# THDC INDIA LIMITED

## Environmental Studies for Vishnugad Pipalkoti Hydro Electric Project

## Final Report

# Consolidated Environmental Assessment (EA)

# (Volume – I)

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CONSULTING ENGINEERING SERVICES ( INDIA ) PRIVATE LIMITED
57, Manjusha Building (5th Floor), Nehru Place New Delhi - 110 019

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# Introduction & Project Description

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## 1.1 INTRODUCTION

THDC India Ltd. proposes to commission Vishnugad Pipalkoti Hydro-electric Power (VPHEP) Project on the river Alaknanda, a major tributary of the river Ganga. It is a run-of-the-river (ROR) hydropower project with an installed capacity of 444 Mega Watts. A dam is to be located at village Helong in Joshimath Tehsil and an underground power house, at village Haat in Chamoli Tehsil.

The Government of India has requested World Bank financing for VPHEP. Prior to GoI's decision to request World Bank funding, THDC had already undertaken an Environmental Impact Assessment (EIA) of VPHEP through Water & Power Consultancy Services (WAPCOS), a PSU under Ministry of Water Resources, engaged in consultancy in water resources, water supply, hydro power and allied sectors. The Project also obtained Environmental Clearance from the Statutory Authority on the basis of this original EIA.

On reviewing the approved EIA of VPHEP, it was found that some aspects, such as managed river flow, terrestrial biodiversity, environmental impacts of advanced construction sites and archaeological survey etc., needed further analysis to strengthen the report and to comply with World Bank policy requirements for environmental assessment. In order to address these shortcomings, THDC assigned the work to M/s

Consulting Engineering Services (India) Private Limited, New Delhi to carry out additional environmental studies and consolidate the initial EIA into a comprehensive Environmental Assessment in line with the requirements of the Government of India and the World Bank.

In addition, the Social Impact Assessment (SIA) & Resettlement Action Plan (RAP) has been undertaken through the Centre for Management & Social Research (CMSR), Hyderabad. The project involves acquisition of public (government and forest land) and private land from titleholders located in 19 villages. The acquisition of land and consequent displacement will have potential impacts on the social, economic, cultural and environmental attributes of the affected population.

## 1.2 BACKGROUND OF THE STUDY

River Alaknanda is originating from the glacial regions of the Himalayas. The river has tremendous scope for development of hydro-power, which needs to be harnessed to meet the ever-growing demand for power. At present, various hydropower schemes are in different stages of development on the river. Vishnugad Pipalkoti hydropower is one such scheme envisaged in this region.

The operation of VPHEP is linked to the upstream projects on Vishnugad (by M/S Jai Prakash) and Topovan- Vishnugad (by M/S NTPC). Downstream of this project, further run of the river power projects are planned.

## 1.3 SCOPE OF WORK

The brief Scope of Work of the Environmental Study is given below:

- Review of available reports / studies
- Analysis of residual Gaps
  - Archaeological study
  - Preparation of management plan for preventing landslide
  - Preparation of management plan for muck disposal sites
  - Analysis of alternatives
  - Review of Catchment Area Treatment Plan
  - Development of comprehensive environmental monitoring plan
- Environmental screening of the advanced construction works/ sites and preparation of environmental analysis report
- Assessment of managed river flow issues
  - Measurement of current river flow of the tributaries
  - Water use & river bed utilization survey
  - Study of aquatic ecology
  - Pollution load study
  - Water borne diseases
  - Downstream hazards
- Analysis of the managed flow issues and recommendation of management measures
- Establishment of baseline conditions of terrestrial biodiversity

- Policy & legal context
- Baseline of the project's influence area
- Baseline of the project's impacted area
- Assessment of direct, indirect, cumulative and induced impacts
- Impacts on Nanda Devi Biosphere Reserve

❖ Recommendation of management measures related to terrestrial biodiversity
❖ Development of an adaptive Environmental Capacity Building plan for THDC
❖ Preparation of consolidated EA and EMP Reports
❖ Assist THDC in Public Disclosure

## 1.4 THE STUDY AREA

The study area includes the area between proposed intake structure to tailrace outlet and stretches immediately above and downstream of the project, including influence area of 7km around the project (27 km).

## 1.5 CONTEXT OF THE PROJECT

Development of hydro power resources is important for energy security of the country. Considering the fact that hydro power is a renewable source of energy and is environment-friendly compared to coal based thermal power plants, and also the fact that India has huge hydro power potential, policy decisions were taken at national level to develop hydro power to meet the country's growing energy demand. It takes about 10 years for developing a large size hydro project from planning to commission. It is therefore necessary to prepare a long term plan of hydropower development

### 1.5.1 Hydropower Potential Assessment

A systematic survey of hydro power potential in India was first undertaken during the period 1953 to 1959 by the erstwhile Central Water and Power Commission. According to this survey, hydro power potential of the country was assessed to be about 42,000 MW from a total of 250 schemes. This survey provided the base for development of hydro power projects in the country for the next two decades.

During the period 1978 to 1987, a re-assessment of hydro power potential was undertaken by the Central Electricity Authority (CEA) on the advice of the Planning Commission. The scope of the re-assessment study included assessment of Gross Theoretical Potential, Secondary Energy contribution and Identification of possible sites for Pumped Storage development in addition to assessment of economic potential and computation of annual energy contribution in dependable and average flow conditions.

The re-assessment study assessed the hydro power potential of the country at about 84,000 MW from a total of 845 schemes. In addition, 56 sites for development of pumped storage schemes with total likely installed capacity of about 94,000 MW were also identified in various regions of the country. The river basin-wise hydro power potential identified in this study is given in **Table-1.5.1**.

**Table-1.5.1 River Basin-wise Hydroelectric Power Potential Identified in Reassessment Study**

| River Basin | No. of Schemes | Potential of 60% load factor (MW) | Date of Completion of Study |
|---|---|---|---|
| Indus | 190 | 19,988 | March , 1983 |
| Brahmaputra | 226 | 34,920 | January, 1984 |
| Ganga | 142 | 10,715 | August, 1984 |
| Central Indian River | 53 | 2,740 | June, 1985 |
| West flowing Rivers of Southern India | 94 | 6,149 | November, 1985 |
| East flowing Rivers of Southern India | 140 | 9,532 | April, 1986 |
| **Total** | **845** | **84,044 ≅ Installed capacity – 1,50,000 MW** | |
| **Pumped Storage Scheme Sites** | **56** | **94,000 MW** | **August, 1984** |

Source: Central Electricity Authority

The reassessment study revealed that the State of Uttarakhand in the Ganga basin has substantial potential for development of hydro power. The whole of Uttarakhand practically comes under the Ganga Basin, particularly, Upper Ganga Sub-Basin.

### 1.5.2 Hydropower Potential in India

As per the Central Electricity Authority of India, 2009, the status of Hydro power potential development of the country is:

Identified capacity : 148701 MW
Capacity Developed : 33091.5 MW (22.25%)
Capacity under Construction : 12970 (8.72%)
Capacity yet to be Developed : 102639.5MW (69.02%)

India is currently facing an energy deficit. In Northern region there is an energy deficit of 13.41 percent and a peaking deficit of 17.62 percent and the demand for energy is projected to rise further. According to estimates by the Central Electricity Authority, the demand for peaking power in the Northern Region alone is projected to rise from 35,145 MW during 2007-08 to 48137 MW in 2011-12.

To meet the all India peak demand and energy requirement at the end of 12th Plan, a capacity addition of more than 90,000 MW has been assessed during 12th Plan (2012-2017), which includes 30,000 MW of hydro electric power. To achieve the ambitious programme of hydro capacity addition in the 12th Plan period, shelf of hydro power projects with aggregate installed capacity of 58,573 MW were identified by CEA in the year 2006-07.

### 1.5.3 Necessity of Hydropower Development in Uttarakhand

The requirement of power (Source: Ministry of Power) during the year 2002-03 in the state of Uttarakhand and the Northern Region was 3774 MU and 156610 MU against availability of 3670 MU and 144218 MU respectively. Thus there was a deficit of 2.8% and 9.1% respectively.

The main resources for generating electricity are by utilizing the hydro potential available along the river drops besides the use of fossil fuel. With the limited coal resources and difficult oil position all over the world, it is necessary that electric generation be aimed to achieve the economic balance of 40:60 between the hydro and thermal generation of power, as against the existing 25:75 ratio.

To improve the share of hydro-power generation, it is essential to develop hydro-electric power potential. Uttarakhand is one state which has tremendous scope for development of Hydro power projects. The hydro power potential of the State is assessed by CEA on 31 Jan 2009 is given below.

Identified Capacity : 18,175 MW
Capacity Developed : 3056.1 MW (16.81%)
Capacity under Construction : 1850 MW (10.18%)
Capacity yet to be Developed : 13269 MW (73.01%)

The details of major hydro power projects under construction in the state of Uttarakhand are listed in Table-1.5.2.

**Table-1.5.2 Major Hydro-Power Projects under construction in Uttarakhand**

| S. No. | Project | Capacity (MW) |
|---|---|---|
| 1. | Maneri Bhali Stage II | 340 |
| 2. | Lakhawar Vyasi Stage-I | 300 |
| 3. | Lakhawar Vyasi Stage-II | 120 |
| 4. | Srinagar H.E.Project | 330 |
| 5. | Vishnuprayag Scheme | 400 |
| 6. | Tehri Dam Project, Stage-I | 1,000 |
| 7. | Tehri Dam Project, Stage-II | 1,000 |
| 8. | Koteshwar Dam Project | 400 |
| 9. | Dhauliganga H.E. Project, Stage-I | 280 |
| | **Total** | **4,170** |

Source: EIA Report prepared by WAPCOS

There is an urgent need to develop its huge untapped hydro power potential capacity with the purpose of harnessing hydro-power resources in the state for economic well being and growth of the people in the whole region. The Alaknanda valley has a vast potential for water resources development, substantial of which is yet to be harnessed. Accordingly, a number of hydro-power schemes have been envisaged on river

Alaknanda and its tributaries, many of which are in different stages of construction / investigations. Some of the major hydro-electric schemes identified in Ganga Valley for development in the state of Uttarakhand are given in Table-1.5.3.

**Table-1.5.3 Major Hydro Schemes Identified in Ganga valley**

| S. No | Name of Scheme | River Basin |
|---|---|---|
| 1 | Badrinath | Alaknanda |
| 2 | Jhelam Tamak | Dhauliganga |
| 3 | Malari Jelam | Dhauliganga |
| 4 | Rishi Ganga-I | Rishiganga |
| 5 | Rishi Ganga-II | Rishiganga |
| 6 | Deodi | Rishiganga |
| 7 | Harsil Dam | Rishiganga |
| 8 | Gangotri | Bhagirathi |
| 9 | Bhairon Ghati | Bhagirathi |
| 10 | Khartoli Lumti Talli | Sarda |
| 11 | Kalika Dantu | Sarda |
| 12 | Mapang Bagudiyar | Sarda |
| 13 | Sela Urthing | Sarda |
| 14 | Sirkari Bhoyl Rus Bagar | Sarda |
| 15 | Sobla Jhimrigaon | Sarda |
| 16 | Sirkari Bhyol Bagudiyar | Sarda |
| 17 | Chhanger Chal | Sarda |
| 18 | Kharsiya Bada | Sarda |
| 19 | Garba Tawaghat | Sarda |
| 20 | Garjla Dam | Sarda |
| 21 | Bokang Belling | Sarda |
| 22 | Nelang | Jadhganga |
| 23 | Karmoli | Jadhganga |
| 24 | Jadhganga | Jadhganga |
| 25 | Devasari Dam | Pinder |
| 26 | Gohana Tal | Birahinganga |

Source: DPR; Volume-I, Main Report

The Power Supply and Demand scenario at the end of the 10th and 11th Plans for the Northern Region and the Country as a whole considering the benefits arising out of the ongoing schemes would be as follows (Source : 16th Electric Power Survey):

**Table-1.5.4 Energy Status of India and Northern Region**

| Energy Status | India | Northern Region | |
|---|---|---|---|
| | 2006 – 2007 | 2006 – 2007 | 2011 - 12 |
| Energy demand (MU) | 719097 | 220820 | 308528 |
| Energy Available (MU) | 626621 | 181468 | 249731* |
| Surplus / Deficit in (MU) | -92476 | -39352 | -58797 |
| Surplus Deficit in % | -12.9% | -17.3% | -19.05% |
| Peak demand (MW) | 115705 | 35540 | 49674 |

| | India | Northern Region | |
|---|---|---|---|
| Peak availability (MW) | 101527 | 29667 | 35073* |
| Deficit in (MW) | -14178 | -5873 | -1460 |
| **Surplus / Deficit in %** | **-12.3%** | **-17%** | **-29.4%** |

Source: DPR; Volume-I, Main Report

There is Energy and Peaking deficit of 12.3% and 17% respectively in India and Northern Region by the end of 10th Plan. The energy will be 19% and 29% at the end of 11th Plan respectively in India and Northern Region hence the capacity addition by implementing the Vishnugad Pipalkoti H.E. Project is pertinent.

VPHEP is suited to help provide peaking power to the national grid. Once commissioned, the project will provide 1813 million units of electricity each year to the Northern Region to meet India's growing energy needs. The Project shall also help to improve the hydro-thermal mix in the country.


View of Dam Site

## 1.6 PROJECT LOCATION

Vishnugad Pipalkoti Hydro Electric Project (4 x 111 MW) is located on Alaknanda River, a major tributary of river Ganga, in district Chamoli in the state of Uttarakhand. It is a run-of-the river hydro power project & envisages construction of a diversion dam of 65 m height near village Helong (79°29'30" E and 30°30'50" N). An underground power house is proposed at village Haat (79°24'56" E and 30°25'31"N), 3 km from Pipalkoti.
The nearest railway station is at Rishikesh about 225km from project site. National Highway NH-58 from Ghaziabad-Rishikesh –Pipalkoti-Joshimath is located on the Left Side of the River and all the project components are located on right bank of the river. The Index of the project is given as **Figure-1.1.** The location of the project site in Uttarakhand is given in the **Figure-1.6.1**.

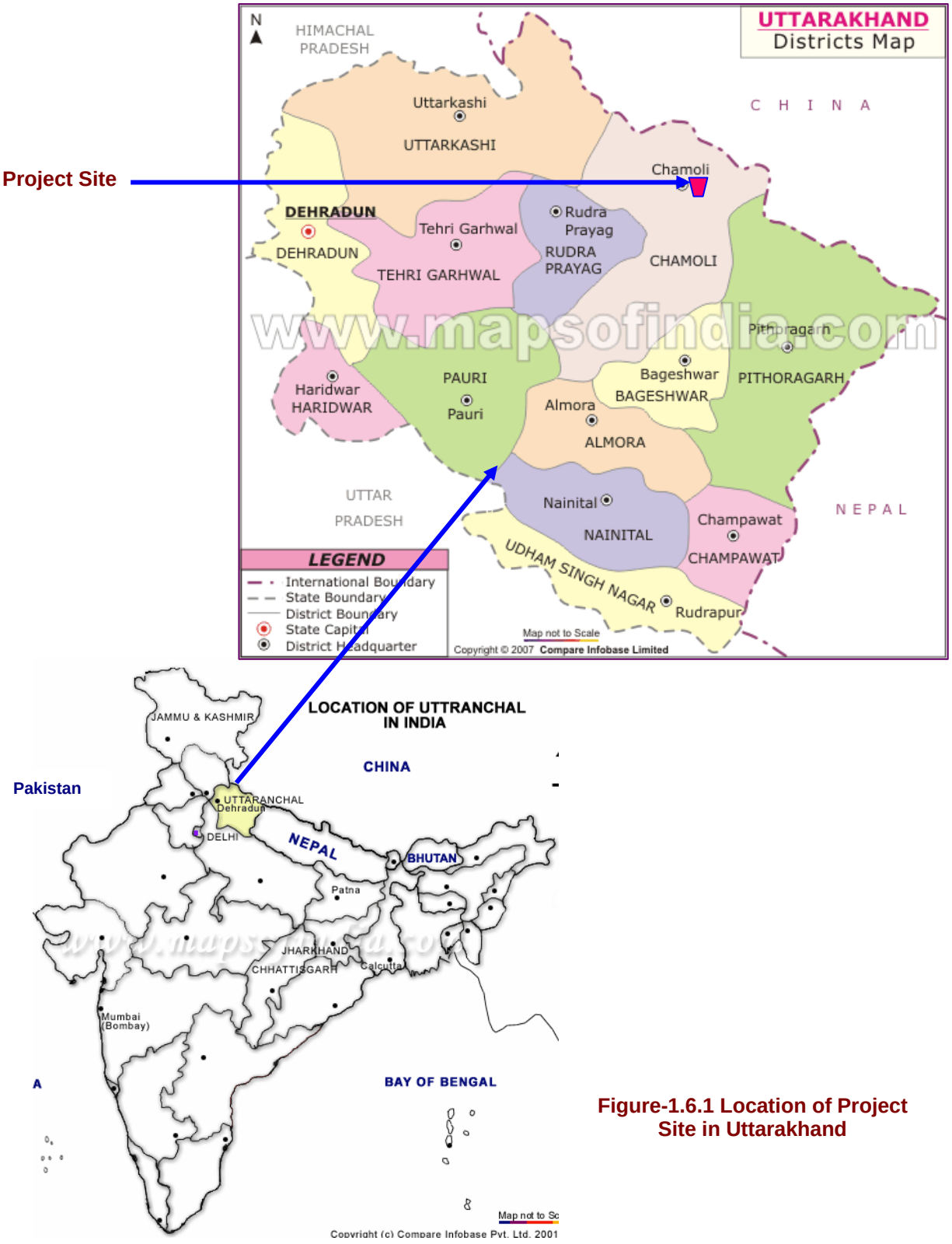


**Figure-1.6.1 Location of Project Site in Uttarakhand**

## 1.7 PROJECT HIGHLIGHTS

The project comprises the following main components:

- **Dam Site:** A 65m high concrete diversion dam with spillway section having 4 No. 6.6m x 15m opening is proposed near village Helong. The reservoir will have a gross storage capacity of 3.63 million cum, out of which 2.47 million cum shall be live storage. A diversion cum spill tunnel of 10 m dia shall divert the discharge of 725 $m^3$/sec during the construction period.

- **Power House Site:** The power house site is located inside a hill in right bank of Alaknanda River downstream of Haat village. It will comprise of two separate underground caverns for installation of turbines and transformers. The dimensions of power house will be 127 m x 20.3 m x 50 m. The size of transformer cavern is 112 m x 16 m x 24.5 m. The power house will have 4 units of 111MW. The project would afford an annual energy generation of 1813.03 GWH on 90% dependability basis

- **Head Race Tunnel:** 13.4 km long & 8.8 m dia modified horse shoe shaped head race tunnel has been proposed on right bank of the Alaknanda River.

- **Tail Race Tunnel:** 3.07km long & 8.8 m dia modified horse shoe shaped tail race tunnel has been proposed on right bank of the Alaknanda River.

- Intake structure with 3 No. modified horse shoe shaped intake tunnel of 6m diameter
- 3 No. underground sedimentation chambers
- Silt flushing tunnel of size 3.6m x 4.0m
- Earlier, four Adits located at Gulabkothi village (Adit -1), Langsi (Adit-2), Maina Nadi (Adit- 3) and Adit-4 on U/s of Surge shaft had been envisaged by Project. THDC has introduced, Tunnel Boring Machine for the portion of Head race tunnel operations. This will reduce the use of identified muck disposal sites. Adit–1 at Gulabkoti & Adit-4 on U/s Surge Shaft shall be utilized for muck disposal and will be constructed. Adit 3 at Maina Nadi shall be considered for construction at later stage in view of any contingency

## 1.8 ANALYSIS OF ALTERNATIVES

### 1.8.1 Dam Site

In 1984, Uttar Pradesh (U.P.) Irrigation Department identified Vishnugad – Pipalkoti Hydro Electric Project (VPHEP) for development with an installed capacity of 340 MW. Several alternative sites were considered in the identification report which included barrage at Helong and underground power house at Birahi on the right bank. The report also considered construction of a high dam and creation of a large storage. Two alternatives were considered. In the first case, an underground power house at Birahi on right bank was considered, and in the second alternative, a surface power house near village Haat, on the left bank, was proposed. However, no detailed investigations were carried out at the time.

In a subsequent development, the Government of Uttarakhand assigned the THDC the task of investigating and developing Vishnugad Pipalkoti site for hydro power generation.

In order to decide on a barrage or a dam, investigations were carried out by THDC at several locations in the area. The various alternatives considered are given below. While assessing the alternatives for final site selection, a lot of emphasis was laid on environmental and social aspects. The objective was to avoid or minimize impacts on physical environment, terrestrial and aquatic biodiversity and human settlements not only due to the dam but also due to the construction and operation of HRT, spillways, power house, sedimentation chambers, tail race tunnels and other facilities like approach roads, project township, labour colony, etc. For unavoidable impacts, appropriate mitigation measures were taken into account.

**a) Dam Site 1**

The Pipalkoti site, as identified and suggested in the 1984 report, was investigated for construction of 202 m high concrete gravity dam, but it was found that a storage is not suitable at the site due to the following reasons:

- A part of the National Highway-58, which connects Rishikesh and Joshimath, and passes through Pipalkoti, is lying below pond level at Pipalkoti. This will require realignment of NH-58 in a reach of about 20 to 30 km.
- About six villages and Pipalkoti town will be submerged due to the reservoir.
- There will be huge submergence of forest land with damage to flora and fauna.
- Geological formations are not suitable for storage dam.
- Presence of Main Central Thrust (MCT) nearby is also not suitable for such a large storage dam.

The option of having a diversion dam or a barrage near Helong was then investigated. The following alternative sites for barrage and dam were investigated:

**b) Upper Barrage Site**

This is in immediate downstream of the confluence of Animath nalla and Alaknanda river. A diversion structure was found feasible. This would help utilize the total head available between tail waters of Vishnuprayag Project and full reservoir level of Bowala-Nandprayag Project near the confluence of Birahiganga and Alaknanda. However, much excavation work would be required due to considerable depth of overburden.

**c) Lower Barrage Site**

The site is located between two bridges on Alaknanda near Helong (EL 1244 m). A 20 m high barrage was proposed to divert the water of Alaknanda through a tunnel on the right bank to an underground power house near Haat village with tail race of EL 1027 m. The geological formations appeared to be suitable for tunneling and locating underground sedimentation chamber upstream of barrage near Helong. The

site falls in the vicinity of MCT. The barrage, if located here, would not be able to utilize the full head available between Vishnugad and Helong, but the discharges of Karmanasa and Kalpganga rivers would be available for power generation.

**d) Dam Site 2**

The site is about 120 m downstream of dam site 1. There is strong possibility of rock fall here on right abutment. Depth of overburden is little over 19 m.

**e) Dam Site 3**

The site, located about 200 m downstream of dam site 2, was not found suitable as about 20 m thick river borne material terrace exists above water level on the left and right bank. There is also possibility of rock fall.

**f) Dam Site 4**

The location is about 1.5 km downstream of dam site 1. Construction of a small dam was considered with head race tunnel (HRT) on right bank and underground power house near Haat village. The area above the site, at a higher level, is covered with debris and forests. There is a major shear zone upstream, but is sufficiently away from the proposed dam site. Geologically, the site reveals hard and compact quartzite and is comparatively free from the danger of rock fall. The proposed tunnel on the right bank will not have to cross MCT. Waters from Karmanasa and Kalpganga rivers will be fully utilized. Since the gorge is steep and narrow, underground sedimentation chamber will be required.

**g) Dam Site 5**

Taking into consideration the studies carried out by THDC, detailed investigations were carried out by the DPR consultants. On the basis of these investigations, a new site has been selected for construction of a diversion dam with low height spillway. This site is 50 m downstream of dam site 1, near village Helong.

A summary of the findings of various alternatives is given in Table-1.8.1.

**Table-1.8.1 Summary of findings of various Alternatives of Dam Site**

| Alternatives | Location | Environmental, Social & Technical issues | Remarks |
|---|---|---|---|
| D-1 site | Near Pipalkoti | ▪ Pipalkoti town and 6 villages will submerge<br>▪ Huge forestland under submergence<br>▪ NH-58 below pond level, will need realignment in 20/30 km stretch<br>▪ Main Central Thrust close to the site<br>▪ Calcareous rock-not suitable for | Not suitable |

| Alternatives | Location | Environmental, Social & Technical issues | Remarks |
|---|---|---|---|
| | | storage dam | |
| Upper Barrage Site | Just d/s of Animath nala - Alaknada confluence | ▪ Overburden depth too much-much excavation required | Not suitable |
| Lower Barrage Site | Near Helong | ▪ Close to MCT<br>▪ Full head not able to utilize | Not suitable |
| D-2 Site | 120 m d/s of D-1 | ▪ Overburden depth too much | Not suitable |
| D-3 Site | 200 m d/s of D-2 | ▪ Rockfall prone<br>▪ 20m thick river borne material terrace above water level on both bank | Not suitable |
| D-4 Site | 1.5 km of d/s of D-1 | ▪ Least environmental and social problem | Found suitable |
| D-5 | 50 m d/s of D-4 | ▪ Most appropriate from environmental, social and technical aspects | Finally selected |

**Conclusion:** On the basis of these investigations, **Alternative-D5** has been selected for construction of a diversion dam with low height spillway.

### 1.8.2 Other Components

Once the dam site was finalized, location/ alignments of other project components like HRT, power house, approach road etc. were selected. Environmental and social aspects were taken into consideration while finalizing the location/ alignments of these components, as detailed below:

#### a) Head Race Tunnel (HRT) Alignment

The 13.4 km long 8.8 m dia modified horse shoe shaped head race tunnel has been proposed on right bank of the river. The geological profile of the rock structure in the tunnel are completely folded and faulted. The alignment of the tunnel is crossed by several perennial and ephemeral nallas and Maina nadi, which is an important drainage and intersects the tunnel at a distance of about 9 km from the dam. The alignment of the tunnel has been optimally fixed to provide adequate rock cover below the nala crossings. As the most critical stretch of the HRT passes through Maina nadi which required proper rock cover, detailed and adequate site investigations were carried out for finalizing and selecting the layout of the alignment.

The construction of HRT will not have any significant impact on environment as it is an underground tunnel. The HRT traverses though sparsely vegetated area with scattered Pine trees. It does not involve clearing of land. Hence the flora & fauna of the area will not have any adverse impact. It does not involve acquisition of land hence the individual and community will not be affected.

### b) Power House

Geology and ecology of the area, availability of head and discharge in the river, as well as human habitation and density of population are some of the main issues considered for the location of the Hydro-Electric Power Project. Although the proposed project falls outside the buffer zone of the Nanda Devi Biosphere Reserve, which is also a World Heritage Site, in order to minimize the impact on the surrounding environment THDC abandoned the option of Surface Power House and opted for the proposed underground structure which is more secure and environmentally viable. The Power House site is selected inside a hill in right bank of Alaknanda river downstream of Hat village covering an area of 2.00 ha.

The underground power house was also proposed as the river banks are steep and there was paucity of space for surface power house in other alternate site which was considered near Birahi Ganga confluence with Alakhnanada River. In fact the hill slopes of the surrounding area are considerably steep and constructing a surface power house by excavation was also not considered practical. So the site which is located about 15 km downstream of the proposed diversion dam was selected for the construction of underground power house.
The detailed topographical study of the area surrounding and the geological investigations carried out also revealed that the power house complex was suitable for accommodating other tunnels such as cable tunnel, ventilation tunnel, adit tunnel to penstock. Therefore the orientation of the power house has been decided on the basis of in-situ stress and foliation direction.

The under ground power house complex will comprise of two separate caverns. The main machine hall cavern is 127m long, 20.3m wide and 50m high. It will have a 35m long service bay and 20m long control room and space for 4 units of 111 MW. The transformer cavern will be 112m long, 16m wide & 24.5m high to accommodate transformer and Gas Insulated Switchgear (GIS) etc. The draft tubes shall be provided with a draft tube gate.


View of Power house site

The construction of under ground power house site is likely to reduce the impact on surrounding environment. The area is sparsely vegetated and floral species found at the site are common in occurrence and are found extensively throughout the degraded areas. The site in located on right side of the river hence the traffic on NH -58 on left bank will not be impacted significantly.

### c) Spillway & Energy Dissipation

For optimal utilization of the head and water available from the different streams joining the river the site an ogee spillway with vertical gates is proposed to pass the

design flood of 8004 $m^3$/sec corresponding to PMF. Four openings, each with clear opening of size 6.6m x 15m (height) are proposed to cater to design flood discharge which is inclusive of one gate for additional factor of safety as per BIS Code. Radial Gates will be operated by means of hydraulic hoists. Provision of stop log gates with gantry crane has also been made.
Energy dissipation is proposed through a trajectory type of bucket which throws the feet of water through the air and into the plunge pool. Protection works in term of concrete apron are proposed immediately downstream of bucket.

### d) Approach Roads

Vishnugad Pipalkoti H E Project is connected on Ghaziabad –Haridwar-Rishikesh-Srinagar-Pipalkoti-Joshimath-Mana National Highway (NH- 58). The project site is about 225 k m from Rishikesh.

Various approach roads covering a total length of 25.578 km length are proposed to be constructed in the project area to provide good accessibility to various work fronts i.e. Dam Site, Power House, Adits, Quarry & Borrow Area, Muck Disposal Sites, Pot Yard Area etc. The various components of the project will be connected by project road diverted from National Highway (NH-58). They are as follows:

(i) Approach Road to dam site ( Animath to Dam)
(ii) Approach Road to Langsi Adit (Gulabkoti to Dwing)
(iii) Approach Road to Maina Adit (Pipalkoti to Maina Nadi)
(iv) Approach Road to Power house & colony site (Koriya to Siyasain)

These roads will cover a total area of 38 Ha. The road to dam complex will be diverted from the NH-58 and will be connected to dam top, bridge, and various work fronts up to river bed etc and will be of permanent nature. The site does not have any rare/endangered or threatened species of flora. It traverses through the Van Panchayat area and the species found at the location are common and planted. The construction of road does not involve disturbance to any wildlife habitat and human settlement. There is no settlement located at the site hence no impact on local people due to the road construction.

**Starting point of Approach Road to Dam site**

**Approach Road to Langsi Adit (Old road route to Badrinath below NH 58)**

Construction of approach road to Langsi Dwing Adit does not involve any road cutting on left bank. The existing PWD road which was an old road route to Badrinath will be utilized from Langsi up to the Bridge on Alaknanda. The section will be updated and connected to the adit portal opposite Patal Ganga. It will avoid cutting of trees, cutting of hill and land acquisition on the left bank. Therefore the impacts on environment and social aspects are minimized by the utilizing the old abandoned road

The approach from National Highway near Pipalkoti will be diverted to the adit portals on Maina Nadi and will be of permanent nature. It will provide connectivity to the villages on the right bank Tenduli, Math and Guniyala. The villagers have to frequently/ daily walk and reach Pipalkoti for marketing, hospital, school etc. The construction of road will save time and energy of the villagers.

**Approach Road to Maina Adit**

**View of Approach Road to Power House Site**

The approach road near Kodia village will be of permanent nature and diverted to connect power house, switch yard, surge shaft top & bottom, TRT outfall and residential/non residential complex will be of dual carriage way. The alignment traverses through open area with some agricultural land. There is no forest present in the area. The vegetation is dominated by thorny bushes and all species found are common in occurrence.

### e) Project Township

The proposed project township is in Siyasain which is located on the right bank of Alaknanda River approx. 20 km downstream from the dam site. The proposed township site is a flat patch of land with gentle slope of approx. 13 Ha. Within this township residential / non-residential buildings, Post office, Bank, Fire station, Guest houses, Market, Police station etc., will be provided for the officers and staff for operation and maintenance of the plant. Water treatment plant/ Sewage treatment is also planned to be provided for a clean living environment. The complex is planned to be located on the right bank of Alaknanda, D/S of the power house road bridge near village Jaisal/Siyasain. The proposed site falls in building Zone-V (Seismic Zoning Map of India, IS 1893 part I, 2002). All the project components will be looked after from this residential/ non-residential complex.

This site has been selected as it has good accessibility with the surrounding facility area, power house, dam site of THDC and the nearest commercial complex i.e.

market, community center, guest houses, hotels, offices etc. located at Pipalkoti. The local town of Pipalkoti is located approx. 4km away from this proposed project township. Secondly most of the construction activities related to the dam construction are located on the right bank of the Alaknanda River.

This site has been selected, as major portion of the land is barren with a minimal covering of grass, few scattered trees, a school and few houses of the Jaisal/Siyasain village. Major portion of this site (i.e. approx. 60 % of the total area belongs to village panchayat) and about 40% of the land is forest land.

Sites on the left bank were not considered as NH-58 transverses on the left bank of Alaknanda River. But proper approach roads for various work areas for construction and operation and maintenance of the project would be provided and diverted from National Highway at different locations by bridges across Alaknanda River for various approach roads.

**f) Contractors Accommodations**

The proposed contractors accommodation including the labour camps and construction workers camps are to be located in Gulabkoti, Langsi, Guniyala and Batula. The contractors accommodation, labour and construction workers camps at Gulabkoti, Langsi (Dwing) and Batula are located on the left bank of the river as topography on the right bank are steep as there is paucity of space and flat land on the right bank. These site has been selected by project authority as they have good accessibility with the surrounding facility area, power house, dam site of THDC and the nearest commercial complex These labour camps and construction workers camps and the various components of the project will be connected by the 4 project roads diverted from National Highway no. 58 (NH-58) by bridge crossing over Alaknanda River at four points at Haat, Tenduli, Huna and Tapan Nala. Presently all these bridge crossings are foot bridges. Four new bridges are also under construction over Alaknanda River at Birahi, Haat, Pipalkoti, Langsi and Helong.

**g) Quarry and Borrow Areas**

The Quarry Areas sites are located at Gulabkoti. Patalganga and Gari gaon. Gulabkoti Quarry area is located around 2 km downstream of the proposed dam site and adjacent to National Highway (NH-58). The Patalganga Quarry area with terrace deposits to be used as coarse aggregate in concrete for non-wearing surfaces is located at about 5 km downstream of the dam site. The third site of Garigaon near Birahi River for coarse aggregate to be used in concrete for non-wearing surfaces is located at 5 km away from the proposed power house.

All these Quarry areas have been selected as they are near the proposed construction sites for the various components of the project like Power House, Dams, Head and Tail Race Tunnels and Surge Shafts. The proposed quarry sites also have good accessibility and are well connected with the surrounding facility areas of power house and dam site of THDC by the four approach roads from NH-58 to dam site, Langsi to Dwing, Pipalkoti to Maina Nadi and Koriya to Siyasain.

The Quarry site is represented by open barren area dominated by common shrubs such as *Colebrookia oppositifolia* and *Euphorbia royleana*. The impact on biodiversity is insignificant.

The Borrow Areas are located at Bajipur, Haat and Bhagisera villages. Koria village borrow area having fine aggregate is located at about 10 km down stream of confluence of Birahi and Alaknanda Rivers. The quarry area at Haat village with fine aggregate is located along River Alaknanda. The third site at Koria village with terrace sand deposits is located 1.5 km away from the proposed power house site.

All these Borrow areas have been selected as they fall within the proposed construction sites for the various components of the project like Power House, Dams, Head and Tail Race Tunnels and Surge Shafts. Borrow area material sites has been selected near the construction sites for project to cut down the cost of construction and maintain the ecological balance of the area by using indigenous material found locally.

**View of Quarry Area near Patalganga**

**View of Quarry Area near Birahi**

### h) Muck Disposal Sites

For dumping of the muck Four Muck Disposal Sites viz. (i) Haat, (ii) Jaisaal, (iii) Gulabkoti and (iv) Maina nadi have been identified adjacent to project components in which dumping will be done and further they will be restored and re-vegetated with proper landscaping.

The identified sites of muck disposal has been selected in such a way that they are in conjunction with various characteristics viz. landscape, cost effectiveness, nearness to source of generation, groundwater/blockage to surface water, relief and scope of afforestation and erosion control/sediment arrest.

The muck disposal sites are degraded areas. The vegetation found on the area constitutes of *Eupatorium adenophorum, Colebrookia oppositifolia, Plectranthus coesta* and *Rumex hastatus. Parthenium hysterophorus* is dominant grass species occurring in the area. The impact on flora and fauna will be insignificant. No impacts on local people as the sites are away from settlement area.

### 1.8.3 No-Project Scenario

The demand for power in the agricultural, industrial and domestic sectors in Uttarakhand and other States in the northern region of India is increasing. Most of the States in the region are experiencing power shortage. In order to overcome this shortage, it is felt necessary to increase generation of hydro power, for which there is huge potential in Uttarakhand. The Central Electricity Authority (CEA), in its 16th Electric Power Survey, projected the growth in demand in the northern region at the rate of 7 % during the 10th Plan and at the rate of 6.9 % during the 11th Plan. The current deficit in power supply in Uttarakhand is 2.8 % and in the northern region as a whole, 9.1 %.

VPHEP is one of the important projects to improve the power generation. In the 'No-Project-scenario', that is, if VPHEP does not materialize, the present environmental status in the area may not change, but this may lead to other problems like:

- Non-availability of electricity affecting households, hospitals, tourism and other commercial activities, industry and agriculture.
- Dependence on diesel generators and firewood to meet local requirements, leading to green house gas emissions and other environmental and health related problems.

Taking all these aspects into consideration, it may be stated that environmental and health related problems would be there in the 'No-Project-Scenario' and, at the same time, power shortage problems will aggravate. It is, therefore, concluded that VPHEP is required to be implemented with adequate safeguards for environmental and social concerns due to the project.

## 1.9 UPSTREAM AND DOWNSTREAM LINKAGES

The proposed Vishnugad Pipalkoti Hydro Electric Project (VPHEP) to be located in Chamoli district of Uttarakhand is envisaged as a run off river scheme to harness hydro potential of river Alaknanda available between tail water level of Tapovan – Vishnugad Hydro Electric Project and Bowala Nandprayag Hydro Electric Project. The scheme envisages utilization of 228.86 cumecs discharge and design head of 237.0 m to generate 444 MW of hydropower.

There are several hydro projects expected to come up upstream and downstream of the VPHEP. The proposed up-stream projects are as follows:

a) Tapovan Vishnugad (Dhauli Ganga River)
b) Lata Tapovan (Dhauli Ganga River)
c) Vishnu Prayag Scheme Alaknanda River- Badrinath HPP
d) Malari Jhelum on Dhauliganga
e) Jhelum Tamak on Dhauliganga

Hydro power projects likely to come up in the down stream section are as follows:

a) Bowala Nand Prayag Hydro Electric Project (Alaknanda River)

b) Nand Prayag -Langasu(Alaknanda River)
c) Utvasu Dam (Alaknanda River)
d) Srinagar Hydro Electric Project (330 MW) Alaknanda River

## 1.10 CONSTRUCTION MATERIAL

The details of construction material and source of Construction material required for the project is given in tables below.

**Table-1.10.1 Details of Construction Material Required**

| Material | Quantity |
|---|---|
| Quantity of material to be excavated | 1413800 $m^3$ |
| Concrete | 400,000 $m^3$ |
| Steel | 50,000 Tonnes |

Source: EIA Report prepared by WAPCOS

**Table-1.10.2 Sources of Construction Material**

| S.No. | Material | Source |
|---|---|---|
| 1. | Coarse Aggregate | • Rock quarry in power house area<br>• Rock quarry in shaft drift area<br>• Riverbed materials along river Birahi<br>• Boulders along river bed along river Birahi<br>• Terrace deposit in Patalganga |
| 2. | Fine Aggregate | • Crushed sand made out of rock |
| 3. | Cement | • From Open market |
| 4. | Steel | • Rishikesh stock yard |
| 5. | Explosives | • Authorized dealers from Dehradun |
| 6. | Miscellaneous materials like drill nodes, diamond bits, welding rods, oil & lubricants, etc. | • From open market |

Source: EIA Report prepared by WAPCOS

## 1.11 INFRASTRUCTURE WORKS

The implementation of the project requires development of infrastructure works at site, so as to facilitate timely completion of the project and proper operation & maintenance of the project. The Infrastructure works include

- **Communication**: The nearest rail head is Rishikesh at about 225 km from the project site. The project is located on the right bank of Alaknanda river. National Highway no. 58 from Ghaziabad-Rishikesh –Pipalkoti- Joshimath is passing nearby the Dam complex and Power House complex.

  Pipalkoti is well connected by telephone lines and also covered under BSNL mobile network. For effective execution and monitoring of the work at various work fronts and for liaison with the Consultants, various authorities and the contractors etc., an electronic automatic exchange of 100 lines will be required. BSNL net work of 200 mobiles may also be arranged for the project during execution & operation & maintenance.

- **Approach Roads and Bridges**: Approach roads and bridges planned

- **Water Supply & Sewage Disposal**: The water requirement for all residential accommodation for officers & staff, hospitals and other utilities will be met by lifting the water from Alaknanda River and subsequent water treatment as per standard practice. The water will be supplied to various users by a dedicated water supply network laid in the area

  A dedicated sewer line is proposed in the residential & non residential area which will be connected to the sewage treatment plant d/s of residential complex.

- **Power Supply**: The construction power at various works fronts and power for residential / non buildings and other infrastructure facilities will be taken from Uttaranchal Power Corporation. However, to ensure continuous and un interrupted power supply for the project, stand by arrangements of power from DG set will also be made during execution and operation and maintenance of the project

## 1.12 POWER POTENTIAL & INSTALLED CAPACITY

The power potential studies have been carried out for VPHEP. This is a run-of-the-river type development with diurnal storage and would utilize a net rated head of water of 204.72 m. The plant would operate as peak load station. For determination of power potential, the following efficiency applicable for Francis turbine driven generating unit have been considered:

- Efficiency of turbine: 94.5%
- Efficiency of Generator :98.5%
- Combined efficiency of turbine and generator: 93.08%

The power potential studies carried out indicates that installed capacity of 444 MW comprising 4 generating units of 111 MW each would be required for this power project to derive optimum power benefits.

## 1.13 POWER EVACUATION

The power of this project is intended to be evacuated by proposed 400 kV D/C line to Pooling Station (Kunwari Pass). The total length of this line from Vishnugad-Pipalkoti Hydro Electric Project to Pooling Station (Kunwari Pass) is 30 km.

## 1.14 PROJECT COST & IMPLEMENTATION SCHEDULE

The cost of the Project at March'08 PL is **Rs. 2491.58 Crores** including IDC and FC of **Rs. 366.8 Crores**. The first year and levellised tariff from the project would be Rs.2.53/KWh and Rs.2.07/KWh respectively.

The Project is planned to be completed by June, 2013.

## 1.15 STRUCTURE OF THE REPORT

The structure of the Consolidated EA report is given below

Chapter-1 : Introduction and Project Background
Chapter-2 : Policy and Regulatory Framework
Chapter-3 : Baseline Environment, Impacts & Mitigation Measures
Chapter-4 : Environmental Management Plan
Annexes

# Policy, Legal & Regulatory Framework

2



## 2.1 CONSTITUTIONAL PROVISIONS

The constructional provisions and key points of policy and regulatory framework of India are discussed below:

### 2.1.1 Water Resources

- As per Constitution of India water is primarily a State subject and the role of Government of India comes in only in the case of interstate river waters.
- States are free to enact “water” laws and frame policies in accordance with this provision.
- Regulation and development of inter-state rivers and river valleys is under the control of the Union.
- Indian Parliament may, by law (1) provide for the adjudication on any dispute or complaint with respect to the use, distribution or control of the waters of, or in, any inter-state river or river valley” and (2) “that neither the Supreme Court nor any other court shall exercise jurisdiction in respect of any such dispute or complaint” as referred to in (1).

### 2.1.2 Constitutional Provision related to Environment

The first constitutional provisions related to environment were made in the Forty-Second Amendment to the Indian Constitution. This amendment was passed in response to India being party to the Stockholm Declaration adopted by the International Conference on Human Environment in 1972. The Forty-Second Amendment introduced Article 48-A into the Directive Principles of State Policy in Chapter IV of the Constitution. The article declared the State's responsibility to protect and improve the environment and safeguard the forests and wildlife of the country. Another provision, included in Article 51-A (g), stipulated the duty of every citizen to "protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures." These amendments imposed an obligation on the Government and the courts to protect the environment for the people and the nation.

**Specific Reference to Environment Protection in the Constitution**

The State's responsibility with regard to environmental protection has been laid

down under Article 48-A of our Constitution, which reads as follows:

*"The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country".*

Environmental protection is a fundamental duty of every citizen of this country under Article 51-A(g) of our Constitution which reads as follows:

*"It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures."*

Article 21 of the Constitution is a fundamental right which reads as follows:

*"No person shall be deprived of his life or personal liberty except according to procedure established by law."*

Article 48-A of the Constitution comes under Directive Principles of State Policy and Article 51 A(g) of the Constitution comes under Fundamental Duties.
The State's responsibility with regard to raising the level of nutrition and the standard of living and to improve public health has been laid down under Article 47 of the Constitution which reads as follows:

*"The State shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties and, in particular, the State shall endeavour to bring about prohibition of the consumption except for medicinal purposes of intoxicating drinks and of drugs which are injurious to health."*

The 42nd amendment to the Constitution was brought about in the year 1974 makes it the responsibility of the State Government to protect and improve the environment and to safeguard the forests and wildlife of the country. The latter, under Fundamental Duties, makes it the fundamental duty of every citizen to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.

## 2.2 ENVIRONMENTAL REGULATIONS & LEGAL FRAMEWORK FOR THE PROJECT

### 2.2.1 Environment (Protection) Act, 1986

The Environment (Protection) Act is the most comprehensive law on the subject. The law grants power to the Central Government to take all measures necessary to protect and improve the quality of environment and to prevent pollution of the environment.

In terms of responsibilities, the Act and the associated Rules requires for obtaining environmental clearances for specific types of new/expansion projects

(addressed under Environmental Impact Assessment Notification, 14th September 2006) and for submission of an environmental statement to the State Pollution Control Board annually.

### 2.2.2 EIA Notification, September 2006

As per the EIA Notification, 14th September 2006, new projects or activities require Prior Environmental Clearance. Projects have been grouped under Category 'A' requiring clearance from Expert Appraisal Committee (EAC) of MoEF, GoI and Category 'B' requiring clearance from the State Expert Appraisal Committee (SEAC). All hydropower projects with more than or equal 50 MW capacity and/or 10,000 ha of culturable command area come under "Category A". Projects less than 50 MW capacity but more than or equal 25 MW capacity and loss than 10,000 ha of culturable command area come under "Category B". The concerned Committee (EAC or SEAC) will finalize the TOR on the basis of Form-1, proposed TOR & Pre-Feasibility/ Feasibility Report. Environmental Impact Assessment study is to be carried out as per the TOR provided by the Committee. Public Hearing is required for Category 'A' project.

### 2.2.3 Forest (Conservation) Act, 1980 and its amendment

This Act provides for the conservation of forests and regulating diversion of forestlands for non-forestry purposes. When projects fall within forestlands, prior clearance is required from relevant authorities under the Forest (Conservation) Act, 1980. State Governments cannot de-reserve any forestland or authorize its use for any non-forest purposes without approval from the Central Government. For diversion of forestland, the project proponent needs to apply to the State Government. Depending on the area required to be diverted, the proposals are cleared by MoEF Regional or Central Offices provided that the cost of compensatory afforestation, cost of rehabilitation of endangered/rare species of flora/fauna, and the net present value of the forest resources are deposited upfront with the state Forest Department.

### 2.2.4 Wild Life (Protection) Act, 1972

Wild Life (Protection) Act, 1972, amended in 2002 and in 2006, provides for "*the protection of wild animals, birds and plants, and for matters connected therewith or ancillary or incidental thereto, with a view to ensuring the ecological and environmental security of the country*". Under the Act, animals include "*mammals, birds, reptiles, amphibians, fish, other chordates and invertebrates, and also includes their young and eggs*". Wildlife is defined to include "*any animal, aquatic or land vegetation which forms part of any habitat*", which has been interpreted to imply that the destruction of habitat amounts to destruction of wildlife itself.

The Wild Life (Protection) Act provides for two kinds of protection to species– protection of specific endangered species listed in Schedules I, II, III and IV

(especially against hunting), regardless of its location, and the protection of all species in designated Protected Areas (PAs). Protected Areas categories include national parks, sanctuaries, conservation reserves, community reserves and tiger reserves, notified under Sections 18, 35, 36A, 36C and 38V of the Act. While '**biosphere reserves**' are not legally a PA category, they are an important entity since they are formed by a Central Government notification under the UNESCO-Man and Biosphere programme.

The Wild Life (Protection) Act restricts entry into a Sanctuary and National Park, and nobody is allowed in, except certain specified categories, such as those permitted by the Chief Wildlife Warden, or those who have immovable property within the limits of the national park/sanctuary. The Act also states that no person shall destroy, exploit or remove any wildlife from a national park/ sanctuary or destroy or damage the habitat of any wild animal or deprive any wild animal or its habitat within such a national park.

### 2.2.5 Water (Prevention & Control of Pollution) Act, 1974 & Air (Prevention & Control of Pollution) Act, 1981

These two laws are in force to prevent and control land-based pollution. These laws prescribe the standards for effluent discharge and air emissions and established the State Pollution Control Board to enforce the provisions of the Acts. The requirement is to obtain a No Objection Certificate i.e., Consent to Establish and Consent to Operate from State Pollution Control Board.

### 2.2.6 Biological Diversity Act, 2002

The Ministry of Environment and Forests has enacted the Biological Diversity Act, 2002 under the United Nations Convention on Biological Diversity signed at Rio de Janeiro on the 5th day of June, 1992 of which India is also a party. This Act is to "*provide for the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits arising out of the sued of biological resources, knowledge and for matters connected therewith or incidental thereto*." As per the provision of the Act, certain areas, which are rich in biodiversity and encompasses unique and representative ecosystems are identified and designated as biosphere reserve to facilitate its conservation.

### 2.2.7 Hazardous Wastes (Management and Handling) Amendment Rules, 2003

These Rules classify used mineral oil as hazardous waste under the Hazardous Waste (Management & Handling) Rules, 2003 that requires proper handling and disposal. Organisation will seek authorisation for disposal of hazardous waste from concerned State Pollution Control Boards (SPCB) as and when required.

### 2.2.8 Serais Act, 1867

The Act enjoined upon a keeper of Serai or an inn to keep a certain quality of

water fit for consumption by "persons and animals using it" to the satisfaction of the District magistrate or his nominees. Failure for maintaining the standard entailed a liability of rupees twenty.

### 2.2.9 Indian Fisheries Act, 1897

The Indian Fisheries Act, 1897 contains seven sections. Section 5 of the Act prohibits destruction of fish by poisoning waters.

### 2.2.10 Factories Act, 1948

Factories Act, 1948 is a social welfare legislation intend to secure health, safety and welfare of the workers employed in factories. However, some of the provisions of this Act are concerned with prevention of water pollution.

### 2.2.11 Ancient Monuments and Archaeological Sites and Remains Act, 1958

The legal requirement is to obtain from ASI a no-objection certificate if any protected cultural property is within 10km of the project.

## 2.3 STATUTORY CLEARANCES OBTAINED FOR THE PROJECT

The VPHE project has been developed by meeting the requirements of the State as well as Central Government environmental regulations. Following clearances have been obtained for the project.

### 2.3.1 Environmental Clearance

A 3-stage procedure for project preparation as per the guidelines of the Ministry of Power was followed for VPHEP. Activities of the three stages were tied up with a clearance from the Ministry of Environment & Forest (MoEF), Government of India.

**Stage-I Environmental Clearance**

This comprised activities for preliminary selection of the project site including a desk study on meteorology, hydrology & topography; establishment of observations for weather & river flow; preliminary layout of project facilities; preliminary cost estimate as well as cost estimates for Stage-II activities.

Site Clearance (Stage-I) for VPHE project was obtained from the MoEF in July 2003.

**Stage-II Environmental Clearance**

Stage-II clearance is only for undertaking investigations at the site and for collection of environmental data for preparation of EIA report as per EIA

Notification 1994.

Site Clearance (Stage-II) for VPHE project was obtained from the MoEF in May 2005.

**Stage-III Environmental Clearance**

Environmental Clearance for VPHE project was obtained from the MoEF in August 2007. Environmental Clearance was granted by MoEF subject to strict compliance of the terms and conditions as given below:

**Part-A: Specific conditions:**

i) 6,202 hectare degraded catchment area of high & very high category to be treated. Catchment Area Treatment Plan has been proposed should be completed in three years.
ii) 346 project affected families are likely to loose their agricultural land. All the PAFs would be compensated as per the rates that would be assessed and decided by the district authorities. Over and above these compensation, the PAFs will be given “land for land” or “Vocation/Job” or “financial assistance” in addition to various rehabilitation benefits as per the NPRR-2003.
iii) A Monitoring Committee for R&R should be constituted which must include representative of project affected persons from SC/ST category and a women beneficiary.
iv) All the equipment which are likely to generate high noise levels are to be fully mollified (noise reduction measures) in view of the proximity of the project to Nanda Devi Biosphere Reserve.
v) 3 cum minimum water flow should be released down stream during lean season.
vi) Consolidation and compilation of the muck should be carried out in the muck dump sites and the dump sites should be above high flood level.
vii) The project area is situated in close proximity of Nanda Devi Biosphere Reserve, the possibility of the endemic flora can not be ruled out completely. Hence, suggested the plantation of those species which come under Rare, Endangered and Threatened (RET) category, if any, should be planted during the implementation of CAT and Compensatory Afforestation works.
viii) Commitment made during public hearing should be fulfilled.

**Part-B: General conditions:**

i) Adequate free fuel arrangement should be made for the labour force engaged in the construction work at project cost so that indiscriminate felling of trees is prevented.
ii) Fuel depot may be opened at the site to provide the fuel. Medical facilities as well as recreational facilities should also be provided to the labourers.

iii) All the labourers to be engaged for construction works should be thoroughly examined by health personnel and adequately treated before issuing them work permit.
iv) Restoration of construction area including dumping site of excavated materials should be ensured by leveling, filling up of borrow pits, landscaping etc. The area should be properly treated with suitable plantation.
v) Financial provision should be made in the total budget of the project for implementation of the above suggested safeguard measures.
vi) A Multidisciplinary committee should be constituted with representatives from various disciplines of forestry, ecology, wildlife, soil conservation, NGO etc. to oversee the effective implementation of the suggested safeguard measures.
vii) Six monthly monitoring reports should be submitted to the Ministry and its Regional Office, Lucknow for review.

### 2.3.2 Forest Clearance

For the VPHE project, 100.39 ha of forest land is to be diverted; out of which 23.13 ha of land shall be required for underground works. The balance of 77.26 ha shall be utilized to create the necessary facilities and infrastructures under VPHEP. Forest clearance is required to acquire forest land for the project. After joint survey and verification of forest land to be transferred for the project, GoUK has recommended the forestland to be acquired for the project for approval before MoEF and clearance is expected shortly. The events of Forest Clearance are given below:

| Sl. No. | Events |
|---|---|
| 1. | Submission of case to Forest department |
| 2. | Forwarding of case to C.F. by D.F.O |
| 3. | Forwarding of case to Nodal Office by C.F. |
| 4. | Forwarding of case to Govt. of Uttarakhand by Nodal Office |
| 5. | Clearance by Govt. of Uttarakhand |
| 6. | Forwarding of case by Nodal Office to MoEF Lucknow/ MoEF Delhi |
| 7. | Clearance from MoEF Committee |
| 8. | Approval from MoEF Committee |
| 9. | Raising of Demand of NPV etc. by Nodal Office |
| 10. | Deposit of NPV and funds for compensatory Afforestation |
| 11. | Final approval from MoEF |
| 12. | Raising of Demand by Nodal office for lease rent |
| 13. | Deposition of lease rent |
| 14. | Possession of land |

### 2.3.3 NOC FROM STATE POLLUTION CONTROL BOARD

No Objection Certificate (NOC) under Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981 is a mandatory requirement for Hydropower project. To obtain NOC from Uttara

Khand Pollution Control Board (UKPCB) a detailed environmental impact assessment study was carried out and public hearing was undertaken through UKPCB. NOC (Consent to Establish) for VPHE project was obtained from the UKPCB in April 2007.

**Condition laid by the State Government**

i) To provide monthly progress report regarding use of essential equipments/tools, forestation, inflow purification equipments and establishment of management of noise pollution control.
ii) Operation of hydro-power project can not be started without taking No Objection Certificate (Consent to Operate) under Air and Water Act.
iii) Submit the order copy of proposed purification for pollution control and supply of construction material.
iv) Geological setting of the project & nearby area is to be surveyed through concerned department and their recommendation is to be implemented.
v) Minimum flow is to be maintained in the Alaknanda River which is required for aquatic life.
vi) There should be no negative impact on regional forest resources, biota (fauna & flora) and livelihood due to project implementation. NOC is to be obtained from Forest Department, Department of Fisheries, Agriculture and other concerned departments within three months and to be submitted in the State Pollution Control Board otherwise NOC released from the board will be treated as cancelled.
vii) The Muck disposal proposal is to be submitted before starting the construction work

## 2.4 APPLICABILITY OF THE WORLD BANK SAFEGUARD POLICIES

The World Bank safeguard concerns and the policies that are applicable to the VPHEP are summarized below. The project has been designed with full compliance to the requirement of WB safeguard policies.

- **Environmental Assessment (OP/BP 4.01) - APPLICABLE**

  The major environmental issues in the project would include (a) disturbance to the forest cover in the project influence area, and the catchment; (b) impacts on the potential water use downstream; (c) induced erosion and landslides in the project area and its vicinity; (d) impacts from the project's associated facilities; and (e) the construction-related impacts.

- **Natural Habitats (OP/BP 4.04) –APPLICABLE**

  The natural habitat is triggered as a part of the project area falls in the transitional zone of Nanda Devi Biosphere Reserve. The impact will be insignificant and, localized and limited to construction phase only. Appropriate measures are suggested to mitigate and enhance the surrounding environ of the project area.

- **Forests (OP/BP 4.36) - APPLICABLE**

  For the proposed development, there will be direct impact on forest due to acquisition of forest land. The project acquires 100.39 ha of forest land out of which 23.13 ha land shall be required for underground works.

  Total 6,153 trees are to be felled, out of which 4,672 trees come under private land and the balance 1,481 trees come under forestland. The species reported are commonly distributed throughout the project immediate influence area and project influence area. Therefore, adverse impact on terrestrial biodiversity due to tree felling is not envisaged.

- **Involuntary Resettlement (OP/BP 4.12) - APPLICABLE**

  The project involves land acquisition and physical displacement. For the proposed development, 31.621 ha private land is to be acquired and total number of project affected families are 769 of which about 265 are displaced/Homestead Oustee (HSO) (source: RAP, VPHEP)

- **Indigenous Peoples (OD 4.20) – NOT APPLICABLE**

  The impact on tribal is negligible for the proposed development. Out of the total population of the study area, general caste comprised 76.1%, scheduled caste (SC) comprises 17.4% and scheduled tribe (ST) comprises only 6.5%. The socio-economic characteristics of general caste and tribal of the project area reveal that agriculture is the main occupation. The tribal of the study area do not exhibit any indigenous characteristics as described in the Bank's Operational Policy on Indigenous Peoples as confirmed by the social analysis described in EIA Report. The analysis carried out by the borrower indicates that the tribal are fully integrated into the mainstream economy of the local area.

- **Safety of Dams (OP/BP 4.37) - APPLICABLE**

  The project is a run of the river scheme involving construction of a 65m high diversion dam across river Alaknanda. The dam is to be constructed following the Bank's policy on safety of dams (as the project will be funded by the World Bank).

  The borrowers (THDC) have their own Safety Manual/ Safety Assurance Plan, which will takes care of the safety features for the project, and reconfirms the safety of the dam.

- **Physical Cultural Resources (OPN 11.03) –APPLICABLE**

  Within the project affected area, there are few old abandoned building/ structures, which lie on the way from Haat village to Siyasain village. Pilgrims used to halt at this place during their journey to Badrinath. It is suggested that the exact age of the structures may be ascertained. However, for the proposed development there will be

no impact on the structures.

There is only a small possibility of impacts on cultural properties (such as community religious properties, sacred groves, and chance-finds). The EIA includes procedures to identify such properties, and mitigate and manage impacts in the case, such properties are impacted. During construction if any artifacts are found then the chance find procedure will be applicable.

- **Projects in Disputed Areas (OP/BP/GP 7.60) – NOT APPLICABLE**

  No part of the project area is under any international dispute.

- **Projects on International Waterways (OP/BP/GP 7.50) –APPLICABLE**

  The Alaknanda is a tributory of Ganga River that begins at the confluence of the Satopanth and Bhagirath Kharak glaciers in Uttarakhand. It meets the Bhagirathi R at Devprayag after flowing for approx. 229 km through the Alaknanda valley. After Devprayag, the river is known as the Ganga.

  The source of Alaknanda river is close to the international boundary -China hence it is applicable.

# Baseline Environment, Impacts & Mitigation Measures

3



## 3.1 INTRODUCTION

Baseline environmental study was conducted to understand the present status of the environmental resources in the project area.The environment status of project area was based on detailed field survey and secondary data review. **The environmental study was conducted in the Project Influence Area-PIA (7km around the Project Sites), Project Immediate Affected Area-PIAA (500m on either side of Project sites) and at the Project Affected Areas-PAA (land acquired for Project).** The Environment Assessment consisted review of topography, geology, hydrology, landuse, aquatic ecology, terrestrial biodiversity and archaeology of the Project area. Primary survey was followed by consultation with local people to get the relevant information about the area. Public consultation is attached as **Annex 3.1.1**. (11 environmental and 18 social consultations were held) The Project sites with sampling locations are attached as **Drawing 2008026/EC/VPHEP/01.**

Environmental impact assessment involved prediction of potential impacts by the development of the project on the surrounding area. Based on baseline environmental status and proposed project activities potential impacts have been assessed and predicted and appropriate mitigation measures are suggested to avoid / reduce/ compensate the potential adverse impacts and enhance the positive impacts.

## 3.2 TOPOGRAPHY

The topography is by and large rugged, the entire region is mountainous. The cross profiles of the fluvial valleys show convex form with steep valley sides, interlocking spurs

descending towards the main channel, hanging valleys, water falls and rapids and terraced agricultural fields on the gentle slopes on the valley sides. The clustering of villages is confined mainly on the gentle slopes of the ridges on the fluvial terraces.

The construction of project does not have any significant impact on the topography as it is a run off project with underground tunneling.

***Mitigation Measures***

- Landscaping / reclamation of quarry/ borrow area
- Implementation of muck disposal plan
- Implementation of green belt development

## 3.3 GEOLOGY & GEOTECHNICAL ASPECTS

The region belong to Garhwal Group, rocks belonging to Proterozoic age are exposed in the area. These are separated in the north from Central Crystalline group of rocks by the Main Central Thrust.

### 3.3.1 Geomorphology

The area is drained by Alaknanda River, which has originated from the Satopanth-Bhagirath Kharak group of glacier. There are number of countless perennial and ephemeral tributaries of River Alaknanda. The prominent tributaries of River Alaknanda are Dhauli Ganga, Nandakini, Pinder, Mandakini and Bhagirathi. This is an antecedent river and flows transverse to the structural axes in a deeply incised channel with irregularly terraced patches of Quaternary gravelly and sandy deposits along its path in the Inner Lesser Himalayan belt. The Inner Lesser Himalayan belt south of Helong is of comparatively gentle gradient and milder topography than metamorphic belt of Higher Central Himalaya. The hills around the valley rise to lofty heights highly dissected and reveal various geomorphic landforms. The average height ranges from 1500 m to 4500 m. Generally higher slopes shows gentle slopes, while the lower reaches shows deep recently rejuvenation, dissected topography and concave hill slope.

Around Pipalkoti three prominent river terraces have been reported while the maximum villages of the project area are situated over the colluvial deposits. The small streams feeding the main river flow to the structural strike and drain the areas either northeastward or southwestward. Generally a trellis type of drainage has developed in this area.

Most of the geomorphic features present in the project area are the result of polycyclic endogenic and exogenic processes of varying intensities through times. From Dam site to TRT outfall Alaknanda River is drained by its three major tributaries namely Maina Nadi, flowing almost in northwest-southwest direction, while the Patal Ganga and Garur Ganga flowing in southeast-

northwest direction. This is an antecedent river and flow transverse to the structural axes in gorgeous channels with irregularly terraced patches of sub-recent gravelly and sandy deposits along their paths. The study area is covered by closely spaced network of channels, tributaries and streams fed by spring water. It seems that the drainage of the area is still in its mature stage, which is mainly controlled by lithology, structure and tectonics. Higher order streams have both tectonic and lithological control while lower order streams have developed on the neo-tectonic uplifts etc.

The present landscape scenario of the study area represents the complex process of denudation under the influence of fluvial condition, which was later modified by recent reactivation. The area is characterized by gentle and mature topography exhibiting tell-tale evidence of recent rejuvenation. The Alaknada watershed in the project area is part of Inner Lesser Himalaya with minimum and maximum altitudes of 1000 m and 5100 m above sea level. It is deeply dissected resulting in steep valley flanks and narrow crested ridges. The valley flanks have a slope of $70^{o}$ to $90^{o}$ and width of valley floor is limited to width of drainage channel. The higher peaks are snow-clad during the winter season. The geomorphic cycle is in youthful stage. The hill slopes are formed of frequent rock outcrops, free faces (rocky cliffs), and mantle of colluvium and in places deposits of quaternary. The geomorphic processes operative are sheet wash (laminar flow), fluvial dissection and deposition, freezing and thawing, and mass wasting.

The Alaknanda River from Helong to Birahi has almost flow along northeast-southwest direction. The valley floor is narrow, valley sides are steeper, axial slope of valley is not yet graded and hence the flow is swift. The rocky hill slopes form riverbanks in most of the places and 2 to 8 m high vertical face within fluvial terraces (in patches) form the bank in a few places. Major tributaries such as Dwing Gad, Tirosi Gad, Mena nadi, Ghanpani Nala and Jaisal Nala (all in the right bank of Alaknanda) have near straight valleys indicating structural control but the tributaries of Mena Nadi viz. Gangartoli and Barma Gad flow in a cascade pattern indicating glacial origin. Mena Nadi is the major tributary of Alaknanda in the project area which is feeding by its nine tributaries namely Gangartoli Gad, Barma Gad, Dogara Gad, Gairal Gad, Bagdari Gad, Rikhni Gad, Pang Gad, Sari Gad and Laudau Gad. Gangartoli Gad has originated from Kalpani Glacier and Barma Gad is originated from Ruptalla bank, while all the other tributaries are spring fed. The tributary valleys are deep, narrow, steep, and channel gradient is higher. The Alaknanda river valley and its tributary valleys are being down-cut and have rocky channel with channel materials formed mostly of pebbles, cobbles and boulders resting over rocky floor. On both the bank of Alaknanda along the hill slopes from channel to crest there are no significant break in slope.

The fluvial terrace is preserved in the powerhouse area near bridge mainly on the left bank of river. The terraces have near flat topography with very gentled axial and cross slopes. The fluvial terrace material consists of predominantly cobbles, boulders, pebbles which are semi- rounded to rounded in a matrix of

coarse sand and they are semi-consolidated. The direct effects of surface drainage and associated landslides have given rise to a wide variety of soil types on moderately sloping to moderately steep sloping banks of the river Alaknanda in the form of a narrow valley. These are excessively drained loamy-skeletal soils with slight stoniness and moderate erosion. The soil on cliff and precipitous slopes are excessively drained loamy skeletal soils with strong stoniness and very severe erosion.

On the summit and ridge tops different types of soil is present. Steeply sloping (>30$^o$) surfaces register mostly coarse-grained soils with rock fragments. Moderately steep slope (16$^o$-30$^o$) surfaces exhibit thick soil cover. They are well to somewhat excessively drained, coarse-loamy to fine-loamy soils, with little or no rock fragments. Moderately sloping (<15$^o$) surfaces are composed of well-drained fine-loamy soils with local strewn pebbles on the surface. They are also associated with coarse loamy soils at places

### 3.3.2 Seismicity of the Area

State comes under **Seismic Zones V and IV** of Seismic Zoning Map of India, which corresponds to Zone Factors of 0.36 and 0.24 (effective peak ground acceleration in terms of 'g') (IS 1893 part I, 2002). The earthquake record reveals that several seismic events have ravaged different parts of the State in the last 200 years Oldham (1869) mentions of a strong earthquake occurring in the upper valley of Ganga on 1$^{st}$ September 1803 at 1.35 hrs. The tremors, which were reported to be very violent, killed 200-300 people at Barabal and inflicted severe damage at Badarinath. Another major earthquake of an estimated magnitude of 6.5 at Richter's scale occurred in Mathura 1 hrs 5 min before the Upper Ganga event. The Oldham catalogue mentions of another major earthquake near Gangotri on 25 May 1816 that included numerous landslides. On 28 August 1916 an earthquake of magnitude 7.5 on Richter's Scale having its epicenter in west Nepal had a considerable influence in Kumaon region and caused heavy damage at Dharchula. In the Kapkot earthquake of 28 December 1958 over a dozen houses collapsed. The 29$^{th}$ July 1980 Dharchula-Bajang earthquake of M 6.1 and epicentral intensity VIII on MM scale caused extensive damage and even well constructed building in Dharchula town were not spared. The tremors induced numerous landslides and ground fissures.

The most destructive earthquake documented so far in Uttarakhand was that of Uttarkashi of 20$^{th}$ October 1991 which took a toll of 768 human lives, caused injuries to 5000 people and damaged 45,765 houses, besides inducing numerous rock slides, ground fissures and changes in hot spring chemistry (GSI, 1992). The epicentral tract occupying an area of 20 sq km around Maneri in Bhagirathi valley recorded an intensity of IX on MSK-64 scale. The main shock was followed by a series of over 2000 aftershocks in a period of two months.

On the 29 March 1999 another major earthquake shook the entire State and inflicted moderate to heavy damage in the central part of Uttarakhand. The

event, referred to as Chamoli earthquake, registered a magnitude of 6.8 at Richter's scale and an epicenter intensity of VIII. Its effects, most severe in the Alaknanda valley, were noticeable as far as up to Delhi. The strong motions damaged a total of 1,87,619 houses in Chamoli, Rudraprayag, Tehri and Pauri districts causing death of 106 persons and injuries to 453.

Numerous landslides were induced by the tremors apart from development of tension fissures. Uttarakhand, including the western part of Nepal Himalaya has been classified in to four hazard classes as very high (VHH), High (HH), moderate (MH) and (LH) (Pande 1996). The HH zone lying between energy contours 1015 and 1017 ergs km-2 yr-1 occupies 36% area of Uttarakhand and encompasses major parts of Uttarkashi, Chamoli, Bageshwar, Almora, Pithoragarh and Champawat districts. Here, possibility of occurrence of earthquake of 6<M<7 exists in every 100 years. The MH zone, where there is possibility of 5<M<6 in every 100 years, spreads in 41% of the area. Places like Purola, Tehri, Rudraprayag and Haridwar fall under this zone.

GSI and BRGM France carried out an exercise on seismic hazard assessment of Northwest India in 1994-95 (Pandey 1996). It evaluated the Peak Ground Acceleration (PGA) values using a probabilistic approach. In Uttarakhand – West Nepal the PGA varied from 130 cm/sec2 in the Foot Hill region to 340 cm/sec2 in the Indo-Nepal border, respectively, corresponding to a return period of 475 years. These values were of the order of 290-320 cm/sec2 in the Uttarkashi-Chamoli region.

Since the project area forms a part of the **Seismic Zone V**, which corresponds to a zone factor of 0.36 (Effective Peak Ground Acceleration in terms of 'g' as per IS 1893: Part 2002). The north dipping Main Central Thrust (MCT) lies about 2 km northeast of the proposed dam site and the seismic status of this thrust is not properly known. The Alaknanda fault, and Srinagar thrust (NAT) are located about 32 km and 45 km southwest respectively of the proposed dam site. A number of other less prominent structural dislocations are also present in the area. All the project components of this project lie downstream of the Main Central Thrust.

### 3.3.3 Thermal Springs

In the Garhwal Himalaya, as many as 62 thermal springs are reported. As per the Geothermal Atlas of India (GSI Pub.) as many as 19 thermal springs have been recognized in Alaknanda valley from Kharbagar in the south (29o59'30": 79o55'56") to Madhyamaheshwar (30o59'20": 79o12'30") and the area includes the Tapovan (30o 29'30" : 79o 33'30") which is upstream of the dam site in the Dhauli Ganga valley. In addition to this site, one hot spring had been reported on the right bank of river Dhauliganga closer to river bank at Charmi Village (30o30'49.6'': 79o36'36.9'') during the geological mapping of Tapovan-Vishngad Hydroelectric Project.

During the reconnaissance and mapping of the Dam site area, for locating the intakes and sedimentation tank, hot water springs have been recorded at three location, two are closer to the right bank and one to the left bank. In the drill hole El. 1229.07 (Ground Elevation) (E3843517.505, N754281.482) on the right bank (No.DH-8) hot water was encountered in overburden and the temperature was 68oC recorded by drilling party. The details of the thermal springs are presented in **Table-3.3.1**.

**Table-3.3.1 Detail of Thermal springs**

| Location | Lat/Long | Elevation | Geological Setting | Approx Temperature ($^oC$) |
|---|---|---|---|---|
| Left Bank of Alaknada | E3843547.416 N754365.372 | 1230.30 m | On the left bank of river through the vertical joints in quartzites | 50$^o$C (approx.) |
| Right Bank of Alaknada | E3843492.948 N754411.086 | 1231.84 m | Through foliation joint of the quartzite on the right bank. | 55$^o$C (approx.) |
| Right Bank of Alaknada | E3843500.135 N754407.922 | 1231.20 m | Through oblique joint of the quartzite on the right bank. | 60$^o$C (approx.) |

Source: DPR, VPHEP

### 3.3.4 Geology of the Project Area

The project area forming a part of Alaknanda valley exposes rocks belonging to Garhwal Group and Central Himalayan Crystalline and are composed mainly of calc arenaceous rocks with basic intrusive and migmatite bodies, while around Helong low to medium grade metamorphic rocks are exposed.

The rocks occurring at the dam site are quartzites and along most of the length of the tunnel alignment are: quartzite with biotite schist, interbedded and interbanded grey slates and dolomites/limestone, grey thinly bedded slates with minor interbeds of limestone, dolomitic limestone with subordinate grey slates, grey pyritous shale / slates, thinly bedded dolomitic limestones, grey slate / phyllite, white siliceous dolomite with magnesite and talc schist; light grey dolomite with stromatolitic structures, interbedded quartzite phyllite and dolomite belong to Garhwal Group.Calcareous shale and dolomitic limestone / dolomite are observed at the dam site. Along Tail race Tunnel, dolomitic limestone, metabasics, augen gneisses and schist are observed. The Lithootectonic set up in the Vishnugad Pipalkoti H.E. Project area is given in **Table-3.3.2**.

**Table-3.3.2 Litho-Tectonic Setup of the Vishnugad-Pipalkoti H-E Project**

| | Litho-Units | Lithology |
|---|---|---|
| Central Crystalline | Joshimath Fm. (Inner Crystalline) | Kyanite gneiss, banded augen gneiss, migmatite, garnetiferous-biotite-schit and amphibolite |
| | ----------Vaikrita Thrust / MCT-II---------- (Jharkula-Bargaon-Saldhar) | |
| | Helong Fm. (Outer | Mylonitised augen gneisses and migmatites, mica- |

| | Litho-Units | Lithology |
|---|---|---|
| | Crystalline) | schist, amphibolites and crystalline marble<br>Sericite quartzite and quartz mica schist<br>Quartzite and chlorite schist. |
| | ----------Munsiari Thrust / MCT-I / Floor Thrust----------<br>(1.5 km South-west of Helong to south of Tapovan via Salur) | |
| Garhwal Group / Lesser Himalaya | Chamoli/ Gulabkoti Formation | Grey fine-grained dolostone. Siliceous on the top and base. Numerous magnesite lenses.<br><br>Medium grained, grey to greyish green quartzite along the contact. Subordinate schistose quartzites with a thin band of amphibolite. |
| | | ----------Gulabkoti Thrust (?)---------- |
| | Pipalkoti Formation | Alternate slate and dolostone units. Slates are mainly graphitic and calcareous. Thinly intercalated limestone and slate unit. In the upper horizon of this unit limestone becomes massive and contains chip of bluish limestone. This is arenaceous phyllite and chloritoid slate. Numerous pockets of magnesite. |
| | | ----------Birhi Fault---------- |
| | Chamoli/ Chinka Formation | Shear Zone: Mylonite quartzites, blasto mylonites, augen mylonites, augen schists. Thin amphibolites along Birhi fault. |
| | | ----------Chinka Fault---------- |
| | | Pure quartzites of greyish green colour. Orthoquartzites and subordinate schistose quartzites |

Source: DPR VPHEP

### 3.3.5 Various Studies

- **Seismic Refraction Studies**

The Seismic refraction studies in the dam area on surface and subsurface was carried out by CWPRS, Pune. Seismic refraction survey both on land and under water was carried out along five traverses upstream of proposed dam axis. The seismic traverse on land reveled three subsurface layers consisting of loose boulders, 2nd layer indicate compact / partially saturated boulders. The depth of rock as per the interpreted results is from 15 m to 23 m. No major shear zone or fault has been detected in the foundation of dam complex which may create problem during execution. This has been confirmed by the various hole drilled in the dam complex where in the compact rock is available at 10 to 25 m depth.

- **Electrical Resistivity Survey & Investigation**

For the efficient and economical design of earthing system of transmission towers so as to minimise the transmission losses, apparent resistivity of the subsurface material is required. As lower the apparent resistivity of the material better will be the electrical contact and hence minimum the transmission losses. With the above in view electrical resistivity profiling and imaging survey at two terraces in the switch yard area to measure apparent and true resistivity of the subsurface strata was carried out. The apparent resistivity values will help in deciding the level and in designing the earthing system for electrical installations efficiently and economically.

The profiling was carried out in the terraces in switchyard area. The centre of the electrodes in both the cases was moved by 2 m i.e. apparent resistivity profile with 10 m electrode separation on the lower level terrace revealed that depending on the variation of resistivity, the area along this profile can be divided into three zones. Zone-1 having average apparent resistivity 235 ohm m is the most conducting of the three zones. For Zone-II & III, the apparent resistivity is 290 ohm-m and 420 ohm-m respectively. It is inferred from the results that apparent resistivity values for these three zones that along this traverse from upstream to dam stream either clay or moisture content or both are decreasing. On lower level terrace zone-1 with lower apparent resistivity values should be preferred for earthing purpose.

On the upper level terrace, the more or less uniform nature of strata is available. However, the resistivity imaging carried out at the upper level terrene revealed that in the middle of profile there exists a narrow zone with high trace resistivity values. This zone either be avoided for earthing purpose or special care are to be taken for earthing to minimize the transmission losses.

- **Geo-thermal Investigation**

Hot springs have been noticed near the dam area. To have on the spot assessment Geo-thermal investigations have been taken up through GSI & IIT Roorkee, and the effect of results will considered during detailed design stage of the project.

- **Tectonics**

The main tectonic unit namely the higher Himalyan central crystalline is thrust South ward along the main central thrust (MCT) over the rocks belonging to the lesser Himalyan. Gneisses of the Joshimath formation are falling into a broad symform with plunge towards north. Major tectonic lineament has been identified along Dhauli Ganga and Alaknanda valley's having general westerly trend. The other lineaments are along NW & NE-SW directions. Few minor lineaments are noted along N-S ad NNE-SSW direction.

- **Design Seismic Parameter**

The project area falls under seismic zone V of seismic zoning map of India (IS8493:2002) corresponding to zone factors of 0.36 & 0.24 (effective peak ground acceleration in terms of (g) of seismic intensities VIII and > IX (MSK-64 scale). Detailed site specific seismic study to estimate the design parameters are being worked out by IIT, Roorkee.

### 3.3.6 Recommendations

- **Dam:** The geological mapping has indicated that rock types exposed on both the bank are quartzites with minor bands of schist. At least two drift at the Final Dam site one at the left bank and other on the right bank should be excavated at the final dam axes to know the depth of the stripping during pre-construction period. Exploration by ten Drill holes on the left and right bank of the river has been carried out. These drill holes have proved overburden up to 25 m below which bed rock consist of quartzites with minor bands of schist down to the bottom of the hole.

- **Desilting Chamber:** In the desilting area it is likely to encounter hot water springs as has been recorded in the dam site area. Therefore it is suggested to take care of the findings of geothermal investigations.

  Accordingly, project authorities have taken up the Geo-thermal investigations separately & the results will be taken into consideration during the execution of the project.

- **Diversion Tunnel:** For locating the inlet portal of the diversion tunnel the rock is not available as proved by the drill hole (DTH-2), drilled at the site i.e., the initial reach will be in open cut / channel with suitable protective measures of the bank / slope before opening the portal in the quartzite.

- **Head Race / Tail Race Tunnel:** A drill hole is drilled along the HRT alignment at the Ghanpani nala, to ascertain the depth of overburden and physical condition of the rock at the tunnel grade.

  In addition to the general tunneling problems high temperature during tunneling may also be encountered. Geo-thermal investigations already conducted. Accordingly, preventive measures should be adopted in the effective reaches.

  Due to the presence of sets of number of joints the tunnel is beset with the problems of rock fall and roof collapse in the reaches where chlorite schist, shale/slates shall be encountered. This problem is likely to be more pronounced in the weak zones where water seepage is also encountered. Mena Nadi is another important drainage which has to be negotiated by the

HRT. Three number drill holes have been drilled during the feasibility stage in this area. The area has been topographically resurveyed which indicate that more than 3 D rock cover (30.50 m) shall be available while driving the tunnel at the proposed location of the crossing. A fault has been interpreted along Mena Nadi which shall have to be negotiated while driving the HRT. It is suggested that advance probe hole may be planed along the HRT alignment in this reach to know the tunneling condition in advance and for planning the support system.

The flat dips occurring in certain reaches of HRT may also pose problems of roof collapses and over breaks. The zones where the rocks are more closely jointed and charged with water shall require heavy supports therefore it is suggested that advance probe hole ahead of face are very necessary to know such eventuality in advance. In addition, fore polling, control blasting, rock bolting, shotcreating and steel rib support etc. shall also be planned in advance while driving the tunnel.

In the course of tunneling water seepage is apprehended below the major perennial streams and dolomite reaches. These reach of the tunnel calls for suitable tunneling technique, supporting systems and monitoring connectivity with excavations.

- **Surge Shaft / Pressure Shaft:** The surge shaft will be located in the hard and compact, moderately jointed dolomite and no major problem is anticipated during the excavation of surge shaft / pressure shaft but encountering of inflow of water can not be rulled out in the pressure shaft excavation.

- **Power House & Transformer Caverns:** The underground power house/ Transformer caverns are being planned to be located in moderately jointed and compact dolomite. Suitable drainage galaries all around and these caverns shall have to be planed in advance for excavating the power house cavity as ingress of water while excavation can not be rulled out and the same have to be retained during Operation & Maintenance of the project.

  Proper steel support system alongwith rock bolts, shotcrete etc. are to be planned in advance while excavating the power house cavity. As the dolomite which shall be encountered during excavation are expected to be moderately to highly jointed, and water charged. Control blasting with protective measures shall have to be adopted for safe excavation of these cavities.

  A detailed Scientific and Technical studies to determine seismic parameters with regard to the safety of the dam have been conducted by Dept. of Earthquake Engineering, IIT Roorkee. Based on this, dynamic analysis has also been conducted. The studies have been approved by the National

Standing Committee on Seismic Design Parameters (NCSDP). It has been concluded that the present design of the dam is safe.

- During tunnel construction and underground power house construction proper air circulation should be maintained inside the work area. Proper ventilation should be provided.

- Employees should be removed from any area where there is air borne contamination at a concentration which exceeds the exposure limit for that contamination.

- Portable instruments should be provided to test atmosphere quantitatively for carbomn monoxide, hydrogen sulphide, nitrogen dioxide, flammable or toxic gases.

- Whenever workers are liable to be injured by sliding or falling of material from roof , face or wall of the tunnel, suitable measyres such as shoring, spray creating, use of rock bolts or other appropriatre measures should be taken to ensure safety of workers. The stability of temporary support should be checked regularly.

- Emergency generators should be provided to ensure adequate illumination of the tunnel.

- No person should be employed in compressed air unless he as been examined by medical practioner and cerified fit for such employment.

- Internetional guidelines for underground work with respect to air circulation, fire protection, communication, health, emergency preparedness must be followed.

## 3.4 METEOROLOGY

### 3.4.1 General Meteorological Scanerio

The climate of the area is tropical characterized by a hot summer from March to Mid June, a little humid monsoon or rainy season stretching from Mid June to mid October, a short pleasant post-monsoon from middle of October to November, and a very cool winter spanning between December to February. Therefore, climatologically, four seasons viz. summer (pre-monsoon), monsoon, post-monsoon and winter could be deciphered comprising the following months:

| | | |
|---|---|---|
| Summer | : | March, April, May |
| Monsoon | : | June, July, August, September, mid October |
| Post-monsoon | : | mid October, November |
| Winter | : | December, January, February. |

The Temperature in the area varies with elevation. It rises rapidly after March and the month of July is the hottest month of the year with mean daily maximum temperature going up to 27-28$^{o}$C. With the withdrawal of monsoons, by the end of September, there is a sharp decrease in temperatures. The months of December and January are the coolest months of the year, with mean daily minimum tempoerature as low as 4-5$^{o}$C

The average annual rainfall is about 125 cm per annum. The maximum rainfall is received in the months of July and August. About 60% of the rainfall is received under the influence of south west monsoons during the months from July to September. On an average, there are about 88 rainy days (i.e. days with rainfall of 2.5 mm) in a year.

The average `humidity' is about 61% Apart from the monsoon months, humidity is around 50-55% throughout the year.

### 3.4.2 Meteorological Scenario during Study Period

A meteorological monitoring station was established at Pipalkoti for collection of meteorological data from November 2008 to December 2008. A double storied building free from any obstruction around was considered for setting up the weather station. A temperature and humidity combined sensor, rain fall sensor and wind sensors (both wind speed and wind direction) were mounted on a T-bar assembly. Output of all these sensors was connected to the data logger to obtain automatic continuous recording of hourly values.

The detailed on-site hourly monitoring results of meteorological parameters i.e., temperature, humidity, rainfall, wind speed and wind direction presented in **Annex-3.4.1.**