PK HOSPITALITY SERVICES PVT LTD JV

HALAIPANI HYDROELECTRIC PROJECT

16 MW (4 X 4.0 MW)

ANJAW DISTT.

ARUNACHAL PRADESH

DETAILED PROJECT REPORT
(BALANCE WORKS)

MARCH 2021

DESIGN CONSULTANT: ***PRIME CONSULTING GROUP, GURGAON***

HALAIPANI HYDROELECTRIC PROJECT (16 MW)

ARUNACHAL PRADESH

FOREWORD

The Detailed Project Report (Balance Works) of HALAIPANI Hydroelectric Project (4 x 4 MW) has been prepared by Prime Consulting Group consultant to M/s PK Hospitality Services Pvt. Ltd. JV, Mumbai in one volume as below:

Volume – I: Project Engineering

Comprises of Engineering details of the Project and includes chapters on project summary, Stage development, Salient features, Hydrology, Power studies, Optimization studies, Site survey & investigation, Design of Civil Engineering Structures, Power Plant Mechanical & Electrical equipments, Ecological & Environmental Studies, Project cost and Economical evaluation, etc.

HALAIPANI HEP (16 MW)

DETAILED PROJECT REPORT

This Detailed Project Report is presented in following volumes:

VOLUME	TITLE
Vol – I	Project Engineering

TABLE OF CONTENTS

HALAIPANI HYDROELECTRIC POWER PROJECT (16 MW)

CHECKLIST

Sr. No.	PARTICULARS	REMARKS
1	**NAME OF THE PROJECT**	Halaipani Hydro Power Project
	i. State	Arunachal Pradesh
	ii. District	Anjaw
	iii. District Head Quarters	Hawai
	iv. Nearest Village	Hilong / Latul
	v. Category of the Project	Small Hydro Power
	vi. Name of Stream on which project is located	Halai River
	vii. Name of Basin	Lohit Basin
2	**PLANNING**	
	Have the alternative proposals been studied and their merits and demerits discussed?	Yes
	Have the detailed topographical survey been carried out for the following items and drawings prepared as per prescribed scales?	
	(i) Stream surveys	Yes
	(ii) Head work surveys (Weir or diversion structure)	Yes
	(iii) Plant site and camp site	Yes
	(iv) Water conductor system	Yes
	v) Powerhouse, switchyard, tailrace	Yes
	(vi) Penstock, Surge shaft	Yes
	(vii) Communication etc.	Yes
3	**GEOLOGY**	
	Have the geological surveys for head works, powerhouse, tailrace etc. been carried out and report on general geology of the area and on geology of the sites of principal structures appended?	Yes

4	**FOUNDATION INVESTIGATION**	
	Have the foundation investigation for the major civil structures and of the schemes etc been carried out?	Yes
5	**MATERIAL SURVEYS**	
	Have the surveys and laboratory test for construction material like previous and Impervious soil sand aggregate etc and carried out?	Yes
6	**HYDROLOGICAL & METEOROLOGICAL INVESTIGATIONS**	
	Have the hydrological and meteorological investigations been carried out and status of data discussed in report	Yes
	(i) Rainfall in the catchment	Yes
	(ii) Gauge and discharge data of the stream	Yes
7	**HYDROLOGY**	
	Have hydrological survey been carried out to establish the availability of water for the benefits envisaged and what is the dependability of the potential?	Yes
8	**LAND ACQUISITION & RE-SETTLEMENT (wherever applicable)**	
	Have the provisions for land acquisition been considered?	Yes
	Have the socio-economic problems involved in re-settlement been investigated and discussed?	Re-settlement Not involved
9	**DESIGN**	
	Has the layout of the project area viz. location of diversion, structures, water conductor system, Powerhouse and tailrace been finalized?	Yes. Diversion structure and all other components have been finalized.
	Have the preliminary designs been prepared for the following components	

	(a) Diversion weir	Yes
	(b) Penstock and water conductor system	Yes
	(c) Power house and switchyard	Yes
	(d) Powerhouse equipment, LT HT switching equipment and control and protection equipment	Yes
10	**POWER BENEFITS**	
	Have the following points discussed?	
	(i) Total energy production and installed capacity of the grid system	Yes
	(ii) How does the scheme fit into overall development of power of the region?	Yes
	(iii) Energy generated from the project, firm power, seasonal power, and total power.	Yes
	(iv) Proposal of transmission and or connecting the existing system	Yes
	(v) Cost of generation per kW installed as per kWh generated as compared to the various micro-hydel projects and various services in the region to justify the economic variability of scheme	Yes
11	**CONSTRUCTION PROGRAMME**	
	Are the major components of work projects to be done departmentally or through contractor? Have the year / month – wise quantities of the following items been worked out for various components of the project (Total quantity)	Contractor
	(i) Excavation – soft and hard strata	Yes
	(ii) Earth work in filling	Yes
	(iii) Stone for masonry	Yes
	(iv) Coarse aggregate for concrete	Yes
	(v) Steel of various size and type of reinforcement	Yes

	(vi) Cement	Yes
	(vii) Controlled items – steel, special steel for penstock	Yes
	(viii) Other material – POL (Petroleum, oil, and lubricants), electricity, explosives etc	Yes
12	**COST ESTIMATES**	
	Is the estimate prepared?	Yes
	Have the analysis of rates for items / various major items and the components of the project been furnished with analysis and the price index at which estimate is based?	Yes. As per AP PWD, Arunachal Pradesh Schedule of Rates basis and for other items fairly good estimation has been done.
13	**ECOLOGICAL AND ENVIRONMENTAL ASPECTS**	
	Is the area likely to have any environmental and Ecological problems due to the alternate surface water pattern and preventive / corrective measures discussed?	No environmental and ecological degradation
14	**CAMPS AND BUILDINGS**	
	Has the provisions for camps / building made?	Yes.
15	**SOIL CONSERVATION**	
	Is the need for soil conservation measures in the project discussed?	Not Applicable

EXECUTIVE SUMMARY

INTRODUCTION:

Originally the detailed DPR for Halaipani SHP was prepared by Alternate Hydro Energy Centre (AHEC), IIT Roorkee for an installed capacity of 3X3 MW at an estimated cost of Rs. 5137.00 Lakhs only during 1997. The administrative approval and expenditure sanction were accorded vide order No. PWRS/EC-I/EST-58/96-97/1862-68 Dated 23.03.1997.

In the meantime, the project was allotted to the NHPC by the State Government in the year 2000. NHPC after further detailed study of the project found that discharge available in the stream was sufficient to generate 12MW power. On the basis of the said report, NHPC proposed for upgrading the installed capacity to 12 MW to 9 MW. The DPR for 12 MW installed capacity was sanctioned and Administrative Approval was accorded for Rs. 6429.93 Lakhs vide No. PWRS/EC-I/EST-58/96-97/339-44 Dated 27.02.2002.

During the year2002, the project was again taken over from NHPC by the Department of Hydro Power Development. Meanwhile DHPD engaged the Alternate Hydro Energy Centre of IIT, Roorkee as consultant for detailed design and drawing of all components of the project. Accordingly, the representative of AHEC of IIT, Roorkee visited the project site and on the basis of field data obtained by the representatives of the AHEC of IIT, Roorkee, the project was found with potential of 16 MW installed capacity instead of 12 MW subjected to minor modification in the bed slope and raising of the power channel, trench weir, etc. The DPR was prepared for 3X3MW+4MW installed capacity at an estimated cost of Rs. 11240.50 lakhs (Rs.6441.90 for Civil Works & Rs.4798.60 lakhs for EM & HM Works) and Administrative Approval was accorded vide No.PWRS/HPD/EST-29/5098-06 Dated 29.11.2009. In this DPR provision was kept for 16 MW civil structures and 3X4 MW EM equipments. And 1 set of 4MW Unit EM equipments was planned for installation in future.

But seeing the technical problem of installing the one set of 4 MW unit in future, it was decided to install all the 4 sets (4X4MW) at a time by laying 1(one) row of additional penstock pipe. Accordingly, the DPR was revised for 16 MW (4X4MW) for a sum of Rs. 15551.35 Lakhs (Rs.10698.47 lakhs for Civil works & Rs.4852.88 lakhs for EM works) and Administrative approval accorded vide No. PWRS/HPD/EST-29/2009/3249-57 Dated 27.06.2013.

WORK EXECUTED:

The following components/ Sub-head have been completed with the cumulative expenditure of Rs. 12081.38 Lakhs (Rs. 7531.74 lakhs for Civil components & Rs. 4549.64 lakhs E&M components up to March'2018. There is pending liabilities of Rs. 330.13 lakhs against civil work as on March'2018. All the necessary fund required for EM & HM works are available in the LC being operated for the turnkey contractor as per the agreements clause.

1) Barrage Structure : - 10% (Structure damaged in flood)
2) Feeder & Power Channel : - 95% (Damaged in some locations)
3) Desilting Tank :- 60% (Structured Damaged in flood)
4) Forebay Tank :- 90%
5) Saddle & Anchor Block :- 60% (partially Damaged near road)
6) Power House :- 0% (Structured Damaged in flood)
7) Approach Road :- 90% (Road damaged in landslide)
8) Building- 100% 9) T&P :- 100%
9) Miscellaneous & others :- 100%
10) Electro Mechanical Works :- 98% supply & 5% erection work
11) Hydro Mechanical Works :- 50% supply & 5% erection work

FLOOD DAMAGES:

The work was in full swing during 2012-13 and was targeted to complete in March'2013. But, the cloud burst on 25th and 26th June 2012 led to unprecedented flood in Halai River and under construction Power House

was completely damaged. The heavy flooding caused the major damage to the other major components of the project. Barrage Structure, Feeder & Power Channel, Desilting Tank, Forebay Tank, Saddle & Anchor Block & Switchyard were badly damaged due to landslide & erosion of formation.

BALANCE WORK TO BE DONE:

After the flood of June'2012 where heavy damages were caused to the under-construction Intake barrage, Desilting Tank and Power House site, representatives of AHEC, IIT Roorkee and NHPC had visited the project during 2013 and 2016 respectively. As per the assessment of NHPC team the following balance works need to be completed to commission the project.

Sr. No.	Component/Structure	% of Balance Work required
1	Barrage & Intake structure	100%
2	Power Channel	5%
3	Desilting tank	40%
4	Forebay tank & Bye-pass	10%
5	Anchor & Saddle Blocks	40%
6	Power House, Switchyard & Tail Race Channel	100%
7	Protection Works of Power House Area	100%
8	Supply of Equipments: Hydro Mechanical	50%

STATUS OF PROJECT AS ON DATE:

As per the PROJET ASSESSMENT by NHPC in 2016 around Rs.7000.00 Lakhs are required for completion of the remaining works to commission the project. However, only Rs.3469.97 Lakhs is the balance fund against the project. It is pertinent to mention here that the FINAL DPR shall have to be prepared through AHEC, IIT Roorkee before projection of actual requirement of funds to commission the project.

After unprecedented flood on 25/06/2012 & 26/06/2012, there has been no work progress in Civil Components front and all work has been stopped at the Project.

The project site was visited by representative of AHEC, IIT Roorkee in 2013 and submitted the report to the Govt. It has been conveyed in the report that the fund requirement projected by DHPD as per DPR of 2013 will not be able cover the cost of remaining work to be executed to commission the project. As per the report it has also been suggested to get the project completed preferably through Private Developer or a dedicated team of DHPD officers. DHPD at the level of Chief Engineer has made a proposal to convey to the Govt. for engaging a private developer to complete the project.

COST OF ASSETS:

The Value of Assets of Halaipani have been assessed for both Civil and EM&HM works. The assessment has excluded the assets like Division office and staff quarters at Hayuliang and light vehicle etc purchased against the project.

The details of assets of Halaipani are as follow: -

1. Civil Structure :- 3496.19 lakhs
2. EM & HM Works :- 3559.99 lakhs

The EM & HM works of the project are being executed through turnkey agreements for which payments are being released through LC's operated through SBI, Tezu branch. The necessary funds for executing

the remaining balance work of the turnkey agreements are available in the LC.

However, for the cost escalation of the erection work and reconditioning of the supplied EM & HM equipment have to be taken care of through additional funds. The E&M equipment have been stored for more than 5 years and will be requiring re-conditioning before erection.

The cost estimates & Tariff have been worked out again at December 2020 price level and the same have been given in details in Chapter 16 and Chapter 17 respectively.

MAIN COMPONENTS OF THE PROJECT:

The Halaipani Small HE Project comprises of the following main components:

a) A Barrage structure across the Hali River for diverting the river water for power generation. The Barrage will cover full width of the river.
b) 405 m long rectangular vehicular feeder channel to lead the water from intake to settling basin.
c) A settling basin to remove sediment particles above 2mm size.
d) A power channel on the right bank of Hali River to lead the design discharge to Forebay tank. The power channel is rectangular.
e) A forebay tank to ensure supply of immediate water demand on starting the generation units and to remove sediment particles above 0.2 mm size.
f) A spill on one side of forebay tank to allow water to escape from forebay tank in case of emergency shut down of the machines as well as for spillway arrangement. Water from spillway pipe is discharged into river Hali through bye pass channel.
g) Four nos. pressurized penstock pipe for taking the water from forebay to the power house.
h) A gate valve for each unit at the upstream of power house to run and stop the turbine.
i) A surface power house for accommodating turbo generator sets, it's auxiliaries, control panel, battery room, maintenance space, office room and

stores. An EOT crane shall be provided for handling of the equipments inside the machine hall. The approximate building size of the power house is 46.6 m X 16.5 m X 25.05 m high.

j) A manually operated draft tube gate for each unit for isolation of the draft tube to facilitated dewatering for inspection and maintenance.

k) A Tail Race Channel connected to Hali river lead the water coming out from the turbines. The tail race channel is also rectangular in shape.

l) An open switchyard is envisaged by the side of the power house main building. Power will be stepped up to 33 KV level through 11/33 KV generator transformers. Two 33KV bays have been envisaged to feed 33KV lines being constructed in the area by DOP.

CHAPTER – 1

INTRODUCTION (Including Salient Features)

1.1 Type of the project:

Halaipani hydroelectric project (16 MW) is essentially a run of the river project on Halai River, a right bank tributary of Lohit River in Anjaw District of Arunachal Pradesh.

1.2 Location of the project area:

The project lies in the Anjaw District near Latul Village in the State of Arunachal Pradesh. The longitude and latitude of barrage site and power house sites in WGS - 84 co-ordinate system is as under: -

Barrage site :	Latitude	27°58'40.75" North
	Longitude	96°43'10.98" East
Power house site:	Latitude	27°57'57.28" North
	Longitude	96°42'45.31" East

1.3 Accessibility:

Halaipani Hydroelectric Project area is well connected by a black topped motor able road from Tezu to Halaipani Project via Hayuliang (130 km from Tezu).

The nearest rail head is Tinsukia which is connected to Guwahati via Dibrugarh. Nearest airport is at Dibrugarh, which is 220 km, from the Tezu.

The distance of project site from nearby important towns of Arunachal Pradesh are as follows:

ROUTE	DISTANCE	TERRAIN
Hayuliang-Halaipani project site	30 km	Hilly (fair weather road)

Tezu-Hyauliang	100 km	Hilly (all weather road)
Dibrugarh (Assam)-Tezu	220 km	Hilly
Tinsukia-Dibrugarh	45 km	Plain & Hilly (all weather road)
Guwahati-Tinsukia	560	Plain (all weather road)

1.4 General climatic conditions in the project area:

While Latul Village is situated at 2100 m elevation, the barrage and power house sites are at general elevation range of 880 m to 770 m.

The minimum and maximum temperatures recorded in winter and summer are 15^0C and 30^0C respectively. Due to great aridity and high altitude this area falls in rain fall shadows hence the rain fall is not much. The construction season is almost round the year except some period during the rainy season of July-September due to restriction in transportation. Due to excessive rainfall, humidity and temperature, the growth of vegetation is good.

1.5 General description of topography, physiography and geology of the project area:

The project area is covered in the survey of India toposheet No. 91D/12, 91D/16, 90A/9 on 1: 50,000 scale. General topographic of the project area is hilly terrain with moderate to dense forestation. Project is located on Halai River which originates from an elevation of El 4500 m and joins Lohit River at El 720 m. Halai River is the right bank tributary of Lohit river which is further a tributary of main Siang/Brahmaputra River. Halai River mainly flows from North to South direction in the project area with many curves and rapids. Total catchment area of Halai River is about 280 sq. km however catchment area of Halai River at Barrage axis of Halaipani HEP is 270 sq.km.

The Barrage structure, Head Race Channel, Penstock domain and Power House Complex consist of granodiorite rock with magmatic banding as

well as foliation parallel to the magmatic banding. Apart from these massive in situ granodiorites, big boulders of these massive rocks are also present, which may cause problems for the construction of any structure. There are several slide zones along the channel. Therefore, it is advisable that the proper precautions should also be taken during the construction. The detailed geological aspects are discussed in chapter 5.

1.6 Historical background of the project:

Department of Hydro Power Development (DHPD), Govt. of Arunachal Pradesh is wholly entrusted with the design and construction, operation and maintenance of the power projects in Arunachal Pradesh. The state has been partially electrified through diesel generating sets and a few small hydro projects in the past. Recently 405 MW Ranganadi Hydro Power Station has been constructed by NEEPCO in Lower Subansiri distt. of the State. DHPD had entrusted Alternate Hydro Energy Centre (AHEC) of University of Roorkee for preparation of detailed project report, technical specifications for bidding and detailed engineering design and drawing work for the Halaipani small hydroelectric project on Hali River near Hilong village which is about 313 kms from Itanagar, capital of Arunachal Pradesh. A detailed project report (3X3MW) was prepared by AHEC, Roorkee in 1998 on the basis of information and data provided by DOP and technically suitability of different hydro power equipment available from various manufacturers in the Country. Further, DOP has supplied additional data of Hali river for the period January 1995 to February 2000 based on the above discharge data, water availability and power studies were carried out by AHEC. These studies revealed that discharge in the river is available for about 16.31 MW of power generation on 50% dependable flow. On review of the power potential available in the river, it was preferred by AHEC to install 4 units of MW each i.e. a Power plant 16 MW capacity instead of 12 MW. As such the DPR of Halaipani SHEP has been revised, based on latest information and data supplied by

DHPD Govt. of Arunachal Pradesh and AHEC, Roorkee for installed capacity of 16MW (4X4MW).

The renewable sources of energy which could make substantial contribution to meet the rural energy needs are solar, biogas, wind and water power. The power potential under mini & small hydel schemes in Arunachal Pradesh is about 160 MW from 46 schemes. Although the rate of grid power supplied by DOP, Arunachal Pradesh, remains same irrespective of the point of drawal, however but the fact remains that the supply of power at the tail is erratic due to low voltage with frequent and long shutdowns. Further far-flung areas are being electrified through diesel-operated sets, which are not only expensive but also too meagre to meet the demand. Power generation from Halaipani Small Hydro Scheme will result in availability of power to the rural masses of the area which at present is deprived of the power and upliftment thereof.

The Govt. of India has entrusted the Ministry of New & Renewable Energy (MNRE) with the task of overseeing the development of small hydro project generation up to an installed capacity of 25 MW which signifies the thrust attached to this activity by the Govt. of India. The MNRE has announced Small Hydro Power Programs (up to 25 MW station capacity) sanction for SHP scheme for the year 2001-2002 vide their Circular No. 14 (1)/2001-SHP dt. 18 September 2001.

The main points of MNRE Policy related to Small Hydro Schemes are as follows:

a) Promotional Incentives Scheme for carrying out Detailed Survey and Investigation (DSI) and preparation of Detailed project Reports (DPRs) for Small Hydro Power (SHP) project sites up to 25 MW potential. It envisages DSI incentive up to Rs. 3.00 lakhs (Three lakhs) per site and DPR incentive up to Rs. 2.00 lakhs (Two lakhs) per project.

b) Interest Subsidy Scheme for Commercial SHP Projects up to 25 MW station capacity. It envisages interest subsidy up to 7.5% for hilly areas, North-East States, Sikkim and A&N Islands and up to 5% for other areas.

c) Capital Subsidy Scheme for setting up of Small Hydro Power projects up to 2 MW station capacity in the State Sector. It envisages financial support up to Rs.75,000/- per KW for SHP projects in the NE region and Sikkim, up to Rs.45,000/ per KW in middle Himalayas, Ladakh and A&N island and up to Rs. 30,000/- per KW in another hilly areas.

Scheme for financial support to works for Renovation, Modernization and Capacity Upgrading of Small Hydro Power (SHP) projects up to 25 MW station capacity. It envisages financial support for R&M works up to Rs. 2.00 crores per MW.

1.7 Need for the project, possible options and justification for selected option:

Power is most important and essential input for economic development of a country. Hydro power is essentially required for quality power i.e. for the grid stability. The basic advantage of the hydro power over the other modes of power generation is fairly well known to the World. The greatest merit of Hydro power is its suitability, durability, variability and economic viability. As such development of Hydro power becomes essential as an infrastructure development of the country for quality of power/grid stability. As it is well known that there is huge demand for the power in the country. To balance the hydro thermal mix, any new proposal for hydro power development shall provide relief to the national grid to mitigate the miseries of power-starved industry and people. Accordingly, Halaipani hydroelectric project in combination with other hydroelectric projects being conceived in the state of Arunachal Pradesh and other Himalayan State is

justified for long term power needs of the country for economic development.

Hydro power being environment friendly is being given preference to other sources of power generation such as thermal, gas and nuclear.

1.8 Natural resources of the State

The North-east zone has the richest diversity in comparison to any other part of India. Arunachal Pradesh having the largest area (32 per cent of entire North-east), contributes maximum cultural and biological diversity in the region. It has an area of 83,743 km^2 with 13.84 lakh population of which 77.06 per cent live in rural and 22.94 per cent in urban areas. The population density is the minimum in the country, while the literacy is 65.38 per cent, of which 72.55 per cent were male and 57.70 per cent female. With 26 major and over 110 sub-tribes that distinguish themselves with their diverse culture the State can truly be considered as being at the biological and cultural crossroads of Asia. The State exhibits diverse climatic conditions, from heavy rainfall to rain-shadow areas, and flood plains to dry lands. Of the total land area, the State has 51,540 km^2 under recorded forest, 260 km^2 not available for cultivation, 40 km^2 under permanent pasture, 360 km^2 land under miscellaneous tree crops & groves, 370 km^2 cultivable wasteland, 470 km^2 fallow land other than current fallow, 300 km^2 under current fallow, and 1640 km^2 land under net area sown. Of the total forest area, 20.46 per cent is under reserved forests, 18.49 per cent protected forests, and 61.05 per cent unclassified State forests. It is believed that about 40 per cent forest areas are yet to be surveyed and flora has to be classified. There are tropical to alpine conditions with thick forests all over that are full of trees, flowers, orchids, rhododendron, medicinal plants, non-timber forest products (NTFPs), bamboos, canes, and wildlife. There are large numbers of primitive and at least 239 endemic species out of 5000+ known flowering plants. Nearly 53 species are reported as threatened. The region is still one of the active

centers of natural mutation, hybridization and floral evolution. The huge biodiversity in the state may be attributed to very good growing conditions as well as the contiguity of its borders with other neighboring countries, such as China, Myanmar, and Bhutan, which perhaps has helped in mobility as well as micro-speciation of species. The suitable environmental and undisturbed condition has protected hot spot of genetic pool in the region. Shifting cultivation (Jhum), wet cultivation, home gardens, tea, agro-forestry is major economic activities. There are a few famous places, lakes, gompas and monasteries in the State. Also the crop selections are traditionally done by different ethnic groups who live in diverse agro-climate conditions, which have contributed immensely to the genetic diversity of crops. The State also has high tourism and hydropower potential. Despite the availability of such a massive resource base and thin population density, the State maintained a low economic growth because of geographical isolation till the recent past. Similar to other North-eastern States, the State remained isolated for a long time and even now the transport facilities are meager, and accessibility is rather poor in many parts.

1.9 Land required for the project construction

The land required for the Halaipani Small Hydro Project belongs to State Govt. Department and private parties. The total approximately land required is 100000sqm (approx.)

1.10 Population affected by the project and occupation of the people affected

At subsequent stages of EIA/EMP studies, precise details on ownership of land is being ascertained in terms of river bed land, forest land, private agricultural land, etc. The nearby settlement that may be affected by land acquisition is Selari. The number of affected families and their

Demographic Profile, Population, Literacy rate and Male/ Female ratios will also be determined during the course of EIA studies.

1.11 Environmental aspects

Halaipani SHE Project envisages the power generation from river Hali and this development is without any pondage. Mini/small hydel development projects, while sharing all the benefits of hydroelectric generation, harness a renewable source of energy in extremely environmentally benign manner. Social costs therefore are almost nil to even an environmentally conscious state. Being small it does not involve any submergence or violation of the sanctity of forest.

The locations of all the components are so selected that it involves about 6-10 m wide strip of land for the power and other channels in almost 1.78 km length and some small areas each for powerhouse and forebay tank as acquired. It does not cause any environmental/ ecological imbalance of the area.

1.12 Inter State / Inter-national aspects:

The Halai River (on which the Halaipani project is located) originates within the State of Arunachal Pradesh and joins the river Lohit within the State of Arunachal Pradesh itself. Therefore, any interstate or international aspects are not involved in Halaipani HE project.

1.13 Defence angle, if any:

There is no Defence establishment within the project area and its vicinity. Hence, no Defence angle is involved.

1.14 Cost and benefits of the scheme

Power is most important and essential input for economic development of a country. Hydro power is essentially required for quality power i.e. for the

grid stability. The basic advantage of the hydro power over the other modes of power generation is well known to the World. The greatest merit of Hydro power is its suitability, durability, variability, and economic viability. The project has been found commercially viable as the levelised tariff of the project is about Rs. 4.69 per unit at 50% PLF as per prescribed norms of CERC which is generally reasonable and affordable to the consumer at a place where logistic and transportation is difficult. This will also help the socio-economic development of the Arunachal Pradesh and the people.

1.15 PROJECT OBJECTIVES:

Halaipani Small HE Project is envisaged on Hali river near village Hilong in Anjaw District. The Area has a vast potential for development of small hydroelectric project and presently it does not have many small hydro stations in the area.

The development of Halaipani Small HE Project scheme is important as it is very suitable to meet the power demand of the Anjaw District and the State as whole. Development of this scheme shall:

a) Improve basic living conditions and education standard.
b) Establishment and sustain small-scale and rural agro based industries.
c) Improve agricultural productivity by getting assured reliable and stable power supply for the irrigation needs.
d) Improve and further promote tourism in the valley.

The development of the project will benefit the state in the following ways:

i) The development of the project will save precious diesel which is required to run D.G. sets.

ii) The D.G. power generation exhausts carbon mono oxide & carbon dioxide in atmosphere. Therefore, development of project will arrest discharge of these gases.

iii) The development of the project will save fuel wood.

iv) The proposed project can meet the energy requirement of about one lakh persons annually, which would eventually reduce urban migration.

The development of Halaipani Small HE Project scheme is quite favorable due to availability of proven technology, short gestation period of project, cheap and simple operation due to proximity of other similar projects, no escalation in cost of production, long service life and no bad impact on environment. This would not only stimulate the economic activity in the area but would also help in preserving and developing a well-balanced eco-environment.

1.16 Salient Features:

SALIENT FEATURES

1.	**LOCATION**		
	(i)	State	Arunachal Pradesh
	(ii)	District	Anjaw
	(iii)	River	Halai, a tributary of Lohit river
	(iv)	Location of Barrage site (WGS-84) Latitude Longitude	 27°58'40.75" North 96°43'10.98" East
	(v)	Location of Power House (WGS-84) Latitude Longitude	 27°57'57.28" North 96°42'45.31" East
	(vi)	Nearest rail head	Tinsukia
	(vii)	Nearest Airport	Dibrugarh
2.	**HYDROLOGY**		

	(i)	Catchment Area	270 Km^2
	(ii)	Design flood (SPF)	1938 cumecs
4.	**BARRAGE**		
	(i)	Barrage top	EL 895 m
	(ii)	River bed level at Barrage site	EL 879 m
	(iii)	Barrage height (above river bed level)	16 m
	(iv)	Design flood (1 in 100 years)	1938 cumecs
	(v)	Crest elevation	EL 879 m
	(vi)	Nos. and size of spillway opening (w x h)	3 nos. 6 m x 4.50 m
	(vii)	Energy dissipation	Straight Reach
5.	**RESERVOIR**		
	(i)	Full Reservoir (FRL)	EL 894.300 m
	(ii)	Min. draw down level (MDDL)	EL - m
6.	**FEEDER CHANNEL**		
	(i)	Length	405 m
	(ii)	Shape	Rectangular
	(iii)	Size	Width – 4.00 Depth – 2.64 m
	(iv)	Bed Slope	1 in 275
	(v)	Full Supply Depth	2.04 m
	(vi)	Design discharge	27.20 cumecs

7.	**DESILTING BASIN**		
	(i)	Numbers	Two
	(ii)	Length Transition Length (Upstream) Transition Length (Downstream)	63.0 m 42.0 m 21.0 m
	(iii)	Design discharge	27.20 cumecs
	(iv)	Width	18 m
8.	**POWER CHANNEL**		
	(i)	Length	1539 m
	(ii)	Shape	Rectangular
	(iii)	Size	Width – 4.00 m Depth – 2.42 m
	(iv)	Bed Slope	1 in 400
	(v)	Full Supply Depth	1.97 m
	(vi)	Design discharge	21.75 cumecs
9.	**FOREBAY TANK**		
	(i)	Size	66 m x 10 m
	(ii)	Depth	4.80 m to 8.30 m
	(iii)	Storage	2 minutes
	SPILLWAY CHANNEL		
	(i)	Length of Bye pass Crest	38 m
	(ii)	Length of Bye pass Channel	200 m
	(iii)	Shape of Bye pass Channel	Circular with MS pipe 1300 mm dia

10.	**PENSTOCK**		
	(i)	Numbers	Four
	(ii)	Type	Steel lined
	(iii)	Diameter & Length	1.30 m & 174 m long
	(iv)	Design Discharge	5.44 cumecs/ each pipe
11.	**POWERHOUSE COMPLEX**		
	(i)	Type	Surface
	(ii)	Gross head	102.965 m
	(iii)	Machine floor level	EL 772.45 m
	(iv)	Type of turbine	Horizontal Francis
	(v)	Generating units	4 x 4 MW
	(vi)	Installed capacity	16 MW
	(vii)	Rated net head (Design head)	95.00 m
	(vii)	Power house size	46.6 m (L) X 16.5 m (W) X 25.05 m (H)
12.	**TAIL RACE CHANNEL**		
	(i)	Numbers	One
	(ii)	Size & type	4.00 wide x 2.50 m D, concrete lined.
	(iii)	Design discharge	21.75 cumecs
	(iv)	Length	20 m
13.	**SWITCHYARD**		
	(i)	Type, size	Surface 53.50 m x 30 m
14.	**POWER GENERATION**		

	(i)	Installed capacity	16 MW (4 x 4 MW)
	(ii)	Energy generation at 55% PLF	58.43 MU
		Energy generation at 50% PLF	53.12 MU
	(iv)	Energy generation at 60% PLF	63.74 MU
		Energy generation at 73.88% PLF	79.68 MU
15.	**CONSTRUCTION PERIOD**		2.5 Years
16.	**COST ESTIMATE & TARIFF**		
	Total Hard Cost		Rs. 12942.77 Lakhs
	Escalation		Rs. 650.58 Lakhs
	Interest During Construction		Rs. 987.47 Lakhs
	Financing Charges		Rs. 204.13 Lakhs
	Total Soft Cost		Rs. 14784.95 Lakhs
	Levelized Tariff @ 50% Load factor		Rs. 4.69 per kWh
	Levelized Tariff @ 55% Load factor		Rs. 4.27 per kWh

CHAPTER-2

JUSTIFICATION OF THE PROJECT FROM POWER SUPPLY ANGLE

2.0 General

This chapter contains data and the result of studies of the power position in India, the consequences of power production at the proposed Halaipani HEP and the integration of its power into the North Eastern Grid.

2.1 Justification of the project from power supply – demand consideration on all India / regional basis.

The power system in India has grown into large regional power grids from small, isolated stations, serving limited consumers in and around large cities. The installed generating capacity in the country has already grown to 345495 MW (as per CEA report of power sector, 31 July 2018).

Grid Management in India is carried out on a regional basis. The country is geographically divided in five regions namely, Northern, Eastern, Western North Eastern and Southern. All the states and union territories in India fall in either of these regions. The first four out of these five regional grids are operating in a synchronous mode, which implies that the power across these regions can flow seamlessly as per the relative load generation balance. The Southern Region is interconnected with the rest of India grid through asynchronous links. This implies that quantum and direction of power flow between Southern Grid and rest of other regional grids can be controlled manually.

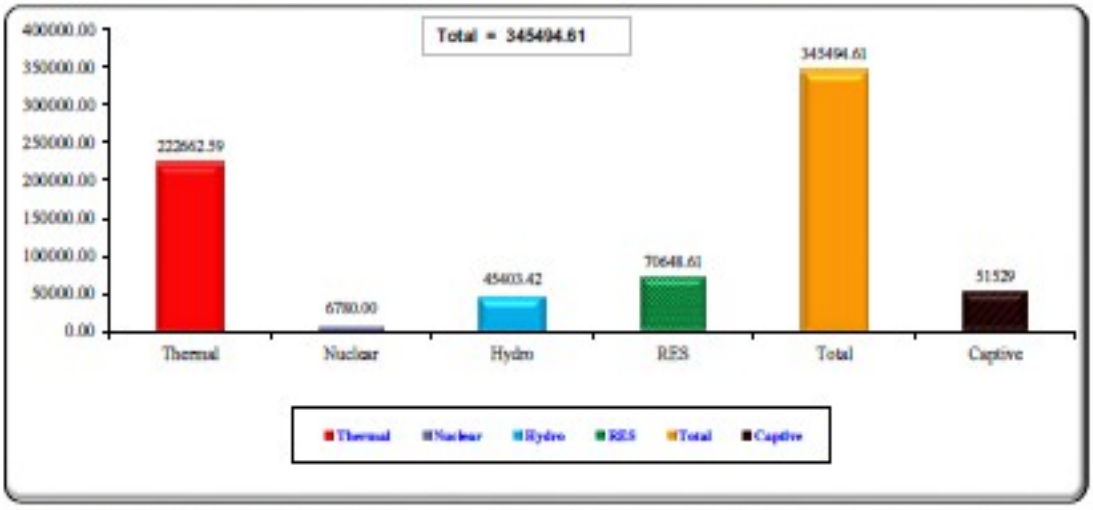
The objective of the system development is to evaluate self sufficient regional grid catering to the individual regional power demands. It is also aimed at achieving the maximum benefits from integrated operations, through a proper mix of thermal and hydro generation and ultimately to tie

the five regional grids together to form a strong National Power Grid, providing even better reliability.

The present power position in the five regional grids as on 31st July 2018 is as follows (Refer Table 2.1):

Table 2.1: All India Installed Capacity Region wise as on 31.07.2018

Region	Thermal				Nuclear	Hydro	RES	Grand Total
	Coal	Gas	Diesel	Total				
Northern	52845.20	5781.26	0.00	58626.46	1620.00	19653.77	13012.88	92913.11
Western	70608.62	10806.49	0.00	81415.11	1840.00	7547.50	20725.38	111527.99
Southern	45782.02	6473.66	761.58	53017.26	3320.00	11808.03	35535.49	103680.78
Eastern	27201.64	100.00	0.00	27301.64	0.00	4942.12	1075.85	33319.61
North-East	520.02	1706.05	36.00	2262.07	0.00	1452.00	286.46	4000.53
Islands	0.00	0.00	40.05	40.05	0.00	0.00	12.56	52.61
ALL INDIA	196957.50	24867.46	837.63	222662.59	6780.00	45403.42	70648.61	345494.61



Note: Captive Generation is not included in the total. *Captive Power capacity is as on 31.03.2017 RES as on 31.03.2018.

The actual power supply and demand position in India to the current date is shown in the Table 2.2 and 2.3. From the table it is observed that north eastern region in July 2018 had deficit in peak capacity of 3.8% and energy deficit of 3.5%. From the same table the Eastern Region in July, 2018 was short in peak capacity of 0.1% and energy deficit by 0.6%. The northern region was short in peaking by 1.8% and energy deficit by 1.4%.

Table 2.2: Energy Power Supply Position (Actual)

राज्य/State प्रणाली / System क्षेत्र / Region	जुलाई, 2018 /July,2018				अप्रैल,2018 -जुलाई,2018/ April,2018 to July,2018			
	ऊर्जा आवश्यकता Energy Requirement (MU)	ऊर्जा उपलब्धता Energy Supplied (MU)	ऊर्जा पूर्ति में कमी Energy not Supplied (MU)	(%)	ऊर्जा आवश्यकता Energy Requirement (MU)	ऊर्जा उपलब्धता Energy Supplied (MU)	ऊर्जा पूर्ति में कमी Energy not Supplied (MU)	(%)
चंडीगढ़/ Chandigarh	177	177	0	0.0	635	635	0	0.0
दिल्ली / Delhi	3,691	3,688	3	0.1	13,579	13,570	10	0.1
हरियाणा / Haryana	5,935	5,935	0	0.0	19,961	19,961	0	0.0
हिमाचल प्रदेश / Himachal Pradesh	856	794	62	7.3	3,176	3,097	78	2.5
जम्मू कश्मीर / Jammu & Kashmir	1,536	1,232	303	19.8	6,374	5,105	1,269	19.9
पंजाब / Punjab	7,048	7,048	0	0.0	21,441	21,428	13	0.1
राजस्थान / Rajasthan	6,094	6,084	10	0.2	25,416	25,262	153	0.6
उत्तर प्रदेश / Uttar Pradesh	11,627	11,525	102	0.9	44,135	43,789	346	0.8
उत्तराखंड / Uttarakhand	1,301	1,287	14	1.1	4,972	4,913	59	1.2
उत्तरी क्षेत्र / Northern Region	**38,266**	**37,771**	**495**	**1.3**	**139,687**	**137,760**	**1,928**	**1.4**
छत्तीसगढ़ / Chhattisgarh	2,299	2,297	3	0.1	8,900	8,893	7	0.1
गुजरात / Gujarat	8,746	8,746	1	0.0	39,534	39,521	14	0.0
मध्य प्रदेश / Madhya Pradesh	5,267	5,267	0	0.0	21,931	21,931	0	0.0
महाराष्ट्र / Maharashtra	11,967	11,966	0	0.0	54,154	54,152	2	0.0
दमन और दिउ / Daman & Diu	226	226	0	0.0	891	891	0	0.0
दादर व नगर हवेली / Dadra & Nagar Haveli	532	532	0	0.0	2,131	2,131	0	0.0
गोवा / Goa	327	327	0	0.0	1,441	1,441	0	0.0
पश्चिमी क्षेत्र / Western Region	**29,364**	**29,361**	**4**	**0.0**	**128,981**	**128,959**	**23**	**0.0**
आन्ध्र प्रदेश / Andhra Pradesh	5,140	5,136	4	0.1	20,988	20,962	26	0.1
तेलंगाना / Telangana	5,267	5,262	5	0.1	19,411	19,384	28	0.1
कर्नाटक / Karnataka	5,323	5,318	5	0.1	22,067	22,036	31	0.1
केरल / Kerala	1,917	1,901	16	0.8	8,274	8,233	41	0.5
तमिल नाडु / Tamil Nadu	9,666	9,658	8	0.1	38,693	38,647	46	0.1
पुडुचेरी / Puducherry	240	239	1	0.6	977	972	4	0.4
लक्ष-द्वीप / Lakshadweep #	4	4	0	0	16	16	0	0
दक्षिणी क्षेत्र / Southern Region	**27,553**	**27,513**	**40**	**0.1**	**110,410**	**110,234**	**176**	**0.2**
बिहार / Bihar	2,785	2,783	2	0.1	10,703	10,596	106	1.0
दामोदर घाटी निगम / DVC	1,895	1,893	1	0.1	7,538	7,489	50	0.7
झारखण्ड / Jharkhand	700	699	0	0.1	2,830	2,784	46	1.6
ओडिशा/ Odisha	2,721	2,713	7	0.3	11,136	11,118	18	0.2
पश्चिम बंगाल / West Bengal	5,394	5,390	4	0.1	19,177	19,082	94	0.5
सिक्किम / Sikkim	39	39	0	0.1	159	159	0	0.1
अंडमान-निकोबार/ Andaman- Nicobar #	29	27	2	7	115	108	8	6.7
पूर्वी क्षेत्र/ Eastern Region	**13,533**	**13,518**	**15**	**0.1**	**51,543**	**51,229**	**314**	**0.6**
अरुणाचल प्रदेश / Arunachal Pradesh	70	69	1	1.4	282	278	4	1.5
असम / Assam	1,027	991	36	3.5	3,360	3,207	152	4.5
मणिपुर / Manipur	73	72	1	1.5	274	270	4	1.6
मेघालय / Meghalaya	172	172	0	0.0	586	586	0	0.0
मिज़ोरम / Mizoram	52	51	1	1.6	190	187	3	1.7
नागालैंड / Nagaland	80	71	8	10.5	300	267	33	11.1
त्रिपुरा / Tripura +	149	147	2	1.3	527	513	14	2.7
उत्तर-पूर्वी क्षेत्र / North-Eastern Region	**1,623**	**1,574**	**50**	**3.1**	**5,520**	**5,308**	**212**	**3.8**
अखिल भारत / All India	**110,339**	**109,736**	**603**	**0.5**	**436,142**	**433,488**	**2,653**	**0.6**

Lakshadweep and Andaman & Nicobar Islands are stand- alone systems. power supply position of these does not form part of regional requirement and availability.

Table 2.3: Peak Power Supply Position (Actual)

राज्य/State प्रणाली / System क्षेत्र / Region	जुलाई, 2018 /July,2018				अप्रैल,2018 -जुलाई,2018/ April,2018 to July,2018			
	अधिकतम मांग Peak Demand	अधिकतम उपलब्धि Peak Met	मांग की पूर्ति में कमी Demand not Met		अधिकतम मांग Peak Demand	अधिकतम उपलब्धि Peak Met	मांग की पूर्ति में कमी Demand not Met	
	(MW)	(MW)	(MW)	(%)	(MW)	(MW)	(MW)	(%)
चंडीगढ़/ Chandigarh	368	368	0	0.0	369	369	0	0.0
दिल्ली / Delhi	7,016	7,016	0	0.0	7,016	7,016	0	0.0
हरियाणा / Haryana	10,270	10,270	0	0.0	10,270	10,270	0	0.0
हिमाचल प्रदेश / Himachal Pradesh	1,471	1,290	181	12.3	1,474	1,474	0	0.0
जम्मू कश्मीर / Jammu & Kashmir	2,750	2,200	550	20.0	2,945	2,356	589	20.0
पंजाब / Punjab	12,556	12,556	0	0.0	12,556	12,556	0	0.0
राजस्थान / Rajasthan	11,057	11,057	0	0.0	11,698	11,698	0	0.0
उत्तर प्रदेश / Uttar Pradesh	19,880	19,353	527	2.7	20,498	20,062	436	2.1
उत्तराखंड / Uttarakhand	2,143	2,143	0	0.0	2,143	2,143	0	0.0
उत्तरी क्षेत्र / Northern Region	**61,812**	**59,897**	**1,915**	**3.1**	**61,812**	**60,715**	**1,097**	**1.8**
छत्तीसगढ़ / Chhattisgarh	3,977	3,654	323	8.1	3,977	3,718	259	6.5
गुजरात / Gujarat	14,590	14,569	21	0.1	17,053	16,327	726	4.3
मध्य प्रदेश / Madhya Pradesh	7,711	7,664	47	0.6	8,764	8,745	19	0.2
महाराष्ट्र / Maharashtra	19,327	19,327	0	0.0	23,395	23,254	141	0.6
दमन और दिउ / Daman & Diu	351	351	0	0.0	351	351	0	0.0
दादर व नगर हवेली / Dadra & Nagar Haveli	778	778	0	0.0	778	778	0	0.0
गोवा / Goa	497	493	4	0.8	562	562	0	0.0
पश्चिमी क्षेत्र / Western Region	**44,879**	**44,574**	**306**	**0.7**	**53,841**	**52,442**	**1,399**	**2.6**
आन्ध्र प्रदेश / Andhra Pradesh	8,532	8,532	0	0.0	9,253	9,249	4	0.0
तेलंगाना / Telangana	10,419	10,419	0	0.0	10,419	10,419	0	0.0
कर्नाटक / Karnataka	9,463	9,463	0	0.0	10,690	10,688	2	0.0
केरल / Kerala	3,663	3,489	174	4.7	4,050	3,997	53	1.3
तमिल नाडु / Tamil Nadu	15,017	14,918	100	0.7	15,017	14,981	36	0.2
पुडुचेरी / Puducherry	387	383	4	1.0	420	400	19	4.6
लक्षद्वीप / Lakshadweep #	8	8	0	0	8	8	0	0
दक्षिणी क्षेत्र / Southern Region	**44,844**	**44,719**	**125**	**0.3**	**45,946**	**45,684**	**262**	**0.6**
बिहार / Bihar	4,562	4,562	0	0.0	4,900	4,900	0	0.0
दामोदर घाटी निगम / DVC	3,127	3,127	0	0.0	3,127	3,127	0	0.0
झारखण्ड / Jharkhand	1,198	1,198	0	0.0	1,284	1,284	0	0.0
ओडिशा/ Odisha	4,652	4,652	0	0.0	4,652	4,652	0	0.0
पश्चिम बंगाल / West Bengal	8,461	8,461	0	0.0	8,906	8,899	7	0.1
सिक्किम / Sikkim	85	85	0	0.0	90	90	0	0.0
अंडमान-निकोबार/ Andaman- Nicobar #	58	54	4	7	58	54	4	7
पूर्वी क्षेत्र/ Eastern Region	**21,442**	**21,442**	**0**	**0.0**	**21,516**	**21,487**	**29**	**0.1**
अरुणाचल प्रदेश / Arunachal Pradesh	138	128	10	7.2	138	133	5	3.7
असम / Assam	1,863	1,776	87	4.7	1,863	1,776	87	4.7
मणिपुर / Manipur	174	171	3	1.7	193	186	7	3.6
मेघालय / Meghalaya	334	332	2	0.6	371	368	2	0.7
मिज़ोरम / Mizoram	101	98	3	3.0	103	98	5	4.5
नागालैंड / Nagaland	133	126	7	5.3	156	129	26	17.0
त्रिपुरा / Tripura *	298	288	10	3.4	298	288	10	3.4
उत्तर-पूर्वी क्षेत्र / North-Eastern Region	**2,899**	**2,798**	**101**	**3.5**	**2,899**	**2,798**	**101**	**3.5**
सम्पूर्ण भारत / All India	**170,165**	**167,798**	**2,367**	**1.4**	**172,381**	**170,765**	**1,617**	**0.9**

The power is the most important and essential input for economic development of the country. Hydro Power is essentially required for quality power. The basic merit of hydro power is its suitability, durability, variability and economic viability.

The proposed Halaipani HEP would form an integral part of the north eastern grid and will contribute to projected energy requirement. It can also provide peaking load capacity to other regional grids inturn helping in optimizing the generation from thermal stations which are forced to operate at an extremely poor load factor due to absence of matching hydropower contribution.

The project has been found commercially viable and the generation from the project shall mitigate the miseries of power-starved industry and people particularly in the eastern and north eastern state. The power tariff should be fixed as per prescribed norms and shall be reasonable and affordable to the consumers.

2.2 Details of scheme for wheeling evacuating power.

The North-eastern region called land of seven sisters, comprises the states of Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram and Tripura. The North-Eastern Grid comprises the power system controlled by the Electricity Boards/ Departments of the above states.

The Eastern Region comprises the states of Bihar, Jharkhand, West Bengal, Sikkim and Orissa. The Eastern grid comprises the power system controlled by Electricity Boards/ Corporations of the above states including D.V.C.

The Northern Region comprises the states of Punjab, Haryana, Delhi, UP, Uttaranchal, Chandigarh and J&K. The Northern grid comprises the power system controlled by Electricity Boards/ Corporations of the above states.

It is proposed to provide two outgoing bays for evacuating 16 MW of power at 33 KV level from Halaipani HEP switchyard to the 132-kV transmission line. The 132-kV substation has been proposed by GoAP at Tezu.

2.3 Resources for power development in the region/ state

Arunachal Pradesh - the "Land of the dawn-lit mountains", is situated in the north east of India. The State, with a population of only 13.84 lakhs as per 2011 Census inhabiting over an area of 83,743 sq. km., largest amongst NE States, has a very low density of 17 people per sq. km. Bounded by Bhutan to the West, China to the North and North-East and Myanmar to the East, the State is one of the most splendid and variegated tribal areas of the country. The total length of international border is about 1628 km. It has inter-State borders with Nagaland in East and South-East and Assam in the South.

There are no reserves of coal available in the state therefore pit head power plants cannot be thought and further there is poor network of roads/rail roads as such the coal power plants shall be unviable in this state. Therefore, no such plants have been envisaged in this area.

The State has enormous hydel power potential. Its untapped hydropower potential is estimated to be 50,000 MW. Due to techno-economic limitation this enormous potential has remained unexploited. The State suffers both peak and energy deficits. The focus is on completion of mini/micro hydel projects, renovation and improvement of defunct hydel projects, construction of sub-transmission line for distribution of power from coming up generation projects, electrification of villages and effective use of NRSE and implementation promotion of IREP like bio-gas, wind mill, solar water heating system, solar lantern, village electrification through SHS and setting up of IREP Cells, especially in the rural areas.

The Govt. of Arunachal Pradesh has signed Memorandum of Agreement Understanding (MoA/MoU) with Central Public Sector Undertakings (CPSUs) like NHPC, NEEPCO and NTPCs and Integrated Power Developers (IPDs) for development of 37 Hydro Electric Projects with aggregate capacity of 25,962 MWs as on date.

The present power scenario in the State is indicated below:

Peak Power Demand	**105.00 MW**
Firm Power Generation a) Hydel:- b) D. G. Sets :-	 **22.00 MW** **20.00 MW**
Total:-	**42.00 MW**
Total Short fall :-	**63.00 MW**
Total Installed Capacity a) Hydel:- b) D. G. Sets :-	 **33.83 MW** **27.12 MW**
Total:-	**60.95 MW**

2.4 Available Generating Capacity in the state from different sources.

The topography of the State provides for very ideal conditions for development of hydro-electric power projects. There are five major river basins in the State, viz., Kameng River basin, Subansiri River basin, Siang River basin, Dibang River basin and Lohit River basin. There are many smaller river systems in the State which also offer very conducive sites for hydro power projects. Almost all the major river system flows in the North-South direction and ultimately drains into the Brahmaputra. Apart from the major rivers, the State has many small rivulets which are perennial in nature and providing ideal condition for developing projects in the category of micro/mini and small HEP. As per the preliminary ranking study done by the Central Electricity Authority (CEA), the total potential from 89 major projects

is estimated to be about 49,126MW. The potential from micro/ mini/small projects is also estimated to be about 1600 MW.

Total Installed Capacity	
Through hydro projects	33.83 MW
Through D.G Sets	27.12 MW

2.5 Power Situation in North Eastern Region

The installed capacity of the Northern region power grid, which comprises 7 states including Assam, Arunachal Pradesh, Sikkim, Meghalaya, Nagaland, Tripura, Manipur as on 31st March 2014 is 2910 MW (including Central Sector Projects. The region presently faces shortage in peak load and energy availability to the extent of 5%.

Although the country has achieved capacity addition of about 2,43,029 MW over the last Six decades, peak and energy shortages of varying magnitude are being experienced. During the year 2013-14, the country faced an energy shortage of 86,905 MU (8.7%) and a peak shortage of 12,159 MW (9%).

2.6 Addition to generating capacity due to development of Halaipani HEP

The main objectives of Hydro-Electric Project are: - The Project lies in Inner Himalayas and is one of the backward areas of the State due to harsh climate and difficult communication. The local population depends on forest for fuel, heating requirements. This Project shall provide electricity to the population for domestic use and thus it shall help in reducing the pressure on forest.

The Project will promote small-scale industrial units for local needs.

The other objectives are:

- To conserve kerosene, oil products and wood used for space heating cooking, lighting and other purposes by local people.
- To conserve forests which are being destroyed at an alarming rate to meet rural energy needs.

- To increase productivity and output in rural areas by reducing the cost of energy thereby increases efficiency and profitability.
- To add to the standard of living in village communities i.e. to promote entrepreneurship.
- To create employment opportunities and thus help check rural migration to urban areas.
- To reduce in emission of greenhouse gases.
- To preserve biological diversity.
- To arrest the pollution of water.
- To preserve ozone layer.
- To reduce global warming.

2.7 Conclusion

In the present scenario of continued unreliable power supply and having regard to global warming phenomenon the utilization of small power potential abundantly available in the perennial streams of Arunachal Pradesh assumes significance. It is also the call of the National policy to develop renewable resources of energy to conserve fossil fuels and valuable foreign exchange. In addition, the significant socioeconomic development in an environment friendly manner triggered off by the development of small hydel schemes in hilly and remote areas deserves special consideration.

The Halaipani Hydro-Electric Project has been conceived against this background of reducing the global warming damage and while generating essential power. This will usher a new era of socio-economic development in the neighboring areas of the Project in the District Anjaw.

CHAPTER – 3

BASIN DEVELOPMENT

3.1 The course of the river:

Halai river is a right bank tributary of river Lohit in Lohit basin. The Halai river basin is fan shaped and the catchment elevation ranges from El 4500 m to El 720 m. In the initial reaches the river falls in the Southern direction and then takes South western direction till it joins river Lohit on its right bank in the Anjaw District. The average slope of the river is about 10.1 m / Km. The slope of the river is steep in the initial reaches up to the barrage site then it flows at less steep slope up to its confluence with Lohit River. Total length of the river from its origin up to its confluence with Lohit river is 40 Km. The river length up to diversion site of Halaipani project is 36.7 Km. The confluence with Lohit River is 5 Km downstream of Halaipani diversion site. In the downstream 5 Km reach, the river bed elevation drops from El 870 m (at Halaipani diversion site) to El 720 m at Lohit confluence.

The catchment area of the river basin up to the proposed diversion site of Halaipani project is 270 sq. km., while the total catchment area up to Lohit confluence is 280 sq. km.

3.2 Power potential of the river basin and stages of development:

No other hydro power project other than Halaipani HEP is being planned on Halai river.

3.3 Whether trans-basin diversion of waters involved:

No trans basin diversion of water is involved in Halaipani project.

3.4 Fitment of the scheme in the overall basin development

The proposed Halaipani project fits well into overall basin development of Halai River.

3.5 Effect of future upstream/downstream developments on the potential of proposed scheme:

The present scheme does not affect any of the hydro projects as it is the first one to be developed on Halai River. The second stage project will be located downstream of this project as per the CEA norms and State Government regulations.

CHAPTER- 4

INTER - STATE / INTER - NATIONAL ASPECTS

The Halai River (on which the Halaipani Project is envisaged) originates within the State of Arunachal Pradesh and joins the river Lohit within the State of Arunachal Pradesh itself. Therefore, any inter state or international aspects are not involved in Halaipani project.

CHAPTER- 5

SURVEY AND INVESTIGATION

5.1 GENERAL INTRODUCTION

Halaipani Hydro-Electric Project is located across river Halai in District Anjaw of Arunachal Pradesh. The proposed Barrage site is located at 27°58'40.75" N and longitude 96°43'10.98" E is located near village Latul/Hilong, while the proposed Powerhouse is located just downstream of Latul Village. The nearest rail head is at Tinsukia and the nearest airport is at Dibrugarh. It is planned to have installed capacity of 16 MW having 4 units of 4 MW each.

River Halai is a tributary of river Lohit, which is a major tributary of Brahmaputra River. A diversion barrage, free flow channel, forebay, penstock and a surface powerhouse on right bank of Halai river are envisaged in this project. The channel is proposed on the right bank of Halai river. About 102.965 m gross head is available for generation of 16 MW of power. The proposed 11 m high barrage site is located at latitude 27°58'40.75" N and longitude 96°43'10.98" E in Survey of India toposheet No. 91D/12, 91D/16, 90A/9.

Field survey and investigations were carried out with the objective of preparing grid maps, establishing ground control points, fixing alignments and obtaining the river's L-section, cross sections etc.

Detailed topographical survey covering the head works area and the powerhouse complex area was carried out for designing the project components. The river profile was mapped at key points for assessing the power potential of the river.

Geological investigations comprising subsurface investigations, surface geological mapping and traverse along WCS alignment were carried out after preliminary surveys. Subsurface investigations included study of rock properties using exploratory drill holes has been carried out.

Topographical Survey and Geological investigation of the proposed Halaipani hydroelectric project has been again carried out by the Developer. The investigation consisted of geological mapping of the project on 1:1000 and 1:5000 scales and development of geological section through proposed engineering structure on same scale.

5.2 TOPOGRAPHICAL SURVEY

The Survey work of the project has been conducted by DHPD, Arunachal Pradesh. The detailed survey was carried out at the site from weir site to powerhouse site along the river Halai. This survey covered the area from proposed location of the weir to tail arce channel in scale of 1:2000 with 5m contour interval.

But the topographical survey of diversion weir available in 1:500 scale and forebay area to tail race available in 1:500 scale covered mainly the location of the structures as proposed by Department of Power, Arunachal Pradesh. Longitudinal section of penstock from the location of the forebay tank as proposed by DHPD, in vertical and horizontal scale of 1:500 is also available. Longitudinal section of Hali river from the weir site as proposed by DHPD is also available in a vertical scale of 1:500 and horizontal scale of 1:2000.

5.3 REGIONAL GEOLOGICAL SET UP

The Himalaya forms one of the highest mountain chains in the world, with more than 30 peaks, rising to the height of 7300 m above sea level. The Himalaya stretches uninterruptedly in a curvilinear fashion along a regional strike of about 2400 km in length, form west to east, characterised by the two syntaxial bends, the western syntaxis at Nanga Parbat and the eastern syntaxis at Namcha Barwa at its western extremities respectively. The width of the Himalaya from north to south varies between 230 km to 300 km with an average width approximating 270 km. To the north, the Himalaya is bordered by the high plateau of Tibet and to the northwest by the mountain ranges of Karakoram and Hindu-Kush. To its south lies the Gondwanan Indian subcontinent.

The eastern Himalaya is also known as the North eastern Himalaya. It extends in E-NE to north-westerly direction from Kameng to Siang up to Siang River gorge; further east it takes an orogenic bend to the SE in Lohit district, defending the so-called Eastern Syntaxial Bend(ESB).

Geology between Kameng-Subansiri-Siang Himalaya contains rock from foothills to the Upper Himalaya towards north. The geological formations are Siwalik Group, Gondwana Supergroup, Buxa, Daling and High grade

crystallines. The Siwalik Group (Upper Tertiary) of NE Himalaya is in strike continuation of the Siwalik succession of central and eastern Himalaya. The sequence extends eastward from Kameng district along the belt up to Dibang river section in Lohit district, other name of this secession as Tipam. The Siwalik sequence is predominantly arenaceous with local variations. The dominant arenaceous, coarsening upward succession compare closely with the section of Darjeeling-Duas foothills and have been correlated with Middle Siwalik subgroup. The pebbly sandstone and conglomerate correlates with the western side but does not show an apparent continuity with the Tipam-Dising series of the Tirap district. A change from ENE-WSW structural trend to E-W in the Sesseri River and then to NW-SE in Dibang valley area is noteworthy.

The Gondwana exposed are like those of Darjeeling, Sikkim and Kashmir. They are bounded to the north by the Buxa or the Daling. The belt extending from Bhutan to Abor Hills tapers off in the Sesseri River region and is not encountered in the Dibang River. This formation is truncated by the metamorphic and sedimentary rocks of the Lohit district, which successively override the Siwalik group and the Brahmaputra alluvium along NW-SE tending Mishimi Thrust. It seems that the Mishimi Thrust turns E-S in the region of Sesseri River and joins with northerly heading Igo Thrust. in the west. The Igo-Mishirni Thrust extends in Subansiri and Kameng district, where it brings the Metamorphic rocks directly over' Godwana while in Lohit district it separates the Mishimi metamorphic from the Tertiary Naga-Patkai sediments.

North of the Gondwana Belts lies vast Precambrian-Palaeozoic Siang and Miri Group of metamorphic, volcanic and sedimentary rocks, which are thrust southward along the Igo Thrust. These exhibits gradational and intertangling contacts.

The geology of the Lohit Himalaya is quite different from that of the area in the west. It contains the NW-SE tendering metamorphic belt (comprising quartz-sericite schist, augen gneiss, kyanite schist, chlorite-actinolite schist with crystalline limestone and serpentinite) between Brahmaputra alluvium (Mishimi Thrust) and Lohit Thrust and is continuing into metamorphic of Siang - district across Siang fracture to the NW. The metamorphic belt is overridden along NW-SE Lohit Thrust by Diorite-Granodiorite Complex of Mishimi block and terminates along Siang fracture.

Garnrtiferous amphibolites are also been reported as small bands within the main Diorite-Granodiorite Complex of Mishimi block. Syntectonic diorite-gneiss, late-tectonic hornblende granodiorite and biotite leucogranodiorite, hornblende schist, amphibolite, metadolerite and minor crystalline limestones are also observed.

Site Geology:

The area contains granodiorite rock with magnetic banding as well as foliation development which is parallel to the magmatic banding. Apart from these massive insitu granodiorites there are also big boulders of these massive rock are present, which may cause problems for the construction of any structures. The soil is also well developed due to high rain and shadow below the trees, which cause several slide zones along the channel. Therefore, it is advisable that the proper precaution should also be taken during the construction.

These granodioritic rocks are cut by the set of joints, where, all three are equally prominently developed because of the massive character of the rock. Sometimes, the thinly banded variety appears to be mylonitic zone with a very narrow zone, otherwise the rocks are massive in nature. The main foliation paralleling the magmatic banding strikes N 45° - N 225° with a dip of moderate to high (average 60°) angle towards southeast. The first joint set's average strike is N 130° - N 310° with high dip (average 75°) angle towards south-westerly, whereas, the second set of joint strikes almost E-W , (average N 1000 - N 280°) with low angle dip (average 32°). The third joint set is very steep almost vertical with a strike of about N 65° - N 245°.

5.4 RESERVOIR AREA

Reservoir area has a stretch of 0.4 Km in the upstream of Barrage axis and should cover an area of 0.8 ha. Geologically, reservoir seems to be quiet competent without any significant threat to the stability of the project structures. The riverbed area is covered all along the river with river borne material while the slopes are steep inclined at about 70 degrees on the left bank and on right bank.

5.5 INVESTIGATIONS FOR THE PROJECT COMPONENTS

SOIL INVESTIGATION:

The work of the soil investigation for the project site was entrusted to Regional Research Laboratory in 1997 by DOP, Arunachal Pradesh. The following detailed field investigations were carried out:

i) 11 numbers of boreholes (BH-1 to BH-11) were advanced at location of powerhouse, penstock pipeline, forebay tank, power channel, settling basin, weir and intake. But the boreholes could not be advanced beyond 2 to 4 m depth due to resistance of boulders and gravels. Standard penetration tests were carried out in power channel area. A few disturbed and undisturbed samples were collected from few strata for testing in laboratory.

ii) One number of plate load tests was conducted in powerhouse area by using 60cm X 60cm plate at a depth of 1.5m by gravity loading.

i) Sub Soil

The sub soil mainly consists of non-cohesive material having boulder, gravel. Sand-silt mixture upto a maximum depth of 2 m. beyond this layer, boulders mixed with gravel was encountered.

ii) Ground Water Table

The water table was not observed in any bore hole during investigation (Feb 1998).

iii) Safe Bearing Capacity

The plate load test indicates an ultimate value of 37.0 t/m^3. The safe bearing capacity of 15 t/m^3 was obtained by adopting a factor of safety 2.50. the finding of load-settlement curve was used in computation of settlement of various sizes of footings and given in Table 5.1.

The values of safe bearing capacity were computed based on standard penetration tests values (N) with settlement considerations. The values are shown in Table 5.2. Net safe bearing capacity values based on plate load

test i.e. 15.0 t/m^3 is recommended for entire area. The settlement for plate load test is shown in Table 5.1.

iv) Stability of Slope

During construction, care should be taken not to reduce the vegetation cover specially the trees on the slopes. The edge distance at least 5 B should be maintained from the edge of slope for any type of construction (B is the width of foundation). As far as possible, natural drainage should not be obstructed.

Table 5.1

SETTLEMENT FROM PLATE LOAD TEST

WITH S.B.C=15 T/M^3

DEPTH (m)	SIZE OF FOOTING (m)	SETTLEMENT (mm)
1.5	1.5 X 1.5	11.72
	2.0 X 2.0	12.75
	3.0 X 3.0	
	4.0 X 4.0	14.60
	5.0 X 5.0	
	6.0 X 6.0	15.31
	10.0 X 10	16.34

SETTLEMENT FROM 'N' VALUES

DEPTH (m)	SIZE OF FOOTING (m)	SETTLEMENT (mm)
1.0	2.0 X 2.0	17.00
	3.0 X 3.0	25.00
	4.0 X 4.0	25.00
	5.0 X 5.0	33.00
	6.0 X 6.0	50.00
2.0	2.0 X 2.0	27.00
	3.0 X 3.0	36.00
	4.0 X 4.0	44.00
	5.0 X 5.0	50.00
	6.0 X 6.0	50.00

Table 5.2

SAFE BEARING CAPACITY BASED ON N-VALUES CONSIDERING BOTH SHEAR AND SETTLEMENT

DEPTH (m)	WIDTH (m)	SAFE BEARING CAPACITY (m)	SETTLEMENT (mm)
1.0	2.0 X 2.0	17.27	17.00
	3.0 X 3.0	21.35	25.00
	4.0 X 4.0	25.55	25.00
	5.0 X 5.0	35.70	33.00
	6.0 X 6.0	33.30	50.00
2.0	1.0 X 1.0	25.73	-
	2.0 X 2.0	27.30	27.00
	3.0 X 3.0	30.70	36.00
	4.0 X 4.0	34.55	44.00
	5.0 X 5.0	33.71	50.00
	6.0 X 6.0	33.30	50.00
3.0	1.0 X 1.0	40.78	-
	2.0 X 2.0	38.69	38.00
	3.0 X 3.0	40.95	48.00
	4.0 X 4.0	38.69	50.00
	5.0 X 5.0	33.71	50.00
	6.0 X 6.0	33.30	50.00

5.6 CONSTRUCTION MATERIALS

The following four sources of construction material are available in the project area and its close surroundings. These sources can provide the relatively small quantity of the construction materials, mainly aggregates for concrete that may be required for the project.

Preliminary information on these sources based on the present investigation is given below, and the material quality and deserves need detailed estimation.

The small gravelly river terrace deposits

There are various small gravelly terrace deposits are in the project area along the riverbed. Their surface areas vary between 1000m^2 and 6500m^2 and depths may range between 3 m and 7 m.

Riverbed deposit

It also carries gravel and coarse sand. It is a generally shallow almost continuous deposit of nearly 20 m width expected depth.

5.7 Seismotectonic Aspects of the Project Area

The project area lies in the Seismic zone 'V' of India as incorporated in the Indian Standard Criteria for Earthquake Resistant Design of Structures (IS: 1893 Part 1-2002) and lies in Seisat 15 of "Seismotectonic Atlas of India and its Environ".

5.8 Conclusion

Detailed geotechnical investigations and surface geological mapping of the entire project area has been carried out. Based on available data, prima facie it has been found that the site is suitable for construction of project components as discussed above. No adverse geological feature on the surface and during the investigations has been observed. Hence, the project area may be categorized to the extent having satisfactory geological conditions.

CHAPTER – 6

HYDROLOGY

6.1 GENERAL

Halaipani HE Project has been planned as a run-off-the- river development and envisages the construction of a barrage of 11 m height across river Halai, a Tributary of Lohit river in Anjaw district of Arunachal Pradesh. The site is located at Latitude 27°58'40.75" N and Longitude 96°43'10.98" E. which is about 130 kms from Tezu. The catchment area up to the project site is 270 sq km. It is proposed to utilize a gross head of about 102.965 m. The proposed installed capacity of the project is 4 X 4 MW.

6.2 RIVER SYSTEM & BASIN CHARACTERISTICS

Lohit River, a Major left bank tributary of Bhramputra River, originates at an elevation of 6190m from the snow clad peaks of Nimbout Chcumbouri Nechai Gongra Tirap Phasi ranges (approximate elevation of 6000m) in the eastern Tibet, constituting part of Kangrigarpo range, and flows down as Kangrigarpo Qu (also called Zayal Nga Chu and Rongtu Chu), forming the eastern-most river basin of India. The River flows into India near its eastern most inhabited tip Kibithoo and surges through Arunachal Pradesh for two hundred kilometres before emptying itself in the plains of Assam. Its flow is uncontrolled and turbulent, and the river is therefore is known as the river of the blood in the local language. The river flows through Mishmi hills to meet the Siang at the head of the Brahmaputra valley.

The catchment of Halai River (a tributary of Lohit River) lies in the state of Arunachal Pradesh, the largest mountain state in India. The state is situated in the north – eastern part of the Himalayan region and can be divided in to four distinct zones; the snow capped mountains above 4500 m, the lower Himalayan ranges between 3500 m and 2000 m; the

sub – Himalayan Siwalik hills at around 700 m and the eastern Assam plain. The Halai river basin is fan shaped and the catchment elevation varies from 4500 m to 720 m. In its initial reaches, the river flows in the southern direction and then takes south eastern direction, till it joins river Lohit near Chamukh village in the Anjaw district. The slope of the river is about 10.1 m/km. The catchment area up to the proposed diversion site is 270 sq km. The river network is trellis type, and its tributaries are sub-parallel in nature which shows presence of structural control and flows the geomorphological trends of the hills and mountains. In the hilly terrain, the river has deep gorge along their courses. The total length of the river up to the Barrage site is 36.7 km. The bed level of Halai River at proposed Barrage site of Halaipani Hydroelectric Project is 873 m.

6.3 WATER AVAILABILITY FOR POWER GENERATION:

Daily discharge data of Halaipani Nallah has been measured since December 1991 to February 1992 and from January 1995 to February 2000 by H.C.D, Department of Hydro Power Development, Arunachal Pradesh and the same data has been taken for analysis. The daily discharge has been averaged as 10-daily discharge data and is given in Table 6.1. The average year discharge data for the above period is also given in Table 6.1.

The computation for 75% dependable discharges has been made by arranging the 10-daily average discharge in descending order and considering each variant to have equal probability of occurrence. Percentage dependability has been arrived at using Weibul's Distribution Method and is indicated in Table 6.2. From the 10-daily series, it can be inferred that:

- Minimum Flow: 11.03 cumecs
- Maximum Flow: 37.38 cumecs
- Average Annual Flow: 21.82 cumecs

- Min. 50% Dependable Flow: 21.87 cumecs
- Min. 75% Dependable Flow: 18.60 cumecs

Table 6.1

HALAIPANI SMALL H.E PROJECT

AVERAGE TEN DAILY FLOW STATEMENT

PERIOD	1991	1992	1995	1996	1997	1998	1999	2000	AVG.
JAN-I		23.95	27.45	21.42	17.45	14.76	11.77	15.32	18.87
JAN-II		18.55	19.41	16.48	18.80	23.96	11.55	13.52	17.47
JAN-III		18.55	19.47	15.89	18.14	23.63	11.73	12.23	17.09
FEB-I		27.79	26.54	15.38	17.15	19.11	11.85	11.91	18.53
FEB-II		25.40	22.69	18.98	16.17	15.21	11.52	13.24	17.60
FEB-III			21.33	19.96	19.36	14.65	11.31	14.98	16.93
MAR-I			20.06	20.19	24.06	15.03	11.71		18.21
MAR-II			20.94	20.20	28.38	18.03	14.79		20.47
MAR-III			21.79	20.44	26.14	23.40	15.13		21.38
APR-I			21.57	21.63	21.21	17.06	11.86		18.67
APR-II			21.12	22.88	21.62	19.79	12.59		19.60
APR-II			20.57	21.73	22.90	20.61	13.03		19.77
MAY-I			22.47	22.61	25.19	18.49	20.61		21.87
MAY-II			24.45	23.12	24.60	17.76	23.09		22.60
MAY-III			23.61	23.10	23.31	16.96	24.77		22.35
JUN-I			23.54	23.44	21.96	17.42	26.33		22.54
JUN-II			23.69	23.72	25.23	18.17	28.22		23.81
JUN-III			24.11	25.77	24.04	17.80	29.74		24.29
JUL-I			24.52	26.92	24.77	25.97	30.02		26.44
JUL-II			26.12	32.07	25.63	26.01	28.80		27.73
JUL-III			26.22	29.53	25.39	25.49	30.58		27.44
AUG-I			21.48	31.02	20.72	25.88	28.24		25.47
AUG-II			27.22	29.48	26.01	27.03	29.83		27.91
AUG-III			26.42	29.01	25.27	22.59	30.84		26.83
SEP-I			23.34	25.21	26.97	23.38	30.21		25.82
SEP-II			34.63	23.70	28.17	20.40	29.72		27.32
SEP-III			27.67	29.14	32.59	18.54	28.88		27.36
OCT-I			24.46	27.09	37.38	17.34	28.99		27.05
OCT-II			21.98	19.88	34.02	17.81	27.92		24.32
OCT-III			20.50	19.67	23.30	19.46	28.82		22.35
NOV-I			19.98	17.83	17.79	11.03	25.28		18.38
NOV-II			19.48	17.62	17.66	11.31	26.94		18.60
NOV-III			19.13	18.37	17.68	11.49	26.59		18.65
DEC-I			17.95	17.33	17.80	11.59	23.03		17.54
DEC-II	21.10		19.33	17.30	18.58	11.64	18.17		17.69
DEC-III	24.83		19.15	17.50	18.39	11.47	15.17		17.75
Note: **All discharges are in cumecs**									

Distribution of average 10-daily flow series obtained at Halaipani HEP is presented in Figure 6.1.

Figure 6.1: Variation of Average 10- daily flow at Project Site

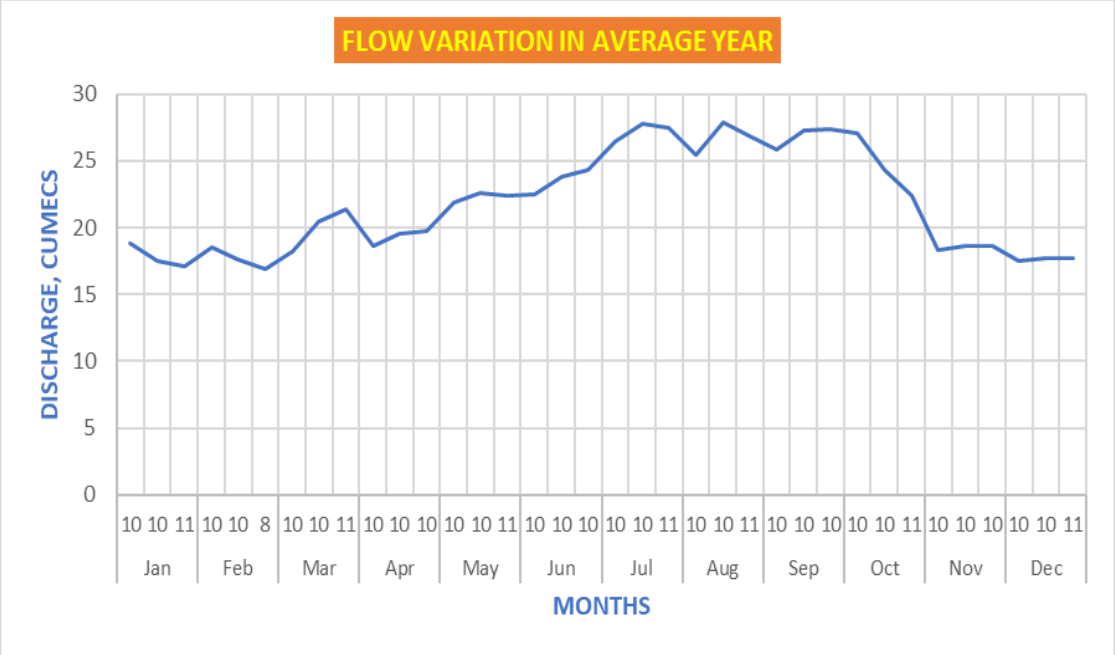


Table 6.2

AVERAGE YEAR DEPENDABLE DISCHARGE

S. No.	Average Discharge	Avg. Discharge (Descending Order)	% of time equaled or exceeded
1.	18.87	27.91	2.75
2.	17.47	27.73	5.50
3.	17.09	27.44	8.30
4.	18.53	27.36	11.11
5.	17.6	27.32	13.80
6.	16.93	27.05	16.60
7.	18.21	26.83	19.40
8.	20.47	26.44	22.22
9.	21.38	25.82	25.00
10.	18.67	25.47	22.70
11.	19.60	24.32	30.50
12.	19.77	24.29	33.30
13.	21.87	23.81	36.10
14.	22.60	22.60	38.80

15.	22.35	22.54	41.60
16.	22.54	22.35	44.40
17.	23.81	22.35	44.40
18.	24.29	**21.87**	**50.00**
19.	26.44	21.38	52.70
20.	27.73	20.47	55.55
21.	27.44	19.77	58.33
22.	25.47	19.60	61.11
23.	27.91	18.87	63.80
24.	26.83	18.67	66.60
25.	25.82	18.65	69.40
26.	27.32	18.60	72.22
27.	27.36	**18.53**	**75.00**
28.	27.05	18.38	77.70
29.	24.32	18.21	80.50
30.	22.35	17.75	83.30
31.	18.38	17.69	86.10
32.	18.60	17.60	88.88
33.	18.65	17.54	91.16
34.	16.17	17.47	94.44
35.	17.59	17.09	97.22
36.	18.27	16.93	100.00

Dependable Year Estimation

The dependable year calculations have been carried for the observed flow series measured at the project site. The annual runoff at project site for various years has been calculated and arranged in descending order and the exceedance probability has been calculated. The dependable year calculations have been shown in Table 6.3.

Table 6.3: ANNUAL FLOW AT HALAIPANI HEP

Observed Series		Rank	Descending Order		Probability of Exceedance
Year	Annual Runoff at Project Site, MCM		Year	Annual Runoff at Project Site, MCM	
1995	722.17	1	1997	730.90	16.67%
1996	706.00	2	1995	722.17	33.33%
1997	730.90	3	1996	706.00	50.00%
1998	588.94	4	1999	693.85	66.67%
1999	693.85	5	**1998**	**588.94**	**83.33%**

75% DY – 1998 – 588.94 MCM

FLOW DURATION CURVE:

The Flow duration analysis is carried out and the average 10-daily flow duration is given in Table 6.2 and the corresponding flow duration curve is shown in Figure 6.1. The discharge equalled or exceeded with time is as flows:

For Average Flows,

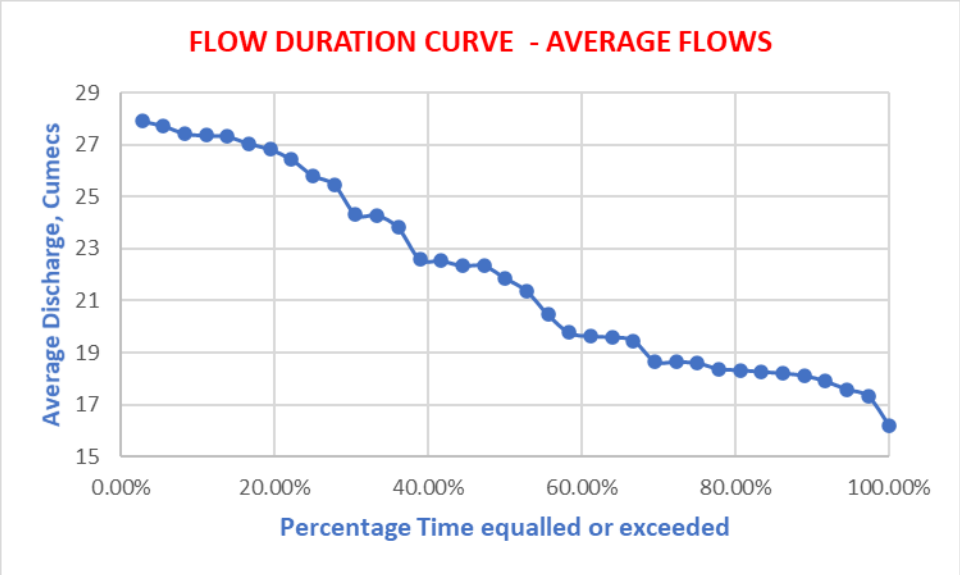
At 100 percent time equalled or exceeded = 16.97 Cumecs

At 75 percent time equalled or exceeded = 18.53 Cumecs

At 50 percent time equalled or exceeded = 21.87 Cumecs

At 25 percent time equalled or exceeded = 25.82 Cumecs

Figure 6.1: Flow Duration Curve for Average Flows



The flow duration curve is also plotted at Figure 6.2 for 75% dependable year (1998) and the discharge equalled or exceeded with time is given below:

For 75% dependable year – 1998,

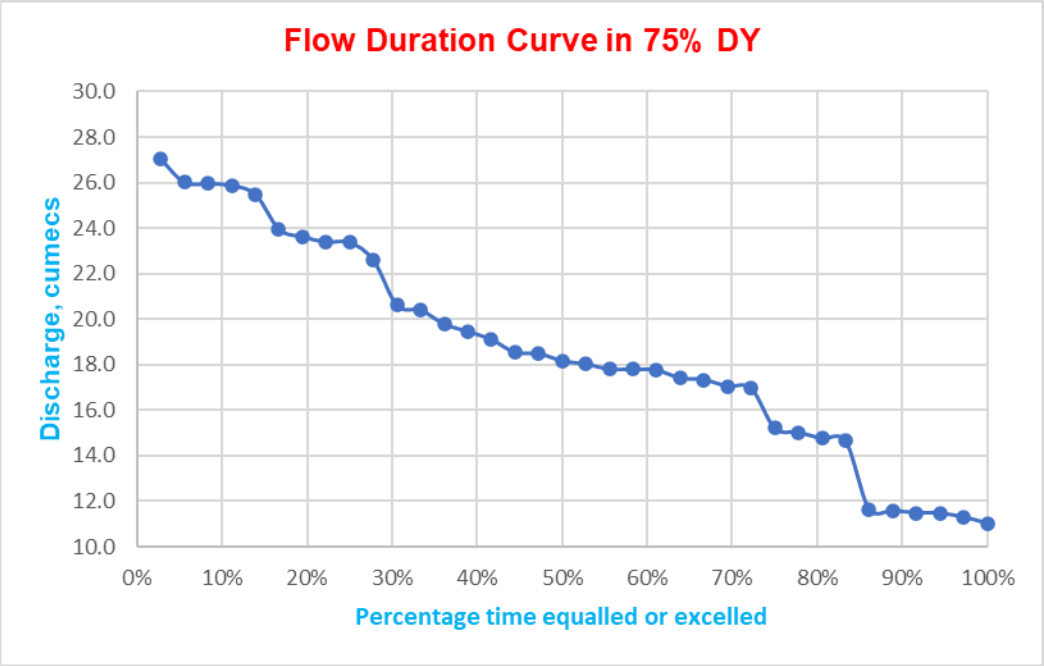
At 100 percent time equalled or exceeded = 11.03 Cumecs

At 75 percent time equalled or exceeded = 15.21 Cumecs

At 50 percent time equalled or exceeded = 18.17 Cumecs

At 25 percent time equalled or exceeded = 23.38 Cumecs

Figure 6.2: Flow Duration Curve for 75% Dependable Year – 1998



The water availability studies were approved by HRED (formerly as AHEC), IIT Roorkee in 2010. The design discharge for power generation has been fixed at 21.75 cumecs which is available for 50% of the time in an average year and 30% in 75% Dependable Year - 1998.

DESIGN FLOOD:

The design flood at diversion structure for Halaipani HEP is estimated at 1938 cumecs as approved by HRED, IIT Roorkee vide letter no. HRED/M-56/SD/119 dated 04th November 2020. The letter is attached herewith as **Annexure 6.1** and the detailed design flood studies has been annexed at **Annexure 6.2**.

ANNEXURE 6.1

भारतीय प्रौद्योगिकी संस्थान, रुड़की

जल एवं नवीकरणीय ऊर्जा विभाग

(पूर्व वैकल्पिकजलऊर्जा केन्द्र)

रुड़की–247 667 (उत्तराखण्ड), भारत

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

DEPARTMENT OF HYDRO AND RENEWABLE ENERGY

(Formerly Alternate Hydro Energy Centre)

Fax : (01332) 273517, 273560, Phone: (01332) 285165,

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डॉ. एम. के. सिंघल
एसोसिएटप्रोफेसर
Dr. M.K. SINGHAL
Associate Professor

HRED/M-56/SD/119
Dated: Nov. 04 , 2020

Sri Manoj Patne
Consultant,
M/s PK Hospitality Service Pvt. Ltd. JV
201, A Wing, Fortune 2000, C-3 Block,
Bandra Kurla Complex,
Bandra East, Mumbai- 400051
Email:manoj.patne@gmail.com

Sub: Techno-Economic Review of Detail Project Report for Halaipani HEP (4×4 MW) in District Anjaw of Arunachal Pradesh

Ref: Email: dated Oct. 27, 2020

Dear Sir,

We have received the design calculations for estimation of design flood for above project vide. your email referred above. These calculations have been reviewed and following discrepancies have been observed in the values of parameters.

S. No.	Parameter for Design Flood Study	Values taken in Design calculations	Values recommended by HRED
1	Value of W50	0.88	2.17
2	Value of W75	0.43	1.07
3	Value of WR50	0.43	0.88
4	Value of WR75	0.21	0.43

By using above recommended values, the design flood for 100 yr return period for above project has been estimated as 1938 cumecs in place of 1880 cumecs. It is proposed that revised design calculations may be submitted for assessment of design flood by taking above values and for the planning and designing of Barrage of this project, the design flood of 1938 cumec may be adopted.

Yours faithfully,

(M.K. SINGHAL)

CC:

1) Chief Engineer (Monitoring)
Department of Hydropower Development,
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ANNEXURE 6.2

ARTEMIS GREENPOWER PRIVATE LIMITED

HALAIPANI HYDROELECTRIC PROJECT

16 MW (4 X 4.0 MW)

ANJAW DISTT.

ARUNACHAL PRADESH

HYDROLOGY DESIGN FLOOD STUDIES

OCTOBER 2020

DESIGN CONSULTANT: ***PRIME CONSULTING GROUP, GURGAON***

TABLE OF CONTENTS

AMENDEMENT TO CHAPTER – 6

HYDROLOGY – DESIGN FLOOD STUDIES

6.1 BACKGROUND

As per the Detailed Project Report submitted in 2009, the diversion structure was proposed at riverbed level of El. 878 m. This barrage site was situated in a V – shaped gorge with width of river close to 20 m. The hill side slopes on both the sides of bank are very steep in nature (close to 80 degrees). The diversion structure was designed for a flood of 600 cumecs corresponding to 1 in 50-year return period. The catchment area of the Halai River up to the diversion site is 270 sq. km. (Refer Catchment area attached at **Annexure 1**).

6.2 REVISED DIVERSION STRUCTURE FEATURES

Riverbed level at new barrage site – El. 873 m

Pond level – El. 883.200 m

Hydraulic Head – 10.20 m

6.3 NEED FOR REVISION IN DESIGN FLOOD

The earlier hydraulic head of the diversion structure as per DPR was close to 7 m. as per the design flood criteria mentioned in clause 6.4, the diversion structure must be designed for a flood corresponding to 1 in 100 years flood as against 1 in 50 years return period as per the earlier designs.

Now, due to site constraints, the newly proposed structure has a hydraulic head of 10.20 m and must be designed for 1 in 100 years return period. As such, the 24-hour rainfall value of 300 mm has been taken from CWC Flood Estimation Report of North Brahmaputra Basin, Sub-zone 2a. The SPS value as supplied by IMD for Gimliang HE Project in vicinity of Halaipani HE project is 360 mm. As such, 24-hour rainfall value of 300 mm is judiciously adopted for Halaipani Diversion structure design flood.

6.4 DESIGN FLOOD

6.4.1 Design Flood Criteria

The standards and guidelines for the prescription of the appropriate design flood given by CWC & Bureau of Indian Standards (BIS) are summarized in Table – 6.1

Table – 6.1: Design Flood Criteria

Type of Structure	Flood Description
CWC: criteria for pick up weir	According to the importance and level conditions, a flood of 50 to 100 years return period should be adopted
IS: 6966 (1989): Criteria for hydraulic design of barrages & weirs	For purpose of design of items other than free board, a design of 50 years may normally suffice. In such cases, where risks and hazards are involved, a review of this criteria based on site conditions may be necessary. For designing the free board, a minimum of 500 years return period flood or the Standard Project Flood (SPF) may be desirable.
IS 11223 (1985): Guidelines for determining spillway capacity	Spillways of small dams with gross storage between 0.5 and 10 MCM and hydraulic head between 7.5 and 12 m are to be designed to safely pass the 100-year flood. Intermediate dams with gross storage capacity between 10 and 60 MCM and hydraulic head between 12 and 30 m are to be designed for safely pass the Standard Project Flood (SPF). Large dams with gross storage capacity greater than 60 MCM & hydraulic head greater than 30 m are to be designed to safely pass the Probable maximum Flood (PMF).

6.4.2 Design Flood Approach

Following approaches are adopted for the estimation of design flood:

i) Hydro – meteorological approach

ii) Flood frequency analysis of annual peak series

In Hydro-meteorological approach, the two basic inputs i.e. unit hydrograph and design storm input, are required to finalize the design flood. It is the most rational method for flood estimation and generally recommended.

The Probabilistic approach is the most common procedure for the analysis of flood data at a gauged location. In general, this approach can be applied to any type of hydro-meteorological data, but it is widely used with flood data. Therefore, it is sometimes designated as flood frequency analysis. This method is not being used in the present analysis with the peak discharge data as no long term hourly discharge data is available at nearest G&D stations.

Hence design flood for the project has been worked out based on synthetic unit hydrograph derived from the basin characteristics and used for the estimation of design flood from hydro – meteorological approach.

For estimating the design floods for gauged and ungauged catchments in India, under Short – Term and Long – Term plans, as recommended by Khosla committee, India was divided into hydro – meteorologically similar zones (8 Zones and 22 Sub – Zones). After detailed analysis of short duration gauge, discharge, and rainfall data for a number of catchments, varying from 25 to 3200 Sq. Km. Central Water Commission has published design flood estimation reports of 22 Sub – Zones. Regression equations presented in the sub – zone reports for deriving representative 1 – hour Unit Hydrographs based on physiographic parameters of the catchment, vary for various sub – zones. Since Halaipani H.E Project falls in North Brahmaputra basin, Sub – Zone 2a, the relations developed in sub – zone 2 a report of CWC have been utilized for estimating Synthetic Unit Hydrograph, based on the physiographic characteristics of the catchment of Halai river up to diversion site.

6.4.3 Development of Unit Hydrograph

Physiographic characteristics of the catchment viz., A, L, L_c, S have been found out and utilized for deriving the synthetic unit hydrograph parameters by utilizing the relations developed in Sub- Zone 2a Report of CWC.

Table 6.2: Physiographic Parameters

Parameters	Definition	Formula	Unit	Value
L	Length of longest mainstream along the river course	Measured on Topographical Map	km	36.30
Lc	Length of longest mainstream from a point opposite to centroid of the catchment area to barrage	Measured on Topographical Map	km	17.20
A	Rainfed Area	Below 4800 m Measured on Topographical Map	Km^2	270
S	Equivalent Stream Slope	[Sum (Li x (Di-1 + Di))]/L2	m/ km	76.80
DLR	Design Loss Rate		Cm/hr	0.24

Table 6.3: Equivalent Stream Slope

Sl No	Reduced Distance Starting From Bridge Site (Point of Study) (km)	Reduced Level of River Bed (m)	Length of Each Segment (L_i) (km)	Height Above Datum* (D_i)=Difference Between the Datum Line and its R.L (m)	(D_{i-1} + D_i) (m)	L_i x (D_{i-1} + D_i) (m*km)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	879.00	-	-	-	-
2	5.00	1315.00	5.00	436.00	436.00	2180.00
3	10.00	1653.00	5.00	774.00	1210.00	6050.00
4	15.00	1947.00	5.00	1068.00	1842.00	9210.00
5	20.00	2342.00	5.00	1463.00	2531.00	12655.00

6	25.00	2805.00	5.00	1926.00	3389.00	16945.00
7	30.00	3187.00	5.00	2308.00	4234.00	21170.00
8	35.00	3597.00	5.00	2718.00	5026.00	25130.00
9	36.30	4211.00	1.30	3332.00	6050.00	7865.00
SUM			**36.30**		-	**101205.00**

S = [Sum(Li x (Di-1 + Di))]/L^2

= 76.80 m/km

Equivalent Slope= 76.80 m/km

Table 6.4: 1-hour Unit Hydrograph Parameters

Parameter	Definition	Formula	Unit	Value
qp	Peak discharge unit Hydrograph per sq km	qp=2.272(LLc/S) ^- 0.409	M^3/sec/km 2	0.964
tp	Time from center of effective rainfall duration to Unit Hydrograph Peak.	tp=2.164*(qp)^- 0.940	hrs	2.24
W50	Width of Uh measured at 50% peak discharge ordinate	W50=2.084(qp)^- 1.065	hrs	0.88
W75	Width of Uh measured at 75% peak discharge ordinate	W75=1.028(qp)^- 1.071	hrs	0.43
WR50	width of rising limb of UH measured at 50% of peak discharge ordinates	WR50=0.856(qp)^- 0.865	hrs	0.43
WR75	width of rising limb of UH measured at 75% of peak discharge ordinates	WR75=0.440(qp)^- 0.918	hrs	0.21

Tb	base width of UH	TB=5.428(tp)^0.852	hrs	11.85
Tm	time from start of rise to the peak of UH	tm=tp+(tr/2)	hrs	3.00
Qp	Peak discharge of UH	Qp=qpxA	M3/sec	260.35

The Unit Hydrograph is plotted with these parameters. The runoff volume is computed, and the ordinates of the unit hydrograph were adjusted to give a runoff depth of 1.0 cm over the catchment. The ordinates of the Unit Hydrograph are tabulated in Table 6.5.

Table 6.5: Unit Hydrograph Ordinates

Time (in hrs)	1-hr Synthetic U.G. ordinates
0.00	0
1.0	49
2.0	120
3.0	260
4.0	145
5.0	85
6.0	45
7.0	23
8.0	12
9.0	7
10.0	3
11.0	1
12.0	0

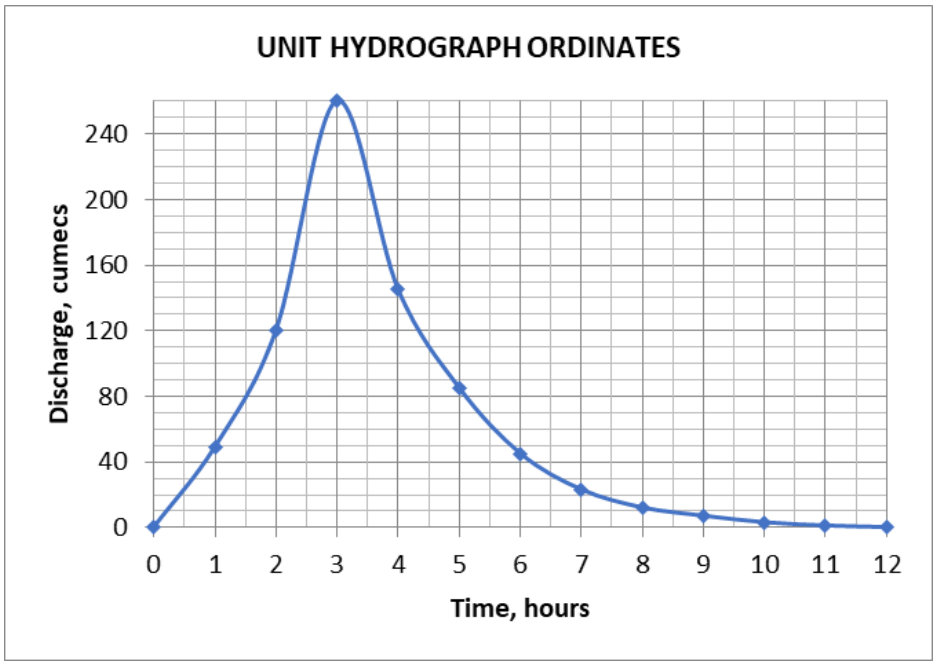
Sum = 750.00 ---- 1

Sum (Qi) = (A * d) / (tr * 0.36)

= (270 *1) / (1 * 0.36)

= 750 cumecs ----- 2

Since, Equations 1 & 2 are equal, the unit graph drawn is in order.



6.4.4 Design Storm

Now, following the computations in Table 6.4, 1.1 * tp = 2.75 hours, ≈ 3.00 hours, say. These equations yield reasonably similar results. (refer Annexure 2). However, for the purpose of this study, time of rainfall duration T_D has been adopted as 12 hours as adoption of $T_D = T_B$ has been reported to yield higher discharges for most of the cases (Clause 3.1.1, page -23, CWC, 1991).

6.4.5 Design Loss Rate

It is assumed that at the time of occurrence of design storm, the soil is nearly saturated. Design loss rate of 0.24 cm / hour as suggested in Subzone 2 a Report for North Brahmaputra Basin has been adopted and hourly rainfall excess values computed.

6.4.6 Base Flow

The design base flow for the catchments of North Brahmaputra basin was arrived in the flood estimation report after studying 237 flood events. Design base flow of 0.05 Cumec per sq. km. of the catchment area has been recommended and the same has been adopted for the estimation of base flow.

6.4.7 Estimation of Design Flood

Distribution of rainfall

100-yr, 24-hr rainfall	=	30.00	cm	
Ratio of 12-hr rainfall to 24-hr rainfall	=	0.805		(from Fig-3)
So, 100-yr 12-hr point rainfall	=	24.15	cm	
Areal reduction factor corresponding to area 270sq km and TD=12 hrs				
	=	0.865		(From Table 6)
So, 100-yr 12-hr areal rainfall	=	20.89	cm	

Critical Sequencing of Rainfall Excess

Duration (hrs)	Distribution coefficient	Design Loss Rate (cm/hr)	Storm Rainfall (cm)	Hourly Rainfall Increment (cm)	Rainfall Excess (cms)
1	0.17	0.24	3.57	3.57	**3.33**
2	0.33	0.24	6.87	3.30	**3.06**
3	0.42	0.24	8.80	1.92	**1.68**
4	0.53	0.24	10.99	2.20	**1.96**
5	0.62	0.24	12.92	1.92	**1.68**
6	0.68	0.24	14.29	1.37	**1.13**
7	0.74	0.24	15.39	1.10	**0.86**
8	0.80	0.24	16.77	1.37	**1.13**
9	0.86	0.24	17.87	1.10	**0.86**
10	0.91	0.24	18.97	1.10	**0.86**
11	0.96	0.24	20.07	1.10	**0.86**
12	1.00	0.24	20.89	0.82	**0.58**

Note: Design loss rate in this zone is recommended as 0.24 cm/hr AS PER Figure 13 of report.

Step : - 7 Estimation of base flow

The design base flow

q_b = 0.0500 cumec per sq km

Total base flow

Qb = 13.50 cumecs

Estimation of 100-yr Flood Peak

For the estimation of the peak discharge the effective rainfall units were re-arranged against the ordinates such that the maximum effective rainfall was placed against the maximum U.G. ordinates, the next lower value of effective rainfall against the next maximum discharge value and so on.

Time in hrs	1-HR UG ordinates	1-hr effective rainfall (cm)	Direct Runoff (cumecs)
0.00	0	0	0
1.0	49	1.68	83
2.0	120	1.96	235
3.0	260	3.33	867
4.0	145	3.06	443
5.0	85	1.68	143
6.0	45	1.13	51
7.0	23	1.13	26
8.0	12	0.86	10
9.0	7	0.86	6
10.0	3	0.86	3
11.0	1	0.86	1
12.0	0	0.58	0

Total	=	1867.7	cumecs			
Base Flow	=	13.50	cumecs			
100-yr peak flood	=	**1881.25**	cumecs	say	**1880**	**cumecs**

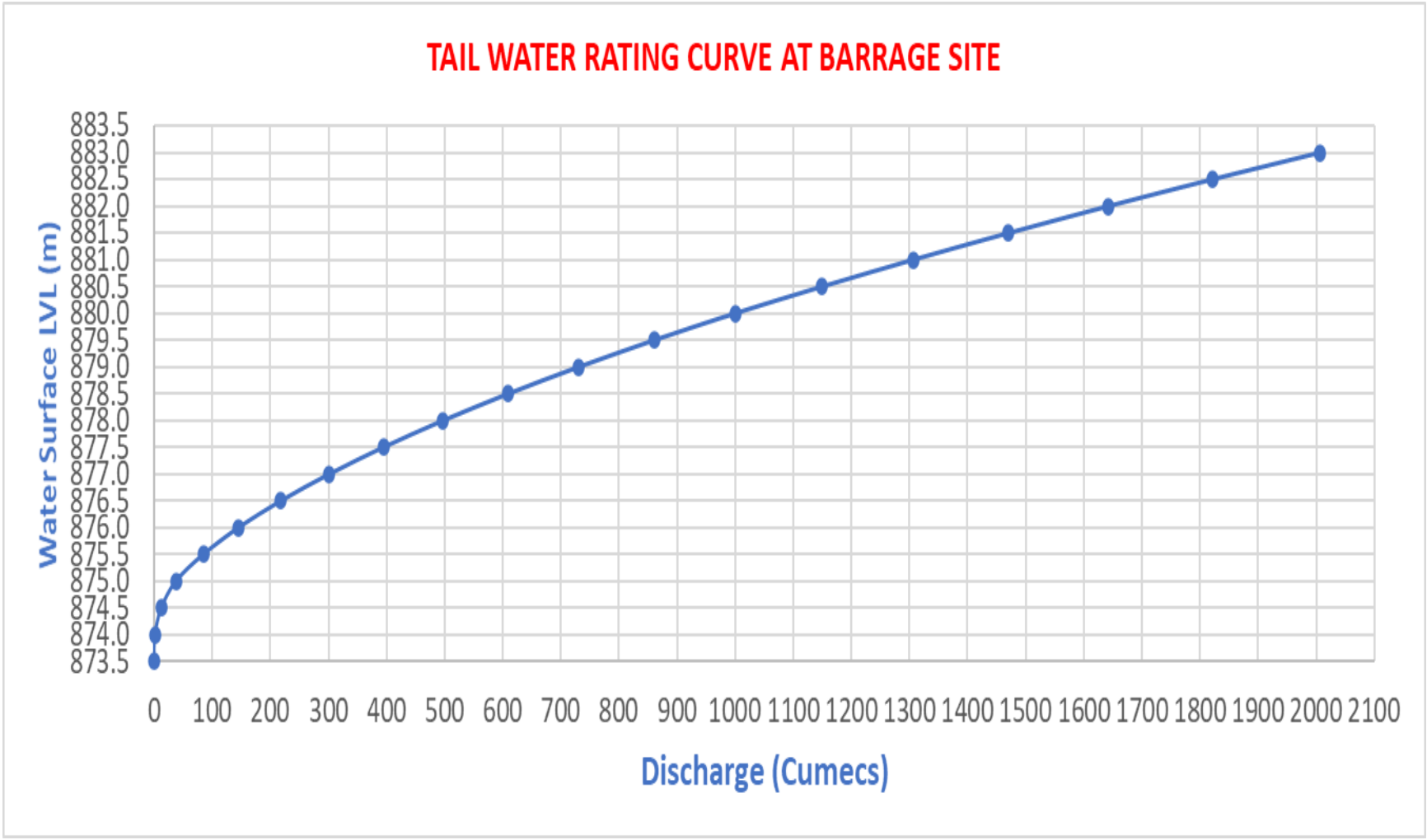
Accordingly, the Halaipani Diversion Structure has been proposed to plan for 1880 cumecs. As compared to the earlier proposal in DPR of 600 cumecs (prepared by AHEC, IIT Roorkee), 1880 cumecs of flood looks reasonable.

6.5 DEVELOPMENT OF GAUGE DISCHARGE CURVE AT BARRAGE AND POWERHOUSE SITE

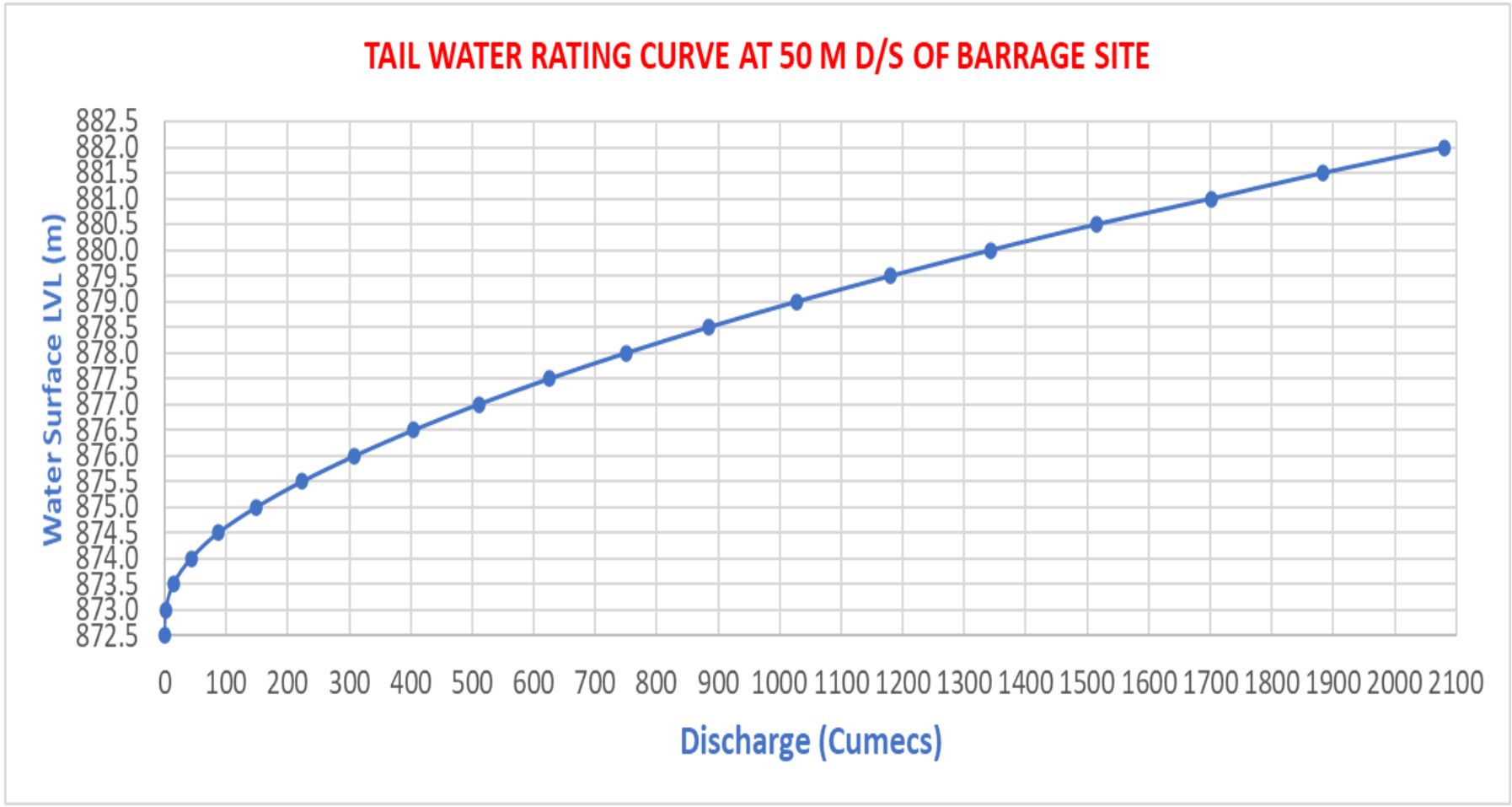
The tail water rating curves at Barrage and Powerhouse sites have been developed using open channel flows principle. The cross sections as per the Toposurvey at the barrage and the powerhouse site have been used in the analysis. The upstream and downstream boundary conditions have been given as the input (Slope of the river). The Manning's Constant has been considered as 0.061 for the riverbed and the riverbanks as per Ven Te Chow recommended values.

The design calculations and rating curves are appended below.

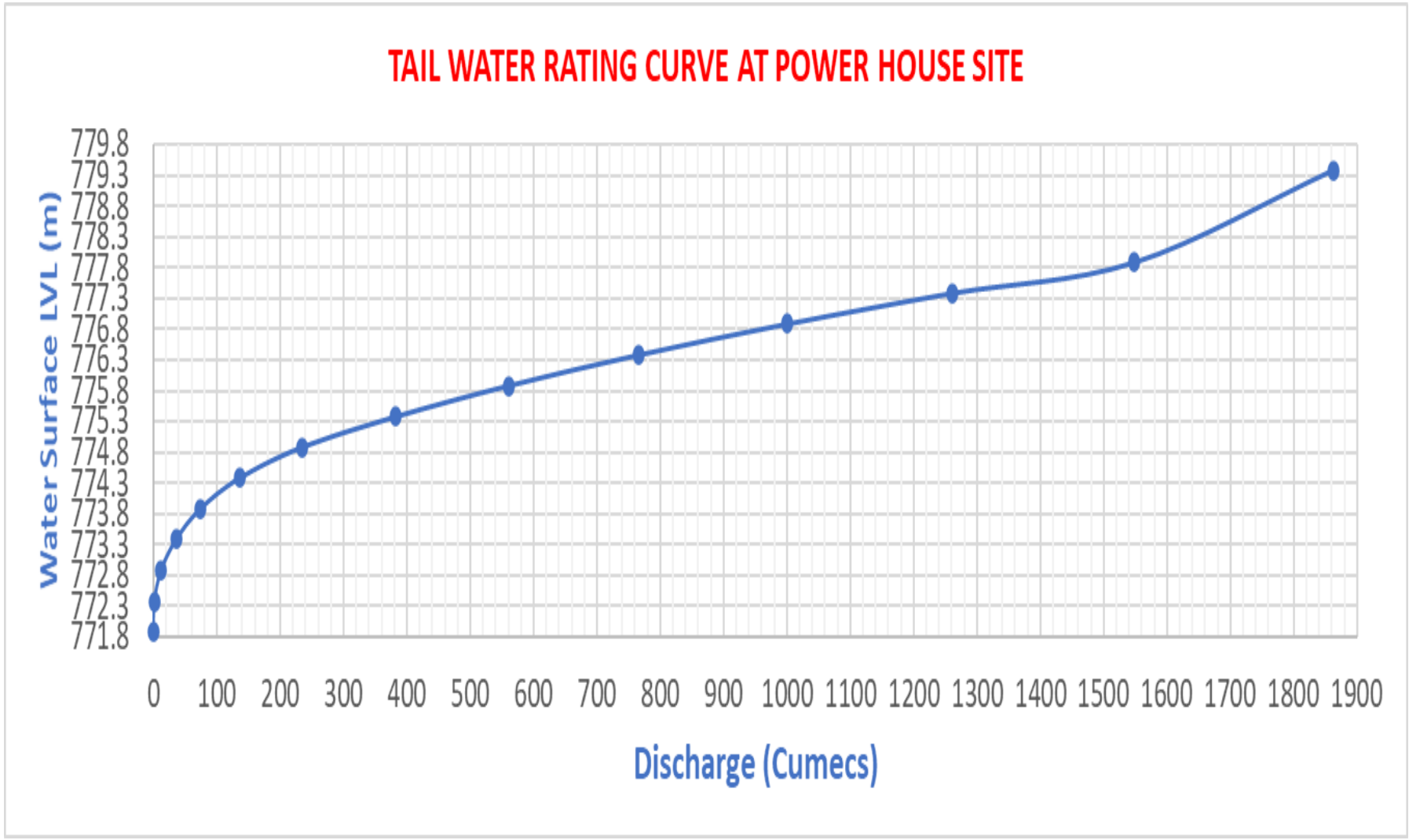
Rating Curve at Barrage									
RBL (m)	Water Surface LVL (m)	Depth of Flow (m)	Area A, (Sqm)	Wetted Perimeter P (m)	Hydraulic Radius R (m)	Manning's N	Riverbed slope	Flow Velocity v (m/s)	Discharge (cumecs)
873.500	873.500	0.000	0.00	0.00	0.00	0.061	0.0625	0.00	0
873.500	874.000	0.500	1.25	5.08	0.24	0.061	0.0625	1.60	2
873.500	874.500	1.000	4.98	10.17	0.49	0.061	0.0625	2.55	13
873.500	875.000	1.500	11.20	15.10	0.74	0.061	0.0625	3.36	38
873.500	875.500	2.000	18.88	16.55	1.14	0.061	0.0625	4.47	85
873.500	876.000	2.500	26.86	17.71	1.52	0.061	0.0625	5.41	145
873.500	876.500	3.000	35.13	18.88	1.86	0.061	0.0625	6.20	218
873.500	877.000	3.500	43.69	20.04	2.18	0.061	0.0625	6.89	301
873.500	877.500	4.000	52.55	21.20	2.48	0.061	0.0625	7.51	394
873.500	878.000	4.500	61.69	22.37	2.76	0.061	0.0625	8.06	497
873.500	878.500	5.000	71.12	23.53	3.02	0.061	0.0625	8.57	609
873.500	879.000	5.500	80.85	24.69	3.27	0.061	0.0625	9.04	731
873.500	879.500	6.000	90.86	25.85	3.51	0.061	0.0625	9.47	861
873.500	880.000	6.500	101.17	27.01	3.75	0.061	0.0625	9.88	1000
873.500	880.500	7.000	111.72	28.10	3.98	0.061	0.0625	10.29	1149
873.500	881.000	7.500	122.47	29.18	4.20	0.061	0.0625	10.66	1306
873.500	881.500	8.000	133.42	30.26	4.41	0.061	0.0625	11.02	1470
873.500	882.000	8.500	144.56	31.33	4.61	0.061	0.0625	11.36	1642
873.500	882.500	9.000	155.91	32.41	4.81	0.061	0.0625	11.68	1821
873.500	883.000	9.500	167.45	33.49	5.00	0.061	0.0625	11.98	2007


TAIL WATER RATING CURVE AT BARRAGE SITE
Water Surface LVL (m)
883.5
883.0
882.5
882.0
881.5
881.0
880.5
880.0
879.5
879.0
878.5
878.0
877.5
877.0
876.5
876.0
875.5
875.0
874.5
874.0
873.5
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100
Discharge (Cumecs)

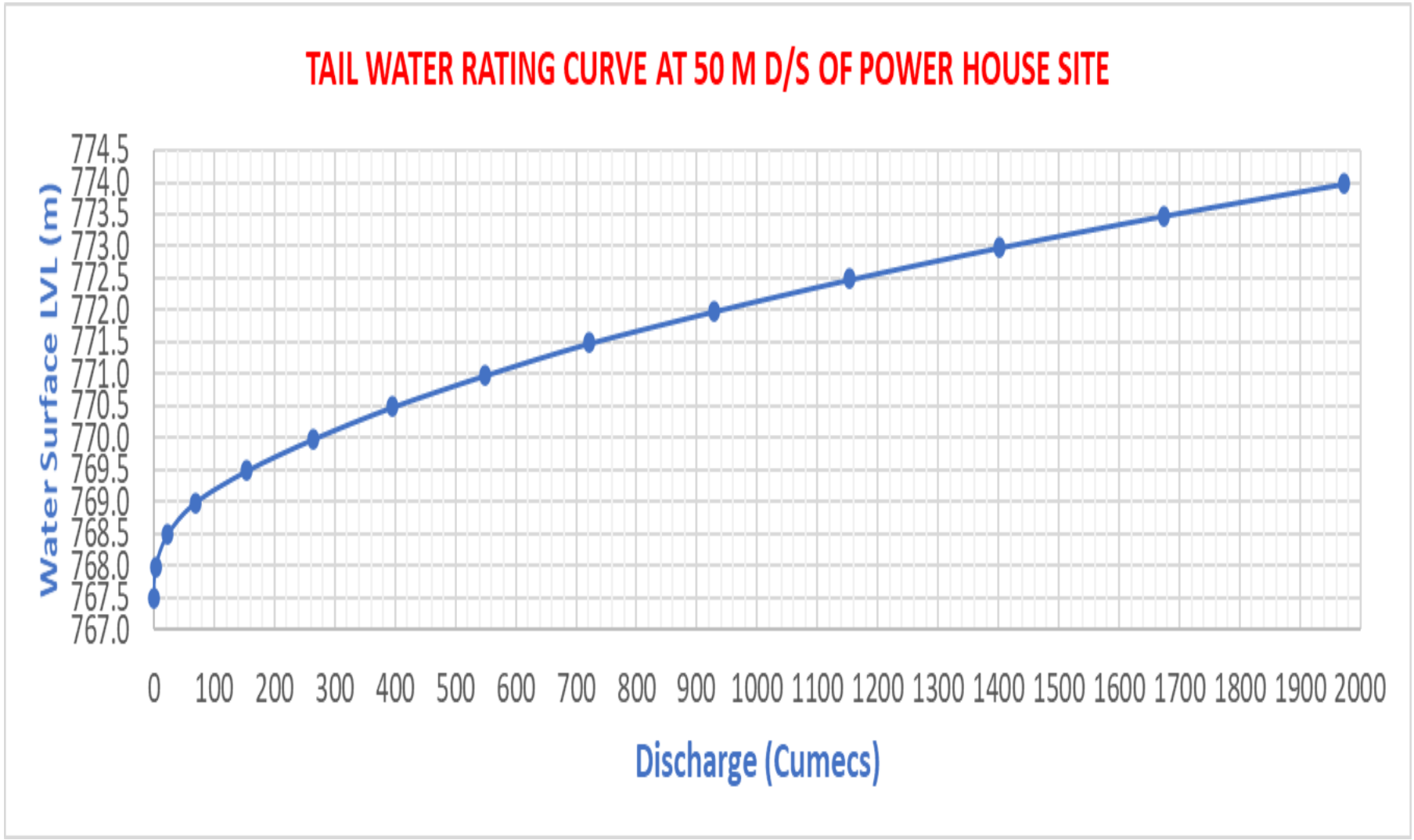
Rating Curve at Section 50m D/S of Proposed Barrage									
RBL (m)	Water Surface LVL (m)	Depth of Flow (m)	Area A, (Sqm)	Wetted Perimeter P (m)	Hydraulic Radius R (m)	Manning's N	Riverbed slope	Flow Velocity v (m/s)	Discharge (cumecs)
872.500	872.500	0.000	0.00	0.00	0.00	0.061	0.0625	0.00	0
872.500	873.000	0.500	1.38	5.64	0.25	0.061	0.0625	1.61	2
872.500	873.500	1.000	5.53	11.28	0.49	0.061	0.0625	2.55	14
872.500	874.000	1.500	11.82	14.18	0.83	0.061	0.0625	3.63	43
872.500	874.500	2.000	19.25	16.62	1.16	0.061	0.0625	4.52	87
872.500	875.000	2.500	27.35	17.80	1.54	0.061	0.0625	5.46	149
872.500	875.500	3.000	35.76	18.97	1.88	0.061	0.0625	6.25	224
872.500	876.000	3.500	44.47	20.14	2.21	0.061	0.0625	6.95	309
872.500	876.500	4.000	53.48	21.31	2.51	0.061	0.0625	7.57	405
872.500	877.000	4.500	62.80	22.48	2.79	0.061	0.0625	8.13	510
872.500	877.500	5.000	72.42	23.65	3.06	0.061	0.0625	8.64	626
872.500	878.000	5.500	82.34	24.82	3.32	0.061	0.0625	9.12	751
872.500	878.500	6.000	92.56	25.99	3.56	0.061	0.0625	9.56	885
872.500	879.000	6.500	103.09	27.16	3.79	0.061	0.0625	9.97	1028
872.500	879.500	7.000	113.92	28.33	4.02	0.061	0.0625	10.36	1180
872.500	880.000	7.500	125.03	29.47	4.24	0.061	0.0625	10.74	1343
872.500	880.500	8.000	136.41	30.60	4.46	0.061	0.0625	11.10	1514
872.500	881.000	8.500	148.41	31.72	4.68	0.061	0.0625	11.46	1701
872.500	881.500	9.000	159.95	32.85	4.87	0.061	0.0625	11.77	1883
872.500	882.000	9.500	172.11	33.98	5.06	0.061	0.0625	12.09	2080


TAIL WATER RATING CURVE AT 50 M D/S OF BARRAGE SITE
Water Surface LVL (m)
882.5
882.0
881.5
881.0
880.5
880.0
879.5
879.0
878.5
878.0
877.5
877.0
876.5
876.0
875.5
875.0
874.5
874.0
873.5
873.0
872.5
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100
Discharge (Cumecs)

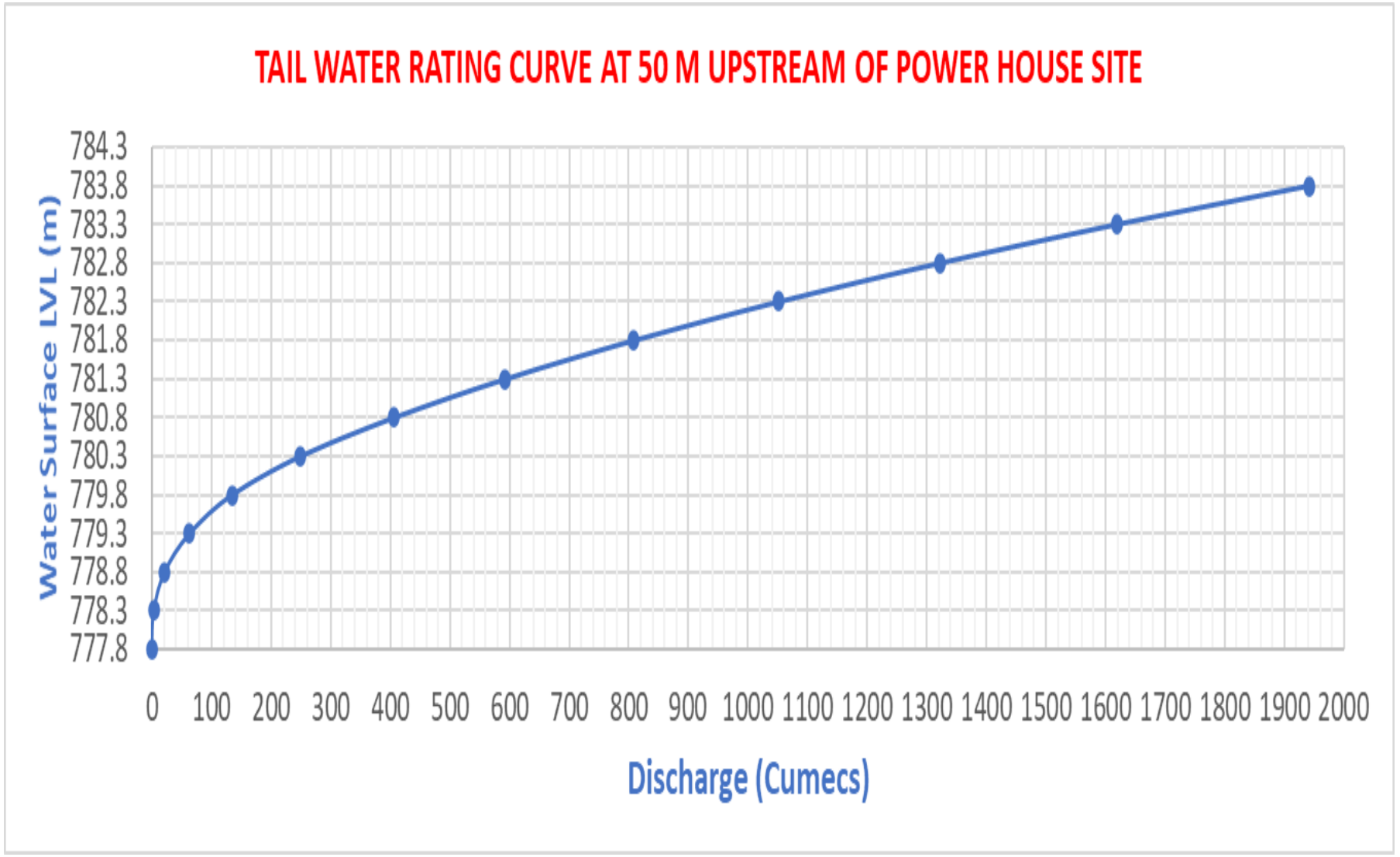
Rating Curve at Section Power House Site									
RBL (m)	Water Surface LVL (m)	Depth of Flow (m)	Area A, (Sqm)	Wetted Perimeter P (m)	Hydraulic Radius R (m)	Manning's N	Riverbed slope	Flow Velocity v (m/s)	Discharge (cumecs)
771.884	771.884	0.000	0.00	0.00	0.00	0.061	0.04375	0.00	0
771.884	772.384	0.500	1.41	5.73	0.25	0.061	0.04375	1.35	2
771.884	772.884	1.000	5.64	11.46	0.49	0.061	0.04375	2.14	12
771.884	773.384	1.500	12.69	17.19	0.74	0.061	0.04375	2.80	36
771.884	773.884	2.000	22.71	24.67	0.92	0.061	0.04375	3.25	74
771.884	774.384	2.500	37.30	34.13	1.09	0.061	0.04375	3.64	136
771.884	774.884	3.000	56.04	41.72	1.34	0.061	0.04375	4.17	234
771.884	775.384	3.500	76.70	43.71	1.75	0.061	0.04375	4.99	383
771.884	775.884	4.000	98.22	45.78	2.15	0.061	0.04375	5.70	560
771.884	776.384	4.500	120.63	47.85	2.52	0.061	0.04375	6.35	766
771.884	776.884	5.000	143.92	49.92	2.88	0.061	0.04375	6.95	1000
771.884	777.384	5.500	168.10	51.98	3.23	0.061	0.04375	7.50	1260
771.884	777.884	6.000	193.16	54.05	3.57	0.061	0.04375	8.01	1548
772.884	779.384	6.500	219.11	56.12	3.90	0.061	0.04375	8.50	1863


TAIL WATER RATING CURVE AT POWER HOUSE SITE
Water Surface LVL (m)
779.8
779.3
778.8
778.3
777.8
777.3
776.8
776.3
775.8
775.3
774.8
774.3
773.8
773.3
772.8
772.3
771.8
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
Discharge (Cumecs)

Rating Curve at Section 50 M DOWNSTREAM OF Power House Site									
RBL (m)	Water Surface LVL (m)	Depth of Flow (m)	Area A, (Sqm)	Wetted Perimeter P (m)	Hydraulic Radius R (m)	Manning's N	River bed slope	Flow Velocity v (m/s)	Discharge (cumecs)
767.485	767.485	0.000	0.00	0.00	0.00	0.061	0.04375	0.00	0
767.485	767.985	0.500	2.64	10.62	0.25	0.061	0.04375	1.36	4
767.485	768.485	1.000	10.57	21.23	0.50	0.061	0.04375	2.15	23
767.485	768.985	1.500	23.71	30.64	0.77	0.061	0.04375	2.89	69
767.485	769.485	2.000	39.50	32.72	1.21	0.061	0.04375	3.89	154
767.485	769.985	2.500	55.86	34.45	1.62	0.061	0.04375	4.73	264
767.485	770.485	3.000	73.17	37.00	1.98	0.061	0.04375	5.40	395
767.485	770.985	3.500	91.56	39.53	2.32	0.061	0.04375	6.00	550
767.485	771.485	4.000	111.02	42.50	2.61	0.061	0.04375	6.50	722
767.485	771.985	4.500	131.55	44.58	2.95	0.061	0.04375	7.05	928
767.485	772.485	5.000	153.16	47.11	3.25	0.061	0.04375	7.52	1152
767.485	772.985	5.500	175.83	49.64	3.54	0.061	0.04375	7.97	1401
767.485	773.485	6.000	199.58	52.17	3.83	0.061	0.04375	8.39	1674
767.485	773.985	6.500	224.41	54.70	4.10	0.061	0.04375	8.79	1972

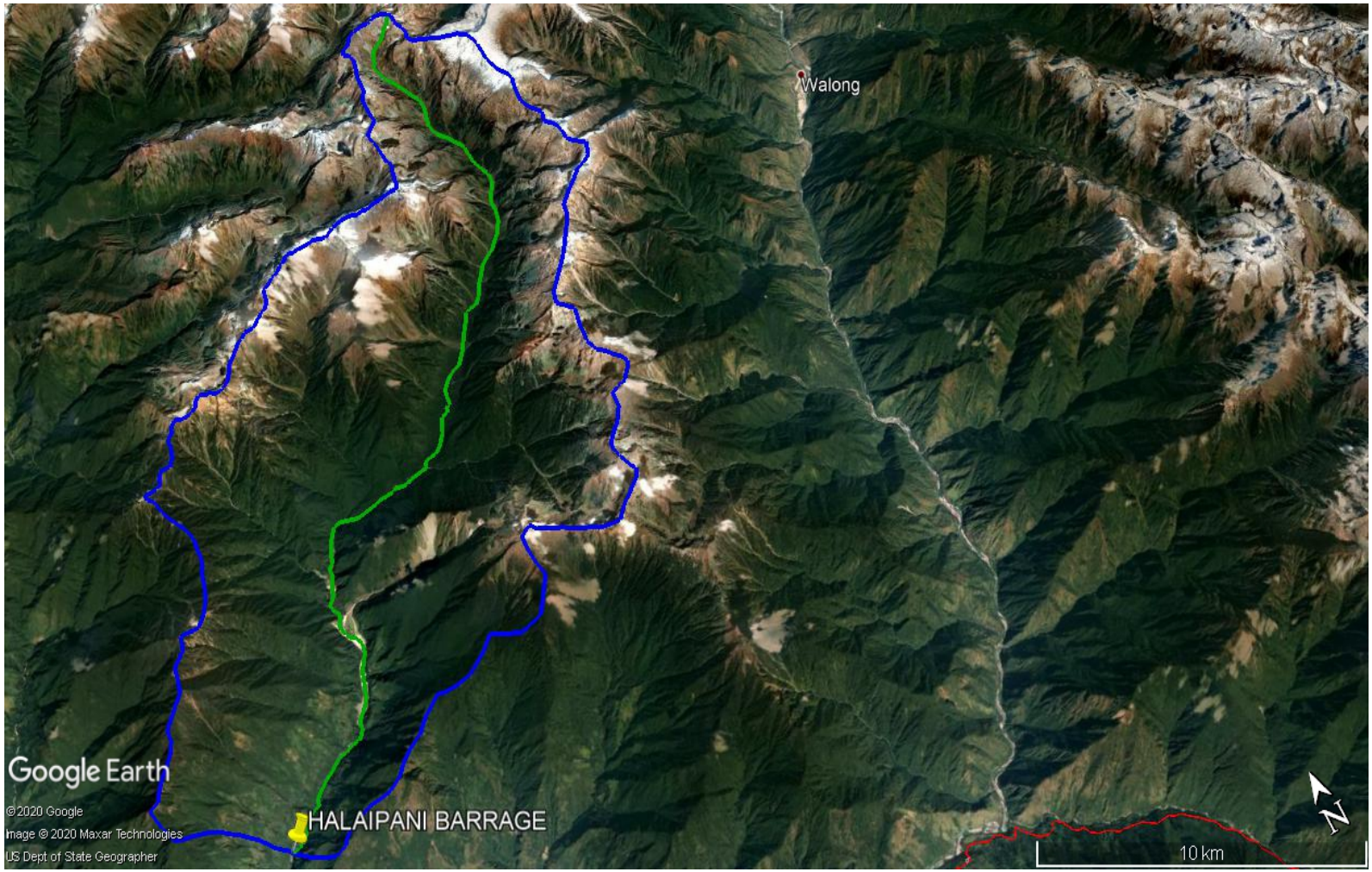

TAIL WATER RATING CURVE AT 50 M D/S OF POWER HOUSE SITE
Water Surface LVL (m)
774.5
774.0
773.5
773.0
772.5
772.0
771.5
771.0
770.5
770.0
769.5
769.0
768.5
768.0
767.5
767.0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Discharge (Cumecs)

Rating Curve at Section at 50 m Upstream of Power House Site									
RBL (m)	Water Surface LVL (m)	Depth of Flow (m)	Area A, (Sqm)	Wetted Perimeter P (m)	Hydraulic Radius R (m)	Manning's N	River bed slope	Flow Velocity v (m/s)	Discharge (cumecs)
777.750	777.750	0.000	0.00	0.00	0.00	0.061	0.04375	0.00	0
777.750	778.250	0.500	2.45	9.84	0.25	0.061	0.04375	1.36	3
777.750	778.750	1.000	9.79	19.67	0.50	0.061	0.04375	2.15	21
777.750	779.250	1.500	21.93	28.84	0.76	0.061	0.04375	2.86	63
777.750	779.750	2.000	38.37	37.33	1.03	0.061	0.04375	3.49	134
777.750	780.250	2.500	58.60	42.56	1.38	0.061	0.04375	4.24	249
777.750	780.750	3.000	80.04	44.55	1.80	0.061	0.04375	5.07	406
777.750	781.250	3.500	102.27	46.54	2.20	0.061	0.04375	5.80	593
777.750	781.750	4.000	125.28	48.52	2.58	0.061	0.04375	6.45	808
777.750	782.250	4.500	149.09	50.51	2.95	0.061	0.04375	7.06	1052
777.750	782.750	5.000	173.68	52.50	3.31	0.061	0.04375	7.61	1322
777.750	783.250	5.500	199.06	54.48	3.65	0.061	0.04375	8.13	1619
777.750	783.750	6.000	225.22	56.47	3.99	0.061	0.04375	8.62	1942


TAIL WATER RATING CURVE AT 50 M UPSTREAM OF POWER HOUSE SITE
Water Surface LVL (m)
784.3
783.8
783.3
782.8
782.3
781.8
781.3
780.8
780.3
779.8
779.3
778.8
778.3
777.8
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Discharge (Cumecs)

ANNEXURE – 1

CATCHMENT AREA OF HALAIPANI RIVER AT BARRAGE



ANNEXURE – 2

SUH CALCULATIONS FOR DESIGN STORM DURATION = 3 HOURS

1 Synthetic Unit Hydrograph Method

A FLOOD ESTIMATION

Name and number of subzone: North Bramhaputra Subzone 2(a)

1 By Unit Hydrograph Method

Step : - 1 Determination of Physiographic Parameter

Area, A	=	270.00	sq km
Length of longest stream, L	=	36.30	km
Length of main stream from bridge gauging site to a point nearest to centriod of the stream basin along stream course, Lc	=	17.20	km

Equivalent stream slope (Main Stream)

Sl No	Reduced Distance Starting From Bridge Site (Point of Study) (km)	Reduced Level of River Bed (m)	Length of Each Segment (L_i) (km)	Height Above Datum* (D_i)=Difference Between the Datum Line and its R.L (m)	(D_{i-1} + D_i) (m)	L_i x (D_{i-1} + D_i) (m*km)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	879.00	-	-	-	-
2	5.00	1315.00	5.00	436.00	436.00	2180.00
3	10.00	1653.00	5.00	774.00	1210.00	6050.00
4	15.00	1947.00	5.00	1068.00	1842.00	9210.00
5	20.00	2342.00	5.00	1463.00	2531.00	12655.00
6	25.00	2805.00	5.00	1926.00	3389.00	16945.00
7	30.00	3187.00	5.00	2308.00	4234.00	21170.00
8	35.00	3597.00	5.00	2718.00	5026.00	25130.00

9	36.30	4211.00	1.30	3332.00	6050.00	7865.00
SUM			**36.30**		-	**101205.00**

S = [Sum(Li x (Di-1 + Di))]/L^2

= 76.80 m/km

Equivalent Slope= 76.80 m/km

Step : - 2 Determination of Synthetic (1-hr) Unit graph Parameters

Time from the center of Unit rainfall duration to the peak of Unit Hydrograph

t_p = 2.164*qp^-0.940

= 2.24 hrs

say 2.50 hrs

Peak discharge of hydrograph per unit area

Qp/A = q_p = 2.272*[L*Lc/S]^(-0.409)

= 0.964 cumecs per sq km

Width of U. G. measured at 50% maximum discharge ordinate

W_{50} = 2.084*qp^-1.065

= 0.88 hrs

say 0.90 hrs

Width of U. G. measured at 75% maximum discharge ordinate

W_{75} = 1.028*qp^-1.071

= 0.43 hrs

say 0.45 hrs

Width of the rising side of U. G. measured at 50% of maximum discharge ordinate

W_{R50} = 0.856*qp^-0.865

= 0.43 hrs

say 0.45 hrs

Width of the rising side of U. G. measured at 75% of maximum discharge ordinate

W_{R75} = 0.440*qp^-0.918

= 0.21 hrs

say 0.20 hrs

Base width of Unit Hydrograph

T_B = 5.428*tp^0.852

= 11.85 hrs

say 12 hrs

Time from start of rise to the peak of unit hydrograph

T_m = t_p + tr/2

= 3 hrs

Peak discharge of Unit Hydrograph

Q_p = qp * A

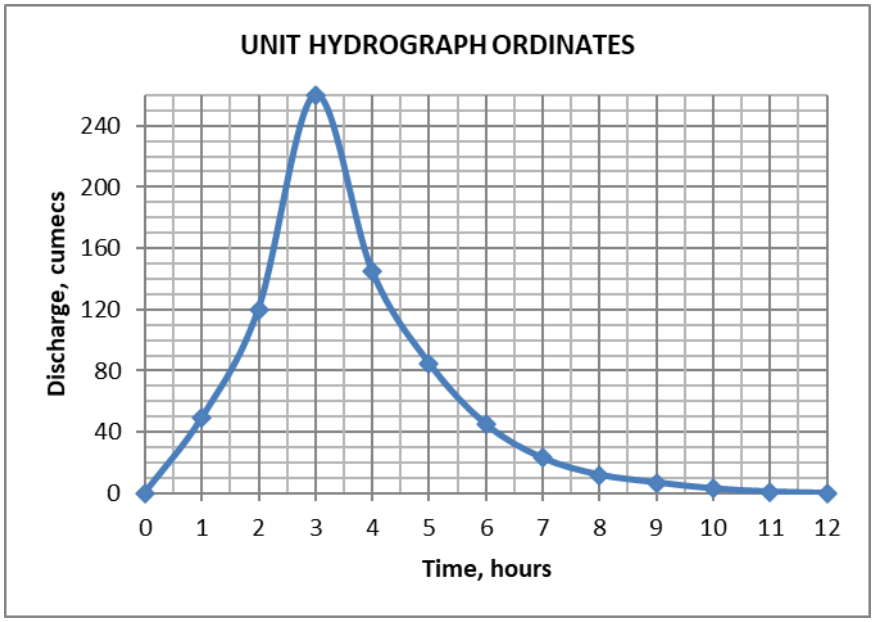
= 260.35 cume

	say	260.00	cs cume cs

Step : - 3 Drawing of Synthetic Unit graph

Estimated parameter of Unit graph in step-2 were plotted to scale. The plotted points were joined to draw synthetic unit graph. The discharge ordinates of unit graph at ti=tr=1 hr interval were summed up and compared with the volume of 1.00 cm direct runoff

Time (in hrs)	1-hr Synthetic U.G. ordinates
0.00	0
1.0	49
2.0	120
3.0	260
4.0	145
5.0	85
6.0	45
7.0	23
8.0	12
9.0	7
10.0	3
11.0	1
12.0	0



Sum	750.00	cumecs		……1
Sum(Qi)	=	(A*d)/(tr*0.36)		
	=	750	cumecs	……2

Since Eq-1 = Eq-2, so unitgraph drawn is in order

Step : - 4 Estimation of design storm duration

The design storm duration

T_D	=	1.1 * tp	
	=	2.75	hrs
	Say	3.00	hrs

Step : - 5 Distribution of rainfall

100-yr, 24-hr rainfall	=	30.00	cm	
Ratio of 3-hr rainfall to 24-hr rainfall	=	0.457		(From Fig-10)
So, 100-yr 3-hr point rainfall	=	13.71	cm	

Areal reduction factor corresponding to area 270sq km

and TD=3 hrs

	=	0.670		(From Table 6)
So, 100-yr 3-hr areal rainfall	=	9.19	cm	

Step : - 6 Critical Sequencing of Rainfall Excess

Duration (hrs)	Distribution coefficient	Design Loss Rate (cm/hr)	Storm Rainfall (cm)	Hourly Rainfall Increment (cm)	Rainfall Excess (cms)
1	0.67	0.24	6.15	6.15	**5.91**
2	0.91	0.24	8.36	2.20	**1.96**
3	1.00	0.24	9.19	0.83	**0.59**

Step : - 7 Estimation of base flow

The design base flow

q_b	=	0.0500	cumec per sq km

Total base flow

Qb	=	13.50	cumecs

Step : - 8 Estimation of 100-yr Flood Peak

For the estimation of the peak discharge the effective rainfall units were re-arranged against the ordinates such that the maximum effective rainfall was placed against the maximum U.G. ordinates, the next lower value of effective rainfall against the next maximum discharge value and so on.

Time in hrs	**1-HR UG ordinates**	**1-hr effective rainfall (cm)**	**Direct Runoff (cumecs)**
2.0	120	0.59	70
3.0	260	5.91	1538
4.0	145	1.96	285

Total	=	1893.0	cumecs		
Base Flow	=	13.50	cumecs		
100-yr peak flood	=	**1906.52**	cumecs	≈	**1910 cumecs**

CHAPTER – 7

RESERVOIR

7.1 RESERVOIR

The Halaipani HE project is a typical run off river scheme with no storage capacity i.e. the plant will be operated as a base load station. There is no provision for any diurnal storage also. The length of reservoir shall be about 400 m upstream of the diversion structure. The area capacity curve is not required for this project.

7.2 RESERVOIR CAPACITY:

This is not applicable as explained above in 7.1.

7.3 PEAKING CAPABILITY:

This is not applicable as explained above in 7.1.

7.5 PRESERVATION OF CAPACITY OF RESERVOIR:

Since the gross capacity of the reservoir is very small, the capacity of the reservoir shall be lost due to sedimentation soon after project commissioning, if measures are taken to keep the reservoir clean during monsoon period.

During monsoon, the reservoir shall be periodically flushed by reservoir draw down. This practice is now universally followed for all operating hydro power plants with small reservoir. This practice ensures preservation of capacity of the plant on long term basis.

7.6 SEDIMENTATION

Halaipani H E Project is proposed to be located over river Halai. Halai River is a right bank major tributary of river Lohit which is again a tributary of

Brahmaputra River. The river Halaipani originates at the altitude of around EL. 4500 m. The river travels about 36.70 km up to the proposed barrage site. At the proposed barrage site, the river bed elevation is around EL. 873 m. Hence the river has a very steep slope with a fall of 3627 m in 36.70 km. Up to barrage site, the river has a catchment of 270 sq.km.

The catchment is covered by dense forest and little population. The river bank slope and general catchment does not indicate extensive erosion. The river bed at barrage site and upstream indicates boulders of huge size which appears to be relatively stable. Refer Fig.7.1 of river bed at barrage site.

Fig. 7.1: Proposed Diversion site at Halaipani HEP

Fig. 7.2: Proposed Power House site at Halaipani

Conclusion

All the figures indicate that the load carried by the river is very coarse regarding silt load as the catchment is medium and not much distress and erosion has been observed in the catchment the sediment load during the monsoon appears to be low.

However, as the barrage is only 11 m high and has only a pond of 400 m length, a low-level barrage crest requires to be provided so that the sediment and boulders as it can come can pass through the structure easily. Simultaneously the intake floor should be in reasonably higher level than the crest of the barrage. A suitable silt exclusion system below the intake requires to be provided to exclude the entry of silt coarse and

middle size in to the HRT. A surface desilting chamber has been envisaged for continuous flushing during monsoon season and thus keep the inflow water into WCS free from sediments.

CHAPTER- 8

POWER POTENTIAL STUDIES

8.1 GENERAL & INSTALLED CAPACITY APPROVED

Halaipani HE Project is a run-off-the river scheme with no diurnal peaking power benefits and operating as a base load plant. This project is part of the Lohit river basin development.

The optimization study of Halaipani HE Project was done by HRED, IIT Roorkee in 2010 based on the discharge data of the stream available from January 1995 to December 1999. The installed capacity of this project has been approved for 16 MW comprising of 4 units of Horizontal Francis turbines each being 4 MW in the surface power station. The project parameters like Pond level/FRL, TWL, Head losses, combined efficiency of turbines are not changed.

8.2 STUDIES FOR OPTIMIZATION FRL AND MDDL

8.2.1 Project Parameters

Full reservoir level (FRL)

FRL has been fixed at El 883.200 m keeping in view the topographical condition and least submergence of the region. It is a run-off-the river scheme with negligible storage.

Minimum Draw Down Level (MDDL)

As the Halaipani HE project is a base load plant, MDDL is not applicable.

Maximum Tail Water level (Max. TWL)

Maximum tail water level corresponding to design discharge with all four units running has been fixed at El 773.090 m.

Head losses

The head losses through intake, water conductor system, MIV works out to 7.965 m in accordance with the provision of IS Codes/ Relevant

International Standards. As per the calculations provided at Chapter 9, the head loss from forebay to Power house is 4.0 m but the value as per the earlier studies has been taken into account.

Environmental Releases

As per SEAC norms, the environmental releases through diversion structure shall be 20% of the average flows in the leanest season of that year. The leanest season has been decided based on the inflow discharges volume and December to March period has been found to be the leanest period for the dependable year 75% and average year. The environmental releases estimation in 75% DY & average year has been given in **Table 8.1** below.

Sr. No.	Month	75% DY 1998	Average Year
		Inflow Discharges, cumecs	
1	December	11.59	17.54
2		11.64	17.69
3		11.47	17.75
4	January	14.76	18.87
5		23.96	17.47
6		23.63	17.09
7	February	19.11	18.53
8		15.21	17.60
9		14.65	16.93
10	March	15.03	18.21
11		18.03	20.47
12		23.40	21.38
	Average=	**16.87**	**18.294**
	Env. Rel.=0.2 x Q	**0.2 x 16.87 = 3.37 cumecs**	**0.2 x 18.29 = 3.66 cumecs**

Environmental Releases Summary:

75% DY - 1998 = 3.37 cumecs

Average year = 3.66 cumecs

(f) Operating Head/Design Head

The design net head of the project has been adopted as 95 m as per the DPR pf Halaipani SHEP (Balance Works) prepared by DHPD, GoAP in 2018.

(g) Efficiency

- Combined efficiency of turbine and generator – 85%.

The efficiency of turbine and generator has been approved by the E&M Contractor and also reported in the DPR of Halaipani SHEP (Balance Works) prepared by DHPD, GoAP in 2018.

8.3 FIXING OF INSTALLED CAPACITY

As explained above, the installed capacity has been fixed at 16 MW by HRED, IIT Roorkee. In this chapter, no attempt has been made to change or revisit the installed capacity studies. The results of annual generation have been presented based on 16 MW.

Halaipani Small HE Project is planned to meet the local load at Hayuliang and Tezu, the district headquarters of Arunachal Pradesh, as intimated by Department of Hydro Power Development, Govt. of Arunachal Pradesh. In view of the current practice, it is to opt for largest size hydro units permissible within the parameters of economy, operating efficiency, maintenance, optimum utilization of available water, transport limitations, etc. Therefore 4 units of 4 MW each Horizontal axis Francis turbines have been proposed as the maximum weight limit for transportation of a single package to site is 9 MT.

Studies were also conducted for various alternatives of unit sizes keeping 16 MW as Installed Capacity of the Power station and found that 4 MW Unit size is the optimum size for this Project on technical and economical point of view and also from the angle of the transport limitation.

8.4 DESIGN ENERGY

Taking 16 MW as an Installed Capacity, Design energy has been computed for the 75% dependable year (i.e. the year 1998). In the computations, a release of 3.37 cumecs has been considered as downstream release for environmental reasons as explained earlier. The unrestricted energy generation in 75% DY after environmental releases is 105.81 MU. Design energy considering 95% machine availability works out to be 103.31 MU as given in Annexure – 8.1.

Similar calculations have also been done for average year discharges (Refer Annexure 8.2).

Summary of design energy in 75% and Average dependable years is also given in Table 8.2.

Table 8.2: Design energy generation for 75% and Average DY

Dependable year	75% DY, 1998	Average Year Flows
Unrestricted Energy, MU	105.81	126.25
Average Power, kW	11793	13714
Design energy (95% machine availability) MU	103.31	120.14
Load Factor, %	73.71	85.71

As per the approved power optimization studies, the design energy generation in 75% dependable year (1998) with 95% machine availability has been estimated at 140.16 MU at 100% load factor and 84.10 MU at 60% load factor. The design energy as estimated above in table 8.2 is higher than the energy approved by IIT Roorkee. It is judiciously recommended to adopt the design energy values as estimated by HRED, IIT Roorkee.

ANNEXURE 8.1
75% DEPENDABLE YEAR ENERGY GENERATION

Sr. No.	% Time Equaled or Exceeded	Water Availability , cumecs	Environmental flow, Cumecs	Water Available for generation, cumecs	Net Head , m	Unrestricted Power Potential, kW	RESTRICTED POWER, kW
1	2.78%	17.42	3.37	14.05	95.00	11130	11130
2	5.56%	18.17	3.37	14.80	95.00	11724	11724
3	8.33%	17.80	3.37	14.43	95.00	11431	11431
4	11.11%	25.97	3.37	22.60	95.00	17903	16000
5	13.89%	26.01	3.37	22.64	95.00	17934	16000
6	16.67%	25.49	3.37	22.12	95.00	17523	16000
7	19.44%	25.88	3.37	22.51	95.00	17831	16000
8	22.22%	27.03	3.37	23.66	95.00	18742	16000
9	25.00%	22.59	3.37	19.22	95.00	15225	15225
10	27.78%	23.38	3.37	20.01	95.00	15851	15851
11	30.56%	20.40	3.37	17.03	95.00	13490	13490
12	33.33%	18.54	3.37	15.17	95.00	12017	12017
13	36.11%	17.34	3.37	13.97	95.00	11066	11066
14	38.89%	17.81	3.37	14.44	95.00	11439	11439
15	41.67%	19.46	3.37	16.09	95.00	12746	12746
16	44.44%	11.03	3.37	7.66	95.00	6068	6068
17	47.22%	11.31	3.37	7.94	95.00	6290	6290
18	50.00%	11.49	3.37	8.12	95.00	6432	6432
19	52.78%	11.59	3.37	8.22	95.00	6512	6512
20	55.56%	11.64	3.37	8.27	95.00	6551	6551
21	58.33%	11.47	3.37	8.10	95.00	6416	6416
22	61.11%	14.76	3.37	11.39	95.00	9023	9023
23	63.89%	23.96	3.37	20.59	95.00	16311	16000
24	66.67%	23.63	3.37	20.26	95.00	16049	16000
25	69.44%	19.11	3.37	15.74	95.00	12469	12469
26	72.22%	15.21	3.37	11.84	95.00	9379	9379
27	75.00%	14.65	3.37	11.28	95.00	8936	8936
28	77.78%	15.03	3.37	11.66	95.00	9237	9237
29	80.56%	18.03	3.37	14.66	95.00	11613	11613
30	83.33%	23.40	3.37	20.03	95.00	15867	15867
31	86.11%	17.06	3.37	13.69	95.00	10845	10845
32	88.89%	19.79	3.37	16.42	95.00	13007	13007
33	91.67%	20.61	3.37	17.24	95.00	13657	13657
34	94.44%	18.49	3.37	15.12	95.00	11977	11977
35	97.22%	17.76	3.37	14.39	95.00	11399	11399
36	100.00%	16.96	3.37	13.59	95.00	10765	10765
				Average Power (kW)		**12079**	**11793**
				Annual Energy (MU)		**105.81**	**103.31**
				Load factor (%)		**75.50%**	**73.71%**

ANNEXURE 8.2
AVERAGE YEAR FLOWS ENERGY GENERATION

Sr. No.	% Time Equaled or Exceeded	Water Availability, cumecs	Environmental flow, Cumecs	Water Available for generation, cumecs	Net Head, m	Unrestricted Power Potential, kW	RESTRICTED POWER, kW
1	2.78%	22.54	3.66	18.88	95.00	14956	14956
2	5.56%	23.81	3.66	20.15	95.00	15962	15962
3	8.33%	24.29	3.66	20.63	95.00	16342	16000
4	11.11%	26.44	3.66	22.78	95.00	18045	16000
5	13.89%	27.73	3.66	24.07	95.00	19067	16000
6	16.67%	27.44	3.66	23.78	95.00	18838	16000
7	19.44%	25.47	3.66	21.81	95.00	17277	16000
8	22.22%	27.91	3.66	24.25	95.00	19210	16000
9	25.00%	26.83	3.66	23.17	95.00	18354	16000
10	27.78%	25.82	3.66	22.16	95.00	17554	16000
11	30.56%	27.32	3.66	23.66	95.00	18742	16000
12	33.33%	27.36	3.66	23.70	95.00	18774	16000
13	36.11%	27.05	3.66	23.39	95.00	18529	16000
14	38.89%	24.32	3.66	20.66	95.00	16366	16000
15	41.67%	22.35	3.66	18.69	95.00	14805	14805
16	44.44%	18.38	3.66	14.72	95.00	11661	11661
17	47.22%	18.6	3.66	14.94	95.00	11835	11835
18	50.00%	18.65	3.66	14.99	95.00	11874	11874
19	52.78%	17.54	3.66	13.88	95.00	10995	10995
20	55.56%	17.69	3.66	14.03	95.00	11114	11114
21	58.33%	17.75	3.66	14.09	95.00	11161	11161
22	61.11%	18.87	3.66	15.21	95.00	12049	12049
23	63.89%	17.47	3.66	13.81	95.00	10940	10940
24	66.67%	17.09	3.66	13.43	95.00	10639	10639
25	69.44%	18.53	3.66	14.87	95.00	11779	11779
26	72.22%	17.6	3.66	13.94	95.00	11043	11043
27	75.00%	16.93	3.66	13.27	95.00	10512	10512
28	77.78%	18.21	3.66	14.55	95.00	11526	11526
29	80.56%	20.47	3.66	16.81	95.00	13316	13316
30	83.33%	21.38	3.66	17.72	95.00	14037	14037
31	86.11%	18.67	3.66	15.01	95.00	11890	11890
32	88.89%	19.6	3.66	15.94	95.00	12627	12627
33	91.67%	19.77	3.66	16.11	95.00	12762	12762
34	94.44%	21.87	3.66	18.21	95.00	14425	14425
35	97.22%	22.6	3.66	18.94	95.00	15003	15003
36	100.00%	22.35	3.66	18.69	95.00	14805	14805
				Average Power (kW)		**14412**	**13714**
				Annual Energy (MU)		**126.25**	**120.14**
				Load factor (%)		**90.07%**	**85.71%**

CHAPTER 9

DESIGN OF CIVIL STRUCTURES

9.1 Project Background of Existing Structures

The Halaipani DPR was approved from HRED (then AHEC) IIT Roorkee in 2009 for 12 MW and later extended to 16 MW. The construction of project commenced in early 2012 and was targeted to complete in March 2013. The detailed Design and Drawings were supplied by HRED, IIT Roorkee to DHPD, GoAP who were the owner of Halaipani HE Project.

The work was in full swing until the cloud burst on 25th and 26th June 2012 led to an unprecedented flood in Halai River and under construction powerhouse was completely damaged. The work was completely stopped, and no further progress is there at site till now. The heavy flooding caused the major damage to the other major components of the project. Barrage structure, feeder and power channel, desilting tank, forebay tank, saddle and anchor block & switchyard were severely damaged due to landslide and erosion.

The Construction & ownership of the project on BOOT Basis has been awarded to M/s PK Hospitality Services Pvt Ltd JV to build the project and finish the remaining balance of works. The EPC Contractor has given the task of preparing the revised DPR and Detailed Engineering Designs of remaining civil works to Prime Consulting Group.

The Barrage was earlier designed for a flood of 600 cumecs as per the DPR prepared by AHEC (now HRED), IIT Roorkee in 2009. After the flood event of 2012 and during the revision of DPR, it is planned to the revise the design flood of the barrage. As per the BIS & CWC guidelines, the barrage shall be designed for 1 in 100 years return period with flood value corresponding to 1938 cumecs. The same was approved by HRED, IIT Roorkee in November 2020.

The officials of HRED, IIT Roorkee and NHPC had visited the Halaipani Project after the flood of June 2012 where heavy damages were caused to under construction structures like Intake Barrage, Desilting tank, and

powerhouse site. As per the assessment of the teams, the following works need to be completed to commission the project.

Sr. No.	Component/Structure	% of Balance Work required
1	Barrage & Intake structure	100%
2	Power Channel	5%
3	Desilting tank	40%
4	Forebay tank & Bye-pass	10%
5	Anchor & Saddle Blocks	40%
6	Power House, Switchyard & Tail Race Channel	100%
7	Protection Works of Power House Area	100%
8	Supply of Equipments: Hydro Mechanical	50%

The hydraulic design of Barrage is being revisited in this present DPR and the same shall be carried forward for implementation during detailed engineering. The designs of all other components shall be the same as per the previous DPR and detailed construction drawings. Few minor changes in the designs of structures shall be done as and where required.

The photographs of the current scenario of the project site have been presented below for better understanding of the project area.

9.2 Structures and Layout

Halaipani Hydroelectric Project is a run of the river scheme proposed on Halai River in Anjaw District of Arunachal Pradesh near Hilong. Halai River is a tributary of main river Lohit, which is a major tributary of river Brahmaputra at the head of Brahmaputra valley.

The project is located near Latul Village. The project envisages a generation capacity of 16 MW of power by utilizing the available head. The

project components include a barrage on Halai River and an intake structure for diversion of 21.75 cumecs of water for power generation. The project is envisaged as run of the river scheme with no pondage. The plant will operate as a base load station. Water diverted from the barrage is proposed to flow through feeder channel feeding to surface desilting basin. Silt flushing duct emanating from desilting basin discharge silted water back to the river. The water from desilting basin is led to the forebay tank through power channel. The forebay is located on a flat topography with spill arrangements. Water from forebay is being taken to the surface power house to run four horizontal Francis turbines (each 4 MW capacity) through four individual pressurized penstocks running from forebay tank. Turbine discharge from the power house shall be fed back to Halai River through the tail race channel of 40 m length.

9.3 General Layout Plan

Main civil structures of the project are

- Temporary River Diversion works
- Barrage
- Power Intake
- Desilting and Silt Flushing arrangements
- Headrace Channel
- Forebay & Spill Pipe Arrangements
- Penstocks
- Powerhouse complex
- Tailrace channel
- Switch yard

9.4 River Diversion

Prior to the commencement of construction of any work in the bed of a river, it becomes obligatory to exclude temporarily the river flow from the proposed work area during the construction period, so as to permit the work to be done in dry or semidry conditions. An efficient scheme of diverting the river flow away from the work area should aim at limiting the seepage into

the work area to a minimum, so that the work area can be kept dry with minimum effort.

The barrage shall be planned in two stages. During the non-monsoon period the water will be diverted through right bank by constructing pier in the river. This pier shall form as an integral part of the barrage later. The excavation of the hill side slope on the left bank shall be carried out to provide enough space for the barrage construction. After the construction of left portion of barrage, the water shall be allowed to flow through the left portion of the river and the right bank barrage construction work shall be commenced along with the intake portion.

9.5 Barrage

At barrage location rock outcrop is available up to the riverbed level on both the banks and hard rock shall be available at shallow depth of 1.0-2.0 m. Accordingly it is proposed to found the barrage structure on rock.

As the river carries large size boulders i.e. 1.0 m to 2.0 m size in high floods, complete closure of river width by way of constructing a barrage with gate (sill level at river bed) is feasible. Therefore, a gated barrage-spillway with crest level at EL. 879 m is proposed across the full width of river. The concrete structure is designed to pass the design flood and its total height above the river bed level is about 16 m. As per IS 11223, a design flood of 1 in 100-year frequency has been considered for the design of barrage components. For free board, the IS-6966 recommends a flood frequency of 1 in 500/SPF. Further, as per Standards/ Manuals/ Guidelines for Small Hydro Development of Alternate Hydro Energy Center, Indian Institute of Technology Roorkee, normally the design flood for barrage/ weir is taken as flood of 50 to 100 years return period and standard project flood (SPF) for the spillway of a diversion dam is taken as flood of 100 years. Accordingly, 1 in 100-year return period flood has been considered for design of structure.

The Design flood report for Halaipani HE Project had been submitted to HRED, IIT Roorkee on 27th October 2020. The same was reviewed and the

design flood of 1938 cumecs was approved by HRED, IIT Roorkee vide letter no. HRED/M-56/SD/119 dated 04th November 2020.

Gauge – Discharge Table & Curve at Barrage Site

The gauge discharge calculations and curve have been developed at barrage site and 50 m downstream of barrage site. The tail water rating calculations and curve at barrage site and 50 m downstream of barrage site have been presented below in Table 9.1 & Table 9.2 and Figures 9.1 & 9.2 respectively.

Table 9.1: Gauge Discharge calculations at Barrage site

Rating Curve at Barrage Site									
RBL (m)	Water Surface LVL (m)	Depth of Flow (m)	Area A, (Sqm)	Wetted Perimeter P (m)	Hydraulic Radius R (m)	Manning's N	Riverbed slope	Flow Velocity v (m/s)	Discharge (cumecs)
879.000	879.000	0.000	0.00	0.00	0.00	0.061	0.0625	0.00	0
879.000	879.500	0.500	1.25	5.08	0.24	0.061	0.0625	1.60	2
879.000	880.000	1.000	4.98	10.17	0.49	0.061	0.0625	2.55	13
879.000	880.500	1.500	11.20	15.10	0.74	0.061	0.0625	3.36	38
879.000	881.000	2.000	18.88	16.55	1.14	0.061	0.0625	4.47	85
879.000	881.500	2.500	26.86	17.71	1.52	0.061	0.0625	5.41	145
879.000	882.000	3.000	35.13	18.88	1.86	0.061	0.0625	6.20	218
879.000	882.500	3.500	43.69	20.04	2.18	0.061	0.0625	6.89	301
879.000	883.000	4.000	52.55	21.20	2.48	0.061	0.0625	7.51	394
879.000	883.500	4.500	61.69	22.37	2.76	0.061	0.0625	8.06	497
879.000	884.000	5.000	71.12	23.53	3.02	0.061	0.0625	8.57	609
879.000	884.500	5.500	80.85	24.69	3.27	0.061	0.0625	9.04	731
879.000	885.000	6.000	90.86	25.85	3.51	0.061	0.0625	9.47	861
879.000	885.500	6.500	101.17	27.01	3.75	0.061	0.0625	9.88	1000

879.000	886.000	7.000	111.72	28.10	3.98	0.061	0.0625	10.29	1149
879.000	886.500	7.500	122.47	29.18	4.20	0.061	0.0625	10.66	1306
879.000	887.000	8.000	133.42	30.26	4.41	0.061	0.0625	11.02	1470
879.000	887.500	8.500	144.56	31.33	4.61	0.061	0.0625	11.36	1642
879.000	888.000	9.000	155.91	32.41	4.81	0.061	0.0625	11.68	1821
879.000	888.500	9.500	167.45	33.49	5.00	0.061	0.0625	11.98	2007

Figure 9.1: Stage Discharge Curve at Barrage Axis

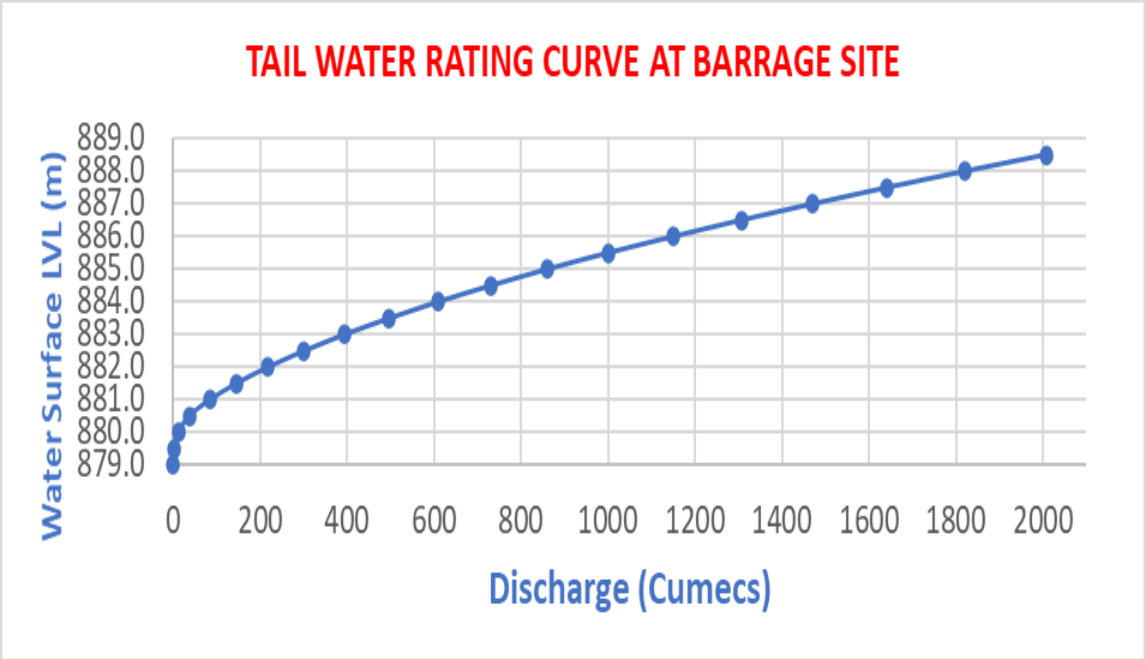
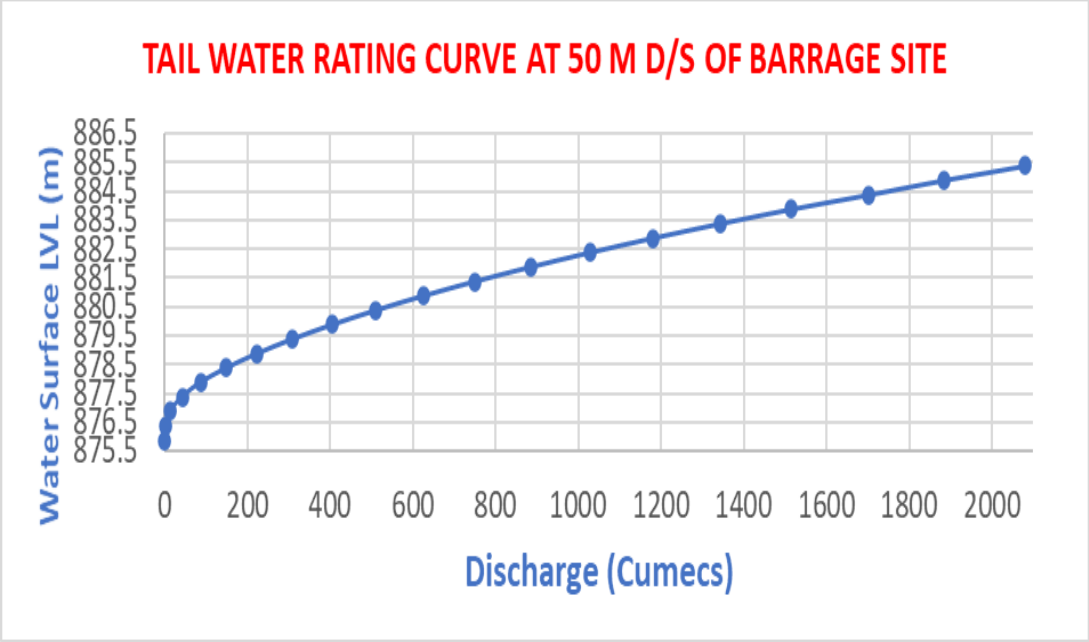


Table 9.2: Gauge Discharge calculations at 50 m D/S of Barrage site

Rating Curve at Section 50m D/S of Proposed Barrage Site									
RBL (m)	Water Surface LVL (m)	Depth of Flow (m)	Area A, (Sqm)	Wetted Perimeter P (m)	Hydraulic Radius R (m)	Manning's N	Riverbed slope	Flow Velocity v (m/s)	Discharge (cumecs)
875.875	875.875	0.000	0.00	0.00	0.00	0.061	0.0625	0.00	0
875.875	876.375	0.500	1.38	5.64	0.25	0.061	0.0625	1.61	2
875.875	876.875	1.000	5.53	11.28	0.49	0.061	0.0625	2.55	14
875.875	877.375	1.500	11.82	14.18	0.83	0.061	0.0625	3.63	43
875.875	877.875	2.000	19.25	16.62	1.16	0.061	0.0625	4.52	87
875.875	878.375	2.500	27.35	17.80	1.54	0.061	0.0625	5.46	149
875.875	878.875	3.000	35.76	18.97	1.88	0.061	0.0625	6.25	224
875.875	879.375	3.500	44.47	20.14	2.21	0.061	0.0625	6.95	309
875.875	879.875	4.000	53.48	21.31	2.51	0.061	0.0625	7.57	405
875.875	880.375	4.500	62.80	22.48	2.79	0.061	0.0625	8.13	510
875.875	880.875	5.000	72.42	23.65	3.06	0.061	0.0625	8.64	626
875.875	881.375	5.500	82.34	24.82	3.32	0.061	0.0625	9.12	751
875.875	881.875	6.000	92.56	25.99	3.56	0.061	0.0625	9.56	885
875.875	882.375	6.500	103.09	27.16	3.79	0.061	0.0625	9.97	1028
875.875	882.875	7.000	113.92	28.33	4.02	0.061	0.0625	10.36	1180
875.875	883.375	7.500	125.03	29.47	4.24	0.061	0.0625	10.74	1343
875.875	883.875	8.000	136.41	30.60	4.46	0.061	0.0625	11.10	1514
875.875	884.375	8.500	148.41	31.72	4.68	0.061	0.0625	11.46	1701
875.875	884.875	9.000	159.95	32.85	4.87	0.061	0.0625	11.77	1883
875.875	885.375	9.500	172.11	33.98	5.06	0.061	0.0625	12.09	2080

Figure 9.2: Stage Discharge Curve at 50 m D/S of Barrage Axis



It is established from the above information that the HFL corresponding to 1938 m^3/s discharge is EL.888.400 m and same value is used for the design of Barrage. Spillway with 3 bays of opening size 6 m (W) x 4.50 m (H) each will be able to pass 2066 cumecs with 17.46 m head above the crest and with one gate considered in-operational condition as per provisions of IS-11223-1985, the water level shall rose below El. 895.000 m. The sill of the gate is kept at the EL 879.0 m which is river bed level of the river. The spillway has been designed to pass 1 in 100 floods with reservoir at HFL i.e. 894.150 m and MWL (one gate inoperative condition) at El. 895.0 m. The top of barrage has been kept at El 895.00. The width of the piers is assumed to be 2.0 m and, consequently, the total length of barrage structure is estimated to be 25.50 m. Three vertical gates, each 6.0 m (W) x 4.50 m (H), are provided in the spillway. In view of the heavy bed load movement including boulders in Halai River, extra care will be required in the operation of gates. Furthermore, gates, piers and barrage & spillway sill/floor will also require additional protection against damage caused by the boulder movement. It is proposed that 500 mm thick high-performance concrete on the top of floor shall be provided in order to protect the same from boulders.

To protect the piers from the direct impact of the moving boulders; they are clad with a 12 mm thick steel plate up to a height of 1.0 m above the floor throughout their length.

Hydraulic Design of Barrage

Hydraulic design of barrage involves finalization of waterway requirements, upstream and downstream cutoffs, energy dissipation arrangements and protection work at upstream and downstream of barrage. Khosla's method of independent variables is invariably used for determining the uplift pressures exerted by the seepage water on the floor of the barrage but as the barrage is being founded on rock strata, the Khosla's Theory is not applicable and the length of barrage is judiciously adopted not being dependent on the seepage line theory.

i. Spillway Capacity

The spillway bay has been fixed to pass a flood of 1938 m^3/s. Keeping in view all these aspects, three bays of gate size 6.00 m (W) × 4.50 m (H) with all operative gate condition is proposed which will pass a discharge of 1966 m^3/s which is more than the design flood. The calculations for the discharging capacity of spillway is given in **Annexure 9.2.1**.

ii. Energy Dissipation

Energy Dissipation arrangement is not applicable for such steep bouldery rivers where excavation into the rock is not feasible to locate the cistern level of stilling basin. The average bed slope of the river is about 10 m/km. the aim of the energy dissipation arrangement is to dissipate the energy of the incoming flows i.e. from super critical velocities to sub-critical velocities. But in Halai River, the flows are always supercritical. Hence, it is prosed to provide straight floor ahead of the gate arrangement wherein the river flows in natural state. The length of basin ahead of the gates is proposed at 30 m which is judiciously adopted and anchored into the rock below with rock anchors staggered at 5 m c/c.

iii. Type of Cut off

Concrete cut off walls are barriers provided below the floor of the structure both at the upstream and downstream ends. An upstream cut off is designed for safety against scour and downstream cut off is designed for safety against scour and piping action. 3 m cutoffs are proposed into the river bed as no scour or piping action shall take place.

iv. Scour

Depth of scour has been computed from the Lacey's formula, Extent of scour at upstream and downstream impervious floor is considered as 1.25 R and 1.5 R respectively as per IS code.

R = 1.35*(q2/f) 1/3 for looseness factor less than 1 as per IS code

Where

R =Depth of scour below the highest flood level in m

f =Silt factor

q =Intensity of flood discharge in $m^3/s/m$

v. Cut Off

Upstream and downstream cut-offs have been provided at the end of the impervious floor to restrict scours up to 1.25 R.

vi. Protection Works

Launching apron of loose boulder/stone in wire crate placed above graded filter has been provided. The length of Launching apron has been kept 2.25 times the depth of Scour.

Stability of the Barrage Structure

The Barrage has been designed as a gravity structure with crest level at EL.879.0m. High performance concrete of has been provided on the outer

profile of Barrage to minimize the damage by rolling boulders. The Barrage stability is assured by considering various loads like dead load, live load, water pressure, earth pressure, earthquake loads, etc.

Excavation and Slope Stabilization

The barrage shall be constructed by excavating left and right bank on the proposed location. In order to accommodate barrage, proposed excavation slope shall be initially benched down from surface to the desired level in varying stable slopes. The cut slopes shall be made stable by providing supports like rock bolts/anchors, shotcrete, drainage holes, etc. as shown in the barrage drawing.

9.6 Power Intake

Based on the study of the topographical features of the area, the power house is proposed on right bank of Halai River. A power Intake is provided on the right bank in line with Barrage axis. The crest level of the Intake has been kept at EL. 881 m. Higher intake invert level shall help to minimize sediment entry in the flowing water before entering into the water conductor system. The flow in to the feeder channel shall be controlled through two vertical lift gates provided in to the body of the Intake structure. A set of stop logs has also been provided for maintenance of the Intake gates. A rectangular feeder channel has been provided to feed the water in to the desilting basin.

To control the entry of the trash in to feeder channel an inclined trash rack has been provided up to the top of the Intake structure. Mechanical cleaning arrangement has been provided to prevent entry of any floating material into feeder tunnel. Suitable arrangement to dispose off the trash shall be made. A separate rope drum hoist has been provided for intake bulk head and intake gates. A platform has been provided at an elevation of 895.0 m to provide approach to Intake gates. Each intake out of two has been designed to carry a discharge of 13.60 m^3/s including flushing.

The size of the trash rack opening results in an intake net velocity less than 1.5 m/s. The top level of the Intake structure is at EL. 891.0 m, same as the Barrage top. This allows access also during floods.

Two tier of gate arrangement has been provided with emergency gate of 5.0 m (w) x 2.5 m (h) in the upstream followed by service gate of equivalent size in the downstream. Trash rack arrangement has been provided at the extreme upstream to facilitate the uninterrupted entry of debris free water into the Intake and the approach channel. The trash rack has been placed at an angle of 15° from the vertical.

9.7 Feeder Tunnel

The water from intake is led to desilting tank through a rectangular feeder channel (bed width 4.00 m, water depth 2.04 m and free board 0.60 m). Since the section of channel may get submerged under water during heavy floods so it is proposed that section of channel may be provided as R.C.C. box section with manholes at suitable locations (@ 30 m) for maintenance purposes. The length of feeder channel is 405 m.

The design features of channel are as follows:

1. The design discharge for feeder channel is taken as 27.20 m3/s. The design discharge in feeder channel is kept 15% higher than that of head race channel as extra discharge is required for silt flushing in desilting tank.

2. The bed slope in channel is kept as 1 in 275. The flow velocity in the channel shall be 2.99 m/s. This will keep the sediments moving.

9.8 Desilting Basin

The nallah carries appreciable quantities of coarse silt during rainy season. A desilting chamber is considered necessary to remove silt particles to minimise the abrasion effects on the turbine runners. The Halaipani small hydro scheme is medium head scheme (gross head 92.935 m), so it proposed to provide a desilting chamber to remove sediment particles of 0.25 mm size and above. The design has been made by using computer

programme developed according to CBIP publication No. 175 entitled " Small Hydro Stations- Standardisation".

The design features of desilting tank are as follows:

(1) The discharge coming from feeder channel is 27.20 cumecs. It is proposed that 5.45 cumecs may be used in continuous flushing of silt deposited in the tank and balance *21.75 cumecs* may be led to head race channel.

(2) Particles of 0.25 mm size and above have been proposed to be trapped in the tank, keeping in view the turbine type proposed.

(3) The size of tank has been provided with 63 m long (Transition length= 42 m and 21 m at inlet and outlet end respectively) based on the time taken by particles to settle down. The desilting tank is proposed to be constructed in M 25 R.C.C mix.

(4) Due to the larger width the tank is divided into two chambers of equal width i.e. width of each chamber is kept 9 m. Control gates have been provided at entry and exit of each chamber so that in case of requirement, one chamber may be closed without effecting the operation in other chamber.

(5) The free board in the tank is kept 0.60 m.

It is proposed to carryout continuous flushing during monsoon, when the discharge in the river is more than the design discharge for power generation. Sediment basin is designed to carry additional 20% discharge for flushing out the sediment deposited at the bottom of the basin. Flushing of the collected sediments will be carried out through silt flushing duct of 0.5 m x 0.5 m size into the Halai River. Valves are proposed at the outlet of desilting basin for maintenance. Suitable protection works are proposed at the junction of pipe with nallah disposing the silt ridden water.

9.9 Head Race Channel (WCS)

The water fed from the desilting basin is led to forebay tank through power channel running along the contour on the right bank of halai river. The length of the power channel has been estimated at 1539 m. Along its course, the power channel crosses about 3 nos. of existing nallahs for which cross drainage structures have been provided. The power channel has been designed to carry forward silt particles up to 2mm size to forebay

tank as most of the bed load/suspended silt above 2 mm present in water would get removed in the settling basin.

The design features of power channel are as follows:

1. The section for channel adopted is rectangular section with PCC. The bed width of the channel is 4.00 m and the full supply depth is 1.97 m. the section is designed as hydraulically efficient section to carry a discharge of 21.75 cumecs to compensate the water losses due to seepage, evaporation and silt flushing at forebay. The total depth of channel is 2.42 m. the slope of the channel is 1 in 400. The velocity generated is 2.37 m/sec.

2. A free board of 0.45 m is considered necessary for the channel for any likely afflux caused by possible dropping of stones/boulder into the channel from the hill slopes.

3. An open drain 250 mm deep is provided on the right bank to keep off the surface runoff of the hill slopes away from the channel.

9.10 Forebay

The forebay, penstocks and power house are treated as integral unit so far as their location is concerned. The power channel terminates into a forebay tank located at RD 2070 m from the diversion structure. The forebay would be located on a rather flat area followed by the penstock provided along moderately sloping hill side leading to the power house on a flat terrace. The geology and the terrain is favourable. The layout will not involve any significant excavation for the forebay. The forebay has been provided for desilting of sediment particles above 0.2 mm size and to ensure supply of immediate water demand on starting the generating units.

The design features of the forebay tank are as flows:

1. The storage time has been kept 2 minutes as per guidelines issued by Central Electricity Authority:1982. Accordingly, the size of tank is kept as 66.0 m x 10.0 m x 4.80 m to 8.30 m, silt storage and its flushing and for passing discharge over spillway.

2. A Mild Steel bell mouth of circular section is provided at the inlet of penstock to reduce the entry losses.
3. Four mild steel trash racks of size 2.06 m (W) x 8.30 m (H) each with racks at 30 mm clear spacing is provided at penstock intake to check the entry of trash into the penstock.

9.11 Penstock

Water from forebay is being taken to the power house to run hydraulic turbines through pressurised penstock pipe running from forebay tank. Four numbers mild steel pipe penstock about 174.08 m long is proposed to be installed. The penstock pipe of mild steel is proposed to be erected as penstock made of other materials such as R.C.C., high density polythene plastic etc. are not suitable and economical for such size & conditions (transportation, erection etc) in comparison to steel pipe.

The criterion adopted for penstock design are as follows:

1. Four Separate steel penstocks of 1300 mm outer dia and 12.0 mm thickness is proposed for each unit of 4000 kW.
2. The optimum diameter is determined by minimizing the sum of annual loss of generation due to friction and annual working lost including interest on capital loan, depreciation, O&M charges. This diameter will develop 3.519 m/sec of maximum velocity in the penstock.
3. The design head for the penstock pipe is about 95 m plus 50 percent water hammer pressure.
4. The penstock is supported over saddles and anchor blocks. The saddles are provided at a spacing of 5.50 m *c/c.* The anchor blocks are provided at bends.
5. The penstock intake is provided with bell mouthing to have smooth entry of water and to reduce entry losses.
6. A slide type gate of size 1.8 m x 1.8 m along with manually operated screw hoist arrangement is proposed near the intake to control the flow in penstock along with bye pass valve of 150 mm NB which shall fill the penstock in the start to have balancing head across the gate valve.
7. A trash rack before the bell mouthing is provided for preventing entry of trash in the penstock.

8. An air vent pipe of 300 mm dia is provided with each pipe just downstream of gate (provided near penstock intake) to pass the air during filling and emptying of the penstock.

9.12 Powerhouse Building

Power house building is a simple structure housing the generating units, auxiliary equipments, control panels and suitable outlet for tail water discharge. The main features of the power house building are as follows:

i) The building of size 46.6 m X 16.5 m in plan is provided to accommodate 4 machines of 4000 KW each, control panels, auxiliary equipments etc. One service bay for the maintenance of machine is also provided in the same space.

ii) The height of the building is kept 25.05 m including the position of Crane to facilitate handling of equipment during erection and maintenance.

iii) Walls of the building are made of stone masonry with intermediate R.C.C columns.

iv) An E.O.T Crane of 20 tons capacity to facilitate the handling of equipment is provided over rails supported on R.C.C columns.

v) A trench of 0.3 m X 0.3 m with slope of 1 in 100 for drainage is provided around the power house building discharging into tail race channel to cater to rain water, plinth protection etc.

vi) Machine foundation has been provided as block foundation of reinforced cement concrete of M 20.

vii) The floor of power house building is provided at an elevation of 785.0 m which is above the highest flood level of Hali river at the proposed location of the power house.

viii) Four nos. draft tube gates of size 4.5 m X 2.8 m with gantry cranes.

ix) A valve of 50 mm dia may be provided for dewatering of the penstock.

Gauge – Discharge Table & Curve at Power House Site

The gauge discharge calculations and curve have been developed at power house site, 50 m upstream and 50 m downstream of power house site. The tail water rating calculations and curve at power house site, 50 m upstream

and 50 m downstream of power house site have been presented below in Table 9.3, Table 9.4 & Table 9.5 and Figures 9.3, 9.4 & 9.5 respectively.

Table 9.3: Gauge Discharge calculations at Power house site

Rating Curve at Section Power House Site									
RBL (m)	Water Surface LVL (m)	Depth of Flow (m)	Area A, (Sqm)	Wetted Perimeter P (m)	Hydraulic Radius R (m)	Manning's N	River bed slope	Flow Velocity v (m/s)	Discharge (cumecs)
771.884	771.884	0.000	0.00	0.00	0.00	0.061	0.04375	0.00	0
771.884	772.384	0.500	1.41	5.73	0.25	0.061	0.04375	1.35	2
771.884	772.884	1.000	5.64	11.46	0.49	0.061	0.04375	2.14	12
771.884	773.384	1.500	12.69	17.19	0.74	0.061	0.04375	2.80	36
771.884	773.884	2.000	22.71	24.67	0.92	0.061	0.04375	3.25	74
771.884	774.384	2.500	37.30	34.13	1.09	0.061	0.04375	3.64	136
771.884	774.884	3.000	56.04	41.72	1.34	0.061	0.04375	4.17	234
771.884	775.384	3.500	76.70	43.71	1.75	0.061	0.04375	4.99	383
771.884	775.884	4.000	98.22	45.78	2.15	0.061	0.04375	5.70	560
771.884	776.384	4.500	120.63	47.85	2.52	0.061	0.04375	6.35	766
771.884	776.884	5.000	143.92	49.92	2.88	0.061	0.04375	6.95	1000
771.884	777.384	5.500	168.10	51.98	3.23	0.061	0.04375	7.50	1260
771.884	777.884	6.000	193.16	54.05	3.57	0.061	0.04375	8.01	1548
772.884	779.384	6.500	219.11	56.12	3.90	0.061	0.04375	8.50	1863

Figure 9.3: Gauge Discharge Curve at Power house site

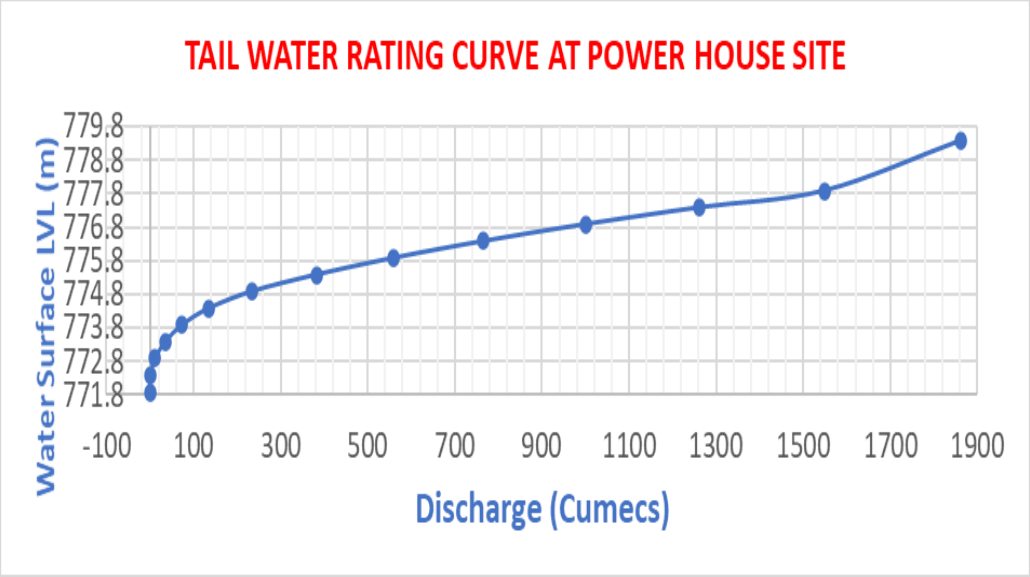


Table 9.4: Gauge Discharge calculations at 50 m U/S of Power house

Rating Curve at Section at 50 m Upstream of Power House Site									
RBL (m)	Water Surface LVL (m)	Depth of Flow (m)	Area A, (Sqm)	Wetted Perimeter P (m)	Hydraulic Radius R (m)	Manning's N	River bed slope	Flow Velocity v (m/s)	Discharge (cumecs)
777.750	777.750	0.000	0.00	0.00	0.00	0.061	0.04375	0.00	0
777.750	778.250	0.500	2.45	9.84	0.25	0.061	0.04375	1.36	3
777.750	778.750	1.000	9.79	19.67	0.50	0.061	0.04375	2.15	21
777.750	779.250	1.500	21.93	28.84	0.76	0.061	0.04375	2.86	63
777.750	779.750	2.000	38.37	37.33	1.03	0.061	0.04375	3.49	134
777.750	780.250	2.500	58.60	42.56	1.38	0.061	0.04375	4.24	249
777.750	780.750	3.000	80.04	44.55	1.80	0.061	0.04375	5.07	406
777.750	781.250	3.500	102.27	46.54	2.20	0.061	0.04375	5.80	593
777.750	781.750	4.000	125.28	48.52	2.58	0.061	0.04375	6.45	808
777.750	782.250	4.500	149.09	50.51	2.95	0.061	0.04375	7.06	1052
777.750	782.750	5.000	173.68	52.50	3.31	0.061	0.04375	7.61	1322
777.750	783.250	5.500	199.06	54.48	3.65	0.061	0.04375	8.13	1619
777.750	783.750	6.000	225.22	56.47	3.99	0.061	0.04375	8.62	1942

Figure 9.4: Gauge Discharge Curve at 50 m U/S of Power house site

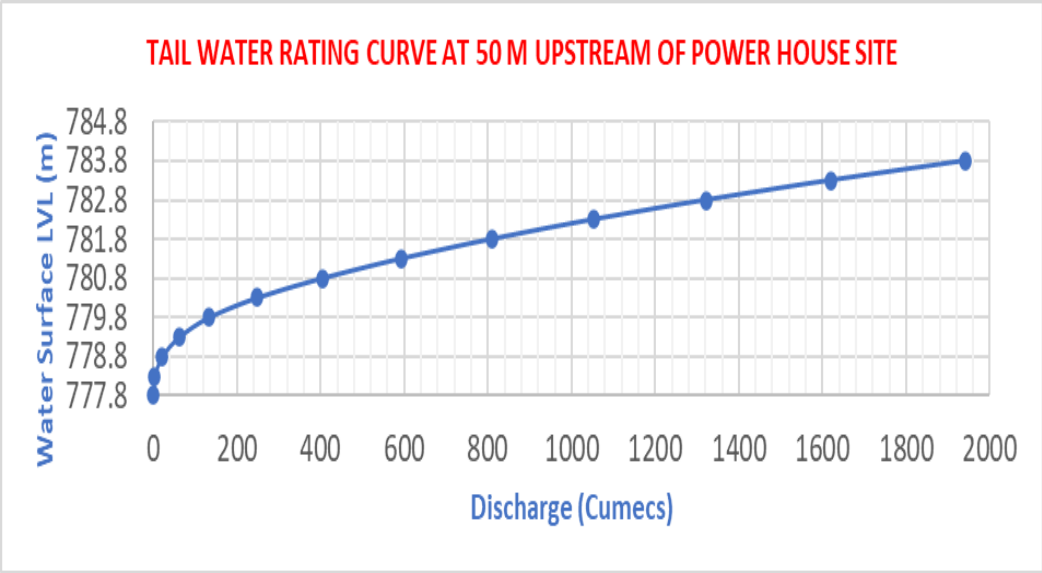
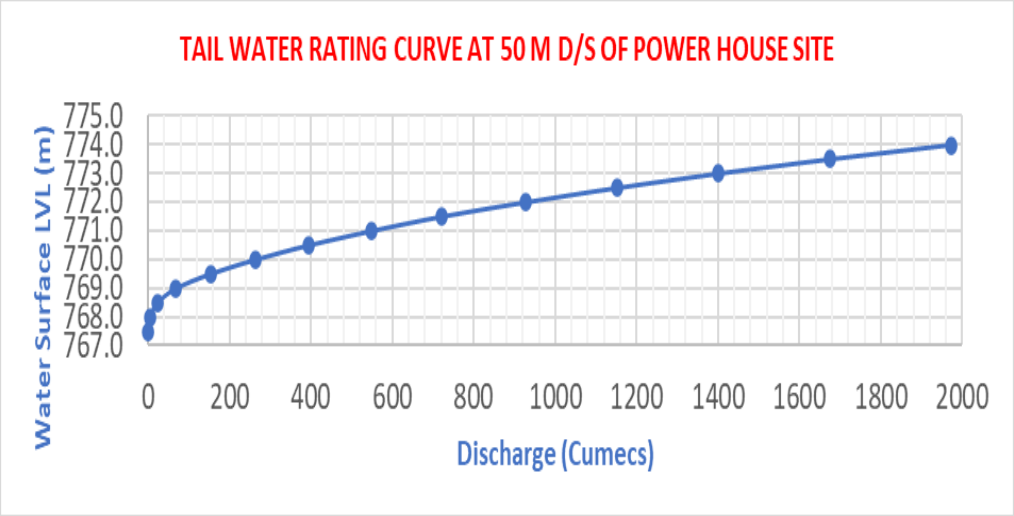


Table 9.5: Gauge Discharge calculations at 50 m D/S of Power house

Rating Curve at Section 50 M DOWNSTREAM OF Power House Site									
RBL (m)	Water Surface LVL (m)	Depth of Flow (m)	Area A, (Sqm)	Wetted Perimeter P (m)	Hydraulic Radius R (m)	Manning's N	River bed slope	Flow Velocity v (m/s)	Discharge (cumecs)
767.485	767.485	0.000	0.00	0.00	0.00	0.061	0.04375	0.00	0
767.485	767.985	0.500	2.64	10.62	0.25	0.061	0.04375	1.36	4
767.485	768.485	1.000	10.57	21.23	0.50	0.061	0.04375	2.15	23
767.485	768.985	1.500	23.71	30.64	0.77	0.061	0.04375	2.89	69
767.485	769.485	2.000	39.50	32.72	1.21	0.061	0.04375	3.89	154
767.485	769.985	2.500	55.86	34.45	1.62	0.061	0.04375	4.73	264
767.485	770.485	3.000	73.17	37.00	1.98	0.061	0.04375	5.40	395
767.485	770.985	3.500	91.56	39.53	2.32	0.061	0.04375	6.00	550
767.485	771.485	4.000	111.02	42.50	2.61	0.061	0.04375	6.50	722
767.485	771.985	4.500	131.55	44.58	2.95	0.061	0.04375	7.05	928
767.485	772.485	5.000	153.16	47.11	3.25	0.061	0.04375	7.52	1152
767.485	772.985	5.500	175.83	49.64	3.54	0.061	0.04375	7.97	1401

767.485	773.485	6.000	199.58	52.17	3.83	0.061	0.04375	8.39	1674
767.485	773.985	6.500	224.41	54.70	4.10	0.061	0.04375	8.79	1972

Figure 9.5: Gauge Discharge Curve at 50 m D/S of Power house site



9.13 Tail Race Channel

Turbine discharge shall be fed back to river Halai through the tail race channel. The width of Tail Race Channel is 4.0 m with a depth of 2.50 m. the length of Tail Race Channel is approximately 20 m including upstream transition. To dissipate energy and to prevent erosion on account of high velocity occurring due to steep slope of terrain, the tailrace channel has been provided with a series of falls. At the end of channel where it joins with river, protection works have been provided consisting of boulders in crates.

9.14 Switch Yard

An open switchyard of 53.50 m X 30 m has been envisaged by the side of power house main building at an elevation of 785.0 m.

Protection works have been provided consisting of boulders in crates.

9.15 Approach Road & Buildings

A suitable motorable approach road is proposed to be constructed to reach the trench weir and power house site for transportation of equipment. Suitable provision in cost for this road construction has been made. Provision has been kept for office, stores and residential buildings.

9.16 HYDRO – MECHANICAL EQUIPMENTS

General

In accordance with the provision of civil structures planning following hydro-mechanical equipments have been envisaged for Halaipani Hydroelectric Project.

9.17 HM Equipments in Barrage

Barrage Spillways consists of three bays of opening size 6.0 m x 4.5 m with crest at EL 879.00 m. Three nos. fixed vertical gates of opening size of 6.0 m x 4.5 m shall be provided to control the discharge through the spillway. The sill of the gate is located at EL. 879.00 m. These vertical gates shall be designed to sustain and operate against a head corresponding to HFL i.e., EL 894.300 m. Each gate shall be operated by means of electrically operated rope drum hoist of designed Capacity.

The inspection and maintenance of the vertical gate shall be carried out by lowering one set of slide type stop logs on the upstream side of these gates. The stop logs shall be fabricated in three units for opening size 6 m wide x 4.5 m high. The stoplog shall have u/s skin plate and d/s sealing. The Stoplogs shall be designed for a head corresponding to HFL (EL 894.300 m) and shall be operated under balanced head condition. The top unit shall be provided with a filling–in-valve to create balance head condition. The stop log units shall be operated under balance head condition by means of a gantry crane of 10 T capacity and a lifting beam.

The total cost of these equipments shall be Rs. 350.37 lakhs as per enclosed annexure.

9.18 HM equipments in Feeder Channel

Two nos. feeder channel gates are envisaged to feed water into the feeder channel. Dedicated fixed wheel type gate for opening size 5.0 m wide x 2.20 m high shall be provided. The sill of the gate is located at El 881.00 m. The gate is to be designed for a head corresponding to Pond Level (EL. 883.200 m). The gate will have an upstream skin plate & upstream sealing. The gate shall be lifted under balanced head conditions created by crack opening of gate against

U/S water level up-to FRL i.e. EL.883.200 m. The gate shall be designed for self-lowering under emergency conditions. The hoist capacity is calculated accordingly. The gate shall be operated by means of electrically operated rope drum hoist of suitable capacity located on the hoist platform installed over trestles. A hoist platform for accommodating rope drum hoists of intake gate is proposed. The operation of the gate is done by local control panels provided adjacent to the rope drum hoist. The inspection and maintenance of the vertical gate shall be carried out by lowering one set of slide type stop logs on the upstream side of these gates. The stop logs shall be fabricated in one unit for opening size 5 m wide x 2.2 m high. The stoplog shall have u/s skin plate and d/s sealing. The stop log unit shall be operated under balance head condition by means of the same barrage gantry crane of 10 T capacity and a lifting beam as the barrage and feeder channel are in same line.

On upstream face of the intake, an inclined trash rack (2 nos.) shall be provided. Each trash rack screen shall be of size approximately 5 m wide x 14.0 m high and shall be fabricated in panels of suitable height. Two such screens are provided in the intake structure.

The cleaning of incoming trash accumulated at the trash rack panels shall be done by manual means at El.895.000 m on the intake deck. Suitable trash removal trolley/lorry shall be provided.

9.19 HM equipments in Desilting Basin

The desilting basin is proposed to be provided with inlet (from feeder channel) and outlet (To power channel) gates. 2 nos. vertical fixed wheel gates at starting of desilting basin and 2 nos. vertical fixed wheel gates at end of desilting basin are proposed to isolate the two chambers of desilting basins. The size of each gate shall be 2.0 m x 2.3 m. The gates shall be operated with manually & electrically driven screw hoist mounted over a frame and hoist bridge suitable for taking out gate up to pier top for maintenance.

2 sets of silt flushing steel pipes have been proposed in Desilting Basin. The diameter of each pipe is 800 mm, 8 mm thick and 60 m long. To control the flow in the silt flushing pipes, two sluice valves each 800 mm diameter have been proposed.

9.20 HM equipments in Forebay & Penstock

4 nos. vertical fixed wheel gates are proposed for four nos. individual penstocks feeding the water to the turbines. The size of each gate shall be 1.85 m x 2.4 m. The gates shall be operated with manually & electrically driven screw hoist (5 MT) mounted over a frame and hoist bridge suitable for taking out gate up to pier top for maintenance.

4 nos. inclined trash racks each sized at 2.06 m x 8.30 m is provided at the penstock entrance. A provision is also been made for the flushing of silt from forebay using 20 m long steel pipe having thickness of 8 mm and 300 mm diameter. The penstock is also well equipped with inlet bell mouth transition and Sluice valves.

5 nos. steel pipes each 110 m long 1300 mm dia 10 mm thick and 60 m long 1300 mm dia 12 mm thick spirally welded have been proposed to feed the water from the forebay to the turbines. Out of 5 nos, 1 pipe is for surplus escape from the forebay during power house shutdown in emergency condition.

9.21 HM equipments in Draft Tube

Independent d/s draft tube gate at the outlet have been proposed for each of the four generating units. Each d/s draft tube flume has been provided with a gate of opening size 4.5 m wide X 2.8 m high to enable isolation of each generating unit from tail water and for maintenance purpose. The gate is of fixed wheel type. The gate shall have both sealing and skin plate on the tailrace channel side and wheels on the turbine side. A total four such gates are provided one in each draft tube opening to isolate all the units at a time. These gates shall be operated under balanced head condition and shall be designed

to sustain a head corresponding to normal TWL and shall be checked for maximum tail water level corresponding to flood with increased stresses.

Each individual gate shall be operated by means of an electrically & manually operated rope drum hoist of designed capacity. Balanced head shall be achieved by a filling in valve provided on the gate. The gate shall be generally kept in dogged position within the gate groove below the deck level of the gate opening bay using suitable dogging devices. Suitable interlocks shall be provided between draft tube gate position and generating unit to prevent starting of turbine till the gate is in dogged position.

The total cost of remaining hydro mechanical equipments of Cl. nos. 9.18, 9.19, 9.20 & 9.21 shall be Rs. 1396.70 lakhs as per enclosed annexure.

REVIEW OF DESIGN OF CIVIL STRUCTURES

1. HYDRAULIC DESIGN OF BARRAGE

BARRAGE BAYS CALCULATION:

Barrages are constructed to divert the water that may be required for the purposes of irrigation, hydroelectric power, water supply for thermal power stations, etc. As per IS & CWC Guidelines, barrages with hydraulic head up to 12 m shall be designed for 1 in 100-year Flood. Following flood value has been adopted for Halaipani DPR.

1 in 100 years flood = 1938 Cumecs.

Design discharge for power generation = 27.20 cumecs

Add 10% continuous overload during monsoon period = 2.72 cumecs

Total Discharge passed through Feeder intake = 29.20 cumecs

Design Flood passed through Barrage = 1938 – 29.20 = 1908.08 cumecs

Important parameters for barrage gates calculations are:

1. Barrage top = El.895.00 m
2. HFL = El. 894.150 m
3. Pond Level = El.883.200 m
4. Average River bed level at the control section = El.879.000 m
5. Average river bed level at the end of stilling basin = El.878.000 m
6. Crest level = El.879.000 m

The barrage shall be designed to pass floods for the criterion as mentioned in para. 9.10.2.

Criteria 1:

1 in 100 years flood (Q=1938 cumecs) to be passed at water level corresponding to HFL (El.894.150 m) with all gates in operative condition.

According to ‘IS: 6966’,

Discharge through gates is given by,

$Q = C \times L \times (H_e)^{3/2}$

Where,

Q = Discharge through one gate

L = Length of crest excluding piers

H_e = Head over the crest (velocity head not considered)

C = Coefficient of discharge

The proposed structure shall be provided with 6.00 m (W) x 6.40 m (H) size gates.

Head acting over the crest

= 894.150 – 879

= 15.15 m

L = 6 x 3 = 18 m

$\therefore$ Q, Total discharge = $1.8 * 18 * (15.15)^{3/2}$

= 1910.6 cumecs > 1908.08 cumecs ----- OK

Number of bays provided = 3 nos.

Hence provide 3 nos. of gates each sized 6.00 m (W) x 6.40 m (H).

Total barrage width is,

B = (6 x 3) + (3 x 2) + (1 x 1.5)

= 25.50 m

Provide 25.50 m wide barrage.

CALCULATION FOR SCOUR DEPTH

$$\text{Scour depth (Ds)} = 1.5 \text{ X } 1.43 \text{ X } \left(\frac{q^2}{f}\right)^{1/3}$$

q = 1938/40

= 48.45 cumecs/m

(Silt factor varies from 1.0 for sandy rivers to 20.0 for rivers having big boulder movement).

Take f = 6.0

D_s = $1.5 \text{ X } 1.43 \text{ X } [48.45^2/6.0]^{1/3}$

= 15.70 m

Cut off wall level = 888.40 – 15.70

= 872.700 m

The placing cut-off wall 6 m below the river bed level is not practical as excavation into bed rock is uneconomical. It is recommended to found the cut-off 3 m below the river bed level i.e. at El. 876 m.

DESIGN FOR SUBSURFACE FLOW: -

As the bed material in barrage is a mixture of boulders, gravels, etc. the barrage needs to be guarded against the possibility of piping and failure by uplift.

The structure should be designed such that the piping failure does not occur due to subsurface flow. The upstream and downstream cutoff walls will help to reduce the uplift pressure and to increase the creep length. The thickness of floor should be sufficient to resist the uplift pressure due to subsurface flow. The barrage floor length is calculated by using Lane's Creep theory.

Calculation of barrage floor length:-

(100% Design flood @ HFL)

The river bed material consists of heavy boulders & gravels. So, the adopted value for Lane's coefficient, C is 2.5.

H = Maximum head acting

= 888.400 – 879 (RBL)

= 9.40 m

Depth of Cut off = 3.0 m & Thickness of slab = 1.50 m

Total Lane's Creep Length, L is

L =3 + 1.5 + 1.5 + 3 + (50/3)

= 25.67 m

Now, C.H = 2.5 * 9.40

= 23.50 m

The barrage is safe against piping as the total creep length is greater than C*H. A barrage of 50 m length is provided keeping in view the other considerations with straight floor.

2. Feeder Channel

Q = 27.20 m^3/s

S = 1/275

n = 0.018

Rectangular box section has been provided.

Width of channel, B = 4 m

Full supply depth in canal, d = 2.04 m

Area A = Bd

= 4 x 2.04 = 8.16 sq.m.

Wetted perimeter P = B + 2d

= 4 + 2 x 2.04

= 8.08 m

Hydraulic radius, R = A/P

= 8.16 / 8.08 = 1.01 m

$$Q = \frac{AR^{2/3} S^{1/2}}{n}$$

Provided B = 4.0 m

d = 2.04 m

Free board provided = 0.60 m

Flow velocity = $(1/0.018) \times (1.01)^{2/3} \times (1/275)^{1/2}$

= 3.37 m/s

Discharging capacity = 8.16 x 3.37

= 27.52 m^3/s > 27.15 cumecs **O.K.**

3. Desilting Tank

Hydraulic Design of Desilting Basin

1 Purpose

1.1 Hydraulic design of Desilting Basin

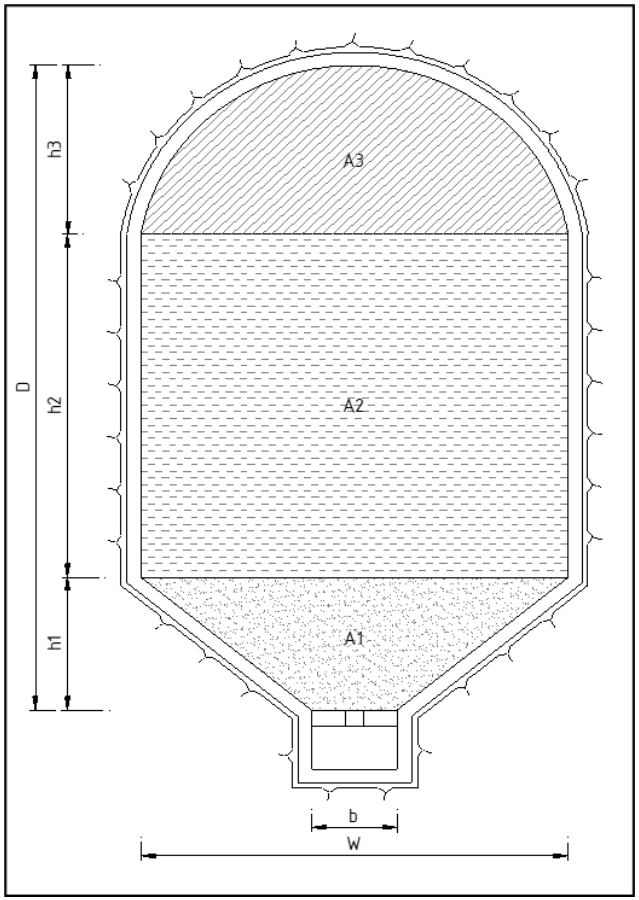
2 Design Data & Assumptions

Project Design Data

Design Discharge for the Plant, Q_d	=	21.75	m^3/s
Continuous Overleading	=	0.00	%
depth of Feeding Canal	=	2.04	m
Width of feeding canal	=	4.00	m

Assumptions

Flushing Discharge as % of Design Discharge	=	20.00	%
Particle Size to be Removed, d	≥	0.2	mm
Desired Hopper angle, q	=	45	degree
Trench Width, b	=	0.50	m
Trench Depth, h	=	0.50	m
Manning's Coefficient, n	=	0.016	
Max. flow through velocity(as per CWPRS), V_o	=	0.35	m/s
Max. width of bay, B	=	9.00	m
Number of Bays	=	2.0	
Fall Velocity of Particle (by L Sundry) , V_o	=	0.050	m/s



A3 section is not applicable.

Cross Section of the Desilting Basin

3 Computations (as per CWPRS Guidelines)

Step 1

Flow at entry (with overloading and flushing discharge)	=	26.10	m^3/s
Flow at exit (less flushing discharge)	=	21.75	m^3/s

Average flow in the desilting chamber, Q		=	23.93	m^3/s	
Average flow in one bay, Q_1		=	11.96	m^3/s	
Required X-Sectional Area per bay (A_r) (corresponding to max flow through velocity)		=	34.2	m^2	
	Adopt, A_{ad}	=	35.0	m^2	
Total X-Sectional Area of Desilting Chamber, A_t		=	70.0	m^2	

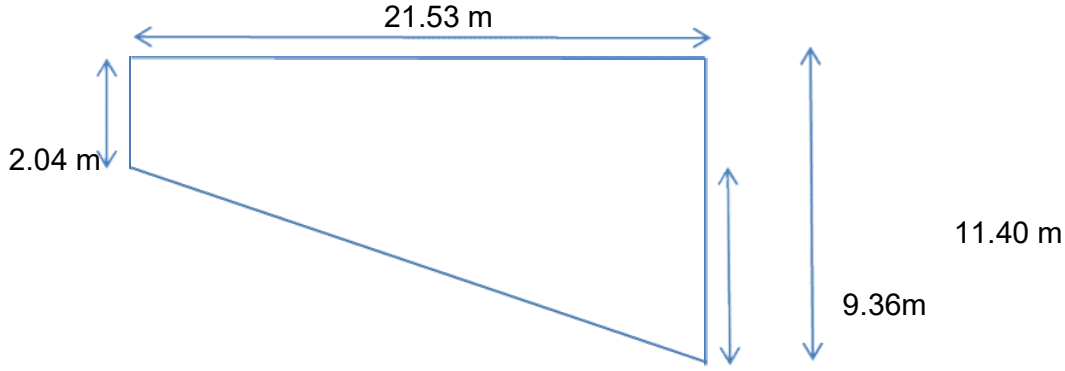
Sizing of the bay

Area of each Basin,		=	A1+A2+A3		
h1, calculated to ensure assumed hopper slope		=	4.25	m	
		say	4.00	m	
	A1	=	19.00	m^2	
h3, calculated as semi circle of diameter equal to bay width			0.00	m	
		say	0.00	m	
	A3	=	0.00	m^2	
Required area from middle portion,	A2	=	16.00	m^2	
Therefore, h2		=	1.78	m	
	But Provided Depth	say	7.40	m	
Actual X-sectional Area of one bay, A_a		=	85.60	m^2	
Actual velocity through the desilting chamber, V_a		=	0.14	m/s	OK
Total Flow Depth in the chamber, D		=	11.40	m	
Wetted Perimeter, P		=	40.69	m	
Hydraulic Radius, R		=	2.10	m	

Step 2

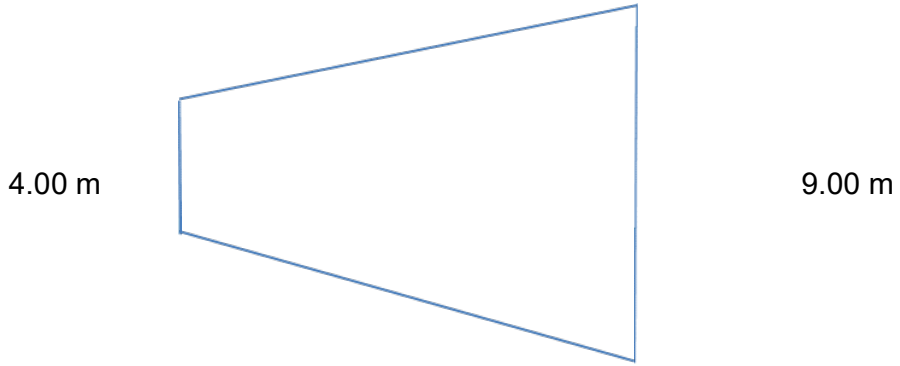
Length of Inlet Transition
CWPRS recommends a bed slope between 1V:2H to 1V:2.3H

Assuming slope of transition, 1V in 2.3 H
Inlet Transition Length 21.528 m
Say = **21.53** m



Step 3

Check for Flare Angle of Inlet Transition
CWPRS recommends a flare angle between 6^0 to 9^0.



Tanφ	=	0.12		
φ	=	6.6	degree	OK

Step 4

Length of Basin (L)

Effective depth, D	=	11.40	m
Average Forward Velocity/Flow through Velocity, Va	=	0.14	m/s
Required fall velocity, Vo = $D*V_a/L$			
Assuming L	=	63.00	m
Vo	=	0.025	m/s OK

Step 5

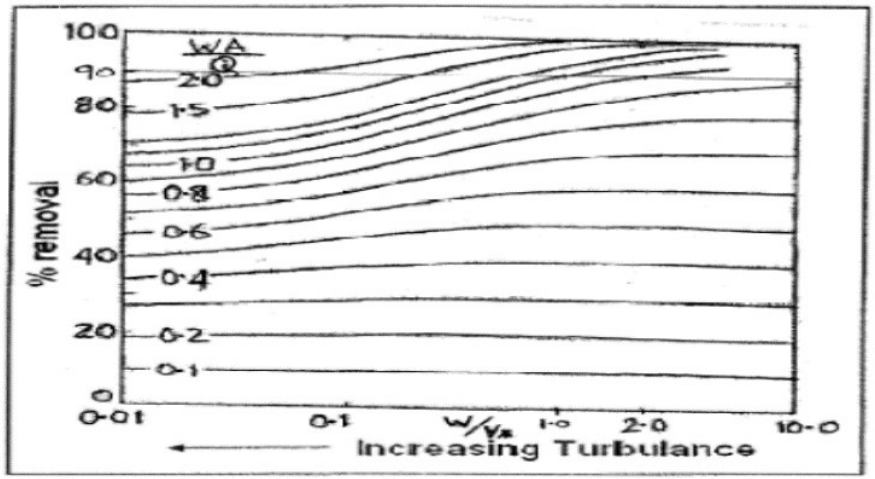
Calculation of Efficiency of removal of Settling Basin

Hydraulic Gradient, $S = \frac{Q^2 n^2}{A^2 R^{4/3}}$ = 1.85E-06

Shear Velocity, $v^*=(gRS)^{0.5}$ = 0.006187 m/s

$\frac{w}{v^*}$ = 8.08

$\frac{wAs}{Q} = \frac{wL}{V_a D}$ = 1.98



From the above graph of Camp, Efficiency = 98.00 %

4 Results and Conclusions

Provide, Desilting Basin of Dimensions

Length (L)		=	63.00	m
Width of bay (B)		=	9.00	m
Overall Depth (D)		=	11.40	m
	Depth of Semicircular Portion		0.00	m
	Depth of Rectangular Portion	=	7.40	m
	Depth of Hopper Portion	=	4.00	m
Inlet Transition Length		=	21.53	m

5 References

5.1 Guidelines for Design of Desilting Basins by Central Water & Power Research Station

5.2 Water Power Development by EMIL Mosonyi

4. Head Race Channel

Q = 21.75 m^3/s

S = 1 in 400

n = 0.018

Rectangular section has been provided with following dimensions:

Width of channel, W = 4.0 m

Full Supply Depth, d = 1.97 m

$$Q = \frac{AR^{2/3} S^{1/2}}{n}$$

Provided bottom width = 4.0 m

Water depth (d) = 1.97 m

Free board = 0.45 m

Total depth = 2.42 m

Cross section area of flow = 4 x 1.97 = 7.88 m^2

Wetted perimeter = 4 + 2 x 1.97 = 7.94

Hydraulic radius, R = 7.88 /7.94 = 0.9924 m

Flow Velocity = $(1/0.018) \times (0.9924)^{2/3} \times (1/400)^{1/2}$

= 2.764 m/sec

Discharging capacity = 2.764 x 7.88

= 21.78 m^3/s > 21.75 cumecs ….. **O.K.**

5. Forebay Tank and Spillway

Design discharge = 21.75 m^3/s

Storage required = 2 minute

Capacity of tank = 21.75 x 2 x 60

= 2610 m^3

Taking water depth = 4.0 m

Area required = 2610/4 = 652.5 m^2

Provide width = 10.0 m

Length required = 65.25 m

Provide length = 66.0 m

Free board = 0.750 m

Volume provided = 50 x 4 x 10 + 16 x 75 x 5

= 2600 m^3 ……. **O.K.**

Spillway

Discharging capacity (Q) = 21.75 m^3/s

Q = CL $H^{3/2}$

C = 2.0

Water depth over crest (H) = 0.45 m

Length of crest required (L) = 36.06 m

Provide length of crest = 38.0 m

6. Penstock

Separate Penstock pipe has been provided for each machine.

Design discharge = 21.75/4 = 5.44 m^3/s

Length = 174.08 m (each pipe)

Velocity (say) = 3.5 m/s

Area of pipe required = 5.44/3.5

= 1.554 m^2

Diameter of pipe required = 1407 mm

Diameter of pipe provided = 1400 mm (55” O.D)

Design of thickness

Gross Head = 877.725 – 773.090 m

= 104.635 m

$$\text{Thickness} = \frac{PD}{2\sigma}$$

P = Water pressure including water hammer in kg/cm^2

D = Inside Diameter of penstock in cm

σ = Permissible stress in steel in kg/cm^2

$$\text{Thickness required} = \frac{0.1 \times 104.635 \times 1.5 \times (140)}{2 \times 1000}$$

= 1.10 cm

= 11 mm

Add 1.5 mm for corrosion allowance

The thickness required including corrosion allowance

11 + 1.5 = 12.5 mm

Provide 14.0 mm thick pipe

External dia of penstock (d) = 1400 + 2 x 14.0

= 1428 mm

Thickness from handling criteria

$$t = \frac{D + 50}{400}$$

D = Diameter in cm

$$t = \frac{140 + 50}{400}$$

= 0.475 cm or 4.75 mm O.K.

Calculation for Head Losses

The detailed calculations of head losses are carried out as follows:

Friction Loss

$$h_f = \frac{fLV^2}{2gD}$$

Where,

f = friction factor

L = length of penstock

V = velocity of flow

D = Diameter of pipe

Calculation for friction factor – The friction factor depends upon Reynold's number of flow and relative Roughness of pipe.

$$\text{Reynold's number (Re)} = \frac{VD}{\gamma}$$

Where,

γ = kinematic viscosity of water

$$Re = \frac{3.87 \times 1.219}{1 \times 10^{-6}}$$

$$= 4.72 \times 10^6$$

Relative Roughness

$$= k/D$$

$$Re = \frac{0.045}{1.400 \times 1000}$$

$$= 0.000032$$

Friction factor (f) from Moody's diagram = 0.010

$$0.010 \times 174.08 \times (3.5)^2$$

Friction loss (hf) = ----------

2 X 9.81 X 1.400

= 0.78 m

Entrance Loss

$$h_e = \frac{0.25\ v^2}{2\ g}$$

= 0.16 m

Trash rack loss

$$h_t = K_t \frac{v^2}{2\ g}, \quad Kt = 0.35$$

= 0.22 m

Exit loss

$$h_E = K_E \frac{v^2}{2\ g}, \quad K_E = 1.0$$

= 0.62 m

Bend loss

$$h_B = n\ K_b \frac{v^2}{2\ g}$$

= 6 X 0.2 X 0.62 m

= 0.75 m

Valve losses

(a) Near forebay

For gate valve

$$hvg = 0.5 \times \frac{V^2}{2\ g}$$

= 0.312 m

(b) Inside Power House

For gate valve

$$hvb = 0.5 \times \frac{V^2}{2g}$$

$$= 0.312 \text{ m}$$

For butterfly valve

$$hvg = 0.6 \times \frac{V^2}{2g}$$

$$= 0.374 \text{ m}$$

$$h_v = 0.312 + 0.374$$

$$= 0.686 \text{ m}$$

Transition and bifurcation losses = $0.65 \times V^2/2g$

= 0.41 m

Total head loss = 0.78 + 0.16 + 0.22 + 0.62 + 0.75 + 0.312 + 0.686 + 0.41

= 3.938 m

= 4.00 m (say)

CHAPTER 10: ELECTRO MECHANICAL WORKS

10.1 General

The Halaipani Hydro-Electric Project is proposed as a surface Powerhouse having 16.0 MW with 10% continuous overloading capacities. Based on the hydrology of the available discharge data for the desired dependable year and calculated head losses of the waterways, the project is proposed having four numbers horizontal Francis type hydro turbine-generating units of 4.0 MW operating at rated net head of 95.00 m.

10.2 Type and size of Turbine Generating Unit

The optimum plant capacity as per power potential studies is 16 MW. The rated net head is 95.00 m and Francis turbines are best suited. The rating of each unit and number of units are selected with the criterion of operational flexibility vis-à-vis seasonal variations in availability of water during the year, plant reliability, flexibility of operation, part load operation, maintenance of equipment etc. provision of single unit alternative is not considered. Installation of four units shall fully meet all the technical aspects with the lowest investment, flexibility and hydrology, as identified above.

The project is proposed having four numbers horizontal Francis type hydro turbine-generating units of 4.0 MW operating at rated net head of 95.00m and rated discharge per unit of about 5.3 m^3/s. Francis turbine's part load is 50%, as recommended in Table 1 of IS 12837. However, as per latest market trend, the Francis turbine operates safely up to 40% of part load.

The generator directly coupled to the Turbine would have a rated output of 4000 KW with continuous over load capacity of 20%, synchronous type with 11 KV generating voltage and frequency 50Hz. The rated power factor would be 0.85 lagging.

10.3 Mechanical Equipment

The mechanical equipment will consist of turbine, main inlet valve, governor oil pumping system, compressed air system and other powerhouse auxiliaries such as Crane, Air conditioning and ventilation system, cooling water and dewatering system, drainage and fire protection system

10.3.1 Turbine

The Turbine is proposed as horizontal Francis type turbines, each turbine consisting of the main parts.

Selection of Turbine Speed

It is proposed to specify the type of turbine as Francis type, since the rated head of 95.0 m lies within the operating range of Francis turbine (125m-65m) as per IS: 12837-1989, Table 1 & clause no. 5.

For the selection of the turbine speed & dimensioning of the power house reference is made as per Indian Standard IS: 12800 (Part 1, 3): 1991,

As per Figure 1 of IS: 12800 (Part 1) specific speed range is 70-400 for Francis turbines. For net of 95.00 m. The specific speed of 238.85 m-kw is considered, and the nearest synchronous speed determined as 750 rpm.

Selection of Turbine Runner Diameter

Francis Turbine Runner is radial-axial type runner. Runner converts water-hydraulic energy into mechanical energy.

Pressure Rise and Speed rise

As per IS 12837, permissible pressure-rise for Francis type turbine is 130% to 135 % and permissible speed rise for Francis type turbine is 35 % to 55%. Water conductor system and TG components will be designed accordingly. Pressure rise, and speed rise values are proposed as 35% of static head and 55 % synchronous speed. The flywheel effect of generator and guide vane closing and opening times will be chosen to achieve these limits.

Turbine Setting

The setting of the turbine with respect to minimum tailrace level must be set to limit cavitation damage to the turbine. Refer clause 4.3 Turbine Setting of IS 12000 (Part 1), the specific speed against the given installation (Runner center line elevation) & operating data (net head, specific speed) is determined and final setting of (-)3 m is adopted based on data obtained from various equipment-manufactures.

Major Assemblies of Turbine

The horizontal Francis turbines, each consisting of the main parts, which are specified as below:

a) Francis runner

The runner blade and runner crown & skirt is proposed of stainless steel - 13/4 Chromium-Nickel or better material conforming to ASTM A-743, grade CA6 NM, with high resistance to silt erosion. It shall be mounted at the other end of turbine shaft. The runner and the rotating parts of turbine shall be dynamically balanced at the manufacturer's works as per requirements of ISO 1940-1973.

b) Shaft and Coupling:

Turbine shaft of forged steel conforming to ASTM A-338, having connection at one end with runner flange and on another end with generator flange, is proposed. The shaft shall be properly heat treated to relieve all stresses due to forging and machining. Shaft will be designed to operate in all conditions of normal operation, load throw off, maximum run-away speed and short circuit at generator terminals safely without undue vibrations and distortions.in. Runner, shaft and other rotating parts shall operate at any speed without vibration and distortions

A renewable and removable sleeve of stainless steel shall be provided wherever the shaft passes through a shaft seal or a gland.

c) Shaft seal arrangement:

The shaft seal is proposed to be provided on down-stream of runner and it shall give adequate seal against water and air during operation as well as at rest. The sealing elements shall run against a replaceable sealing surface of stainless-steel material mounted on the shaft. The shaft seal shall be easy to inspect & adjust. It shall be possible to replace sealing elements without dismantling other parts. The shaft seal will have cooling/sealing arrangement from cooling water system and will be suitable for filtered potable-water after filtering. A maintenance seal of inflatable rubber will be provided

The leakage flow shall be radially splashed off into the seal housing by a splash ring and flows off naturally through an adequately dimensioned pipe. The leakage pipe shall be connected to the drain chamber.

d) Stay ring:

The stay ring is proposed of cast steel or welded steel plates. The stay ring shall be designed to guide the water flow to guide vanes.

The stay ring is proposed of welded steel construction of boiler quality plates designed to bridge the throat of spiral casing and to transfer the weight of the entire unit to the foundation with hydraulically profiled stay vanes. The upstream ring will carry the main turbine cover and pit liner and the downstream-ring will be connected to the pivot ring and foundation ring. The two rings will be rigidly tied together by the stream lined stay vanes which guide the water smoothly to the guide vanes. The foundation ring (discharge ring) will be of welded or cast steel construction and heavily ribbed to maintain circularity.

e) Spiral case

The spiral case shall consist of several spiral carbon steel plate sections, which shall be welded to the side plates of the stay ring. On the upstream side, one welded-on flange with a make-up piece shall be provided for connection between spiral casing and penstock

Spiral case shall be tested to water pressure of 1.5 times the working pressure for duration of 30 minutes after assembly at site. Pressure testing pump-motor set, of adequate capacity, along with pipes and other accessories shall be provided.

Spiral case shall be complete with a water tight inspection hole & its cover; drain outlet with S.S. grating, foundation plates, anchoring material, flanges, studs, and other fittings etc.

f) Draft tube cone and elbow Liner:

Draft tube is proposed of elbow type with one vent consisting of plate steel welded suction cone, steel lined elbow of enough length along with levelling / tightening / anchoring material to prevent erosion and a concrete lined horizontal section upto draft tube outlet. Draft tube (suction cone) is proposed to have a watertight inspection hole / manhole & its door. A draft tube drain arrangement with tapping at invert level.

g) Turbine Bearing

The turbine guide bearing is proposed of pivoted pad type (having Babbitt material lined) having oil lubrication located above the runner. The bearing housing shall, split into two halves. Bearing will be designed to operate at all speeds including run way speeds without damage. The temperatures of bearing pad and oil shall not exceed 70°C and 65°C respectively. Under normal operating conditions, in case of failure of cooling water supply the guide bearing shall be designed to run at least for 15 minutes without any damage. The bearing shall also be designed and constructed to operate at runaway speed for 15 minutes with cooling water. An external oil heat exchanger shall be provided as per design requirement.

h) Guide Apparatus

- Guide vanes with its operating mechanism:

  The guide vanes of aerofoil positive self-closing type and having 13Cr, 4Ni stainless steel material (to ASTM A-743 CA) resistant to silt, shall guide & control the water flow. The spindles and vanes will be cast in one piece. Suitable special packing or synthetic rubber seals will be provided at the stems to prevent leakage of water. The guide vanes will have one bottom guide in pivot ring and two top guides in top cover. The guide bushes will be of PTFE type and self-lubricating.

- Regulating Mechanism

  The guide vane operating ring of rigid construction is proposed to transfer the motion of servomotor to individual guide vanes through the connecting levers, links, pins etc. for safe uniform and synchronous operation of guide vanes. The ring will be provided with suitable bearing and renewable guides. Shear pin or breaking links will be provided on each connecting rod which will break or shear when any vane movement gets blocked and protects rest of the mechanism. Such failure of shear pins will give alarm and will not cause progressive failure of adjacent shear pins.

  The operating mechanism shall be easily accessible for maintenance and inspection and as well as for easy resetting of guide vanes.

i) Pivot Ring and Stationary Labyrinth Rings:

Pivot ring is proposed be of cast steel / weld-fabricated, stress relieved and machined from boiler quality steel plates. Their hydraulic surfaces exposed to erosion shall be preferably coated with stainless steel or abrasion resistant coating. These shall be supported on stay ring and shall house the stationary labyrinth rings, self-lubricated bushes and lower stems of guide vanes and renewable stainless-steel liners below the guide vanes, which covers the guide vanes closed position

j) Turbine Cover and Stationary Labyrinth Rings:

Turbine cover is proposed of weld-fabricated, stress relieved and machined from boiler quality steel plates and with stainless steel liners in the area above the guide vanes, which covers the guide vanes closed position. The turbine cover will be designed for withstanding the up-thrust from runner. Turbine cover shall be supported on stay ring and shall house the stationary labyrinth rings, self-lubricated bushes and upper stems of guide vanes . Head cover shall support the operating mechanism.

Arrangement for draining the leakage water from top cover will be provided by pumps/ siphon.

k) Guide vane Servomotors:

The guide vanes is proposed to be positioned with precision by the oil operated servomotors, and suitably mounted on headcover / turbine pit, through regulating ring. Two double acting servomotors acting as a couple will move the guide vanes. The capacity will be designed to operate the guide vanes through full range at maximum head and with minimum operating pressure of oil. Servomotors will be controlled by the directional control valves of the governing system.

Servomotors shall actuate the gate operating ring and shall be complete with integral feedback transmitter, adjustable throttling retarding device, oil piping, flanges, fasteners, air vent, drain cock, manual locking device etc.

l) Pit Liner

Turbine pit liner is proposed to be fabricated from structural steel conforming to IS 226 / 2062. Provision will be made to mount the guide vane servomotors on Turbine floor. The pit liner, as required shall have the

provision for welding to the stay ring with full penetration. The liner shall be adequately ribbed and anchored to the surrounding concrete in order that the forces may be transmitted from the structure above the spiral casing to the stay ring without appreciable distortion of the pit liner. Adequate reinforcement shall be fitted to protect the liner from deformation or strain during transportation as well as while placing it for concreting. A circular mono rail with chain in block in the pit liner to hand le shaft seal and servomotor will be provided.

10.3.2 Governing System

Turbine governor is proposed of modern design and shall comprise of an electronic, microcomputer-based part for control and regulating function and a hydraulic part acting as a power amplifying servo unit conforming to IEC 61262 & 60308 with combined proportional, integral and derivative function (P.I.D.). The PID governor shall be of digital type and shall comprise of a CPU, the electronic processing and interface boards. It shall house all the digital / electronic devices and circuitry of the governor viz. microprocessor circuits, speed sensing transducer and circuits, stabilizing circuits and other essential circuits / controls for adjustment of various governor parameters, indications etc. The governor system shall be complete with feedback sensors, oil pressure pumping unit, Hydraulic Actuator (Proportional) valves, piping, valves, instrumentation and various devices for automatic shutdown, emergency shutdown, devices for adjustment of governor closing and opening times and all accessories and equipment necessary for operation. The governor shall prevent the turbine and generator from hunting and instability at all levels and ensure stable operation under all possible operating conditions. All the basic features of the governor shall be specific software based. The governor shall receive the signals from speed signal generator (SSG) directly on the turbine shaft and transmit through an Actuator (Proportional Valve) an amplified signal to the guide vane servomotors.

The Governor will perform the following functions.

(i) Speed control for start-up and synchronizing and block loading.

(ii) Steady State, Small transient, Large transient control of machine

(iii) Isolated Operation

(iv) Grid Operation

(v) Manual and automatic Control

(vi) Over speed detection

(vii) Adjustable speed drop control

(viii) Load control/position control/flow control selectable with settable load limiter

The digital control system of governor will output the appropriate current / voltage signal which will be interfaced to hydraulic proportional control valves. The proportional control valves will allow the required oil flow through the servomotors of guide vane to position them. The governor control will achieve the guide vane closing time to limit the speed-rise and pressure-rise within limits in all transient operating conditions. The governor will function as a closed loop control system with PID control having speed, position and load as measured input para meters, guide vane position as measured input parameters, guide vane position as manipulated variable and speed or load or flow as the controlled variable. Toothed wheel speed signal generator with speed sensor or PMG will provide the turbine speed input flowmeter / level meter with transducer will provide the flow / level input and load transducer will provide the load input to the governing system functions. Governor panel will have the required indications of speed, load, flow, position, etc. Control modes of position or load will be selectable and whenever the unit goes to isolated grid operation governor will automatically change over to speed control.

10.3.3 Oil Pressure System

The final control elements for positioning of guide vanes will be hydraulic oil servomotors through directional valves. The required oil pressure and oil flow will be provided unit wise by the Governor Hydraulic system consisting of an oil-sump, a set of two screw type oil pumps, accumulator, oil filters, proportional control valves, servomotors, logic elements etc. Accumulator will be provided with high-pressure nitrogen or air cushion depending on the oil pressure chosen. There will be two (2) (one running and other as stand by) pump-motor-sets. The standby pump will be automatically switched on upon failure of the pump in service. A set of smooth operating unloader valves, non-return valves and safety valves will be provided to regulate the oil pressure. Pressure switches will be

provided for loading/unloading of pumps and for stand by pump starting. Pressure switch will also be provided for alarm and trip at desired values

A High-pressure air compressor system will be provided to cater to the needs of Governor and Main inlet valve oil systems, alternatively providing a Nitrogen bladder in the accumulator to maintain the system pressure will be examined during implementation

Common oil-pressure-units for Turbine& Governor and main inlet valve shall be provided for each generating unit.

10.3.4 Main Inlet Valve

Inlet valve is required to shut off water to the turbine in case of shut down and to permit dewatering of the turbine for inspection. This valve will also close against turbine flow under emergency conditions. The inlet valve will be designed to operate and seal properly under pressure during all operating conditions and during transient water hammer conditions.

The diameter of valve will be about 1000 mm (matching with spiral case inlet diameter) and will be designed for the expected pressure rise up to 135% of maximum head. Butterfly valves are better suited for these duty parameters.

Body and disc will be fabricated steel construction. Valve-door will be with piston-ring type of seal. The service seal on the downstream side of the valve body will consist of stainless-steel ring type. Maintenance seal on the upstream side will be used when maintenance work is to be carried out on the service seal.

The inlet valves will be located immediately upstream from each of the spiral cases, to which they will be directly Connected via a downstream dismantling joint.

The opening of the valve will be by oil pressure and closing will be by counter weight. Oil-hydraulic pumping set for this MIV, shall be common required for turbine & governor for each unit. The set will be complete with a motor operated bypass valve and dismantling joint.

10.3.5 Cooling Water System

Cooling water system is proposed to be provided to meet the cooling water requirements of generator air coolers (if applicable), turbine guide bearing,

generator thrust and guide bearing and turbine shaft seal (if applicable) and potable water etc. Each of the three units will be provided with a cooling water pump and one common stand by pump which can be lined up to any of the unit's cooling water system. Alternatively, the cooling water can be tapped from inlet side of the turbine and provided with a suitable pressure reducer. The system will be complete with nonreturn valves, discharge and suction valves, sectionalizing valves, motorized valve duplex filters, sectionalizing valves, piping, pressure gauges and flow meters fine mesh filters, flow indicators, flow relays, pressure gauges, etc.

10.3.6 Drainage & Dewatering System

Drainage and dewatering pumping system are proposed to be provided which will be common to all the units. The drainage and dewatering system shall permanently and automatically ensure the delivery to the outside of all effluents collected in the plant.

The dewatering system (dewatering the water from penstock and draft-tube elbow), including necessary valves, piping, pump-motor sets, instruments, will be used to dewater the turbine and draft tube for accessing the runner and other underwater parts during routine maintenance and also during emergencies caused by abnormal inflows.

The drainage system shall handle all leakage and drains from all the equipment within the power station. The main flows and volumes to be handled by the systems shall account for permanent drainage of all floors, turbine shaft seals cooling system, firefighting water, emptying of a unit waterway, emptying of the draft tube and downstream waterways. Drainage & dewatering pumps will be of submersible type so that, in the event of partial flooding, the pumps will continue to operate to de water the power station. The pumps shall operate automatically based on the rising and falling water level in the sump.

The turbine drainage & dewatering system pits will be designed to enable dewatering of the turbine within four hours' time. This system will act as back up to the drainage system in the event of emergency in-flows. Suitable arrangement for interconnection of both dewatering and drainage pit by gate shall be provided. Normally the pumps shall operate automatically based on the rising and falling water level in the sump. D&D systems will have pump-motor

sets controlled by level float switches. Pumps of each system will be connected to an independent common outlet. Pumps will discharge to the tailrace.

10.3.7 Workshop Equipment

Workshop having suitable facility shall be provided in the powerhouse for carrying out the normal O&M of various electro-mechanical equipments. The workshop shall be mainly equipped with the requisite machine tools like lathes, drilling machines as described below.

i) Drilling machine

ii) Welding set

iii) Grinding machine

iv) Cutting machine

v) Bench vice

10.3.8 Air Conditioning System

The control room is proposed to be air conditioned using spilt AC for maintaining the temperature and to avoid ingress of dust and foreign materials thereby providing comfort and maintaining the accuracy and performance of sophisticated instruments and controls located inside the control room.

Ventilation system shall be conforming to IS: 4720- 1982 “Code of Practice for Ventilation of Surface Hydel Power Stations” comprising of

a. Inlet Ventilation blowers, air-ducts, louvers, etc. shall be for ventilation purpose in power house.

b. Axial type Exhaust fans shall be provided for exhausting the used air from (i) battery fumes from Battery room, (ii) Wash / WC Rooms, (iii) Powerhouse Building

10.3.9 EOT Crane and Hoists

One number electrically operated Overhead Crane for installation and maintenance of E&M in the power house is proposed.

EOT crane capacity of 35/5 MT hook shall be provided in the powerhouse for erection and maintenance purpose of handling the generating unit’s parts such

as Runner, Main Inlet Valves, Guide Apparatus, Bearings, Generator, Transformer etc.

The crane shall be as per IS: 3177 and shall have cabin/pendent controls. The crane shall be complete with electrical control panels, pendent controls, hoist, brakes, safety devices, platform, ladders, fittings and connections, rails for runway. Operation of crane shall be smooth and silent for all travels. The cranes shall be assembled in the manufacturer's workshop and test run with rated load and 125% load.

10.3.10 Fire Protection System

Fire Detection & Protection system is provided to meet following requirements:

a). To detect Fire Situation

b). To Protect, Control and Extinguish Fire.

An effective Fire Detection & Protection System results in minimizing the loss of property, human-life and downtime.

Following stated codes are proposed to be referred

Sl. No.	Standard	Description
1.	NFPA 10	Standard for Portable Fire Extinguishers
2.	NFPA 13	Standard for the Installation of Sprinkler System
3.	NFPA 14	Standard for the Installation of Standpipes and Hose Systems
4.	NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection
5.	NFPA 20	Standard for the installation of stationary fire pumps for fire protection
6.	LPA	Guide lines of LPA (Loss Prevention Association of India) Earlier known as TAC (Tariff Advisory Committee)

a) Fire Detection, Alarm and Control System

The fire detection, alarm and control system shall consist of different types of fire detectors, fire alarm panels, repeater panel (in electrical room), local panels etc. Panels It shall be microprocessor based, analogue addressable type.

i) Fire Detection System

The system is suitable to detect the presence of fire's smoke / heat in the room or around the equipment. Following are the types of fire's smoke / heat detectors:

- Ionization type Smoke Detector is suitable for automatic water sprinkler / Inert gas system
- Quartzoid bulb heat detection system is proposed to be provided for Oil hazard area, Transformer area etc. protected by HVW spray.
- Electrical type Heat Detector is proposed for Battery Room.
- Manual Break Glass Boxes is proposed to have a push button element kept in pressed condition by the glass fitted in the front of the box. Break glass boxes shall be used as manual call points.

ii) Fire Alarm System

A Fire alarm system will be installed to provide visual and audible alarm in the power station for fire detection. This system will comprise manual call points located at strategic location in areas which are normally manned, and automatic smoke and heat detectors located at important points such as the cable vault, the control room, the switchgear room etc. It detects fire at an early stage and provide visual and audible alarm. The Fire alarm system consist of following:

- Hooters, in the event of fire, shall raise pulsating audio alarm and lamp shall flash.
- The panel shall consist of solid circuitry on a printed circuit board, a loudspeaker and flashing lamp housed in weatherproof dust tight, wall mounted type enclosure. Fire Alarm Panel and operate with DC supply.
- Siren shall be industrial type of 2.5 km (min) against the wind direction.
- In case of any Multi Sensor Detectors or Manual Call Points being actuated a signal shall be transmitted to the Fire Alarm Panel which in turn actuates an Audio / Visual alarm in the Fire alarm panel and simultaneously initiate the signal for external hooters at

the various places - such as on Pontoon, Pathway to Pontoon, Security room, control & Switchgear room, etc.

iii) Public Address / Talk Back System

The public address & talk back system shall be provided for power house, switchyard area, Dam area and shall consist of a main communication console located in the Electrical room and speaker / talk back units located along the above said area.

b) Fire Protection System

Fire protection systems of following types (as applicable) shall be provided.

i. Overhead Fire Storage Water Tank Filling Arrangement

It is proposed to provide the overhead fire water tank near the Surge shaft, so that operating pressure of Hydrant system shall be 4.5 bar to 6.9 bar, as stated in clause No. 7.8.1 of NFPA 14.

This tank shall be filled by water drawn from Surge shaft through pump-motor set. The water storage tank shall be of capacity suitable for, as per NFPA 851, Clause Nos. 6.2.2 & 8.7.4-(2). The water supply for the, permanent / in-service, fire protection installation should be based on the largest fixed fire suppression not less than 500 gpm (1890 L/min) for a 2-hour duration.

ii. Hydrant system

The System comprises of a reliable source of water supply; network of pipe, combination of underground and above ground piping throughout the project. The system includes Hydrant arrangement, water mains network, hydrant valves, landing valves at each landing locations, water monitors. Hose cabinets with hoses, branch pipes, nozzles, hose boxes, central hose houses etc, at strategic locations.

The Hydrant system, along with Hose Reel and wet riser, is proposed to be provided for the complete project, including at least the following:

- In the power house at Turbine and Generator Floor
- Switchyard area including around Transformer (Oil Type), DG Set area

iii. Water Spray Emulsifier system for Generator-Transformer

The system comprises of network of underground and above ground piping, control valve, compressor receiver, deluge valve, HVW Spray Nozzles / Projectors.

In HVWS system the deluge Valve which is normally in closed position. Whenever the fire breaks down and temperature around the protected equipment goes beyond the temperature rating of (79 °C) Quartzoid Bulb detector, installed around the equipment), then Quartzoid Bulb detector will collapse, and it reduces the pressure in the detection line by draining the air, which results in opening of deluge valve and then water will rush to spray water network, through the opened Deluge Valve. The DV operation makes the diaphragm in action to spray the water on protected transformer.

iv. Portable Fire Extinguisher

Portable fire extinguishers along with sand buckets shall be provided at strategic locations considering easy access as per NFPA 10 & TAC Guidelines at all strategic points of the Power house, Barrage, Switchyard.

Various portable extinguishers are selected as per applicability as stated in below **Tables 10.3**

Table 10.3 Portable Fire Hydrant Classification

Sr. No	Class of Fire	Description	Type of Extinguishers
1	Class A	Fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.	Water type, Multipurpose dry chemical type & Wet chemical type
2	Class B	Fires in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.	Aqueous film-forming foam (AFFF), Film-forming Fluor protein foam (FFFP), Carbon dioxide, and Dry chemical type.

3	Class C	Fires that involve energized electrical equipment where the electrical non- conductivity of the extinguishing media is of importance. (When electrical equipment is de-energized, fire extinguishers for Class A or Class B fires can be used safely.)	Carbon dioxide, Dry chemical type.

v. Piping Layout and Schematic

Piping for all the protection systems will generally be laid over ground, on RCC pedestals, except in locations such as road or in main plant area where it may not be feasible to route over ground.

10.4 Electric System

The electric system scheme consists of 4.8 (+ 20% continuous overload) MVA, 11kV, 0.85 power factor Generators; Switchgears; 8MVA, 11/33kV Transformers; 33 kV Switchyard; Auxiliary Transformers, LT Switchgears, 110 V DC System; Emergency DG Set; etc.

The Scheme is as shown in Single Line diagram, which is described below Generators will be connected through 11 KV XLPE cables to 11 KV outdoor switchgear. Each generator will have one 33 KV vacuum circuit breaker for synchronizing and tripping. 33 KV switch gear will be connected to 8 MVA generator transformer through 33 KV vacuum circuit breakers. Generator transformer will be connected on 33 KV side through set of isolators and Vacuum circuit breakers. 2 Nos. Power Evacuation lines take off from 33 KV bus through set of isolators and circuit breakers.

Auxiliary Transformer will be connected on 33 KV switchgear through 33 KV breakers. The 415-volt side of auxiliary transformer will be connected to 415-volt switchgear through LT power cable and ACB. The 415-volt switchgear bus will also be fed from emergency supply DG set. The 2 incomers in 415-volt switchgear will be interlocked so that only one breaker can be closed without paralleling

10.4.1 Generators

It is proposed to install three generators conforming to IS: 4722 /IEC 60034 and major parameters would be as given below:

Table 10.4: Generator Parameters

Description	Value
Type	Horizontal, salient pole synchronous generator
Capacity	4 MW (with 10% continuous overloading)
Rated Voltage	11 kV
Range of voltage variation	± 10%
Power Factor	0.85 lagging
Rated Speed	750 rpm
Frequency	50Hz
Range of frequency variation	±5%
Phase	3 phases
Inertia Constant	> 1.0
Short Circuit ratio	1.1 (minimum)
Stator Winding Connection	Star
Generator Earthing	Star point earthed through distribution transformer
Insulation Class of Stator and Rotor Winding	Class-F (155-degree Centigrade)
Excitation	Brushless
Protection Class of Generator	IP 44
Cooling	Air cooled

The generator will be complete with standstill heaters, excitation system, and neutral grounding arrangement, phase and neutral side C.T.s, RTDs, bearings with bearing oil level and temperature monitoring / protection system, brake and jack assembly. The generator insulation will be class F with temperature rise limited to that corresponding to class B so that generator will have possibility of overloading for short durations. As hydro station will be operated under varying conditions and intent of specifying higher insulation class is to have winding life of 35 years or more. The short circuit ratio will be at least 1 .1 considering stability of the machine. Generator is not likely to charge long line hence the line-charging mode for the genera tor may not be required.

Major assemblies of Generator

(a) Generator Stator

Generator stator core will be built up of insulated CRNGO silicon steel laminations of high quality and low loss designed to prevent any hot spots. The winding will have epoxy rich resin non-hygroscopic insulation. Type of winding will be coil or bar type.

(b) Generator Rotor

The rotor comprises of a welded steel rotor centre (outside serves as a yoke) and magnetic poles bolted on the periphery of salient pole type with damper windings on face of the pole. Rim will be made up of laminated tensile steel. Rim plates are assembled on to the spider. Spider will be provided with the brake track at the bottom. The field winding will be strip on edge copper with class F insulation.

(c) Generator thrust and guide bearings

The generator bearings will be in the bracket. Thrust bearing will have Babbitt metal lined, the guide bearings will be with Babbitt metal lined pads. Bearings will be designed to operate at all speeds including runaway speeds without damage. The bearing will be capable of operating at runaway speed and from zero (0) to 115% of rated speed for 15 minutes without cooling water supply. The maximum operating temperature will be 70 degrees centigrade for metal and 65 degrees centigrade for oil.

Instrumentation for monitoring and protections consisting of RTD's, dial thermometers, alarm and trip contacts either from scanner or from thermostat/dial will be provided.

10.4.2 Excitation System

The excitation system will be brushless type and will be suitable for parallel operation of the generators with the grid. The system will include AVR, field suppression equipment, field circuit breaker, brushless excitation system etc. The ceiling voltage of the excitation system will be at least 180% of the normal field voltage and response ratio will be at least 2.0. The regulation shall be within + /- 0.25% of the set value. The voltage set point shall be

adjustable from 90 % to 110 % and PF set point shall be adjustable from 0.8 lead to 0.8 lag. The excitation system shall have the following features.

a) AVR will have one manual channel working as a field current regulator and one auto channel working as selectable voltage regulator or PF regulator with reference setters and auto-manual follow up features and PID adjustment features. Smooth change from 'Auto position of voltage regulator to Manual position and vice -versa will be provided. AVR will have soft start features, such as following

(i) Compounding system with current transformers for quadrature droop characteristic.

(ii) Rotor current limiter

(iii) Stator current limiter

(iv) Automatic Power factor regulator

(v) Exciter diode monitor

(vi) Under excitation MVAR limiter

(vii) PT Fuse failure protection

(viii) Automatic Fault detector

(ix) Automatic over fluxing control of generator transformer.

(x) Solo and parallel operation modes.

(xi) Rotor earth fault protection

10.4.3 Brakes

Generator will be provided with air-operated brakes to bring the rotary parts of the generator and turbine to stop from about 15% of rated speed during normal operation. The brakes will also be suitable for application at higher speed during emergency shutdown of the unit, to bring the rotor to rest at faster rate. The brakes will operate automatically/ manually from local control panel/unit control board.

10.4.4 33 KV Switchgear

The power generated from the generator will be fed to outdoor 33 kV switchgear. The main electrical parameters of switchgear will be:

a) Rated voltage : 33 KV

b) 1 sec. withstanding current : 25 KA.

c) Rated current of busbar : 800 Amps.

The 33 KV Switchgear will comprise draw out type circuit breakers housed in indoor, metalclad cubicles. The circuit breaker will be of vacuum type.

The main electrical parameters of circuit breaker will be:

a) Rated voltage : 33 KV

b) 1 sec. withstanding current : 25 KA.

c) Rated current : 630 Amps.

d) Type of breaker : Vacuum.

Synchronizing of the Generator with Bus will be at 33 KV.

10.4.5 Generator Transformers

Each generator will be provided with a step-up generator transformer to step up the voltage from 11 kV to 33 kV. Transformers of 8 MVA rated capacity which will cater to each 4000 KW generators with 10% over load are proposed. These will be connected as shown in Single Line Diagram enclosed.

The transformers will be installed outdoor switchyard in the proximity of the power station building. To encounter voltage variations of the grid and for satisfactory operation of the generating units, on-load tap changers on the HT side of the transformer having a voltage range of –10% to +5% in steps of 1.25% will be provided. The main electrical characteristics of the transformers are proposed as stated below:

Table 10.5: Transformer Parameters

S. No.	Description	Generator Transformer
1	Rating in KVA	8000 kVA
2	Number of units	4
3	No. of Phases	3
4	Standard applicable	IS 2026
5	Vector group	Ynd11
6	Guaranteed no load voltage ratio	33 / 11 kV
7	Frequency	50 Hz
8	Type of cooling.	ONAN
9	Temperature Rise	60 / 65 Deg C as per IS

		2026
10	Type of Tapping	OLTC, (-) 10% TO +5% insteps of 1'25%

The primary terminals shall be suitable for cable connection to the 33 KV Switchgear. The secondary terminals will be brought out through bushings for connection to switchyard equipment.

10.4.6 LAVT Cubicle & Generator Neutral Grounding Transformer

The lightning arrestor or surge protection and voltage transformer (SPVT) cubicle will consist of surge protection equipment and voltage transformers. The surge protection equipment would comprise of lightning arresters with suitable discharge characteristics to suit the generator insulation level in parallel with suitable rated capacitor for smoothening the rate of rise of impulse voltage. The LAVT cubicle will be connected by means of 11 KV XLPE Cables to generator. The voltage transformer will be single phase, star connected, dry type units with draw-out features. The VTs for metering and protection shall be as indicated in the single line diagram.

10.4.7 33 KV Switchyard

The 33kV outdoor type switchyard equipped with 33kV Vacuum type circuit breakers, Oil filled type Current Transformer and potential transformers, horizontal double break type motor operated type isolators, LA, support structures & other ancillary items are proposed. Protective equipment shall be provided for protection of the feeder under fault condition. Over current, overvoltage protection shall be provided for the feeder. DC power for the switchyard shall be provided from the power house DC system.

The switchyard shall have provision for the following feeders:

- Power evacuation feeder – 2 Nos.
- Incoming feeders from generating units – 4 Nos.
- Station Auxiliary transformer – 2 Nos.

The proposed 33kV Switchyard shall be installed adjacent to power house. Basic system parameter of the 33kV system:

Equipment	Characteristics
Highest System Voltage	36kV

Power frequency withstand voltage	70 KV (rms)
Basic Insulation Level	170 KV peak
33 KV breaker	Vacuum type
Short Circuit level	25 KA for 1 second

10.4.8 Control & Protection and Metering System

A. Control & Monitoring System

Control & monitoring system will have all the necessary sensors, devices monitoring and logging the various temperatures of all the vital components of the generator, turbine, generator transformer, etc. All the operating parameters of the unit shall have visual display as well as logging of the same. Variation in the operating parameters from the pre-set values shall result as audible alarm and visual display or shutting of the unit as the condition may be. It will have provision for SCADA control comprising computer for plant control, unit control, switching equipment control, essential auxiliary control and data acquisition system. The system will also include provision of data base, uninterrupted power supply system, mosaic boards etc. however, the extent of computerization will be worked out at the time of detailed design stage.

B. Protection System

Electrical protection system consisting of numerical multifunctional relays and static discreet relays, for sensing (i) the faults and high-speed tripping relays (ii) tripping functions, will be provided for isolation of affected equipment during faults and abnormal operating conditions. The configuration and protection philosophy of the system will be as follows.

a) One numerical multifunction generator protection relay catering to all major generator protections and some discreet relays as back up and for catering to those functions not provided by numerical relay will form the generator protection. The tripping functions will be grouped in to 3 groups as follows.

- Emergency trip function to trip GCB, Field circuit breaker and turbine for complete isolation of generator on serious faults.

• Electrical shut down function to trip GCB and Field circuit breaker to electrically isolate the generator and keep the machine running at rated speed on such electrical faults not requiring turbine trip.

• Controlled action shut down function to trip the turbine first and then GCB and FCB after closure of guide vanes to provide tripping without sudden load throw off on such mechanical faults like bearing temperature very high etc. For all generator faults the 33kV Brakers will trip to isolate the unit from grid.

• For all generator and transformers faults the respective 33 kV VCB will trip.

b) One numerical transformer protection relay catering to transformer overall differential over fluxing and restricted earth fault and static discreet over current and earth fault relay as back up protection will form transformer protection. All transformer protections will trip the 33-kV side Breaker in addition to tripping the generator.

Protection of functions will be as follows:

(1) Generator

The following protections will be provided for the generator:

i.	Over Speed	12
ii.	Trip Circuit Supervision Relay	95
iii.	Under voltage protection	27
iv.	Reverse power protection	32
v.	Bearing Temperature High	38
vi.	Loss of field protection.	40
vii.	Negative phase sequence current protection	46
viii.	High temperature	49 S
ix.	Breaker Failure Relay	50 BI
x.	Voltage restraint over current	51 V
xi.	Over voltage protection	59
xii.	Stator earth fault protection	64 S

xiii.	Rotor earth fault protection.	64 R
xiv.	Under / Over frequency	81 O/U
xv.	Master Trip Relay	86
xvi.	Differential protection	87 G
xvii.	Over voltage relay	59
xviii.	Over current relay	50/51
xix.	Over/under frequency relay	81 O/U
xx.	Fuse failure supervision	60
xxi.	Over excitation	24

(b) Step-Up Generator Transformer

The following protections will be provided for step-up generator transformers:

i.	OTI Alarm	49 OA
ii.	OTI Trip	49 OT
iii.	WTI Alarm	49 WA
iv.	WTI Trip	49 WT
v.	Over-current	50/51
vi.	Earth fault current	50N/51 N
vii.	Buchholz, oil and winding temperature alarm/trip.	63 A
viii.	WTI Alarm / Trip	63 T
ix.	Restricted earth fault	64 REF
x.	Master Trip	86T
xi.	Overall differential protection	87 GT
xii.	Oil level alarm	LOLA
xiii.	Pressure relief valve	PRV
xiv.	Trip circuit supervision relay	95
xv.	Breaker failure protection	50Z

(c) Transmission line protection

33 KV Transmission line will be provided with two numerical protection relays as main and Directional over current and Earth fault protections as back up. Rate of change of frequency and rate of change of voltage (df / dt and dv / dt) protection will be provided for tripping the lines during isolated grid conditions. Under voltage and overvoltage (27, 59) protections shall also be provided.

10.4.9 Power & Control Cables

a) All cables will be selected to carry the load current under site conditions, with permissible voltage drop. In addition, high voltage cables would be sized to withstand the short circuit current. For connection of CTs, 4 mm^2/2.5 mm^2 size cable shall be preferred. For control cable, size of 2.5 mm^2 and 1.5 mm^2 cables shall also be considered. The following types of cables would be used.

b) For 11 KV System: 11KV unearthed grade, single /multi core, stranded aluminum conductor, cross linked polyethylene insulated, screened, aluminum wire /galvanized steel wire armored and over all PVC sheathed cables conforming to IS7097 – Part II.

c) Low voltage power cables: 1100 V grad e stranded aluminum conductor, HR PVC /PVC insulated, Color coded, P VC sheathed and aluminum wire/galvanized steel wire armored overall PVC sheathed cables conforming to IS –1554.

d) Control, protection, signaling, DC and supervisory cables would be of 1100 V grade, annealed high conductivity stranded copper conductor, PVC/ Elastomer insulated overall.

e) PVC / Elastomer sheathed, signaling and supervisory cables would be in twisted pairs and screened wherever required.

f) The inner and outer sheaths of all the above cables would have firm retardant capabilities. Cables would be laid in steel ladder type cable trays. In outdoor areas, cables will be laid in racks/built up trenches or will be buried directly underground.

Lightning Protection System

A lightning protection system will be provided as per IS: 2309 and Indian Electricity rules. The protections shall consist of roof conductors, air terminals and down conductors and will be provided for all structures.

10.4.10 Communication System

It is proposed to provide a separate P&T line with four extension handsets at the powerhouse for external communication.

10.4.11 Earthing System

A separate earthing grid will be provided for powerhouse and switch yard and will be interconnected with the buried portion of the earth conductor, which will be of mild steel. Exposed earth conductor will be of galvanized steel. Required number of earth pits will be provided. A separate earthing mesh will be laid in the tailrace if required and interconnected with plant grid.

Earthing system shall be designed considering adequate fault level, earth resistivity and various potentials with sizes of mats to achieve system resistivity below 1 ohm.

10.4.12 11 KV Connection between Generator & SPVT Cubicle

The connection between generator and 11 KV SPVT cubicle will be by11 KV XLPE Cables.

10.4.13 11 KV Connection between 11 KV SPVT and Generator Transformer

The connection between 11 KV SPVT cubicle and Generator Transformer will be by suitably rated 11 KV XLPE Cable.

10.4.14 Station Auxiliary Power Supply Arrangement

a) Station Auxiliary Transformers

The total station auxiliary load of the power plant is estimated to be below 315 KVA. A 100% capacity oil cooled auxiliary transformer will cater to this load. Two numbers station Auxiliary transformers, connected to 33kV Busbar and station Service Board shall be provided. The main electrical parameters of the transformers will be as stated below:

i) Voltage ratio : 33 KV/433V, 3 phases, 50Hz.

ii) Rating : 315 KVA

iii) Primary connection : Delta

iv) Secondary connection : Star with neutral solidly earthed

v) Type of cooling : ONAN

v i) Off circuit tap changer : ± 7.5% in steps of 2.5%

b) Unit Auxiliary Transformer

11 kV/0.433 kV, 200 kVA dry type unit auxiliary transformers shall be provided for each unit for unit auxiliary requirement.

c) 415V Switchgears (Station Service Board)

The auxiliary transformer will be connected to bus bar of 415V auxiliary switchgear. The 415V Auxiliary Switchgear will feed the entire unit's and station loads. The main electrical parameters of switchgear will be: auxiliary boards

i) Rated voltage : 415 V

ii) 1 sec. withstanding current : 40 KA

iii) Rated current of busbars : 1200 Amps.

The 415V Switch gear will be of metal enclosed construction type with signalized main bus bar and will be equipped with all the associated accessories.

The various auxiliaries of the power plant will be supplied at the following nominal voltages depending upon their ratings and functions.

i) Motors : 415V, 3 phase AC supply

ii) Lighting & space heaters : 240V, Single phase AC Supply.

iii) Power receptacles : 415V, 3 phase AC supply.

iv) Control Circuit : 110V, ungrounded DC supply

d) Appurtenant works

i. **Barrage site:**

11 kV line is available at barrage. 250kVA 11 kV/433 V, 3 phase, 50 Hz auxiliary transformer shall be provided for barrage power requirement and for emergency conditions, it is proposed to provide one DG set of 160 kVA, 415V, 50Hz, 0.8PF silent type.

iii. **Colony**

One 125 kVA 11/0.433 kV distribution transformer shall be provided for colony requirement

10.4.15 DG Set (Emergency Power System)

Diesel Generator set along with its auxiliary is proposed for emergency power.

The unit and station auxiliary supply can be obtained through the auxiliary transformer, which will be fed 33 KV System. First back up power supply in the event of all units under shut down will be grid supply from the 33 KV line. The in-feed from the diesel set will be second back up to be used for essential supplies like dewatering, battery chargers, emergency lighting etc.

It is proposed to provide two sets of 250 kVA, 415V, 50Hz, 0.8PF silent type DG set for emergency purposes. The DG set shall have Auto Main Failure panel, automatically start in case of failure of supply from SAT. It shall be complete with acoustic enclosure, battery chargers, battery etc.

10.4.16 Direct Current Supply System

The Direct Current System (DC) is the most reliable source of supply in the power station and will be used for the control and protection of the power plant equipment. The DC system will be used for the following:

i) Electrical control of equipment and indications on the control panel.

ii) Power supply to the following services in case of total AC power failure:

a) Communication system

b) DC lighting of strategic areas for safe personnel movement.

iii) The battery sizing will be done to cater to the following type of loads

(a) Momentary load for 1 minute

(b) Emergency load for 2 hours

(c) Continuous load for 10 hours

Under normal conditions, the battery will be on float charger. The float charger is connected to a distribution board and meets the requirements of the DC load. In case of additional demand of load or AC supply failure; the battery will meet the requirements of DC loads.

The boost charger will be designed to charge the fully discharged battery in 10 hours before bringing it back on float charge. A set of 110V battery banks of 300AH with float and boost chargers and a direct current switchboard will meet the DC load. The batteries would be of stationary lead acid type, complete with racks, porcelain insulators, inter-cell and inter connectors. The chargers would be of silicon rectifier type with automatic voltage control and load limiting features.

10.4.17 Lighting

The power station lighting system would comprise of the following:

i) Normal 240V AC Lighting System

The lighting circuit in the normal 240V AC lighting system would be fed through 415/433 volts, 3 phase, 4 wire lighting transformers connected to 415V feeders from SSB.

ii) Direct Current Emergency Lighting System

Direct current emergency lights would be provided at strategic points in the power station, viz. near entrances, staircases, the main control room etc.

These would be fed from the station 110V DC system and would be off when the normal AC power supply is available. These would be automatically switched on when the normal AC supply fails. The proposed illumination levels for various areas are given below: -

Area level	**: Illumination**
Control room	:300 lux
Switchgear/MCC room	:200 – 250 lux
TG building	:200 lux
Open areas	:50 lux

Transformer yard and switch yard	:10 – 20 lux
Work shop	:300 lux
Stores	:100 – 150 lux
Battery room	:100 lux
Administration building and office rooms	:300 lux
Roads	:20 lux.

10.4.18 Power Evacuation

TRANSMISSION

The evacuation of power is proposed through two outgoing 33 kV transmission lines for 16 MW of power from Halaipani hydroelectric project. There is an existing 33 kV substation at Halaipani Substation. The length of power evacuation line from power house to the nearest pooling station is about 5 km.

COMMUNICATION

A fibre-optic cable system consisting of terminals at both ends with multiplexing equipment, and a transmitter and receiver coupled to fibre-optic light conductors that are routed to the other terminal, which also has a receiver, transmitter and multiplexing equipment shall be provided. Optical Fibre Cables with terminal equipment shall be used between project and grid substation for voice and data communication, on- line monitoring and control.

INVENTORY LIST HALAIPANI HYDRO POWER PROJECT

Sr. No.		Particulars	Qty.	Unit	Remarks
1	**Turbine Parts**	Draft tube cone	4	pcs.	
		Draft tube section Bend	4	pcs.	
		Spiral Casing	4	pcs.	
		Distributor Assembly	4	pcs.	
		Runner Assembly	4	pcs.	
		Shaft Seal	4	pcs.	
		Embeded Parts	1	set	
		Main Inlet (Butterfly) Valves	4	pcs.	
		Oil Pressure unit	4	pcs.	
		Cooling Water System	1	Lot	
		Drainage & De Watering	1	Lot	**It is evident that these items are not in very good condition hence needs overhauling and reconditioning**
2	**Generator And Auxiliaries**	Synchronous Generator 5.0 MVA, (4.0 MW)	4		
		Brushless Excitor System (AVR Pannel)			
		Lube Oil System	4		
		Breake System Unit	1	pcs.	
		Line Terminal Equipment (LAVT)	4		
		Neutral Grounding Transformar (NGT)	4		
3	**Electrical Control Pannel**	Turbine Auxiliary governer Pannel (TAGP)	4		
		Generator Control Protecion Rely And Merering Pannel (GRMP)	4		
		33 KV Power Transformer Protection Rely & Metering Panel (TRMP)	4		
		33 KV Feeder Panel	2		
		33 KV Bus Protection Panel	1		
		Synchronizing Panel	1		
		Scada System	1	Lot	
		LT AC Panel	1	Lot	
		Batterys And Charger Panel (110 V)	1	Lot	
4					
5	**Cables**	Power Cable	1	Lot	
		Control Cable	1	Lot	
		Instrumentation Cable	1	Lot	
		Cable Trays	1	Lot	
		Cable Glands & Joining Kits	1	Lot	
6		100 KVA 11/.415 KV Auxiliary Transformer	4	pcs.	
7		Lighting System	1	lot	
8		Internal Communication System	1	Lot	
9		Grounding System For Power House And Switch Yard	1	Lot	
10		Lighting Protection For Power House & Switch Yard	1	Lot	
11		30/5 Tonnes EOT Crane	1	Lot	
12		Diesel Generator 125 KW	1	pcs.	
13		Transformer Oil Purifiers	1	pcs.	
14		Electrostatic Type Oil Purifier For Governor Oil	1	pcs.	
15		Air Conditioning System	1	Lot	
16		Ventilation System	1	Lot	
17		Fire Protection system	1	Lot	
18	**Outdoor Switchyard Equipment**	6 MVA 11 Kv / 33 Kv Power Transfomer	4	pcs.	
		315 KVA, 33/.415 KV Station Transformer	1	Nos.	
		33 Kv Vaccum Circuit Bracker	8	Nos.	
		33 Kv Motorized Isolator Without Earthing Blade	16	Nos.	
		33 Kv Motorized Isolator With Earthing Blade	2	Nos.	**Mostly in damanged condition**
		33 Kv Current Transformer (Singal Phase)	21	Nos.	
		33 Kv Potential Transformer (singal Phase)	12	Nos.	
		30 KVA Lighting Arrestor	18	Nos.	
		Busbars Conductors Insulators Hardware Clamps And Connector	1	Lot	
		Emulsyfire System For 6 MVA	1	Lot	
		Galvanished Steel Struture 33 KV	1	Lot	

19	**INTAKE BARRAGE GATE**	EP - 1	2	Sets	
		EP - 2	1	Sets	
		GATES	3	Nos.	
20	**Stope Lock Gate Gate**	EP - 1	2	Sets	
		EP - 2	1	Sets	
		GATES	1	Nos.	
		DD Hoist (15 Mt)			
21	**Feeder channel Head Regulator Gate**	EP - 1	1		
		EP - 2	2		
		GATES	3		
22	**Trask Rack Feeder Channel**	EP	3		
		Track Rack	3		
23	**Pen Stock Gates**	EP	4		
		GATES	4		
24	**Trash Rack of forbay intack gate**	EP	4	Sets	
		Track Rack	4	Nos.	
25	**Desilting Tank Flushing Steel Pipe**		2	Pcs.	
26		**Penstock Pipe 10 MM**			
27		Penstock Pipe 12 MM			
28		Penstock Bellmouth	4	Pcs.	

CHAPTER – 11

TRANSMISSION OF POWER AND COMMUNICATION FACILITIES

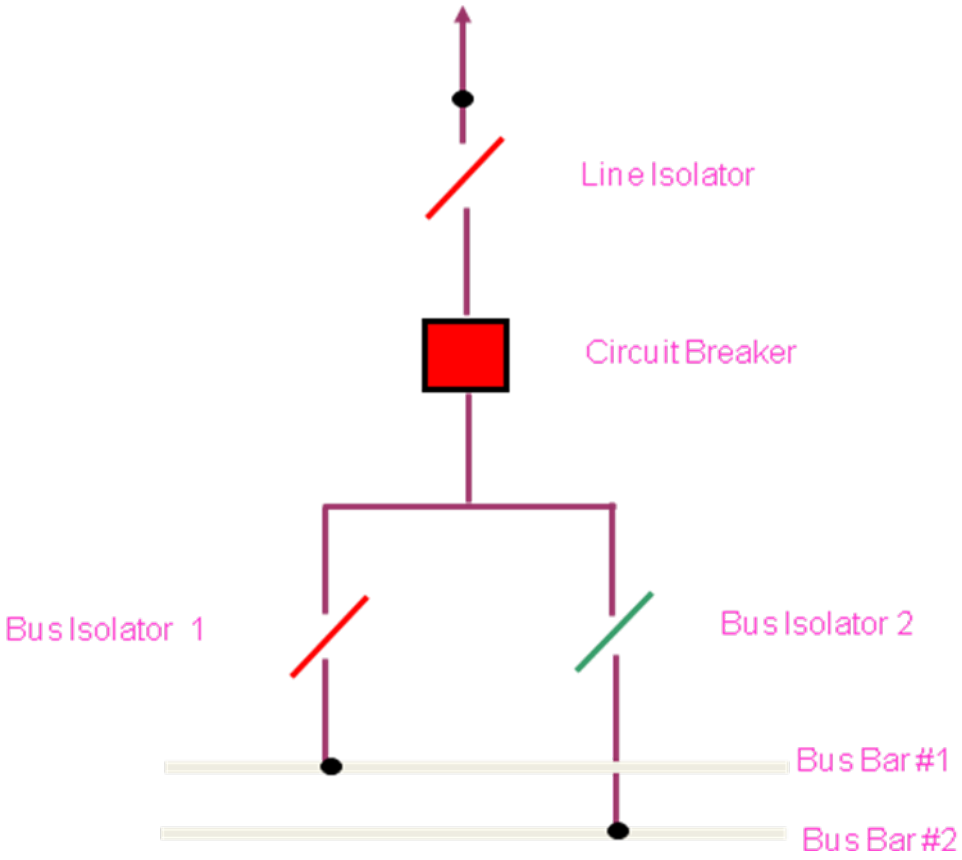
TRANSMISSION

The evacuation of power is proposed to provide two outgoing bays for evacuating 16 MW of power at 33 KV level from Halaipani hydroelectric project. There is an existing substation with 1 x 1 MVA, 33/11 kV at Halaipani. The Halaipani - Hayuliang 33 kV line and Tezu – Hayuliang 33 kV line is being upgraded to 132 kV by State Government. The power from Yammeng hydro electric project would be pooled to the to be upgraded Tezu 132 KV substation which is under planning by Arunachal Power Department and to feed other nearby loads the Power will be given at 33 kV level.

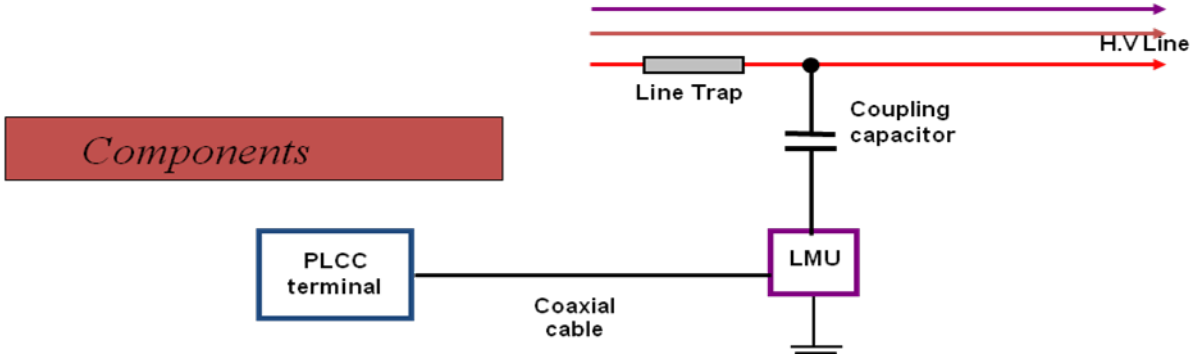
COMMUNICATION

PLCC system for telecommunication purpose uses the same High Voltage transmission line connecting two stations i.e. the Potyard /Switchyard to Pooling Station. PLCC is used in all power utilities as a primary communication service to transmit speech, telemetry and protection tripping commands. This is economic and reliable for inter grid message transfer as well as low bit rate RTU signals. The voice/data are mixed with radio frequency carrier (40-500 kHz), amplified to a level of 10-80W RF power and injected into high voltage power line using a suitable coupling capacitor. The power line as a rigid long conductor parallel to ground, guides the carrier waves to travel along the transmission line. Point to point communication takes place between two SSB transceivers at both ends.

Bay-1 to another S/S



Single Line diagram



PLCC Terminal = Translates voice and data into High Frequency Carrier. Output Power =10 to 80W

LMU = Line Matching Unit = For impedance matching between line and coaxial cable, includes high voltage protection devices like drainage coil(20mH), lightening arrestor(500V) and an earth switch.

Coupling Capacitor = Couples high frequency carrier with Power Line (4000 to10000pF)

Line Trap = Do not allow the transmitted HF carrier to enter inside the sub-station. (L = 0.5 to 2mH) With out Line trap HF carrier get by-passed to some other line on the same bus bar and may leak to ground (a earth switch inside the yard provided for each bay is kept closed during maintenance)

CHAPTER 12

CONSTRUCTION METHODOLOGY AND CONSTRUCTION PROGRAMME

12.1 Construction Schedule

The Construction of Project commenced in year 2012 in full swing and was targeted to complete in March 2013. But the cloud burst event in June 2012 led to unprecedented flood in halai River and the under-construction power house got totally damaged. The heavy flooding caused the major damage to the other major components of the project as well. The construction of project stalled for more than 7 years due to the incompetency of the state government to incur the expenses required for the completion of project. The project got formally started when it was awarded to a private IPP/EPC Contractor to complete the project on BOOT basis.

The project is now proposed to be completed within a time span of 30 months (thirty months). This includes mobilization period comprising of mobilization of resources (man and equipment), construction of temporary camps, installation of stationary plants, etc. The construction of main component of the project is planned to commence after completion of the mobilization period and envisaged to be completed in 30 months. Construction activities at various components are so sequenced to optimize the use of construction equipment and machinery. Access to the various work sites and all the basic infrastructures facilities will be provided in advance during the mobilization period, before commencement of the main works. It is proposed to mobilize and utilize the newest equipment in order to get consistent quality and faster progress rate. The activity of Barrage, Power house and Transmission line falls under the critical path.

The construction period may be reviewed and adjusted upon availability of more results of the geotechnical field and investigations. The construction schedule of the project and equipment required for implementation of the project schedule is provided as **Annexure 12.1**.

The main features of the construction schedules are as follows:

Project Period: 30 months (Including initial infrastructure development & mobilization).

STATUS OF THE CIVIL STRUCTURES AS ON SITE:

After the unprecedented flood of June 2012, various civil structures got damaged varying from less severe to severe. The following balance works need to be completed to commission the project.

Sr. No.	Component/Structure	% of Balance Work required
1	Barrage & Intake structure	100%
2	Power Channel	5%
3	Desilting tank	40%
4	Forebay tank & Bye-pass	10%
5	Anchor & Saddle Blocks	40%
6	Power House, Switchyard & Tail Race Channel	100%
7	Protection Works of Power House Area	100%
8	Supply of Equipments: Hydro Mechanical	50%

12.2 Scheduled Working Hours

As could be seen from the discharge data, there are low discharges in river from December to March i.e. for about 4 months, which would form the working season at the Diversion weir site. All the works are proposed to be executed in two shifts throughout the year. The scheduled working hours considering 25 working days per month accordingly works out as under and shown in **Table 12.1**.

Table 12.1: Schedule Working Hours

No. of Shift (No.)	Total Time (Hr.)	Availability factor	Actual Available Time (Hr.)	Days/ Year (No.)	Schedule Machine Hour (Hr.)	Utilization Factor	Schedule Production Hour (Hr.)

1	8	0.9	7.2	200	1440	0.85	1224
2	16	0.8	12.8	200	2560	0.85	2048

On the basis of the above computation, in accordance with "Guidelines for Detailed Calculations for the Requirement of Each Category and Size of the Production Equipment, August 2000 published by the Central Water Commission" following scheduled working hours have been considered in surface works.

a. Single shift work/day - 1200 hrs.

b. Two shift work/day - 2000 hrs.

Two shifts working of equipments is normally considered most economical in view of the high cost of three shift working on account of low availability of equipment and higher stand-by equipment requirement.

There is both surface and underground work involved in this project, thus, planning for all over works has been carried out based on two shifts per day working. The work at the Diversion Barrage site especially below the crest level will have to be completed within the non-monsoon period only. The work is planned to be carried for 8 months in a year due to high monsoon. The monsoon period is from June to September every year which results heavy flood in the river and around the project area and also the approach leading to the project is badly affected.

Provision of stand by equipment has been considered as follows:

- Single shift working - 10%
- Two shifts working - 20%

12.3 Project Components

Halai SHP envisages diversion of water from river Halai. The Project is located near Hilong town which can be accessible from Hayuliang.

The diverted water from the Diversion structure would be carried to the Forebay through Intake, Desilting Basin and Head Race Channel. From the Forebay, the water will be diverted through individual penstocks to the Power House. The penstocks have been fixed to draw water at the steady state level

of the forebay. The surface powerhouse would be equipped with 4 nos. of Horizontal axis Francis Turbines of 4.0 MW each. The water released by turbine is carried through a Tail Race Channel to join the river Halai.

Main civil structures of the project are

- Temporary River Diversion works
- Barrage-Spillway
- Power Intake
- Desilting and Silt Flushing arrangement
- Power channel
- Forebay tank
- Penstocks
- Powerhouse complex
- Tailrace channel
- Switch yard

12.4 Barrage

The Barrage and Intake structure got completely damaged in the floods. The structures will have to be completely redone.

At the proposed barrage axis the river is straight in a reach of about 500 m between two bends. The average river bed level at the Barrage axis is EL. 879.00m. The width of gorge available at the crest level is approximately 30 m. The barrage top elevation is EL. 891.00 m. It has 3 central piers of 2 m thickness each and abutments on each bank to retain the water. The deepest foundation for barrage is at EL. 877.00m. Barrage structure is 12 m high from the river bed.

Excavation

Once the river is diverted and after dewatering of the working area, the excavation of left and right bank abutments, till foundation level (V= 60,000 m^3), can be carried out; 6 months are foreseen for this stage when the average progress of 15,000 m^3/month must be achieved. Rock will be excavated, with drilling and blasting method, in benches of 3-6 m height; rock

support and protection will be done bench by bench and must be synchronized with the progress of the excavation.

Concrete Construction

When the foundation level is reached, the construction of the barrage structure will be undertaken. Total volume of concrete for barrage and downstream floor is 5000 m^3. The bridge construction will be undertaken after the completion of the piers. Gates erection will start also upon the completion of the piers.

Barrage construction requires the following supporting infrastructure, in addition to the above-mentioned details

- Reinforcing steel bar cutting and bending yard
- Formwork preparation workshop
- Prefabrication yard
- Fabrication workshop
- Concrete laboratory

The scope of these structures is to prepare well in advance all the elements required during the progress of barrage construction such as: barrage formwork, special wooden formwork, embedded pieces, and prefabricated items. Lack of these items in the right moment will stop the concrete placement and therefore will affect the rate of progress.

12.5 Intake

The intake has been proposed on the right bank of river Halai adjacent to the barrage in line with barrage axis. The crest level of the intake is kept at EL. 881.00m. The intake top elevation is EL. 891.00 m. It has 2 gates to feed two feeder channel connecting two bays of desilting basin.

Excavation

Once the river is diverted and after dewatering of the working area, the excavation of right bank near intake shall be taken up along with the excavation of barrage. Rock will be excavated, with drilling and blasting method, in benches of 3-6 m height; rock support and protection will be done bench by bench and must be synchronized with the progress of the excavation.

Concrete Construction

When the foundation level is reached, the construction of the intake structure will be undertaken. Total volume of concrete for intake is 1250 m^3. The top slab construction will be undertaken after the completion of the piers and walls. Gates erection will start also upon the completion of the pier and side walls.

12.6 Desilting Basin

The balance works of desilting basin is about 40%. The works for desilting basin shall commence along with Intake.

As a part of the water conductor system, two de-silting basins have been proposed. Each De-silting chamber is 9 m (W) x 8.26 m (H) x 63 m Long.

The construction of the desilting basins and silt flushing arrangements will be sequenced in such a way that they are completed in 8 months. For excavation and concreting operations, dumpers, transit concrete mixers and concrete pumps will be deployed.

12.7 Power Channel

The Power channel is damaged to negligible extent (only 5% balance works required). The power channel works shall be completed within four months' time as only refurbishing and cleaning works are involved. Small civil works are required.

12.8 Forebay tank & Bye – Pass

The construction of forebay and Bye – pass arrangements shall take only 5 months to complete the remaining civil works including the HM works. The forebay was less affected during the floods and some damage took place due to landslides or erosion.

12.9 Penstock & Anchor – Saddle blocks

It consists of four number of individual Penstocks taking off directly from the forebay and terminating into powerhouse. The length of penstock is 174.08 m. Penstock would be erected on saddle and anchor blocks. In case of rock exposure at foundation, necessary dowel bars will be installed to have

continuous monolithic concrete support providing foundation to penstock shells.

Penstock Construction: 6 months

12.10 Power House

Excavation

The excavation will be carried out by developing different stages and routing of construction ramps, zones, and levels to be tackled. Excavation requiring no blasting operation shall be executed in accordance with theoretical cut line defined by cross section on the construction drawing taking in to account the nature of ground. Surfaces shall be perfectly levelled and excavations carried out to ensure final shape. Excavations in rock requiring blasting shall be carried out in accordance with blasting specifications. The excavation area shall be blasted in layers with thickness as required to meet the specified excavation levels. Controlled perimeter blasting techniques shall be used only and if required to obtain the excavation faces on permanent works to the lines, grades and levels as specified. Material excavated and kept in temporary storage for using later for back filling shall be well protected, to maintain the material properly regardless of the weather conditions. The storage area shall be safe with slopes in accordance with angle of internal friction of materials and with necessary drainage to prevent water flooding during heavy rainfall. Hydraulic excavators will be used to load the excavated soil / blasted rock into the dumpers, which will be disposed off to the disposal yard.

Powerhouse Concrete & E&M Works

Stage – 1: After completion of final excavation, raft concreting below draft tube will be carried out in lifts of 1.5 m. Concreting will be carried out non-stop till the completion in successive lifts of 1.50m. Simultaneously mobilization of column formwork for lifts of 2.4m. All beams forming a frame/grid with the columns will be simultaneously concreted and completed along with the columns.

Stage-2: After the achievement of required strength for columns and EOT beams, EOT gantry will be erected to facilitate erection of mechanical equipment/items. Before starting of Stage 2 concreting, a portion of raft (unit

wise) will be taken up for mechanical installation, laying of conduits, penstock erection and alignment, draft tube and knee liner erection.

Stage-3: After the erection, positioning and aligning of turbine completed for one unit, concreting will be carried out up to turbine floor level in lifts of maximum 1.5m. After the erection of second turbine unit sequentially, concreting will be carried out for the respective units and completed. Concreting will be carried out by deployment of concrete pump and pipeline or a combination of both. After the erection, positioning and aligning of generator is completed for one unit, Concreting will be carried out up to machine floor level in lifts of maximum 1.5m. After the erection of other generator units sequentially, concreting will be carried out for the respective units and completed. Concreting will be carried out by concrete pump and pipeline or a combination of both. After completion of erection works and concreting works i.e. backfilling will be carried out where specified.

The time period estimated for construction of power house of similar magnitude including civil, electro-mechanical and hydro-mechanical works as per the industry practice, standard norms and past experience is 20 months Power House including electro mechanical works with two months lag of civil works from electro mechanical works. Start and completion of power house including commissioning shall be as follows

Civil Works:	M6-M21
Electro Mechanical Works:	M22-M26
Unit Commissioning:	M27-M30

Tail Race Channel

The construction activity for tail race channel shall be taken once the concreting of draft tube is completed. The early TRC excavation shall cause the river water to rush to downstream of draft tube gate thus may cause serious construction related issues.

12.11 Switchyard

A surface switchyard is proposed on right shoulder of the power house structure. The development of the area will be done followed by the required protection works. The civil foundation work will be carried by use of the same

equipment which has been deployed for construction of Power house. It is estimated that the switchyard will be completed in 26th month with effective working time of 4 months.

Annexure 12.1: Construction Schedule

S. No.	Description of Items	Year 1												Year 2												Year 3					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
I	**Pre Construction Activities**																														
	Land Acquisition																														
	Signing of PPA																														
	Statutary and Non Statutary Clearances																														
II	**Infrastructure and Mobilization**																														
1	Mobilisation of man and machinery																														
2	Construction of project approach road and infrastructure primary set-up																														
3	Construction of all project component approach road																														
4	Construction of Camps, offices for all category																														
5	Water supply system for construction, camps and offices, etc.																														
6	Installation and setup of Electric Power supply and telecom facility																														
III	**DETAILED ENGINEERING DESIGNS & DRAWINGS**																														
IV	**Construction Activities**																														
1	Diversion Arrangements																														
2	Barrage																														
3	Intake																														
4	Desilting Basin																														
5	Power channel																														
6	Forebay & Spill Pipe																														
7	Penstock																														
8	Power House and Tail Race Channel																														
9	Electro Mechanical Works																														
10	Switchyard																														
11	Erection and Commissioning																														

CHAPTER – 13
PROJECT ORGANISATION

13. PROJECT ORGANISATION

13.1 INTRODUCTION

Halaipani Hydro Electric Project (16 MW) envisages construction of barrage, power intake, WCS, forebay, penstock, surface power house and tail race channel. During construction phase of the project, a suitable site organization shall be established to follow construction activities and quality assurance.

13.2 SITE ORGANIZATION

The organization at Project site would be headed by a Senior Vice President / Sr. General Manager, who will be assisted by various engineers and other support functionaries. It is proposed to organize the works at site in the following five (5) modules:

Module 1	-	Barrage Complex.
Module 2	-	WCS, forebay, penstock, Power House, Tail Race Channel and switchyard civil works.
Module 3	-	Hydro Mechanical Works.
Module 4	-	E & M Works.
Module 5	-	Infrastructure Works.

In addition to above, other support functions like HR, Safety, Finance and Accounts, Project Monitoring, Quality Assurance and Contract Management would supplement and assist the above-mentioned Works Modules for achieving the optimum progress and desired quality.

A brief description of the modules and various support departments including their organizations are given as below:-

13.2.1 Module 1 - Barrage Complex (including Power intake and upstream portion of WCS)

The activities at the Barrage complex shall commence from the very beginning of the project construction phase.

Following key engineering personnel are proposed to be deputed for the Barrage complex works during the entire period of project execution:

Table 15.1

S. No.	Description	Strength
1.	GM/Additional General Manager as in charge of Barrage complex	1
2.	Sr. Manager (C) / Manager (C)	1
3.	Dy. Manager (C) / Asstt. Manager (C)	1
4.	Engineer (C)	2
5.	Junior Engineers	2
6.	Sr. Manager / Manager - Geology	1
7.	Dy. Manager / Asstt. Manager / Engineer - Geology	1
8.	Surveyors - Barrage	1
	Total	**10**

13.2.2 Module 2 – WCS, Forebay, Penstocks, Power House, Tail Race Channel and Switchyard Civil Works.

The work of WCS, Forebay, & Penstocks, Power House, Tail Race Channel and Switchyard Civil works would start from the very beginning and work on the same shall progress simultaneously. The organization of this module is therefore proposed to cater to this

requirement during entire duration of project execution. The key personnel for supervision and quality assurance required are tabulated as below:-

Table 15.2

S. No.	Description	Strength
1.	GM/Additional General Manager as in charge of Module - 2	1
2.	AGM / DGM (C) - WCS	1
3.	AGM / DGM (C) - Forebay and Penstock	1
4.	AGM / DGM (C) - Power house, Tail Race Channel and switchyard	1
5.	Dy. Manager (C)/ Astt. Manager (C)	1
6.	Engineers (C)	2
7.	Junior Engineers (C)	3
8.	Sr. Manager / Manager - Geology	1
9.	Dy. Manager / Asstt. Manager/ Engineer - Geology.	1
10.	Surveyors	1
	Total	**13**

13.2.3 Module 3 - Hydro - Mechanical works Module

Hydro- Mechanical works for Barrage gates, Power intake gates, surge shaft gates, draft tube gates including their hoists and Hydro-Mechanical works for Penstocks and Pressure shaft steel liner shall require a competent supervision team during fabrication, erection and commissioning. The team shall be needed from 3rd year onwards. The key personnel required is tabulated as below: -

Table 15. 3

S. No.	Description	Strength
1.	AGM / DGM - HM Works	1
2.	Sr. Manager / Manager – Barrage Complex HM works.	1
3.	Sr. Manager / Manager - Power House complex HM works.	1
4.	Dy. Manager / Astt. Manager / Engineer – HM works.	1
5.	Junior Engineers – HM works.	2
	Total	**6**

13.2.4 Module 4 - E & M Works Module

The erection works of various power house and switchyard equipment would be started w.e.f. 4th year and hence the organization of this module is proposed to cater to this requirement. The key personnel are tabulated as below:-

Table 15. 4

S. No.	Description	Strength
1.	AGM / DGM (E/M) E&M Works	1
2.	Sr. Manager (E/M) / Manager (E/M) - Power house	1
3.	Sr. Manager (E/M) / Manager (E/M) - Switchyard and Construction Power.	1
4.	Sr. Manager (E/M) /Manager (E/M) - Transmission	1
5.	Dy. Manager/Asstt. Manager / Engineer.	1
6.	Junior Engineers.	2
	Total	**7**

13.2.5 Module 5 - Infrastructure Works Module

Infrastructure works shall be taken up soon after financial closure. Construction of link roads to the project components, establishments of camps, development of platforms for construction facilities, establishment of explosive magazines, and temporary site offices at various locations shall be covered under infrastructure Module. The manpower required for this module is tabulated below.

Table 15.5

S. No.	Description	Strength
1.	AGM / DGM (C) - Infrastructure Works.	1
2.	Sr. Manager (C) / Manager (C) - Roads and Bridges.	1
3.	Sr. Manager (C) / Manager (C) - camps	1
4.	Sr. Manager (C) /Manager (C) – Construction facilities.	1
5.	Dy. Manager /Asstt. Manager / Engineer	1
6.	Junior Engineers	2
7.	Surveyors	1
	Total	**8**

The Organization Chart for the Project is enclosed at Annexure 15 -1. Besides these the various support functions, identified for this project are as under:

(a) Quality Control and Quality Assurance cell.

(b) Safety Cell,

(c) HR and administration cell.

(d) Project monitoring cell.

(e) Site contract management cell.

(f) Environment cell.

(g) Field engineering and quantity survey cell.

(h) Site accounts cell.

These cells will be staffed in the following manner:

Table - 15.6

S. No.	Description	Strength
A)	**Quality Control Cell**	
1	Sr. Manager (C), In-charge of Q.C. Cell	1
2	Dy. Mgr/Asstt. Mgr/Engineer (C)	1
3	Lab Technicians/J.E. (C)/J.E(C)	2
B)	**Safety Cell**	
1	Sr. Manager (Safety), In-charge of Safety cell	1
2	Dy. Mgr./Asstt. Mgr/Engineer (Safety and Fire)	1
3	Safety Supervisors/	1
C)	**HR and Administration cell**	
1	Addl. V.P. and in-Charge (HR & Admin.)	1
2	Dy. Mgr/Manager/Asstt. Mgr (HR)	1
3	Dy. Mgr/Manager/Asstt. (Admin)	1
D)	**Project Monitoring Cell**	
1	Addl. G.M.; In charge of Project monitoring cell	1
2	Sr. Manager/Manager Dy. Manager	1
3	Engineer	2
E)	**Site Contract Manager cell**	
1	Sr. Manager/Manager	1
2	Dy. Mgr/Asstt. Mgr/Engineer	1
F)	**Environment cell**	
1	Sr. Manager/Manager (Env.)	1
2	Dy. Mgr/Asstt. Mgr/Engineer (Env.)	1
G)	**Field Engg services and Quantity survey cell**	
1	DGM (C) and In charge of FES and QS cell	1
2	Sr. Manager/Manager (C)	1

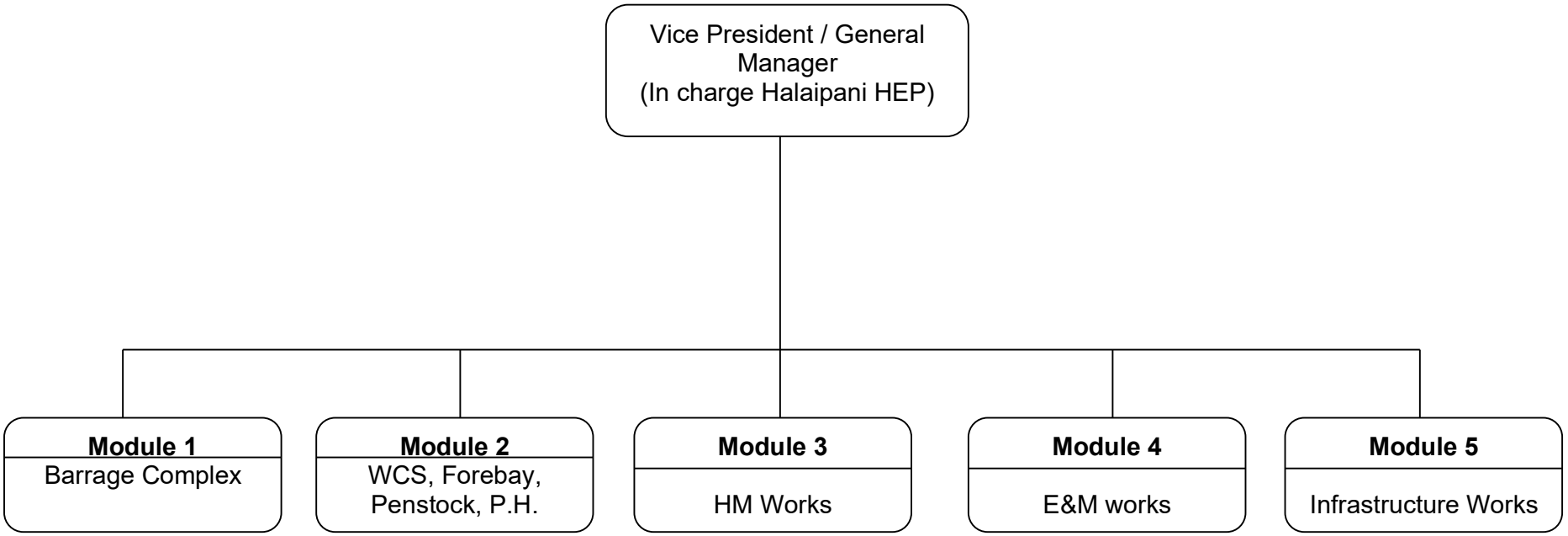
3	Dy. Manger/Asstt. Manager/Engineer	1
4	Quantity Surveyor	2
5	Architect	1
6	Draftsman	2
H)	**Site Accounts cell**	
1	Manager (Accounts)	1
2	Accountants	1
	Total strength for all support functionaries	**28**

Thus, the total strength at site is summarized as below:

- Project Head - 1 No.
- Module 1 – Barrage Complex Module - 10 Nos.
- Module 2 - Powerhouse, Penstock and Switchyard Civil works Module - 13 Nos.
- Module 3 - Hydro Mechanical works Module - 6 Nos.
- Module 4 - E &M works Module – 7 Nos.
- Module 5 - Infrastructure works Module - 8 Nos.
- Support functionaries - 28 Nos.

Therefore, total strength would be 72 Nos.

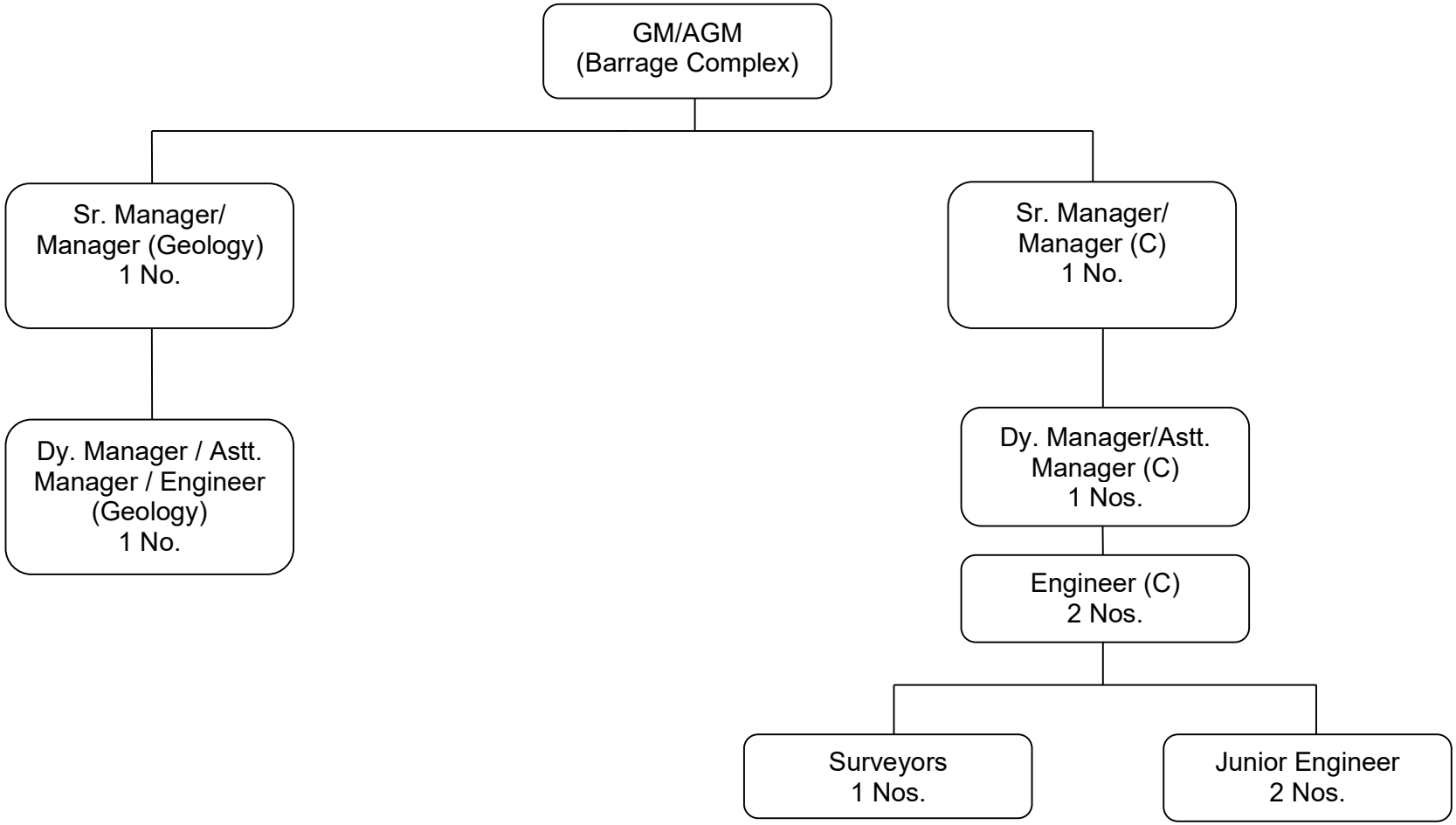
ANNEXURE 13-1 (a)



ANNEXURE 13-1 (b)

Organization Chart For Module- 1

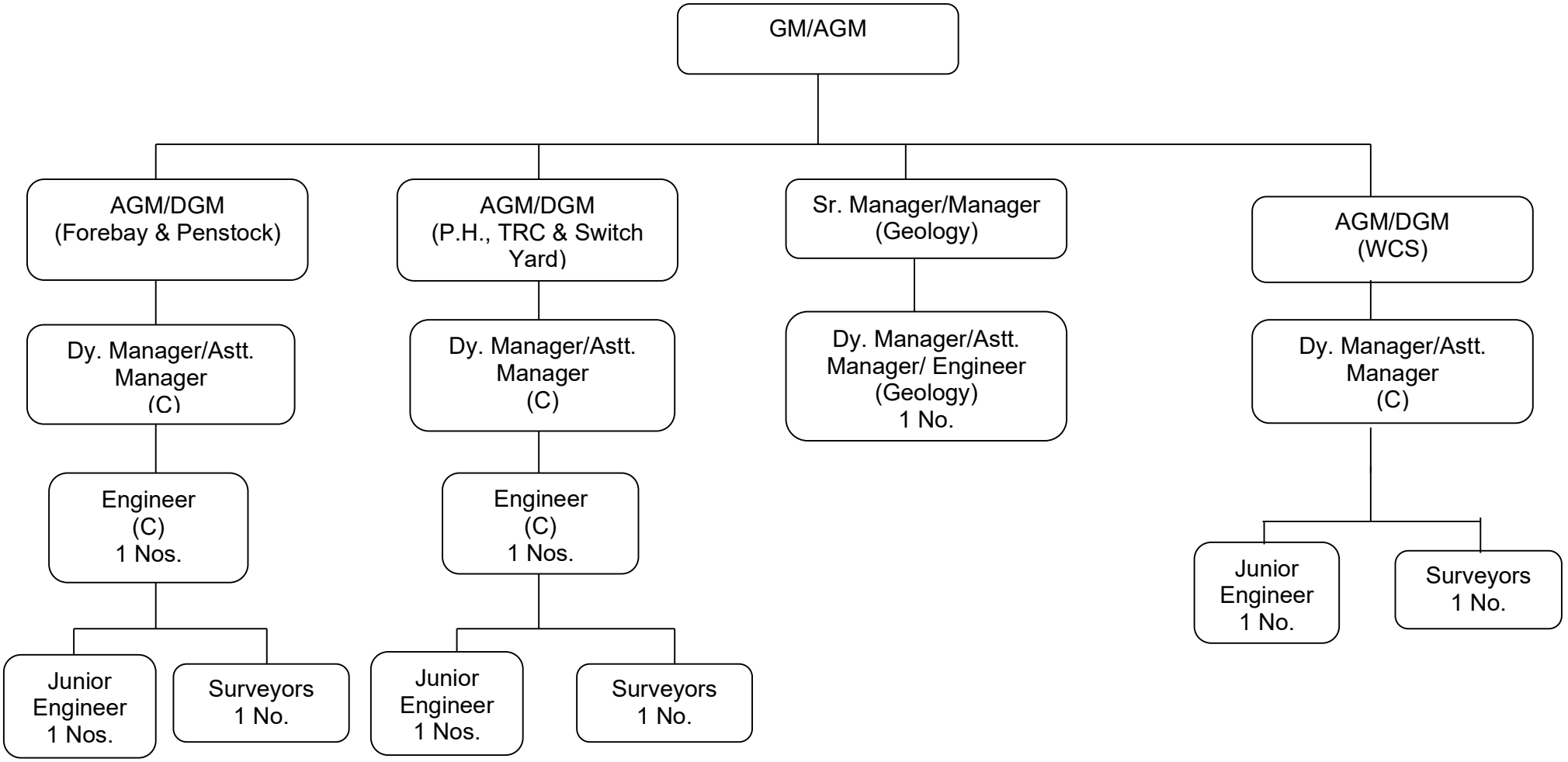
(Barrage Complex)



ANNEXURE 13-1 (C)

Organisation Chart For Module - 2

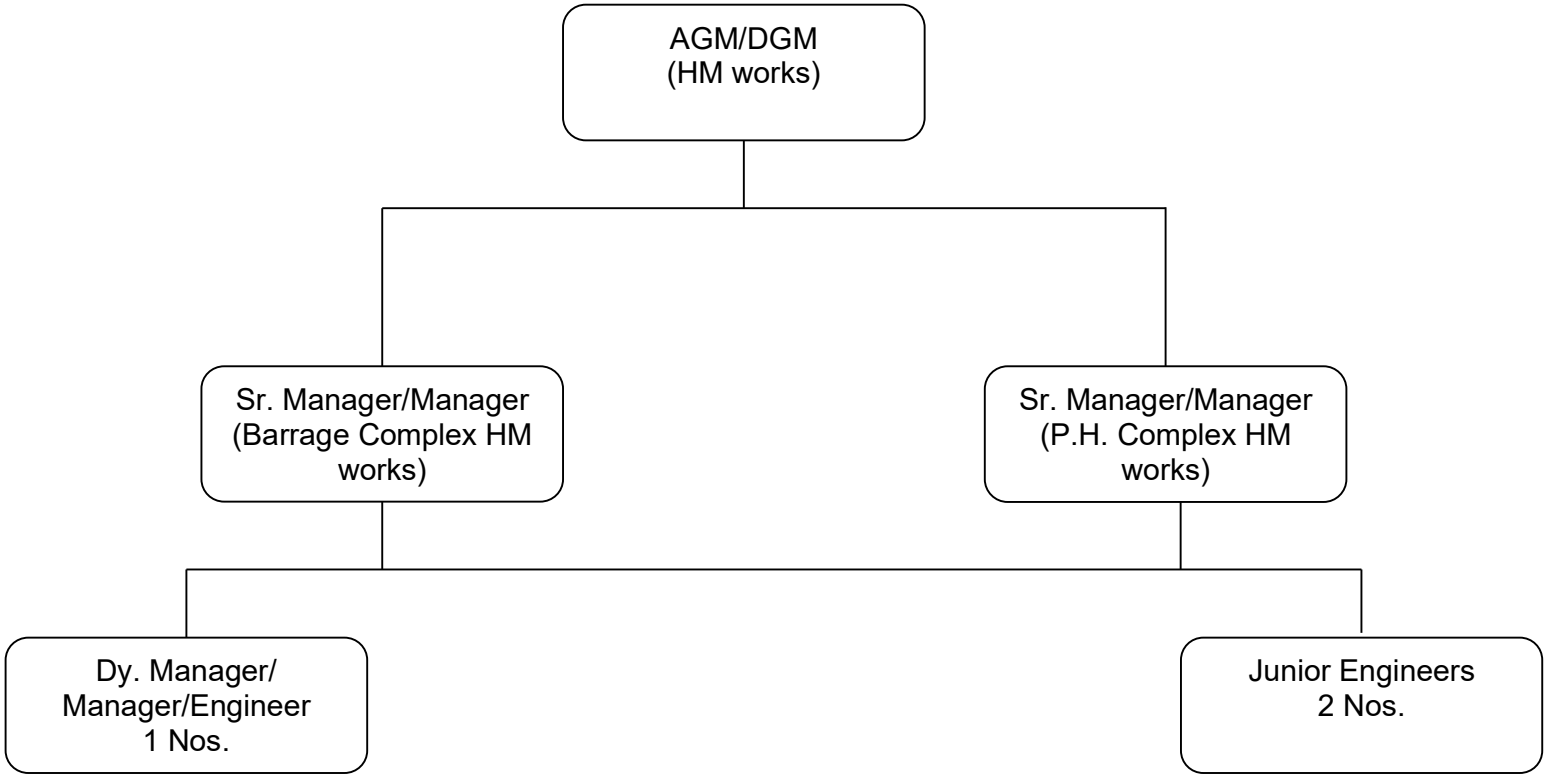
(WCS, Penstocks, Forebay, P.H.)



ANNEXURE 13-1 (d)

Organisation Chart For Module - 3

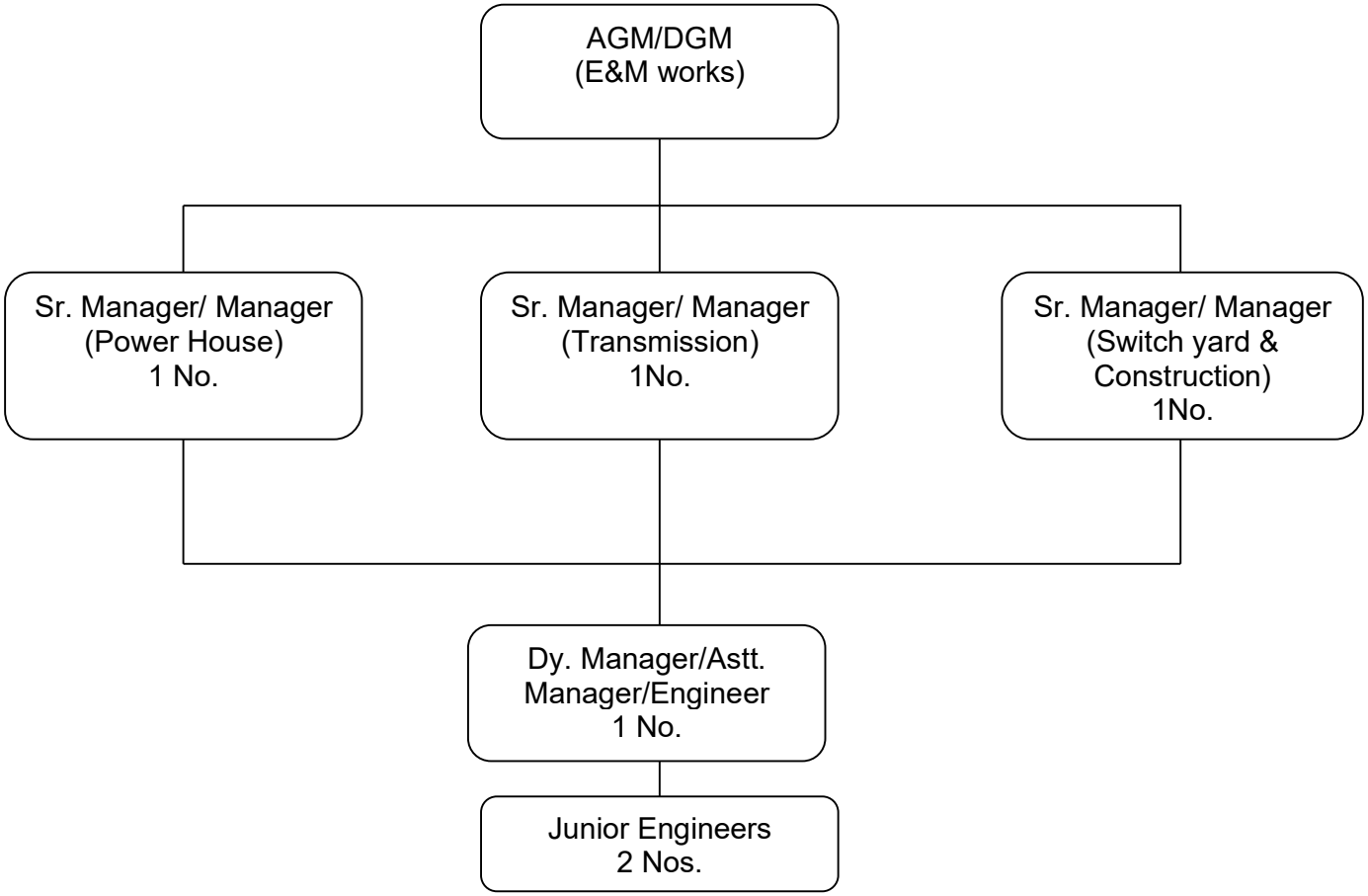
(HM Works)



ANNEXURE 13-1 (e)

Organisation Chart For Module - 4

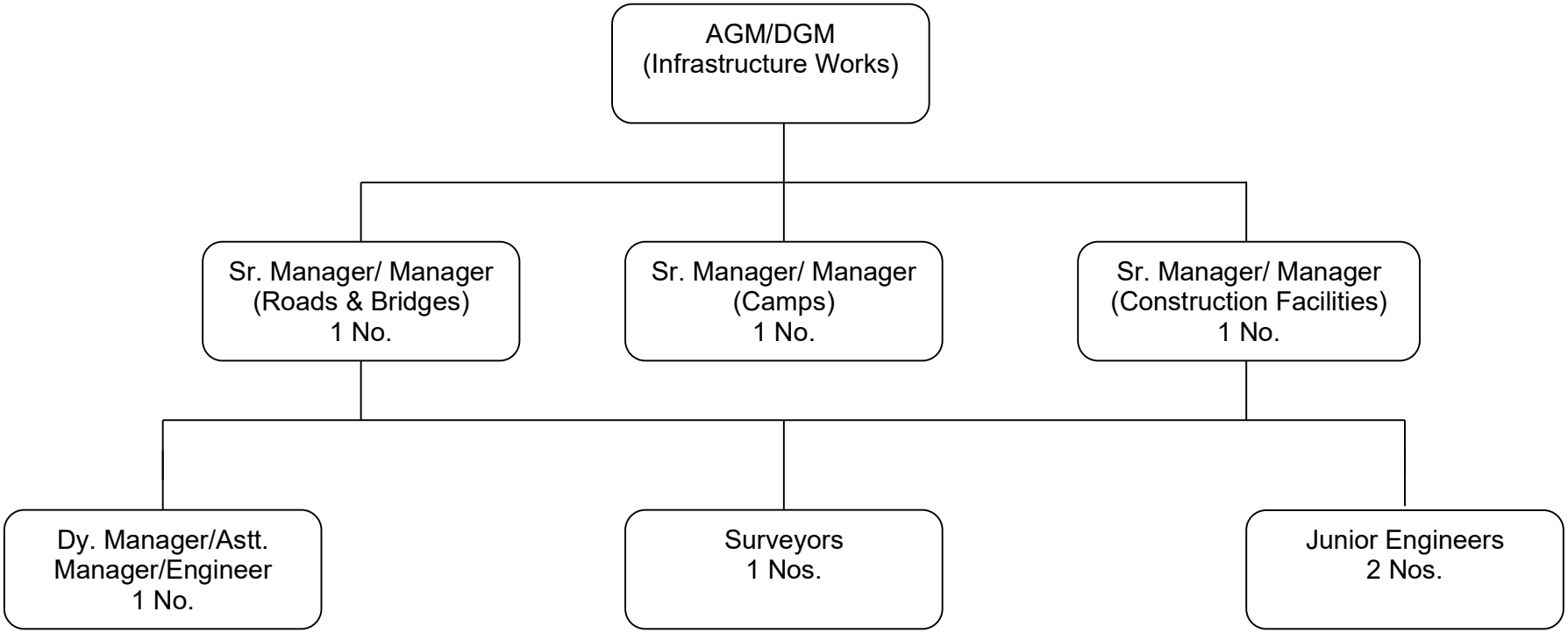
(E & M Works)



ANNEXURE 13-1 (e)

Organisation Chart For Module - 5

(Infrastructure Works)



CHAPTER - 14

INFRASTRUCTURE FACILITIES

14.1 General

Halaipani HEP, (16 MW IC) located in Anjaw District of Arunachal Pradesh, is a run of the river scheme (base load plant) proposed to harness the hydro power potential of Halai River. The project involves construction of 12 m high barrage, an open water conductor system and forebay, penstocks and surface power house along with 20 m long 4 m wide tail race channel.

The project colony and office will be located near to the project site near Hilong village. The place shall be about 30 Km from Hawai, the head quarter of Anjaw District.

14.2 Infrastructure and construction facilities

Infrastructure and construction facilities for Halaipani HE Project as incorporated in this chapter have been divided into the following components: -

(a) Project Roads
(b) Land Requirement
(c) Project Headquarter: Offices and Residential / Non-Residential Complexes.
(d) Liaison Office, Transit Camp and Transit Store.
(e) Workshops
(f) Warehouses/Stores Complex
(g) Muck Disposal Area
(h) Construction Power
(i) Telecommunication
(j) Security & Safety Arrangements

14.3 Project Roads

14.3.1 Roads in barrage area

The existing road in the barrage area is about 200 m above the river bed. A road shall take of from the existing road to reach the river bed at barrage site and also to reach the WCS area. Length of this road shall be about 1 Km.

The road will be about 6 m wide.

14.3.2 Roads in power house complex

The existing road in the power house complex is about 50 m above the river bed. A road shall take of from the existing road to reach the forebay area, the power house complex. The length of the road shall be about 1.5 Km.

The road will be about 6 m wide.

14.3.3 Other roads

Other roads shall include the road to construction facilities area and office complex. The length of these roads shall be about 2.5 Km.

14.3.4 Project Office and Residential Complexes

Construction of Halaipani Project is proposed to be undertaken through mechanized operations will latest construction methodology to minimize man power and expedite execution. All the major works shall be got executed through experienced contractors. Departmental operations would remain restricted to over all supervision, quality and quantity monitoring, financial control, legal and safety aspects etc.

The residential complex shall include both permanent and temporary accommodations. Following are the tentative details of temporary and permanent residential units.

Non residential accommodation shall include administrative building, dispensary, guest house, canteen, model room, fire station, workshop, DG building, quality control laboratory etc. following details.

Permanent Residential Buildings:

S. No.	ITEM	No. of Unit	No. of Bldg.	Plinth area per Bldg.	Total Area (sq. m.)
1	Type A @ 50sqm / unit	6	2	50	300
2	Type B @ 150sqm / unit	2	1	75	150
3	Type C @ 200sqm / unit	2	2	100	200
	BACHELOR ACCOMODATION				
4	Hostel – A @ 30sqm/unit	10	5	30	300
5	Hostel – B @ 50sqm/unit	6	2	50	300
				Total	**1250**

Temporary Residential Buildings:

S. No.	ITEM	No. of Unit	No. of Bldg.	Plinth area per Bldg.	Total Area (sq. m.)
1	Type I @ 50sqm / unit	6	2	50	300
2	Type II @ 150sqm / unit	2	1	75	150
3	Type III @ 200sqm / unit	2	2	100	200
	BACHELOR ACCOMODATION				
4	Dormitory – category - 1	10	5	30	300
5	Dormitory – category - 2	6	2	50	300
				Total	**1250**

Permanent Non-Residential Buildings:

S. No.	ITEM	No. of Unit	QTY (sq. m.)
1	Office building	sqm	250
2	Store/godown	sqm	50

3	Hospital	sqm	100
4	Guest House	sqm	100
5	Laboratory	sqm	75
6	Magazine Building	sqm	50
7	Fire Station	sqm	50
8	canteen	sqm	50
		Total	**725**

Temporary Non-Residential Buildings:

S. No.	ITEM	No. of Unit	QTY (sq. m.)
1	Office building	sqm	300
2	Store/godown	sqm	100
3	Hospital cum dispensary	sqm	100
4	Work shops	sqm	150
5	Railway Siding	sqm	
a	Office Building	sqm	100
b	Open Yard	sqm	150
c	Weigh Bridge/POL station	sqm	100
		Total	**1000**

14.3.5 Workshop

Central workshop for heavy earth moving equipment and transport vehicles shall be set up at the project site. The area shall be developed including open space and parking area. The workshop shall comprise of covered/semi-covered repair sheds.

The work shop shall comprise facilities for the engine repairs and overhauling, transmission, Torque converter repair shops, auto-electrical shops, machine shop, tyre repair shop, welding and fabrication shops, chassis repairs, body and seat repairs, denting/painting, maintenance yard etc. The workshop shall be securely fenced with control of operations.

14.3.6 Warehouse/stores Complex

Space for construction of transit stores for Cement, Steel and other materials including Chemicals downstream of the dam site have been provided in a relatively flatter area. The steel and other store items like bitumen etc. which do not require covered area would be kept outside in open. For cement storage, covered sheds shall be developed enabling storage of adequate quantity of cement.

14.3.7 Construction power

The estimated requirement of the construction power shall be about 1.5 MW. About 0.5 MW shall be needed in barrage complex, 0.5 MW for power house complex and 0.5 MW for hydro mechanical and other requirements.

14.3.8 Telecommunication

It is proposed to have one VSAT connection at site for communication with head office. For local communication wireless sets shall be used. LAN connectivity for inter office communication is planned for better efficiency in office.

CHAPTER 15

ENVIRONMENTAL ASPECTS

15.1 INTRODUCTION

The state of Arunachal Pradesh is situated in the north-eastern region of the country and lies between latitude 26°28' to 29°30' North and longitude 91°31' to 97°30' East. The state shares international boundaries with China along the snow line in the north, with Bhutan in the west and Myanmar in the south-east. The state shares most of its southern boundary with Assam. The state also shares its boundaries with Nagaland for a small stretch on the southern side. The total geographical area of Arunachal Pradesh is 83743 sq km. Subansiri, Siang (or, Dihang), Dibang (or, Sikang), Siyom, Kameng, Lohit and Tirap are the major rivers of the state. Arunachal Pradesh has a huge hydro-potential, which is required to be tapped to meet the power demand of the country.

The proposed Halaipani small hydro Project (16 MW) is located near Latul village in Anjaw District of Arunachal Pradesh. The project envisages construction of a concrete barrage of 12 m (above river bed level), Water Conductor system of 1539 m long, Forebay, four individual penstocks, a surface Power House and a tail race pool. Full Reservoir Level (FRL) of the proposed project is El 883.200 m.

15.2 CLIMATE

Lohit basin experiences a warm, humid, sub-tropical climate. The project area has four distinct seasons. The winter season lasts from December to February, followed by summer from March to May, followed by the rainy season which begins in June and continues up to October. The period from October to November is the post monsoon season with occasional rainfall during May and October.

15.3 RAINFALL

The climate of Lohit basin is a typical monsoon type. The south-west monsoon normally enters Assam and adjoining areas by second week of May, establishing firmly over the entire north-eastern India by the end of June. It withdraws from the region by the second week of October. The maximum rainfall is experienced during the months from June to September with occasional rainfall during May and October. During the months of November to March the region periodically comes under the influence of western disturbances causing precipitation, mostly as snowfall over the mountains.

Thunderstorms mainly occur during the months from February to September. The frequency is maximum in April and minimum in the month of December. During the pre-monsoon months, thunderstorms are often violent and from December to April they are occasionally accomPanied by hail. Fog is also frequent in the valley during the winter months.

15.4 TEMPERATURE

The basin covers practically all the classified climatic zones, i.e. from tropical to alpine. There is considerable variation in temperature from place to place depending on the elevation. The minimum and maximum temperatures recorded in winter and summer are 15 degree Celsius and 30 degree Celsius respectively.

15.5 HUMIDITY

The relative humidity in the project area is high throughout the year. However, winter months are slightly less humid and humidity ranges from a minimum of 19 % to a maximum of 93 %.

15.6 WIND

Winds are generally light during the south-west monsoon season. In rest of the year, winds are moderate, becoming strong at times in association with thunderstorms. Strong winds are experienced down the valley. The direction of wind is highly influenced by the local conditions.

15.7 SEISMICITY

The project lies in the Eastern Himalayas, which are seismologically active as per the seismic zoning map of India. The entire project area falls under seismic Zone V.

15.8 WATER QUALITY

Water samples from Halaipani River was not tested.the water quality should be checked during the pre construction period of the project**.**

The catchment is very thinly inhabited, no population density is there. As no industrial or commercial activities have been noticed in the catchment, river water is naturally expected to be undisturbed or unpolluted from effluents of any industries or municipal disposals.

15.9 SOCIO-ECONOMIC ASPECTS

Majority of the population of Arunachal Pradesh is primarily rural, residing in about 3649 backward, remote and often inaccessible villages. About 64% of the population is designated as Scheduled Tribes who are dependent on the forest produce for their livelihood.

Agriculture is the main occupation of the tribal people of the project area. Both jhum and settled cultivation in the form of Wet Rice Cultivation (WRC) and Terrace Rice Cultivation (TRC) are practiced in the area. The common crops grown in the area are paddy, maize, millet, chilli, potato, green vegetables etc. The livestock mainly reared by the people are mithun, pig, goat, cattle, poultry etc. Animals are reared mainly for providing meat as a part of the diet and discharge of social and religious rituals. Cattle are rarely reared for milk production. This could be attributed to the fact that consumption of milk is not yet adopted on a large scale by the population. Mithun is considered as a status symbol and reflects the status and socio-economic condition of an

individual. More the number of Mithun owned by a family, more is its social status. No part of the tribal population's social life is complete without the active participation of Mithuns: either as a gift, bride price or sacrifice.

15.9.1 Socio-Economic Condition

15.9.1.1 Occupational Distribution

Agriculture and horticulture are the most important occupations in which majority of households are engaged. On an average, every family has two earning members. There is no system of engaging agricultural labour as the owners do their own farming.

15.9.1.2 Land Holding Pattern

As the whole economy of the villages is fully land based, and that to on traditional jhuming, where productivity is practically half than that of plain area with settled cultivation practices (Rice – 9 to 10 quintal/ha; Maize – 12 to 14 quintal/ha; Vegetables – 8 to 10 quintal/ha), requirement of jhum land per family, on an average, for subsistence only, is 2 to 3 ha, which according to classification falls under medium farmer's group. However, it will be wrong to apply this yard stick in shifting cultivation practice. Further in entire Arunachal Pradesh, the ownership of land does not rest with the cultivators. Land is either under the control of Village Chief or Village Authority.

15.10 ASSESSMENT OF ENVIRONMENTAL IMPACTS

The environmental impacts of proposed Project no need to carried out for small hydro project as per government notification, in the light of construction of barrage and other project components, submergence of land, dumping of excavated material, quarrying, changes in the landuse pattern, etc. Majority of the impacts due to construction works are temporary in nature, lasting mainly during the construction phase. However, if these issues are not properly addressed, the impacts can continue even after the construction phase. The major anticipated impacts are as follows:

15.10.1 Impact on Land Environment

Halaipani Project envisages construction of about 11 m high concrete barrage across river Halai. Considering the reservoir FRL at El. 883.20 m, the total reservoir area is less than 1 ha. The reservoir length is about 0.4 km only during the monsoon season. With the construction of the project, the land environment of the area will get affected due to construction of project components, land submergence, quarrying operations, construction of infrastructure and various components of the project etc. which may lead to change in land-use and may trigger soil erosion in the area.

However, due to the peculiar topography of the area, the reservoir area is 0.4 km long stretch with mostly wooded catchment. The forests here stand on rather steep slopes with sandy loam to loamy sand soils. Any major disturbance to the present ecosystem due to deforestation or extension of shifting cultivation may aggravate the possibilities of accelerated soil erosion and consequent rapid silting up of the reservoir. Every effort would, therefore, be made to protect the USF (unclassified state forest) in the direct drainage area, in particular, during the construction phase.

15.10.2 Impact on Water Resource and Water Quality

The barrage/ reservoir is not designed to store water as the Halaipani HE Project is a base load station. There shall be no impact on the water quality of the river as there will be no siltation and if any sedimentation is there, that will be flushed out through barrage gates.

15.10.3 Impact on Climate and Air Quality

A hydel project being eco-friendly, as it neither generates atmospheric pollution caused by combustion of fossil fuels nor generates dust, smoke and other gases, is not likely to affect local climate adversely in any manner. However, special care needs to be taken during the construction phase, so that pollution of air, caused by road construction, operation of machineries and blasting of rocks are kept at the lowest possible level.

15.10.4 Impacts on Biodiversity

The impacts on biological environment due to construction of the project may be summarized as follows:

Loss of forest cover due to the proposed developmental activities and construction of barrage.

Loss of private land due to inundation and construction of project component.

Formation of the reservoir, clearing of vegetation, movement and stocking of construction material, widening of roads, establishment of colonies and labour camps, blasting and excavation of tunnels etc may disturb biological set up of the area.

A large number of faunal species are the residents of catchment area. But the proposed Halaipani project does not involve portion of any National Park, Wild Life Sanctuary or Biosphere Reserve. Also no elephant corridors are likely to be disturbed. The Project Authority will take certain precautions that the labour force engaged in the construction works or the floating populations of outsiders, who visit the site, do not come in conflict with the wild life population in the working area as well as its neighbourhood forests.

15.10.5 Deforestation and Soil Conservation

Large scale damage to the adjacent forest areas, particularly in the direct catchment of reservoir, by floating population of labourers, road construction, movement of transport and machineries are commonly noticed in projects of

this kind. New conservation problems are often created, sometimes unknowingly, by injudicious use of heavy machineries and blasting material on unstable geologic formations. Considering that most of the hill slopes in the direct catchment are steep (35% to 75%) and the existing forests hold the soil in delicate balance, special attention would be paid in this respect during construction phase.

15.10.6 Impacts on Noise Levels

The impact on ambient noise levels are anticipated only during the project construction due to the operation of construction equipment. Likewise noise due to quarrying, blasting, vehicular movement etc. may have some adverse impacts on the ambient noise levels in the area. Proper mitigatory measures shall be implemented to reduce the noise levels during construction phase.

15.10.7 Dumping of Excavated Material (Muck)

A huge quantity of excavated material (muck) of different properties from foundation excavation of components like main barrage, Feeder channels and power channel, Forebay, surface penstocks, power house cavern, draft tube gate, tail race channel, etc. will be generated. Most of the muck generated will be utilised for the construction of the dam. However, the remaining muck needs to be disposed of properly, conforming to the topography of the layout area, so that material would not drain into the river.

15.12.8 Impacts due to Quarrying Process

A project of such magnitude requires very less amount of construction material. A part of the requirement would be met by using the muck generated during excavation works, depending upon its utility for construction. Remaining requirement would be met by quarrying from appropriate locations. The excavation and transportation of construction materials from various borrow areas will be planned and managed in proper way so as to avert any hazardous effect on the environment. Restoration of these borrow areas is proposed to be carried out before the onset of next monsoon so that there is no adverse effect on environment during construction stage as well as in post-construction period.

15.13 Disaster Management Plan

The barrage break analysis has been done for the worst situation that may arise due to failure of dam. Measures such as establishment of effective dam safety surveillance and monitoring programme including rapid analysis and interpretation of instrumentation and observation data, periodic inspection and safety reviews/evaluation, formulation of an Emergency Action Plan etc. shall be proposed to minimize to the maximum extent possible, the probable loss of life and damage to property in an event of failure of dam. This plan presents warning and notification procedure to be followed in case of potential failure of the dam to provide timely warning to nearby residents and alert key personnel responsible for taking action in case of an emergency.

15.14 Muck Disposal Plan

Most of the muck generated will be utilised for the construction of the barrage. However, the remaining muck needs to be disposed properly at certain muck disposal sites, conforming to the topography of the layout area, so that it not causes any hazard in the project area. After completion of the project the muck disposal areas will be stabilized through various biological and bio-engineering measures. Excess muck would be dumped at the pre-identified muck disposal sites. For retaining the dump and unused material and subsequent stabilization along the hill slopes, proper engineering measures will be proposed.

15.13.11 Water Quality Monitoring

At present no developmental activities such as industries etc. is going on in the catchment, therefore any probability of water quality degradation is ruled out. From water quality analysis it has been inferred that the quality of water in Halai river and its tributaries is good. Also, there are hardly any human habitations draining their refuse into the river. However, the project authority would take effective and proactive measures to ensure that such activities will not be carried out in the upstream catchment which may bring about water quality degradation in the future as well.

The Performa prescribed by the Department of Environments for the project has been duly filled in and is attached as Table 15.1.

QUESTIONNAIRE ISSUED BY THE DEPARTMENT OF ENVIRONMENT FOR RIVER VALLEY PROJECTS

1. DETAILED BASIC IMFORMATION AFFECTING THE ENVIRONMENT

1.01	Predominant existing land use pattern (agriculture land reserve and the forests etc.) in the project area and upto 10 km. upstream.	:	For agricultural purposes.
1.02	Break up of submerged area total submerged area (hectares).	:	The project is on Hali River near Hilong village in Lohit distt. No submergence is caused due to this small hydel scheme.
	Forest Land	:	
	Cultivated Land	:	
	Shrubs & Fellow	:	
	Rocky Outcrop	:	Nil
	Wet Land	:	
	Open Water	:	
	Other use	:	
1.03	*(a)* Forest Type in Catchment and Submerged areas. *(b)* Extent and nature of forest to be cut for construction of roads, colony and other appurtenant works.	:	NA Nil
1.04	Duration of project's construction	:	NA
1.05	Estimated peak labour strength- *Skilled* – *Unskilled* – Labour to be recruited from outside affected local population – *Skilled* – *Unskilled* –	:	No population would be shifted by this project, however labour required would be available from the area.
1.06	Population density in the area per sq. km.	:	Lesser populated
1.07	Number of villages and population to be displaced –	:	No. of displacement of population of villages.

	No. of Villages - Nil *Size of Villages* - Nil Affected families in each village – *ST - SC - Other* - Nil Occupation of the affected people – *Agriculture* - Nil *Industrial labour* - Nil *Forest Based* - Nil Owner cultivators by size of land holdings – *Marginal* (1.0 hect.) - Nil *Small* (1.0 – 2.5 hect.) - Nil *Medium* (2.5 -5.0 hect.) - Nil *Big* (over 5.0 hect.) - Nil	: :	*Nil* There is no displacement of any population due to construction of the project. The information required is not relevant.
1.08	Resettlement Is a rehabilitation committee being constituted? Existing guidelines, if any for compensation. Level of compensation in cash and kind. Number of oust families likely to be settled in new settlement. Size of proposed new settlement. Layout plans/ master plans for new settlements. Distance of new settlements from the present habitat.	: : : : : : :	Resettlement is not required. NA NA NA NA NA NA
1.09	Number and type of facilities (e.g. school, post offices, bank, panchayat ghar, police station, approach road, drainage and water supply etc.) proposed to be provided.	:	Nil
1.10	Is the affected area covered by development programmes like IED, SED, Drought prone area, tribal development etc.	:	No
1.11	Any proposal to provide or create employment for oustees; nature & quantum of employment to be provided.	:	There would be no oustees due construction of the project.
1.12	What is the expected rate of siltation? Is down stream area subject to flooding?	: 	Not applicable for this project. Not applicable for this project.
1.13	Wind at Dam site (diagram giving statistical information concerning	:	Not applicable for this project.

	direction and speed of the wind at the site).		
1.14	Hurricane tornadoes, cyclones Frequency of occurrence Wind velocity (average)	: : :	Nil Not applicable Not applicable
1.15	Plan of area, on the reservoir periphery subject to erosion, slides and slips.	:	Not applicable
1.16	The depth of ground water table – Maximum Minimum Quality of ground water potable/ non potable/ fit for irrigation/ industry	 : : :	 NA NA Potable
1.17	Present ground water use pattern in the command area under irrigation.	:	Only surface water from stream in the command area.
1.18	Based on the experience of similar project in the area, specify the inter action between the altered surface water patterns and underground aquifers and their recharge.	:	This being hydel project, hence not applicable.

2. ENVIRONMENTAL STATUS

2.01	(a) Indicate known pollution sources in the region (indicate the industrial like chemicals, textiles & other thermal power units, mining operations etc.)	:	Nil
2.02	Indicate the industrial and other development project likely to be taken up in the area during the next five to ten years.	:	The area has potential for further industrial development.
2.03	*(a)* Does the area support economically viable aquatic life, fish, crocodiles? *(b)* Are there any fish/ crocodile breeding ground in the river tributaries in the submergence?	: :	No No
2.04	Does the site contain a wild life (including birds) habitat, breeding area, migration route including the number of wild life available in the area?	:	No
2.05	Is the site a potential wild life sanctuary?	:	No
2.06	Specify any rare or endangered species of flora and fauna in the effected area	:	No

	along with their approx.. number and measures to salvage/ rehabilitate them.		
2.07	Is the area a tourist resort?	:	No
2.08	Are any monument/ sites of cultural, historical, religious, archaeological or recreational importance including wild life sanctuaries, national park etc. likely to be affected by the proposed project. If so, details thereof.	:	No
2.09	Does the proposed area suffer from endemic health problems due to water/ soil borne diseases?	:	No

3. ENVIRONMENTAL IMPACTS

3.01	What measures are planned to develop the site to enhance its aesthetic aspects (i.e. recreation & water sport facilities and picnic sites etc.)	:	Suitable plantation is envisaged.
3.02	Will the project help in flood control, reduction for even eradication of flood havoc downstream?	:	Not applicable
3.03	Are any changes in water salinity expected? If yes, give details of proposed measures to counteract this.	:	No
3.04	Are problems of water logging envisaged in the command area? If so, give details of proposed steps to combat the problem.	:	The project is not expected to change any existing situation.
3.05	Will the reservoir be used for fisheries development, fish culture as well as fish breeding, crocodile, farming etc.? If yes, give details thereof.	:	Not applicable
3.06	Will fish ladders/ lift and like arrangements be provided to allow movements of important migratory fish population?	:	Not applicable
3.07	Measures proposed to prevent grazing the cultivation on reservoir slopes to avoid erosion & premature silting up the impoundment.	:	Not applicable
3.08	Will any important natural resources (mineral, coal, timber etc. be lost or their use precluded because of the project? If yes, specify the resources estimated loss.	:	No
3.09	What is potential loss in aquatic	:	No

	production on site up and down stream, fish and other useful animals and plants.		
3.10	Will the formation and use of the water body result in the introduction or enhancement of water born disease?	:	Not applicable
3.11	Will the impeded reservoir lead to: *i)* Noxious aquatic weeds like salina, water Hyacinth etc. *ii)* Intermittent host (vector) like snails, mosquitoes etc.	: : :	There is no reservoir Nil Nil
3.12	How will aquatic weeds be controlled in submerged areas so as to provide an improved habitat as for exploitation.	:	No area would be submerged due to construction of the project.
3.13	Will the project induce adverse climatological changes (regarding temperature, humidity, wind and precipitation including modifications to macro and micro climate).	:	No
3.14	What impact is expected on geological factors (eg. Seismic impact or reservoir loading)?	:	No impact
3.15	Indicate the magnitude of impact due to population pressure on: *i)* Felling of trees for firewood. *ii)* Forest fires. *iii)* Over grazing leading to depletion of the pastures. *iv)* Visual population and damage to scenic values.	: : : : :	No impact Nil Nil Nil Nil
3.16	What arrangements are being made? *i)* To meet fuel requirements of the labour force during construction period to prevent indiscriminate felling of trees for firewood? *ii)* For compensatory afforestation *iii)* To enforce anticipating laws? *iv)* To control flow of sediments & pollutants due to fertilizer and pesticide runoff for cultivated area. *v)* For restoration of land in construction areas (filling, grading and reforesting etc. to prevent erosion). *vi)* For soil conservation in the catchment?	: : : : : : : :	The question of indiscriminate felling of trees for firewood does not rise. The arrangements of the fuel for labour would be made by the agencies constructing the project. Not applicable Not applicable Not applicable Not applicable Not applicable

4. COST OF ENVIRONMENTAL STUDIES AND PROJECT MANAGEMENT

4.01	Provision for Environmental studies/ surveys need for this project.	:	It is a part of the project.
4.02	Cost of proposed remedial and mitigative measures, if any, to protect the environment.	:	Not required
4.03	Has the cost of environmental studies/ protection measures been considered in the cost benefit analysis of the project?	:	Not required

CHAPTER 16

COST ESTIMATE

16.1 INTRODUCTION

The cost of the project has been worked out based on preliminary designs and drawings as referred and annexed in the present report. Costs of equipment and materials have been taken on the basis of similar projects in similar area. Unit prices have been derived for major works based on preliminary survey and assumptions.

16.2 PRICE LEVEL

The cost estimate has been made at the price level of 2018 (Arunachal Pradesh Schedule of rates). All costs have been first estimated on a per unit basis for each of the components. These have been added to obtain the entire project cost. Lump sum costs have been allocated for components where a detailed breakdown of costs is not available or worthwhile.

16.3 RATE ANALYSIS

Unit rates of major items of civil works have been derived on the basis of preliminary market surveys and available data. List of unit rates of various items as derived is presented below:

SUMMARY OF UNIT RATES OF VARIOUS ITEMS OF WORK

Sl. No	Item of work	Unit	Rate	Ref. No.
1	Common Excavation in All Types of Soil	Rs./cum	233.00	I-1
2	Excavation in Hard Rock	Rs./cum	689.00	I-2
3	Tunnel Excavation: Diversion Tunnel	Rs./cum	1816.00	I-3
4	Tunnel Excavation: HRT	Rs./cum	1767.00	I-4
5	Tunnel Excavation: TRT	Rs./cum	1910.00	I-5

6	Excavation for Rock in Surge Shaft	Rs./cum	1738.03	I-6
8	Tunnel Excavation: Adits	Rs./cum	1760.00	I-8
9	Concrete - M 10 - A40 (by Tower Crane)	Rs./cum	6786.00	I-9
10	Mass Concrete - M 15 - A80 (by Tower Crane)	Rs./cum	6957.00	I-10
11	Concrete - M 20 - A20 (by Tower Crane)	Rs./cum	8848.00	I-11
12	Concrete- M 25 - A40 (by Concrete Pump)	Rs./cum	8188.00	I-12
13	Concrete M 25 - A20 (by Tower Crane)	Rs./cum	8936.00	I-13
14	Concrete- M 30 - A20 (by Tower Crane)	Rs./cum	9583.00	I-14
15	Concrete - M 25 - A20 (by concrete pump)	Rs./cum	8346.00	I-15
16	HPC Grade - M 50 - A20 (by Tower Crane)	Rs./cum	13921.00	I-16
17	Concrete Lining in Tunnels - M 25 - A20 (by Concrete Pump)	Rs./cum	8797.00	I-17
18	Precast Concrete Lagging	Rs./cum	15706.00	I-18
19	Concrete Lining (M-30) in Surge Shaft:	Rs./cum	9507.00	I-19
20	Shotcrete with Steel Fiber Reinforcement	Rs./cum	17513.80	I-20
21	Plain Shotcrete	Rs./cum	14203.50	I-21
22	Grouting	Rs./Bag	1211.00	I-22
23	First Class Brick work	Rs./cum	5608.00	I-23

24	Stone Masonry in 1:6 for Muck Dumping & Reservoir Treatment	Rs./cum	2435.00	I-24
25	Stone Masonry in 1:6 (1 Cement, 6 Sand Mortar)	Rs./cum	3280.00	I-25
26	Gabions	Rs./cum	1379.00	I-26
27	Dumped Rockfill in Coffer dams	Rs./cum	907.00	I-27
28	Rock bolts 25 mm Dia in Tunnel (Underground)	Rs. /m	816.00	I-28
29	Rock bolts 32 mm Dia in Tunnel (Underground)	Rs. /m	1050.00	I-29
30	Rock bolts 25 mm Dia (in Surface)	Rs. /m	951.00	I-30
31	Rock bolts 32 mm Dia (in Surface)	Rs. /m	1167.00	I-31
32	Rock Anchors 32 mm dia	Rs. /m	1179.00	I-32
33	Drilling of 45 mm dia holes for grouting upto 4 m length	Rs./m	346.00	I-33
34	Drilling of 45 mm dia holes for grouting for more than 4 m length	Rs. /m	455.00	I-34
35	Tor Steel Reinforcement for RCC Works	Rs. /MT	97265.00	I-35
36	Steel Supports for Tunnel	Rs. /MT	132127.00	I-36
37	Welded Wire mesh in Tunnel	Rs./Sqm	299.00	I-37
38	MS Works for various structures	Rs./MT	128122.00	I-38
39	CGI sheet Roofing for Power House	Rs./Sqm	839.00	I-39
40	Radial Gate for Spillway	MT	301000.00	I-40
49	Concrete Lining in Tunnels - M 20 - A20 (by Concrete Pump)	Rs./cum	8074.00	I-49
50	Cable Anchors	Rs./m	143020.00	I-50
51	Backfill Concrete Lining in Tunnels - M 15 - A20 (by Concrete Pump)	Rs./cum	8560.00	I-51

52	Concrete Lining in Pressure S. - M 20 - A20 (by Concrete Pump)	Rs./cum	8428.00	I-52
53	Concrete Lining in Tunnels - M 20 - A20 (by Concrete Pump)	Rs./cum	8074.00	I-53
54	Dowel Bars 16 mm dia.	Rs/Rm	154.00	I-35
55	Dowel Bars 32 mm dia.	Rs/Rm	615.00	I-35

16.4 PRELIMINARY COST ESTIMATE FOR CIVIL, HYDRO- MECHANCIAL, ELECTRO-MECHANICAL WORKS: -

The estimate has been prepared to arrive at the Capital Cost of Halaipani H.E. Project. The base date of the estimate is 2018 and the Cost is expressed in Indian Rupees. The Cost Estimate is divided into Civil, Electrical and Transmission Works, for Civil Works, the sub heads are as under: -

I – WORKS

Under this head, provision has been made for various components of the Project as detailed here under: -

A – PRELIMINARY

Under A-Preliminary, provision has been made for all surveys and investigations design and engineering consultancy done to optimize the project layout and its project components.

B - LAND

This covers the provision for acquisition of land for construction of the Project, colonies, offices and stores and compensation for trees and standing crops etc. This head also contains the provision for Rehabilitation and Resettlement measures for Project Affected People.

C - WORKS

This covers the cost of Barrage with associated Hydro-mechanical equipment.

J - POWER PLANT CIVIL WORKS

This covers the cost of project components viz. Intake Structure, Headrace Tunnel, Surge Shaft, Penstock, Power House, TRC and other Appurtenant Works.

The unit rates for various principal items are taken as per the Guidelines for preparation of project estimates for River valley projects.

K - BUILDINGS

Buildings, both residential and non-residential have been provided under this head. Under the permanent category only those structures have been included which shall be subsequently utilized during the operation and maintenance of the project.

O – MISCELLANEOUS

Provision under this head has been made for the Capital and running cost of Water Supply, Sewage Disposal, Fire Fighting Equipments, Medical Assistance, Telephone and Recreation etc. The Provisions have been made for the security arrangements, inspection vehicles, transport of labour, laboratory testing, R&M of guest house and transit camps, retrenchment compensation, photographic instruments as well as R&M charges etc.

P - MAINTENANCE DURING CONSTRUCTION AND Y-LOSSES ON STOCK

A provision of 1% and 0.25% of C-Civil works, J-Power Plants, K- Buildings & R-Communications has been made for maintenance of works during construction

period and losses on stock respectively.

Q - SPECIAL TOOLS AND PLANT

It is assumed that the work will be carried out through Contracts and not through departmental construction. Accordingly, provision for general purpose equipment and inspection vehicle only has been made as per CWC guidelines.

R-COMMUNICATION

Provision under this head covers the cost of new roads, widening/ improvement of roads and strengthening of bridges. The costs of roads and bridges are based on the rate structure prevalent in the area of the project, for the type of construction involved.

X - ENVIROMENT AND ECOLOGY

Provision under this head covers the cost of bio-diversity Conservation, creation of Green belt, Restoration of Construction Area, Catchment Area Treatment, Compensatory Afforestation etc.

III - TOOLS AND PLANTS

This provision is distinct from that under Q-Special T&P and is meant to cover cost of survey instruments, camp equipment and other small tools and paints.

IV – SUSPENSE

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

V - RECEIPTS AND RECOVERIES

Under this head, provision has been made for estimated recoveries by way of resale or transfer of equipment used

in infrastructure works.

ELECTRICAL WORKS AND GENERATING PLANT

The cost of Generating Plant and Equipment is based on indigenous sources. The prices of auxiliary equipment and services are based on prevailing market prices/costs incurred at other ongoing or commissioned projects.

ABSTRACT OF COST ESTIMATE

Sl. No	Item	Amount in Rs. Lakhs		
		Civil	E/M	Total
1	2	3	4	5
	I-Work			
1	A- Preliminary	69.00		69.00
2	B-Land	0.00		0.00
3	**C-Works**	**3030.00**		3030.00
(i)	Barrage and Coffer Dams	2679.84		2679.84
(ii)	HM works	350.37		350.37
4	**J-Power Plant Civil works**	**7180.45**		
(i)	Feeder Channel	136.69		136.69
(ii)	Desilting basin	423.78		423.78
(iii)	Power Channel	35.19		35.19
(iv)	Forebay Tank and Spillway	119.93		119.93
(v)	Penstock	495.33		495.33
(vi)	Power House & Tail race Channel	4498.33		4498.33
(vii)	Strengthening & Protection of vulnerable Portion of Power House and Tail Race	0.00		0.00
(viii)	Protection wall, Retaining Wall of Anchor Block & Saddle Block and Gref Road	49.92		49.92
(ix)	Switchyard	24.59		24.59
(x)	HM works	1396.70		1396.70
	Total C+J- Works	**10210.45**		10210.45
5	K- Buildings	376.84		376.84
6	O- Misc	375.00		375.00
	C+J+K+R	**10602.30**		
7	P- Maintainence @1% of (C+J+K)	105.87		105.87
8	Q- Spl. T&p	0.00		0.00
9	R- Communication	15.00		15.00
10	X-Environment	0.00		0.00
11	Y-losses on stocks @ 0.25% of C+J+K	26.47		26.47
I	**Total I works**	**11178.64**		**11178.64**
II	**Establishment**	0.00		0.00
III	**Ordinary Tools and Plants**			
1	Ordinary T&P	0.00		0.00
IV	**Receipt and Recoveries**	0.00		0.00
	Total of direct charges	**0.00**		0.00
V	**Indirect Charges**	0.00		0.00
1	Audit and Account @ 0.5% of I - Work	0.00		0.00
2	Capitalisation of abatement cost	0.00		
	Grand Total	**11178.64**	**3528.26**	**12942.77**
	Say Rs.	**12942.77**	**LAKHS**	

E&M COST= 3528.26/2= **1764.13 LAKHS**

TOTAL HARD COST = **12942.77 LAKHS**

A - PRELIMINARY

SL. No.	Description	Unit	Qty.	Rate	Amount (in Lacs)
I).	**Survey & Investigations**				
1	Revised Survey				0.00
2	Exploratory Drilling				0.00
3	Exploratory drifting				0.00
4	Rock mechanic testing				0.00
5	Store Shed				3.00
6	Hydro-meteorological observation and G & D sites,				0.00
7	Cost of running charges of G & D sites including collection of water sample & analysis of silt data				0.00
8	Cost of Environmental & Ecological studies and ground water studies				0.00
9	Expenses towards Travelling & Vehicles for site inspections including running and maintenance during Pre-Construction investigations				5.00
	Sub Total of (I)				**8.00**
II).	**Administration**				
1	Employees Renumeration & Benefits				2.00
2	Administration & Other Expenses				2.00
	Sub Total of (II)				**4.00**
III).	**Additional survey and investigation proposed**				
A	**Survey**				
	Topographical and other survey				5.00
IV)	Project stationary, preparation and printing of reports for DPR				2.00
	Sub Total of (III & IV)				**7.00**
V).	Collection of water sample & analysis of silt data				0.00
VI).	Construction Material survey and testing				0.00
VII)	Design consultant charges				50.00
	Total				**69.00**

K-Building

S.No.	Description of Building	Unit	Total Plinth Area (Sqm)	Rate (Rs.)	Amount in Lakhs (Rs.)
1	Expenditure incurred upto Feb 2007				
1	**Permanent Buildings**				
i).	Residential Buildings	Sqm	1250	8500	106.25
	Service charges at 31%	31.00%			32.94
ii).	Non-Residential Buildings	Sqm	725	7000	50.75
	Service charges at 22.5%	22.50%			11.42
	Total Permanent Buildings				**201.36**
2	**Temporary Buildings**				
i).	Residential Buildings	Sqm	1250	6500	81.25
	Service charges at 27%	27.00%			21.94
ii).	Non-Residential Buildings	Sqm	1000	6000	60.00
	Service charges at 20.5%	20.50%			12.30
	Total Temporary Buildings				**175.49**
	Total				**376.84**
	Works Tax @ 4.2%		0.00%		0.00
	Grand Total				**376.84**

O-MISCELLANEOUS

S. No.	Description	Unit	Amt. (Rs. In Lacs)
1	**CAPITAL COST**		
1.1	Electrical & Construction Power		
1.1.1	33/11 Kv at different locations of the Project area	LS	100
1.1.2	DG Sets	LS	50
1.2	Water supply including purification and distribution arrangements	LS	5
1.3	Providing sewage disposal and storm water drains at various colony sites.	LS	5
1.4	Providing and fixing of fire fighting equipment at various site and stores of project.	LS	10
1.5	Providing hospital equipments.	LS	10
1.6	Providing telecommuncation system and satellite communication		
(i)	V-sat Network System		
	Supply, Erection and Commission-1 Nos.	LS	10
1.7	Furnishing of children park and welfare centres for officials and labourers	LS	5
1.8	Furnishing and equipping of Guest/Rest houses and field hostel of officers and staff.	LS	10
1.9	Purchase of furniture and other articles for labour welfare centres and clubs schools including cable TV etc. and sports activities.	LS	10
1.10	Purchase of equipment for quality control/field laboratories.	LS	10
	Sub Total:		**225**
2	**Maintenance and Service charges of**		
2.1	Details of expenditure of maintenance of Power arrangement		15
2.2	R&M of Building and Roads		20
2.3	R&M of water supply facilities to the staff and labour colonies		5
2.4	R&M of sanitation and drainage facilities for various colonies		5
2.5	R&M of fire fighting equipments		5
2.6	Maintenance of Telecommunication system and post office		10

2.7	R&M of Dispensary for 6 years		10
2.8	Maintenance of parks and welfare centres, clubs and school		5
2.9	R&M of Rest house and field hostels for 6 years including VIP and dignitaries visits and other expenditures.		8
2.1	R&M of research and quality control laboratories including material testing and sample testing.		10
2.11	R&M of lighting fxtures for offices, residential complex and road/street lighting.		5
2.12	Labour welfare compensation and retrenchment benefits L.S.	**LS**	10
2.13	Providing security		5
2.14	Telecommuncation/telephone charges etc. including satellite charges		10
	SubTotal:		**123**
3	**Miscellaneous**		
3.1	Weigh bridge and maintenance		6
3.2	Installation and Maintenance of petrol and Diesel pumps Rs. 3 lacs per year		6
3.3	Technical literature/journals		3
3.4	Model exhibits		2
3.5	Canteen facilities and cooperative stores		5
3.6	Photographic and cinemagraphic equipments and their maintenance and video filming/centrailse documentation		5
	Sub Total:		**27**
	Grand Total (1+2+3)		**375**

C1 - BARRAGE STRUCTURE

Sr. No.	Description	Unit	No.	Quantity	Rate (Rs./unit)	Amount, in Rs.
1	**Site Clearance**					
1.1	Site Clearance	LS				500000
2	**SURFACE EXCAVATION AND ROCK SUPPORT**					
2.1	Surface excavation in all types of soil /overburden and rock including all tools and plants & accesories, loading, transport, Construction of haul road (if any) and its maintenance, all lift and lead upto 2 km from the excavation area/working site and unloading and dumping at disposal sites or stockpiles and maintenance of the disposal sites or stockpiles and labour complete in all respect.					
2.1.1	Excavation in Weathered Rock	m^3				
	Barrage upto end of gate	m^3	1	300	242	72,600
	Straight Floor	m^3	1	1,450	242	3,50,900
	Upstream & downstream portion of barrage	m^3	1	2,320	242	5,61,440
2.1.3	Excavation in hard rock	m^3				
	Barrage upto end of gate	m^3	1	600	756	4,53,600
	Straight Floor	m^3	1	2,900	756	21,92,400
	Upstream & downstream portion of barrage	m^3	1	3,480	756	26,30,880
2.2	Anchor bars 20 dia, 3.0 m long @ 1.0 m c/c in both directions including making holes & grouting with C.c. 1:1.5:3 complete	Nos.	1	1386	800	11,08,800
3	Concrete					
3.1	Providing and laying reinforced cement concrete (M-25 grade) including cost of all material, Tools and Plants (T&P) and accessories, shuttering, scaffolding, curing labour, etc complete in all respect.					
3.1.1	Pier	m^3	2	684	9835	67,27,140
3.1.2	Abutments	m^3	1	2082	9835	2,04,76,470
3.1.3	Raft	m^3	1	1845	9073	1,67,39,685
3.1.4	Trunnion Beam	m^3	3	203.58	9835	20,02,209
3.1.5	Deck Slab	m^3	1	82.955	9835	8,15,862
3.2	High Performance Concrete Raft	m^3	1	625	13921	87,00,625
4	Providing, cutting, bending and laying in position, binding, tack welding of reinforcement steel of different diameter and sizes including cost of all material, Tools and Plants (T&P) and accessories, and labour etc complete in all respect	MT		870	97265	8,46,20,550
5	PCC Blocks					
	Upstream	m^3	1	614	8024	49,28,742
	Downstream	m^3	1	921	8024	73,93,113
	Toe Wall	m^3	2	156	7867	12,27,252
6	Boulders in Wire crates					
	Upstream	m^3	1	410	2400	9,82,800
	Downstream	m^3	1	410	2400	9,82,800
7	Filter					
	Upstream & Downstream	m^3	2	1,536	1256	19,28,745
8	Supplying & placing in position the steel railing including painting etc. all complete as per the drawings, specifications & direction of EIC	m	1	78	3900	3,04,200
9	Diversion of river for construction of barrage	Job	1		LS	35,00,000
10	**Other Items**					
10.1	Furnishing and placing PVC water stop in expansion joints between blocks	m	1	500	500	2,50,000
10.2	Steel Cladding over piers and abutments 12 mm thick atleast 1.0 m high	MT		17	1250000	21250000
9	Instrumentation @ 2% of above items except LS Items				2%	33,79,016
10	Dewatering of construction sites @ 2% of				2%	33,79,016
	above items except LS items.					
	Add 22.5% C.I. over APSR 2018 i.e. 7.5% per annum	%			22.5	4,43,15,740
	Add GST 28% on cement	%			28	59,66,711
	Add GST 18% on steel	%			18	1,05,71,288
	Add Contingencies @ 3%					72,53,238
	Add Labour Cess @ 1%					24,17,746
					Total	**26,79,83,569**
					Say Rs.	**2679.84** Lakhs

HYDRO-MECHANICAL WORKS - BARRAGE

Sr. No.	Description	Quantity	Unit	Rate in Rs. Lakhs	Amount, Rs. Lakhs
1	Barrage fixed wheel vertical steel gates 3 nos., of size 6.00 x 4.50 m including electrically and manually operated rope drum hoist with all embedments, superstructure with steel columns & hoist bridge with dogging arrangement as per approved drawings	65.0	MT	2.5	162.50
2	Barrage Stoplogs steel gates (6mx4.5m size for all bays 1 set)	12	MT	2.5	30.00
3	Embedded parts (3 sets) for all the bays	12	MT	1.5	18.00
4	Gantry Cranes 10 T Capacity for stoplog gates	1	Nos.	40	40.00
5	Lifting beam (1 set)	1	Sets	5	5.00
6	Support Structure & Operation facilities (6 concrete girders & rails including chequered plates for all 3 bays)	1	Job	LS	30.00
				SubTotal	**285.50**
	Add GST 18%		%	18	51.39
				Total	**336.89**
	Add Contingencies @ 3%		%	3%	10.11
	Add Labour cess @ 1%		%	1%	3.37
				Total	**350.37**
				Say Rs.	**350.37 lakhs**

HYDRO-MECHANICAL WORKS - J WORKS (TO BE EXECUTED)

Sr. No.	Description	Quantity	Unit	Rate as per LOA Rs. Lakhs	Amount, Rs. Lakhs as per LOA	Billed Amount, Rs. Lakhs for executed works	Reference
1	Feeder Channel Gates of size 5.00x2.20m (ht) at upstream of undersluice gates in wing wall, vertical lift fixed wheel gate electrically/manually operated rope and drum hoist with all embedments, superstructure of suitable height hoist bridge and stator case with dogging arrangement						**nce Works", Details of EM & HM Equipments supplied by Flovel for 3 Units and 4th Unit of Halaipani SHP. But the sizes and Quantities shall be as per the current Construction Drawings.**
	EP-1	2	Set	4.03	8.06	3.95	
	EP-2	2	Set	4.03	8.06	7.89	
	Gates	2	Nos.	9.16	18.32	14.69	
	Hoist bridge of designed capacity	2	Nos.	10.71	21.41	0.00	
	Hoist of designed capacity	2	Nos.	11.95	23.90	0.00	
2	Trash rack size 5.0 m x 14.0 m (H) at feeder channel						
	EP	2	Nos.	1.06	2.11	2.07	
	Trash rack	2	Nos.	8.81	17.61	11.56	
3	Stoplog for Feeder Channel size 5.0 m x 2.2 m included EP & Gantry Crane girder & rail	1	set		10.29		
4	Penstock gate at Forebay intake 1.85x2.4 m (Ht) vertical fixed wheel with manually /electrically driven screw hoist mounted over a frame and hoist bridge suitable for taking out gate upto pier top for maintenance						
	EP	4	Nos.	4.87	19.46	19.06	
	Gates	4	Nos.	5.96	23.84	23.44	
	Hoist bridge	4	Nos.	4.72	18.86	0.00	
	Screw Hoist (5 MT)	4	Nos.	8.01	32.04	0.00	
5	Trash rack size 2.06x8.30 m (Ht) at forebay intake gates						
	EP	4	Nos.	2.74	10.97	10.74	
	Trash rack	4	Nos.	8.23	32.90	32.20	
6	DT gate 4.5x2.8 m (ht) vertical lift fixed wheel operated by an electrically & manually operated rope drum hoist with all embedments, superstructure of suitable height hoist bridge & dogging arrangement						
	EP	4	Set	14.06	56.24	27.50	
	Gates	4	Nos.	10.85	43.42	0.00	
	Hoist bridge of designed capacity	4	Nos.	10.71	42.82	0.00	
	Hoist of designed capacity	4	Nos.	11.95	47.80	0.00	
7	Desilting Basin Gates						
A	Desilting Basin Inlet gate 2.0x2.3 m (Ht) vertical fixed wheel with manually /electrically driven screw hoist mounted over a frame and hoist bridge suitable for taking out gate upto pier top for maintenance						
	EP	2	Nos.	4.87	9.73	0.00	
	Gates	2	Nos.	5.96	11.92	0.00	
	Hoist bridge	2	Nos.	4.72	9.43	0.00	
	Screw Hoist of designed capacity	2	Nos.	8.01	16.02	0.00	
B	Desilting Basin Outlet gate 2.0x2.3 m (Ht) vertical fixed wheel with manually /electrically driven screw hoist mounted over a frame and hoist bridge suitable for taking out gate upto pier top for maintenance						
	EP	2	Nos.	4.87	9.73	0.00	
	Gates	2	Nos.	5.96	11.92	0.00	
	Hoist bridge	2	Nos.	4.72	9.43	0.00	
	Screw Hoist of designed capacity	2	Nos.	8.01	16.02	0.00	
	The item at Sr. No. 7A and 7B were not considered in LOA. However, now these items have been incorporated and the rates have been taken as per LOA.						

8	Desilting tank flushing steel pipes 800mm dia., 8mm thick 60m long & Sluice Valves 800 mm diameter	2	Set	16.44	32.88	0.00	Refer DHPD document "DPR Bala
9	110 m long 1300 mm dia 10mm thick & 60m long 1300mm dia 12mm thick spirally welded steel penstock pipe assemblies with intake bell mouth, expansion joints, anchor bends, embedments						
	Penstock Pipe 10mm	4	Nos.	71.23	284.93	224.32	
	Penstock pipe 12mm	4	nos.	43.51	174.05	109.67	
	Penstock (10mm thick) comprising of bellmouth			71.23		10.31	
	Penstock 10mm comprising of expansion joints			71.23		3.80	
	Note: The 4 no. of penstock pipe comprises of 3 unit penstocks and 1 spillway pipe for surplus escape.						
10	Flushing conduit steel pipe 8mm thick, 300mm dia 20m long with bell mouth and sluice valve in forebay tank	1	No.	5.05	5.05	4.96	Refer DHPD document "DPR Balance Works", Details of EM & HM Equipments supplied by Flovel for 3 Units and 4th Unit of Halaipani SHP. But the sizes and Quantities shall be as per the current Construction Drawings.
				Total	**1029.23**	**506.15**	
11	Total Amount as per LOA				**1029.23**		
	Total Billed Amount as per DHPD Report				**506.15**		
	Balance Works to be executed for 3 units				**523.07**		
	HM-WORKS FOR 4TH UNIT						
	110 m long 1300 mm dia 10mm thick & 60m long 1300mm dia 12mm thick spirally welded steel penstock pipe assemblies with intake bell mouth, expansion joints, anchor bends, embedments						
	Penstock Pipe 10mm	110	m	0.74	81.59	0.00	
	penstock pipe 12mm	60	m	0.76	45.69	0.00	
				Total	**127.28**		
	Balance Works to be exceuted including for 4th unit	**=523.08+127.28**			**650.35**		
	Add 75% escalation over LOA 2011 rates i.e. 7.5% per annum		%	75.00	**487.77**		
	Total Works to be executed as per Feb 2021 Price				**1138.12**		
	Add GST 18%		%	18.00	**204.86**		
	Add Contingencies @ 3%		%	3.00	40.29		
	Add Labour cess @ 1%		%	1.00	13.43		
				Total	**1396.70**		
				Say Rs.	**1,396.70**	**Lakhs**	

J1- INTAKE CUM FEEDER CHANNEL

Name of Project: Halaipani SHEP (4x4 MW)

Sub-Head: Feeder Channel

Sr. No.	Sub-Head and Item of Work	Unit	Civil Work yet to be Executed		
			Quantity	Rate, Rs./unit	Amount in Rs.
1	Providing and laying cement concrete 1 : 3 : 6 (1 cement : 3 coarse sand : 6 graded stone aggregate 40 mm nominal size) excluding the cost of centring an shuttering in a) Foundations and plinth	cum	5.30	6,786.00	35,965.80
2	Reinforced concrete work in foundations, footings, bases of columns etc. and mass concrete excluding cost of centring, shuttering and reinforcement in: a) 1 : 1.5 : 3 (1 cement : 1.5 coarse sand : 3 stone aggregate 20 mm nominal size).	cum	25.00	9,835.00	2,45,875.00
3	Reinforcement of RCC work including bending, binding and placing in position complete. a) Cold twisted bars.	MT	32.54	97,265.00	31,65,003.10
4	Back filling with Soil/RBM in the structures including all leads & lifts, cost of labour, T&P etc. all complete as per the specification, drawing and as per direction of Engineer-in-Charge.	cum	1,908.90	115.50	2,20,477.95
5	Reinforced cement concrete in walls (any thickness) including attached pillasters, buttresses, plinth and string course, fillets etc from top of foundation up to floor two level including finishing and plastering the exposed surfaces with cement mortar 1 : 3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface excluding cost of centring, shuttering and reinforcement in: a) 1 : 1.5 : 3 (1 cement : 1.5 corase sand : 3 stone aggregate 20 mm nominal size)	cum	25.00	9,835.00	2,45,875.00
6	Reinforced cement concrete in suspended floors, roofs, landings and balconies upto floor two level including finishing and plastering the exposed surface with cement mortar 1 : 3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface but excluding cost of centring and shuttering and reinforcement with 1 : 2 : 4 (1 cement : 2 coarse sand : 4 stone aggregate 20 mm nominal size).	cum	585.75	9,073.00	53,14,509.75
7	Instrumentation @ 2% of above items except LS Items			2%	1,84,554.13
8	Dewatering of construction sites @ 2% of above items except LS items.			2%	1,84,554.13
	Add 22.5% C.I. over APSR 2018 i.e. 7.5% per annum	%		22.5	21,59,283
	Add GST 28% on cement	%		28	8,00,609
	Add GST 18% on steel	%		18	4,07,254
	Add Contingencies @ 3%			3%	3,52,683
	Add Labour cess @ 1%			1%	3,52,683
			TOTAL	**Rs.**	**1,36,69,327.90**
				Say Rs.	**136.69**

J2 - DESILTING BASIN

Name of Project: Halaipani SHEP (4x4 MW)

Sub-Head: Desilting Tank

Sr. No.	Sub-Head and Item of Work	Unit	Civil Work yet to be Executed		
			Quantity	Rate	Amount
1	Excavation in foundation trenches not exceeding 1.50 m width or 10 Sq.m. on plan or drains not exceeding 1.50 m in width or 10 Sq.m. on plan including dressing of sides and ramming of bottoms, lift upto 1.50 m including getting out the excavated soil as directed, within a lead of 50 m.				
	a) Hard Soil	cum	23.04	242.00	5,575.68
	b) Ordinary Rock (with or without blasting)	cum	34.56	756.00	26,127.36
	c) Hard Rock requiring blasting	cum	57.60	756.00	43,545.60
2	Re-filling excavated earth in foundations and plinth etc. in 15 cm layer including ramming and watering etc. complete.	cum	2,640.39	115.50	3,04,965.05
3	Providing and laying cement concrete I : 3 : 6 (1 cement : 3 coarse sand : 6 graded stone aggregate 40 mm nominal size) excluding the cost of centring an shuttering in: a) Foundations and plinth	cum	304.48	6,786.00	20,66,201.28
4	Reinforced concrete work in foundations, footings, bases of columns etc. and mass concrete excluding cost of centring, shuttering and reinforcement in : a) 1 : 1.5 : 3 (1 cement : 1.5 coarse sand : 3 stone Cum aggregate 20 mm nominal size).	cum	32.96	9,835.00	3,24,161.60
5	Reinforcement of RCC work including bending, binding and placing in position complete. a) Cold twisted bars.	MT	46.73	97,265.00	45,45,115.64
6	Supplying & placing in position the steel railing including painting etc. all complete as per the drawings, specifications & direction of Engineer-in-Charge.	Mtr	63.00	3,900.00	2,45,700.00
7	Reinforced cement concrete in walls (any thickness) including attached pillasters, buttresses, plinth and string course, fillets etc from top of foundation up to floor two level including finishing and plastering the exposed surfaces with cement mortar 1 : 3 (I cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface excluding cost of centring, shuttering and reinforcement in: a) 1 : 1.5 : 3 (I cement : 1.5 corase sand : 3 stone aggregate 20 mm nominal size)	cum	505.96	9,835.00	49,76,116.60
8	Reinforced cement concrete in suspended floors, roofs, landings and balconies upto floor two level including finishing and plastering the exposed surface with cement mortar I : 3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface but excluding cost of centring and shuttering and reinforcement with 1 : 2 : 4 (1 cement : 2 coarse sand : 4 stone aggregate 20 mm nominal size).	cum	45.20	9,073.00	4,10,099.60
9	Centring and shuttering including strutting, propping etc and removal of form work for:				
	a) Foundation, footings, bases of columns etc. and mass concrete.	Sq.m	75.68	350.87	26,553.84
	b) Walls (any thickness) including attached pilasters, buttresses, plinth and string courses etc.	Sq.m	5,405.51	475.02	25,67,725.36
	c) Suspended floors, roofs, landings shelves and their supports, balconies and chajjas (3.5 in height).	Sq.m	211.95	719.42	1,52,481.07
10	Random rubble masonry with hard stone in foundations and plinth in cement mortar 1 : 6 (1 cement : 6 fine sand) including levelling up with cement concrete 1 : 6 : 12 (1 cement : 6 coarse sand : 12 stone aggregate 20 mm nominal size) at plinth level.	cum	2,400.00	4,457.00	1,06,96,800.00
11	Manufacturing and supplying of double flange non rising spindle type extra heavy duty sluice valve IS SS 410 spindle and gun metal internal with oprating hand wheel for 600 mm dia penstock pipe as per IS Trade mark specification.	Each	7.00	4,68,000.00	32,76,000.00
12	Manufacturing and supplying of flange duly mechanical and drill IS 1538/93 including gasket, Bolt & Nut etc. for the following penstock size.: i) 600mm dia	Each	14.00	48,128.60	6,73,800.40
13	Instrumentation @ 2% of above items except LS Items			2%	6,06,819.38
14	Dewatering of construction sites @ 2% of above items except LS items.			2%	6,06,819.38
	Add 22.5% C.I. over APSR 2018 i.e. 7.5% per annum	%		22.5	70,99,787
	Add GST 28% on cement	%		28	9,22,349
	Add GST 18% on steel	%		18	12,54,713
	Add Contingencies @ 3%			3%	11,59,632
	Add Labour cess @ 1%	%		1	3,86,488
			TOTAL	**Rs.**	**4,23,77,575.87**
				Say Rs.	**423.78 lakhs**

J3 - POWER CHANNEL

Name of Project: Halaipani SHEP (4x4 MW)

Sub-Head: Power Channel

Sr. No.	Sub-Head and Item of Work	Unit	Civil Work yet to be Executed		
			Quantity	Rate	Amount
1	Providing and laying cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 40 mm nominal size) excluding the cost of centring an shuttering in: a) Foundations and plinth	cum	9.60	6,786.00	65,145.60
2	Reinforced concrete work in foundations, footings, bases of columns etc. and mass concrete excluding cost of centring, shuttering and reinforcement in: a) 1 : 1.5 : 3 (1 cement : 1.5 coarse sand : 3 stone aggregate 20 mm nominal size).	cum	27.60	9,835.00	2,71,446.00
3	Reinforcement of RCC work including a) Cold twisted bars.	MT	9.34	97,265.00	9,08,186.65
4	Back filling with Soil/RBM in the structures including all leads & lifts, cost of labour, T&P etc. all complete as per the specification, drawing and as per direction of Engineer-in- Charge.	cum	4,875.00	115.50	5,63,062.50
5	Reinforced cement concrete in walls (any thickness) including attached pillasters, buttresses, plinth and string course, fillets etc from top of foundation up to floor two level including finishing and plastering the exposed surfaces with cement mortar 1 : 3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface excluding cost of centring, shuttering and reinforcement in: a) 1 : 1.5 : 3 (1 cement : 1.5 corase sand : 3 stone aggregate 20 mm nominal size)	cum	34.56	9,835.00	3,39,897.60
6	Reinforced cement concrete in suspended floors, roofs, landings and balconies upto floor two level including finishing and plastering the exposed surface with cement mortar 1 : 3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface but excluding cost of centring and shuttering and reinforcement with 1 : 2 : 4 (1 cement : 2 coarse sand : 4 stone aggregate 20 mm nominal size).	cum	27.84	9,073.00	2,52,592.32
7	Centring and shuttering including strutting, propping etc and removal of form work for:				
	a) Foundation, footings, bases of columns etc. and mass concrete.	Sq.m	12.00	350.87	4,210.44
	b) Walls (any thickness) including attached pilasters, buttresses, plinth and string courses etc.	Sq.m	230.40	475.02	1,09,444.61
	c) Suspended floors, roofs, landings shelves and their supports, balconies and chajjas (3.5 m height).	Sq.m	92.00	719.42	66,186.64
	Add 22.5% C.I. over APSR 2018 i.e. 7.5% per annum	%		22.5	5,80,539
	Add GST 28% on cement	%		28	1,11,908
	Add GST 18% on steel	%		18	1,11,314
	Add Contingencies @3%	%		3%	1,01,518
	Add Labour Cess @1%	%		1%	33,839
			TOTAL	**Rs.**	**35,19,290.88**
				Say Rs.	**35.19 lakhs**

J4 - FOREBAY & SPILLWAY

Name of Project: Halaipani SHEP (4x4 MW)

Sub-Head: Forebay Tank and Spillway

Sr. No.	Sub-Head and Item of Work	Unit	Civil Work yet to be Executed		
			Quantity	Rate	Amount
1	Excavation in foundation trenches not exceeding 1.50 m width or 10 Sq.m. on plan or drains not exceeding 1.50 m in width or 10 Sq.m. on plan including dressing of sides and ramming of bottoms, lift upto 1.50 m including getting out the excavated soil as directed, within a lead of 50 m				
	a) Hard Soil	cum	213.77	242.00	51,732.34
	b) Ordinary Rock	cum	320.65	756.00	2,42,411.40
	c) Hard Rock requiring blasting	cum	534.41	756.00	4,04,013.96
2	Providing and laying cement concrete 1 : 3 : 6 (1 cement : 3 coarse sand : 6 graded stone aggregate 40 mm nominal size) excluding the cost of centring an shuttering in: a) Foundations and plinth	cum	40.26	6,786.00	2,73,204.36
3	Reinforced concrete work in foundations, footings, bases of columns etc. and mass concrete excluding cost of centring, shuttering and reinforcement in: a) 1 : 1.5 : 3 (1 cement : 1.5 coarse sand : 3 stone aggregate 20 mm nominal size).	cum	280.46	9,835.00	27,58,324.10
4	Reinforcement of RCC work including bending, binding and placing in position complete. a) Cold twisted bars.	Mtr	30.89	97,265.00	30,04,262.96
5	Supplying & placing in position the steel railing including painting etc. all complete as per the drawings, specifications & direction of Engineer in-Charge.	Mtr	132.00	3,900.00	5,14,800.00
6	Reinforced cement concrete in walls (any thickness) including attached pillasters, buttresses, plinth and string course, fillets etc from top of foundation up to floor two level including finishing and plastering the exposed surfaces with cement mortar 1 : 3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface excluding cost of centring, shuttering and reinforcement in: a) 1 : 1.5 : 3 (1 cement : 1.5 corase sand : 3 stone aggregate 20 mm nominal size)	cum	93.03	9,835.00	9,14,950.05
7	Reinforced cement concrete in suspended floors, roofs, landings and balconies upto floor two level including finishing and plastering the exposed surface with cement mortar I : 3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface but excluding cost of centring and shuttering and reinforcement with 1 : 2 : 4 (I cement : 2 coarse sand : 4 stone aggregate 20 mm nominal size).	cum	27.60	9,073.00	2,50,414.80
8	Centring and shuttering including strutting, propping etc and removal of form work for:				
	a) Foundation, footings, bases of columns etc. and mass concrete.	Sq.m	295.75	350.87	1,03,769.80
	b) Walls (any thickness) including attached pilasters, buttresses, plinth and string courses etc.	Sq.m	331.48	475.02	1,57,459.63
	c) Suspended floors, roofs, landings shelves and their supports, balconies and chajjas (3.5 m height).	Sq.m	12.00	719.42	8,633.04
			TOTAL	**Rs.**	**86,83,976.44**
	Add 22.5% C.I. over APSR 2018 i.e. 7.5% per annum	%	22.5%		19,53,894.70
			TOTAL	**Rs.**	**1,06,37,871.14**
	Add GST on Cement @28%	%	28%		5,07,065.67
	Add GST on Steel @18%	%	18%		3,86,522.65
			TOTAL	**Rs.**	**1,15,31,459.46**
	Add Contingencies @3%	%	3%		3,45,943.78
	Add Labour Cess @1%	%	1%		1,15,314.59
			TOTAL	**Rs.**	**1,19,92,717.84**
					-
				Say Rs.	**119.93** **Lakhs**

J5 - PENSTOCK & ANCHOR BLOCKS

Name of Project: Halaipani SHEP (4x4 MW)

Sub-Head: Penstock

Sr. No.	Sub-Head and Item of Work	Unit	Civil Work yet to be Executed		
			Quantity	Rate	Amount
1	Earth work in excavation in foundation trenches not exceeding 1.5 m in width or 10 sqm on plan or drains not exceeding 1.5 m in width or 10 sqm on plan including dressing of sides and ramming of bottoms, lift upto 1.5 m including getting out the excavated soil and disposal of surplus excavated soil as directed, within a lead of 50 m.				
	a) Hard Soil	cum	989.35	242.00	2,39,422.70
	b) Ordinary Rock	cum	742.01	756.00	5,60,959.56
	c) Hard Rock requiring blasting	cum	742.01	756.00	5,60,959.56
2	Providing and laying cement concrete 1 : 3 : 6 (1 cement : 3 coarse sand : 6 graded stone aggregate 40 mm nominal size) excluding the cost of centring an shuttering in: a) Foundations and plinth	cum	79.00	6,786.00	5,36,094.00
3	Reinforced concrete work in foundations, footings, bases of columns etc. and mass concrete excluding cost of centring, shuttering and reinforcement in: a) 1 : 1.5 : 3 (1 cement : 1.5 coarse sand : 3 stone aggregate 20 mm nominal size).	cum	2,186.83	9,835.00	2,15,07,473.05
4	Reinforcement of RCC work including bending, binding and placing in position complete. a) Cold twisted bars.	MT	114.81	97,265.00	1,11,66,849.92
5	Centring and shuttering including strutting, propping etc and removal of form work for: a) Foundation, footings, bases of columns etc. and mass concrete.	Sq.m	2,900.56	350.87	10,17,719.49
			TOTAL	**Rs.**	**3,55,89,478.28**
	Add 22.5% C.I. over APSR 2018 i.e. 7.5% per annum	%	22.5%		80,07,632.61
			TOTAL	**Rs.**	**4,35,97,110.89**
	Add GST on Cement @28%	%	28%		26,62,145.45
	Add GST on Steel @18%	%	18%		13,68,308.45
			TOTAL	**Rs.**	**4,76,27,564.79**
	Add Contingencies @3%	%	3%		14,28,826.94
	Add Labour Cess @1%	%	1%		4,76,275.65
			TOTAL	**Rs.**	**4,95,32,667.38**
				Say Rs.	**495.33** **Lakhs**

J6 - POWER HOUSE & TRC

Name of Project: Halaipani SHEP (4x4 MW)

Sub-Head: Power House & Tail race Channel

Sr. No.	Sub-Head and Item of Work	Unit	Civil Work yet to be Executed		
			Quantity	Rate	Amount
A	POWER HOUSE AND TAIL RACE CHANNEL				
1	Earth work in excavation in foundation trenches not exceeding 1.5 m in width or 10 sqm on plan or drains not exceeding 1.5 m in width or 10 sqm on plan including dressing of sides and ramming of bottoms, lift upto 1.5 m including getting out the excavated soil and disposal of surplus excavated soil as directed, within a lead of 50 m.				
	a) Hard Soil	cum	130.50	242.00	31,581.00
	b) Ordinary Rock	cum	459.40	756.00	3,47,306.40
	c) Hard Rock requiring blasting	cum	695.70	756.00	5,25,949.20
2	Extra for lead of 50 m or part thereof for earth work in all soils including shingles, small size boulders upto 30 cm size and saturated soil.	cum	7,200.00	16.40	1,18,080.00
3	Refiling excavated earth in foundations and plinth etc. in 15cm layer including ramming and watering etc. complete.	cum	6,836.72	115.50	7,89,641.16
4	Providing and laying cement concrete 1 : 3 : 6 (1 cement : 3 coarse sand : 6 graded stone aggregate 40 mm nominal size) excluding the cost of centring an shuttering in: a) Foundations and plinth	cum	46.04	6,786.00	3,12,427.44
5	Providing R.C.C. M-20 with approved gradient, approved coarse sand and cement including scaffolding, vibrating, providing construction joints, finishing, curing, T & P etc. complete as per E/I.				
	i) Base slab	cum	5,828.20	9,073.00	5,28,79,258.60
	ii) Walls any thicknesscum	cum	695.30	9,073.00	63,08,456.90
	iii) Slab suspended floor	cum	669.19	9,073.00	60,71,560.87
	iv) Beam lintel	cum	1,960.00	9,073.00	1,77,83,080.00
	v) Column	cum	1,920.00	9,073.00	1,74,20,160.00
6	TOR steel Reinforcement of RCC works including bending, binding and placing in position complete	MT	905.82	97,265.00	8,81,05,019.99
7	Cement plastering 1:4	Sq.m	1,688.58	120.00	2,02,629.60
8	Rolling shutter	Sq.m	23.00	87,275.00	20,07,325.00
9	Brick masonry wall	cum	211.08	10,562.00	22,29,426.96
10	CGI Sheet + Truss machine hall on switchgear room	Sq.m	812.90	1,382.00	11,23,427.80
11	P/F shutters for doors/windows panel/glazed	Sq.m	150.00	2,753.00	4,12,950.00
12	P/F A fluminium panel for glazing	Sq.m	342.12	3,256.00	11,13,942.72
13	White Washing with snocem	Sq.m	1,688.58	19.00	32,083.02
14	Flooring tiles	Sq.m	730.95	2,350.00	17,17,732.50
15	Add for water supply, sanitation, septic tank including electrification etc. @ 12.5%	LS		16,00,000.00	16,00,000.00
16	Dewatering	LS		12,00,000.00	12,00,000.00
17	Reinforced cement concrete work in foundations, footings, bases of columns etc. and mass concrete excluding cost of centring and shuttering and reinforcement in: a) 1:2:4 (1 cement :2 coarse sand : 4 stone aggregate 20 mm nominal size).	cum	38.21	9,073.00	3,46,679.33
18	Reinforced cement concrete work in lintels, beams and breasumers upto floor two level including finishing and plastering the exposed surfaces with cement mortar 1:3(1cemenc3 fine sand) of thickness not exceeding 6mm to give a smooth and even surface but excluding cost of centring and shuttering and reinforcement in: a) 1:2:4 (lcement :2 coarse sand : 4 stone aggregate 20 nun nominal size).	cum	45.23	9,073.00	4,10,371.79
19	Reinforced cement concrete work in columns,pillars, piers, abutments, post and struts etc. upto floor two level including finishing and plastering the exposed surfaces with cement mortar 1 :3(lcemenr:3 fine sand) of thickness not exceeding 6mm to give a smooth and even surface but excluding cost of centring and shuttering and reinforcement in: a) 1:2:4 (lcement :2 coarse sand : 4 stone aggregate 20 mm nominal size).	cum	17.59	9,835.00	1,72,997.65

20	Centring and shuttering including strutting, propping etc. and removal of form work for:				
	a) Foundation, footings, bases of columns etc. and mass concrete.	Sq.m	241.20	350.87	84,629.84
	b) Lintels, beams, girders, bresummers and cantilevers etc.	Sq.m	512.55	475.02	2,43,471.50
	c) Columns, pillers, posts and struts etc	Sq.m	281.40	719.42	2,02,444.79
21	Reinforcement of RCC work including bending, binding and placing in position complete. a) Cold Twisted bars.	MT	8.49	97,265.00	8,25,388.26
22	Masonary with precast cement concrete 1:3:6(1 cement:3 coarse sand:6 graded stone aggregate 20 mm nominal size) blocks in cement mortar 1:6(1 cement:3 fine sand) in foundation and plinth.	cum	90.45	6,786.00	6,13,793.70
23	12mm cement plaster 1:4 (1 cement : 4 fine sand)	Sq.m	452.25	129.50	58,566.38
24	15mm cement plaster 1:4 (1 cement : 4 fine sand) on the rough side of single or half brick wall.	Sq.m	452.25	153.00	69,194.25
25	White washing with whiting on new work(three or more coats) to give an even shade.	Sq.m	1,292.00	16.20	20,930.40
			TOTAL	**Rs.**	**20,53,80,507.05**
	Add 22.5% C.I. over APSR 2018 i.e. 7.5% per annum	%	22.5%		4,62,10,614.09
			TOTAL	**Rs.**	**25,15,91,121.14**
	Add GST on Cement @28%	%	28%		1,68,26,641.21
	Add GST on Steel @18%	%	18%		1,19,07,293.81
			TOTAL	**Rs.**	**28,03,25,056.15**
	Add Contingencies @3%	%	3%		84,09,751.68
	Add Labour Cess @1%	%	1%		28,03,250.56
			SUBTOTAL	**Rs.**	**29,15,38,058.40**
B	**PROTECTION OF RIVER BANK & TRC**				
1	Excavation in foundation trenches not exceeding 1.5 m in width or 10 sqm on plan or drains not exceeding 1.5 m in width or 10 sqm on plan including dressing of sides and ramming of bottoms, lift upto 1.5 m including getting out the excavated soil and disposal of surplus excavated soil as directed, within a lead of 50 m.				
	a) Hard Soil	cum	1,300.00	242.00	3,14,600.00
	b) Ordinary Rock	cum	5,118.75	756.00	38,69,775.00
2	Providing and laying cement concrete 1 : 3 : 6 (1 cement : 3 coarse sand : 6 graded stone aggregate 40 mm nominal size) excluding the cost of centring an shuttering	cum	180.00	6,786.00	12,21,480.00
3	Reinforced concrete work in foundations, footings, bases of columns etc. and mass concrete excluding cost of centring, shuttering and reinforcement in: a) 1 : 1.5 : 3 (1 cement : 1.5 coarse sand : 3 stone aggregate 20 mm nominal size).	cum	6,000.00	9,835.00	5,90,10,000.00
4	TOR steel Reinforcement of RCC works including bending, binding and placing in position complete	MT	420.00	97,265.00	4,08,51,300.00
5	Dewatering	LS		15,00,000.00	15,00,000.00
6	Centring and shuttering including strutting, propping etc and removal of form work for:				
	a) Foundation, footings, bases of columns etc. and mass concrete.	sqm	2,205.79	350.87	7,73,945.00
	b) Walls (any thickness) including attached pilasters, buttresses, plinth and string courses etc.	sqm	3,699.70	475.02	17,57,431.00
7	Refiling excavated earth in foundations and plinth etc. in 15cm layer including ramming and watering etc. complete.	cum	28,800.00	115.50	33,26,400.00
8	Providing & Supplying of Quick Setting compound.	kg	175.00	5,750.00	10,06,250.00

			TOTAL	**Rs.**	11,36,31,181.00	
	Add 22.5% C.I. over APSR 2018 i.e. 7.5% per annum	%	22.5%		2,55,67,015.73	
			TOTAL	**Rs.**	**13,91,98,196.73**	
	Add GST on Cement @28%	%	28%		77,52,691.80	
	Add GST on Steel @18%	%	18%		52,55,849.03	
			TOTAL	**Rs.**	**15,22,06,737.55**	
	Add Contingencies @3%	%	3%		45,66,202.13	
	Add Labour Cess @1%	%	1%		15,22,067.38	
			Subtotal	**Rs.**	**15,82,95,007.05**	
			TOTAL	**Rs.**	**44,98,33,065.45**	
				Say Rs.	**4,498.33**	**Lakhs**

J8 -PRTECTION WORKS FOR ANCHOR & SADDLE BLOCKS AND GREF ROAD

Name of Project: DPR Work of Halaipani SHEP (4x4 MW)

Sub-Head: Protection wall, Retaining Wall of Anchor Block & Saddle Block and Gref Road

Sr. No.	Sub-Head and Item of Work	Unit	Civil Work yet to be Executed			Remarks
			Quantity	Rate	Amount	
1	Excavation in foundation trenches not exceeding 1.5 m in width or 10 sqm on plan or drains not exceeding 1.5 m in width or 10 sqm on plan including dressing of sides and ramming of bottoms, lift upto 1.5 m including getting out the excavated soil and disposal of surplus excavated soil as directed, within a lead of 50 m.					
	a) Hard Soil	cum	78.75	242.00	19,057.50	
	b) Ordinary Rock	cum	78.75	756.00	59,535.00	
2	Providing and laying cement concrete 1 : 1.5 : 3 (1 cement : 1.5 coarse sand : 3 graded stone aggregate 20 mm nominal size	cum	52.50	9,835.00	5,16,337.50	
	a) Foundations and plinth					
3	Random rubble masonry with hard stone in foundations and plinth in cement mortar 1 : 6 (1 cement : 6 fine sand) including levelling up with cement concrete 1 : 6 : 12 (1 cement : 6 coarse sand : 12 stone aggregate 20 nun nominal size) at plinth level.	cum	945.00	3,280.00	30,99,600.00	
			TOTAL	**Rs.**	**36,94,530.00**	
	Add 22.5% C.I. over APSR 2018 i.e. 7.5% per annum	%	22.5%		8,31,269.25	
			TOTAL	**Rs.**	**45,25,799.25**	
	Add GST on Cement @28%	%	28%		2,74,164.19	
	Add GST on Steel @18%	%	18%		-	
			TOTAL	**Rs.**	**47,99,963.44**	
	Add Contingencies @3%	%	3%		1,43,998.90	
	Add Labour Cess @1%	%	1%		47,999.63	
			TOTAL	**Rs.**	**49,91,961.98**	
				Say Rs.	**49.92**	**Lakhs**

J9 - SWITCH YARD

Name of Project: Halaipani SHEP (4x4 MW)

Sub-Head: Switchyard

Sr. No.	Sub-Head and Item of Work	Unit	Civil Work yet to be Executed		
			Quantity	Rate	Amount
1	Earth work in excavation in foundation trenches not exceeding 1.5 m in width or 10 sqm on plan or drains not exceeding 1.5 m in width or 10 sqm on plan including dressing of sides and ramming of bottoms, lift upto 1.5 m including getting out the excavated soil and disposal of surplus excavated soil as directed, within a lead of 50 m.				
	a) Hard Soil	cum	59.28	242.00	14,345.76
	b) Ordinary Rock	cum	35.57	756.00	26,890.92
	c) Hard Rock requiring blasting	cum	23.71	756.00	17,924.76
2	Providing and laying cement concrete 1 : 1.5 : 3 (1 cement : 1.5 coarse sand : 3 graded stone aggregate 20 mm nominal size a) Foundations and plinth	cum	19.16	9,835.00	1,88,438.60
3	Reinforced concrete work in foundations, footings, bases of columns etc. and mass concrete excluding cost of centring, shuttering and reinforcement in: a) 1 : 2 : 4 (1 cement : 2 coarse sand :4 stone aggregate 20 mm nominal size).	Cum cum	108.94	9,073.00	9,88,412.62
4	Reinforcement of RCC work including bending, binding and placing in position complete. a) Cold twisted bars.	MT	3.94	97,265.00	3,82,809.36
5	Centring and shuttering including strutting, propping etc and removal of form work for: a) Foundation, footings, bases of columns etc. and mass concrete.	Sq.m	419.24	350.87	1,47,098.74
6	Brick work with best available local bricks in foundation and plinth in cement mortar 1:3 (1 cement : 3 fine sand).	cum	15.76	9,073.00	1,42,990.48
			TOTAL	**Rs.**	**19,08,911.24**
	Add 22.5% C.I. over APSR 2018 i.e. 7.5% per annum	%	22.5%		2,86,336.69
			TOTAL	**Rs.**	**21,95,247.93**
	Add GST on Cement @28%	%	28%		1,21,884.48
	Add GST on Steel @18%	%	18%		46,906.15
			TOTAL	**Rs.**	**23,64,038.56**
	Add Contingencies @3%	%	3%		70,921.16
	Add Labour Cess @1%	%	1%		23,640.39
			TOTAL	**Rs.**	**24,58,600.11**
				Say Rs.	**24.59 Lakhs**

Annexure - S

Cost Estimates of Electro Mechanical Works
(Abstract)

(Rs. In Lakhs)

S.No.	Item	INR Component	USD Components
1	**Preliminary**		
a)	Preparation of DPR documents	5.00	
b)	Model tests	0.00	
2	**Generating Plant and Equipment**		
a)	Generator, turbine and accessories – **Annex- S-1**	1,717.28	
b)	Auxiliary Electrical equipment for power station – **Annex- S-2**	549.34	
c)	Auxiliary mechanical equipment and services for power station- **Annex- S-3**	140.39	
d)	GST @ 18.00 % on 2 (a), (b), (c)	433.26	
e)	Transportation, handling and Insurance @ 6.00 % on 2 (a), (b), (c)	144.42	
f)	Erection and commissioning charges @ 8% of 2 (a) to (e) excluding spares.	186.78	
g)	GST @ 18.00 % on (2e + 2f)	59.62	
	Sub-Total (Generating Plant and Equipment)	**3,231.09**	
3	**Switchyard Equipment alongwith Barrage & Colony Areas equipment**		
a)	33 kV Switchyard Equipment – **Annex- S-4**	98.14	
b)	Auxiliary Electrical equipment for Barrage & Colony Areas – **Annex- S-5**	27.31	
c)	GST @ 18.00 % on 3 (a) & 3 (b)	22.58	
d)	Transportation, handling and Insurance @ 6.00 % on 3 (a)and (b)	7.53	
e)	Erection and Commissioning charges @ 8% of 3 (a)& 3 (b) excluding cost of Spares.	9.73	
f)	GST @ 18.00 % on 3 (d), 3 (e)	3.11	
	Sub Total of Switchyard Equipment	**168.40**	
4	**33 kV Transmission and Grid substation works Annex- S-6**	**46.35**	
	GST @ 18.00% on 4	**8.34**	
	Sub Total of 33 kV transmission and grid Substation	**54.69**	
5	Contingency @ 1.00% on item 2, 3 and 4	34.54	
6	Tools & Plants @ 0.5% on item 2, 3 and 4	17.27	
7	**Sub-Total (Item 1 to 5)**	**3,510.99**	
8	Audit & Account Charges @ 0.5%	**17.27**	
	GRAND TOTAL	**3,528.26**	

Annexure - S-1

Cost Estimate of Electro Mechanical Works
(Generator, Turbine and Auxiliaries)

(Rs. In Lakhs)

S.No.	Item	Quantity	Rate	Amount
1	**2**	**3**	**4**	**5 (=3X4)**
1 a)	Turbine-Generator units each of 4 MW with 10% Continuous Overload, 750 rpm, 0.85 p.f, 11 kV complete with associated equipment such as MIV, Governor, Excitation system & AVR, Vibration Monitoring System, Flow & Head measuring device, Air Admission Valve, Silt measuring instrument, Structural Steel and Paint.	4 Set	365.00	1460.00
b)	Cooling water system comprising pump sets, Heat Exchangers, valves, piping, strainer, local control panel etc.	4 Set	6.00	24.00
c)	Drainage and Dewatering System	1 Lot	12.79	12.79
d)	Compressed air system including pipes and valves	1 Lot	2.76	2.76
e)	Special Tools & Devices	1 Lot		10.00
f)	Spares @ 5 % on items 1(a) to 1e			75.48
2	Terminal equipment comprising of 11kV LAVT Cubicles and NG Cubicle etc.	4 Set	6.80	20.40
3	Power House Control & Monitoring System (Supervisory Control and Data Acquisition System) PLC panel, UPS System	1 Lot		30.00
4	Unit Auxiliary Boards, Station Service Boards and other LT Boards in power house and switchyard	1 Lot		30.00
5	Control & Protection Panels for turbine, Generator Transformer and Feeders	1 Lot	48.00	48.00
6	Lubricating oil & Governor oil for first filling	1 Lot	Included in 1 (a) above	
7	**Sub Total of Items 2 to 6**			**128.40**
8	Spares @ 3 % on items 2 to 6			3.85
	TOTAL Cost			**1717.28**

Annexure - S-2

Cost Estimate of Electro Mechanical Works
(Auxiliary Electrical Equipment for power station)

(Rs. In Lakhs)

S.No	Item	Unit	Quantity	Rate	Amount
1	2		3	4	5
1	Step Up Transformer 8 MVA, 11/33kV, 3-phase, ONAN Type along with all accessories & first filling of oil	Nos.	4	75.00	300.00
2	Unit Auxiliary Transformers 200 kVA, 11/0.433kV, 3Ph, Dry Type	Nos.	4	13.03	52.14
3	Other Transformers				
3.1	Station Auxiliary Transformer 315KVA, 33/0.433kV, 3Ph,oil filled ONAN	Nos.	2	8.10	16.20
4	LT AC Switchgear for power supply to PH and outdoor switchyard				
5	DC Batteries 110V , 300AH Battery charging equipment, DC to DC convertor, DC. Distribution Board with DC switchgear	Set	1	13.50	13.50
6	2X20 kVA UPS with distribution board		LOT	Covered in Annexture- S-1	
7	Diesel generating set 250kVA, 0.415kV with Auto Mains Failure Panel	Set	2	20.00	40.00
8	Control & Power cables for power house and switchyard		LOT	45.00	45.00
9	Cable racks, Trays and accessories		LOT	20.00	20.00
10	Ground mat and earthing for P.H.and switch yard,		LOT	15.00	15.00
11	Illumination of Power House, and switch yard		LOT	12.50	12.50
12	Electrical Test Lab		LOT	12.00	12.00
13	Communication system and EPBAX at power house		LOT	7.00	7.00
14	Sub-Total (items 1 to 13)				533.34
15	Spares @ 3% of 14				16.00
16	**TOTAL COST**				**549.34**

Annexure - S-3

Cost Estimate of Electro Mechanical Works
(Mechanical Auxiliary Equipment and Services for power station)

(Rs. In Lakhs)

S.No.	Item	Unit	Quantity	Rate	Amount
1	**2**		**3**	**4**	**5**
1	Electrical Overhead Travelling crane for PH (Capacity 45/10T)	No	1	74.50	74.50
2	Fire fighting system comprising fire stations with rack/reels, hoses, nozzles, fire alarm system with panels, pumps, valves, pipings, portable fire extingushers, etc complete for power house and switchyard		LOT	35.00	35.00
3	Air conditioning equipment for power house Control Room, Office and Conference Room		LOT	1.80	1.80
4	Ventilation equipment for power house		LOT	5.00	5.00
5	Mobile Filtration Plant for Transformer oil, Lubrication oil filtration plant along with pipings, tanks ,fittings etc.		LOT	10.00	10.00
6	Workshop machines and equipment		LOT	10.00	10.00
7	Sub-Total (item 1 to 6)				136.30
8	**Spare** 3% on item 7				4.09
9	**TOTAL COST**				**140.39**

Annexure - S-4

Cost Estimates of Electro Mechanical Works
(Switchyard Equipment)

(Rs. In Lakhs)

S.No.	Item	Unit	Quantity	Amount
1	**2**		**3**	**4**
1	33 kV, 630 A, Vacuum Circuit Breaker	Nos.	8	40.00
2	33 kV, 630 A Isolator with earth switch (without Steel Strc.)	Nos.	2	2.79
3	33 kV, 630 A Isolator without earth switch (without Steel Strc.)	Nos.	8	10.00
4	Current Transformer - 33 kV, Single Phase - 3 core	Nos.	23	10.50
5	33 kV, Single Phase Potential Transformer	Nos.	23	9.20
6	Lightning Arrester , 30 kV, 10 kA	Nos.	22	3.19
7	Galnanized latticed Structures including Foundation			
a	Main Structures	MT.	10	10.00
b	Auxiliary Structures	MT.	6	6.00
8	Conductor ACSR	Mtrs	150	0.45
9	7/3.66 Ground Wire	Mtrs	150	0.15
10	Tension and Insulators with Suspension		LOT	1.00
11	CLAMPS, CONNECTORS, HARDWAREs		LOT	2.00
12	Sub Total (1 to 11)			95.28
13	Spares @ 3.00% of 12			2.86
	TOTAL COST			**98.14**

Annexure - S-5

Cost Estimate of Electro Mechanical Works
(Auxiliary Electrical Equipment for Barrage & Colony Areas)

(Rs. In Lakhs)

S.No	Item	Unit	Quantity	Rate	Amount
1	2		3	4	5
1	**Barrage Site**				
1.1	Transformer for Barrage 250KVA, 11/0.433kV, 3Ph, ONAN.	No.	1	3.38	3.38
1.2	Diesel generating set 160 kVA, 0.415kV with Auto start panel	No.	1	12.00	12.00
1.3	Double Pole structure with TPMO, DO Fuse set etc.	No.	1	1.00	1.00
1.4	Cable etc		LOT	0.25	0.25
1.5	LT Distribution Board Including MCCB etc	No.	1	2.00	2.00
2	**Fore Bay**				
2.1	Oil immersed Transformer for Colony (Rating 100 kVA, 11/0.433 kV, 3Ph, ONAN)				1.00
2.2	Double Pole structure with TPMO, DO Fuse set etc.				0.70
2.4	Cables etc				1.25
2.5	LT Distribution Board Including MCCB etc				
3	**Colony**				
3.1	Oil immersed Transformer for Colony (Rating 125 kVA, 11/0.433 kV, 3Ph, ONAN)	No.	1	1.69	1.69
3.2	Double Pole structure with TPMO, DO Fuse set etc.	No.	1	1.00	1.00
3.3	Cables etc		LOT	0.25	0.25
3.4	LT Distribution Board Including MCCB etc	No.	1	2.00	2.00
6	**Sub-Total**				**26.52**
7	Spares @ 3% of 4				0.80
8	**TOTAL COST**				**27.31**

Annexure - S-6

Cost Estimates of Electro Mechanical Works
(33 kV Transmission & Grid Substation Works)

(Rs. In Lakhs)

S.No.	Item Particulars	Unit	Quantity	Amount
1	**2**		**3**	**4**
1	Equiments and Works at Grid Substation for 2 feeders	Lot	1	45.00
2	Construction of 33 kV double circuit transmission line from power house switchyard to proposed substation-Including/ survey, Supply of all material labor, peg marking, excavation, pole erection, grooving , assembly, insulator hoisting, conductor/earthing wire paying, stringing and final sagging etc for proper clearances. all supports shall be provided with number plates phase plates, danger boards, ant climbing devices and earthing etc as per REC standards and practices	km	0	0.00
3	Sub Total (1 to 2)			45.00
4	Spares @ 3.00% of 3			1.35
	TOTAL COST			**46.35**

CHAPTER – 17

FINANCIAL EVALUATION

17.1 GENERAL

Detailed financial analysis for working out energy tariff has been carried out. A summary of assumptions and inputs for financial analysis are summarized as follows:

17.1.1 PROJECT COST

Base Cost

Cost of the project is taken as estimated and discussed in earlier chapter – 16. The cost is estimated at 2020 price level.

IDC

Interest during construction is worked out based on the disbursement of cash flow. The interest rate is taken as 10.41% p.a.

Escalation in cost

Escalation of 2% p.a. for Civil & HM works and 2% p.a. for E & M works have been considered for working out the completed cost of the project. However, it is submitted that the completed may be allowed to be worked out from time to time, based on actual escalation worked out as per price indices using price escalation formula as per industry practices.

Phasing

Capital cost for the project will be disbursed during the project construction period. Six monthly phasing of expenses is presented below for both Civil and Electro Mechanical works: -

Phasing of Civil Works

Months	Total Outlay (Rs. In Lakhs)
6	1138.16
12	1727.53
18	2912.96
24	4125.58
30	1788.40
Total	**11692.63**

Phasing of Electro Mechanical Works

Months	Total Outlay (Rs. In Lakhs)
6	0.00
12	91.80
18	186.48
24	757.41
30	865.03
Total	**1900.72**

17.1.2 FINANCING

The project shall be financed at the rate of interest of 10.41% p.a. For analysis purpose 70.00% of capital cost is considered as debt and balance is equity. The debt shall be payable in 10 years after 2.5 years of construction period.

17.1.3 ENERGY BENEFITS

The financial analysis is based on the energy output on 75% dependable year at 95% plant availability. 1% auxiliary consumption and 23.05% free power to state government have been considered in preliminary financial evaluation of the project. For the purpose of calculation of tariff, the free power has been considered as per provisions of CERC norms.

17.1.4 ENERGY SALE PRICE

The energy tariff has been worked out as per practice with 16.96% for first 20 years and 21.52 for next 20 years as per new CERC guidelines.

17.1.5 ANNUAL COSTS

Annual operation and maintenance expenses including insurance have been taken as 31.34 lacs per MW, which shall be escalated by 3.84% annually.

17.1.6 OTHERS

The financial evaluation of the project has been carried out for 40 years of generation, and the Discount rate is taken as 8.61%.

17.2 MAJOR FINANCIAL RESULTS

The tariff of the project based on Present day cost completed is worked out and has been attached in the report. The results are shown in **Table A** below:

TABLE A

Basic cost at 2020 Price Level	Rs. 12942.77 Lakhs
Interest during Construction	Rs. 987.47 Lakhs
Escalation	Rs. 650.58 Lakhs
Total	Rs. 14580.83 Lakhs
Financing Charges @ 2%	Rs. 204.13 Lakhs
TOTAL PROJECT COST	Rs. 14784.96 Lakhs

Levelized Tariff for 40 years with free power @ 50% Plant Load Factor as per IIT Roorkee	Rs. 4.69 per kWh

HALAIPANI HYDRO POWER PROJECT (16 MW)

YEAR- WISE PHASING OF FUNDS

		COST	ESCALATION	TOTAL COST	Amount in Rs.			
Unit- I	Civil Works	11178.64	513.99	11692.63	Cr.	Units	106.24/58.43	MU
Unit -II	EM Works	1764.13	136.59	1900.72	Cr.	Gen. Hard Cost	13593.35	Rs. Cr.
Unit -III	Transmission	0.00	0.00	0.00	Cr.			
	TOTAL	12942.77	650.58	13593.35	Cr.			

All figures in Rs. Cr.

Months	%age of work	Unit-I Civil works	% age of work	UNIT- II EM Works	% age of work	T-Trans.	Generation Cost	Escalated Gener. Cost inc. Trans.
1	2	3	4	5	6	7	5	6
							Col.3+5	Col.3+5+7
6	10.0%	1117.86	0.0%	0.00	0.0%	0.00	1117.86	1117.86
12	15.0%	1676.80	5.0%	88.21	0.0%	0.00	1765.00	1765.00
18	25.0%	2794.66	10.0%	176.41	0.0%	0.00	2971.07	2971.07
24	35.0%	3912.52	40.0%	705.65	0.0%	0.00	4618.18	4618.18
30	15.0%	1676.80	45.0%	793.86	0.0%	0.00	2470.66	2470.66
Total	100%	11178.64	100%	1764.13	0%	0.00	12942.77	12942.77

HALAIPANI HYDRO POWER PROJECT (16 MW)

ESCALATED COST

Escalation on civil works 2.42%

Escalation on elect. works 3.26%

All figures in Rs. Cr.

Months	Unit-I Civil works Hard cost	Escalated Hard Cost @2.42%	UNIT- II E&M Hard cost	Escalated Hard Cost @3.26%	T-Trans Hard cost.	Escalat-ed Hard Cost	Escalated Generation Cost (in Rs. Cr.)	Escalated Gener. Cost inc. Trans. (in Rs. Cr.)
1	2	3	4	5	6	7	8 Col.3+5	9 Col.3+5+7
6	1117.86	1138.16	0.00	0.00	0.00	0.00	1138.16	1138.16
12	1676.80	1727.53	88.21	91.80	0.00	0.00	1819.33	1819.33
18	2794.66	2912.96	176.41	186.48	0.00	0.00	3099.44	3099.44
24	3912.52	4125.58	705.65	757.41	0.00	0.00	4882.99	4882.99
30	1676.80	1788.40	793.86	865.03	0.00	0.00	2653.43	2653.43
TOTAL	**11178.64**	**11692.63**	**1764.13**	**1900.72**	**0.00**	**0.00**	**13593.35**	**13593.35**
								650.58

HALAIPANI HYDRO POWER PROJECT (16 MW)

INTEREST DURUNG CONSTRUCTION - CIVIL & HM

Rate of interest:- **9.67%**

EQUITY 30%

LOAN 70%

COST OF THE PROJECT INCLUDING ESCALATION AND IDC.

All figures in Rs. Cr.

Half-Year	Escalated Hard Cost	Equity 30%	LOAN 70%	Interest @ 9.67%	Outstanding Total Loan	Equity after every half year	Total Cost with IDC
1	2	3	4	5	6	7	8
6	1138.16	341.45	796.71	19.26	815.97	341.45	1157.42
12	1727.53	518.26	1209.27	68.69	2093.93	859.71	2953.64
18	2912.96	873.89	2039.07	150.54	4283.55	1733.60	6017.14
24	4125.58	1237.67	2887.91	276.92	7448.37	2971.27	10419.64
30	1788.40	536.52	1251.88	390.39	9090.64	3507.79	12598.43
TOTAL	**11692.63**	**3507.79**	**8184.84**	**905.80**	**9090.64**	**3507.79**	**12598.43**

HALAIPANI HYDRO POWER PROJECT (16 MW)

INTEREST DURUNG CONSTRUCTION - EM

Rate of interest:- **9.67%**

EQUITY 30%

LOAN 70%

COST OF THE PROJECT INCLUDING ESCALATION AND IDC.

All figures in Rs. Cr.

Half-Year	Escalated Hard Cost	Equity 30%	LOAN 70%	Interest @ 9.67%	Outstanding Total Loan	Equity after every half year	Total Cost with IDC
1	2	3	4	5	6	7	8
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	91.80	27.54	64.26	1.55	65.81	27.54	93.35
18	186.48	55.94	130.53	6.34	202.69	83.48	286.17
24	757.41	227.22	530.19	22.62	755.49	310.71	1066.20
30	865.03	259.51	605.52	51.17	1412.18	570.22	1982.40
TOTAL	**1900.72**	**570.22**	**1330.50**	**81.68**	**1412.18**	**570.22**	**1982.40**

HALAIPANI HYDRO PROJECT (16 MW)
COMPLETION COST OF THE PROJECT

Sr. No.	Description	Amount in Rs. Lakhs
1	Civil Works	11178.64
2	E & M Works	1764.13
3	Transmission Works	0.00
4	Escalation	650.58
5	IDC	987.48
	Sub Total	14580.83
6	Financial Charges @2%	204.13
	Total	14784.96
	Grand Total	**14784.96**
	Loan @ 70%	10349.47
	Equity @ 30%	4435.49

ABSTRACT OF COST ESTIMATE

Sl. No	Item	Amount in Rs. Lakhs		
		Civil	E/M	Total
1	2	3	4	5
	I-Work			
1	A- Preliminary	69.00		69.00
2	B-Land	0.00		0.00
3	**C-Works**	**3030.00**		3030.00
(i)	Barrage and Coffer Dams	2679.84		2679.84
(ii)	HM works	350.37		350.37
4	**J-Power Plant Civil works**	**7180.45**		
(i)	Feeder Channel	136.69		136.69
(ii)	Desilting basin	423.78		423.78
(iii)	Power Channel	35.19		35.19
(iv)	Forebay Tank and Spillway	119.93		119.93
(v)	Penstock	495.33		495.33
(vi)	Power House & Tail race Channel	4498.33		4498.33
(vii)	Strengthening & Protection of vulnerable Portion of Power House and Tail Race	0.00		0.00
(viii)	Protection wall, Retaining Wall of Anchor Block & Saddle Block and Gref Road	49.92		49.92
(ix)	Switchyard	24.59		24.59
(x)	HM works (52.5% enhancement on 2011 rates as per DHPD document & add GST 18% & labour Cess @ 1%)	1396.70		1396.70
	Total C+J- Works	**10210.45**		10210.45
5	K- Buildings	376.84		376.84
6	O- Misc	375.00		375.00
	C+J+K+R	**10602.30**		
7	P- Maintainence @1% of (C+J+K)	105.87		105.87
8	Q- Spl. T&p	0.00		0.00
9	R- Communication	15.00		15.00
10	X-Environment	0.00		0.00
11	Y-losses on stocks @ 0.25% of C+J+K	26.47		26.47
I	**Total I works**	**11178.64**		**11178.64**
II	**Establishment**	0.00		0.00
III	**Ordinary Tools and Plants**			
1	Ordinary T&P	0.00		0.00
IV	**Receipt and Recoveries**	0.00		0.00
	Total of direct charges	**0.00**		0.00
V	**Indirect Charges**	0.00		0.00
1	Audit and Account @ 0.5% of I - Work	0.00		0.00
2	Capitalisation of abatement cost	0.00		
	Grand Total	**11178.64**	**1764.13**	**12942.77**
	TOTAL HARD COST	**12942.77**	**LAKHS**	
VI	ESCALATION	**513.99**	**136.59**	**650.58**
VIII	IDC	**905.80**	**81.68**	**987.48**
VIII	FINANCING CHARGES	**204.13**		**204.13**
	Sum of Escalation, IDC, Financing Charges	**1623.93**	**218.27**	**1842.19**
	TOTAL SOFT COST	**12802.56**	**1100.33**	**14784.96**
	TOTAL PROJECT COST, LAKHS		**14784.96**	

HALAIPANI HEP (16 MW) _____

Calculation of energy rate with present day cost @ 100% Load factor

Annual Generation in a Average year	140.16	Total Cost including IDC	147.85	O&M Charges	31.34	Interest rate on Loan	9.67%	Sale of Energy	2.59
		Equity	44.35	Rate of increase of O&M Charges	3.84%	Interest rate on Working Capital	11.17%		
Auxiliary Consumption	1.00%	Loan	103.49			Return on Equity(first 20 yrs)	16.96%		
				Depreciation Rate for 1st 15 yrs	4.67%	Return on Equity(after 20 yrs)	21.52%		
Transformer Losses	0.50%			Depreciation Rate 16th year onwards	0.80%	Discounting Rate for LT-I	8.61%	**as per CERC 20-21**	
Free power to home state	23.05%	First 10 yr.	After 10 yr.			Discounting Rate for LT-II	8.61%		
Net Saleable Energy in MU Avg. Year		106.24	106.24	Maintainence Spares	15.00%	Corporate Tax	34.94%		

Year	Outstanding loan	Interest on loan	Depreciation	Return on Equity	O&M Charges	O&M for 1 month	Maintenance Spares	45 days billing	Interest on Working Capital	Total Annual Plant Charges	Charges/Unit	Discounting Factor @8.61%	Discounting Tariff	Discounting Factor @8.61%	Discounting Tariff
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	103.49	10.01	6.90	7.52	5.014	0.418	0.75	6.11	0.81	30.26	2.85	1.00	2.85	1.00	2.85
2	96.59	10.31	6.90	7.52	5.207	0.434	0.78	6.11	0.82	30.76	2.90	0.92	2.67	0.92	2.67
3	89.69	9.67	6.90	7.52	5.407	0.451	0.81	6.11	0.82	30.33	2.85	0.85	2.42	0.85	2.42
4	82.78	8.94	6.90	7.52	5.615	0.468	0.84	6.11	0.83	29.81	2.81	0.78	2.19	0.78	2.19
5	75.88	8.20	6.90	7.52	5.830	0.486	0.87	6.11	0.83	29.29	2.76	0.72	1.98	0.72	1.98
6	68.97	7.46	6.90	7.52	6.054	0.504	0.91	6.11	0.84	28.78	2.71	0.66	1.79	0.66	1.79
7	62.07	6.72	6.90	7.52	6.286	0.524	0.94	6.11	0.85	28.28	2.66	0.61	1.62	0.61	1.62
8	55.16	5.98	6.90	7.52	6.528	0.544	0.98	6.11	0.85	27.79	2.62	0.56	1.47	0.56	1.47
9	48.26	5.25	6.90	7.52	6.779	0.565	1.02	6.11	0.86	27.31	2.57	0.52	1.33	0.52	1.33
10	41.35	4.51	6.90	7.52	7.039	0.587	1.06	6.11	0.87	26.84	2.53	0.48	1.20	0.48	1.20
11	34.45	3.77	6.90	7.52	7.309	0.609	1.10	6.11	0.87	26.38	2.48	0.44	1.09	0.44	1.09
12	27.54	3.03	6.90	7.52	7.590	0.632	1.14	6.11	0.88	25.93	2.44	0.40	0.98	0.40	0.98
13	20.64	2.29	6.90	7.52	7.881	0.657	1.18	6.11	0.89	25.49	2.40	0.37	0.89	0.37	0.89
14	13.74	1.55	6.90	7.52	8.184	0.682	1.23	6.11	0.90	38.79	3.65	0.34	1.25	0.34	1.25
15	6.83	0.81	6.90	7.52	8.498	0.708	1.27	6.11	0.90	24.64	2.32	0.31	0.73	0.31	0.73
16	0.00	0.00	1.18	7.52	8.824	0.735	1.32	6.11	0.91	18.44	1.74	0.29	0.50	0.29	0.50
17	0.00	0.00	1.18	7.52	9.163	0.764	1.37	6.11	0.92	18.79	1.77	0.27	0.47	0.27	0.47
18	0.00	0.00	1.18	7.52	9.515	0.793	1.43	6.11	0.93	19.15	1.80	0.25	0.44	0.25	0.44
19	0.00	0.00	1.18	7.52	9.881	0.823	1.48	6.11	0.94	19.53	1.84	0.23	0.42	0.23	0.42
20	0.00	0.00	1.18	7.52	10.260	0.855	1.54	6.11	0.95	19.92	1.87	0.21	0.39	0.21	0.39
21	0.00	0.00	1.18	9.55	10.654	0.888	1.60	6.11	0.96	22.34	2.10	0.19	0.40	0.19	0.40
22	0.00	0.00	1.18	9.55	11.063	0.922	1.66	6.11	0.97	22.76	2.14	0.18	0.38	0.18	0.38
23	0.00	0.00	1.18	9.55	11.488	0.957	1.72	6.11	0.98	23.20	2.18	0.16	0.35	0.16	0.35
24	0.00	0.00	1.18	9.55	11.929	0.994	1.79	6.11	0.99	23.65	2.23	0.15	0.33	0.15	0.33
25	0.00	0.00	1.18	9.55	12.387	1.032	1.86	6.11	1.01	24.12	2.27	0.14	0.31	0.14	0.31
26	0.00	0.00	1.18	9.55	12.863	1.072	1.93	6.11	1.02	24.61	2.32	0.13	0.29	0.13	0.29
27	0.00	0.00	1.18	9.55	13.357	1.113	2.00	6.11	1.03	25.12	2.36	0.12	0.28	0.12	0.28
28	0.00	0.00	1.18	9.55	13.870	1.156	2.08	6.11	1.04	25.64	2.41	0.11	0.26	0.11	0.26
29	0.00	0.00	1.18	9.55	14.402	1.200	2.16	6.11	1.06	26.19	2.47	0.10	0.24	0.10	0.24
30	0.00	0.00	1.18	9.55	14.955	1.246	2.24	6.11	1.07	26.76	2.52	0.09	0.23	0.09	0.23
31	0.00	0.00	1.18	9.55	15.530	1.294	2.33	6.11	1.09	27.35	2.57	0.08	0.22	0.08	0.22
32	0.00	0.00	1.18	9.55	16.126	1.344	2.42	6.11	1.10	27.96	2.63	0.08	0.20	0.08	0.20
33	0.00	0.00	1.18	9.55	16.745	1.395	2.51	6.11	1.12	28.59	2.69	0.07	0.19	0.07	0.19
34	0.00	0.00	1.18	9.55	17.388	1.449	2.61	6.11	1.14	29.25	2.75	0.07	0.18	0.07	0.18
35	0.00	0.00	1.18	9.55	18.056	1.505	2.71	6.11	1.15	29.94	2.82	0.06	0.17	0.06	0.17
36	0.00	0.00	1.18	9.55	18.749	1.562	2.81	6.11	1.17	30.65	2.88	0.06	0.16	0.06	0.16
37	0.00	0.00	1.18	9.55	19.469	1.622	2.92	6.11	1.19	31.39	2.95	0.05	0.15	0.05	0.15
38	0.00	0.00	1.18	9.55	20.217	1.685	3.03	6.11	1.21	32.15	3.03	0.05	0.14	0.05	0.14
39	0.00	0.00	1.18	9.55	20.993	1.749	3.15	6.11	1.23	32.95	3.10	0.04	0.13	0.04	0.13
40	0.00	0.00	1.18	9.55	21.799	1.817	3.27	6.11	1.25	33.78	3.18	0.04	0.13	0.04	0.13
												LT-I	**2.58**	LT-II	**2.59**

HALAIPANI HEP (16 MW) _____

Calculation of energy rate with present day cost @ 50% Load factor								
Annual Generation in a Average year	70.08	Total Cost including IDC	147.85	O&M Charges	31.34	Interest rate on Loan	9.67%	Sale of Energy	5.17
		Equity	44.35	Rate of increase of O&M Charges	3.84%	Interest rate on Working Capital	11.17%		
Auxiliary Consumption	1.00%	Loan	103.49			Return on Equity(first 20 yrs)	16.96%		
				Depreciation Rate for 1st 15 yrs	4.67%	Return on Equity(after 20 yrs)	21.52%		
Transformer Losses	0.50%			Depreciation Rate 16th year onwards	0.80%	Discounting Rate for LT-I	8.61%	**as per CERC 20-21**	
Free power to home state	23.05%	First 10 yr.	After 10 yr			Discounting Rate for LT-II	8.61%		
Net Saleable Energy in MU Avg. Year		53.12	53.12	Maintenance Spares	15.00%	Corporate Tax	34.94%		

Year	Outstanding loan	Interest on loan	Depreciation	Return on Equity	O&M Charges	O&M for 1 month	Maintenance Spares	45 days billing	Interest on Working Capital	Total Annual Plant Charges	Charges/Unit	Discounting Factor @8.61%	Discounting Tariff	Discounting Factor @8.61%	Discounting Tariff
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	103.49	10.01	6.90	7.52	5.01	0.42	0.75	6.10	0.81	30.26	5.70	1.00	5.70	1.00	5.70
2	96.59	10.31	6.90	7.52	5.21	0.43	0.78	6.10	0.82	30.76	5.79	0.92	5.33	0.92	5.33
3	89.69	9.67	6.90	7.52	5.41	0.45	0.81	6.10	0.82	30.33	5.71	0.85	4.84	0.85	4.84
4	82.78	8.94	6.90	7.52	5.61	0.47	0.84	6.10	0.83	29.81	5.61	0.78	4.38	0.78	4.38
5	75.88	8.20	6.90	7.52	5.83	0.49	0.87	6.10	0.83	29.29	5.51	0.72	3.96	0.72	3.96
6	68.97	7.46	6.90	7.52	6.05	0.50	0.91	6.10	0.84	28.78	5.42	0.66	3.59	0.66	3.59
7	62.07	6.72	6.90	7.52	6.29	0.52	0.94	6.10	0.85	28.28	5.32	0.61	3.24	0.61	3.24
8	55.16	5.98	6.90	7.52	6.53	0.54	0.98	6.10	0.85	27.79	5.23	0.56	2.93	0.56	2.93
9	48.26	5.25	6.90	7.52	6.78	0.56	1.02	6.10	0.86	27.31	5.14	0.52	2.66	0.52	2.66
10	41.35	4.51	6.90	7.52	7.04	0.59	1.06	6.10	0.87	26.84	5.05	0.48	2.40	0.48	2.40
11	34.45	3.77	6.90	7.52	7.31	0.61	1.10	6.10	0.87	26.38	4.97	0.44	2.17	0.44	2.17
12	27.54	3.03	6.90	7.52	7.59	0.63	1.14	6.10	0.88	25.92	4.88	0.40	1.97	0.40	1.97
13	20.64	2.29	6.90	7.52	7.88	0.66	1.18	6.10	0.89	25.48	4.80	0.37	1.78	0.37	1.78
14	13.74	1.55	6.90	7.52	8.18	0.68	1.23	6.10	0.89	38.79	7.30	0.34	2.50	0.34	2.50
15	0.00	0.00	6.90	7.52	8.50	0.71	1.27	6.10	0.90	23.83	4.49	0.31	1.41	0.31	1.41
16	0.00	0.00	1.18	7.52	8.82	0.74	1.32	6.10	0.91	18.44	3.47	0.29	1.01	0.29	1.01
17	0.00	0.00	1.18	7.52	9.16	0.76	1.37	6.10	0.92	18.79	3.54	0.27	0.94	0.27	0.94
18	0.00	0.00	1.18	7.52	9.52	0.79	1.43	6.10	0.93	19.15	3.61	0.25	0.89	0.25	0.89
19	0.00	0.00	1.18	7.52	9.88	0.82	1.48	6.10	0.94	19.53	3.68	0.23	0.83	0.23	0.83
20	0.00	0.00	1.18	7.52	10.26	0.86	1.54	6.10	0.95	19.91	3.75	0.21	0.78	0.21	0.78
21	0.00	0.00	1.18	9.55	10.65	0.89	1.60	6.10	0.96	22.34	4.21	0.19	0.81	0.19	0.81
22	0.00	0.00	1.18	9.55	11.06	0.92	1.66	6.10	0.97	22.76	4.28	0.18	0.76	0.18	0.76
23	0.00	0.00	1.18	9.55	11.49	0.96	1.72	6.10	0.98	23.20	4.37	0.16	0.71	0.16	0.71
24	0.00	0.00	1.18	9.55	11.93	0.99	1.79	6.10	0.99	23.65	4.45	0.15	0.67	0.15	0.67
25	0.00	0.00	1.18	9.55	12.39	1.03	1.86	6.10	1.00	24.12	4.54	0.14	0.63	0.14	0.63
26	0.00	0.00	1.18	9.55	12.86	1.07	1.93	6.10	1.02	24.61	4.63	0.13	0.59	0.13	0.59
27	0.00	0.00	1.18	9.55	13.36	1.11	2.00	6.10	1.03	25.11	4.73	0.12	0.55	0.12	0.55
28	0.00	0.00	1.18	9.55	13.87	1.16	2.08	6.10	1.04	25.64	4.83	0.11	0.52	0.11	0.52
29	0.00	0.00	1.18	9.55	14.40	1.20	2.16	6.10	1.06	26.19	4.93	0.10	0.49	0.10	0.49
30	0.00	0.00	1.18	9.55	14.96	1.25	2.24	6.10	1.07	26.75	5.04	0.09	0.46	0.09	0.46
31	0.00	0.00	1.18	9.55	15.53	1.29	2.33	6.10	1.09	27.34	5.15	0.08	0.43	0.08	0.43
32	0.00	0.00	1.18	9.55	16.13	1.34	2.42	6.10	1.10	27.96	5.26	0.08	0.41	0.08	0.41
33	0.00	0.00	1.18	9.55	16.75	1.40	2.51	6.10	1.12	28.59	5.38	0.07	0.38	0.07	0.38
34	0.00	0.00	1.18	9.55	17.39	1.45	2.61	6.10	1.13	29.25	5.51	0.07	0.36	0.07	0.36
35	0.00	0.00	1.18	9.55	18.06	1.50	2.71	6.10	1.15	29.94	5.64	0.06	0.34	0.06	0.34
36	0.00	0.00	1.18	9.55	18.75	1.56	2.81	6.10	1.17	30.65	5.77	0.06	0.32	0.06	0.32
37	0.00	0.00	1.18	9.55	19.47	1.62	2.92	6.10	1.19	31.39	5.91	0.05	0.30	0.05	0.30
38	0.00	0.00	1.18	9.55	20.22	1.68	3.03	6.10	1.21	32.15	6.05	0.05	0.28	0.05	0.28
39	0.00	0.00	1.18	9.55	20.99	1.75	3.15	6.10	1.23	32.95	6.20	0.04	0.27	0.04	0.27
40	0.00	0.00	1.18	9.55	21.80	1.82	3.27	6.10	1.25	33.78	6.36	0.04	0.25	0.04	0.25
												LT-I	**5.17**	LT-II	**5.17**