KRISHNA KNITWEAR TECHNOLOGY LTD.

MORI HANOL

HYDROELECTRIC PROJECT

(2 X 32 MW)

UTTARAKHAND

PRE-FEASIBILITY REPORT

MARCH 2015

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SALIENT FEATURES

1. SALIENT FEATURES

1. LOCATION			
	State	:	Uttarakhand
	District	:	Uttarkashi
	Tehsil	:	Purola
	Place	:	Mori - Hanol
	Stream	:	Tons, a tributary of Yamuna river
	Nearest Rail Head	:	Dehradun
	Geographical Coordinate	:	Longitude Latitude
	Barrage site	:	78º 02' 52"E 31º 01' 36" N
	Power House site	:	77º 57' 15" E 30º 58' 33" N
2. HYDROLOGY			
	Catchment area at diversion	:	1570 km^2
	Design Flood (50 year return period)	:	2204.0 m^3/sec
	Design Flood (100 year return period)	:	2594.0 m^3/sec
	Standard Project Flood (SPF)	:	4708 m^3/sec
	Design Discharge	:	68.05 m^3/sec
3. RESERVOIR			
	Full Reservoir Level (FRL)	:	1160.00 m
	Minimum draw down level (MDDL)	:	1156.00 m
	Gross storage up to FRL	:	1.0175 Million m^3
	Peaking Capacity	:	3.0 Hours Minimum

4. DIVERSION BARRAGE			
A. Spillway			
	Type	:	Gated
	Maximum Water level (1 in 100 years)	:	1160.0 m
	Average river bed level at barrage axis	:	1145.0 m
	Crest level of Spillway bays	:	1148.0 m
	Bridge deck level	:	1162.0 m
	No. of bays	:	5
	Type of gate	:	Vertical lift gate
	Size of gates	:	9.5 m (W) x12.0 m (H)
	Energy Dissipation System	:	Stilling Basin.
B. Head regulator			
	Size of opening	:	5.0m (W) x 4.0m (H)
	No. of bays Type of gates	: :	4 Vertical lift with rope drum hoist
	HFL	:	1160.00 m
	FRL	:	1160.00 m
	MDDL	:	1156.00 m
	Average river bed level	:	1145.00 m
	Crest level	:	1152.00 m
	Bridge deck level	:	1162.00 m

5. DESILTING BASINS			
	Type	:	Surface
	No of basins	:	4 Nos. 50.0 m (L) x 19.5 m (W) x 9.6 m (H) with hoppers
	Particle size to be excluded	:	0.20 mm and above
	Maximum discharge	:	74.86 m^3/sec (with 10% overload)
	Flow through velocity	:	0.30 m/sec
	Flushing velocity	:	4.0 m/sec
	Silt flushing gates	:	12 Nos. Vertical lift, 1.5 m (W) x1.5 m (H) with screw hoist
6. INTAKE POND / TUNNEL INTAKE STRUCTURE			
	FRL	:	1159.50 m
	MDDL	:	1155.50 m
	Type	:	Bell mouth entrance
	Sill level	:	1143.00 m
	Trash rack	:	Vertical (4 panels)
	Design Discharge	:	74.86 m^3/sec including 10% overload
7. HEAD RACE TUNNEL			
	Type Diameter	: :	Modified inclined leg Horse shoe shape 6.0 m, concrete lined
	Velocity	:	2.25 m/sec
	Length	:	11116 m
	Design discharge	:	68.05 m^3/sec
	Slope	:	1V : 440 H

8. CONSTRUCTION ADITS			
	Adit-1 (at RD 1356 m)		
	Type and Size	:	D – Shaped, 6.5 m diameter
	Length	:	470 m
	Adit-2 (at RD 3986 m)		
	Type and Size	:	D – Shaped, 6.5 m diameter
	Length	:	750 m
	Adit-3 (at RD 6661 m)		
	Type and Size	:	D – Shaped, 6.5m diameter
	Length		427 m
	Adit-4 (at RD 9174 m)		
	Type and Size	:	D – Shaped, 6.5m diameter
	Length		518 m
	Adit-5 (at RD 11112 m)		
	Type and Size	:	D – Shaped, 6.5m diameter
	Length		123 m
9. SURGE SHAFT			
	Type	:	Open to sky, Restricted orifice
	Size:	:	18.0 m dia circular
	Orifice	:	3.5 m dia
	Maximum Upsurge Level	:	1180.58 m
	Minimum Down surge Level	:	1134.12 m
	Invert Level of HRT	:	1120.0 m
	Lining	:	1000 mm thick Concrete lined
	Top Level	:	1185.00 m
10. PRESSURE SHAFT / PENSTOCK			
	Type	:	Partly Underground and partly in
	Size Main	:	1 No., 4.0 m dia, 203 m long
	Branches		2 nos. , 2.5 m dia, 15 m each
	Velocity	:	5.42 m/sec
	Type & thickness of steel liner	:	IS : 2002-1992 Grade-1, 16 mm to
11. POWER HOUSE			
	Type	:	Surface
	Installed Capacity	:	64 MW (2 x 32 MW)
	Size	:	
	Minimum Tail Water Level	:	1045.55 m
	Normal Tail Water Level	:	1047.0 m
	Maximum gross head	:	113.0 m
	Minimum gross head	:	109.0 m
	Head Loss (Barrage to Power House)	:	8.67 m
	Max Net head	:	104.33 m
	Min Net Head	:	100.33 m
	Rated head	:	103 m
	Centre Line of Turbine	:	1044.55 m

	Service bay level	:	1055.55 m
	Flood Level (100 yr return period)	:	1052.41 m
	Capacity of E.O.T crane	:	125/32 tons
12. TAIL RACE CHANNEL			
	Type	:	Surface, open channel
	Size	:	20.1 m wide, about 100 m long
	Velocity	:	2.535 m/sec
13. TURBINES			
	No. & Type	:	2, Francis (Vertical Shaft)
	Rated Power (at generator terminal)	:	32.0 MW
	Rated net Head	:	103 m
	Max/Min net Head	:	104.33 / 100.33 m
	Rated discharge	:	34.03 m^3/sec
	Speed	:	250.0 RPM
	Specific Speed	:	144.06 (m. kW)
14. MAIN INLET VALVE			
	Type	:	Butterfly valve
	Diameter	:	2.5 m
	Location	:	In the power house
15. GENERATOR			
	Type	:	Vertical shaft synchronous generator
	Number	:	2
	Rated Capacity	:	35 MVA
	Nominal Active Power of each generator	:	32.0 MW
16. MAIN GENERATOR STEP UP TRANSFORMER			
	Location	:	Upstream side of Powerhouse
	No. of Three Phase Transformer	:	2
	Rated Output	:	2 x 45 MVA
	Rated Voltage	:	11 KV / 220 KV
	Frequency	:	50 Hz
	Type of cooling	:	OFWF
17. 220 kV SWITCHYARD			
	Area	:	110 m x 70 m
	Type	:	Surface at EL 1055.55 m
18. TRANSMISSION SYSTEM			
	220 kV transmission systems.	:	To be undertaken by PTCUL from Switchyard of Mori Hanol HEP
	Transmission station	:	Mori

19. ESTIMATED COST			
	Pre operative and Civil Works	:	Rs. 615.41 Crore
	Electrical /Mechanical Works	:	Rs. 109.12 Crore
20. ESTIMATED COST- FOR TARIFF CALCULATIONS			
	Pre-operative Expenses	:	Rs 50.84 Crore
	Civil works	:	Rs. 564.67 Crore
	Elect./Mech. Works	:	Rs. 109.12 Crore
	Total Basic cost	:	Rs. 724.53 Crore
	Escalation	:	Rs 32.31 Crore
	Interest During Construction	:	Rs. 95.39 Crore
	Fund Management Expense	:	Rs. 3.02 Crore
	Total (Generation Works)	:	**Rs. 855.25 Crore**
	Cost per MW installed	:	Rs. 13.36 Crore
21. POWER BENEFITS			
	Annual Energy generation in 90% dependable year at 95% Plant availability (Design energy)	:	318.89 MU
22. FINANCIAL ASPECTS			
	Cost of generation for first year (with GOI norms including 15.5% ROE)	:	Rs 6.19 /kWh
23. CONSTRUCTION PERIOD		:	4.0 years including pre-construction activities

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EXECUTIVE SUMMARY

2. EXECUTIVE SUMMARY

Introduction

Energy and more notably electrical energy has been acknowledged as the principal catalyst for economic and social growth of any society and country. Consumption of electrical energy has been considered as a yardstick for economic growth universally.

The electricity sector in India had an installed capacity of 255.012 GW as of end November 2014 and generated around 703.1 BU for the period April - November 2014. India became the world's third largest producer of electricity in the year 2013 with 4.8% global share in electricity generation surpassing Japan and Russia. Renewable Power plants constituted 28.43% of total installed capacity and Non-Renewable Power Plants constituted the remaining 71.57%. India generated around 967 TWh (967,150.32 GWh) of electricity (excluding electricity generated from renewable and captive power plants) during the 2013–14 fiscal. The total annual generation of electricity from all types of sources was 1102.9 TeraWatt-hours (TWh) in 2013.

As of March 2013, the per capita total electricity consumption in India was 917.2 kWh. The per capita average annual domestic electricity consumption in India in 2009 was 96 kWh in rural areas and 288 kWh in urban areas for those with access to electricity in contrast to the worldwide per capita annual average of 2,600 kWh and 6,200 kWh in the European Union. Electric energy consumption in agriculture is highest (18%) in India. The per capita electricity consumption is lower compared to many countries despite cheaper electricity tariff in India.

In a May 2014 report, India's Central Electricity Authority anticipated, for 2014–15 fiscal year, a base load energy deficit and peaking shortage to be 5.1% and 2% respectively. India also expects all regions to face energy shortage up to a maximum of 17.4% in North Eastern region.

All India (Anticipated) Power Supply Position in FY2014-15

Region	Energy			Peak Power		
	Requirement (MU)	Availability (MU)	Surplus(+) / Deficit(-)	Demand (MW)	Supply (MW)	Surplus(+) / Deficit(-)
Northern	328,944	318,837	-3.1%	47,570	46,899	-1.4%
Western	288,062	289,029	+0.3%	45,980	52,652	+14.5%
Southern	298,180	260,366	-12.7%	41,677	32,423	-22.2%
Eastern	118,663	114,677	-3.4%	17,608	17,782	+1.0%
North-Eastern	14,823	12,248	-17.4%	2,543	2,215	-12.9%
All India	***1,048,672***	***995,157***	***-5.1%***	***147,815***	***144,788***	***-2.0%***

Gujarat has the highest power surplus of any Indian state, with about 1.8 GW more power available than its internal demand. The state was expecting more capacity to become available. It was expecting to find customers, sell excess capacity to meet power demand in other states of India, thereby generate revenues for the state. Andhra Pradesh leads in the greatest power deficit with peak power being less by 3.2 GW against demand.

The total installed capacity of thermal, hydel, nuclear and gas based power projects and renewable energy sources in India, as on October 2014 is about 254049 MW. The Northern Region, comprising of Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Punjab, Rajasthan and Uttar Pradesh, accounts for about 62670 MW of this capacity. Being a developing country with growing power and energy requirements, the country experienced energy shortfall of about 5% during the year 2013-14. The shortfall in peak power was 6.3% during the same period.

To overcome the problem of short fall of energy, Government of India has set a goal for providing power for all by 2012. A comprehensive blueprint for power sector development has been prepared encompassing an integrated strategy for the sector development with an objective to provide reliable, quality power sufficient to achieve GDP growth rate of 8%. In order to achieve this objective, Power Generation strategy, Transmission and Distribution strategy, Regulation strategy and Conservation strategy have been planned. As a part of Power Generation Strategy, Govt. of India has sought active participation of private sector in power generation. The Electricity Act has been amended to facilitate entry of private sector in power generation. Various incentives have been offered to attract private investors, both domestic and overseas to enter in the field of power generation. The untapped hydroelectric potential of Uttarakhand provides excellent opportunities for power generation to bridge the gap between demand and supply of power in the Northern Region.

In line with the policy guidelines of Govt. of India, the Uttarakhand Govt. has allowed development of small, medium and large capacity hydroelectric power projects in the State by the private sector on Build, Own, Operate and Transfer (BOOT) basis. Uttaranchal Jal Vidut Nigam Ltd. (UJVNL) has been appointed by the government as nodal agency for the process of selection of developers for private sector participation in power development in the state. In year 2006, UJVNL invited bids from private developers for design, engineering, financing, procurement, construction, operation and maintenance of hydro power plants on build own and operate basis. After techno commercial bidding and evaluation process, the Mori Hanol Hydroelectric Project (63MW) was allotted to M/S Krishna Knitwear Technology limited vide UJVNL letter of award no. 254/1/2006-04(8)-19/2006 dated 22nd February 2006. The memorandum of understanding (MOU) for development of this project has been signed between M/s Krishna Knitwear technologies Ltd. and Government of Uttarakhand on 19th July 2006. The MOU lays down the broad terms to allow investigations and implementation of the project.

M/s Krishna Knitwear Technology limited is company of fabrics. The primary business activity of Krishna Knitwear Technology limited is in the field of garments. The flagship company has keen interest of developing hydro power plants in India. The Company has its registered office and spinning mill at Krishna Nagar, Samarvarni Shilvaasa (U.T) and corporate office at Prabhadevi Mumbai.

As per the MOU signed with Uttarakhand Government, KKTL is required to carry out the detailed survey and field investigations for preparation of a Detailed Project Report (DPR). The DPR shall be submitted to Uttarakhand Government for approval, prior to taking up project construction. Krishna Knitwear Technology Limited has undertaken the work of topographical survey, geo-technical investigations, and Environmental Impact Assessment studies through reputed agencies. KNTL has further engaged M/s Indo Canadian Consultancy Services Ltd (ICCS) as Indian consultants, for the work of preparing the Detailed Project Report for Mori Hanol Hydroelectric Project.

Power Development In Tons Basin

Mori Hanol Hydroelectric Project is located in Western part of Uttarakhand across Tons river. The Pabar, Giri and Tons River are the main tributaries of river Yamuna in the state of Uttarakhand. River Yamuna and its tributaries have immense potential for hydro power development. Pabar River joins Tons from the right bank near Tiuni. Tons river joins Yamuna River near Dakpathar. The Tons River has attracted priority in hydro power development in Uttarakhand. A total of seven hydro power projects located downstream of Mori Hanol Hydroelectric Project viz., Hanol Tuini 60 MW, Chilla 144MW, Chibro 240MW, Khodri 120MW, Dhakrani 34MW, Dhalipur 51MW and Kulhal 30MW have been commissioned on Tons/Yamuna River in Uttarakhand.

The identified hydropower potential in Tons river basin includes Tiuni Plasu Hydroelectric Project and Kishau storage dam Hydroelectric Project located downstream of Mori Hanol Hydroelectric Project and Sankhri Mori HEP, Taluka Sankhri Hydroelectric Project and Jakhol Sankhri Hydroelectric Project located upstream of Mori Hanol HEP. Arakot Tiuni Hydroelectric Project located on Pabar River upstream of confluence with Tons River has also been identified by UJVNL.

Project Studies For Mori Hanol Hep

The state of Uttaranchal is endowed with vast hydropower. The pre-feasibility study for Mori Hanol Hydroelectric Project has been prepared by UJVNL and the project capacity had been identified as 63 MW. In the revised PFR prepared by KKTL, the owner and developer of the project, the capacity envisages to be of 64 MW. The project components include a gated barrage, head regulator, Desilting basin, HRT, surge shaft, pressure shaft / penstock and surface power house.

In order to confirm the earlier investigations and studies done by Uttarakhand Government, a program for additional field investigations was finalized to facilitate alternative studies for optimizing the project capacity and layout, necessary to produce a bankable detailed project report with detailed evaluation and preparation of estimates of cost to establish the technical, environmental and economic viability of the project.

The objectives of this study include:

- Review of the data as provided by Uttarakhand Jal Vidut Nigam Ltd.
- Detailed field investigations to supplement the existing information on the site for the purpose of design optimization and construction planning including topographical survey, geotechnical investigation, hydrological measurement and environmental studies.
- Review and optimize the preliminary power plant capacity and designs as required for all the main works; and preparation of drawings, in sufficient detail to evaluate the cost estimates with sufficient accuracy.
- Preparation of a bankable project report to assess the techno-economic viability of the project to enable KNTL to obtain techno-economic clearance of Uttarakhand Government prior to project development and all other statutory clearances from pertinent agencies of the Government of Uttarakhand and the Government of India, and to achieve financial closure for project financing.

Site Investigation

Hydrological data collection

For Hydrological investigation and knowing the trend of flow duration, dependability and water availability at the barrage location have been done by using ten daily discharge data for year 1977 to 2014. This information is used for arriving at the long term discharge series for Tons River at the diversion site of Mori Hanol HEP. The complete inflow series has been used for power potential studies.

Topographical Survey

The detailed field survey for diversion barrage, desilting basin, collection pool, intake, colonies, and plant areas has been done in the scale of 1:500 with one meter contour has been carried out by DD Surveys and Consultants. Details of survey are given in the Chapter V Topographical Surveys. The project layout and its optimization have been carried on the basis of detailed topographical survey.

Geotechnical Investigation

The geological investigations comprising of detailed geological mapping, core drilling, in situ testing and logging has been carried out at barrage, desilting basin, tunnel intake, surge shaft and power house area. Rock mechanic tests & petrography analysis, construction material survey and testing to assess alkali-silica reactivity have also been carried out by Super Engineering Works, Delhi. Details of the geotechnical investigations are given in Chapter VII of this volume and in separate volume of Geological Investigations.

Environmental Impact Assessment Study

The initial study for Environmental Impact Assessment and Environmental Management Plan was carried out in 2008-2009 at the project site. Now, WAPCOS has been entrusted for detailed study to assess the impact of project during construction as well as operation stage.

Silt and Chemical Analysis

Silt and chemical analysis of water samples of tons river has been carried out. Tests including chemical analysis, grain size distribution and petrographic analysis have been conducted on water and silt samples. Results of the analysis are given in a separate report.

Project Layout

Mori Hanol Hydro Electric Project (64 MW) has been contemplated as an upstream development of Hanol Tuini Hydroelectric Project (60MW). It envisages the construction of a diversion structure across river Tons near village Mori, head regulator structure, surface desilting arrangement, head race tunnel, a surge shaft, Penstock and surface power house near village Hanol and a tail race tunnel to discharge the water back into Tons River upstream of Hanol Tuini HEP. The optimal project capacity has been worked out as 64 MW, and the detail is given in chapter VIII. The project layout involves the construction of a diversion barrage with river bed El 1145 m, reservoir to store 1.075 Million m3 of water to provide peaking generation of minimum 3.0 hour during lean season, head works, desilting basin to remove silt particles above 0.2 mm in size to feed the available discharge into 11116 m long 6.0 m diameter modified inclined leg horse shoe shaped head race tunnel. 18 m diameter surge shaft with a height of 65 m, main steel pressure shaft / penstock of 203 m length and 4.0 m diameter and two unit penstocks of about 15 m long and 2.5 m diameter, surface power house having installation of two Francis type generating units each of 32.0 MW capacity with compatible generator and other auxiliary equipment, and tail race channel. The project proposes to utilize 113 m of maximum gross head and a rated discharge of 68.05 m3/sec for power generation. The energy benefits have been assessed at 318.89 Million Units in 90% dependable year based on annual runoff with 95% plant availability.

As per Government of Uttarakhand decision, Power Transmission Corporation of Uttarakhand (PTCUL) will evacuate power from Mori Hanol Hydroelectric Project through 220kV D/C Arakot Tuni-Mori Transmission Line which will pass from Mori-Hanol Hydroelectric Project at a distance of 2KM (approx.). It is envisaged to construct 220kV D/C Transmission Line with ACSR ZEBRA conductor, of length 2KM (approx.) and connect the same by LILO of one circuit of 220kV D/C Arakot Tuni-Mori Transmission Line for evacuating power from Mori Hanol Hydroelectric Project to proposed 2x50MVA, 220kV Mori Sub-station.

Project Cost

The completed project cost has been assessed at Rs. 855.25 Crores (including escalation, IDC and finance fees) and the project shall be completed in a period of 4 years including 8 months for preconstruction activities, after obtaining all clearances and financial closure. The cost of generation in the first year works out as Rs. 6.19 per kWh. The average cost of generation for first 10 years after construction is Rs. 5.17 per kWh.

Clean Development Mechanism

Carbon credit is Green House Gases (GHG) emission reduction. These emission reductions are created when project reduces or avoids the emission of GHG, such as carbon dioxide or methane, relative to what would have been emitted under a business as usual scenario. The power generated in hydro power project does not lead to emission of GHG (CO_2), whereas the power generated in fossil fuel based power plants leads an emission of GHG (CO_2). Thus the proposed project leads to mitigation in the emission of GHG and addressing the issue of global warming and hence is eligible to benefit under the Clean Development Mechanism (CDM) of Kyoto protocol. Hence the project is proposed to be taken up as a CDM Project. The monetary benefits available under CDM will have positive impact on the viability of the project.

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PROJECT SUMMARY

3. PROJECT SUMMARY

General

Mori Hanol hydro-electric project has been envisaged to harness the available power potential in intermediate reach of Tons River. This intermediate reach falls between EL 1160.0 to EL 1047.0 m. The project headwork involves construction of a barrage comprising of gated spillway, head regulator, desilting basins, collection pool and a tunnel intake. The water conductor system comprises of a 6.0 m diameter and 11.11 km long modified inclined leg horse shoe shaped head race tunnel culminating in surge shaft open to sky. A partly underground and partly buried pressure shaft / penstock conveys water to the surface powerhouse housing two Francis turbines to generate 64 MW (2 x 32 MW) of power. The project is expected to provide annual energy generation of about 318.89 Gwh in 90% dependable year based on annual runoff at 95% plant availability. The project shall provide peaking capacity benefits of 64 MW for minimum 3.0 hours per day during lean season. The project will be constructed in a period of four years. Some preliminary works on infrastructure facilities will be carried out prior to taking up construction of the main power plant.

Main Components

The project envisages construction of barrage, head regulator, desilting basin, intake structure, head race tunnel, surge shaft, pressure shaft / penstock, powerhouse, tailrace channel and switchyard.

Diversion works

Barrage comprising of five gated spillway bays of 9.5 m width has been proposed. The barrage has been designed to pass 100 year design flood of 2594.0 cumecs in Tons River at Flood Level (HFL) of 1160m. The crest levels of spillway bays is kept at El 1148.0 m. To facilitate the construction of barrage, cofferdams have been proposed in two stages of construction.

Head Regulator

The head regulator is located upstream of barrage axis, on the right bank of Tons river. The head regulator gates are designed to draw the required discharge for power generation, including discharge for overload capacity and for flushing of the desilting basin, at different water levels in the barrage. Four bays of 5 m clear width each are provided to feed the four desilting basins. The head regulator is designed to divert a discharge of 74.86 m3/sec including 10% overload for power generation. A trash rack with TRCMl is proposed to facilitate removal of floating trash in the river trapped at the trash racks.

Desilting Basin

The desilting basin is located downstream of head regulator and comprises of four longitudinal chambers, each having a length of 50 m and width of 19.5 m, with three 2.5 m wide longitudinal flushing trenches at the bottom. The desilting basin is designed for a flow through velocity of 0.28 m/s. A 1500 mm (W) x 1500 mm (H) silt flushing duct is provided at the end of the flushing gallery to convey the silt from desilting basin, back into river. The desilting basin is designed to remove silt particles of size to 0.2 mm and above.

Storage Reservoir

The topographical and hydrological parameters for this project allow peaking generation for a period of minimum 3.0 hours daily during the lean season. A small reservoir having a storage capacity of 1.0175 million m3 is provided upstream of the barrage to provide water storage for peaking generation. The reservoir is designed to utilize the maximum head by maintaining the FRL up to the TWL of upstream Naitwar Mori HEP. The bed level at barrage axis is at El 1145 and MDDL is kept at 1156.0m. FRL of the reservoir is kept at El 1160.0m and top of the barrage at El 1162.0 m. Silt particles are likely to get settled in reservoir, and may reduce the reservoir capacity over a period of time. For efficient functioning of reservoir, spillway bay adjacent to intake will be used from time to time as per requirement for removal of silt, gravel and debris from reservoir bed.

Head Race Tunnel

An intake structure with invert level at El 1143.0 m is provided downstream of desilting chambers. The intake is provided with bell mouth shaped transition to have smooth entry into the tunnel. A minimum water cushion of 7.5 m above centerline is provided to prevent entry of air in to the tunnel. The 6.0 m diameter modified inclined leg horse shoe shaped headrace tunnel has a length of 11.11 km up to the surge shaft. The pressurized tunnel is fully concrete lined and is provided with a bed slope of 1 in 483 upto surge shaft junction. The velocity of water in the tunnel is 2.25 m/sec. Five no.

D shaped adits of 6.5 m finished diameter having lengths of 470m, 750m, 427m, 518m & 123m with inward slope for adit 1 and outward slope for all other adits have been proposed to reduce the construction period of HRT to match the schedule of construction of entire project.

Surge Shaft

A restricted orifice type surge shaft is provided at the downstream end of headrace tunnel. The surge shaft dimensions are designed to absorb the hydraulic transients due to variations in discharge during load changes, load rejection and sudden load acceptance. The surge shaft is located at the junction of HRT and pressure shaft. The circular steel lined surge shaft has an orifice of 3.5 m diameter in 1.5 m height and thereafter a diameter of 18 m up to its top at EL1185.

Pressure Shaft / Penstock

The pressure shaft / penstock alignment between surge shaft and powerhouse comprises of 76 m long pressure shaft and 127 m long penstock bifurcating into two unit penstocks of about 15 m each. For pressure shaft, a single pipe of 4.0m diameter with steel lining thickness of 16 mm has been provided. Thickness of penstock varies from 16 mm to 34 mm. After bifurcation, unit penstocks of 2.5 m dia will carry water up to Power House. The steel penstock will be buried below the ground in a trapezoidal trench. Each unit penstock carries a design discharge of 34.03 m3/sec.

Power House And Switchyard

The power house is located on the right bank of Tons river about 1000m downstream of its confluence of Doba Gad with Tons River. 32.7 m long and 18.50 m wide machine hall has been proposed for housing the two vertical axis Francis turbines. For accommodating battery, cable spreadings, auxiliary equipment, services etc. control room of size 18.50 m long x 10 m wide has been proposed. Two number of 11KV/220V 3 phase step up transformers are placed upstream of the powerhouse. A 220kV (110 m long x 70 m wide) surface switchyard proposed on the right bank of Tons river near powerhouse. The powerhouse is approachable from Hanol – Mori road through a 270 m long road and a 50m span bridge across Tons river.

Tailrace Channel

A common open Tailrace channel has been provided for the two generating units to discharge water back into the Tons River. The total length of the tailrace is 100 m and an upward slope of 1 in 4 is provided in the bed of tail race channel up to crest i.e. El 1045.40 m to maintain the minimum tail water level at EL 1047.0 m.

Electro Mechanical Equipment

Turbine

For the available gross head of 113.00m, Francis type turbine is used, further, for the rated head of 103m, the optimum synchronous speed of 250 rpm is selected for the Francis turbine having vertical shaft arrangement. An inherent continuous overloading capacity of 10% is proposed for the turbine which would be useful during planned and forced outage of the other unit, as the capacity loss due to outage could be partially compensated and to harness more energy from the excess discharge during the monsoon season.

Generator

The generator will be, vertical shaft synchronous machine with rated continuous output of 42 MVA at rated parameters such as, rated voltage of 11kV, power factor of 0.9, rated frequency of 50Hz. and having rotational speed of 250.0 rpm to match with that of the turbine.

Main Inlet Valve

The main Inlet Valve shall be Butterfly valve one for each turbine and shall be accommodated in the power house. The MIV shall be of 2500 mm nominal size and nominal turbine flow of 34.03 m3/sec. The valve shall be of dual seal type i.e. one main or service seal and one repair or maintenance seal for repairing the service seal without the need for dewatering the penstock header/pressure shaft.

Transformers

Two numbers three phases, 42.00 MVA, 11/220 kV Delta/Star step up Power transformer of ONAF type with normal protective devices such as restricted earth fault, etc. will be installed. Two number of 11kV/415 V, 500kVA capacity ONAN type Unit Auxiliary Transformers shall be provided to meet the requirement of unit auxiliary loads. One number of 11 kV/415 V, 500kVA capacity ONAN type Station Service Transformer shall be provided to meet the requirement of station loads.

EOT Crane

One cabin operated EOT crane with 125 tones main hook for handling the rotor and 32 tonnes auxiliary hook will be provided.

Transmission System

The construction of transmission line for evacuation of power from private power projects is being taken up by Power Transmission Corporation of Uttarakhand (PTCUL). Accordingly, power from Mori Hanol shall be evacuated through 220 KV D/C Arakot Tuni-Mori Transmission Line (which will pass near proposed Mori-Hanol Hydroelectric Project at a distance of 2KM approximately) to evacuate power from above mentioned project to proposed 2x42MVA, 220kV Sub-station at Mori.

Power Benefits

The annual energy benefits from the project have been assessed as about 318.89 MU in 90% dependable year based on annual runoff at 95% plant availability. The project would afford peaking capacity benefits of 64 MW for minimum three hours per day during lean season.

Project Cost

The project is estimated to cost Rs. 855.25 Crore at December 2014 price level including Rs. 32.31 crores as escalation, Rs 95.39 Crore as interest during construction and fund management expenses of Rs. 3.02 Crore. It is proposed to finance the project on a 70:30 debt - equity ratio basis.

Financial Aspects

As per Government of India (GOI) norms the average cost of unit generation (for first five years) with 15.5% return on equity (ROE) works out to Rs. 6.19 per kWh and average DSCR as 1.09. Details of financial analysis are summarized in chapter XIX, Financial and Economic Evaluation.

4

ECONOMIC SCENE OF UTTARAKHAND GROWTH AND CONSTRAINTS

4. ECONOMIC SCENE OF UTTARAKHAND GROWTH AND CONSTRAINTS

General

Uttarakhand, formerly Uttaranchal, is a state in the northern part of India. It is often referred to as the Devbhumi (literally "Land of the Gods") due to the many Hindu temples and pilgrimage centres found throughout the state. Uttarakhand is known for its natural beauty of the Himalayas, the Bhabhar and the Terai. On 9 November 2000, this 27th state of the Republic of India was created from the Himalayan and adjoining northwestern districts of Uttar Pradesh. It borders the Tibet Autonomous Region, China on the north; the Mahakali Zone of the Far-Western Region, Nepal on the east; and the Indian states of Uttar Pradesh to the south and Himachal Pradesh to the northwest. The state is divided into two divisions, Garhwal and Kumaon, with a total of 13 districts. The provisional capital of Uttarakhand is Dehradun, the largest city in the region, which is a railhead. The High Court of the state is in Nainital.

According to the 2011 census of India, Uttarakhand has a population of 10,116,752 comprising 5,154,178 males and 4,962,574 females, with 69.45% of the population living in rural areas. The state is the 20th most populous state of the country having 0.84% of the population on 1.69% of the land. The population density of the state is 189 people per square kilometre having a 2001–2011 decadal growth rate of 19.17%. The gender ratio is 963 females per 1000 males. The crude birth rate in the state is 18.6 with the total fertility rate being 2.3. The state has an infant mortality rate of 43, a maternal mortality rate of 188 and a crude death rate of 6.6.

The per-capita income in Uttarakhand has zoomed to Rs 1.03 lakh in the financial year 2013-14 which is Rs 11,158 more than the previous year's income of Rs 92,191.

Geography

Physical Characteristics

The state is located at altitudes ranging from 400 m to 7000 m above mean sea level. There is general increase in elevation from west to east and from south to north.

Rivers

Uttarakhand has the unique distinction of providing water both to the Yamuna and the Ganges basins. The major river systems of the region are Yamuna, Bhagirathi, Alaknanda, Ganga, Ramganga, Tons and Kali. These perennial rivers are both snow & rain fed and are protected by fairly extensive cover of natural vegetation. The Yamuna originates from Yamunotri glacier near Banderpoonch peaks in district Uttarkashi and traverses 1370 km before merging into river Ganges at Allahabad (Uttar Pradesh). The Ganga River originates in the Gangotri glacier in district Tehri Garhwal and travels about 2500 km before merging into Bay of Bengal. The upper Ganges River, known here as Bhagirathi, emerges from Gangotri Glacier. Bhagirathi eventually joins the Alaknanda River at Devprayag (about 70 km upstream of Rishikesh) and becomes Ganga. The seven streams of Ganga are Alaknanda, Bhagirathi, Bhilangana, Janhvi, Mandakini, Rishiganga and Saraswati which merge into Ganga at Devprayag. The other major tributaries of Ganga are Balganga, Dhauli Ganga, Girthi Ganga, Mandakini and Pindar. Tons are the tributary of Yamuna on which Mori-Hanol H.E.P. is proposed.

Climate

The seasonal system of the weather and vertical zoning of the climate are two important characteristics of the climate of Uttarakhand. There is great diversification in climatic conditions of the state mainly due to large variation in altitude (400m-7000m) and presence of imposing main Himalayan mountain wall. It varies from hot and sub-humid tropical in southern low tracts to temperate, cold alpine and glacial in northern and eastern high mountain ranges. The tracts lying close to the plains of Uttar Pradesh and Haryana are the hottest where mercury soars to about 41ºC. On the other hand Mukteshwer is the coldest where temperature falls 2.7ºC below the freezing point during winters. The average rainfall in the state is 1397mm.

Forest & Wildlife

Forest in Uttarakhand covers an area of 24,323 sq. km. and form about 45% of the total geographical area of the state. They are, however, not uniformly distributed and are mostly confined to higher hills and interior valleys. Due to wide range of altitudes and climatic conditions, several varieties of vegetation from Himalayan meadows to tropical shrubs and bamboo forests on low foothills are found in the state.

Until few years ago, the forests were considered as main source of income and their felling went on unabated. However, the concept has since undergone total change. The focus has now shifted to the conservation and the forests have now been nationalized. The Government is now planning to provide green cover by bringing 50 percent of the total area under forest. A World Bank sponsored Social Forestry Project has been launched to raise fuel, fodder and small timber species to meet basic necessities of the people. Forests are now being protected from biotic interference and a centrally-sponsored scheme has been launched to detect illicit felling and smuggling of timber.

Six of the seven national parks including Corbett National Park, Rajaji National Park, Nanda Devi National Park and Valley of flowers and Kedarnath Sanctuary are in Uttarakhand. It is the home of a wide variety of mammals, birds, reptiles and avifauna. These include Tiger, Leopard, Elephant, Musk Dear, Black Bear and Sloth Bear. With a view to intensifying wildlife preservation and management, the state Govt. has banned 'hunting' and has established a number of "National Parks" and "Sanctuaries" which cover nearly eight percent of its geographical area.

Population

According to the 2011 census of India, Uttarakhand has a population of 10,116,752 comprising 5,154,178 males and 4,962,574 females, with 69.45% of the population living in rural areas. The state is the 20th most populous state of the country having 0.84% of the population on 1.69% of the land. The population density of the state is 189 people per square kilometre having a 2001–2011 decadal growth rate of 19.17%. The gender ratio is 963 females per 1000 males. The crude birth rate in the state is 18.6 with the total fertility rate being 2.3. The state has an infant mortality rate of 43, a maternal mortality rate of 188 and a crude death rate of 6.6.

Sociology

Education

On 30 September 2010 there were 15,331 primary schools with 1,040,139 students and 22,118 working teachers. At the 2011 census the literacy rate of the state was 79.63% with 88.33% literacy for males and 70.70% literacy for females. The language of instruction in the schools is either English or Hindi. There are mainly government-run, private unaided (no government help), and private aided schools in the state. The main school affiliations are CBSE, CISCE or the state syllabus defined by the Department of Education of the Government of Uttarakhand.

Uttarakhand is also home to a number of universities and degree colleges. In Uttarakhand there are 15,331 primary schools with 1,040,139 students and 22,118 working teachers (Year 2011).

Health And Family Welfare

Health & family welfare department in Uttarakhand is providing service such as public health, health education, family welfare, and maternal and child healthcare through a network of State Helath infrastructure detailed below. As a result of various public health measures, the death rate, over the years, has come down and it was 6.4 per thousand.

STATE HEALTH INFRASTRUCTURE

Health Facility	Number of Institutions
District Hospitals	12
Female Hospitals	06
Base Hospitals	03
Combined Hospitals	15
CHC including Identified FRUs	55
PHC's	239
Sub Centre	1765
State Allopathic Dispensaries	322
Ayurvedic Hospitals & Dispensaries	543
Homeopathic Dispensaries	107
Unani Hospitals	03
Blood Banks	23
T.B.Clinic	13

Economy

The Uttarakhand state is the second fastest growing state in India. Its gross state domestic product (GSDP) (at constant prices) more than doubled from ₹24,786 crore in FY2005 to ₹60,898 crore in FY2012. The real GSDP grew at 13.7% (CAGR) during the FY2005–FY2012 period. The contribution of the service sector to the GSDP of Uttarakhand was just over 50% during FY 2012. Per capita income in Uttarakhand is ₹1,03,000 (FY 2013) which is higher than the national average of ₹74,920 (FY2013). According to the Reserve Bank of India, the total foreign direct investment in the state from April 2000 to October 2009 amounted to US$46.7 million.

Uttarakhand Economy at a Glance[51] figures in crores of Indian Rupees	
Economy at a Glance (FY-2012)	In Indian Rupees
GSDP (current)	₹95,201
Per capita income	₹1,03,000

Transportation

Uttarakhand has 28,508 km of roads, of which 1,328 km are national highways and 1,543 km are state highways. The State Road Transport Corporation (SRTC), which has been reorganized in Uttarakhand as the Uttarakhand Transport Corporation, is a major constituent of the transportation system in the state. The Corporation began to work on 31 October 2003 and provides services on interstate and nationalized routes. As of 2012, approximately 1000 buses are being plied by the "Uttarakhand Transport Corporation" on 35 nationalized routes along with many other non-nationalized routes. There are also private transport operators operating approximately 3000 buses on non-nationalised routes along with a few interstate routes in Uttarakhand and the neighbouring state of U.P. For travelling locally, the state, like most of the country, has auto rickshaws and cycle rickshaws. In addition, remote towns and villages in the hills are connected to important road junctions and bus routes by a vast network of crowded share jeeps.

The air transport network in the state is gradually improving. Jolly Grant Airport in Dehradun is the busiest airport in the state with six daily flights to Delhi Airport. Pantnagar Airport, located in the Kumaon region does not have any commercial air services. There government is planning to develop Naini Saini Airport in Pithoragarh district, Bharkot Airport in Chinyalisaur in Uttarkashi district and Gauchar Airport in Chamoli district. There are plans to launch helipad service in Pant Nagar and Jolly Grant Airports and other important tourist destinations like Ghanghariya and Hemkund Sahib.

As over 90% of Uttarakhand's terrain consists of hills, railway services are very limited in the state and are largely confined to the plains. In 2011, the total length of railway tracks was about 345 km. Rail, being the cheapest mode of transport, is most popular. The most important railway station in Kumaun Division of Uttarakhand is at Kathgodam, 35 kilometres away from Nainital. Kathgodam is the last terminus of the broad gauge line of North East Railways that connects Nainital with Delhi, Dehradun, and Howrah. Other notable railway stations are at Pantnagar, Lalkuan and Haldwani.

Dehradun railway station is a railhead of the Northern Railways. Haridwar station is situated on the Delhi–Dehradun and Howrah–Dehradun railway lines. One of the main railheads of the Northern Railways, Haridwar Junction Railway Station is connected by meter gauge and broad gauge lines. Roorkee comes under Northern Railway region of Indian Railways on the main Punjab – Mughal Sarai trunk route and is connected to major Indian cities. Other railheads are Rishikesh, Kotdwar and Ramnagar linked to Delhi by daily trains.

Industrial Development

The state accounts for 809 nos. of Khadi Udhyog / Gramodhyog and about 32116 nos. of SSI (Small Scale Industries). Khadi units give employment to about 4987 no of people and SSI employs 87279 no of people.

There are 752 factories registered under factory act 1948 which provide employment to 35349 no of people and about 51762 people are engaged with it.

The value of product & by product is Rs.91463.30 Millions, and net value added is Rs.19480.10 Millions for the year 2004-05. The gross fixed capital formation for the year 2004-05 is Rs.7772.60 Millions.

The profit from industrial sector for the year 2004-05 is Rs.10567.70 Millions. Other key industries include tourism and hydropower, and there is prospective development in IT, ITES, biotechnology, pharmaceuticals and automobile industries. The service sector of Uttarakhand mainly includes tourism, information technology, higher education, and banking.

During 2005–2006, the state successfully developed three Integrated Industrial Estates (IIEs) at Haridwar, Pantnagar, and Sitarganj; Pharma City at selaqui; Information Technology Park at Sahastradhara (Dehradun); and a growth centre at Siggadi (Kotdwar). Also in 2006, 20 industrial sectors in public private partnership mode were developed in the state.

Sr	Items	Year/ Period	Unit	Statistics
Rural and Small Scale Industries				
1.	Khadi Udhyog / Gramodhyog Units	2006-2007	No.	809
2.	Small Scale Industries (SSIs)	2006-2007	No.	32116
3.	Total Employees of Khadi Units	2006-2007	No.	4987
4.	Total Employees of SSIs	2006-2007	No.	87279
Factories (Regd. under Act, 1948)				
1.	No. of Factories	2004-2005	No.	752
2.	No. of Workers	2004-2005	No.	35349
3.	Total Person engaged	2004-2005	No.	51762
4.	Value of product & by product	2004-2005	Rs. Lakh	914633
5.	Net Value Added	2004-2005	Rs. Lakh	194801
6.	Value of output	2004-2005	Rs. Lakh	1007348
7.	Gross fixed capital formation	2004-2005	Rs. Lakh	77726
8.	Profits	2004-2005	Rs. Lakh	105677

Reference: http://ua.nic.in

Agriculture

Uttarakhand is traditionally an agrarian state. Close to 78 percent of the population depends on agriculture for livelihood. The total food grain and cereal production in the state in 2011-12 was estimated at approximately 1.75 lakh MT. Sugarcane, wheat and rice are the key agricultural products of the state. Wheat is the main crop and accounts for about 50% of total food grain production in the state. Uttarakhand is deficit in production of food grains and depends on imports from other states. Production of key agricultural is given in the following table.

Produce	Annual Production in 2011-12 (000 Tonnes)
Sugarcane	6596
Wheat	874
Rice	599

Horticulture

The geographical attributes and climatic conditions of the state are ideal for production of temperate and subtropical fruit crops. In hilly areas, fruits like apple, pear, peach, plum, khumani and walnut are produced while mango, litchi, malta, santra, lemon, aonla, guava, and pomegranate are mostly grown in Tarai and valley areas. Major vegetables grown in the state are potato, cauliflower, tomato, onion, brinjal, pea, cabbage and okra. The state has a unique advantage of producing off-season vegetables in hilly areas, which fetches good price in the market. Major spices are ginger, garlic, turmeric and chilly. Details of area, production and productivity of major Horticulture crops in the state are as under (2011-12):

Crops	Area (lacs ha)	Production (lacs MT)	Productivity (MT/ha) State	Productivity (MT/ha) National level	Rank in the Country-in terms of productivity	Rank in the Country-in terms of production
Fruit	2.00	8.02	4.00	11.70	30th	18th
Vegetable (including Potato)	0.89	11.97	12.00	17.30	23th	19th
Spices	0.10	0.75	7.21	1.80	01st	19th
Flowers	0.015	Loose-0.181, Cut-3567 lacs no	-	-	-	Overall 7th and 2nd in cut flowers

Ranking of Uttarakhand in Horticulture in India

- Uttarakhand is second in production of cut flowers (3567.56 lakh spikes) after Maharashtra, second in walnut (21.8 thousand MT) after J&K, and third in apples (1.23 lakh MT) after J&K and Himachal Pradesh in the country.

- Productivity of spices is highest in Uttarakhand (7.21MT/ha) against national average of 1.8 MT/ha.

Irrigation

The state has gross irrigated area of approximately 537439 hectare in year 2000-01 and net irrigated area of 343608 hectare for the corresponding year. 100673 hectare of land is irrigated through canals, 191815 hectare of land is irrigated through tube wells, 12136 hectare of land is irrigated through other wells, 568 hectare of land is irrigated through tanks and 38416 hectare of land is irrigated by other sources. The total length of canal in the state is 7030 kms. (Till 2006-07), 136 km is the length of lift canals and there are about 710 tube wells. The revenue collected through irrigation in the financial year 2004-05 was 18.94 Million.

Livestock and Dairy

Dairy and Livestock

According to the 18th Livestock Census 2007, total livestock in the state was approximately 51 lakh. Poultry population stood at 26 lakh. Production of Meat (goats and sheep) was 6192 MT and Production of Meat (cattle &Buffalo) was 1470 MT. Additionally, milk production was at 12.06 lakh MT, fish production was 3818 MT and production of fish seed stood at approximately 350.00 lakh in 2009-10. Egg production stood at 2614 lakh in 2010-11.

Tourism

Uttarakhand has many tourist spots due to its location in the Himalayas. There are many ancient temples, forest reserves, national parks, hill stations, and mountain peaks that draw large number of tourists. There are 44 nationally protected monuments in the state. Oak Grove School in the state is on the tentative list for World Heritage Sites. Two of the most holy rivers in Hinduism the Ganga andYamuna, originate in Uttarakhand.

View of a bugyal (meadow) in Uttarakhand

Gurudwara Hemkund Sahib, an important pilgrimage site for Sikhs

Uttarakhand has long been called "Land of the Gods", as the state has some of the holiest Hindu shrines, and for more than a thousand years, pilgrims have been visiting the region in the hopes of salvation and purification from sin. Gangotri and Yamunotri, the sources of the Ganga and Yamuna, dedicated to Ganga and Yamuna respectively, fall in the upper reaches of the state and together with Badrinath (dedicated to Vishnu) and Kedarnath (dedicated to Shiva) form the Chota Char Dham, one of Hinduism's most spiritual and auspicious pilgrimage circuits. Haridwar, meaning "Gateway to the God", is a prime Hindu destination. Haridwar hosts the Kumbha Mela every twelve years, in which millions of pilgrims take part from all parts of India and the world. Rishikesh near Haridwar is known as the preeminent yoga centre of India. The state has an abundance of temples and shrines, many dedicated to local deities or manifestations of Shiva and Durga, references to many of which can be found in Hindu scriptures and legends. Uttarakhand is, however, a place of pilgrimage not only for the Hindus. Piran Kaliyar near Roorkee is a pilgrimage site to Muslims, Hemkund, nested in the Himalayas, is a prime pilgrimage center for the Sikhs. Tibetan Buddhism has also made itself felt with the reconstruction of Mindrolling Monasteryand its Buddha Stupa, described as the world's highest at Clement Town, Dehradun.

Some of the most famous hill stations in India are in Uttarakhand. Mussoorie, Nainital, Dhanaulti, Lansdowne, Sattal, Almora, Kausani, Bhimtal and Ranikhet are some popular hill stations in India. The state has 12 National Parks and Wildlife Sanctuaries which cover 13.8 percent of the total area of the state. They are located at different altitudes varying from 800 to 5400 meters. The oldest national park on the Indian sub-continent, Jim Corbett National Park, is a major tourist attraction. The park is famous for its varied wildlife and Project Tiger run by the Government of India. Rajaji National Park is famous for its Elephants. In addition, the state boastsValley of Flowers National Park and Nanda Devi National Park in Chamoli District, which together are a UNESCO World Heritage Site. Vasudhara Falls, near Badrinath is a waterfall with a height of 122 metres (400 ft) set in a backdrop of snow-clad mountains. The state has always been a destination for mountaineering, hiking, and rock climbing in India. A recent development in adventure tourism in the region has been whitewater rafting in Rishikesh. Due to its proximity to the Himalaya ranges, the place is full of hills and mountains and is suitable for trekking, climbing, skiing, camping, rock climbing, and paragliding.Roopkund is a popular trekking site, famous for the mysterious skeletons found in a lake, which was covered by National Geographic Channel in a documentary.The trek to Roopkund passes through the beautiful meadows of Bugyal.

Tourism industry has emerged as a major sector in the development of the State's economy. While the Private Sector has been roped in for development of infrastructure. Pilgrims and heritage tourism is being given priority. Adventure tourism is being developed by encouraging mountaineering, skiing, trekking, water and winter sports.

As a result, religious tourism forms a major portion of the tourism in the state. The tourism business in Uttarakhand generated ₹23,000 crores during 2013-14, however due to 2013 North Indian Floods, it is expected to witness a 70% fall to ₹6,900 crores during 2014-15.

Table 1 shows the Domestic and Foreign tourist arrival in Uttarakhand. According to the statistics available, the share of Uttarakhand to the total tourist in India (domestic tourist) has increased in past few years while in case of foreign tourist, the growth is almost stagnant. It can also been observed that the tourist inflows in the state, both domestic and foreign, has shown a significant increase in past 2-3 years.

Table 1: Tourist arrival in the State

State/Country		2008		2009		2010	
		Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
Uttarakhand		20546323	99910	21934567	106470	30206030	127258
All India		562982298	14112590	650038673	13717522	740214297	17852777
% Growth	Uttarakhand	-	-	6.8	6.6	37.7	19.5
	All India	-	-	15.5	-2.8	10.7	24.2
Share of Uttarakhand to India		3.6	0.7	3.4	0.8	4.1	0.7

Source: India Tourism Statistics, 2009 and 2010

Tourism has the potential to be a major industry in Uttarakhand where there is considerable scope for cashing in on the boundless natural attractions. Realizing this, the state govt. has declared tourism as an industry. This has also helped in the development of local cottage industry and tiny industrial sector famous for shawls, caps, jewellery, wood craft and hosts of other handicrafts. Further as a result of generous subsidies and loans, the hotel industry has made considerable progress at important tourist resorts. There are around 146 tourist rest houses, 1889 hotels/paying guest houses, 800 Dharamshalas and 30 Rain Basera (night shelters) in the state (till 2008) However, according to government data, there were a mere 4,547 hotels, guest houses and night shelters in the state in 2011. That explains the mushrooming illegal tourist infrastructure.

Energy

Status of the Power Sector

Uttarakhand was formed in the year 2000 after the bifurcation of Uttar Pradesh. This separation from Uttar Pradesh propelled Uttarakhand on an upward growth path. However, the status of an independent state brought in pressures on Uttarakhand in terms of the development and infrastructure needs of the state and the capital Dehradun to meet the increasing economic and political activities. This lead to an increase in the energy demand of the state too but the current power situation does not seem to be meeting it. As per the Central Electricity Authority (CEA), the anticipated demand of the energy for Uttarakhand for the year 2011-12 is 10480 MU and the available energy is 8363 MU; while the peak demand of the state is 1600 MW and the availability is of 1430 MW.

Energy Capacity

Installed Capacity of Uttrakahand Power Utility (in MW) AS ON 31.10.2012:

Total Installed Capacity	Thermal	Nuclear	Hydro	RES*
2556.56	700.46	22.28	1998.18	185.87

RES: Renewable Energy Souces (includes: small hydro, biogas, biomass, waste and wind energy)

Energy Consumption

Energy, particularly, power consumption in the state of Uttarakhand has grown more than 5 times in the last eight years (2002- 2010). Electricity consumption in the domestic sector of Uttarakhand has been quite substantial and higher than the country’s average, but over the years this proportion has shifted in favor of the industrial sector. In 2001-02 around 45 per cent of the total electricity consumption was in the domestic sector which dropped to 29 per cent by 2006-07. With the increasing demand from the industrial sector, in 2006-07 almost 40 per cent of the total electricity consumption was by industries. The share of electricity consumption for farming purposes has declined substantially from 14.4 per cent in 2001-02 to 9.9 per cent although the total actual electricity consumption has marginally increased.

Electricity Consumption by different sectors in Uttarakhand:

Sector	2001-02	2006-07
Domestic	44.7%	29%
Commercial	11.4%	15%
Industrial	21.4%	40.4%
Agriculture	14.4%	9.9%
Others*	8.2%	5.7%
	2229.09 MW	3885.96 MW

*Others include street lighting, water works and traction & railways.

It can be deduced from the table above that the percentage share of electricity consumption has increased only for commercial and industrial sectors. Since both the types of activities are usually concentrated in the urban settlements and industrial areas (plains in case of Uttrakhand), this tells us about the grim picture of the electricity consumption in the hilly rural areas.

Energy Supply

Share of Electricity of Uttarakhand: 8936 MU for 2009-10:

State Generation	4081
Central Share	3391
Others	1464

As is evident from the table above, the state is able to meet only 52% of its power needs through its own resources. Although, currently, Uttarakhand is an exporter; it plans to become an importer of power in the coming years.

Rural Electrification

As per 1991 census, there are 15681 villages in the state of Uttarakhand. As of 31st march 2005, out of these 15681 villages, 13783 have been electrified which amounts to 85% of the total villages.[6] Whereas, as per the 2001 census, 50.35% of rural households have been electrified.[7] Around 96 per cent of the rural villages in Uttarakhand are provided with electricity by Uttarakhand Power Corporation Ltd. UREDA, Micro-Hydel and Kuteer Jyoti connections are also prevalent but in less so in villages.

Energy Demand

The power supply position in the state during 2012-13 as per the LGBR is given in the table below:

Energy Demand during 2012-13

Period	Peak Demand (MW)	Peak Availability (MW)	Surplus(+)/ Deficit(-) (MW)	Surplus(+)/ Deficit(-) (%)	Energy Requirement (MU)	Energy Availability (MU)	Surplus(+)/ Deficit(-) (MU)	Surplus(+)/Deficit(-) (%)
2012-13	1692	1606	-86	-5.1	11322	8573	-2749	-24.3

(Source: CEA Website)

It is evident from the table that there is a shortage of energy in the state. So the proposed Mori-Hanol Hydroelectric Project is going to meet partially this deficit.

5

POWER SCENARIO IN UTTARAKHAND & NORTHERN REGION

5. POWER SCENARIO IN UTTARAKHAND & NORTHERN REGION

Introduction

Electrical Power is essential for socio-economic development of any country. The standard of living of people and status of industrialization of any country largely depend upon the extent of the use of electricity and can be judged by the per capita electricity consumption. In India concerted efforts have been made to increase the availability of power to give a fillip to Indian economy. As of March 2013, the per capita total electricity consumption in India was 917.2 kWh. The per capita average annual domestic electricity consumption in India in 2009 was 96 kWh in rural areas and 288 kWh in urban areas for those with access to electricity in contrast to the worldwide per capita annual average of 2,600 kWh and 6,200 kWh in the European Union. The power system planning in the country has been done on the basis of five regions comprising of Northern, Western, Southern, Eastern and North Eastern regions. The Northern Grid comprises of the states of UP, Rajasthan, HP, Haryana, Punjab, Uttarakhand, Jammu & Kashmir, Delhi and Union territory of Chandigarh. The power system in this region is operating in an inter-connected and coordinated manner. The installed generating capacity, planned additions to generating capacity, existing and anticipated energy demand patterns for Uttarakhand in the northern region of India are discussed in this chapter.

Power Development In India

The power sector since independence has undergone a tremendous change and grown from 1712 MW at the beginning of First Five Year Plan (1951-52) to 255013 MW as on 30.11.2014. The share of Northern Regional Grid is about 68929 MW, accounting for 27.03% of the total installed capacity in the country. Development of the large hydro electric potential of India is being presently favored due to its renewable, non-polluting and low generating cost characteristics. India is world's 6th largest energy consumer, accounting for 3.4% of global energy consumption. Due to India's economic rise, the demand for energy has grown at an average of 3.6% per annum over the past 30 years More than 50% of India's commercial energy demand is met through the country's vast coal reserves About 70% of the electricity consumed in India is generated by thermal power plants, 16% by hydroelectric power plants, 2% by nuclear power plants and 12% by Renewable Energy sources. The country has also invested heavily in recent years on renewable sources of energy such as wind energy.

Power Planning Concept

The country has been divided into 5 power regions for the purpose of planning and development of electric power. The concept of regional planning has been adopted as energy resources are not evenly distributed amongst the various states. The approach in various Five Year Plans has been found extremely useful for exploitation of available resources and to achieve proper mix of hydro and thermal energy in the region, which is essential to achieve cost economy in power production.

Central Electricity Authority (CEA) formulates National Power Policy, coordinates the planning for power development in the country and draws long-term perspective plans. In drawing up such a plan, CEA identifies the projects, which could be considered for implementation during the successive Five Year Plan periods to achieve a proper mix of hydro and thermal in a particular region. Such identification helps the executing agencies to proceed with further detailed investigations and preparation of detailed project reports. The names of the constituent States and Union Territories in the various regions are given below:

- Northern Region - Haryana, Uttarakhand, Jammu and Kashmir, Punjab, HP, Rajasthan, Uttar Pradesh, Chandigarh U.T.and Delhi.
- Western Region - Gujarat, Madhya Pradesh, Maharashtra, Goa, Dadra & Nagar Haveli (UT), Daman & Diu and Chattisgarh.
- Southern Region - Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, NLC, Pondicherry (UT) and Lakshadeep
- Eastern Region - Bihar, DVC (System), Odisha, West Bengal, Sikkim, Jharkhand and Andaman & Nicobar Islands
- North Eastern Region - Assam, Manipur, Meghalaya, Nagaland, Tripura, Arunachal Pradesh, Mizoram.

Various State Govts / State Electricity Boards are doing power development work in various states of the regions.

Power Sector Reforms in India

The State Electricity Boards, responsible for providing electricity to people are found to incur perpetual losses and owe large sums to central power generating companies because of their deteriorating financial performance. So the Govt. has taken steps in the power sector to gradually eliminate losses. This process in India was initiated in 1991.The govt. has amended Electricity Supply Act, 1948 and the Indian Electricity Act, 1910 in order to attract private sector participation.

The Govt. enacted Electricity Act 2003. The objective is to introduce competition, to protect consumers' interests and provide power for all. This aims at commercial growth of power sector and to enable center and states to move in harmony and co-ordination.

The Govt. of India has kept a target to provide availability of over 1000 units of per capita electricity by year 2012 by need based capacity addition of more then 100000 MW during 2002-2012. So the Govt has created favorable environment for adding power generation by attracting the private sector, Section 63 of the Act provides for participation of suppliers on competitive basis in different segments which will further encourage private sector for investment.

Installed Capacity in the Country

The total installed generating capacity in the country as on 2014 is 255013 MW distributed as below:

Total Installed Capacity: (As on 30.11.2014)

Sector	MW	%age
State Sector	94,753	37.2
Central Sector	69,357	27.2
Private Sector	90,903	35.6
Total	2,55,013	

Fuel	MW	%age
Total Thermal	1,77,742	69.7
Coal	1,53,571	60.2
Gas	22,971	9.0
Oil	1,200	0.5
Hydro (Renewable)	40,799	16.0
Nuclear	4,700	1.9
RES** (MNRE)	31,692	12.4
Total	2,55,013	

Renewable Energy Sources (RES) include SHP, BG, BP, U&I and Wind Energy SHP= Small Hydro Project, BG= Biomass Gasifier, BP= Biomass Power, U & I=Urban & Industrial Waste Power, RES=Renewable Energy Sources

All India (Anticipated) Power Supply Position in FY2014-15 In a May 2014 report, India's Central Electricity Authority anticipated, for 2014–15 fiscal year, a base load energy deficit and peaking shortage to be 5.1% and 2% respectively. India also expects all regions to face energy shortage up to a maximum of 17.4% in North Eastern region.

All India (Anticipated) Power Supply Position in FY2014-15

Region	Energy			Peak Power		
	Requirement (MU)	Availability (MU)	Surplus (+) / Deficit(-)	Demand (MW)	Supply (MW)	Surplus (+) / Deficit(-)
Northern	328,944	318,837	-3.1%	47,570	46,899	-1.4%
Western	288,062	289,029	+0.3%	45,980	52,652	+14.5%
Southern	298,180	260,366	-12.7%	41,677	32,423	-22.2%
Eastern	118,663	114,677	-3.4%	17,608	17,782	+1.0%
North-Eastern	14,823	12,248	-17.4%	2,543	2,215	-12.9%
All India	1,048,672	995,157	-5.1%	147,815	144,788	-2.0%

Power Scenerio For Northern Region And Uttarakhand

Power Consumption

The rate of electricity consumption growing every year not only in Northern Region but also through out the country. Due to limited availability, the growth rate of electricity consumption which averaged 12-19 % per annum compounded during the decade (1960-61 to 1979-80) declined sharply to 6.54% during the decade (1970-71 to 1979-80). The growth rate in energy consumption has, however, increased to 8.36% in 2003-04 compared to 2002-03.

The monthly energy consumption of Northern region and Uttarakhand in particular for the year 2004-05 is given in below table

Monthly Energy Consumption of Northern Region and Uttarakhand

Sr. No.	Month	Northern Region (MW)	Uttarakhand (MW)
1	April 04	12918.60	380.40
2	May 04	14626.42	419.43
3	June 04	15289.80	420.30
4	July 04	16853.46	415.71
5	August 04	18369.05	442.06
6	September 04	15864.90	413.10
7	October 04	15818.68	419.12
8	November 04	14490.60	393.00
9	December 04	15661.20	424.08
10	January 05	16375.75	438.96
11	February 05	15162.07	383.88
12	March 05	14905.42	407.96
	Total	**190950.37**	**4958.00**

6

TOPOGRAPHICAL SURVEY

6. TOPOGRAPHICAL SURVEY

Introduction

Detailed field investigations / surveys have been carried out for the project to update the existing information and to obtain additional data for the purpose of design, construction planning, preparation of layout plans, and optimization of various parameters, components of the project, cost estimate and preparation of DPR. Field survey has been carried out covering around 3000 hectares in project area.

This chapter deals with topographic survey carried out to establish relative disposition of various project components with respect to each other and with respect to the defined benchmarks.

As a prelude to the survey work, vertical control was established starting from listed Survey of India control point and carrying the control to barrage site, desilting arrangement, Head Race Tunnel, pressure shaft, and powerhouse. The traverse was run using Total Station Machine. The control traverse was closed on the starting control point and the observed error was insignificant, thereby, confirming the high quality of the control work.

Topographical Survey

General layout

The topographical survey for general layout extending about 2000 m on the upstream of the identified diversion location and about 1000 m downstream of proposed power house location has been carried out on a scale of 1: 5000 with 5 m contour interval. Different alternatives were studied and general layout has been marked indicating proposed location of the diversion barrage, intake structure, desilting tank, collector pool, head race tunnel, surge shaft, pressure shaft / penstock alignment and power house, switchyard and tail race channel and in addition, surveys along tentative alignment of approach road required for project implementation has also been carried out. The general layout plan is given in drawing no 1355-CD-103 and details are discussed below:

Barrage & Desilting Area

An area covering 2000 m upstream and 1000m downstream of the diversion barrage / desilting tank has been surveyed on 1:1000 scale with 1 m contour interval. Cross-Section of Tons river has been taken along proposed axis of diversion site and at a regular interval of 200 m. Cross section of the river has been taken along 12 locations upstream of barrage axis, one at barrage axis and two locations downstream of barrage axis.

Barrage has been proposed at average river bed EL 1145m. Survey plan of barrage location for Mori Hanol is indicated in drawing no. 1355-CD-203.

Water Conductor System

The water conductor consists of Head Race Tunnel. The length of head race tunnel is 11116 m. The survey along the headrace tunnel and construction adits covered area of 500m on either side of the proposed tunnel alignment. In addition survey is also carried out for longitudinal profile of all Nallahs joining Tons river in this reach for selecting the best suitable option for its alignment of water conductor system. The detail of survey for water conductor system is indicated in drawing no. 1355–CD-401.

Surge Shaft and Pressure Shaft / Penstock

The area covering Surge shaft extending up to a width of 300m on both side and penstock extending up to a width of 500 m on either side of penstock alignment has been surveyed to a scale of 1:1000 with contour interval of 1m.

The L-section of the pressure shaft has been prepared on scale of 1:1000. Details of Surge shaft area and penstock alignment are given in drawing no. 1355-CD-501. The L-section along pressure shaft alignment has been shown in drawing no 1355-CD-502.

Powerhouse Site

Two alternative locations for powerhouse were studied i.e. one with surface power house option and one with underground power house option. First being near village Shakriyan and second being about 500 m upstream of first location. Later on based on detailed studies of both options, first location with surface powerhouse was finalized where ample flat land is available for locating powerhouse as well as switchyard.

An area covering the proposed locations of powerhouse, switchyard, and tailrace channel has been surveyed and plotted on 1:1000 scale with contour interval of 1m. A longitudinal section along the penstock alignment has been prepared and shown in drawing no. 1355-CD-502.

Approach roads

Power House

Existing unmetalled road for Power House location is to be widened and matelled for approach to power house. A bridge is proposed at Tons river to reach proposed power house site. From bridge approach roads are planned to Powerhouse, Surge Shaft, Adit-4 and Adit-5. Survey with 1m contour interval has been carried out for the alignment of this road network.

Barrage

Survey was also carried out for road alignment on left bank of Tons River for the approach road to diversion site with 1m contour interval. These approach roads have been indicated in drawing no 1355-CD1001.

Cross- Sections of Tons River

In order to prepare area elevation capacity curve and for calculating the reservoir area and elevation for the requisite storage for peaking, cross sections of Tons river have been taken as per following details.

- In the barrage area i.e. 2000 m upstream of diversion site to 1000 m downstream of diversion site, Cross-sections of Tons River have been prepared at an interval of 200 m. Total cross-sections in this area are 15 numbers (12 no. on upstream, one at diversion axis and 2 numbers at downstream).
- Cross sections of the river have also been taken at 50 m interval for area covering 230 m upstream of diversion axis to 220 m downstream of diversion axis.

Twelve number cross-sections have been surveyed at an interval of 100 m near Power house area for preparing the tail water curve and for calculating the HFL at powerhouse.

Plan and L- Sections

Plan and L-sections of various Nallahs joining Tons river in the project area have been prepared for the planning of Head Race Tunnel and Adits to tunnel. Following are the nallahs for which plan and longitudinal sections have been prepared:

Mautar Gad, Sella (Dhuprati) Gad, Mori Gad, Dathotra Gad, Doba Gad.

L-section covering a reach from bed level of Tons at confluence of these nallahs and up to about EL 1250 to EL 1750m has been covered.

7

HYDROLOGY

7. HYDROLOGY

General

Introduction

The success of any Hydro- Electric Project depends primarily on the availability of water and its planning. The estimation of availability of water depends on the reliability of discharge data which in many projects are not available for adequate length. As a consequence, the underestimation or overestimation of discharge in any catchment may lead to critical problem which will be ultimately affect the design of structure such as dam, barrage, spillway, tunnel,etc. The design of any structure related to water may be considered to consist of three parts, Viz, hydrologic design, hydraulic design and structural design.

The hydrologic design deals with the estimation of quantities of water to be handled at the site of structure; especially their time distribution, time of occurrence and frequency of occurrence. It may not be economically feasible to design the structure to withstand the severe most and rare flood. The problem is to find not only the magnitude of flood discharge but also its probability of occurrence so that the structure may be designed for such a discharge. Apart from these, excessive erosion in the catchment feeds sediment in to runoff which leads to many undesirable effects. The reservoir may lose its capacity at a faster rate which may ultimately produce adverse effect on success of project.

These hydrological studies consist of three components:-

- Water Availability Studies
- Design Flood Studies
- Sedimentation studies (Assessment of annual silt load)

The Project

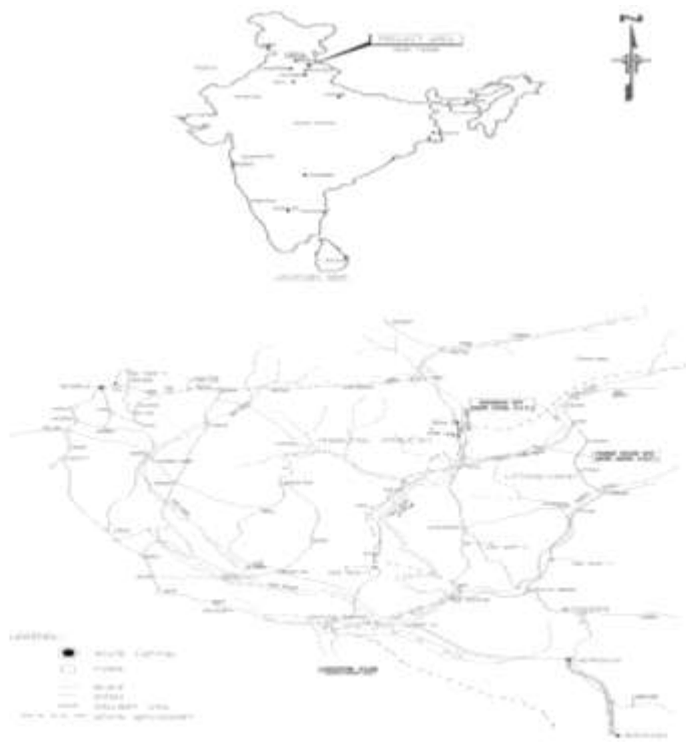
Mori Hanol H.E. Project (Uttarakhand), a run of the river scheme has been proposed on the river Tons in Uttar Kashi District. The project envisages construction of a barrage on river Tons and diverted water shall be carried through a water conductor system (Tunnel) planned on the right bank of Tons river.

The salient features of the project are given below:

- State Uttarakhand
- District Uttar Kashi
- Location of Diversion site Mori
- Location of Power House Hanol
- River Basin Tons/Yamuna
- River Tons
- Latitude of Diversion axis 78°2’23” N
- Longitude of Diversion axis 31°1’1” E
- Catchment Area 1570 Km2
- Installed Capacity 64 MW
- River Bed Elevation 1145 m
- Full Reservoir Level 1160 m
- Minimum Draw down Level 1156 m
- Proposed Diversion Structure Barrage
- Water Conductor System Tunnel

Location of Project Area

In order to generate power it is planned to harness the water of river Tons in phase wise manner. The location of the project has been shown in below figure.



Location map of Project

Water Availability Study

Water availability study as done in DPR is from the Year 1977-1999 and it is to be said as Step-I. For further extending the series up to year 2014, authentic discharge data measured at Hanol (2004-2014) has been used and an extended yield series at diversion site (Mori) for the year 2000-2014 has been developed and it is to be said as Step-II.

The yield series at diversion site developed by Step-I (1977-1999) and Step-II (2000-2014) has been combined and a complete yield series from (1977-2014) for 37 years has been developed. The detailed methodology adopted for Step-I and Step-II has been explained below.

STEP-I (1977-1999)

Introduction

Mori Hanol H.E.Project (Uttarakhand), a run- of- the- river scheme, envisages construction of a barrage on Tons river and its latitude and longitude is 78°2’23”N and 31°1’1”E respectively. The total catchment area is 1570 Sq. Km., out of which 252 Sq. Km. (above EL 4500 m) is covered with permanent snow. It is proposed to generate power to the tune of 64 MW.

Design Requirement

As the proposed diversion structure is barrage with pondage for meeting the peak demand, the minimum length of discharge data of 10 years on 10- daily basis is essential for simulation studies.

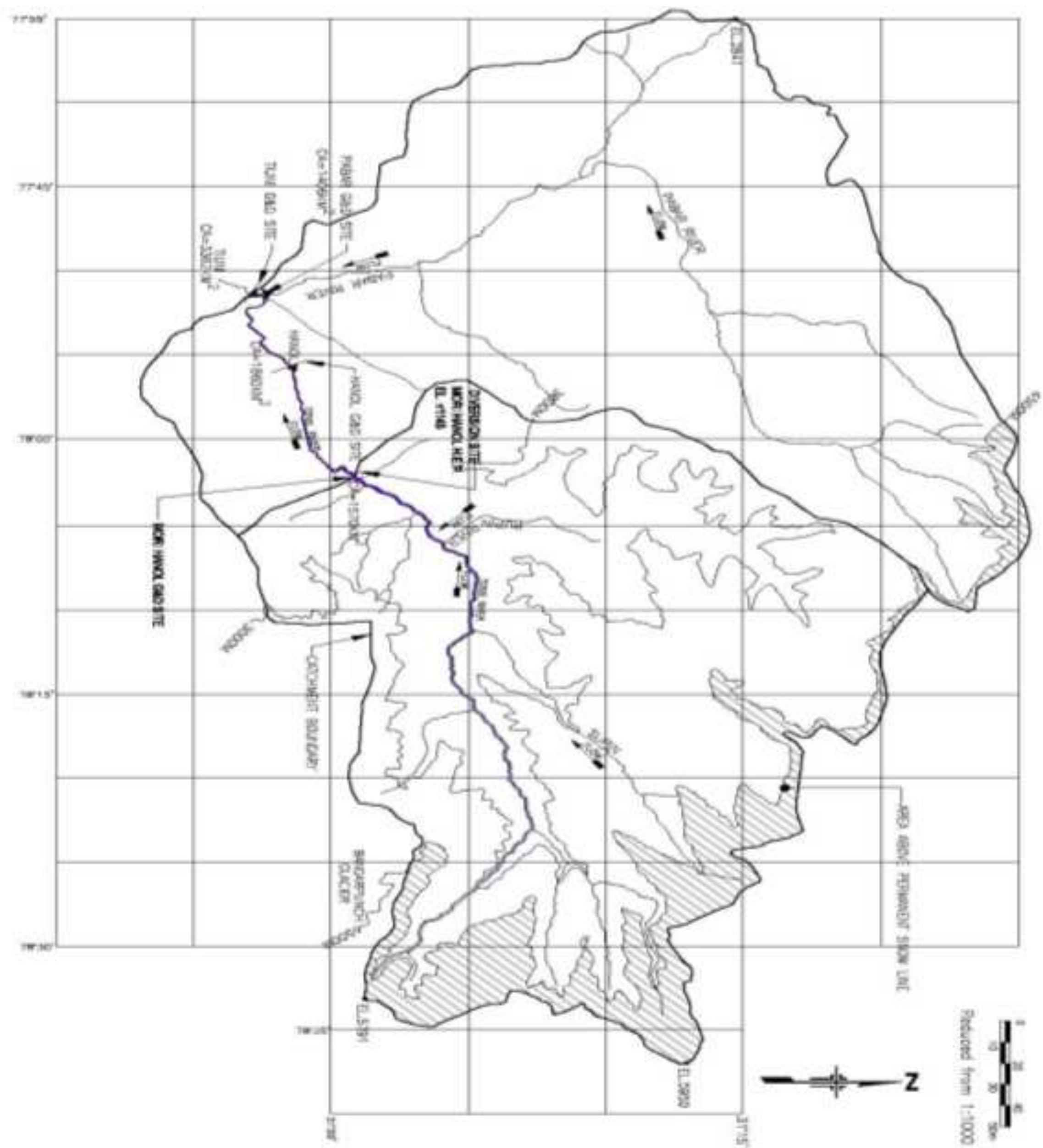
Data Availability

Discharge data :

Discharge data availability

S.N.	Name of Gauge and Discharge Observation site	Period of Availability
1.	Tuini	1947-1999
2.	Pabar	1977 -1999
3.	Hanol	May 2004 –October 2014

Location of Proposed diversion site and different gauge and discharge site has been shown in Figure below



Contour map showing proposed diversion site along with Guage and Discharge sites

Location Map for Upper Yamuna Catchment

Rainfall

Rainfall data has not been made available .However; on perusal of isohyetal map of region it is found that average annual average rainfall above Tuini may be around 1200 mm.

River Characteristics

Yamuna River Basin

The Yamuna is the most important tributary of Ganga joining it on the right bank. It receives in its turn on the right a large tributary, the Chambal and four other important tributaries, the Hindon, the Sarda, the Betwa and the Ken. It rises from Yamunotri Glacier in Tehri Garhwal district of Uttarakhand at an elevation of 6330m. Many small streams, the Rishiganga, the Uma and Hanuman Ganga and several others join it in the mountains. The Tons, the longest tributary rise at an elevation 3900m and join Yamuna below Kalsi. At this site, The Tons carries twice the water that is carried in the Yamuna. The Giri river rises near Shimla and joins Yamuna near Paonta.

The Yamuna emerges from the hills near Tajewall where the water is taken off by the western and eastern Yamuna canals It flows further 280 Km down to Okhla in Delhi territory from where the Agra canal takes off. The Hindon 256 km long rises in the district of Sharanpur and joins the Yamuna on its left bank 40 km below Okhla. From Delhi at 130 Km is located the holy place of Mathura and further down 50 km the city of Agra with the world famous Taj Mahal as its principal tourist attraction. It flows in the south easternly direction till it reaches Allahabad. Small tributaries like, the Karan , the Sagar and the Rind join it on its left bank and the Chamba, the Sind, the Betwa and the Ken flowing from the Vindhyas join it on its right bank. The total length of the Yamuna from its origin to Allahabad is 1376 km; the drainage area is 366,223 sq. km of which 139,468 Sq. Km is the drainage area of the Chambal alone.

Tons River Basin

Tons river is important tributary of the Yamuna river. Tons river joins Yamuna at Kalsi in the Northwestern part of Dehradun Valley, which is about 48 km away from Dehradun. Its source lies in the 6316metre (20720 Feet) high Bundar poonch and is one of the most perennial Indian Himalayan river. The origin of the Tons river is at the convergence of two feeder streams- the Supin river from the Northern part of the Tons catchment near the Himachal Pradesh and Uttarakhand border and Rupin river rises from a glacier at the head of famous Har-Ki- Dun valley in the North –North Eastern

Part of Tons Catchment. These two feeder streams converge near the mountain hamlet of Naitwar and the Channel downstream of Naitwar is known as Tons river. The river flows along a V-shaped valley.

River Tons carries almost twice the volume of waters as the Yamuna and is considered as the principal source of that river. Another important tributary, the Giri rises further north-west of the Tons draining areas in Himachal Pradesh.

Pabar River basin

Pabar is the major tributary of Tons river. The Pabar River originates in the Gangdari Dhar ranges of the Great Himalayas. The river flows in a southwesterly direction down to Rohru Township, some 55 Km from its source where it turns in southeasterly direction. Some 20 Kms southeast of Rohru the Pabar River leaves Himachal Pradesh territory and enters Uttrakhand. The Pabar River joins the Tons River near Tiuni .Three rivers namely Yamuna, Tons and Pabar has been shown in Figure No-6.3.

Drainage Pattern and Geological characteristics of the catchment

Overall drainage pattern in both the sub-catchment (Tons and Yamuna) show the well recognized tree –branch like pattern known as Dendritic drainage pattern. The Tons catchment falls within the geological region of the outer Himalayas. Though complex in nature, the following geological formations are generally encountered in the area

- The Chandpur Series mainly slate with Quartzite and Phyllite and tentacles of limestone.
- Nahan series- Sandstone and Claystone,
- Talcs upper (Quartzite)
- Talcs Lower Slate, Phyllite,Shail and Limestone

The catchment area covering the upper reaches of the river consists mainly of metamorphosed rocks (Schist, Phyllite, and Gneiss).

Climate

The Himalayas form part of a common mountain system beginning with the Pyrenees and the Alps in Europe and extending right up to eastern frontiers of India and much beyond. The factors influencing the climate of India are many and varied. Some of the factors or phenomena responsible for weather in India lie much beyond its geographic limits. The low pressure system-Western disturbances-visiting northern India in winter originates in Mediterranean region. The furry of monsoon and occasional long dry spells often depend upon temperature and pressure conditions in East Africa, Iran, Central Asia and Tibet. Equally important are the weather conditions in the Indian subcontinent, the Indian Ocean, and the China sea typhoons originate. Similarly, the upper air currents or jet steam also determine the climatic condition in India.

Girdled by the chain of high mountains, the north, even northern India, lying beyond the tropical zone, and acquires a tropical touch marked by the relatively high temperatures and dry winters.

Perhaps the most unifying influence on the varied climatic conditions of India is noticed through the all pervading monsoons.

On the basis of monsoon variations the year is divided into four seasons.

- Cold weather season. (December-February)
- Hot weather season, (March-May)
- South-west monsoon season (June-September)
- Retreating south-west monsoon season, (October-November)

I) Cold weather Season: - The cold weather season starts in early December and at beginning of January the North-East monsoon is full established over India. January and February are typical cold months in most part of India. During this season the temperature distribution over India shows a marked decrease from South to North. In this season a feeble, a high pressure area developed over the planes in North-West and western disturbance bring light rainfall.

II) Hot Weather Season: - The period March to May is a period characterized by a rapid shift of the belt of the greatest heat from south to north. In northern India, it is a period of rising temperature and decreasing pressure.

III) South West Monsoon Season: - The low pressure area of the North Western planes continues to intensify. In early June it is intense enough to attract even the South East trade winds from south of equator. These winds of oceanic origin, extending in to the Bay of Bengal and the Arabian Sea, are suddenly caught off in the air circulation over India. They are deflected inland as South-Westerly winds. The moisture laden winds approach suddenly with violent thunder and lighting. The sudden advent of the violent rain bearing winds is known as the burst or break of monsoon. These rain bearing winds varies from, blowing at an average speed of 30 km/hour. In about a month's time they run over almost the entire country.

IV) The retreating south-west monsoon season: - By October the intensity of rainfall becomes much less. The south westerly monsoon winds gradually retreat, leaving Punjab by mid of September. With retreat of Monsoon the sky clears and temperature increases. In the later of the October the temperatures begin to decrease rapidly, especially in Northern India, and by December winter is well established.

Both the sub-catchments of Tons and Yamuna have very steep valley slopes, with hills on both sides rising upto 500 m above the riverbed and the pronounced orographic features favor a quick runoff. The average rainfall varies in the Tons sub-catchment between 1300 mm to 2000 mm and in the Yamuna sub catchment between 1000 mm to 2000 mm, while the maximum temperature, in either case is about 350C.

Sources of Himalaya Water During the Various Seasons

On account of the peculiar geographic position of India and the diagonal trend of Himalayas the snow conditions in India become unique. From the climatic point of view India has four seasons. Source of Himalayas water during each season are described below:-

A) Winter Season- November or December to About February

Generally the precipitation in high regions in this season is in the form of snow. As the elevation increases, we pass from a zone of rain to a zone of rain-plus-snow and ultimately to a zone of only snow. Only a very little proportion of runoff may be coming down from the zone of rain-plus-snow and some even from portions of snow zone which are exposed directly to the rays of sun. The runoff from higher zones depends mainly on the temperature Viz. higher the temperature higher the contribution of runoff.

This is a season of ground water flow whose duration depends on the retentiveness of the soil. Since monsoon water in India is excess of the capacity of soil, the soil may be considered as saturated every year. Therefore, the time necessary for soil to drain dry can be computed since the date of cessation of ground water flow will depend on the date of ending of monsoon. The period of ground water flow can be found from some rain-fed streams by observing the flow of ground water for a number of years.

B) Snow-melt Season- March to June

Runoff during this season is mostly from snow. Rains occurring during this period do also contribute to runoff but to a comparatively lesser extent. If these rains become more or less than normal, a correction to the forecast of snow-runoff becomes necessary. Temperature is another disturbing factor which may affect the distribution of discharge over the season. If temperature is higher the snow will melt more quickly and more discharge over the season. If temperature is higher the snow will melt more quickly and more discharge will run down in the beginning, leaving less for the closing part of the season, but the total amount of estimated discharge during the season will not change.

Another important point is the moisture content of soil surface which affects the amount of priming required from snow cover. If in a particular year the soil gets primed before the snow-melt starts, e.g.; by rains, the round will absorb less water and, therefore, we shall get relatively more runoff. Similarly, if the soil is too dry we shall get relatively less runoff. This factor will thus affect the total amount of water coming down during the season.

C) Monsoon Season- June or July to September or October

In India this is a season of abundant water. In fact the rivers are in flood and cause in number of cases vast amount of damage to the country along their edges.

Monsoon will generally be early or late depending on whether snowfall in the previous winter was less or more. In India the monsoon mechanism starts with the establishment of low pressure over Northwest India. When the snow is less, the winter is not so persistent and there is a tendency for the monsoon to start earlier. When, however, there is more snow, winter persists and the development of the seasonal low pressure over Northwest India is delayed with consequent delay in the starting of the monsoon.

Permanent Snow Line

“Flood Estimation Report for Western Himalaya, Zone- 7, and (Published by Central water Commission)” covers Indus river system and Ganga river system. Under the Indus river System River Indus, Jhelum, Chenab, Ravi, Beas and Sutlej has been covered and under the Ganga river system river Ganga, Yamuna, Ram Ganga and Sharda has been covered for the purpose of analysis of flood.

The permanent snow lines for all these rivers have been considered at an elevation of 4500 m. During winter season the snow line dips to height about 1800m.

But as per "Manual on planning and designing of small hydroelectric scheme", Publication No. 280 (CBIP, New Delhi) – "Snow covered catchments are found frequently in Himalayas. A catchment is permanently snow covered above an elevation about 4200m above MSL. In winter the snow coverage comes down temporarily below the permanent snow line".

Permanent snow line varies from river basin to river basin. The permanent snow line above an elevation of 4500 m or 4200 m cannot be accepted for all the Himalayan river basin. In Eastern Himalayan basin permanent snow line starts from an elevation of about 5500 m but in Western Himalayan basin permanent snow line starts from 4000 m or even less.

It is well known fact that with increase elevation there is an ever greater proportion of precipitation in the form of snow, and the snow cover remains for longer period. The elevation of the lower limit of permanent snow line is determined by air temperature, slope exposure to sun and depth of snow fall. In India the slopes are very steep and there are hill slope facing north as well south. The hill face facing south would be obviously more exposed to sun than facing north. Similarly, there is difference between in slope facing east and west.

It is clear from the contour map that permanent snow line starts from the elevation of 4500 metres. From the catchment Area map, it is also evident that upper portion of the catchment is studded with glaciers including the famous Bandar poonch glacier which is spread over the upper reaches of Tons, Supin and Rupin.

In the light of above fact the permanent snow line has been considered at an elevation of 4500 m which seems to be reasonable for this catchment.

Method of discharge observation at Tuini and Pabar Site

The flow in the hilly river changes seasonally and from year to year due to temporal and spatial variation in precipitation. The flow pattern of Tons river is no exception to this and it follows the trend of Himalayan rivers in which most of the runoff is available during monsoon months of June to September. Winter rains swell the river flow to some extent for a short situation during the months of December to February. During these winter months, the river runoff is usually minimum. Tons River receives perennial flow and important tributary of river Yamuna.

Velocity-area technique has been used for discharge measurement at Tuini gauge and discharge site. The method involves measurement of river cross-section at discharge measurement site. The total width of River is divided into 12 to 14 vertical sections of 5 m width each and river bed profile is measured at each vertical from the water surface. The River bed profile measurement is planned at beginning and end of high flow season. The area of flow of water at each vertical section is computed and multiplied with the flow velocity measured with the help of float and current meter in each vertical section. The velocity coefficient has been estimated by vertical velocity distribution method.

The velocity has generally been measured by float method but current meter is generally used once in a week to cross check the velocity. The discharge measurement has been carried out by central water commission from 1977 onwards.

Discharge observation at Hanol site

A Gauge and Discharge site has been established at Hanol in April 2004 and discharge observation started from 1st May 2004. Cableways have been installed across the river for the purpose of taking observation. The total width of River is divided into 12 or 14 vertical sections of 5 m width each and River bed profile is measured at each vertical from the water surface. Velocity of flow is measured at 0.6 times the depth of water. The current meter is lowered to water surface from the trolley by the gauge-reader at the selected verticals. The revolutions of current meter are used in calculating the velocities using the rating curve given in the calibration chart. This measurement is taken twice or thrice in each section for each section at 0.6 times of depth for the purpose of an accurate estimate of velocity.

Discharge in each vertical is arrived at after multiplying corresponding velocity and cross sectional area of each vertical. Total discharge is calculated by adding discharge values at each vertical.

Catchment Area Characteristics

The total catchment area of river Tons at proposed diversion site i.e. at Mori is 1570 Sq. Km, out of total catchment area 252 Sq. Km is permanently snow covered area. In absence of observed discharge data at proposed diversion site, available discharge data at Tuini site which is in the downstream of the confluence of Tons and Pabar river has been utilized for the development of the yield series at Mori. The catchment area at different gauge and discharge site are given below in.

Catchment Area

S.N.	PARTICULAR	MORI	HANOL	TUINI	PABAR
1.	Total Catchment Area (Sq. Km.)	1570	1860	3362	1406
2.	Rainfed Area (Sq. Km.)	1318	1608	3079	1375
3.	Snowfed Area (Sq. Km.)	252	252	283	31

8

GEOLOGY AND GEO-TECHNICAL ASPECTS

8. GEOLOGY AND GEO-TECHNICAL ASPECTS

Introduction

The project envisages a 17 m high barrage across the river Tons, about one km upstream of Mori, an 11.116 km long head race tunnel, and a surface power house complex about two km upstream of Hanol. It is proposed to utilize a rated discharge of 68.05 cumec and a gross head of 113 m for generation of the 64 MW of power.

The geotechnical investigations of the 64 MW Mori Hanol Hydro Electric Project have been carried out by the Indo Canadian Consultancy Services Ltd (ICCS Ltd.), Bhilwara Group, Noida. The work involved detailed geological mapping of the project area involving area of 12 sq km on 1:5,000 scale, 0.41 sq km for barrage site including HRT inlet on 1:1000 scale, 0.12 sq km area for the power house site on 1:1000 scale, and an aggregate area of 0.14 sq km for the portal sites of five adits (Nos. 1, 2, 3, 4 and 5) on varying scales of 1:500 to 1:2000. Identification of probable construction material quarry sites through traverses in the project area, have also been carried out.

Regional Geology

The project area falls in the Lesser Himalaya and is disposed about 58 km from Main Boundary Fault (MBF) and about 25 km from Main Central Thrust (MCT). It is occupied by the rocks of Proterozoic and Palaeozoic age. In a 42 km long section along the Tons River from Naitwar to Tiuni, the rocks of Almora, Ramgarh, Jaunsar and Tejam Groups are found. In general the area is reported to be falling under Purola Schuppen Zone dissected by as many as 5 thrusts, viz. Munsiari Thrust, Jarmola Thrust, Hudoli Thrust, Barkot Thrust and Berinag Thrust. The Munsiari Thrust and Hudoli & Barkot thrusts, in turn are offset by NNE-SSW trending faults. The strata in general are northerly dipping with the exception of tightly folded sequence underlying Hudoli Thrust in Bathotara Gad area where large scale dip variations are shown.

The augen gneisses and associated rocks of Almora Group occurring upstream of Mori and near Purola have also been referred to as Purola Crystallines (GSI). The contact of this unit with the quartzite of Jaunsar Group is considered a thrusted one and termed as Purola Thrust (Munsiari Thrust of Valdiya). Unlike the Munsiari Thrust, that is shown offset by a NNE-SSW fault, the Purola Thrust has been shown as a normal feature (GSI). As it takes a sudden northward bend on the right bank of Tons R., after following a WNW-ESE course along the Gadu Gad near Mori, its normal disposition is difficult to explain. The offset by a fault, as shown by Valdiya, is more likely.

Traverses upstream of the project area reveal that the Purola crystallines comprise three distinct units, viz. biotite gneiss, augen (pebbly) gneiss and mica schist. The augen gneiss occurs in the middle and is conspicuously found between Mian Gad and Salra Gad confluences with the Tons. The mica schist occurs upstream of the augen gneiss and predominates Naitwar area, that is plagued by rock slides on the left bank of Tons. On the other hand, the biotite gneiss occurs downstream of the augen gneiss and continues up to the Purola thrust.

The Regional Stratigraphic Sequence in the Naitwar-Tiuni section is given below

Group / Formation	Lithology	Age
Ramgarh Gr. (Barkot Fm.)	Phyllite, schistose phyllite, sericitic flaggy quartzite,	Devonian
Jaunsar Gr. (Berinag Fm./ Sandra Fm.)	Quartz arenite with amygdaloidal, vesicular dolerite and tuffite	
Tejam Gr. (Mandhali Fm.)	Slate, conglomerate and limestone	Proterozoic
Damtha Group (Chakrata Fm.; Rautgara Fm.)	Greywacke, siltstone, slates ; Muddy quartzite, olive green & purple slates	
Almora Gr. (Munsiari Fm.)	Crystallines represented by gneiss, Schist, quartzite	

Site Geology

General Geology of Project Area

In the project area the River Tons flows in a general NE-SW direction and descends from El. 1145m at the barrage site to El. 1040m at powerhouse at an average gradient of about 1:100. The left bank tributaries Gadu Gad and Khuni Gad are remarkably in linear continuity with their right bank counterparts, viz. Mautar Gad and Bathotara Gad respectively. These locations are marked by the presence of two important thrusts viz. Munsiari / Purola Thrust close to Gadu Gad and Mautar Gad confluences, and Hudoli Thrust at the Khuni Gad and Bathotara Gad confluences. The project area, in general has a moderate relief of about 700 m with ground elevations rising up to 1760m.

The course of the river is characterized by intermittently located large river terraces and a few alluvial fans. Generally three levels of terraces are found at most of the locations but four levels have been found at barrage and powerhouse sites.

The project area is occupied by the rocks of Purola Crystallines, Berinag Formation of Jaunsar Group and Barkot Formation of Ramgarh Group. Purola Crystallines represented by gneiss and schist occupy only a small section of the project area. It is found exposed upstream of Gadu Gad confluence on the left bank of Tons River and in a narrow, elongated stretch on the right bank. The Berinag Formation is represented by quartzite and occupies major portion of the project area. It is continuously exposed downstream of Gadu Gad confluence up to about 500m upstream of Khuni Gad confluence, i.e. an overall stretch of about 8 km. Upstream of Gadu Gad it is exposed as high cliffs on the right bank beyond the narrow stretch of Purola Crystallines. Barkot Formation is represented by phyllite, schistose phyllite, schist, limestone and quartzite with slate bands. As explained earlier, the contact between the Purola Crystallines and the Jaunsar quartzite is interpreted to be a thrusted one viz. Munsiari / Purola Thrust. On the right bank of Tons, upstream of Gadu Gad, this contact could even be a faulted one that offsets the thrust. The contact of the Jaunsar quartzite with rocks of Barkot Formation is also interpreted to be a thrusted one viz. Hudoli Thrust. The strata in the project area predominantly dip upstream at moderate to low angles. This is particularly true for the entire stretch of Jaunsar quartzite. Upstream of Gadu Gad, the rocks dip in opposite directions on the river banks making the Tons valley as an antiformal valley. Large variations in dip directions due to tight folding are found in the area around Bathotara and Khuni Gad. A prominent body of basic rock (Dolerite) is also found associated with these rocks.

Discontinuity analysis

Discontinuity data collection and analysis, mostly of joints, have been carried out separately for Jaunsar quartzite and Ramgarh Group of rocks. In all, 240 discontinuity readings have been taken in Jaunsar quartzite and 64 in Ramgarh Group of rocks. The data analysis has been done using GeOrient software. The identified joint sets are tabulated below :

Joint sets in Jaunsar quartzite

S. No.	Joint Set No.	Dip (dir/amt)
1	J1	227/61
2	J2	044/35
3	J3	036/75
4	J4	318/89

Joint sets in Ramgarh Group of rocks

S. No.	Joint Set No.	Dip (dir/amt)
1	J1	333/18
2	J2	027/77
3	J3	155/83
4	J4	016/65

Joints sets in project area (combined for Jaunsar quartzite and Ramgarh Group of rocks)

S. No.	Joint Set No.	Dip (dir/amt)
1	J1	044/34
2	J2	319/22
3	J3	110/73
4	J4	228/62

From the above data, it is found that the steeply NE dipping joints (N027-036/75-77) are common to both Jaunsar and Ramgarh rocks. Other threes sets differ in both these units. Hence, respective joint sets have been used for data analysis and site assessment.

Geology of Barrage site

Although the barrage with its appurtenant structures is interpreted to lie entirely within Purola Crystallines, the Jaunsar quartzite is disposed just adjoining the site on the right bank and exposed close to the inlet portal location of the HRT. The site is predominantly under overburden cover (Photograph-1). While the left bank of the river is almost occupied by river terraces with sporadic rock outcrops of biotite gneiss, the lower elevation reaches of the right bank are occupied by a river terrace that culminates into colluvium covered moderate slopes with outcrops of chlorite gneiss & schist and overlying quartzite. The left bank exposes a complete sequence of river terraces from T0 to T3. The terraces T0, T1, T2 and T3 are at El. 1146m, 1150m, 1181m & 1190m respectively. On the right bank only terraces T0 and T1 are exposed and these are located at El. 1147m-1150m and 1150m-1157m respectively. The mode of occurrence of the river terraces suggests that the thickness of the river borne material may be considerably high, say over 25m.

Photograph-1:Barrage site; downstream view

The gneisses on the left bank have moderate dips of 30º–50º in N090-130 direction, i.e. into the hill. On the other hand, the gneiss, schist & quartzite on the right bank have generally low dips of 10º-25º in N290-320, again in to the hill on that side. Steepening of dips to 40º is noticed. The opposite dip directions on the two banks are suggestive of an antiformal structure and qualify the Tons valley as an antiformal valley in this part of the project area. The rocks are moderately jointed with the joints belonging to sets N120-140/60-85, N200/82, N050-060/65-80.

The contact between the Purola gneiss & schist and the Jaunsar quartzite on the right bank could either be a thrusted or faulted one.

Geology of Head Race Tunnel

The 11.116 km long HRT traverses a moderately dissected terrain with elevations rising up to El 1760 m near Mora Village. The groundcover over the tunnel varies between the minimum of 35m at Doba Gad and maximum of 631m near Mora Village. The tunnel cuts across five major nalas where ground covers vary between 35m and 69m. There are other minor gulleys and nalas where the ground cover over the tunnel is expected to be satisfactory.

The area around HRT is characterized by vast stretches of rock and overburden alike. The river terraces are conspicuous. In general, extensive rocky stretches are found in the spur of the Mautar Gad and Tons and in a 3 km long stretch from Salla Village to just u/s of Khuni Gad confluence with the Tons (Photograph.2). Among the conspicuous overburden covered reaches, Bathotara area opposite Khuni Gad is the most extensive and conspicuous. Mautar Gad is another predominantly overburden covered section.

Photograph-2: Rocky stretch between Mora and Khuni Gad

The Jaunsar quartzite constitutes the predominant rock type along the HRT. Barring a limited portion in gneiss & schist at the HRT inlet portal, quartzites occupy about 3/4th area of the HRT towards upstream and are found continuously exposed for a 9 km stretch from the barrage site to Ugmer Village, opposite Khuni Gad (Photographs.3&4). The rock is predominantly white in colour and contains occasional veins of quartz. Upstream of Salla, it is frequently friable in nature.

Photograph-3: Quartzite on left bank of Mautar Gad

Photograph-4: Shear zone near Khuni Gad Bridge

The rocks of Barkot Formation occupy the downstream 1/4th area of HRT and can be divided into three parts, viz interbedded phyllite and limestone in Ugmer area adjoining the Hudoli Thrust, interbedded schist and quartzite in the middle around Bathotra-Bindri villages, and schistose phyllite and schist in the powerhouse area. The Barkot quartzite is micaceous and friable. Interbands of slate are common close to the suspension bridge at Khuni Gad. The ridge west of Ugmer Village, exposes limestone and brecciated limestone in its upper reaches. Dark grey in color, the brecciated limestone has fairly big angular fragments set in a fine grained matrix. This rock has been interpreted as Collapse Breccia and, hence, may not have any tectonic implications. Limestone outcrops are found to have small but conspicuous solution cavities on the surface of the ridge. The schistose phyllite is chloritic and contains mica and quartz. A conspicuous basic rock body (Dolerite) has been found in Ugmer-Bijoti area as extensive colluvial material. Exposures of this rock type are limited.

The mode of occurrence of rock formations favours the presence of Purola/ Munsiari Thrust at the barrage site and the Hudoli Thrust in Khuni Gad area. The possibility of the gneiss-quartzite contact being a faulted one, instead of a thrust (Purola), is quite likely. However, evidences of any large scale crushing or shearing along this plane have not been found. The Hudoli Thrust, on the other hand, is largely under the cover of overburden and it may not be possible to comment upon crushing along this plane. The evidences for the existence of the third thrust, viz. the Jarmola Thrust, have not been found. Therefore, the HRT area may be considered as traversed by two thrusts.

The rock dips are predominantly moderate to low in northeasterly direction. In the Mautar Gad-Sandra area, the dip of quartzite is N 020/18 and N 010/30. In the Dhumrali Gad (Salla area), quartzites dip N 060/45 and N 050/48. In Salla-Mora section, the dips are N050/48. Northeasterly dips of N 040/ 20 are found in Mori Gad section near Mora Village. Around Mandal Village, the rocks dip N 040/25.

Contrary to nearly uniform dips in Jaunsar quartzite, the rock dips are highly variable in the Barkot units in Ugmer-Bathotara-Bindri area. This is attributed to considerable tectonic disturbances in this sector including tight folding. In general, the dip pattern is indicative of synclinal and antiformal structures. Some of the prominent foliation dips in this sector are N040/30, N260/55, N345/20 and N190/45.

In the HRT outlet area, the foliation dips of N 345/20 are once again uniform.

The shear zones found in the strata are invariably parallel to the bedding/ foliation. The thickness of the shear zones is found to be 2cm (Salla Village), 5cm (Mandal Village), 10cm (d/s of Mora Village) and 30cm (Bathotara Gad & Mora Village). The sheared material varies from crushed rock to clay gouge.

Geology of Powerhouse Complex

The site for the surface powerhouse in located adjoining Sarkhyan Village, about 2 km upstream of Hanol Village (Photograph.5). The site can be considered mostly rocky as the slopes are covered with sporadic, presumably shallow overburden patches. The information obtained from drill holes indicate that overburden thickness is least on the hill top near surge shaft location, gradually increasing down the slope. Base of the slope is marked by thick terrace deposits at the powerhouse location. The site lies over schistose phyllite and schist (Barkot Formation of Ramgarh Group) that dips fairly uniformly at 20°-25° in N345-N010 direction (Photograph.6) The rock is moderately jointed with joints belonging to sets N320/35-40, N160-190/78-82, N110-130/55-75.

Photograph-5: Powerhouse site

Photograph-6: Schist at Powerhouse site

Subsurface Exploration

Subsurface exploration through 12 drill holes aggregating 517.25m depth has been carried out for various components of the project. In all, three bore holes viz. BDH-1, BDH-2 and BDH-3 aggregating depth of 111.85m, have been drilled in barrage area, six bore holes viz. HDH-1, HDH-2, HDH-3, HDH-4, HDH-5 and HDH-6 aggregating depth of 281m, have been drilled along the HRT alignment; and three bore holes viz. PDH-1, PDH-2 and PDH-3 aggregating depth of 124.4m, have been drilled in powerhouse complex area.

Geotechnical Evaluation

Barrage

The Barrage site is occupied by river borne material (RBM) comprising boulders and pebbles embedded in sandy and silty matrix. Drilling in the area has suggested the thickness of RBM to be over 40.7m well below the deepest foundation level of barrage (El.1130m). The Barrage is proposed to be 17m above river bed level and 32m high from the deepest foundation level. The deepest foundation of the upstream cut-off-wall of the Barrage is proposed at El. 1141.5m; that of the energy dissipation arrangement (EDA) at El. 1132m; and that of the downstream cut-off-wall at 1130.0m. The Barrage and its appurtenant structures therefore, would be designed as floating structures founded over heterogeneous river borne material of medium permeability that is dominated by sand and pebbles/boulders of gneiss and quartzite. The proportion of sand to pebbles/ boulders is interpreted to be 70% & 30% respectively. The desilting basin and its appurtenant structures including intake, are located over terrace T1 on the right bank. The terrace is characterized by presence of big boulders closer to the river. The deepest level of the desilting basin would be at El. 1149.0m. As such this would also be designed for permeable heterogeneous foundation.

On the left bank of the River Tons, the proposed barrage would abut against the steep valley side face of river terrace T2 that is 10m high and is considered stable in its present state. However, abutment excavations would require appropriate slope design and stabilization. The slopes above are much gentler and stable.

On the right bank, while the barrage and the adjoining desilting complex would rest over river terrace T1, the Guide Wall beyond that would abut against the oberburden slopes in a limited height of only 3m. These slopes also are stable in their present state. The slope excavation for abutting the Guide Wall may not be much and would require only limited stabilization measures.

Summary of results of drilling

S. No.	Component	Bore Hole No.	Location	Depth of Drilling (m)	Depth to Bedrock (m)	Remarks
1	**Barrage**	**BDH -1**	66m d/s of barrage axis; Left bank	**40.70**	**-**	Bed rock is not encountered up to the final drilling depth.
2		**BDH -2**	Barrage axis; Right bank river edge	**35.60**	**-**	Bed rock is not encountered up to the final drilling depth.
3		**BDH -3**	12 m d/d of Barrage axis & 43m towards right bank from BDH-2	**35.55**	**-**	Bed rock is not encountered up to the final drilling depth.
4	**HRT**	**HDH -1**	HRT Inlet portal	**45.00**	**1.0**	Encountered shear zones wit gouge that may be associate Purola Thrust Zone. Main purpos establish rock conditions at inlet and develop the design of slope portal.
5		**HDH -2**	Mautar Gad crossing; Left bank	**45.55**	**12.0**	Main purpose is to find the depth to bed rock and subsurface rock conditions.
6		**HDH -3**	Mautar Gad crossing; Right bank	**50.05**	**21.0**	Main purpose is to find the depth to bed rock and subsurface rock conditions.
7		**HDH -4**	Dhuprati Gad crossing (near Salla Village)	**45.10**	**3.0**	Main purpose is to find the depth to bed rock and subsurface rock conditions.
8		**HDH -5**	Mori Gad crossing (near Mora Village)	**45.30**	**16.50**	Main purpose is to find the depth to bed rock and subsurface rock conditions.
9		**HDH -6**	Bathotara Gad crossing (near Bathotara Village)	**50.00**	**4.5**	Main purpose is to find the depth to bed rock and subsurface rock conditions.
10	**Powerhouse Complex**	**PDH-1**	Powerhouse	**30.00**	**-**	Main purpose is to find the depth to bed rock for designing foundation of the powerhouse.
11		**PDH-2**	Surge shaft	**63.65**	**2.0**	Main purpose is to find the depth to bed rock and subsurface rock condition up to the total depth of surge shaft.
12		**PDH-3**	Penstock alignment	**30.75**	**6.0**	Main purpose is to find the depth to bed rock along the hill slope for designing anchor blocks for penstock.

As the barrage and its appurtenant structures are located over river borne material (RBM), the seepage from the pondage area is considered a matter of some concern. Depending upon the results of permeability tests in the barrage site drill holes, provision of clay blankets may have to be considered.

A seasonal nala flows through the barrage site on the right bank. This nala needs to be drained and diverted upstream of barrage, so as to debouch into the pondage area.

Head Race Tunnel

A major portion of the 11.11 km long, 6.4 m dia, horse shoe shaped HRT is interpreted to cut across the Berinag quartzite in its upstream section. The total estimated length of the tunnel through this rock is 8241 m, i.e. 74.18 % of the total length of the tunnel. Remaining 2869 m length of the tunnel is estimated to pass through 123 m of Purola gneiss/schist (1.11%) and 2746 m (24.72%) of Barkot formations represented by interbedded phyllite and limestone (1184m, 10.66%), interbedded schist and quartzite (765m, 6.88%), and schistose phyllite and schist (797m, 7.17%). The proportions of lithological varieties in Barkot Formation, downstream of Hudoli Thrust, are subject to large variations in view of the structural complexities. These may have to be investigated thoroughly during construction phase when the improved communication network facilitates such studies. Advance probing during tunneling would also throw light on this aspect.

The tunneling media has been classified based on Rock Mass Quality “Q” that has been calculated from discontinuity data of rock outcrops. The Rock Mass Rating “RMR” of the strata has also been calculated for correlation purposes. Rock mass has been divided into five categories – from Class-I to Class-V – and excavation and support methodologies have been given for each class. It may be seen that the rock mass along the tunnel generally falls under rock class categories I to IV with a limited section of Class-V rock at the HRT Inlet. However, more Class-V rock may be expected in zones of shearing, faulting and thrusting. As the rock classes have been projected at the tunnel grade on the basis of field measurements, these may be treated as tentative and actual rock class categorization may be carried out during construction phase through advance probing.

While the major portion of the tunnel is interpreted to fall under rock class - II (6734 m length, 60.6 % of total tunnel length), the proportion of rock under classes I, III and IV is interpreted to be 450 m (4 %), 2362 m (21.3 %) and 1566 m (14.1 %), respectively. Presence of class-V rock would lead to reduction in the proportions of rocks of other classes.

The intersection of thrust zones, viz Purola and Hudoli, along with major shears, present special tunneling conditions of very poor category. The thrust zones need not be necessarily in a crushed and gougy state. However, caution needs to be exercised while driving these well defined zones. The Purola Thrust is interpreted to be intersected in the HRT inlet zone itself. The 45m deep drill hole HDH-1 at this site has revealed very poor rock conditions with very poor RQD/ 'Q' and as many as four shear zones – two with clay gouge. The tectonically more disturbed area d/s of Hudoli Thrust may present tunnelling problems greater than those indicated by the rock mass classification. Shear zones, on the other hand, may not be very uncommon and may have to be tackled carefully.

In general, subsurface water in the tunnel is expected to remain normal with low seepage conditions. Precaution, however, may be exercised under nala beds like Mautar and Mori Gads. Perched water tables are difficult to predict, but, advance probing may help in forecasting such zones leading to appropriate measures.

While emphasis is laid on rock bolts and shotcrete for Rock Classes-I to IV, steel ribs may be required in Class-V rock. Full face excavation may be advisable in Classes I to III, while heading and benching may have to be adopted in Classes IV and V. Provision of drain holes may be required in zones of high seepage. Forepoling and pipe roofing may be needed across crushed zones.

Advance probing is of utmost importance and may be carried out in sections of at least 15m length with about 3m overlap. Besides picking up vulnerable zones, this would help in dependable rock class categorization and adoption of appropriate excavation and support technology.

HRT inlet portal is dominated by overburden. Bed rock of quartzite is exposed only in upper section, i.e. above El. 1185m. The 45m deep bore hole at this location suggests presence of fairly fresh to moderately weathered gneiss, schist, amphibolite and vein quartz. The strata are interpreted to be traversed by as many as four shear zones that collaborate the presence of Purola Thrust almost at the drill hole location. The overburden is characterized by coalescing debris cones near the base of the hill slope (El. 1165m approximately). The 35-40m deep excavations for developing the HRT portal and for creating about 10m deep intake pool, therefore, would encroach upon the toe portions of both these debris cones. Coupled with poor bed rock condition, this calls for elaborate designing of the slope cuts and appropriate stabilization & slope draining arrangements.

The HRT alignment has been explored through six drill holes for bedrock condition and vertical rock cover available across all the major nalas, viz. Mautar Gad (HDH-2 & HDH-3), Dhuprati Gad (HDH-4), Mori Gad (HDH-5) and Bathotara Gad (HDH-6). Based on drilling results, the minimum vertical rock cover over HRT crossing is 42m at Mautar Gad, 52m at Dhuprati Gad, 44m at Mori Gad and 58m at Bathotara Gad. At all these locations, the rock cover over HRT has been found to be adequate. The HRT stretches across all these nalas may face difficult tunneling conditions due to Poor to Very Poor category rock rock coupled with possible water ingress, and have been adequately taken care of while determining rock mass classification of HRT.

The 3D wedge analysis of HRT has been carried out using UN WEDGE software for identification and analysis of critical wedges, around the excavated boundaries, if any, of Head Race Tunnel for Mori-Hanol HEP, Uttarakhand.

Rock Classes and Recommended Support/ Excavation Technology

ROCK CLASS	EXCAVATION/ SUPPORT
Class-I & II Good Rock (Q=10-100)	*25mm dia Spot Bolts 3000 Long@ 2500 c/c and 50 TH. Shortcrete * 38mm 5000 Long Drain Holes as required(During construction only)
Class-III Poor Rock (Q=4-10)	*25mm dia Rock Bolts 4000 Long@ 2000 c/c (Staggered) * 75 TH Shortcrete with wiremesh * 38mm 5000 Long Drain Holes As required(During construction only),
Class-IV & V V. Poor Rock (Q=0.01-4)	*25mm dia Rock Bolts 4000 Long@ 2000 c/c (Staggered) * 100 TH Shortcrete * ISHB 150@ 500 c/c RCC Lagging * 38mm 5000 Long Drain Holes As required(During construction only), Fore poling/ Pipe roofing as required.

Note: * All dimensions in mm.
* Advance probing for 15m length with at least 3m overlap is strongly recommended all through tunneling.

Adit Portals

Based on preliminary layout of the HRT, self draining adits were planned and portals selected on the basis of desk studies. Field investigations were carried out to identify stable rocky portals as close to the planned portals as possible.

The portal faces may require normal slope stabilization through rock bolting and shotcreting.

Powerhouse

The powerhouse complex, in general, is located over stable slopes comprising schistose phyllites and schists. Having moderate, in-to-the-hill foliation dips, the rocks are favourably disposed. Besides foliation joints, the rock is dissected by three sets of joints dipping N190/80, N130/55 and N320/40. Two of these sets are valley dipping, but due to their steeper dips, do not daylight in to the natural slopes. The other two sets have dips in to the hill.

The surface Powerhouse is located over terraces T1 and T2. The drill hole PDH-1 located on the river terrace T1 (El.1048m) confirmed the thickness of river borne material of medium permeability to be minimum 30.0m. Thus, powerhouse complex would be located in the terrace material as rock is not available up to the deepest foundation level of powerhouse i.e.1038m. Hence, this would be designed for overburden foundation.

The Penstock is located over moderate rocky slope with sporadic shallow overburden. The hole PDH-3 located at penstock alignment has established colluvium thickness to be 6m that is considered exceptionally high. But, going by the generally rocky hill slope and patchy overburden seen at the site, bed rock may be expected for most of the anchor blocks. Any undue stability problem may not be expected for the anchor blocks.

The 65m deep, 18m dia. Surge Shaft is located in rocky area at El. 1185m. The drill hole PDH-2 has intersected slightly to moderately weathered quartz mica schist at a shallow depth of 2m. Thus, Surge Shaft is to be excavated through rock for almost its entire depth. Rock is found to be of Poor to Fair Category (Q value 1.06-4.9), with poor RQD. The four sets of joints make the strata blocky that have sliding tendency along foliation and set J2 joints that have inclinations of about 30 & 55, respectively. The joints of set J2 may be considered more critical. By virtue of the dip directions of the ruling joints, the northwestern and southern faces of the Shaft are more vulnerable for block failures. These two would, therefore, be provided additional support through rock bolts and shotcrete.

Construction Material

For the construction of barrage, HRT, powerhouse and ancillary structures of the project, an estimated 2,50,000 and 1,40,000 m3 of coarse and fine aggregates, respectively, would be required. The sources for the construction material could be the excavated muck from the HRT, rock quarries and river terraces. As the major portion of the HRT is to be excavated through quartzite, much of the excavated muck could be considered for use as coarse aggregate. This alone is estimated to provide 4,63,950 m3. It may, however, be pointed out that the quartzite muck from HRT u/s of Adit-2 may not be suitable as it is mostly friable. Quartzite from Bathothara section of HRT could also be considered, but, the quantities there are uncertain in view of the complex tectonic setup d/s of Hudoli Thrust. Other rock types like phyllite and schist are not considered suitable. The muck generated from excavation for the barrage and ancillary structures would be only RBM that could provide some portion of the coarse and fine aggregates.

For the rock quarries, 4 km long stretch of extensively exposed quartzite from d/s of Salla Village to u/s of Khuni Gad offers prospective sites. Three quarry sites identified in this stretch lie on the right bank of the River Tons and include RQ-1 between Salla and Mora Villages, RQ-2 between Mora and Mandal Villages and RQ-3 d/s of Mandal Village. The 1.8 km wide belt of pebbly gneisses, u/s of the barrage site, also appears to be prospective source. However, these rocks are extensively overburden covered on the left bank of the river and areas of low overburden may have to be searched for opening quarry sites. On the right bank of the river, the rock is very well exposed u/s of Salra Gad (Kewal Gaon) that lies adjacent to the proposed HRT of Naitwar-Mori Project of SJVNL and, hence, may not be available for exploitation.

River Borne Material is available in plenty along the course of the Tons River. Four levels of terraces have been recorded in the project area. Of these, the thick T2 and T3 terraces are well habited and may not be available for exploitation. Mori, Dei, Bagi, Sandra, Salla and Mora are some of the Villages that rest over these terraces. Terraces T1 are low terraces of about 3m height above the river bed and may provide only limited quantities. Significant T1 terraces are found at the barrage site, Dei, Sandra, Mora and Mandal Villages. T0 terraces (river bed) may be the most important sources of coarse and fine aggregates as these could be expected to seasonally replenish themselves. U/s of Salla Village, in general, these terraces are found to be composed of 60-70% of gneisses and remaining 30-40% of quartzite, schist and basic rocks. D/s of the Salla Village, quartzite dominates the RBM with 70%, remaining 30% being constituted by gneiss, schist and basic rocks. Sand occurs both as the matrix in the bouldery terrace material and also as thick deposits such as at Sandra and d/s of Mandal Villages (Photograph-7). Nine prospective quarry sites in T0 terraces have been identified. These include R1 just d/s of the barrage site, R2 below Dei Village at the confluence of Tons and Gadu Gad (Mori), R3 opposite Bagi Village, R4 below Sandra Village, R5 d/s of Salla Village, R6 and R7 d/s of Mandal Village, R8 opposite Bijoti Village and R9 below Ugmer and Bijoti Villages.

Photograph-7: Sand deposit d/s of Mandal Village

Field investigations involved reserve estimation based on the dimensions of the mineable portion of the quarry sites. The reserve estimates are based on the product of average cross-sectional area of the quarry up to the proposed mining height of 50m and the available length of the respective quarries. The available quantities have been adjusted for 40% swelling factor and 38% wastage. The wastage includes 20% during mining, 10% during transit from quarry to APP (aggregate processing plant), 5% rejection at APP and 3% APP to batching plant. The swelling factor has been adjusted for 20%.

Representative samples of coarse and fine aggregates have been collected from the identified quarry sites as per ASTM D75: Standard Practice for Sampling Aggregates. For coarse aggregates the most representative location for sampling was selected in the identified rock. Similarly, for fine aggregates samples have been collected from two quarry sites.

The samples have been tested for use as construction materials in concrete for the physical parameters of coarse and fine aggregates as per specified Indian Standard. In all, five samples have been collected viz., three for coarse aggregate and two for fine aggregate. The samples have been tested at NCCBM, Ballabhgarh.

Seismo-tectonic Evaluation

The project area lies in the Lesser Himalayan Seismic Belt and is located at a minimum distance of about 58 km from the Main Boundary Fault (MBF) that demarcates the Frontal Foothill Seismic Belt towards south and 25 km from the Main Central Thrust that separates the Lesser Himalayan Seismic Belt from the Great Himalayan Seismic Belt towards north. Besides these two main Himalayan thrusts, the area around the project is characterized by several thrusts of lesser extent that correspond to the Purola Schuppen Zone. Three such thrusts, viz the Purola Thrust, Jarmola Thrust and Hudoli Thrust cut across the Head Race Tunnel of the project. Several regional transverse faults are also found to occur in the area. Some of the important faults include the Sundernagar Fault, Kishtwar Fault, Kaurik Fault, etc. In general, the project area falls in a tectonically active region.

Seismically, 80 moderate to large magnitude earthquakes (M 4 to 6.9) have been recorded in a 100 km radius of the project area (up to Year1997). As many as 83% of these earthquakes lie to the east of the project area and only 17% to its west. Further, 52% of the earthquakes lie in the south-eastern quadrant and represent the tip of the NW-SE aligned belt of earthquakes along the MCT. The peripheral earthquakes in the north-eastern quadrant, accounting for 31% of total earthquakes, belong to the NS swarm of earthquakes in the Kaurik Fault Zone.

Three well known and devastating earthquakes are considered lying close to the project area. These include the M 6.8 Uttarkashi Earthquake of 20 October 1991 (Epicenter: 30.75 N, 78.86 E; Focal Depth: 12 km) at a distance of about 80 km, the M 6.8 Chamoli Earthquake of 29 March 1999 (Epicenter: 30.41 N, 79.42 E; Focal Depth: 21 km) at a distance of about 150 km, and the M 7 Kinnaur Earthquake of 19 January 1975 (Epicenter: 32.45 N, 78.43 E; Focal Depth: 15 km) at a distance of about 170 km. The site lies in the Isoseismal VI-VII of the Uttarkashi Earthquake and Isoseismal IV-V of the Kinnaur Earthquake. It lies outside Isoseismal IV of the Chamoli Earthquake. The project area lies at a distance of about 230 km SE of the famous M 8.6 Kangra Earthquake of 04 April 1905 and falls within Isoseismal VII-VIII.

As per the Map of Seismic Zones of India (IS 1893: Part 1:2002 Criteria for Earthquake Resistant Design of Structures - Part 1: General Provisions and Buildings), that uses a four-fold classification from Zone II to Zone V, the project area falls in Zone IV and can be considered a region of high seismicity.

In view of the overall seismo-tectonic setting, and considering that the proposed diversion structure of 17m height barrage (27m from deepest foundation) is to be founded over river borne material (RBM), a seismic coefficient of 0.15 g to 0.2 g is being considered to be incorporated in its design. However, if considered necessary, elaborate seismic studies for verifying the adopted seismic coefficient may be carried out in due course.

9

POWER POTENTIAL STUDIES

9. POWER POTENTIAL STUDIES

General

Mori Hanol Hydroelectric Project envisages harnessing of power potential in Tons river. The power plant is designed for diurnal peaking generation based on the storage volume available in the reservoir. For optimization of project capacity, power potential analysis is carried out with power plant capacity ranging from 50 MW to 72 MW and the details are presented in this chapter.

Hydrological Data

A detailed study of discharge data of Tons river measured by CWC for the period 1977 to 2014 is done and on the basis of annual inflow study, the ten daily discharges for 90% dependable year (year 2000-01) based on annual runoff is selected. This ten daily discharge data is used for optimization of the plant capacity. Further, in accordance to the ecological requirements 20% of average of lean period (Dec. to Mar) ten daily discharge shall be released in the natural path of the stream. Accordingly, a minimum of discharge 5.11 m3/sec shall be released downstream of the diversion structure in Tons river. The 90% dependable discharge series (i.e. year 2000-01), and 50% dependable discharge series (i.e year 1993-94) are tabulated below. The 90% dependable discharge series based on annual runoff is used to carry out the power potential study of the project:

90% and 50% dependable year 10-daily discharge data.

Month	Days	90% Dpd. Year discharge	50% Dpd. Year discharge
		(2000-01)	(1993-94)
Jun	10	79.77	82.16
	10	67.30	93.07
	10	42.30	102.78
Jul	10	66.70	118.19
	10	50.15	248.84
	11	98.47	150.43
Aug	10	125.38	113.23
	10	128.17	93.54
	11	89.73	81.77

Month	Days	90% Dpd. Year discharge (2000-01)	50% Dpd. Year discharge (1993-94)
Sep	10	62.56	130.54
	10	77.51	141.34
	10	74.56	90.41
Oct	10	53.58	75.73
	10	51.36	43.27
	11	68.18	32.43
Nov	10	46.60	31.61
	10	46.95	31.60
	10	44.31	34.25
Dec	10	40.04	30.05
	10	36.51	22.61
	11	26.89	19.10
Jan	10	20.15	20.21
	10	23.06	21.95
	11	19.82	22.04
Feb	10	18.05	23.26
	10	22.09	21.62
	8	23.80	23.37
Mar	10	23.96	15.95
	10	24.72	25.74
	11	27.53	28.76
Apr	10	25.40	35.22
	10	27.10	25.24
	10	24.02	24.07
May	10	23.65	33.18
	10	34.46	45.45
	11	42.07	59.04
Sum		**1756.92**	**2192.02**
Max.		**128.17**	**248.84**
Min.		**18.05**	**15.95**

Head

The net operating head, which is expected to be available for the turbines, has been estimated from the data given below :

Salient features

Full Reservoir Level (F.R.L.)	EL 1160.0 m
Minimum Draw Down Level (M.D.D.L.)	EL 1156.0 m
Minimum Tail Water Level (Min. T.W.L.) at Power House	EL 1047.0 m
Maximum Tail Water Level (Max. T.W.L.) at Power House in Water Conductor Sustem	EL 1048.0 m
Head Losses in Water Conductor System corresponding to plant's rated discharge	8.5 m
Maximum Net Head	104.5 m
Minimum Net Head	99.5 m
Net Rated Head	103.00 m

Combined Turbine Generator Efficiencies Of The Unit

Corresponding to the rated head of 103.00 m, Francis turbine has been considered for power potential analysis of the project. The power plant shall run as peaking station which will be based on the reservoir operation i.e running the machines within the operating head range w.r.t. FRL & MDDL levels of the reservoir and at rated load. During monsoon when the water is in abundance, the machines can operate on rated load/overload on continuous basis.

In view of the above, the machines shall be generating most of the time at rated load conditions and very seldom at up to 75% of the rated load. The efficiency of Turbine and generator adopted are shown below :

Efficiency of Turbine –Generator

S. No.	Operating condition	Efficiency		Combined TG efficiency
		Turbine	Generator	
1	100% of rated load	94.50%	98.50%	93.08%

However, considering the project operation period of 30 years, the average turbine and generator efficiencies of 94.5% and 98.5% respectively have been considered for power potential studies.

Power Potential Analysis

Power potential study is first carried out based on 90% dependable year flow data assessed on the basis of annual runoff. Subsequently for verification purposes, the annual energy generation is also verified for 90% dependable discharge series based on annual energy generation with plant capacity restricted to 64 MW.

The methodology adopted for Power potential study comprises of analyzing the generation pattern for the power plant at various capacities varying from 50 MW to 72 MW in incremental steps of 2 MW.

Computation of unrestricted energy, restricted energy generated from the plant, plant load factor is done for various power plant capacities.

The unrestricted energy for the project has been assessed as 361.82 million units for 90% dependable year discharge series based on annual runoff and considering the sacrificial discharge of 5.11 m3/sec.

Restricted energy generation in 90% dependable year (2000-01)

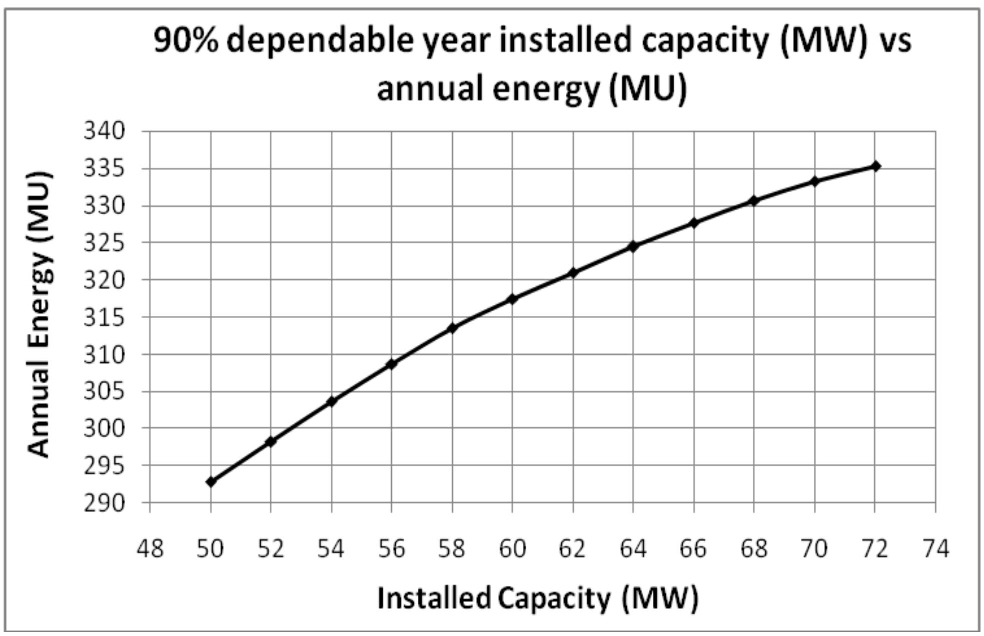
Restricted energy generation in 90% dependable year (2000-01)							
Sl. No.	Plant Capacity	Generation (MU)		Annual PLF	Lean PLF	Capacity	Incr. In
	(MW)	Gross (MU)	Saleable (77%)	(%)	%	Utilization	Gen.(MU)
1	50	292.86	225.50	66.86%	38.47%	80.94%	Base
2	52	298.28	229.68	65.48%	36.99%	82.44%	5.42
3	54	303.71	233.85	64.20%	35.62%	83.94%	5.43
4	56	308.66	237.67	62.92%	34.35%	85.31%	4.95
5	58	313.58	241.46	61.72%	33.16%	86.67%	4.92
6	60	317.51	244.48	60.41%	32.06%	87.75%	3.93
7	62	320.96	247.14	59.10%	31.02%	88.71%	3.45
8	64	324.42	249.80	57.87%	30.05%	89.66%	3.46
9	66	327.71	252.34	56.68%	29.14%	90.57%	3.29
10	68	330.69	254.63	55.51%	28.29%	91.40%	2.98
11	70	333.21	256.57	54.34%	27.48%	92.09%	2.52
12	72	335.28	258.16	53.16%	26.71%	92.66%	2.07

Restricted energy generation in Average year (1977-2014)

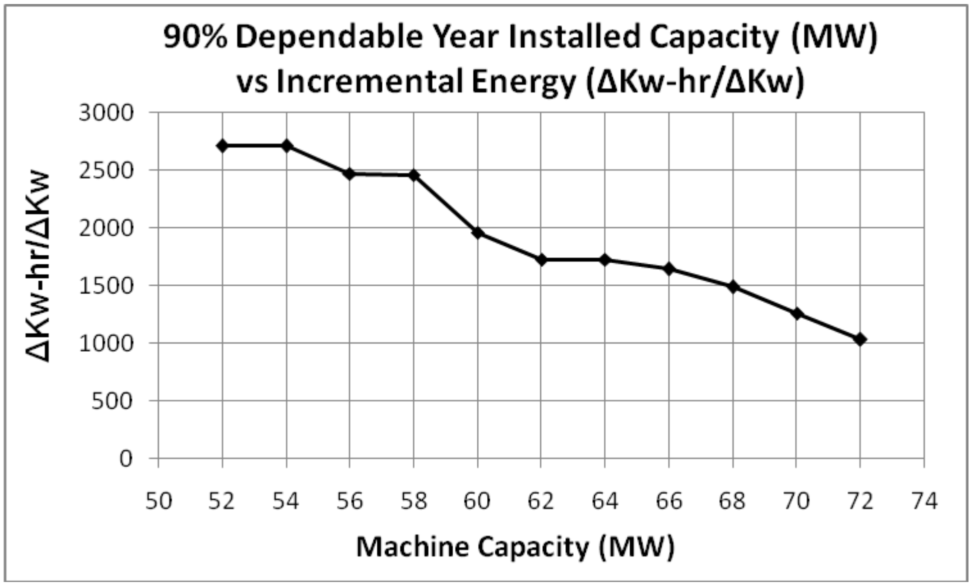
Restricted energy generation in average year (1977 to 2014)							
Sl. No.	Plant Capacity	Generation (MU)		Annual PLF	Lean PLF	Capacity	Incr. In
	(MW)	Gross (MU)	Saleable (77%)	(%)	%	Utilization	Gen.(MU)
1	50	320.27	246.61	73.12%	45.95%	65.04%	Base
2	52	327.85	252.45	71.97%	44.50%	66.48%	7.58
3	54	335.16	258.07	70.85%	43.15%	67.87%	7.31
4	56	342.24	263.53	69.77%	41.88%	69.21%	7.08
5	58	349.12	268.82	68.71%	40.69%	70.50%	6.87

6	60	355.82	273.98	67.70%	39.56%	71.76%	6.70
7	62	362.18	278.88	66.68%	38.48%	72.95%	6.36
8	64	368.27	283.57	65.69%	37.46%	74.08%	6.10
9	66	374.17	288.11	64.72%	36.48%	75.17%	5.89
10	68	379.81	292.46	63.76%	35.54%	76.21%	5.65
11	70	385.26	296.65	62.83%	34.64%	77.22%	5.44
12	72	390.53	300.71	61.92%	33.77%	78.19%	5.28

Note: Saleable Energy is considered 77% of Gross Energy Generation considering deductions for plant availability, auxiliary consumption, transformation losses, wheeling charges and transmission losses and free power to state.



90% dependable year installed capacity (MW) vs annual energy (MU)



90% dependable year installed capacity (MW) vs incremental energy (ΔKw-hr/ΔKw)

It is analyzed that there is not any appreciable increase in the generation and capacity utilization by increasing the capacity any further from 64 MW, thus, making them, on a prima-facie, non feasible capacities beyond 64 MW. In addition, it may also be noted that the optimized plant load factor for such hydro projects is normally considered to be between 50% to 60%, on gross generation, which therefore suggests that the optimized plant capacity to be in the range of 58 MW to 72 MW. The considered capacities have been further optimized on the basis of economic (Benefit cost ratio) analysis as explained in the subsequent paragraph. A graph for Gross energy and incremental energy with various plant capacities are shown.

Verification Of Power Potential In 90% Dependable Year Based On Unrestricted Annual Energy Generation

In addition to the above analysis based on annual river inflow, verification is also done for project capacity optimization on the basis of annual energy generation for a period of 1977-2014 based on unrestricted plant capacity of 64 MW.

Unrestricted energy in MU from (1977-2014)

Year	Unrestricted energy (MU)		Year	Unrestricted energy (MU)	Rank	% exceedance
1977-78	650.20		1990-91	1005.94	1	2.63%
1978-79	768.10		1991-92	926.31	2	5.26%
1979-80	441.46		1978-79	768.10	3	7.89%
1980-81	545.71		1992-93	744.82	4	10.53%
1981-82	526.41		1989-90	734.28	5	13.16%
1982-83	509.35		1994-95	732.16	6	15.79%
1983-84	585.73		1997-98	679.77	7	18.42%
1984-85	306.08		1995-96	671.14	8	21.05%
1985-86	457.05		1977-78	650.20	9	23.68%
1986-87	458.55		1983-84	585.73	10	26.32%
1987-88	377.11		2013-14	568.17	11	28.95%
1988-89	535.90		1996-97	566.96	12	31.58%
1989-90	734.28		1980-81	545.71	13	34.21%
1990-91	1005.94		1988-89	535.90	14	36.84%
1991-92	926.31		1981-82	526.41	15	39.47%
1992-93	744.82		1982-83	509.35	16	42.11%
1993-94	460.52		1998-99	489.29	17	44.74%
1994-95	732.16		1999-00	470.39	18	47.37%
1995-96	671.14		**1993-94**	**460.52**	**19**	**50.00%**
1996-97	566.96		1986-87	458.55	20	52.63%
1997-98	679.77		1985-86	457.05	21	55.26%
1998-99	489.29		2002-03	456.33	22	57.89%
1999-00	470.39		1979-80	441.46	23	60.53%
2000-01	361.82		2005-06	434.64	24	63.16%
2001-02	367.78		2011-12	426.33	25	65.79%
2002-03	456.33		2009-10	413.16	26	68.42%
2003-04	410.12		2010-11	410.57	27	71.05%
2004-05	380.60		2003-04	410.12	28	73.68%
2005-06	434.64		2012-13	401.81	29	76.32%
2006-07	338.78		2008-09	389.95	30	78.95%
2007-08	276.25		2004-05	380.60	31	81.58%
2008-09	389.95		1987-88	377.11	32	84.21%
2009-10	413.16		2001-02	367.78	33	86.84%
2010-11	410.57		**2000-01**	**361.82**	**34**	**89.47%**
2011-12	426.33		2006-07	338.78	35	92.11%
2012-13	401.81		1984-85	306.08	36	94.74%
2013-14	568.17		2007-08	276.25	37	97.37%

The unrestricted annual energy generation corresponding to 10 daily discharge data available from 1977-2014 for 64 MW plant capacities is indicated in Table. The 90%, and 50% dependable years based on unrestricted energy works out as year 2000-01, and year 1993-94 respectively, the energy calculations for 90% and 50% dependable year has been shown. The 90% dependable unrestricted energy works out to 361.82 MU.

For 64 MW machine capacity, restricted energy for 95 % plant availability in 90% dependable year for series (1977 to 2014) works out to 318.89 MU.

Being on conservative side, the criteria for the selection of optimized plant capacity (64 MW) shall remain on the 90% dependable year based on annual runoff, for which, the gross annual restricted energy is 324.42 MU.

Number Of Generating Units

The number of Generating units in the power station are fixed primarily with consideration of harnessing the potential power to the maximum extent i.e. with increase in the number of generating units it is intended that even the lean discharges could also be exploited efficiently, however, with the increase in the nos. of units the power house size, cost of the electromechanical works and cost of the operation & maintenance of the generating units increases thus increasing the overall project cost. Since, Mori Hanol Hydroelectric Project is envisaged as peaking power station based on the reservoir operation having sufficient storage for minimum 3 hrs peaking, the Generating units shall not run at lesser load conditions with respect to less discharge during lean season, as during the lean season the stream discharges shall be accumulated in the reservoir and upon filling of the reservoir the machines shall run at full load. It is therefore recommended to provide two generating units for the optimized plant capacity so that at least one unit is available for generation in case of breakdown of another unit. In order to take benefits from the extra discharge available during the monsoon seasons, an inherent continuous overloading capacity of 10% in the Turbine Generator units is recommended.

Diurnal Pondage Requirements

The average discharge during lean Season in 90% dependable year (2000-01) based on annual runoff has been assessed as 25.55 m3/sec after deducting 20% of lean period (Dec. to Mar) discharge (5.11cumec) as environmental release the net inflow is 20.44 cumec. The rated discharge corresponding to the installation of 64 MW is (68.05) m3/sec for peaking. To enable the station to provide peaking benefits, diurnal pondage would be required. A pondage of 0.6254 million m3 is available between FRL and MDDL of 1160.0 m and 1156.0 m respectively.

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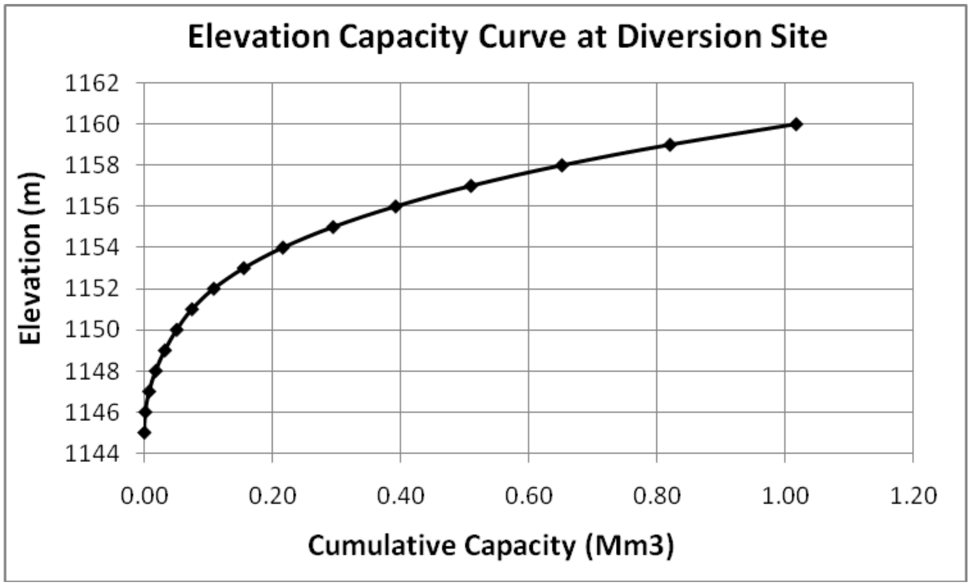

Elevation Capacity Curve at Diversion site

To workout the peaking capacity, average discharge during lean season (December to March) of 90% dependable year is considered which is worked out as 25.55 m^3/s.

- Available Live Storage between FRL & MDDL = 0.6254 MCM
- Plant Peaking Design Discharge = 68.05 m^3/s
- Average discharge during lean Season = 25.55 m^3/s
- Ecological Release = 5.11 m^3/s
- Live Stoarge Capacity for min. 3 hr Peaking = (68.05-(25.55-5.11))*3*3600
  = 514188m^3 (Say 0.51 MCM)
  < 0.6254 MCM (Live Storage)

In 90% dependable year, a pondage of 0.6254 MCM would be adequate to provide minimum 3 hours daily peaking operation of the power house.

Based on hourly simulation of the available pondage during peaking operation of the Power House considering flow in 90% dependable year based on annual runoff, it is observed that pondage available between the proposed FRL and MDDL would be adequate for daily peaking operation of the power house for about 7.21 hours and additional MW generation is 13.33 MW as indicated below.

Hourly simulation of the available pondage during peaking operation.

FRL (M)	**1160.00**		**Average Lean Flow (cumecs)**	**25.55**
Installed Capacity (MW)	**64.00**		**Hectare metre (HAM) per hr.**	**9.20**
Design Discharge (Cumecs)	**68.05**		**Live Storage (Ha m)**	**62.54**
Hectare metre (HAM) per hr.	**24.50**		**Ecological Release (HAM) per hr.**	**1.84**

HOUR	INITIAL STORAGE (Ha.m)	INFLOW (Ha.m)	TOTAL STORAGE (Ha.m)	PEAK OUTFLOW (Ha.m)	ECO. REL. (Ha.m)	FINAL STORAGE (Ha.m)	PEAKING HOURS	ADDL Mw (cont.)
21-22	0.00	9.20	9.20	**0.00**	1.84	7.36	0.00	0.00
22-23	7.36	9.20	16.56	**0.00**	1.84	14.72	0.00	0.00
23-24	14.72	9.20	23.91	**0.00**	1.84	22.08	0.00	0.00
24-1	22.08	9.20	31.27	**0.00**	1.84	29.43	0.00	0.00
1-2	29.43	9.20	38.63	**0.00**	1.84	36.79	0.00	0.00
2-3	36.79	9.20	45.99	**0.00**	1.84	44.15	0.00	0.00
3-4	44.15	9.20	53.35	**0.00**	1.84	51.51	0.00	0.00
4-5	51.51	9.20	60.71	**24.50**	1.84	34.37	**1.00**	0.00
5-6	34.37	9.20	43.57	**24.50**	1.84	17.23	**1.00**	0.00
6-7	17.23	9.20	26.43	**24.50**	1.84	0.09	**1.00**	0.00
7-8	0.09	9.20	9.28	**0.00**	1.84	7.44	0.00	0.00
8-9	7.44	9.20	16.64	**0.00**	1.84	14.80	0.00	0.00
9-10	14.80	9.20	24.00	**0.00**	1.84	22.16	0.00	0.00
10-11	22.16	9.20	31.36	**0.00**	1.84	29.52	0.00	0.00
11-12	29.52	9.20	38.72	**0.00**	1.84	36.88	0.00	0.00
12-13	36.88	9.20	46.08	**0.00**	1.84	44.24	0.00	0.00
13-14	44.24	9.20	53.43	**0.00**	1.84	51.59	0.00	0.00
14-15	51.59	9.20	60.79	**24.50**	1.84	34.45	**1.00**	0.00
15-16	34.45	9.20	43.65	**24.50**	1.84	17.31	**1.00**	0.00
16-17	17.31	9.20	26.51	**24.50**	1.84	0.17	**1.00**	0.00
17-18	0.17	9.20	9.37	**0.00**	1.84	7.53	0.00	0.00
18-19	7.53	9.20	16.73	**0.00**	1.84	14.89	0.00	0.00
19-20	14.89	9.20	24.08	**0.00**	1.84	22.25	0.00	0.00
20-21	22.25	9.20	31.44	**29.60**	1.84	0.00	**1.21**	13.33
Total				**176.60**	**44.15**		**7.21**	**13.33**

Conclusion and Recommendations

Summary of the power potential studies is given below:

- Inflow data for the period of 37 years (for year 1977 to year 2014) has been considered in the studies for assessment of power benefits from the project.
- The maximum, minimum and average annual inflows at diversion site for year 1977 to 2014 are 4011.50 Million m^3, 1220.56 Million m^3 and 2156.34 Million m^3 respectively.
- The rated Gross Head and Net Head on the turbines are 111.5 m and 103.0 m respectively.
- Incremental energy (KWh/KW) per MW of drop for installed capacity beyond 64 MW tends to fall sharply.
- Annual Gross Energy Benefits have been assessed as 324.42 MU in 90% dependable year based on annual runoff,
- A live storage of about 0.6254 million m^3 would be available between the FRL 1160.0 m and MDDL 1156.0 m. The station would operate for about 7.21 hours peaking daily with an additional 13.33 MW power during the lean flow period in a 90% dependable year.
- Installed capacity of 64 MW comprising of 2 Units of 32.0 MW is recommended considering incremental benefits of energy, rate of return and potential exploited.
- Corresponding to installed capacity of 64 MW, annual energy generation of 324.42 MU in 90% dependable year based on annual runoff is recommended for financial evaluation.

10

PROJECT OPTIMIZATION

10. PROJECT OPTIMIZATION

General

A study has been carried out of various alternative project layouts for optimization of various structures. The details are indicated in this chapter.

Placement Of Project Components

As per Pre-feasibility report prepared by UJVNL the project components have been placed on the left bank of Tons river. In order to prepare Detailed Project Report (DPR) both banks of Tons river have been studied for placement of project components and topographical survey has been carried out accordingly. The merits and demerits of right bank and left bank alternative are indicated below:

Merits of Right Bank alternative

- Shorter length of head race tunnel
- Good rock availability on right bank compared to left bank where loose strata is existing.
- Suitability of surface Power House, where in with project components on left bank, the power house has to be underground.

Merits of Left Bank alternative

- Approach road is existing along this bank.
- Less rehabilitation.

Demerits of Left Bank

- Geologically more problematic for tunnel alignment in comparison to right bank
- Power house has to be Underground.

Demerits of Right Bank

- Longer length of head race tunnel due to deep Nallahs i.e. Mautar Gad, Sella (Dhuprai Gad), Mori Gad, Dhatatora Gad and Doba Gad.
- Few Rehabilitation is required.
- More Cultivation land under the project components.

- Aproach road is required for tunnel intake, five adit locations and Surge shaft and Power House location.

Based on evaluation of merits and demerits of right bank layout verses left bank layout, right bank layout has been preferred due to better geological conditions along HRT alignment and possibility of Surface Power House.

Selection Of Barrage Location

The following three options for barrage location were studied

Location 1

1500 m Upstream of confluence of Mautar Gad with Tons river (River Bed level = 1145.0 m)

Location 2

Downstream of newly constructed Iron bridge at confluence of Mautar Gad with Tons river (River bed level = 1135.0 m)

Location 3

At around 1500 m downstream of confluence of Mautar Gad (River bed EL = 1115.0 m)

The merits and demerits of above barrage locations are indicated below:

Merits of Location 1

- No part of Mori village is under submergence at FRL i.e. 1160.0 m, hence the FRL can be maintained at this level and full had can be utilized.
- Flat land is available for locating head regulator, intake channel and desilting basin etc.
- Rock is available at inlet portal location.
- Firm abutment is available on left bank.

Demerits of Location 1

- The storage capacity of reservoir is low. For three hour peaking storage, MDDL has to be 4.0 m lower than FRL, thus net head operating on machine will reduce.
- Firm abutment is not available on right bank
- Barrage location is on upstream of two major nallahs i.e. Mautar Gad and Gadu Gad, joining river Tons on right bank and left bank respectively.

Merits of Location 2

- Discharge received from Mautar Gad of left bank and Gadu Gad on right bank of tons river can be utilized.
- Flat land is available for locating head regulator, intake channel and desilting basin etc.
- Newly constructed Iron Bridge is available for access to right bank.
- The storage capacity of reservoir is sufficient at FRL and 3 hour peaking can be achieved by keeping MDDL around 2 m below FRL.

Demerits of Location 2

- Mori village, newly constructed Iron bridge near Mautar Gad confluence and school is under submergence at proposed FRL of 1160.0 m. In case of lowering of FRL, complete head can not be utilized.
- Firm abutments are not available on both banks
- Suitable inlet portal location is not available on right bank.

Merits of Location 3

- Firm rock is available on both banks of Tons river.
- Discharge received from Mautar Gad of left bank and Gadu Gad on right bank of Tons river can be utilized.
- The storage capacity of reservoir is around 16 million m3 at FRL and 3 hour peaking can be achieved by keeping MDDL around 0.5 m below FRL.
- Flat land is available for locating desilting basin etc.

Demerits of Location 3

- Mori village, newly constructed Iron bridge near Mautar Gad confluence and school shall be under submergence at proposed FRL of 1160.0 m. In case of lowering of FRL, complete head can not be utilized.
- Flat land is not available for river diversion and it has to be done through diversion tunnel, which is a costly affair.

After thorough study of all the alternatives, the Location 1 was selected for planning barrage structure.

Selection Of Penstock Alignment

For the surface Power house location, following two alignments of penstock were studied:

Alignment 1

In alignment 1, the pressure shaft / penstock is reaching Power House location in the shortest length, but the hill slope at portal location was comparatively steeper and hence more excavation and slope stabilization is involved.

Alignment 2

In alignment 2, which is around 100 m downstream of alignment 1 has flatter hill slope and involves lesser cutting, but the penstock has to be slightly longer length as compared to alignment1.

After thoroughly, studying both the alignments, alignment 2 is proposed for laying of penstock.

Selection Of Power House Location

Initially two power house locations, one with surface Power House and one with underground Power house were envisaged. Later on after detailed field survey and study, option of underground Power house was abolished and surface Power house proposal was decided. For surface power house, the following two terrace locations were studies

Terrace 1

Terrace 1 location is on slightly higher elevation and involves a bit more cutting for setting of various power house components. This terrace is higher than river HFL and also there is no agricultural land in this area.

Terrace 2

Terrace 2 location is nearer to river bank and it is proposed on cultivation land. The hills lope is relatively flat and major cutting is not involved. Switch yard can be placed by filling the nearly low lying area and thus muck can also be dumped.

After thoroughly studying the all features of both terraces, the terrace 1 was selected for placing of Power House because of safety of structure during flood.

Alternative Installations

The following alternative installations have been studied in detail to arrive at the optimum installation keeping in view the estimated cost, assessed benefits, system requirements and finally to enable optimum development of the renewable potential of the reach of Tons river under consideration:

- 50 MW installed capacity (2 x 25 MW)
- 52 MW installed capacity (2 x 26 MW)
- 54 MW installed capacity (2 x 27 MW)
- 56 MW installed capacity (2 x 28 MW)
- 58 MW installed capacity (2 x 29 MW)
- 60 MW installed capacity (2 x 30 MW)
- 62 MW installed capacity (2 x 31 MW)
- 64 MW installed capacity (2 x 32 MW)
- 66 MW installed capacity (2 x 33 MW)
- 68 MW installed capacity (2 x 34 MW)
- 70 MW installed capacity (2 x 35 MW)
- 72 MW installed capacity (2 x 36 MW)

The main salient features for the above alternative installations are given below

SALIENT FEATURES

S. No.	Installed Capacity (MW)	Net Rated Head (m)	Discharge m^3/sec	Head race Tunnel diameter (m)	Penstock diameter (m)
1	50	103	53.16	5.3	3.5
2	52	103	55.29	5.4	3.6
3	54	103	57.41	5.5	3.7
4	56	103	59.54	5.6	3.7
5	58	103	61.67	5.7	3.8
6	60	103	63.79	5.8	3.9
7	62	103	65.92	5.9	3.9
8	64	103	68.05	6.0	4.0
9	66	103	70.17	6.1	4.1
10	68	103	72.30	6.2	4.1
11	70	103	74.43	6.3	4.2
12	72	103	76.55	6.4	4.2

The energy generation from the project for various installed capacities works out as indicated below.

GROSS ANNUAL ENERGY BENEFITS (Gwh)

Installed Capacity (MW)	90% Dependable year (Gwh) based on Annual Runoff
50.00	292.86
52.00	298.28
54.00	303.71
56.00	308.66
58.00	313.58
60.00	317.51
62.00	320.96
64.00	**324.42**
66.00	327.71
68.00	330.69
70.00	333.21
72.00	335.28

The optimum installed generating capacity has been determined as 64 MW based on the incremental benefit cost analysis.

11

POWER EVACUATION ARRANGEMENT

11. POWER EVACUATION ARRANGEMENT

Introduction

The Mori Hanol Hydro Electric Project (64 MW) is located on River Tons, which is a major tributary of Yamuna River. Mori Hanol Hydroelectric Project is located in Uttar Kashi District of Uttarakhand. The Project consists of two Nos. turbine driven Generating units of 32 MW each. It is expected that bulk of the power generated at this Project would be available in the Northern Region of India. This chapter details the power evacuation arrangement from the Project to the injection point.

Load Demand

As per projections (including Ultra Mega Projects) for the year 2013-14 given by CEA in the National Electricity Plan 2007, the Northern Region shall be power deficit region (with a power deficit of - 6890 MW during Winter Off Peak, - 11772 MW during Winter Peak, - 4368 MW during Summer off Peak & - 5535 MW during Summer Peak conditions).

As per Annual Report 2012-13 of NRLDC there was a minimum deficit of 1093 MW in September, 2012 and a maximum deficit of 4343 MW during January, 2013. During Evening Peak hour this deficit was 1349 MW on 30.11.2014 (Power Supply Position in Northern Region for 30.11.2014 as available on NRLDC website).

Thus, the power deficiency in Northern Region still remains. The proposed Mori Hanol Hydroelectric Project shall partly meet power deficiency in Northern Region.

M/s Krishna Knitwear Technologies Ltd. intends to evacuate power from Mori Hanol Hydroelectric Project (64MW) to Northern Region by developing the associated transmission line & connect it to the nearby Grid S/stn. of Central/ State Transmission Utility for onward transmission to Northern Region. It is estimated that Uttaranchal has a hydropower potential to the tune of 16500MW, out of which till today only 1160MW have been harnessed. The projects under implementation stage are of 3854MW capacity collectively. The projects under investigation and cleared from Environment Directorate are 938 MW collectively. About 938 MW of power of various projects is planned to be generated from major and minor sites identified in Uttaranchal and is to be evacuated by development of suitable evacuation arrangement.

Transmission Lines

Project just upstream of Mori-Hanol Hydroelectric Project (64MW) is Naitwar-Mori Hydroelectric Project (60 MW) and just downstream is Hanol Tiuni Hydroelectric Project (60MW), and further downstream are Tiuni Plasu Hydroelectric Project (72MW) on Tons river and Arakot Tiuni Hydroelectric Project (72MW) on Pabar river joining Tons river on it's right bank at Tiuni. Power from these HEPs shall be evacuated to proposed 2x50MVA, 220kV Sub-station at Mori. PTCUL has plans to construct 220kV D/C Arakot Tuni-Mori Transmission Line (which will pass near proposed Mori-Hanol Hydroelectric Project at a distance of 2KM approximately) to evacuate power from above mentioned projects to proposed 2x50MVA, 220kV Sub-station at Mori.

One more 220kV D/C Mori-Nogaon Transmission Line shall interconnect proposed 2x50MVA, 220kV Mori Sub-station with proposed 2x50MVA, 220kV Sub-station at Nogaon. Further, power shall be fed from proposed 2x50MVA, 220kV Nogaon Sub-station to 400/220kV sub station (under construction) of PGCIL at Dehradun through proposed 220kV D/C Transmission Line. One 220kV D/C Transmission Line is also proposed from 400/220kV sub station (under construction) of PGCIL at Dehradun to 220kV Sub-station at Dehradun (Jhajra) which in turn will be connected to existing 400kV S/C Rishikesh – Khodri Transmission Line.

Existing Khodri Hydroelectric Project (120MW) is already feeding power to Saharanpur through 220kV D/C Transmission Line. Existing 400kV Rishikesh sub station is also connected to 400kV Roorkee sub station of PGCIL which is feeding power to Muzafarnagar (U.P.)

The existing and proposed transmission system based on Power Evacuation & Transmission System of Uttarakhand (28.06.2014) is shown in Annexure 12.3.

Identification Of Transmission System

For transmission of power of the order of 64MW, normally the economic voltage would be 132kV. However, to match with integrated plan of PTCUL at 220kV, it has been proposed to step up the generation voltage of both units at Mori Hanol Hydroelectric Project to 220 kV.

For transmitting 64MW (rated power)/ 70.4MW power (including 10% overloading) at 220 kV, One circuit of ACSR ZEBRA Conductor is just sufficient. To facilitate, Loop in & Loop Out (LILO) of one circuit of 220kV D/C Arakot Tuni-Mori Transmission Line, it is proposed to construct One no. 220kV

D/C Transmission Line from Mori-Hanol Hydroelectric Project to 220kV D/C Arakot Tuni-Mori Transmission Line (2KM away from Mori Hanol HEP).

Power Evacuation from Mori Hanol HEP

M/s Krishna Knitwear Technologies Ltd. envisages to construct 220kV D/C Transmission Line with ACSR ZEBRA conductor, of length 2KM (approx.) and connect the same by LILO of one circuit of 220kV D/C Arakot Tuni-Mori Transmission Line for evacuating power from Mori Hanol Hydroelectric Project to proposed 2x50MVA, 220kV Mori Sub-station.

12

CONSTRUCTION SCHEDULE

12. CONSTRUCTION SCHEDULE

General

The major components to be constructed for Mori Hanol Hydroelectric Project are:

- Upstream Works including Barrage, Intake Structure, Feeder Channel, De-silting Chamber, Collection Pool and Silt Flushing Arrangement.
- Head Race Tunnel
- Surge Shaft, Valve House & Penstock
- Power House complex
- Tail Race Channel
- Pot Head Yard

The execution of the project work has been divided in two phases. The total duration of Phase-I for Pre Construction activities including creation of Infrastructure is 8 months. Phase-II covers the execution of main works including commissioning of both units in total duration of 40 months.

All works are proposed to be done in three shifts and the scheduled working hours have been taken as 20 hours per day & 25 working days have been considered on an average in a month.

Phase-I : Pre-construction works includes the following (8 months)

The works under this phase includes:

- Detailed Topography Survey, Pre construction geotechnical investigation and marking the Layout at site
- Clearance from Government agencies like Pollution Control Board, Public Health, Irrigation and Forest Clearance
- Acquisition of Land
- Financial Closure
- Detailed design and preparation of tender documents for Civil, Electro-mechanical, Hydro mechanical works
- Award of Contracts
- Setting up of Site office/Camps/workshops etc.
- Arranging of construction power
- Construction of approach roads/ paths

- Route survey of Transmission line
- Mining Licence for construction materials
- Formation of project team

Phase-II: Mobilisation and Completion of main Civil works, Hydro-mechanical works and Electro-mechanical works including commissioning of both units (40 months)

The works under this phase are proposed to be carried out in various contract packages as detailed below:

CIVIL WORKS

- **Package I** : All Civil Works excluding hydromechanical works.
- **Package II** : Hydromechanical works.

➢ **Electro-Mechanical Works**

Package III : Generating Units (Turbine & Generator), Cooling Water System, Drainage/ Dewatering System, Unit Control & Automation, Bus duct.

- **Package IV** : Valves-MIV& BFV
- **Package V** : EOT Crane,
- **Package VI** : Air Conditioning, Ventilation etc.
- **Package VII** : Fire Fighting,
- **Package VIII** : Transformers (Generator Transformer),
- **Package IX** : 415 V Switchgear & 11 kV Switchgear
- **Package X** : Illumination
- **Package XI** : DG sets
- **Package XII** : Cable & Cable Trays
- **Package XIII** : Switchyard & Protection metering
- **Package XIV** : Transformer (Dry Type UAT SST),
- **Package XV** : DC System (Battery & Battery Charger), UPS
- **Package XVI** : Miscellaneous and finishing works

Based on realistic assessment and following the construction methodology, the project can be completed in total duration of 48 months including the activities for Phase-I and II.

13

ENVIRONMENTAL AND ECOLOGICAL ASPECTS

13. ENVIRONMENTAL AND ECOLOGICAL ASPECTS

Introduction

Like any other developmental activity, the proposed hydroelectric project, while providing planned benefit i.e. hydro-power generation could also lead to a variety of adverse environmental impacts as well. However, by proper planning at the inception and design stages and by adopting appropriate mitigatory measures in the planning, design, construction and operation phases, the adverse impacts can be minimized to a large extent, whereas the beneficial impacts could be maximized.

A Comprehensive Environmental Impact Assessment (CEIA) report is a prerequisite for obtaining Environmental Clearance. The principal Environmental Regulatory Agency in India is the Ministry of Environment and Forests (MOEF), Government of India. MOEF formulates environmental policies and accords environmental clearance for the projects. The State Pollution Control Board (SPCB) accords No Objection Certificate (NOC) for Consent to Establish and Consent to Operate for the projects.

A Comprehensive Environmental Impact Assessment (CEIA) study will be conducted. The present Chapter outlines the information on baseline environmental setting and also attempts a preliminary assessment of impacts likely to accrue during project construction and operation phases of the proposed project. The Chapter also outlines the framework of Environmental Management Plan (EMP) for mitigation of adverse impacts. An Environmental Monitoring Programme too been delineated in the present chapter for implementation during project construction and operation phases.

Study Area

The study area can be divided as below:

- Submergence area
- Area to be acquired for various project appurtenances
- Area within 10 km radius of the main project components like dam, power house, etc.
- Area within 10 km upstream of reservoir tip
- Area within 10 km distance from the reservoir rim along both the river banks.
- Catchment Area

Environmental Baseline Status

The description of environmental setting or baseline environmental status is an integral part of any EIA study. The objectives of the assessment of baseline environmental status of the study area are to:

- Assess the existing environmental quality, as well as the environmental impacts of the alternatives being studied.
- Identify environmentally significant factors or areas that could preclude the proposed development.
- Provide sufficient information so that decision-makers and reviewers can develop an understanding of the project needs as well as the environmental characteristics of the area.

The environmental baseline status has been described in the following sections.

Meteorology

The climate in the project area varies significantly with altitude. Climatologically, following four seasons are identified in the project area:

- Summer: Mid April to Mid June
- Monsoon: Mid June to Mid-September
- Post-monsoon: Mid-September to Mid-November
- Winter: Mid-November to Mid-April

Within the study area, significant temperature variations, vis-à-vis elevation and exposure to the sun are observed. As the insolation at high altitudes is intense, temperatures in the open are considerably higher than in shade in summer. The months of May and June are the warmest months with mean maximum temperature at around 30.0^{o}C. With the withdrawal of monsoons, towards the end of September, day and night temperatures begins to fall up to December-January, which are the coolest month with mean minimum temperature of 2.6 to 2.7^{o}C.

Rainfall in the study area shows high spatial variation and varies significantly with elevation and aspect. Majority of rainfall occurs during monsoon season lasting from June to September. Rainfall decreases rapidly after September and October to December are the driest months of the year. Thunder storms accompanied by rains occur in summer season and also in the month of October. On an average, there are about 120 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year.

The relative humidity is high during monsoon months. During rest of the year, the relative humidity is slightly lower.

During the monsoon months, the sky is heavily overcast, while for the rest of the year, it is lightly or moderately clouded. Cloud cover increases in May. In winter mornings, lifted fog frequently covers the hilly regions.

The average meteorological conditions in the project area are summarized below

Rainfall, Temperature and Relative Humidity observed in the project area.

Months	Monthly Rainfall (mm)	Monthly Mean Temperature (^oC)		Monthly Mean Relative Humidity (%)	
		Maximum	Minimum	8.30 AM	5.30 PM
January	71.9	20.7	2.6	64	65
February	17.0	19.2	3.3	60	60
March	0.3	25.4	6.6	40	39
April	29.3	28.3	10.3	47	47
May	73.2	30.7	9.9	73	59
June	197.0	29.0	10.3	79	67
July	438.2	27.5	11.1	83	64
August	678.6	24.9	12.7	88	74
September	158.1	27.0	11.1	70	53
October	184.2	21.5	5.6	69	62
November	0.9	22.6	3.0	47	44
December	5.9	23.0	2.7	53	47
Total	**1854.6**				
Average		**24.98**	**7.43**	**64.42**	**56.75**

Water Quality

The proposed project is located in an area with low population density with no major sources of pollution. There are no industries in the area. The area under agriculture is quite less, which coupled with negligible use of agro-chemicals, means that apart from domestic sources, pollution loading from other sources is virtually negligible. The water quality in the area is quite good.

Ambient Air Quality

There is no major source of air pollution in the project area. The area has no industries and vehicular pollution. The only sources of pollution are fuel combustion from households and vehicular pollution. Considering the low population intensity and vehicular traffic air quality is quite good in the area.

Terrestrial Flora

The type of vegetation met within a particular area depends on the climatic conditions, soil topographical situation and geographical location. The forests occur in all aspects and therefore, vary greatly in composition from place to place ranging from river catchments, steep well drained slopes to moist shady ridges and spurs. As per Champion and Seth (1968) classification, following forest types were encountered in the study area:

- Himalayan subtropical chir pine forests
- Himalayan subtropical broad-leaved forest

Himalayan subtropical chir pine forests

This forest type is widely distributed, occupying the lower slope in the catchment, chiefly at the altitudes between 700 m to 1000 m, occasionally extending above and below this zone. Towards upper limit these forests extend upto 2,100 m, confining to hotter exposed sites, like ridges and spurs. Generally, the pine forests are pure patches; however, at some places Pinus roxburghii (Chir pine) is associated with trees like Lyonia ovalifolia, phyllanthus emblica, Ougeinia oojeinensis, Pyrus pashia, Lannea coromandelica, and in drier rocky places with Euphorbia royleana. In shady and moist pockets Alnus nepalensis, Myrica esculenta and Quercus glauca are typical associates of pine. Rubus ellipticus, Woodfordia fruticosa, Berberis lyceum, Indigofera cassioides, Carissa opaca, Prinsepia utilis, Dodonea viscose etc., are the common elements found as undergrowth in this type of forest. With the onset of monsoon season these perennate vegetatively. The ground vegetation contribute most of the general appearance in the forests are Imperata cylindrical, Heteropogon contortus, Anaphalis spp., Lespediza gerardiana, Coniza Canadensis, Reinwardtia indica, Achyranthus aspera, Artemisia nilagirica, Justicia procumbens, Bidens biternata, and Duchesnea indica etc.

Himalayan subtropical broad-leaved forest

This type of forests are predominant in undisturbed areas in the subtropical zone similar to subtropical pine forests areas. An interesting aspect of the subtropical broad-leaved forest is the occurrence of numerous temperate elements, such as Lyonia ovalifolia, Rhododendron arboreum, Alnus nepalensis etc. Unlike deciduous forests this type of forests exhibit high degree of species diversity with numerous shrubby and herbaceous species although there is no clear stratification of the forests. The epiphytic flora is well represented with species of orchids and ferns. Persea obovatissima, P. duthiei, Neolitsea cuipala, Cinnamomum tamala, Olea ferruginea, Alnus nepalensis, Rhus punjabensis, Quercus glauca, Syzygium cumini, Ficus palmata etc., are some of the dominant tree species commonly noticeable in this type. Some of the grass species are also common in this forests which include Arundinella nepalensis, Chrysopogon fulvus, Heteropogon contortus, Bothriochloa bladhii, Imperata cylidrica, Themada spp., Saccharum spp., etc.

The list of major floral species reported in the study area is given below.

Major floral species found in the project area

Family	Botanical Name	Local Name
TREE SPECIES		
Sapindaceae	*Sapindus mukorossi* Gaertn.	Athu/ Ritha
Mimosaceae	*Albizia chinensis* (Osb.)Merr.	Bandir
Mimosaceae	*Albizia julibrissin* Durazz.	Shrish
Mimosaceae	*Albizia lebbeck* (L) Benth.	Shrish
Betulaceae	*Alnus nepalensis* D.Don	Kuinchh
Caesalpiniaceae	*Bauhinia variegata* L.	Goriyal
Bombacaceae	*Bombax ceiba* L.	Simbal
Ulmaceae	*Celtis australis* L.	Kharik
Lauraceae	*Cinnamomum tamala* (Buch.-Ham.) Nees	Gulaldra/ Dalchini
Ehretiaceae	*Cordia dichotoma* Forst.	Lisora
Fabaceae	*Dalbergia sissoo* Roxb.	Shisham
Ehretiaceae	*Ehretia acuminata* R.Br.	Poon
Myrtaceae	*Eucalyptus tereticornis* Smith	Ecalyptis
Moraceae	*Ficus palmata* Forsk.	Fedu
Tiliaceae	*Grewia optiva* J.R. Drumm. ex Burrett	Bhinola

Family	Botanical Name	Local Name
Juglandaceae	*Juglans regia* L.	Akhrot
Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Ladoria
Euphorbiaceae	*Mallotus philippensis* (Lam.) Muell.-Arg.	Royini
Meliaceae	*Melia azedarach* L.	Dekren
Sabiaceae	*Meliosma simplicifolia* (Roxb.) Walp.	Khatha kaol
Myricaceae	*Myrica esculenta* Buch.-Ham.ex D.Don	Kaphal
Lauraceae	*Neolitsea cuipala* (Buch.-Ham. ex D. Don) Kosterm.	Kaol
Oleaceae	*Olea ferruginea Royle*	Kou
Fabaceae	*Ougeinia oojeinensis* (Roxb.) Hochr.	Chhanen
Euphorbiaceae	*Phyllanthus emblica* L.	Amla
Pinaceae	*Pinus roxburghii* Sarg.	Salli/ Chir
Anacardiaceae	*Pistacia khinjuk* Stocks	Kaked
Rosaceae	*Prunus cerasoides* D.Don	Phasa
Rosaceae	*Pyrus communis* L.	Nashpati
Rosaceae	*Pyrus pashia* Buch.-Ham. ex D.Don	Moul
Fagaceae	*Quercus glauca* Thunb.	Inni
Anacardiaceae	*Rhus punjabensis* J.L. Stewart	Titrai
Myrtaceae	*Syzygium cumini* (L.) Skeels	Jamun
Meliaceae	*Toona ciliata* M. Roem.	Toon
SHRUBS		
Acanthaceae	*Adhatoda zeylanica* Mendik	Bayinsh
Agavaceae	*Agave cantula* Roxb.	Rambans
Berberidaceae	*Berberis lycium* Royle	Kasmol
Urticaceae	*Boehmeria macrophylla* Hornem.	-
Apocynaceae	*Carissa opaca* Stapf ex Haines	Karonda
Lamiaceae	*Colebrookia oppositifolia* J.E. Smith	-
Urticaceae	*Debregeasia salicifolia* (D.Don) Rendle	Siyaru
Fabaceae	*Desmodium concinnum* DC.	-
Euphorbiaceae	*Euphorbia royleana* Boissier	Suru
Moraceae	*Ficus semicordata* Buch.-Ham. ex J.E. Smith	Khanu
Fabaceae	*Indigofera cassioides* Rott. ex DC.	-
Verbenaceae	*Lantana camara* L.	Lalten
Rubiaceae	*Leptodermis lanceolata* Wallich	-
Fabaceae	*Lespedeza gerardiana* Graham ex Maxim.	-
Rosaceae	*Prinsepia utilis* Royle	-
Rhamnaceae	*Rhamnus virgatus* Roxb.	-
Anacardiaceae	*Rhus parviflora* Roxb.	-
Euphorbiaceae	*Ricinus communis* L.	Arandi
Rosaceae	*Rosa brunonii* Lindley	-

Family	Botanical Name	Local Name
Lamiaceae	*Roylea cinarea* (D. Don) Baillon	-
Rosaceae	*Rubus ellipticus* Smith	hisar
CLIMBERS		
Caesalpiniaceae	*Caesalpinia decapetala* (Roth) Alst.	-
Ranunculaceae	*Clematis grata* Wallich	Khagsi
Asclepiadaceae	*Cryptolepis buchananii* Roemer & Schult.	-
Dioscoreaceae	*Dioscorea melanophyma* prain & Burkill	-
Araliaceae	*Hedera nepalensis* K. Koch	-
Convolvulaceae	*Ipomoea pes-tigridis* L.	-
Convolvulaceae	*Ipomoea purpurea* (L.) Roth.	-
Vitaceae	*Vitis jacquemontii* Parker	Shimoniya
HERBS		-
Acanthaceae	*Barleria cristata* L.	-
Acanthaceae	*Dicliptera bupleuroides* Nees	-
Acanthaceae	*Justicia peploides* (Nees) T. Anders	-
Acanthaceae	*Justicia procumbens* L.	-
Acanthaceae	*Peristrophe bicalyculata* (Retz.) Nees	-
Amaranthaceae	*Achyranthes aspera* L.	Chirchira
Amaranthaceae	*Alternanthera sessilis* (L.) DC.	-
Asteraceae	*Ageratum conyzoides* L.	-
Asteraceae	*Artemisia nilagirica* (Clarke) Pamp.	Chammra
Asteraceae	*Artemisia scoparia* waldstein & Kitaibel	Tallaghas
Asteraceae	*Aster peduncularis* Wall. ex Nees	-
Asteraceae	*Bidens biternata* (laur.) merill & sherff	-
Asteraceae	*Bidens pilosa* L.	-
Asteraceae	*Blumea lacera* (Burm. f.) DC.	-
Asteraceae	*Blumea laciniata* (Roxb.) DC.	-
Asteraceae	*Blumea mollis* (D.Don) Merrill	-
Asteraceae	*Conyza stricta* Willd.	-
Asteraceae	*Cotula anthemoides* L.	-
Asteraceae	*Cythocline purpurea* (D. Don) Kuntze	-
Asteraceae	*Eclipta prostrata* (L.) L.	-
Asteraceae	*Gnaphalium luteo-album* L.	-
Asteraceae	*Parthanium hysterophorus* L.	Gajarghas
Asteraceae	*Siegesbeckia orientalis* L.	Choped
Asteraceae	*Sonchus brachyotus* DC.	-
Asteraceae	*Tricholepis elongata* DC.	-
Asteraceae	*Tridax procumbens* L.	-

Family	Botanical Name	Local Name
Asteraceae	*Xanthium indicum* Koenig	Kumra
Asteraceae	*Youngia japonica* (L.) DC.	-
Boraginaceae	*Cynoglossum lanceolatum* Forsk.	-
Cannabaceae	*Cannabis sativa* L.	-
Cyperaceae	*Fimbristylis dichotoma* (L.) Vahl	-
Cyperaceae	*Pycerus flavidus* (Retz.) T. Koyana	-
Euphorbiaceae	*Acalypha brachystachya* Hornem	-
Euphorbiaceae	*Euphorbia heterophylla* L.	-
Euphorbiaceae	*Euphorbia hirta* L.	-
Euphorbiaceae	*Euphorbia hypericifolia* L.	-
Fabaceae	*Alysicarpus vaginalis* (L.) DC.	-
Fabaceae	*Crotalaria medicaginea* Lam.	-
Fabaceae	*Desmodium triflorum* (L.) DC.	-
Lamiaceae	*Ajuga parviflora* Benth.	-
Lamiaceae	*Anisomeles indica* (L.) Kuntze	-
Lamiaceae	*Clinopodium umbrosum* (M.Bieb.) C. Koch	-
Lamiaceae	*Leucas lanata* Benth	-
Lamiaceae	*Origanum vulgare* L.	-
Liliaceae	*Gloriosa superba* L.	-
Malvaceae	*Malva parviflora* L.	-
Malvaceae	*Malvastrum coromandelianum* (L.) Garcke	-
Malvaceae	*Sida spinosa* L.	-
Oxalidaceae	*Oxalis corniculata* L.	Almori
Oxalidaceae	*Oxalis debilis* Humb.	-
Polygonaceae	*Fagopyrum dibotrys* (D. Don) Hara	-
Polygonaceae	*Rumex hastatus* D.Don	-
Polygonaceae	*Rumex nepalensis* Sprengel	Kharacha
Primulaceae	*Lysimachia alternifolia* Wallich	-
Ranunculaceae	*Thalictrum foliolosum* DC.	-
Rosaceae	*Duchesnea indica* (Andr.) Focke	Bumle
Scrophulariaceae	*Lindernia ciliata* (Colsm.) Pennell	-
Scrophulariaceae	*Verbascum thapsus* L.	-
Solanaceae	*Physalis divaricata* D.don	Banchulu
Solanaceae	*Physalis peruviana* L.	-
Solanaceae	*Solanum nigrum* L.	Bamni
Solanaceae	*Solanum viarum* Dunal	Bhafal
Urticaceae	*Urtica ardens* Link.	Kalla

GRASSES		
Poaceae	*Apluda mutica* L.	-
Poaceae	*Aristida adscensionis* L.	-
Poaceae	*Arundo donax* L.	Fillu
Poaceae	*Avena fatua* L.	Lawan
Poaceae	*Cyrtococcum accrescens* (Trin.) Stapf.	-
Poaceae	*Digitaria ciliaris* (Retz.) Koeler	-
Poaceae	*Echinochloa colona* (L.) Link	Shaunka
Poaceae	*Heteropogon contortus* L.	-
Poaceae	*Imperata cylindrica* (L.) P.Beauv.	Dapsha
Poaceae	*Themada caudata* (Nees) A. Camus	Poaceae
Poaceae	*Chrysopogon fulvus*	-
Poaceae	*Phragmites karka* (Retz.) Trin. ex Steud.	-
Poaceae	*Saccharum spontaneum* L.	Kansh

Fauna

Based on the review of secondary data and interaction with the Forest Department, major faunal species reported in the forests of the project area and its surroundings include Goral, Jungle cat, squirrel, common langur, Mongoose, etc. Amongst the avi-fauna, the commonly observed species include myna, koel, jungle crow, dove, etc., The reptilian species observed in the study area include house gecko, garden lizard including monitor lizard etc. The list of mammals, avi-fauna and reptile species observed in the study area is outlined below.

Common terrestrial faunal species

Zoological Name	Common Name
MAMMALS	
Naemorhedus goral	Goral
Felis chaus	Jungle cat
Marmota himalayana	Ground squirrel
Pesbytis entellus	Common langur
Herpestes edwadsi	Newla/ Common Mongoose
Funambulus pennantii	Five Striped Squirrel
Rattus rattus	Common House Rat
Golunda ellioti	The Indian Bush Rat
Lepus nigricollis	Common Indian Hare
Sus scrofa	Wild Pig
Hytrix indica	Saula/ Porcurpine
Macaca mutatta	Bandar/ Monkey
Muntiacus muntjak	Kakar/ Barking Deer
Panthera pardus	Bagh/ Panther Leopard
BIRDS	

Zoological Name	Common Name
Acridotheres fuscus	Jungle Myna
Actitis hypoleucos	Sandpiper
Columba livia	Blue Rock Pigeon
Corvus macrorhynchos	Jungle Crow
Egretta garzetta	Little Egret
Endynamys scolopaceus	Asian Koel
Francolinus francolinus	Black patridge
Lanius schach	Long tailed Shrike
Lanius vittatus	Bay backed Shrike
Ploceus philippinus	Baya Weaver
Cuculus varius	Common Hawk-Cuckoo
Dicrurus macrocercus	Black Drongo
Enicurrus scouleri	Little Forktail
Streptopelia orientalis	Oriental Turtle Dove
Zosterops palpebrosus	Oriental White eye
Gyps indicus	Indian vulture
Streptopelia chinensis	Spotted Dove
Glaucidium radiatum	Jangle Owl
Grus antigone	Crane/Saras
Ictinaetus malayensis	Black eagle
Milvus migrans	Black kite
Picus canus	Wood pecker
Bubulcus ibis	Cattle egret
REPTILES	
Bugnarus caeruleus	Common krait
Callotus versicolor	Garden lizard
Hemidactylus brooki	House Gecko
Ophiophagus hannah	King Cobra
Varanus monitor	Indian monitor lizard
Xenochorpis piscator	Water snake

National Parks and Wildlife Sanctuary

Govind National Park and Wildlife Sanctuary is located near Natwar village of Mori tehsil in Uttarkashi district. The park extends from latitude 35°55’ – 31°17’30” in the North and longitude 77°47’30” – 78°37’30” in the East. The park is located within 10 km aerial distance from barrage site.

Major floral species found in the sanctuary are chir pine (Pinus roxoburghii), cedar (Cedrus deodata), blue pine (Pinus wallichiana), silver fir (Abies pindrow), Spruce (Picea smithiana), Yew (Taxus baccata), and broad-leaved species such as oaks (Quercus spp.), maples (Acer spp.), walnut (Juglans regia), horse chestnus (Aesculus indica), hazel (Coryllus jacquemontii) and rhododendron (Rhododendron spp.)

The park is the natural habitat of several varieties of fauna including red panda, sambhar, musk deer, brown bear, bharal, serow, snow leopard, Indian Porcupine, common otter, barking deer, goral, Himalayan palm civet, hedgehog, Sikkim vole, Himalayan rat, Hodgson's fly squirrel, and wild boar.

Fisheries

The most dominant fish species were of Snow trout in the project area. In addition to snow trout, the species of the mahseer (Tor tor, Tor putitora), and species of Crossocheilus, Garra, Glyptothorax and Pseudoecheneis were also found in the stretch of Tons. The commercial fisheries in the area are non-existent. However, fishing by individuals is common.

Snow trout and Mahsheer are migratory fish species. Their migration will be affected as aresult of construction of the project. Appropriate mitigation measures need to be suggested as a part of the CEIA study for the of the amelioration of adverse impacts on riverine fisheries including migratory fish species.

Prediction Of Impacts

Prediction is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur because of the implementation of the project. Based on the project details and the baseline environmental status, potential impacts as a result of the construction and operation of the proposed project have been identified.

Impacts On Water Environment

Construction phase

i) Sewage from labour camps

The peak labour strength likely to be employed during project construction phase is about 1500 workers and 500 technical staff. The employment opportunities in the area are limited. Thus, during the project construction phase, some of the locals may get employment. It has been observed during construction phase of many of the projects; the major works are contracted out, who bring their own skilled labour. However, it is only in the unskilled category, that locals get employment.

The construction phase, also leads to mushrooming of various allied activities to meet the demands of the immigrant labour population in the project area. Based on experience of similar projects and above referred assumptions, the increase in the population as a result of migration of labour population during construction phase is expected to be of the order of 8,000.

The domestic water requirement has been estimated as 70 lpcd. Thus, total water requirements work out to 0.56 mld. It is assumed that about 80% of the water supplied will be generated as sewage. Thus, total quantum of sewage generated is expected to be of the order of 0.45 mld. The BOD load contributed by domestic sources will be about 450 kg/day. It is recommended to commission units for treatment of sewage generated from labour camps. In the proposed project, sewage is proposed to be treated, prior to disposal.

ii) Effluent from crushers

During construction phase, at least one crusher will be commissioned at the quarry site by the contractor involved in construction activities. It is proposed only crushed material would be brought at construction site. The total capacities of the two crushers are likely to be of the order of 120-150 tph. Water is required to wash the boulders and to lower the temperature of the crushing edge. About 0.1 m^3 of water is required per ton of material crushed. The effluent from the crusher would contain high-suspended solids. About 12-15 m^3/hr of wastewater is expected to be generated from each crusher. The effluent, if disposed without treatment can lead to marginal increase in the turbidity levels in the receiving water bodies. It is proposed to treat the effluent from crushers in settling tank before disposal so as to ameliorate even the marginal impacts likely to accrue on this account.

OPERATION PHASE

The major sources of water pollution during project operation phase include:

- Effluent from project colony.
- Impacts on reservoir water quality.

i) Effluent from project colony

During project operation phase, due to absence of any large-scale construction activity, the cause and source of water pollution will be much different. Since, only a small number of O&M staff will reside in the area in a well-designed colony with sewage treatment plant and other infrastructure facilities, the problems of water pollution due to disposal of sewage are not anticipated.

In the operation phase, about 100 families (total population of 500) will be residing in the project colony. About 0.23 mld of sewage will be generated. The total BOD loading will be order of 68 kg/day. It is proposed to provide biological treatment facilities including secondary treatment units for sewage so generated from the BOD load after treatment will reduce to 7 kg/day. It shall be ensured that sewage from the project colony be treated in a sewage treatment plant so as to meet the disposal standards for effluent. Thus, with commissioning of facilities for sewage treatment, no impact on receiving water body is anticipated. Thus, no impacts are anticipated as a result of disposal of effluents from the project colony.

ii) Impacts on reservoir water quality

The flooding of previously forest and agricultural land in the submergence area will increase the availability of nutrients resulting from decomposition of vegetative matter. Phytoplankton productivity can supersaturate the euphotic zone with oxygen before contributing to the accommodation of organic matter in the sediments. Enrichment of impounded water with organic and inorganic nutrients will be the main water quality problem immediately on commencement of the operation. However, this phenomenon is likely to last for a short duration of few years from the filling up of the reservoir. In the proposed project, most of the land coming under reservoir submergence is barren, with few patches of trees. These trees too are likely to be cleared before filling up of the reservoir. The proposed project is envisaged as a runoff the river scheme, with significant diurnal variations in reservoir water level. In such a scenario, significant re-aeration from natural atmosphere takes place, which maintains Dissolved Oxygen in the water body. Thus, in the proposed project, no significant reduction in D.O. level in reservoir water is anticipated.

iii) Eutrophication risks

Another significant impact observed in the reservoir is the problem of eutrophication, which occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. However, in the present case, fertilizer use in the project area is negligible, hence, the runoff at present does not contain significant amount of nutrients. Even in the post-project phase, use of fertilizers in the project catchment area is not expected to rise significantly. Another factor to be considered that the proposed project is envisaged as a run off the river scheme, with significant diurnal variations in reservoir water level. Thus, residence time would be of the order of few days, which is too small to cause any eutrophication. Thus, in project operation phase, problems of eutrophication, which is primarily caused by enrichment of nutrients in water, are not anticipated.

Impacts On Air Environment

In a water resources project, air pollution occurs mainly during project construction phase. The major sources of air pollution during construction phase are:

- Pollution due to fuel combustion in various equipment
- Emission from various crushers
- Fugitive emissions from various sources.
- Blasting Operations
- Pollution due to increased vehicular movement
- Dust emission from muck disposal
- Pollution due to fuel combustion in various equipment

The operation of various construction equipment requires combustion of fuel. Normally, diesel is used in such equipment. The major pollutant which gets emitted as a result of combustion of diesel is SO2. The SPM emissions are minimal due to low ash content in diesel. The short-term increase in SO2, even assuming that all the equipment are operating at a common point, is quite low, i.e. of the order of less than $1\mu g/m^3$. Hence, no major impact is anticipated on this account on ambient air quality.

Emissions from crushers

The operation of the crusher during the construction phase is likely to generate fugitive emissions, which can move even up to 1 km in predominant wind direction. During construction phase, one crusher each is likely to be commissioned near proposed dam and proposed power house sites. During crushing operations, fugitive emissions comprising mainly the suspended particulate will be generated. Since, there are no major settlements close to the dam and power house, hence, no major adverse impacts on this account are anticipated. However, during the layout design, care should be taken to ensure that the labour camps, colonies, etc. are located on the leeward side and outside the impact zone (say about 2 km on the wind direction) of the crushers.

Fugitive Emissions from various sources

During construction phase, there will be increased vehicular movement. Lot of construction material like sand, fine aggregate are stored at various sites, during the project construction phase. Normally, due to blowing of winds, especially when the environment is dry, some of the stored material can get entrained in the atmosphere. However, such impacts are visible only in and around the storage sites. The impacts on this account are generally, insignificant in nature.

Blasting Operations

Blasting will result in vibration, which shall propagate through the rocks to various degrees and may cause loosening of rocks/boulders. The overall impact due to blasting operations will be restricted well below the surface and no major impacts are envisaged at the ground level.

During tunneling operations, dust will be generated during blasting. ID blowers will be provided with dust handling system to capture and generated dust. The dust will settle on vegetation, in the predominant down wind direction. Appropriate control measures have been recommended to minimize the adverse impacts on this account.

Pollution due to increased vehicular movement

During construction phase, there will be increased vehicular movement for transportation of various construction materials to the project site. Similarly, these will be increased traffic movement on account of disposal of muck or construction waste at the dumping site. The maximum increase in vehicle is expected to 50 vehicles per hour. Large quantity of dust is likely to be entrained due to the movement of trucks and other heavy vehicles. Similarly, marginal increase in Hydrocarbons, SO2 and NOx levels are anticipated for a short duration. The increase in vehicular density is not expected to significant. In addition, these ground level emissions do not travel for long distances. Thus, no major adverse impacts are anticipated on this account.

Dust emission from muck disposal

The loading and unloading of muck is one of the source of dust generation. Since, muck will be mainly in form of small rock pieces, stone, etc., with very little dust particles. Significant amount of dust is not expected to be generated on this account. Thus, adverse impacts due to dust generation during muck disposal are not expected.

Impacts on Noise Environment

a) Construction phase

In a water resource projects, the impacts on ambient noise levels are expected only during the project construction phase, due to earth moving machinery, etc. Likewise, noise due to quarrying, blasting, vehicular movement will have some adverse impacts on the ambient noise levels in the area.

i) Impacts due to operation of construction equipment

The noise level due to operation of various construction equipment is given below.

Noise level due to operation of various construction equipment

Equipment	Noise level dB(A)
Earth moving	
Compactors	70-72
Loaders and Excavator	72-82
Dumper	72-92
Tractors	76-92
Scrappers, graders	82-92
Pavers	86-88
Truck	84-94
Material handling	
Concrete mixers	75-85
Movable cranes	82-84
Stationary	
Pumps	68-70
Generators	72-82
Compressors	75-85

Under the worst-case scenario, considered for prediction of noise levels during construction phase, it has been assumed that all these equipment generate noise from a common point. The increase in noise levels due to operation of various construction equipment is given in Table.

Table: Increase in noise levels due to operation of various construction equipment

Distance (m)	Ambient noise levels dB(A)	Increase in noise level due to construction activities dB(A)	Increased noise level due to construction activities dB(A)	Increase in ambient noise level due to construction activities dB(A)
100	36	45	45	34
200	36	39	39	29
500	36	31	31	25
1000	36	25	25	25
1500	36	21	21	24
2000	36	19	19	24
2500	36	17	17	24
3000	36	15	15	24

It would be worthwhile to mention here that in absence of the data on actual location of various construction equipment, all the equipment have been assumed to operate at a common point. This assumption leads to over-estimation of the increase in noise levels. Also, it is a known fact that there is a reduction in noise level as the sound wave passes through a barrier. The transmission loss values for common construction materials are given below.

Transmission loss for common construction materials

Material	Thickness of construction material (inches)	Decrease in noise level dB(A)
Light concrete	4	38
	6	39
Dense concrete	4	40
Concrete block	4	32
	6	36
Brick	4	33
Granite	4	40

Thus, the walls of various houses will attenuate at least 30 dB(A) of noise. In addition there are attenuation due to the following factors.

- Air absorption
- Rain
- Atmospheric inhomogeneties.
- Vegetal cover

Thus, no increase in noise levels is anticipated as a result of various activities, during the project construction phase. The noise generated due to blasting is not likely to have any effect on habitations. However, blasting can have adverse impact on wildlife, especially along the alignment of the tunnel portion. It would be worthwhile to mention that no major wildlife is observed in and around the project site. Hence, no significant impact is expected on this account.

Impacts on labour

The effect of high noise levels on the operating personnel, has to be considered as this may be particularly harmful. It is known that continuous exposures to high noise levels above 90 dB(A) affects the hearing acuity of the workers/operators and hence, should be avoided. To prevent these effects, it has been recommended by Occupational Safety and Health Administration (OSHA) that the exposure period of affected persons be limited as per the maximum exposure period specified below.

Maximum Exposure Periods specified by OSHA

Maximum equivalent continuous Noise level dB(A)	Unprotected exposure period per day for 8 hrs/day and 5 days/week
90	8
95	4
100	2
105	1
110	½
115	¼
120	No exposure permitted at or above this level

Impacts On Land Environment

a) Construction phase

The major impacts anticipated on land environment during construction are as follows:

- Quarrying operations
- Operation of construction equipment
- Muck disposal
- Acquisition of land

i) Quarrying operations

A project of this magnitude would require significant amount of construction material. The quarrying operations are semi-mechanized in nature. Normally, in a hilly terrain, quarrying is normally done by cutting a face of the hill. A permanent scar is likely to be left, once quarrying activities are over. With the passage of time, rock from the exposed face of the quarry under the action of wind and other erosional forces, get slowly weathered and after some time, they become a potential source of landslide. Thus it is necessary to implement appropriate slope stabilization measures to prevent the possibility of soil erosion and landslides in the quarry sites.

ii) Operation of construction equipment

During construction phase, various types of equipment will be brought to the site. These include crushers, batching plant, drillers, earthmovers, rock bolters, etc. The siting of this construction equipment would require significant amount of space. Similarly, space will be required for storing of various other construction equipment. In addition, land will also be temporarily acquired, i.e. for the duration of project construction for storage of quarried material before crushing, crushed material, cement, rubble, etc. Efforts must be made for proper siting of these facilities.

Various criteria for selection of these sites would be:

- Proximity to the site of use
- Sensitivity of forests in the nearby areas
- Proximity from habitations
- Proximity to drinking water source

Efforts must be made to site the contractor's working space in such a way that the adverse impacts on environment are minimal, i.e. to locate the construction equipment, so that, impacts on human and faunal population is minimal.

iii) Muck disposal

Muck generation and disposal could lead to various adverse impacts. The muck needs to be disposed at designated sites. This could lead to following impacts:

- loss of land
- problems regarding stability of spoil dumps
- access to spoil dump areas

A part of the muck can be used for the following purposes:

- use of suitable rock from the excavation as aggregate in the mixing of concrete.
- use of muck for maintenance of roads.
- use of muck in coffer dam.

- use as backfill material in quarry and borrow pits.

The balance muck shall be disposed at designated sites Muck, if not securely transported and dumped at pre-designated sites, can have serious environmental impacts, such as:

- Muck, if not disposed properly, can be washed away into the main river which can cause negative impacts on the aquatic ecosystem of the river.
- Muck disposal can lead to impacts on various aspects of environment. Normally, the land is cleared before muck disposal. During clearing operations, trees are cut, and undergrowth perishes as a result of muck disposal.
- In many of the sites, muck is stacked without adequate stabilisation measures. In such a scenario, the muck moves along with runoff and creates landslide like situations. Many a times, boulders/large stone pieces enter the river/water body, affecting the benthic fauna, fisheries and other components of aquatic biota.
- Normally muck disposal is done at low lying areas, which get filled up due to stacking of muck. This can sometimes affect the natural drainage pattern of the area leading to accumulation of water or partial flooding of some area which can provide ideal breeding habitat for mosquitoes.

iv) Acquisition of land

The total land to be acquired for the project is 90.64 ha. The details of land acquired are given below.

Breakup of land to be acquired in the project area.

S.No	Particulars	Area (ha)
1	Reservoir Area	21.25
2	Diversion Structure	7.0
3	Head regulator & Desilting basin	6.0
4	Intake	0.20
5	Head Race Tunnel	7.78
6	Adits and working area at Portal	9.53
7	Penstock	0.62
8	Power house	0.36
9	Working area at power house	3.0
10	Tail Race Channel	0.12
11	Switchyard	0.94
12	Colonies	1.50
13	Project office, Store	2.0

14	DG shed, Dispensary	0.4
15	Magazine	0.15
16	Roads	14.06
17	Muck disposal sites	16.17
	Total	90.64

Based on the ownership status of land to be acquired for the project, appropriate compensatory measures shall be implemented.

Impacts On Biological Environment

a) Construction phase

Impacts on Terrestrial flora

Increased human interferences

The direct impact of construction activity of any water resource project in a Himalayan terrain is generally limited in the vicinity of the construction sites only. As mentioned earlier, a large population (10,000) including technical staff, workers and other group of people are likely to congregate in the area during the project construction phase. It can be assumed that the technical staff will be of higher economic status and will live in a more urbanized habitat, and will not use wood as fuel, if adequate alternate sources of fuel are provided. However, workers and other population groups residing in the area may use fuel wood, if no alternate fuel is provided for whom alternate fuel could be provided. There will be an increase in population by about 8,000 of which about 6,400 are likely to use fuel wood. On an average, the fuel wood requirements will be of the order of 2,700 m3. The wood generated by cutting tree is about 2 to 3 m3. Thus every year fuel wood equivalent to bout 1500 trees will be cut, which means every year on an average about 2-2.5 ha of forest area will be cleared for meeting fuel wood requirements, if no alternate sources of fuel are provided. Hence to minimize impacts, community kitchens have been recommended. These community kitchens shall use LPG or diesel as fuel.

Impacts due to Vehicular movement and blasting

Dust is expected to be generated during blasting, vehicle movement for transportation of construction material or construction waste. The dust particles shall settle on the foliage of trees and plants, thereby reduction in amount of sunlight falling on tree foliage. This will reduce the photosynthetic activity. Based on experience in similar settings, the impact is expected to be localized upto a maximum of 50 to 100 m from the source. In addition, the area experiences rainfall for almost 8 to 9 months in a year. Thus, minimal deposition of dust is expected on flora. Thus, no significant impact is expected on this account.

Acquisition of forest land

During project construction phase, land will be required for location of construction equipment, storage of construction material, muck disposal, widening of existing roads and construction of new project roads. The total land requirement for the project is 90.64 ha, a part of which could be forest land. A detailed forest conservation and Biodiversity conservation plan will be formulated.

Impacts on Terrestrial fauna

a) Construction phase

Disturbance to wildlife

Based on the field studies and interaction with locals, it was confirmed that no major wildlife is reported in the proposed submergence area. It would be worthwhile to mention here that most of the submergence lies within the gorge portion. Thus, creation of a reservoir due to the proposed project is not expected to cause any significant adverse impact on wildlife movement. The project area and its surroundings are not reported to serve as habitat for wildlife nor do they lie on any known migratory route. Thus, no impacts are anticipated on this account.

During the construction period, large number of machinery and construction workers shall be mobilized, which may create disturbance to wildlife population in the vicinity of project area. The operation of various equipments will generate significant noise, especially during blasting which will have adverse impact on fauna of the area. The noise may scare the fauna and force them to migrate to other areas. Likewise siting of construction plants, workshops, stores, labour camps etc. could also lead to adverse impact on fauna of the area. During the construction phase, accessibility to area will lead to influx of workers and the people associated with the allied activities from outside will also increase. Increase in human interference could have an impact on terrestrial ecosystem. The other major impact could be the blasting to be carried out during construction phase. This impact needs to be mitigated by adopting controlled blasting and strict surveillance regime and the same is proposed to be used in the project. This will reduce the noise level and vibrations due to blasting to a great extent.

Likewise, siting of construction equipment, godowns, stores, labour camps, etc. may generally disturb the fauna in the area. However, no large-scale fauna is observed in the area. Thus, impacts on this account are not expected to be significant. However, few stray animals sometimes venture in and around the project site. Thus, to minimize any harm due to poaching activities from immigrant labour population, strict anti-poaching surveillance measures need to be implemented, especially during project construction phase. The same have been suggested as a part of the Environmental Management Plan (EMP).

b) Operation phase

Increased accessibility

During the project operation phase, the accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem. The increased accessibility to the area can lead to increased human interferences in the form of illegal logging, lopping of trees, collection of non-timber forest produce, etc. Since significant wildlife population is not found in the region, adverse impacts of such interferences are likely to be marginal.

Aquatic Flora

a) Construction phase

During construction phase wastewater mostly from domestic source will be discharged mostly from various camps of workers actively engaged in the project area. Ssufficient water for dilution will be available in Tons to keep the DO of the river to significantly high levels.

b) Operation phase

The completion of proposed Mor-Hanol hydroelectric project would bring about significant changes in the riverine ecology, as the river transforms from a fast-flowing water system to a quiescent lacustrine environment. Such an alteration of the habitat would bring changes in physical, chemical and biotic life. Among the biotic communities, certain species can survive the transitional phase and can adapt to the changed riverine habitat. There are other species amongst the biotic communities, which, however, for varied reasons related to feeding and reproductive characteristics cannot acclimatize to the changed environment, and may disappear in the early years of impoundment of water. The micro-biotic organisms especially diatoms, blue-green and green algae before the operation of project, have their habitats beneath boulders, stones, fallen logs along the river, where depth is such that light penetration can take place. But with the damming of river, these organisms may perish as a result of increase in depth.

Impacts due to damming of river

The proposed hydroelectric project would lead to formation of reservoir area of 21.25 ha. The barrage will change the fast flowing river to a quiscent lacustrine environment. The creation of a pond will bring about a number of alterations in physical, abiotic and biotic parameters both in upstream and downstream directions of the proposed barrage site. The micro and macro benthic biota is likely to be most severely affected as a result of the proposed project.

The reduction in flow rate of river Tons especially during lean period is likely to increase turbidity levels downstream of the dam. Further reduction in rate of flow may even create condition of semi-dessication in certain stretches of the river. This would result in loss of fish life by poaching. Hence, it is essential to maintain minimum flow required for well being of fish life till the disposal point of the tail race discharge.

Impacts on Migratory Fish Species

The obstruction created by the barrage would hinder migration of species Schizothorax sp.Tor tor Tor pulling. These fishes undertake annual migration for feeding and breeding. Therefore, fish migration path may be obstructed due to barrage. A detailed fisheries management plan needs to be developed as a part of CEIA study.

Impacts On Socio-Economic Environment

A project of this magnitude is likely to entail both positive as well as negative impacts on the socio-cultural fabric of the area. During construction and operation phases, a lot of allied activities will mushroom in the project area.

Impacts due to influx of labour force

During the construction phase a large labour force, including skilled, semi-skilled and un-skilled labour force of the order of about 2000 persons, is expected to immigrate into the project area. It is felt that most of the labour force would come from other parts of the country. However, some of the locals would also be employed to work in the project. The labour force would stay near to the project construction sites.

The project will also lead to certain negative impacts. The most important negative impact would be during the construction phase. The labour force that would work in the construction site would settle around the site. They would temporarily reside there. This may lead to filth, in terms of domestic wastewater, human waste, etc. Besides, other deleterious impacts are likely to emerge due to inter-mixing of the local communities with the labour force. Differences in social, cultural and economic conditions among the locals and labour force could also lead to friction between the migrant labour population and the total population.

Economic impacts of the project

Apart from direct employment, the opportunities for indirect employment will also be generated which would provide great impetus to the economy of the local area. Various types of business like shops, food-stall, tea stalls, etc. besides a variety of suppliers, traders, transporters will concentrate here and benefit immensely as demand will increase significantly for almost all types of goods and services. The business community as a whole will be benefited. The locals will avail these opportunities arising from the project and increase their income levels. With the increase in the income levels, there will be an improvement in the infrastructure facilities in the area.

Impacts due to land acquisition

Another most important deleterious impact during construction phase will be that, pertaining to land acquisition. Out of total 90.64 ha of land proposed to be acquired for the proposed Mori Hanol hydroelectric project, about 7.83 ha is private land. Based on the present level of investigations, the ownership status of land to be acquired for the project is not known.

As a part of EIA study, the quantum of private land to be acquired needs to be identified. Subsequently, the number of families likely to lose land or homestead or both needs to be identified.

Socio-economic survey for the Project Affected Families (PAFs) to be conducted. Based on the findings of the survey an appropriate Resettlement and Rehabilitation Plan will be formulated.

Environmental Management Plan

Based on the environmental baseline conditions and project inputs, the adverse impacts will be identified and a set of measures will be suggested as a part of Environmental Management Plan (EMP) for their amelioration. An outline of various measures suggested as a part of Environmental Management Plan is briefly described in the following sections.

Environmental Measures During Construction Phase

Facilities in labour camps

It is recommended that project authorities can compulsorily ask the contractor to make semi-permanent structures for their workers. These structures could be tin sheds. These sheds can have internal compartments allotted to each worker family. The sheds will have electricity and ventilation system, water supply and community latrines.

The water for meeting domestic requirements may be collected from the rivers or streams flowing upstream of the labour camps.

Sanitation facilities

One community toilet can be provided per 20 persons. The sewage from the community latrines can be treated in a sewage treatment plant before disposal.

Solid waste management from labour camps

For solid waste collection, suitable number of masonry storage vats, each of 2 m3 capacity should be constructed at appropriate locations in various labour camps. These vats should be emptied at regular intervals and should be disposed at identified landfill sites. Suitable solid waste collection and disposal arrangement shall be provided. A suitable landfill site should be identified and designed to contain municipal waste from various project township, labour colonies, etc.

Provision of free fuel

During the construction period of the project, there would be around 600 labour and technical staff would be involved in the project construction work. Many families may prefer cooking on their own instead of using community kitchen. In the absence of fuel for cooking, they would resort to tree cutting and using wood as fuel. To avoid such a situation, the project authority should make LPG and/ or kerosene available to these migrant workers. The supply of LPG and kerosene can be ensured on regular basis. A local depot can be established through LPG/ kerosene suppliers for supply of the same.

Muck Disposal

A part of the muck generated, is proposed to be utilised for construction works after crushing it into the coarse and fine aggregates. The balance quantum of muck would have to be disposed. The muck shall be disposed in low-lying areas (preferably over non-forest land). The sites shall then be stabilized by implementing bioengineering treatment measures.

In the hilly area, dumping is done after creating terraces thus usable terraces are developed. The overall idea is to enhance/maintain aesthetic view in the surrounding area of the project in post-construction period and avoid contamination of any land or water resource due to muck disposal.

Suitable retaining walls shall be constructed to develop terraces so as to support the muck on vertical slope and for optimum space utilization. Loose muck would be compacted layer wise. The muck disposal area will be developed in a series of terraces of boulder crate wall and masonry wall to protect the area/muck from flood water during monsoons. In-between the terraces, catch water drain will be provided.

The terraces of the muck disposal area will be ultimately covered with fertile soil and suitable plants will be planted adopting suitable bio-technological measures. Various activities proposed as a part of the management plan are given as below:

- Land acquisition for muck dumping sites
- Civil works (construction of retaining walls, boulder crate walls etc.)
- Dumping of muck

- Levelling of the area, terracing and implementation of various engineering control measures e.g., boulder, crate wall, masonry wall, catchwater drain.
- Spreading of soil
- Application of fertilizers to facilitate vegetation growth over disposal sites.

For stabilization of muck dumping areas following measures of engineering and biological measures have been proposed

Engineering Measures

- Wire crate wall
- Boulder crate wall
- Retaining wall
- Catch water Drain

Biological Measures

- Plantation of suitable tree species and soil binding species
- Plantation of ornamental plants
- Barbed wire fencing

Restoration Plan For Quarry Sites

The following biological and engineering measures are suggested for the restoration of quarry site:

- Garland drains around quarry site to capture the runoff and divert the same to the nearest natural drain.
- Construction of concrete guards check the soil erosion of the area.
- The pit formed after excavation be filled with small rocks, sand and farmyard manure.
- Grass slabs will be placed to stabilized and to check the surface runoff of water and loose soil.
- Bench terracing of quarry sites once extraction of construction material is completed.

Restoration And Landscaping Of Project Sites

The working area of dam site, power house complex colony area have been selected for beautification of the project area after construction is over. The reservoir created due to the construction of barrage may be a local point of tourist attraction. This could be used for sport fishing, so there is a need to construction of benches for sitting, development of resting sheds and footpath. The beautification would be carried out by developing flowering beds for plantation ornamental plant and flower garden.

There would be sufficient open space in power house complex and colony area. Forested area in the power house complex would provide aesthetic view and add to natural seismic beauty. The beautification in the colony area would be carried out by development of flowering beds for plantation of ornamental plant, creepers, flower garden and a small park, construction of benches for sitting, resting sheds, walk way and fountain.

Compensation For Acquisition Of Forest Land

Based on the ownership status of land to be acquired, it is proposed to afforest twice the forest area being acquired for the project. The species for afforestation shall be selected in consultation with local forest department.

Wildlife Conservation

It is recommended to commission check posts along few sites, i.e. barrage site, power house site, labour camps, construction material storage site etc. during project construction phase. Each check post will have 4 guards. One Range Officer would be employed to supervise the operation of these check-posts and ensure that poaching does not become a common phenomenon in the area. These check posts also will also be provided with appropriate communication facilities and other infrastructure as well.

Greenbelt Development

Although the forest loss due to reservoir submergence and other project appurtenances have been compensated as a part of compensatory afforestation, it is proposed to develop greenbelt around the periphery of various project appurtenances, selected stretches along reservoir periphery.

The green belt on either side of the reservoir will reduce the sedimentation and ensure protection of the reservoir area from any other human activity that could result in the reservoir catchment damage. On moderately steep slopes tree species will be planted for creation of green belt which are indigenous, economically important, soil binding in nature and an thrive well under high humidity and flood conditions. In addition greenbelt is recommended around permanent colony for the project.

Sustenance Of Riverine Fisheries

a) Release of minimum flow

The dry segment of river between barrage/dam site and tail race at certain places may have shallow water subjecting the fish to prey by birds and other animals. Such a condition will also enable the poachers to catch fish indiscriminately. It is therefore, recommended to maintain a minimum flow of to ensure survival and propagation of invertebrates and fish.

In case of proposed hydroelectric project, the Environmental Flows are recommended as below:

- May to September - 30%
- October to November - 25%
- December to March - 20%
- April - 25%

b) Sustenance of Endemic Fisheries

It is proposed to implement supplementary stocking programmes for the project area. It is proposed to stock reservoir, river Tons upstream and the downstream sides. The stocking will be done on the upstream and downstream sides of dam site. The stocking can be done annually by the Fisheries Department, State Government of Uttarakhand. To achieve this objective, facilities to produce seed of trout need to be developed at suitable sites.

Public Health Delivery System

The suggested measures are given in following paragraphs:

- The site selected for habitation of workers shall not be in the path of natural drainage.
- Adequate drainage system to dispose storm water drainage from the labour colonies shall be provided.
- Adequate vaccination and immunization facilities shall be provided for workers at the construction site.
- The labour camps and resettlement sites shall be at least 2 km away from a main water body or quarry areas.
- As a part of Health Delivery System, following measures shall be implemented:
- Clearing of river basins, shoreline, mats and floating debris, etc. to reduce the proliferation of mosquitoes.
- Development of medical facilities in the project area and near labour camps
- Implementation of mosquito control activities in the area.

Infrastructure

Dispensary: Considering the number of rooms, staff quarters and open space etc., it is estimated that 10,000 sq.feet of plot will be required for dispensary, out of which about 8000 sq.feet will be the built-up land which includes staff quarters, etc.

First Aid Posts: Temporary first aid posts shall be provided at major construction sites. These will be constructed with asbestos sheets, bamboo, etc.

Maintenance Of Water Quality

The sewage generated from the labour camps, as mentioned earlier, is proposed to be treated in sewage treatment plant prior to disposal. In the project operation phase, a plant colony with about 50 quarters is likely to be set up. The sewage so generated would be treated through a sewage treatment plant, equipped with secondary treatment units.

Control Of Noise

The contractors will be required to maintain properly functioning equipment and comply with occupational safety and health standards. The construction equipment will be required to use available noise suppression devices and properly maintained mufflers.

- vehicles to be equipped with mufflers recommended by the vehicle manufacturer.
- staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible.
- notification will be given to residents within 100 m of major noise generating activities. The notification will describe the noise abatement measures that will be implemented.
- monitoring of noise levels will be conducted during the construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to stop work and remedy the situation prior to continuing construction.

The following Noise Standards for DG sets are recommended for the running of DG sets during the construction:

- The maximum permissible sound pressure level for new diesel generator sets with rated capacity upto 1000 KVA shall be 75 dB(A) at 1 m from the enclosure surface.
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.
- The Acoustic Enclosure should be made of CRCA sheets of appropriate thickness and structural/ sheet metal base. The walls of the enclosure should be insulated with fire retardant foam so as to comply with the 75 dBA at 1m sound levels specified by CPCB, Ministry of Environment & Forests.
- The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB(A) Insertion Loss or for meeting the ambient noise standards, whichever is on the higher side.
- The DG set should also be provided with proper exhaust muffler.
- Proper efforts to be made to bring down the noise levels due to the DG set, outside its premises, within the ambient noise requirements by proper siting and control measures.

- A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

Noise due to crusher

Based on literature review, noise generated by a crusher is in the range of 79-80 dB(A) at a distance of 250 ft or about 75 m from the crusher. Thus, noise level at a distance of 2 m from the crusher shall be of the order of 110 dB(A). The exposure to labour operating in such high noise areas shall be restricted upto 30 minutes on a daily basis. Alternatively, the workers need to be provided with ear muffs or plugs, so as to attenuate the noise level near the crusher by atleast 15 dB(A). The exposure to noise level in such a scenario to be limited upto 4 hours per day.

It is known that continuous exposure to noise levels above 90 dB(A) affects the hearing of the workers/operators and hence has to be avoided. Other physiological and psychological effects have also been reported in literature, but the effect on hearing acuity has been specially stressed. To prevent these effects, it has been recommended by international specialist organizations that the exposure period of affected persons be limited.

The contractors will be required to maintain properly functioning equipment and comply with occupational safety and health standards. The construction equipment will be required to use available noise suppression devices and properly maintained mufflers.

- vehicles to be equipped with mufflers recommended by the vehicle manufacturer.
- staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible.
- notification will be given to residents within 100 m of major noise generating activities. The notification will describe the noise abatement measures that will be implemented.
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The following Noise Standards for DG sets are recommended for the running of DG sets during the construction:

- The maximum permissible sound pressure level for new diesel generator sets with rated capacity upto 1000 KVA shall be 75 dB(A) at 1 m from the enclosure surface.
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.
- The Acoustic Enclosure should be made of CRCA sheets of appropriate thickness and structural/ sheet metal base. The walls of the enclosure should be insulated with fire retardant foam so as to comply with the 75 dBA at 1m sound levels specified by CPCB, Ministry of Environment & Forests.
- The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB(A) Insertion Loss or for meeting the ambient noise standards, whichever is on the higher side.
- The DG set should also be provided with proper exhaust muffler.
- Proper efforts to be made to bring down the noise levels due to the DG set, outside its premises, within the ambient noise requirements by proper siting and control measures.
- A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

Control of Air Pollution

a) Control of Emissions

Minor air quality impacts will be caused by emissions from construction vehicles, equipment and DG sets, and emissions from transportation traffic. Frequent truck trips will be required during the construction period for removal of excavated material and delivery of select concrete and other equipment and materials. The following measures are recommended to control air pollution:

- The contractor will be responsible for maintaining properly functioning construction equipment to minimize exhaust.
- Construction equipment and vehicles will be turned off when not used for extended periods of time.
- Unnecessary idling of construction vehicles to be prohibited.

- Effective traffic management to be undertaken to avoid significant delays in and around the project area.
- Road damage caused by sub-project activities will be promptly attended to with proper road repair and maintenance work.

b) Air Pollution control due to DG sets

The Central Pollution Control Board (CPCB) has issued emission limits for generators upto 800 KW. The same are outlined below, and are recommended to be followed.

Emission limits for DG sets prescribed by CPCB

Parameter	Emission limits (gm/kwhr)
NOx	9.2
HC	1.3
CO	2.5
PM	0.3
Smoke limit*	0.7

Note : * Light absorption coefficient at full load (m^{-1})

The above standards need to be followed by the contractor operating the DG sets.

The other measures are recommended as below:

- Location of DG sets and other emission generating equipment should be decided keeping in view the predominant wind direction so that emissions do not effect nearby residential areas.
- Stack height of DG sets to be kept in accordance with CPCB norms, which prescribes the minimum height of stack to be provided with each generator set to be calculated using the following formula:

  $H = h+0.2x \sqrt{KVA}$

  H = Total height of stack in metre

  h = Height of the building in metres where the generator set is installed

  KVA = Total generator capacity of the set in KVA

c) Dust Control

The project authorities will work closely with representatives from the community living in the vicinity of project area to identify areas of concern and to mitigate dust-related impacts effectively (e.g., through direct meetings, utilization of construction management and inspection program, and/or through the complaint response program).

To minimize issues related to the generation of dust during the construction phase of the project, the following measures have been identified:

- Identification of construction limits (minimal area required for construction activities).
- When practical, excavated spoils will be removed as the contractor proceeds along the length of the activity.
- When necessary, stockpiling of excavated material will be covered or staged offsite location with muck being delivered as needed during the course of construction.
- Excessive soil on paved areas will be sprayed (wet) and/or swept and unpaved areas will be sprayed and/or mulched. The use of petroleum products or similar products for such activities will be strictly prohibited.
- Contractors will be required to cover stockpiled soils and trucks hauling soil, sand, and other loose materials (or require trucks to maintain at least two feet of freeboard).
- Contractor shall ensure that there is effective traffic management at site. The number of trucks/vehicles to move at various construction sites to be fixed.
- Dust sweeping - The construction area and vicinity (access roads, and working areas) shall be swept with water sweepers on a daily basis or as necessary to ensure there is no visible dust.

Resettlement And Rehabilitation Plan

The total land to be acquired for the project is 90.64 ha, a part of which is private land. Based on the present level of investigations, the number of project affected families is not available. The number of families likely to lose land will be finalized. In addition, information of any family losing homestead or other private properties shall also be ascertained. Socio-economic survey for the Project Affected Families (PAFs) will be conducted. Based on the findings of the survey an appropriate Resettlement and Rehabilitation Plan will be formulated as per the norms outlined in Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013.

Catchment Area Treatment

The following aspects are proposed as a part of the Catchment Area Treatment Plan to be prepared as a part of the EIA study:

- Delineation of micro-watersheds in the river catchment and mapping of critically degraded areas requiring various biological and engineering treatment measures.
- Identification of area for treatment based upon Remote Sensing & GIS methodology and Silt Yield Index (SYI) method of AISLUS coupled with ground survey.
- Prioritization of watershed for treatment based upon SYI.
- Spatial Information in each micro watershed to be earmarked on maps.
- CAT plan would be prepared with year-wise Physical and financial details.

Infrastructure Development Under Local Area Development Committee (Ladc)

A lump-sum budget @ 0.5% of the Project Cost has been earmarked for construction of Infrastructure and Local Area Development Committee works. The activities envisaged are given as below:

- Education Facilities
- Strengthening of existing PHSCs/ Health Care Facilities
- Bus Stops
- Approach Roads and Widening of Existing Road
- Infrastructure and Community Development
- Drinking Water Supply and Restoration of Dried Up Sources
- Miscellaneous activities

Environmental Monitoring Programme

The Environmental Impact Assessment is basically an evaluation of future events. It is necessary to continue monitoring certain parameters identified as critical by relevant authorities under an Environmental Monitoring Programme. This would anticipate any environmental problem so as to take effective mitigation measures. An Environmental Monitoring Programme will be formulated for implementation during project construction and operation phases. The cost estimates and equipment necessary for the implementation of this programme shall also be covered as a part of the Comprehensive EIA study.

The Environmental monitoring programme for implementation during construction and operation phases is given below.

Summary of Environmental Monitoring Programme during Project Construction Phase

S. No.	Item	Parameters	Frequency	Location
1.	Effluent from septic tanks	pH, BOD, COD, TSS, TDS	Once every month	Before and after treatment from Sewage Treatment plant
2.	Water-related diseases	Identification of water related diseases, adequacy of local vector control and curative measure, etc.	Three times a year	Labour camps and colonies
3.	Noise	Equivalent noise level (L_{eq})	Once in three months	At major construction sites.
4.	Air quality	PM_{10} SO_2 and NO_2	Once every season	At major construction sites

Summary of Environmental Monitoring Programme during Project Operation Phase

S. No.	Items	Parameters	Frequency	Location
1.	Water	pH, Temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates,	Thrice a year	• 1 km upstream of dam site • Reservoir area • 1, 5 and 10 km downstream of Tail Race discharge

S. No.	Items	Parameters	Frequency	Location
		Nitrates, DO. COD, BOD, Iron, Zinc, Manganese		
2.	Effluent from Sewage Treatment Plant (STP)	pH, BOD, COD, TSS, TDS	Once every week	• Before and after treatment from Sewage Treatment Plant (STP)
3.	Erosion & Siltation	Soil erosion rates, stability of bank embankment, etc.	Twice a year	-
4.	Ecology	Status of afforestation programmes of green belt development	Once in 2 years	-
5.	Water-related diseases	Identification of water-related diseases, sites, adequacy of local vector control measures, etc.	Three times a year	• Villages adjacent to project sites
6.	Aquatic ecology	Phytoplanktons, zooplanktons, benthic life, fish composition	Once a year	• 1 km upstream of dam site • Reservoir area • 1, 5 and 10 km downstream of Tail Race discharge
7.	Landuse	Landuse pattern using satellite data	Once in a year	Catchment area
8.	Soil	pH, EC, texture, organic matter	Once in a year	Catchment area

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ESTIMATED COST OF THE PROJECT

14. ESTIMATED COST OF THE PROJECT

The total cost of the project at December, 2014 price level works out as under:

MORI HANOL H. E. PROJECT, (2x32=64 MW) UTTARAKHAND ABSTRACT OF COST		
S.No.	**Description**	**Amount (Rs In Crore) (December-2014)**
	CIVIL WORKS	
1	**DIRECT CHARGES**	
	I-Works	
	A-Preliminary	9.25
	B-Land	23.12
	C-Works	
	C-1 - Cofferdam	4.70
	C-2 - Barrage	40.06
	Sub-Total - C-Works	**44.76**
	Contingencies @ 3% on C Works	**1.34**
	Construction workers Cess Tax @ 1% on C Works	**0.45**
	Service Tax @ 4.944% on C Works	**2.21**
	Total - C-Works	**48.76**
	J-Power Plant Civil Works	
	J-1 - Intake Channel & Structure	12.31
	J-2 - Desilting Chamber & Collection Pool	31.90
	J-3 - Silt Flushing Arrangement	4.56
	J-4 - Power Intake Structure	4.67

MORI HANOL H. E. PROJECT, (2x32=64 MW)

UTTARAKHAND

ABSTRACT OF COST

S.No.	Description	Amount (Rs In Crore) (December-2014)
	J-5 - Construction Adits	33.02
	J-6 - Head Race Tunnel	221.13
	J-7 - Surge Shaft	9.93
	J-8 - Valve House	0.65
	J-9 - Penstock Tunnel & Penstock	12.16
	J-10 - Power House Complex	15.31
	J-11 - Tail Race Channel	1.20
	J-11 - Pothead Yard	1.47
	J-12 - Hydromechanical Works	29.66
	Sub-Total - J-Works	**377.98**
	Contingencies @ 3% on J Works	**11.34**
	Construction workers Cess Tax @ 1% on J Works	**3.78**
	Service Tax @ 4.944% on J Works	**18.69**
	Total - J-Works	**411.78**
	K-Buildings	5.92
	M-Plantation	0.65
	O-Miscellaneous	11.82
	P-Maintenance During Construction	4.90
	Q-Special Tools and Plants	1.44
	R-Communication	23.36
	S-Power Plant And Electro-Mechanical system	105.00

MORI HANOL H. E. PROJECT, (2x32=64 MW) UTTARAKHAND ABSTRACT OF COST		
S.No.	**Description**	**Amount (Rs In Crore) (December-2014)**
	Power Evacuation system	4.12
	X-Environment and Ecology	31.00
	Y-Losses on Stock	1.17
	Sub Total - I	**682.29**
	II-Establishment	40.00
	III-Tools and Plants	1.00
	IV-Suspense	0.00
	V-Receipt & Recoveries	-0.35
	Total Direct Charges	**722.94**
2	**INDIRECT CHARGES**	
	I-Capitalised Value of Abatement of Land Revenue (5% of Cost of Culturable Land)	0.59
	II- Audit and Accounts Charges	1.00
	Total Indirect Charges	**1.59**
	TOTAL (1 + 2)	**724.53**
3 (a)	**ESCALATION**	**32.31**

MORI HANOL H. E. PROJECT, (2x32=64 MW) UTTARAKHAND ABSTRACT OF COST		
S.No.	**Description**	**Amount (Rs In Crore) (December-2014)**
3 (b)	**INTEREST DURING CONSTRUCTION**	**95.39**
3 (c)	**FUND MANAGEMENT EXPENSES**	**3.02**
	Total (3a + 3b+3c)	**130.72**
	GRAND TOTAL (1 + 2 + 3)	**855.25**

15

FINANCIAL AND ECONOMIC EVALUATION

15. FINANCIAL AND ECONOMIC EVALUATION

General

This Chapter assesses the financial and economic viability of Mori Hanol H.E. Project. Sensitivity studies have been carried out to ascertain robustness of financial and economic findings due to changes in certain key parameters.

The evaluation has been carried out adopting the following basic and normative parameters.

- Estimated cost (December 2014 Price Level)
- Construction period: 4 years
  (Including development of infrastructure facilities)
- Annual energy benefits with 95% plant availability in a 90% dependable year based on annual runoff
- Full energy absorption
- Auxiliary Consumption: 0.50% of gross energy generation
- Transformation losses: 0.5 %
- Transmission losses / charges: 2 %
- Operation and maintenance charges: 2.0%.
- Salvage Value: 10%
- Weighted Average of Straight Line Depreciation: 3.4%.
- Interest during Construction (IDC): Computed on the loan.

Project Cost; Phasing Of Experndíture & Energy Benefits

The Project is estimated to cost Rs. 855.25 crores considering 3 % escalation per annum for civil works and E&M works and including IDC and financial management charges.

The financial analysis has been carried out considering the cost of the project at HT Bus Bar at the Power House. The summary of the cost is given below in Table:

Sl. No.	Particulars	Estimated cost (Rs. Crores)
1 (a)	Pre-Operative expenses	50.84
1 (b)	Civil Work	564.57
1 (c)	E&M Works including transmission line	109.12
	Basic Cost (Sub-total)	**724.53**
2 (a)	Escalation	32.31
2 (b)	Interest during construction	95.39
2 (c)	Fund Management Expenses	3.02
	Total (Generation Works) (2(a) +2(b) +2(c))	**855.25**

The year-wise phasing of expenditure based on proposed construction programme is given in Table below (the actual completed cost could be higher if the construction period is more due to any reason as the latter will affect IDC).

Year	Capital Expenditure (Escalated)	Pre-operative	IDC	FM	Total Cost
1	61.91	5.08	2.89	3.02	**72.90**
2	127.21	10.17	11.68	-	**149.06**
3	216.18	15.25	27.86	-	**259.29**
4	300.70	20.34	52.96	-	**374.00**
Total	**706.00**	**50.84**	**95.39**	**3.02**	**855.25**

Financial Evaluation

Project Finance

A debt equity ratio of 2.33:1 has been adopted for financial evaluation. The expenditure out of loan and equity is being proposed to be shared in the same proportion every year. The year-wise requirement of capital, both loan and equity, during construction is indicated in Table below:

Year	Equity	Loan	Total
1	21.87	51.03	**72.90**
2	44.72	104.34	**149.06**
3	77.79	181.50	**259.29**
4	112.20	261.80	**374.00**
Total	**256.58**	**598.67**	**855.25**

The loan capital for the project is proposed to be raised through a rupee loan @ 12.0% per annum from Indian Financial Institutions to the extent of 70% of project cost.

The equity capital will be raised through issue of equity shares to promoters (30% of project cost).

Tariff Calculation

The generation cost of energy has been computed considering provision of policy guidelines published by the Ministry of Power for private sector participation in power sector. The rate of depreciation for the project has been taken as 3.4% constant for entire project duration i.e. 1st to 30th year. The studies have been carried out to compute the tariff rate for 30 years of normal useful plant life. The study assumes interest charges on Rupee loan capital @ 12.0% per annum, interest charges on working capital @ 12.5% per annum and repayment period of 10 years with a moratorium of 4 years during construction period. Interest during construction for the loan has been capitalized at 12.0% per annum. The Debt-Equity Ratio of 70:30 has been adopted.

A)	**Base Capital Cost (December 2014)**	724.53		
B)	**Capital cost with escalation IDC and Fund Management expenses**	855.25		
	Equity	**256.58**		
	Loan Capital	**598.67**		
C)	**Particular**	**1st Year**	**Average for 1st to 5th year**	**Average for 6th to 10th year**
	(a) Interest charges	68.93	54.42	18.14
	(b) O&M Expenses	17.11	19.18	25.33
	(c) Interest on working capital	2.68	2.48	2.00
	(d) Depreciation	29.08	29.08	29.08
	(e) Income Tax	10.65	10.65	10.65
	Total	128.45	115.81	85.20
D)	**Energy Generation Cost (Rs / kWh) (Tariff)**	6.19	5.73	4.60

Further observations from the 30 years study are given below :

- Average tariff reduces progressively with the reduction in the interest charges till Income Tax becomes payable.
- The loan capital would be repaid out of the sum of annual revenue and depreciation.

Sensitivity Analysis

The key parameter considered in the sensitivity analysis is rate of interest on loan and thereby change in capital cost of the project. The average generation cost of energy for 1st to 5th year and 6th to 10th year period of operation, for various alternatives considered in the Sensitivity Studies, are summarized below:

Particulars	Interest Rate on Loans		
	11.5%	12.0%	12.5%
Escalation (%)	5.72%	5.72%	5.72%
Variation in basic cost (%)	0%	0%	0%
Cost with IDC and Escalations etc. (Rs. Crores)	851.13	855.25	859.39
Average generation cost with escalation in O&M expenses (Rs./kWh)			
1st year	6.06	6.19	6.33
1st to 5th year	5.62	5.73	5.84
6th to 10th year	4.55	4.60	4.66

As seen from the Tables, average energy generation cost for first ten years varies from Rs 6.33/kWh to Rs. 4.55/ kWh depending upon the rate of interest on loan. Tariff in first year with 12.0 % rate of interest on loan worked out as Rs 6.19/ kWh is considered favourable as compared to other projects in the region. The tariff would be firmed up after the financing package is negotiated and finalized.

Clean Development Mechanism

Hydro Power projects are proposed to be taken up as a CDM (Clean Development Mechanism) Project. As per guidelines, one million units of electricity will generate 800 CER (Certified Emission Reduction). The design energy of project (energy at 90% dependable year at 95% plant availability) is 318.89 MU. Thus, total CER generated will be = 318.89 X 800 = 2,55,112. One CER generally varies from 11 to 20 Euro. Being on conservative side, taking one CER = 11 Euro, the total Euro per year will be = 28,06,232. Considering 1 Euro equivalent to 70 rupees as per current rate, the total annual CDM benefits will be = Rs. 19,64,36,240 i.e. Rs. 19.64 Crore. These CDM benefits have not been considered for financial analysis. The monetary benefits available under CDM will have positive impact on the viability of the project.

Conclusions

The project is financially viable and the generation cost of energy compares favourably with other alternative modes of power generation.

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RECOMMENDATIONS

16. RECOMMENDATIONS

General

The project involves construction of conventional civil structures as detailed below.

- Barrage with Intake and Head Regulator, Temporary diversion arrangement
- Feeder Channels
- Surface De-silting basins
- Collection pool
- Modified Inclined Leg Horseshoe shaped Head Race Tunnel and Adits
- Vertical Surge Shaft
- Pressure Shaft / penstock and 2 nos. unit Penstocks
- Surface power house with installed capacity of 64 MW by installing 2 generating units each of 32 MW and transformer yard.
- Switch yard
- Tail Race Channel
- Dedicated transmission line of about 2.0 km

The project construction work is expected to be completed in a period of 48 months including 8 months for development of infrastructure facilities.

Preliminary And Pre-Construction Works

To ensure project completion in 48 months, it is essential to accomplish the following activities in a period of 8 months including obtaining all clearances before start of Main Civil works. However some of the activities will continue during phase-II.

- Acquisition of land
- Completion of main infrastructure facilities such as roads and buildings, bridges across Tons River.
- Completion of detailed design and specifications
- Financial Closure
- Tender and award of main Civil, Hydro-mechanical and Electro-mechanical works.

Civil And Hydro Mechanical Works

A total time period of 40 months has been considered for main Civil and Hydro-mechanical works. The Head race tunnel construction falls in critical path. Adequate construction equipment planning has been done to achieve the desired progress rates.

Timely completion of construction works also depends on the timely supply of construction material to Diversion site, Head race Tunnel, pressure shaft / penstock and power house through development of project roads. Sufficient storage shall be ensured at project sites to ensure continuous construction without stoppage due to shortage of materials.

Electro-Mechanical Works

Two numbers of 32 MW Francis machines have been proposed to generate 64 MW of power. The orders for Electro-Mechanical equipments will be placed in line with civil works so as not to cause any delay in completion of civil works.

Construction Power

Availability of adequate construction power plays a major role in the scheduled completion of construction works. Construction power required for various components shall be supplied through dedicated D.G. Sets. However, if power is available in the local grid the same shall also be utilized for construction of the project.

Benefits

The annual energy benefit from the project in 90% dependable year at 95% availability of water is 318.89 MU.

Project Cost And Financial Indicators

The completion cost of the project is Rs 855.25 Crores (at December, 2014 price level).

As per financial analysis, the first year tariff works out to Rs 6.19/ kWh and levelised cost is Rs 5.38 /kWh. The financial indicators are given below:

- Maximum Debt Service Coverage Ratio (DSCR) : 1.14

- Average Debt Service Coverage Ratio (DSCR) : 1.09
- Minimum Debt Service Coverage Ratio (DSCR) : 1.07

Recommendations

- The Mori Hanol Hydroelectric Project has an optimal potential to generate about 64 MW power utilising a design head of 103 m and rated discharge of 68.05 cumecs. The project is expected to generate about 318.89 MU of energy annually in 90% dependable year at 95% availability and the project is estimated to cost Rs 724.53 Cr. at December, 2014 price level excluding IDC, Escalation & Financial Charges.
- The installed capacity of 64 MW based on the project layout proposed in this DPR appears technically feasible.
- As per financial analysis, cost of generation in first year works out as Rs 6.19 /kWh and levelised tariff works out as Rs 5.38 /kWh. Sale of power corresponding to levelised tariff of Rs 5.38/kWh appears feasible at the time of expected project commissioning in year 2019-20.