Executive Summary
of
Environmental Impact Assessment Report

Bajoli Holi H. E. Project (180 MW)
Chamba, Himachal Pradesh

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EXECUTIVE SUMMARY

1.1 INTRODUCTION

The proposed project by GMR Bajoli Holi Power Pvt. Ltd. is located in Chamba district in Himachal Pradesh (Figure 1) and is one of the projects that are being developed in Ravi River basin (Figure 2).

Ravi River is one of the four major river systems of Western Himalaya in Himachal Pradesh, the other three being Sutlej, Beas and Chandra-Bhaga (Chenab) rivers. It is a glacier-fed river originating from the glaciated areas of Beas Kunderi Dhar, the water divide between Beas and Ravi Rivers. Ravi is formed by the confluence of Bhadal Nala originating from Bhadal glacier, Rai Nala originating from Rai Ghar glacier and Tantgari Nala originating from Tantgari and Karu glaciers.

1.2 PROJECT FEATURES

The project is envisaged as a run-of-the-river scheme in the upper reaches of Ravi with project area lying between longitudes 76^0 40' 36" and 76^0 27' 30" E and latitudes 32^0 16' 49" and 32^0 20' 37" N. The project is proposed to harness the head available between Bajoli and Holi villages upstream of the under investigation Kutehr H.E. (240 MW) project and is accessible via Chamba-Holi road. The proposed diversion site is located between Bajoli and Nayagram villages and is about 15 km upstream of Holi, a large village in the area. The powerhouse site is located near Barola village, which is about 2 km downstream of Holi village and upstream of confluence of Kee Nala with Ravi River with an installed capacity of 180 MW.

The project area is connected by a metalled road from Chamba, which itself is connected to Pathankot through National Highway 33. In the project area, the Chamba-Holi-Nayagram road runs on the left bank of Ravi River.

Salient Features

The salient features of the proposed Bajoli Holi H.E. Project are given in Table 1. Drainage cum study area map of Bajoli Holi H.E. Project catchment has been shown as Figure 3 and project layout map has shown at Annexure - I.

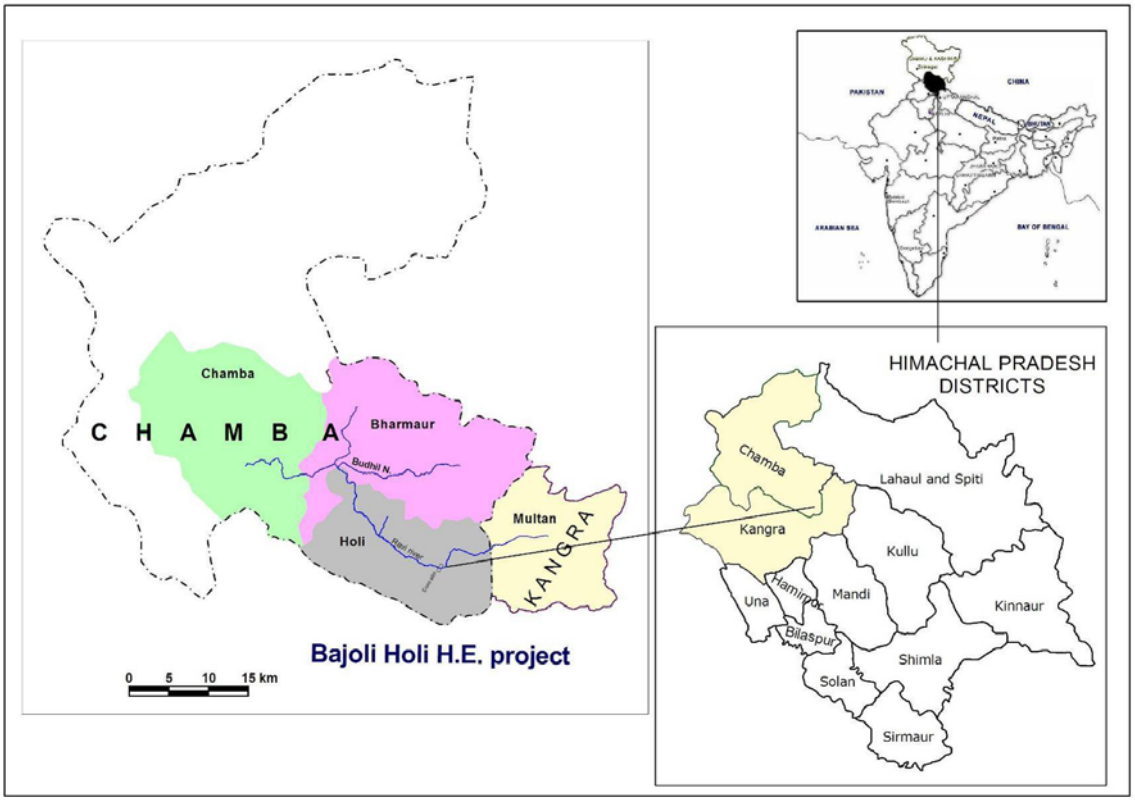

Figure 1: Location map of Bajoli Holi H.E. Project

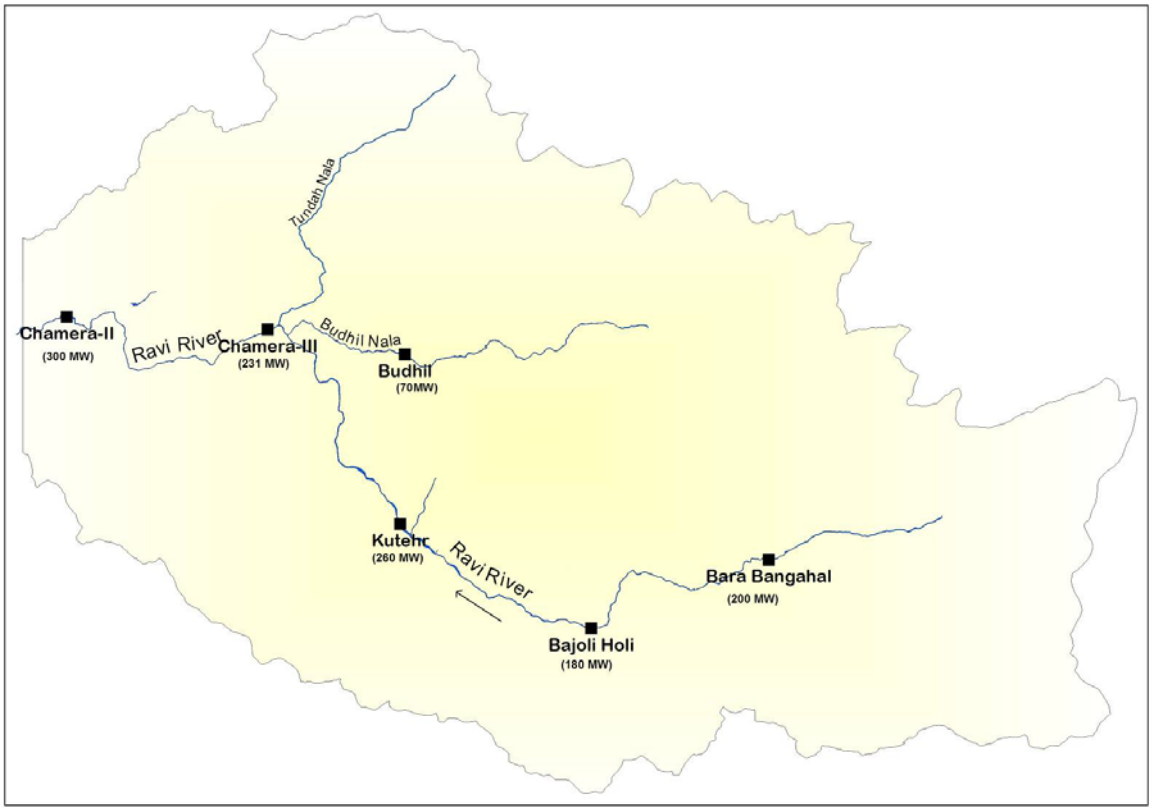

Figure 2: Cascade development in Ravi basin

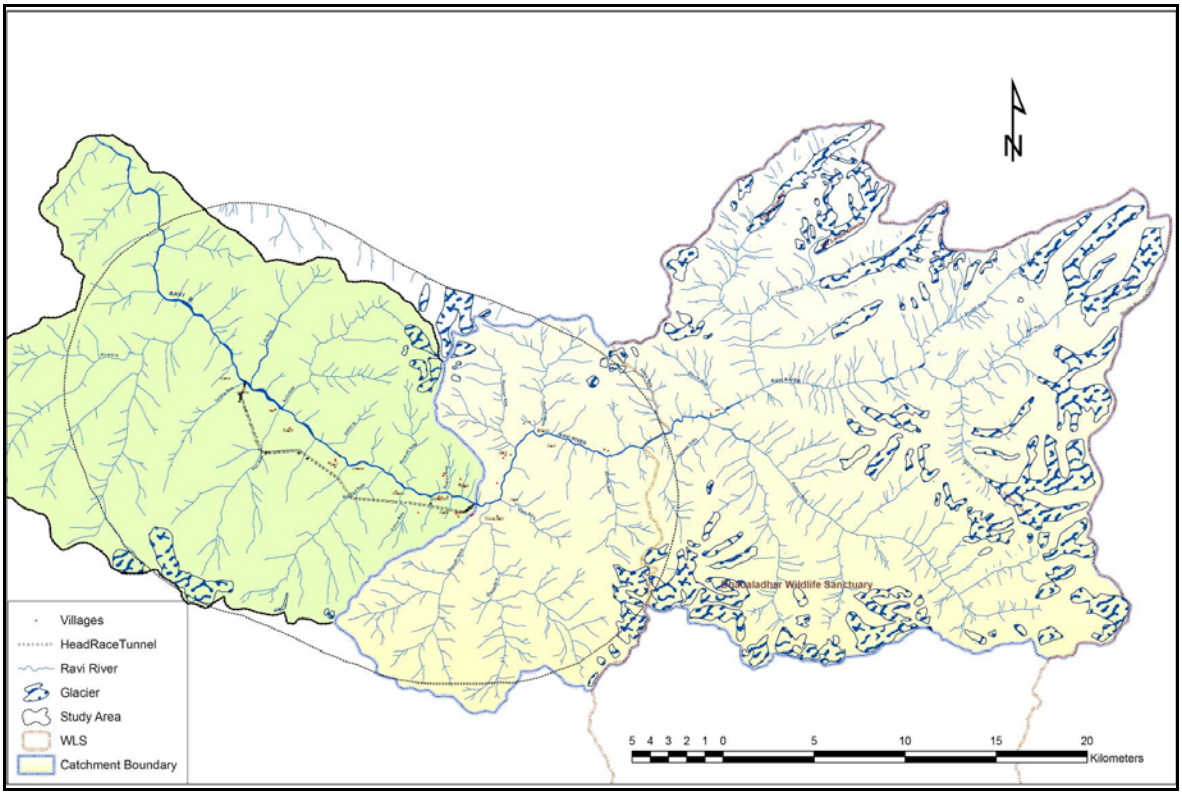

Figure 3: Drainage cum study area map of Bajoli Holi H.E. Project

Table 1: Salient features of Bajoli Holi H.E. Project

Project Location	
State	Himachal Pradesh
District	Chamba
River	Ravi
Vicinity	Holi Village
Hydrology	
Catchment area	902 km^2
Area under snow	296.00 km^2
Rain fed area	606.00 km^2
Elevation of Snow Line	4500 m a.s.l.
Probable Maximum Flood	7419 m^3/s
One Day PMP	38.92 cm
Reservoir	
Full Reservoir Level (F.R.L.)	2018.25 m a.s.l.

Minimum Draw-down Level (M.D.D.L.)	2012.00 m a.s.l.
Length of Reservoir at FRL	2.42 km
Area of Reservoir at FRL	16.50 ha
Dam-Spillway	
Latitude	32^0 16’ 49”
Longitude	76^0 40’ 36”
Top of Dam	2020.0 m a.s.l.
Stream Bed Level	1975 m a.s.l.
Dam Foundation Level (Lowest)	1954.00 m a.s.l.
Dam Height from Foundation Level	66.00 m
Dam Length	178.0m
Spillway Crest Elevation	1985.0 m a.s.l.
Gate Type and Size (W x H)	4 Nos. Radial; 10.0 m x 15.21 m
Hoist Type and Capacity	Twin Hydraulic hoist (4 sets, 2x150 MT)
Stop log Type and Size (W x H)	Vertical lift slide type, 10.0 m x 19.13 m (One set)
Hoist Type and Capacity	Gantry Crane, 50 MT
Pier thickness	7.0 m
Intake (On Left bank)	
Numbers	02 nos
Intake Crest elevation	2000 m a.s.l.
Nominal Discharge	83.10 m^3/s
Trash rack Size	8 Nos. 3.0 m x 7.5m
Clear Opening between trash bars	100 mm
Gate Type	Vertical lift fixed wheel type
Gate Size (W x H)	2 No., 3.5 m x 4.25 m
Hoist Type and Capacity	Rope Drum Hoist, 10 MT
Feeder Tunnels	
Nos.	Two nos.
Size (W x H) of each tunnel	3.5 m x 4.25 m Modified D-shaped
Length	198.0m , 180.0m
De-sanding Chambers	

No. & Size (L x H x W)	2 Nos., 240m x 14.5m x 10.8 m
Headrace Tunnel	
Excavated Shape	Modified Horse shoe
Finished Size	5.6 m Diameter Modified Horse shoe
Surge Shaft	
Type	Open to sky gated Vertical Shaft
Diameter	12 m
Gate size	3 m (w) X 3.8m (H)
Pressure Shaft	
Number and Diameter	1 Nos., 3.8 m dia
Thickness of Liner	22-36 mm
Type of Steel	ASTM A517 GR-F & A537 GR-II
Length of main Pressure Shaft	845.0 m(Vertical Reach 293.8 m)
Design Discharge through Pressure Shaft	69.25 m^3/s
Unit Penstock	
No. & Dia	3 Nos., 2.2 m
Combined Length	125.5 m (39 m to Unit-I, 32.5 m to Unit-II, 54 m to Unit-III)
Surface Powerhouse	
Latitude	32^0 20’ 52” N
Longitude	76^0 31’ 58” E
Dimensions (W x H x L)	19 m x 43.6m x 82.5 m
Turbine Type	Vertical Axis Francis Turbine
Number of Units	3
Turbine Setting Elevation	1693.40 m a.s.l.
Rated Discharge per Unit	23.08 m^3/s
Turbine Speed	428.57 rpm
Max./Min. Gross Head	318.95m / 305.23 m
Rated Head	291.47 m
Installed Capacity per Unit	60.0 MW
Tailrace Channel	

Length/Slope	48 m; 1:4
Adits	6 nos.
Switchyard	
Type	Out door
Area (L x W)	35 m x 60 m
Estimated Cost	
Civil works	912.24 Cr
E & M works	252.70 Cr
Total basic cost	1164.94 Cr
Escalated cost for Civil and E&M works	1437.37 Cr
Interest during construction & Financing Charges	366.61 Cr
Lada & CAT Plan @ 4% of Project Cost	72.61 Cr
Total (Generation works excluding Transmission Line Cost)	1876.14 Cr
Cost per MW installed	10.42 Cr
Tranmission Line Cost	58.05 Cr
Power Benefits	
90% dep. Year Energy	782.41 MU
50% dep. Year Energy	888.65 MU
Financial Aspects	
Levellised Tariff / Kwh	Rs. 5.03
Construction Period	5 Years

For the construction of Bajoli Holi H.E. Project, elaborate infrastructure works are required to be set up. Heavy equipment for the power house as well as heavy earthmoving machinery would have to be transported to the various sites which would require roads of adequate width and proper geometry.

Plants of various kinds would be set up at appropriate locations to serve the requirements of the civil structures.

The infrastructure works for the Bajoli-Holi HEP would broadly comprise of the following:

i. Rail Head Facilities,
ii. Road Transport Facilities,
iii. Owners' and Contractors' Colonies,

iv. Construction Plants,
v. Repair Facilities,
vi. Storage of Material,
vii. Construction Power Set Up,
viii. Telecom System,
ix. Project Roads leading to all sites,
x. Muck Disposal Areas,
xi. Borrow Areas/ Quarries,
xii. Explosive Magazines Set Up,
xiii. Acquisition of Land for the project, and
xiv. Construction adits.

General layout plan of project infrastructure is given at Figure 4.

1.3 GEOLOGY

The Chamba and Tandi basins lie in the SE extension of Bhadarwah basin of Jammu and Kashmir, which palaeogeographically links up with the Tethyan basin of Kashmir. Thus, Spiti-Zanskar and Kashmir-Bhadarwah-Chamba-Tandi are reported to represent two palaeogeographically separate and independent Tethyan basins (Srikantia and Bhargava, 1998).

The diversion structure comprises a 66 m high concrete gravity dam with FRL at El. 2018.25m has been proposed at the site. This would lead to creation of storage that would be utilised for peaking purpose.

Himachal Pradesh has experienced several earthquakes during the twentieth century. The most devastating earthquakes were the Kangra earthquake of April 4, 1905, the Kinnaur earthquake of January 19, 1975, the Dharamsala earthquake of June 14, 1978. As per the Sesimic Zoning map of India, the area covered by Himachal Pradesh falls in IV and V zones.

Based on the parameters like regional geology, seismotectonic set up, characteristics of various seismogenic sources present in the region and seismic history, the maximum probable earthquake that can occur in the area with peak ground acceleration by using different formulae has been estimated. Site specific seismic parametric study carried out by IIT, Roorkee recommended MCE & DBE Coeffients as 0.31g & 0.16g which are being used for design of various structures.

1.4 HYDRO-METEOROLOGY

The Ravi River is a major river of Indus basin, originating from Bara-Bangahal branch of Dhaula-Dhar range at an elevation of 4229 m, approximately 75 km northeast of the Chamba town in Himachal Pradesh. The Bara-Bangahal comprises of snow covered peaks at heights ranging from 3000 m to about 6000 m elevation.

The climate of Ravi basin is affected by the tropical weather systems during the summers and the cold weather systems known as Western Disturbances during winter and pre-monsoon months. The western disturbances have their origins near the Mediterranean Sea and as mentioned above move in the westerly wind regime along Himalayan latitudes during the winter season. These disturbances may be in the form of a depression or a low-pressure area formation or an upper air cyclonic circulation or a trough in lower isobaric levels. They shift to more northerly latitudes as the summer season approaches.

Summer precipitation in the Ravi basin area is mainly associated with the Southwest monsoon which is dominant from June to September; most of the precipitation is in the form of rainfall. Extreme rainfall floods are mostly experienced during this season.

Based on the information available from different sources, the project basin broadly gets affected by the following seasons:

Winter	:	Dec to Mar
Summer/Pre-monsoon	:	Apr to Jun
Monsoon	:	Jul to Sept
Post-monsoon/Autumn	:	Oct to Nov

There are 12 (Twelve) RG stations located in the Chamba district of Ravi River basin. The normal annual and annual rainfall records for most of the stations are available since 1960.

The rainfall characteristics of Ravi basin is given below.

- The average annual rainfall for the basin is 1370 mm
- The highest amount of rainfall is received in the month of August i.e. 20% of the average annual value
- Significant amount of rainfall occurs during winter month of January to March i.e. 26% of the average annual value, which reflects the significant contribution of Western Disturbances

The typical flow regime of this river can be described as below:

- A base flow regime is observed from November to February. During this period, water originates from soil drainage and limited snowmelt during warmer days from low altitude areas.
- The flow progressively increases from March to May. It is generated by progressive snowmelt and glacier melt. The gradual increase in flow pattern is attributable to the increase in daily temperature.
- The flow remains high during May to September. The high discharge in the river is contributed by snow and glacier melt, augmented by monsoon rain on the lower parts of the watershed.
- The flow progressively decreases from October to November with few isolated event of high flow. The discharge in the river is contributed by delayed surface runoff and glacier melt along with post monsoon rain and delayed ground water contribution
- February is the driest month of the year, having only 1.0 % of the total annual flow and minimum water balance carry over.

1.5 ENVIRONMENTAL BASELINE DATA

The baseline survey for the EIA of proposed Bajoli Holi H. E. project was carried out in three seasons viz. Pre monsoon (April - May 2008), Monsoon (August 2008) and Winter (November 2008).

During all three seasons the data on the following component are collected.

- Soil
- Air, Noise and Traffic
- Landuse/Landcover
- Floristic Diversity
- Faunal Diversity
- Aquatic Ecology

The study area was delineated as area within 10 km radius of the main project components like dam site, power house site and also area within 10 km upstream of reservoir tail, submergence area, the river stretch from downstream of barrage to power house and catchment area of the river and its tributaries up to the dam site.

1.5.1 Soil

Little variation was observed in the bulk density of different sampling sites. The soil of Deol village (S3) contained 69.85% of sand and around 22.65% of clay. The maximum percentage of clay was observed in the soil samples of

powerhouse site (S1) and Tayari bridge (S2) site. The water holding capacity was maximum in the soil samples of Nayagram area (S4) site. The soil texture showed its correlation with bulk density. The percentage of clays in these soil samples varied from 4.8% to 7.5%.

The soil samples collected from area downstream of powerhouse site (S1) were poor in organic matter contents. Only the soil samples collected from Nayagram area (S4) were rich in organic matter. The dam site particularly the right bank is covered with grasses that come up during monsoon and get dried in winters and becomes part of soil. The right bank of dam site contained pine and deodar trees. However, the nitrate, phosphate and chloride were minimum in the soil samples collected from dam site than the samples of other sites. However, the range of phosphate, potassium content in the soil samples varied from 6.01 mg/kg to 13.21 mg/kg at all the sites and being maximum at site-S2. The magnesium concentration in the soil samples collected from various places varied from a low of 99.16 to 148.63 mg/kg. The soil samples were poor in nitrogen contents with concentration of nitrogen in the soil samples varying from 0.09% to 0.57% only. In this region use of chemical fertilizers in the field were minimum.

1.5.2 Air Environment

The study area is mainly comprised of rural environment. Sources of air pollution affecting the region currently are vehicular traffic, dust arising from unpaved village roads and domestic fuel burning. The air environment around project site is free from any significant pollution source. Therefore, ambient air quality is quite good in and around the project area. Ambient air monitoring was undertaken in the project area in the winter season during November 2008 at Holi and Nayagram.

1.5.3 Land use/ land cover

The land use/ land cover map of the study area shows that major portion of the catchment is under barren land and shrubs/bushes/grasses. The dense and open mixed coniferous and deodar forest constitute major portion of total forest cover. Next major land use is scrub which is comprised of slope grasslands, alpine grasslands temperate and sub-temperate scrub grasslands.

1.5.4 Forest Types

The Bajoli Holi H.E. Project is located in the vicinity of Dhauladhar Wildlife Sanctuary which comprises mainly the upper catchment of Ravi River upstream of confluence of Thamsar Nala with Ravi River and its left bank ridge forms the western boundary of the Sanctuary. However no part of the project

falls within Dhauladhar Wildlife Sanctuary and nearest boundary is more than 11 km from the project components. The major forest types found in the study area and in catchment area are:

i) Lower Western Himalayan Temperate Forest,
ii) Upper Western Himalayan Temperate Forest,
iii) *Alnus nepalensis* Forest, and
iv) Moist Alpine Forest.

1.5.5 Floristics

From the study area 272 flowering plant species were recorded which include 28 trees, 48 shrubs, 10 climbers and 186 herbs. The Betulaceae and Pinaceae are the dominant families in the trees with four species each, shrubs layer is dominated by the Rosaceae, Fabaceae and Lamiaceae. The herbaceous vegetation was dominated by Poaceae, Cyperaceae and Asteraceae. Gymnosperms are represented by single family Pinaceae.

i) Dam Site and Submergence Area

The moderate to steep right bank slopes being south facing receives maximum sunlight are covered with grassland. Tree canopy is almost absent on the right bank, the shrubs are sparse and only grows near the shaded slopes. The common grasses are *Microstegium nudum*, *Capillipedium parviflorum, Poa annua, Arundinella nepalensis, Themeda anathera,* etc.

The vegetation cover on the left bank slopes on the other hand is good to very good because of north facing shaded areas and high moisture content. The right bank represented by the Moist Deodar Forest. The tree canopy is dominated by the *Cedrus deodara* with trees of *Pinus wallichiana*. The middle canopy was totally absent in this forest only the ground layer was represented by the shrubs and herbs. *Coriaria napalensis, Cotoneaster microphyllus, Daphne retusa, Desmodium elegans, Rabdosia rugosa, Rhamnus purpureus, Sorbaria tomentosa* and *Wikstroemia canescens* are the common among the shrubs. The herbaceous layer represented by *Anaphalis triplinervis, Androsace sarmentosa, Cirsium arvense, Galium vernum, Mentha longifolia, Prunella vulgare, Salvia lanata* and *Viola pilosa.*

ii) Downstream of Dam Site

The right bank was remains covered with grass throughout the area. Left bank shows varied type of vegetation from Nayagram to Holi because of altitudinal gradient. *Cedrus deodara* was frequent near the Nayagram village with some

Pinus wallichiana, Aesculus indica, Lyonia ovalifolia, Pyrus pashia and *Salix karelinii*. *Alnus* nepalensis is observed only near the river banks.

From Nayagram to Gharo the tree canopy is dominated by the *Cedrus deodara* at only higher altitude, near the river *Alnus nepalensis* was present along with *Pinus wallichiana, Populus ciliata* and *Salix karelinii.* As one moves down stream from Gharo to Deol the Moist deciduous forest is observed near the road side with some *Cedrus deodara* and *Pinus wallichiana. Quercus semecarpifolia* forest is observed near the Deol to Holi village and further up to the Tayari village interrupted by the *Alnus nepalensis* near the helipad area.

iii) Power House Area

The proposed power house is on the left bank of the Ravi River and right bank of Kee nala near the Tayari village. This area is covered with the Ban oak forest dominated by *Quercus leucotrichophora* with few trees of *Cedrus deodara, Pinus wallichiana.* The Alder (*Alnus nepalensis*) forest is present only near the river side. *Desmodium elegans*, *Wikstroemia canescens, Rabdosia rugosa, Deutzia compacta, Lonicera quinquelocularis, Sorbaria tomentosa, Cotoneaster microphyllus, Indigofera heterantha,* etc. represent the shrub layer. The common herbaceous species found are: *Anaphalis triplinervis, Echinops cornigerus, Salvia moorcroftiana, Poa annua, Mentha arvensis, Inula royleana, Campanula latifolia, Origanum vulgare, Phytolacca acinosa, Pimpinella acuminata,* etc.

1.5.6 Community Structure

In the stretch downstream of dam site the dominant trees are *Pinus wallichiana* and *Cedrus deodara* near the Nayagram village the tree density was 180 and 140 plants ha^{-1}, respectively (Table 2). Other common trees are *Alnus nepalensis, Salix karelinii, Lyonia ovalifolia, Aesculus indica* and *Pyrus pashia*.

Near the power house area tree strata was dominated by the *Quercus leucotrichophora* on the lower altitude and *Cedrus deodara* on higher altitude. The density and frequency of *Q. leucotrichophora* was 90 to 280 plants ha^{-1} and 35 to 80%, respectively. *Cedrus deodara* has density of 60 to 120 plants ha^{-1} and frequency 20 to 40%. The other tree species found in this area are *Alnus nepalensis, Pinus wallichiana, Engelhardtia spicata* and *Celtis australis*. Upper reaches of catchment of the Ravi river remain covered with snow. The areas immediately below the snowline are characterised by the grasslands and alpine pastures. The shaded areas from 2200 m to 3000 m, are mostly comprised of Moist Deodar, Mixed Coniferous and Kharsu Oak (*Quercus*

semecarpifolia) forest. The tree layer is dominated by *Cedrus deodara, Quercus semecarpifolia* and *Pinus wallichiana* followed by *Salix denticulata, Acer caesium, Populus ciliata*, etc.

Maximum numbers of plant species were rceorded at sites near dam site and herbaceous diversity was maximum at sites near powerhouse and at dam site (Figure 5). While the Importance Value Index (IVI) of *Cedrus deodara* was highest at site VII, *Quercus leucotrichophora* was most dominant at sites near powerhouse whereas *Q. semecarpifolia* was most dominant at a site in the catchment area. Amongst the shrubs Desmodium elegans was most dominat species at almost all the sampling sites.

The lowest species diversity was recorded from 500m upstream from the Dam site in catchment area i.e. 0.50 and the highest from down stream of the dam site near Deol village i.e. 1.78. The highest species diversity in shrubs was recorded from power house site (2.00) and the lowest was from 1 km upstream from the power house site (1.27), in catchment area it ranges from 1.73 to 1.84.

Table 2: Density of trees at different sampling sites

SITE	Location	Trees (No./ha)
Dam Site and Submergence Area		
Site I	Dam Site and Submergence Area	330
Site II	Near Nayagram village (1 km downstream of Dam site)	480
Site III	Near Deol village (5 km downstream of Dam site)	385
Power house Area		
Site IV	Power house Site (Left bank of Ravi River near Tayari village)	355
Site V	1 km upstream of Power house site	415
Site VI	500 m downstream of Power house site	420
Catchment Area		
Site VII	Near Urna village (500 m upstream of Dam site)	150
Site VIII	5 km upstream of Dam site	340
Site IX	Near Dharadi village (10 km upstream of Dam site)	390

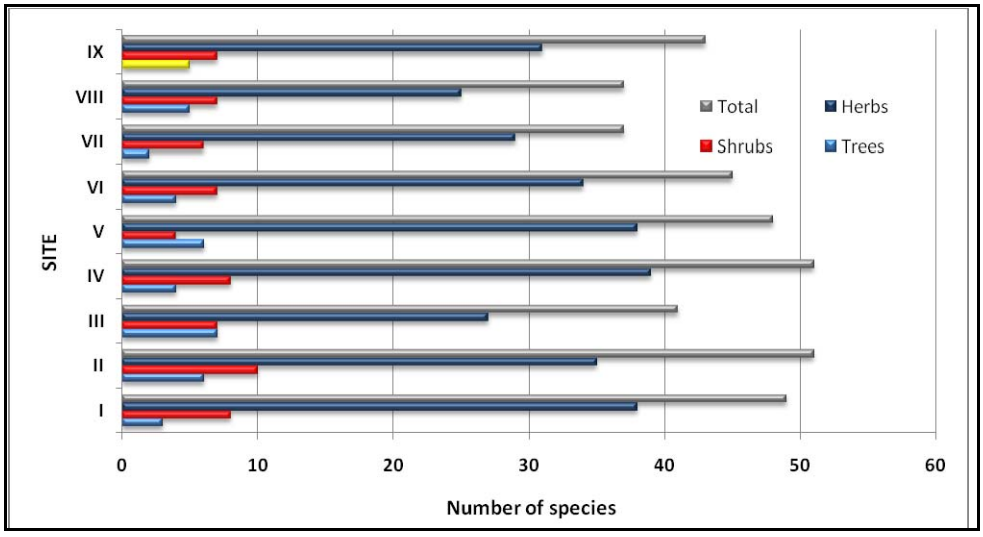

Figure 5: Number of plant species recorded at different locations

Evenness index ranged from 0.71 to 0.98 for trees, 0.84 to 0.97 for shrubs.

Perusal of the literature on the rare, endangered and threatened plants of India (Nayar & Sastry 1987-90) reveals that none of the species recorded within the project area falls under any of the Red Data Book (RDB) categories of Indian plants. However, *Delphinium uncinatum* (Ranunculaceae) is reported from a patch of *Quercus* - *Rhododendron* forest (ca. 1500 m) which has been listed under "Indeterminate" category of India's Red Data Book.

1.5.7 Faunal Elements

Mammals

The habitat areas of musk deer, snow leopard and Himalayan ibex overlap and no specific study on magnitude of overlapping area and altitude has been done systematically. Himalayan tahr, Musk deer, Ibex and Serow are restricted to the upper reaches of Ravi catchment (2,800 – 4,000m) and occupies the upper cold desert layer. *Naemorhaedus goral* (Goral) and *Muntiacus muntjak* (Barking deer) are most common ungulates in this region. These animals are distributed in the temperate to sub-alpine forests in elevations between 2,400 and 2,800m. Among the Primates, *Macaca mulatta* (Rhesus macaque) and *Presbytis entellus* (Langur) apart from other animals like squirrel, jackal, leopard and porcupine etc. are found to inhabit the same ecological niche from the lower parts to upper parts of the hills (1,400 - 3,400m). Further down to lower foothills layer comprises of squirrel, jackal, macaque, leopard and porcupine etc.

Mamalian species sighted during the field surveys are listed below in a table below.

Mammalian seasonal data				
Common name	**Scientific name**	**Pre Monsoon**	**Monsoon**	**Winter**
Himalayan tahr	*Hemitragus jemlahicus*	+	-	-
Rhesus macaque	*Macaca mulatta*	+	-	-
Serow	*Capricornis summatraensis*	+	-	-
Bonnet macaque	*Macaca radiata*	+	-	-
Himalayan langur	*Preshytis entellus*	+	-	-

The villagers of the study area practice hunting. As a tradition they used to hunt for wild animals in and around Dhauladhar Wildlife Sanctuary. Inspite of the strict vigil and tougher law being enforce hunting in small scale continues in this area (short communication with villagers).

Birds

Among all the faunal elements found in this area birds show the maximum diversity with a diversity index of 4.6 and species evenness index value of 0.96. A total of 122 species were observed and 356 individuals were recorded with species richness index of 122, this area is a paradise for avian fauna.

During the survey pre-monsoon data shows the highest sighting season with 82 species followed by monsoon with 57 species and post monsoon with 25 species respectively.

Reptiles

Among reptiles ery few species were sighted during all the three season survey. Due to the insufficient data no meaningful information could be retrieved except their presence in the study area. Kashmiri spotted Agama was recorded in all the three seasons both in the lower part of the project area (2000 m) and upper part towards the catchment area (3000 m).

Insects

All the entomofauna except butterflies sighted in this area during monsoon season were absent during the winter survey. This might be by the influence of chilled winter season weather which forces them to migrate and hibernate. Insects have a variety of methods for surviving the coldness of winter.

Butterflies

During the survey a total of 35 species with 108 total individuals were encountered of which two species could not be identified. Sighting was very good during the monsoon season survey than the other two survey seasons. Not a single species was recorded during pre monsoon, 30 species in monsoon

and 15 species in winter survey respectively. A diversity index of 3.469285 shows a good diversity of species.

1.5.8 Aquatic Ecology

To study various physico-chemical and biological characteristics of Ravi river, survey and sampling was carried out at 7 different sites in the proposed hydro-electric project study area.

Physico-chemical Characteristics

The pH at all sampling sites was observed to be slightly alkaline. The pH of the Ravi River ranges from 7.3 – 7.8. Dissolved oxygen in water depends on the temperature and concentration of various ions. It is important to aquatic fauna. Usually, it shows negative correlation with temperature. The dissolved oxygen of the river water ranges from 9.6 – 12.5 mg/l. It lowers during monsoon season when temperature was high. In the sampling sites of the proposed hydro – project, turbidity was not found in the samples. The maximum alkalinities were recorded during post monsoon season. Total alkalinity comprises of bicarbonates. River water is soft; total hardness ranged from 40 to 80 mg/l. The chloride concentration was ranges from 6 – 12 mg/l. The total dissolved solid ranges from 23 – 98 mg/l. During monsoon season, varying amount of phosphates washed from farm soils into nearby channels. The phosphate was not detected in the samples collected from various sites.

Biotic Characteristics

River water was rich in all biotic richness. Phybenthos were represented by 53 species which could be identified from different sampling sites of the proposed hydroelectric project. The density of phytobenthos ranges from 36 to 1342 individual/mm^2 at various sites. The density of phytobenthos was observed to be low in monsoon season due to highly turbulent water and turbidity, as compared to pre-monsoon and post-monsoon season. *Achnanthidium, Cocconeis, Cymbella, Gomphonema* and *Nitzschia* were the dominant genera and were present throughtout the year. In the diatom community *Achnantihidium biasolettiana, A. minutissima, Cocconeis placentula, Diatoma mesodon, Encyonema minutum, E. silisiacum, Gomphonema minutum, Reimeria sinuta and Synedra ulna* were pre-dominant at different sampling sites in all the three seasons*. Achnanthidium minutissima* is the most common fresh water diatom species in the world. Few species viz. *Cymbella australica, C. tumida, Frustulia weinholdii, Gomphonema angustum, G. parvulum* var. *elliptica, Navicula radiosafallex, N. symmetrica, Sinuta tabellaria* and *Tetracyclus rupestris* were found only at one site.

Macro–invertebrate fauna comprised of families Heptageniidae, Baetidae, Ephemerillidae, Leptophlebiidae, Hydropsychidae, Rhyacophilidae, Brachycentridae, Limnephilidae, Perlidae, Chironomidae, Rhagionidae and Polycentridae. During monsoon season, densities of macro-invertebrates were observed to be less as compared to pre-monsoon and post-monsoon. The density of macro–invertebrates ranges from 55 to 484 individual/m^2.

No serious stress was observed in this river. Among the biological characteristics, majority of the taxa were pollution intolerant. The abundance of pollution sensitive species such as *Achnanthidium minutissima* and *Reimeria sinuata* were recorded from all the sampling sites of the proposed hydro-electric project. *Achnanthidium minutissima*, a common diatom associated with scouring or extreme flows (Stevenson and Bahls, 1999). Pollution tolerant species, *Gomphonema parvulum* was also found but were present only in few sampling sites.

Coliforms were found to be absent at all the sampling sites. The presence of coliforms depends on the thickness of human population in the vicinity of the river and sewage outfall in the river system.

1.5.9 Fishes

A total of 13 fish species are known to inhabit the Ravi River. In addition to these a few species, viz. *Barilius* spp. and *Puntius* spp. are found in different brooks and khads of Ravi River. These fishes are known to perform local migration from these brooks to main channel, but do not undertake long migration. Two exotic species namely brown trout (*Salmo trutta fario*) and rainbow trout (*Salmo gairdnerii gairdneri*) have been introduced in the Ravi River. The rainbow trout propagation has become more successful as compared to that of brown trout. These species are more frequent and abundant in the upstream of dam. An indigenous species, snow trout (*Schizothorax plagiostomus*), is distributed abundantly with others below the proposed dam site. Some of the other species, which are found near the proposed dam site and upstream of Chamba, are *Labeo dero, Labeo dyocheilus, Garra lamta* and *Barilius bendelisis*. No migratory fish species were observed in this river during the course of investigation. Though, according to fishermen of the region mahseer (*Tor putitora*) occasionally comes in the fish catch of Ravi River near Chamba. However, this species is well distributed in the reservoir of Chamera H.E. Project Stage-I (downstream of Chamba) along with a few Indian major carp (*Labeo rohita, L.calbasu, Cirrhinus mrigala,* etc.). It is likely that mahseer may have ascended upstream from the reservoir area of the Chamera Stage-I H.E. project to Chamba region.

1.6 SOCIO-ECONOMIC STATUS IN THE AREA

The Bajoli Holi H.E. project is located on Ravi River in district Chamba with proposed dam near village Bajoli.

Majority of the project study area falls within Holi Sub-tehsil of Chamba district. The Chamba is the second largest (6,528 sq km) among the twelve districts of Himachal Pradesh and having the population of 4, 60,887 persons according to Census 2001. The sex-ratio is 959. The density of population in the district is 71 persons per sq km. It consists of 6 sub-divisions, 7 tehsils and 3 sub tehsils namely Bhaillai, Sihunta and Holi. There are 270 gram panchayats in the district. It has 6 development blocks. The population of Scheduled Castes and Scheduled Tribes are 92,359 and 1, 17,569 respectively. Total literacy rate in the district is 62.9% in which male has 76.4% and female has 48.8%.

Most of the study area of Bajoli Holi H.E. Project lies within the Sub-tehsil Holi, which covers an area of about 1793.30 sq km while only the upper catchment falls within Multhan sub-tehsil of Kangra district. Holi is the headquarters of the sub-tehsil and is located about 80 km away from Chamba town. The area is bounded by Chamba tehsil in west, sub-tehsil Multhan of district Kangra in east, tehsil Tisa in north-west and district Lahul and Spiti in northeast. Total number of villages in Bharmaur and Holi tehsils is 252 of which only 99 are inhabited villages comprising 6611 households.

Total population of Holi sub-tehsil is 14,514 which belong to 3,032 households. The population of Scheduled Castes (SC) and Scheduled Tribes (ST) is 2,500 and 10,880 respectively. The population in the age group of 0-6 years accounts 2,049. The sex ratio in sub-tehsil Holi is 929. Holi tehsil has population density of 13.82 persons/sq km.

There is only one Primary Health Centre located in the entire Holi sub-tehsil while there is one allopathic hospital each in the 2 sub-tehsils. ayurvedic and homeopathic hospitals. There are 7 Primary Health Sub Centers, only one Child Welfare Centre located in the village Kuarsi.

The literacy rate in sub-tehsil Holi is about 60.9%. In Multhan sub-tehsil it is 56.9% only.

Agriculture has traditionally been the major feature of Himachal Pradesh's economy. Besides this the economy of the villages in the area depends mainly on the government and non-government services. The major cash crops like paddy, maizes, rajmas, potato, apple, etc., are found in this area.

About 40% of the total population falls in the main workers category in the area. Marginal workers contribute 19% of the total work force, dominated by females. About 42% of the total population is in the non-worker category.

In the area, majority of houses are single storeyed, the roofs are sloping designed for the snowfall resistance and made of slates or shingles. The walls of houses are generally built of stone and wood. The timber mainly comprises of Toon, Kail and Deodar.

The socio-economic survey team visited the villages located in the project area and collected the data regarding public perception and awareness of the project. In general, people welcome the project as it will bring infrastructural development and progress in the area. Most of the respondents in the project area have a positive outlook towards the construction of the project. The educated youth in the area are looking forward to employment opportunities during construction and operation and hence have positive mindset about the development.

1.7 CDM BENEFITS

In the techno-economic evaluation, apart from the investment and technological risk Bajoli Holi H.E. Project is likely to face several barriers such as Government policies, regulatory risk and other externalities etc. and to overcome these barriers during project implementation and operation, GMR Bajoli Holi Hydro Power Pvt. Limited is conceptualizing the project under consideration as Clean Development Mechanism (**CDM**) project.

This project has a net potential to generate is **772643** MWh of power which results in emission reduction of approximately **620091** tCO_2 per year.

Looking at the present scenario, (one CER equivalent is traded around 12 Euros, in the carbon market and exchange rate Rs. 64/- per Euro), the Bajoli Holi H.E. Project shall generate revenue of about Rs. 47,62,29,876.00 (~ 48) Crores per year throughout the crediting period of 10 years.

1.8 IMPACTS

1.8.1 Impacts during Construction

Impacts due to Activities

Impacts due to migration of Construction Workers

At the time of peak construction work in the project, maximum of 350 persons may be engaged, most of these will be from the local population. Around 100

nos. of the work force, which will include technical, non-technical and service class, will come from outside. In the first and fifth year 60% of the peak force will be required and in the second to fourth years 80% of the peak force will be required

Based on these assumptions the peak migrant population has been calculated as 1282 persons which is expected to reside in the project area at any given time. Immigration of such a large population for a long duration in remote area can cause serious impact on various environmental resources including socio-economic profile of local population. The congregation of large number of construction workers during the peak construction phase is likely to create problems of sewage disposal, solid waste management, tree cutting to meet fuel requirement, etc. Appropriate mitigating measures have been suggested in EMP, which needs to be implemented to minimize such impacts.

Impacts due to Construction of Head Race Tunnel

Excavation of the head race tunnel up to the Power House complex will involve movement of vehicles, use of excavating equipment, explosives and other construction machinery. A primary impact of this construction will be placement of spoils removed from the tunnel. The clearing of the area and muck disposal will be source of impact. A total of **12.32 lakh cum** of muck will be generated from dam intake, diversion tunnel, HRT and Power House complex and, about 75% of this will be disposed off in muck dumping sites.

Impacts due to Quarrying Operations

Opening of the quarries will cause visual impacts because they remove a significant part of the hills. Other impacts will be the noise generated during aggregate acquisition through explosive and crushing, which could affect wildlife in the area, dust produced during the crushing operation to get the aggregates to the appropriate size and transport of the aggregates, and transport of materials. The total quantity of coarse aggregate required for concreting and masonry in the proposed dam is about **6.47 lakh cum**. To meet the requirement of coarse and fine aggregates for all components of the Bajoli Holi HE Project, one nos. *in situ* rock quarries, one nos slide material have been identified in the vicinity of the project. The quarry sites would lead to disturbance of 3.55 ha of forest land and 0.65 ha of private land.

Impacts due to Operation of Construction Plant and Equipment

During the construction phase, various types of equipment will be brought to the site and construction plants and repair workshops will be set up. These include crushers, batching plant, drillers, earth movers, rock bolters, etc. The siting of these construction equipments would require significant amount of

space. In addition, land will also be temporarily acquired, i.e. for the duration of project construction; for storage of the quarried material before crushing, crushed material, cement, rubble, etc.

Impacts due to Movement of Vehicles

During construction phase, there will be increased vehicular movement for transportation of various construction materials to the project site. Large quantity of dust is likely to be entrained due to movement of trucks and other heavy vehicles on unpaved road. Additionally, loose construction material loaded on trucks in open condition also adds to air pollution in the area. Movement of vehicles also generates noise. As the construction phase is large, substantial increase in traffic in otherwise calm area will have serious impacts on air and noise environment. Therefore, sufficient mitigation measures, as discussed in the EMP, would be required to be implemented to minimize the impact on health of the people living in the vicinity and laborers working in the project area.

Impacts due to Muck Disposal

About 12.32 lac cum of muck is expected to be generated as a result of construction of dam, head race tunnel, power house and other appurtenant works. The project proposes to utilize about 25% of the muck to be generated as construction material in various project structures. Therefore, most of the muck is proposed to be dumped at pre-identified locations.

Impacts due to Road Construction

The topography of the project area has steep slopes, which descend rapidly into narrow valleys. The conditions can give rise to erosion hazards due to downhill movement of soil aggregates. The project construction would entail significant vehicular movement for transportation of construction material and heavy construction equipment. Most of the roads in the project area would require widening apart from the new roads proposed to be constructed for this project.

Approximately 13.8 km of new roads are proposed to be constructed as a part of the proposed Bajoli Holi hydroelectric project. The major impacts likely to accrue as a result of construction of the roads are:

- Loss of forest and vegetation by cutting of trees
- Geological disturbance due to blasting, excavation, etc.
- Soil erosion as the slope cutting operation disturbs the natural slope and leads to land slips and landslides.
- Interruption of drainage and change in drainage pattern

- Disturbance of water resources with blasting and discriminate disposal of fuel and lubricants from road construction machinery
- Siltation of water channels/ reservoirs from excavated debris
- Effect on flora and fauna
- Air pollution due to dust from debris, road construction machinery, etc.

As discussed above, the major project activities will have impact of various degrees on different environmental resources and same is discussed in ensuing paragraphs resource-wise.

Impacts on Water Quality

The major sources of water pollution during project construction phase are as follows:

- Sewage from Construction work camps/colonies
- Effluent from Construction Plants and Workshops
- Disposal of muck

a) Sewage from Construction worker Camps

The project construction is likely to last for a period of 5 years. As mentioned earlier, about 910 workers and 300 technical staff are likely to work during project construction phase. Most of the employees/workers during construction phase are likely to be employed from outside the project area. The construction phase, also leads to mushrooming of various allied activities to meet the demand of immigrant Construction Worker population in the project area. Additionally drivers and labour associated with transportation of material will also stay in the area on temporary basis.

The domestic water requirement for the construction worker and the technical staff migrating into the project area is of the order of 141 cum/day @ 110 lpcd. Assuming that about 80% of the water supplied will be generated as wastewater/sewage. The BOD load contributed by domestic sources will be about 28 kg/ day, assuming 250 mg/l of BOD in wastewater.

b) Effluent from Construction Plants and Workshops

As discussed earlier, two major construction plants viz. aggregate processing and concrete mixing and two major repair workshops will be established, apart from minor workshops and other construction equipment. Water is used and in these construction plants and wastewater generated with high suspended solids. Similarly from workshops, major pollutant will be oil and grease. Discharge of untreated wastewater will have serious impact on water quality of receiving water body. Turbidity and oil & grease levels will increase

substantially in small tributaries, especially, in lean season. To minimize the impact, such effluent needs to be treated in situ before discharge to any water body or for land application.

c) Disposal of Muck

The major impact on the water quality arises when the muck is disposed along the river bank. The project authorities have identified suitable muck disposal sites which are located near the river channel. The muck will essentially come from the road-building activity, tunneling and other excavation works. The unsorted waste going into the river channel will greatly contribute to the turbidity of water continuously for long time periods. The high turbidity is known to reduce the photosynthetic efficiency of primary producers in the river and as a result, the biological productivity will be greatly reduced. Therefore, the prolonged turbid conditions would have negative impact on the aquatic life. Therefore, muck disposal has to be done in line with the Muck Disposal Plan given in EMP to avoid any negative impact.

Impact on Terrestrial Flora

The direct impact of construction activity for any water resource project in a mountainous terrain similar to that of proposed project is generally limited in the vicinity of the construction sites only. As mentioned earlier, a large population (1282) including technical staff, workers and other group of people are likely to congregate in the area during peak project construction phase. It can be assumed that the technical staff will be of higher economic status and will live in a more urbanized habitat, and will not use wood as fuel, if adequate alternate sources of fuel are provided. However, workers and other population groups residing in the area may use fuel wood, if no alternate fuel is provided. There will be an increase in population by about 1,282 of which about 1026 (80%) are expected to use fuel wood. On an average, the fuel wood requirements will be of the order of 1 kg per person per day. Therefore, for 1026 persons it works out to be 374,490 Kg/annum or 535 m^3 (taking average density of wood as 700 kg/m^3). The wood generated by cutting one tree is about 2.5-3.0 m^3. Thus, about 214 trees will be cut every year to meet the fuel wood requirements, which mean every year on an average about 0.60 ha of forest area (with average tree density of about 350 trees/ha) will be cleared for meeting fuel wood requirements, if no alternate sources of fuel are provided. Hence, to minimize such impacts, it is proposed to provide alternate fuel for cooking e.g. Kerosene, LPG to the construction workers. The other alternative is to provide community kitchens on a cooperative basis by the contractor. The details of the same have been covered in Environmental Management Plan.

Impact on Terrestrial Fauna

a) Disturbance to Wildlife

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

Forest cover in the vicinity of proposed project working sites and their immediate vicinity is comprised of open to dense forest at places to degraded scrub forest near the habitations. However no major wildlife population is found in the immediate vicinity of these sites due to encroachment and habitations in the influence zone. Only stray incidents of wildlife are reported from these areas. However the area has a good bird and butterflies population. Therefore adequate measures will be required during the construction phase not to cause any adverse impact on avifaunal and butterflies population. Blasting during construction may cause adverse impacts. Hence it is recommended that delayed blasting techniques as already stated above would be utilized to minimize the impact, as a result of noise and vibration generated due to blasting.

b) Impacts on Migratory Routes

The faunal species observed in the project area are not migratory in nature. The proposed submergence area is not the migratory route of wild animals. The construction of the proposed Bajoli Holi H.E. Project will form a reservoir of about 16.5 ha, which is also not reported to be on the migratory route of any major faunal species.

Impact on Aquatic Ecology

The physico-chemical and biological water quality of river Ravi in the project area is very good. The dissolved oxygen is high in the river. The reason for good quality can be ascribed to high water discharge, low temperature and absence of any industrial activity. Fecal contamination is below detectable limits.

Major sources of construction related impacts on water quality will be from erosion of the disturbed area required for the construction activities (construction sites, concrete batch plants, material storage areas, vehicle maintenance areas, disposal areas), from waste water discharge from the construction labour camps and from contaminated water (oil, grease, petro chemicals, cement and chemicals) resulting from various construction activities. The primary impact will be the potential for introducing sediments and pollutants to the adjacent river body during the period of construction, thereby affecting aquatic habitats, fishes and water source for residents and wildlife downstream of the construction areas.

a) Impacts due to excavation of construction material from river bed

During construction phase, a large quantity of construction material like stones, pebbles, gravel and sand would be needed. Significant amount of material is available in the river bed just downstream of dam. It is proposed to extract construction material from the river bed. The extraction of construction material may affect the river water quality due to increase in the turbidity levels. This is mainly because the dredged material gets released during one or all the operations mentioned below:

- Excavation of material from the river bed.
- Loss of material during transport to the surface
- Overflow from the dredger while loading
- Loss of material from the dredger during transportation.

The cumulative impact of all the above operations is increase in turbidity levels. Good dredging practices can however, minimize turbidity. It has also been observed that slope collapse is the major factor responsible for increase in the turbidity levels. If the depth of cut is too high, there is possibility of slope collapse, which releases a sediment cloud. This will further move outside the suction radius of dredged head.

The dredging and deposition of dredged material may affect the survival and propagation of benthic organisms. The macro-benthic life which remains

attached to the stones, boulders etc. gets dislodged and is carried away downstream by turbulent flow. The areas from where construction material is excavated, benthic fauna get destroyed. In due course of time, however, the area gets decolonized, with fresh benthic fauna. The density and diversity of benthic fauna will however, be less as compared with the pre-dredging levels.

The second important impact is on the spawning areas of fishes. Almost all the cold water fish breed in the flowing waters. The spawning areas of these fish species are found amongst pebbles, gravel, sand etc. The eggs are sticky in nature and remain embedded in the gravel and subsequently hatched. Any disturbance of stream bottom will result in adverse impacts on fish eggs. Even increase in fine solids beyond 25 ppm will result in deposition of silt over the eggs, which would result in asphyxiation of developing embryo and also choking of gills of young newly emerged fry. Thus, if adequate precautions during dredging operations are not undertaken, then significant adverse impacts on aquatic ecology are anticipated.

b) Impacts due to discharge of sewage from Construction Worker camp/colony

The proposed hydro-power project would envisage construction of temporary and permanent residential colonies to accommodate Construction Worker and staff engaged in the project. This would result in discharge of sewage which is usually discharged into the nearby water body. However, to avoid negative impact on the receiving water, it is proposed to treat the domestic sewage before its disposal in to the river. Septic tanks have been proposed and overflow will go to soak pits to avoid any pollution of river. Therefore, no adverse impacts on water quality are anticipated due to discharge of sewage from Construction worker camp/colony, as long as wastewater is treated.

c) Impacts due to human activities

Accumulation of Construction Work force in the project area might results in enhancement in indiscriminate fishing including use of explosives. The use of explosive material to kill fishes in the river in the project area would result in complete loss of fishes and other aquatic life making river stretch completely barren. Indiscriminate fishing will reduce fish stock availability for commercial and sport fishermen. These aspects have been adequately covered in the Environmental Management Plan (EMP) report.

Impact on Noise Environment

Sources of noise will be the vehicles and equipment for excavation and stationary equipment, including concrete batch plant located at the construction sites. Other sources of noise will be the use of explosives for

blasting purposes for construction activities, drilling machines and quarrying and crushing activities.

a) Noise due to Construction Equipment

Under the worst case scenario, considered for prediction of noise levels during construction phase, it has been assumed that all these equipment generate noise from a common point. The increase in noise levels due to operation of the different construction equipment has been worked out. However, such noise levels will only affect the operators and construction workers only who will be in the vicinity of the noise generating equipment and they should always be using PPEs to ward off any negative impact due to exposure to high noise levels. As the distance from the source increases the noise levels decrease by 6 dB(A) for every doubling of distance in the absence of any noise barrier. Additionally, there is a reduction in noise level as the sound wave passes through a barrier.

b) Noise Generated due to Drilling:

After the adoption of the norms of Occupational Safety and Health Administration (OSHA) for construction phase of the proposed project the increased noise levels due to drilling are not expected to adversely affect the workers operating the drill or involved in other mining activities closely.

c) Noise Generated due to Blasting

It is expected that noise level due to blasting operations are expected to be of the order of 75-86 dB(A). Since, the nearest settlement is at least 1 km away, the incremental noise due to blasting is expected to be 50-60 dB(A). As the blasting is likely to last for 4 to 5 seconds depending on the charge, noise levels over this time would be instantaneous and short in duration. Considering attenuation due to various sources, even the instantaneous increase in noise level is not expected to be more than 60 dB(A). Hence, noise level due to blasting is not expected to cause any significant adverse impact.

i) Impacts due to Ground Vibrations:

The explosive energy generated during blasting sets up a seismic wave within the surface, which may affect the structures and cause discomfort to human population. When an explosive charge is fired in a hole, stress waves traverse in various directions, causing the rock particles to oscillate. Blasting also generates ground vibrations and instantaneous noise.

Noise in and around the construction site will likely affect the wildlife and residents in the nearby areas. Wildlife in the area will likely to move away from the noise and eventually return to the area when construction is

complete. However, there is no major wildlife observed in and around the construction site and hence this may not be a significant issue.

Impact on Air Quality

Vehicles and stationary equipment will impact air quality at the construction site through emissions from the engines and equipment, fugitive emissions due to material handling, etc. Additionally quarry site activities including operation of crushers, concrete batch plants, construction work and movement of vehicles along unpaved road will generate dust & gaseous emission and impact air quality. The burning of waste will also affect air quality. In absence of proper fuel, construction workers at the project site may use wood for fuel burning.

The following impacts are envisaged on air quality:

i. Pollution due to fuel combustion in various equipments
ii. Emissions from various crushers and other construction plants
iii. Fugitive Emissions from material handling and transportation

Impact on Socio-economic Environment

A project of this magnitude is likely to entail both positive as well as negative impacts on the socio-cultural fabric of area.

Positive Impacts on Socio-Economic Environment

The following positive impacts are anticipated on the socio-economic environment of the local people of villages of project area during the project construction and operation phases:

i) A number of marginal activities and jobs would be available to the locals in the project improves the job opportunities during construction phase.
ii) Developer bringing large scale investment to the area will also invest in local area development and benefit will be reaped by locals. Education, medical, transportation, road network and other infrastructure will improve.
iii) The availability of electricity to the rural areas will reduce the dependence of the locals on alternative energy sources namely forest.
iv) With increased availability of electricity, small-scale and cottage industries are likely to come up in the area.
v) The proposed project site is well connected by road. Efforts to be made to develop eco-tourism, which could earn additional revenue.

a) Negative Impacts on Socio-Economic Environment

There are certain negative impacts due to influx of outside population. Workforce will reside in that area for around five years and also there will be large influx of drivers and other workers on temporary basis. This influx of people in otherwise isolated area may lead to various social and cultural conflicts during the construction stage. Developers need to take help of local leaders, Panchayat and NGOs to ensure minimum impact on this count.

b) Water Related Diseases

The construction of a reservoir will convert the riverine ecosystem into lacustrine ecosystem. The vectors of various diseases breed in shallow water areas not very far from the reservoir margins. The magnitude of breeding sites for mosquitoes and other vectors in the impounded water is in direct proportion to the length of the shoreline. The construction of the reservoir would increase the shoreline by many times as compared to the pre-project shoreline of river Ravi under submergence. Thus, the construction of the proposed reservoir would enhance the potential breeding sites for various diseases vectors. There are chances that incidence of malaria may increase as a result of the construction and operation of the proposed project. In addition to the construction of the reservoir, the following factors too would lead to the increased incidence of malaria in and around the project area:

- aggregation of Construction Worker
- excavation,
- inadequate facilities in Construction Workers camp, and
- HIV/AIDS Risk Level

Indirect and Cumulative Impacts on Natural Resources

The improved year round access to the whole project area from new and upgraded roads will enable people to settle in the area. Use of the improved access will enable movement from one area to another. This translates into the development of roadside villages, and a potential increased pressure on the natural resources in the vicinity of the roads. The increased pressure will include uncontrolled logging, hunting, and fishing, wildlife and non-timber forest product collection, livestock husbandry, the shifting cultivation in forest areas and forest fires. These impacts are expected during the economic development of the Ravi basin, and are expected to be managed by the basin level catchment area treatment plan, and the proposed Environmental Master Plan for the state.

1.8.2 Impacts during Operation Phase

Impact on Water Resources

a) Impact of reduction in downstream flow

The construction of dam and diversion of water to HRT for power generation would lead to the reduction in water discharge in the river stretch downstream of dam up to tail race discharge from power house near Kee Nala. There are 34 villages which are located on the downstream of the dam till the proposed Power House of Bajoli Holi H.E. Project. Most of these villages are located at a distance of more than 2-3 km away from the main Ravi river. Only 3 villages namely Nayagram, Jhikri and Bajol are located within 500m of Ravi river. None of these villages are directly dependent upon Ravi river for their water use requirement. They all either have water supply connection to use tap water for their drinking purposes and other daily needs. Additionally, all the villages also use stream water for drinking and agriculture.

During the field surveys following observations were made:

i) There are no fishermen as fishing is allowed only on the basis of licence @ Rs 100/day.
ii) None of the villages use the river water for irrigation purpose they usually depend on rain water for the crops. People are looking forward to Sprinkler method for irrigation purpose being introduced by Government of Himachal Pradesh
iii) Most of the Shepherd's move to higher reaches with their livestock and stay there for days together for grazing of livestock and the livestock is dependent on stream water only.
iv) Some of the villages use river for cremation of dead bodies on its banks.

In view of the above observations, no significant impact is foreseen downstream of the dam on the water requirement of the people living in this stretch. However, adequate arrangements are being made to address the issue of water required for cremation and bathing in the Environmental Management Plan.

b) Minimum Environmental flow Requirement

As per the notification no. MPP-F(2)-16/2008 of Department of MPP and Power, Government of Himachal Pradesh, the ROR projects shall ensure minimum flow of 15% water immediately downstream of the diversion structure of the project throughout the year. For the purpose of determination of minimum discharge, the average discharge in the lean

months i.e. from December to February shall be considered. The developer is committed to provide this minimum discharge at all times on account of ecology and environment and to address issues concerning riparian rights, drinking water, health, aquatic life, wildlife, fisheries, silt and even to honor the sensitive religious issues like cremation and other religious rites, etc. on the river banks.

i) Estimation of Lean Season Flows in downstream reach

There are 9 streams that drain into Ravi River between dam and power house stretch of the river. As the water discharge for 90% dependable year is 8.9 cumec, a mandatory release of 1.335 cumec is required to be made during the lean season to sustain the essential aquatic ecological functions of the river. Under the worst case scenario only 1.335 cumec will be available immediately downstream of dam during lean season. It would be augmented by contribution from 4 small streams that join Ravi on both banks within a distance of about 4km. However, Kurhed Nala contributes significantly to the flow where the cumulative discharge becomes 2.75 cumec. Therefore it is first 5-6 km during operation of the project that will become comparatively dry in the lean season. However as stated above this being the worst case scenario i.e. taking into account flow of 90% dependable year that too the minimum flows that were recorded in certain years.

In actual scenario the average of average discharge over the period of time is higher than the lean season in Ravi River and its small tributaries as well. Therefore the impact of reduced flow may not as significant as envisaged under worst case scenario. Notwithstanding the impact of reduced flow, the project developer is required to compensate for the reduced flow and impact on aquatic ecosystem by the Fisheries Department also.

c) Impact on Water Quality

The self purifying capability of running water is directly related to its current velocity and water discharge. The regulated flow results in alteration of ecological characteristics including its purifying capacity. The creation of a reservoir would lead to desiltation, therefore, water in the downstream section would be less turbid with much lower water current velocity as compared to the normal velocity. The shallowness of the water in this section during the lean season would also lead to increase the water temperature, thereby affecting the dissolved oxygen contents adversely. Dilution of organic pollutants, if any, also decreases and results in increase in concentration of pollutants in the river channel.

Due to decrease in the discharge and change in water quality, the population of microorganisms will be affected. Algae like *Achnanthidium minutissima*, which is characteristic of fast flowing and clean river water, would be affected due to decreased discharge. The species like *Synedra ulna* and *Nitzschia* sp. will become abundant in the stretch between dam site and powerhouse site as these species prefer shallow waters.

i) Effluent from Project Colony

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 treatment plant and other infrastructural facilities, the problems of water pollution due to disposal of sewage are not anticipated. The treated sewage will be reused for gardening and green belt around the colony.

ii) Impacts on Reservoir Water Quality

The flooding of previously forest and agricultural land in the submergence area will increase the availability of nutrients resulting from decomposition of the vegetative matter. Phytoplankton productivity can supersaturate the euphotic zone with oxygen before contributing to the accommodation of organic matter in the sediments. Enrichment of impounded water with organic and inorganic nutrients will be the main water quality problem immediately on commencement of the operation. However, this phenomenon is likely to last for a short duration of few years from the filling up of the reservoir.

iii) Eutrophication Risks

Another significant impact observed in the reservoir is the problem of eutrophication which occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. The fertilizer use in the project area is negligible, hence, runoff at present does not contain significant amount of nutrients. Even in the post-project phase, the use of fertilizers in the project catchment area is not expected to rise significantly. Thus, in the post-project phase, problems of eutrophication, which is primarily caused by enrichment of nutrients in water, are not anticipated.

Terrestrial Fauna

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. Since

significant wildlife population is not found in the region, no major adverse impacts are anticipated on this account.

Aquatic Ecology

a) Impacts due to damming of river

The damming of river Ravi near village Nayagram will result in creation of 16.5 ha of submergence area. The dam will change the fast flowing river to a quiescent lacustrine environment. The creation of a pond will bring about a number of alterations in physical, abiotic and biotic parameters both in upstream and downstream directions of the proposed dam site. The micro and macro benthic biota is likely to be most severely affected as a result of the proposed project.

The positive impact of the project will be the formation of a water body which can be used for fish stocks on commercial basis to meet the protein requirement of region. The commercial fishing in the proposed reservoir would be successful, provided all tree stumps and other undesirable objects are removed before submergence. The existence of tree stumps and other objects will hinder the operation of deep water nets. The nets will get entangled in the tree stumps and may be damaged.

The reduction in flow rate of river Ravi especially during lean period is likely to increase turbidity levels downstream of the dam. Further reduction in rate of flow may even create condition of semi-dessication in certain stretches of the river. This would result in loss of fish life by poaching. Hence, it is essential to maintain minimum 15% flow required for sustenance of riverine fisheries.

b) Impacts on migratory fish species

The obstruction created by the dam would hinder the migration of certain commercial species especially *Schizothorax* sp. These fishes undertake annual migration for feeding and breeding. Therefore, fish migration path may be obstructed due to high dam and fishes are expected to congregate below the dam wall. Under this situation poaching activities may increase in the area.

Most of the species will shift to the section of the river where they find favorable environment for breeding since the dam is 66m high, the construction of fish ladder is not feasible in the proposed dam. However, it is proposed that the artificial seed production in hatchery may be adopted which can be stocked in the river stretches downstream and upstream of the proposed dam.

The *Schizothorax* species are steno-thermal. During winter months, they migrate from headwaters to flood plains in search of suitable feeding and breeding grounds. The sampling in river Ravi both on upstream and downstream of the proposed dam site for macro-benthic life gave 2 units/sq m of fry of *Schizothorax* sp. This observation further strengthens the fact that *Schizothorax* sp. migrates during winter months. With the onset of summer season, these species migrate upstream. These species during project construction phase are likely to congregate in the reservoir. It is expected that in due course of time these species will adapt themselves to the changed habitat.

1.9 ENVIRONMENTAL MANGEMENT PLAN

Adequate measures have been recommended as a part of Environmental Management Plan to mitigate these impacts.

1.9.1 Biodiversity Conservation & Mangement Plan

During the construction period various activities like road construction, blasting, excavation for tunnels, quarrying, dumping of excavated material and human population pressure on land and biological resources are likely to exert pressure on the biological resources of the region.

Keeping in view of above impacts a biodiversity conservation and management plan has been proposed for Bajoli Holi H.E. Project. The main objectives of said plan are as follows:

i) Maintenance of ecological balance through preservation and restoration of wherever it has been disturbed due to project developmental activities,
ii) Conservation and preservation of natural habitats in catchment area
iii) Rehabilitation of critical species (endangered, rare and threatened species), if any with provisions for *in-situ* or *ex-situ* conservation of critical/ important plant/ animal species,
iv) Mitigation and control of project induced biotic and/or abiotic pressures/influences that may affect the natural habitats,
v) Habitat enhancement in project catchment area by taking up afforestation and soil conservation measures,
vi) Creating all round awareness regarding conservation and ensuring people's participation in the conservation efforts and minimizing man animal conflict.

It is proposed that the project authorities will provide funds to the tune of **Rs. 206.25 lacs** as outlined in the table below for the conservation works over a period of five years.

Particulars	Amount (Rs. in lacs)
Establishment of Botanical Garden	82.30
Noise Mitigation & Management	20.00
Habitat improvement (30 ha) - (Cost covered under CAT)	
Afforestation - 18 ha	
Pasture Development - 10 ha	
Nursery Development - 2 ha	
Habitat improvement for Wildlife	11.95
Medicinal Plants Cultivation and Conservation: 1 no. of herbal garden in 10 ha	5.00
Eco-Development Works	
Compensation	5.00
Publicity & Awareness	5.00
Observance of Wildlife Week, Nature Club & Website development	10.00
Anti-poaching measures	
Engagement of part-time informers & Engagement of contractual staff	5.00
Purchase of anti-poaching kits	2.00
Construction of watch towers & qtrs	15.00
Purchase of survey equipment, vehicle & communication system	15.00
Construction of check posts	5.00
Miscellaneous expenditure @Rs.5.00 lakh per year for 5 years	25.00
Total (Rs. in lacs)	**206.25**

1.9.2 Catchment Area Treatment (CAT) Plan

The catchment area treatment plan involves:

- Understanding of the erosion characteristics of the terrain and,
- Suggesting remedial measures to reduce the erosion rate.

In the present report, CAT Plan as per the slope, land use pattern, soil characteristics has been suggested based on the prioritization of sub watersheds using SYI method. The CAT plan has been suggested for Sub-watersheds with very high and high erosion categories as the cost for treatment for such watersheds out of 15 sub-watersheds in the free draining catchment is to be borne by the project proponents.

The cost required for Catchment Area Treatment is **Rs. 2742.40** lacs. Provision of 10% per year to offset inflationary trends has been kept in costing. However as per Government of Himachal Pradesh notification, an amount of **Rs. 4509.96 lacs** has been earmarked for CAT implementation.

1.9.3 Fisheries Conservation & Management Plan

Fish management program should be undertaken by project developer in consultation with the Fisheries Department, Government of Himachal Pradesh. In this connection Government of Himachal Pradesh published a policy/ norm for hydro power projects as follows: "In case of macro projects being envisagesd on the run of river development, the Department of Fisheries will charge compensation @ Rs. 0.50 lacs per MW power capacity and Rs. 0.50 lacs per km from tail race to weir of the project".

For the setting up of fish farms infrastructure and its maintenance, budgetary provision of **Rs. 53.75 lacs** has been made.

The total cost of implementation of Fisheries Conservation and Management Plan will be **Rs. 153.75 lacs** including payment of compensation.

1.9.4 Solid Wastes Mangement

Solid waste generated from temporary and permanent colonies in construction as well as operation phase requires special management to dispose off as warranted under the Municipal Solid Wastes (Management and Handling) Rules 2000. For that an efficient waste management system will be required to put in place to keep the environment of the region clean and healthy.

The total budget in order to manage the solid waste generated from this population, provisions for community toilets for labours and nearby villagers as well as septic tanks and soak pits, has been proposed to **Rs. 120.00 lacs.**

1.9.5 Public Health Delivery System

The medical facilities available to the villages in the project area are very poor. Present medical facilities in Holi sub-tehsil is one ayurvedic dispensary, one community health centre (Holi), one primary health center, 7 primary health sub-centers and single child welfare unit. Nearest hospital is located in Chamba town located at a distance of 80 km from Holi. The villages are sparsely populated and scattered far and wide and many of the villages are not covered by the primary health care units. None of the PHCs are provided with ambulance and the drugs stocked in these health centers are grossly

inadequate. Budgetary estimates for public health delivery system have been worked out as **Rs. 70.00 lacs.**

1.9.6 Energy Conservation Measures

During construction phase of the project, migration of labour, road development, etc. will be carried out. It is the general tendency that the migrant labourers will use forest wood for the fuel purpose, creating biotic pressure on the nearby forest. A total grant of **Rs. 18.00 lacs** has been assigned towards the provision of kitchen fuel, and other facilities including establishment of community kitchen or canteens for the migrant workers.

1.9.7 Muck Disposal Plan

Due to construction of various project components, total quantity/volume of material (muck) to be dug out or excavated is estimated to be **12.32 lakh cubic meters** including the 0.4 swelling factor. However more than 25% of muck generated from underground works will be utilized for different project construction works. The balance excavated material (muck) will be rehabilitated in pre-identified dumping sites. Most of the muck disposal sites have been identified nearer to the muck generation locations in order to minimize the cost of transport and mitigation of dust pollution which may occur during transportation. These proposed locations are spread over land area of **26.13** ha.

Total cost of engineering as well as biological measures for muck disposal will be **Rs. 1016.23 lacs.**

1.9.8 Landscaping & Restoration Plan

During construction phase of the project, number of temporary construction sites and working areas will come up. In addition mining for construction material will also be carried out. To restore these areas to its original landscape as much as possible and retain its aesthetic values following restoration measures have been suggested. In addition avenue plantations around the colonies and working sites will be carried out.

The estimated cost for the restoration works and landscape designing would be **Rs. 97.00 lacs.**

1.9.9 Air & Water Management Plan

During construction phase, the activities like site preparation, approach roads, excavation, drilling, blasting, foundation, tunneling, deployment of machinery, erection, transportation, dumping will be taken up. Tunneling and foundation works will involve land excavation, affecting environment by noise and dust

pollution. Structural work, deployment of machinery, approach roads construction and erection work will also result in dust, noise pollution and vehicular traffic. Material handling and transportation would also lead to significant increase in air and noise pollution. Muck generation, its transportation and disposal may pollute surface water due to the generation of large quantities of suspended particulate matter. Wastewater from labor camps and colonies may also pollute water bodies in the area.

Some of the measures suggested have already been covered under other heads of environmental management; therefore, an estimate of only additional cost is **Rs. 85.00 lacs**.

1.9.10 Green Belt Development Plan

A green belt around the reservoir periphery, road side and office complex/colony area will be created to avoid erosion of soil, prevention of land slips, minimize the air pollution and noise pollution in the project area. Development of green belt not only minimizes these impacts but also improves the aesthetic environment of the region. For the creation of green belt around the reservoir sufficient financial provision has been made by the project authorities. Plantations would be carried out around reservoir, roads as well as areas in colonies and construction sites. The estimated cost of plantations as well as maintenance for 5 years will be **Rs. 9.28 lacs**.

1.9.11 Reservoir Rim Treatment Plan

There is a accumulated debris mass which is located in the upstream of dam site in the reservoir area just above FRL of the reservoir but it is located much upstream of any of the appurtenants of the project. To stabilize the debris accumulation above the FRL, a toe wall with drainage holes will be constructed above the FRL as a part of Reservoir Rim Treatment Plan.

1.9.12 Compensatory Afforestation Plan

The total land required for the construction of Bajoli Holi H.E. Project activities is approximately 93.92 ha with a component of 82.51 ha of forestland including the horticulture land. Out of which, 46.46 ha land will be permanently acquired (excluding the horticulture land 0.9 Ha), 22.55 ha land taken on lease and 12.6 ha will be utilized for underground works

As per the guidelines of Forest Conservation Act 1980 block plantation is to be taken up two times of the land diversion (69.01 ha x 2 = 138.02 ha). So that the compensatory afforestation to be taken up on 138.02 ha on forestland in the denuded or degraded forest areas, it is also proposed to have avenue plantation along the proposed roads with iron guard fencing work around the

new plantation with angle iron in the diverted land to maintain the ecological balance of the areas. The estimated cost of Compensatory Afforestation programme shall be **Rs. 104.87 lacs.**

The Hon'ble Supreme Court of India has made it mandatory vide its order dated 28.03.2008 for the user agency to compensate for the diversion of forest land for non-forest use for developmental activities on the recommendations of Central Empowered Committee (CEC) to make payment of **Net Present Value (NPV)** of such diverted land so as to utilize this for getting back in the long run which are lost by such diversion. The total cost of NPV for this project has been computed as **Rs. 746.32 lacs**.

1.9.13 Dam Break Modeling & Disaster Management Plan

Dam break may be summarised as the partial or catastrophic failure of a dam leading to the uncontrolled release of water. Although, the probability of dam failure is very low, the same have been addressed through computer simulation modeling. The problem of simulating the failure of Bajoli Holi H.E. Project is considered, by computing the outflow hydrograph from the breached dam and routing this hydrograph along the downstream channel using dynamic routing technique to obtain the maximum water level marks reached during the passage of flood wave.

The model computes maximum flood elevation at each original or interpolated cross-section. In present case, the cross-sections used are up to 35 km d/s of dam i.e. till confluence of Tundah Nalla with Ravi River. An inundation map depicting the d/s areas vulnerable to inundation by the dam break flood has been generated. In case of dam break, even under worst case scenario, though there would be inundation of lower areas however, there is no settlement.

A disaster management plan has also been prepared to address all the critical issues related to emergency management in case of dam failure, such as:

- Surveillance and Monitoring Program
- Emergency Action Plan
- Administrative and Procedural Aspects
- Preventive Action
- Communication System
- Evacuation Plans
- Notifications

The estimated total cost of execution of disaster management plan including the equipment would be **Rs. 92.00 lacs.**

1.9.14 Rehabilitation & Resettlemt Plan

For the development of Bajoli Holi H.E. project land would be acquired for the construction of various project components like dam, reservoir, head race tunnel, surge shaft, penstock, power house and for office and labour colonies, quarrying, magazine, batching plants, muck dumping sites, etc. For this purpose land is likely to be acquired on permanent as well as on temporary lease basis. Major part of the land is a forest land (82.51 ha) while private land requirement is 11.41 ha only and the total land required is 93.92 ha.

Table 3: Land Requirement for Bajoli Holi H.E. Project

S.No.	Classification of required Land	Area (ha)
1.	**Forest Land**	
a	Permanent Requirement (excluding horticulture)	46.46
b	Temporary Requirement/ Lease for construction Facility	22.55
c	Area for Underground Works	12.60
	Total Forest Land	**81.61**
2.	Horticulture land (Nursery & apple Garden)	0.90
	Total Horticulture Land	**0.90**
3.	**Private land**	
a	Permanent Requirement	5.25
b	Temporary Requirement/ Lease for construction Facility	6.16
	Total Private Land	**11.41**
	Grand Total Land	**93.92**

In all there are 262 PAFs whose land is likely to be acquired permanently by the project proponent and 2 PAFs whose land as well as homestead are acquired for the project construction.

A total of 4 Panchayats (11 villages) are likely to be affected due to acquisition of land for various components of proposed Bajoli Holi H.E. Project.

The financial requirement for implementation of the Resettlement and Rehabilitation plan as per National Rehabilitation & Resettlenet Poliyc, 2007 will be Rs. **561.14 lacs.**

1.9.15 Environmental Monitoring Programme

Based on the findings of the Environmental Impact Assessment study, various Environmental Management Plans *viz*. Catchment Area Treatment, Biodiversity Conservation & Management, Public Health Delivery System, Fisheries Development, Relocation & Rehabilitation of Dumping Sites, Landscaping and Restoration of Construction Area, Creation of Green Belt, etc. have been proposed. In order to monitor the impact and efficacy of these plans a number of parameters have been proposed during and after the completion of the management plans.

1.9.16 Cost Estimates of EMP

An amount of **Rs.11346.24 lacs** has been allocated for the implementation of different environmental management plans. The summary of total cost estimates for the execution of different plans is given in table below.

Cost estimates for the implementation of various measures under EMP

S. No.	Management Plan	Amount (Rs. in lacs)
1	Biodiversity Conservation & Management Plan	206.25
2	Catchment Area Treatment Plan@ 2.5% of Project Cost (Rs. Actual cost is Rs.2740.42 lacs)	4509.96
3	Fisheries Conservation & Management Plan	153.75
4	Solid Waste Management Plan	120.00
5	Public Health Delivery System	70.00
6	Energy Conservation Measures	18.00
7	Muck Disposal Plan	1016.23
8	Landscaping & Restoration of Quarry & Construction Areas	97.00
9	Air & Water Hazard Mitigation Plan during Construction	85.00
10	Green Belt Development Plan	9.28
11	Reservoir Rim Treatment Plan	4.67
12	Compensatory Afforestation Plan	104.87
13	Disaster Management Plan	92.00
14	Rehabilitation & Resettlement Plan	561.14
15	Environmental Monitoring Programme	95.80
16	Cost of Trees	750.00
17	NPV	746.32
18	LADF @ 1.5% of Project Cost	2705.98
TOTAL		**11346.24**

Annexure – I

General layout map of Bajoli Holi H.E. Project