Hydro Power Development Corporation
Arunachal Pradesh Limited

Techno-Economic Review Report

Sumbachu Small Hydro Power Project
(2 X 1.5 MW)

District : Tawang (Arunachal Pradesh)

Project Developer : M/s Hydro Power Development Corporation
Arunachal Pradesh Ltd.

Prepared by:

Alternate Hydro Energy Centre
Indian Institute of Technology
Roorkee-247667

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TABLE OF CONTENTS

ITEMS			Page No.
(i)	Recommendation for Acceptance of the Project		1
(ii.)	Salient Features		S-i to S-iii
(iii)	Photographs		P-i to P-xiii
1.0	Introduction		2
2.0	The sponsor		2
3.0	The assignment		2
4.0	Technical review report		
	4.1	General	3
	4.2	Site Visit	3
5.0	Basic Data		
	5.1	Location	3
	5.2	Topography	3
	5.3	Access	3
	5.4	Climate	4
	5.5	Seismicity	4
	5.6	Geology	4
	5.7	Hydrology	6
6.0	Civil Works		6
	6.1	General	6
	6.2	Diversion Weir & Intake	7
	6.3	Feeder Channel	7
	6.4	Desilting Tank	8
	6.5	Power Channel	9
	6.6	Forebay Tank	9
	6.7	Penstock	10
	6.8	Spillway & Spill Channel	10
	6.9	Power House Building	10
	6.10	Tail Race Channel	11
7.0	Present Status of Civil Works		11
7.1	General		11
7.2	Cost Estimate		12
8.0	Cost Estimate Vis-À-Vis DPR Cost		16
8.1	General		16
8.2	Generation Cost		16
9.0	Recommendations		21

Drawings

(i) General Layout Old & New

(ii) Penstock L-Section

Recommendation for Acceptance of the Project

Techno-Economic Appraisal Report of AHEC, IIT Roorkee for Sumbachu Small Hydro Electric Project in Tawang District of Arunachal Pradesh

After detailed scrutiny of the DPR and other relevant information/site details, we confirm that:

i) The project is technically feasible and financially viable.
ii) Cost estimates of the project have been reviewed and the project is observed to be feasible for implementation.

Following information is recommended for Sumbachu Hydro Electric Project.

Project Name and Developer	Consultants	Parameters	Cost as per DPR (December-2013)	Cost as reviewed by AHEC
Sumbachu Hydro Electric Project (2 × 1.5 MW) (Hydro Power Development Corporation Arunachal Pradesh Ltd., Itanagar)	Concept Green Energy Pvt. Ltd., New Delhi	Estimated Project Cost(Crores)	30.35	30.60
		Unit Available (i) at 75% PLF (ii) at 60% PLF	 19.71 MU 15.77 MU	 19.71 MU 15.77 MU
		Levellised Tariff (i) at 75% PLF • With Subsidy • Without subsidy (ii) at 60% PLF • With subsidy • Without subsidy	 ₹ 2.17/unit ₹ 2.62/unit ₹ 2.71/unit ₹ 3.28/unit	 ₹ 2.43/unit ₹ 2.89/unit ₹ 3.04/unit ₹ 3.61/unit

SALIENT FEATURES

Sl. No.	General		As per DPR	As per AHEC (Mentioned if there is any change and agreed by the Developer
1.0	**LOCATION**			
(i)	State	:	Arunachal Pradesh	
(ii)	District	:	Tawang	
(iii)	Town	:	Zemithang	
(iv)	Village	:	Zemithang	
(v)	Access	:	90 km from Tawang city	
(vi)	Nearest Rail head	:	Bhalukpong 370 km from Zemithang	
(vii)	Nearest Airport	:	Tezpur430 km from Zemithang	
2.0	**NAME OF RIVER/NALLAH**		Sumbachu Nallah	
(i)	Design discharge with 10% over rating flow as adopted in Design for power generation	:	1.485cumec	
(ii)	Type of Nallah	:	Perennial	
(iii)	Minimum flow	:	0.45cumec	
(iv)	Maximum flow(Flood)	:	142 cumec	
(v)	Gross head	:	281m	
(vi)	Net head	:	271m	
3.0	**DIVERSION WEIR**			
(i)	Type	:	Trench weir	
(ii)	Shape	:	Trapezoidal	
(iii)	Length	:	20m	
(vi)	Design discharge	:	1.84 m^3/s including 5%flushing Discharge at intake & 15% flushing discharge in desilting tank	
4.0	**FEEDER CHANNEL**			
(i)	Length	:	55m	
(ii)	Shape/Material	:	Rectangular/R.C.C. (cut &cover)	
(iii)	Size	:	Bed Width - 1.00 m Height -1.20 m	
(vi)	Bed slope	:	1 in200	
(v)	Full supply depth	:	1.0 m	
(vi)	Freeboard	:	0.2 m	
(vii)	Design Discharge	:	1.747cumec	
5.0	**DESILTING TANK**			
(i)	Total Length	:	35.0 m	
(ii)	Width	:	5 m	
(iii)	Full supply depth	:	1.80 m	
(vi)	Freeboard	:	0.30 m	
(v)	Type/Material	:	R.C.C.	
(vi)	Design Discharge	:	1.747m^3/s	

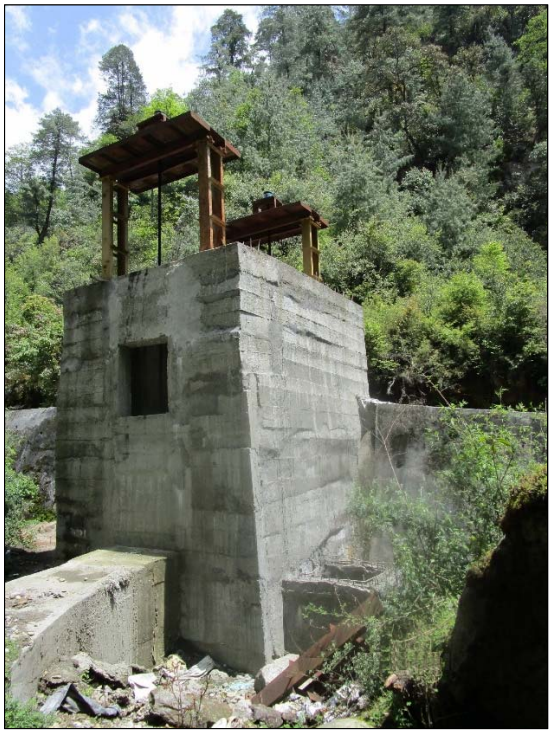
6.0	**POWER CHANNEL**			
(i)	Length	:	270m	
(ii)	Shape/Material	:	Rectangular/R. C. C (cut & cover)	
(iii)	Size	:	Bed Width -1.17 m Height -1.20m	
(vi)	Bed slope	:	1 in500	
(v)	Full supply depth	:	1.0m	
(vi)	Freeboard	:	0.2m	
(vii)	Design Discharge	:	1.485cumecs	
7.0	**FOREBAY TANK**			
(i)	Total Length	:	12.0m	
(ii)	Width	:	6m	
(iii)	Full supply depth	:	2.70m	
(iv)	Free board	:	0.50m	
(v)	Type/Material	:	R.C.C.	
(iv)	Design discharge	:	1.485m^3/s	
8.0	**PENSTOCK**			
(i)	Number	:	one	
(ii)	No, of Anchor block and bands	:	16	18
(iii)	Diameter –Main pipe After bifurcation (for unit penstock)	:	750 mm (I.D.) 520 mm (I.D) and 16 mm thickness	
(iv)	Thickness for main pipe	:	8 mm, 12 mm, 16 mm & 20 mm. Up to 65m, 140m, 205m & 281m respectively	
(v)	Length	:	728 m	743 m
(vi)	Design Discharge	:	1.485cumec	
(vii)	Material	:	Steel	
9.0	**POWER HOUSE**			
(i)	Type	:	R.C.C. masonry with intermediate R.C.C pillars with C.G.I. sheet Roofing.	
(ii)	Size	:	23.0 m × 12 m × 11m	
(iii)	Capacity	:	2 × 1500kW	
(iv)	Gross head	:	281 m	
(v)	Net head	:	271 m	
10.0	**ELECTRO-MECHANICAL EQUIPMENTS**			
(i)	Turbine			
	(a) Type	:	Pelton Horizontal	
	(b) Number	:	2 Nos.	
	(c) Capacity of each turbine	:	1500 kW	
(ii)	Generator	:		
	(a) Type of generators	:	Synchronous	
	(b) Number	:	2 Nos.	

11.	**TAIL RACE CHANNEL**			
(i)	Shape	:	Rectangular	
(ii)	Size	:	1.17 m × 1.0 (water depth) with a free board of 0.2 m	
(iii)	Length	:	80 m (approx.)	
12.	**POWER**			
(i)	Installed capacity	:	2 × 1500kW	
(ii)	No. of Units generated	:		
	(a) at 75% load factor	:	19.71MU	
	(b) at 60% load factor	:	15.77MU	
13.	**ESTIMATE OF COST**			
(i)	Civil Works	:	₹ 1390.64 Lakh	1415.54 Lakh
(ii)	Electro -Mechanical Works	:	₹ 1394.00 Lakh	1394.00 Lakh
(iii)	other expenses	:	₹ 250.12 Lakh	250.12 Lakh
	(a) Cost of Project	:	₹ 3034.76 Lakh	3059.66 Lakh
	(b) Cost Per kW	:	₹ 1.01 Lakh per kW	1.02 Lakh per kW
	(c) Cost of Generation per kWh			
	(i) At 75 % load factor	:		
	- without subsidy	:	₹ 2.62 per unit	₹ 2.89 per unit
	- with subsidy	:	₹ 2.17 per unit	₹ 2.43 per unit
	(ii) At 60 % load factor	:		
	- without subsidy	:	₹ 3.28 per unit	₹ 3.61 per unit
	- with subsidy	:	₹ 2.71 per unit	₹ 3.04 per unit

SITE PHOTOGRAPHS

Pic-1: Weir site

Pic-2: Trench weir



Pic-3 Intake Structure

Pic-4 Feeder Channel

Pic-5 Desilting Tank

Pic-6 Another view of Desilting Tank

Pic-7 Opening for Inspection on Power Channel

Pic-8 Damage roof of Power Channel

Pic-9 Forebay Tank

Pic-10 Escape at U/S of Forebay

Pic-11 Another view of Forebay

Pic-12 D/S view of Forebay

Pic-13 Control Valve at head of Penstock

Pic-14 View of Penstock

Pic-15 Anchor Block at Penstock

Pic-16 Supports below Penstock

Pic-17 Penstock with supports going to Power House

Pic-18 Outer view of Power House

Pic-19 Side view of Power House

Pic-20 Inside view of Power House

Pic-21 Pelton Turbine inside Power House

Pic-22 Butterfly valve

Pic-23 Crane & Other equipment in Power House

Pic-24 Control Panels in Power House

Pic-25 Equipment at site (To be installed)

Pic-26 View of Switchyard (under construction)

SUMBACHU SMALL HYDRO PROJECT (2 × 1.5 MW)

1.0 INTRODUCTION

Sumbachu small hydroelectric project is located in Tawang District in the state of Arunachal Pradesh and envisages utilization of the flow of Sumbachu Nallah for generation of power. The project envisages a generation capacity of 3 MW of power by utilizing the available head between the Nallah elevations at EI 2678.5 m & EI 2389.5m. The project comprises a Trench weir which diverts the water into an intake placed on the right bank of the river. The diverted water is planned to be passed through Desilting basin. Desilted water enters into water conductor system, forebay and the steel pressure shaft. A proposed surface powerhouse is suitably located on a terrace at right bank of the river. Tail water from the powerhouse will be discharged back into the nallah. The project envisages utilization of a net head of about 271.0 m.

2.0 THE SPONSOR

Hydro Power Development Corporation Ltd. of Arunachal Pradesh is responsible for the development of Sumbachu Small Hydel Project on Sumbachu Nallah near Zemithang. The detailed project report had been prepared by Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee (AHEC) in the year 2009. The detailed Engineering design and drawing works was also done by AHEC, Roorkee. The project construction work was awarded as a Turn – key EPC contract to M/s Nortech Power Projects (P) Ltd, Kolkata on 28th February 2009. Subsequently M/s Concept Green Energy Pvt. Ltd., New Delhi was assigned to assess the works already executed and to further assess balance works, preparation of drawings for any revision required and prepare a revised cost estimate of project based on actual condition. Accordingly the report by M/s Concept Green Energy Pvt. Ltd., New Delhi was submitted on Dec. 2013 to HPDCAPL.

3.0 THE ASSIGNMENT

M/s Hydro Power Development Corporation, Itanagar, Arunachal Pradesh has assigned Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee (AHEC) to undertake the techno-economic review of the Detailed Project Report (DPR) of this project vide letter no. HPDC/MD/cont-13/2017-18/119-23 Dated 16.04.2018.

4.0 TECHNICAL REVIEW REPORT

4.1 General

A report – regarding Recasting of DPR cost estimate prepared by M/s Concept Green Energy Pvt. Ltd. has been made available by the developer vide letter no. DC/MD/cont-13/2017-18/119-23 Dated 16.04.2018.

4.2 Site Visit

A team from AHEC made a site visit to the project on May 10, 2018. The scheme was found to be in advance stage of construction. A site inspection report along with the observations by AHEC was sent to the developer vide letter no. AHEC/C-1017/SG/SS/69 Dt. May 24, 2018. It was also requested to send further information documents relevant to the subject matter in the above mentioned letter.

Subsequently, some of the data/information required by AHEC have been made available by the sponsor vide letter no. HPDC/MD/cont-13/2017-18/795-96 Dated Sept. 11, 2018.

5.0 BASIC DATA

5.1 Location

Sumbachu Small Hydel Project is located on the Sumbachu Nallah near Zemithang village in Tawang District of Arunachal Pradesh. The Project site is connected to Tawang by all-weather road which is 90 kms away from Zemithang. There is Pucca all-weather road between Tawang and Zemithang. The project site is located about 430 kms from Tezpur.

5.2 Topography

Sumbachu Small Hydel Project is located in the hilly region of Arunachal Pradesh.

5.3 Access

The project area is accessible from Tawang and Zemithang, through all-weather pucca road and through Railway upto Bhalukpong which is 370 kms from Zemithang.

By Road	:	90 kms from Tawang District Headquarter
	:	430 kms from Tezpur
Nearest Rail Head	:	Bhaluk pong 370 km fromsite
Nearest Airport	:	Tejpur - 430 kms from Zemithang.

5.4 Climate

The project area experiences severe cold in winter & moderate hot in summer season. The maximum temperature is in the order of 30°C and Minimum –15°C during summer and winter respectively. The project receives heavy snowfall during winter.

Due to excessive dryness and high altitude this area also falls in the rain falls shadows and the rainfall is not much. The average depth of snow is stated to be 200 cm.

5.5 Seismicity

The Sumbachu Small Hydel Scheme falls in the seismic zone V as per seismic zoning map of India (IS code-IS: 1983-1986). Accordingly the basic seismic coefficient for the site is 0.08.

5.6 Geology

5.6.1 General

The Himalaya forms one of the highest mountain chains in the world, with more than30 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, from west to east, characterized by the two syntaxial bends, the western syntaxis at Nanga Parbat and the eastern syntax is at Namcha Barwa at its western extremities respectively. The width of the Himalaya from north to south varies between 230 kms to 300 kms with an average width approximating 270 kms. 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. In the south lies the Gowndwani an Indian subcontinent.

The Himalaya is divided, from west to east, into three distinct regions; the Western, Central and Eastern Himalaya. The Nepal Himalaya occupies the central segment, and to its west and east lies the western Himalaya and the eastern Himalaya respectively. From south to north, the Himalaya can be grouped into four parallel, longitudinal mountain belts of varying width, each having distinct physiographic features and its own geological histories:

5.6.2 Regional Geology

The rocks exposed in the Bomdila-Tawang Area of Arunachal Pradesh can be classified into nine lithostraligraphic units viz a-Sela Group, b- Bomdila Group,

c- Tenga Group, d- Bichom Group, e- Gondwana Group, f- Doimara Formation, g- Dafla formation, h- Subansiri formation, and I- Kimin formation.

Sela Group rocks or Sela crystallines are exposed northwest of Dirang and are well developed near sela ridge. It comprises Migmatities, Granites, Gneisses, Calc-gneisses, Kyanite -sillimnite- staurolite sehist with profuse granitic and feldspathic injections. The group as a whole is tranversed by post – tectonic, non-foliated fourmaline granite, pergmatites and vein quartz. These rocks are dominent in the Tawang district (Zemithang area).

5.6.3 Geology of the Site

The area has experienced massive slides in the past and the slided blocks of granitic rocks are found spread all over the valley. The present ground profile seems to have attained a stable terrain where thick vegetation has grown.

5.6.4 Diversion and Intake Structure Site

The diversion site is in a narrow zone of the valley, where the walls of valley are steep. The valley is U-shaped. The diversion site is just below the confluence point of two streams. The U-shape of the valley provides good ground for trench type of weir. In the course of the stream huge boulders are lying. At the diversion site, two huge boulders blocks are lying on both the sides of stream, which are going to provide stability to the structures. The site is ideal one for diversion structure.

5.6.5 Power Channel Intake cum Head Race Channel

Power channel is about 325 m long and is located along the moderate slope of the hill. Along its course the insitu soil cover and hard granitic/gneissic rock is encountered cutting of platform for power channel in the hard rock is going to be difficult one. At the same time in the soil zone in steeper sections the breast wall and retaining wall may be required to check the flow of soil mass and provide stability to the power channel platform. The power channel alignment seems to be stable.

5.6.6 Desilting Cum Forebay Tank

Desilting tank is located on a narrow elongated terrace situated on the moderately sloping side of the valley. The terrace seems to be stable and feasible.

5.6.7 Forebay Tank and Spillway

Forebay tank is located along a hill slope facing the Zemithang River. It is having soil cover with few scanty exposures around it. The spur seems to be stable and ideal one for the Forebay site.

5.6.8 Penstock

In the initial reaches, the penstock is placed over the steep to moderate slope and in the lower reaches it rest over the gentle slope. In the initial segment the slopes are having thick soil cover over the hard rocks, and in the lower portions it rests over the terraces formed out of slided debris. All along its course the vegetation is thick and the alignment seems to be stable. Along the road cuts the toe wall will be required to protect the steeper section of slopes.

5.6.9 Power House

Power house site is placed on a terrace made up of slided debris by the side of Zemithang River. The terrace is having huge blocks of granitic rocks embedded in the matrix of sand, silt and clay. Thick trees are growing all over the place. The terrace seems to be stable for the powerhouse.

5.7 HYDROLOGY

Discharge measurements were conducted by developer for the period of 2001 to 2002. In the absence of hydrological data the design flood for trench weir has been calculated with the help of Manning formula. High flood level is taken as (2682.773). Slope is obtained from L-section of nallah which is about 1/6. The value of N has been assumed 0.3. The flood discharge works out to 142m^3/s.

6.0 CIVIL WORKS

6.1 General

The major part of the supply and project construction has been completed and the balance works are under progress. Some of the selected photographs showing different components are enclosed.

6.2 Diversion Weir & Intake

The design features of weir are as follows.

a. A Trapezoidal trench type weir of having 2.25 m top width & 1.75 m bottom width is provided across the stream for a width of 20 m long. Depth of water

varying from 0.725m to 1.725m. Thickness of trench weir walls and base is 0.70 m.

b. The intake structure has been provided on right side of the stream. This shall ensure passage of water to the intake channel.

c. The weir has been designed for a design flood of 142 m^3/sec. The top of abutments and operation deck are therefore provided at suitable elevation.

d. A vertical trash rack consisting of 12×50 mm mild steel flats at 30 mm clear spacing in full width of intake channel is provided so that the entry of stones, boulders etc. into the weir is checked. The clogging of the trash rack is not envisaged for more than 50-60percent.

e. A vertical gate is also provided to regulate the flow of water into the intake well.

Weir site and trench weir are shown in Pic-1 & 2 respectively and the Intake structure has been shown in Pic-3 enclosed with the report.

6.3 Feeder Channel

The water fed from diversion weir is led to de-silting tank through a Rectangular R.C.C. channel (bed width 1.00 m x water depth 1.00 m and bed slope = 1/200). At every interval of 50.0m suitable man holes have been provide for inspection and maintenance purpose. Pic-4 shows the part of constructed feeder channel.

The channel is designed on the following criteria:

a. To keep incoming sediment moving in the supply channel up to de-silting tank, the flow velocity is kept 1.88 m/s which is more than the velocity required to move the particles up to 30 mm size. The slope of channel is provided as 1 in 200.

b. Design discharge of the feeder channel is 1.76m^3/s.

c. Free board is kept 0.20m.

d. Total length of feeder channel is 55m.

6.4 Desilting Tank

The nallah carries appreciable quantities of coarse silt during rainy season. A desilting chamber is considered necessary to remove silt particles to minimize the abrasion effects on the turbine runners. The Sumbachu small hydro schemes is medium head scheme (gross head 281 m), so it is proposed to provide a desilting chamber to remove sediment particles of 0.25 mm size and above. The design is

calculated according to CBIP publication No. 175 entitled “Small Hydro Stations – standardization”. The design features of desilting tank are as follows:

a. The discharge coming from feeder channel is 1.76 cumecs. It is proposed that 15% is used in continuous flushing of silt deposited in the tank.
b. Particles of 0.25 mm size and above have been proposed to be trapped in the tank, keeping in view the turbine type proposed.
c. The flow velocity is reduced to 0.20 m/s. The size of tank is fixed as 15.0 m × 5.0 m × 1.8 m (depth), based on the time taken by particles to settle down. The desilting tank is proposed to be constructed in M 20RCC.
d. The tank is divided into three Hoppers of equal width i.e. width of each chamber is kept 5.0m. Hoppers have been provided for silt collection and flushing out the silt.
e. The free board in the tank is kept 0.30m.
f. Suitable channel transitions of 12.0 m length on upstream and 8.0 m length on downstream.
g. Small RCC outlet of size 0.40 m × 0.4m × 0.4m has been provided below each hopper to collect silt ridden water.
h. One pipe each of 200 mm dia. with gate valve has been provided at the end of all three RCC. Chambers to discharge the silt ridden water into flushing channel.
i. Suitable protection works are proposed at the junction of flushing channel with nallah disposing the silt ridden water.

Desilting tank has been shown in Pic-5 & 6 enclosed in the report.

6.5 Power Channel

The water fed from de-silting tank is led to forebay tank through Rectangular R.C.C. channel (bed width 1.17 m × water depth 1.00 m and bed slope = 1/500). At every interval of 50.0m suitable man holes have been provided for maintenance & cleaning purpose.

The channel is designed on the following criteria:

a. To keep incoming sediment moving in the supply channel up to de-silting tank, the flow velocity is kept 1.28 m/s. The slope of channel is provided as 1 in500.
b. Design discharge of the intake channel is 1.5m^3/s.

c. Free board is kept 0.20m.

d. Total length of Power channel is 270 m.

Power channel is shown in Pic-7&8 and the escape provided in the power channel U/s of Forebay is shown in Pic-10 enclosed in the report.

6.6 Forebay Tank

The forebay tank has been 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 terrain is favorable. The forebay is provided to ensure supply of immediate water demand on starting the generating units and to meet the demand in emergency like breach of power channel. The forebay is designed for the discharge of 1.5 cumecs. Features of forebay tank are as follows:

a. Storage time has been kept 2 minutes as per guide lines issued by Central electricity Authority-1982. Accordingly, the size of tank is kept as 12.0 m (L) × 6.0 m (W) × 2.7 m (D), keeping in view that the combined storage of desilting tank and forebay tank would be available.

b. A minimum water cover of 0.80 m is provided over the crown of penstock intake from the MDDL in the forebay tank to prevent any possible air entry into the penstock.

c. Storage of 0.35 m (Depth) is provided below the penstock invert for possible silt deposition which would be by silt flushing pipe of 150 mm dia.

d. A mild slope for the silt movement is provided in the floor towards the silt flushing outlet.

e. A bell mouth entry in provided at the inlet of penstock pipe to reduce the entry losses.

f. A mild steel trash rack with racks at 30 mm clear spacing is provided at penstock intake to check the entry of trash into penstock.

Enclosed Pic-9, 11 & 12 show the different view of the forebay tank.

6.7 Penstock

Water from forebay is being taken to the powerhouse to run hydraulic turbine through pressurised penstock pipe running from forebay tank. The penstock pipe of mild steel has been erected as penstock made of other material such as R.C.C., P.V.C., high density polythene plastic etc. are not economical for such sizes & site conditions in comparison to steel pipes. Various criterions adopted for penstock design are as

follows:

a. A steel penstock of 750mm inner dia. is erected from economical point of view. The penstock thickness is kept as 8 mm, 12 mm, 16mm & 20 mm for the head up to 65 m, 140m, 205m & 281 m respectively. This penstock will feed 2 units through a bifurcation piece. The length of penstock pipe (main) is 743 m per revised layout.

b. The design head for the penstock pipe is 281.0 m plus 50 percent water hammer pressure.

c. The penstock is to be kept buried into the ground duly supported over saddles and anchor blocks, to provide insulation to it.

d. The penstock intake is provided with bell mouthing to have smooth entry of water.

e. A gate valve of 750 NB which is shown in pic-13 enclosed in the report is provided near the penstock intake to control the flow in penstock along with a bye-pass valve of 150 mm NB which shall fill the penstock in the start to have balancing head across the gate valve.

f. A trash rack before the bell mouthing is provided for preventing entry of trash in the penstock.

g. An air vent tube of 100 mm dia. is provided just downstream of penstock intake to release the air if entered into penstock.

Pic-14 to 17 show different view of penstock with anchor block and saddle supports provided.

6.8 Spillway & Spill Channel

To allow the water to escape from forebay tank in case of emergency shutdown of the machines, 5 m wide spillway is provided on left side of power channel about 50 m u/s of forebay tank. Just below the spillway, a spill channel is provided to discharge spilling water into Sumbachu Nallah.

The spillway is designed for the flow of 1.5 cumecs discharge with crest level 5 cm higher than the full supply level of power channel.

6.9 Power House Building

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

a. The building of size 29.75 m × 16.75 m in plan is provided to accommodate 2 machines of 1500 kW each, control panels, auxiliary equipment etc.
b. The height of the building is kept 11m upto roof beam including the provision of crane to facilitate handling of equipment during erection and maintenance.
c. Walls of the building are made of stone masonry with R.C.C. columns running in between the walls as shown in the drawing.
d. E.O.T Crane is provided to facilitate the handling of equipment over rails supported on R.C.C. columns.
e. A trench of 0.3 m × 0.3 m with slope 1 in 100 for drainage may be provided around the power house building discharging into tail race channel.
f. Machine foundation has been provided as block foundation of reinforced cement concrete of M20.
g. The floor of powerhouse building is provided at an elevation of EL 2388.40m.
h. All the windows and ventilators be provided on southern side in order to arrest maximum sunrays.

Outside view of power house building in shown in Pic-18 & 19 enclosed in the report. Pic-20 to 24 show the inside of power house with different equipment installed in it. Pic-25 shows the equipment to be installed in power house.

A view of the switchyard (under construction) is shown in Pic-26.

6.10 Tail Race Channel

Turbine discharge shall be disposed off to Nyaritang Chhu River through a common tailrace channel for both the units. The width of channel as 1.00 m and water depth of 1.0 m with a free board of 0.20 m. The length of tail race channel is approximately 80 meter and channel is provided with the slope suitable to the terrain. At the end of channel, where it joins with river, protection works have been provided consisting of boulders in crates.

7.0 PRESENT STATUS OF CIVIL WORKS

7.1 General

The major part of the project construction has been completed. Some minor works along with repair and maintenance work are yet to be done.

The component wise status of civil works up to August 2018 is given below:

Sl. No.	Subhead	Project Status	Remarks
1.	Trench weir	Completed	
2.	Intake Structure	Completed	
3.	Feeder Channel	Completed	Minor repairs and maintenance is required.
4.	Desilting Tank	Completed	Silt pipe is clogged which is to be cleared.
5.	Power Channel	Completed	Minor repairs to be done
6.	Forebey Tank	Completed	Roof covering & full size wall of valve chamber is to be completed.
7.	Spillway	Completed	
8.	Penstock		
(a)	Anchor blocks	Completed	
(b)	RCC works	Completed	
(c)	Saddle blocks	Completed	
(d)	Pipe laying	Completed	Pipeline between AB7 and AB8 is deformed which is to be corrected.
9.	Power House	80% complete	Rolling shutter fixing of ceiling, door & window shutters, main hall flooring finishing, priming and painting work in building is yet to be done.
10.	Tail Race Channel	Completed	Repair at cooling sump to be done
11.	Switchyard	Completed	Boundary fencing and frame fixing work to be done.
12.	Buildings	Completed	Minor repair works to be done
13.	Approach Roads	Completed	Black topping to be done

7.2 COST ESTIMATE

7.2.1 Revised Cost Estimate

The project cost estimate has been revised in this report according to the change of penstock layout and the components designs and the rates based on the contract documents. For the revised estimation purpose, the quantities as per the actual work executed at site are adopted. The major deviation of cost with respect to recast estimate is in the penstock section as the penstock length has been increased from 728 m to 743 m.

The detailed breakup of the cost estimation of penstock is presented in Table-I.

TABLE-I: PENSTOCK PIPE

Sl. No.	Brief description of work	Unit	Rate*	As per Contract		As per Revised Estimate by M/s Concept Green Energy Pvt. Ltd.		As per AHEC	
				Qty.	Amount (Rs.)	Qty.	Amount (Rs.)	Qty.	Amount (Rs.)
1	2	3	4	5	6	7	8	9	10
A.	**Items as per DPR prepared M/s Concept Green Energy Pvt. Ltd.**								
1.	Excavation in foundation trenches not exceeding 1.50 m width or 10 m^2 on plan or drains not exceeding 1.50 m in width or 10 m^2 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 50 mm								
(a)	Ordinary Rock	Cum	584	675	394200	1202.15	702056	1202.15	702056
(b)	Hard Rock requiring and watching etc. complete	Cum	878	450.11	395242	570.17	500666	570.17	500666
2	Re-filling excavated earth in foundation and plinth etc. in 15 cm layer including ramming and watering etc. complete.	Cum	110	337.58	37134	510.26	56129	510.26	56129
3	Providing and laying cement concrete 1 : 2 : 4 (1 cement 2 coarse sand 4 graded stone aggregate 40 mm nominal size) including the cost of centering an joints finishing curing T&P etc. complete as per i/c.								
(a)	Foundation and plinth	Cum	5730	46.61	267052	94.13	539318	94.13	539318
4	Reinforced concrete work in foundation, footings bases of columns etc. and mass concrete excluding cost of centering shuttering and reinforcement in								
(a)	1 : 1.5 : 3 (1 cement : 1.5 coarse sand : 3 stone aggregate 20 mm nominal size)	Cum	7998	282.84	2262126	1587.06	12693147	1587.06	12693147
5	Reinforced of RCC work including bending, binding and placing in position								
(a)	Cold twisted bars	Kg	75	22200	1656120	61617.01	4596629	61617.01	4596629
6	Providing and supplying penstock pipe	Kg	154	167000	25634500	210711.00	32344139	210711.00	32344139

7	Installation and erection of penstock pipe @ 30% of item no 5.	Kg	46	167000	7690350	210411.00	9703242	210411.00	9703242
8	Providing expansion joints in penstock as per drawing and specifications.	No.	198100	9	1782900	11.00	2179100	11.00	2179100
9	Supply steel bends trifurcating piece for penstock including cutting welding all	No.	115000	9	1035000	15.00	1725000	15.00	1725000
10	Bend fabrication	No.	287000	9	2583000	15.00	4305000	15.00	4305000
11	plate below pipe on saddle blocks	No.	8200	103	844600	86.00	705200	86.00	705200
12	Sluice valve 750dia 10 kg/cm^2	No.	599951	1	599951	-		-	
13	Sluice valve 520dia 10 kg/cm^2	No.	650000	2	1300000	-		-	
	Total		A		**464,82,174**		**700,49,624**		**700,49,624**
	Extra cost on A/C of interior place absence of the infrastructure facility statutory clearances for labour & materials remote boarder are and deviation of work in foundation etc.			15 over A	6972326	15% over B	10507444	15% over B	10507444
	Total (Rs.)				**534,54,501**		**80557068**		**80557068**

Sl. No.	**Brief description of work**	**Unit**	**Rate****	**As per Contract**		**As per Revised Estimate by M/s Concept Green Energy Pvt. Ltd.**		**As per AHEC**	
				Qty.	**Amount (Rs.)**	**Qty.**	**Amount (Rs.)**	**Qty.**	**Amount (Rs.)**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B.	**Extra Items envisaged during site visit of AHEC Team**								
1.	Excavation in foundation trenches not exceeding 1.50m width or 10 m^2 on plan or drains not exceeding 1.50 m in width or 10 m^2 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 50 mm								
(a)	Ordinary Rock	Cum	584					2500	1460000
(b)	Hard Rock requiring and watching etc. complete	Cum	878					20.0	17560

2	Re-filling excavated earth in foundation and plinth etc. in 15 cm layer including ramming and watering etc. complete.	Cum	110					2000	220000
3 (a)	Providing and laying cement concrete 1 : 2 : 4 (1 cement 2 coarse sand 4 graded stone aggregate 40 mm nominal size) including the cost of centering an joints finishing curing T&P etc. complete as per i/c. Foundation and plinth	Cum	8063.6					100	806960
4 (a)	Reinforced concrete work in foundation , footings bases of columns etc. and mass concrete excluding cost of centring shuttering and reinforcement in 1 : 1.5 : 3 (1 cement : 1.5 coarse sand : 3 stone aggregate 20 mm nominal size)	Cum						1677.58	16995177
5 (a)	Reinforced of RCC work including bending, binding and placing in position Cold twisted bars							-	-
6	Providing, laying, fabrication installation of penstock pipe including red oxide painting	RM						118	10092304
	Total (B)								**29592001**
	Total A (Cost as per Contract)								**53454501**
	Grand Total (A+B)								**83046502**

* Rates as per agreement

** Rates as per measurement book against which the payment has been made to contractor for extra items.

8.0 COST ESTIMATE VIS-À-VIS DPR COST

8.1 General

Based on the present condition of the project and efforts required to complete the balance works for completion of the project AHEC has worked out final cost estimate. A comparative statement of the DPR cost estimate, recast cost estimate and final cost estimate by AHEC has been shown below in the tabular form.

Sl. No.	Sub Head	Estimated Cost as per DPR (Rs. in lakh)	Revised Cost Estimate (Rs. in lakh)	Cost Estimate by AHEC
1.	Civil works	508.10	1390.64	1415.54
2.	E&M works	1070.93	1394.00	1394.00
3.	Other expenses	458.20	250.12	250.12
4.	Project cost	2037.23	3034.76	3059.66
5.	Installation cost (per kW)	0.68	1.01	1.02

8.2 Generation Cost

The cost of generation mentioned below is in the line with the standard procedure and guidelines for the small Hydel power projects and hence there are no changes envisaged in this sub-head and quoted below from DPR.

i. Cost of generation per kWh of power depends on total annual generation and annual working expenditure.

ii. The annual expenditure will consist of

   a. Operation cost @ 1 percent of works cost

   b. Maintenance cost @ 1 percent of cost of civil works
      @ 2 percent of cost of electro-mechanical works

   c. Depreciation charges-considering life of civil works and electro-mechanical works as per standard norms given in the Gazette of India Extraordinary part-II section -3, sub section (ii) published by Ministry of power and non-Conventional energy sources, Dept. of power Govt. of India, vide notification No. 14155/2003 dated 29.07.2003.

   d. Interest @ 12% per annum on capital invested.

iii. The annual working expenses has been worked out and given in Table-8.4

iv. Annual units generated are computed as 19.71 Million units at 75% load factor & 15.77 MU at 60% load factor. The generation cost per kWh has been worked out and given in Table - 8.3 with subsidy and without respectively.

Table 8.1:- Abstract of Cost Estimates

Sl. No.	Items	Cost as per DPR (Rs. Lakh)	Cost as per M/s Concept Green Energy Pvt.Ltd. (Rs. Lakh)	Cost as per AHEC (Rs. Lakh)
I	**I - Works**			
	A - Preliminary	21.33	21.33	21.33
	B- Land	35.25	35.25	35.25
	C - Civil Works	508.10	1390.64	1415.54
	J - Power Plant	558.33	1394.00	1394.00
	K- Building	74.65	92.50	92.50
	M - Plantation	22.63	0.00	0.00
	O- Miscellaneous Fixed Assets	30.20	0.00	0.00
	P - Maintenance	10.66	0.00	0.00
	Q- Special T & P	2.75	0.00	0.00
	R -Communication	35.00	80.50	80.50
	Y - Losses on stock	2.67	0.00	0.00
	Sub -Total (I -Works)	**1301.57**	**3014.22**	**3039.12**
II	Establishment	130.16	0.00	0.00
III	Ordinary T & P	13.02	0.00	0.00
IV	Suspense	0.00	0.00	0.00
V	Receipts and Recoveries	(-) 6.58	(-) 5.81	(-) 5.81
VI	Indirect Charges	86.47	26.35	26.35
VII	Transmission and Distribution line	512.60	Included in J-works	Included in J-works
	Total Project Cost	**2037.24**	**3034.76**	**3059.66**

Table 8.2:- Abstract of Cost of Civil Works

Sl. No.	Items	Cost (Rs. Lakh)
1	Diversion Weir and Intake	104.80
2	Feeder cum Power channel	95.11
3	Desilting cum forebay Tank and Spillway channel	133.70
4	Penstock	830.47
5	Power house and Tail Race	251.46
	Total	**1415.54**

Table 8.3 - Cost of Generation

Sl. No.	Items	Cost with Subsidy (Rs. Lakh)	Cost without Subsidy (Rs. Lakh)
1	Project Cost	3059.66	3059.66
2	Capital Subsidy As per MNRE	675.00	-
3	Balance Project Cost	2384.66	-
4	Annual Interest during Construction	264.41	339.26
5	Total Project Cost	2649.07	3398.92
6	Interest @ 12% on Total project cost	317.89	407.87
7	Annual working expenses (As per table -8.4)	161.62	161.62
8	Total annual expenses	479.51	569.49
9	Net Annual generation at power house (Million Units)		
	(i) At 75 % PLF	19.71	19.71
	(ii) At 60 % PLF	15.77	15.77
10	Cost of generation per kWh (in Rs.)		
	(i) At 75 % PLF	2.43	2.89
	(ii) At 60 % PLF	3.04	3.61

Table: 8.4:-Statement of Yearly Working Expenses

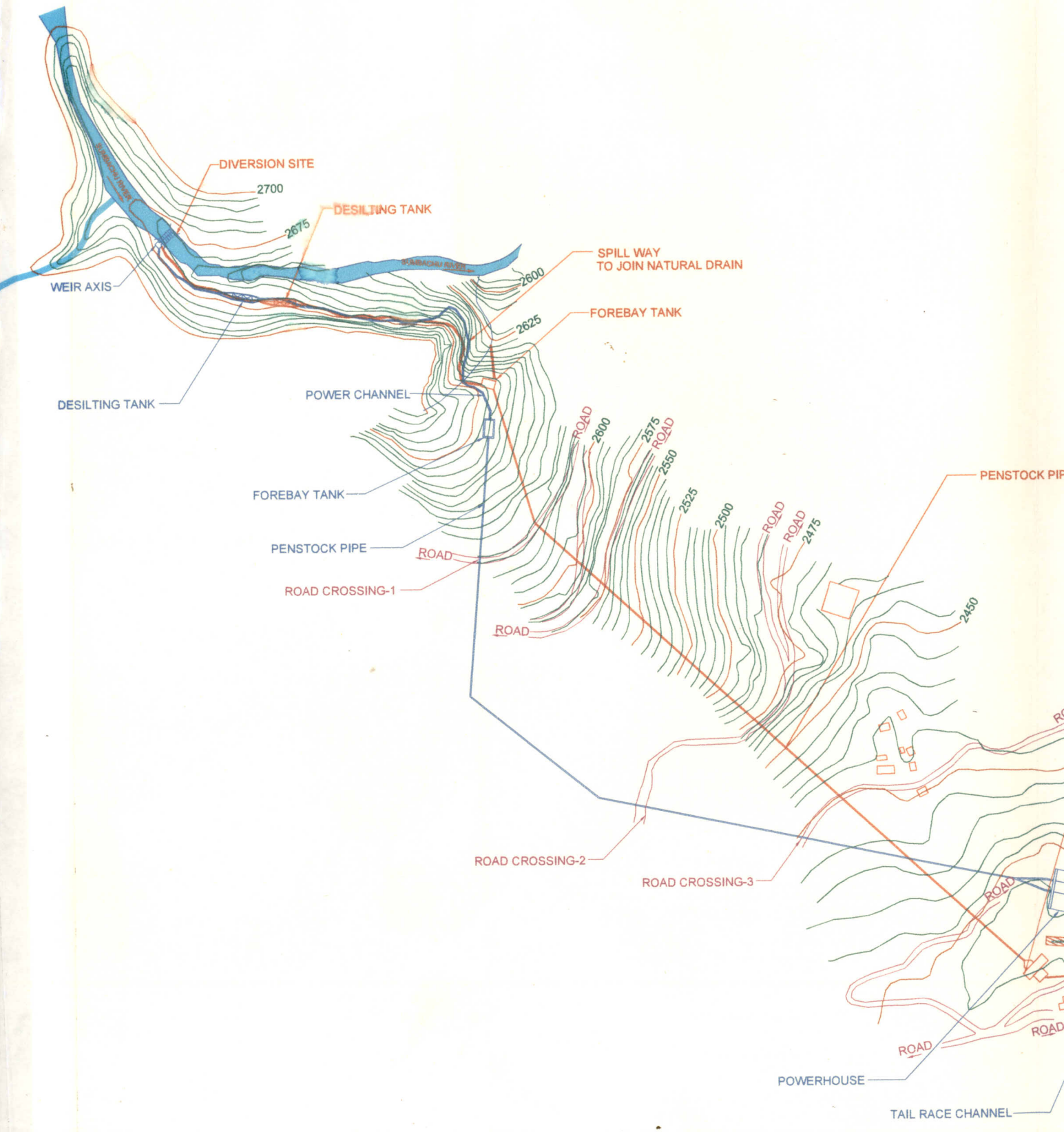
Sl. No.	Items	Cost (Rs. Lakh)
1	Operation cost @ 1% of Total cost	30.60
2	Maintenance cost of C-works @ 1%	14.16
3	Maintenance cost of E & M works @ 2%	17.63
4	Annual depreciation charges (As per Table- 8.5)	99.24
	Total	**161.62**

Table 8.5:-Annual Depreciation of Assets

Sl. No.	Items	Life in Year	Cost (Rs. Lakh)	Rate of Depreciation (%)	Depreciation (Rs. Lakh)
1	Land	Infinity	0.00	**NIL**	**NIL**
2	Intake channel, Power Channel , D. tank, HRC, tail race ,approach road and other Misc. Works	50	333.61	1.95	6.51
3	Power house building , Penstock, valves etc.& Hydro-Mechanical works	35	1099.69	3.40	37.39
4	Turbines, Generators and other E&M works	35	1118.00	3.40	38.01
5	Transformers, switchgears ,LT Distribution board, Transmission line, Isolator and control cables , D.G set etc.	25	197.26	7.84	15.47
6	Fire Fighting Equipment, Ventilation equipment, Compressed air system and Water system, Drainage & dewatering. communication system etc.	15	4.68	8.24	0.39
7	Lighting system & Illumination	15	3.00	12.77	0.38
8	Batteries with charger	5	3.87	21.55	0.83
9	Earthing of Power house & Switchyard	50	8.84	3.02	0.27
	Total				**99.24**

9.0 RECOMMENDATIONS

1. The penstock realignment works executed finally at site are correct and as per the site conditions.
2. The revised cost of the project increased to Rs.3059.66 lakh from DPR cost of Rs.2037.23 lakh. The increase in cost is mainly due to
   (i) Cost difference between the time of estimation and actual construction
   (ii) Realignment of Penstock.
   (iii) The revised cost of Rs. 3059.66 lakh may be accepted.



NEW LAYOUT PREPARED BASED ON DRAWING NO. 39410063, JULY 2010.

OLD LAYOUT PREPARED BASED ON DRAWING NO. 39410007,MAY 2009.

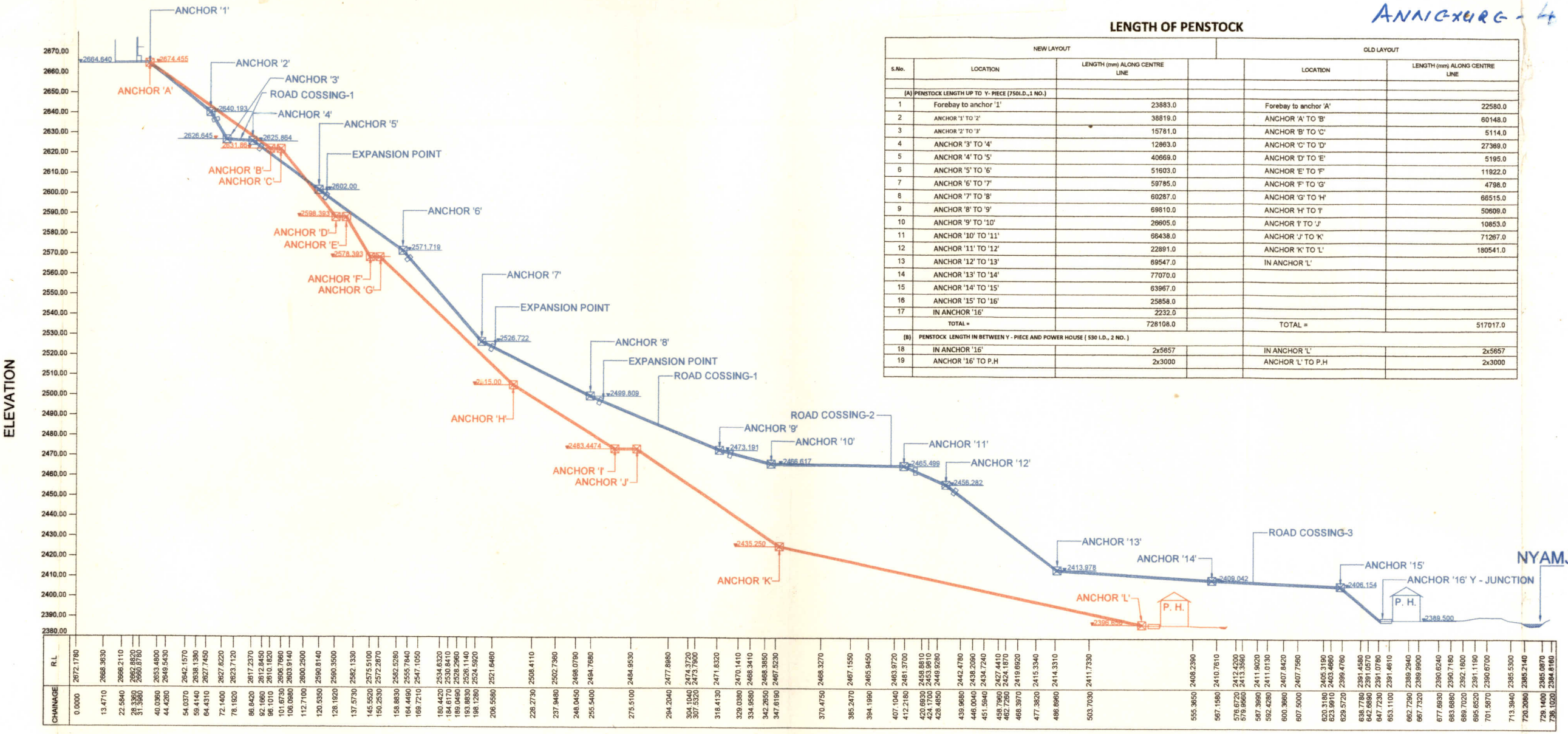
NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS.
2. INDICATIVE DRAWING FOR REFERENCE ONLY
3. DRAWING PREPARED BASED ON DRAWING NO. 39410007 & 39410063

NOT TO BE USED FOR CONSTRUCTION

CONSULTANT : CONCEPT GREEN ENERGY PRIVATE LIMITED			
DEVLOPER : HYDRO POWER DEVELOPMENT CORPORATION ARUNACHAL PRADESH LIMITED			
PROJECT : SUMBACHU SMALL HYDRO PROJECT			
PREPARED : KAS	DATE : 12/09/13	DRAWING TITLE : GENERAL LAYOUT OLD & NEW	
CHECKED :	DATE :		
APPROVED :	DATE :	SCALE : NTS	FORMAT : A1
DEPARTMENT : ENGINEERING	DRAWING TYPE: DPR DRAWING		REV.NO. : 0
PROJECT CODE:	DOCUMENT NO. CGE/SUMBACHU/DPR-R/001		SHEET : 1/1

ANNEXURE - 4



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22.5940	2666.2110
28.3060	2665.0760
31.3060	2664.6760
40.0360	2653.4600
44.4260	2649.5430
54.0370	2642.1570
59.4140	2638.1380
64.4310	2627.7450
72.1400	2627.6220
78.1920	2623.7120
86.8420	2617.2370
92.1660	2612.8450
96.1010	2610.1620
101.6730	2606.7660
106.0980	2603.9140
112.7100	2600.2500
120.5350	2590.8140
128.1920	2580.3500
137.5730	2582.1330
145.5520	2575.5100
150.2530	2572.2870
158.8830	2562.5280
164.4490	2555.7840
169.7210	2547.1050
180.4420	2534.6320
184.6170	2530.8410
189.0490	2528.2960
193.9830	2524.5140
198.1290	2524.5920
206.5580	2521.6460
226.2730	2508.4110
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275.5100	2484.9530
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304.1040	2474.9720
307.3320	2474.7060
318.4130	2471.8320
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334.9580	2468.3410
342.2650	2468.3850
347.8190	2467.5230
370.4750	2468.3270
385.2470	2467.1550
394.1990	2465.9450
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412.2180	2461.3700
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486.6960	2414.3310
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555.3650	2408.2390
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592.4280	2411.0130
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607.5000	2407.7560
620.3180	2405.3190
623.9910	2403.4660
629.5720	2399.4760
638.7780	2391.4580
642.6680	2391.0570
647.7230	2391.0780
653.1100	2391.4610
662.7290	2389.2940
667.7320	2389.9900
677.6930	2390.6240
683.6880	2390.7160
689.7020	2392.1600
695.6520	2391.1190
701.5870	2390.6700
713.3940	2385.5300
720.2060	2385.2140
729.1400	2385.0870
736.1020	2384.8160

LENGTH OF PENSTOCK

	NEW LAYOUT			OLD LAYOUT	
S.No.	LOCATION	LENGTH (mm) ALONG CENTRE LINE		LOCATION	LENGTH (mm) ALONG CENTRE LINE
(A)	PENSTOCK LENGTH UP TO Y- PIECE (750I.D.,1 NO.)				
1	Forebay to anchor '1'	23883.0		Forebay to anchor 'A'	22580.0
2	ANCHOR '1' TO '2'	38819.0		ANCHOR 'A' TO 'B'	60148.0
3	ANCHOR '2' TO '3'	15781.0		ANCHOR 'B' TO 'C'	5114.0
4	ANCHOR '3' TO '4'	12863.0		ANCHOR 'C' TO 'D'	27389.0
5	ANCHOR '4' TO '5'	40669.0		ANCHOR 'D' TO 'E'	5195.0
6	ANCHOR '5' TO '6'	51603.0		ANCHOR 'E' TO 'F'	11922.0
7	ANCHOR '6' TO '7'	59785.0		ANCHOR 'F' TO 'G'	4798.0
8	ANCHOR '7' TO '8'	60287.0		ANCHOR 'G' TO 'H'	66515.0
9	ANCHOR '8' TO '9'	69810.0		ANCHOR 'H' TO 'I'	50609.0
10	ANCHOR '9' TO '10'	28605.0		ANCHOR 'I' TO 'J'	10853.0
11	ANCHOR '10' TO '11'	66438.0		ANCHOR 'J' TO 'K'	71267.0
12	ANCHOR '11' TO '12'	22891.0		ANCHOR 'K' TO 'L'	180541.0
13	ANCHOR '12' TO '13'	69547.0		IN ANCHOR 'L'	
14	ANCHOR '13' TO '14'	77070.0			
15	ANCHOR '14' TO '15'	63967.0			
16	ANCHOR '15' TO '16'	25858.0			
17	IN ANCHOR '16'	2232.0			
	TOTAL =	728108.0		TOTAL =	517017.0
(B)	PENSTOCK LENGTH IN BETWEEN Y - PIECE AND POWER HOUSE (530 I.D., 2 NO.)				
18	IN ANCHOR '16'	2x5657		IN ANCHOR 'L'	2x5657
19	ANCHOR '16' TO P.H	2x3000		ANCHOR 'L' TO P.H	2x3000

NEW LAYOUT PREPARED BASED ON DRAWING NO. 39410074, OCT 2011.

OLD LAYOUT PREPARED BASED ON DRAWING NO. 39410005, MARCH 2009.

NOT TO BE USED FOR CONSTRUCTION

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS.
2. INDICATIVE DRAWING FOR REFERENCE ONLY
3. DRAWING PREPARED ON DRAWING NO. 39410005 & 39410074

CONSULTANT : CONCEPT GREEN ENERGY PRIVATE LIMITED			
DEVLOPER : HYDRO POWER DEVELOPMENT CORPORATION ARUNACHAL PRADESH LIMITED			
PROJECT : SUMBACHU SMALL HYDRO PROJECT			
PREPARED : KAS	DATE : 12/09/13	DRAWING TITLE : PENSTOCK L-SECTION	
CHECKED :	DATE :		
APPROVED :	DATE :	SCALE : 1:1000	FORMAT : A3
DEPARTMENT : ENGINEERING	DRAWING TYPE: DPR DRAWING		REV.NO. : 0
PROJECT CODE:	DOCUMENT NO. CGE/SUMBACHU/DPR-R/002		SHEET : 1/1