EXECUTIVE SUMMARY

1. INTRODUCTION

1.1. GENERAL

Mago Chu HEP is located in Tawang district of Arunachal Pradesh and envisages utilization of the waters of the Mago Chu, a tributary of Tawang Chu, for power generation in a run of river type development harnessing a gross head of 199.68m at FRL. The project with a proposed installation of 96 MW (3 x 32 MW) would afford an Design energy generation of 404.42 GWh in a 90% dependable year. The tariff from the project at present day cost with 13 % free power to the state would be Rs.4.98 (levellised).

The Barrage site is located at latitude 27°37'42.3" North and longitude 92°02'32.7" East approx. 3.1 km upstream of Confluence of Mago Chu & Nyukcharong Chu. Nearest town is Jang. Presently Barrage site can be approached from Jang through jeepable road by travelling a distance of approx. 12 Km upto the confluence of Mago Chu & Nyukcharong Chu and thereafter 3.1 km upto the Barrage site. The Power House site is located on the right flank of Mago Chu about 200 m upstream of the confluence of Mago Chu & Nyukcharong Chu. Jang is about 248 km from Bhalukpong which is approx. 105 km from Nagaon (nearest broadgauge rail link). The nearest airport is located at Guwahati in Assam.

The project was allotted to SEW in the following terms:

- SEW shall provide royalty in form of free power to GoArP @ 12% of free power.
- An additional free power of 1% is earmarked for local area development fund
- Agreement period is 35 years after scheduled Commercial Date of operation

Jayaprakash N.,
Business Associate

SEW MAGO CHU POWER CORPORATION LTD
Date
JANG A.P

Figure 1-1 Pro ect location in India

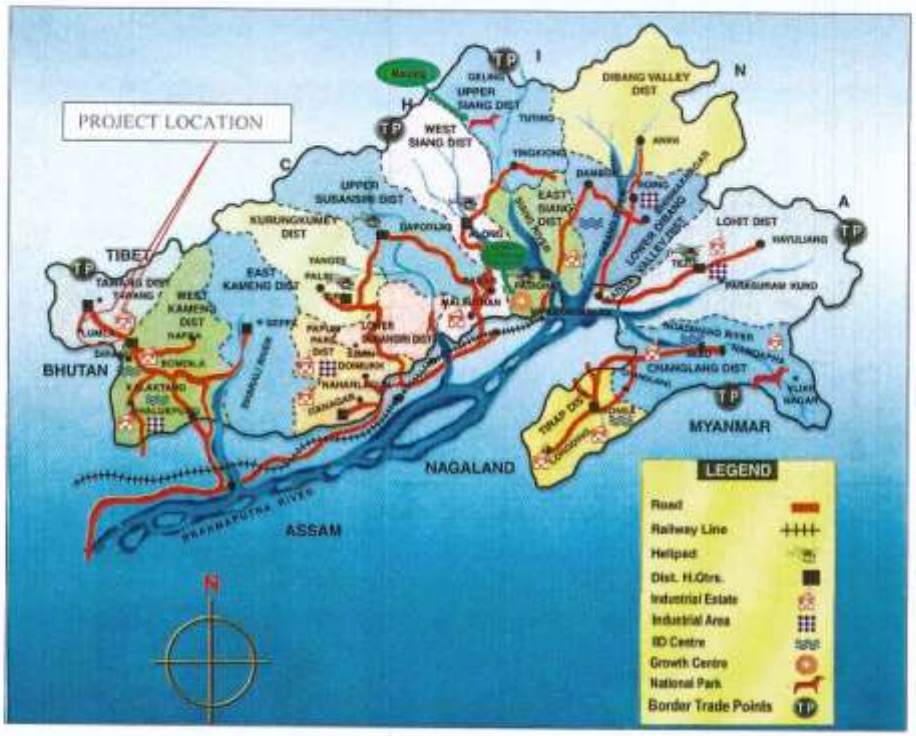

Figure 1-2 Basin location in Arunachal Pradesh

1.2. PREVIOUS STUDIES OF THE PROJECT

Pre-feasibility studies, followed by studies for preparation of Detailed Project Report for Mago Chu project have been undertaken by SMEC. The initial layout proposed by the SMEC included construction of a diversion dam across the River Mago Chu about 2.7 km upstream of confluence of Mago Chu with Nyukcharong Chu, a 2.773 km long Head Race Tunnel (HRT) aligned on the right bank of the river and an underground powerhouse 200 m upstream of confluence of Mago Chu with Nyukcharong Chu near the village Rho. The diversion site was not considered suitable for a concrete dam due to non-availability of bedrock even at 31 m depth and presence of sand layer in the river bed. Keeping the above constraints in view, another alternative site for Barrage located about 420 m upstream of the above Dam axis was selected and explored. The explorations carried out by SEW indicated that deep overburden exists in the river bed. Therefore, it was concluded that a low height Barrage will be suitable as diversion structure.

The HRT alignment has been fixed on the right bank of the river as the Power house is also on the right bank of the river. Moreover the left bank has steep slopes and the area is inaccessible in most of the reaches. The HRT alignment also crosses one Nala but there is sufficient cover available above HRT.

Due to non-availability of sufficient alternative open space for surface power house, a common underground Power House cavern with Nyukcharong chu HEP near the confluence of Mago Chu with Nyukcharong Chu is envisaged.

1.3. GENERAL FEATURES OF THE PRESENT STUDY

The selected scheme comprises a medium head peaking power project with a 20.5 high (from river bed) Bararge as the diversion structure and an underground water conductor system. It entails two nos. Desilting Basin each 70 m long, two nos. 38m long Feeder tunnels, 2.773 km long headrace tunnel which culminates in a surge shaft, from where steel lined pressure shaft conveys the water to an underground powerhouse with tailrace tunnel discharging the water into Mago Chu. The rated net head of the scheme is 186.75 m with nominal turbine discharge of 56.4 m^3/sec. The powerhouse has an installed capacity of 96 MW.

The project will only have power-benefits, as the rugged mountainous terrain does not provide much scope of irrigation from the river flowing in a relatively deep valley. The project will feed power to the Eastern Region

2. PROJECT AREA

2.1. COMMUNICATION AND TRANSPORT FACILITIES

Accessibility to the project area needs improvement from Jang town . With the development of hydroelectric projects such as Tawang-I, Tawang -II and Nyamjang Chu, which are in the vicinity, the access roads will be improved.

The project area is located about 275 km from Bhalukpong in Assam state, and 150 km from Bomdila, the district headquarters of West Kameng district in Arunachal Pradesh. The nearest broad gauge rail head is at Nagaon, Assam and nearest airport is at Guwahati. The road from Nagaon to Jang (approx. 353 km) is connected through national highway (NH- 52 & NH-37). The road from Jang to the project site (approx. 15 km) is partially constructed and the remaining stretch is under construction by PWD.

It is envisaged to transport equipment and bulk material for the project through the broad gauge rail line up to Guwahati/Nagaon, from where the transportation will be via road passing through Jang.

2.2. GENERAL CLIMATIC CONDITIONS

The project area experiences a moderate climate for many months of the year. The place gets rainfall for many months of the year and the monsoon season experiences extreme amount of rain. Winters are cold and the temperatures can be expected to drop to around the freezing point.

The summer season starts in the month of March and ends in June. The temperatures range from a minimum of 5 degrees Celsius and can rise up to a maximum of around 22 degrees Celsius during this period. The hottest month of the year is usually June.

The place gets rainfall during the months from July to October. The predominant rainfall is from the South West Monsoon and the conditions are wet for most of these months. Temperatures are much lower during this period.

The months of December, January and February constitute the winters season. Temperatures range from a minimum of -2 degrees Celsius and can go up to a maximum of around 5 degrees Celsius during this time. January is the coldest month of the year.

2.3. GEOLOGY OF PROJECT AREA

The rocks in the project area are represented by granite gneiss with occasional minor bands of schist and migmatites. They have been intruded by pegmatite and quartz veins. The granite gneisses are mostly light to dark grey coloured, fine to medium grained and moderately jointed. The granites are mostly leucocratic to mesocratic, medium to coarse grained and intrusive into gneisses. The rock foliation (J1) generally strikes in NW – SE direction and dip at 20^0 - 45^0 towards north and southwesterly directions. This indicates an asymmetrical anticlinal fold in the downstream part of the project area.

2.4. PHYSIOGRAPHIC FEATURES AND TOPOGRAPHY

Arunachal Pradesh consists of mountainous area with high hills and valleys. The topography of the Tawang district represents:

1. The snow covered Himalayan ranges from 11,000ft.to 22,000 ft. which mostly include bare mountains and are mostly uninhabited.
2. The high altitude mountainous belt from 6000 ft. to 11000 ft., which contains plateau and narrow valleys and are sparsely, populated.

The main ridges and spurs of the Sub-Himalaya fan out the plains mostly in transverse direction except in some places where the prominent ridges run more or less parallel to each other from west to east.

The high mountains in the northern ridge remain snow clad almost throughout the year rendering them almost inaccessible. Amidst the highly rugged terrain, there are valleys, lakes and plateau.

The Himalayan ranges of the project area covers about 350 km of the eastern most part of the Himalayas, referred here as the Arunachal Himalaya and extends from the eastern border of Bhutan to the Dibang and Lohit valleys in the east abutting against the Mishmi hills. This part of the Himalaya, as elsewhere in the western sector, is subdivided into the following four parallel linear zones:

1. Tethys or Tibetan Himalaya to the north
2. Higher Himalaya
3. Lesser or the Lower Himalaya and

Sub-Himalaya to the south

The physiographic condition of a region refers to the sculptures on the natural landscape and ongoing changes by several geomorphic agents like water, glacier, wind etc. These agents are controlled by the prevalent climatic conditions of the region and the internal dynamism of the earth. For a hydroelectric project, the study of physiographic condition of the river catchment is very crucial as it has a strong control on water availability and sediment load supplied to the river.

2.5. DEMOGRAPHIC DETAILS

Arunachal Pradesh covers an area of 83743 sq.km. As per 2011 census report, the population of Arunachal Pradesh is 1,383,727 of which 713,912 are male and 669,815 are female, the sex ratio being 938 females to 1000 males. Tawang is a thinly populated mountainous tract lying roughly between the latitude 27 ° 45 ' N and the longitude 90° 15' E on the Northwest extremity of Arunachal Pradesh. The district is surrounded by the Tibet in the North East, Bhutan in south West and West Kameng district in the south East. The district has an area of 2,172 sq. km. Total population of Tawang is 49,977 (as per 2011 census) out of which 29,151 are male and 20,826 are female, the sex ratio being 714 females to 1000 males.

2.6. INTERSTATE ASPECTS

There are no Inter-state aspects of territory, property etc. coming under submergence, oustees, rehabilitation, compensation, sharing of waters, sharing of benefits and costs involved in this project.

As the catchment area of Mago Chu HEP lies in India, there are no Inter-national aspects involved with this project.

3. SURVEY AND FIELD INVESTIGATIONS

Field survey and investigations were carried out with the objective of preparing grid maps, establishing ground control points, fixing alignments and obtaining the river L-sections, cross sections etc. Detailed topographical survey covering the head works area

and the powerhouse complex was carried out for detail planning and estimates of the project components.

Geological investigations comprising subsurface investigations and surface geological mapping were carried out after preliminary surveys. Subsurface investigations, study of rock properties by laboratory test on samples collected from drill holes were also carried out at the proposed location of various components.

River discharge measurement and observation of other hydro-meteorological data was taken up during the preparation of DPR and is proposed to be continued till the completion of construction and further operation of the project.

The potential quarries for extraction of Coarse and fine aggregates were identified within the project area. However it is estimated that the quantity of muck generated from underground excavation shall be sufficient for the Coarse and fine aggregates required for construction. Rock core samples collected during drilling operation has also tested in laboratory to determine the engineering properties of the bedrock.

Route survey for the feasibility of transportation of Over Dimension Components (ODC's) was carried out after considering the heaviest and the longest part to be transported to project site. As on today, most of the stretch of the road from Tezpur to Jang is double lane and road widening is in progress in some stretches. There are some critical locations and bends along the under construction road from Jang to Mago Chu project site. The widening and smoothing of curves for the critical points along the 15 km of the road beyond Jang to Mago Chu project needs to be taken up by the project authorities.

Keeping in view the projects coming up in the vicinity and also the proposed pooling station by the Power transmission authority, power evacuation from the Project has been planned through a 132 KV Line upto proposed pooling station at Tawang-II.

3.1. PHOTOGRAPHS OF THE PROJECT AREA

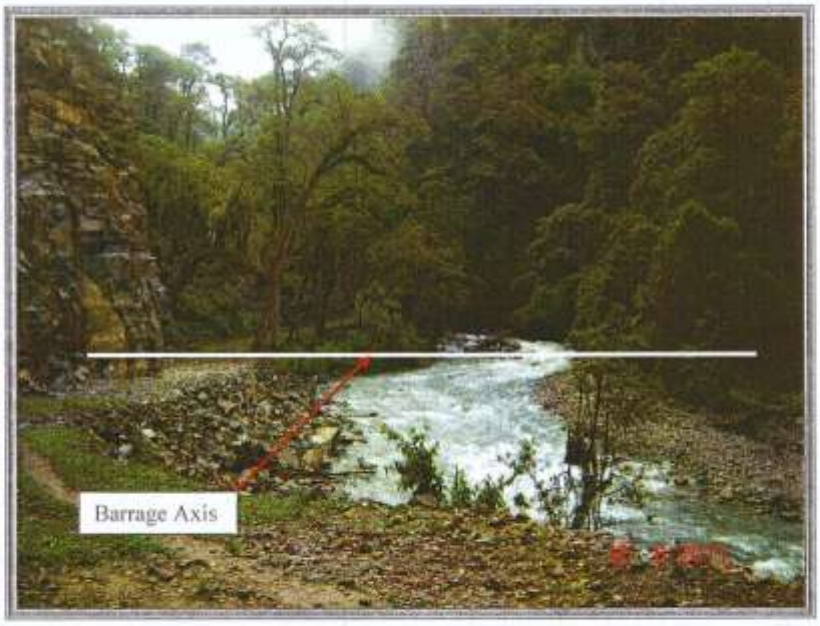

Photo 3-1 Area of the proposed Barrage site

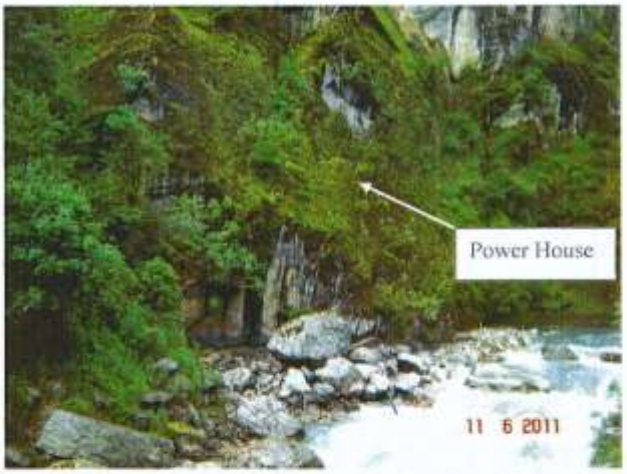

Photo 3-2 Area of the proposed underground Power house

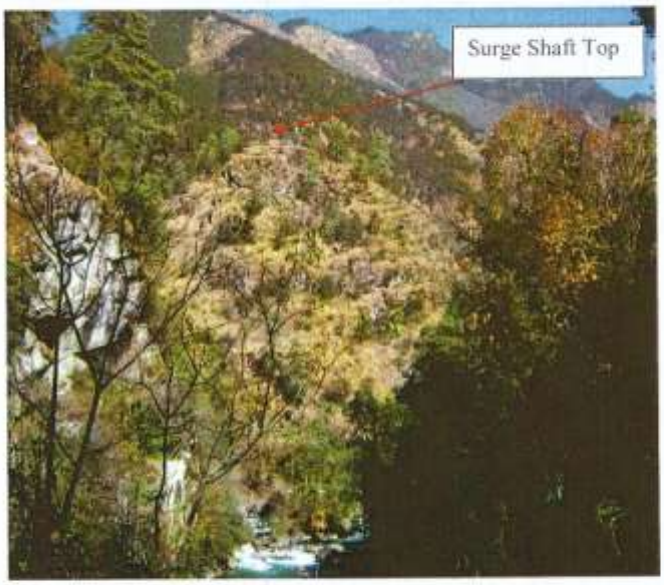

Photo 3-3 Area Location of Surge shaft

4. PROJECT HYDROLOGY

4.1. WATER ASSESSMENT

The water availability at the project diversion site has been determined by using the available hydro-meteorological data in and around the project catchment. Pertinent hydrological data for the catchment is summarized below.

Hydrology of the Catchment	
Catchment area (km^2)	830
Mean annual flow ($x10^6$ m^3)	1375
Rainfed catchment area (km^2)	614
Permanent snow covered catchment area (km^2) (above 5000 m elevation)	216

Length of the river up to the proposed diversion site is about 45 km (between the diversion site and origin at El. 6500m); equivalent stream slope of the river is 83m/Km.

Rainfall

No SRRG data is available in the region. However details of ORRG stations data availability is indicated in table below:

List of ORRG Stations

S. No.	Station name	Data availability
1.	Murga Bridge	Jan 1998 to May 2000
2.	800 m d/s. of China Bridge	Aug. 1999 to June 2000
3.	Bhalukpong	Jan1997 to Dec 2007
4.	Bomdila	Jan 1999 to Dec 2007
5.	Kalaktang	Jan 2002 to Dec. 2007
6.	Dirang	Jan. 1999 to Dec. 2007

The average monthly rainfall (with varying data availability) of these stations which are located at lower elevation are indicated in table below:-

Average monthly rainfall of rain gauge stations (mm)

Station Name Month↓	Murga Bridge	800m D/s of China bridge	Bhalukpong	Bomdila	Kalatang	Dirang
Jan	14	38.4	20	16	6	5
Feb	40	23	48	33	19	6
Mar	177	157	76	39	38	15
Apr	148	168	120	132	95	65
May	207	243	345	191	101	95
Jun	299	214	722	171	256	154
Jul	372	NA	827	303	347	171
Aug	427	456	682	292	230	211
Sep	153	153	701	202	112	180
Oct	161	159	269	168	105	82
Nov	7	14	52	32	14	16
Dec	5	13	13	14	3	3
Annual	**2010**	--	**3875**	**1593**	**1326**	**1003**

Temperature

Most of the inhabited regions enjoy a temperate climate with temperatures rarely exceeding 25^0C in summer or dropping below 0^0C in winter. The average annual temperature for most of region is around 10^0C. Monthly meteorological data are

available at Bomdila (1969-72) and at Tawang station (1969-2008) in the region. In addition, long term average climatological parameters at Murga Bridge in the region are available whose details are given in the Hydrology Chapter-6 of Volume-I of DPR.

River discharges

At present there are five G & D stations maintained by various agencies in the region whose data are available (as reported in various reports) near to the Mago Chu HE Project site viz. Mago Chu (on Mago Chu river), China Bridge (on the Nyukcharong Chu river), Murga Bridge (on Tawang Chu River) Yusum (On Tawang Chu river) and. Uzorong (on Gongri Chu river).

Field Observations

The following field data is being collected at site-

- ORG installed near diversion site and daily data being collected from January,2010
- Self Recording Rain Gauge (Telemetry) established in Nyukcharong Chu near diversion site and data being recorded from 12th February,2011
- Self Recording Water Level Recorder(Telemetry)established in Nyukcharong Chu near diversion site and data being recorded from 12th February,2011
- Daily Discharge Observations are being carried out once a day on Nyukcharong Chu stream from January,2011
- Daily Maximum Minimum Temperature being recorded from January -2010
- Relative Humidity observations are being recorded from April,2010
- Wind Velocity data being recorded with Anemometer from April,2010

4.1.1. PHILOSOPHY FOR FLOW RECONSTRUCTION

It has been indicated in earlier paras that the network of existing rain gauge station are inadequate for assessing the catchment rainfall so as to develop a rainfall – runoff model. As such, recourse was taken to utilize the runoff observed at various G&D sites for assessment of yield for the proposed HE Project.

Stream flow records are available at three G&D sites viz. China Bridge, Mago Chu and Murga ridge whose details are given in earlier paras and observed data at Annexure- 6.1 to 6.3. Further it has been indicated in earlier paras that the observed discharges at all sites are not reliable, though consistent. The observed data of Mago Chu G & D site is of smaller duration and shows inconsistencies with data observed at other sites. As such the same are not considered in yield assessment.

It has been indicated in earlier paras that China bridge (CA=2040 km2) discharge data is available for the period Jan 1999 to Jul 2008 while that of Murga bridge (CA=2910km2) is available for the period Nov 1998 to May 2008. Since Uzorong data is available form

1992-1993 to 2007-2008, it is proposed to utilise the same for development of a Runoff – Runoff model between the concurrent period of China bridge and Murga bridge with Uzorong. Utilizing the same model the runoff series at China Bridge and Murga Bridge were extended for the period 1992-93 to 1998-99. Since Murga Bridge encompasses the yield of Nyukcharong Chu and mago Chu rivers, these observed and extended series of Murga Bridge and China Bridge were used to develop runoff series for the intermediate catchment (Murga Bridge-China Bridge) of 870 Km2 by simply subtracting China Bridge flows from the Murga Bridge one for the concurrent period (1992-93 to 2007-08). This developed series for intermediate catchment is thus transferred in catchment area proportion to proposed Mago Chu HE site (catchment area- 830 Km2) to yield runoff series at the proposed HEP site.

4.2. FLOOD HYDROLOGY

4.2.1. DESIGN FLOOD

Estimation of design flood for the design of different types of structures is a very significant component of hydrological studies. Proper selection of design flood value is of great importance. While a higher value results in increase in the cost of hydraulic structure, an underestimated value is likely to place the structure and population at risk on the downstream of the diversion site.

At Mago Chu, a Barrage is envisaged with FRL 2472 m. As per guidelines contained in the Bureau of India Standard (BIS) code IS 6966 (Part-I): 1989, the present Barrage comes under the 'Intermediate" category and consequently Inflow Design Flood for the project is to be the Standard Project Flood (SPF).

For carrying out the flood studies for the proposed project, India Meteorological Department (IMD) was requested to carry out the storm studies specifically for New Melling HEP catchment to estimate PMP and SPS values based on the available data. IMD carried out the study during August 2011 and indicated the results of their study as under.

Duration	SPS values (cm)	PMP values (cm)
1 Day	12	16.9

IMD further opined that 1-day values may be increased by 15% so as to convert them into 24-hour values with short term distribution.

The results of the study made specifically for New Melling H E project. However, the same value of SPS and PMP has been adopted for the flood studies of proposed Mago

Chu HEP catchment, which appears to be reasonable as Mago Chu HEP site is just 4 Km (approx.) downstream of the New Melling HEP site.

CEA vide their letter no. Dir (PAC) 2/ARP/355/CEA/2011-PAC/713-15 dated 3.2.2012 have approved the design flood for a value of 2452 cumec (SPF) for the project.

4.2.2. DIVERSION FLOOD

The diversion flood at proposed HEP site is computed using two cases for both Monsoon and Non-Monsoon period peaks utilizing the available data of Yusum, Uzorong and China Bridge G&D site by converting them into instantaneous values using a factor of 1.20. Temporary diversion flood for the project is estimated as 357 cumec.

CEA vide their letter no. Dir (PAC) 2/ARP/35/CEA/2011-PAC/713-15 dated 3.2.2012 have approved the diversion design flood for a value of 357 cumec for the project.

4.3. SEDIMENTATION

Daily suspended sediment data at China Bridge G & D site is available for the period August 1998 to March 2000. An examination of the same reveals that sediment inflow is less than 1000 ppm and the highest sediment load observed in this period (August 1998 to March 2000) is 768 ppm on 12th Sep 1998 and 757 ppm on 24th Jun 1999. The detailed silt load studies in case of diversion project are neither warranted nor necessary. Since the Mago Chu diversion Barrage is planned as purely run of river and is also having provision for flushing out the deposited silt on regular basis, detailed sedimentation study has not been carried out.

5. GEOLOGY, SEISMICITY AND SEISMOTECTONIC STUDIES

5.1. REGIONAL GEOLOGY

In general the litho units of Western Arunachal Himalaya are in perfect structural continuity with that of the Sikkim and Bhutan Himalaya. These litho-units belong to Higher & Lesser Himalayan sequences. The lithounits are thrust bound and geochronological data in this part is insufficient to build up a perfect stratigraphic column. Therefore, only a tectono- stratigraphic column can be established.

The Higher Himalayan sequence or Tibetan slab represented in this part which is a zone of regional metamorphic rocks, migmatite intruded by crustal melt derived leucogranite. These occupy the topographically highest mountains. This slab dips northwest ward and is bounded along its top by the normal fault (South Tibetan Detachment System or STDS) and to its south by Main Central Thrust (MCT). The tertiary leucogranite bodies tend to concentrate along the top of the High Himalayan slab. Metasedimentary sequences which are lower in grade, occur as linear patches. One such patch is recorded along Tawang - Bumla road section and another along Tawang - Gashe la section. The

medium grade Lum la metasedimentaries also occurs as a linear patch with tectonic contacts within Sela metamorphics.

5.2. GEOLOGY OF PROJECT AREA

The rocks in the project area are represented by granite gneiss with occasional minor bands of schist and migmatites. They have been intruded by pegmatite and quartz veins. The granite gneisses are mostly light to dark grey coloured, fine to medium grained and moderately jointed. The granites are mostly leucocratic to mesocratic, medium to coarse grained and intrusive into gneisses. The rock foliation (J1) generally strikes in NW – SE direction and dip at 20^0 - 45^0 towards north and southwesterly directions. This indicates an asymmetrical anticlinal fold whose axis trend in $N148^0$ – $N328^0$ direction and shall pass toward the end reach of HRT about 55 m short of surge shaft.

5.3. SEISMICITY AND SEISMOTECTONICS

Seismically the North-eastern parts of the Himalayas are one of the most active zones in the world. Area is located at the tri-junction of three tectonic plates;-the Indian, the Indo-Burmese and the Eurasian. These plates are constantly in collision with each other, and as a result, the rocks of this area have undergone repeated intense folding, faulting and thrusting in a highly complex manner so much so that many of the rock sequences have either been eliminated or repeated. The structural pattern has at most of the times controlled the drainage pattern of the rivers. This pattern is generally elongated in a WSW to NE-SW direction but many transverse structural features have modified them.

Neo-tectonic activity is also reported from some places form of rejuvenation of existing tectonic lineaments and development of cross- faults. It is these cross-faults that have controlled the sedimentation of the Older (Mid. To Lr Pleistocene) and the Newer (Holocene) Alluviums and have off-set the major thrusts; viz the MCT (Main Central Thrust), the MBF (Main Boundary Fault) and the FHF (Foot Hills Fault). Generally most of the epicenters of the earthquakes are concentrated along major cross faults whereas no evidence of activity is observed along the latter. One such cross fault/lineament is the Bomdila Lineament. It is seen to continue southeastwards as Jai Bhareli Fault. This has offset the MBF. Epicentres of a few major earthquakes are located close to it, however evidence of such activity have not been noticed in the project area.

As per the Seismic Zoning Map of India (IS 1893:2002), the whole of the northeast including Arunachal Pradesh has been placed in Zone V.

5.4. SITE SPECIFIC SEISMIC STUDIES

Keeping in view of the high seismicity of the area, it is essential to carry out the study for site specific design earthquake parameters for the designing purposes. Subsequently, the

Department of Earthquake Engineering, Indian Institute of Technology, Roorkee (IIT Roorkee) has been engaged for this purpose.

After carrying out the detailed studies, IIT – Roorkee have recommended the Peak Ground Acceleration (PGA) values for Maximum Credible Earthquake (MCE) and Design Base Earthquake (DBE) conditions as 0.35 g and .018 g respectively, which have been recommended for inclusion in the designs.

5.5. GEOLOGICAL FIELD INVESTIGATIONS

The field investigations pertaining to geological investigations for Mago Chu Hydroelectric Project carried out so far include surface geological mapping on different scales and subsurface exploration by drilling at the sites of different appurtenants of the project. Drifting has been proposed in the Power House complex.

5.5.1. GEOLOGICAL MAPPING

Geological mapping was carried out for different components of the project as well as reservoir area. The detailed geological mapping on 1:1000 & 1:10000 scale was carried out at the sites of diversion structure, HRT, powerhouse complex and reservoir submergence. The geological maps of the project area are appended in Volume-V of the Detailed Project Report. Different litho units and structural data have been marked on the geological maps.

5.5.2. SUBSURFACE INVESTIGATIONS

Subsurface investigations carried out at sites included drilling of boreholes at different project components to assess the depth to bedrock nature and quality of foundation media for various structures The subsurface investigations conducted are:

5.5.3. EXPLORATORY DRILLING

Exploratory drilling at head works, head race tunnel and powerhouse area were conducted to ascertain the subsurface geological features. A total of 25 nos of drill holes aggregating 1546.86 m were drilled at the location of various project components. The details of the drill holes and their logs are appended at Volume-V of the Detailed Project Report.

5.5.4. EXPLORATORY DRIFTS

One exploratory drift with cross cuts has been proposed for underground Power House complex.

Diversion Site

To know the allowable bearing capacity of strata at the barrage location, a plate load tests need to be carried out at least at two locations, one on each bank of river near to the barrage axis.

Power house Site

One exploratory drift as already proposed at the Power house site with cross-cuts to conduct in-situ rock mechanic tests like plate load, shear block and hydro fracturing to determine the characteristics of the rock mass and the magnitude of in-situ stresses.

6. POWER POTENTIAL AND INSTALLED CAPACITY

6.1. GENERAL

The Project is being developed as a run-of-the-river scheme. Power generated at the Project will be fed into North-Eastern grid and is intended to meet the growing power requirement of the Northern & Southern Regional Grid of Indian Power Supply System.

Assessment of the power potential of the Project has been done through detailed calculation of energy for various possible installed capacities. Optimization of the installed capacity is done by considering various parameters such as incremental energy ratio and plant load factor.

6.2. DETERMINATION OF 90% AND 50% DEPENDABLE YEARS

The following parameters are used in the calculations:

- Full reservoir level = 2472m
- Minimum drawdown level = 2460.0 m
- Normal tail water level = 2272.32 m
- Average gross head = 195.68 m
- Head loss = 8.93 m
- Net head = 186.75m
- Efficiency of turbine = 94.5%
- Efficiency of generator = 98.5%
- Overall efficiency of turbine and generator = 93.06%
- Minimum Riparian flow = 20% of the average discharge in the lean months i.e. from December to March and 20% of the average discharge in the monsoon months i.e. from

June to September in 90% dependable year

Using the method recommended by CEA, the 90% and 50% dependable years have been determined on the following basis:

90% dependable year = (16+1) x 0.9 = 15th rank.

50% dependable year = (16+1) x 0.5= 9th rank.

Based on the above, year 1999-2000 and year 1996-1997 have been determined as the 90% and 50% dependable years respectively.

6.3. DETERMINATION OF THE INSTALLED CAPACITY

The various parameters derived are tabulated below:

Table 6-1: Incremental Energy Benefits for average flows

Installed Capacity	Annual Energy, MUU	Annual Load Factor (%)	kkWh/kWk	d kWh/d kkWW	Incremental Energy, MUU
80	476.46	67.99%	5955.8		
82	480.54	66.90%	5860.2	2040.0	4.08
84	484.48	65.84%	5767.6	1970.0	3.94
86	488.40	64.83%	5679.1	1960.0	3.92
88	492.34	63.87%	5594.8	1970.0	3.94
90	496.08	62.92%	5512.0	1870.0	3.74
92	499.54	61.98%	5429.8	1730.0	3.46
94	503.00	61.09%	5351.1	1730.0	3.46
96	506.44	60.22%	5275.4	1720.0	3.44
98	509.90	59.40%	5203.1	1730.0	3.46
100	513.36	58.60%	5133.6	1730.0	3.46
102	516.52	57.81%	5063.9	1580.0	3.16
104	519.50	57.02%	4995.2	1490.0	2.98
106	522.27	56.25%	4927.1	1385.0	2.77
108	524.77	55.47%	4859.0	1250.0	2.50
110	527.21	54.71%	4792.8	1220.0	2.44
112	528.94	53.91%	4722.7	865.0	1.73
114	530.15	53.09%	4650.4	605.0	1.21
116	530.83	52.24%	4576.1	340.0	0.68

Thus from the above consideration 96 MW appears to be the possible threshold beneficial value for the installed capacity at Mago Chu project. Further perusal of results

show that the lean flow period load factor corresponding to 96 MW installed capacity is 28.31%, which is considered to be quite reasonable. Consequently, 96 MW is considered as the upper beneficial limit of installed capacity from incremental energy consideration.

The installed capacity at Mago Chu is therefore, proposed to be 96 MW; the corresponding design discharge is 56.4 cumec.

6.4. PEAKING ENERGY

As per CERC, a run-of-the-river generating station with pondage for peaking generation should be capable of providing minimum 3 hours peaking in 24 hours period for full installed capacity. As the project lies on a river which has a very steep gradient (1 in 20), it is possible to achieve the peaking requirement of 1.5 hrs in a 12 hour cycle. Therefore the project is planned as a peaking plant.

6.5. NUMBER OF GENERATING UNITS

It is generally economical to install smaller number of large capacity units. However, for flexibility in operation and maintenance as well as limitations on transportation of equipment in hilly terrain, a plant with 3 units of 32 MW each is proposed.

6.6. DESIGN ENERGY

As per CERC, design energy is the energy generated in a 90% dependable year at 95% plant availability. The design energy generated in the 90% and 50% dependable years with an installed capacity of 96 MW is 404.42 GWh and 479.02 GWh, respectively.

7. CIVIL ENGINEERING STRUCTURES

7.1. GENERAL

Civil Engineering structures for the Project comprise the following components:

- Construction and approach Adits
- Barrage
- Desilting Basin
- Intake structure
- Cut and cover tunnels
- Feeder tunnels
- Headrace Tunnel
- Surge Shaft
- Pressure Shaft/Tunnel
- Underground Power House Complex

7.2. CONSTRUCTION/APPROACH ADITS

Two Construction Adits for HRT will be constructed out of which one will also be used for construction of Feeder Tunnels also. Other HRT adit will be common for construction of Surge Shaft. A bifurcation from the HRT adit near surge shaft bottom will be used for the top horizontal reach of Pressure shaft including assembly chamber. One adit for bottom horizontal reach of Pressure shaft including bifurcation chambers and for the Tailrace tunnel would be constructed. Construction adits to the top of Power House cavern and Transformer cavern would also be constructed which would be later used as bus duct/cable tunnel to the Pothead yard and ventilation tunnel. In addition, Main access tunnel to the Power house cavern would be common for Mago Chu HEP & Nyukcharong Chu HEP.

7.3. BARRAGE

Exploratory holes drilled at the site did not encounter bedrock at even 55m below the river bed level. A Barrage founded on overburden is, therefore proposed for the diversion structure.

The Barrage axis is placed perpendicular to the direction of flow. Lateral positioning of the Barrage is done in such a manner that the excavation of both the banks is optimized.

7.3.1. DESIGN FLOOD AND ITS PASSAGE THROUGH BARRAGE BAYS

At Mago Chu, the SPF approved by CWC is 2452 cumec. Radial gates are proposed to be provided and, to limit the height of the gates, breast walls have been proposed in each bay. Four bays with opening size of 9.2m(W)x6.8m(H) are found to pass the project design flood of 2452 cumec + 1252 cumec (GLOF).

Energy dissipation arrangement has been proposed for 1 in 100 yr flood.

7.3.2. BARRAGE SPILLWAY CREST LEVEL, FRL AND MDDL

The Full Reservoir Level (FRL) at the project has been fixed at EL 2472m. Reservoir area-capacity curve has been developed at the proposed Barrage axis. The live storage capacity of the reservoir is about 0.257 MCM corresponding to the MDDL of EL 2460m. The sill level at the Radial gate is 2453m.

7.4. TEMPORARY RIVER DIVERSION

In order to pass a discharge of 357 cumec, partial coffering of the river in two stages is proposed.

Due to scarcity of clay near the project site, cofferdam has been proposed with rockfill having 300mm thick M20 on the water face. Maximum height of the first stage cofferdam is approx. 3.0m. To prevent seepage, if required, jet grouting is proposed from the top of coffer dam upto a minimum depth of 4 m below the deepest excavation level.

The second stage coffer dam will consist of Gabion walls with 300 thick concrete face built on the Barrage floor completed in first stage. Maximum height of the second stage cofferdam is approx. 5.0m. To divert the river flow towards the two Barrage bays constructed in first stage, a rockfill cofferdam and gabion in wire crates will be constructed.

7.5. DESILTING BASIN

A continuous flow dufour type surface Desilting arrangement is proposed, which is based on conventional settling chambers principle. The size of sediment to be excluded is taken as 0.25 mm with 90 % efficiency, each basin is of 70 m length, 14 m width and 19m depth.

Independent flushing ducts are provided underneath each Desilting basin which later combine to bring the extracted sediment back to the river.

7.6. CUT AND COVER FEEDER DUCTS

Two Cut and cover ducts 3.5m x 3.5 m offlakes with invert elevation 2453.25 m from the Intake well at the end of Desilting Basin. Length of the two cut and cover ducts id 43.0 m and 66.7 m respectively. The proposed location has been kept keeping in view aspects of Geological considerations, hydraulic considerations of drawl of water from Intake well.

7.7. FEEDER TUNNELS

Two D-shape feeder tunnels of lengths 38 m each having size 3.5m (W) X 3.5m (D) are provided to convey water from the cut and cover ducts to the Headrace tunnel.

7.8. HEAD RACE TUNNEL

Total length of head race tunnel from junction of Feeder tunnel to the surge shaft is 2773.0 m with a constant slope of (1: 86).

Optimization Study for economical diameter of HRT has been carried out for a design discharge of 56.4 cumec. The cross section of HRT is proposed to be modified horse shoe, having 4.8 m finished diameter with velocity in the tunnel as 3.08 m/sec. 300 mm un-reinforced concrete lining has been proposed for HRT.

Two construction adits with two heading faces are planned for 2.773 Km Headrace tunnel to allow excavation to proceed unhindered on both the faces simultaneously.

7.9. SURGE SHAFT

Based on the recommendations of IS 7396 (part-I), different combinations of full load acceptance and/or full load rejection were considered to determine the extreme surge

values. The detail characteristics of the surge shaft that has been adopted are tabulated below:

Top elevation	2510.0 masl
Bottom elevation/ top of orifice slab	2425.0 masl
Total height	85 m
Maximum upsurge	2505.14 masl
Minimum down surge	2428.02 masl
Surge tank	
Internal diameter	7 m
Orifice	2.1m +Gate opening also acts as orifice
HRT invert at Surge shaft	2420.3 masl

Plain concrete lining 300 mm has been proposed in the Surge shaft. A gate of size 3.7m (W) x 3.7m (H) is provided on the downstream side of the surge shaft.

7.10. PRESSURE SHAFT

The combined length of the pressure shaft/tunnel is 366.4 m long with two 90 degree bends and two bifurcation points. The different diameters at the various section of the Pressure shaft are tabulated below:

Section	Diameter
First 250.4 m	3.7 m
Next 22.5 m	3.0 m (Intermediate shaft)
Next 43.5 m	2.2 m (to unit 1)
30 m	2.2 m (to unit 2)
20 m	2.2 m (to unit 3)

The proposed arrangement of pressure shaft would have one pressure shaft with two bifurcations upstream of the powerhouse to divide in three individual penstocks.

7.11. LINER DETAILS

ASTM A537 Class 2 steel is proposed in the liner sections. Design thickness of plate varies from 20 mm to 34 mm. The total weight of the steel liner was optimized to 860 MT and the total length worked out to 366.4 m.

7.12. POWERHOUSE COMPLEX

7.12.1. UNDERGROUND POWER HOUSE

The Power House cavern is common for Mago chu HEP (3x32 MW) and Nyukcharong Chu HEP (3x32 MW) which is another project with the developer M/s SEW Green Energy Ltd. The general arrangement of the Mago Chu powerhouse has been developed for installation of three, 32 MW, vertical axis Francis turbines. The powerhouse size is of 87m (L) x 19m (W) x 38.5m (H). The three generating units are spaced at 14.5 m c/c. The 20 m long Erection bay is located at the centre of the machine hall on the western end of the units, and the 20 m long Control Block is located at the eastern end of the machine hall. The centerline of machines is set at El. 2265.50 m.

There are four main floors in the Power house and four floors have been provided in the Control Block. The structural framework of the powerhouse and the Control Block is proposed as reinforced concrete frame.

7.12.2. EOT CRANE

One gantry crane of 130 t capacity with one auxiliary hook of capacity 30t is provided for the machine hall. The crane beam elevation is set at El 2286.50 m.

7.12.3. TRANSFORMER CAVERN

The overall dimension of the transformer cavern is 60m (L) x 14.0m (W) x 19.0 m (H) provided on upstream of power house cavern. It accommodates three triple phase GSU (Generator set up) transformers. Transformer rails would be embedded in the floor of transformer area and the passage joining the erection bay & transformer area. This would allow handling of the transformers by the EOT gantry crane.

7.12.4. DRAFT TUBE AND TAILRACE TUNNEL

3 Nos. duct each of size 4.6m (W) x 2.5m (H) emanates from the draft tubes which join to form a single tailrace tunnel. 3 Nos. Draft Tube gates of size 4.6m (W) x 2.5m (H) have been provided which are operated from a gate chamber. Tailrace tunnel of 5.5 m diameter, approximately 60 m long is provided to carry the water from back to the river. The plan of the tunnel is oriented in such a way that it meets the direction of flow in the river. An outfall structure is proposed at the outlet of TRT. A raised crest is provided in the floor at El. 2270.1 at the outlet to maintain the normal and minimum tailwater level for the operation of turbine.

A gate has been provided at TRT outfall. Operating level of gate is kept at 2480 m which is above the maximum flood level El. 2478 m.

7.12.5. POTHEAD YARD

A 20mx57m surface Pothead yard is proposed on the terrace at east side of the powerhouse at El.2290 m. It accommodates capacity voltage transformer, isolator, lightening arrestor etc.

8. HYDRO-MECHANICAL EQUIPMENTS

The hydro mechanical equipment at the Project comprises of:

- Four (4) nos. of spillway radial gates of size 9200 mm x 6800 mm (w x h). For operation of gates, single acting double cylinder hydraulic hoists shall be provided.
- One set of sliding type, vertical lift stoplog for opening size of 9200 mm x 11054 mm (w x h). Each stoplog unit shall be capable of self closing i.e. by gravity under its own weight. The stoplog units shall be handled by a TRCM cum gantry crane.
- Two (2) nos. sliding type, vertical lift stoplog gates for opening size of 6000 mm x 17000 mm (w x h) are provided at desilting basin. The stoplog units shall be handled by a TRCM cum gantry crane.
- The desilting basin shall have Eight (8) sets of trash racks of size 2500 mm x 17000 mm (w x h). The cleaning and handling of trashrack shall be done by a TRCM cum gantry crane.
- One Service Gate of size 3500mm x 4500mm (w x h) are proposed to be provided in each Feeder Tunnel. The gates are fixed wheel, vertical lift type. The gates are required to isolate the Feeder Tunnels from Desilting Basin for the maintenance / inspection of the Feeder Tunnels. The gate shall be operated by means of electrically operated rope drum hoist.
- Two silt flushing gates of size 900 mm x 1400 mm (w x h) are proposed to be provided in each Silt Flushing duct. The gates shall be operated by individual double acting hydraulic hoist.
- One fixed wheel, vertical lift type gate of the size of 3.7 m x 3.7 m (w x h) is proposed to be provided in Surge Shaft. The gate shall be operated by means of electrically operated rope drum hoist.
- Three nos. of fixed wheel type Draft-tube gate of size 4.6m x 2.5m (w x h) are required to stop flow of water back into Draft-tube when it is under maintenance. The gates shall be operated by independent rope drum hoists.
- One no. of fixed wheel type Tail Race gate of size 5.5 m x 5.5 m (w x h) is required to stop flow of water back into TRT when it is under maintenance. The

gates shall be operated by mean of electrically opertaed independent rope drum hoist.

9. ELECTROMECHANICAL EQUIPMENT

Mago Chu Hydroelectric Project envisages an underground powerhouse having:

- Three vertical shaft Francis turbines each of rated capacity corresponding to generator output of 32 MW at rated net head of 186.75m and rated speed of 375 rpm.
- Runner made of 13Cr-4Ni stainless steel and shall be cast in one piece.
- Turbine and generator shafts made of forged steel according to ASTM A668 class D and will be provided with integrally forged coupling flanges designed to ANSI B-49.1.
- Main inlet valve (MIV) of Spherical type for each unit, having nominal diameter of 1600 mm and rated flow of 18.8 m^3/sec
- Electro hydraulic governor of digital type and compatible with station SCADA system.
- An independent cooling water system for each unit, three cooling water pumps with one standby along with automatic back wash strainers will be provided for each unit.
- HVAC equipment for powerhouse & Transformer cum GIS cavern. Dedicated air conditioning units will be provided for the control room.
- One (1) E.O.T crane of 130 /30/5 MT capacity. One (1) pendent operated 10 MT capacity EOT crane shall be provided in the GIS cavern
- Generators with vertical shaft and suspended type. The generator shall be directly coupled to the turbine shaft and rated for 35.56 MVA with 0.9 lagging Power Factor, with 50 Hz(-5% to +3%) frequency and generation voltage of 11 kV.
- Three digital excitation systems consisting of excitation transformer (3phase, 50 Hz, 11kV, indoor type), Thyristor bridge, voltage regulator etc., for matching the field requirement of hydro generators.
- Segregated Phase Bus Ducts (SPBD) between the generator terminals and the generator step-up transformer with taps to LAVT, Excitation and Unit auxiliary transformer.
- Three nos., three phase transformers with rated capacity of 40 MVA, 11/132 kV, 50 Hz suitable for indoor installation.

- Transformers shall be directly connected with 132 kV GIS through oil to SF6 bushing & GIS shall be installed on the floor directly above the transformers.
- 132 kV XLPE insulated cables are envisaged for the outgoing line feeder for the connection to pothead yard.
- Two pumps (one main and one standby) provided to fill the overhead water storage tank for supplying fire fighting water to the powerhouse complex and pothead yard by gravity. Fire fighting system will also include the hydrant system, the emulsifier system, the Medium Velocity Water Spray System , HighVelocity Water Spray System and portable fire extinguishers.
- Two (2) 500kVA, 415 V, 50 Hz, 0.85 pf diesel generator (DG) set installed at Pothead yard will provide emergency source of power in the event of a power outage from the local 11 kV network.

The Power evacuation plan for Mago Chu HEP has been proposed through a 132 KV line upto pooling station at Tawang-II.

10. INFRASTRUCTURAL FACILITIES

Nearest town is Jang which is 505 km from Guwahati and 353 km from Nagaon. At present, the Barrage site is approachable from Jang through a jeepable road approx. 15 km long which is under construction by PWD. Power house site which lies near the confluence is also approachable through the same jeepable road.

10.1. COMMUNICATIONS

10.1.1. RAIL HEAD FACILITIES

Jang town, the nearest town from the project site, is connected to both Guwahati & Nagaon by road from where Railway facility is available. Nagaon is the nearest railway station. The heavy machinery and equipment is proposed to be transported up to Nagaon/Guwahati by rail. A store yard with crane facilities for unloading the railway wagons will be provided at Nagaon/Guwahati. Sheds will also be provided to store electrical and other equipment till it is transported to site of works.

10.1.2. ROAD TRANSPORT FACILITIES

The road from Guwahati to Jang is connected through national highway (NH-52). The road from Jang to the project site is presently jeepable road which is under construction. Road and bridges/culverts between Jang and project site needs to be improved and upgraded.

10.1.3. PROJECT ROADS & BRIDGES

The access roads and adits are required during construction. The project roads will have formation width of 10 m. In addition, haul roads (10 m wide) will be required to be constructed for plant areas, quarry sites, disposal sites and explosive magazines, etc. The total length of these roads would be about 3.06 km. Internal roads will also have to be constructed in the colony and store areas.

Two river crossings will be required to access the project component area due to extremely difficult terrain. There is an existing Bailey Bridge (New India bridge) on Mago Chu upstream of the confluence with Nyukcharong Chu. However this bridge cannot be used for transporting heavy ODC components. Therefore one permanent steel bridge downstream of the existing bailey bridge would be constructed on Mago Chu connecting the existing PWD road under construction to the MAT on the right bank of Mago Chu. Thereafter the road will follow the right bank of Mago Chu. A Bailey bridge will be constructed across Mago Chu approx. 300 m downstream of barrage axis to access the river diversion works.

10.2. BUILDINGS AND COLONIES

Residential quarters are required to be constructed for the staff to be deployed on the execution of the project.

A permanent colony for the operation and maintenance staff for the power station and regulation of Barrage gates and Desilting basin is proposed to be constructed along the road to Jang on the left bank of river Tawang Chu. Contractor's colonies and requisite labour colonies with all amenities will be located at sites near the major works. The details of the land required for the facilities is elaborated in Chapter-14.

10.3. CONSTRUCTION PLANT AREAS

Construction plant areas, the aggregate processing plant, batching and mixing plant, compressor house, field workshops proposed to be provided at different sites has been elaborated in Chapter-14. Suitable dumping areas for excavated material and quarry sites have also been elaborated in the above chapter.

10.4. CONSTRUCTION POWER

The power requirement for construction activities is estimated about 2.5 MVA taking into consideration the capacity of electric driven equipments which are to work during the construction period and lighting. The power requirement can be met from DG sets.

10.5. TELECOMMUNICATION

It is proposed to take 2-3 dedicated lines from the nearest P&T exchange by laying cables from the exchange to the project area. It is also proposed to provide an

independent 100 line exchange for the project works. The lines from this exchange will be extended to all project camp and work sites.

One (1) Point to Multipoint digital radio system including Central base station, antenna, transmitter/receiver and integrated multiplexer (MUX) shall be provided for the different work sites, colony, stores and offices, for communication during emergency and during failure of EPABX station.

11. CONSTRUCTION PROGRAMME AND PROJECT PLANNING

The construction of some of the major components will be taken up even when partial infrastructural activities are completed. However, basic minimum facilities to sustain the job requirements would be made available before those works start.

11.1. BASIS OF STUDY

The construction cost and construction period depend to a great extent on the method adopted to carry out the work and equipment deployed for the same. As there are alternative methods/equipment, due care has been exercised in selection of most efficient construction method/equipment so as to optimize construction cost and time. These two factors are inter-related and, generally, any attempt to reduce one results in increasing the other. Therefore, a balance has been maintained and construction cost and construction period are optimized.

11.2. MATERIAL SOURCES

Based on preliminary investigations, requirement of suitable material for use as coarse aggregates in concrete will be fulfilled from the muck generated in underground excavation. However quarry areas in close vicinity have also been identified in case of any additional requirement of coarse aggregate. Suitable sand for use as fine aggregate is, however, not available in the vicinity. Crushed sand is therefore proposed to be used.

Areas for disposal of excavated material from various works have been identified keeping in view the availability of land optimization of lead from the construction site. Locations of Quarries, Aggregate Plants, Batching and Mixing Plants, Dumping areas have been identified and shown in drawing given in the infrastructure chapter (Chapter 14, Volume-I). Lead distances from various project components to construction facility areas, for working out unit rate of civil work items and equipment planning has been worked out.

Two Batching & Mixing Plants and one Aggregate Processing Plants of required capacity have been proposed.

11.3. WORKING SEASON

Equipment planning for calculating requirement of equipment is carried out based on the number of working days available, which depend upon climatic conditions in the project area. In the project area a working season of 8 months is considered possible after allowing for monsoon season of 4 months. The scheduled working hours, considering 25 working days per month, accordingly work out as under:

Single shift work/day	=8x25x6	=1200 hours
Two shift work/day	=8x25x11	=2200 hours
Three shift work/day	=8x25x15	=3000 hours

Planning for all above-ground and underground works has been done considering three shifts-working.

11.4. CONSTRUCTION METHODOLOGY- BASIC CONSIDERATIONS

Mechanized construction has been planned for almost all types of construction activities so as to achieve consistent quality at a faster progress rate. The sequencing of construction activities, wherever possible, has been attempted in such a way that equipment from one activity, on its completion can be shifted to the other. This way, the total requirement of equipment at any given time would be optimized and sufficient utilization of equipment on the project would be ensured.

General construction practices have been adopted in framing the construction methodology of the project. The guidelines laid out in the Working Group Report of the Central Water Commission (CWC) have been followed.

11.5. CONSTRUCTION SCHEDULE

It is proposed to complete the project and commission all the three units in a period of 42 months from the date of start of the project excluding 18 months pre-construction period. Construction of all the works shall be taken up simultaneously in such a manner so as to complete the works in a period of 38 months allowing a period of 4 months for initial filling and testing of the water conductor system and commissioning and testing of the units at an interval of 1 month thereafter. A pre-construction period of 18 months has been envisaged for the construction of approach roads & bridges and other site facilities.

12. ENVIRONMENTAL AND ECOLOGICAL ASPECTS

The identification of environmental parameters, data collection and impact prediction forms the crux of any Environmental Assessment study. It is pre-requisite to assess the baseline status of the proposed project site. This helps to anticipate the adverse impacts due to various stages of project implementation. The information on baseline

environmental setting has been collected through secondary data sources, reconnaissance site visit and field studies as well.

The land requirement for the project is 33.24 Ha. The project shall submerge 2.42 Ha of land comprising entirely of Unclassified State Forest land.

The study area for the CEIA study shall comprise of the following:

- Submergence area
- Area within 10 km of periphery of major project components.
- Catchment area intercepted at the diversion structure site and limited up to upper project diversion structure site

As a part of EIA study, baseline data for various physico-chemical and biological environmental components in the project study area for three seasons has been collected. Main aspects have been described below:

Terrestrial Ecology

The proposed project falls under Unclassified State Forest (USF) for the purpose of construction of various project components. The vegetation on both the banks of the river is relatively undisturbed. However, at places the vegetation cover is very low owing to steep slopes with exposed rocks. The catchment site is a mosaic of degraded forest, primary forest, grassland and human habitation. The area is represented by steep hills on both the sides with rocky outcrops. The surroundings of left bank of barrage site is rocky, very steep and devoid of thick vegetation. The area in general is represented by vertical hills and the vegetation is represented by grass species on such slopes. The Power house site is represented by steep hills with rocky outcrops.

Aquatic Ecology

River Mago Chu is turbulent in all the seasons and number of fast flowing streams / Nalas with rocky bed are present in the project area. The presence of cold snow-melt water is not conducive for much fish diversity at these altitudes. No fishing activity was found in project area since majority is tribal population and fishing is not practiced by Monpa community. There is rare possibility of fish migration from Tawang Chu to Mago Chu and facilitating breeding or acting as a breeding ground for snow trout due to low temperature regime.

Socio-economic profile

Basic information about the various facilities, amenities available in the area as well as general information with respect to agriculture, occupation etc. was also collected during the interaction with the stakeholders and the summary of the same is presented below:

- A total 9 villages were identified and taken for detailed socio-economic survey. The estimate of population of these villages is 5148.
- The overall literacy rate in the study area as per 2011 census is 65%
- The majority of the population in the study area belong to scheduled tribes (66%). The schedule caste population is only 1%.
- The socio-economic survey conducted in 2010 revealed that maximum landholding size in the study area is 3 ha, which suggests that the area is mostly inhabited by marginal and small farmers.
- The cattle and Yak dominate as domestic animals with economic significance. Horse and Yak are used as pack animals.
- There are 36 pre-primary schools, 78 primary schools, 39 middle schools, and 09 secondary schools and 4 higher secondary schools in Tawang district. Most of the educational facilities are run by the government of Arunachal Pradesh.
- The Tawang district has 22 rural health centres as on March 2011 in rural areas. It has one CHC in Jang town and 6 PHC in addition to 114 health sub-centres to cover its 183 villages.
- 261 out of 361 habitations in Tawang are covered under drinking water supply.
- As on March 2011, around 85.5 % of villages (including hamlets) in Tawang district have been electrified

Prediction of impacts and Environmental Management Plan

Prediction is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur because of the implementation of the project .Based on the project details and the baseline environmental status, potential impacts as a result of the construction and operation of the proposed project have been identified. A detailed EIA study is being conducted, which shall cover impacts Assessment in detail. The present Chapter however outlines the key impacts likely to accrue as a result of construction and operation of the proposed project.

- Land environment
- Water resources
- Water quality
- Noise environment
- Ambient air quality
- Soil quality
- Terrestrial flora and fauna
- Aquatic ecology
- Socio-economic environment

Based on the environmental baseline conditions, planned project activities and impacts assessed above, Environmental Management Plan (EMP) enumerating the set of

measures is to be adopted to minimize the adverse impacts. The most reliable way to ensure the implementation of EMP is to integrate the management measures in the overall project planning, designing, construction and operation phases. EMP has been formulated as below and adequate financial resources have been earmarked to implement these measures

- Environmental Measures during Construction Phase
  - Facilities in labour camps
  - Provision for free fuel distribution
  - Sewage Treatment
  - Solid waste management
  - Environmental management in road construction
  - Muck Disposal
- Compensation for acquisition of forest land and compensatory afforestation
- Maintenance of Water Quality
- Wildlife Conservation
- Restoration Plan and Landscaping for Quarry Sites/ other utility area
- Public Health Delivery System
- Control of air Pollution
- Sustenance of Riverine Fisheries
- Greenbelt Development
- Catchment Area Treatment Plan

13. COST ESTIMATES & ECONOMIC EVALUATION

The estimate of cost has been prepared in detail to arrive at the total capital cost of the project. The estimate is based on the prices prevailing in July, 2013, for material, labour etc. Interest charges during construction period have been worked out separately. The detailed estimate of cost of civil works is based on planning and design of various components of works after review of site conditions, carrying out detailed field investigations and analysis and studies.

The provisions under various sub-heads are based on the Guidelines for Preparation of Detailed Project Reports of Irrigation and Multipurpose Projects issued by Ministry of Water Resources, Government of India. All provisions are in Indian Rupees.

The total cost of the project at July, 2013 price level works out as under:

Estimated Cost	Amount
Civil works	453.65 Crores

E & M works	158.38 Crores
Total basic cost (excluding transmission cost)	612.03 Crores
Escalated cost for Civil and E&M works (excluding transmission cost)	131.47 Crores
Interest during construction & Financing Charges	135.62 Crores
Project Cost including, Escalation, IDC and Finance charges	879.12 Crores
Cost per MW installed	9.16 Crores
Levellised Tariff / Kwh (with free power to the State)	INR 4.98

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Business Associate

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