EXECUTIVE SUMMARY

1. Introduction

Kalkot Barikot Patrak Hydropower Project was one of the several projects identified during the joint study of Pakhtunkhwa Energy Development Organization (PEDO) and its German Consultant, GTZ in 1992. Kalkot Barikot Patrak Hydropower Project was proposed as run-of-river scheme on Panjkora River in upper Dir District of Khyber Pakhtunkhwa. Kalkot Barikot Patrak Hydropower Project is located upstream Patrak, a village 48 Km NE of Dir Town in Shringal valley.

In the year 2012, PEDO appointed M/s ELECTRA in association with M/s INTGERATION to conduct feasibility study for Kalkot Barikot Patrak Hydropower Project i.e. 34 MW (TOR) in upper Dir District of KP. Location of the project is shown on Figure 8.1 of the main report.

The present Feasibility Report pertains to Kalkot Barikot Patrak Hydropower Project is preceded by Draft Feasibility Report, Inception Report and Mid Term Report submitted earlier. The latest planning studies and surveys reveal that the project can be upgraded to as much as 47 MW capacity instead of 34 MW mentioned in TOR. Salient features of the project are given in Table 1 at the end of the Executive Summary.

2. Topographic Survey and Satellite Images (GIS)

Topographic survey of Kalkot Barikot Patrak HPP area is conducted earlier in 2013. Planning and layout studies are based on Topographic maps developed there from.

Topographic Survey has been carried out in the project area for establishing, inter alia, the existing ground levels. Locations of physical features like rivers, streams, roads and communication systems have been marked using modern equipments. Consultants also established control points at locations easily accessible and identifiable at later stage and acquired field survey data in digital format. The data has been processed using appropriate computer software.

To carry out the project layouts and the feasibility level engineering design of hydropower project sites, following main tasks have been included in the survey scope of work:

- Installation of Permanent survey control points established at appropriate locations with BM level.
- Processing of topographic survey digital data by using survey software.

- Generation of topographic sheets by using CAD/CAM techniques.
- Production of topographic survey drawings for different structures as per scale and mentioned in TOR.

Most of the survey mapping was carried out at different structures at a scale of 1:500 and contour interval of 1m. Survey maps were prepared on standard format containing location of each control point, its detailed description, final coordinates and elevation above sea level. Traversing was carried out to establish control points whereafter vertical control was established and detailed topographic survey was completed. Topographic map of the project area is shown in chapter 3 of main report.

3. Geology and Geotechnical Investigation and construction materials

Geological and geotechnical investigations have been carried out to study regional and local area geological and tectonic set up through geological mapping, scan line discontinuity survey, drilling works and geophysical survey. Test pits were excavated for determining potential sources of construction materials.

Kalkot Barikot Patrak Hydropower project is located in Dir, near the vicinity of Main Mantle Thrust (MMT) and Reshun Fault, in a zone which is seismically active due to the Continuing northward drifting of the Indian plate and its subduction under the Eurasian plate.

The project site is located on Panjkora River, immediately downstream of Kalkot village as shown in surface geological mapping figure number KBPG-002-03 (chapter 05), proposed weir of Kalkot Barikot Patrak Hydropower Project. Apparently at banks of proposed weir rock is well exposed while at river bed of right bank, rock can be seen and exposed randomly showing shallower depth of rock at right bank river bed.

The weir site has been investigated by 3 boreholes (KBP-01R, KBP-02L and KBP-03L) at right, river bed of weir axis and at left bank respectively; right bank of the weir axis has been investigated by the drill hole KBP-01 up to 30 meters depth. Rock has been encountered at 1.5 meters depth, rock encountered is confirmed (Pyroclasts rocks/Volcanic origin) from 1.5 meters to drilling depth of 30 meters. Field tests and laboratory testing has been analyzed and interpretations are incorporated in this final volume. Two numbers of water pressure tests were performed in KBP-01 R at 4 to 9 meters and at 22 meters to 25 meters, resultant lugeon value at 4 to 9 meters section is 22 is very high while in deeper section from 22 to 25 meters lugeon value is 8 which is also at higher level but relatively deeper zone of right bank has better rock conditions.

Intake structure is coming on rock and during present stage of studies at right bank, rock even exposed at the surface or under few meters cover of scree and overburden materials. Anticipated depth can be predicted at one to two meters depth.

In Sand trap Location at top thick cover of scree/overburden and alluviums have been encountered up to depth of 18 meters later from 18 meters to drilling depth of 35 meters strata is rock of Pyroclasts/Volcanic rock.

The total length of headrace tunnel will be about 10.9 Km. The tunnel would be a low pressure tunnel, lined with shotcrete as well as concrete. Most of the tunnel area falls in Class-A rock while Class-B and C is also anticipated. Very week and poor quality of Pyroclasts can also be observed and recorded in headrace tunnel. Rock mass characterization and stereonet plotting along the headrace tunnel has been done and analyzed and included in chapter 6 of geotechnical design.

Rock mass characterization around Surge Shaft area has been carried out and are described in final volume of geotechnical design for accurate assessment of rock class, later support systems have also been identified in headrace tunnel and around surge shaft by using different softwares, details are included in chapter 6 of geotechnical design studies. Safe cut Slopes around Surge shaft have also been analyzed and details are included in relevant section of geotechnical design.

At the proposed power house site from top to six (6) meters strata is overburden/scree but rock exposures can be seen just upstream side of the power house and same exposures have been marked during present stage of surface geological mapping. From 6 meters to drilling depth of 50 meters strata encountered is Pyroclasts/Volcanics group means it is the origin of volcanic rocks of light green in colour, highly fractured and week with few quartz veins. RQD % is reflecting very poor rock and final analysis have been carried out in section of geotechnical design.

The availability of the construction materials for the Project has also been studied and it has been found that suitable materials for concrete aggregates shall be available at and near the vicinity of site. The Panjkora river bed and its higher terraces are the major source of nearly all types of the construction materials. The coarse and fine (sand) aggregates are currently being mined at numerous places from the river bed for local use.

Cement can be transported from Cherat, Nizamabad and Bestway cement near Nowshehra and Islamabad or other cement manufacturing industry.

Water in general seems quite suitable for construction purposes; however with reference to some other close vicinity Panjkora water analysis, results meet the requirement of portable water and can be used for all construction works.

Steel and cement, are not locally available and shall have to be procured from markets in Peshawar, Rawalpindi and Lahore.

4. Hydrology and Sedimentation

The available Hydro-meteorological data such as daily and hourly rainfall, daily stream flows, temperatures, evaporations and sediment data etc. has been collected and used for determining power potential, maximum floods and flow duration curve.

Flow measurements are being performed on Panjkora River at Kalkot hydrological station since the installation of the gauge i.e. October 2012. The same has been collected from site for further processing to study the behavior of the flows. However this information is only for few months (i.e. Oct 2012-June 2013).

Extension of flows for Panjkora River at Kalkot has been made with the help of available long term recorded daily flows of nearby rivers having same characteristics. In this regards nearby rivers Panjkora at Koto, Zulam, Bibior, Sharmai,Swat at Kalam and Chitral River at Chitral were considered and relationships were investigated. Long term flow series 1961-2011 of Panjkora River at Kalkot have been used for the final selection of flow pattern for water availability. Location of these stations is given in Chapter-4 (Hydrology and Sedimentation) of the main report.

From flow duration curve and the subsequent optimization studies, it has been concluded that the optimum discharge for power generation is the one that is available for about 35% of the time during the year which comes to 23 m^3/s.

Flood studies have been carried out using statistical approach, Flood Frequency Analysis, Unit Hydrograph method, Regional Method, Method of Relationship with Peak Floods in Sub-catchments, Slope Area Method, 24 hours maximum rainfall data and estimation of floods using HEC-HMS. It is concluded that 1,000 year return period flood of 1352 m^3/s is appropriate for the design of weir. The above mentioned analysis can be seen in Chapter-4 of Main Report.

Total sediment load at proposed dam site has been computed by adding the bed load to the estimated suspended sediment load as given below:

Sr. No.	Description	Sediment Load (Million Tons)
1	Mean Annual Suspended Sediment Load	0.0994
2	Mean Annual Bed Load	0.0215
3	Total Annual Load	0.1209

Mean monthly variation of the total sediment load is shown in Figure 4.85 of the main report.

The results show a large amount of sediment inflow which requires appropriate arrangements and design for effective and timely flushing of the sediments for proper operation of the power plant.

5. Seismic Hazards

Geotectonic of the Northern Pakistan is related to the collision of the two plates namely Indian Plate with Eurasian plate, and subsequent formation process of the Himalayan ranges. The intercontinental collision has resulted in intense deformation with complex folding involving strike-slip and thrust faulting. This tectonic process is the origin of the seismicity along the Himalayas and in particular where Northern Pakistan is located. The major regional faults related to the intercontinental collision and considered to be active and capable of generating earthquakes, include

- Main Karakorum Fault (MKF)
- Main Mantle Thrust (MMT)
- Panjal Thrust
- Main Boundary Thrust (MBT)
- Main Frontal Thrust (MFT)
- Salt Range Thrust

Kalkot Barikot Patrak Hydropower project is located in Dir, near the vicinity of Main Mantle Thrust (MMT) and Reshun Fault, in a zone which is seismically active due to the Continuing northward drifting of the Indian plate and its subduction under the Eurasian plate. This tectonic activity has resulted in the production of a crustal accretion wedge; The Himalayan range. Seismic Hazard Evaluation, based on available data / literature regarding regional geology, tectonics, non-instrumental and instrumental seismicity, has been carried out for Kalkot Barikot Patrak Power Project by including some 1832 events in the present study (since 1928).

The Deterministic Seismic Hazard Analysis (DSHA) has revealed that for Kalkot Barikot Patrak Hydropower Project, Main Mantle Thrust/Reshun Fault could be the critical fault, capable of generating a magnitude 7.6 Mw Earthquake (equivalent October 8, 2005 Kashmir Earthquake). Maximum Credible Earthquake due to active faults in the region is calculated to be of the order of 0.143g due to an earthquake 7.6 magnitude, having a hypocenter at 80 km from the site.

Operating Basis Earthquake (OBE) acceleration can be assumed to be half of MCE value, but keeping the fact in mind that the seismic gap perpetually floats on the fault and wherever the situation is seismically suitable, a quake is triggered. Once an area experiences a quake, its epicentral volume is crushed and it becomes unable to accept any further geo-technical stress. This means that once an area has experienced an earthquake, it will not experience another earthquake of a similar magnitude for a long time. The time gap is usually about three to five times the return period of the earthquake. The available seismic data has been analyzed to evaluate Peak Ground acceleration (PGA) at the site. The calculated value of Peak Ground acceleration for Kalkot Barikot Patrak Hydropower project site is 0.08g. After applying the necessary safety factor and calculating the rupture of MMT and Reshun fault the calculated PGA again comes out to be 0.11 g,

Peak Ground Acceleration at Kalkot Barikot Patrak Hydropower Project Site from Earthquake records	0.08g
Design Spectral Acceleration value	0.05-0.2g (Mean 0.11)
Operational Basis Earthquake value at Kalkot Barikot Patrak Hydropower Project site.	0.11g

Kalkot Barikot Patrak site is around 80 km from major tectonic features called Main Mantle Thrust (MMT) and Reshun Fault and appears to be a seismically active tectonic zone. Data of 1832 earthquake events within 111 kilometers (1 degree) quadrangle distance, around Kalkot Barikot Patrak has been collected from International and National agencies. The density of earthquakes is quite thick in the area.

6. Project Layout and Hydraulic Design Considerations

6.1 Project Layout

The headwork site from GTZ report has been discarded to avoid the difficult realignment of existing right bank road and also to avoid the underground sand trap. The headwork is proposed near Kalkot village. The headwork comprises of two distinct sections in plan view, one for flood flows and other for sluicing purpose. The intake of water is located on the right bank of Panjkora River. The sand trap is connected to the intake by a 33 m long concrete channel. Two chambered sand trap has been proposed along the right bank for sediment exclusion. From the end of the sand trap, the water is conveyed to the headrace tunnel directly. The headrace tunnel is 10.9 Km long and the section is D-shaped with cross-sectional area of 12.89 m^2 finish. Surge shaft is located at 10.9 Km length along the tunnel measured from the inlet portal and is exposed to the surface. The height of the surge shaft is 31.2 m and the diameter is 10 m finish. About 324 m long two parallel penstocks convey water further and feeding two generating units accommodated in the powerhouse in open cut on the right bank of Panjkora River. The powerhouse site is located near the village Patrak which is about 8.2 km downstream of the GTZ dam site measured along the river centerline. A 110 m long tailrace channel conveys water from powerhouse and discharges into the Panjkora River.

6.2 Hydraulic Design Considerations

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

The hydrological studies show that minimum and maximum mean monthly discharges in Panjkora River at Kalkot Barikot Patrak site are 5.3 and 48.1 m^3/s respectively. Based on economic evaluation and optimization, it was decided that power intake would be designed for rated discharge of 23 m^3/s that will produce approximately 47 MW of power.

The overall weir length is 140 m comprising an overflow section of 120 m. The full reservoir elevation is 1780 masl giving a gross storage volume of 4,76,060 m^3. The average river bed level is at El. 1764 masl. The total height of the weir is 16 m above the average bed. The ogee weir and undersluices are designed to pass a flood of 1352 cumecs corresponding to a flood level of 1782.36 masl. The overflow section with stilling basin has been provided to handle medium to large floods. It will be used to spill excess flows and small floods in summer season while the powerhouse is still in operation. It has a discharge capacity of 947 m^3/s with the design head of 2.36 m above the crest.

The sluicing section will mainly be used to release environmental flows during normal operation of project during and to periodically flush out the river bed load deposited in front of intake structure. It will be used to spill excess flows and small floods in summer season while the powerhouse is still in operation. It has a discharge capacity of 326 m^3/s at normal operating level of 1780 masl. The plan and sections of weir structure are shown in Figures 8.4 to 8.7 of the main report.

The intake structure offtakes from the right bank of Panjkora River. The intake consists of 2 no. culvert inlets each 5m x 4.6m. The height of inlet gradually reduces from 4.6m to 3m through a parabolic profile of roof curve. The width of inlets reduces from 5m to 3m in a length of 5m. Two vertical lift type intake gates, each 3m x 3m, are provided after the transition. There is provision of stop logs at the downstream side of intake gates in order to carry our repairs of one gate while the other gate is still open and transferring flows to the connecting channel. The inlet structure is shown in Figure 8.8 of the Main Report.

The flows for sand trap are proposed to be carried through a reinforced concrete connecting channel along the right bank of river. The connecting channel is of rectangular cross section 5m x 5.5m, and 33m long. The slope of the channel is proposed to be 0.001. The plan and cross section of connecting channel at RD 0+000 is shown in Figure 8.9 of the main report.

The inlet width of sand trap is 6.8m which gradually increases to its maximum width of 20.8m in a length of 15m. The sand trap is divided into two main chambers each 10m in width. Each chamber has been further divided into two hopper shaped compartments through vertical vanes/walls. The flushing duct/gallery is located at the end of 75 m length of sloping floor of sand trap. It is designed to retain 0.2 mm and bigger sized sediment. Complete arrangement of the sandtrap is shown on Figures 8.10 and 8.11 of the Main Report.

The power tunnel is designed as a D-shaped conduit of 3.8 m diameter having 12.89 m^2 area. It is 10.9 km long, and has a slope of 1 in 500. At start of the power tunnel the invert has an elevation of 1769 masl and at the end elevation of 1748 masl. The velocity in the power tunnel will be 1.78 m/sec. The plan, profile and cross section of the power tunnel are shown on Figures 8.12 and 8.13 of the Main Report.

Surge tank has been provided at the end of concrete lined tunnel. Based on the hydraulic considerations, Simple surge tank has been selected with finished diameter of 10m as required by Thoama’s criteria. The total height of surge tank will be 31.2m including 3m freeboard.

Combination of horizontal pressure tunnel 65m long, valve chamber and two no. of penstocks, each 324m long and 2m diameter have been envisaged for waterway from surge tank to powerhouse. Anchor blocks will be provided on bends as required. A valve chamber is provided at El. 1748 masl for the penstock off-taking from horizontal pressure tunnel.

A surface type powerhouse in open cut has been proposed on the right bank on the inner side of a small bend of river. The powerhouse will be equipped with two Pelton turbine units having vertical axis. The plan of powerhouse is shown in Figure 8.17 and the longitudinal section is shown in Figure 8.18 of the main report.

The length of concrete lined tailrace channel from draft tube outlet gates is about 26m.

Tailwater calculations at the site of weir have been carried out by means of HEC-RAS computer programme. To facilitate calculations and correctness of results 50 no. river cross-sections have been used at the weir site and 6 no. cross-sections used at the powerhouse site.

The diversion arrangements on the Panjkora River for constructing the main weir cater for 24 months of construction period. The diversion discharge will be equivalent to 10 years return period which is 475 cumecs.

The total head loss in the power system including all the components involving flow would be 14 m at full discharge.

7. Mechanical Equipment Studies

Mechanical equipment and systems will include turbines, governors, inlet valves, gates, stoplogs, trashracks, cranes and hoists etc. The turbine selection was made considering 239m as rated head. As stated earlier, for the installed capacity of power plant 23 m^3/sec flow at 35% exceedence has been selected. From the comparative study of various turbine sizes and combinations, two units of pelton turbines each with 11.5m^3/sec flow have been selected. During 85% of the total time both of the turbines will operate, simultaneously, while for 15% of the total time only one turbine will operate. Considering turbine efficiency of 91% for the net head of 239m and design flow of 11.5m^3/s, the power will be 23.5 MW for each turbine. These values will result in the turbine specific speed (Ns) of 272.7 rpm. An average runner diameter is considered as 2.28m.

For determining the 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. Considering generator efficiency as 97.4%, the turbine output will be 47MW corresponding to total rated discharge of 23m^3/s and rated head of 239m.

8. Electrical Equipment Studies

The most important components of the main electrical equipment are the 11 kV self-excited brush less type synchronous generators, for direct coupling to Pelton-type turbines through epicycle gear, complete with excitation equipment and other auxiliary equipment as specified. Two generators with generating capacity of 27.64 MVA have thus been selected.

For transmission of electrical power, two number unit step-up power transformers with rated capacity of 27.64 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. Transmission Line will be Single circuit from Kalkot Barikot Patrak HPP to Patrak Shringal HPP, from where it will become Double Circuit up to Dir Grid Station.

9. Initial Environmental Examination, Resettlement and Social Assessment

Lands in Kalkot Barikot Patrak HPP area comprise cultivated lands, waste lands and settlements. The project will consume 325 kanals of private land, of which 53 kanals are under cultivation while the rest include community land and waste land.

The present IEE reveals that some moderate to significant negative environmental impacts are likely to occur due to the construction activities with few minor impacts during operations after the proposed construction. Recommendations are made to mitigate expected negative impacts. Implementation of appropriate mitigation measures during the construction, and operation phases will minimize the negative impacts of the Project to acceptable levels.

The Project will have an overall beneficial impact and any negative environmental impacts will be carefully monitored and mitigated. Therefore, the completion of this IEE fully meets the ADB and EPA standards.

The construction of the project will open job opportunities for the local people. This will help in raising their livelihood.

The total environmental and resettlement cost is estimated as Rs. 182.32 million including land acquisition for the reservoir upto retention level of El: 1780 masl.

The client should make necessary arrangements such that during operation of the project sufficient release of water is ensured from the Weir for downstream uses because some agricultural practices do depend on river water.

10. Construction Planning and Cost Estimate

10.1 Construction Planning

The construction planning for 47 MW Kalkot Barikot Patrak Hydropower project is largely dependent on Construction of weir, power tunnel and powerhouse, which are on the critical path, High and low flow periods in the Panjkora River, Excavation in hard strata of powerhouse & power tunnel and Transmission line.

Main components of the project are Weir & intake, Connecting channel, Sandtrap, Power Tunnel, Surge Tank, Penstock, Powerhouse and Transmission line.

The work on all these components can be carried out independently and the schedule has been prepared in such a way, that the work is taken up simultaneously on various sites in order to complete the project in the shortest possible time. It is thereby estimated that the construction of the project will be completed in 48 months. The sequence, in which the construction of various components of the project will be taken up, has been shown in Figure-14B of the Main Report. The construction activities along with time required to complete them is summarized as follows:

Summary of Construction Schedule

Sr. No.	Description of Activity	Duration
1.	Mobilization	30 Days
2.	Acquisition of Land	7 Months
3.	Temporary and Preliminary works	12 Months
4.	Coffer Dams (two Nos.)	3 / 2 Months
5.	Right part of main Weir, Intake and ancillary works	8 Months
6.	Left part of main Weir and ancillary works	10 Months
7.	Connecting channel	3 Months
8.	Sandtrap and ancillary works	11 Months
9.	Power Tunnel and ancillary works	36 Months
10.	Surge Shaft	8 Months
11.	Pressure Tunnel, Valve Chamber and Penstocks	11 Months
12.	Powerhouse Civil works	23 Months
13.	Tailrace and ancillary works	3 Months
14.	Powerhouse E&M manufacturing and installation	26 Months
15.	Switchyard, Transmission Line ancillary works	20 Months
16.	Testing and Commissioning	6 Months

10.2 Cost Estimate

The estimated cost of the project has been worked out as Rs. 14,961.27 million out of which local cost is Rs. 11,872.18 million, while for import of Electrical / Mechanical & transmission line equipment, a provision of Rs. 3,089.09 Million has been made. For realistic cost estimate the following factors / criteria has been considered.

i. Market Rate System 2013 Khyber Pakhtunkhwa.
ii. Prevailing market Rates
iii. Unit rates adopted for similar constructed / under construction projects
iv. US$ versus Pak rupee impact.

1. The summary of the project capital cost is given as under:

(Amount in Million Rs.)

Sr. No.	Component	Estimated Cost		
		Local	**FEC**	**Total**
A	Preliminary Works	463.47	0.00	463.47
B	Environment & Resettlement Costs(Land Acquisition)	182.32	0.00	182.32
C	Civil Works	7561.62	0.00	7561.62
D	Electrical & Mechanical Works	245.17	2206.46	2451.63
	Transmission Line	82.50	742.50	825.00
	Total Works Cost	**8535.08**	**2948.96**	**11484.04**
E	Physical Contingencies (Unforeseen) @2% of (C+D)	157.79	58.98	216.77
F	Transportation and Erection Charges of E&M Equipments @3% of D	98.30	0.00	98.30
G	Survey ,geotech investigation and Detail Design of Civil and E&M Works @ 2 % of (C + D)	216.77	0.00	216.77
H	Management Consultancy Cost @ 4% of (A + C + D)	452.06	0.00	452.06
	Total Base Cost	**9460.00**	**3007.94**	**12467.94**
I	Client Expenses, Administration and Legal Costs @1% Base Cost	124.68	0.00	124.68
J	Custom Duty@ 5% of D (on FEC)	147.45	0.00	147.45

K	Escalation @ 6.50% on Local cost &1.3% on FEC	812.21	81.15	893.36
L	Interest during Construction (IDC) @10.65% of Base Cost	1327.84	0.00	1327.84
	Total Project Cost	**11872.18**	**3089.09**	**14961.27**

11. Economic and financial analysis

The annual energy of the Project is 225 GWh. Based on it the unit generation cost comes out to be Rs. 8.55 & US cent 8.64. A summary of Economic and Financial Analysis indicator is given as under:

NPV (Million Rs.)	6647.79
BCR	1.64
EIRR	23.25 %
FIRR (Without CDM)	15.29 %
FIRR (With CDM)	16.11 %

The sensitivity analysis results are summarized as under:-

Scenario	**NPV (Rs. Millions)**	**EIRR**	**BC Ratio**
10 % cost over-run.	5614	20.48 %	1.49: 1
One year delay in benefits	4823	18.54 %	1.47 :1
Combination of above	3789	16.68 %	1.33: 1

12. Conclusions & Recommendations

12.1. Conclusions

- Base cost of the project is estimated as Rs.12,467.94 million, while the capital cost is estimated as Rs.14,961.27 million.

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

- The EIRR calculated in comparison with equivalent thermal plants as replacement alternative to the proposed Hydropower Project, comes to 23.25 %.

- Financial analysis indicates a Financial Internal Rate of Return (FIRR) as 15.29 % and the project is adjudged viable.

12.2. Recommendations

Flow measurements and gauge observations should be continued at PEDO Gauge Station located near proposed weir site in order to have essential data of flows, floods and sediment before project implementation.

Additional Geotechnical Investigations as elaborated in Chapter-5 of the Main Report are recommended at detail design / construction stage.

Engineering, economic and financial studies have classified Kalkot Barikot Patrak Hydropower Project as viable. **Hence the project is recommended for detailed engineering design or Engineering Procurement Contract and execution**.

Table 1: SALIENT FEATURES

Hydrology	
Catchment Area	778 km^2
Design Discharge	23 m^3/s
Working Head	
Normal Head Water Level	1780 masl
Turbine Center Line	1527 masl
Gross Head	253 m
Net Head	239 m
Diversion Weir	
Type of Intake	Gated
Height Above River Bed	16 m
Length of the Overflow Crest	120 m
Sluicing Section	3 No. (4.5m x 3.0m)
Type of Energy Dissipater	Stilling Basin Type II
Stilling Basin Length	25 m
Sand Trap	
Number of Chambers	2
Total Width of Sand Trap	20.8 m
Length of Sand Trap Chamber	75 m
Height of Chamber	11 m
Headrace Tunnel	
Length	10.9 km
Diameter	3.8 m
Surge Shaft	
Diameter	10 m
Height	31.2 m
Power House	
Type	Surface
Size (L x W x H)	50m x 16.9m x 34m
No. of Turbines	2

Type of Turbine	Pelton
Crane	65 Ton
Tailrace Channel	
Section (w x h)	9m x 5.5m
Length of the Channel	110 m (only 26 m will be concrete lined)
Power Potential	
Gross Power	47 MW
Annual Energy	225 GWh
Plant Factor	54.7 %
Project Cost & Economic Viability	
Total Project Cost	14961.3 Million Rs.
Benefit / Cost Ratio	1.64
Unit Cost Generated	8.55 Rs. / kWh
Unit Cost Generated	8.64 US Cent / kWh