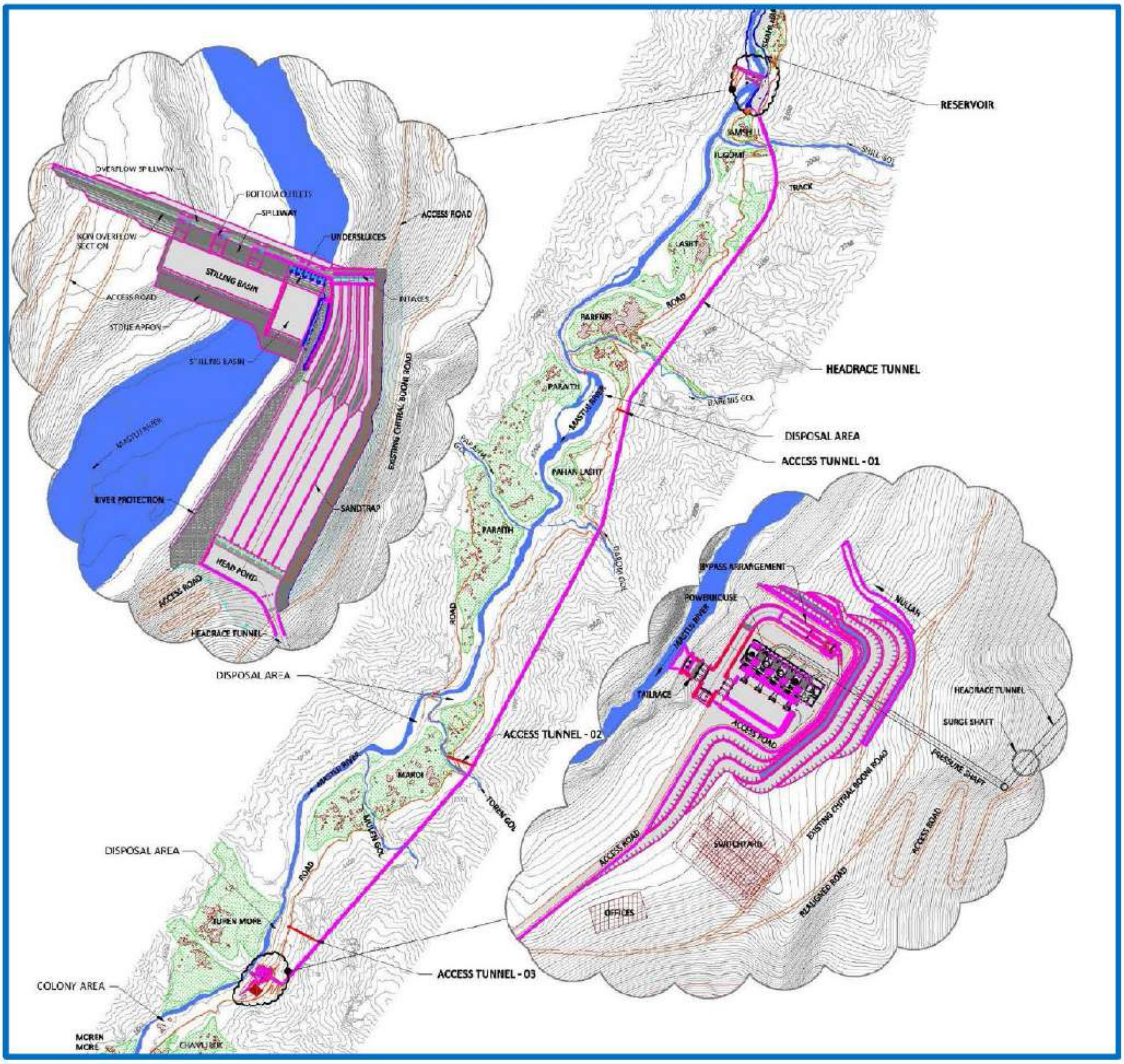
PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

ENERGY AND POWER DEPARTMENT, GOVERNMENT OF KHYBER PAKHTUNKHWA

FEASIBILITY STUDY OF JAMSHILL-TUREN MORE HYDROPOWER PROJECT



SECTION-1: FEASIBILITY STUDY REPORT

EXECUTIVE SUMMARY

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FEASIBILITY STUDY OF
JAMSHILL - TUREN MORE HYDROPOWER PROJECT (260 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 estimated to be 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 the rest of 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 Jamshill - Turen More Hydropower Project (260MW) 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 Drosh), 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 (Drosh, 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 as well as flood flows of various return periods for the project. Similarly, sediment measurement data (at Chitral town) have been used to estimate sediment load at the intake and subsequently design the sandtrap. The estimated long term flows at the dam site are as follows:

Estimated Flows at Dam Site

Month	10-Daily	Flow at Dam Site	Month	10-Daily	Flow at Dam Site
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
Apr	I	58	Oct	I	149
	II	68		II	121
	III	88		III	102

Month	10-Daily	Flow at Dam Site	Month	10-Daily	Flow at Dam Site
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

Similarly, on the basis of flood flow analysis, the recommended design flood for various return periods are given below:

Recommended Design Flood

Return Period	Adopted Design Flood (cumec)		
	Chitral town	Dam Site	Powerhouse
Year	**Cat. Area 11950**	**8770**	**9010**
2	1120	822	844
5	1336	981	1007
10	1497	1099	1129
25	1719	1262	1296
50	1898	1393	1431
100	2089	1533	1575
200	2292	1682	1728
1000	2830	2077	2134
10000	3782	2776	2852

Annual sediment load at the dam site has been estimated as 28.75 mst or 26.70 MCM from the Chitral River data at Chitral town. At 30 m dam height, available capacity of the reservoir is estimated to be 7.42 MCM or about one third of annual sediment yield. The estimated mean annual water yield at the dam site is 6,829 MCM which is about 920 times the capacity at 30 m high dam. Thus, the economic life of the reservoir without continuous sluicing may not be more than a year.

Simulation of dam break for various scenarios has been carried and the computed flood peak levels indicate that even in the case of worst scenario, the elevations of populated areas are higher than the flood wave levels. Thus, the establishment of the reservoir would not have serious impacts on the settlements. However, its impact on alluvial river banks cannot be ruled out.

3 GEOLOGICAL AND SEISMIC HAZAARD 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 areas 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 at about 80-150 km northwest of Chitral. Among the regional faults, Reshun fault is the nearest one from the project area and thus the layout has been selected such that this fault can be avoided. This is a North dipping major thrust fault, running approximately parallel to the MKT in center of Chitral District in NE / SW direction and marked by the occurrence of the Reshun formation in its foot wall.

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

As Jamshill - Turen More dam is categorized as Low Risk Dam, the recommended ground motion for Safety Evaluation Earthquake (SEE) is 0.33g corresponding to a return period of 1,000 years. The dam structure has been designed to maintain its integrity during shaking from such earthquake events. For other major structures, a Design Basis Earthquake (DBE) of 0.29g (475 years return period) has been adopted which is also consistent with the Building Code of Pakistan for the project area. PGA of

0.20g with a return period of 145 year has been adopted for Operation Basis Earthquake (OBE) for minor structures.

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 percent of this capacity. Thermal plants take up about 67 percent and nuclear 3 percent 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 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 are 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

Six weir sites and six powerhouse sites were identified / explored for the development of alternate schemes. The identified weir sites were Miragram, Booni, Koragh, Koragh I, Jamshill and Turen More while the powerhouse sites were Koragh, Zait, Paraith, Turen More, More Lasht and Kari. After identification of these sites, the next step was the selection of most suitable combination of weir, powerhouse and alignment of headrace tunnel. Selection criteria for most suitable combination was based on the relatively shorter length of tunnel with possibility of shorter adits, proximity to the existing road network, flow availability at weir site and geological conditions at the project structures.

Geology of the area between Miragram and Reshun is very complex due to presence of Reshun fault and Reshun Red Shale. Thus, any potential weir site upstream of Reshun Fault was discarded. From planning and design aspects, alternatives that were cost effective and technically sound with less environmental impacts were given priority.

On the basis of detailed evaluation using the above criteria, it was concluded that the Jamshill - More Lasht, Jamshill - Turen More, More Lasht - Kari and Turen More - Kari be considered for further studies. In these schemes, the complex geology of upper Chitral could be avoided. As a result of further refinement; a cascade, namely Jamshill – Turen More and Turen More – Kari has been selected for the feasibilities. The flows from Jamshill - Turen More powerhouse would be diverted to Turen More - Kari waterway. 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.

Various options for the weir axis for Jamshill - Turen More were considered. The weir axis at Jamshill was finalized on the basis of geology, location of the tunnel inlet portal and ease of flow diversion during construction. The tunnel alignment was finalized based on geology along the tunnel and location of adits. Length of the finalized tunnel alignment from Jamshill to Turen More is 13.5 km. Similarly, the powerhouse location was finalized considering location of surge shaft, pressure shaft, penstock alignment as well as the location for aqueduct across the river to convey the flows to the waterway for Turen More - Kari part of the cascade.

After evaluating various types of dams, a concrete gravity dam has been finalized based on cost and availability of construction materials. Similarly, a modified horseshoe shaped headrace tunnel has been finalized considering the required diameter and geological conditions along the tunnel and stress concentration in the excavated tunnel sections. Due to high overburden downstream of the surge shaft location, an underground vertical pressure shaft followed by a horizontal pressure tunnel has been adopted instead of penstock.

7 PROJECT OPTIMIZATION

Once the initial layout of the project is selected, the next step is to optimize the project parameters. The basic objective is to recommend the optimum installed capacity of the project corresponding to optimum dam height and dimensions of water conveyance system. Optimum parameters of a project are those envisaged to provide maximum economic benefits collectively.

For the project costs, combination of a number of approaches including composite schedule rates (CSR), market rate analysis, manufacturer's rates and standard curves for rates of electro-mechanical equipment have been considered. The under construction Golen Gol Project (106 MW) and Neelum Jhelum Project (970 MW) rates have also been considered. All of the rates considered in the optimization exercise as well as in the final cost estimates have been escalated to June 2014.

For the unit cost of energy, prevailing sale price of Peshawar Electric Supply Company (PESCO) at 15.10 Rs/kWh and 8.30 Rs/kWh for peak and off peak hours respectively have been considered. Exchange rate of 1.0 US dollar = 100 PKR has been adopted for costs of equipment and materials / consumables to be imported.

Design discharge ranges considered for the optimization study were 175 m^3/s, 205 m^3/s, 240 m^3/s, 265 m^3/s, 305 m^3/s, 365 m^3/s and 420 m^3/s corresponding to the 35%, 32.5%, 30%, 27.5%, 25%, 22.5% and 20% time of flow availability, respectively. The corresponding benefits and costs were estimated for all these discharges.

Reservoir depth has been varied from 10 m to 110 m above the river bed at 10 m intervals for the above mentioned discharges. Dam quantities have been calculated based on the initial design of dam for the 10 m dam height interval. Power and energy have been calculated for each interval to determine the benefits associated with the dam height and ultimately the gross head. During the environmental and geological assessment, it has been found that the high terraces of Barum village located on unstable slopes at right bank of the Mastuj River would restrict the water level in the reservoir at 1800 m asl which corresponds to a reservoir depth of 30 m at the dam axis. Moreover, a reservoir depth deeper than 40 m may inundate the Chitral - Booni road. Therefore, the depth of reservoir under normal flow has been compromised at the level of 1800 m asl irrespective of the optimisation result.

The tunnel diameter has been varied from 6 m to 14 m with an interval of 0.2m for the optimization analysis. Optimum diameters of the tunnel have been selected for all the discharges considered taking into account the head losses in tunnel and the costs involved. Corresponding changes in the benefits have been then evaluated for selection of optimum set of parameters. Due to geological constraints, maximum finished diameter in Chitral region had to be limited to 10 m. Thus, when the optimisation results suggest a diameter larger than 10 m, the diameter was either reduced to 10.0 m or twin tunnel option (of equivalent total diameter) was considered.

For the final capacity / discharge optimization, for the each discharge considered from 20% to 35% exceedance, cost benefit analyses have been undertaken. The tunnel diameter was individually optimised for each of the design discharge considered. The results of such analysis suggest that the design discharge to be 305 m^3/s and the tunnel diameter of 9.7 m (finished) to be optimum. From the optimization study, the following key parameters have been finalized.

Reservoir Water Depth	=	30 m at Dam Axis
Gross Head	=	117 m
Design Discharge	=	305 m^3/s
Tunnel Diameter	=	9.7 m Finished Modified Horseshoe
Installed capacity	=	260 MW
Annual Energy Estimate	=	1158.06 GWh

8 DESIGN OF CIVIL COMPONENTS

The proposed concrete gravity dam across the river near Jamshill village would retain the river flows to create a reservoir, about three and a half kilometers long with a maximum of 30 m water depth. The crest level of the dam overflow spillway has been set at 1800 m asl and that of the non-overflow section at 1805 m asl. The dam has been designed to safely route 1000 year flood through the undersluices, low level outlets and overflow spillway. The overflow spillway alone can route a 100 year flood.

The dam would also provide storage facility for hourly peaking operation (if required), especially during low flow season. To route the floods safely, overflow spillway of three bays (36.5 m long each) has been provided alongwith six low level outlets (6.0 m x 4.0 m) in the dam body. Alongwith flood routing, the low level outlets would also be used for flushing sediments deposited in the reservoir. Furthermore, five undersluices (5.0 m x 7.0 m each) have also been provided to prevent chocking of the intake area by sediment deposition.

For the diversion of flow from the reservoir for power generation, a gated intake with five gates (9.0 m x 7.5 m each) has been provided. The waterway alignment is along the left bank of the river in proximity of the main Chitral Booni road.

Each of the five intake gates has been connected to 153 m long connecting conduit (9.0 m x 7.5 m) separately which then convey the flows into the Sandtrap. The sandtrap has five chambers each 20 m wide and 215 m long. The sandtrap would retain sediments above 0.2 mm size and convey relatively clean water downstream to the system. The conveyance system comprises of a 13.5 km long modified horseshoe shaped headrace tunnel of 9.7 m diameter, surge shaft of 27.0 m diameter, pressure shaft of 8.50 m diameter, pressure tunnel of 8.50 m diameter, penstock of 8.50 m diameter and the tailrace alongwith a bypass arrangement. The headrace tunnel has been proposed to be fully concrete lined to convey the design discharge of 305 m^3/s with nominal head losses. Five types of tunnel support classes comprising combinations of rock bolts, shotcrete, concrete and steel ribs have been designed taking into account geology of the project site. The pressure shaft and pressure tunnel have been proposed to be steel lined.

A surface powerhouse has been proposed to accommodate four generating units of vertical Francis Turbines. The tailwater has been proposed to be diverted to the waterway of the downstream Turen More - Kari Hydropower Project. A bypass arrangement comprising two hollow jet valves alongwith a stilling basin has been proposed at the end of the penstock. In case of shut down of upstream Jamshill - Turen More Project, the flows may be diverted from the bypass arrangement to keep the downstream Turen More - Kari Project functional.

A conventional two stage cofferdam arrangement is proposed for construction works at the dam site. The river diversion arrangement has been designed to route the 25 years return period flood of 1262 m^3/s safely. During the first stage a channel would be excavated along the right bank of the river with cofferdams placed at the upstream and downstream of the channel to isolate the construction area. Then construction work of the intake, undersluices and part of the overflow spillway alongwith two sets of low level outlets would be commenced.

In second stage, the diversion channel would be plugged at the upstream and downstream ends and a continuous coffer dam would be constructed connecting the plugged ends of the channel. The middle length of this coffer dam has been planned to be tied into the newly constructed spillway at the right of the first set of low level outlets. Then the flows can be routed through the undersluices while the last set of low level outlets and the non-overflow section of the dam at the right bank would be completed.

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. Earth pressures due to seismic actions have been calculated taking into account active earth pressure or earth pressure at rest, as applicable.

Calculations of forces under various load conditions have been carried out using three dimensional analysis software SAP2000, which is based on finite element method of structural analysis. Boundary spring elements have been adopted for modeling subsoil supporting the structures.

Structurally, the dam has been designed to be safe against sliding, overturning, uplift and bearing pressure when the reservoir is full in combination with an earthquake forces of 0.33 g. For design of other major structures 0.29g has been adopted as recommended by the Building Code of Pakistan (SP 2007).

10 HYDROMECHANICAL 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 300 RPM and the rated power at the turbine shaft would be 66.5 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 design head would be 147 m which includes transient pressure. The approximate diameter of the valve has been proposed to be 4.0 m.

An overhead travelling crane has been provided in the powerhouse for installation and dismantling of the electro-mechanical equipment. The capacity of the crane has been sized tentatively at 70 ton, which is 20% higher than the maximum weight of the single heaviest component of the electromechanical equipment.

Other required major hydro-mechanical equipment provided in the powerhouse are:

- Unit Cooling Water System
- Heating, Ventilation and Air Conditioning (HVAC) System
- Firefighting system

Adequate space has been provided for office and control room building while the staff colony has been proposed close to the powerhouse.

11 ELECTROMECHANICAL COMPONENTS OF THE PROJECT AND TRANSMISSION LINE

Four 65 MW, vertical shaft, 0.85 power factor, 50 Hz, 11 kV, silent pole synchronous generators alongwith necessary auxiliary equipment complete with control, monitoring, switchgear / protection systems have been provided to produce 260 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 30/40 MVA have been proposed.

The 220 kV high voltage switchgears 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 powerhouse station services, outdoor switchyard, housing colony and dam area. This transformer would be in addition to the backup supply to the powerhouse 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 and dam site.

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 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, 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 ongoing projects be designed to accommodate the power likely to be generated from the upstream projects and then to dispatch the cumulative power to the subsequent downstream project.

As per the direction of PEDO, in Jamshill Turen More Project, a high voltage 220 KV outdoor Switchyard and outgoing double circuit transmission have been designed. Therefore, the transmission line of the Jamshill - Turen More Project has been proposed to be linked with the upstream hydropower plants and to the downstream Turen More -

Kari power plant using “Loop In and Loop Out” arrangement proposed at the switchyard of Jamshill - Turen More Project.

12 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

The preparation of Environmental and Social Impact Assessment (ESIA) report of JTHPP is part of the feasibility study. ESIA report is based on 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 was 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 were conducted in these villages. Focused Group Discussions (FGDs) and individual interviews were also 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 was 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, from dam to colony site, people use spring (local name Gol) water for agriculture, drinking and other domestic activities. Furthermore, no water requirements from the river were discussed by the community during scoping sessions and FGDs; the same was reaffirmed during transect walks along the river and from direct interactions of the field staff with the local community. However, from ecological perspective, 2.5 m^3/s of water would be ensured in the Mastuj River to keep the natural environment of the area intact.

The construction of JTHPP would affect the land based resources of the area. A total of about 1843 kanals land have been estimated to be consumed on permanent basis by the Project. This includes 271 kanals of agricultural land, about 14 kanals residential land, 126 kanals waste land and 1432 kanals of barren land. This translates to 14.74% agriculture, 0.75% residential, 6.83% waste, and 77.68% communal land that would be permanently occupied by the project. Out of this total barren land about 135 kanals identified at colony site is disputed land between the villagers of Mori Bala and sons of Abdul Manan of Istan Gol. Furthermore, 8 houses with 59 persons in Shahchar and Biyani villages would be displaced by the project activities.

During the execution of the project, huge quantity of muck would be produced at different locations. Spoil areas have been identified at dam, access tunnels and powerhouse sites for the disposal of such muck materials. After serving the purpose, about 181 kanals of the spoil area at dam and access tunnels sites would be reclaimed for agriculture activities. A detailed program has been formulated for the rehabilitation of such areas in order to make them more functional and agriculturally productive.

Pre-construction monitoring of air, water and noise has been carried out at dam, 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 is 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.678.01 million.

In light of the international laws dealing with environmental and social impact assessments, it can safely be concluded that JTHPP (260 MW) is one of the environment friendly projects which would play an important role in overcoming the prevailing energy crises and in boosting the 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

Heavy construction machinery is normally 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 and arrangements.

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 slopes. 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, Lowari 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 Lowari 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 along the route between Dargai and Chitral is likely to create inconvenience to the commercial activities in the vicinity of the road and therefore, should be given due consideration in planning.

The bridges and culverts on the road between Dargai and Chitral are designed for loading capacity of 70 tonnes with axle load of 11.3 tonnes. Due Consideration shall be given to the axle load limits in customization of the trailer. Similarly, there is a short tunnel with clearance height 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 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 problematic; however clearances 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 and taxes, interest during construction, environmental and social cost and 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 the complexity of 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 the 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	1,036,718,547	660,000	1,102,718,547	11,027,185
B	Civil Works	37,151,947,836	26,011,485	39,753,096,319	397,530,963
C	Electro-Mechanical Works	1,717,254,769	127,169,595	14,434,214,297	144,342,143
	PROJECT CONSTRUCTION COST	**39,905,921,152**	**153,841,080**	**55,290,029,164**	**552,900,292**
D	Design Review, Preparation of Contract Documents and Assistance in Tendering @ 1.5% of Construction Cost	829,350,437	-	829,350,437	8,293,504
E	Contract Management, Quality Control and Construction Supervision @ 3% of Construction Cost	1,658,700,875	-	1,658,700,875	16,587,009
F	Client Expenses, Administration and Legal Costs @ 1.5%	829,350,437	-	829,350,437	8,293,504
G	PEDO Head Office Charges @ 1 % of Construction Cost	552,900,292	-	552,900,292	5,529,003
	PROJECT BASE COST	**43,776,223,194**	**153,841,080**	**59,160,331,205**	**591,603,312**
H	Duties and Taxes	769,205,401	-	769,205,401	7,692,054
I	Escalation and Price Adjustment	8,764,779,240	12,701,972	10,034,976,398	100,349,764
J	Interest During Construction (IDC)	7,840,068,749	23,960,672	10,236,135,961	102,361,360
K	Unforeseen @ 0.5%	218,881,116	769,205	295,801,656	2,958,017
	TOTAL PROJECT COST	**61,369,157,699**	**191,272,929**	**80,496,450,621**	**804,964,506**

Note: 1 USD = 100 Rs.

15 FINANCIAL AND ECONOMIC ANALYSIS

Evaluation of any large infrastructure project are 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 economic 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 the 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			Without Transmission Line		
	Local Cost	Foreign Cost	Total	Local Cost	Foreign Cost	Total
1	1,827.3	45.8	1,873.1	1,813.0	45.7	1,858.7
2	5,226.4	301.7	5,528.2	5,217.9	301.6	5,519.5
3	9,919.8	553.6	10,473.5	9,911.3	553.5	10,464.8
4	11,796.0	5,733.5	17,529.5	11,602.7	5,687.6	17,290.3
5	11,380.6	6,586.4	17,967.0	11,073.5	6,512.1	17,585.7
6	3,825.6	2,240.0	6,065.6	3,695.2	2,209.5	5,904.8
Custom Duty	773.1	-	773.1	765.5	-	765.5
Escalation and Price Adjustment	8,800.2	1,274.6	10,074.7	8,622.0	1,261.2	9,883.2
Interest During Construction	7,872.7	2,407.5	10,280.3	7,757.5	2,384.9	10,142.4
Financial Cost	61,421.7	19,143.1	80,564.8	60,458.7	18,956.2	79,414.8

Economic and financial analysis 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

Economic Parameter	With Transmission Line		Without Transmission Line	
	With CDM	Without CDM	With CDM	Without CDM
COMPARISON WITH EQUIVALENT THERMAL FURNACE OIL PLANT				
PW of Benefits@12% (Million Rs.)	101,129.9	96,548.2	101,129.9	96,548.2
PW of Costs @12% (Million Rs.)	36,472.9	36,472.9	36,019.1	36,019.1
Net Present Worth (Million Rs.)	64,657.1	60,075.3	65,110.9	60,529.1
Benefit Cost Ratio	2.8	2.6	2.8	2.7
EIRR	42.96%	41.66%	43.47%	42.17%
COMPARISON WITH EQUIVALENT THERMAL COMBINED CYCLE GAS TURBINE				
PW of Benefits @12% (Million Rs.)	84,547.5	81,658.7	84,547.5	81,658.7
PW of Costs @12% (Million Rs.)	36,472.9	36,472.9	36,019.1	36,019.1
Net Present Worth; (Million Rs.)	48,074.6	45,185.9	48,528.4	45,639.7
Benefit Cost Ratio	2.3	2.2	2.3	2.3
EIRR	29.99%	29.13%	30.34%	29.47%

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 this 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 powerhouse to the downstream project's (Turen More - Kari) switchyard. 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	13.89	14.05
10% less benefits	12.66	12.81
20% cost over-run	11.82	11.96
Combined impact	10.71	10.85

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 design complexity of the project. Significant concrete works would be required for the construction of Main Dam and Sandtrap which cannot be started during the winter months, especially at night when the ambient temperature reaches sub-zero levels. Similarly, the coffer dams have to be constructed in low flow season. 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), work force required, construction camps and facilities need to be arranged before starting the construction work.

After completion of the detailed design, tendering process and award of the Contract, the Contractor submits a performance guarantee to execute the construction work as a normal practice for infrastructure projects in the country. Once the Client issues “letter to proceed”, the Contractor will mobilize his team, equipment and construction materials at site. Contractor mobilization is scheduled within one month of the contract signing date. If EPC contract is opted for, generally after detailed feasibility study, the tender drawings and tender documents will be prepared for the process of tendering and awarding the contract. After awarding the contract the contractor will be responsible for the detailed design. Planning presented in this section is based on the EPC Contract mode as per normal practice in PEDO.

The schedule of completion for the major works of temporary camps, access road, water supply, electricity and sanitation system have been estimated separately in the construction schedule. Similarly, the construction of permanent housing and other necessary infrastructure would be continued as required and planned in construction schedule.

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. Similarly, the schedule and plan would be prepared and implemented accordingly for the required construction materials, human resources, equipment and also monitor regularly for the adequate human resources and construction materials' stock at site for completion of the project within the stipulated schedule.

The essential aspect in the project construction is efficient and smart project management at site with regular meetings, coordination and monitoring of the schedules with proper interface coordination among different contractors and suppliers. Interface coordination planning is worked out in this study and addressed in planning and construction schedule preparation. However such interface coordination should be readjusted and monitored closely during the construction of the project as well.

The main civil construction work would be started by the Contractor after planning and proper setting of all the required facilities as described above. Construction of the project should start at several locations simultaneously. The work on Dam, Inlet portal, Access Tunnel 1, Access Tunnel 2, Access Tunnel 3, Surge Shaft, Pressure Tunnel and Powerhouse area may be carried out concurrently. The tunnel, dam and powerhouse have been considered the major construction works and any of these components may be in the critical path during construction. Electro-mechanical equipment also needs to be manufactured and supplied on time to avoid delays. Total project construction duration has been estimated to be 5 years with additional six months in case of EPC Contract to provide cushion to the contractor for detailed design activities.

17 CONCLUSIONS

The feasibility study has clearly demonstrates that Jamshill - Turen More Hydropower Project (260 MW) is technically feasible, financially viable and environmentally acceptable. Furthermore, the project would have significant economic impact in the country as it would replace high cost thermal plants and to some extent curb the load shedding situation, the country 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 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 49 km North East of Chitral Town on the 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	**HYDROLOGY**	
	Catchment Area at Dam Site	8770 km^2
	Catchment Area at Powerhouse Site	9011km^2
	Mean Monthly Discharge	215 m^3/sec
	Design Flood ($Q_{1,000}$)	2077 m^3/sec
	Maximum Flood ($Q_{10,000}$)	2776 m^3/sec
4	**RESERVOIR**	
	Normal Conservation Level	1800.00 m asl
	Flood Surcharge Level	1803.56 m asl
	Minimum Operating Level	1797.00 m asl
	Depth of Reservoir at Dam Site	30.00 m
	Length of Reservoir	4.50 km
	Reservoir Capacity at NCL	7.41 MCM
	Live Capacity at NCL	1.56 MCM
5	**DAM**	
	Dam Type	Concrete Gravity
	Crest Elevation	1805.00 m asl
	Freeboard	5.00 m

Sr. No.	DESCRIPTION	VALUE
	Slope: Upstream Face	0.2H : 1V
	Slope: Downstream Face	0.75H : 1V
	Height of Dam above River Bed	35.00 m
	Maximum Height above Foundation	45.00 m
	Crest Length	394.00 m
	Crest width	6.00 m
6	**OVERFLOW SPILLWAY**	
	Type	Un-gated Ogee Crest
	Crest Level	1800.00 m asl
	Length of Crest	109.50 m
	No. of Bays	3 Nos.
	Design Flood (Q_{100})	1533 m^3/sec
	Stilling Basin	Type I, USBR
	Size of Stilling Basin	166 m X 45 m
	Stilling Basin Level	1764.00 m asl
7	**UNDERSLUICES**	
	Type	Orifice Shaped with Breast Walls
	Crest level of Undersluices	1772.00 m asl
	Head on Crest at NCL	28.00 m
	No. and Type of Gates	5 Nos. Radial Gates
	Gate Size	7 m x 5 m each
	Total Length of Undersluices Section	49.00 m
	Flood During Construction (Q_{25})	1262.00 m^3/sec
	Maximum Capacity at NCL	$Q_{1,000}$
	Undersluices Crest Height above River Bed	2.00 m
	Stilling Basin Type	Type I, USBR
	Size of Stilling Basin	47 m x 70 m each
	Stilling Basin Level	1762.00 m asl
8	**LOW LEVEL OUTLETS**	
	Type	Orifice Shaped
	Crest Level	1775.00 m asl
	Head on Crest at NCL	25.00 m
	No. and Type of Gates	6 Nos. Slide Gates
	Gate Size	6 m x 4 m each

Sr. No.	DESCRIPTION	VALUE
	Total Length of Waterway	36 m
	Maximum Capacity at NCL	$Q_{1,000}$
	Crest Height above Foundation Level	16 m
	Stilling Basin Type	Type I, USBR
	Size of Stilling Basin	166 m X 45m
9	**POWER INTAKE**	
	Type	Horizontal
	Invert Level of Power Intake	1784.00 m asl
	Working Head on Intake Crest	16.00 m
	Submergence Provided	7.00 m at NCL
	No. and Type of Gates	5 Nos. Fixed Wheel Slide Gates
	Size of Gates	7.5 m x 9.0 m each
	Total Width of Intake Structure	63.50 m
	Width of Waterway	37.50 m
	Design Discharge	305.00 m^3/sec
	Discharge Capacity (Including Sediment Flushing Requirements)	350.80 m^3/sec
	Intake Crest Height above River Bed Level	14.00 m
10	**FISH LADDER**	
	Type	Vertical Slot Type
	Design Discharge	0.35 m^3/sec
	Step Pools	134 Nos.
	Size of Pool	1.85 m x 2.85m
	Opening of Slot	0.17 m
	Height of Cross Walls	0.80 m
	Total Length of Fish Ladder	270 m
	Start Invert Level	1797.00 m asl
	End Invert Level	1770.00 m asl
11	**RIVER DIVERSION DURING CONSTRUCTION**	
	Coffer Dam	
	Type	Earthfill Embankment Type
	Crest Elevation of Coffer Dams	1785.00 m asl
	Diversion Flood (Q_{25})	1262.00 m^3/sec
	Freeboard (Above maximum Water Level)	6.2 Ms
	Embankments Upstream Slope	1.5H : 1V

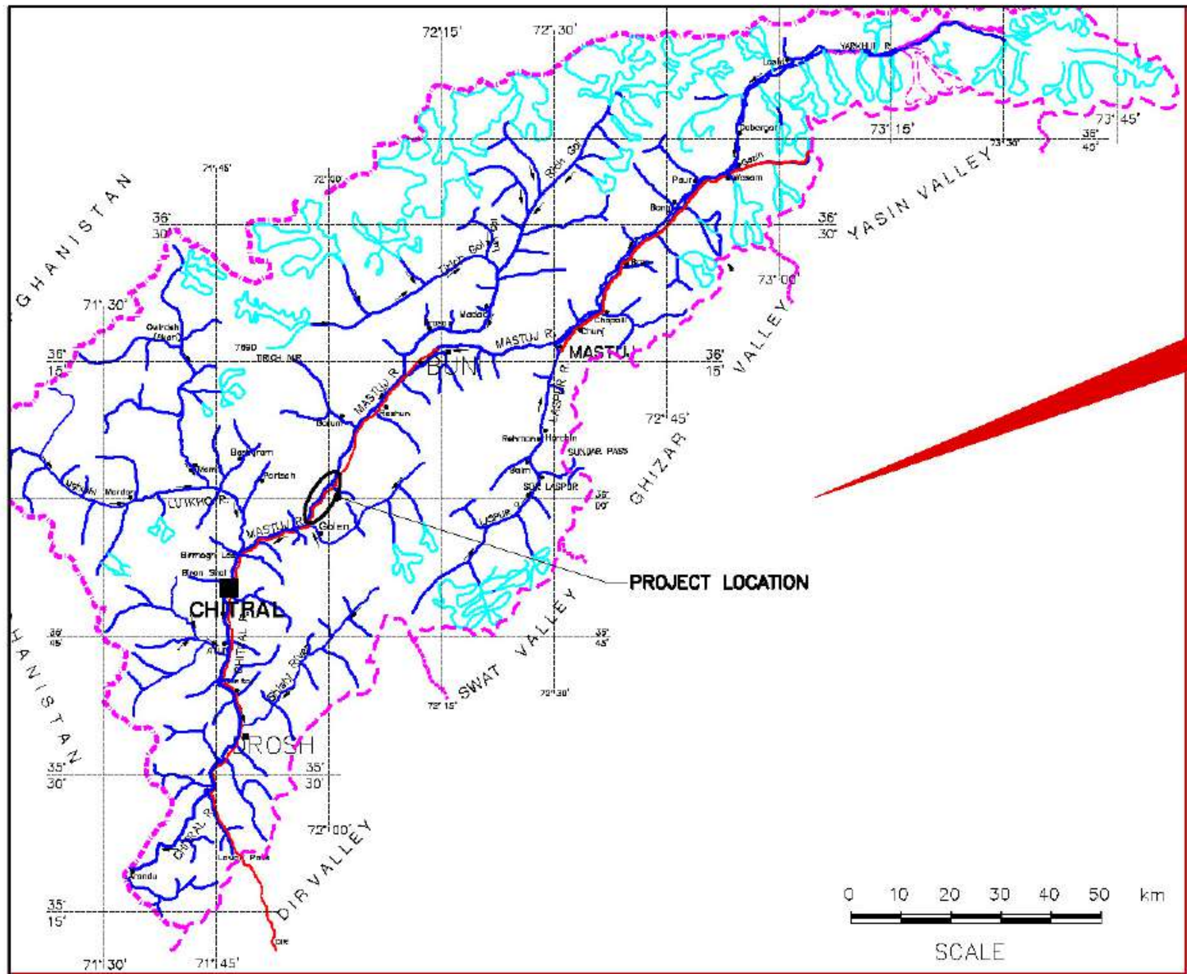
Sr. No.	DESCRIPTION	VALUE
	Embankments Downstream Slope	1H : 1V
	Length of Upstream Coffer Dam	171 m
	Length of Downstream Coffer Dam	108 m
	Diversion Channel	
	Type	Trapezoidal Concrete Lined
	Lining Thickness	75+75 mm
	Size of Diversion Channel (WxD)	25 m x 11m
	Length of Diversion Channel	750 m
	Depth of Flow in Diversion Channel	8.60 m
	Freeboard	2.40 m
	Flow velocity	3.90 m/sec
12	**CONNECTING CONDUIT**	
	Type	Low Pressure Rectangular Section
	Number of Conduits	5 Nos.
	Design Discharge	305.00 m^3/sec
	Size	7.50 m x 9.00m
	Average Length of Conduit	153.00 m
	Average Flow Velocity	1.12 m/sec
	Bed Level at Start	1784.00 m asl
	Bed Level at End	1783.80 m asl
	Losses in Connecting Conduit	0.26 m
13	**SANDTRAP**	
	Type	Low Pressure, Hoper Shaped
	Particle Size to be Removed	0.2 mm
	Average Velocity in Chambers	0.18 m/sec
	Length of Chamber	215 m
	Length of Upstream Transition	16 m
	Size of Sandtrap Chamber	19 m X 20 m each
	Invert Level of Sandtrap at Start	1783.80 m asl
	Roof Top Level of Sandtrap	1795.75 m asl
	Outflow Crest Elevation from Sandtrap	1792.30 m asl
	Nos. and Type of Outflow Control Gates	10 Nos. Fixed Wheel Slide Gates
	Outflow Control Gates Size	7.5 m x 4.5m
	Flushing Arrangement per Chamber	3 Units in Series with 2 Gates each
	Flushing Discharge	45.75 m^3/sec

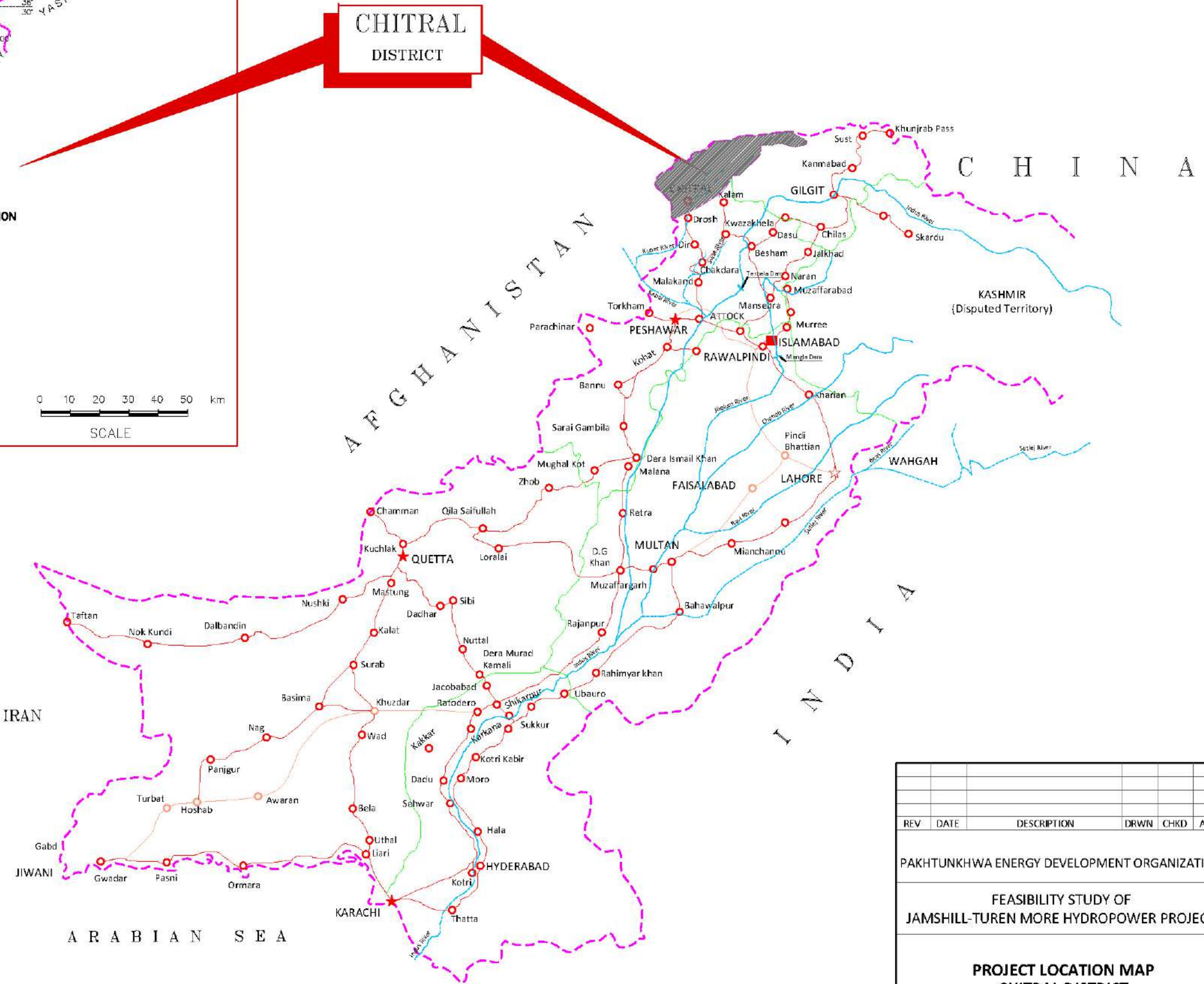
Sr. No.	DESCRIPTION	VALUE
	Total head losses in the sandtrap	0.34 m
	Trap Efficiency	77%
14	**INLET POND**	
	Type	Low Pressure Pond
	Invert Elevation at Start	1780.25 m asl
	Invert Elevation at Tunnel Inlet	1780.00 m asl
	Size of Inlet Pond	106 m x 30m
	Depth of Flow	16.75 m
	Submergence to Headrace Tunnel	7.15 m
	Elevation of Inlet Pond Top	1797.75 m asl
	Transition between inlet pond and Headrace	Smooth Curved
	Velocity at Design Discharge	0.61m/sec
15	**HEADRCE TUNNEL**	
	Type	Concrete Lined Pressure Tunnel
	Shape	Modified Horseshoe
	Invert Elevation of Tunnel	1780.00 m asl
	Flow Area	76.53 m^2
	Average Flow Velocity	3.99 m/sec
	Diameter of Tunnel	9.70 m
	Length of Tunnel upto Surge Shaft	13.50 km
	Invert Level of Tunnel at Surge Shaft	1749.30 m asl
	Head Loss in Tunnel	14.84 m
16	**ACCESS TUNNELS**	
	No. of Access Tunnels	3 Nos. (A1, A2 & A3)
	Shape	Inverted U Shaped (A1, A2) Modified Horseshoe (A3)
	Diameter / Height of Tunnels	6.00 m (A1, A2) 9.70 m (A3)
	Length of Tunnels	250 m (A1) 370 m (A2) 550 m (A3)
17	**SURGE SHAFT**	
	Type	Restricted Orifice Concrete Lined
	Geometry	Circular
	Maximum Surge Level	1826.42 m asl
	Minimum Surge Level	1765.04 m asl
	Diameter of Surge Shaft	27.00 m

Sr. No.	DESCRIPTION	VALUE
	Diameter of the Throat	4.20 m
	Full Operational Water Level	1786.34 m asl
	Top Level of Surge Shaft	1831.50 m asl
	Height of Surge Shaft	70.00 m
18	**PRESSURE SHAFT / TUNNEL**	
	Type	Pressurized Steel Lined Section
	Geometry	Circular
	Top Elevation of Pressure Shaft	1749.30 m asl
	Diameter of Pressure Shaft and Tunnel	8.50 m
	Flow Area	56.75 m^2
	Length of Pressure Shaft	75.25 m
	Length of Pressure Tunnel	296.00 m
	Average Flow Velocity	5.37 m/sec
	Steel Lining thickness	24-32 mm
	Invert Level of Pressure Tunnel End	1674.75 m asl
	Head Losses in Pressure Shaft / Tunnel	0.93 m
19	**PENSTOCK**	
	Invert Level of Penstock	1674.75 m asl
	Length of Penstock	66.00 m
	Diameter of Penstock	8 .50 m
	Thickness of Steel Lining	44.00 mm
	Velocity in Penstock at Design Discharge	5.37 m/sec
	Net Head at Penstock	95.00 m
	Head Losses in Penstock	1.59 m
	Invert Level of Penstock at Powerhouse	1675.75 m asl
20	**MANIFOLD**	
	Type	Straight Symmetrical Wye
	Number of Branches	4 Nos.
	Diameter of each Branch Pipe	4.25 m
	Velocity in Manifold at Design Discharge	5.37 m/sec
	Thickness of Steel lining	44 mm
21	**POWERHOUSE AND ACCESSORIES**	
	Type	Surface Powerhouse
	Size of Powerhouse	25 m X 111m
	Turbine	Vertical Francis

Sr. No.	DESCRIPTION	VALUE
	Generation Units	4 X 65 MW
	Unit Discharge	76.25 m^3/sec
	Generator Type	Synchronous Vertical, 11 kV, 50Hz
	Power Transformers	12+1 Nos. Single Phase, 30/40 MVA, 11/220 KV
22	TAILRACE POND / CHANNEL	
	Type	Rectangular Concrete Section
	Size	84 m x 31m
	Elevation of Tailrace Pond	1675.00 m asl
	Average Velocity	0.28 m/sec
	Depth of Tailrace Pond	15.00 m
	Freeboard	2.00 m
	Flow Depth	13.00 m
	Submergence for Draft Tube	7.80 m
	Tailrace Channel Size	16 m x 6m
	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	1683.00 m asl
23	SWITCHYARD	
	Size of switchyard area	135 m X 112.2m
	Switchgear	220 KV, SF 6, Circuit Breaker
24	TRANSMISSION LINE	
	Transmission line Length	23 km
	Type	220 KV, Double Circuit with Twin Bundle Rail Conductors
25	HEAD AND DISCHARGE	
	Gross Head	117.00 m
	Rated Net Head	94.68 m
	Head Loss at Design Discharge	17.32 m
	Design Discharge of Plant	305.00 m^3/s
26	CAPACITY AND OUTPUT	
	Plant Capacity	260.00 MW
	Capacity per Unit	65.00 MW
	Plant Factor	50.80%
	Average Annual Energy	1158.06 GWh

Sr. No.	DESCRIPTION	VALUE
27	**PROJECT COST**	
	Project Construction Cost	55,290 Million Pak Rs.
	Project Base Cost	59,437 Million Pak Rs.
	Project Total Cost	80,565 Million Pak Rs.
28	**ECONOMIC AND FINANCIAL INDICATORS**	
	Economic Parameters (With Transmission Line) – CCGT	
	Net Present Value (NPV)	45,185.87 Million Pak Rs.
	B/C Ratio	2.24
	EIRR	29.13 %
	Economic Parameters (Without Transmission Line) – CCGT	
	Net Present Value (NPV)	45,639.67 Million Pak Rs.
	B/C Ratio	2.27
	EIRR	29.47 %
	Financial Parameters (With Transmission Line)	
	Net Present Value (NPV)	72,473.79 Million Pak Rs.
	B/C Ratio	2.33
	FIRR	13.89 %
	Financial Parameters (Without Transmission Line)	
	Net Present Value (NPV)	73,191.01 Million Pak Rs.
	B/C Ratio	2.36
	FIRR	14.05 %
29	**IMPLEMENTATION**	
	Pre-construction	12 Months
	Construction Period	60 Months
	Total Implementation Time	72 Months





REV	DATE	DESCRIPTION	DRWN	CHKD	APPR

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

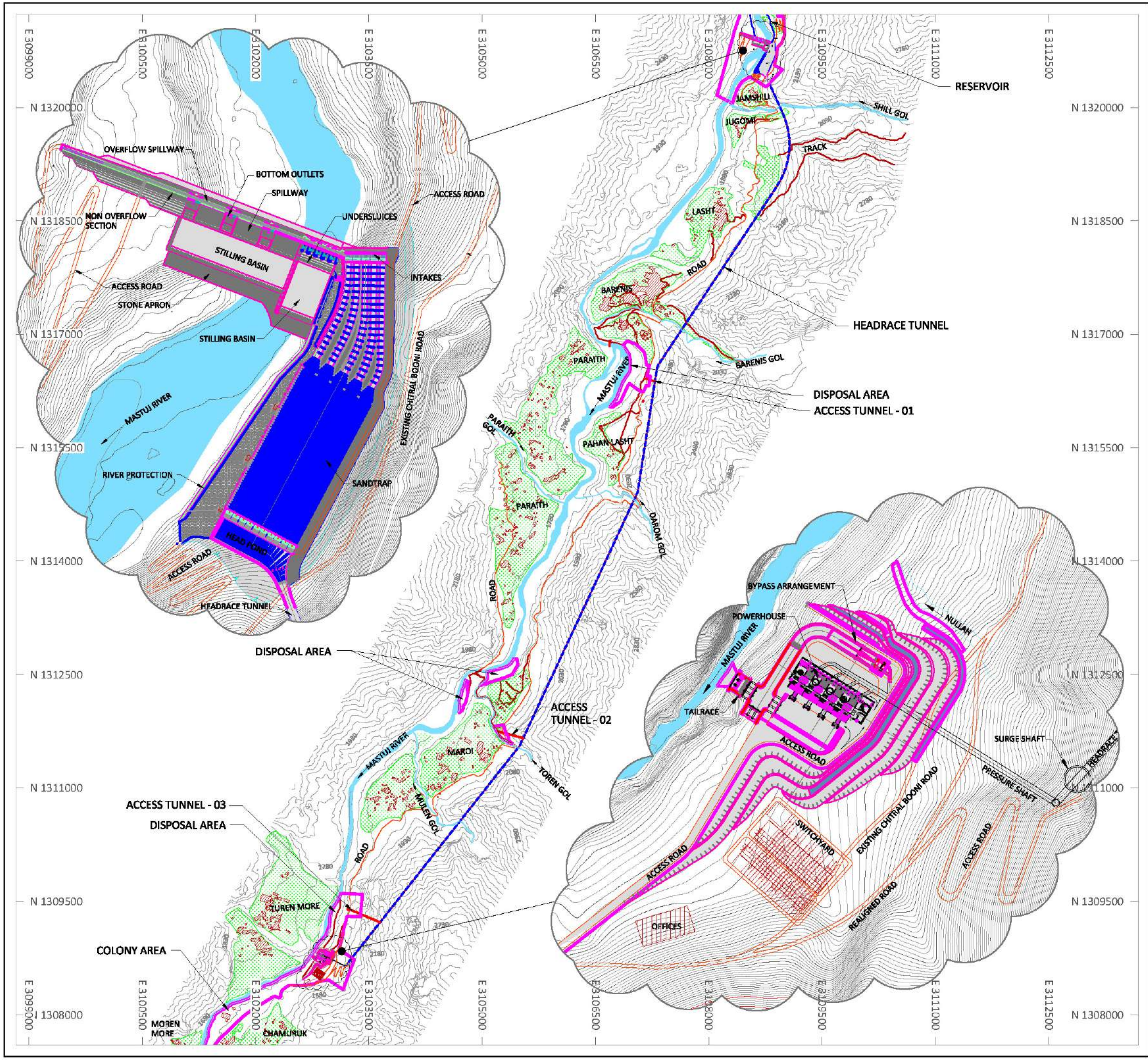
FEASIBILITY STUDY OF
JAMSHILL-TUREN MORE HYDROPOWER PROJECT

PROJECT LOCATION MAP
CHITRAL DISTRICT

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

Consultants AGES, SHELADIA ASSOCIATES INC., Hydro Consult, IDC

SCALE: N.T.S | FIGURE - 1.1 | DATE: NOV, 2014



NOTES:

1. ALL DIMENSIONS AND LEVELS ARE IN METERS UNLESS NOTED OTHERWISE.
2. CONTOUR INTERVAL IS 10M
3. CONNECTING CHANNEL & SANDTRAP TOP FILLING IS NOT SHOWN.

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
JAMSHILL-TUREN MORE HYDROPOWER PROJECT

PROJECT LAYOUT PLAN
JAMSHILL-TUREN MORE

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

Consultants AGES — Hydro Consult — SHELADIA — IDC

SCALE: 1:50,000 | FIGURE 1.2 | DATE: NOV, 2014

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. CONTOUR INTERVAL IS 2M.
3. CONNECTING CHANNEL & SANDTRAP TOP FILLING IS NOT SHOWN.

LEGEND:-

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

SCALE: 0 25 50 75 100 125m

REV	DATE	DESCRIPTION	DRWN	CHKD	APPR

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

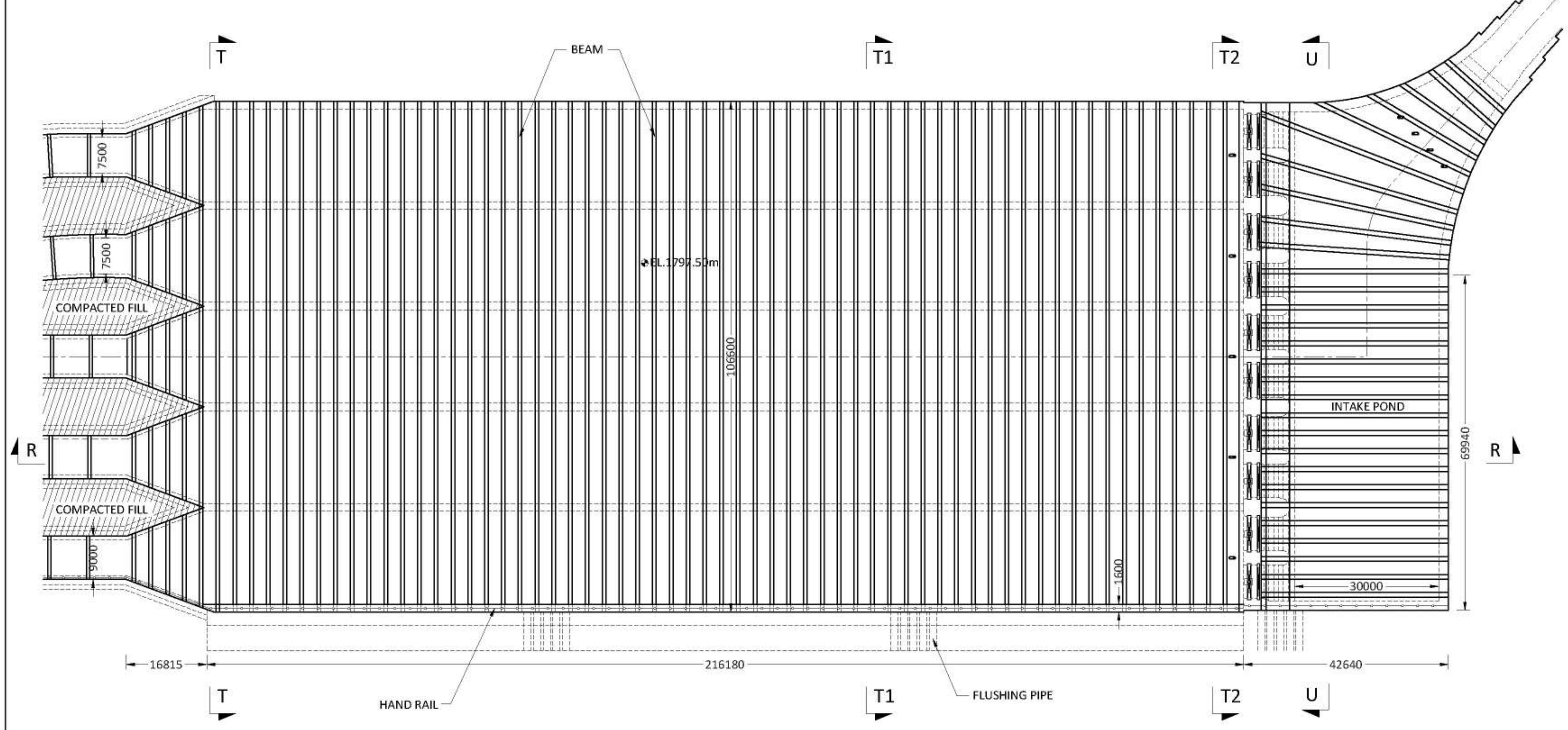
FEASIBILITY STUDY OF
JAMSHILL-TUREN MORE HYDROPOWER PROJECT

GENERAL LAYOUT PLAN OF DAM AREA

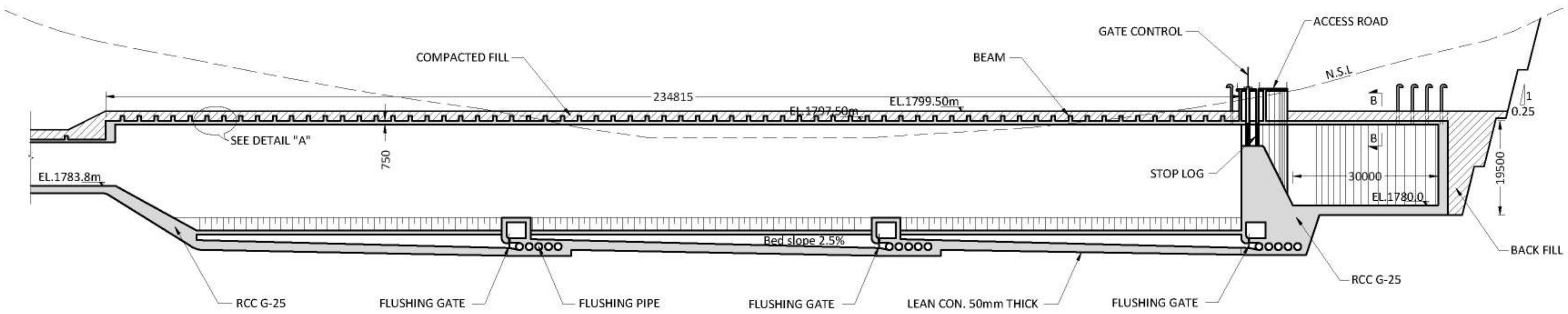
		NAME
DRAWN		ABBAS ALI
PREPARED		ARSHAD IQBAL
CHECKED		SIBTUL HASSAN
APPROVED	CD	ZAHOOR AHMAD
	PM	TARIQ KHURSHID

JV. CONSULTANTS: Consultants AGES, SHELADIA, Hydro Consult, IDC

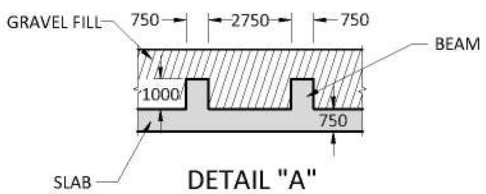
SCALE: 1:2500 | DWG. NO. FIGURE -1.3 | DATE: NOV, 2014



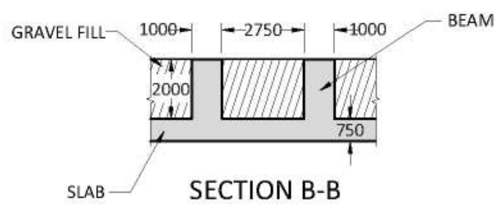
SANDTRAP PLAN



SECTION R-R



DETAIL "A"
SCALE 1:250



SECTION B-B
SCALE 1:250

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE.
2. TOP FILL IS NOT SHOWN.

SCALE: 0 11 22 33 44 55 m

REV	DATE	DESCRIPTION	DRWN	CHKD	APPR

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

FEASIBILITY STUDY OF
JAMSHILL-TUREN MORE HYDROPOWER PROJECT

SANDTRAP PLAN & L-SECTION

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

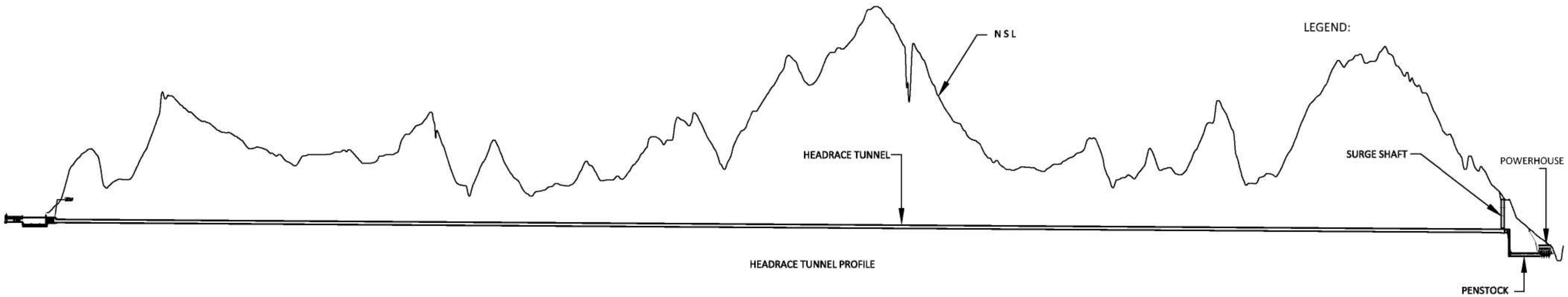
JV. CONSULTANTS: Consultants AGES, SHELADIA, Hydro Consult, IDC

SCALE: 1:1100 | DWG. NO. FIGURE -1.4 | DATE: NOV, 2014

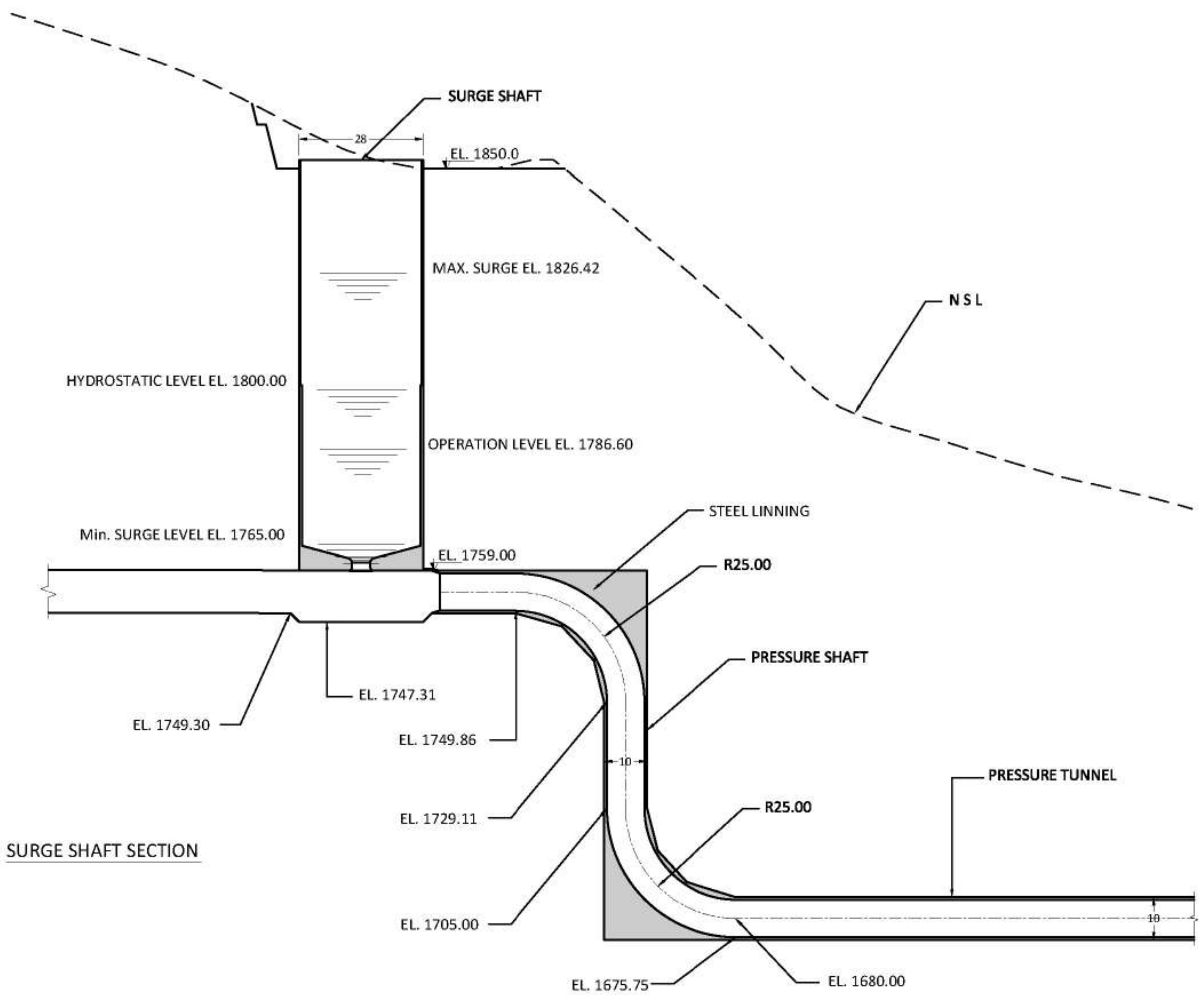
NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

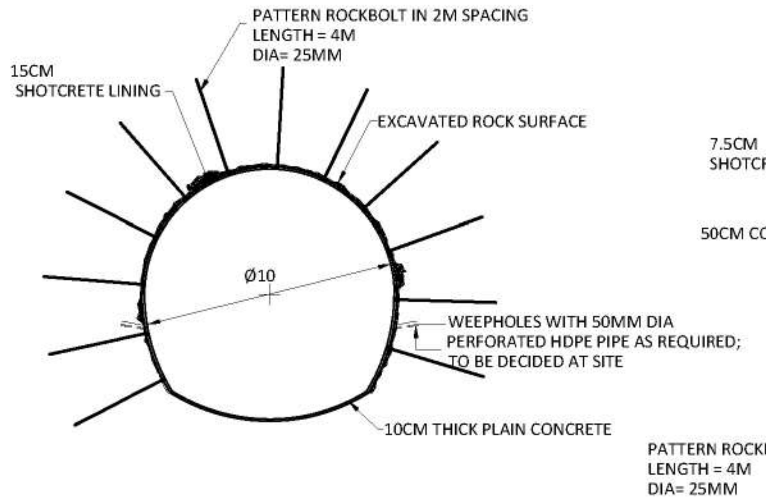
LEGEND:



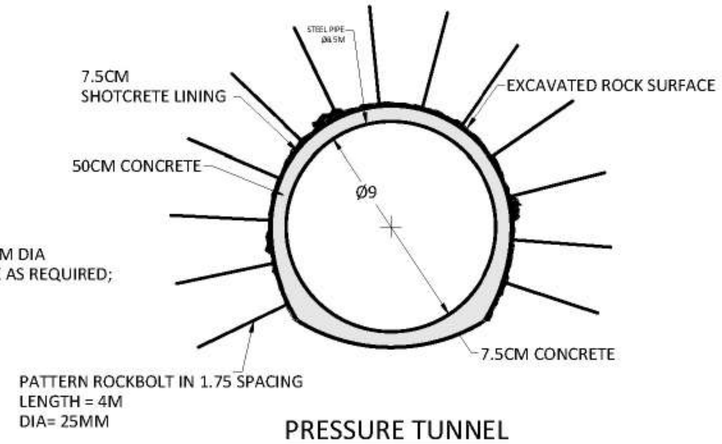
HEADRACE TUNNEL PROFILE



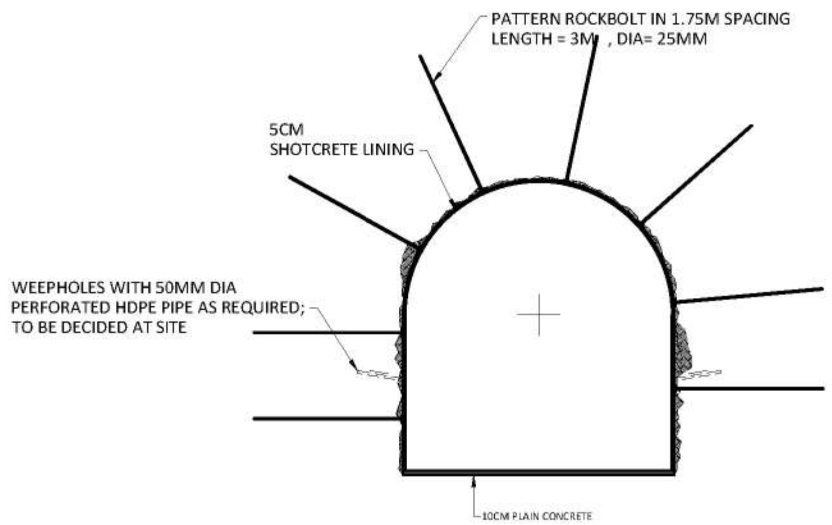
SURGE SHAFT SECTION



SUPPORT CLASS II



PRESSURE TUNNEL



SUPPORT CLASS II

REV	DATE	DESCRIPTION	DRWN	CHKD	APPR

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

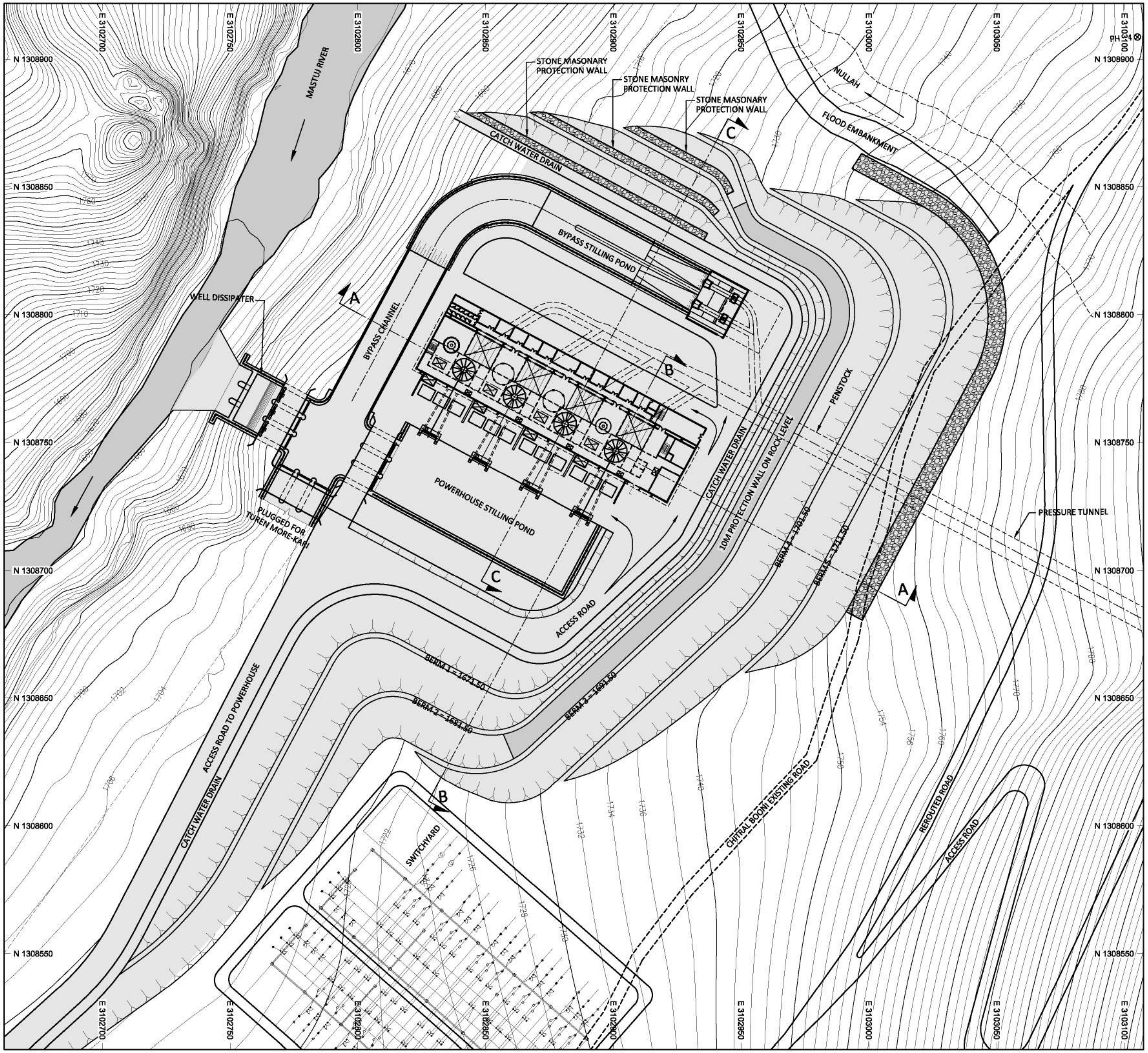
FEASIBILITY STUDY OF
JAMSHILL-TUREN MORE HYDROPOWER PROJECT

HEADRACE TUNNEL SURGE SHAFT & PRESSURE TUNNEL SECTIONS

		NAME
DRAWN		ABBAS ALI
PREPARED		UMAR AZEEM
CHECKED		SIBTUL HASSAN
APPROVED	CD	ZAHOOR AHMAD
APPROVED	PM	TARIQ KHURSHID

JV. CONSULTANTS: Consultants AGES, SHELADIA, Hydro Consult, IDC

SCALE: ---- | DWG. NO. FIGURE - 1.5 | DATE: NOV, 2014



NOTES:

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

LEGEND:

- RIVER
- TRACK
- EXISTING ROAD
- NEW ROAD
- CONTOURS

SCALE: 0 15 30 45 60 75m

REV	DATE	DESCRIPTION	DRWN	CHKD	APPR

PAKHTUNKHWA ENERGY DEVELOPMENT ORGANIZATION

FEASIBILITY STUDY OF
JAMSHILL-TUREN MORE HYDROPOWER PROJECT

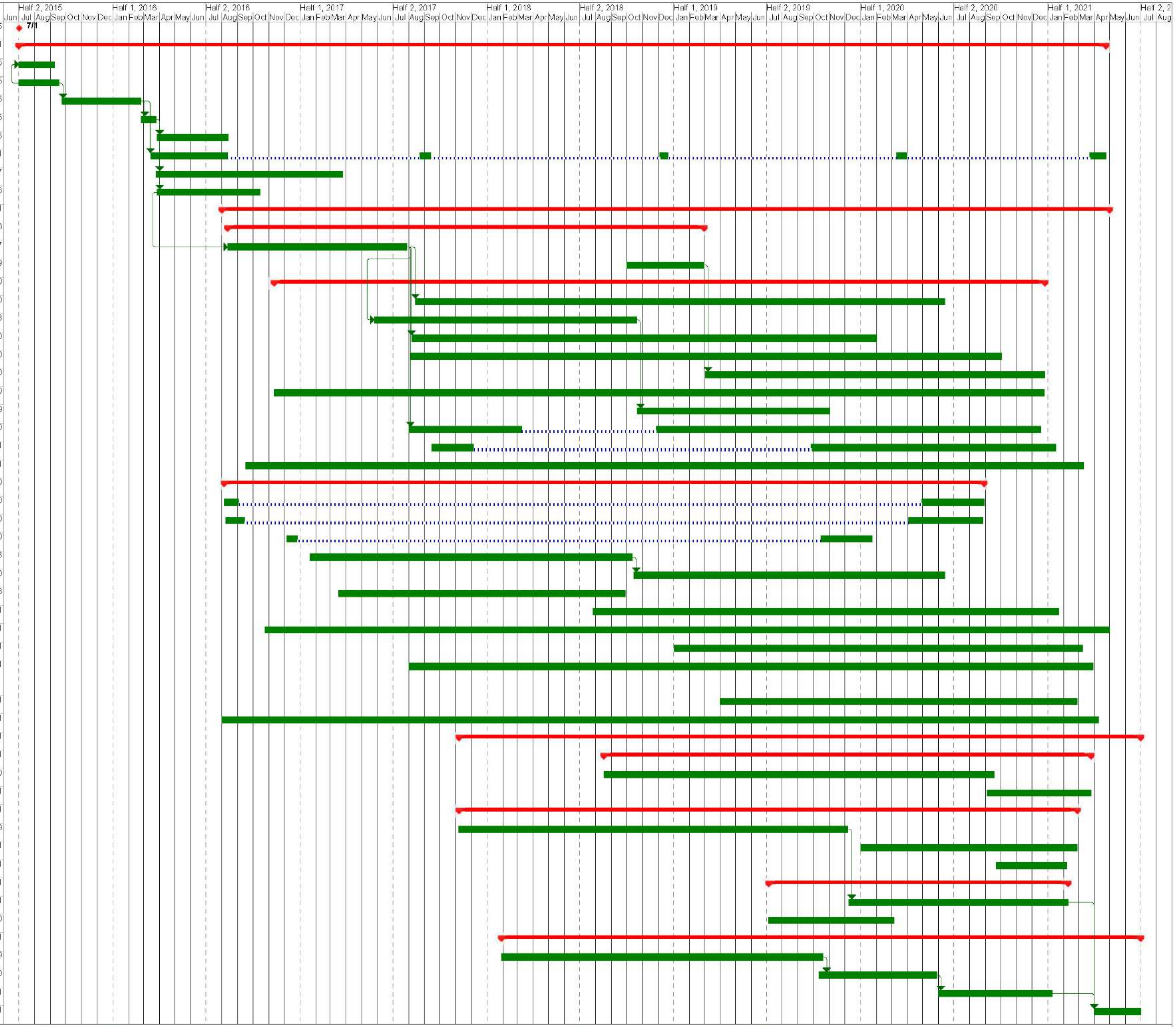
POWERHOUSE
LAYOUT PLAN

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

JV. CONSULTANTS: Consultants AGES, SHELADIA ASSOCIATES, INC., Hydro Consult, IDC

SCALE: 1:1500 | DWG. NO. FIGURE -1.6 | DATE: NOV,2014

ID	Task Name	Start	Finish
1	**ACTIVITIES**	Wed 7/1/15	Wed 7/1/15
2	**A. PRELIMINARY AND GENERAL WORKS**	**Wed 7/1/15**	Fri 4/23/21
3	Review and Update of The Report	Wed 7/1/15	Tue 9/8/15
4	Preparation of Tender Documents	Wed 7/1/15	Thu 9/17/15
5	Tendering and Award of Contract	Thu 9/24/15	Wed 2/24/16
6	Mobilization of Contractor	Thu 2/25/16	Thu 3/24/16
7	Site Investigations	Sun 3/27/16	Fri 8/12/16
8	Design, Drawings and Report	Mon 3/14/16	Fri 4/23/21
9	Construction/ Hiring of Site Facilities	Fri 3/25/16	Fri 3/24/17
10	Construction of Access Roads	Sun 3/27/16	Fri 10/14/16
11	**B. CIVIL WORKS**	**Mon 8/1/16**	Fri 4/30/21
12	**River Diversion**	**Fri 8/12/16**	Thu 2/28/19
13	First Stage Diversion	Fri 8/12/16	Thu 7/27/17
14	Second Stage Diversion	Mon 10/1/18	Thu 2/28/19
15	**Dam and Appurtance Structures**	**Fri 11/11/16**	Fri 12/25/20
16	Foundation Treatment	Mon 8/14/17	Fri 6/12/20
17	Intake Structure	Fri 5/26/17	Fri 10/19/18
18	Undersluices Sections	Mon 8/7/17	Fri 1/31/20
19	Spillway and Low Level Outlets	Fri 8/4/17	Thu 10/1/20
20	Non Overflow Section	Mon 3/4/19	Fri 12/25/20
21	Protection Works	Fri 11/11/16	Thu 12/24/20
22	Connecting Conduit	Mon 10/22/18	Fri 11/1/19
23	Sandtrap	Tue 8/1/17	Thu 12/17/20
24	Inlet Pond	Fri 9/15/17	Fri 1/15/21
25	Headrace Tunnel	Fri 9/16/16	Thu 3/11/21
26	**Access tunnles**	**Fri 8/5/16**	Fri 8/28/20
27	Access Tunnel 1	Fri 8/5/16	Fri 8/28/20
28	Access Tunnel 2	Tue 8/9/16	Wed 8/26/20
29	Access Tunnel 3	Tue 12/6/16	Wed 1/22/20
30	Surge Tank	Fri 1/20/17	Thu 10/11/18
31	Pessure Shaft	Mon 10/15/18	Fri 6/12/20
32	Pressure Tunnel	Fri 3/17/17	Thu 9/27/18
33	Penstcok and Manifold	Fri 7/27/18	Thu 1/21/21
34	Powerhouse	Mon 10/24/16	Fri 4/30/21
35	Tailrace	Tue 1/1/19	Mon 3/8/21
36	Bypass arrangement (Included in 2nd Stage Cascade Project in Turen More Kari HPP)	Tue 8/1/17	Mon 3/29/21
37	Switchyard	Mon 4/1/19	Fri 2/26/21
38	Road and infrastructure Facilities	Mon 8/1/16	Fri 4/9/21
39	**C. ELECTRO MECHANICAL WORKS**	**Tue 11/7/17**	Wed 6/30/21
40	**Hydro-mechanical Equipments**	**Fri 8/17/18**	Thu 3/25/21
41	Installtion of Main Components in Powerhouse	Fri 8/17/18	Wed 9/16/20
42	Interconnection and Minor Works	Fri 9/4/20	Thu 3/25/21
43	**Hydraulic steel structures**	**Tue 11/7/17**	Fri 2/26/21
44	Powerhouse Equipments	Tue 11/7/17	Fri 12/6/19
45	Intake, Undersluices, and Low Level Outlet Gates	Wed 1/1/20	Fri 2/26/21
46	Sandtrap Gates	Mon 9/21/20	Fri 2/5/21
47	**Electrical equipments**	**Fri 7/5/19**	Mon 2/8/21
48	Electrical Equipments in Powerhouse	Mon 12/9/19	Mon 2/8/21
49	Electrical Installations in Switchayard	Fri 7/5/19	Thu 3/5/20
50	**Transmission line and interconnections**	**Mon 1/29/18**	Wed 6/30/21
51	Main Transmission Lines	Mon 1/29/18	Fri 10/18/19
52	Auxialliary Transmision Lines	Fri 10/11/19	Thu 5/28/20
53	Interconnections to Main Grid	Mon 6/1/20	Fri 1/8/21
54	Testing and Commissioning	Thu 4/1/21	Wed 6/30/21



FEASIBILITY STUDY OF JAMSHILL - TUREN MORE HYDROPOWER PROJECT (260 MW)

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