EXECUTIVE SUMMARY

BACKGROUND

Ghorband and Nandihar Hydropower Projects were identified by Pakhtunkhwa Hydel Development Organisation (PHYDO) [the then SHYDO], Peshawar, Pakistan and Deutsche GesellschaftfuerTechnischeZusammenarbeit GmbH (GTZ), Eschborn, Germany through a report titled "Hydropower Development in Mountainous areas of NWFP: 1992". The details for these Projects are given in "Vol. III Chapter–5 of 'Regional Development Study Indus Swat / Mansehra West" through an inventory of hydropower potential for Indus Swat and Mansehra area. Only small portion of hydropower potential (about 15%) has since been developed. A large portion of the same is yet to be harnessed.

Afterwards PHYDO had planned to develop step–wise several of these identified schemes with selective alternatives. Out of these Ghorband Hydropower Project was identified as SCHEME No. 2 / Alternative 1 – SeraiKarora – on Ghorband / Shin River (18 MW) now called as Ghorband Hydropower Project [GHPP] and Scheme No. 7/ Alternative 1 – Thakot – on Nandihar River (10.3 MW) now called as Nandihar Hydropower Project [NHPP] and are entrusted to Ghorband Nandihar Hydropower Consultants [GNHPC] for present Feasibility Stage Study.

Accordingly, Consultancy Agreement for Feasibility Studies of both Ghorband and Nandihar Hydropower Projects was signed on 22 June, 2012 between Joint Venture of Consultants comprising of **NDC, BAK** and **Hydro-Tech**in association with **LI and KEC**(GNHPC)by **Pakhtunkhwa HYDEL Development Organization** (PHYDO) Peshawar (Client) at a total cost of Rs. 65,864,464/- breakup of which is tabulated below:

Sr. No.	Description	Amount (Rs.)
1	Salary Cost/Remunerations	34,058,067
2	Direct (Non Salary) Cost Projection Office	14,362,589
3	Direct Cost Field Office	3,103,808
4	Field Survey and Investigations Cost	14,340,000
	Grand Total:	**65,864,464**

(Rupees Sixty Five Million Eight Hundred&Sixty Four Thousand Four Hundred and Sixty Four only)

Note: *Later, on the request of the Consultants an Addendum No. 01 was issued in Nov 2012 wherein Consultants were allowed to adjust/reallocate funds within various Direct Costs Heads and for new items of Costs as warranted for completion of services. Consultants were also allowed to adjust Salary Costs within the provisions earlier made.*

As a part of Services, the Consultants prepared a combined **Inception Report**for both the Hydropower Projects which was submitted to the Client in Oct 2012, whereas, combined **Mid Term Report** was submitted in Jul 2013.

In this Report only Ghorband Hydropower Project is discussed.

INTRODUCTION

Ghorband Hydropower Project (GHPP) was proposed as run of the river (Diurnal peaking Project) on Khan Khwar River in Shangla District of KPK. After thorough deliberations in different meetings and discussions with the Client, finally it was decided that a **Power Tunnel** from Belay Baba to Serie Village, where**Power House**would be located, is to be constructed. This option was approved by PHYDO and the Consultants were allowed to carry out additional topographic surveys, Geotechnical studies etc for conductingthe Feasibility Studies of this option.The proposed Hydropower Station, as per TOR, will have no huge reservoir. However, it would include Weir, Tunnel,Penstock, Powerhouse and Transmission lines etc. These components may have some impact on the environments, temporary or permanent.

GENERAL DESCRIPTION OF THE PROJECT

The Project concept is based on diverting partial flow of GhorbandRiver by means of a diversion weir and further through a 5.8Km power tunnel to the Power House where water is returned to the GhorbandRiver some 9.6 Km further downstream.

By this concept some 275m head can be obtained for Power Generation which permits a maximum available capacity ex-generator of 20.6 MW and a mean annual energy generation of 111.4 GWh at a base cost of US $ 58.602 million. Salient features of the project are as follows:

Salient features of the Ghorband Hydropower Project

Description	**Symbol**	**SI**	**Unit**
Design Discharge	Qd	8.5	m^3/sec
Environmental Flows	Qe	0.2	m^3/sec
No. & Type of Units		2	Pelton
Design Discharge (single unit)	Qunit	4.25	m^3/sec
Net Head	Hn	274.7	m
Turbine Efficiency at QD	η_T	92	%
Generator Efficiency	η_G	98	%
Transformer Efficiency	η_{Tr}	99.5	%
Annual Shutdown	T_{AS}	20	days
Results			
Gross Power	P_G	20.6	MW
Annual Energy	EA	111.4	GWh
Plant Factor	PF	61.7	%

General Information

Total Cost of the Project	PKR7422.399 M (US $ 69.368 M)
Unit Cost of Generation	PKR 3.607
EIRR (Compared to CCGT)	15.71%
Period of Construction	36 Months
Project Layout	Left Bank of Ghorband River
Weir Location	Pagorai, Ghorband Valley
Catchment Area	253 km^2
Powerhouse location	Serai Bridge Karora
Weir & reservoir	
Weir Height	13 m
Free board	1.8 m
Normal Reservoir level	1208.2 m a.s.l
Minimum reservoir level	1204.5 m a.s.l
Reservoir Capacity @1208.2	0.08 MCM
Weir Top Level	1210 m a.s.l
Tail water level	914 m a.s.l
Length of the Weir crest	112 m
Desander	
TYPE	Surface
No. of Chambers	2 No.
Total Length	90.5 m
Total Width of 2. Chambers	11.3 m
Gross Head	288.5 m
Total Head loss	13.8 m
Net Head	274.7 m
Power & energy	
Design Discharge	8.5 Cumecs
Intake (Lateral Intake) at Left	Single Intake with Trashrack
Headrace tunnel (HRT) Length	5809.0 m
HRT Diameter (Horse Shoe)	2.3 m

Penstock length	564.0 m
Penstock Dia (Steel Penstock)	1.4 m
No. of Turbine	2 Pelton Units
Rated Power	20.6 MW
Annual Estimated Energy	111.4GWh
Annual Shutdown	20 Days
Plant Factor	62%
Spillways details	
Main Upper Spillway	
Gated/Ungated	Radial Gated
Height of the Spillway	3.0 m
Width of the Spillway	4.5 m
No. of Bays	5 No.
Discharge capacity at Max. RWL	330.0 Cumecs
Bottom Outlets	
Gated/Ungated	Vertical Lift Gate
Height of the Spillway	1.5 m
Width of the Spillway	2.0 m
No. of Bays	5 No.
Discharge capacity at Max. RWL	160.0 Cumecs
Total Discharge Capacity	490.0 Cumecs
Surge shaft	
Surge Shaft Dia	5.0 m
Surge Shaft Height	31.0 m
Power house	
Type	Surface Power House
Main Dimensions (W x L x H)	14 x 43 x 17
Tailrace Channel	
Type	Trapezoidal
Total length	23 m

SCOPE OF SERVICES

Scope of services of the Consultants was elaborated in the Terms of Reference (TOR) issued by the PHYDO, which comprises the following tasks:

- **TOPOGRAPHIC SURVEY**
- **HYDROLOGY AND SEDIMENTATION**
- **ENGINEERING GEOLOGY & EVALUATION OF SEISMICITY**
- **ASSESSMENT OF ENVIRONMENTAL AND SOCIAL IMPACTS**
- **DESIGN AND LAYOUT OF STRUCTURES**
- **DEVELOPMENT OF CONSTRUCTION PLAN**
- **TRANSMISSION OF POWER**
- **UNIT PRICE**
- **BENEFITS OF PROJECT**
- **ECONOMIC PARAMETERS**
- **SENSITIVITY ANALYSES**
- **OPERATONAL COST ESTIMATE**
- **SERVICES AND REPORTING BY THE CONSULTANTS**
- **PC-I**

All the aforementioned tasks are described in detail in the succeeding chapters; however, the status of each task is briefly given here under:

Topographic Survey

Topographic Survey of Ghorband HPP Area was commenced during the month of Jan 2013. In order to achieve much suitable result, the Topographic Survey was repeated time and again with the help of TOS and Satellite Images etc. The survey was finally completedto the satisfaction of all concerned in the month of July 2013.

Hydrology and Sedimentation

The hydrological studies for Ghorband HPP were required to determine probable runof the river project catchment and the discharges available for power generation in its magnitude and seasonal variationsas well as quantum of sediments flow. These studies included Installation of Gauge Station and fielding of suitable Hydrographer, Gauge/Sediments observers etc. All the Hydrological and Sedimentation studies were carried out according to TOR provided by the Client and completed in Oct 2013, however, gauge observation/sediment measurementwere continued till end Dec 2013.

Engineering Geology & Evaluation of Seismicity

Geological and Geotechnical Engineering was conducted satisfactory, however, it was a little bit delayed because of late fielding of Chief Geologist. Simultaneously,construction material survey was carried out as a parallel activity. Similarly, Seismic Hazard Evaluation was also carried out by relevant experts. All these activities were successfully completed by Oct 2013 and reports by concerned experts were submitted in Nov 2013.

Project Layout and Hydraulic Design

The information provided in PHYDO/GTZ report is of very basic level. The power estimated was 18 MW. Several layouts were studied for this project. In planning various layouts, recommendations of the GTZ report were kept in view, however, several significant changes

were found necessary in the light of latest available topographic, hydrological and environmental data.

The hydraulic design studies of Ghorband Hydropower Project include design of weir, intake, sand trap, power tunnel, surge shaft, penstock, powerhouse and tailrace.

Seismic Hazards

The proposed Ghorband HPP is a run of river scheme on Ghorband river approximately 300 m upstream of village Kuz Kana in Shangla District. The project is nearly 25 km from Besham which is about 225 km from Islamabad. It is located in a zone which is seismically active due to the continuing northward drifting of the Indian plate and its sub-duction under the Eurasian plate. To ensure proper designing of the critical structures, Seismic Hazard Evaluation has been carried out. Such analysis involves quantitative estimation of ground shaking at the Project site. Both Deterministic as well as Probabilistic approaches were used.

Structural Design Studies

Structure design of the project has been done ensuring the stability and safety of structures against encountered forces/loads including hydrostatic pressure, earth pressure, imposed live, uplift, seismic and other design loads etc using guidelines of established manuals and code of practices. Reinforcement Design is based on ACI Ultimate Strength Design (USD) method. Grade 60 bars are used. Load factors for components other than power tunnel, are based on ACI 318-01. Factors for power tunnel are adopted from US Army Corps of Engineers EM 1110-2-2901 – Tunnels and Shaft in Rock. Design strength of structural members has been taken as a product of nominal strength and strength reduction factor. Allowable stresses are according to ACI 318. Design considerations for all individual Project Components are elaborated in the relevant Sections of the report.

Mechanical Equipment

Mechanical equipment includes turbines, governors, inlet valves, gates, stop-logs, trash-racks and cranes etc. For the operating net head range of 269.9 m to 274.7 m a Francis type of turbine could be considered for Ghorband power plant. However for the range of discharges available, from 9.88 m^3/s (maximum) to 0.85 m^3/s (minimum), a Pelton turbine is considered more appropriate, as it has a better efficiency over the whole range of discharges. From the comparative study of various turbine sizes and combinations, two turbines each with 4.25 m^3/sec flow have been selected. Considering turbine efficiency of 92% for the head range of 269.9 m to 274.7 m and design flow of 4.25m^3/s, the total output power will be 20.6 MW considering generator efficiency as 98%.For determining appropriate unit capacity, both technical as well as economic aspects have been examined in a comparative study taking into account equipment dimensions, transport limitations, power and energy benefits, manufacturing experience, power system regulation, and cost estimates etc.

Electrical Equipment

The generators consists of the 2 (two) vertical type, self-excited brush less type 11KV synchronous generators, for direct coupling to pelton wheel turbines through epicycle gear, complete with excitation equipment and other auxiliary equipment as specified. For transmission of electrical power, two number three-phase step up power transformers with

rated power of 14 MVA each have been proposed. The proposed switchyard scheme for this hydropower station is of standard configuration i.e. single bus with single circuit breaker arrangement.

Environmental and Social Assessment (IEE & SIA)

A series of meetings were held by the GNHPC Environmentalist/Social Expert with local population, elites of the area, public representatives, district administration, revenue, forest, agriculture, irrigation & other departments for consultation, information sharing and obtaining their views about the proposed project**.** Land in Ghorband Project area comprises cultivated, waste lands and settlements. Fruits and thick forest lies in the Project area, which will have to be removed during construction stage of this Project.

It is concluded that the Project activities will have some adverse environmental impacts. The overall environmental impact will be from “low to medium”. There should be trained staff at the project site for environmental management and monitoring.

Cost Estimates

The total project construction cost of civil works has been estimated on the basis of current market. Appropriate escalation factor has also been applied to match with current market prices. In case of cost of E&M Equipment, due consideration has been given to the current recession in the market. Equipment which can be manufactured locally has also been appropriately utilized. The estimate is based on current price level and in converting US dollars to Pak Rupees, the prevailing exchange rate as in January -2014 has been adopted viz US$ 1 = Rs. 107.00.

Base cost of the project has been estimated as PKR 6270.432 million (58.602 million US $) and the investment cost as PKR 7422.339 million including price escalation, custom duties and interest during construction.

Based on these cost estimates for the project, economic and financial analyses of the project have been carried-out.

Economic Analysis

To demonstrate economic feasibility of Ghorband Hydropower Project, equivalent thermal power cost approach has been used. The life cycle cost of Ghorband HPP has been compared with the life cycle of cost of alternative equivalent thermal plant i.e. Steam Generation Plant using Furnace Oil (FO Plant) and a Combined Cycle Gas Turbine (CCGT).

Above analysis reveal that;

- Ghorband Hydropower Project (GNHPP) is an economical and feasible Project on River Ghorband. Its installed capacity, as estimated through different studies, comes to 20.6MW. The Project will generate 111.4GWh of annual energy when fully commissioned, which is anticipated to take 36 months after fulfillment of requisite formalities like detailed Engineering Design, Tendering and Letter of Commencement to the Contractor.

- Environmental Impact Assessment (EIA) Studies have determined the overall impact rating of the Project activities as “low to medium”.

- It is concluded that the IEE is adequate to justify environmental and social clearance of the Project. There is no need for further analysis and the environmental and social assessment of the Project.

- Project Economic analysis reveals that the project is economically viable as the Economic Internal Rate of Return (EIRR) is greater than the opportunity cost of capital.

- EIRRs calculated for the Combined Cycle Gas Turbine (CCGT) & Furnace oil Thermal alternatives come to 16.40% & 28.47% with CDM benefits and 15.71% &27.77% without CDM Benefits respectively.

- Economic Sensitivity Analysis without CDM for CCGT Thermal Plant (with 10% benefits. 20% cost over and combine impact) indicate EIRR of 13.87%, 12.55% &10.93% respectively.

- FIRR comes to 12.68% whereas cost of Generation is PKR 3.607 per unit.

- The economic comparison of FO plant and CCGT with Hydropower plant indicates CB ratio without CDM as 2.03 & 1.26 and with CDM as 2.05 &1.29 respectively.

- Revenue has been estimated on the basis of system sale price of 10.35 PKR/Kwh. 2% auxiliary consumption has been assumed.

Conclusions

From the study it has been concluded that the project is viable and recommended for detailed engineering design and execution.