PAKHTUNKHWA HYDEL DEVELOPMENT ORGANIZATION
GOVERNMENT OF KHYBER PAKHTUNKHWA

188 MW NARAN HYDROPOWER PROJECT

DRAFT FEASIBILITY STUDY REPORT

EXECUTIVE SUMMARY

December, 2013

Naran Hydropower Consultants:

Mirza Associates Engineering Services (Pvt) Ltd.

ILF BeratendeIngenieure ZT GmbH, Austria

Berkeley Associates

Sub-Consultants:

ILF Pakistan (Pvt) Ltd. **ESUPAK, UET, Lahore** **NCEG, Peshawar** **HEC Peshawar**

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1 INTRODUCTION

Naran Hydropower Project (HPP) is one of the series of hydropower development projects launched by PHYDO (Pakhtunkhwa Hydel Development Organization), Government of Pakhtunkhwa (KP). The objective of the proposed hydropower scheme is to generate and add cheap energy to the system in order to meet the current shortfall and increasing demand of electricity in the region through economical and sustainable means.

Montreal Engineering Company (MONENCO),a Canadian Consulting Engineering Organization, identified three hydropower projects on Kunhar River, namely Naran, Suki Kinari and Patrind in 1984. Subsequently in 1995, the project was reviewed under the study "Identification of Hydropower Potential in Kaghan Valley" by Sarhad Hydel Development Organization (SHYDO) with the technical collaboration of the German Agency for Technical Cooperation (GTZ). The project envisaged a 140 m high dam with a 10.6 km long headrace tunnel and an underground powerhouse on the right bank of Kunhar River. The dam axis was, identified 2 km upstream of Naran town, headrace tunnel on the right bank and the powerhouse 2 km downstream of Bhimbal nullah confluence with Kunhar River.

PHYDO carried out ICB in 2011 for the selection of Consultant to carry out detailed Feasibility Study of the Project. As a result of competitive bidding, the Consortium of Consultants led by Mirza Associates Engineering Services (Pvt.) Ltd. (MAES) and consisting of ILF Beratende Ingeniere ZT GmbH, Innsbruck, Austria and Berkeley Associates, Pakistan, had been selected for implementation of the Feasibility Study of Naran HPP. The Consultants carried out services for eighteen months and prepared this bankable Feasibility Study Report of the Project.

The study has resulted in a project size of 188 MW with an excellent economic rate of return. **Table - 1** presents the salient features of the Project. Naran dam and powerhouse have been proposed in the river stretch between Kaghan and Batakundi on Kunhar River. The dam site on Kunhar River is 12 km upstream of Naran town. The powerhouse is to be located on the left bank of Kunhar River, 11 km downstream of Naran town. The whole project layout including the headrace tunnel is proposed on the left bank of Kunhar River.

Table - 1: Salient Features of the Project

HYDROLOGY (DESIGN FLOWS)	
Catchment area at dam site	905 km^2
Mean annual flows	39.2 cumecs
Design discharge	70 cumecs
Design flood (10,000 Year Flood)	1182 cumecs
Probable maximum flood	1420 cumecs
Maximum flood level	2570 m.a.s.l

RESERVOIR	
Reservoir length	3500 m
Reservoir area	0.555 km^2
Max. Reservoir operating level	2566 m.a.s.l
Min. Reservoir operating level	2558 m.a.s.l
Reservoir capacity at 2566 m.a.s.l	14.636 MCM
Reservoir capacity at 2558 m.a.s.l	4.14 MCM
DAM STRUCTURE	
Dam height above riverbed	74 m
Dam crest level	2572 m.a.s.l
Dam Type	RCC Concrete gravity
DIVERSION TUNNEL	
Length of diversion tunnel	455 m
Size of tunnel (W x H)	5 x 7.0 m
SPILLWAYS	
Type of spillway	Gated surface
Number & type of gates	3 (Three), Radial gate
Gate size	5 x 8 m
Discharge capacity	1059 Cumecs
LOW LEVEL OUTLETS/ FLUSHING SLUICES	
No. of outlets	3 (Three)
Gate type	Vertical lift gate
Gate size (W x H)	3.0 x 3.0 m
Discharge capacity	390 Cumecs
POWER WATERWAYS **POWER INTAKE**	
Type	Lateral intakes
No. of gates	2 (Two)
Gate size (W x H)	7 m x 6 m
Deck elevation	2572 m.a.s.l
Sill level of intake racks	2548 m.a.s.l
LOW PRESSURE HEADRACE TUNNEL (SHOTCRETE LINED)	
Diameter	6.8 m

Length	17,930 m
SURGE SHAFT	
Diameter	10 m
Height	94 m
PRESSURE SHAFT	
Diameter **(CONCRETE LINED)**	5.8 m
Length	274 m
HIGH PRESSURE TUNNEL	
Diameter **(CONCRETE LINED)**	5.8 m
Length	226 m
Diameter **(STEEL LINNED)**	4.4 m
Length	100 m
PENSTOCKS (Bifurcation)	
No. of penstock	4 (Four)
Diameter	2.2 m
Length of Penstock (total of 4)	100 m
POWER GENERATION	
Gross head	336.0 m
Installed plant capacity	188 MW
Mean annual energy (average 51 years.)	705.46 GWh
Plant factor	42.8% (Average year)
Firm power	92 MW
Turbine type	Francis, 375 rpm
No. of units	4 (Four)
Turbine Setting	- 4.0 m
Turbine centreline level	2224 m.a.s.l.
Generator	4 (Four)
Powerhouse type	Underground Cavern
Transmission line	500 kV
TAILRACE TUNNEL (CONCRETE LINED)	
Diameter of tunnel	6.0 m
Length of tailrace tunnel	300 m

This Feasibility Study Report consists of a Main Report (Volume-1) and nine (9) supporting volumes. The Main Report consists of eighteen (18) sections completely covering all aspects of the Project at feasibility level, whereas the nine (9) volumes present details of the studies, field data, drawings and other required information related to different sections of the Main Report.

2 TOPOGRAPHIC AND HYDROGRAPHIC SURVEYS

For the preparation of a bankable Feasibility Study Report of international standard for Naran HPP, a comprehensive topographic survey program was established and executed in the field by a qualified and experienced survey team of the Consultants.

The survey had been carried out in one uniform system of co-ordinates and elevations using S.O.P. Benchmark at Batrasi as datum. All survey work was then duly verified through GPS.

Following scales with contour interval of 2 m have been adopted for the survey maps of the project:

I.	Reservoir area, Headrace Tunnel / Channels, Access Roads	1:2000
II.	Dam Site and Intake Area	1:500
III.	Surge Tank, Pressure Tunnel/Penstock, Powerhouse and Tailrace	1:1000
IV.	Project Layout	1:25,000

The terrestrial survey has been carried-out for all alternatives of project layouts conceived and selected for field work at the Inception Stage and covers all the project components**.**

For the inaccessible areas of the tunnel alignments, topographic maps have been developed with the help of high resolution Digital Elevation Models (DEM), ortho-rectified with ground survey.

Hydrographic survey was carried out and longitudinal profiles of the relevant stretch of Kunhar River were prepared.

3 HYDROLOGY AND SEDIMENTATION STUDIES

The Project has a catchment area of 1905 Km^2 up to the dam site. Mean annual flows estimated for the Naran/Kaghan stream gauging station, dam site and powerhouse site are 46.2, 39.2 and 58.1cumecs, respectively.

The recommended flood magnitudes corresponding to 10,000 year return period for the dam and powerhouse sites are computed as 1182 and 1601 cumecs, respectively. The computed PMF at the dam site is 1420 cumecs.

Average annual total sediment inflow to the dam site is 0.177 MCM (143.5 AF). Average annual trapped sediment load at the dam site is 0.096 MCM (78 AF). Optimum discharge to carryout efficient flushing of the reservoir is computed as 80 to 160 cumecs, with flushing duration one to two weeks (after about 10 years). The life of Naran reservoir without flushing option is about 120 years. The life of the reservoir could be enhanced to about 450 years with appropriate flushing operations once in 10 years in the month of July. Dam breach analyses for PMF

shows that the generated flood peaks between the dam and powerhouse sites indicate no chances of flooding of the downstream settlements.

4 NEO-TECTONIC AND SEISMIC HAZARD ANALYSES

The region encompassing the Naran HPP is highly complex in terms of its tectonic set up. The estimated seismic hazards in terms of peak ground acceleration (PGA) with 10% probability of exceedance in 50 years i.e.,475 year return period as computed by different workers for Kaghan, range between 0.2 and 0.35 with the recommended value as 0.35.

4.1 Seismic Design Parameters Based on Deterministic Seismic Hazard Assessment (DSHA) Approach

According to ICOLD (2010), DSHA is used for assessment of Maximum Credible Earthquake (MCE), and PGA values for both 50-percentile (median) and 84-percentile (mean plus one standard deviation) are listed.

For the dam site, at GMPE with 84-percentile value, four of 7 identified faults are capable of generating PGA >0.5g. The maximum PGA is expected from MMT Fault that passes close to the dam site with a value of 0.68g.

For the powerhouse site, at GMPE with 84-percentile value, 3 of 11faults generate PGAs > 0.89g, which is close to PGA generated by the Batal Fault due to extremely close location near to the site and its high magnitude potential. Therefore, for the Project, MCE is defined by a ground motion of 0.89g.

4.2 Seismic Design Parameters Based on Probabilistic Seismic Hazard Assessment (PSHA) Approach

Ground motion parameters for return periods from 150 to 10,000 years for appropriate selection as the MDE design parameters corresponding to PGAs of 0.33 to 0.68g for the dam and 0.37-0.74g for the powerhouse have been included. However, considering the seismic history of the Naran area, it is recommended that the ground-motion parameters for the MDE may be selected for 1000 year return period as a minimum and 10,000 year as the maximum.

The OBE may be expected to occur during the lifetime of the structure. No damage or loss of service is allowed. It has a probability of occurrence of about 50% during the service life of 100 years. The return period is taken as150 years (ICOLD 2010). The OBE ground motion parameters are estimated based on PSHA. For the Project 150 year return period has been recommended for selection of the OBE ground-motion parameters, which corresponds to 0.15g for the dam site and 0.17g for the Powerhouse.

5 GEOLOGICAL AND GEOTECHNICAL STUDIES

The field work for the Project comprised surface geological mapping including scan line surveys, geophysical survey using seismic refraction method, drilling of boreholes, coring and logging, performance of permeability and water pressure tests and excavation of test pits at potential construction material sources.

Igneous and Metamorphic Rocks are exposed in the project area. The following five formations/rock units will be encountered along the Dam site, headrace tunnel and Powerhouse area of the Naran Hydropower Project.

Dadar Migmatites (Sharda Group)

Granite Gneisses / Granite (Sharda Group)

Naran Gneisses. (Sharda Group)

Gorian katha Gneisses (Sharda Group)

Pellite (Kaghan Group)

A total of 15 scan line surveys and 7 profiles of seismic refraction survey were carried out at the dam/ intake area, headrace tunnel, powerhouse etc.

For collection of the soil/ rock samples and to perform in-situ tests, 18 boreholes were drilled at the proposed structure locations, with total drilling depth of 1567 m.

Test pits were also excavated at various structure locations for verification of the extent of overburden and physical inspection of its nature at the site. Some other pits were excavated in prospective borrow areas for evaluation of the construction materials i.e. coarse as well as fine aggregate, and cohesive material.

Suitability of the potential construction material sources has been examined through laboratory testing of representative samples.

On the basis of observed RQD values, the bedrock can be classified as “Very Poor to Excellent” with a very wide range of core recovery from 0 % to 99 %.

In the light of data collected and analyses carried out, the rock mass design parameters were determined for various components of the project, and used for evaluating the stability as well as foundation design parameters for the various structures. For the underground structures i.e. headrace tunnel, surge shaft, powerhouse caverns and tailrace tunnel, stability analyses and design of support systems have been carried out.

6 DESIGN CRITERIA (CIVIL, ELECTRICAL AND MECHANICAL)

A design criteria is necessary for setting out the guidelines/ basis of all designs and field operations necessary for preparing the Feasibility Report. The design criteria document for Civil, Electrical and Mechanical works has been prepared, which covered all the aspects of design and field operations.

7 PROJECT LAYOUT STUDIES

The Consultants studied two alternative dam sites including the previously identified site by PHYDO/GTZ. Based on the parameters for screening viz: good topographical, hydrological and geological conditions and minimal environmental issue etc, the dam site selected is located 12 km upstream of Naran town. At the selected dam site, the valley sections are narrow at the upstream cofferdam, downstream cofferdam, diversion tunnel, main dam, plunge pool and power intake area.

Two powerhouse sites including the one identified by PHYDO/GTZ were investigated. The GTZ identified site had poor geological structure along the depth, and was rejected as unsuitable for underground powerhouse**.** The second site some 2.5 km upstream of Kaghan town was found to have better geological structure for the surge tank, pressure shaft and the underground powerhouse. Necessary investigations were conducted to confirm the location of the underground structure at the powerhouse.

The selected layout **(Drawing - 01)** has much smaller dam, longer tunnel and a reservoir with adequate storage for daily peaking.

8 DAM AND OTHER HYDRAULIC STRUCTURES

Hydraulic analysis and sizing of the Project structures, has been carried out to the feasibility level for the following structures:

a. Main Dam- concrete gravity
b. Power intake structure on the left bank of the river
c. Low pressure headrace tunnel
d. Surge tank
e. Steel lined vertical pressure shaft
f. High pressure tunnel/penstocks
g. Underground powerhouse with transformer cavern.
h. Freeflow tailrace tunnel

9 POWER TRANSMISSION AND INTERCONNECTION STUDIES

The interconnection of the Project to evacuate its maximum power of 188 MW is envisaged and has been studied in detail as follows:

a) According to National Power System Expansion Plan (NPSEP) of NTDC, a 500 kV double circuit (D/C) line will connect all stations in Kunhar Valley with 500 kV Aliot S/S (a switching station located on the right bank of river Jhelum downstream of Neelum-Jhelum HPP).

   For dispersal of this power Aliot S/S will be connected to 500 kV Islamabad S/S through 500 kV D/C transmission line, in addition another 500 kV D/C will connect it to 500 kV Gujranwala S/S, thus ensuring complete integration with the NTDC system.

b) It has been planned that Naran HPP(188 MW) will be looped In-Out in one of the 500 kV D/C line to Aliot S/S.

c) The proposed scheme for 500 kV substation has double bus bars of 500 kV with breaker-and-half scheme;

d) Space for future collection of power from Batakundi HPP (102 MW) through double circuit 132 kV cable has also been made.

Detailed load flow, short circuit and transient stability studies have been carried out for the peak load conditions of June 2020 for the proposed interconnection scheme. June 2020 has been selected because the plant is expected to be commissioned by the end of year 2019.

A load flow analysis reveals that proposed scheme is adequate to evacuate the maximum power of 188 MW of the plant under normal and N-1 contingency conditions.

The short circuit analysis has been done and it has been found that the short circuit levels of 500 kV are17.19 kA and 12.80 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 50 kA would be adequate to be installed at 500 kV switchyard of Naran HPP taking care of huge fault current contribution from large future generation

additions to be connected with the same 500 kV network such as Basha and Bunji HPPs etc.

The transient 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 500 kV bus bar of the substation followed by the final trip of 500 kV circuits emanating from this substation, has been performed for fault clearing of 5 cycles (100 ms), as understood to be the normal fault clearing time of 500 kV protection system. The system has been found to be strong enough to stay stable and recovered with fast damping, and therefore, passed the transient stability checks.

10 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT STUDIES

The broad objective of ESIA studies is to assess the beneficial and adverse impacts of the project implementation on the environment including physical, biological and socio-economic parameters and to mitigate the adverse impacts.

The Project area of the reservoir is under, agriculture, range land with some forest and fruit trees, mixed shrubs and rough grasses.

There are no industries in and around the project area; therefore, noise pollution is generally below the EPA limit of 65 dB (A). The air quality in the area is also good.

The environmental and ecological water releases downstream of the dam will be 1.0 cumecs and 2.5 cumecs in winter and summer respectively. In addition to this, water ranging from 3.4 to 8.1 cumecs in winter and 14.0 to 61.3 cumecs in summer will also be added through the downstream streams and nullahs.

The flora existing in the Project as well as study areas falls under moist sub-tropical pine forests generally called Deodar forests.

Fauna of the tract consists of mammals, reptiles, amphibians and birds. Some of the most colourful and beautiful fowls like Monal pheasants and Kaleej are found in the surrounding mountains.

Archaeological/ historical sites in the reservoir and powerhouse areas do not exist.

The population of the Project area is a mixture of Punjabi, Kashmiri and Pathan. The major language of project area is Urdu, Hindko, Shina and Gojri.

In the Project area, no proper medical facilities exist. Only one BHU and some private medical stores are available in Naran town.

Majority (78%) of the female respondents also participate in work other than household chores and livelihood earning is the responsibility of males.

The reservoir of the Project will permanently occupy 116.0 acres of land. Out of this land, only 37 acre land is irrigated agricultural land whereas 39, and 40 acres of land is forest/ grazing and barren land respectively. In addition, area of 5 acre will be occupied for residential colony near the powerhouse site.

In the reservoir area, 730 trees (715 forest and 15 fruit) are being impacted. There will be no danger to large wildlife with the execution of the project as they live in forest areas, which are located at higher altitude.

There will be positive impact on the birds and the fowl communities as a suitable habitat will be formed for this community with the creation of the reservoir.

Construction of the project will result in the creation of job opportunities, better potential for business, transport and tourism development.

During construction, environmental monitoring will be done for air quality, noise and vibration, drinking water quality, sewage effluent, solid waste, explosive material used, hazardous/toxic materials and their proper disposal, flora/fauna, excavated material and traffic handling system etc.

Due to the construction of the project, 32 houses are being affected, which will require resettlement or compensation.

All the owners of the land and land based assets will be resettled or compensated according to the D.C. rates or the rates assessed by the Committee constituted for this purpose by the D.C. The survey revealed that more than 88 % of the affectees favored cash compensation. A Grievance Redressal Committee (GRC) is proposed, which will look into all the grievance cases.

The project environmental and resettlement cost amounts to Rs.319 million.

PHYDO will be responsible for the overall implementation of environmental mitigation measures and the RAP through its Project Director and field offices, with the collaboration of district government departments.

11 PROJECT IMPLEMENTATION AND CONSTRUCTION PLANNING

Project implementation period is estimated to be 5 years including pre-construction activities.