Background

Phukot Karnali Hydro Electric Project (PKHEP) is located in Kalikot district, Karnali Province of Nepal. The project will use the flow from the Karnali River for power generation, and the generated power will be fed into integrated power system of Nepal at the nearest grid substation proposed at Regil.

According to the Desk Study Report, the capacity of the project was estimated to be 426 MW with a total energy of 2510.02 GWh. The available gross head was 180 m and the average design discharge was 278 m3/s. After the feasibility study, the capacity has been revised to 480 MW with average annual generation of about 2,443 GWh. The corresponding gross head is 168.3 m at design discharge of 348 m3/s.

At present the capacity of the project is estimated to be around 480 MW which is capable of producing a total average annual energy of 2455.19 GWh including 6 MW generation from the plant at toe of dam from the environmental release. The main scheme has a gross head of 168.62 m and a design discharge of 348 m3/s.

Accessibility

The project area is accessible throughout the year via road as it lies in the close vicinity to the Humla - Karnali Highway. The project site can be reached from Kathmandu by road by following route:

• Kathmandu to Mugling via the Prithvi Highway: 110.6 km, paved road

• Muglin to Narayangadh via the Narayanghat-Mugling Highway: 35.7 km, paved road,

• Narayangadh to Kohalpur via the East West Highway: 353.4 km, paved road

• Kohalpur to Jitegada via the Ratna Rajmarg and Karnali Highway: 249 km, paved road

• Jitegada to the Project Site via the Karnali Highway: 16 km, all weather road

The total distance between the Kathmandu and the project site is about 780 km.

Alternatively, it is also possible to fly to Nepalgunj from Kathmandu (about 55 mins) and travel via road to the project site via Nepalgunj-Kohalpur-Jitegada- Project Site (about 260 km).

Details

Topographic Survey

The detailed topographical mapping of headworks site, construction adit and powerhouse site are completed. Mapping covered a total area of 120.2 ha. The Karnali Highway near the dam location has to be realigned due to impoundment. The 20 km realigned section of the road Sanigad and Ghurbagar has also been surveyed in a scale of 1:1,000 covering 15m Right of Way.

Hydrology

The headwater of the PKHEP catchment originates from the High Mountain of Tibetan Plateau and then drains through Western Nepal into the Ganges river system in India. The catchment area of PKHEP is 16,902 km^2. The semi distributed hydrological model has been used in order to understand the response of the catchment area between the two gauging stations at Lalighat and Asaraghat located near to the PKHEP headworks. The parameters of the model were calibrated to fit the observed discharge at Asaraghat station. For the purpose of daily flow estimation Hydrologic Modelling System (HEC-HMS) developed by U.S. Army Corps of Engineers for precipitation-runoff simulation has been used. The long term mean monthly flows in the project has been estimated to have an average discharge of 328 m^3/s, maximum discharge of 881.50 m^3/s and minimum discharge of 77.00 m^3/s. These data have been used for the calculation of power and energy of the selected dam options.

The Probable Maximum Floods (PMF) from both hydro-meteorological and statistical approaches has been performed using the corresponding Probable Maximum Precipitation (PMP). The resultant superimposed flood hydrographs at headworks site based on PMPs of 13 sub-basins has a peak value of 15,882 m^3/s. As the catchment area of Headworks (16,901.8 km^2) and Powerhouse (16,967.7km^2) are almost the same, PMF at Powerhouse site was estimated using the catchment area ratio (CAR). The PMF at the Powerhouse was estimated as 15,944 m^3/sec. The flood of various return period has been estimated to be 3,648 m^3/s, 4,813 m^3/s and 5,956 m^3/s. for 100 years, 1000 years and 10,000 years respectively.

Geology

The main rock types in the project area are banded gneiss, calcareous gneiss and augen gneiss. The head works area and upper part of head race tunnel passes through augen gneiss, the middle part of the head race tunnel lies in banded gneiss and surge tunnel and powerhouse/ tailrace tunnel areas are situated in calcareous gneiss formations.

These are mainly thickly to very thickly foliated rocks with occasional thinly foliated layers and the rocks are strong. Attitude of the foliation ranges from 095˚/24˚ to 054˚/24˚ (dip direction/ dip amount) in the project area. Two set plus random and three set of joints are observed in the project area. As per Q-system, the rock mass quality in the project area is ranging from poor to good, mainly falls in good and fair quality. The underground powerhouse and transformer caverns are proposed in the calcareous gneiss which is fair to poor in the rock mass class.

In the headworks site, bedrock is estimated at the maximum depth of around 50 m from riverbed. Riverbed deposit is partially compacted. Right bank slope is dip slope, relatively gentle and left bank slope is anti-dip slope, relatively steep. At powerhouse area, the Karnali River valley is V-shaped with steep to very steep slope on both banks and some overhanging cliff to the right bank slope, dissected with several gullies.

Project Components

As mentioned earlier, PKHEP utilizes water from Karnali River to generate 480 MW of electricity in total including 6 MW generation from the plant at toe of dam from the environmental release. The proposed headworks of the Project is about 1.5 km downstream from the confluence of Karnali and Sanigad Rivers. The PKHEP reservoir will stretch 11 km along the river from the dam to the Lapha Bagar. The drop-in riverbed elevation on this stretch will be about 104 m varying from 910 masl to 806 masl. The main civil structures of the project consist of two diversion tunnels, one Sediment bypass tunnel, roller compacted concrete (RCC) dam, intake, upstream (U/S) and downstream (D/S) coffer dams, two headrace tunnels, two surge tunnels, two pressure shafts / tunnels, underground powerhouse cavern, underground transformer cavern, two tailrace tunnels and so on.

Diversions structures includes the upstream and downstream coffer dams, inlet and outlet portals with diversion tunnels, bypass tunnel, and inlet for bypass tunnel arrangement requirements Two diversion tunnels of finished diameter 11 m on the right bank of the Karnali River have been proposed. The inlet of the diversion tunnels are about 1100 m downstream from the confluence of the Karnali and Sanigad River. The diversion tunnel 1 has a length of about 1145m and the diversion tunnel 2 has a length of about 945 m. A sediment bypass tunnel with its inlet about 280 m upstream of the diversion inlets has also been proposed. The sediment by-pass arrangement is designed to divert sediment laden water and help increase the trapping efficiency of the head pond during operation of the power plant. The sediment Bypass inlet consists of four set of gates and stoplogs of size 9.5 m X 8 m (B X H) followed by a weir with a labyrinth spillways whose crest is designed at 904 masl after which there is a vertical

drop shaft leading to a tunnel that is connected with the diversion tunnel 1. 36m high upstream cofferdam and 10m high downstream coffer dams have been proposed about 235 m upstream and 375 m downstream from dam axis, respectively. An RCC dam with a height of 109.0 m high (from riverbed) has been proposed. It is designed with three gated overflow spillways of size 13.5 m X 19 m (B X H) and three gated breast wall spillways of size 7 m X 13 m (B X H) designed to safely spill the design flood and the PMF ,an auxillary spillway of size 4 m X 3 M (B X H) to pass the floating debris and a bottom outlet of size 3 m X 3 m (B X H) which is 3 m above the original river level at the dam axis the purpose of which is to control water evacuation from reservoir during initial reservoir filling phases . Two power intakes have been planned and designed to handle the flow for the power generation The power intake is situated on the right bank of the Karnali River and consists of eight openings of width 4.8 m each. Two numbers of vertical gates of size 8.4 m X 8.4 m are proposed at the end of Intake structure.

From the power Intake, there are circular twin headrace tunnels of approx. length 6,044 m and 5,878 m with finished diameter of 8.4 m up to the surge tunnels. The headrace tunnels are designed completely on the right bank of the Karnali River. Two surge tunnels, each having length of about 862 m and 848 m and finished diameter of 6.5 m, have been proposed at the end of headrace tunnels. After the surge tunnels, the water is conveyed through steel lined pressure shaft which is divided into three portions i.e upper horizontal portion, vertical shaft and lower horizontal portion. The pressure shaft consists of two horizontal 6.5 m steel lined horizontal pressure tunnels followed by two vertical pressure shafts of finished diameter 6.5 m leading to the lower horizontal portion of two 6.5 m steel lined penstock. Each lower horizontal pressure shaft is then branched into 3 penstock branches with the help of two manifolds of varying sizes. The water is then conveyed to the turbines through six steel lined penstock branches of different sizes.

An underground power station of dimension 156.0 m X 20.0 m X 44.6 m (LX B X H) has been proposed. The powerhouse is designed for the generation of 474 MW The main power house of PKHEP is equipped with six (6) number of Francis turbines – generator – transformer sets each with generating capacity of 79 MW and auxiliary and ancillary facilities for control and protection. From the draft tube at powerhouse cavern, the water is conveyed to two downstream surge chambers of size 71 m X 10 m X 30 m (L X B X H) through six tailrace tunnels of varying cross sections. Finally, two tailrace tunnels with finished diameter of 9.5 m conveys the water from downstream surge chamber back to the Karnali River.

A 2.3 km long transmission line with a transmission voltage of 400 kV with double circuit twin Moose configuration is planned to evacuate the power to the nearest grid hub substation at Regil.

Additionally, to maximize the financial benefits of the project, the water from the environment release is proposed to be used to generate 6 MW additional RoR energy. The discharge is passed through an intake at the dam to penstock and then to power plant downstream of dam and plunge pool. The powerhouse is located about 420m downstream of the dam axis. Two Francis turbine each capable of generating 3 MW has been proposed at the Powerhouse.

Construction Planning and statement

The project area lies on the Karnali Highway. Hence, separate access road is not necessary to reach the project site. The transportation of construction materials is proposed via trucks through Karnali Highway. The materials which are not available in Nepal shall be imported from India or other country via. Kolkata Port. Plenty of local construction materials are available near the project area, the other construction materials like cement, fly ash, reinforcement bars, steel etc. is expected to be purchased from the nearest Indian border. The construction works are divided into two packages. The infrastructure development activities which can be carried out by local contractors like access road development, camp facilities construction and construction power are grouped as package 1. The second package (package 2) consist of Civil, Hydromechanical works Electro -Mechanical work, Transmission Line and Sub-station work. Total construction power required is estimated to be around 6,300 kW. All the underground excavation is expected to be carried out by drilling and blasting procedure. The total duration for the construction of the project is estimated to be about 5 years. In this project, the activities like, Construction of Diversion Tunnel, U/S Coffer dam and Headwork Dam Spillway lies in the critical path of the project. Therefore, it is important to complete the critical activities on time for the timely completion of the entire project.

Salient Features of the Project

SALIENT FEATURES

S. No	Parameters	Details
1	General	
	Project Name	Phukot Karnali Hydro Electric Project
	Location	Karnali Province, Kalikot District
	Co-ordinates of the Project Area	29°19’03” N to 29°09’32” N latitude,

		81°45'00" E to 81°35'28" E longitude
	Nearest Highway	Karnali Highway
	Nearest All Weather Airport	Surkhet Airport- 160 km from project site
	Alternative All WeatherAirport	Nepalgunj Airport – 260 km from project site
	River	Karnali
	Climate	Moderate
2	Organization	
	Developer	Vidhyut Utpadan Company Ltd.
	Consultant	NEA Engineering Company Ltd.
3.	Hydrology	
	Catchment Area	16,902 km^2
	Mean Annual flow	328 m^3/s
	Maximum Monthly Discharge	881.50 m^3/s
	Minimum Monthly Discharge	77 m^3/s
	Design Discharge	348 m^3/s
	Maximum Discharge	361 m^3/s
	1 in 100 years flood (Q_{100})	3,648 m^3/s
	1 in 1000 years flood (Q_{1000})	4,813 m^3/s
	1 in 10,000 years flood ($Q_{10,000}$)	5,956 m^3/s
	Probable Maximum Flood (Q_{PMF})	15,882 m^3/s
4.	Reservoir	
	Gross storage volume	79.78 Mm^3
	Live storage volume upto 904 masl	14.29 Mm^3
	Surface area at FSL	2.51 km^2
	Storage required for 6 hours peaking	7.52 Mm^3
	Length of Reservoir at FSL	11 km
	Dry Season Full Supply Level	910 masl
	Minimum Draw Down level	904 masl
5.	River Diversion Works	
	Diversion Discharge	2,777 m^3/s (1 in 20 years flood)
	Number of Tunnels	2 Nos.
	Size and Shape	11 m diameter circular shaped
	Lining	Concrete Lining
	U/S Coffer Dam	
	Location	235 m u/s from Dam Axis
	Height	36 m
	Top Length	145 m

	D/S Coffer Dam	
	Location	375 m d/s from Dam Axis
	Height	10 m
	Top Length	100 m
6.	Sediment By-Pass Tunnel	
	Location	775 m U/S from Dam axis
	Number of tunnel	1 No.
	Size and Shape	8 m diameter Cirular
	Length	660 m
9.	Dam	
	Type of Dam	Roller Compacted Concrete (RCC)
	Location of Dam	Approx. 1.5 km D/S from Sanigad Confluence
	Dam length at top	313 m
	Dam Height	109 m from River Bed 160 m from Foundation Bed
	Top Width	10.0
	Dam Top elevation	915.00 masl
10.	Spillway	
	Overflow Spillway	
	Type	Ogee and gated
	Crest elevation	891 masl
	Number and Size of gates	3 Nos., 13.5 m x 19 m (B X H)
	Energy Dissipation	Flip Bucket
	Sluice Spillway	
	Type	Ogee
	Crest elevation	860 masl
	Number and Size	3 Nos. , 7 m x 13 m(B X H)
	Energy Dissipation	Flip Bucket
	Trash Overflow Spillway	
	Type	Ogee
	Crest elevation	902.5 masl
	Number and Size	1 No. , 4m X 3 m
	Energy Dissipation	Flip Bucket
11.	Power Intake	
A	**Main Power Intake**	
	Type of Intake	Side intake
	Number and Size of Trashrack openings	8 Nos., 4.8 m x 28 m (BXH)

	Number and Size of Intake Gate	2 Nos., 8.4 m x 8.4 m (BXH) vertical lift gate
	Dry Season Design Discharge	348 m^3/s
	Wet Season Design Discharge	361 m^3/s
	Environmental Riparian Release	7.7 m^3/s
	Invert Level	883 masl
	Deck Level	915 masl
	Trash rack	Inclined at 80^o with horizontal
B	**For Environment Release PH**	
	Type of Intake	Embedded in dam
	Number and Size of Trashrack opening	1 No., 3.8 m x 3.1 m (BxH)
	Number and size of Intake Gates	1 No., 2.1 m x 2.1 m
	Invert Level	883 masl
	Design Discharge	7.7 m^3/s
	Trash Rack	Vertical
12.	Headrace Tunnel	
	Number	2 Nos.
	Size and Shape	8.4 m Diameter Circular shape
	Length	6,043.9 m and 5,878.5 m
	Lining	300 mm thick Reinforced Concrete Circular Lining
	Maximum velocity	3.3 m/s
13.	Surge Tunnel	
	Type	Surge Tunnel (Slope: 1V:10H)
	Number	2 Nos.
	Length	848 m and 863 m
	Diameter	6.5 m circular
	Upsurge level	935.43 masl
	Downsurge level	871.15 masl
14.	Pressure Shaft and Tunnel	
	Number	2 Nos.
	Orientation	Vertical and horizontal
	Diameter	6.5 m diameter circular (main), 5.3 m diameter circular and 3.75 m diameter circular (after bifurcation)
	Total Length	366 m & 447.8 m
	Lining	Steel Lining (25 mm to 40 mm) for both
15.	Powerhouse	
	Main Powerhouse	

	Type	Underground
	Installed Capacity	474 + 6 = 480 MW
	Cavern Size	156 m X 20 m X 44.6 m (L X B X H)
	Number and capacity of units	6 Nos. x 79 MW
	Type of Turbine	Francis, Vertical Axis
	Normal Tail water level	741.38 masl
	Gross Head	168.62 m
	Rated Net Head	159.6 m
	Machine Floor Level	742.54 masl
	Generator Floor Level	737.94 masl
	Turbine Floor Level	733.64 masl
	Turbine Center Line Level	734.70 masl
	Powerhouse for Environmental Release	
	Type	Surface
	Installed Capacity	6 MW
	PH Size	37.15 m X 10.5 m X 15.75 m (L X B X H)
	Number and capacity of units	2 Nos. x 3 MW
	Type of Turbine	Francis, Horizontal Axis
	Normal Tail water level	815 masl
	Gross Head	95 m
	Rated Net Head	88.88 m
	Machine Floor Level	813.70 masl
	Generator Floor Level	813.70 masl
	Turbine Floor Level	813.7 masl
	Turbine Center Line Level	815.60 masl
16.	Tailrace Tunnel	
	Number	2 Nos.
	Size and Shape	9.5 m Diameter Circular shape (Finished)
	Lining	500 mm thick Concrete Circular Lining
17.	Energy	
	Wet Season Energy	1704.63 GWh/yr (1679.52+25.11)
	Dry Season Peak Energy	481.05 GWh/yr (474.61+6.44)
	Dry Season Off Peak Energy	269.50 GWh/yr (250.18+19.32)
	Dry Season Total Energy	750.55 GWh/yr
	Total annual energy	2455.19 GWh(2404.31+50.87)
18.	Transmission line	
	Connection Length	2.3 km appox
	Voltage	400 kV
19.	Construction period	5 years

Project's Progress Status

Detailed Feasibility Study & EIA Study

Contract Signed with Consultant for Detailed Feasibility Study	10 October, 2017
Updated Feasibility Study Report Received	November 2020
Detailed Feasibility Study Report Received	November 2020
Final Tender Document Received	November 2020
Contract Signed with Consultant for EIA Study	November, 2017
Scoping and TOR Document Received	15 July, 2020
Final EIA Report Submission *(Expected Date)*	July 2021

Test Adit Tunnel

General	
Client	Vidhyut Utpadan Company Limited
Contractor	M/S Waiba Infratech Pvt. Ltd.
Contract Title	Construction of Test Adit/Tunnels
Contract Date	29 November, 2019
Contract Completion Date	20 May, 2021
Test Adit Length at Powerhouse	519 m
Test Adit Length at Headworks	70 m on both banks
Shape of Test Adit	Inverted D-Shape
Diameter of Test Adit	3 m

Lining	Unlined
Physical Progress in Test Tunnel	
Test Adit Length constructed till now at Powerhouse	80 m
Test Adit Length constructed till now at Headworks	11 m on right bank

	
Face mark for first blast at Test Adit Tunnel (Powerhouse)	Test Adit Tunnel at Powerhouse after blasting

	
Mucking at Test Adit Tunnel (Powerhouse)	Drilling at Test Adit Tunnel (Powerhouse)

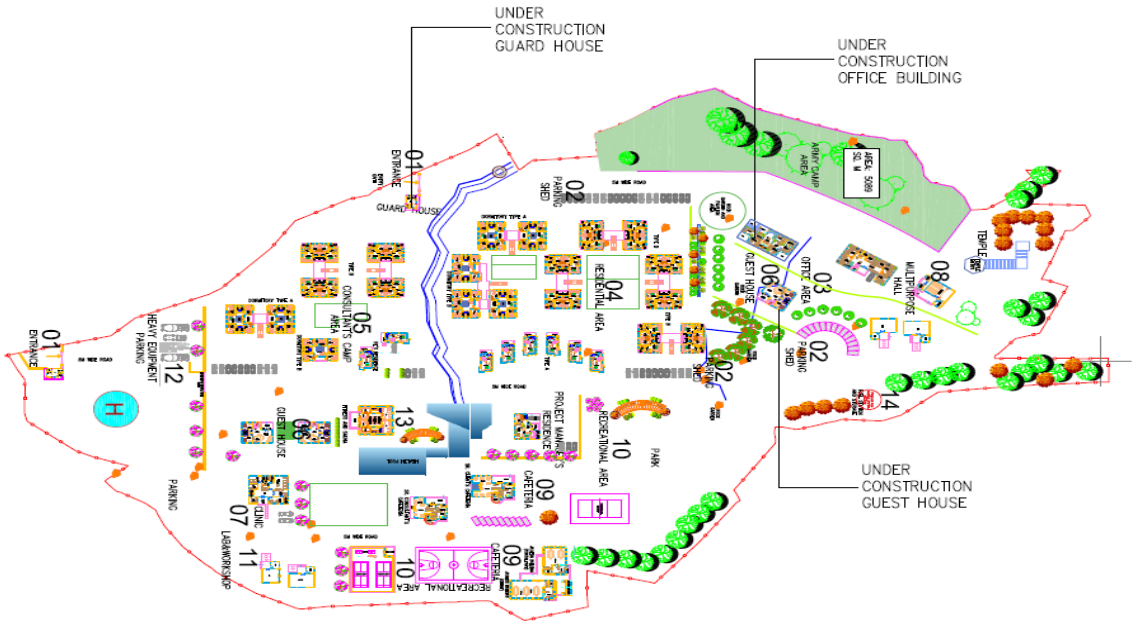
	
Geological Mapping being done at Test Adit Tunnel (Powerhouse)	Test Adit Tunnel at Powerhouse

	
Face drilling works at Test Adit Tunnel (Headworks)	Test Adit Tunnel (Headworks)

Camp Facilities

General	
Client	Vidhyut Utpadan Company Limited
Contractor	M/S Fewa-Acharya J/V
Contract Title	Construction of Camp Facilities (Access Road and Camp Buildings)
Contract Date	26 July, 2020
Contract Completion Date	17 January, 2022
Plinth Area of Office Building/Storey	246.41 sq. m/ Two storey
Plinth Area of Guest House	138.37 sq. m/ Two storey
Type of Building	Reinforced Concrete

Length of Access Road	1417 m
Width of Access Road	3.75 m carriageway + 0.5 m shoulder on both sides
Type of Road	Earthen
Physical Progress in Camp Facilities	
Work being carried out till December, 2020	Grade cutting of roads and collection of aggregates.



Masterplan of Camp Facilities

	
Access road under construction	Boulder encountered during road cutting

	
Grade Cutting along Access Road	Ground Levelling at Camp Area

Land Acquisition

Total Land Required for the project	1075 Ropani.
Inundation Land	943 Ropani.
Land for Project structure, Camp facilities and Site Office	135 Ropani.
Physical Progress in Land Acquisition	
Land for Project structure, Camp facilities and Site Office	135 Ropani Acquired.
Inundation Land	Land classification works on progress for rate fixation of 943 Ropani Inundation Land.
Physical Progress in Camp Facilities	
Work being carried out till December, 2020	Grade cutting of roads and collection of aggregates.