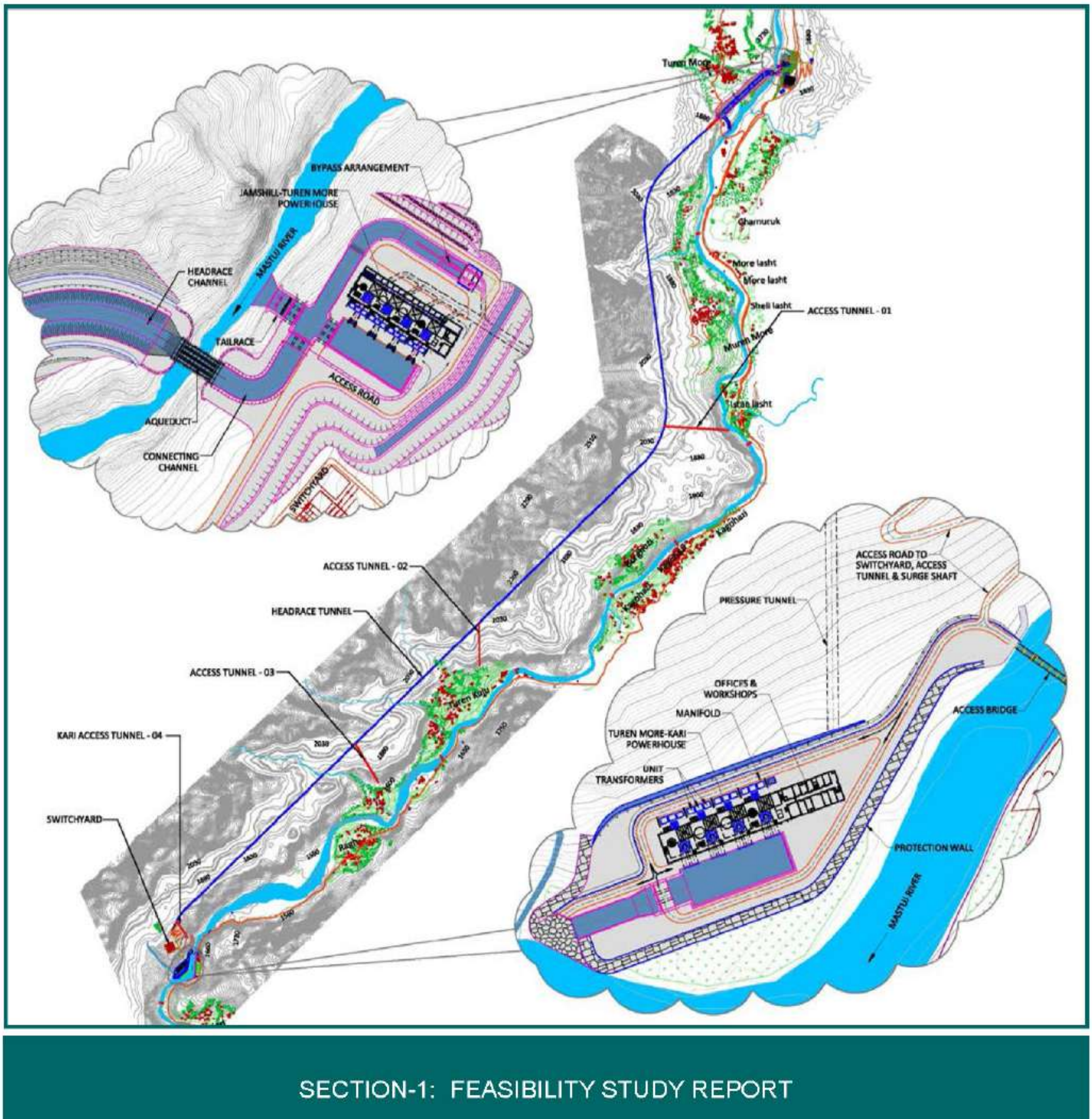
PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

ENERGY AND POWER DEPARTMENT, GOVERNMENT OF KHYBER PAKHTUNKHWA

TUREN MORE – KARI HYDROPOWER PROJECT (350 MW)



SECTION-1: FEASIBILITY STUDY REPORT

EXECUTIVE SUMMARY

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FEASIBILITY STUDY OF
TUREN MORE – KARI HYDROPOWER PROJECT (350 MW)
DISTRICT CHITRAL, KHYBER PAKHTUNKHWA

STRUCTURE OF THE REPORT

EXECUTIVE SUMMARY

1 INTRODUCTION

Pakistan is presently facing acute power crisis which is hindering economic growth and hence impacting the life of more than 190 million people. Although, Allah Almighty has blessed Pakistan, particularly Khyber Pakhtunkhwa with abundant hydropower potential, such potential is yet to be materialised in true spirit. The total identified hydropower potential in Pakistan is more than 60,000 MW, of which Khyber Pakhtunkhwa Province alone has a contribution of more than 25,000 MW. Unfortunately, only 6,900 MW hydropower potential has been developed throughout the country, while rest of the potential remains unharnessed.

With the commissioning of Tarbela Dam in 1976-77, the need for advance planning of major hydropower projects became evident. Consequently, the Government of Pakistan (GOP) engaged Montreal Engineering Company “MONENCO” of Canada to undertake preparation of an inventory and ranking study of potential storage and hydropower generation sites along the upper reaches of Indus River and its main tributaries; Jhelum (above Mangla); Swat and Chitral basins.

To explore and develop the hydropower potential at provincial level, Government of the NWFP (now Khyber Pakhtunkhwa) constituted Small Hydel Development Organization in 1986-87 which was later on renamed as Sarhad Hydel Development Organization (SHYDO), under the SHYDO Act 1993. SHYDO has recently been transformed to PEDO, Pakhtunkhwa Energy Development Organization. After the 18th amendment in the constitution of Pakistan, the provinces can now implement power projects with capacities of more than 50 MW.

During the 80s and 90s, identification and ranking studies for hydropower schemes on the rivers and their tributaries in Azad Jammu and Kashmir (AJK); North West Frontier Province (NWFP) and Northern Areas were also carried out by WAPDA and Sarhad Hydel Development Organization (currently renamed as PEDO) in collaboration with GTZ, German Agency for Technical Co-operation (currently renamed as GiZ). As a result of the study, a number of sites for development of small and medium size hydropower projects were identified.

Feasibility study of Turen More - Kari Hydropower Project (350MW) was awarded to a consortium led by AGES Consultants. After signing of the Consultancy Services Agreement between PEDO and the Consultants, the feasibility study commenced from June 20, 2012.

Salient Features of the Project are presented at the end of the Executive Summary.

2 HYDROLOGICAL AND SEDIMENTATION STUDIES

Chitral River originates from Chiantar glacier at Broghil and runs through Chitral valley. Upto Mastuj village, the river is known as Yarkhun River. From here till its confluence with Lutkho River just north of the regional center of Chitral, it is called the Mastuj River. Thereafter, it is called Chitral River till it flows south into upper Kunar Valley of Afghanistan, where it is referred to as Kunar River. Kunar River joins Kabul River east of Jalalabad city in Afghanistan and is named as Kabul River. Kabul River then flows eastward into Pakistan where it is joined by River Swat at Charsadda. Flowing further, it joins Indus River at Khairabad / Attock.

Chitral valley is not affected by the Indian summer monsoon at all due to the high mountain barriers, except for the extreme southern part of the district (around Darosh), where monsoonal rains account for about 11% of the annual rainfall. Almost the entire annual precipitation falls during winter and spring months, while the summers are almost dry. The annual amount of precipitation is around 400 mm in central Chitral, reaching a maximum of 500 mm in the southern mountain ranges (Darosh, 500 mm) and decreases to around 200 mm in the north where precipitation is mostly as snow.

Long term record of flow and sediment measurements at Chitral River in Chitral town have been used to estimate the river flows available for power generation from the upstream Jamshill – Turen More Hydropower Project. As the tailwater of Jamshill – Turen More Hydropower Project will be used as inflows for Turen More – Kari Hydropower Project, the flows available for power generation will be the same for both the cascade hydropower projects.

The estimated long term flows at the weir site for Jamshill – Turen More Hydropower Project are also the flows available for Turen More – Kari hydropower project, are as follows:

Estimated Flows Available For Power Generation

Month	10-Daily	Flow Available for Power Generation	Month	10-Daily	Flow Available for Power Generation
Jan	I	59	Jul	I	626
	II	57		II	673
	III	54		III	674
Feb	I	52	Aug	I	686
	II	51		II	607
	III	49		III	492
Mar	I	49	Sep	I	373
	II	50		II	285
	III	53		III	203

Month	10-Daily	Flow Available for Power Generation	Month	10-Daily	Flow Available for Power Generation
Apr	I	58	Oct	I	149
	II	68		II	121
	III	88		III	102
May	I	109	Nov	I	90
	II	147		II	83
	III	195		III	78
Jun	I	269	Dec	I	72
	II	378		II	67
	III	511		III	64

Since power generation flows are to be supplied from the tailrace of upstream Jamshill - Turen More powerhouse, there will be no direct flood impacts on Turen More – Kari Hydropower Project. Furthermore, the powerhouse floor level and the tailrace have been kept well above the 10,000 year return period flood of 3047 m^3/s and thus safe from flood impacts. Similarly, as this project would be receiving clean water, sediment handling is not required in this project. Detailed discussions on floods and sediments in the Mastuj River in the project area have been provided in the Feasibility Study of Jamshill – Turen More Hydropower Project. .

3 GEOLOGICAL AND SEISMIC HAZARD EVALUATION

District Chitral is occupied by the Hindukush Range of the south-western Pamirs that terminates southwest in Afghanistan as the Nooristan Range. Eastwards, the Hindukush Range swings and merges with the Karakoram Range. The Pamir Range of the Central Asia borders with the Hindukush Range in its north and Kohistan Ranges of Swat and Dir bound in the South.

District Chitral lies in north western part of Pakistan. This region has high mountain ranges and deep valleys. It covers about 15000 Km^2 area in the mountain ranges of the Hindukush, stretching from central Afghanistan. The Hindukush range is the western continuation of the Karakorum and represents the western part of the Himalayan System. During Mesozoic period, the site of these mountains was the southern margin of the Asian Plate. Later on subduction in the northwards direction took place along the margin and the Kohistan. Ladakh Island Arc was accreted along the main Karakorum thrust (MKT) with the development of the Northern Suture Mélange (NSM) in the early late cretaceous period. It was followed by the India-Asia collision in the Eocene period. Chitral and its surroundings are characterized by this suture zone between the Asian and Indian plates. The under thrusting of the Indian Plate beneath the Hindukush and Pamir has made this area seismically an active zone. Historical earthquake data shows that intensity upto IX (as per M.M scale) has been felt in the project region

There are a number of large regional scale faults, each trending North East / South West and extending upto 100km distance. From north to south, three most important faults are Tirich Mir boundary zone; Reshun Fault and Karakoram Kohistan suture Zone. These faults traverse the eastern Hindukush, marking collision lines between the three micro - continents / island arc terrains in middle cretaceous. This composite terrain at the southern margin of Eurasia suffered another phase of tectonic uplift and deformation related to India - Kohistan collision of the Eocene time took place. These Faults are the surface manifestations of the Hindukush seismic Zone, located about 80-150 km north-west of Chitral. Among the regional faults, Reshun fault is the nearest one to the project area and thus the layout, especially for the upstream Jamshill-Turen More Hydropower Project has been selected such to avoid this fault. This is a North dipping major thrust fault, running approximately parallel to the MKT in center of Chitral District in NE / SW direction.

The location of the project components alongwith the waterways structures have been finalized such that they can be placed on favourable geological settings.

4 GEOTECHNICAL AND GEOPHYSICAL INVESTIGATIONS

Geotechnical investigations including Seismic Refraction Survey, Test Pits, borehole drilling followed by various in situ and laboratory tests on samples have been carried out. The results of such geotechnical investigations have been used to estimate the depth of bed rock available at various project locations and to design underground structures and associated protection works.

The headrace tunnel support classes required along various tunnel lengths have also been estimated based on geotechnical and geophysical investigations. These include analysis of borehole logs and determining the corresponding rock classifications using RMR, Q and GSI systems.

Similarly, availability and locations for construction materials such as boulders, aggregates and sand have been estimated / identified and their quality assessed.

5 POWER MARKET AND DEMAND FORCAST

The installed capacity in the Pakistan Energy and Power Company (PEPCO) system is about 23,000 MW of which hydropower accounts for approximately 30 % of this capacity. Thermal plants take up about 67 % and nuclear 3 % of the total capacity. The maximum energy demand in the country in 2011-12 was over 24,000 MW. However, since electricity is generated at almost fifty per cent of the installed capacity due to inefficient recovery system, wear and tear of plants and inappropriate fuel mix, the unmet demand is significant and has led to even over 12 hours of load shedding per day. Therefore, it is evident that the current generation capacity is unable to meet the increasing demand.

Decline of natural gas, increase in use of expensive furnace oil and decrease of hydel share in the energy mix system have resulted in high cost of electricity. The cost of energy delivered to Distribution Companies (DISCOS) at their interface point was Rs. 9.12 per kWh in 2011-12 including transmission losses in high voltage lines.

The estimated hydropower generation potential of Khyber Pakhtunkhwa province is more than 25,000 MW. The Current hydropower potential of the province identified by PEDO is more than 6000 MW, which can be developed.

PEDO has completed four hydropower projects with an installed capacity of 105.3 MW, out of which 81 MW Malakand-III HPP and 18 MW Pehur HPP have been connected to national grid. The other two are, Shishi HPP 1.8 MW and Reshun HPP 4.2 MW. Both are located in Chitral and their generated power is consumed locally. PEDO has planned to develop 56 MW within next three years, 600 MW in five years and 1500 MW within ten years. Golen Gol Hydropower Project with an installed capacity of 106 MW is currently under construction at Golen Gol, a major tributary of the Mastuj River.

Since, KP has significant hydropower potential, the demand for electricity on one hand is increasing steadily in Pakistan and the growth in supply has been sluggish. Furthermore, as hydropower projects are capable to supply cheaper electricity as compared to thermal or nuclear plants, significant market opportunities would be there for hydropower projects in the years to come. As KP has significant hydropower potential, it can prove a major source of revenue for the province.

6 PROJECT LAYOUT PLANNING

On the basis of detailed evaluation, two cascade projects; namely Jamshill – Turen More and Turen More – Kari have been finalized. Jamshill-Turen More HPP lies along left bank of the river while, Turen More-Kari HPP along right bank of the river. Flows from Jamshill - Turen More powerhouse tailrace would be diverted directly to Turen More - Kari waterway without discharging it into the river. With this arrangement, the need of new diversion structure / dam and sandtrap for the downstream part of the cascade i.e. Turen More – Kari could be eliminated, thereby decreasing its cost significantly.

Flows from the tailrace or bypass arrangement of Jamshill-Turen More Powerhouse would be conveyed to the waterway of Turen More-Kari HPP through an aqueduct located immediately downstream of the powerhouse to cross the main river. The change in alignment of the waterway for the downstream project is due to poor geology along the left bank downstream of Turen More and longer length of waterway.

In order to reduce dependence on the upstream hydropower plant a bypass arrangement comprising of hollow jets alongwith stilling basin have been provided at Turen More powerhouse. In case Jamshill – Turen More powerhouse needs to be closed for maintenance, the flows can be routed through the bypass arrangement into the aqueduct. Therefore, the bypass arrangement is an integral part of the cascade development.

The aqueduct is followed by a 849 m long concrete lined trapezoidal headrace channel which falls into the inlet pond located near the inlet portal of Turen More-Kari HPP headrace tunnel. A superpassage has been provided over the headrace channel to route the flows from Morisan Gol to the river. A free overflow spillway has been provided in the left side wall of the inlet pond to divert the flows to the river in case of emergency closure of Turen More - Kari HPP powerhouse.

At the inlet portal of the headrace tunnel, a coarse trashrack has been provided to prevent entry of logs and large floating debris into the conveyance system.

The headrace tunnel would be 14.1 km long with finished diameter of 9.7 m, modified horseshoe shaped. The entire headrace tunnel will be concrete lined for hydraulic efficiency. In the tunnel alignment two major bends have been proposed based on the findings of the geological and geotechnical investigations. The first bend is southwards and the second one towards the west. These bends are aimed to reduce the stress induced problems due to high overburden. With a straight tunnel alignment, the length could be shortened by about 1 km; but the overburden would be more than 800 m, resulting in significant cost increase and longer construction period. With the bends, the maximum overburden has been brought to acceptable limit with no squeezing zone in most of the reach. However due to emerging ridge in front of Kaghozi village, still a small reach of squeezing exist.

In order to reduce the construction period of headrace tunnel, four access tunnels (adits) have been provided. Each access tunnel will provide two working fronts for the construction of headrace tunnel. The access tunnels have been located based on the distance between consecutive access tunnel, lengths of access tunnels, and ease of access to the portals so that excavation, mucking and lining works could be carried out easily. Elevations suitable for gravity drainage of the headrace tunnel and location of adit portals in exposed rock were the other important criteria for the adits. Based on the above criteria, the locations of the access tunnels are as follow:

- Near Kaghozi village
- Near Dalo Gol
- At Muren Kuju Village
- Near surge/pressure shaft

The locations of surge shaft and pressure shaft depend on the location of powerhouse and geology of the area. The surge shaft has been located about 600 m upstream of the powerhouse where both the geology and topography are adequate to fulfil the requirements of the surge shaft.

The pressure shaft has been located nearly 75 m downstream of the surge shaft while, the 550 m long horizontal pressure tunnel has been provided from the bottom of the pressure shaft to the powerhouse. The finalized dimensions of these underground waterway structures are as follows:

Structure	Diameter (m)	Length/Height (m)	Lining
Surge shaft	27. 0	93.0	Concrete lined
Pressure shaft	8.5	109.0	Steel lined embedded in concrete
Pressure tunnel	8.5	550.0	Steel lined embedded in concrete

The pressure tunnel is followed by a 65 m long buried penstock to convey the flows from the pressure tunnel to the turbines. The main penstock pipe has been branched into four manifolds to feed the turbines.

Due to complex geology of the region, attempts have been made to find location suitable for surface powerhouse rather than cavern. The selected site is a terrace of adequate size with exposed rocks all along towards the river. The site located on right bank of the Mastuj River just upstream of Kari village, is suitable for a surface powerhouse.

The powerhouse building comprises of a main machine hall and a separate control room and offices. The powerhouse comprises of four generating units with vertical Francis turbines.

The outflows from the powerhouse would be discharged into a stilling pond and onwards to the river via an open channel.

The switchyard needs to be located close to the powerhouse so that transmission losses and length of the cables can be minimized. The upper terrace to the north of powerhouse has been found suitable for the switchyard. The lines from the transformers would be raised directly to the upper terrace of the switchyard. This location is not only the nearest to the powerhouse but also isolated from the main villages.

About 116 m by 112 m area has been estimated to be adequate for the switchyard. From the switchyard, a 220 kV double circuit transmission line would convey the generated electrical energy to the grid station at Chitral, about 12 km from the switchyard.

7 ESTIMATION OF POWER AND ENERGY

Once the initial layout of the project has been selected, the next step was optimization of the project parameters. However, as Turen More – Kari hydropower is stage-II of the cascade project, the discharge optimization became irrelevant. The project will receive flows from the tailrace of the upstream project, therefore, the design flow (305 m^3/s) will be same as that of the upstream project i.e. Jamshill – Turen More Hydropower Project (260 MW). Similarly, optimization of the dam height is also irrelevant as no dam is required in this case.

Once the layout is fixed, the gross head also becomes fixed. Thus, mainly the headrace tunnel needs to be optimized for the design flow. On the basis of marginal cost benefit analysis, the tunnel diameter has been optimized as 9.75 m.

The estimated power on the basis of the optimized tunnel diameter and other parameters is 350 MW. The corresponding annual energy generation has been estimated as 1574.28 GWh.

Auxiliary consumption and loss of energy during maintenance and forced closure has been considered to be 2.5%. Based on this, the estimated available annual energy for sale is presented in Table E.1.

Table E.1: Annual Energy Available for Sale

Description		Unit	Value
Installed Capacity		MW	350.0
Annual Energy		GWh	1534.93
Annual Energy	Peak	GWh	255.82
Annual Energy	Off Peak	GWh	1279.11
Plant Factor		%	50.1

8 DESIGN OF CIVIL COMPONENTS

The discharge for Turen More – Kari Hydropower project will be diverted from the tailrace of Jamshill – Turen More powerhouse or from its bypass arrangements. Being a cascade development and Turen More-Kari Hydropower project is stag-II of the cascade, its design discharge (305 m^3/s) is the same as the upstream project. The Bypass comprises of two Hollow jet valves of 2.4m diameter, a stilling basin (45m long and 15.5m deep) and a 100m long rectangular concrete channel (16.0m high and 7.0m wide) section. The water level at the end of bypass channel is at 1688.0 m asl which is consistent with Jamshill – Turen More powerhouse tail water level.

The design discharge either from the bypass arrangements or tailrace pond enters into a junction pond. From the pond the flow is conveyed into a channel where stop log arrangement has been provided. This channel is rectangular shaped and is 227 m long, 20.5 m wide and 6.5 m deep. At the design flow of 305 m^3/s depth in the channel will be 5 m.

The conveyance system of Turen More – Kari Hydropower Project lies along right bank of the river while, Jamshill - Turen More Hydropower Project along its left bank. Being a cascade development, Turen More - Kari HPP is dependent on Jamshill - Turen More HPP. It therefore, requires a river crossing structure to interlink the tailrace of Turen More powerhouse to the headrace of Turen More - Kari HPP. Fortunately, the river at Turen More powerhouse site passes through a narrow gorge of nearly 50 m width with exposed stable rocks along both banks, making the location more attractive for an aqueduct to cross the river. Normal water level in the river is about 25m below the bed level of the tailrace channel of Turen More powerhouse, allowing 1000 years return period flood with more than enough freeboard. The aqueduct comprises of four parallel channels each 4.5m wide and 6.5m deep. The flow depth in the aqueduct at the design discharge of 305m^3/sec will be 5.0 m. Reinforced concrete abutments have been provided on both banks of the river to support the aqueduct.

The aqueduct will convey the flows to a concrete lined trapezoidal headrace channel along the right bank of the Mastuj River. A 25 m long smooth transition has been provided between the aqueduct and the headrace channel to minimize head losses.

The headrace channel is 849m long having bed width of 15m and flow depth 5.08 m. Total depth of the channel is 6.5 m having a freeboard of 1.42 m. The lining comprises of three layers; two 100mm thick PCC layers with HDPE material sheet in between to improve its seepage tightness. A natural drain, Morison Gol crosses the headrace channel. A superpassage with cascade channel has been proposed to convey the drain water to the river. The super-passage has been designed to safely manage 100 year return period flood of 22 m^3/s.

The outflow from the headrace channel will enter into an inlet pond. The purpose of the inlet pond is to reduce flow velocity and allow turbulence free flow into the headrace tunnel. The pond is a rectangular concrete structure of 30m width, 60m length and 17.77 m depth. Due to pressurized conveyance system downstream of the inlet pond, sufficient submergence has been provided above the headrace tunnel crown at the inlet pond.

A free overflow spillway has been provided in the inlet pond to release the design discharge to the river in case of Turen More-Kari HPP powerhouse emergency closure. The spillway is Labyrinth shaped, sized to spill the design discharge of 305m^3/s with 1.0 m surcharge. In order to accommodate the overflow depth during the spillage of the design flow a freeboard of 1.4 has been provided in the headrace channel. The freeboard is sufficient to accommodate the surcharge. Crest width of the spillway is 59.0m and its elevation is 1687.35 m asl. Downstream of the spillway, a 30m wide stepped channel has been proposed to dissipate the flow energy and safely discharge it into the river at 1650.0 m asl.

The Headrace tunnel is of modified horseshoe shape with 9.7 m diameter and 14.1 km length. The tunnel has 300mm thick concrete lined section designed for internal and external loads. Five types of tunnel supports comprising combinations of rock bolts, shotcrete, concrete and steel ribs have been proposed. The selected support types for the headrace tunnel are based on geology of the concerned reach.

In order to accommodate surges during operation of the powerhouse, a surge shaft with restricted orifice has been provided at the end of the headrace tunnel. The diameter of the surge shaft is 27m and its height is 93m. At the end of the surge shaft a 109 m long, 8.5m diameter circular pressure shaft has been provided. To withstand the high hydraulic pressure in the shaft, steel lining of thickness varying from 30mm to 55mm has been provided depending upon the magnitude of pressure. At the end of the pressure shaft a 549m long steel lined horizontal pressure tunnel has been proposed. The pressure tunnel is 8.5m in diameter with 55mm thick steel lining to convey the flows to the penstock.

A buried penstock, 8.5 m in diameter, 65 m long, 60 mm thick has been proposed between the pressure tunnel and the powerhouse. The penstock has four manifolds, each 4.2m diameter to feed the four turbines.

The powerhouse main hall would be 111 m long and 25 m wide. Control rooms alongwith offices have been provided separately, adjacent to the main hall. Loading/unloading bay, gantry crane and other requirements for the powerhouse building have also been provided. There will be four generating units comprising of vertical Francis turbines. The machine floor level and the turbine centreline are at 1545.65 m and 1534.00 m respectively. The tailwater level fluctuates between 1537.00 m and 1542.00 m respectively, depending on available flows and the number of units in operation.

The outflows from the turbines are to discharge into a stilling pond 84 m long, 31 m wide and 21.2 m deep. From the stilling basin, the flows will be discharged into the Mastuj River via tailrace channel.

9 STRUCTURAL DESIGN

Pseudo-static method of analysis has been adopted for structural analysis based on static solution of the system subjected to inertia forces equal to the product of the mass of the system and the acceleration acting in a selected direction. The effect of earthquake forces impacting earth pressures have been calculated by using Mononobe Okabe method. Similarly, hydrodynamic forces have been calculated using Zanger method.

Calculations of forces under various loading conditions have been done using three-dimensional analysis software SAP2000, which is based on finite element method of structural analysis. Boundary spring elements have been adopted for modelling sub-soil supporting the structures.

Since a dam structure is not required, therefore, risks due to dam failure and consideration of the corresponding Safety Evaluation Earthquake (SEE) criterion are not relevant for this project. For earthquake considerations in the powerhouse building, Pakistan Building Code specified value of 0.32 g has been adopted. For other major project structures, a Design Basis Earthquake (DBE) of 0.29g (475 years return period) has been adopted. Similarly, PGA of 0.20g with a return period of 145 year has been adopted for Operation Basis Earthquake (OBE) for minor structures. These parameters have also been adopted for the upstream Jamshill - Turen More Hydropower Project.

10 HYDRO-MECHANICAL COMPONENTS OF THE PROJECT

Given the head and flow range for the project, the optimum configuration of four vertical shaft Francis Turbines has been proposed. The rated speed of the turbine has been proposed to be 250 RPM and the rated power at the turbine shaft would be 90.0 MW.

Digital, microprocessor type Proportional Integral Derivative (PID) governors have been proposed and each turbine would be provided with such an independent governor. The governor regulator would have an independent hydraulic actuator of sufficient capacity to control the turbine under all operating conditions.

There would be four inlet valves at the manifolds, one for each turbine. The diameter of the valve has been proposed to be 4.0 m.

Two overhead travelling cranes have been provided in the powerhouse for installation and dismantling of the electro-mechanical equipment each with 150 ton capacity. The maximum weight of the single heaviest component of the electromechanical equipment is the generator rotor which will be about 227 ton. Therefore, the rotor needs to be lifted by operating both the overhead travelling cranes together. 300 ton total capacity of the cranes allows for over 20% higher lifting capacity.

As discussed earlier, a bypass arrangement has been proposed at Turen More powerhouse to reduce operational dependence of Turen More - Kari HPP on the upstream Jamshill - Turen More HPP. This arrangement comprises of two sets of bonneted slide gates followed by hollow jets discharging into a stilling basin. From the stilling basin, the flows would be routed to the tailrace of the Turen More powerhouse.

Other required major hydro-mechanical equipment and accessories are:

A. Upstream of Powerhouse

Stop logs at intake, upstream of the aqueduct
Safety rack at aqueduct inlet
Trashrack at tunnel inlet
Bulkhead gates at access tunnels (1 and 4) and headrace tunnel junction
Penstock inlet valve (PIV) downstream of surge shaft

B. At Powerhouse

Draft tube gates in the powerhouse
Units Cooling Water System
Heating, Ventilation and Air Conditioning (HVAC) System
Fire fighting system.

11 ELECTRO-MECHANICAL COMPONENTS OF THE PROJECT AND TRANSMISSION LINE

Four 87.5 MW, 0.85 power factor, 50 Hz, 11 kV vertical shaft, silent pole synchronous generators alongwith necessary auxiliary equipment complete with control, monitoring, switchgear / protection systems have been provided to produce 350 MW installed capacity.

In order to evacuate the generated power from the project to national grid, four (3 single phase bank) step-up power transformers with capacity 40 / 50 MVA have been proposed.

The 220 kV high voltage switchgear equipment such as SF6 Circuit Breakers, Disconnecting Switches with and without Earthing Switches, Instrument Transformers and Control, Monitor and Protection of outdoor switchyard equipment have been selected.

One 4 / 5 MVA, 220 / 11 kV three phase transformer with required protection and control switchgears has been proposed to cater for the power supply from national grid to the power station services, outdoor switchyard, housing colony, inlet pond and channel area. This transformer would be in addition to the backup supply to the power station service. Two 750 KVA transformers have been proposed to tap from the generator bus. Similarly, five 300 KVA auxiliary transformers have been proposed to supply low voltage, 400 V to housing colony.

The power plant would be provided with a state of the art SCADA (supervisory control and data acquisition) system. This would include programmable logic controllers (PLC's) Digital Governor, Automatic Voltage Regulator (AVR) for the complete control system of Turbine/Generator. There would be a PC monitor and hard disc for data display and data acquisition system with graphic display screens to implement a vast array of control schemes. The ACS shall be fully developed, debugged, commissioned and tested for manual and fully automatic control of the power plant. The PLC and SCADA control scheme shall provide flexibility in control, alarming, sequence of events recording, and remote communication. Data acquisition, storage and retrieval shall be provided by the computer.

The transmission line and power evacuation from new identified hydropower projects within the Mastuj River corridor is one of the main concerns in Chitral region. At present the nearest 132 / 220 kV grid station is situated at Chakdara District, Dir Lower which is about 250 km from the project site.

The power evacuation study and construction of High / Extra high voltage transmission line may take some time as various HPPs are currently under study. Therefore, PEDO has directed that all the on-going projects have to be designed to accommodate the power likely to be generated by the upstream projects and then to dispatch the cumulative power to the subsequent downstream project.

By accumulating the upstream power projects, a 500 kV transmission line would be required to transmit the power to Chitral grid. Due to the transportation limitations, 500 kV transformers cannot be transported to the site. Therefore, two separate 220 kV transmission lines have been proposed. The transmission line of Turen More - Kari Hydropower Project would be linked separately with the Chitral grid and upstream cumulative power will be separately transmitted to the grid.

12 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

The preparation of Environmental and Social Impact Assessment (ESIA) ESIA report is based on the analysis and findings of primary and secondary data collected from field survey, scoping sessions, individual interviews, consultation with government departments, NGOs and review of available studies. The environmental policies, acts, legislation, procedures and guidelines of Pakistan and International Donor Agencies (World Bank, Asian Development Bank) were also reviewed and consulted during the study.

General and project area specific baseline information has been collected during a series of field activities. Shahchar, Mori Lasht and Chamuruk are the primary affected villages; therefore, full scale field survey and individual interviews have been conducted in these villages. Focused Group Discussions (FGDs) and individual interviews have also been conducted in other villages located within the project reach which are subject to inconsequential negative impacts. Other broad based physical, biological and social, environmental baseline information of District Chitral has been collected from secondary and primary sources.

During the field survey no significant link could be established between the Mastuj River and the villages located on its banks. In the entire project reach, people use spring (local name Gol) water for agriculture, drinking and other domestic activities. Furthermore, no water requirements from the river have been discussed by the community during scoping sessions and FGDs; the same has been reaffirmed during transect walks along the river and from direct interactions of the field staff with the local community. Since this is a cascade project, environmental release is not required as only the inflows from the upstream Jamshill - Turen More tailrace has to be utilized for power generation. Furthermore, the tributaries of Mastuj River upstream (between Jamshill dam and Turen More powerhouse) will contribute substantial flow of water to maintain the riverine ecosystem.

The construction of this Project will affect the land based resources of the area. A total of about 1250 kanal land have been estimated to be consumed on permanent basis by the Project. This includes 574 kanal of agriculture land (46%) and 634 kanal of barren land (51 %). Residential land is only 3 % of the entire land to be acquired for Turen More-Kari hydropower project. Furthermore barren land at access tunnel-01 is common land of different villages with no defined ownership.

Due to the implementation of the project, 11 houses will be affected/relocated in Turen More, Kuju Payeen and Ragh villages. These include 5 permanent (pacca) and 6 temporary (kacha) houses with a total covered area of about 228,688 ft^2. As such, a total of 11 families with 83 inhabitants need to be relocated.

A significant number of trees in Turen More, Kuju Bala, Kuju Payeen and Ragh villages will also be affected by the project activities. According to primary information a total of around 4443 trees (4 - 30 years old) including 1578 forest trees and 2865 fruit trees will be affected.

During execution of the project, huge quantity of muck would be produced at different locations. Spoil areas have been identified for muck disposal at various project locations. It has been estimated that a total of 180 acres of land will be required to dump the muck materials. Once the muck has been placed and the area rebuilt, about 80 acres of barren land can be reclaimed for agricultural activities.

Pre-construction monitoring of air, water and noise has been carried out at aqueduct, powerhouse and colony sites. Findings of the environmental monitoring would be used for future reference purposes. During construction, environmental monitoring would be done for air quality, noise, drinking water quality, sewage effluent, solid waste, explosive material used, hazardous/toxic materials and its proper disposal, flora/fauna, excavated material and for traffic handling systems etc. The findings would be compared with the pre-construction conditions where possible. For implementation of mitigation measures internal and external environmental monitoring would be a very important component during the project execution phase.

Cost of Environmental and Social Impact Management Plan has been worked out with due consideration to the objectives and policies made by Pakistan Environmental Protection Agency and World Bank/Asian Development Bank. Total environmental cost of the project is estimated to be Rs 685 million.

In light of the international laws dealing with environmental and social impact assessments, it can safely be concluded that Turen More-Kari is one of the environment friendly projects which would play an important role in overcoming the prevailing energy crises and in boosting economy of the country. In the local context; the project would also have significant contribution in the enhancement of socio-economic conditions of the people of Chitral.

13 TRANSPORTATION AND ROUTE SURVEY

Normally heavy construction machinery is used in hydropower projects. Similarly, heavy turbines, generators, governors and transformers have to be transported to the site and installed to generate and supply hundreds of megawatts of energy to the National Grid.

The transportation of heavy construction machinery, electro-mechanical equipment and structural steel components for hydropower projects in northern areas is an uphill task that needs special planning.

The overall objectives of the Route and Transportation study are:

i. Identification of practical and economically viable means and ways of transportation.

ii. Highlighting critical structures/portions of the route to be used for transportation of machinery / equipment to the site.

Transportation of heavy equipment from Upper Dir to Ashriat would be an uphill task due to poor road condition, sharp bends and steep gradients. The planners shall give due attention to this part of the route. Customized trailer would be required for transportation of the heavy construction and electro-mechanical equipment.

According to the project contractor, Lawari Tunnel project is scheduled to be completed by end of 2015. This would be of immense benefit to the project for transportation of the heavy equipment as transportation through Lawari Pass is not feasible. The proposed road at tunnel portal towards Chitral is at higher elevation. This may pose mobility problems during heavy snowfall. The narrow road passing in towns between Dargai and Chitral may create inconvenience to the commercial activities in vicinity of the road and should therefore, be given due consideration in planning.

The bridges and culverts on the road between Dargai and Chitral have been designed for loading capacity of 70 tonnes with axle load of 11.3 tonnes. Due Consideration should be given to the axle load limits in customization of the trailer. Similarly, there is a short tunnel with clear height of 4.88 meters on the road between Dargai and Malakand. Due care should be taken while passing through the tunnel or possibility of using the existing road along the tunnel may be explored.

The transportation of heavy and bulky equipment on broad gauge railway from Karachi to Nowshera would not be a problem; however, clearance of various short tunnels on the railway track should be confirmed prior to start transportation of the equipment. From Nowshera to Dargai, the branch railway line has structure of clear width of 4.1 meters and clear height of 5.8 meters with permissible axle load of 16.5 tonnes. Therefore, due care should be taken not to exceed this limit. There are two culverts which can sustain about 63% and 66% of the design axle load. The railway flat cars with 2 to 3 axle bogies are available for this purpose.

14 PROJECT COST ESTIMATE

Cost estimates comprise quantification of major items in the project components, unit cost determination, estimation of civil, electrical, mechanical and other component's costs and the associated cost including services, duties, taxes, interest during construction, environmental & social cost and cost of unforeseen items.

There are several methods and guidelines for the determination of unit cost of hydropower projects depending on the nature and complexity as well the funding sources. However, it is not possible to use a single source due to different nature of the items in hydropower projects. The unit rate should be realistic and according to complexity of the area as well overall situation in the country. Normally due to law and order situation, the international contractors quote higher rates in countries like Pakistan. Recent examples of this are the rates on WAPDA and PEDO under construction Projects. Therefore, combination of CSR, market rate analysis, rates of hydropower projects under construction in Pakistan as well as budgetary estimates by manufacturers and standard guidelines have been consulted. The itemized cost estimate of different components of the project is summarized in the following table.

SUMMARY OF COST ESTIMATE

S. No.	Description	Amount			
		Local Component (Rs)	Foreign Component (USD)	Total (Rs)	Total (USD)
A	PRELIMINARY AND GENERAL	1,147,947,659	910,000	1,238,947,659	12,389,477
B	CIVIL WORKS	24,693,781,503	48,337,470	29,527,528,517	295,275,285
C	ELECTRO-MECHANICAL WORKS	878,577,000	170,901,437	17,968,720,731	179,687,207
	PROJECT CONSTRUCTION COST	**26,720,306,162**	**220,148,907**	**48,735,196,907**	**487,351,969**
D	DESIGN REVIEW, PREPARATION OF CONTRACT DOCUMENTS AND ASSISTANCE IN TENDERING @ 1.5% OF CONSTRUCTION COST	731,027,954	-	731,027,954	7,310,280
E	CONTRACT MANAGEMENT, QUALITY CONTROL AND CONSTRUCTION SUPERVISION @ 3% OF CONSTRUCTION COST	1,462,055,907	-	1,462,055,907	14,620,559
F	CLIENT EXPENSES, ADMINISTRATION AND LEGAL COSTS @ 1.5%	731,027,954	-	731,027,954	7,310,280
G	PEDO HEAD OFFICE CHARGES @ 1 % OF CONSTRUCTION COST	487,351,969	-	487,351,969	4,873,520
H	UNFORESEEN @ 0.5%	133,601,531	1,100,745	243,675,985	2,436,760
	PROJECT BASE COST	**30,265,371,476**	**221,249,652**	**52,390,336,675**	**523,903,367**
I	DUTIES AND TAXES	1,106,248,260	-	1,106,248,260	11,062,483
J	ESCALATION AND PRICE ADJUSTMENT	6,714,026,972	18,386,275	8,552,654,511	85,526,545
K	INTEREST DURING CONSTRUCTION (IDC)	5,077,729,939	34,172,058	8,494,935,751	84,949,358
	TOTAL PROJECT COST	**43,163,376,647**	**273,807,985**	**70,544,175,197**	**705,441,752**

Note: 1 USD = 100 PKR

15 FINANCIAL AND ECONOMIC ANALYSIS

Evaluation of any large infrastructure project is undertaken to determine its economic feasibility and financial viability before its implementation. The economic analysis is undertaken from the point of view of economy as a whole from the country's perspective. The economic justification of investment in capital intensive projects depends on three factors; first whether there is a need for the project, second where technological options are available that present the most economical choice and third, does the investment generate an acceptable return to the national economy. This process involves the assessment of project benefits and identification of project costs over the economic life of the project. The cost of the project comprises all costs incurred during implementation and subsequently operation of the project.

The estimated annual cost disbursal with and without transmission line alongwith local and foreign cost components and other key parameters are shown in the following table.

Estimate of Annual Cost Disbursal (M. PKR)

Year	With Transmission Line		
	Local Cost	Foreign Cost	Total
Pre-construction	1,389,074,801	456,457	1,434,720,543
1	2,247,845,409	1,324,577	2,380,303,093
2	6,480,969,118	11,164,502	7,597,419,269
3	6,992,989,045	81,535,699	15,146,558,977
4	7,468,077,428	92,157,379	16,683,815,329
5	5,686,415,675	34,611,038	9,147,519,464
Custom Duty	1,106,248,260	-	1,106,248,260
Escalation and Price Adjustment	6,714,026,972	18,386,275	8,552,654,511
Interest During Construction	5,077,729,939	34,172,058	8,494,935,751
Financial Cost	**43,163,376,647**	**273,807,985**	**70,544,175,197**

Economic and financial analyses have been undertaken using the parameters shown in the above table. The following assumptions have been made:

- Price Datum: June 2014
- Custom Duty: 5%
- Opportunity cost of capital: 12%
- Operation and maintenance cost: 1.5% of capital cost per annum
- Interest rate: 10.65%
- Benefits have been calculated based on:

Displacement of equivalent furnace oil plant at US$ 1982 / kW together with fuel cost of PKR 12.7 per kWh.

Displacement of equivalent combined cycle gas turbine plant at US$ 1132 / kW together with fuel cost of PKR 12.7 per kWh.

Based on the above assumptions, the results of the economic analysis are presented in the following table:

Summary of Results of the Economic Analysis

Description	Economical Internal Rate of Return			
	With Transmission Line		Without Transmission Line	
	With CDM	Without CDM	With CDM	Without CDM
COMPARISON WITH EQUIVALENT THERMAL FURNACE OIL PLANT				
Base Case	79.80%	78.59%	81.17%	79.98%
10% Less Benefits	70.43%	69.13%	71.75%	70.47%
20% Cost Over-run	64.08%	62.71%	65.35%	64.01%
Combined Impact	56.08%	54.66%	57.28%	55.97%
COMPARISON WITH EQUIVALENT THERMAL COMBINED CYCLE GAS TURBINE				
Base Case	49.84%	48.74%	50.76%	49.67%
10% Less Benefits	44.42%	43.34%	45.28%	44.57%
20% Cost Over-run	40.81%	39.76%	41.62%	40.57%
Combined Impact	36.32%	35.31%	37.06%	36.05%

The above results of economic analysis clearly demonstrate that the project is technically sound and economically viable. Compared to equivalent thermal combined cycle gas turbine, the project yields larger benefits. Furthermore, the EIRR far exceeds opportunity cost of capital even when the benefits decrease by 10% together with 20% increase in the cost (worst scenario). Therefore, investment in the project does not involve major risks and its implementation is justifiable economically.

Financial analysis of the project has been carried out for the base case alongwith sensitivity analysis which considers 10% decrease in benefits, 20% increase in costs and in the worst case scenario, a combination of both. In all cases, the analysis has been done with and without cost of the transmission line from the project's switchyard to the proposed grid substation in Chitral. For the estimation of benefits, the current tariff of PKR. 8.94 has been projected at 5% annually to the commissioning year (2021) which results in PKR 13.21/kWh. Summarized results of the financial analysis including sensitivity analysis are shown the table below.

Summary of Results of the Sensitivity Analyses

Description	Financial Internal Rate of Return (FIRR)	
	With Transmission Lines	Without Transmission Lines
Base case	20.27	20.62
10% less benefits	18.61	18.95
20% cost over-run	17.47	17.79
Combined impact	15.98	16.28

Result of the financial analysis show FIRR higher than 10.65% (interest rate & 100% loan financing) even in the worst scenario, revenue from the project would be able to payback the debts incurred in all cases.

16 CONSTRUCTION SCHEDULE

The construction schedule has been prepared taking into account the sequence of activities based on local climate, culture, site access, topography and remoteness as well as complexity of the project. Significant concrete works would be required to construct the aqueduct, headrace channel, side spillway and the inlet pond. The concrete work cannot be started during the winter months, especially at night when the ambient temperature reaches sub-zero levels. Similar is the case of concrete works in the powerhouse, both for the machine foundations and the frame structure (beams, columns and slabs) for the building. On the other hand it would be possible to continue with the excavation works inside the tunnel throughout the year.

In order to complete the project on time, it is important to prepare a realistic construction schedule and monitor the progress of work carefully during construction. Identification of quarries for construction materials (aggregates), supply route for cement, reinforcements, POL and other consumables (explosives), workforce required, construction camps and facilities need to be arranged before starting the construction works.

After completion of the detailed design, tendering process and award of the Contract, the Contractor submits a performance guarantee to execute the construction work is a normal practice for infrastructure projects in the country. Once the Client issues “letter to proceed”, the Contractor would mobilize his team, equipment and construction materials at site. Contractor mobilization has been scheduled to be one month after signing the contract. If EPC contract is opted for, tender drawings and documents would be prepared for the process of tendering and award of the contract.

The schedule of completion for the construction of temporary camps and access roads has been estimated separately in the construction schedule while, the construction of permanent housing and other necessary infrastructure would be continued in parallel with the main construction activities.

The exploration of quarry sites, construction material availability at site, brands of cement, brands of steel bars, stores for adequate stock would be planned and set up accordingly. The schedule would be implemented and monitored accordingly for the required equipment, human resources and stock of construction materials for timely completion of the project.

The main civil construction of the project work would start at several locations simultaneously. Bypass and the aqueduct construction work and access tunnels, inlet portal would be started first. Construction of access tunnels would require temporary crossings on the Mastuj River as the existing road is along the left bank. The headrace tunnel work will continue from the inlet portal and as the access tunnels (adits) get completed, more faces would be available to speed up the headrace tunnel construction works. A four and half year construction period has been envisaged for completion of the headrace tunnel. Given the length of the headrace tunnel (~14.1 km) with finished diameter of 9.7 m, the work falls in the critical path.

Since access to Jamshill - Turen More powerhouse will be available the Contractor may start preparatory works for the bypass and aqueduct immediately after mobilization. With provision of temporary crossing of the river, the Contractor can start the execution of headrace channel, superpassage, inlet pond, and spillway within nine months after mobilization. These activities can also be started after completion of the aqueduct when permanent access to the right bank becomes available. As these activities do not fall in the critical path, flexibility is there to adjust its schedule of execution.

Access road to the powerhouse may require about 7 months. As soon as this access road gets completed, work on the pressure tunnel may be started from the outlet portal. Construction work in the powerhouse area has been scheduled to start about one year after mobilization.

Construction of the surge shaft would require access road from the powerhouse. Once this access road is completed, the surge shaft construction works may be started. The pressure shaft execution may be started after four months of completion of Access Tunnel 4, being located about 200 m downstream of the junction of headrace tunnel and Access Tunnel 4.

As mentioned earlier, the headrace tunnel is in the critical path, however, any delay in the powerhouse civil works would also delay the installation of electromechanical equipment. Therefore, the powerhouse civil works together with electromechanical installation may also fall in the critical path. Turbines and generators need to be supplied on time so orders for manufacturing of the equipment should be placed on time.

Total project construction duration has been estimated to be 5 years with additional six months to provide cushion to the contractor for detailed design activities.

17 CONCLUSIONS

The feasibility study clearly demonstrates that Turen More - Kari Hydropower Project (350 MW) is technically feasible, financially viable and environmentally acceptable. Furthermore, the project would have significant economic impact as it would replace the high cost thermal plants and help to some extent to curb the load shedding, the country is currently facing. As the project cost estimates alongwith the financial and economic analysis have been carried out based on 100% loan financing, any equity injection in the project would further improve its financial and economic parameters. Therefore, implementation of the project is justified if funds can be made available.

SALIENT FEATURES OF THE PROJECT

Sr. No.	DESCRIPTION	VALUE
1	**LOCATION**	
	Country	Islamic Republic of Pakistan
	Province	Khyber Pakhtunkhwa
	District	Chitral
	Project Site	About 30 km North East of Chitral Town on Mastuj River
2	**ORGANISATIONS**	
	Client	Pakhtunkhwa Energy Development Organization (PEDO) Power and Energy Department, Government of Khyber Pakhtunkhwa
	Consultants	A Joint Venture of: AGES Consultants Pakistan (Lead Firm) Infra-D Consultant, Pakistan Hydroconsult Engineering, Nepal Sheladia Associates Inc. USA Norconsult AS, Norway (Sub Consultant)
3	**BYPASS ARRANGEMENTS**	
	Number of Bypass Pipes	2 Nos.
	Diameter of Bypass Pipes	4.2m
	Energy Dissipation Type	Hollow Jet with Stilling Basin
	Diversion Angle of Pipe	60 degrees
	Invert Level of Basin	1674.60 m asl
	Size of Hollow Jet Basin	45 X 16 m
	Water Level in Stilling Basin	1688.1 m asl
	Bypass Channel Type	Rectangular Shape Concrete Lined
	Invert Level of Bypass Channel	1683.1 m asl
	Length of Bypass Channel	100 m
	Size of Bypass	16 x 7 m
	Flow Control	Stoplogs
	No. of Stoplogs	3 m

Sr. No.	DESCRIPTION	VALUE
	Size of Stoplogs	5.5 m x 7 m
4	**CONNECTING CHANNEL**	
	Upstream Channel Section	Rectangular Concrete Lined
	Invert Level of Channel	1683.0 m asl
	Design Discharge	305 m^3/sec
	Water Level in Channel Start	1688.0 m asl
	Length of Channel	117 m
	Depth of Flow	5.0 m
	Size of Channel	20.5 m x 6.5 m
	Freeboard	1.5 m
	Bed Slope	0.00045 m/m
	Flow Velocity	2.98 m/sec
5	**AQUEDUCT**	
	Trough Channels	Rectangular Reinforced Concrete
	No. of Trough Channels	4
	Water Level at Start of Trough Channel	1687.99 m asl
	Bed Level at Start	1682.98 m asl
	Trough Span	50 m
	Depth of Flow	5.0 m
	Size of Channel	4.5 m x 6.5 m
	Freeboard	1.5 m
	Bed Slope	0.001 m/m
	Flow Velocity in Trough	3.39 m/s
	Trough Support	Reinforced Concrete Abutments
	Length of Abutments	49.4 m
	Size of Abutments	7 m x 24.7 m
	Downstream Transition	Rectangular to Trapezoidal
	Length of Transition	25 m
6	**HEADRACE CHANNEL**	
	Type	Trapezoidal Concrete Lined
	Headrace Channel Side Slope	2H : 1V

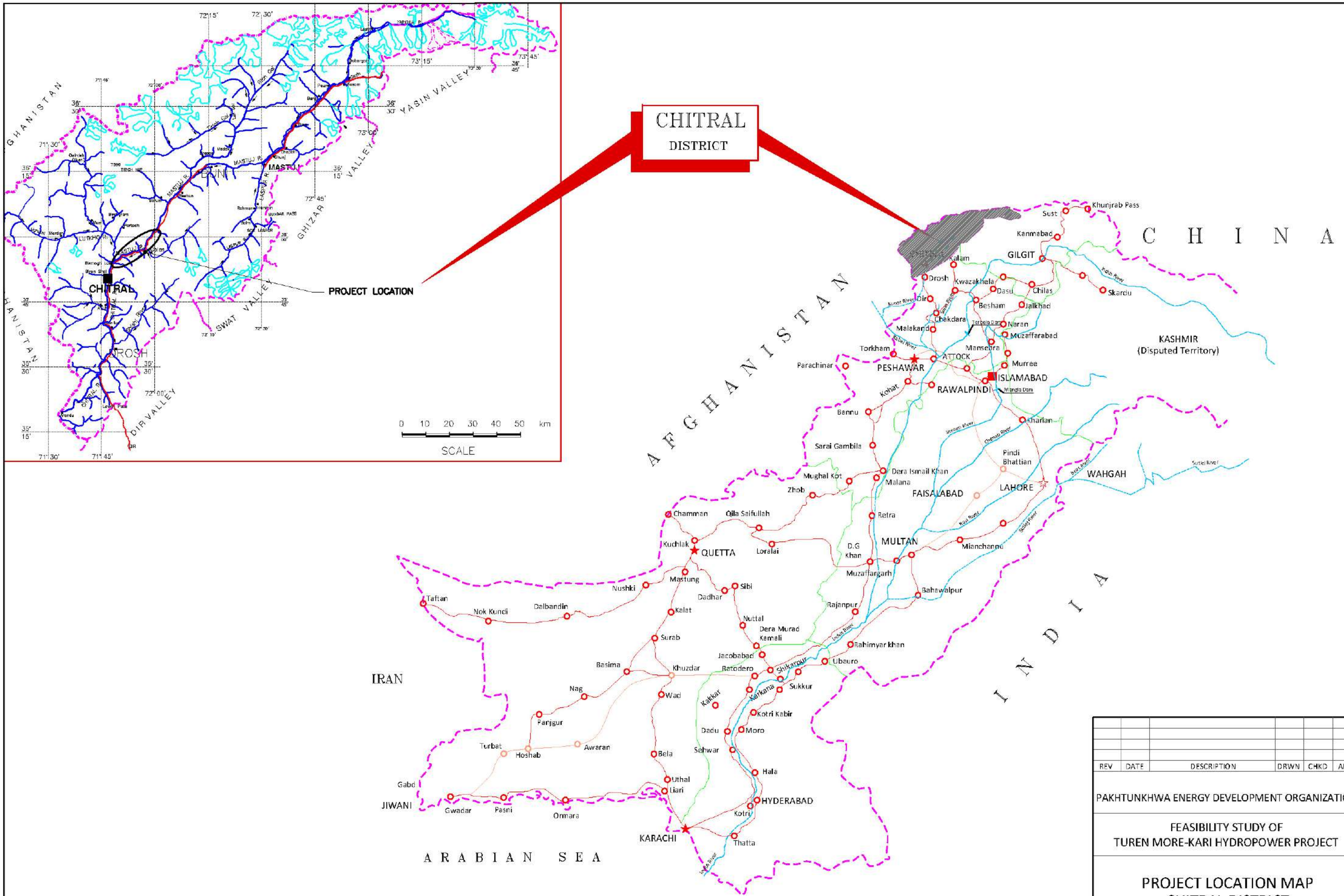
Sr. No.	DESCRIPTION	VALUE
	Design Discharge	305 m^3/sec
	Lining Thickness	100 mm +100 mm
	Seepage Control	Geomembrane
	Size of Headrace Channel (WXD)	15 m x 6.5 m
	Length of Headrace Channel	849 m
	Depth of Flow in Headrace Channel	5.08 m
	Freeboard	1.42 m
	Flow Velocity	2.38 m/s
	Water Level at Start of Headrace Channel	1687.51 m asl
	Water Level at End of Headrace Channel	1687.27 m asl
	Head Loss in Headrace Channel	0.241 m
7	**SUPERPASSAGE**	
	Length of Superpassage Trough	62.8 m
	Clearance from Headrace Channel Water Level	7.8 m
	Bed Level of Superpassage Channel	1695.15 m asl
	Design Flood	100 Year return period
	Flood Peak	22 m^3/sec
	Size of Channel	5 x 4 m
	Superpassage Trough Support	4 Nos. Piers
	Upstream Protection	Stone Masonry Step Drop
	Size of Steps (W X L)	7 m x 3 m
	Drop per Step	1 m
8	**INLET POND**	
	Type	Reinforced Concrete Rectangular
	Invert Elevation at Start	1687.25 m asl
	Invert Elevation at Tunnel Inlet	1669.00 m asl
	Size of Inlet Pond	30 m x 60 m
	Depth of Flow	17.77 m
	Submergence to Headrace Tunnel	6.9 m
	Elevation of Inlet Pond Side Walls	1689.00 m asl
	Velocity at Design Discharge	0.68 m/sec

Sr. No.	DESCRIPTION	VALUE
9	**SPILLWAY**	
	Type of Spillway	Labyrinth
	Crest Level of Spillway	1687.35 m asl
	Surcharge Level Due to Design Discharge	1688.35 m asl
	Width of Spillway	59 m
	Length of Labyrinth Wall	181.4 m
	Design Discharge	305 m^3/sec
	Downstream Level	1686.0 m asl
	Energy Dissipation	Stepped Drop Channel
	Material	Gabions
	Width of Channel	30 m
	Downstream Floor Level	1650.0 m asl
	Length of Stepped Channel	205 m
	Size of End Basin	14 m x 30 m
10	**HEADRACE TUNNEL**	
	Type	Concrete Lined Pressure Tunnel
	Shape	Modified Horseshoe
	Invert Elevation of Tunnel	1670.00 m asl
	Flow Area	76.53 m^2
	Average Flow Velocity	3.99 m/s
	Tunnel Diameter	9.70 m
	Length of Tunnel upto Surge Shaft	14.1 km
	Invert Level of Tunnel at Surge Shaft	1634.85 m asl
	Headloss in Tunnel	15.3 m
11	**ACCESS TUNNELS**	
	No. of Access Tunnels	4 (A1, A2, A3 & A4)
	Shape	Inverted U Shaped (A1, A2, A3) Modified Horseshoe (A4),
	Diameter / Height of Tunnels	6.00 m (A1, A2, A3) 9.70 m (A3)
	Length of Tunnels	820 m (A1) 560 m (A2) 530 m (A3) 240 m (A4)

Sr. No.	DESCRIPTION	VALUE
	Control for maintenance	Bulkhead Gates (A1, A4)
12	**SURGE SHAFT**	
	Type	Restricted Orifice Concrete Lined
	Geometry	Circular
	Maximum Surge Level	1717.6 m asl
	Minimum Surge Level	1652.4 m asl
	Diameter of Surge Shaft	27.00 m
	Diameter of Throat	4.20 m
	Full Operational Water Level	1671.98 m asl
	Top Level of Surge Shaft	1737.5 m asl
	Height of Surge Shaft	99.00 m
13	**PRESSURE SHAFT / PRESSURE TUNNEL**	
	Type	Steel Lined
	Geometry	Circular
	Centreline of Pressure Shaft at Start	1639.65 m asl
	Diameter of Pressure Shaft and Tunnel	8.50 m
	Flow Area	56.75 m^2
	Height of Pressure Shaft	109 m
	Length of Pressure Tunnel	549.70 m
	Average Flow Velocity	5.37 m/s
	Steel Lining Thickness	30 - 55 mm
	Invert Level of Pressure Tunnel End	1534.0 m asl
	Headloss in Pressure Shaft / Tunnel	2.3 m
14	**PENSTOCK**	
	Length of Penstock	65.00 m
	Diameter of Penstock	8.50 m
	Thickness of Steel Lining	60.00 mm
	Velocity in Penstock at Design Discharge	5.37 m/sec
15	**MANIFOLD**	
	Type	Straight Symmetrical Wye
	Number of Branches	4

Sr. No.	DESCRIPTION	VALUE
	Diameter of each Branch Pipe	4.25 m
	Velocity in Manifold at Design Discharge	5.37 m/sec
	Thickness of Steel Lining	60 mm
16	**POWERHOUSE**	
	Type	Surface Powerhouse
	Size of Powerhouse	25 m X 111 m
	Turbine	Vertical Francis
	Generating Units	4 X 87.5 MW
	Unit Discharge	87.5 m^3/sec
	Generator Type	Synchronous Vertical, 11 kV, 50 Hz
	Power Transformers	12+1 Nos. Single Phase, 40 / 50 MVA, 11 / 220 kV
17	**TAILRACE CHANNEL**	
	Type	Rectangular Concrete Section
	Length of the Tailrace Channel	95 m
	Submergence for Draft Tube	7.80 m
	Tailrace Channel Size	16 m x 6 m
	Depth of Flow in CHANNEL	5.00 m
	Freeboard	1.00 m
	Flow Velocity in Tailrace Channel	3.81 m/sec
	Invert Level of Channel	1537.00 m asl
18	**SWITCHYARD**	
	Size of Switchyard Area	112 m X 116 m
	Switchgear	220 KV, SF 6, Circuit Breaker
19	**TRANSMISSION LINE**	
	Transmission Line Length	2 x 12 km
	Type	220 kV, Double Circuit with Three Bundle Drake Conductors
20	**HEAD AND DISCHARGE**	
	Gross Head	150.25 m
	Rated Net Head	127.41 m
	Headloss at Design Discharge	22.84 m

Sr. No.	DESCRIPTION	VALUE
	Design Discharge	305.00 m^3/s
21	**CAPACITY AND OUTPUT**	
	Plant Capacity	350.00 MW
	Capacity per Unit	87.5 MW
	Plant Factor	50.10 %
	Average Annual Energy (Available for Sale)	1534.93 GWh
22	**PROJECT COST**	
	Project Construction Cost	48,735 Million Pak Rs.
	Project Base Cost	52,390 Million Pak Rs.
	Project Total Cost	70,544 Million Pak Rs.
23	**ECONOMIC AND FINANCIAL INDICATORS**	
	Economic Parameters – CCGT	
	Net Present Value (NPV)	76,523 Million Pak Rs.
	B/C Ratio	3.38
	EIRR	48.74 %
	Financial Parameters	
	Net Present Value (NPV)	121,914 Million Pak Rs.
	B/C Ratio	3.62
	FIRR	20.27 %
24	**IMPLEMENTATION**	
	Pre-construction	12 Months
	Construction Period	60 Months
	Total Implementation Time	72 Months



REV	DATE	DESCRIPTION	DRWN	CHKD	APPR

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

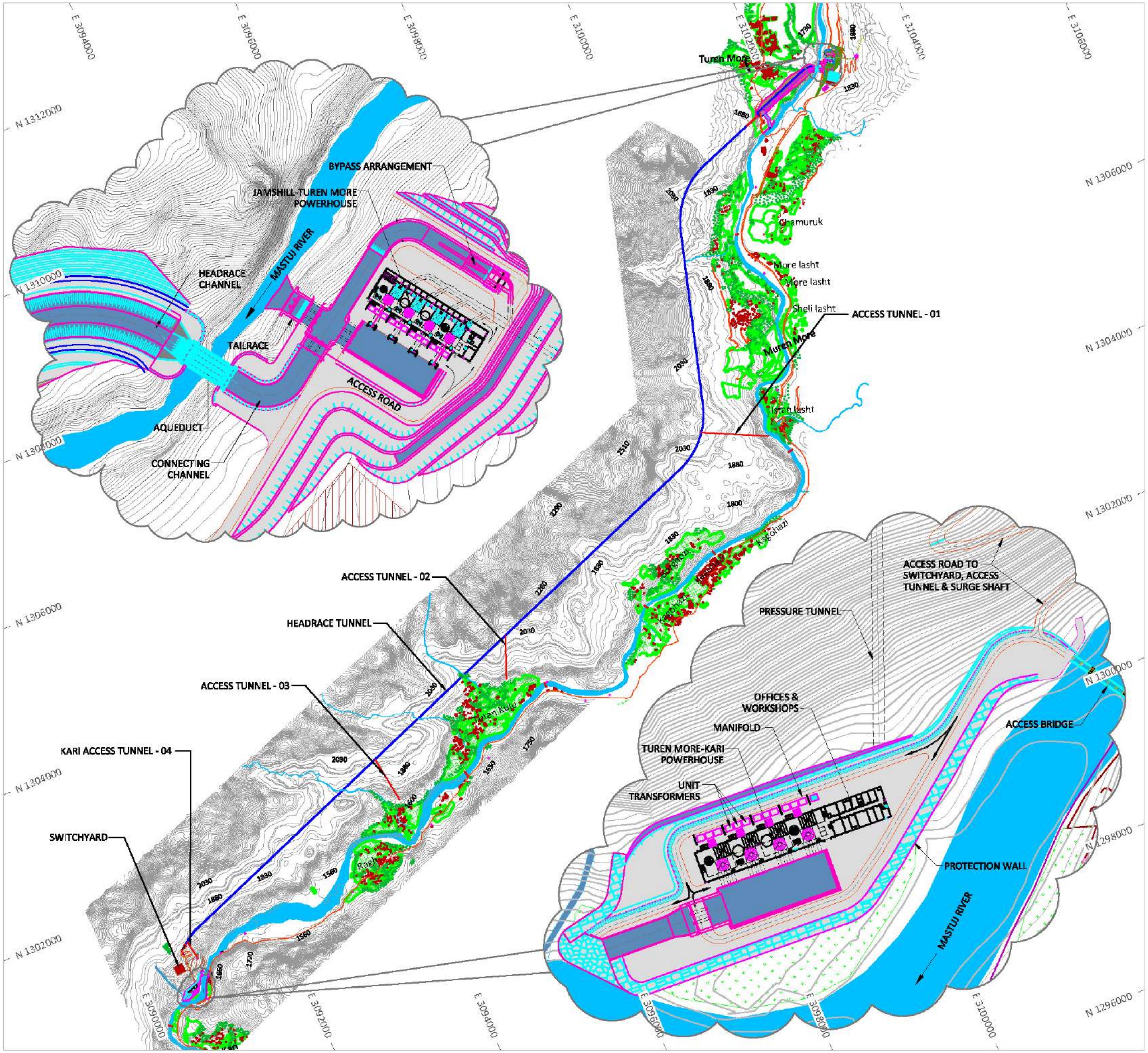
FEASIBILITY STUDY OF
TUREN MORE-KARI HYDROPOWER PROJECT

PROJECT LOCATION MAP
CHITRAL DISTRICT

	NAME
DRAWN	AZMAT ALI
PREPARED	UMER AZEEM
CHECKED	SAEED AFTAB
APPROVED CD	ZAHOOR AHMAD
PM	TARIQ KHURSHID

Consultants AGES, SHELADIA, Hydro Consult, IDC

SCALE: N.T.S	FIGURE - 01	DATE: FEB, 2015



NOTES:

1. ALL DIMENSIONS AND LEVELS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

LEGEND:-

- RIVER / GOL
- TUNNEL
- ACCESS TUNNEL
- TRACK
- ROAD
- CONTOURS
- CULTIVATED AREA
- BUILDING

SCALE: 0 500 1000 1500 2000 2500 m

REV	DATE	DESCRIPTION	DRWN	CHKD	APPR

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

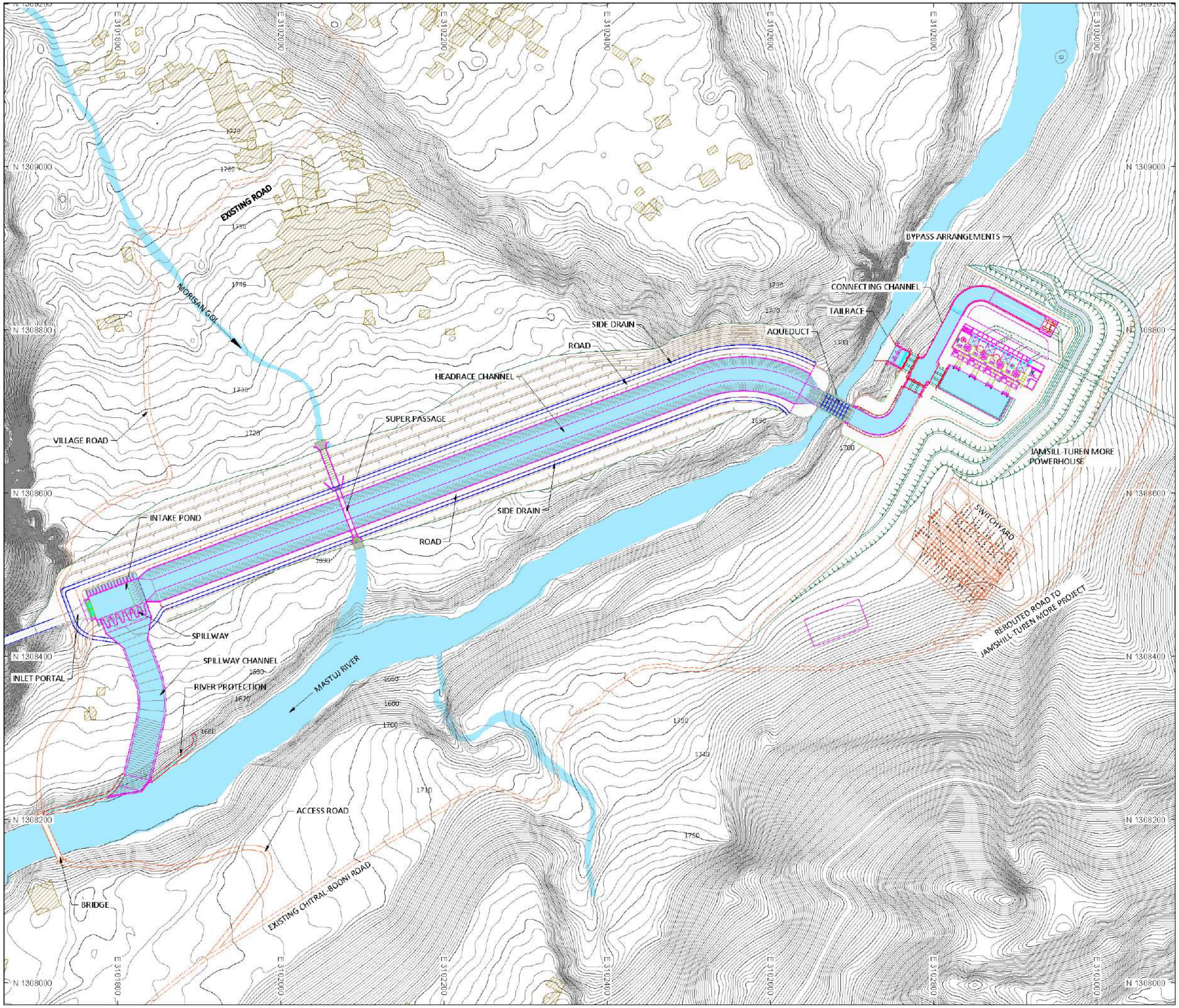
FEASIBILITY STUDY OF
TUREN MORE-KARI HYDROPOWER PROJECT

PROJECT LAYOUT PLAN

		NAME
DRAWN		ABBAS ALI
PREPARED		ARSHAD IQBAL
CHECKED		UMER AZEEM
APPROVED	CD	ZAHOOR AHMAD
	PM	TARIQ KHURSHID

Consultants AGES | SHELADIA | Hydro Consult | IDC

SCALE: 1:50,000 | FIGURE - 02 | DATE: FEB,2015



NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. CONTOUR INTERVAL IS 2M.

LEGEND:-

- RIVER / GOL
- TRACK
- EXISTING ROAD
- NEW ROAD
- CONTOURS
- BUILDING

SCALE: 0 45 90 135 180 225m

REV	DATE	DESCRIPTION	DRWN	CHKD	APPR

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

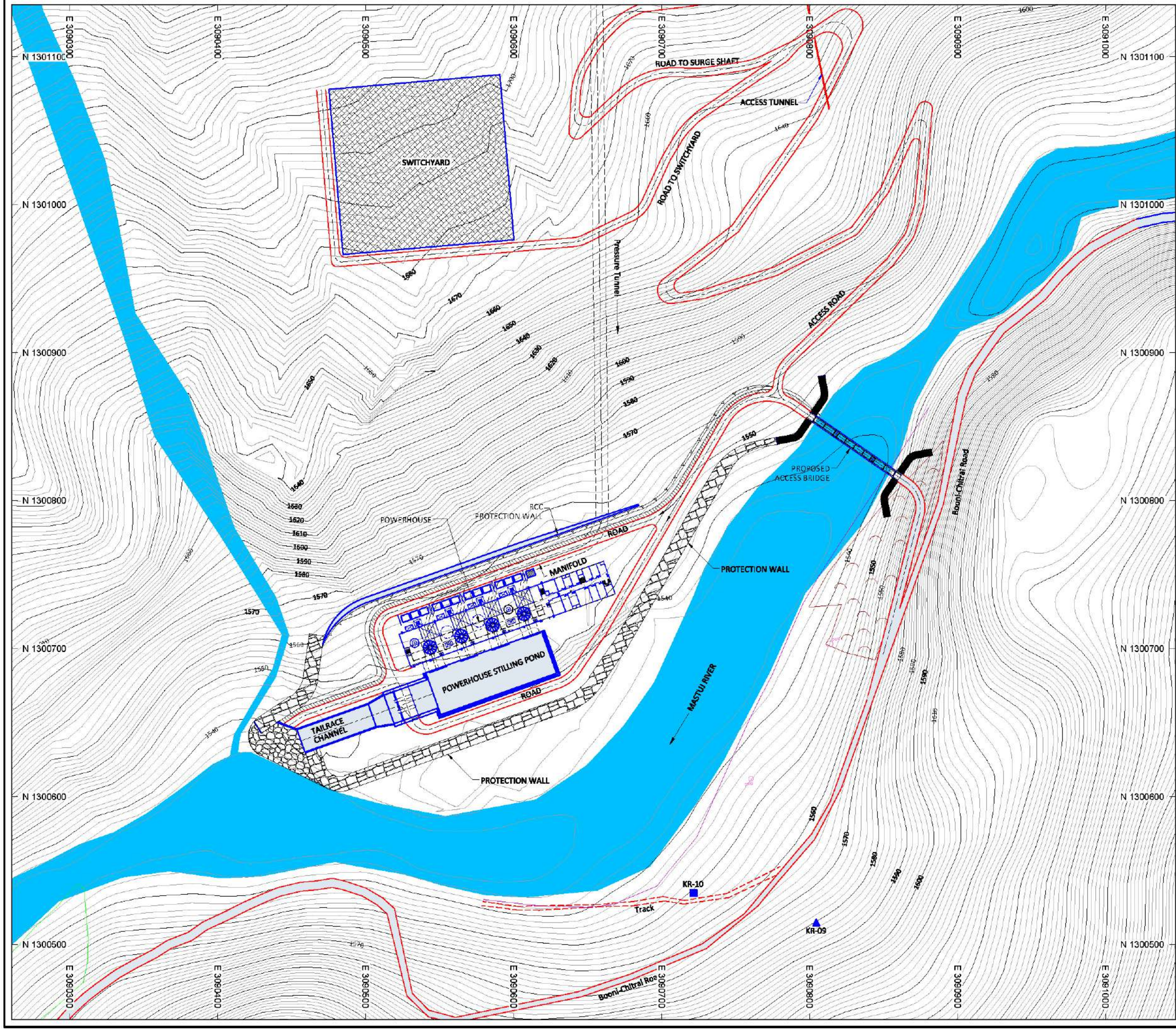
FEASIBILITY STUDY OF
TUREN MORE-KARI HYDROPOWER PROJECT

GENERAL LAYOUT PLAN OF INTAKE AREA

	NAME	
DRAWN	ABBAS ALI	J.V. CONSULTANTS
PREPARED	ARSHAD IQBAL	
CHECKED	SIBTUL HASSAN	
APPROVED CD	ZAHOOR AHMAD	
PM	TARIQ KHURSHID	

Consultants AGES — SHELADIA — Hydro Consult — IDC

SCALE: 1:4500 | DWG. NO. FIGURE - 03 | DATE: FEB, 2015



NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REV	DATE	DESCRIPTION	DRWN	CHKD	APPR

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

FEASIBILITY STUDY OF
JTUREN MORE-KARI HYDROPOWER PROJECT

GENERAL LAYOUT PLAN
OF POWERHOUSE AREA

	NAME
DRAWN	ABBAS ALI
PREPARED	ARSHAD IQBAL
CHECKED	UMER AZEEM
APPROVED CD	ZAHOOR AHMAD
PM	TARIQ KHURSHID

Consultants AGES, SHELADIA, Hydro Consult, IDC

SCALE: 1:2500 | SHEET NO: FIGURE - 04 | DATE: FEB, 2015

ID	Task Name	Start	Finish
1	**ACTIVITIES**	Fri 7/1/16	Thu 6/30/22
2	**A. PRELIMINARY AND GENERAL WORKS**	**Fri 7/1/16**	**Fri 8/6/21**
3	Review and Update of The Report	Fri 7/1/16	Thu 9/8/16
4	Preparation of Tender Documents	Fri 7/1/16	Thu 9/29/16
5	Tendering and Award of Contract	Fri 9/30/16	Thu 2/23/17
6	Mobilization of Contractor	Fri 2/24/17	Mon 3/27/17
7	Site Investigations	Fri 3/17/17	Thu 8/31/17
8	Design, Drawings and Report	Mon 3/6/17	Fri 8/6/21
9	Construction/ Hiring of Site Facilities	Mon 3/6/17	Fri 3/2/18
10	Construction of Access Roads	Mon 3/13/17	Fri 9/29/17
11	**B. CIVIL WORKS**	**Tue 4/11/17**	**Fri 3/18/22**
12	**Bypass and Connecting Channel**	**Tue 4/11/17**	**Fri 4/9/21**
13	Bypass	Tue 4/11/17	Fri 4/9/21
14	Connecting Conduit	Mon 5/1/17	Fri 2/26/21
15	**Aqueduct,Suppepassage, Inlet Pond**	**Wed 6/14/17**	**Fri 3/18/22**
16	Aqueduct	Fri 12/27/19	Thu 1/21/21
17	Headrace Channel	Mon 3/8/21	Fri 3/18/22
18	Superpassage	Mon 10/25/21	Fri 3/4/22
19	Spillway	Fri 11/29/19	Fri 2/5/21
20	Protection Works	Wed 6/14/17	Thu 9/10/20
21	Inlet Pond	Fri 11/1/19	Fri 3/4/22
22	**Headrace Tunnel**	**Thu 5/25/17**	**Tue 3/29/22**
23	**Access tunnles**	**Thu 5/25/17**	**Fri 6/8/18**
24	Inlet Portal for HRT Excavation	Thu 5/25/17	Fri 7/14/17
25	Access Tunnel 1	Fri 6/30/17	Fri 6/8/18
26	Access Tunnel 2	Mon 7/31/17	Fri 4/6/18
27	Access Tunnel 3	Mon 6/26/17	Fri 2/9/18
28	Access Tunnel 4	Tue 7/11/17	Mon 11/27/17
29	Headrace Tunnel	Mon 7/17/17	Fri 12/10/21
30	Surge Tank	Thu 3/15/18	Wed 7/1/20
31	Pessure Shaft	Mon 7/6/20	Fri 3/4/22
32	Pressure Tunnel	Mon 3/19/18	Fri 7/3/20
33	Penstcok and Manifold	Fri 9/27/19	Thu 1/28/21
34	Powerhouse	Wed 7/4/18	Tue 3/29/22
35	Tailrace	Fri 7/17/20	Fri 2/25/22
36	Switchyard	Wed 1/6/21	Tue 3/1/22
37	Road and infrastructure (Environment) Facilities	Fri 5/26/17	Thu 3/10/22
38	**C. ELECTRO MECHANICAL WORKS**	**Tue 1/1/19**	**Thu 6/30/22**
39	**Hydro-mechanical Equipments**	**Tue 8/6/19**	**Fri 3/25/22**
40	Installtion of main components in powehouse	Tue 8/6/19	Fri 9/3/21
41	Interconnection and Minor Works	Mon 9/6/21	Fri 3/25/22
42	**Hydraulic steel structures**	**Tue 1/1/19**	**Mon 3/28/22**
43	Powerhouse Equipments	Tue 1/1/19	Fri 1/29/21
44	Gates and Valves	Tue 6/22/21	Mon 3/28/22
45	Bulkhead and Portal Gates	Mon 11/1/21	Fri 3/18/22
46	**Electrical equipments**	**Fri 1/22/21**	**Fri 3/25/22**
47	Electrical Equipments in Powerhouse	Fri 1/22/21	Fri 3/25/22
48	Electrical Installations in Switchayard	Fri 7/23/21	Thu 3/24/22
49	**Transmission line and interconnections**	**Fri 4/19/19**	**Thu 6/30/22**
50	Main Transmission Lines	Fri 4/19/19	Thu 10/29/20
51	Auxialliary Transmision Lines	Fri 10/30/20	Thu 5/27/21
52	Interconnections to Main Grid	Tue 6/1/21	Mon 1/10/22
53	Testing and Commissioning	Fri 4/1/22	Thu 6/30/22

FEASIBILITY STUDY OF TUREN MORE - KARI HYDROPOWER PROJECT (350 MW)

Task	Project Summary	Inactive Summary	Manual Summary	External Milestone
Split	External Tasks	Manual Task	Start-only	Progress
Milestone	External Milestone	Duration-only	Finish-only	Deadline
Summary	Inactive Milestone	Manual Summary Rollup	External Tasks	