UTTARAKHAND JAL VIDYUT NIGAM LIMITED
(A Government of Uttarakhand Enterprise)

LAKHWAR H.E. PROJECT
(300 MW)

DAKPATTHAR, DEHRADUN (UTTARAKHAND)

DETAILED PROJECT REPORT

VOLUME VI
EXECUTIVE SUMMARY

Dehradun
June 2010
Detailed Project Report of Lakhwar Multipurpose Project was reviewed & prepared by UJVNL from the combined DPR (March, 2006) of Lakhwar Vyasi Project (420 MW) prepared by NHPC and the same was submitted to concerning directorate of CWC/CEA in 2010 for clearance. CWC & CEA raised various comments on DPR & also recommended many design changes in civil structures & E&M machine. All comments, recommendation & suggestion made by CWC/CEA on DPR are enclosed in additional Volume-VII.

DPR was cleared by Technical Advisory Committee of CWC in its meeting held on 14-12-2012 & minutes issued vide letter no. 16/27/2012-PA(N)/8-32, Dated 03-01-2013.

Difference between submitted DPR in 2010 and this DPR prepared (Approved DPR) after clearance of TAC of CWC is as follows:

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Approved DPR consist of seven (07) volumes as detailed below:

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Volume - I
Comprises of Engineering details of the project and includes chapters on Project Summary, Salient Features, Hydrology, Power Studies, Optimization Studies, Geology, design of Civil Engineering Structures, Power plant Mechanical & Electrical Equipments, Ecological & Environmental Studies, Project Cost and Economical Evaluation & Financial Forecasts, etc.

Volume - II

Volume - III
Comprises of Hydrological Analysis.

Volume - IV
Comprises of Site Investigation carried out and Geology. The volume also contains Drill Hole Logs, Reports from various agencies, Rock Mechanic Test results and Seismic Design Parameters of both the projects.

Volume - V
Comprises of details of Construction Materials.

Volume - VI
Contains summary of various volumes of the DPR for quick executive reference.

Volume - VII
Contains comments of CWC/CEA, Reply of UJVNL & recommended design changes during clearance of DPR
CHAPTER-1

INTRODUCTION

1.0 Background

Lakhwar Project is a part of multipurpose scheme primarily a peaking power station on river Yamuna in the district of Dehradun in Uttarakhand. The scheme envisages construction of 204m high concrete dam on river Yamuna near Lohari village. The Multipurpose scheme also envisages construction of Vyasi HEP (Hathiari power station) downstream of Lakhwar HEP. The scheme also includes construction of a barrage at Katapathar about 3 Km downstream of Hathiari powerhouse station (Vyasi HEP) on river Yamuna. The inflow and stored water in Lakhwar and Vyasi reservoir after generation of power at Lakhwar underground power house and Hathiari power house will be balanced at Katapathar barrage for downstream use. As a result of regulated flow from the Katapathar barrage, it is also assessed that about 75 MU of additional energy would be generated from the existing downstream projects of Uttarakhand state such as Dhakrani, Dhalipur, Kulhal and Khara. The live storage of Lakhwar reservoir is estimated to be 330.66 MCum.

The project was originally approved by planning commission with estimated cost of Rs. 140.97 crores in Jan, 1976 as multipurpose scheme. Environmental clearance was accorded to the project by MOE&F in Feb, 1987.

The initial work of Lakhwar Vyasi Project was started in 1979 and three major contracts for construction of main civil works of the project were signed in July, 1987. Some construction works such as abutment stripping for Lakhwar dam, construction of 2 nos. diversion tunnels, part excavation of underground powerhouse, part excavation of tail race tunnel etc at Lakhwar site and abutment stripping for Vyasi dam, excavation of head race tunnel, diversion channel, part excavation of
surge shaft, pressure shaft, surface powerhouse, etc at Vyasi/ Hathiari site have been completed. However, the progress on construction of project works suffered and since the end of 1992 almost all the construction works are stopped. A revised Detailed Project Report (DPR) was also prepared by State Government revising the project cost to Rs 1446 cr. based on 1996 price level and the same was submitted to CEA/ CWC.

1.1 Developments relating to project execution since 2003

Since the end of 1992 works at project sites of Lakhwar and Vyasi were stopped by the then State Govt. After formation of Uttarakhand these projects were handed over to NHPC for its speedy execution through an MOU signed on 1st Nov. 2003.

NHPC after taking over the sites reviewed design, quantities, hydrology, geology etc. and prepared a new DPR for Lakhwar Vyasi combined schemes. During the process of preparation of DPR, additional investigation works relating to construction material survey, drifts (2 nos.) and drill holes (3 nos.) at Lakhwar dam site and river bed on Lakhwar dam axis (1 no.) had been done for further geological investigations.

The project sites are easily accessible by road and approach road to all work sites. Most of residential and non-residential buildings required for the construction of the project have been constructed at various sites. These residential quarters being very old and most of them lying unused, major repair work is required to maintain these buildings. Land required for starting the work is available.

Forest clearance & environment clearance of this project was accorded in 1986 & 1987 respectively in favour of Irrigation Department. MoEF vide letter F.No. 8-172/1986-FC (pt-1) dated 31.01.2014 accorded the approval of the Central Government for transfer of the lease in favour of UJVN Ltd in respect of 768.1552 hectares of forest land already diverted during 1986 in favour of Irrigation Department, GoU for construction of Lakhwar Project. MOEF has conveyed continuity of

1.2 Hydrology

The catchment area of the Yamuna river upto Lakhwar dam is 2080 Sqkm and the snow-covered area is estimated as 60 Sqkm. Vyasi dam is 5 km downstream of Lakhwar dam at the Yamuna river having additional catchment area of 20 Sqkm. The entire catchment is thinly populated and is covered with forests. It is made up of mountainous terrain with steep hill slopes. The riverbed slope is comparatively steeper in its upper reaches, being of the order of 13.3 m/km (1 in 75) from Yamunotri to Lakhwar.

The rainy season is from June to September however, at times, rainstorms also occur during October month in the post monsoon period due to meteorological depressions moving westward over the region. Winter rainfall in this area is insignificant. The monthly maximum and minimum temperatures at Dehradun are 42.8 °C and 0.3 °C respectively. On the basis of evaporation data at Dehradun from Jan 1980 to Dec 2001, the annual average evaporation is 1153 mm.

One gauge & discharge site located about 200 m downstream of proposed Lakhwar dam site was earlier maintained by Uttar Pradesh Irrigation Department (UPID) from 1968 which was later on being maintained by NHPC during preparation of DPR of Lakhwar Vyasi projects. Central Water Commission is maintaining Naugoan gauge & discharge which is about 60 km upstream of proposed Lakhwar dam site and Bausan gauge & discharge site near Hathiari power house. Data from these sites have been used to arrive the available runoff. The design flood value of 8850 cumec, as approved by CWC for the Vyasi H.E. project in December 2006 is recommended by CWC vide letter No: Hydrology(N) Direct./1/97/81/1-2/171 dated: 25.03.2011 *(Annexure-H-1 of Vol-VII)* for planning purpose of Lakhwar project.
1.3 Geology & Seismicity

The Lakhwar Vyasi project area comprises rocks of Jaunsar Group belonging to Pre-Cambrians of Kumaun Lesser Himalayas. The Jaunsar Group of rocks found around both the projects comprise of slate, phyllites, quartzite and limestone of Mandhali, Chandpur and Nagthat Formation. The rock belonging to Chandpur Formation have been intruded by volcanics comprised of basic rocks, at Lakhwar dam site, where a large intrusive body of 'Jaunsar Trap' having a width of nearly 300m has been selected for placing the 204m high dam. The intrusive rock comprised of hard and mainly massive dolerite to hornblende & rhyolite. A huge xenolith body within the volcanic intrusion comprising of slate/ slaty quartzite shall be the part of dam foundation at left abutment. The depth of over burden on river Yamuna consist of RBM ranging between 22m to 29m thickness. The underground power house shall be placed within volcanic rock mass on right bank very near to the dam body.

The Katapatthar Barrage is proposed at 13.65 Km downstream of Lakhwar dam site which would act as a balancing reservoir. Bed rock is exposed on both the banks in small patches. Trace of Nahan Thrust is interpreted to be running along centre of the river. One drill hole indicated that the bedrock exist at 8.8m depth drilled at low level terrace. Being adjacent to Nahan & Krol Thrusts, the rocks are crushed & fractured. Since, the barrage is to be constructed on floating foundation, depth to bed rock is not of much significance.

For the construction of concrete dam, coffer dams, power house and other allied civil structures of Lakhwar project, two river shoal/ nala deposits and two impervious soil deposit have been selected for meeting the requirements and are found suitable for wearing as well as non wearing surface.

The project area is situated in a seismically active area and falls in zone IV of seismic zones map of India. There are histories of
occurrences of very severe earthquakes causing devastating effects. Seismic studies of these projects have been carried out through Department of Earthquake Engineering, IIT, Roorkee who have recommended MCE as 0.36g and DBE as 0.18g for both Lakhwar and Vyasi dams. The Katapathar barrage will also be designed on the same seismic parameters.

1.4 Project component

Various components of the project are:

1.4.1 Lakhwar Scheme

a) River diversion work comprising 2 nos. 5 m dia. Horseshoe shaped Diversion tunnel.

b) 204 m high concrete gravity dam.

c) Water conductor system comprising of intake structures, 3 nos. Pressure shaft of 4.3 m dia.

d) Underground power house of size 165 m X 20 m X 48.05 m (unfinished), D shaped.

e) Collection chamber of size 80 m X 10 m x 42 m, D shaped and additional collection chamber 65 m X 8.5 m X 35 m.

f) 8.25 m dia., Horseshoe shaped, 240.49 m long Tail race tunnel.

g) Switch yard - GIS

1.4.2 Katapathar Barrage

Location – 13.65Km D/S of Lakhwar dam of length 152.5m comprising 3 sluice bays and 5 weir bays.

1.5 Power Generation

Lakhwar Hydro project is a peaking power station with a proposed installed capacity of 3x100 MW. It shall utilize inflow of Yamuna river for power generation. This project will meet peaking demand of state of
Uttarakhand which is facing acute power shortage due to thrust on industrialization of state after its separation from Uttar Pradesh.

Since Uttarakhand does not have any proven coal reserves and there is no proposal for nuclear installation in the state, it has therefore to rely essentially on its underdeveloped hydro potential for meeting states power requirement.

Lakhwar project is geographically very attractive project as it is only 72 km from state capital and most of the infrastructure work is already in place.

1.6 Project Estimate & Financial Forecast

As approved by CWC and CEA on May 2012 PL

Total cost of project (RCE PLJuly-2018) Rs 5747.17 Cr
Cost apportionment as approved by CWC 81.30% : 18.70%
Water component % : power component %

1.7 Construction Methods & Time Schedules

Lakhwar Scheme

Construction works of Lakhwar Project are of partly surface and partly underground in nature. The project is scheduled to be commissioned in 69 months from the date of commencement. The land required for starting the project work is already available. The required infrastructure such as road, buildings etc. are also available. Balance work of land acquisition and infrastructure development will go parallel with the project execution. Finalization of contract and mobilization of equipment would be completed in 3 month from the start of the project.

River diversion work for Lakhwar dam will be completed in 3 months commencing 6th month of the start of the project. Excavation for Lakhwar dam would be completed in 9 months from 7th month to 15th month by Hydraulic Excavator of 3 cum and 1 cum, 35T dumpers, tippers etc. have been proposed. During this period, mobilization for dam concreting will also be completed. For concreting Bi-cable ways of
2 x 28 T capacities have been proposed. Therefore the total capacity of this crane will be 311cum/hr approximately but will be restricted to 280 cum/hr as per actual capacity of 350 cum/hr Batching & Mixing plant. Additional concrete production at this location is not possible due to site constraints and paucity of suitable flat land, however further requirement of concrete would be satisfied by the Batching plant of capacity 100 cum/hr installed at Power house location through 2 nos Tower crane of 6 T capacity and 1No. Concrete pump (38 cum/hr). The excavation quantities in the Dam are decreased to 13, 52,076 cum from earlier 17, 86, 700 cum due to change in the orientation of the dam.

Balance work of excavation and concerting of Lakhwar power house, penstocks etc. has been scheduled to be completed in 29 months from 5th month to 22nd month and erection of units along with 2nd stage concreting would be completed between 38th to 66th month. Testing and Commissioning of the project has been scheduled from 67th to 69th month.

Excavation of Katapathar Barrage has been scheduled in 9 months from 13th month to 21st month. Concreting for Katapathar Barrage would be completed between 19th month to 42th month. Hydro mechanical works would be completed in 12 months commencing from 31st month. However, parts to be embedded would be procured much earlier.
CHAPTER 2
SALIENT FEATURES

(A) LAKHWAR PROJECT

LOCATION
State : Uttarakhand
District : Dehradun
River : Yamuna
Location of Lakhwar Dam & Power House : Lohari village 20 Kms. upstream of Kalsi and 72 Kms. from Dehradun
Nearest Airport & Railhead : Dehradun
Latitude : 30°31'03" N
Longitude : 77°56'58" E

HYDROLOGY
Catchment area (including snow catchment) : 2080 Sq. Km.
Snow catchments : 60 Sq. Km.
Normal rainfall in the catchment : 1150-2550 mm
Design flood (PMF) : 8850 cumec
Maximum annual runoff (1988-89) : 3756 M.m³
Average annual runoff (1963-64) : 2322 M.m³
Minimum annual runoff (1965-66) : 1221 M.m³

DIVERSION TUNNELS
Diversion flood - Non Monsoon (1 in 50 years) : 350 cumec
Location : Left Bank
Number and size : 2 Nos., 5 m dia Horse Shoe Shaped
Length : 567 m and 596 m
Invert elevation at Inlet : 633.0 m and 636.0 m
Invert elevation at Outlet : 622.0 m

COFFER DAM
Type : Rock fill
Top of Dam : 642.25 m
U/S slope : 1 V: 2 H
D/S slope : 1 V: 1.5 H

DAM
Type : Concrete Dam
River bed level : 623.0 m
Expected deepest foundation level : 596.0 m
Top of Dam : 800.0 m
Maximum height above deepest foundation : 204 m
Top width : 10.0 m
Length at top : 481.5 m
Upstream slope (Non over flow blocks)
Between El. 800-761.667 m: Vertical
Between El. 761.667-695.0 m: 0.3: 1
Between El. 695 & foundation level: 0.45: 1

Down stream slope
Between El. 800-790m: Vertical
Between El. 790m & foundation level: 0.78: 1
No. of main NOF blocks of 17.5 m width each: 23 Nos.

SPILLWAYS
Type of spillway: Breast wall type
No. and size of openings: 5 bays of 9 m x 13 m each
Crest elevation: 762.5 m
Discharge capacity: 8850 cumecs
No. of over flow blocks of 15 m width each: 5 Nos.
Energy dissipater: Plunge pool + Splitters & buckets
Buckets invert elevation: 700 m
Splitters invert elevation: 712 m
Plunge pool finished floor level: 610 m
Size of plunge pool: 112 m(L) x 75m(W)
Maximum Tail Water level: 640 m
Normal Tail Water level: 630 m
Minimum Tail Water level: 624.5 m

RESERVOIR
Full Reservoir Level (FRL): El. 796.00 m
Minimum Draw Down Level (MDDL): El. 752.00 m
Gross Storage at FRL: 587.84 M.m³
Gross Storage at MDDL: 257.18 M.m³
Live Storage: 330.66 M.m³
Reservoir Area at FRL: 9.57 Sq. km
Reservoir Area at MDDL: 5.65 Sq. km
Average width of reservoir: 483 m
Length of reservoir: 23 km
River bed slope in reservoir area: 7.4 m per km

INTAKE AND PENSTOCK
Design discharge through each intake: 75 cumecs
Width of intake structure: 52 m
Invert level of Intake: El. 741 m
No. of penstocks: 3
Diameter of penstocks: 4.30 m circular
Length of penstocks: 186.5 m, 211 m, 235 m

POWER HOUSE COMPLEX
Underground Power House
Size of cavern: 130 m x 20 m x 46.8 m D –
(unfinished roof EL652.95 m)  Shaped (unfinished)  
Finished roof EL652.30 m  130 m x 20 m x 46 m D –Shaped (finished)  
Cavern bottom EL 606.30 m)  
Installed generating capacity  :  3 x 100 MW  
Types of Turbines  :  Francis type  
Gross head  :  171.5 m  
Rated head  :  148.00 m  

Machine hall  
Size of machine hall  :  82.5m x 18m comprising 4 floors  
Size of erection bay  :  20 m x 25 m  
MLV floor  :  614.5 m  
Turbine floor  :  621.55 m  
Floor between Generator & Turbine floor  :  625.0 m  
Generator floor  :  628.55 m  

Adit to Collection Chamber  
Size and shape  :  5.7 m D-shaped  
Length  :  186 m.  
Invert level at Power house side  :  644 m  
Invert level at Exit side  :  641m  

Adit to Erection Bay  
Size and shape  :  7.0 m. D-Shaped  
Length  :  213 m.  
Invert level at Power house side  :  628.5 m  
Invert level at Exit side  :  642 m  

Bottom adit to Pressure Shaft & lower Drainage Gallery  
Size and shape  :  6.0 m. D-Shaped  
Length  :  273.50 m.  

Upper drainage gallery  
Size and shape  :  2.5x3.0 m D-shaped  
Length  :  166 m  

Lower drainage gallery  
Size and shape  :  2.0x2.5 m D-shaped  
Length  :  140 m  

Draft tubes  
Nos. & Size  :  3 Nos. of size 8.5 m x 4.746 m.  
Length  :  31.75 m  

Collection chamber  
Size of Cavern  :  80 x 10 m D-shaped  
Crown level  :  EL 652.80 m  
Springing level  :  EL 649.8 m  
Width of Cavern below platform  :  10.0 m  

Additional collection chamber.  
Size of Cavern.  :  65 m x 10 m x 35 m  D-Shaped  
Crown level  :  EL. 645.0 m  
Width from R.L. 642 m to 634 m  :  10.0 m  
Width below R.L. 634 m  :  8.5 m.  

Tail Race Tunnel  
Size and shape  :  8.25 m horse shoe shaped
Length : 159 m.
Discharge capacity : 225 cumecs

Cable Tunnel
Size and shape : 3.50 m dia D-Shaped
Invert level : EL 641.0 m.
Length : 585.0 m

Switch Yard
Size : 60.0 m x 140.0 m
Elevation : 640 m.

(B) KATAPATHAR BARRAGE
Location : 13.65 km downstream of Lakhwar Dam
Length : 152.5 m
No. of Sluice bays : 3 nos.
No. & size of weir bays : 5 nos., 16 m wide with 3.5 m thick piers in between
Crest level of weir bays : EL 501.0 m
Crest level of sluice bays : EL 500.0 m
Bed level of river : 498 m
Design flood : 8850 cumecs
Pond level : EL 515.00 m
CHAPTER – 3

HYDROLOGY

3.0 Basin Characteristics and Physiography

Lakhwar project is located in Dehradun district of Uttarakhand and envisages utilization of water of river Yamuna for power generation at Lakhwar storage scheme. The total installed capacity of the project is 300 MW. It is envisaged to construct a 204 m high concrete gravity dam at Lakhwar dam site to store 587.84 Mcum of water. The region is mountainous, partly covered with vegetation.

3.1 Catchment

The catchment area is bounded between latitude 30°25'N to 31°05'N and longitude 77°52'E to 78°35'E. The catchment area of the Yamuna River up to Lakhwar dam is 2080 Sqkm and the snow-covered area is estimated as 60 Sqkm. The entire catchment is thinly populated and is covered with forests. It is made up of mountainous terrain with steep hill slopes. The riverbed slope is comparatively steeper in its upper reaches, being of the order of 13.3 m/km (1 in 75) from Yamunotri to Lakhwar.

3.2 Hydrometeorology

The project catchment receives precipitation due to southwest monsoon, which lasts generally from June to September, but may occasionally be extended up to October. There is heavy precipitation from June to September. However, at times, rainstorms also occur during October month in the post monsoon period due to meteorological depressions moving westward over the region. Precipitation is very little during winter and spring
periods as compared to monsoon period. The relative humidity is generally high during monsoon and low during post monsoon and winter seasons. At higher altitudes, it is in the form of snow, which contributes to increase in the river runoff from March to September due to rise in temperature. On the basis of evaporation data at Dehradun from Jan 1980 to Dec 2001, the annual average evaporation is 1153 mm. The monthly maximum and minimum temperatures at Dehradun are 42.8 °C and 0.3 °C respectively.

3.3 Water Availability

The average 10-daily water availability series has been prepared from Lakhwar gauge & discharge site, Naugoan gauge & discharge site, which is about 60 km upstream of proposed Lakhwar dam site, and Bausan gauge & discharge site, which is about 10.7 km downstream of proposed Lakhwar dam site. The average ten-daily water availability series at Lakhwar dam site has been developed for the period Jan 1971 to Dec 2009.

3.4 Design Flood and Diversion Flood

The Lakhwar & Vyasi dam are designed for probable maximum flood (PMF) as per IS code 11223-1985. The design flood has been computed by statistical and deterministic approach. The frequency analysis has been carried out for the instantaneous annual peak series for the period 1971 to 2003. In the Deterministic approach, the unit hydrographs have been developed by Snyder’s, Central Water Commission’s Sub Zone-1e, Clark’s and observed flood hydrographs.

The design flood value of 8850 cumec, as approved by CWC for the Vyasi H.E. project in December 2006 is recommended by CWC vide letter No: Hydrology(N) Direct./1/97/81/1-2/171 dated:
25.03.2011 (Annexure-H-1 of Vol-VII of DPR) for planning purpose of Lakhwar project

Frequency analysis for diversion flood has been carried out for the period from 1st Nov to 15th Jun. The flood peaks for this period have been chosen for all the available years at Naugoan, Lakhwar and Bausan G&D sites. The observed flood peak series has been developed adopting the same procedure as in the annual flood peaks mentioned above. The non-monsoon flood peak series from 1970-71 to 2002-2003 thus computed is enclosed as Annexure -9 of vol-III Hydrology.

The abstract of result of frequency analysis by the distributions Gumble EV1, 3-Parameter lognormal and log Pearson type III on mean line is shown in Annexure-10 of vol-III Hydrology. Based on the flood frequency analysis, the 25-year return period non-monsoon flood works out to 255 cumec & 246 cumec by Gumble’s distribution and Log Pearson Type-III respectively. The observed maximum discharge at the project site for non-monsoon season works out to 352 cumec. In view of the above 350 cumec has been adopted as diversion flood which has been approved by CWC vide letter no: Hydrology (N) Direct./1/97/81/1-2/171 dated: 25.03.2011(Annexure-H-1 of Vol-VII of DPR).

3.5 Reservoir Elevation Area Capacity

3.5.1 Lakhwar Reservoir

The reservoir Elevation-Area-Capacity of the Lakhwar reservoir has been prepared using cross sections of Yamuna River & Nallahs falling in the reservoir area. The reservoir capacity at MDDL (EL 752 m) and FRL (EL 796 m) are worked out as 257.18 Mcum and 587.84 Mcum respectively. The live capacity is 330.66 Mcum. The reservoir has a spread of 9.57 Sqkm at EL 796.0 m
3.6 **Post Sedimentation Reservoir Study**

The suspended sediment load rate of 0.128 Ha-m/Sqkm/year has been taken for reservoir post sedimentation studies for planning purpose.

3.6.1 **Lakhwar Reservoir**

The Lakhwar reservoir capacity is large and the trap efficiency varies from 93 % to 88.9 %. The sediment distribution in Lakhwar reservoir has been studied based on empirical area reduction method using the graphs and design surveys and the Lakhwar reservoir Elevation-Area-Capacity after each 10-year block of sedimentation has been computed by empirical area reduction method for Lakhwar reservoir for 70 years. The reservoir live capacity after 70 years is computed as 286.7 Mcum.

3.7 **Reference**

Detailed hydrological studies and hydraulic transient studies along with figure are compiled in hydrology volume-III of DPR.
CHAPTER- 4
POWER STUDIES

4.1 INTRODUCTION
Lakhwar Hydro Project is a peaking station with a installed capacity of 3x100 MW. It utilizes inflow of the Yamuna River for power generation. This project will cater to peaking power requirement of state of Uttarakhand as well as that of Northern Region. Uttarakhand state is facing acute power shortage presently. After formation of separate state lot of industrialization activity has come up in the state and there is shortage of peaking and base load power in the state. For meeting power shortage in the state of Uttarakhand and N.R., the only alternative is to harness abundant hydro power potential available in the state at fast pace.

Lakhwar hydro project with a installed capacity of 300 MW and downstream Vyasi project with installed capacity of 120 MW are geographically very attractive sites having basic infrastructure in place. Necessary clearances for execution of the project have been obtained.

As per studies during clearance of DPR, the firm power, load factor and design energy of project would be 55.8 MW, 18.6% and 572.54 GWh (MU) respectively in 90% dependable year with 95% machine availability. Minimum peaking duration of 4.16 hours would be available during lean period. (Approved by CEA vide HPA Division letter no. 207/29/2010/HPA/670 dated: 23.06.2011 (Annexure-E-1 of Vol-VII)

In addition to direct benefit as mentioned above it will also enhance energy generation from downstream projects such as Dhalipur, Dhakrani, Kulhal & Khara to the tune of 75 MU.

4.2 DEVELOPMENT OF POWER DEMAND IN STATE OF UTTARAKHAND
The demand for power has outstripped availability to an alarming extent in the country as a whole, and in the Northern Region in particular which includes Uttarakhand state also. Northern Region, already under severe power deficit, is in the grip of acute power shortage in 11th plan and beyond even after
accounting for benefits from the ongoing projects and also from other schemes cleared by CEA. NR is presently facing a energy deficit of about 11.6% and peak power deficit of 15.4% whereas the energy deficit and peak power deficit faced by Uttarakhand state are about 6.5% and 6.0% respectively. Table 4.1 Chapter -4 projects demand/ availability and deficit of energy and peak power requirement of N.R and Uttarakhand for the period “April, 2009 to March, 2010”.

As per the “State Wise Long Term Forecast at power stations bus bars (utilities)” projected by CEA in 17th Electric Power Survey, the electric energy and peak electric load requirements are growing considerably in N.R including state of Uttarakhand. (Table 4.2). The electric energy requirement of Uttarakhand which is presently about 8904 MU is expected to increase to 11668 MU by the end of 12th plan and 16191 MU by the end of 13th plan. Similarly the peak electric load requirement of Uttarakhand which is presently 1397 MW is expected to rise to 1533 MW, 2025 MW & 2849 MW by the end of 11th, 12th & 13th plan respectively.

4.3 NEED FOR FURTHER EXPANSION AND DEVELOPMENT OF HYDRO ELECTRIC POWER RESOURCES

From the tables given above it will be observed that presently at the end of March, 2010 against the peak demand of 1397 MW state is able to meet only 1313 MW. This position would further worsen by the end of 11th plan where projected demand of peak power would be about 1533 MW for the state there by state will face a deficit of about 420 MW unless some additional power is available to the state by way of new commissioned project or share from Central pool.

It is in this context that rapid exploitation of Hydropower potential of Uttarakhand assumes more significance.

The power from Lakhwar HEP would be fully utilized in the state of Uttarakhand as per their power requirements and at the same time it would give additional support to the Northern Region as a whole to reduce the deficits being faced by the region.
### Table 4.1
Power Supply Position in Northern Region

<table>
<thead>
<tr>
<th>State/Region</th>
<th>Electric Energy Requirement</th>
<th>Peak Electric Load</th>
<th>Surplus/ Deficit</th>
<th>Surplus/ Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Requirement (MU)</td>
<td>Availability (MU)</td>
<td>Surplus/ Deficit (MU)</td>
<td>%</td>
</tr>
<tr>
<td>Chandigarh</td>
<td>1570</td>
<td>1521</td>
<td>-49</td>
<td>-3.1</td>
</tr>
<tr>
<td>Delhi</td>
<td>24271</td>
<td>24088</td>
<td>-183</td>
<td>-0.8</td>
</tr>
<tr>
<td>Haryana</td>
<td>33520</td>
<td>32006</td>
<td>-1514</td>
<td>-4.5</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td>7009</td>
<td>6762</td>
<td>-247</td>
<td>-3.5</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
<td>12907</td>
<td>9929</td>
<td>-2978</td>
<td>-23.1</td>
</tr>
<tr>
<td>Punjab</td>
<td>45770</td>
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<td>-6319</td>
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<tr>
<td>Rajasthan</td>
<td>44031</td>
<td>42983</td>
<td>-1048</td>
<td>-2.4</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>75822</td>
<td>59390</td>
<td>-16432</td>
<td>-21.7</td>
</tr>
<tr>
<td>Uttarakhand</td>
<td>8904</td>
<td>8321</td>
<td>-583</td>
<td>-6.5</td>
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<tr>
<td>Northern Region</td>
<td>253803</td>
<td>224447</td>
<td>-29356</td>
<td>-11.6</td>
</tr>
</tbody>
</table>

Source: CEA

### Table 4.2
State Wise Long Term Forecast At Power Station Bus Bars (Utilities)

<table>
<thead>
<tr>
<th>State</th>
<th>Electrical Energy Requirement</th>
<th>Peak Electric Load (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delhi</td>
<td>36293</td>
<td>52762</td>
</tr>
<tr>
<td>Haryana</td>
<td>38417</td>
<td>54305</td>
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<tr>
<td>Himachal Pradesh</td>
<td>9504</td>
<td>13136</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
<td>11202</td>
<td>15272</td>
</tr>
<tr>
<td>Punjab</td>
<td>60489</td>
<td>82572</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>48916</td>
<td>67767</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>79268</td>
<td>110665</td>
</tr>
<tr>
<td>Uttarakhand</td>
<td>8445</td>
<td>11668</td>
</tr>
<tr>
<td>Northern Region</td>
<td>2308</td>
<td>3367</td>
</tr>
</tbody>
</table>

Source: CEA
CHAPTER – 5

OPTIMIZATION STUDIES

5.0 Introduction

Lakhwar Project is a peaking station with an installed capacity of 3x100 MW. It utilizes inflow of the Yamuna River for power generation. Lakhwar Project is a reservoir based scheme having an underground power house. This envisages a reservoir which has live storage of 330.66 MCM between FRL (EL 796) and MDDL (EL 752) to meet the peaking requirement.

5.1 Installed Capacity

The DPR of the project was prepared in March 1996 by the state government of erstwhile UP Govt. with Installed capacity of 3x100 MW for Lakhwar project. Further optimization studies have been carried out on the extended hydrological series from 1971 to 2009 and it is observed that optimal installed capacity of Lakhwar HEP still works out to 300 MW as envisaged earlier by UPID and further adopted by NHPC in their DPR. Since there is no change in the installed capacity of the project, the civil works already carried out in the past shall not be disturbed and balance works can be picked up from the existing position.

5.2 Unit Size

Unit sizes of 100 MW for Lakhwar project have also been retained as established in earlier studies on account of the fact that certain civil works like excavation of adit to erection bay and control room, partial excavation of power house, collection chamber, TRT etc. have already been carried out.
5.3 **Energy Generation**
The total annual energy generations in the 90% dependable year with 95% machine availability from Lakhwar HEP is estimated at 572.54 MU.

5.4 **Peaking Availability**
The duration of peaking hours available from the inflow has been calculated. During the lean season a minimum of 4.16 hours of peaking shall be available from the river inflow and storage capacity of the reservoir in 90% dependable year in respect of Lakhwar project.
Table - 5.1

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Year</th>
<th>Energy in Mu</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1998-99</td>
<td>1404.12</td>
</tr>
<tr>
<td>2</td>
<td>1988-89</td>
<td>1393.37</td>
</tr>
<tr>
<td>3</td>
<td>1982-83</td>
<td>1268.97</td>
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<tr>
<td>4</td>
<td>1983-84</td>
<td>1249.18</td>
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<tr>
<td>5</td>
<td>2005-2006</td>
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<td>6</td>
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<td>2008-2009</td>
<td>1027.85</td>
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<tr>
<td>9</td>
<td>2006-2007</td>
<td>991.86</td>
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<tr>
<td>10</td>
<td>1977-78</td>
<td>993.08</td>
</tr>
<tr>
<td>11</td>
<td>2001-2002</td>
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<tr>
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<td>1975-76</td>
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<td>960.34</td>
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<tr>
<td>14</td>
<td>1971-72</td>
<td>958.05</td>
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<tr>
<td>15</td>
<td>1981-82</td>
<td>953.71</td>
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<tr>
<td>16</td>
<td>1985-86</td>
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<td>1997-98</td>
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<td>22</td>
<td>2007-2008</td>
<td>832.61</td>
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<td>23</td>
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<td>24</td>
<td>2000-2001</td>
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<td>25</td>
<td>1996-97</td>
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<td>28</td>
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<tr>
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<td><strong>1974-75</strong></td>
<td><strong>612.93</strong></td>
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<tr>
<td>36</td>
<td>1991-92</td>
<td>604.33</td>
</tr>
<tr>
<td>37</td>
<td>1987-88</td>
<td>477.71</td>
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<tr>
<td>38</td>
<td>1979-80</td>
<td>454.23</td>
</tr>
</tbody>
</table>

(90% dependable year is year 1974-75 with generation of 612.93 MU)
Table 5.2
RESERVOIR OPERATION STUDY
CHAPTER 6
GEOLOGY

6.1 General

The Lakhwar Vyasi Project is envisaged to be constructed across river Yamuna with Lakhwar scheme being located near Lohari village and Vyasi scheme near Juddo village about 70 km North-West of Dehradun in Uttarakhand.

6.2 Geology Around Project Area

The Lakhwar Vyasi Project area comprises rocks of Jaunsar Group belonging to Pre-Cambrians of Kumaun Lesser Himalayas. The Jaunsar Group of rocks comprise slate, phyllites, quartzites and limestones of Mandhali, Chandpur and Nagthat Formations. Intrusives comprising basic rocks, calcite, feldspar and epidote veins are observed in the project area, particularly around Lakhwar Dam. The rocks of Jaunsar Group are having an intrusive contact with the underlying rocks of Deoban Formation and have a thrusted contact with the overlying Subathu Group. The Krol Thrust and Nahan Thrust are nearly 5km SW of the Lakhwar Dam.

6.2.1 Regional Seismicity

The project area lies in a seismically active region where moderate to great earthquakes occur. Based on tectonic setup and seismicity of the area, Dept. of Earthquake Engineering has recommended a value of 0.36g of Peak Ground Acceleration (PGA) for Maximum Credible Earthquake (MCE) and a value of 0.18g of PGA for Design Basis Earthquake (DBE) for the seismic design parameters of the project.
6.3 Geology of Major Civil Structure

6.3.1 Lakhwar Dam Complex

The proposed site for 204m high concrete gravity dam is located near Lakhwar village, approachable by 25km long State Highway as well as project road from Dakpatthar. Substantial amount of stripping has already been completed at old dam site which is extending to the shifted dam axis in the upstream side. However, few overburden patches are noticed on upstream side at the heal portion of new dam. Similarly on left bank also patches of slope wash material are present at higher elevations. The Lakhwar Dam area is mainly occupied by a large intrusive body of Jaunsar Traps which is interpreted to be nearly 300m wide. The country rock is Chandpur Formation comprising of quartzite with slate-phylite both in the upstream and downstream sides. The downstream contact has got a gentle dip 38°-45 towards upstream direction whereas the upstream contact of Traps and Chandpur Formation is steeper at 75°. On the left bank the trap body becomes narrower and tapers further inside whereas it widens on the right abutment. However, on the left bank a xenolith body of quartizitic slates within the traps is present at the dam axis. On the upstream side on the same bank the traps are in contact with Nagthat Quartzites as well as with xenolith body. This contact shows about 1m thick fracture zone which is referred as fault in some GSI reports. NHPC has proposed new dam axis about 40-80 m upstream of old axis.

6.3.1.1 Discontinuities

Quite extensive data on discontinuities has been generated from previous investigations as well as from studies by NHPC geologists in form of mapping and statistical analysis. Stereographic plots of the data have been prepared.

The orientations derived from overall analysis are listed below with ranges.
6.3.1.2 Exploration

The dam site has been explored by 31 exploratory drifts and 88 drill holes by UP Irrigation Department under the guidance of GSI. Several rock mechanic tests have also been carried out. Besides this, NHPC has drilled 3 nos. of drill holes.

6.3.1.3 Left Abutment

On the left abutment Jaunsar traps, slate xenolith & Nagthat Quartzites are expected at foundation grade. Near the river 1-2m stripping is foreseen in traps whereas in slate xenolith and Nagthat Quartzite 5m excavation is anticipated. However, at higher elevation 5-10m stripping is expected in view of patches of slope wash and weathered / jointed Nagthat Quartzites. The new axis is nearly 80 m upstream of old axis on left bank. Provision for adequate grouting has also been kept.

6.3.1.4 Right Abutment

At the new dam axis which is 40m upstream of old axis on right bank, traps are expected throughout the foundation. In the light of already stripped reaches, only 1-2 m of excavation on right abutment is anticipated. Normal provisions for grouting as required for a high concrete dam are kept for right bank.

6.3.1.5 River Bed

Spillway blocks S-1 to S-5 are placed mainly in riverbed where overburden is expected to be 22m near dam axis as 27 to 29 m in
downstream portion. From toe of dam a weak slate band is 125-150 m on surface. Geological sections are developed both at new dam axis and dam toe particularly where weak slate band is shown considering data from exploratory drifts and drill holes. At dam axis, however, only 2m excavation and usual grouting is foreseen.

6.3.1.6 **Plunge Pool**

The plunge pool is 112 m long and 75m wide with base elevation 610m. It is located more towards the left bank with the right guide wall coming in the centre of the river. The weak slate band at the contact of trap & Chandpur Formation is coming at the edge of plunge pool. Suitable treatment for this zone is discussed in Vol.IV.

6.3.2 **Diversion Tunnel**

Two nos. horse shoe shaped, 5m diameter, 567 m & 596 m long diversion tunnels stand completed on left bank. While the invert levels of the two tunnels at inlet are different 633m & 636m respectively, the common invert level at outlet is 622m. Jaunsar Traps, quartzites and phyllite/ slates were encountered in the tunnels.

6.3.3 **Intake**

The power tunnel intakes which are three in number are accommodated on right bank at EL 741M. About 50m high open excavation is involved to create the platform for intake structure. In the already excavated portion traps & quartzites with slates are present.

6.3.4 **Intake Tunnels/ Penstocks**

As the power house is adjacent to dam body on right bank, three nos. intake tunnels/penstocks small in length are leading water to the vertical pressure shafts. The horizontal parts of penstocks are expected to be placed in moderately jointed quartzites. Rock conditions are expected to be generally fair.
6.3.5  Lakhwar Power House Complex

6.3.5.1  Previous Studies

As in case of dam complex, considerable data from previous investigations is available for underground power house. Additionally as a major part of power house is completed and is entirely supported by steel ribs, the data from 3-D geological maps of power house excavations and other openings in the vicinity together with geological information from previous explorations have been used for predicting geotechnical conditions for balance works.

6.3.5.2  Layout

The 3 nos. intakes directly lead water to independent tunnels/penstocks of 186.5m, 211m and 235m lengths respectively. The penstock/pressure shafts are 4.3m in diameter with sufficient lateral cover in between. The water is carried from elevation 743.15M to elevation 618M via three nos. vertical pressure shafts. The size of power house as already mentioned is 130mx20x46.80m (unfinished). About 20m downstream of main cavern, the collection chamber and additional collection chambers are present. These openings are 80mx10mx42m D-shaped and 65mx8.5x35m D-shaped respectively. The length of 8.25m dia, horse shoe shaped tail race tunnel is only 159.2 m.

6.3.5.3  Already Completed works

Underground Power House

The underground power house cavern stands excavated down to elevation 625m (average) as described in previous paragraphs. The power house cavern 130mx20mx46.80m (unfinished) having roof at EI. 652.95M (unfinished) has D-shape with crown arch radius being 13.712m. The cavern is supported by steel arches which show no
signs of distress. However, the pit is filled by water up to elevation 642.00m. As such, inspection of walls was not possible.

**Collection Chamber**
A collection chamber having dimension 80.0mx10mx42m, D-shaped has been provided where the water after just passing the turbines gets collected. The width below platform is 10m and above platform is 11.75m. The chamber is already excavated down to elevation 642m (average).

**Additional collection chamber**
An additional collection chamber with dimensions 65mx10mx35m, D-shaped, is provided just downstream of collection chamber. The crown portion up to El. 642M (10m length approximately) has been completed.

The status of different adits/tunnels is as follows:

**Upper Drainage Gallery**
1. Length : 2.5x3m, D-shaped
2. Status : Original Length 166m with further extension upto cable tunnel is completed.

**Lower Drainage Gallery**
1. Length : 140 m
2. size & Shape : 2.0 m x 2.5 m, D-shaped
3. Invert level: 626.50/ 625.50 m
4. Status: No work has been done till date

**Adit to Erection Bay**
1. Length :213m
2. Size & Shape : 7m, D-shaped.
3. Invert level: 628.5/642 (Filled with water up to El.642.0M).
Adit to Control Room/ Collection chamber

1. Length : 186m
2. Size & Shape : 5.7m, D-shaped.
3. Invert level: 641/644m.

Cable Tunnel

1. Length : 585m
2. Size & Shape : 3.5m, D-shaped.
3. Invert level: 641m.
4. Status : Excavated 105m from inside PH cavern.

Tail Race Tunnel

1. Length : 159.2 m
2. Size & Shape : 8.5m, Horse Shoe shaped
3. Invert level: EL 622 m on river side
4. Invert level: at foundation of additional collection chamber 610 m
5. Status: Excavation of 96m upper half portion form outside completed

Geotechnical Evaluation for Balance works

Power House

Out of 46.8m height of the cavern nearly 19m of benching is yet to be completed. Greyish green to greenish grey coloured, medium to fine grained, fresh and sound basic (trap) rock was encountered in power house excavation. The rocks are traversed by quartz & calcite veins and also epidote, chlorite and ferruginous material. In walls, it is gathered from old reports, that rock bolting and shotcreting has been carried out. Traps are moderate to highly jointed with shear zones 1-5cm thick and crushed/ fracture zones 1cm to 20cm thick. The trap reaches were found to be mostly dry to moist with occasional dripping
at few places. For walls rock bolts / anchors & shotcrete with wire mesh is recommended in balance portion.

**Tail Race Tunnel**

For the benching operation in already excavated reaches, rock bolts/rock anchors with shotcrete and wire mesh are proposed. Similarly for balance tunnel, 50% class-II, 35% class-III and 15% class-IV provision is recommended. In case of class-II & class-III, full-face tunneling is suggested whereas for class-IV reaches heading and benching may have to be done to complete the tunnel.

6.3.6 **Katapathar Barrage**

6.3.6.1 **Layout & Geological Features**

The Katapatthar barrage is proposed 13.65km downstream of Lakhwar. The length of the barrage shall be 152.5m comprising of 3 sluice bays and 5 weir bays. The crest level of weir bays is El. 501.0M whereas of sluice bays it is El. 500.0M. The bed level of river at the barrage location is El 498.0 M thereby meaning that the sluice bays are just 2m above riverbed. Geological log of one drill hole is available for Katapatthar Barrage. Bedrock is expected at banks on higher elevations whereas in river bed RBM is present. Nahan Thrust is passing below the barrage more or less in the centre of river Yamuna. On the right bank Subathu shales, siltstone & black clay are present whereas on the left bank clay stones belonging to Nahan Formation are observed.

6.3.7 **Lakhwar Reservoir**

On the basis of aerial photo studies lineaments, geomorphic units and structures like folds, faults, landslides etc in the vicinity of the reservoir area are mapped. The reservoir extends along Yamuna and its tributary Aglar for about 20km upto Naingaon.
On the basis of studies carried out so far there appears to be no cause of concern regarding the stability of the reservoir periphery. However, activation of some slides cannot be ruled out. To control the existing and probable landslides, provision for remedial measures is kept which would include both biological & engineering measures such as contour bunding, drainage, and assessment of vulnerable slopes & its treatment, check dams etc.

6.3.8 Construction Material

For the construction of concrete dam, coffer dams, diversion channel, power house and other allied civil structures of Lakhwar Vyasi project, two river shoal/nala deposits and two impervious soil deposit have been selected for meeting the requirements. The total requirement of coarse and fine aggregate has been estimated to be 67.65 lac cum. In addition, 0.42 lac cum of impervious soil and 1.27 lac cum of rockfill shall be required for construction of coffer dams.

The material from Yamuna river shoal near Kalsi bridge (LVG-1) and Naro-ka-khala deposit (LVG-2) which are estimated to contain approx. 74.05 lac cum of material are found suitable for wearing as well as non wearing surface concrete and are proposed to be used for the construction of Dam, Power House and other allied civil structures of the project. Impervious soil deposit near village chilio (LVC-1) and near village Kuna (LVC-2) estimated to contain 1.78 lac cum and 0.59 lac cum respectively are proposed to be used as core material for coffer dams.
7.1 GENERAL

The Lakhwar Vyasi project comprises two schemes namely Lakhwar with 300 MW installed capacity and Vyasi with 120 MW installed capacity. The project envisages cascade type power development with Vyasi scheme being proposed on the downstream of Lakhwar scheme. The Lakhwar scheme is a storage scheme and envisages the construction of 204 m high concrete gravity dam on river Yamuna near village Lohari and an underground powerhouse at the dam toe on the right bank of the river. The underground powerhouse will have an installed capacity of 300 MW and a 159 m long tailrace tunnel to discharge the water back into the river.

The project comprises the following main components.

- 2 nos. Diversion Tunnels of 5.0 m diameter, horseshoe shaped having length of 567 m & 596 m.
- 204 m high concrete gravity dam located on river Yamuna near Luhari village.
- Intake Structure leading to 3 Nos. 4.30 m diameter circular penstocks.
- Underground Power House consisting of 3 units of 100 MW each
- 8.25 m diameter horse shoe shaped Tail Race Tunnel of 159.2 m length.

General layout plan of Lakhwar Dam & Power House complex is shown in Drawing No. UJVNL-L-GA-003.
7.2 LAKHWAR SCHEME

7.2.1 Choice of Type of Dam

The river Yamuna, at Lakhwar village, passes through a narrow gorge of trap rock and width of valley is wide enough to accommodate the spillway. A concrete gravity dam with a central spillway has been found to be the best choice for dam keeping in view the height of dam, lack of availability of construction material for rockfill dam and dearth of indigenous expertise for arch dam.

7.2.2 Dam and Diversion

A concrete gravity dam across Yamuna river near Lakhwar village has been proposed. The top of the dam is proposed at EL 800 m and height above the deepest foundation level is 204 m. the total length at top of dam is 481.5 m.

The spillway consists of 5 nos. of bottom outlet radial gates of 9 m x 13 m size with crest at EL 762.5 m. The spillway discharge is guided over the spillters at EL 712 m and buckets at EL 700 m to plunge pool basin at EL 610 m.

Two nos. horseshoe shaped diversion tunnels of 5.0 m dia. of length 567 m & 596 m are located on the left bank for river diversion. A 10.5 m high upstream cofferdam with its top at EL 642.25 m has been proposed to facilitate the construction of dam during non-monsoon season.

River diversion layout and sections have been shown in drg. No. UJVNL-L-GA-005. Layout plan of Lakhwar Dam is shown in Drawing No. UJVNL-L-GA-006.
7.2.3 Power Intake and Penstocks

The intake structure of 52 m length has been proposed on right abutment just upstream of dam body. Three independent circular shaped penstocks of 4.3 m dia. each take off from the intake to feed the 3 nos. machines housed in the underground powerhouse. These steel lined penstocks are taken horizontally and vertically to the center line of the machines i.e EL 618 m.

The details of the intake structure and penstocks have been shown in Drawing No. UJVNL-L-GA-010 & UJVNL-L-GA-011 respectively.

7.2.4 Power House

The underground power house for installation of 3 conventional units of 100 MW each at Lakhwar dam site will be located in right abutment as the same has already been partly excavated along with access tunnels. The powerhouse cavern shall be of size 20 m wide, 130 m long and 46.8 m (unfinished) deep. The cavern has already been excavated upto ± EL 625 m and the crown has already been supported. Lakhwar Power Station would receive water from Lakhwar Reservoir through three independent penstocks of 4.30 m. diameter. The maximum discharge through each penstock would be 75 Cumec and will feed one Francis type turbine of 100 MW capacity.

The machine hall of size 82.5 m x 18 m comprises 4 floors at EL 614.5, EL 621.55, EL 625 and EL 628.55 m. The MIV shall be situated at EL 614.5m. The turbine floor and generator floor would be situated at EL.621.55 m. and EL.628.55 m respectively. The erection bay of size 20.0 m x 25.0 m and control block would be situated lengthwise on the left side of the machine hall. LT control block will be on right side of the machine hall. Three nos. three phase 13.8/200 kV, 125 MVA transformers would be located in the machine hall in an isolated chamber adjacent to the generator barrel of each unit.
Water from the turbines shall discharge into 3 Nos. draft tube tunnels of size at exit as 8.5 x 4.75 m leading to a collection chamber of size 80 x 10 x 42 m followed by a downstream additional collection chamber of size 65 x 35 x 8.5 m. At the end a tailrace tunnel of length 159.2 m and 8.25 m horseshoe shaped with a discharging capacity of 225 Cumec has been provided to carry the water into river Yamuna just downstream of plunge pool.

The details of the powerhouse general arrangement & cross section have been shown in Drawing No. UJVNL-L-GA-012 & UJVNL-L-GA-013 respectively.

7.3 **KATAPATHAR BARRAGE**

Katapathar barrage envisages provision of some additional balancing storage of about 4 million cubic metres of water down stream of Vyasi power station. The barrage comprises 5 nos. weir bays of 16 m width each separated by 3.5 m thick piers and 3 nos. of under sluice bays of 16 m width each separated by 3.5 m thick piers. The crest level of weir bays and sluice bays has been kept at EL 501.00 m and EL 500.0 m respectively.

The layout details of barrage have been shown in Drawing No. **UJVNL-L-GA-032**.
CHAPTER - 8
ESTIMATE OF COST

8.1 INTRODUCTION
A summary of the cost estimate, comprising cost of civil works including direct and indirect charges, Electrical works, IDC and financing charges is provided in Section 6.3 of Volume-II (page 6-6) under heading “Abstracts of Cost”. Quantity and cost for civil works and details of the estimate of direct costs for all the major elements of Electrical works are given subsequently.

8.2 BASIS FOR ESTIMATE

GENERAL
The estimate has been prepared to arrive at the capital cost of Lakhwar Project. The base date of the estimate is May 2012 Price Level and the cost is expressed in Indian Rupees. However, there is a provision of 7.50 Lakhs US$ in foreign exchange for import of XLPE cables.

I - WORKS
Under this heading, provision has been made for various components of the Project as detailed hereunder.

A - PRELIMINARY
Under this heading, provision has been made for surveys and investigations to be conducted to arrive at the optimum of the project components, including investigations already done and expenditure incurred till date.

B - LAND
This covers the provision for acquisition of land and compensation for houses and other properties etc.

C - WORKS
This covers the cost of Diversion Tunnel, Coffer dam and Concrete Dam for Lakhwar HEP and Katapathar Barrage alongwith associated hydro-mechanical equipment.
J - POWER PLANT CIVIL WORKS

This covers the cost of project components viz. Intake structure, Pressure shaft, Power House and TRT for Lakhwar and other appurtenant works.

The quantities indicated in the estimates for C - Works & J-Power Plant Civil Works are calculated from the preliminary engineering drawings and as per experience of other on-going or commissioned projects. A provision of 5% has been made for contingencies and the work charged establishment.

The unit rates for various items are based on Central water Commission norms and worked out at current market rates. The details of items and the supporting analysis are given in Chapter-7 of Volume-II of DPR.

K - BUILDINGS

Buildings, both residential and non-residential have been provided under this head. Under the permanent category only those structures are included which will be subsequently utilized during the operation and maintenance of the project utilities. The costs are worked out on plinth area basis prevalent in the area for the type of construction involved. Also, repair works for already constructed buildings has been proposed as per requirements.

O - MISCELLANEOUS

Under this head provision has been made to cover the cost of the following miscellaneous works.

a) Capital cost of electrification, water supply, sewage disposal, fire fighting equipments etc.

b) Repair and maintenance of electrification, water supply, sewage disposal, medical assistance, recreation, post office, telephone and telegraph office, security arrangements, fire fighting, inspection vehicles, schools, transport of labour etc.
c) Other services such as laboratory testing, R&M of Guest House and transit camps, Community center, retrenchment compensation, photographic instruments as well as R&M charges of transport vehicles etc.

**P - MAINTENANCE DURING CONSTRUCTION AND**

**Y - LOSSES ON STOCK**

A provision of 1% (for maintenance during construction) and 0.25% (for losses on stock) of C-Civil works, J-Power Plant, K-Buildings & R-Communications has been made respectively.

**Q - SPECIAL TOOLS AND PLANT**

The provision under this head has been made to cover the residual value of the equipment to be used for infrastructure works only i.e. capital cost of the equipment less the credit due to resale or transfer of equipment and life of machinery used in works. For this purpose, the provision for the machinery likely to be used in infrastructure works (like buildings, roads etc.) has been taken as 25% of their value and for other equipment and inspection vehicles 100% of their cost has been booked under this head.

**R - COMMUNICATION**

Provision under this head covers the cost of construction/ improvement of roads and strengthening of bridges. The road widths have been planned to cater to the anticipated traffic including movement of heavy trailers. The costs of roads and bridges are based on the present rate structure for the type of construction involved.

**X - ENVIRONMENT AND ECOLOGY**

Provision towards Bio-diversity Conservation, Creation of Green belt, Restoration of Construction Area, Catchment Area Treatment, Compensatory Afforestation etc. and Disaster Management Plan have been made under this head.
ELECTRICAL WORKS
The cost of generating plant and equipment is based on indigenous sources. The prices of auxiliary equipment and services are based on prevailing market prices/ costs incurred at other ongoing or commissioned projects. The switchyard equipments are based on prevailing market costs. Taxes, duties and transport to site are based on prevailing prices. Erection and commissioning charges have been estimated at 8% of the cost of equipment as has been experienced on similar installations in the country. There is a provision of 7.50 Lakhs US$ for Lakhwar HEP in foreign exchange for import of XLPE cables.
A provision of 1% contingencies covering variations in the quantity of equipment and services has also been made.

II - ESTABLISHMENT
Provision for establishment has been made at 9% of l-works minus B-Land for civil works. Electrical works cost indicated in the abstract includes 6% provision for the establishment cost of Electro-Mechanical works.

III - TOOLS AND PLANTS
This provision is distinct from that under Q-Special T&P and is meant to cover cost of survey instruments, camp equipment and other small tools and plants. The outlay is provided at 1% of cost of l-works.

IV - SUSPENSE
No provision has been made under this head as all the outstanding suspense are expected to be cleared by adjustment to appropriate heads at completion of the project.

V - RECEIPTS AND RECOVERIES
Under this provision, estimated recoveries by way of resale or transfer of equipment used in infrastructure works, DG sets and transformers used for generation of construction power and temporary buildings are provided for.
# Chapter 9

## Power Plant, Electrical and Mechanical Equipment

### 9.1 Lakhwar Project

#### 9.1.1 Lakhwar Power Station

Lakhwar powerhouse will be underground type. This project is envisaged for installation of three generating units of 100 MW each operating under a rated net head of 148 m. The generating voltage proposed is 13.8 kV. This voltage will be stepped up to 220 kV voltage level by three phase generator transformers. The salient features of Lakhwar power station are as follows:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed capacity</td>
<td>300MW</td>
</tr>
<tr>
<td>No. &amp; size of units</td>
<td>3 units of 100 MW</td>
</tr>
<tr>
<td>Type of power house</td>
<td>Underground</td>
</tr>
<tr>
<td>Net head</td>
<td>148 m</td>
</tr>
<tr>
<td>Design discharge</td>
<td>224.83 Cumecs</td>
</tr>
<tr>
<td>Type of switchyard</td>
<td>220kV conventional</td>
</tr>
<tr>
<td>Turbine type</td>
<td>Francis</td>
</tr>
<tr>
<td>Speed of turbine</td>
<td>214.3 RPM</td>
</tr>
<tr>
<td>Generation voltage</td>
<td>13.8 kV</td>
</tr>
<tr>
<td>Transmission voltage</td>
<td>220 kV</td>
</tr>
<tr>
<td>GSU Transformer</td>
<td>125MVA, 3phase, 13.8/220 KV</td>
</tr>
<tr>
<td>Energy generation</td>
<td>572.74 MU</td>
</tr>
</tbody>
</table>
9.1.2 Mechanical Equipment

9.1.2.1 Turbines

For the available head and output conditions 214.3 rpm the turbine shall be rated at 102 MW under a net head of 148 meters. The speed of 214.3 rpm has been selected to avoid greater negative suction head and deeper excavation thereof, at higher speed. Provision shall be made for runner removal from bottom.

9.1.2.2 Main Inlet Valves

Butterfly type valve having a diameter of 4 m and metallic upstream seal will be provided at the inlet to each turbine. Provision for downstream service seal is also kept.

9.1.2.3 Governor

The governor of each unit would be of the digital-hydraulic type with an air/oil pressure system. Speed, gate opening, gate limit positioning etc will be indicated both on the governor cubicle and on the unit control board, to facilitate supervision of operation of the unit.

9.1.2.4 EOT Cranes

In power house it is proposed to provide two 175T capacity EOT cranes with auxiliary hooks of 30 T, and will be designed to travel the full length of the power house.

9.1.2.5 Auxiliary Systems of the Power Station

i) Cooling Water System

A pumping system would be provided with each unit with common standby to supply adequate quantity of raw water for cooling of clean water which in turn will cool turbine and generator bearings, generator air coolers, transformer and other selected plant services. Raw water will be tapped from draft tube.
ii) Drainage and Dewatering System

A dewatering system would be provided in the station with a suitable number of pump motor sets arranged to dewater passages of the turbine. A separate station drainage system, with a suitable number of pumps sets, would also be provided to drain and pump off miscellaneous inflows, and ground water seepage in the powerhouse.

iii) Air Conditioning and Ventilating System

The powerhouse, Cable Ventilation Tunnel would be provided with ventilation and air conditioning system as required to maintain the work areas at the selected temperature & humidity levels. The temperature and humidity levels would be selected as per relevant standards.

iv) Oil Handling Systems

Oil handling system comprising of oil heaters, filters, tanks, pumps and hoses etc. would be provided in the power house for the treatment and purification of the insulating oils and lubricating oils etc.

v) Station Compressed Air System

A high-pressure compressed air system would be installed to meet the requirements of the governor oil system and the oil pressure system of the MIV.

A low-pressure compressed air system would also be installed to meet the requirements of the generator brakes and station service air.

vi) Workshop

A small workshop with machine tools, etc. would be provided to carry out normal repairs of the equipment in the powerhouse.
vii) Elevator

An electric lift or elevator will be provided in the powerhouse and dam building. It will be designed, for approximately a load of 10 persons at a time and landings at all floors of the powerhouse.

9.1.3 Electrical Equipments

9.1.3.1 Generator

Each synchronous would be rated for a continuous output of 100 MW at a power factor of 0.90 and a rated voltage of 13.8 kV with a 10% continuous overloading capacity.

The line terminals of the generator would be suitable for connection of isolated phase bus conductors. The generator shall be equipped with the all essential protections.

9.1.3.2 Excitation System

The excitation system of the generator would be of the static type and shall include digital type voltage regulator and the associated accessories. The power for the excitation system would be obtained from a dry type excitation transformer, connected directly to the generator voltage bus.

9.1.3.3 Bus Duct

Each Generator would be connected to its step-up transformers, by means of air insulated Isolated Phase Bus Ducts. The Isolated Phase Bus Duct system would incorporate the required current and voltage transformers for protection and metering on the line and neutral side of generator, and also expansion joints along the bus run and flexible connections to equipment etc. The generator and generator voltage bus would be provided with suitable lightning arrestors and surge protections.
9.1.3.4 **Power Transformers**

The generator transformers of 125 MVA, 13.8/220 kV, 3\( \Phi \), 50 Hz shall be provided. The transformers shall have OFWF cooling. The transformers shall be equipped with all essential protection equipments.

9.1.3.5 **Control, Metering and Relaying System**

Computer based control system is proposed to be provided from power house central control room, units etc. The DCS (Distributed Control System) used for the above purpose shall be of state of the art and display of information in respect of power station will be made available on the controllers and large screen having computerized control.

Commercial meters in accordance with ABT tariff shall be supplied and installed by state government. The control would include all the necessary devices required to efficiently control the various systems of the plant, monitor the systems and identify crossing of threshold limit.

9.1.3.6 **Station Service Supply**

Auxiliary Power requirements of the unit auxiliaries would be provided through unit auxiliary boards (UAB) fed from the dry type unit auxiliary transformers of suitable capacity. Power for the unit auxiliary transformers would be tapped from the respective generator bus ducts.

The station service supply is proposed to be taken from 11 KV lines emanating from SEB station. This will supply power to auxiliaries, adjoining areas related to powerhouse, requirements of intake works etc. In order to take care of non-availability of power supply from the station, two DG sets shall be provided.
9.1.3.7 **PLCC**

Inter circuit phase to phase coupling shall be provided for emanating 220KV double circuit line. One dedicated speech channel for double circuit line and one channel for speech and protection functions shall be provided for each line and thus 3 channels shall be provided along with EPABX for creating an inter dialing facility. Other equipments such as CVT, line traps, HF cable and coupling devices shall be provided.

9.1.3.8 **D.C. Supply System**

Two 220 volt DC System, with approximately 1200 AH battery bank capacity would provide power for the control of switchgear, for the protection and control equipment, and for emergency lighting of the power house. Distribution boards would be provided for feeding various DC loads of the units. A 48 V DC system with 250 AH battery bank will be installed for signaling and the PLCC system.

9.1.3.9 **220 KV Evacuation Station**

Switchyard equipment would be located outdoors on the prepared terraces on the hills on the right flank. The switchyard would be equipped with 220 KV double bus-bars arrangement. It is proposed to inter-connect the Lakhwar Power Station with Hathiari Power station (2x 60 MW) to be constructed 2.7 Km. downstream of Vyasi dam, through a 220 KV single circuit transmission line. The combined power output of Lakhwar and Hathiari power stations is proposed to be fed into grid system at Khodri, 28 kms downstream through three circuits of 220 KV transmission line between Lakhwar and Khodri. A fifth circuit of 220 KV will be between Hathiari and Khodri. There would be in all 8 bays, 3 Nos. incoming transformers, bus coupler, 220 KV interconnector circuit from Hathiari power station and three outgoing 220 KV circuit to Khodri.
9.1.3.10 Equipment Grounding

The power station and switchyard would be provided with separate main grounding grids and the two grids would be interconnected.

All non-current carrying equipment in the powerhouse, Switchyard would be grounded at two distinct points separately and connected to the main ground grid. The grounding system would be designed to minimize the touch potential within acceptable safe limits.

9.1.3.11 Illumination

The power plant lighting shall be as per normal engineering practice and would comprise interior and exterior lights as appropriate for the powerhouse and Pothead Yard. A separate emergency lighting system, fed from the station battery system, would be provided for essential locations, e.g. control rooms, machine hall, transformer area etc. This lighting load would be kept to a minimum.

The illumination levels would be generally as per Illuminating Engineering Society (IES) recommendations and applicable local practices.

9.1.3.12 Communication system in the project

Ground embedded optical fiber has been considered for connecting Power House and Dam site. Communication through EPBAX at project and associated areas shall be provided with outdoor/indoor phones, loud speaker etc.

9.1.3.13 XLPE Cables

The connection from GTs to switchyard shall be made through XLPE cables of single core. Spare cables will be provided as standby with termination kits. The cable would be terminated in outdoor type potheads, with suitable grounding facilities.
CHAPTER-10
ENVIRONMENTAL ASPECTS

INTRODUCTION
The state of Uttarakhand was carved out of the state of Uttar Pradesh as the twenty seventh state of India in the year 2000. Uttarakhand is predominantly a hilly state endowed with vast amount of water resources. Major rivers like Ganga and Yamuna, which are snow fed, originate in the high altitudes and traverse through the state. With high gradients and large discharges, these two rivers along with their tributaries form a formidable reservoir of hydropower in the country. The total hydro power potential in Uttarakhand as per preliminary estimate has been assessed around 16500 MW out of which only 1160 MW has been harnessed so far which constitute hardly 7% of the available potential. The development of hydropower in Uttarakhand will not only benefit the state but will meet the power requirements of the neighbouring states and the Northern region of the country.

The proposed Lakhwar Hydroelectric Project falls in South-West comer of Garhwal Lesser Himalaya and is proposed on the river Yamuna in Dehradun district of Uttarakhand (Refer Fig 1 for location map). The Lakhwar dam site (30°31’ 03” N, 77°56’ 58” E) is 20 km upstream of Kalsi and 72 km from Dehradun. The dam site is approachable by 25 Km long State PWD right bank highway from Dakpathar in Dehradun district of Uttarakhand. The project road from Dakpathar is also constructed on the left bank of river Yamuna. The project is multipurpose in nature and is to be constructed at about 100 km downstream of Yamunotri glacier. The project site can be approached through National Highway 123 passing through the project area; the nearest railhead is at Dehradun, which is about 67 km, whereas the nearest airport is located at Jollygrant in Dehradun and is about 90 km from the project area. The Katapathar Barrage is proposed at 13.65 km downstream of Lakhwar dam site which would act as a balancing reservoir.

The construction work on Lakhwar HEP commenced in the year 1987 by the Irrigation Department of erstwhile Uttar Pradesh state. The environmental clearance and forest clearance were accordingly obtained and granted wide letter no.
8-172/86-FRY(Cons) date 31-10-1986. Though construction of Lakhwar project started in the year 1987 could not proceed beyond 1992 for want of funds as the state government was under financial crunch. The status of works already executed between 1987 and 1992 vis-a-vis remaining works is placed below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>ACTIVITY</th>
<th>COMPLETED WORK</th>
<th>REMAINING WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DIVERSION TUNNELS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2 nos. horse shoe shape 5m dia.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>567 m Length</td>
<td>Completed</td>
<td>Plugging work and due to long closure, some strengthen /maintenance work will be required</td>
</tr>
<tr>
<td>II</td>
<td>596 m Length</td>
<td>Completed</td>
<td>Plugging work and due to long closure, some strengthen /maintenance work will be required</td>
</tr>
<tr>
<td>2</td>
<td>LAKHWAR DAM</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Construction of 204 m high; 481.5 m long concrete gravity dam</td>
<td>NIL</td>
<td>Excavation &amp; all associated work is required to be executed as per design &amp; drawing made available during execution</td>
</tr>
<tr>
<td></td>
<td>Abutment striping</td>
<td>Partially Completed</td>
<td>Remaining stripping work side is required to be executed as per design &amp; drawing made available during execution</td>
</tr>
<tr>
<td>3</td>
<td>LAKHWAR UNDER GROUND POWER HOUSE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Main Power House cavern</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(130 m (L) x 20 m (B) x 46.8 m (H)) (D-Shape) having roof EL 652.95 m. Pit is filled up by water upto EL 642 m</td>
<td>Excavation Mostly Completed upto EL 625.0 m (average)</td>
<td>Further excavation, associated work, and extension/alteration if any shall be carried out as per design &amp; drawing made available during execution</td>
</tr>
<tr>
<td>Project</td>
<td>Length</td>
<td>Size &amp; Shape</td>
<td>Details</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------</td>
<td>--------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Adit to Erection Bay</strong></td>
<td>213 m</td>
<td>7 m D-shaped</td>
<td>Completed Due to long closure, dewatering, some bracing, maintenance &amp; finishing work will be required</td>
</tr>
<tr>
<td><strong>Adit to Control Room</strong></td>
<td>186 m</td>
<td>5.7 m D-shaped</td>
<td>Completed Due to long closure, some bracing, maintenance &amp; finishing work will be required</td>
</tr>
<tr>
<td><strong>Tail Race Tunnel</strong></td>
<td>159 m</td>
<td>8.25 m Horse Shoe Shaped Bottom elevation at foundation of additional collection chamber: 610 m</td>
<td>Excavation of 96 m upper half portion from outlet side is completed 63 m is remaining Further excavation, associated work, and extension/alteration if any shall be carried out as per design &amp; drawing made available during execution</td>
</tr>
<tr>
<td><strong>4 UPPER DRAINAGE GALLERY</strong></td>
<td>166 m</td>
<td>2.5 x 3 m D-shaped</td>
<td>Completed Due to long closure, some bracing, maintenance &amp; finishing work will be required</td>
</tr>
<tr>
<td><strong>5 LOWER DRAINAGE GALLERY</strong></td>
<td>140 m</td>
<td>2 x 2.5 m D-shaped</td>
<td>NIL Excavation &amp; all associated work is required to be executed as per design &amp; drawing made available during execution</td>
</tr>
<tr>
<td><strong>6 DRAFT TUBES (3 Nos.)</strong></td>
<td>31.75 m</td>
<td></td>
<td>NIL Work is required to be executed as per design &amp; drawing made available during execution</td>
</tr>
<tr>
<td><strong>7 CABLE TUNNEL</strong></td>
<td>585 m</td>
<td>3.50 m dia D-shaped</td>
<td>Excavated 105 m from inside 480 m is remaining Further excavation,</td>
</tr>
<tr>
<td>No.</td>
<td>Location</td>
<td>Description</td>
<td>Details</td>
</tr>
<tr>
<td>-----</td>
<td>----------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>8</td>
<td>COLLECTION CHAMBER</td>
<td>(D-Shaped) (80 m x 10 m x 42 m)</td>
<td>The chamber is already excavated down to EL 642 m (average). Further excavation, associated work, and extension/alteration if any shall be carried out as per design &amp; drawing made available during execution.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>ADDITIONAL COLLECTION CHAMBER</td>
<td>(D-Shape) (65 m x 10 m x 35 m)</td>
<td>The crown portion upto EL 642 m (10 m length app has been completed). Further excavation, associated work, and extension/alteration if any shall be carried out as per design &amp; drawing made available during execution.</td>
</tr>
</tbody>
</table>

The main objective of the study is carry out the Comprehensive Environmental Impact Assessment (EIA) for the proposed Lakhwar HEP to meet the Environmental clearance criteria of Ministry of Environment and Forests, Government of India.
Fig 1: Location map of Lakhwar Hydroelectric Project
ENVIRONMENTAL BASELINE DATA

The data has been compiled for: Land Environment; Water Environment; Air Environment; Noise Environment; Ecological Environment and Socio-economic Environment. Primary data related to the environmental attributes like air, noise level, water quality and soil was collected from field studies whereas for Land Environment baseline data set has been generated through RS/GIS. A structured questionnaire was used for collection of primary information on socio-economic aspects. People perception regarding project construction, benefits and impacts were also taken to know their views. Ecological information was collected from field studies as well as secondary sources.

Land Environment

To begin with the baseline data sets, initial information from available literature, reports, government offices and project proponents were collected regarding locations, climate, geology, etc. The influence zone demarcation within 7 km radius has been done with respect to reservoir rim of Lakhwar dam as well as Katapathar barrage. A base map was developed to demarcate the submergence zone and influence zone of the Lakhwar HEP. Subsequently detailed information on the road network, settlements & their demography, etc. was collected. As a part of the study, detailed field studies on aspects related to land use and land cover, physiography, soil type, etc. of the influence zone, catchment area including submergence zone were also conducted (Refer Fig. 2 for maps).

Topography: The catchment and influence zone for proposed Lakhwar HEP lies in Himalayan region inclusive of foothill regions (Siwalik/dun) and varies from lowest elevation of 498 m to maximum elevation of 3400 m amsl. Geo-morphologically, the catchment area is rugged with lofty ridges of mountainous terrain, which are generally aligned in northwest - southeast direction, and are mostly dissected by Nallahs and deep ravines. Dissected hills are also observed in the area where the underlying rock formation is hard and resistant and comprises of mainly volcanics and metamorphics. Gradual erosion of surface layers on certain slopes and depositions in gullies, however, has led to the immature development of soil on the slopes and formation of skeletal soils embedded with stones and boulders.
**Geology:** The formation in the region in which Lakhwar dam is located comprises of phyllites, slates, quartzite's and lime stones belonging to the Mandhali, Chandpur and Nagthat stages which form the southern limbs of the major syncline known as 'Jaunsar syncline'. The rocks of the Jaunsar series are intruded by number of minor basic rock bodies collectively called Jaunsar Traps. The proposed site for Lakhwar Dam is actually located across one such intruded body of basic rock ranging in composition from Dolorite to hornblendes rhyolite. The two major regional thrusts viz. The Nahan and Krol are well exposed in west and south-west of the Lakhwar dam site. The Krol thrust is expected to be at about 3,000 m below the river bed at the Lakhwar dam site. Another major tectonic feature recognized in the area is "Aglar Fault" exposed along the Aglar River joining river Yamuna on the left bank about 1.6 km upstream of the Lakhwar dam site. This fault has a WNW-ESE trend. The Katapathar barrage site is situated at a place where River Yamuna leaves the hilly terrain and has just entered the plains. On the right bank of river still rugged topography is seen whilst on left bank, even ground is present which is under cultivation or is having orchards. At the barrage site, the river is flowing in Northerly direction after which it takes a big curve towards the west and continues to flow in plane ground towards southwest The surveys, both at the barrage site and the famous Katapathar slip, where the Nahan & Krol Thrusts come very close to each other, some discontinuity data is noted. It is also seen that on the right bank, rock is available at 537-544 m elevation whereas on left bank it is available at elevation 505 min a small patch.

**Seismicity:** The project area falls in seismic zone IV (IS 1893:2000) as per the Seismic zonation map of India. The occurrence of earthquake in this region is attributed to presence of several thrusts/faults in the Western Himalayas.

**Slope:** The slope plays a great role in the loss of soil and water from an area and influences its land use capability. Together with the nature and texture of soil, it also determines the erodibility of the soil. In accordance with the classification developed by All India Soil & Land Use Survey (AISLUS) the different classes of slopes identified in the study area are gentle slope (upto 15%), moderate slope (15% to 30%), moderately steep (30% - 50%), strong slope (above 50%), and very steep
slope (more than 80%). There is hardly any zone that can be categorized as level or nearly level.

**Soils:** From pedological point of view the piedmonts are the most common geomorphic unit seen in this portion of the Yamuna Catchment, mostly in the middle slopes. Basically it is this geomorphic unit, which has been developed for agricultural purposes, mainly dry farming. The upper slopes have scattered piedmont deposits, which are developed into slope agriculture fields. The middle and lower piedmonts occur as main fields for agricultural practices. These are usually clayey loams.

**Land Use Pattern:** Land use and land cover patterns are important in environmental impact assessment study from the point of view that land use describes the present use such as agriculture, settlement etc. and land cover describes the material on it such as forest and their types, pasture/grazing land vegetation, rocks or building etc. Among the different land use/land cover classes of upper Yamuna catchment maximum area is under forest (almost 36%). Among the various forest types Oak-pine mixed forest has maximum presence (10021.11 ha), followed by Pine (9537.78 ha), temperate broadleaved (8651.67 ha), Sal-mixed deciduous forest (2062.22 ha) whereas conifers are present only in 1740 ha. Low altitude grasslands occupy about 4974.16 ha while alpine meadows are spread over 638.58 ha. About 3663.40 ha of land is under barren category while scrub occupies maximum area of catchment (23963.37 ha).
Fig. 2: Soil type, Slope, Landuse/land cover type and DEM maps for Lakhwar and Katapathar HEP free draining catchment
Water environment

The domestic, irrigation and other daily needs of water in the project area are met with surface water source, available in plenty in the form of perennial springs and streams. Surface water test results show that most of the parameters are within desirable limits of Bureau of Indian Standard (BIS). The higher concentration of some parameters is probably due to road construction near by the river as a large amount of silt and rock salt is washed to the nearby river water. The physical and chemical properties of water quality of project area are presented below in Table 1 (for details of site refer Fig. 3).

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<th>PARAMETER</th>
<th>SITE-1</th>
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<th>SITE-5</th>
<th>SITE-6</th>
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</table>
Air environment
Five Ambient Air Quality Monitoring locations were identified and monitored. The sampling at each station was done for a period of two days. Air Quality test results (Fig. 4) indicate that the air pollution level in the project area is within the Ambient Air Quality Standard.

Noise environment
While comparing the test results with the Standard Ambient Noise Level, it is observed that prevalent noise levels in the project area are well within the permissible limit. The noise levels, at Kuna village near riverbed were found to be low (27-38 db) as compared to other monitoring sites. The highest noise level of 104 db was observed at Nainbag because of high traffic density during daytime
Fig 3: Location of water quality monitoring sites

Fig 4: Location map of ambient air quality monitoring sites with summarized results
Biological environment
The vegetation of the valley remarkably varies due to various microclimatic and ecological factors. Altitudinally the valley is divisible into sub montane and montane zones. The natural forest vegetation of the valley ranges from dense forested area to grassy slopes and scrubs. The vegetation is generally composed of either thickly populated broad-leaved forest or coniferous forest with their corresponding undergrowths. Field study was carried out for floral and faunal diversity assessment for which the study area has been classified in three categories; (i) submergence zone of Lakhwar dam, 575-800 masl range, which comprises the places such as Kon, Timiliyan, Yamuna bridge, Banderkot and up to Naingaon, covering about 40 km in length and 3-5 km in width, (ii) influence zone of Lakhwar dam, 800-2600 masl, covering 7 km periphery from reservoir rim., and (iii) free draining catchment of Lakhwar catchment. Additionally, the study area for Katapathar barrage has been classified in two categories of (i) free draining catchment area of Katapathar barrage (2200 m) and (ii) its influence zone extending to 7 km radius from the barrage site (upto 1800 m).

Vegetation: The objective of the study was to prepare an inventory of flora, listing of rare, endangered, economically important and medicinal plant species and to determine frequency, abundance and density of different vegetational components. The vegetation occurring in free draining catchment can be divided into Sal forest, Khair-Shisham forest, mixed deciduous forest, scrub and grassy slopes, temperate evergreen forest and temperate broad-leaved forest based on the RS/GIS technique. To understand the composition of plant species of the entire project area, random quadrats were laid both in influence and submergence zones. One hundred and five Quadrats (77 and 28 in influence and submergence zones respectively; Fig. 5) were randomly placed in the entire area, representing all possible vegetation type and localities along the project area. The vegetational data collected in the field survey was assessed by doing phyto-sociological analysis. In the present field survey of the Yamuna valley forming catchment of Lakhwar dam, a total number of 535 plants species (tree, shrub, herbs and other lower plants) were recorded. Of the total species present, 151 were tree species, 97 shrub species, and 226 were herbs. A total of 374 plant species were recorded in the free draining catchment of Katapathar
barrage of which 127 species of trees, 61 species of shrubs, 126 species of herbs were recorded.

The main uses of these species comprise timber, fodder, firewood, fiber and medicine. Many of them were nitrogen fixers which are mostly preferred in agro-forestry for increasing the soil fertility. Besides above uses, the plants which are useful for ornamental value, edible fruits and bee forage were also listed. The studies indicate that a total of 7 species comes under conservation status in entire catchment of Lakhwar hydroelectric power project. Of them 5 species are in vulnerable category, 1 species each fall under endangered category and indeterminate category respectively. Among these species 1 species of endangered category were recorded from the influence zone and none of them was recorded from the submergence zone. The study further indicates that only 1 species comes under conservation status in free draining catchment of Katapathar Barrage. Vulnerable species comprises of Acer caesium, Aconitum ferox, Nardostachy grandiflora, Picrorhiza kurrooa, Allium stracheiyi and the endangered species Acer oblongum and the Heracleum jacquemontii falls in the indeterminate category. In case of Katapathar barrage, only Acer oblongum falls in endangered category following Red Data Book of Indian Plants (Nayar & Shastry 1987-1990).

Fig 5: Location map of quadrats laid in the Lakhwar hydroelectric project
**Fauna:** The results of extensive and intensive survey revealed the project area has rich diversity in fauna. A total of 113 species of birds, 21 species of mammals, 11 species of reptiles, 35 species of insects and 16 species of fishes were found in the entire catchment area. Out of these total species; 149 and 116 faunal species were recorded from the influence zone of Lakhwar dam and Katapathar barrage respectively. From the comparison of the faunal species observed in the influence and submergence zone of the project area, as per the Red data book list. Jackal and Fox fall in endangered and vulnerable categories respectively the world over. However, neither the Jackal nor the Fox are rare in the present area; on the contrary, their sight is a very common feature. Among other categories of animals (e.g., birds and insects), none of the species fall in any categories of conservation importance. The biological analysis of aquatic fauna revealed that two species of fishes falls in endangered category as per Red data book.

**Socio-economic environment**

The construction of the 300 MW Lakhwar multipurpose hydroelectric project is of extreme economic importance to Uttarakhand because it has the opportunity to earn a great deal of revenue by exporting its hydroelectric power and water for irrigation to UP, Delhi, Haryana and other states of the country. The Lakhwar Hydroelectric Project requires total land of 1195.898 ha. Out of this, 177.226 ha land is private land which is spread over 32 villages of district Dehradun and Tehri. On the basis of Census of 2001, the catchment of Lakhwar dam is inhabited by about 91523 people whereas the free draining catchment of Katapathar barrage is inhabited by 6671 persons. Geographically the free draining catchment of Lakhwar and free draining Katapathar catchment stretches in 879.21 km² and about 50.45 km² respectively. On the basis of social survey, a total 648 families are going to be affected by the project, which includes all the families from whom the land has already been acquired or is proposed to be acquired. While revenue record says there are 348 fancies which axe project affected, and classified in to fully (171) and partially affected (177) class. Whereas, for the total land acquisition, the socio-economic survey observed that 171 families fall in fully affected category and 477 families fall in partially affected categories. The total population of affected villages is 6716 (3569 Males and 3147 Females). In this context a detailed understanding of socio-economic features becomes essential.
Socio-Economic Profile of Project Affected Families (PAF):
The area of Lakhwar Hydroelectric Project lies in the Jaunsar-Bawar region of Himalayan ranges of Garhwal Himalayas. The social milieu of this region comprises of mixed caste Hindus, consisting of three social groups i.e. the Brahmins, the Rajputs and the Harijans.

Population: The total population of the 32 villages of the project affected area is 6716, out of which 3569 are males and 3147 are females. Based on preliminary survey, 12.38% of the total population belongs to the Schedule Caste, 22.17% belongs to Schedule Tribe and only 4.13% are of general category while the rest 61.30% comes under OBC category.

Education and Employment: Almost 82.79% of males and 63.71% of females are literate and 18.4% males 36% females are illiterate. Of the total population, about 72.08% people are involved in agriculture, 11.05% are into service sector, 5.1% work as labourers, 2.98% is involved in business and 8.32% are in other sector (Fig. 6).

Immovable Assets: As per the survey 273 houses, 468 cowsheds, 27 water tanks, 111 watermill and 31 canals, 166 threshing yard, 16 boundary walls, 6 Bio gas plant belonging to individuals are likely to be submerged by Lakhwar Hydroelectric Project. The number of fruit trees belonging to individuals likely to be submerged is 12003; where as the number of other trees is 38022. The project affected families have a large number of livestock holding. A total of 15984 animals are reported with the project affected families.
ENVIRONMENTAL IMPACTS

The section summarizes the pollution potential of the proposed construction of Lakhwar HEP, its possible impact on the surrounding environment during construction and operational phases.

Land environment

Very few impacts of construction phase are permanent and majority of the environmental impacts attributed to construction works are temporary in nature, lasting mainly during the construction phase or quite often little beyond the construction period.

Change in land use pattern and pressure on land forms: In summary, 1195.898 ha of land will be required by proposed Lakhwar Hydroelectric Project of this approximately 1103.825 ha will be required only during construction phase, while the remainder will be used permanently by the project. At the same time change in existing land use pattern and pressure on land forms may likely occur due to the immigration of labour population and operation of construction equipment.

Soil pollution: Approximately 4500691.75 cum muck are estimated to be generated during excavation of the tunnel, power house and other project components. It is proposed to utilize part of the muck generated for construction of dam, approach roads, parking lots, etc. Disposal of the remaining quantity of muck may change soil property and causes soil pollution. Besides it, during peak construction phase, congregation of labour force is likely to create problems of sewage disposal, solid waste management and felling of trees for meeting fuel requirements, etc. These aspects need to be addressed in the form of suitable labour camp facilities including fuel and sanitation facilities.

Landslides: Nearly 16 major landslide zones have been identified along the periphery of reservoir rim mostly along the roads network. During construction of project, landslides may be triggered by quarrying, blasting operations and construction of roads, dam and power house.
**Soil erosion:** Any groundbreaking activity for construction works, whether permanent or temporary, would require removal of vegetation cover from ground and accelerate the soil erosion.

During operational phase the obvious impacts are change in land use pattern due to submergence and increase in seismicity.

**Aquatic environment**
The construction of Lakhwar dam would lead to the formation of a reservoir which will mainly store the major flows during the rainy season. The regulated flow of water from the reservoir would take place. However, if for some reasons the release of water is stopped, the immediate downstream aquatic fauna might be affected. In order to maintain the aquatic life in this stretch, about 2 cumecs water would be required to be released from the dam body continuously.

**Water quality**

**Change in water quality /Water pollution during Construction phase:** Impacts on water quality during construction may occur due to water pollution downstream by Soil erosion, Wash water from plant and machinery and sewage disposal.

**Change in hydraulic regime and downstream flow during Operational phase:**
The discharge of the water from the impoundment can strongly influence the quality of water downstream. The major water quality parameters likely to be affected are velocity, water temperature, dissolved oxygen, nutrient transport, and turbidity.

**Water pollution due to disposal of sewage during Operational phase:**
During the operation phase, due to absence of any large scale construction activity, the cause and source of water pollution will be much different. Since, only a small number of O&M staff will reside in the area in a well designed colony with sewage/septic tank facilities and other infrastructural facilities, the problems of water pollution due to disposal of sewage are not anticipated.
**Eutrophication risk during Operational phase:**
A major short-term water quality issue is related to the flooding of 745.415 ha of forest. If not cleared, the drowned organic matter will decay during the first few years after impoundment and could result in the release of obnoxious water that is lethal for fish and aquatic animals.

**Erosion and siltation risk during Operational phase:**
Removal of vegetal cover for construction work gives rise to erosion hazard and resulting in movement of enormous quantities of soil and rock to the reservoir. In the case of reservoir based projects, the quantum of sediment/silt accumulated is enormous; however the provision of silt flushing tunnel in the project design helps in getting rid of silt.

**Terrestrial flora**

**Pressure on existing natural resource:**
Increased human activity in the area will increase the biotic pressure on the forest. Hence, to minimize such impacts, fuel management not only for the labour force but for the villagers as well needs to be formulated.

**Reduced photosynthetic activity:**
During construction phase; large quantity of dust is likely to be entrained due to the movement of vehicles and other construction work. However, such ground level emissions do not travel for long distances but may reduce photosynthetic activity of near by plants .To reduce the quantity of dust, the green belt management plan is proposed under the proposed Lakhwar Hydroelectric Project.

**Loss of floral diversity during operational phase:**
From loss of endangered, threatened and rare plant species point of view, it has been documented that total 7 species of entire catchment area fall in these category and none of them were recorded from the submergence zone of Lakhwar HEP. Moreover, all the species are reported in the nearby forests/region as well. However, still to maintain and even strengthen the biodiversity (flora and fauna), it is proposed to improve the habitat of the forests in the influence zone.
Loss of wood volume during operational phase:
The proposed project envisages acquisition of 1195.898 ha out of which about 394.516 ha is reserve forest land and 376.194 ha is open (civil soyam) forest land. The wood loss estimated for submergence zone has been calculated as 532874.82 m$^3$.

Fauna
Disturbance to wildlife during construction phase:
Based on the faunal survey, it is noted that within the project area, a total of 15 species of mammals were present in the catchment area. As per the Red data list, 8 species of mammals are in vulnerable, 2 species in endangered and one species (Black bear) is in rare category. This is also substantiated by the faunal assessment of the submergence zone which indicated that only 2 faunal species (Jackal and Fox) of endangered and vulnerable category respectively. However, neither the Jackal nor the Fox are rare even in the present area rather they are sighted commonly. It would be worthwhile to mention here that most of the submergence lies within the gorge portion in the foothills of Yamuna catchment, where, the river Yamuna itself acts as a barrier to the movement of wildlife even in the pre-project stage. Thus, the execution of the proposed project is not expected to cause any adverse impact on wildlife movement.

Impacts on avian-fauna during operational phase:
With the damming of the river, the reservoir with surface area of about 957 ha will be created, with quiescent/tranquil conditions which will provide a good habitat for water birds and increase the diversity of water birds.
During project operation phase, the accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem.

Aquatic ecology
Impacts on Aquatic ecosystem and biodiversity during construction phase:
During the construction phase of Lakhwar Hydroelectric Project, the aquatic ecosystem and biodiversity is not expected to alter considerably as the water of river Yamuna will remain in its original course Impact on fish population during
construction phase: The normal practices of fishing very often exercised by local fishermen and the available fish stock in the river is just sufficient to cater their needs only. The river is shallow and do not have many deep holes in it, therefore, the probability of fishing with the help of explosives does not exists. Beside this, effluent from crushers and sewage are not likely to cause any significant change in physicochemical characteristics which may affect fish population. Hence, no adverse impact will fall on fish population.

**Increase in fish population during operational phase:**

During the operation phase of the project the migration of fish species like Mahseer (Tor putitora) and Snow trout (Schizothorax sinatus) is going to be obstructed by the 204 m high dam, which will definitely affect the population of these two species. In order to maintain the population density of these two species in the upstream reaches, efforts must be made to explore the probability offish farm and hatcheries in the upstream section of the project especially.

**Noise environment**

Construction activities are expected to produce noise levels at source in the range of 80-140 dB (A) and the personnel operating the machines and the workers stationed close to the machines are prone to exposure of high levels of noise. Careful planning of machinery operation and scheduling of operations can however reduce the noise levels. Absence of sensitive receptors around the project results into no significant impact.

**Air quality**

Dust levels may slightly increase during construction, however, the impact on ambient air quality will not be significant, since the dust generated is confined to the proposed project area and as it will be taken care of by adopting suitable control measures as described in EMP.

**Socio-economic environment**

**Resettlement and rehabilitation aspects:**

The major problem associated with any hydroelectric project is displacement and dislocation of a large number of populations. The people who are evacuated to new
places have to suffer some social problem because they have to start their life from the beginning. Improper resettlement and rehabilitation is the root cause of discontentment and alienation among PAFs. The rehabilitation Action Plan needs to be formulated sensitively and sensibly so that after a reasonable transition period, the displaced persons improve, or at least regain their previous standard of living, earning capacity and production levels.

**Irrigation facilities:**
The regulated water discharge from Lakhwar HEP will be further released to supply water to the states of Delhi and U.P through a balancing reservoir at Katapathar.

**Employment opportunities:**
About 950 people are likely to work during peak period of activity and during operational phase some of the technical staff will stationed for operation and maintenance of the project. Thus the project would provide substantial direct employment and in addition to these, more people would be indirectly employed for allied activities.

**Recreation and Tourism Potential:**
The entire Jaunsar region, i.e., the area from the project area of Lakhwar HEP to further upstream up to Yamunotri has its own historical background and there exists the famous 'Lakhamahal' which was used by the 'Kauravas' of Mahabharat for killing the 'Pandavas'. Similarly, Yamunotri itself is a well known pilgrimage centre, however, at present, majority of the visitors prefers to reach their via Gangotri side on account of better roads and infrastructure facilities despite the fact that the road to Yamunotri from the project area site is much shorter. It is therefore felt that the area offers tremendous potential for tourism development as well. Considering this a suitable plan is proposed under Landscaping & Restoration plan to develop tourism as well which could open new avenues for higher economic returns to the locals of the area.
**Flood control and regulated water supply:**
One of the beneficial impacts of dam construction is flood control. The dam will store water in the reservoir and will supply a continuous down stream flow. It will provide a regulated water supply throughout the year even in the seasonal scarcity of water.

**Increase in State revenue:**
The total power that will be generated will be 300 MW from Lakhwar dam. The added availability of power in the national power grid will help the nation to progress in a big way.

**Socio-economic development:**
Dams are considered to be the hub of socio-economic development for the region in which they are located. A number of marginal activities and jobs would be available to the locals in the project which will subsequently increase the economic status of the local people. Besides these benefits Lakhwar Hydroelectric Project will surely ensure the development of area through introduction of roads, hospitals, school colleges, tourism activities, etc.

**Increased infrastructure:**
Present infrastructure is either likely to be upgraded or new infrastructure is set up with the implementation of the new project. Basic infrastructures required to be developed are roads, health facilities, educational facilities etc.

**Increased incidence of water related diseases:**
The factor enhancing the proliferation of water related diseases are vectors and pathogens. The stagnant water and vegetation provide favorable breeding places for vector life such as mosquito and snails.

**ENVIRONMENT MANAGEMENT PLANS**
Based on the detailed evaluation of the likely impacts on various environmental parameters, detailed EMPs for the project have been prepared and presented, which defines actions to be undertaken during the construction and operation phase of the project. The mitigative measures for minimization of adverse impacts along with stage wise land reclamation strategy, afforestation (green belt
development/plantation) programme and their implementation have been incorporated in the chapter on environmental management plan.

**Catchment area treatment plan**

Sedimentation of the reservoir is a function of soil erosion rate of the river catchment area. It reduces the water storage capacity of reservoir and availability of water for its designated use. It could, therefore, be concluded that useful life of a hydroelectric project is directly related to the soil erosion rates of the catchment area. The past experience of hydropower projects shows that sedimentation of reservoir has determined the useful life span of such projects. Erosion of topsoil from the catchment also reduces its fertility and the vegetation growth as well. For the longevity of the reservoir of hydropower projects, it is essential to limit the sediment intake to the minimum level possible. For this reason, it is necessary to adopt such tools and practices, which may restrict the sediment inflow. Catchment Area Treatment, therefore, is an integral part of any hydropower development project as it provides a definite insight in the management of factors responsible for sediment yield and its transport.

**Approach and Methodology:**

The catchment area treatment (CAT) plan pertains to preparation of a management plan for treatment of erosion prone area of the catchment through biological and engineering measures; however, a comprehensive CAT plan should also include the social dimensions associated directly or indirectly with the catchment. An effective CAT plan of a hydropower project is a key factor to make the project eco-friendly and sustainable. In this EIA&EMP study report, the management plans for social aspects have also been formulated separately and discussed separately. Therefore, the present CAT plan for Lakhwar Hydroelectric Project is mainly focused on land use wise treatment of erosion prone area of the catchment and landslide treatment applying various biological and engineering measures. Yamuna catchment upto proposed Lakhwar dam site from the dam site of Barnigad-Naingoan HEP in the upstream has been considered as the catchment area of Lakhwar dam whereas the free draining catchment between proposed barrage site and Vyasi dam sites has been considered as the free draining catchment for Katapathar barrage for the purpose of present study. The catchment area of the Lakhwar dam works out to
about 87921.71 ha while the free draining catchment for Katapathar barrage works out to 5045.50 ha only. The entire Lakhwar dam catchment area falls in three forest divisions' viz. Upper Yamuna forest division, Chakrata forest division and Mussoorie forest division whilst in case of free draining catchment of Katapathar barrage, it is controlled by two forest divisions namely Chakrata forest division and Mussoorie forest division.

**Soil Erosion Estimation through GIS:**
GIS proved a very useful tool for soil erosion estimation using thematic maps: Land use/ Land cover map, Slope map and Soil map. Remotely sensed satellite images (LANDSAT) were generated for the year 2002 (Row-39, Path-146, and Date of Pass-25 Nov 2002). Various information maps were also obtained from different secondary sources viz. Survey of India Topo-sheets, National Bureau of Soil Survey & Land Use Planning (NBSS&LUP) Soil map, etc. on the scale of 1:50,000. The printed/drawing maps were scanned and digitized and registered as per requirement and different GIS layers were developed. Different vector layers were also developed using ERDAS IMAGINE software. Land use/Land cover map developed indicate over 24% area has dense forest cover, whereas 11% is occupied by open forest. Agricultural land contributes to only 26% area, whereas a mere 4% and 25% of the area is occupied by Barren and Scrub land respectively.

**Catchment Area Treatment:**
A total of 25552.83 ha area of Lakhwar dam and 1000.63 ha of Katapathar barrage including agricultural, scrub, barren, dense and open forest will be treated under CAT plan by using different engineering and biological measures. Under engineering measure in agricultural land, a total of 332632 agricultural terraces are for repairs and designing, 33264 waterways, 416 water harvesting tanks, 2496 gabion check dams, 33264 brush wire woven dams are proposed for Lakhwar dam whereas in Katapathar barrage 11841 agricultural terraces are for repairs and designing, 1184 waterways, 16 water harvesting tanks, 90 gabion check dams, 1184 brush wire woven dams are proposed. It is pertinent to point out that village wise estimates for work on agricultural land have been provided and it is suggested that all labour intensive works should be implemented through local community participation to provide them immediate economic returns. Under stream bank protection 4258
gabions, 2128 brush wire dams, 2128 waterways, are proposed apart from 85149 bamboo plantations on barren and scrub land in Lakhwar dam are proposed. Similarly 177 gabion works, 79 brush wire dams, 90 water ways and 3125 bamboo plantation are proposed for Katapathar barrage. Overall financial provision for CAT Plan under Engineering, Biological measures, other provisions, administrative changes and contingencies is for Rs. 3577.25 Lakhs.

Resettlement and rehabilitation plan
Baseline status of socio-economic environment in respect of Lakhwar project was evaluated for population status, social and cultural environment, land holdings and other parameters. Based on the baseline data, a comprehensive Resettlement and Rehabilitation (R&R) plan for the Lakhwar Hydroelectric Project has been worked out. In order to formulate the R&R plan, the guideline issued by the Uttaranchal State Government and the recommendations of National Policy on Resettlement and Rehabilitation for Project Affected Families - 2003 (NPRR-2003) are being considered in consultation with the project affected families. The affected families would be compensated for acquisition of their land in accordance with the local norms applicable for such acquisition. It is also obvious that such compensation would never render sufficient to compensate the indirect losses to the local people. It is felt strongly that the local population of the project area deserves certain incentives towards their social upliftment, so that they feel themselves an integral part of the overall development.

The Lakhwar HEP has been evaluated for determining the status of fully and partially affected families. From the socio-economic surveys it was revealed that the number of families residing in the affected villages do not match with the revenue records as the bifurcation on the family level have taken place over the years and the same has not been recorded in the revenue records. On the other hand it has also been revealed that the payment for part land and properties were disbursed between the years 1986-1992 by the Irrigation Department however the acquisition had not been done. This has further complicated the issue by many folds as the payment for acquisition had been made to individuals and with the passage of time the bifurcation in the families continued which has raised the numbers of individual claimants and families which are present in the area as on date.
The socio-economic survey revealed that the total number of project affected families is 648, which includes all the families from whom the land has already been acquired or is proposed to be acquired. The list of families indicating 348 families as per revenue records and their classification in to fully and partially affected class implies that besides the fully affected villages of Ranogi and Kuna, 105 families from 30 villages are also going to be fully affected. As per the socio-economic survey for the total land acquisition, it is observed that 171 families fall in fully affected category and 477 families fall in partially affected category.

Compensation of land for project affected families:
Keeping in view, the extent of submergence in Ranogi and Kuna villages with 20.558 ha area, the financial provisions for compensation packages are made for 66 families of these two villages, irrespective of their land holdings considering the fact that they are to be provided at least Rs. 5 Lakhs including landless grant. Similarly, the land compensation for 105 fully affected families of other villages has also been computed for irrigated and un-irrigated land, which worked out to be less than Rs. 5 Lakhs. However, keeping their status of fully affected nature, they are provided with Rs. 5 Lakhs for their land. It is also pertinent to state that, though, the financial provisions of Rs. 855 Lakhs has been made, an amount of Rs. 75.77 Lakhs has already been disbursed and therefore payment of Rs. 779.23 Lakhs will be made to 171 fully affected families.

The total cost of land belonging to partially affected families works out to Rs. 636.79 Lakhs for 128.083 ha land. In a nutshell, it is to state that the cost of complete 177.226 ha private land belonging to fully and partially affected families works out to Rs. 1749.69 Lakhs. Out of the above, Rs. 333.02 Lakhs had already been made to the affected families and Rs. 1416.67 Lakhs is yet to be paid. In addition to Rs. 1416.67 Lakhs, a provision of lumpsum Rs. 300 Lakhs has also been provided to meet out the financial gaps of already acquired 57.842 ha from partially affected families as it is not known as to how much of this lies in fully affected category as the revenue records of this land is not available since this has been transferred in the name of Lakhwar Vyasi project. It is, therefore, stated that a provision of Rs. 1716.67 Lakhs is available under R&R plan for compensation of land.
Based on the cost of land acquisition and landless grant, compensation for property and compensation for horticulture and other trees of displaced families along with the provisions for special ex-gratia payments to fully affected families, provision for basic amenities, and provisions for project affected families of Scheduled Tribe, the overall R&R Plan works out to Rs. 4254.91 Lakhs as given in Table 2.

Table 2: Overall cost estimates of R&R plan for Lakhwar hydroelectric project.

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<td>Compensation for Fodder Trees</td>
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<td>Compensation for Horticultural Plants</td>
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<td>Community Development Initiatives</td>
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<td>Provision for fuel/LPG depots for project affected families</td>
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Biodiversity management plan

The free draining catchment and the influence zone of Lakhwar dam and Katapathar barrage has a large array of diversity in timber, fuel, food, fodder, vegetables and medicinal plants which are naturally or artificially growing in the region. The biological wealth of the area comprises of more than 535 plant species and about 149 species of wild-life (including fisheries). After the extensive field survey, it was concluded that a total of 7 species of entire catchment area comes under conservation category as per Red Data Book. Among these, species only 1 species of endangered category was recorded from the influence zone and none of them was recorded from the submergence zone. The study further indicates that only 1 species comes under conservation status in free draining catchment of Katapathar.
barrage. To conserve these 7 species and to strengthen the forest area Biodiversity management plan is proposed. Under this plan Ex-situ conservation is proposed for which the total cost estimated to be Rs.93.15 Lakhs. Further recommendations are designed to promote long term stand level maintenance and recruitment of important structural attributes such as: Wildlife trees, Diversity of vegetation species, Special or Unique habitats for floral and faunal wealth, Riparian areas and wetlands, Coarse woody debris, Horizontal and vertical structural diversity. Under biodiversity management plan, after identifying the suitable areas, it is proposed that nearly it is proposed that nearly 40% of the scrub and barren land (5988.28 ha of about 14970.70 ha area;) be re-vegetated by undertaking plantation @50 plants per ha at a cost of Rs.15 per plant amounting to Rs.44.91 Lakhs. Besides it, to improve the avifauna habitat by installation of 2000 nest box.

**Green belt development plan**

To mitigate the environmental impacts arise during project construction require the development of green belt in the project area. After several field visits and intensive discussions with the project proponents, suitable locations in the project area of Lakhwar hydropower project were identified. Different types of activities are proposed in the project area such as road network of various types for different requirements, crusher plants, residential areas, powerhouse, dam site, reservoir rim, etc. It is proposed that all along the roads, either existing or proposed, in the project area together with the entire length of reservoir rim on both the abutments, avenue plantation should be carried out along with the provision of tree guards and caretaker for proper upkeep and maintenance of the plantation.

The development of nursery is proposed to provide plants for plantation under different management plan. Plantation over a length of 61.7 km long road is proposed as per DPR. Plantation and lawn development is also proposed at dam site, power house and at settlement of Kandriyan and Lohari. The other measures are barbed wire fencing at about 20 m distance from reservoir rim, maintenance of plantation, celebration of world environment day and environmental awareness programme, tree guards etc. and a total of Rs 100.58 Lakhs is proposed for this purpose.
Reservoir rim treatment plan
A detailed survey was therefore carried out along the periphery of the submergence zone of Lakhwar Hydroelectric project from dam site to the zero point at Naingoan to delineate the zones of weaknesses (telus cones, stream network draining to the reservoir and the existing landslides). Identification of all such factors revealed that the reservoir rim of Lakhwar dam is characterized by 90 streams and 12 landslides; whereas 5 streams and 4 landslides come in the reservoir rim of Katapathar barrage. Reservoir rim treatment is basically framed to abolish the probability of sliding of any material due to natural factors or due to anthropogenic factors during the drawdown period of project operation. These streams may bring huge amount of debris to the reservoir which may curtail the water storage capacity of the reservoir. Accordingly, the landslide which is active, if not supported, may also bring down lot of debris to the reservoir. It is also felt that the reservoir rim though has a steep face on both the abutments with the left and right bank roads, may be given a grass and plant apron through seeding and natural regeneration to reduce soil erosion, if this area is protected with barbed fencing. Engineering and biological measures are proposed for the treatment of reservoir rim and a provision of Rs 124.30 Lakhs is proposed in the budget.

Landscaping and restoration plan
The landscaping and restoration plan targets towards overall improvement in the environmental conditions of the naturally or artificially disturbed sites in the project area of Lakhwar Hydroelectric Project apart from suggesting few points for adding attraction to the overall landscape of the area. Thus, the objectives are aimed to improve aesthetics of the project area; develop the area as tourist spot and increase vegetal cover. Around the reservoir area, it is therefore, proposed that recreation sites such as view point, gardens, boating points, fishing points, etc. be developed for increasing tourist influx. Total cost works out to be Rs 26 Lakhs.

Dumping and quarry sites management plan
As a consequence of most of the construction activities, modification or change in the existing landscape and/or damage to the aesthetics of the project area will take place because for these activities huge quantities of muck will need to be disposed whereas on the other side large quantum of aggregates would be required for
construction works. Therefore, these quarry and borrow pit areas also require restoration measures. Based on this understanding, details of status of works already completed in respect of Lakhwar project related to dumping and quarry/borrow pits were collected and a detailed map of the various dumping sites was developed. Field visits to the project area were undertaken to have a first hand account of the existing status and develop suitable management plan. It is proposed that all the proposed engineering structures will be erected to support the disposal yard before dumping. The landscaping and restoration of these disposal yards is to be carried out by engineering and biological measures.

The coarse and fine aggregates required for the project would be retrieved from an area of 15 ha at the river shoals near Kalsi. The quarry and borrow pit area are lying at the banks of river Yamuna as such the area shall not ostensibly require any restoration measures. It is suggested that after completion of quarry works, since the peak flows expected would be moderated, some portion of this site can be developed as a fish farm, for which provisions are being separately made under Fisheries Management plan. For the remaining 12.5 ha area, fencing, levelling and plantation are suggested for speedier rejuvenation. A provision of Rs 251.74 Lakhs towards management of muck disposal sites and quarry sites has been made.

**Fishery management plan**

Fish farm and hatcheries are proposed for fish management and to maintain the aquatic diversity. A provision of 1.15 crore including Administrative cost has been made for the same. It is proposed to utilize expertise of local state government department in conjunction with technical guidance of ICAR institutes.

**Health management plan**

Health management facilities will be provided for labours as well as project affected families for which a provision of Rs 54.75 Lakhs has been made.

**Subsidized fuel management plan**

Congregations of a labour force along with villagers are likely to create pressure on forest resource on the area which will imbalance environmental matrix of the area. In this regard subsidy on fossil fuel such as cooking coal, Kerosene, LPG connection,
etc. is proposed. As far as project proponents and their contractors are concerned, supply of subsidized fuel to the labourers should be ensured and provision for subsidized electricity, fossil fuel, etc. to the project affected people may also be provided. The overall cost works out to be Rs 41.60 Lakhs for these measures.

**Solid waste and sanitation management plan**

Improper solid waste management causes all types of pollution: air, soil, and water. Indiscriminate dumping of wastes contaminates surface and ground water supplies. In urban areas, solid waste clogs drains, creating stagnant water for insect breeding and flooding during rainy seasons. Uncontrolled burning of wastes and improper incineration contributes significantly to urban air pollution. Greenhouse gases are generated from the decomposition of organic wastes in landfills, and untreated leachate pollutes surrounding soil and water bodies. After proper understanding of locations of labour camps, residential areas, hospitals, office complex, etc. provisions for solid waste management facilities are made for safe collection, transportation and disposal of solid waste for which about Rs. 46.20 Lakhs is kept in the estimate.

During construction phase of the project, congregation of labour force will generate 1,76,800 litre per day sewage and will cause water pollution. Therefore, it is proposed to commission adequate number of septic tanks for treatment of sewage. To ensure that the sewage from the labour camps do not pollute the river water. It is estimated that about 35 community latrines and 3 septic tanks need to be constructed. However provision for these community latrines and septic tanks is being made by the project proponents in the project cost, hence no budgetary estimate for these are made.

**Disaster management plan**

Disaster is anticipated due to failure of the dam either by technical flow in its design or because of extreme flow in the river or because of some natural calamity/catastrophe like earthquake and may create havoc/huge destruction in the downstream area. Whatever may be the reason of failure, it is very clear that the destruction is expected mainly due to the flooding caused by water stored in the reservoir. Therefore, keeping in view the adverse effects of dam failure, it is
imperative to assess the flows expected in the downstream reaches and prepare a relevant disaster management plan, well in advance to minimize the loss of life and property.

**Dambreak analysis:**
BOSS DAMBRK (originally developed by NWS) model has been used for simplifying the cumbersome process of flood routing. On the basis of the dam break analysis the flood wave is expected to inundate the downstream stretch of about 4.85 km approximately in 10.8 minutes. This means that very little time would be available for execution of any rescue and/or evacuation plan. Therefore, the Disaster Management Plan has been devised mostly for preventive measures.

**Monitoring:**
The project authorities should prepare an effective Dam Safety Plan including dam safety surveillance and monitoring scheme. This should also include rapid analysis and interpretation of instrumentation and different observation data along with periodic inspection, safety reviews and their evaluation.

**Communication System:**
An efficient communication system is absolutely essential for the success of any disaster management plan. This has to be worked out in consultation with local authorities.

A provision of Rs 48 Lakhs has been made for different measures in Disaster management plan.

**ENVIRONMENTAL MONITORING PLAN**
The environmental monitoring will be required during construction and operational phases for: Social Welfare, Water Quality and Public Health, Catchment Area Treatment Measures; and Air Quality and Noise Level. In this regard a monitoring committee consisting of member from Ministry of Environment & Forests, GoI, Ministry of Environment & Forests, Uttarakhand, District Administration of Uttarakhand, and Representative of Project Proponent may be constituted to evaluate the efficacy of works being implemented. It is further strongly felt that the agency
associated with formulation of EIA/EMP study should also be involved in the monitoring of EMPs implementation. This will help in better implementation of treatment suggested. A provision of Rs 41.40 Lakhs has been made for environmental monitoring plan.

OVERALL COST OF ENVIRONMENTAL MANAGEMENT PLANS FOR LAKHWAR HYDRO ELECTRIC PROJECT

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<td>Landscaping &amp; restoration plan</td>
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CHAPTER 11

CONSTRUCTION METHODOLOGY

11.0 Lakhwar Project

11.1 Introduction

Lakhwar Project of 300 MW is located in the district of Dehradun. The project is planned to be constructed on the river Yamuna in Uttarakhand state. The work site is connected through railway and airport from Dehradun. Initially this project was started in 1979 by state govt. of Uttar Pradesh. The construction of main works of the project was started through three major contractors in July 1987. However the progress of construction of the project works suffered due to paucity of funds and by the end of 1992 the construction works were stopped. Before stoppage of the project works, part works on the various components of the project such as abutment stripping of Lakhwar dam, construction of diversion tunnel, part construction of underground powerhouse had been carried out. Later on Uttarakhand govt. had prepared DPR revising the cost of March 96 level and submitted to CWC/CEA. The construction of Lakhwar project has been scheduled for 54 months considering that no major infrastructural development will be required.

The construction methodology and equipment planning of different components of the project are as follows:-

11.1.1 River Diversion and Cofferdam

The diversion of river in Lakhwar project involves 2 nos diversion tunnels (DT) and coffer dams. The construction of DT has already been completed. The construction of cofferdams and diversion of river would be carried out in 4 months commencing from 7th month. Earth filling material would be handled in three working shifts @15hrs/day and 157cum/hr. The equipment required would be 3
cum hydraulic excavator, loader cum excavator, crawler dozer, and 35t rear dumpers etc. for excavation of coffer dam.

11.1.2 Concrete Gravity Dam

The Lakhwar dam is concrete gravity type and the maximum height is 204m. The excavation for abutment stripping up to the level of EL 629m is completed. The river bed excavation along with balance abutment excavation for the dam would be carried out by drilling & blasting in 9 months (effective) @ 15hrs per day and 733 cum /hr. The loading and transportation of muck shall involve Hyd. Excavators of 3 cum & 1.0 cum capacity, 35t dumpers, tippers have been proposed. The excavation would be started from 2nd month and completed in 13th month. Mobilization of tower crane, cable crane and aggregate batching plants etc. would be completed by 12th month so that concreting of the dam can be started from 13th month onwards and completed in 51st months. Thus, 30 months (effective) would be required for concreting of the dam.

For concreting, the total quantity involved would be 4103000 cum out of which 62900cum would be required for apron and plunge pool and approx. 617925cum for river bed concreting which will be carried out in 3months @ 495cum/hr considering 20% requirement for peak hours. For concreting Bi-cable ways of 2 x 30t capacities have been proposed. Therefore the total capacity of this crane will be 300cum/hr approximately and in addition to this a top belt conveyor for concreting 300cum/hr has also been proposed to cope up with the total requirement of 495cum/hr.

11.1.3 Intake Structure

In Lakhwar project the remaining excavation quantity of intake structure is 88000 M³, which would be carried out in 5 months commencing from 22nd month and completed in 26th month. The concreting of intake structure and HM works would be carried out.
in the period of 10 months commencing from 27th month and completing in 36th month. The equipment proposed for the excavation are hydraulic excavator, dumper, jack hammer etc and for the concreting purpose, concrete pumps, transit mixer, vibrators, air compressors etc would be required.

11.1.4 Pressure Shaft/ Penstock

In Lakhwar project there are three nos. pressure shaft/penstock of 4.3m circular finished dia. and 6.1m excavated dia. The maximum length of lower horizontal portion of construction adit is 271m which would be constructed manually in a period of 7 months commencing from 9th month and would be completed in 15th month. For the excavation of penstock 11 months would be required commencing from 16th month. Erection and concreting of the penstock would be started after excavation from 27th month in a period of 5 months. The equipment required for excavation are Hyd. excavator, 10t tippers, winch, jackhammer, air compressor etc. and for the concreting purpose are transit mixer, concrete pumps, vibrators etc.

11.1.5 Power House

The size of main powerhouse cavern of Lakhwar project is 130mx20mx46.80m (unfinished). The powerhouse is underground and part excavation has already been completed. Presently the pit is filled with water, as such dewatering would be required. The dewatering of powerhouse would be continued for one month during 7th month from beginning of the project has been proposed. The excavation up to EL625 has already been completed. The cavern would be further benched down up to EL 611.30 after making suitable ramp. The mucking would be carried out through the adit to erection bay. An approach would also be made to the bottom of powerhouse through TRT.
Additional collection chamber, collection chamber and draft tube would be used to facilitate mucking of the powerhouse. This excavation would be carried out just after dewatering and would continue up to 18\textsuperscript{th} month commencing from 8\textsuperscript{th} month. The concreting of service bay, column and beams for EOT crane would be completed in 3 months commencing from 12\textsuperscript{th} month. The additional collection chamber would be excavated in 5 months commencing from 17\textsuperscript{th} month. The excavation of draft tube would be taken up parallel to above activity in a period of 3 months. Detailed equipment planning has been carried out separately for these activities. Excavation of balance cable tunnel would require 10 months commencing from 7\textsuperscript{th} month and after that concreting of cable tunnel would be carried out in 5 months commencing from 17\textsuperscript{th} month. The concreting of draft tube would be carried out in a period of 4 months commencing from 22\textsuperscript{nd} month. Concreting of generator barrel and erection of draft tube, scroll case, erection of unit no. one would be completed in 27 months commencing from 21\textsuperscript{st} month. Similarly the erection of unit 2 & 3 will be carried out leaving behind 2 months from one after another. All these activities will take 27 months. The hydro mechanical works would require 6 months commencing from 40\textsuperscript{th} month and finally testing and commissioning of units would require 3 months commencing from 52\textsuperscript{nd} month. The equipment required for excavation are Hyd. excavator, 10t tippers, jackhammers, wagon drill, dozers, winch, mucking trolley, skid steer loader etc. and for concreting are B&M plant, transit mixers, concrete trolleys, vibrators, concrete pump, grouting machine, shotcrete machine etc.

11.1.6 Tail Race Tunnel

In Lakhwar Project there would be one TRT of 8.25m finished dia. and 9.05m excavated dia of length 159.2 m, out of which 96 m heading excavation of TRT is already completed and balance 63 m would be excavated by heading and benching in a period of 2 months each. The equipment required for this purpose are 1.0 cum
hydraulic shovel, jack hammer, wagon drill etc. For the concreting of entire length of 159.2 m would be carried out in a period of 2 months with 10m long concrete shutter @ 80m per month progress. The equipment required for this purpose are concrete pump 38 cum per hour, 4 cum transit mixer, B&M plant available at power house site, concrete vibrators etc. After concreting of TRT drilling and grouting operation would be carried out in 1 month in parallel with the concreting and as such no extra time would be required.

11.2 Katapather Barrage
The barrage at Katapathar is to be constructed at 13.65km away from Lakhwar project down stream side. The length of barrage at top is 152.5m (comprising of three under and 5 nos. weir bays separated by 3.5m wide piers in between). The barrage is planned to be constructed for the purpose of balancing the water released from Lakhwar Vyasi project and further uniform release of stored water from Katapathar Barrage will be maintained for downstream use such as augmentaries of electricity from downstream projects drinking water and irrigation water. A temporary diversion is proposed in the river course itself to facilitate the excavation of river bed. The excavation would require 6 months (effective) @ 204 cum/hr removal of muck commencing from 13th month. The concreting would require 15 months (effective) @ 28cum/hr (approx) commencing from 19th month. The HM works would require another 12 months commencing from 31st month. The equipment required for excavation are hyd. Excavator, 25t dumper, 100HP crawler dozer, wagon drill, jackhammer, vibratory compactor, air compressors etc & for concreting B&M plant, concrete pump, transit mixers, grout pump etc are required.
CHAPTER-12
ECONOMIC EVALUATION

12.0 GENERAL
Lakshwar Project has been contemplated as a multipurpose power project to cater for the peaking requirement of Uttarakhand State.

12.1 ENERGY CONTRIBUTION FROM THE PROJECT
The energy generation of the project with an installed capacity of 3 x 100 MW has been estimated at 572.54 MU in a 90% dependable year with 95% machine availability.

12.2 PROJECT COST
(As approved by CWC vide letter no 10/ 22/ 73/ CA (l) /494 dated 6 Aug 2012)

The project has been estimated to cost Rs. 4168.46 Cr including IDC of Rs. 190.82 Cr and Financing Charges of Rs. 11.13 Cr at May 2012 Price Level. Project cost is Rs 3966.51 Cr without IDC & FC. Cost apportionment as decided by CWC is 65: 35 for irrigation and power component respectively. The cost of power component comes out Rs 1388.28 Cr (@ 35% of total cost i.e Rs 3966.51 Cr) on which IDC & FC has been calculated as Rs 190.82 Cr & 11.13 Cr respectively. Therefore total cost of power component including IDC & FC is Rs 1590.23 Cr.

Assuming a debt equity ratio of 70:30 for project financing (power component with IDC & FC), the debt requirement shall be Rs. 1113.16 Cr and Rs. 477.07 Cr shall be equity.

Out of total equity requirement of Rs. 477.07 Cr an amount of Rs. 239.05 Cr (Rs. 186.85 Cr spent up to Oct 2003 by Irrigation Deptt + Rs. 52.20 Cr Paid to NHPC by UJVNL) already spent by State Government
/ UJVNL till date and shall be considered as equity already contributed by the state.

12.3 FIXED AND RUNNING CHARGES

i) Interest rate
The interest rate of 12% has been reckoned for working out the financial return. The interest during construction has also been capitalized as 70% loan and 30% equity.

ii) Return on Equity
For working out the unit cost of energy, the return on equity has been taken at 14% (without tax) as per Uttarakhand Electricity Regulatory Commission (UERC), Regulations, 2004 (extended upto 30/06/2010) for hydro generation tariff.

Depreciation
Depreciation has been calculated annually based on straight line method over the useful life of the project on the 90% capital cost of the project as per UERC Regulations.

Operation and Maintenance charges
As per UERC Regulations Operation and Maintenance charges has been taken as 1.5% of capital cost of the project, subject to an annual escalation of 4% per annum.

Interest on Working Capital
The interest rate on working capital has been taken as 13.50% as per current practice and the working capital covers the cost of (i) O&M charges for 1 month (ii) maintenance spares @ 1% of capital cost with an annual escalation of 6% per annum and (iii) receivables equivalent to 2 months billing for sale of electricity.
12.4 UNIT COST OF ENERGY

The unit cost of energy at Bus Bar, considering return of 14% on the Equity invested based on generation in a 90% dependable year with 95% machine availability as approved by CEA are as follows

Total cost of project including IDC & FC at May 2012 PL as approved by CWC Rs 4168.46 Cr

Cost apportionment as approved by CWC 65% : 35%
Water component % : power component %

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<td>Interest During Construction (IDC)</td>
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<td>Financing charges</td>
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<td>Total cost of power component with IDC &amp; FC</td>
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<td>Levelised</td>
<td>Rs 4.79 per kWh</td>
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CHAPTER 13
INTER – STATE ISSUES

13.1 Introduction

Power is the basic infrastructural need for development of a country. The production in the farm & factory is largely dependant on availability of quality power. After the economic liberalization undertaken in the country, the requirement of power has further increased to sustain the developmental processes in the country. The per capita consumption of power is also an indicator of any country’s development. The demand for power has outstripped availability to an alarming extent in the country as a whole, and in the State of Uttarakhand and Northern Region in particular. Northern Region which includes State of Uttarakhand also is already under severe power deficit and is going to face acute power shortage in 11th Five year plan (2007-12) and beyond even after accounting for benefits from the on-going projects and also from other schemes cleared by CEA. Hydro power projects are the source of providing quality power free from pollution with cheaper cost of generation requiring no fuel. Though, energy from thermal and nuclear power plants can be made available faster, hydro power plants are essentially required for optimum utilization of thermal and nuclear power plant and stability of power system. Energy from Hydro power projects mainly provides peaking power and for this purpose storage schemes assumes greater importance in power scenario of the country. 420 MW Lakhwar Vyasi multipurpose project is a storage scheme to generate primarily peaking power and the project will provide 330 Mcum of water from the storage for much needed irrigation and drinking water purpose. Many part of the country is facing crisis of drinking water. It is in this context that balance work of Lakhwar Vyasi Project should be completed on priority to reap the benefit of peaking power for power starved Uttarakhand state and northern grid & drinking water for adjacent states. This project has been under active...
construction since 1987 to 1992 and thereafter works on this project has been stopped.

To complete the balance works of Lakhwar Vyasi multipurpose scheme project was handed over to NHPC in Nov. 2003. However, due to various reasons construction work at project site could not be recommenced by NHPC. In March, 2009 project was handed over back to GoU and further work on the project is to be completed by UJVNL.

The matter of sharing the project cost by the beneficiary states for Lakhwar Vyasi multipurpose scheme is still unresolved and efforts are under process by various agencies of GoI to resolve the same at the earliest so as to achieve completion of the project at the earliest and reap its benefits.

13.2 **Detail & Status of Inter – State Issues**

Lakhwar Vyasi multipurpose project is located on the river Yamuna in district Dehradun of Uttarakhand. It is primarily a peaking power project the reservoir of Lakhwar dam will have a live storage of 330 Mcum. The water from Lakhwar reservoir will be utilized first to generate 300 MW power in the dam toe under ground power house. The tail water released after generation from Lakhwar power station will fall back into Yamuna river and will be further stored in the reservoir of Vyasi dam which is located 5 km downstream of Lakhwar dam. Water from Vyasi reservoir will be diverted through a head race tunnel to Hathiari power house where 120 MW power will be generated, the tail water released from Hathiari power house will further fall back into Yamuna river ad shall be regulated further at a balancing reservoir at Katapathar Barrage to be constructed 3 km downstream of Hathiari power house as a part of multipurpose project for downstream use of water released from Lakhwar & Vyasi reservoirs.
Beneficiary states of Yamuna river comprises the states of Uttar Pradesh, Uttarakhand, Haryana, Rajasthan, Himachal Pradesh and Delhi. As per the MOU of 12th May 1994 signed among Chief Ministers of beneficiary states, assessed 11.983 BCM annual utilizable flow of river Yamuna has been allocated to the beneficiary states, where in Haryana’s share is 5.730 BCM, share of Uttar Pradesh including Uttarakhand is 4.032 BCM, share of Rajasthan is 1.119 BCM, share of Himachal Pradesh is 0.378 BCM and share of Delhi is 0.724 BCM (Annexure-I). Separate agreement is to be executed in respect of each identified storage schemes on the river Yamuna within the framework of overall allocation made under the agreement of 1994.

After taking over the multipurpose Lakhwar Vyasi scheme, NHPC made efforts to get resolved inter state issues and in this connection the matter was taken up with state government of Delhi and Uttar Pradesh for their consent to share the project cost of Lakhwar Vyasi project for drinking water and irrigation component respectively. Subsequently other beneficiary states like Haryana, Rajasthan etc were also associated with the discussion.

As an effort to resolve the issue of sharing of project cost of Lakhwar Vyasi multipurpose scheme and other storage dam project for irrigation and drinking water by beneficiary states, a meeting of chief secretaries of Upper Yamuna basin states was held in the Ministry of water resources, GoI on 14/02/2006 (Annexure-II). In this meeting various issues such as approach of sharing of water of Yamuna subsequent to construction of dam, the approach to cost sharing of the structures, approach to sharing of power, approach to project financing and sequencing of dam construction were discussed. Subsequently in the 3rd meeting of Upper Yamuna review committee held on 12/04/2006 under the chairmanship of Hon’ble Union Minister of Water Resources a steering committee was
constituted vide notification no. 26/2/95 – IT/1273 dt 22/05/2006 to formulate a strategy to expedite the work on 3 projects i.e. Renuka, Kishau & Lakhwar Vyasi in the upper reaches of upper Yamuna (Annexure-III). Later on many meetings were held at the level of Ministry of Power, Govt. of India as well as Ministry of Water Resources (MOWR), Govt. of India relating to these aspects. In one of the special meeting convened under the chairmanship of Hon'ble Union Minister of Water Resources with the irrigation/ water resources Ministers of Upper Yamuna basin states on 20/12/2006 at New Delhi (Annexure-IV). The Hon'ble Union Minister desired that the DPR’s of both Lakhwar Vyasi project and Vyasi dam may be examined separately and all clearances be obtained at the earliest. The issues related to cost and benefit sharing from the project as brought out by state governments during the discussions in the meeting may also be addressed. He also requested that each basin state should send there proposals on implementation of projects and sharing of water and power benefits and their cost which may be considered in the Ministry of Water Resources. The issue is unresolved at present and under consideration of steering committee constituted by MOWR, Govt. of India.