition from the public was confronted for the project.

6.13 Money Compensation

The land belongs to irrigation department and there is no population in the radius of 2 kilo meter. There is no cutting of flora and no harm to fauna by this project. There is no any structure or residence which is going to be damaged by project so there is no need for money compensation. Project is environment friendly.

6.14 Replacement, Relocation and Rehabilitation

Project is to be installed in an open land where there is no population or any structure. So there is no need for replacement, relocation and rehabilitation of project. The operation of hydropower plant is clean and environment friendly

6.15 Elements of Occupational Health and Safety Management System (OHMS)

For an effective OHMS, the management of the project led towards implementation the following elements:

- Formulation of OHS Policy
- Identification of risks, hazards and countermeasures
- Adoption of OHS Targets based on OHS Policy

- Incorporation of opinions of stakeholders in OHS Plan
- Implementation and operation of OHS plan
- Establishing an organizational documentation
- Routine inspection and improvements system audits
- Revision of OSHMS

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

The proposed project is 2.45MW Hydropower Project at BRB Canal in Kasur. The project falls under Schedule-I (List of projects requiring an IEE). The project requires an Initial Environmental Examination (IEE). In order to ensure compliance with the lawful provision of section 12 of PEPA 1997 (Amended 2012) read with IEE/EIA Regulations 2000, the Initial Environmental Examination Report has been prepared and is being filed to the Environmental Protection Agency, Lahore for issuance of environmental approval.

Accordingly, this IEE report describes social, environmental, physical and other relevant aspects of the project during construction and operational stage and at its regular occupancy. The report also specifies necessary measures to be adopted for mitigation of environmental impact on the environment. It also provides information as desired under the format used for the preparation of this IEE Report.

The installation of hydropower plant is for fulfill the demand of energy in the area of Kasur. Detailed project alternatives have been considered in project description chapter and proper Environment Management Plan also has been discussed in Chapter VI.

The use of hydropower plants should encourage because it doesn't cause air pollution or greenhouse gasses. It is one of the most reliable; cheapest and cleanest sources of energy. Hydroelectric power plants ensure reliable delivery of electricity by enabling a steady and regular production of electricity which isn't the same with other renewable energy sources. This Project will provide employment for people and allow generation of revenues for indigenous peoples and governments. However, there is also a flipside to them as well. Hydropower plants have very long history of use, and generate the largest share of renewable energy in the world. Using hydropower has mostly great advantages. It could help us make more electricity faster, consistently and sustainably for the future.

Hydropower installations bring electricity, highways, industry and commerce to communities, thus developing the economy, expanding access to health and education, and improving the quality of life. Hydropower is a technology that has been known and proven for more than a century. Its impacts are well understood and manageable through measures for mitigating and compensating the damages. It offers a vast potential and is available where development is most necessary.

However, the environmental aspects and impacts associated with construction of power house considered. All infrastructure e.g., road, sewerage, water supply, electric supply, gas etc. already exist in the project area. The project is an environmental friendly site. There will be not wastewater and solid waste because the Hydropower technology is itself environmental friendly and sustainable which use the water resource for production of energy. The baseline study has been conducted reviewing the available literature. The overall impact of the project can be considered positive.

For the effective implementation and management of the mitigation measures, an outline Environmental Management and Monitoring Plan (EMMP) has been developed.

7.1 Conclusion

In view of the above it has been concluded that 2.45 MW proposed Hydropower Plant is environmental friendly and sound practice. It is therefore requested to issue the environmental approval under section 12 of PEPA 1997 (Amended 2012) for the project that is 2.45 MW proposed Hydropower Project at BRB Canal in Kasur.