Final Report on

Preparation of Hydropower Master Plan/Preliminary Feasibility Study of Jugal Rural Municipality, Sindhupalchowk

Submitted To:

Jugal Rural Municipality
Office of Rural Municipal Executives
Baramchi, Sindhupalchowk, Province : 3, Nepal

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July 02, 2018

ABBERVIATIONS

AEPC	Alternative Energy Promotion Centre
BAU	Business As Usual
DHM	Department of Hydrology and Meteorology
DOED	Department of Electricity Development
GIS	Global Information System
GoN	Government of Nepal
GWh	Giga Watt Hour
IT	Information Technology
KW	Kilo Watt
LCOE	Least Cost of Energy
MHP	Micro Hydro Project
MW	Mega Watt
NEA	Nepal Electricity Authority
NPC	National Planning Commission
PPA	Power Purchase Agreement
R& D	Research and Development
RL	Reduced Level
ToR	Terms of Reference
ToE	Tons of Oil Equivalent
VDC	Village Development Committee
WECS	Water and Energy Commission Secretariat

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ANNEX

CHAPTER 1: Hydropower Development Scenario of Nepal

Background

The history of hydropower development in Nepal has begun with the construction of Hydropower Plant in Pharping (500 kW) in 1911, 29 Years after the world's first plant was established. This plant was constructed during Prime Minister Chandra Shamsher's time to meet the energy requirements of the members of ruling class.

In the last 100 years time, about 600 MW of hydropower has been generated. In last few years, Nepal faced extreme load shedding and it worst hit the economy of the country. In last decades, almost all the Governments have given high priority in this sector. As of now, total hydropower development of Nepal is 961.2 MW (as of August 2017) and there is still load shedding in few parts of the country with load shedding in industrial area during peak time. At the present demand pattern, there is energy gap of 482.9 MW.

Major energy stakeholders in Nepal are Nepal Electricity Authority (NEA), Independent Power Producers (IPP) and the imported electricity from India. Now, NEA and NEA subsidiary company led 740 MW hydropower Projects are under construction and these projects are estimated to be operated by 2022 AD. 140 hydropower projects with installed capacity 3524 MW have obtained licenses and in different phases of construction. So, it is expected that very soon Nepal will have sufficient power to meet the normal energy demand very soon. The database of Department of Electricity Development (DoED) shows that till now 757 numbers (including survey applications) of hydropower projects with cumulative installed capacity of 20401 MW are in different phases of Study and development.

Hydro Potential of Nepal

The study made by Er. Khimananda Kandel in the book " A Comprehensive Study on Hydropower Potential of Nepal" has shown the following hydro potential of Nepal.

Table 1: Hydropower Potential of Nepal in Terms of Installed Capacity (MW)

S. N.	River Basin	Q20 Power (MW)	Q40 Power (MW))	Q60 Power (MW)	Q80 Power (MW)	Average Power (MW)
1	Arun River Basin	15538.04	6699.69	3089.58	2126.80	8182.87
2	Tamor River Basin	8749.17	3367.09	1428.63	907.31	4566.41
3	Mai Khola and Branches	478.99	166.36	70.23	42.94	246.53
4	Sunkoshi River Basin , Bhotekoshi and Indrawati	11320.48	4017.48	1913.04	1360.49	5832.52
5	Likhu Khola River Basin	1752.00	661.11	318.97	231.13	891.15
6	Dudh Koshi River Basin	10641.24	4049.24	1959.93	1429.71	5401.44
7	Tamakoshi River Basin	6543.23	2008.82	920.97	609.74	3433.47
8	Bagmati River Basin	1774.81	583.45	261.10	164.74	1028.83

9	Trishuli River Basin	7781.12	4045.84	1696.75	760.24	4423.92
10	Budhi Gandaki River Basin	5838.37	2347.06	1140.44	723.93	2975.41
11	Marsyangdi River Basin	8412.31	3159.79	1527.64	1091.25	4210.24
12	Seti River Basin	1234.33	407.56	185.57	131.76	639.59
13	Madi River Basin Damauli	1043.33	338.31	169.15	124.05	543.04
12	Seti River Basin	2277.66	745.87	354.72	255.81	1182.63
13	Kaligandaki River Basin	12681.38	4080.97	1868.85	1338.03	6617.69
14	Myagdi Khola River Basin	960.52	311.89	151.30	101.41	519.26
15	Bodigad River Basin	1151.55	357.72	160.59	108.01	595.07
13	Kaligandaki River Basin	14793.45	4750.57	2180.74	1547.46	7732.03
14	Rapti River Basin	2990.83	966.28	403.93	304.43	3035.28
15	Bheri River Basin	10944.40	4085.94	1931.49	1370.55	5724.82
16	Babai Sharada River Basin	520.08	174.80	88.57	60.92	285.07
17	Karnali River Basin	23989.22	10049.94	5215.52	3511.48	13051.28
18	Seti River (FarWestern) Basin	6103.27	2002.85	1171.63	847.75	3193.16
19	Mahakali Basin	7086.83	2395.33	1453.16	1125.07	4306.76
	Total	**147535.51**	**56277.51**	**27127.02**	**18471.75**	**79703.81**

The hydropower potential of Nepal in terms of Energy is as followings.

Table 2: Hydropower Potential of Nepal in Terms of Energy (GWh)

S.N.	River Basin	Q20 (GWh)	Q40 (GWh)	Q60 (GWh)	Q80 (GWh)	Average Energy (GWh)
1	Arun River Basin	53197.07	32838.94	20105.28	15424.64	61288.09
2	Tamor River Basin	28254.49	15908.57	9021.35	6529.00	34201.47
3	Mai Khola and Branches	1504.57	788.80	449.87	313.54	1846.48
4	Sunkoshi River Basin , Bhotekoshi and Indrawati	35854.97	19833.66	12567.57	9847.78	43684.38

5	Likhu Khola River Basin	5662.96	3312.48	2124.59	1679.66	6674.54
6	Dudh Koshi River Basin	34696.25	20440.17	13105.38	10402.66	40455.71
7	Tamakoshi River Basin	19974.29	9691.84	5982.80	4448.26	25716.00
8	Bagmati River Basin	5471.47	2812.04	1694.48	1205.52	7705.72
9	Trishuli River Basin	29080.81	21281.29	12391.47	5694.06	33134.28
10	Budhi Gandaki River Basin	19385.97	11595.47	7274.71	5205.12	22285.21
11	Marsyangdi River Basin	27075.13	15739.23	10021.15	7934.01	31533.84
12	Seti River Basin	7088.69	3676.08	2327.44	1856.53	8857.65
13	Kaligandaki River Basin	44755.72	23030.72	14204.82	11196.82	57911.33
14	Rapti River Basin	5433.66	2511.03	1580.62	1183.45	7640.38
15	Bheri River Basin	34665.56	20186.45	12591.01	9902.74	42877.77
16	Babai Sharada River Basin	1631.30	884.05	576.93	441.82	2135.15
17	Karnali River Basin	82353.65	51322.64	33817.98	25377.63	97751.46
18	Seti River (FarWestern) Basin	19119.09	10546.05	7682.99	6194.48	23916.10
19	Mahakali Basin	14883.57	8390.74	6326.33	5394.79	20348.22
	Total	**470089.22**	**274790.25**	**173846.76**	**130232.51**	**569963.79**

CHAPTER 2: Energy Consumption Trends/Demand Forecast

Energy Consumption Trends

The energy needs of the country are supported by Traditional, Commercial and Renewable sources. The energy consumption status of the economic survey of first eight months of 2016/17 shows that the energy consumption in first eight months of the Fiscal Year is 8257.09 thousand Tons of Oil Equivalent (ToE) which comes out to be 12385.635 thousand ToE for annual projection. The summary of the energy consumption is presented in the figure below.

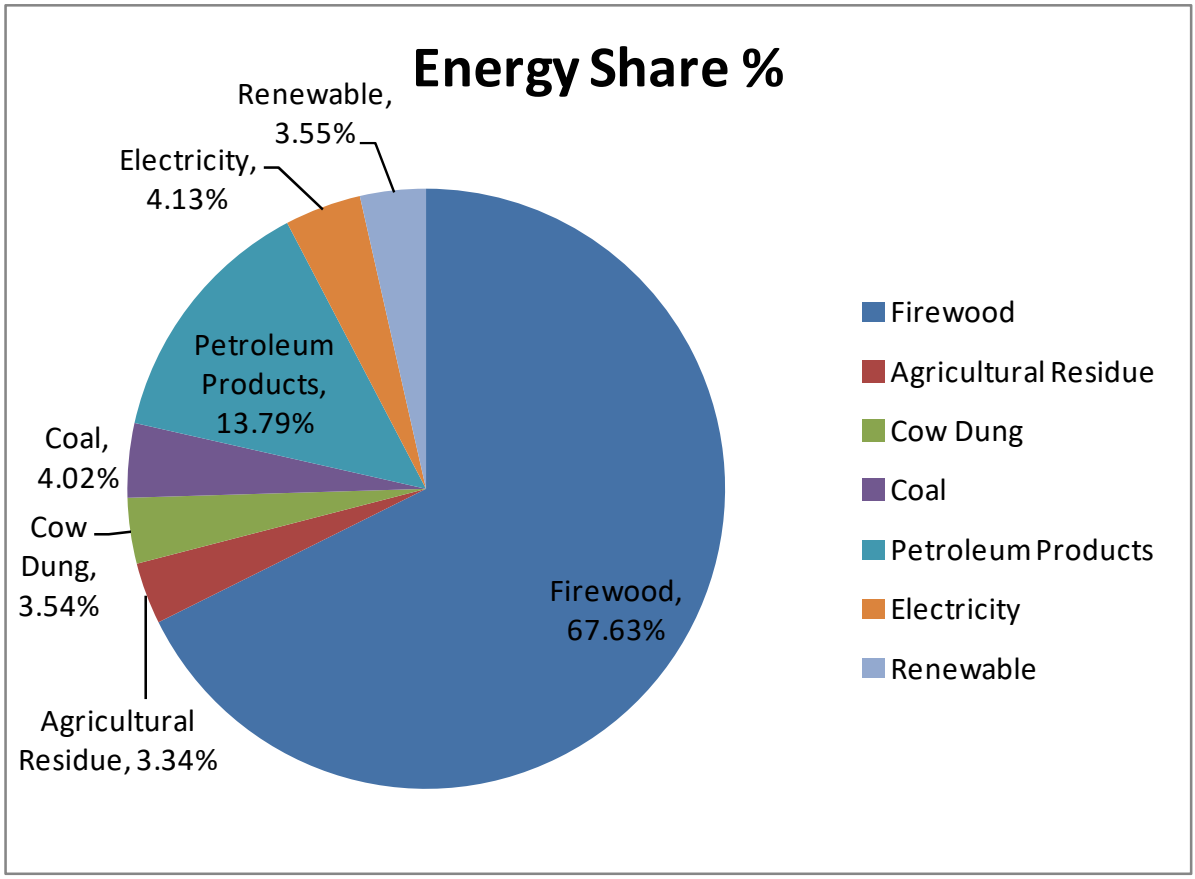

Figure 3.1 Energy Consumption by different sources

In the above figure Electricity means the grid connected supply of electricity (both hydropower and Thermal Energy) and the Renewable means the off-grid energy supply from alternative sources of energy like solar, micro hydro, biogas etc. The comparison of grid connected energy with other energy shows that if all the energy supply is to be replaced by electricity, 24.23 times of energy is needed in the country. If only the electricity supply of Nepal is considered (approximately 2/3 of energy supply of Nepal), 36.34 times of energy is needed in the country.

The above analysis shows that there is huge market of electricity inside Nepal. The present energy supply is 5946 GWh and total equivalent energy consumption is 144045 GWh. Once the annual demand increment is considered, obviously, huge amount of energy will be needed in the country for sustaining the economic activities. Once the energy consumption pattern of

developed countries is considered, it might need huge energy supply in the country. So, for developing own energy sources, country needs to investment huge amount of money with long term planning of energy mix.

Energy Forecast

The above table and chart shows the forecasted per capita demand for different scenario for upto 2040 AD in 5 Years time interval. Minimum forecasted demand in normal case is 1536 kWh and with policy intervention @ 9.2% is 4118 kWh annually in 2040 AD.

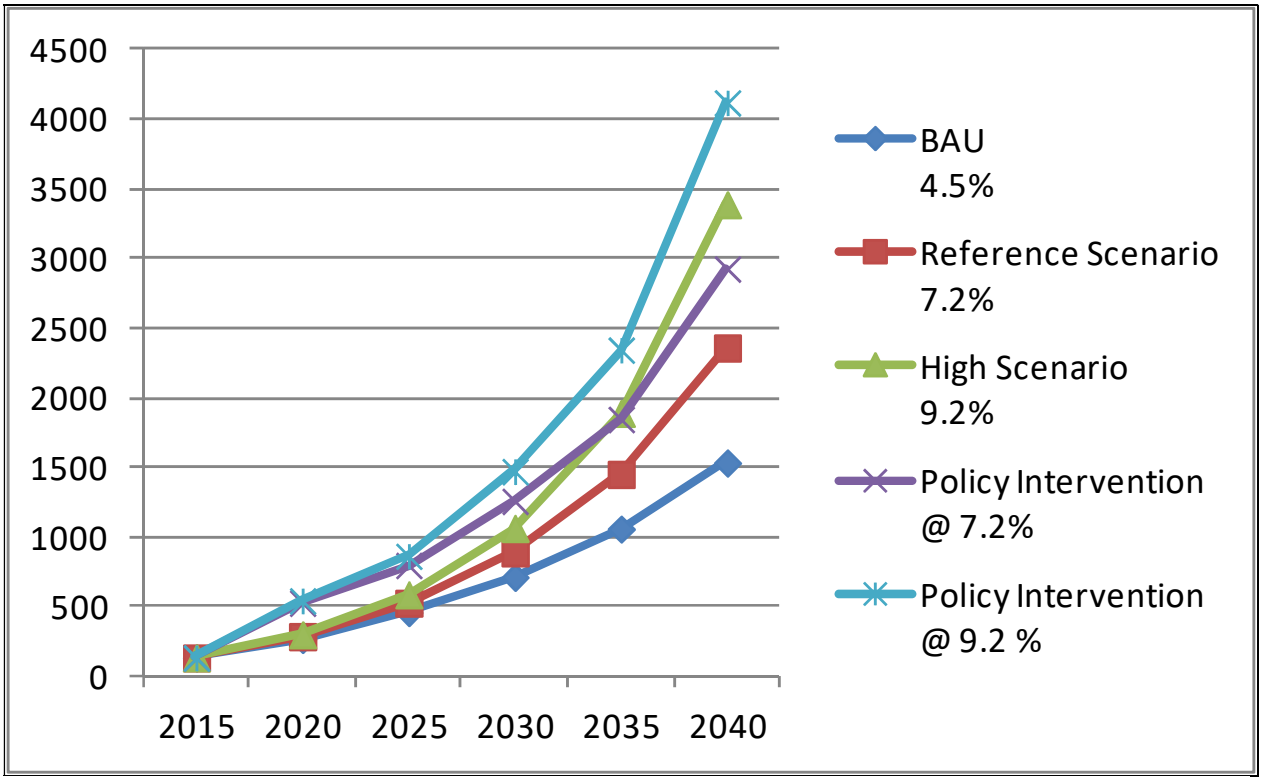

Figure 3.2 Per Capita Electricity Demand (kWh) : Source: WECS

The energy forecast for polynomial equation of second order shows the maximum energy requirement of 7705 kWh per capita per year as maximum and 2651 kWh per capita per year as the minimum energy requirement by 2050 AD.

CHAPTER 3: Study Methodology

Background

This study is carried out for the systematic planning of hydropower resources of the local body. The study is mainly focused for the systematic planning and project development of hydropower projects with systematic planning approach. In this study, "Hydropower Studio Model" is used for the preparation of the reports of the identified projects and Sites have been identified with the thorough study of the license status of Department of Electricity Development (DoED).

Objectives of the Assignment

The objective of the assignment is as following.

- Use of available latest appropriate technology for finding the hydropower projects.
- Preparing the hydropower master plan.
- Supporting Local Government, Provincial Government and Central Government for saving huge amount time.
- Supporting for planning of hydropower projects.
- Utilizing the innovative ideas of Engineers in Development Sector.
- Motivating all the creative brains to work in development sector of Nepal.
- Ultimately support for economic development of the country.

Scope of Work

The scope of the study was as following.

- Coordination with Local Governments for systematic Hydropower Planning.
- Finding out the hydropower potential of Jugal Rural Municipality.
- Finding out the possible hydropower projects of Local Body.
- Preparing the Preliminary Feasibility Study reports of the identified project sites.

Methodology

The study methodology was as following.

Study of the Possible Sites

All the information regarding location of the potential site, DOED licensed sites, best alignment, penstock alignment of all the possible projects in the rivers in Local Body has been studied and required data for Hydropower Studio Model has been collected. The report has been generated by using Hydropower Studio Model.

Preparation of Hydropower Master Plan/Preliminary Feasibility Study

Hydropower Master Plan study report has been developed as per the following approach.

- All the rivers in Local Body has been studied.

- Power sharing will be made as per proportion of the geographical coverage of the river in the boarder between the Municipalities.
- Detailed Study of the licenses issued by Department of Electricity Development has been made.
- Approximate cost for civil and electromechanical items of works has been considered.
- Possible size of the project in Installed Capacity and Potential Energy estimates has been studied.
- Preliminary Feasibility study of all the identified mini/small hydropower project sites have been generated by using Hydropower Studio Model.

Related Stakeholders

There are many stakeholders working in hydropower sector of Nepal. Main stakeholders are as followings.

1. Ministry of Energy, Water Resources and Irrigation for Policy formulation and Planning
2. Water and Energy Commission Secretariat of water and energy sector planning and studies
3. Department of Electricity Development (DoED) for Licensing and technical studies for above 1 MW installed capacities.
4. Municipalities for licensing of hydro projects for below 1 MW.
5. Alternative Energy Promotion Centre (AEPC) for projects below 1 MW for mainly in off grid areas.
6. National Planning Commission (NPC) for planning level support.
7. Nepal Electricity Authority (NEA) for grid connection and management of transmission and distribution lines.
8. Water and Energy Consultants Association Nepal (WECAN) for consulting Support for Hydro project study.
9. Many other Government and Private sector institutions working in some areas related to water and energy.
10. Academic Institutions etc.

CHAPTER 4 : Hydropower Studio Model

Hydropower Studio Model is a Microsoft Excel based application developed for preparing the automated report of hydropower projects for the speedy study, report preparation and planning works. All the hydropower project reports (456 Nos.) in the study entitled **"" Study and Analysis of Optimal Distributed Generation for Access to Grid Electricity for All in five years with Participation from Local Level Government"** were generated by using this model. For now, this model is designed for upto 5 MW installed capacity. In near future, it is planned to develop model to study the hydropower projects for upto at least 10 MW.

Scope of this Model

Mainly this model can be used for the following areas.

- Preparing the comprehensive hydropower study at Local Bodies by Local Government. There are more than 300 Local Bodies where this model can be used.
- Preparing the district level hydropower study reports for all hilly districts of Nepal (For more than 40 districts) by District Coordination Committees.
- Preparing the Provincial Level Hydropower Study Reports by Provincial Government.
- Preparing the River Basin Master Plan of particular River basin where there is huge potential of Small Hydropower Projects by the Government of Nepal.
- Preparation of desk study reports of hydropower projects for licensing purpose by developers for submitting in Department of Electricity Development (DoED).
- Preliminary Review of the Hydropower Projects by the Private developers.
- Preliminary Review of Hydropower Projects by the Banks and Financial Institutions investing in hydro sector.
- Comparision of alternative sites in hydropower projects.
- For the Preparation of Feasibility study of hydropower projects by Alternative Energy Promotion Centre (AEPC)/Renewable Energy for Rural Livelihood (RERL).
- For the Preparation of Feasibility Study of hydropower projects by private consulting Firms.
- This model is very much useful for the academicians in the University and the Students carrying out the thesis work in hydropower projects.

Who will be Benefitted

Potential users of this model are as following.

1. Engineers and Consultants working in Local Bodies of Nepal.
2. Engineers and Consultants Working in Provincial Level.
3. Engineers and Consultants Working in Hydropower Sector in Central Government.

4. Alternative Energy Promotion Centre to promote Mini Hydropower Projects all over Nepal.
5. Private Consulting Companies working in Hydropower Sector.
6. Hydropower Experts and Academicians.
7. Students carrying out higher study in Hydropower.
8. Hydropower Developers.
9. Banks and Financial Institutions for the review of hydropower projects.
10. All stakeholders in hydropower sector at national and international level.

Data Inputs

This model uses very simple inputs which can be collected by the study of map and the secondary data. The main data inputs in this sheet are as following.

Table 1 Data input in Hydropower Studio Model

S.N.	Particulars		Dundun Gad(Duikholi 1)	Dundun Gad(Duikholi 2)	Chunban Khola(Duikholi 3)
1	District		Rolpa	Rolpa	Rolpa
2	Name of Local Body		Duikholi 1	Duikholi 2	Duikholi 3
3	Name of the Project (River Name_1 ….n)		Dundun Gad	Dundun Gad	Chunban Khola
4	Intake No:		1	2	3
5	Coordinate of Intake (Decimal Degree)	Longitude	82.579967	82.553859	82.54107
		Lattitude	28.473188	28.478418	28.524745
6	Coordinate of Powerhouse (Decimal Degree)	Longitude	82.56053	82.536406	82.53263
		Lattitude	28.478736	28.477223	28.502449
7	Catchment Area km2		97.1	115	51
8	Monsoon Wetness Index Wetness Index (mm)		1220	1220	1220
9	RL of Intake (m)		1600	1460	1560
10	RL of Powerhouse (m)		1519.64	1408.78	1460
11	Gross Head (m)		80.36	51.22	100
12	Total Length of Waterways (kM)		2.439	2.356	3.791
13	Length of of Headrace (kM) Water Ways (km)		2.338	2.28	3.403

14	Length of Penstock (kM) (Intake-Forebay) m	0.101	0.076	0.388
15	Toposheet No:	2882 11A	2882 11A	2882 07C
16	Roadhead Distance (kM) Roadhead (kM)	35	28	34
17	Roadhead Name	Korchawang	Korchawang	Korchawang
18	Distance from PH to Grid (kM) Substation (kM)	25.5	24	20
19	Location of the Nearest Grid	Musikot near Bhalakcha	Musikot near Bhalakcha	Musikot near Bhalakcha
20	Sand Available Distance (kM)	65.39	48.1	51.5
21	Sand Available Location	Madi Khola and Lungri Khola Junction at Sari	Madi Khola and Lungri Khola Junction at Sari	Madi Khola and Lungri Khola Junction at Sari
22	Nearest Market Centre	Tulsipur	Tulsipur	Tulsipur
23	Province No	5	5	5

Key Features

Some of the features available in this model are as followings.

- Hydrological Analysis by Hydest, Modified Hydest and DHM Database Based New Model
- Switching Option for Q20, Q40, Q45,Q60, Q65, Q80, Q95 and Q100
- Design Automation for Headrace (Canal/Pipe), Desanding Basin, Penstock (Dia and Thickness)
- BoQ and Cost Estimate Automation
- Approximate Sizing of Electrical Equipments
- Automation of Transportation Distances (Major Supply Points Defined)
- District wise Rate can be used.
- Revenue Generation as per NEA PPA Provision.
- Financial Analysis (All Project Cost / Equity Investment)
- LCOE comparison for Hydro and Solar Mode
- Comparison of Different Hydropower Alternatives
- Reviewing of the Feasibility Study and Detailed Feasibility Study
- Generates brief summary report
- User Friendly and Useful Planning Model for Hydro Projects

Hydropower Studio Output in Front Page

Installed Capacity (kW)	941	661	644
Probability of Exceedence	Q65	District	Achham
Hydrology Basin	Rapti (Jhimrukh Modi) River Ba:	Rapti (Jhimrukh Modi) River E	Rapti (Jhimrukh Modi) River Bas
Canal or All Penstock	Headrace Canal	Headrace Canal	Headrace Canal
Canal Width (m)	1.45	1.5	1.15
Water Depth (m)	0.725	0.75	0.575
Required Discharge (lps)	1560	1720	858
Discharge Capacity of Canal (lps)	1593.00	1744.00	859.00
Width of Desanding Basin	3	3	3
Size of the Basin (LxBxh1xh2)	49.33 x 3 x 3.79 x 4.78 m	54.67 x 3 x 4.09 x 5.18 m	27.33 x 3 x 2.48 x 3.03 m
Length of Forebay (m)	30	35	20
Width of Forebay (m)	3	2.5	3
Height of Forebay (m)	2.56	2.66	2.08
Discharge Holding Capacity (Sec)	130.37	120.00	124.48
Height of the Tank ok ?	OK	OK	OK
Approximate Diameter (mm)	838	869	668
Proposed Diameter (mm)	900	900	700

Figure 0-1 Hydropower Studio Model (Main Studio)

The above studio has both input and output cells. The normal excel cells are the outputs and all the buttons available are the input to be given in the studio by the user. In this studio following inputs are to be given.

Step 1 : Select Probability of Excedence (Q45 or Q65 or Q80 to be selected)
Step 2 : Select the district name
Step 3 : Select Hydrology Basin (Options 1 to 14 are avaialble ranging from Tamor River Basin to Chameliya River Basin, the major rivers of Nepal)
Step 4 : Select Headrace Canal for Headrace Canal and Penstock Option and Select All Headrace Pipe for all pipe in headrace and penstock.
Step 5 : Select Proposed diameter depending upon the headloss. The headloss in percentage is available in the main studio just after the input. In case of all penstock pipe, total headloss can be taken to upto 5% and in case of Penstock Pipe only it is recommended to limit headloss within 3% range.
Step 6: Select the proposed Width of the Desanding Basin. It will give the size of the desanding basin as output in the main studio.
Step 7: Give the input for Length of Forebay (m) and Width of Forebay depending upon the required discharge holding capacity of tank. The height output in main studio is the minimum vortex height.

Velocity of Flow in Pipe (m3/s)	2.45	2.70	2.23
%age Headloss	1.17%	1.97%	2.24%
Penstock Thickness (mm)	7.00	5	7
Factor of Safety	3.59	3.39	3.71
Is Penstock Thickness Ok	Ok	Ok	Ok
Type of Turbine Proposed	Francis	Francis	Francis
Transportation Category	Normal		Not Applicable
Remoteness Factor	1	Transmission Line	33 kV
Equipment Cost (Powerhouse/Transmission Line and Switchyard Cost) per kW	500	1 US$ = (.....NRs.)	106
Hydropower LCOE (Rs./kWh)	5.52	7.22	7.67
Solar LCOE (Rs./kWh)	13.67	13.67	13.67
NPV (Million NRs.)	6.61	-72.51	-91.1
B/C Ratio	1.02	0.78	0.73
IRR (%)	10.28%	6.41%	5.53%
Bank Interest Rate (%)	0.1	0.1	0.1
Peyment Period (Years)	10	10	10
Return on Equity (%)	11.15%	5.03%	4.92%
Rate Analyis	Default	Ok	

Figure 0-2 Hydropower Studio Model (Main Studio)

Step 8 : Select Transportation Category (Extremely Remote where transportation by air is required, Remote are the districts defined by remote in Latest Subsidy delivery Mechanism of AEPC and Normal are the other normal districts)

Step 9 : For Extremely Remote case following botton appears in the studio.

Transportation Category	Extremely Remote	Rate/kg for Air Transportation (Rs.)	Not Applicable

for Extemely remote case, click in applicable Rate/kg for air transportation (Rs.) for transporting by Air.

Step 10 : For Remote Case, click in the remoteness factor. The remoteness factor have been ranged from 1.1 to 2. (1 means the normal district rate and 2 means the rate of materials have been doubled, so make input depending upon the remoteness of the location with prior knowledge of rates).

Step 11 : Select 11 or 33 kV line whichever is available in the project.

Step 12 : In equipment cost per kW include the rate per kW (Water to Wire) in dollar. Generally 400 US Dollar to 600 Dollar per kW can be assumed for preliminary study.)

Step 13 : Give conversion rate of Dollar in the cell in right hand side of input 11.

Step 14: Give input to the Bank Interest Rate.

Step 15: Give input to the loan repayment years (5, 10, 15, 20 and 25 years can be selected)

Step 16: In Rate Analysis input, select district name if detail district rates are available, otherwise select default for the study. For entering the actual district rates, please right click on the worksheet button and select unhide. In the available sheets in the worksheet, select **Rate Analysis Model 1**and give input. In this sheet only the following inputs can be given.

Table 2 District Rate inputs

S.N.	Particulars	Unit	Rate (Rs.)	Remarks
1	Cement (OPC)-Nepali	Bag	750	
2	Reinforcement (dia. 8mm~16 mm)	kg	85	
3	Binding Wire	kg	100	
4	CGI Sheet	Sqm	500	
5	Gabion Wire (all gauge) Commercial	kg	100	
6	MS Plain Sheets for Penstock	kg	100	
7	Easy Load **"Metalled Road"**	Rate/kg/km	0.022	
8	Uneasy Load **"Metalled Road"**	Rate/kg/km	0	
9	Load/Unload **"Metalled Road"**	Rs/kg	0.31	
10	Easy Load **"Gravelled Road"**	Rate/kg/km	0.066	
11	Uneasy Load **"Gravelled Road"**	Rate/kg/km	0	
12	Load/Unload **"Gravelled Road"**	Rs/kg	0.31	
13	Easy Load **"Earthen Road"**	Rate/kg/km	0.132	
14	Uneasy Load **"Earthen Road"**	Rate/kg/km	0	
15	Load/Unload **"Earthen Road"**	Rs/kg	0.31	
16	Transportation By Porter "Easy Load"	Rs/kg/km	1.921875	
17	Transportation By Porter "Difficult Load"	Rs/kg/km	1.921875	
18	Skilled Labor	Per Day	800	
19	Unskilled Labor	Per Day	600	

The rates given in above table are the default rates. The portal is developed for all 75 districts of Nepal.

In the main studio, all the cellss with Click bottons are the input cells and all the other cells are the output cells displayed for observing the key features of hydropower projects like installed capacity, design discharge, size of headrace/penstock, penstock diameter/thickness, headloss in hedrace pipe/penstock, factor of safety in penstock thickness etc.

The model is recommends pelton turbine for head more than 100 m and for upto 100 m gross head francis turbine will be selected automatically. This sheet also compares the Least Cost of Energy (LCOE) with Solar Power Plant.

This models gives the IRR, B/C Ratio, NPV and Return on Equity in the Main Studio. In the estimation of Return on Equity, Loan to Equity ratio is taken as 70:30.

Step 17: With all above input is given then select **Salient Features Project 1**, **Salient Features Project 2** and **Salient Features Project 3** and print the doucment to generate the automated summary report of the projects.

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CHAPTER 6: Study Findings

Thorough study of Hydropower Potential study of Jugal Rural Municipality has been made and the study findings are as following.

Identified Mini/Small Hydropower Projects:

The study has found out following 12 numbers of mini/small hydropower project sites in Jugal Rural Municipality. The summary of the Q40 Power possible from the identified projects and Q40 annual energy generation capacity is as following.

Table 3 : List of Identified Mini/Small Hydropower Projects

S.N.	Project Name and DoED Size (MW)	Q40 Power (kW)	Q40 Energy (GWh)	Remarks
1	Upper Selang Khola	961	5.316	
2	Sipling Khola	1552	8.813	
3	Pagarpu Khola	1739	9.771	
4	Thamran Sun Khola	997	5.574	
5	Dipu Sanglung Khola	552	3.298	
6	Manguin Khola (Lidi)	1967	11.359	
7	Mai Kharka Khola	996	6.180	
8	Duskul Khola	2794	16.315	
9	Tamrang Khola	2079	12.686	
10	Herang Khola	2372	14.864	
11	Teka Ghatte Khola	2175	13.812	
12	Golche Khola	2030	10.982	
	Total	**20214**	**118.970**	

Brief report generated by using Hydropower Studio Model is presented in Annex A of this report.

Hydropower Potential

The hydropower Potential of Jugal Rural Municipality has been studied for different probability of flow exceedence and for both Installed capacity and annual energy generation capacity. The summary of study findings is as followings.

Table 4 : Hydropower Potential of Jugal Rural Municipality (Installed Capacity)

S.N.	Project Name and DoED Size (MW)	Q20 Power (MW)	Q40 Power (MW)	Q60 Power (MW)	Q80 Power (MW)
1	Balephi Cascade, 17.22 MW Jugal Part	31.43	9.98	5.06	3.54
2	Balephi A 10.6 MW	34.65	11	5.57	3.91
3	Balephi 23.52 MW	70.34	22.34	11.32	7.93
4	Upper Balephi 36 MW	179.13	56.88	28.82	20.19
5	Balephi Khola HEP 42.14 MW	121.79	38.67	19.6	13.72
6	Upper Balephi 46 MW	165.26	52.46	26.6	18.64

7	Brahmayani HPP, 40 MW	138.34	43.91	22.25	15.6
8	Upper Bramhayani HEP, 20.07 MW	66.33	21.07	10.65	7.48
9	Nyasim Hydropower Project, 35 MW	44.87	14.25	7.22	5.06
10	Upper Nyasim Khola 43 MW	77.83	24.72	12.54	8.79
11	Upper Nyasim A HEP, 7.5 MW	20.88	6.63	3.37	2.35
12	Yambaling Khola 7.271 MW	14.25	5.78	2.89	2.07
13	Baramchi Khola HPP, 4.2 MW	7.49	3.03	1.49	1.03
14	Gelun Khola HPP, 3.2 MW	5.94	2.44	1.22	0.81
15	Mini/Small Hydro Projects (12 Sites)	49.2	20.21	10.11	6.71
16	Others (All Remaining Sites) Approximate	58	23.82	11.91	7.91
	Total	**1085.73**	**357.19**	**180.62**	**125.74**

Annual Energy Generation Capacity of all the possible hydropower projects in Jugal Rural Municipality has been presented in the following table.

Table 4 : Hydropower Potential of Jugal Rural Municipality (Annual Energy Generation)

S.N.	Project Name and DoED Size (MW)	Q20 Energy (GWh)	Q40 Energy (GWh)	Q60 Energy (GWh)	Q80 Energy (GWh)
1	Balephi Cascade, 17.22 MW Jugal Part	97.21	50.12	33.42	25.88
2	Balephi A 10.6 MW	107.18	55.26	36.84	28.55
3	Balephi 23.52 MW	217.56	112.17	74.79	57.94
4	Upper Balephi 36 MW	554.03	285.65	190.48	147.56
5	Balephi Khola HEP 42.14 MW	376.69	194.19	129.5	100.27
6	Upper Balephi 46 MW	511.15	263.51	175.77	136.23
7	Brahmayani HPP, 40 MW	427.89	220.57	147.05	113.99
8	Upper Bramhayani HEP, 20.07 MW	205.13	105.78	70.43	54.69
9	Nyasim Hydropower Project, 35 MW	138.77	71.55	47.73	36.97
10	Upper Nyasim Khola 43 MW	240.71	124.14	82.82	64.24
11	Upper Nyasim A HEP, 7.5 MW	64.58	33.29	22.26	17.19
12	Yambaling Khola 7.271 MW	47.9	29.11	19.1	15.05
13	Baramchi Khola HPP, 4.2 MW	25.13	15.25	9.86	7.55
14	Gelun Khola HPP, 3.2 MW	19.93	12.21	8.03	5.97
15	Mini/Small Hydro Projects (12 Sites)	194.19	118.970	78.24	58.17
16	Others (All Remaining) Approximate	38.88	23.82	15.67	11.65
	Total	**3266.93**	**1715.59**	**1141.99**	**881.9**

So, Jugal Rural Municipality seems rich from hydro generation perspectives. It is expected that all of these projects will be constructed within 5 to 7 years time. So, there will be huge economic activities and active participation of all the people in Jugal Rural Municipality which will ultimately lead to increased income level.

CHAPTER 7: Recommendations

Hydropower Potential

Hydropower Potential of Jugal Rural Municipality at 40% probability of flow exceedance is found to be 357.19 MW and similarly annual energy generation capacity at this power generation is 1715.59 GWh. This energy is about the one third power supply through national grid in Nepal.

Municipality wise Energy Sharing

In case of Balephi Cascade 17.22 MW project, energy sharing is made between the Municipalities. Power and energy sharing is made based on the head available for this project in Jugal Rural Municipality.

Overview of Hydro Projects

The study has shown that there are 14 hydropower projects licensed by Department of Electricity Development. Among them Baramchi Khola Hydropower Project(4.2 MW) is already constructed. This project has also been seriously affected by earthquake in 2072 BS and now is partially in operation. Similary, another Project Gelun Khola Hydropower Project, 3.2 MW is under construction and most of the components have been constructed.Similary, Construction works seem ongoing for Balephi A 36 MW project and it is expected that almost all the projects will be constructed within 5 to 7 years time period.

Identified Hydro Projects

From this study, 12 additional numbers of mini/small hydropower projects have been identified. The summary and brief report of all of these projects is attached in study findings chapter and the annex of this report.

Project Development Strategy

Following project development strategy may be suitable.

- Upto 5 MW Installed Capacity : By Local Governments and Private Sector
- More than 5 MW : By Government of Private Sector
- Below 100 kW Projects by local communities

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- Website of Upper Tamakoshi Hydropower Limited (tamakoshihydro.org.np)
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ANNEXES

Annex A : Maps and Layouts

Annex B : Site Photographs

Annex C : Contact Information

Annex D : Brief Report of Identified Project Sites

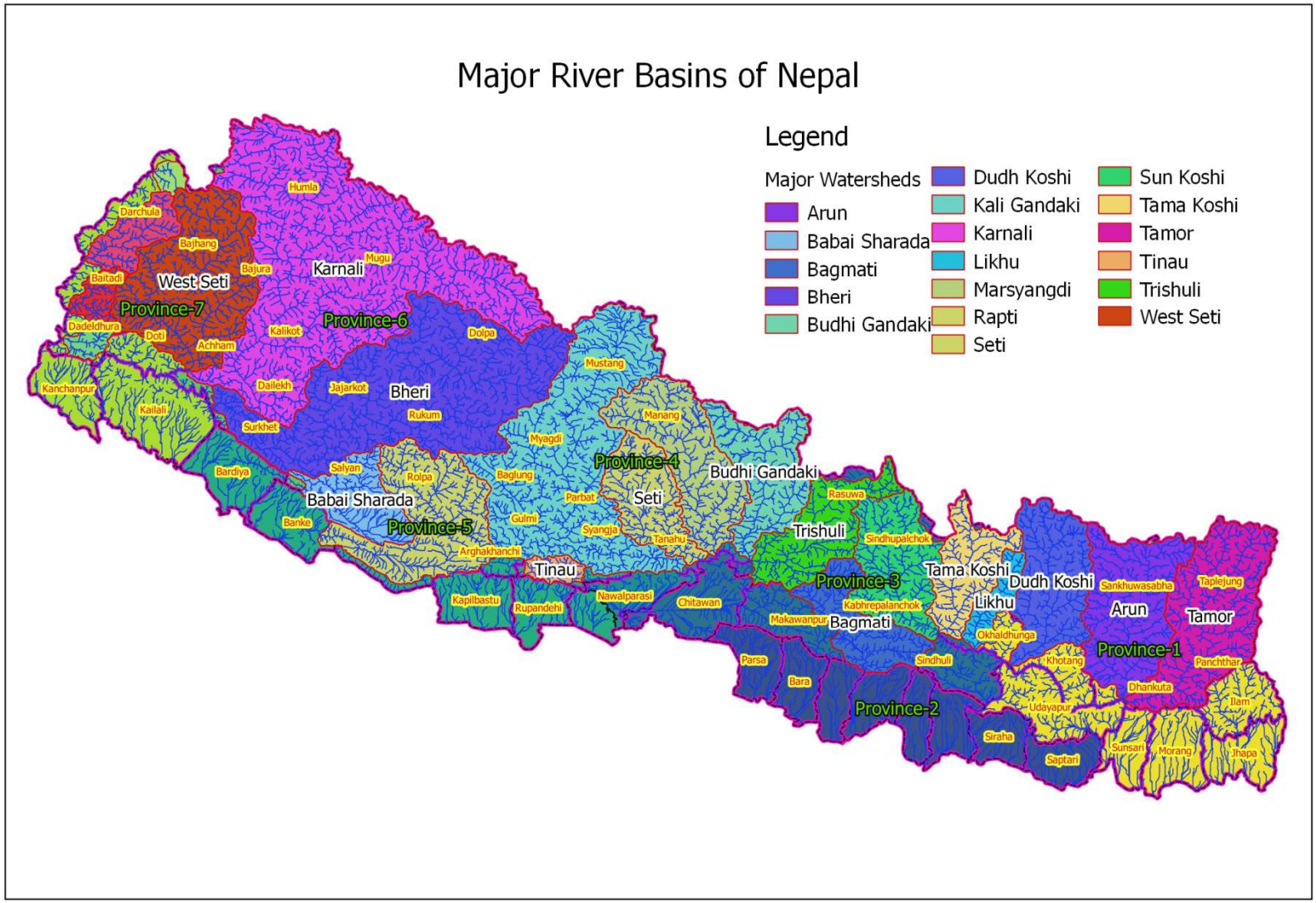
Annex A : Maps and Layouts

Annex B : Site Photographs

Annex C : Contact Information

SN.	Name	Institution	Contact	Remarks
1	Khimananda Kandel	Epsom Engineering Consultancy Pvt. Ltd.	9851070202	Study Team Leader
2	Kishwor Karki	Epsom Engineering Consultancy Pvt. Ltd.	9843694734	Study Team Member
3	Hom Narayan Shrestha	Chairperson, Jugal Rural Municipality	9751003388	
4	Srijana Tamang	Vice Chairperson, Jugal Rural Municipality	9843572999	
5	Prem Tamang	Chairperson, Ward No: 04, Jugal Rural Municipality		
6	Dhakaram Aryal	Chief Executive Officer	9851199087	
7	Suresh Poudel	Engineer, Jugal Rural Municipality	9841120213	
8	Krishna Bahadur Bhujel	Villagers, Kattike	9741224093	
9	Laxman Dong	Political Leader	9741218002	
10	Umesh Karki Kholi	Jugal Rural Municipality "Karyapalika Member"	9741282534	
11	Norbu Sherpa	Jugal Rural Municipality, Ward No: 03 Ward Member	9741261864	
12	Manga Lal Shrestha	Jugal Rural Municipality, Ward No: 04 , Pangtang	9851008524	
13	Lal Bahadur Shrestha	Ward Members	9841901769	
14	Jagat Bahadur Bhujel	Jugal Rural Municipality "Karyapalika Member"	9741217415	

Annex D : Brief Report of Identified Project Sites

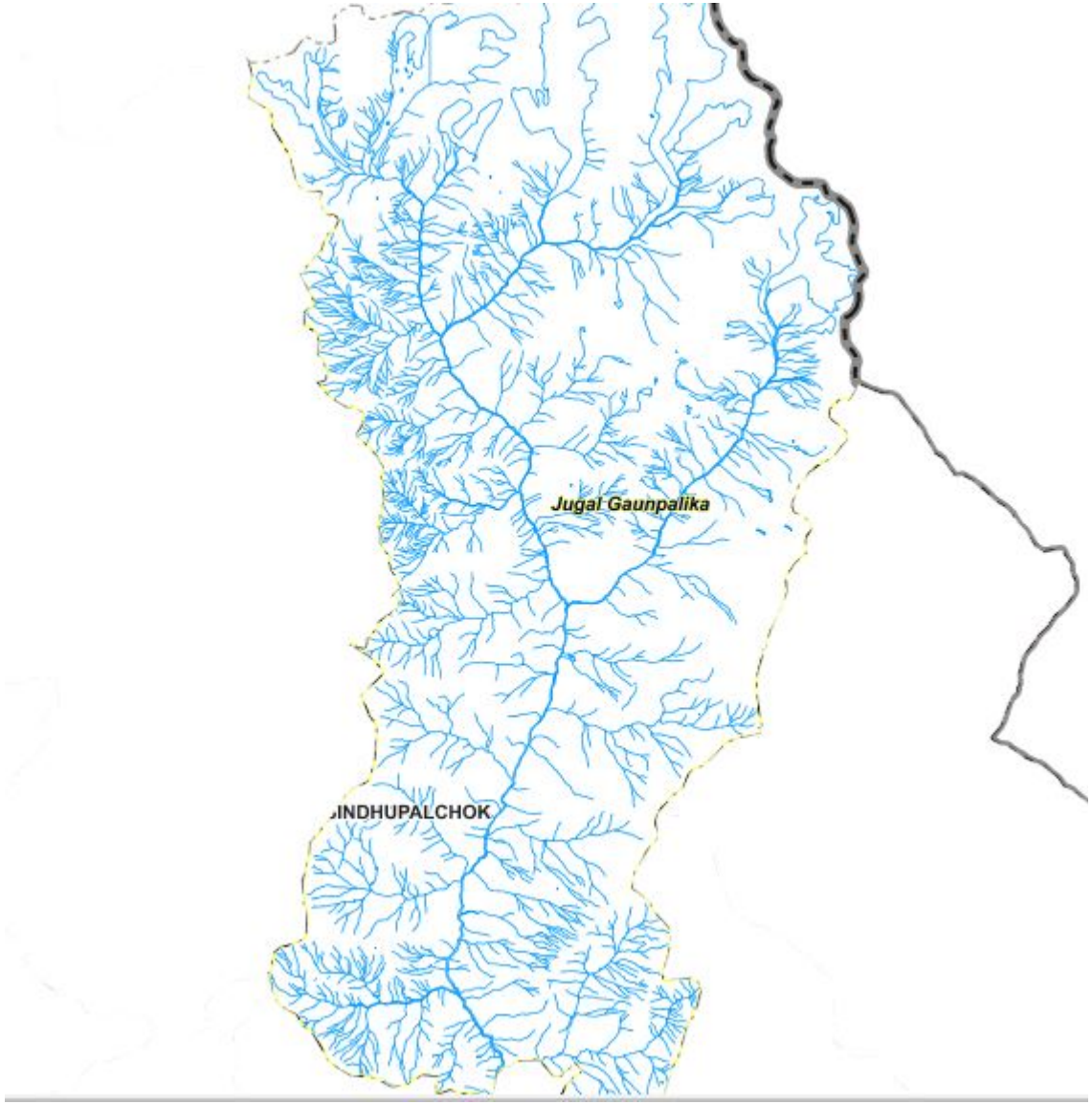


Map 1 : Province wise River Map of Nepal

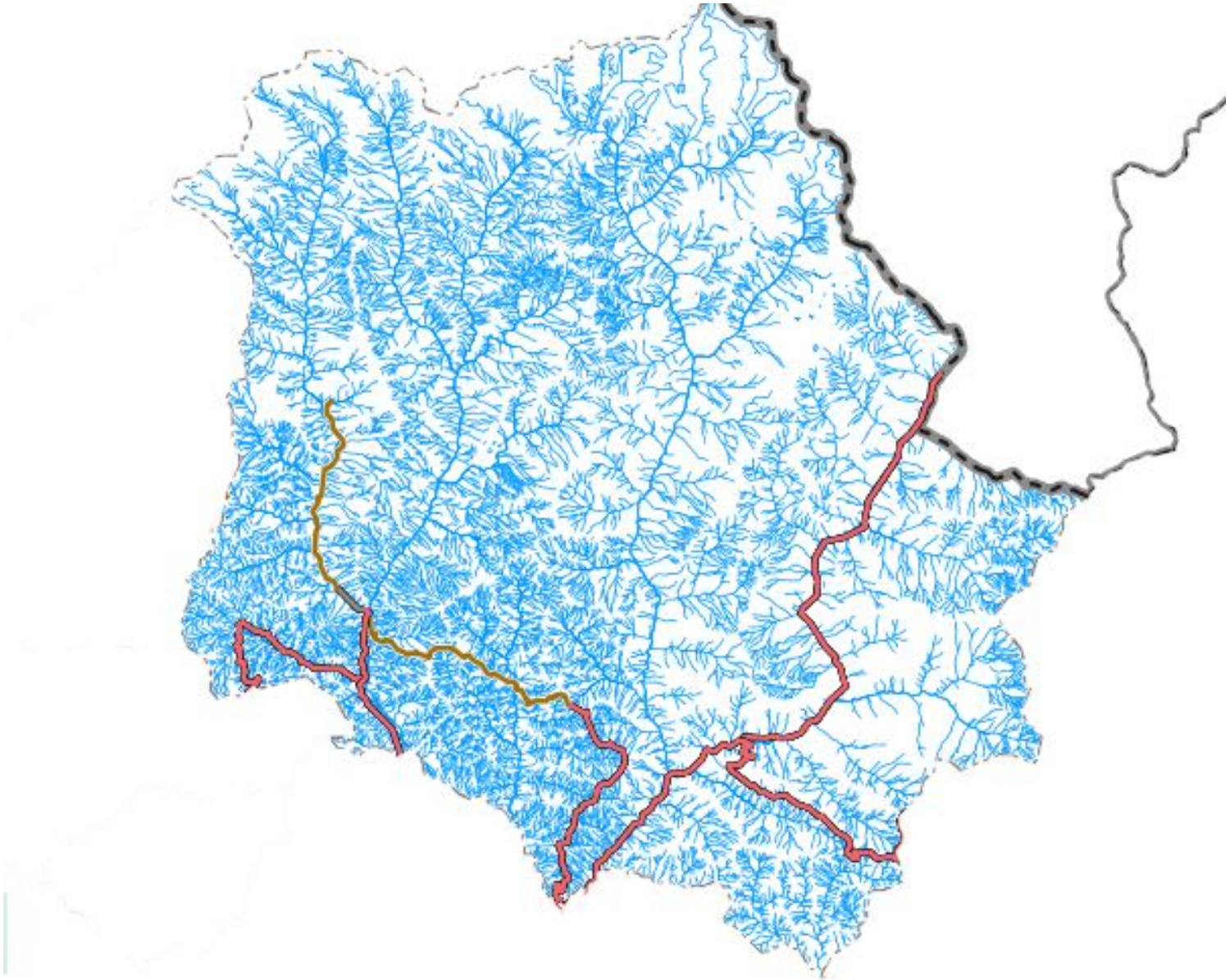
Map 2 : River Basin Map of Provincce No: 3 of Nepal

Map 3 : Municipality Boundary Map of Province No: 03

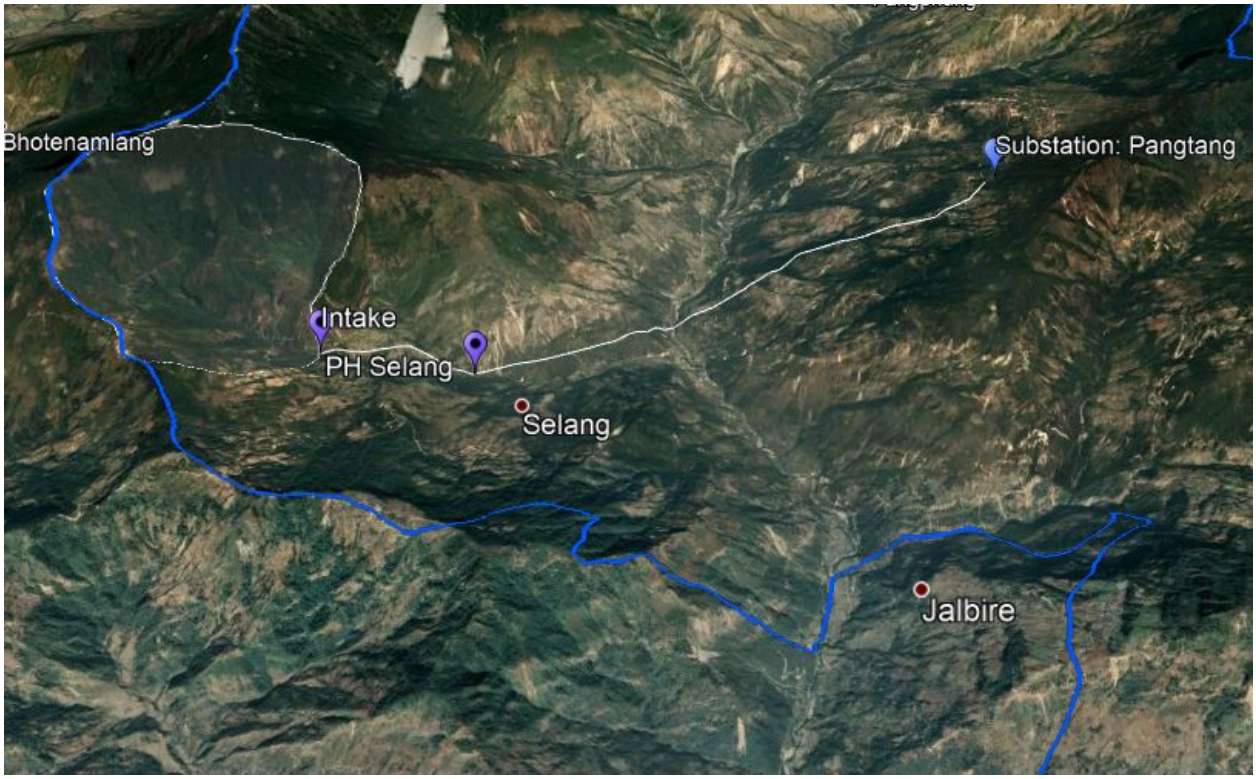
Map 4 : Map of Sindhupalchowk



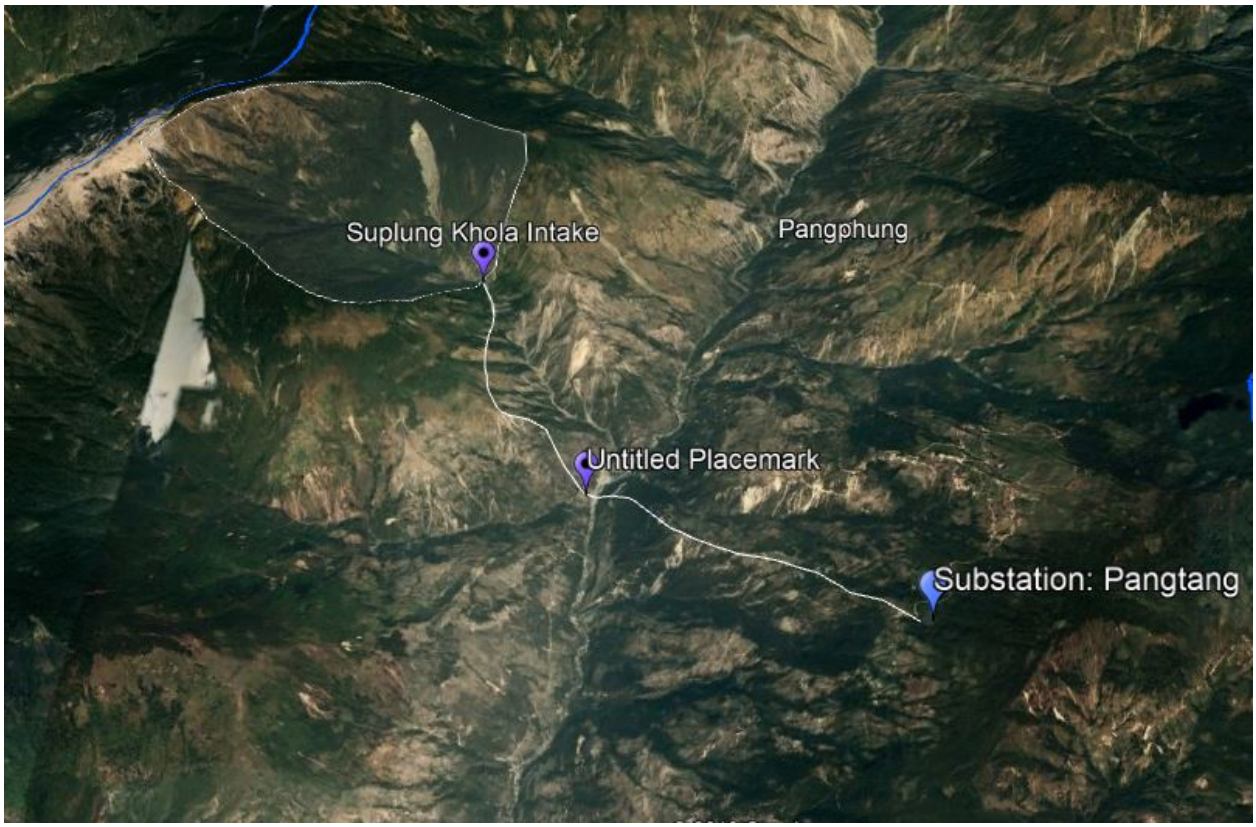
Map 5 : River Map of Jugal Rural Municipality



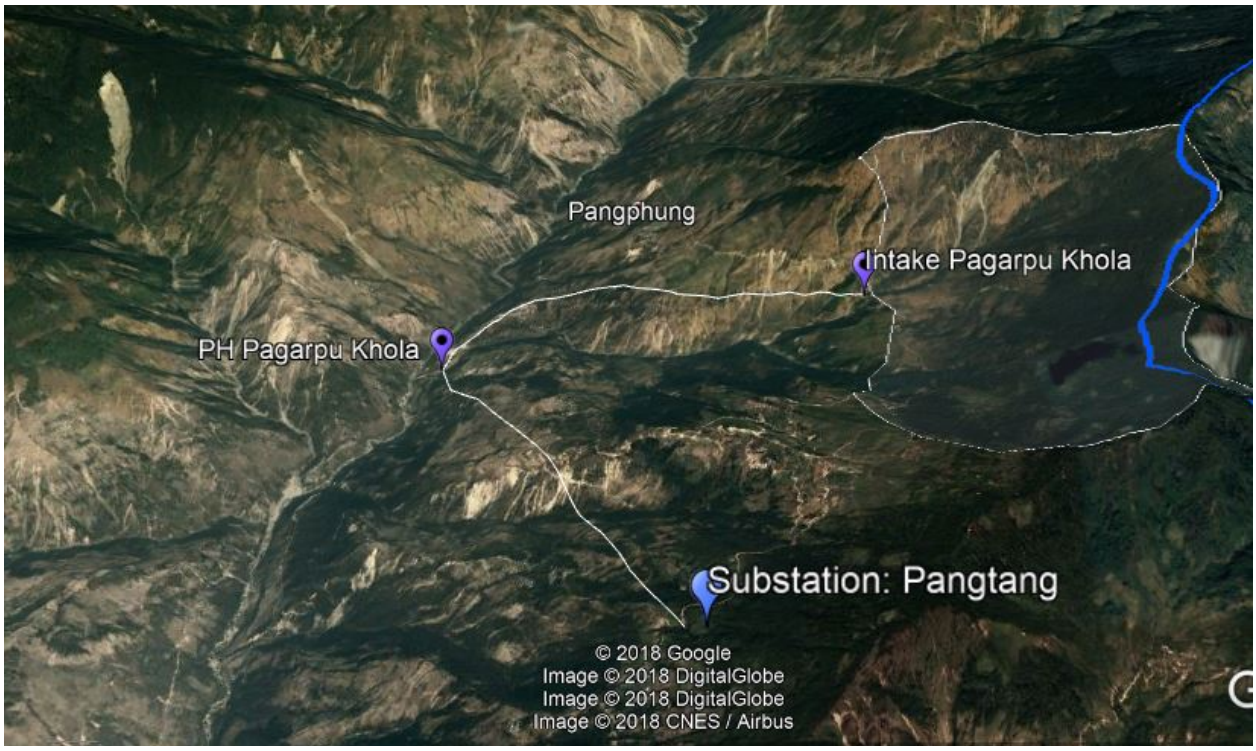
Map 6 : River Map of Sindhupalchowk District



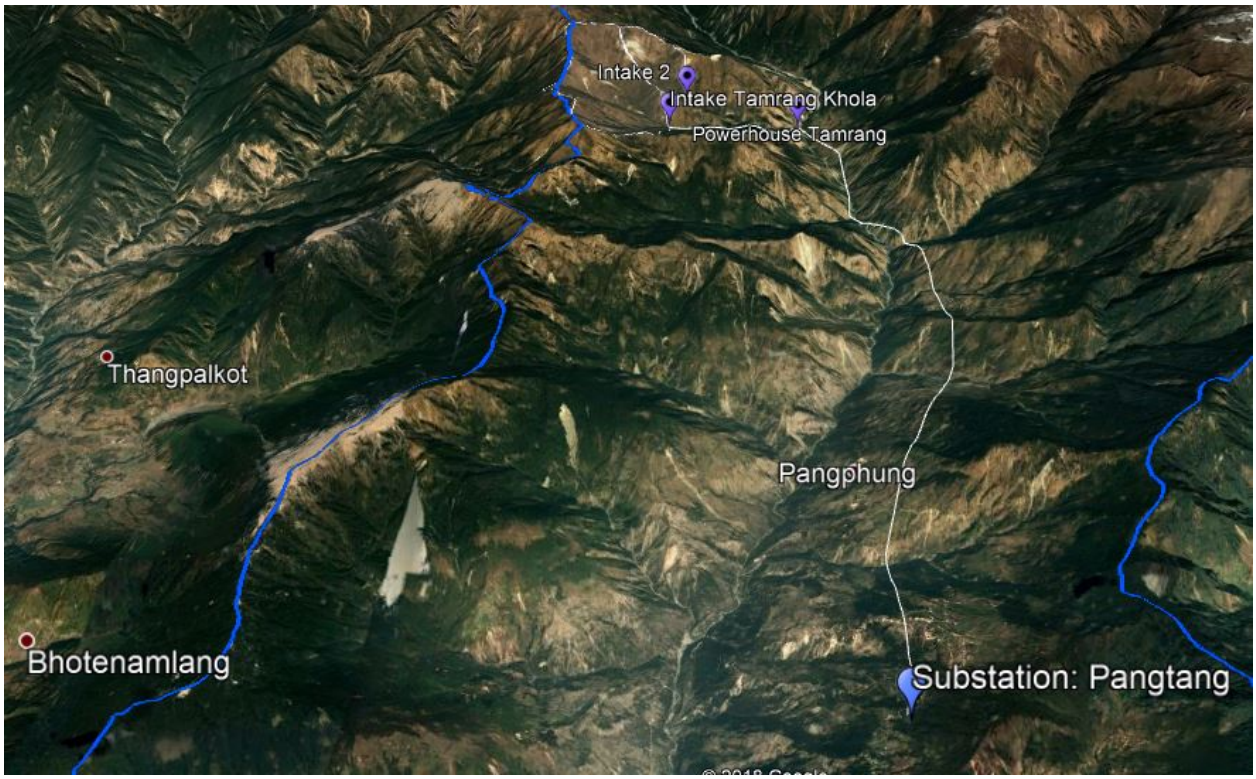
Project 1 : Upper Selang Khola



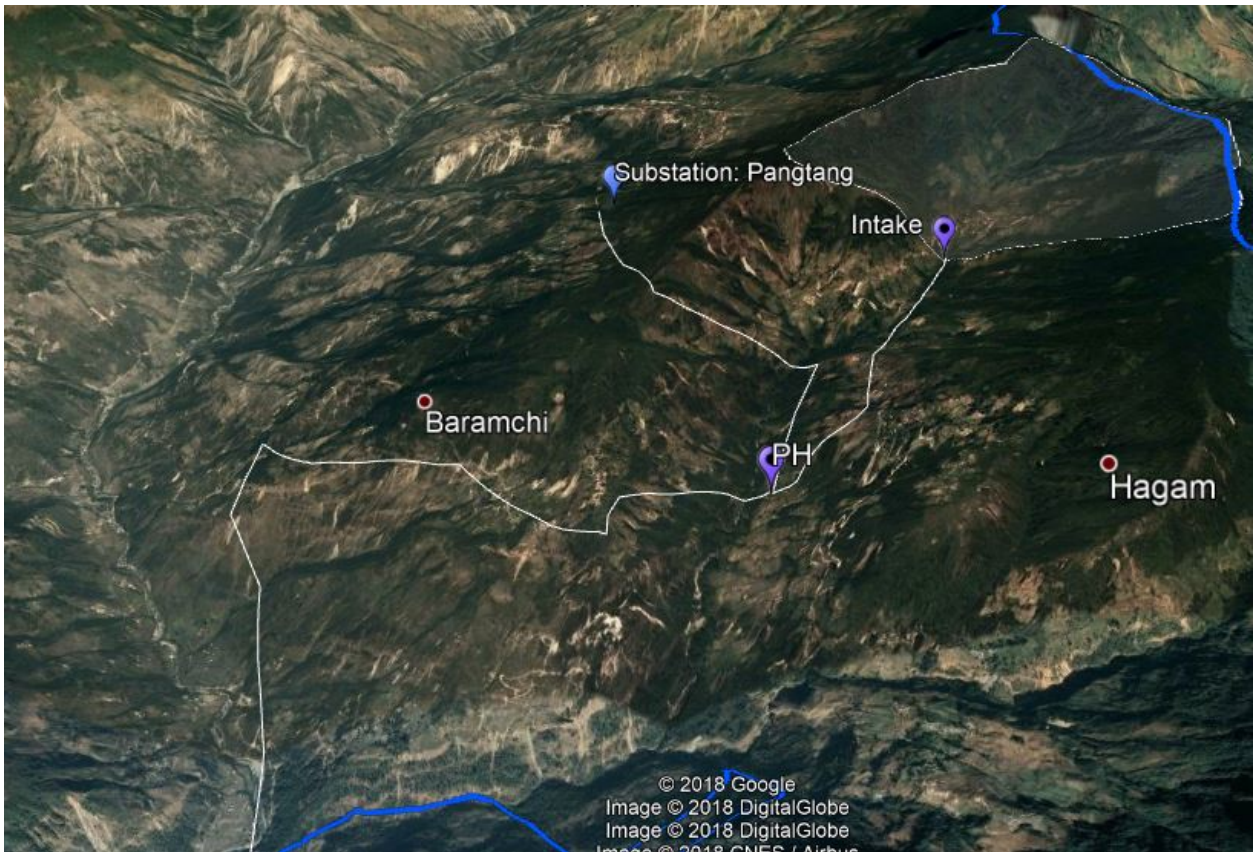
Project 2 : Sipling Khola



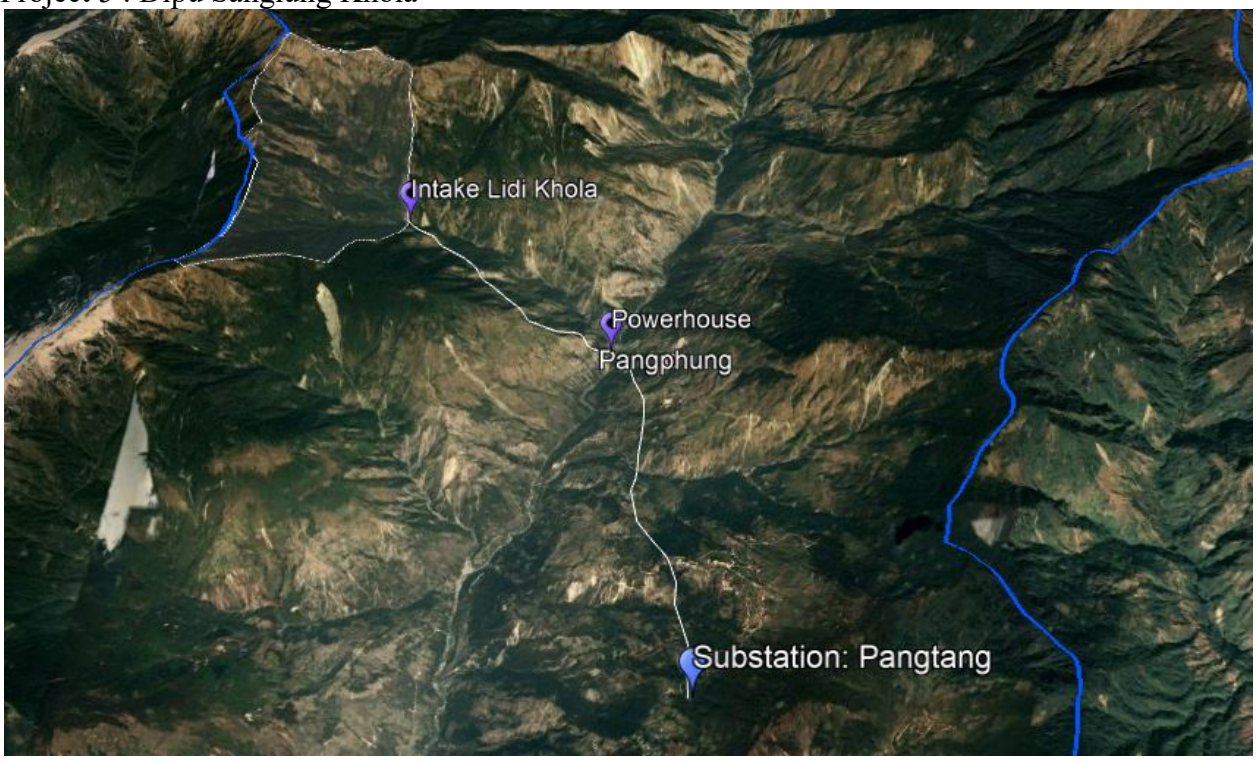
Project 3 : Pagarpu Khola



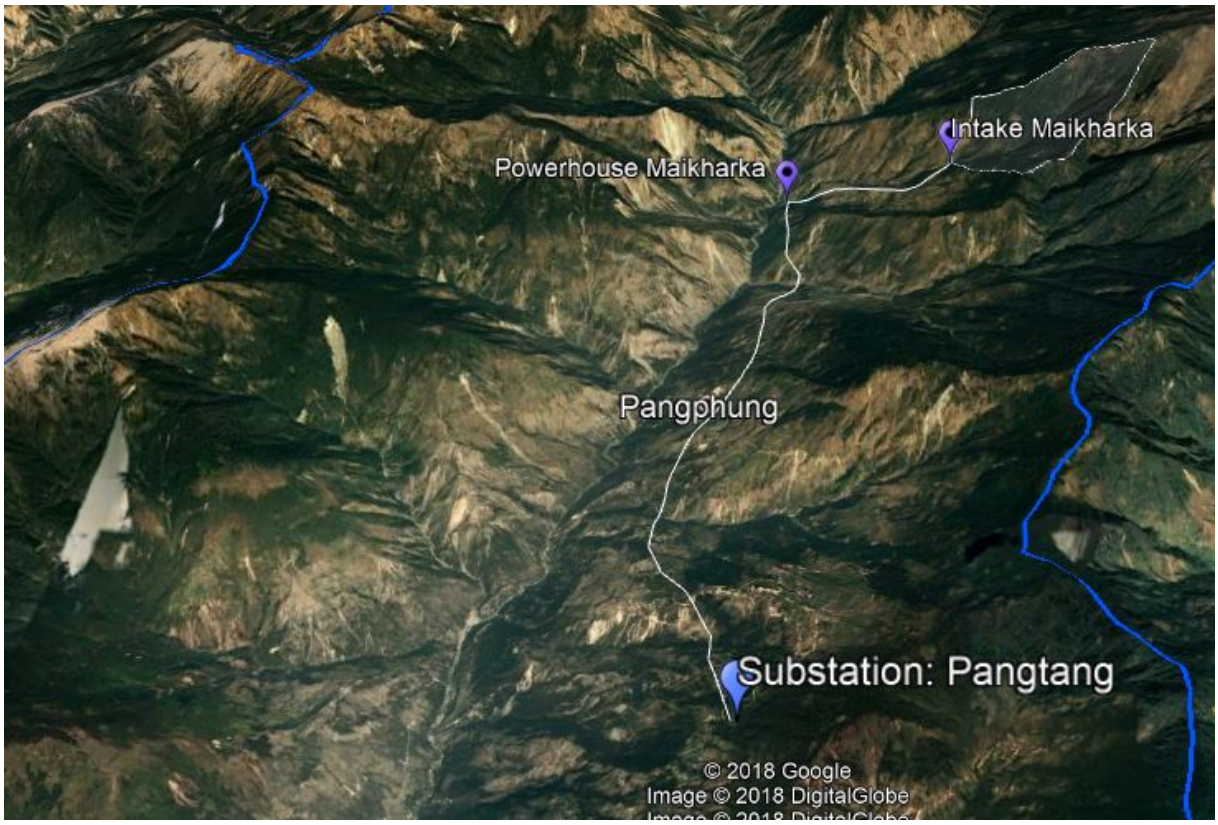
Project 4 : Tamrang Khola



Project 5 : Dipu Sanglung Khola



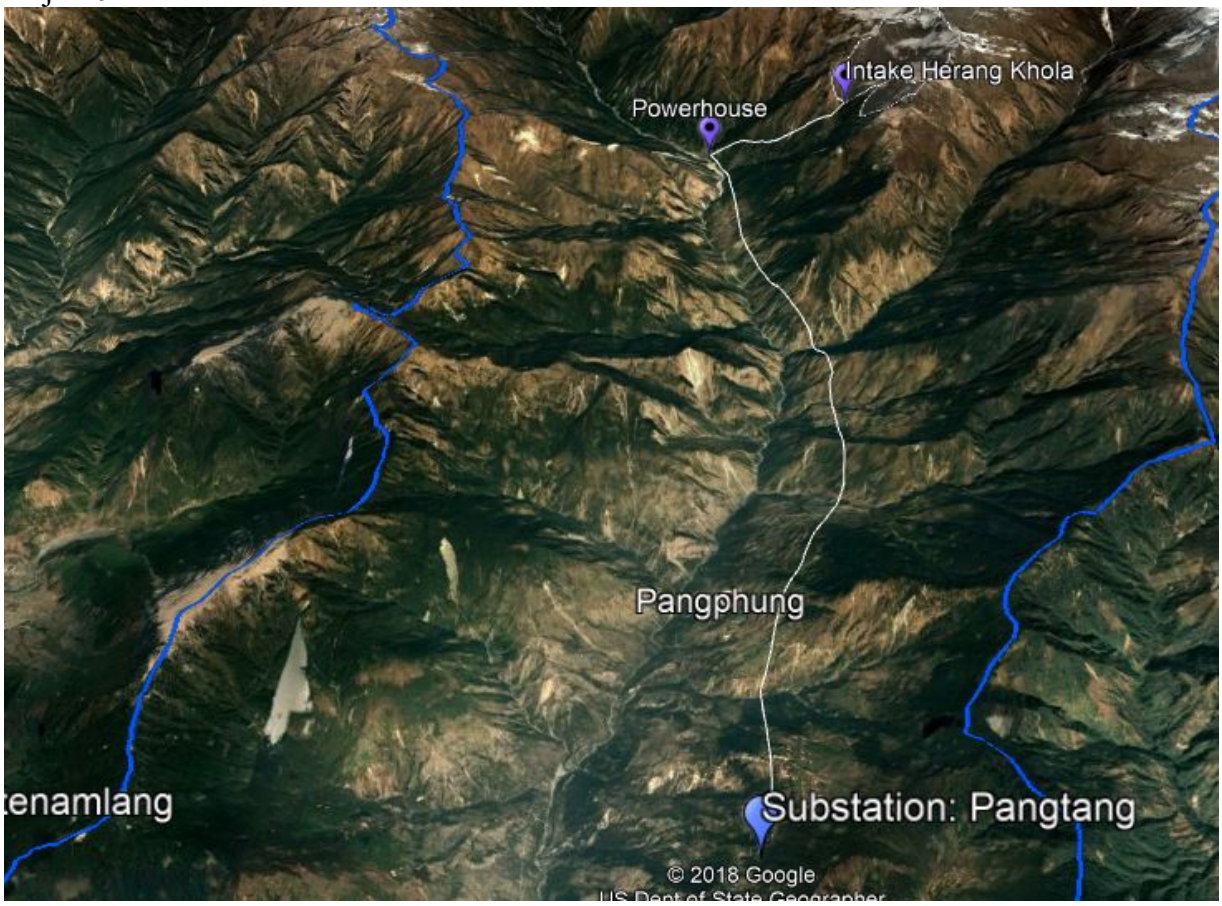
Project 6 : Manguin Khola



Project 7 : Maikharka Khola

Project 8: Duskul Khola

Project 9 : Thamran Sun Khola



Project 10 : Herang Khola

Project 11 : Teka Ghatte Khola

Project 12 : Golche Khola

Photo : Field Survey in Balephi Upper Part

Photo : Flow in Pagarpu Khola

Photo : Flow in Sun Khola

Photo : Flow in Thamran Khola

Photo : Flow in Golche Khola

Photo : Golche Khola PH Area

Photo : Sipling Khola

Photo : Sipling Khola Catchment

Photo : Manguin Khola

Photo : Selang Khola

Photo : Baramchi Khola

Photo : Gelun Khola Hydro

Photo : Baramchi Hydro

Photo : Gelun Khola Powerhouse

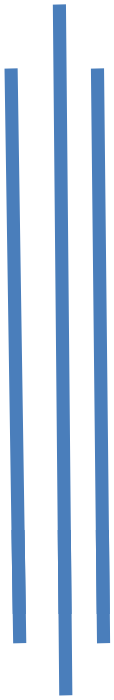
Photo : Hydro Project Tunnel Under Construction in Jugal

Photo : During Field Survey

Desk Study Report of Upper Selang Khola Mini Hydropower Project

Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk



Submitted To:

Jugal Rural Municipality,Sindhupalchowk

Submitted By:

Epsom Engineering Consultancy Pvt. Ltd.

Kalanki, Kathmandau

July 1, 2018

ACKNOWLEDGEMENTS

Its our great pleasure to work with Jugal Rural Municipality,Sindhupalchowk for Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk.

We would like to thank all the team of Jugal Rural Municipality,Sindhupalchowk for their support during the accomplishment of this study.

We would also like to thank to our study team for their valuable time for the accomplishment of the study.

It is expected that this study will pave the foundation for the development of hydropower projects in Jugal Rural Municipality,Sindhupalchowk.

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SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Upper Selang Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindhupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.7178, Lattitude= 27.857	
Powerhouse Coordinate	:	Longitude = 85.7333, Lattitude= 27.858	
Access			
Location of Nearest Roadhe	:	Golche	
Distance from Roadhead	:	3	
Hydrology			
Catchment Area	:	6.9	km2
Q40 /(Adopted)Discharge	:	0.337	m3/s
Power and Energy			
Gross Head	:	380	m
Efficiency %	:	0.85	%
Power at Q40	:	961	kW
Total Annual Energy at Q45	:	5.316	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	1571	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	10.67	m
Breadth	:	3	m
Height	:	1.69	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.85	m
Height of Canal	:	0.64	m
Forebay			
Length (m)	:	15	m
Breadth (m)	:	2.5	m
Height (m)	:	1.53	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	1800	m
Internal diameter (d)	:	500	mm
Thickness (mm)	:	14.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	1191	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 480.5 kW Capacity	
Gross Head	:	380	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2.5	
Height	:	0.64	

Grid Connection

Transmission voltage	:	11 kV	
Line length	:	7	kM
Connection point	:	Pangtang (Sherpa Gaun)	
	:		

Power Transformer

Number of unit	:	1	
Rating	:	1400	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 700	kVA
Rated Voltage	:	0.4	kV
Rated Frequency	:	50	Hz

Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period	:	18	Months

Economic and Financial Indicators

Project cost	:	214.14	Million (NRs.)
Annual Revenue	:	31.34	Million (NRs.)
Internal rate of return (IRR)	:	11.35	%
B/C Ratio	:	1.09	
Net present value (at 10% discount rate)	:	21.55	Million (NRs.)
Cost per kW	:	2102.14	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

Following general assumptions have been made in this study.

1. All DoED license issued and power generated sites for more than 100 kW Installed capacity are avoided in this study.

2. Rivers with discharge more than 5 m3/s at 65% Probability of Exceedence are not studied for power generation. In general, large rivers are not considered in this study.

3. In general, Projects sites have been avoided for head less than 40 m.

4. Discharge of the river is estimated by using Hydest Method, Modified Hydest Method and model generated by using DHM monthly data. The average of the three methods have been adopted in flow estimation.

5. New_LocClim (Local Climate Estimator Software) have been used for the estimation of precipitation data.

6. Total headloss in waterways is taken as 10% of the total head available from Intake to Powerhouse.

7. Overall Efficiency of the proposed project is taken as 85% .

8. This study is completely based on desk study. District level coordination meeting is arranged in District Coordination Committees to the possible extent.

9. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel (email: khimanandakandel@yahoo.com)

Limitations:

1. It was not possible to carry out the detailed site survey of the Project because of ToR and Budgetory Limitations. So, Basically secondary data are used for the preparation of the report after making site

2. The project sites have been identified for 40% probability of flow exceedence.

3. The study area seems to have limited hydro resources and in this study optimization of available resources have been made. Regarding the development of storage type projects, it seems very high size dam which seems infeasible in case of such small streams.

STUDY METHODOLOGY

The study methodology includes the following.

1. Field Visit was made for the stream for the potential hydro development sites.

2. Field Survey was made by using GPS to find out headworks, headrace alignment and Powerhouse.

3. The possibility of developing Reservoir type of project was also surveyed and it was found it is not possible to develop Reservoir sites for such small streams.

4. Field level meeting was made with the leaders of Rural Municipality and the villagers.

5. The Surveyed data were analyzed and Plotted.

6. Hydrological study of the project was made by using Hydropower Guru Software Developed by Er. Khimananda Kandel (khimanandakandel@yahoo.com, 9851070202).

7. The project was designed and report was generated by using Hydropower Studio Model developed by Er. Khimananda Kandel (khimanandakandel@yahoo.com, 9851070202).

8. Reports for possible mini hydropower sites were generated in this study.

APPROACH FOR COST ESTIMATION

Following approach have been made for the estimation of cost estimation.

1. Length of headrace, penstock, distance from existing or proposed substation, nearest roadhead and distance of sand availability was found out by using GIS Map, Google Earth and available maps.

2. Approximate design/sizing of headrace, desanding basin, forebay and penstock pipe (diameter and thickness) is made for the identified alternatives.

3. 11 kV or 33 kV transmission line is proposed for power transmission and unit cost of 11 kV and 33 kV transmission line is prepared by including the cost of swithching station.

4. Water to wire cost is taken as certain dollar per kW.

5. It is assumed that the main construction materials and equipments will be delivered from stations namely; Birtamode, Itahari, Mirchaiya, Bardibas, Hetauda, Narayangadh, Kathmandu, Pokhara, Butwal, Bhaluwang, Tulsipur and Atariya.

6. Government standard has been followed for the estimation of rate of material. For generalizing the study, the rate of materials at Baglung district is taken as base rate and rate has been increased by certain percentage for remote districts with remoteness factor provision in cost estimate model.

7. For remote districts like Humla, Dolpa and Mugu district provision for transportation by air is also considered.

8. Revenue estimation for July to November, tariff rate is taken as Rs. 4.8 / Unit and for December to June Rs. 8.4/Unit is Considered. Tariff rate for revenue generation is increased by 3% per annum for 8 consecutive years and after this the tariff rate is fixed as constant as per the NEA tariff provision for small hydropower projects.

9. Insurance cost is taken as 0.3% of total project cost annually. Royalty is taken as per the hydropower policy of Nepal.

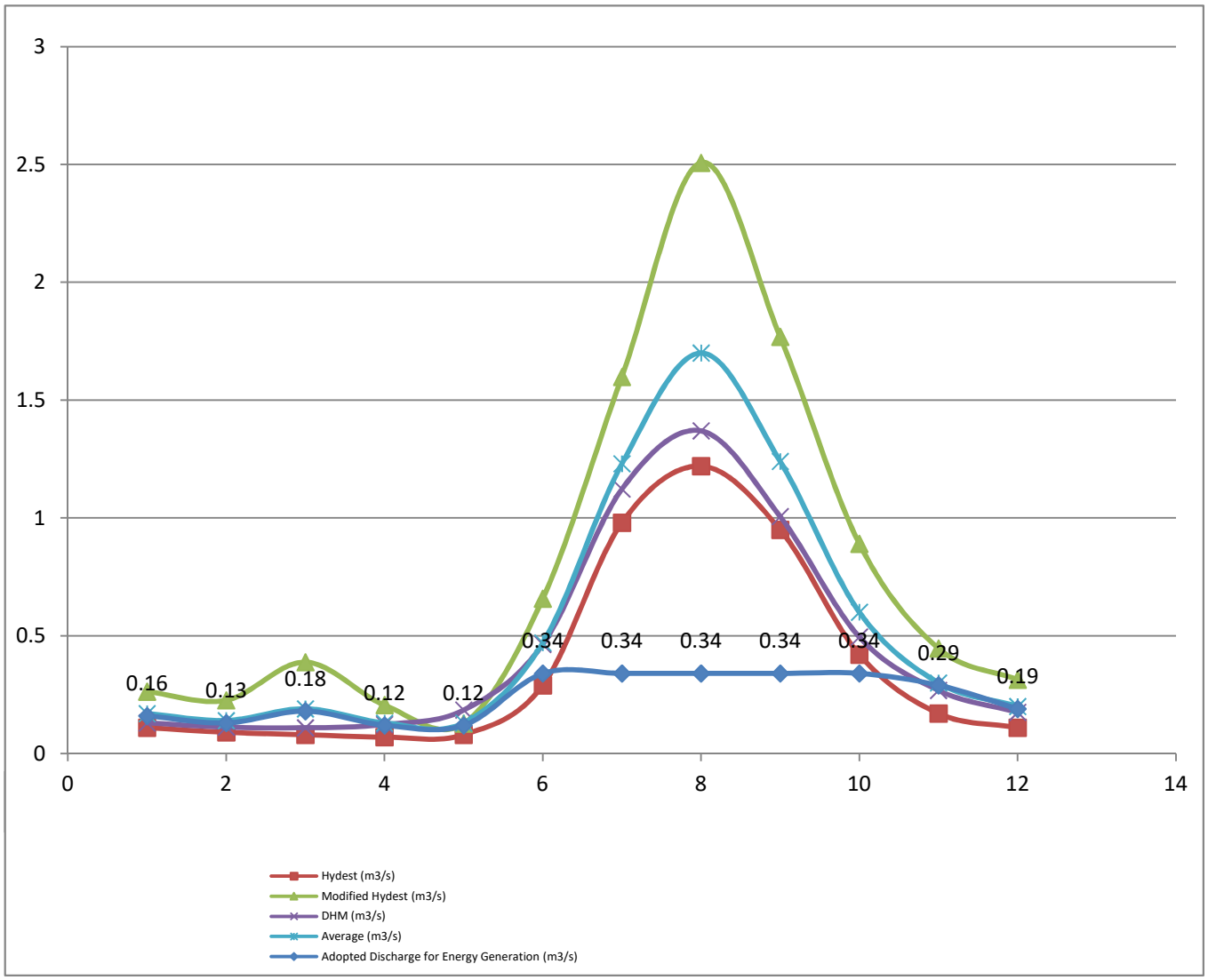
10. Financial parameters have been presented for all investment and equity investment options.

11. Hydropower project is compared with Solar power plant by using Least Cost of Energy (LCoE) mehtod.

12. Physical contingencies for Civil, Electro Mechanical (Water to Wire), Penstock/Hydromechanical are taken as 10%, 2.5 % and 5% respectively. Similarly VAT/Tax is taken as 13% and in case of Electromechanical items (Water to Wire) tax is taken as 1% .

13. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel.

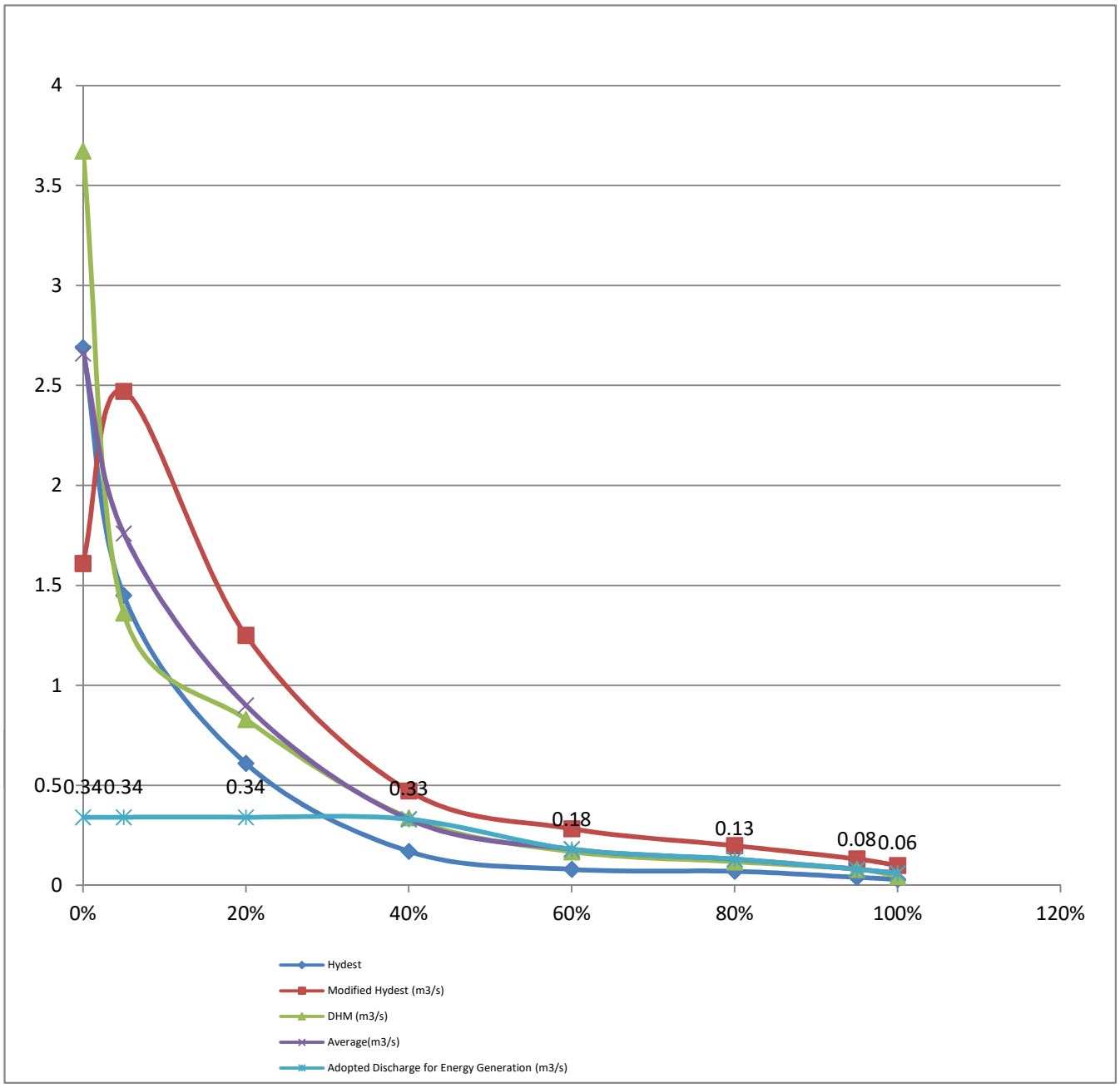
Available and Design Discharge in the River



e and Design Flow (m3/s) in the Stream

S.N.	Month	Discharge in River (m3/s)	Discharge for Power Generation (m3/s)	Remarks
1	January	0.17	0.153	
2	Febrauary	0.14	0.126	
3	March	0.19	0.171	
4	April	0.13	0.117	
5	May	0.13	0.117	
6	June	0.47	0.34	
7	July	1.23	0.34	
8	August	1.7	0.34	
9	September	1.24	0.34	
10	October	0.6	0.34	
11	November	0.3	0.27	
12	December	0.2	0.18	

Flow Duration Curve of the River



e and Design Flow (m3/s) in the Stream

S.N.	Probability of Exceedence (%age)	Hydest (m3/s)	Modified Hydest (m3/s)	DHM (m3/s)
1	0%	2.69	1.61	3.67
2	5%	1.45	2.47	1.36
3	20%	0.61	1.25	0.83
4	40%	0.17	0.47	0.34
5	60%	0.08	0.28	0.17
6	80%	0.07	0.2	0.12
7	95%	0.04	0.13	0.08
8	100%	0.03	0.1	0.04

Adopted Rate of Materials and Items at Project Site

Table : Adopted Rate of Materials and Items at Project Site

S.N.	Particulars	Unit Rate	Unit	Remarks
1	Cement (Ordinary Portland Cement)	750.00	Bag	VAT Additional
2	Sand	3,683.26	m3	At Project Site
3	Agreegate	2,209.15	m3	At Project Site
4	Stone	1,955.00	m3	At Project Site
5	Cutting Bending and Fixing Reinforcement Bars	119.43	kg	At Project Site
6	Penstock Fabrication	180.06	kg	At Project Site
7	Gabion Making with material and filling	4,938.68	m3	At Project Site
8	Earthwork in Excavation	533.03	Cum	At Project Site
9	Earthwork in Backfilling	355.35	Cum	At Project Site
10	Dry Stone Soling	3,732.90	Cum	At Project Site
11	Stone Masonry in 1:4 cement mortar	12,687.91	Cum	At Project Site
12	Stone Masonry in 1:6 Cement Mortar	5,566.00	Cum	At Project Site
13	PCC(1:3:6) in Foundation	12,416.87	Cum	At Project Site
14	PCC (1:2:4) in Structures	15,429.35	Cum	At Project Site
15	PCC (1:1.5:3) in Structures	17,095.04	Cum	At Project Site
16	Wooden Formwork	514.59	m2	At Project Site
17	20 mm thick Plastering	587.11	m2	At Project Site
18	12.5 mm thick Plastering	460.55	m2	At Project Site
19	CGI Roofing	507.55	m2	At Project Site
20	33 kV kV Transmission Line cost per kM	1,857,994.47	kM	At Project Site
21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5589520.052	
1.2	Desanding Basin	1.2	984169.4017	
1.3	Headrace Power Canal	1.3		
1.4	Cross Drainage Works	1.4	4182524.12	
1.5	Forebay Basin/Spillway	1.5	984169.4017	
1.6	Penstock and Hydro Mechanical (Metal Parts)	1.6	41825241.2	
1.7	Anchor Block and Support Pier	1.7	20912620.6	
1.8	Powerhouuse and Tailrace	1.8		
	Sub-Total NRs.		83177329.32	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	2.1	45407250	
3	TRANSMISSION LINE			
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	4.1	5000000	
4.2	Construction Camp Establishment	4.2	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	5.1	5000000	
	Sub-total		154390540.6	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	6.1	7719527.032	
	Sub Total 1-6		162110067.7	
7	Contigencies	7.1	12030164.95	
8	VAT 1-6 (6 Inclusive of VAT)	8.1	17053138.49	
9	Interest During Construction	9.1	22943204.53	
10	TOTAL ESTIMATED COST (NRs)	10.1	214136575.6	
	Cost per kW (1 US$ = NRs. 106)		2102.14	
	Cost per kW in NRs.		**222826.82**	

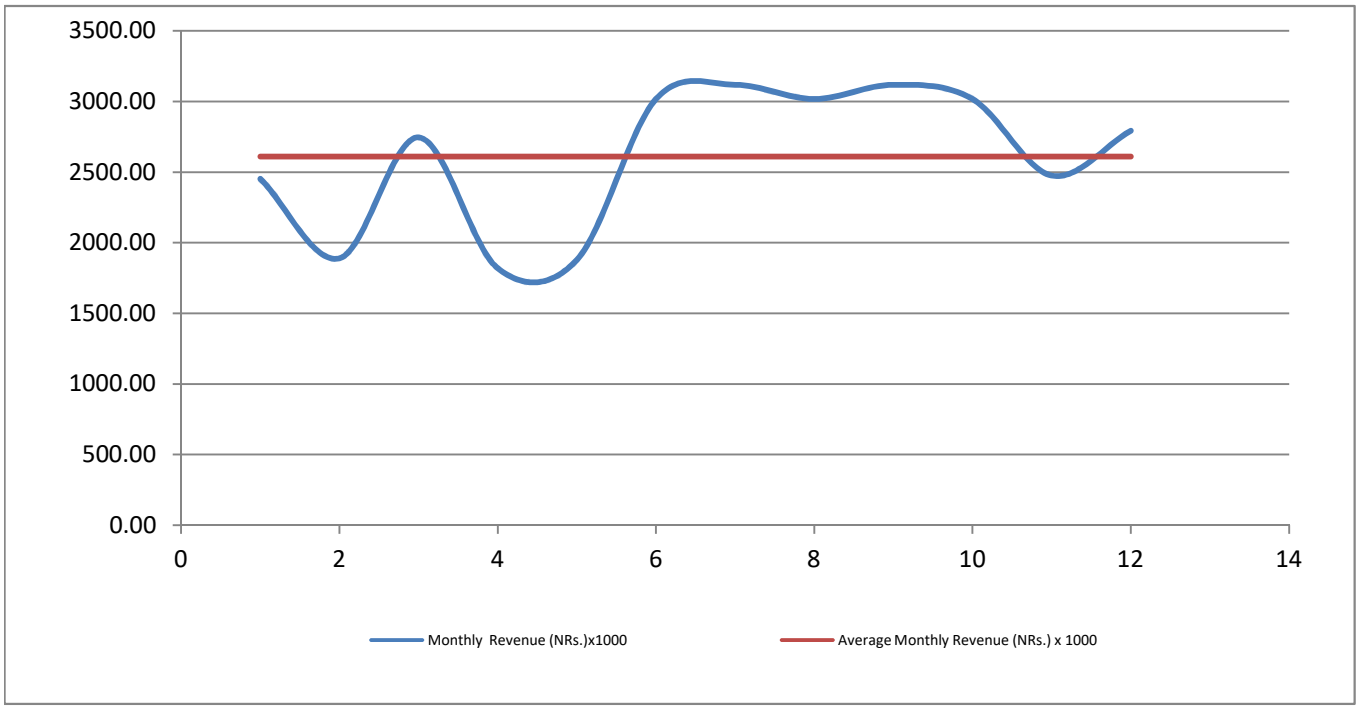


Table: Summary of Monthly and Average Monthly Revenue From the Project

S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	2452.34	2611.38	
2	February	1888.97	2611.38	
3	March	2744.82	2611.38	
4	April	1818.03	2611.38	
5	May	1878.63	2611.38	
6	June	3017.09	2611.38	
7	July	3117.66	2611.38	
8	August	3017.09	2611.38	
9	September	3117.66	2611.38	
10	October	3017.09	2611.38	
11	November	2474.84	2611.38	
12	December	2792.36	2611.38	
	Total	31336.58	31336.56	

Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	214.14	(Million NRs.)	
2	Bank Loan (70%)	149.896	(Million NRs.)	
3	Equity Investment (30%)	64.241	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	21.55	(Million NRs.)	
6	IRR	11.35%		
7	B/C	1.09		
8	Least Cost of Energy (LCOE)	4.72	NRs./kWh	
9	Return on Equity (RoE)	13.03%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	24.39	(Million NRs.)	

Desk Study Report of Sipling Khola Mini Hydropower Project

Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk

Submitted To:

Jugal Rural Municipality,Sindhupalchowk

Submitted By:

Epsom Engineering Consultancy Pvt. Ltd.

Kalanki, Kathmandau

July 1, 2018

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Khimananda Kandel
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9851070202

SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Sipling Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindhupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.7469, Lattitude= 27.9165	
Powerhouse Coordinate	:	Longitude = 85.7884, Lattitude= 27.897	
Access			
Location of Nearest Roadhead	:	Golche	
Distance from Roadhead	:	3	
Hydrology			
Catchment Area	:	5.75	km2
Q40 /(Adopted) Discharge	:	0.281	m3/s
Power and Energy			
Gross Head	:	736	m
Efficiency %	:	0.85	%
Power at Q40	:	1552	kW
Total Annual Energy at Q45	:	8.813	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	1805	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	9	m
Breadth	:	3	m
Height	:	1.5	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.8	m
Height of Canal	:	0.6	m
Forebay			
Particle Size to be Settled	:	0.3	mm
Length (m)	:	15	m
Breadth (m)	:	2	m
Height (m)	:	1.51	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	3000	m
Internal diameter (d)	:	550	mm
Thickness (mm)	:	28.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	1069	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 776 kW Capacity	
Gross Head	:	736	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2	
Height	:	0.6	

Grid Connection

Transmission voltage	:	11 kV	
Connection point	:	4	kM
Line length	:	Pangtang (Sherpa Gaun)	

Power Transformer

Number of unit	:	1	
Rating	:	2300	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 1150	kVA
Rated Voltage	:	0.4	kV

Rated Frequency	:	50	Hz
Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period	:	18	Months

Economic and Financial Indicators

Project cost	:	429.77	Million (NRs.)
Annual Revenue	:	55.66	Million (NRs.)
Internal rate of return (IRR)	:	0.09	%
B/C Ratio	:	0.91	
Net present value (at 10% discount rate)	:	-42.19	Million (NRs.)
Cost per kW	:	2612.41	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

Following general assumptions have been made in this study.

1. All DoED license issued and power generated sites for more than 100 kW Installed capacity are avoided in this study.

2. Rivers with discharge more than 5 m3/s at 65% Probability of Exceedence are not studied for power generation. In general, large rivers are not considered in this study.

3. In general, Projects sites have been avoided for head less than 40 m.

4. Discharge of the river is estimated by using Hydest Method, Modified Hydest Method and model generated by using DHM monthly data. The average of the three methods have been adopted in flow estimation.

5. New_LocClim (Local Climate Estimator Software) have been used for the estimation of precipitation data.

6. Total headloss in waterways is taken as 10% of the total head available from Intake to Powerhouse.

7. Overall Efficiency of the proposed project is taken as 85% .

8. This study is completely based on desk study. District level coordination meeting is arranged in District Coordination Committees to the possible extent.

9. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel (email: khimanandakandel@yahoo.com)

Limitations:

1. It was not possible to carry out the detailed site survey of the Project because of ToR and Budgetory Limitations. So, Basically secondary data are used for the preparation of the report after making site visit.

2. The project sites have been identified for 40% probability of flow exceedence.

3. The study area seems to have limited hydro resources and in this study optimization of available resources have been made. Regarding the development of storage type projects, it seems very high size dam which seems infeasible in case of such small streams.

STUDY METHODOLOGY

The study methodology includes the following.

1. Field Visit was made for the stream for the potential hydro development sites.

2. Field Survey was made by using GPS to find out headworks, headrace alignment and Powerhouse.

3. The possibility of developing Reservoir type of project was also surveyed and it was found it is not possible to develop Reservoir sites for such small streams.

4. Field level meeting was made with the leaders of Rural Municipality and the villagers.

5. The Surveyed data were analyzed and Plotted.

6. Hydrological study of the project was made by using Hydropower Guru Software Developed by Er. Khimananda Kandel (khimanandakandel@yahoo.com, 9851070202).

7. The project was designed and report was generated by using Hydropower Studio Model developed by Er. Khimananda Kandel (khimanandakandel@yahoo.com, 9851070202).

8. Reports for possible mini hydropower sites were generated in this study.

APPROACH FOR COST ESTIMATION

Following approach have been made for the estimation of cost estimation.

1. Length of headrace, penstock, distance from existing or proposed substation, nearest roadhead and distance of sand availability was found out by using GIS Map, Google Earth and available maps.

2. Approximate design/sizing of headrace, desanding basin, forebay and penstock pipe (diameter and thickness) is made for the identified alternatives.

3. 11 kV or 33 kV transmission line is proposed for power transmission and unit cost of 11 kV and 33 kV transmission line is prepared by including the cost of swithching station.

4. Water to wire cost is taken as certain dollar per kW.

5. It is assumed that the main construction materials and equipments will be delivered from stations namely; Birtamode, Itahari, Mirchaiya, Bardibas, Hetauda, Narayangadh, Kathmandu, Pokhara, Butwal, Bhaluwang, Tulsipur and Atariya.

6. Government standard has been followed for the estimation of rate of material. For generalizing the study, the rate of materials at Baglung district is taken as base rate and rate has been increased by certain percentage for remote districts with remoteness factor provision in cost estimate model.

7. For remote districts like Humla, Dolpa and Mugu district provision for transportation by air is also considered.

8. Revenue estimation for July to November, tariff rate is taken as Rs. 4.8 / Unit and for December to June Rs. 8.4/Unit is Considered. Tariff rate for revenue generation is increased by 3% per annum for 8 consecutive years and after this the tariff rate is fixed as constant as per the NEA tariff provision for small hydropower projects.

9. Insurance cost is taken as 0.3% of total project cost annually. Royalty is taken as per the hydropower policy of Nepal.

10. Financial parameters have been presented for all investment and equity investment options.

11. Hydropower project is compared with Solar power plant by using Least Cost of Energy (LCoE) mehtod.

12. Physical contingencies for Civil, Electro Mechanical (Water to Wire), Penstock/Hydromechanical are taken as 10%, 2.5 % and 5% respectively. Similarly VAT/Tax is taken as 13% and in case of Electromechanical items (Water to Wire) tax is taken as 1% .

13. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel.

Available and Design Discharge in the River

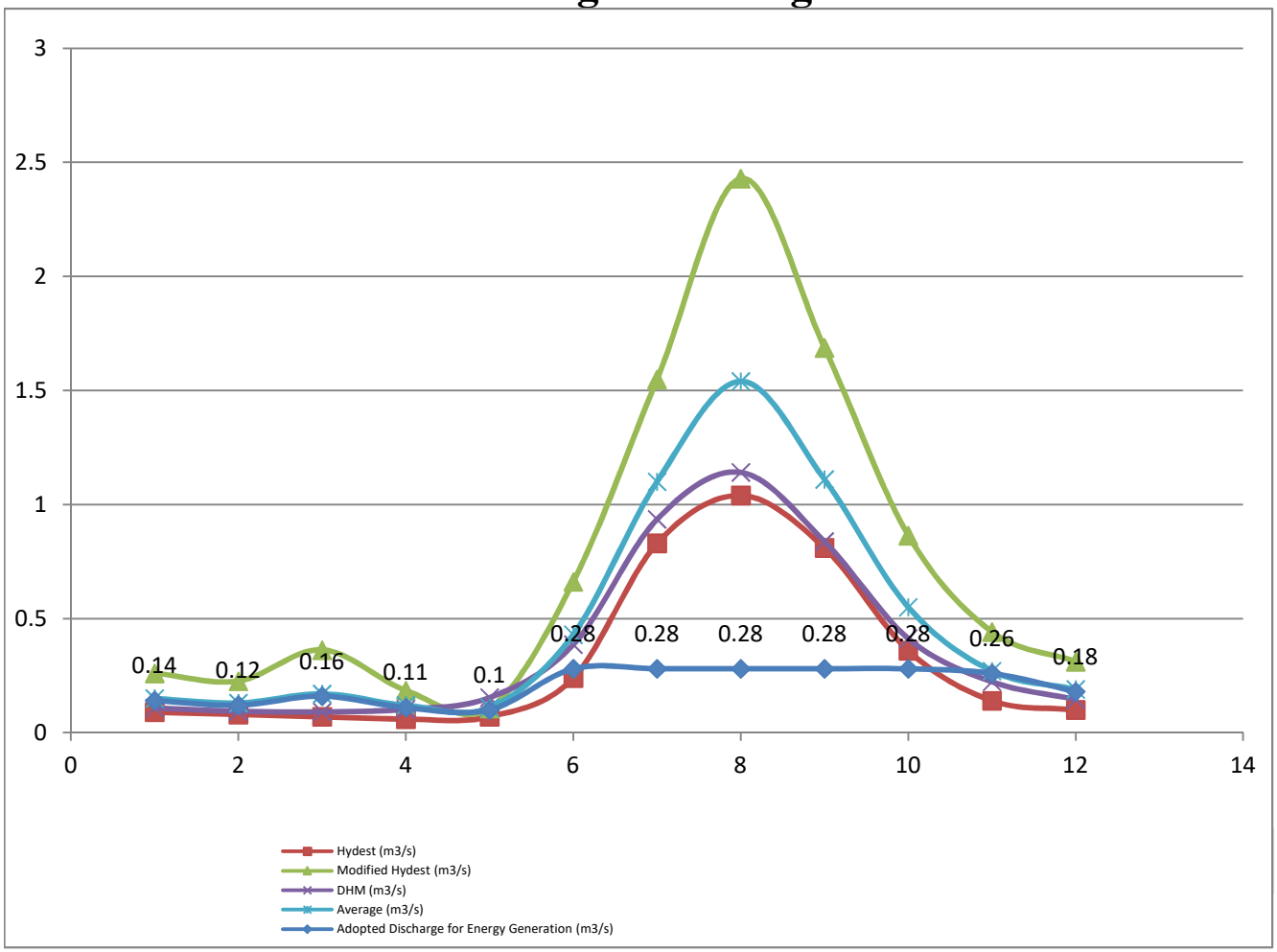


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N.	Month	Discharge in River (m3/s)	Discharge for Power Generation (m3/s)	Remarks
1	January	0.15	0.135	
2	Febrauary	0.13	0.117	
3	March	0.17	0.153	
4	April	0.12	0.108	
5	May	0.11	0.099	
6	June	0.43	0.28	
7	July	1.1	0.28	
8	August	1.54	0.28	
9	September	1.11	0.28	
10	October	0.55	0.28	
11	November	0.27	0.243	
12	December	0.19	0.171	

Flow Duration Curve of the River

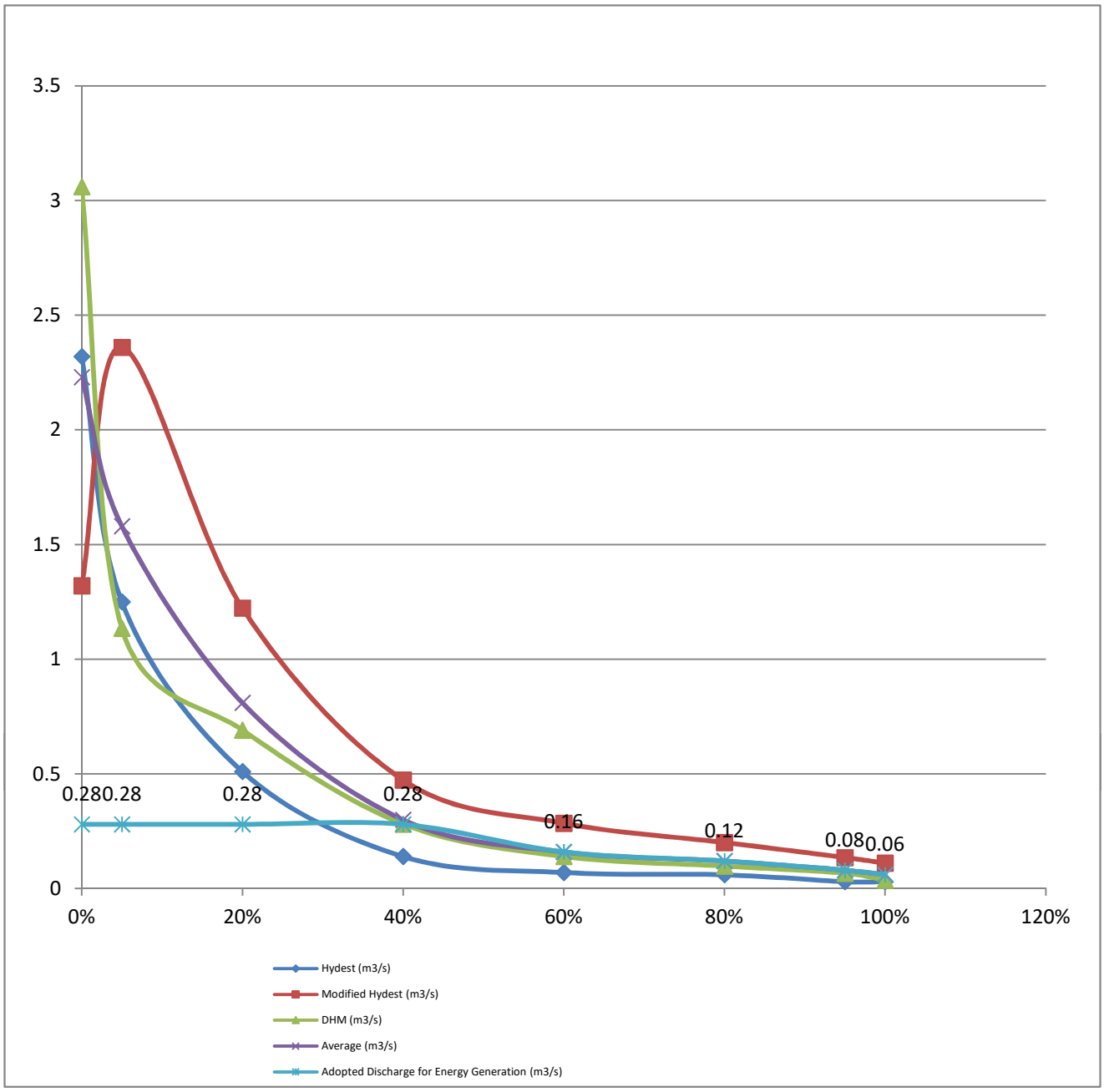


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N.	Probability of Exceedence (%age)	Hydest (m3/s)	Modified Hydest (m3/s)	DHM (m3/s)
1	0%	2.32	1.32	3.06
2	5%	1.25	2.36	1.14
3	20%	0.51	1.22	0.69
4	40%	0.14	0.47	0.28
5	60%	0.07	0.28	0.14
6	80%	0.06	0.2	0.1
7	95%	0.03	0.13	0.07
8	100%	0.03	0.11	0.04

Adopted Rate of Materials and Items at Project Site

Table : Adopted Rate of Materials and Items at Project Site

S.N.	Particulars	Unit Rate	Unit	Remarks
1	Cement (Ordinary Portland Cement)	750.00	Bag	At Project Site
2	Sand	3,740.46	m3	At Project Site
3	Agreegate	2,209.15	m3	At Project Site
4	Stone	1,955.00	m3	At Project Site
5	Cutting Bending and Fixing Reinforcement Bars	119.43	kg	At Project Site
6	Penstock Fabrication	180.06	kg	At Project Site
7	Gabion Making with material and filling	4,938.68	m3	At Project Site
8	Earthwork in Excavation	533.03	Cum	At Project Site
9	Earthwork in Backfilling	355.35	Cum	At Project Site
10	Dry Stone Soling	3,732.90	Cum	At Project Site
11	Stone Masonry in 1:4 cement mortar	12,717.51	Cum	At Project Site
12	Stone Masonry in 1:6 Cement Mortar	11,889.29	Cum	At Project Site
13	PCC(1:3:6) in Foundation	12,447.79	Cum	At Project Site
14	PCC (1:2:4) in Structures	15,458.63	Cum	At Project Site
15	PCC (1:1.5:3) in Structures	17,123.00	Cum	At Project Site
16	Wooden Formwork	514.59	m2	At Project Site
17	20 mm thick Plastering	588.56	m2	At Project Site
18	12.5 mm thick Plastering	461.51	m2	At Project Site
19	CGI Roofing	507.55	m2	At Project Site
20	33 kV kV Transmission Line cost per kM	1,857,994.47	kM	At Project Site
21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5595842.825	
1.2	Desanding Basin	1.2	913412.2518	
1.3	Headrace Power Canal	1.3	0	
1.4	Cross Drainage Works	1.4	12275799.29	
1.5	Forebay Basin/Spillway	1.5	913412.2518	
1.6	Penstock and Hydro Mechanical (M	1.6	122757992.9	
1.7	Anchor Block and Support Pier	1.7	61378996.43	
1.7	Powerhouuse and Tailrace	1.8	8711903.816	
	Sub-Total NRs.		212547359.7	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	2.1	73332000	
3	TRANSMISSION LINE			
3.1	33 Kv Transmission line to Substation	3.1	9931977.893	
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	4.1	5000000	
4.2	Site Facilities with Operators' Village	4.2	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	5.1	5000000	
	Sub-total		306111337.6	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	6.1	15305566.88	
	Sub Total 1-6		321416904.5	
7	Contigencies	7.1	26145191.55	
8	VAT 1-6 (6 Inclusive of VAT)	8.1	36163236.49	
9	Interest During Construction	9.1	46047039.9	
10	TOTAL ESTIMATED COST (NRs)	10.1	429772372.4	
	Cost per kW (1 US$ = NRs. 106)		2612.41	
	Cost per kW in NRs.		**276915.19**	

Revenue of the Project

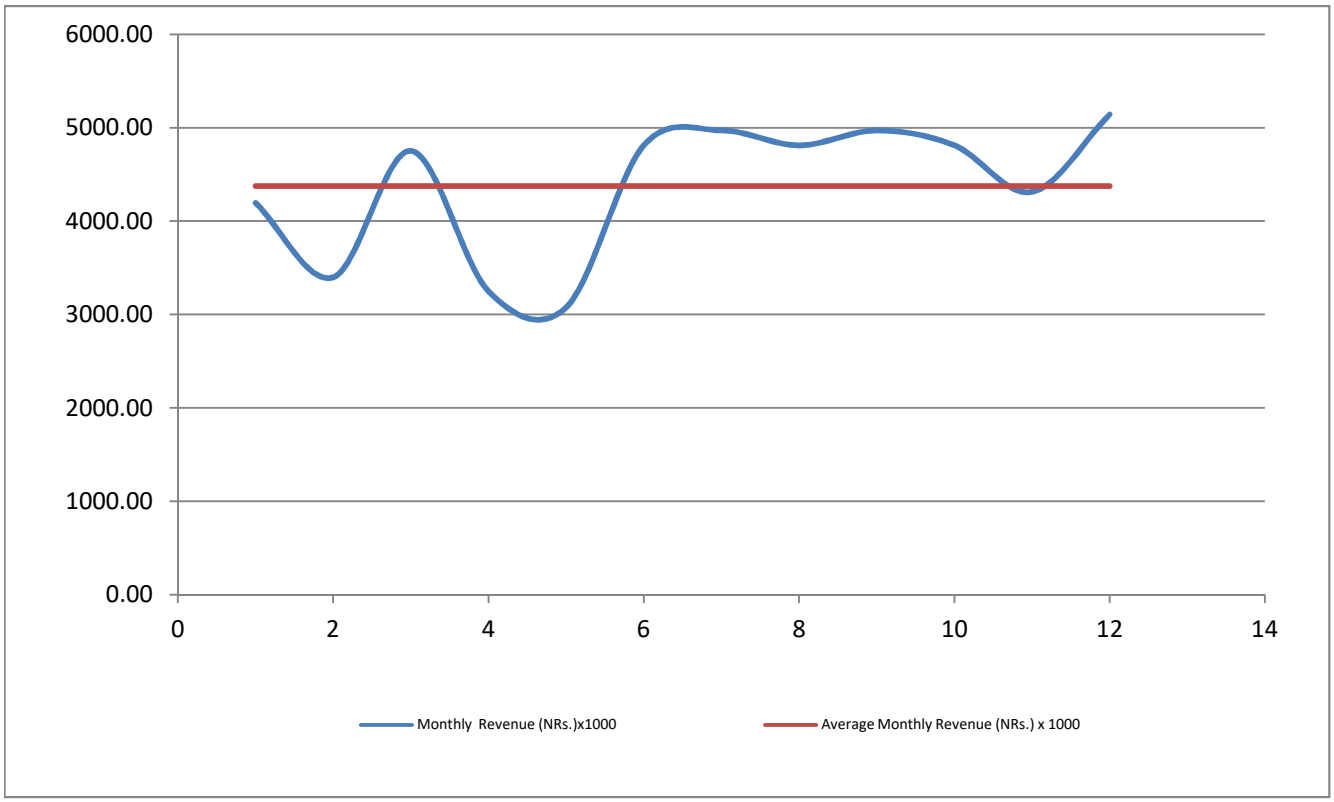


Table: Summary of Monthly and Average Monthly Revenue From the Project

S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	4195.98	4375.92	
2	February	3399.10	4375.92	
3	March	4752.82	4375.92	
4	April	3249.59	4375.92	
5	May	3076.68	4375.92	
6	June	4811.79	4375.92	
7	July	4972.18	4375.92	
8	August	4811.79	4375.92	
9	September	4972.18	4375.92	
10	October	4811.79	4375.92	
11	November	4313.30	4375.92	
12	December	5143.82	4375.92	
	Total	52511.02	52511.02	

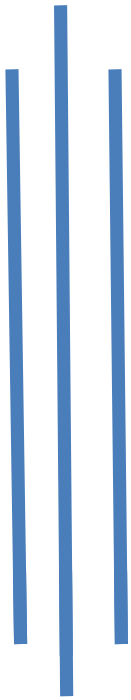
Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	429.77		
2	Bank Loan (70%)	300.841	(Million NRs.)	
3	Equity Investment (30%)	128.932	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	-42.19	(Million NRs.)	
6	IRR	8.62%		
7	B/C	0.91		
8	Least Cost of Energy (LCOE)	5.72	NRs./kWh	
9	Return on Equity (RoE)	8.35%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	48.96	(Million NRs.)	

Desk Study Report of Pagarpu Khola Mini Hydropower Project

Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk



Submitted To:

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Submitted By:

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Kalanki, Kathmandau

July 1, 2018

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Khimananda Kandel
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SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Pagarpu Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.7972, Lattitude= 27.9094	
Powerhouse Coordinate	:	Longitude = 85.7698, Lattitude= 27.9104	
Access			
Location of Nearest Roadhead	:	Pagarpu	
Distance from Roadhead	:	1	
Hydrology			
Catchment Area	:	7.3	km2
Q40 /(Adopted)Discharge	:	0.357	m3/s
Power and Energy			
Gross Head	:	649	m
Efficiency %	:	0.85	%
Power at Q40	:	1739	kW
Total Annual Energy at Q45	:	9.77	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	1807	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	11.33	m
Breadth	:	3	m
Height	:	1.76	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.85	m
Height of Canal	:	0.64	m
Forebay			
Particle Size to be Settled	:	0.3	mm
Length (m)	:	15	m
Breadth (m)	:	2	m

Height (m)	:	1.55	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	3920	m
Internal diameter (d)	:	500	mm
Thickness (mm)	:	23.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	1158	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 869.5 kW Capacity	
Gross Head	:	649	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2	
Height	:	0.64	

Grid Connection

Transmission voltage	:	11 kV	
Line length	:	4.2	kM
Connection point	:	Pangtang (Sherpa Gaun)	

Power Transformer

Number of unit	:	1	
Rating	:	2600	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 1300	kVA

Rated Voltage	:	0.4	kV
Rated Frequency	:	50	Hz
Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period	:	18	Months

Economic and Financial Indicators

Project cost	:	495.19	Million (NRs.)
Annual Revenue	:	57.87	Million (NRs.)
Internal rate of return (IRR)	:	7.98	%
B/C Ratio	:	0.87	
Net present value (at 10% discount rate)	:	-70.47	Million (NRs.)
Cost per kW	:	2686.37	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

Following general assumptions have been made in this study.

1. All DoED license issued and power generated sites for more than 100 kW Installed capacity are avoided in this study.
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1. It was not possible to carry out the detailed site survey of the Project because of ToR and Budgetory Limitations. So, Basically secondary data are used for the preparation of the report after

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4. Water to wire cost is taken as certain dollar per kW.

5. It is assumed that the main construction materials and equipments will be delivered from stations namely; Birtamode, Itahari, Mirchaiya, Bardibas, Hetauda, Narayangadh, Kathmandu, Pokhara, Butwal, Bhaluwang, Tulsipur and Atariya.

6. Government standard has been followed for the estimation of rate of material. For generalizing the study, the rate of materials at Baglung district is taken as base rate and rate has been increased by certain percentage for remote districts with remoteness factor provision in cost estimate model.

7. For remote districts like Humla, Dolpa and Mugu district provision for transportation by air is also considered.

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10. Financial parameters have been presented for all investment and equity investment options.

11. Hydropower project is compared with Solar power plant by using Least Cost of Energy (LCoE) mehtod.

12. Physical contingencies for Civil, Electro Mechanical (Water to Wire), Penstock/Hydromechanical are taken as 10%, 2.5 % and 5% respectively. Similarly VAT/Tax is taken as 13% and in case of Electromechanical items (Water to Wire) tax is taken as 1% .

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Available and Design Discharge in the River

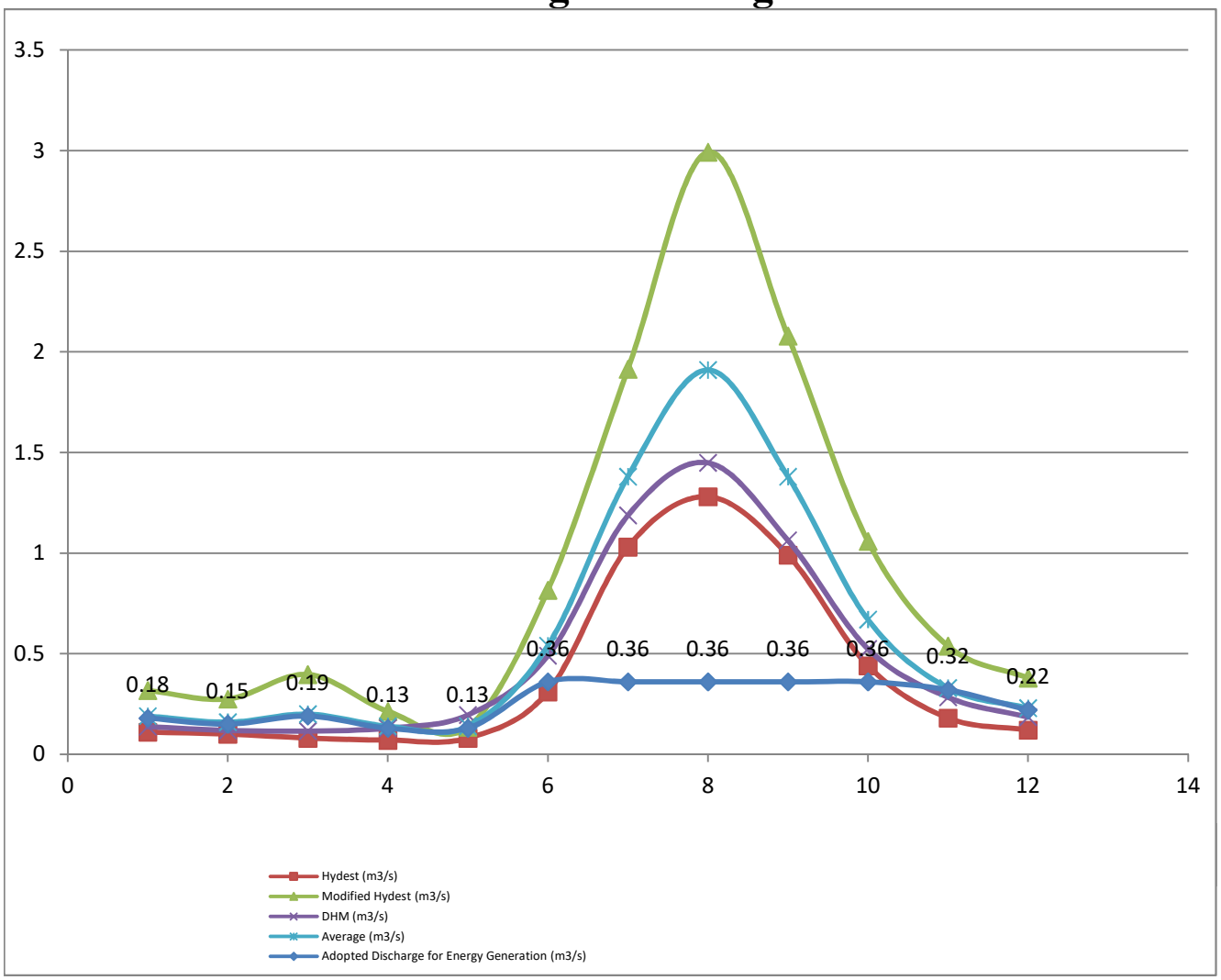


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N	Month	Discharge in River (m3/s)	Discharge for Power Generation (m3/s)	Remarks
1	January	0.19	0.171	
2	Febrauary	0.16	0.144	
3	March	0.2	0.18	
4	April	0.14	0.126	
5	May	0.14	0.126	
6	June	0.54	0.36	
7	July	1.38	0.36	
8	August	1.91	0.36	
9	September	1.38	0.36	
10	October	0.67	0.36	
11	November	0.33	0.297	
12	December	0.23	0.207	

Flow Duration Curve of the River

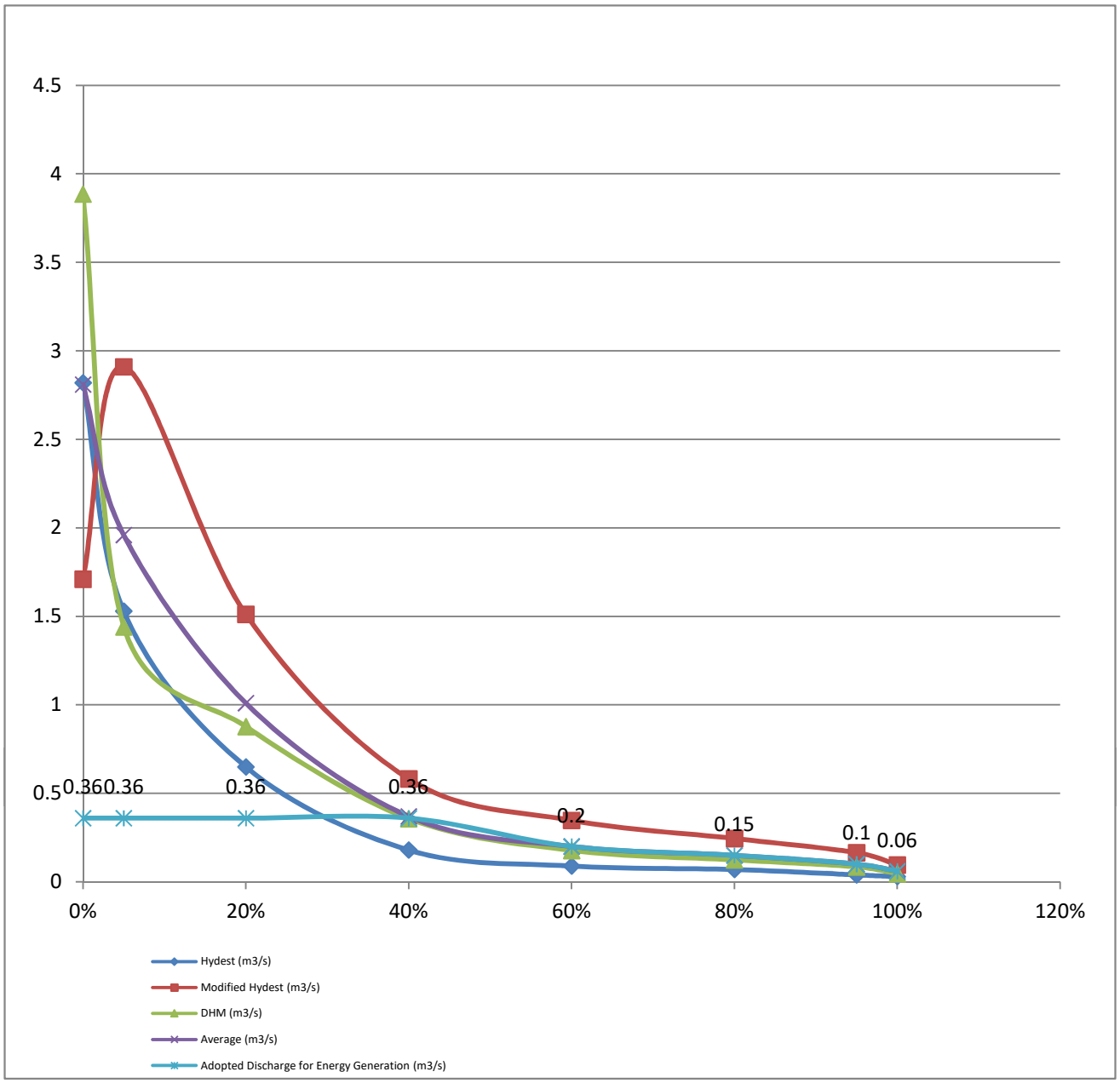


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N	Probability of Exceedence (%age)	Hydest (m3/s)	Modified Hydest (m3/s)	DHM (m3/s)
1	0%	2.82	1.71	3.89
2	5%	1.53	2.91	1.44
3	20%	0.65	1.51	0.88
4	40%	0.18	0.58	0.36
5	60%	0.09	0.35	0.18
6	80%	0.07	0.24	0.12
7	95%	0.04	0.17	0.08
8	100%	0.03	0.1	0.05

Adopted Rate of Materials and Items at Project Site

Table : Adopted Rate of Materials and Items at Project Site				
S.N	**Particulars**	**Unit Rate**	**Unit**	**Remarks**
1	Cement (Ordinary Portland Cement)	750.00	Bag	At Project Site
2	Sand	3,626.06	m3	At Project Site
3	Agreegate	2,209.15	m3	At Project Site
4	Stone	1,955.00	m3	At Project Site
5	Cutting Bending and Fixing Reinforcement Bars	119.43	kg	At Project Site
6	Penstock Fabrication	180.06	kg	At Project Site
7	Gabion Making with material and filling	4,938.68	m3	At Project Site
8	Earthwork in Excavation	533.03	Cum	At Project Site
9	Earthwork in Backfilling	355.35	Cum	At Project Site
10	Dry Stone Soling	3,732.90	Cum	At Project Site
11	Stone Masonry in 1:4 cement mortar	12,658.31	Cum	At Project Site
12	Stone Masonry in 1:6 Cement Mortar	11,827.46	Cum	At Project Site
13	PCC(1:3:6) in Foundation	12,385.95	Cum	At Project Site
14	PCC (1:2:4) in Structures	15,400.08	Cum	At Project Site
15	PCC (1:1.5:3) in Structures	17,067.09	Cum	At Project Site
16	Wooden Formwork	514.59	m2	At Project Site
17	20 mm thick Plastering	585.66	m2	At Project Site
18	12.5 mm thick Plastering	459.59	m2	At Project Site
19	CGI Roofing	507.28	m2	At Project Site
20	33 kV kV Transmission Line cost per kM	1,857,994.47	kM	At Project Site
21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5583197.278	
1.2	Desanding Basin	1.2	1010541.67	
1.3	Headrace Power Canal	1.3		
1	Cross Drainage Works	1.4	14576538.88	
2	Forebay Basin/Spillway	1.5	1010541.67	
2	Penstock and Hydro Mechanical (M	1.6	145765388.8	
2	Anchor Block and Support Pier	1.7	72882694.41	
2	Powerhouuse and Tailrace	1.8		
	Sub-Total NRs.		249515065.6	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	1.9	82167750	
3	TRANSMISSION LINE			
3.1	33 Kv Transmission line to Substation	1.1	10303576.79	
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	1.11	5000000	
4	Site Facilities with Operators' Village	1.12	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	1.13	5000000	
	Sub-total		352286392.4	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	0.05	17614319.62	
	Sub Total 1-6		369900712	
7	Contigencies		30312311.11	
8	VAT 1-6 (6 Inclusive of VAT)		41921059.76	
9	Interest During Construction		53056089.95	
10	TOTAL ESTIMATED COST (NRs)		495190172.9	
	Cost per kW (1 US$ = NRs. 106)		2686.37	
	Cost per kW in NRs.		**284755.71**	

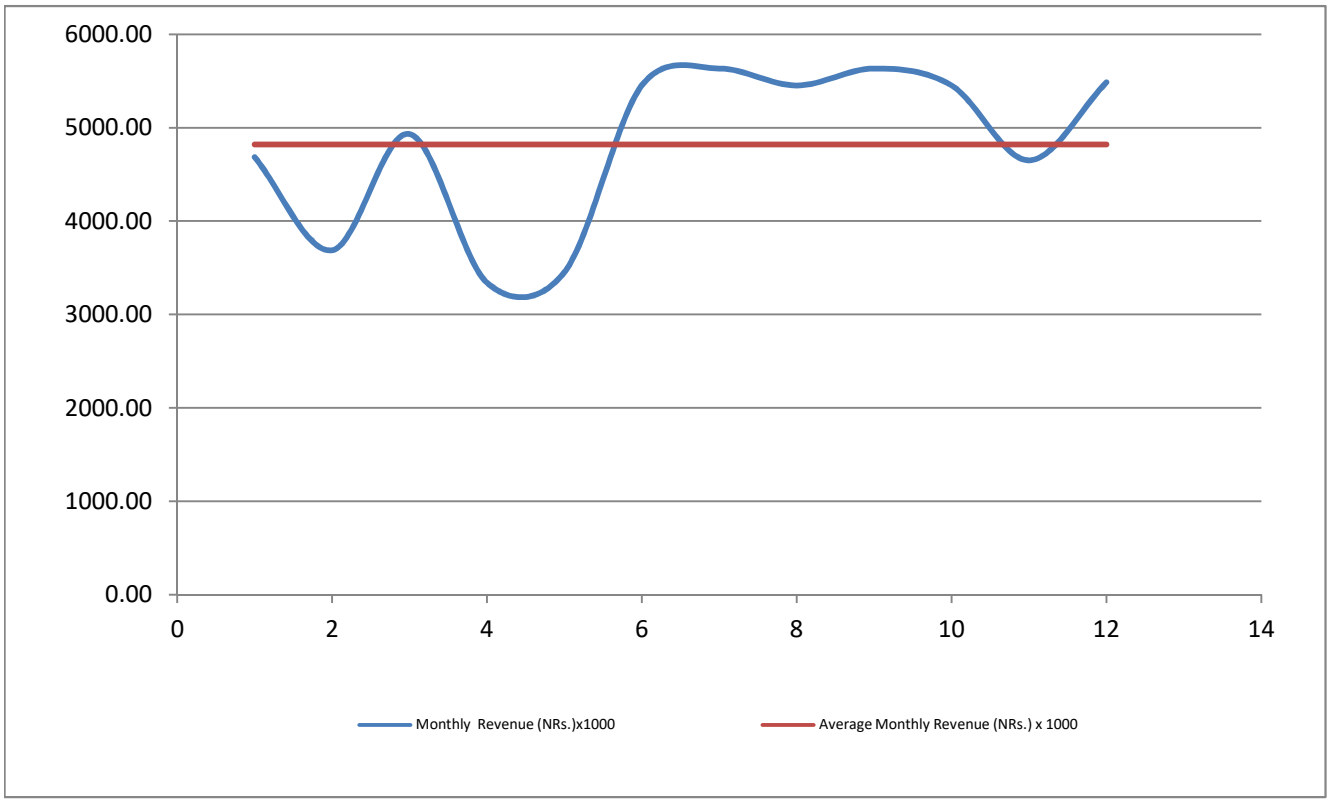


Table: Summary of Monthly and Average Monthly Revenue From the Project

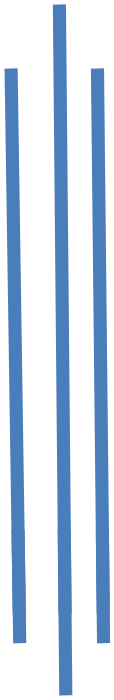
S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	4685.33	4822.16	
2	February	3688.49	4822.16	
3	March	4932.81	4822.16	
4	April	3342.12	4822.16	
5	May	3453.53	4822.16	
6	June	5452.53	4822.16	
7	July	5634.28	4822.16	
8	August	5452.53	4822.16	
9	September	5634.28	4822.16	
10	October	5452.53	4822.16	
11	November	4650.77	4822.16	
12	December	5486.75	4822.16	
	Total	57865.96	57865.96	

Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	495.19		
2	Bank Loan (70%)	346.633	(Million NRs.)	
3	Equity Investment (30%)	148.557	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	-70.47	(Million NRs.)	
6	IRR	7.98%		
7	B/C	0.87		
8	Least Cost of Energy (LCOE)	5.94	NRs./kWh	
9	Return on Equity (RoE)	7.61%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	56.41	(Million NRs.)	

Desk Study Report of Thamran Sun Khola Mini Hydropower Project
Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk



Submitted To:

Jugal Rural Municipality,Sindhupalchowk

Submitted By:
Epsom Engineering Consultancy Pvt. Ltd.
Kalanki, Kathmandau

July 1, 2018

ACKNOWLEDGEMENTS

Its our great pleasure to work with Jugal Rural Municipality,Sindhupalchowk for Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk.

We would like to thank all the team of Jugal Rural Municipality,Sindhupalchowk for their support during the accomplishment of this study.

We would also like to thank to our study team for their valuable time for the accomplishment of the study.

It is expected that this study will pave the foundation for the development of hydropower projects in Jugal Rural Municipality,Sindhupalchowk.

Khimananda Kandel
Managing Director
Epsom Engineering Consultancy Pvt. Ltd.
Kalanki, Kathmandau
khimanandakandel@yahoo.com
9851070202

SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Thamran Sun Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindhupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.7763, Lattitude= 27.8926	
Powerhouse Coordinate	:	Longitude = 85.7596, Lattitude= 27.89	
Access			
Location of Nearest Roadhe	:	Kattike	
Distance from Roadhead	:	1	
Hydrology			
Catchment Area	:	5.52	km2
Q40 /(Adopted)Discharge	:	0.27	m3/s
Power and Energy			
Gross Head	:	492	m
Efficiency %	:	0.85	%
Power at Q40	:	997	kW
Total Annual Energy at Q45	:	5.574	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	1518	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	8.67	m
Breadth	:	3	m
Height	:	1.47	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.75	m
Height of Canal	:	0.56	m
Forebay			
Length (m)	:	12	m
Breadth (m)	:	2.5	m
Height (m)	:	1.42	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	1790	m
Internal diameter (d)	:	450	mm
Thickness (mm)	:	16.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	1026	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 498.5 kW Capacity	
Gross Head	:	492	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2.5	
Height	:	0.56	

Grid Connection

Transmission voltage	:	11 kV	
Line length	:	3.5	kM
Connection point	:	Pangtang (Sherpa Gaun)	
	:		

Power Transformer

Number of unit	:	1	
Rating	:	1500	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 750	kVA
Rated Voltage	:	0.4	kV
Rated Frequency	:	50	Hz

Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period : 18 Months

Economic and Financial Indicators

Project cost	:	209.65	Million (NRs.)
Annual Revenue	:	33.12	Million (NRs.)
Internal rate of return (IRR)	:	12.59	%
B/C Ratio	:	1.18	
Net present value (at 10% discount rate)	:	41.38	Million (NRs.)
Cost per kW	:	1983.74	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

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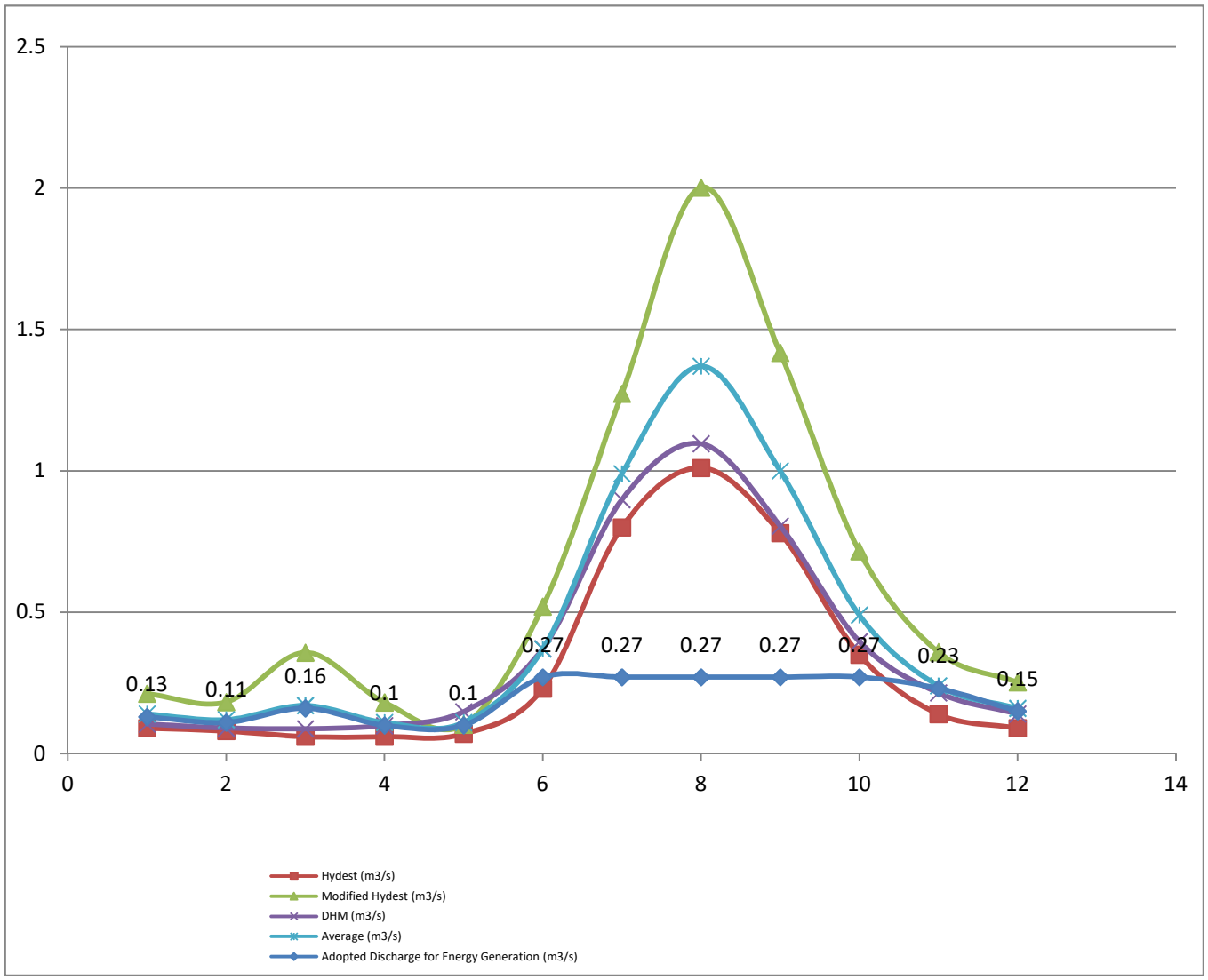

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7	July	0.99	0.27	
8	August	1.37	0.27	
9	September	1	0.27	
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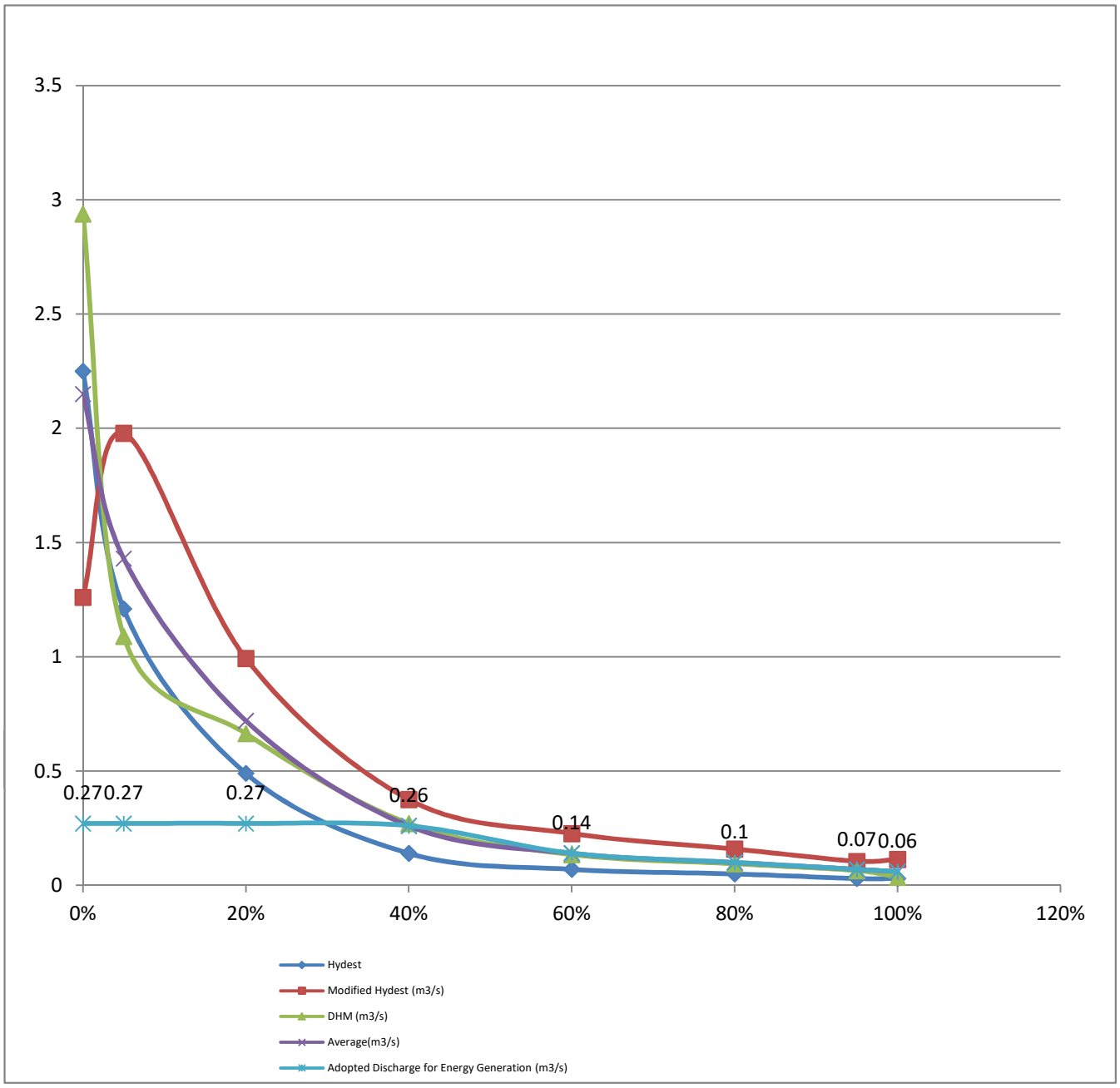

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4	40%	0.14	0.38	0.27
5	60%	0.07	0.23	0.13
6	80%	0.05	0.16	0.09
7	95%	0.03	0.1	0.06
8	100%	0.03	0.11	0.03

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1.3	Headrace Power Canal	1.3		
1.4	Cross Drainage Works	1.4	4302834.364	
1.5	Forebay Basin/Spillway	1.5	901626.7651	
1.6	Penstock and Hydro Mechanical (Metal Parts)	1.6	43028343.64	
1.7	Anchor Block and Support Pier	1.7	21514171.82	
1.8	Powerhouuse and Tailrace	1.8		
	Sub-Total NRs.		84898608.79	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	2.1	47108250	
3	TRANSMISSION LINE			
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	4.1	5000000	
4.2	Construction Camp Establishment	4.2	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	5.1	5000000	
	Sub-total		151307105	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	6.1	7565355.25	
	Sub Total 1-6		158872460.3	
7	Contigencies	7.1	11904114.96	
8	VAT 1-6 (6 Inclusive of VAT)	8.1	16406640.03	
9	Interest During Construction	9.1	22461985.83	
10	TOTAL ESTIMATED COST (NRs)	10.1	209645201.1	
	Cost per kW (1 US$ = NRs. 106)		1983.74	
	Cost per kW in NRs.		**210276.03**	

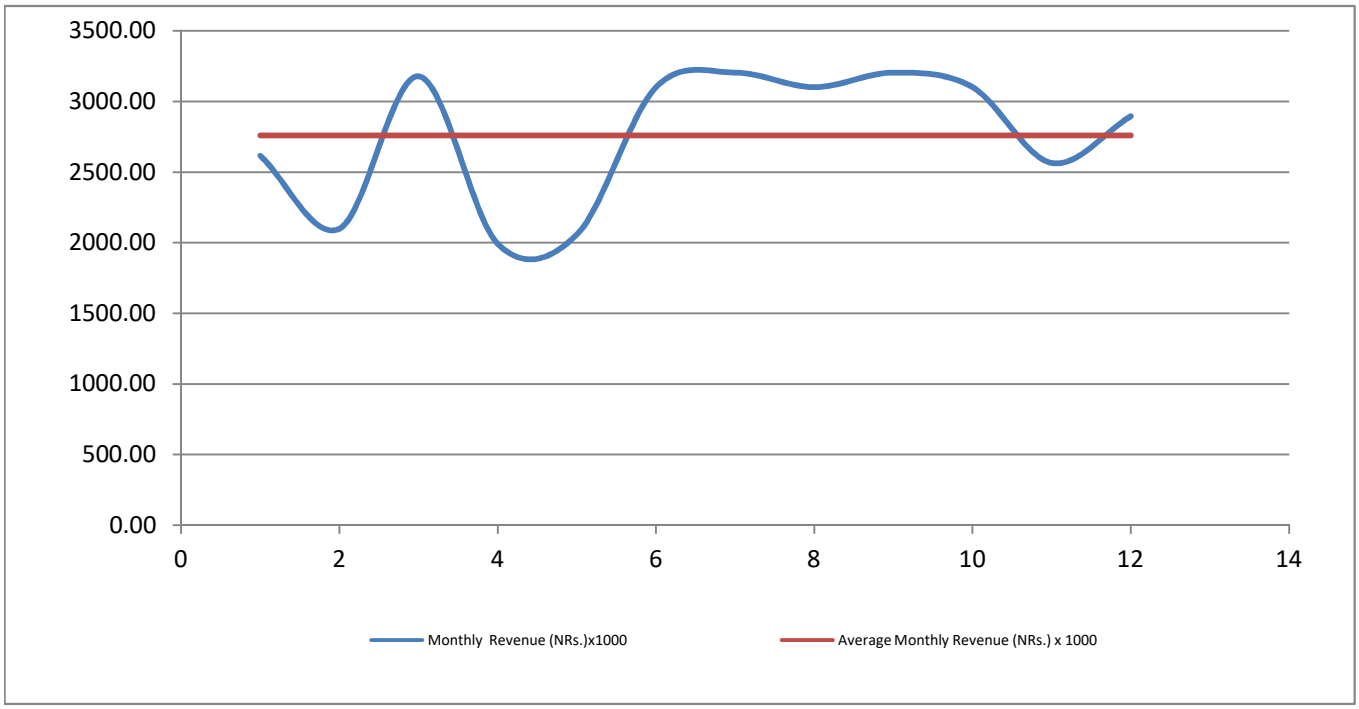

Table: Summary of Monthly and Average Monthly Revenue From the Project

S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	2615.46	2759.70	
2	February	2099.44	2759.70	
3	March	3177.92	2759.70	
4	April	1992.21	2759.70	
5	May	2058.62	2759.70	
6	June	3101.07	2759.70	
7	July	3204.44	2759.70	
8	August	3101.07	2759.70	
9	September	3204.44	2759.70	
10	October	3101.07	2759.70	
11	November	2564.84	2759.70	
12	December	2895.78	2759.70	
	Total	33116.36	33116.40	

Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	209.65	(Million NRs.)	
2	Bank Loan (70%)	146.752	(Million NRs.)	
3	Equity Investment (30%)	62.894	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	41.38	(Million NRs.)	
6	IRR	12.59%		
7	B/C	1.18		
8	Least Cost of Energy (LCOE)	4.41	NRs./kWh	
9	Return on Equity (RoE)	15.33%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	23.88	(Million NRs.)	

Desk Study Report of Dipu Sanglung Khola Mini Hydropower Project

Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk

Submitted To:

Jugal Rural Municipality,Sindhupalchowk

Submitted By:

Epsom Engineering Consultancy Pvt. Ltd.

Kalanki, Kathmandau

July 1, 2018

ACKNOWLEDGEMENTS

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Khimananda Kandel
Managing Director
Epsom Engineering Consultancy Pvt. Ltd.
Kalanki, Kathmandau
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9851070202

SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Dipu Sanglung Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindhupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.8142, Lattitude= 27.8734	
Powerhouse Coordinate	:	Longitude = 85.8017, Lattitude= 27.8556	
Access			
Location of Nearest Roadhead	:	Hapra Gau	
Distance from Roadhead	:	1	
Hydrology			
Catchment Area	:	3.5	km2
Q40 /(Adopted) Discharge	:	0.171	m3/s
Power and Energy			
Gross Head	:	430	m
Efficiency %	:	0.85	%
Power at Q40	:	552	kW
Total Annual Energy at Q45	:	3.298	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	2010	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	5.67	m
Breadth	:	3	m
Height	:	1.13	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.65	m
Height of Canal	:	0.4875	m
Forebay			
Particle Size to be Settled	:	0.3	mm
Length (m)	:	12	m
Breadth (m)	:	2	m
Height (m)	:	1.29	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	2700	m
Internal diameter (d)	:	450	mm
Thickness (mm)	:	15.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	1580	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 276 kW Capacity	
Gross Head	:	430	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2	
Height	:	0.4875	

Grid Connection

Transmission voltage	:	11 kV	
Connection point	:	4	kM
Line length	:	Pangtang (Sherpa Gaun)	

Power Transformer

Number of unit	:	1	
Rating	:	800	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 400	kVA
Rated Voltage	:	0.4	kV

Rated Frequency	:	50	Hz
Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period : 18 Months

Economic and Financial Indicators

Project cost	:	205.18	Million (NRs.)
Annual Revenue	:	21.17	Million (NRs.)
Internal rate of return (IRR)	:	0.05	%
B/C Ratio	:	0.72	
Net present value (at 10% discount rate)	:	-63.36	Million (NRs.)
Cost per kW	:	3506.67	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

Following general assumptions have been made in this study.

1. All DoED license issued and power generated sites for more than 100 kW Installed capacity are avoided in this study.

2. Rivers with discharge more than 5 m3/s at 65% Probability of Exceedence are not studied for power generation. In general, large rivers are not considered in this study.

3. In general, Projects sites have been avoided for head less than 40 m.

4. Discharge of the river is estimated by using Hydest Method, Modified Hydest Method and model generated by using DHM monthly data. The average of the three methods have been adopted in flow estimation.

5. New_LocClim (Local Climate Estimator Software) have been used for the estimation of precipitation data.

6. Total headloss in waterways is taken as 10% of the total head available from Intake to Powerhouse.

7. Overall Efficiency of the proposed project is taken as 85% .

8. This study is completely based on desk study. District level coordination meeting is arranged in District Coordination Committees to the possible extent.

9. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel (email: khimanandakandel@yahoo.com)

Limitations:

1. It was not possible to carry out the detailed site survey of the Project because of ToR and Budgetory Limitations. So, Basically secondary data are used for the preparation of the report after making site visit.

2. The project sites have been identified for 40% probability of flow exceedence.

3. The study area seems to have limited hydro resources and in this study optimization of available resources have been made. Regarding the development of storage type projects, it seems very high size dam which seems infeasible in case of such small streams.

STUDY METHODOLOGY

The study methodology includes the following.

1. Field Visit was made for the stream for the potential hydro development sites.

2. Field Survey was made by using GPS to find out headworks, headrace alignment and Powerhouse.

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5. The Surveyed data were analyzed and Plotted.

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APPROACH FOR COST ESTIMATION

Following approach have been made for the estimation of cost estimation.

1. Length of headrace, penstock, distance from existing or proposed substation, nearest roadhead and distance of sand availability was found out by using GIS Map, Google Earth and available maps.

2. Approximate design/sizing of headrace, desanding basin, forebay and penstock pipe (diameter and thickness) is made for the identified alternatives.

3. 11 kV or 33 kV transmission line is proposed for power transmission and unit cost of 11 kV and 33 kV transmission line is prepared by including the cost of swithching station.

4. Water to wire cost is taken as certain dollar per kW.

5. It is assumed that the main construction materials and equipments will be delivered from stations namely; Birtamode, Itahari, Mirchaiya, Bardibas, Hetauda, Narayangadh, Kathmandu, Pokhara, Butwal, Bhaluwang, Tulsipur and Atariya.

6. Government standard has been followed for the estimation of rate of material. For generalizing the study, the rate of materials at Baglung district is taken as base rate and rate has been increased by certain percentage for remote districts with remoteness factor provision in cost estimate model.

7. For remote districts like Humla, Dolpa and Mugu district provision for transportation by air is also considered.

8. Revenue estimation for July to November, tariff rate is taken as Rs. 4.8 / Unit and for December to June Rs. 8.4/Unit is Considered. Tariff rate for revenue generation is increased by 3% per annum for 8 consecutive years and after this the tariff rate is fixed as constant as per the NEA tariff provision for small hydropower projects.

9. Insurance cost is taken as 0.3% of total project cost annually. Royalty is taken as per the hydropower policy of Nepal.

10. Financial parameters have been presented for all investment and equity investment options.

11. Hydropower project is compared with Solar power plant by using Least Cost of Energy (LCoE) mehtod.

12. Physical contingencies for Civil, Electro Mechanical (Water to Wire), Penstock/Hydromechanical are taken as 10%, 2.5 % and 5% respectively. Similarly VAT/Tax is taken as 13% and in case of Electromechanical items (Water to Wire) tax is taken as 1% .

13. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel.

Available and Design Discharge in the River

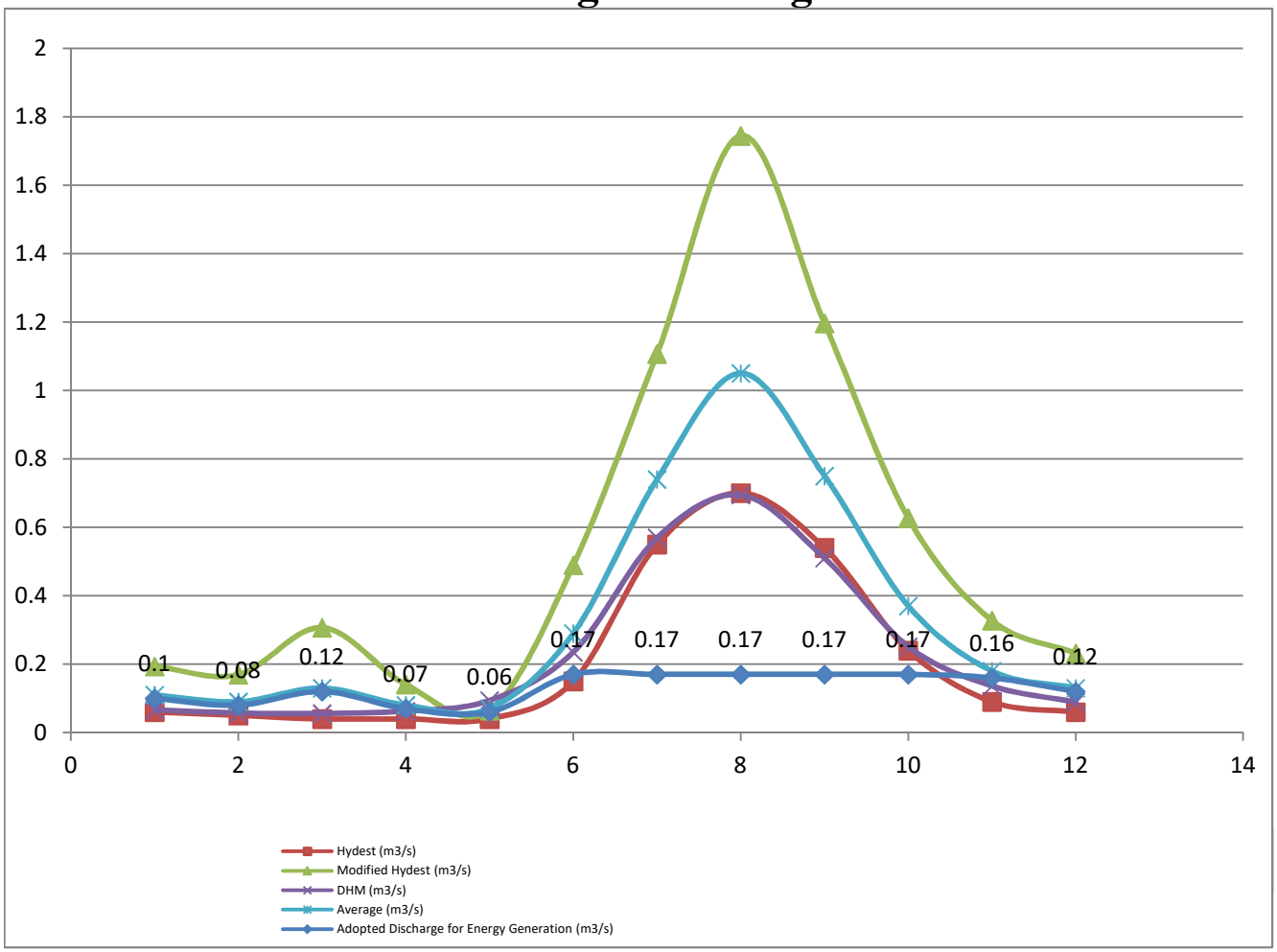

Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N.	Month	Discharge in River (m3/s)	Discharge for Power Generation (m3/s)	Remarks
1	January	0.11	0.099	
2	Febrauary	0.09	0.08	
3	March	0.13	0.117	
4	April	0.08	0.07	
5	May	0.07	0.06	
6	June	0.29	0.17	
7	July	0.74	0.17	
8	August	1.05	0.17	
9	September	0.75	0.17	
10	October	0.37	0.17	
11	November	0.18	0.16	
12	December	0.13	0.117	

Flow Duration Curve of the River

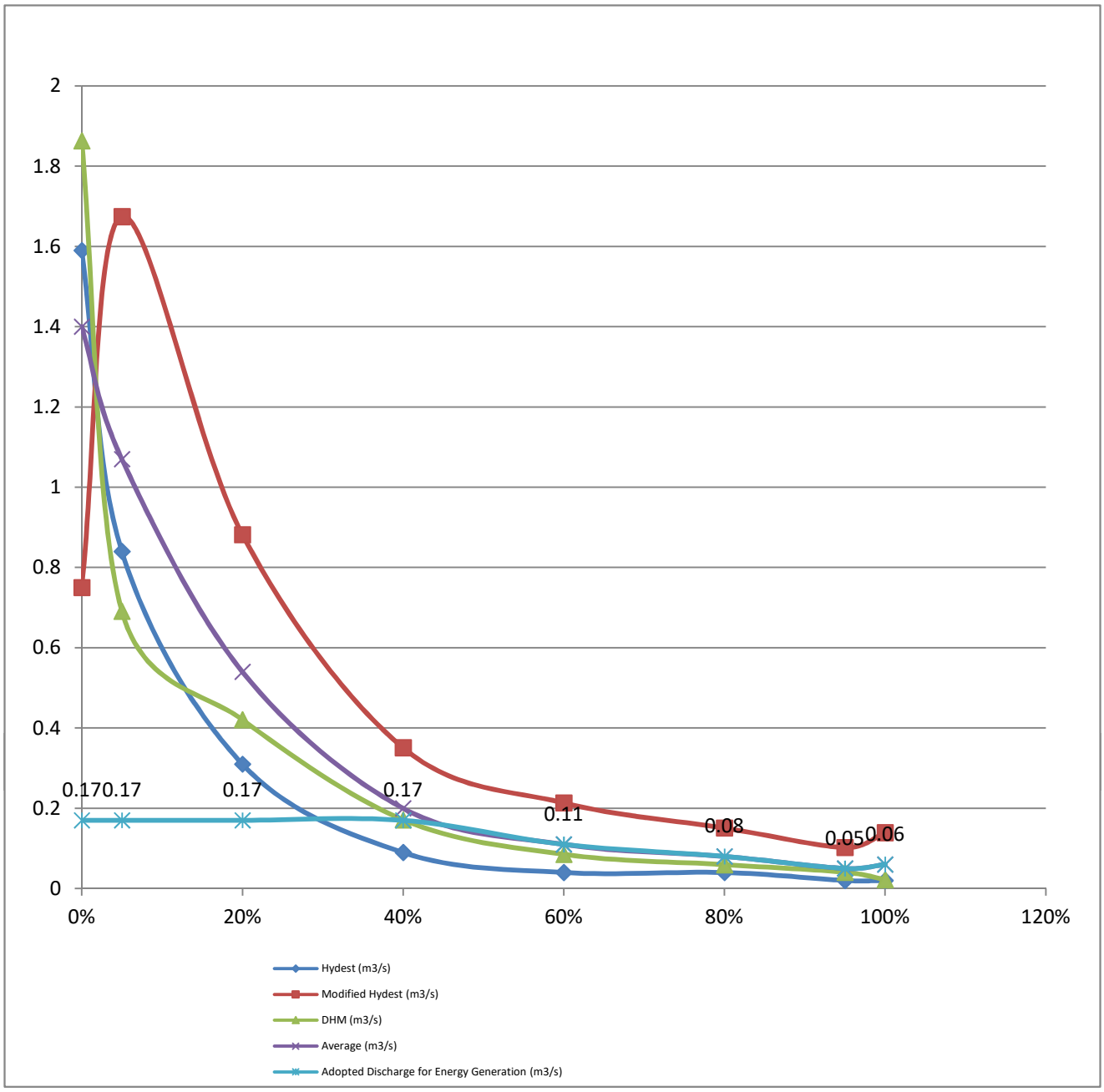

Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N.	Probability of Exceedence (%age)	Hydest (m3/s)	Modified Hydest (m3/s)	DHM (m3/s)
1	0%	1.59	0.75	1.86
2	5%	0.84	1.67	0.69
3	20%	0.31	0.88	0.42
4	40%	0.09	0.35	0.17
5	60%	0.04	0.21	0.09
6	80%	0.04	0.15	0.06
7	95%	0.02	0.1	0.04
8	100%	0.02	0.14	0.02

Adopted Rate of Materials and Items at Project Site

Table : Adopted Rate of Materials and Items at Project Site

S.N.	Particulars	Unit Rate	Unit	Remarks
1	Cement (Ordinary Portland Cement)	750.00	Bag	At Project Site
2	Sand	3,797.66	m3	At Project Site
3	Agreegate	2,209.15	m3	At Project Site
4	Stone	1,955.00	m3	At Project Site
5	Cutting Bending and Fixing Reinforcement Bars	119.43	kg	At Project Site
6	Penstock Fabrication	179.91	kg	At Project Site
7	Gabion Making with material and filling	4,938.68	m3	At Project Site
8	Earthwork in Excavation	533.03	Cum	At Project Site
9	Earthwork in Backfilling	355.35	Cum	At Project Site
10	Dry Stone Soling	3,732.90	Cum	At Project Site
11	Stone Masonry in 1:4 cement mortar	12,747.12	Cum	At Project Site
12	Stone Masonry in 1:6 Cement Mortar	11,920.21	Cum	At Project Site
13	PCC(1:3:6) in Foundation	12,478.70	Cum	At Project Site
14	PCC (1:2:4) in Structures	15,487.90	Cum	At Project Site
15	PCC (1:1.5:3) in Structures	17,150.96	Cum	At Project Site
16	Wooden Formwork	514.59	m2	At Project Site
17	20 mm thick Plastering	590.01	m2	At Project Site
18	12.5 mm thick Plastering	462.47	m2	At Project Site
19	CGI Roofing	507.28	m2	At Project Site
20	33 kV kV Transmission Line cost per kM	1,857,213.20	kM	At Project Site
21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5602165.599	
1.2	Desanding Basin	1.2	774712.0333	
1.3	Headrace Power Canal	1.3	0	
1.4	Cross Drainage Works	1.4	5172524.573	
1.5	Forebay Basin/Spillway	1.5	774712.0333	
1.6	Penstock and Hydro Mechanical (M	1.6	51725245.73	
1.7	Anchor Block and Support Pier	1.7	25862622.87	
1.7	Powerhouuse and Tailrace	1.8	8724404.963	
	Sub-Total NRs.		98636387.8	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	2.1	26082000	
3	TRANSMISSION LINE			
3.1	33 Kv Transmission line to Substation	3.1	9928852.819	
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	4.1	5000000	
4.2	Site Facilities with Operators' Village	4.2	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	5.1	5000000	
	Sub-total		144947240.6	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	6.1	7247362.031	
	Sub Total 1-6		152194602.7	
7	Contigencies	7.1	12766867.62	
8	VAT 1-6 (6 Inclusive of VAT)	8.1	18236905.14	
9	Interest During Construction	9.1	21983805.05	
10	TOTAL ESTIMATED COST (NRs)	10.1	205182180.5	
	Cost per kW (1 US$ = NRs. 106)		3506.67	
	Cost per kW in NRs.		**371706.85**	

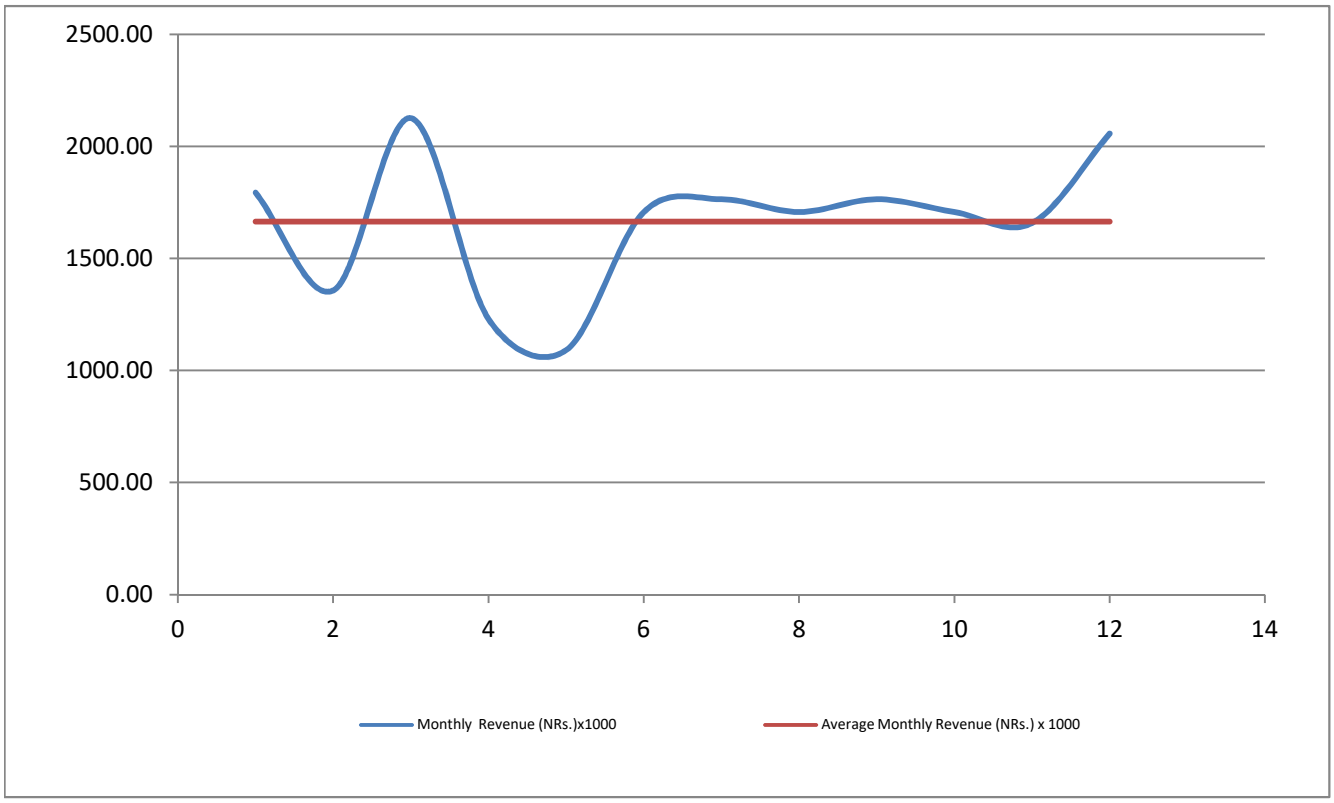

Table: Summary of Monthly and Average Monthly Revenue From the Project

S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	1794.26	1663.93	
2	February	1357.53	1663.93	
3	March	2126.11	1663.93	
4	April	1230.16	1663.93	
5	May	1091.18	1663.93	
6	June	1707.61	1663.93	
7	July	1764.53	1663.93	
8	August	1707.61	1663.93	
9	September	1764.53	1663.93	
10	October	1707.61	1663.93	
11	November	1658.47	1663.93	
12	December	2057.53	1663.93	
	Total	19967.13	19967.14	

Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	205.18		
2	Bank Loan (70%)	143.628	(Million NRs.)	
3	Equity Investment (30%)	61.555	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	-63.36	(Million NRs.)	
6	IRR	5.32%		
7	B/C	0.72		
8	Least Cost of Energy (LCOE)	7.29	NRs./kWh	
9	Return on Equity (RoE)	3.49%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	23.37	(Million NRs.)	

Desk Study Report of Manguin Khola (Lidi) Mini Hydropower Project
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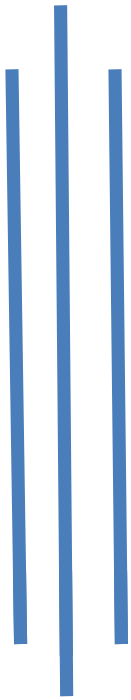

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SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Manguin Khola (Lidi) Mini Hydropower Pr	
Project location	:	Jugal Rural Municipality, Sindupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.7478, Lattitude= 27.9435	
Powerhouse Coordinate	:	Longitude = 85.7767, Lattitude= 27.9288	
Access			
Location of Nearest Roadhead	:	Upper Balephi A Intake	
Distance from Roadhead	:	4	
Hydrology			
Catchment Area	:	6.21	km2
Q40 /(Adopted)Discharge	:	0.304	m3/s
Power and Energy			
Gross Head	:	862	m
Efficiency %	:	0.85	%
Power at Q40	:	1967	kW
Total Annual Energy at Q45	:	11.36	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	2130	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	9.67	m
Breadth	:	3	m
Height	:	1.58	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.8	m
Height of Canal	:	0.60	m
Forebay			
Particle Size to be Settled	:	0.3	mm
Length (m)	:	20	m
Breadth (m)	:	2	m

Height (m)	:	1.48	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	3920	m
Internal diameter (d)	:	500	mm
Thickness (mm)	:	30.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	1268	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 983.5 kW Capacity	
Gross Head	:	862	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2	
Height	:	0.6	

Grid Connection

Transmission voltage	:	11 kV	
Line length	:	6.5	kM
Connection point	:	Pangtang (Sherpa Gaun)	

Power Transformer

Number of unit	:	1	
Rating	:	3000	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 1500	kVA

Rated Voltage	:	0.4	kV
Rated Frequency	:	50	Hz
Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period	:	18	Months

Economic and Financial Indicators

Project cost	:	586.15	Million (NRs.)
Annual Revenue	:	67.98	Million (NRs.)
Internal rate of return (IRR)	:	7.88	%
B/C Ratio	:	0.86	
Net present value (at 10% discount rate)	:	-87.50	Million (NRs.)
Cost per kW	:	2811.27	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

Following general assumptions have been made in this study.

1. All DoED license issued and power generated sites for more than 100 kW Installed capacity are avoided in this study.
2. Rivers with discharge more than 5 m3/s at 65% Probability of Exceedence are not studied for power generation. In general, large rivers are not considered in this study.
3. In general, Projects sites have been avoided for head less than 40 m.

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The study methodology includes the following.

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3. 11 kV or 33 kV transmission line is proposed for power transmission and unit cost of 11 kV and 33 kV transmission line is prepared by including the cost of swithching station.

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5. It is assumed that the main construction materials and equipments will be delivered from stations namely; Birtamode, Itahari, Mirchaiya, Bardibas, Hetauda, Narayangadh, Kathmandu, Pokhara, Butwal, Bhaluwang, Tulsipur and Atariya.

6. Government standard has been followed for the estimation of rate of material. For generalizing the study, the rate of materials at Baglung district is taken as base rate and rate has been increased by certain percentage for remote districts with remoteness factor provision in cost estimate model.

7. For remote districts like Humla, Dolpa and Mugu district provision for transportation by air is also considered.

8. Revenue estimation for July to November, tariff rate is taken as Rs. 4.8 / Unit and for December to June Rs. 8.4/Unit is Considered. Tariff rate for revenue generation is increased by 3% per annum for 8 consecutive years and after this the tariff rate is fixed as constant as per the NEA tariff provision for small hydropower projects.

9. Insurance cost is taken as 0.3% of total project cost annually. Royalty is taken as per the hydropower policy of Nepal.

10. Financial parameters have been presented for all investment and equity investment options.

11. Hydropower project is compared with Solar power plant by using Least Cost of Energy (LCoE) mehtod.

12. Physical contingencies for Civil, Electro Mechanical (Water to Wire), Penstock/Hydromechanical are taken as 10%, 2.5 % and 5% respectively. Similarly VAT/Tax is taken as 13% and in case of Electromechanical items (Water to Wire) tax is taken as 1% .

13. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel.

Available and Design Discharge in the River

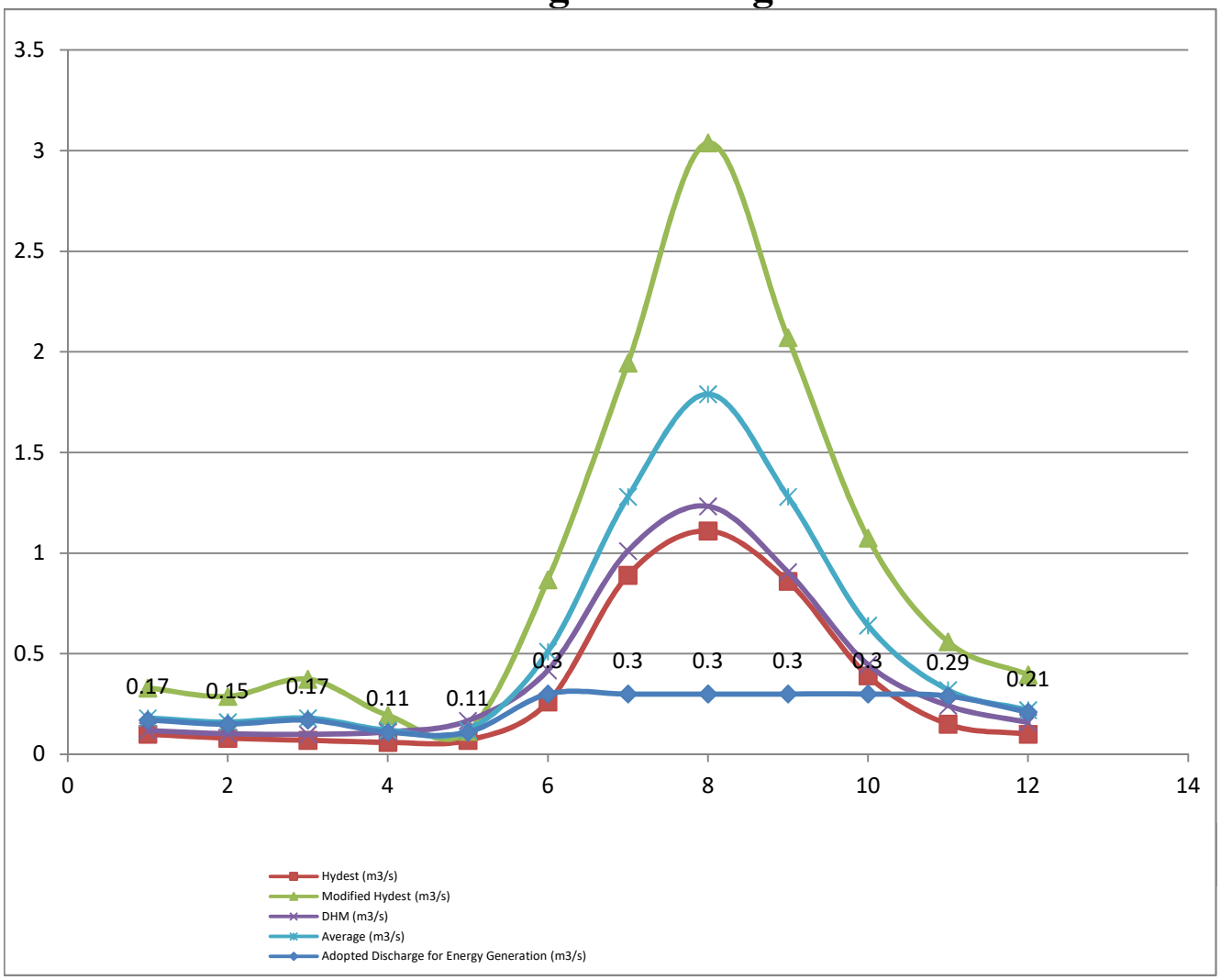


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N	Month	Discharge in River (m3/s)	Discharge for Power Generation (m3/s)	Remarks
1	January	0.18	0.162	
2	Febrauary	0.16	0.144	
3	March	0.18	0.162	
4	April	0.12	0.108	
5	May	0.12	0.108	
6	June	0.51	0.3	
7	July	1.28	0.3	
8	August	1.79	0.3	
9	September	1.28	0.3	
10	October	0.64	0.3	
11	November	0.32	0.288	
12	December	0.22	0.198	

Flow Duration Curve of the River

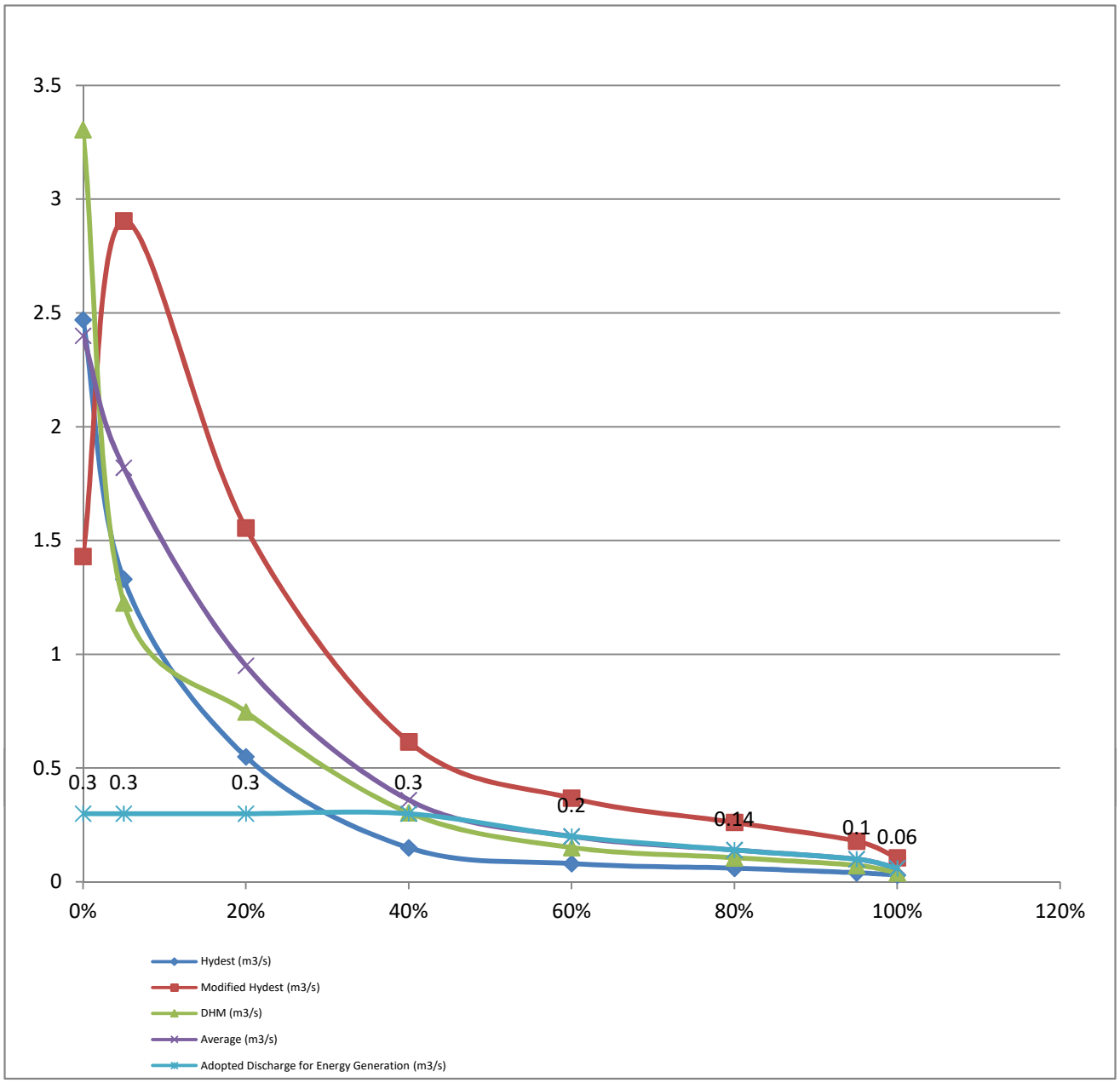


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N	Probability of Exceedence (%age)	Hydest (m3/s)	Modified Hydest (m3/s)	DHM (m3/s)
1	0%	2.47	1.43	3.31
2	5%	1.33	2.9	1.23
3	20%	0.55	1.56	0.75
4	40%	0.15	0.62	0.3
5	60%	0.08	0.37	0.15
6	80%	0.06	0.26	0.11
7	95%	0.04	0.18	0.07
8	100%	0.03	0.11	0.04

Adopted Rate of Materials and Items at Project Site

Table : Adopted Rate of Materials and Items at Project Site

S.N	Particulars	Unit Rate	Unit	Remarks
1	Cement (Ordinary Portland Cement)	750.00	Bag	At Project Site
2	Sand	3,683.26	m3	At Project Site
3	Agreegate	2,209.15	m3	At Project Site
4	Stone	1,955.00	m3	At Project Site
5	Cutting Bending and Fixing Reinforcement Bars	119.43	kg	At Project Site
6	Penstock Fabrication	179.91	kg	At Project Site
7	Gabion Making with material and filling	4,938.68	m3	At Project Site
8	Earthwork in Excavation	533.03	Cum	At Project Site
9	Earthwork in Backfilling	355.35	Cum	At Project Site
10	Dry Stone Soling	3,732.90	Cum	At Project Site
11	Stone Masonry in 1:4 cement mortar	12,687.91	Cum	At Project Site
12	Stone Masonry in 1:6 Cement Mortar	11,858.38	Cum	At Project Site
13	PCC(1:3:6) in Foundation	12,416.87	Cum	At Project Site
14	PCC (1:2:4) in Structures	15,429.35	Cum	At Project Site
15	PCC (1:1.5:3) in Structures	17,095.04	Cum	At Project Site
16	Wooden Formwork	514.59	m2	At Project Site
17	20 mm thick Plastering	587.11	m2	At Project Site
18	12.5 mm thick Plastering	460.55	m2	At Project Site
19	CGI Roofing	507.68	m2	At Project Site
20	33 kV kV Transmission Line cost per kM	1,857,213.20	kM	At Project Site
21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5589520.052	
1.2	Desanding Basin	1.2	943869.298	
1.3	Headrace Power Canal	1.3		
1	Cross Drainage Works	1.4	17651629.94	
2	Forebay Basin/Spillway	1.5	943869.298	
2	Penstock and Hydro Mechanical (M	1.6	176516299.4	
2	Anchor Block and Support Pier	1.7	88258149.7	
2	Powerhouuse and Tailrace	1.8		
	Sub-Total NRs.		298602257.8	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	1.9	92940750	
3	TRANSMISSION LINE			
3.1	33 Kv Transmission line to Substation	1.1	14571885.83	
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	1.11	5000000	
4	Site Facilities with Operators' Village	1.12	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	1.13	5000000	
	Sub-total		416414893.7	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	0.05	20820744.68	
	Sub Total 1-6		437235638.4	
7	Contigencies		36024413.29	
8	VAT 1-6 (6 Inclusive of VAT)		50092094.46	
9	Interest During Construction		62802257.53	
10	TOTAL ESTIMATED COST (NRs)		586154403.6	
	Cost per kW (1 US$ = NRs. 106)		2811.27	
	Cost per kW in NRs.		**297994.1**	

Revenue of the Project

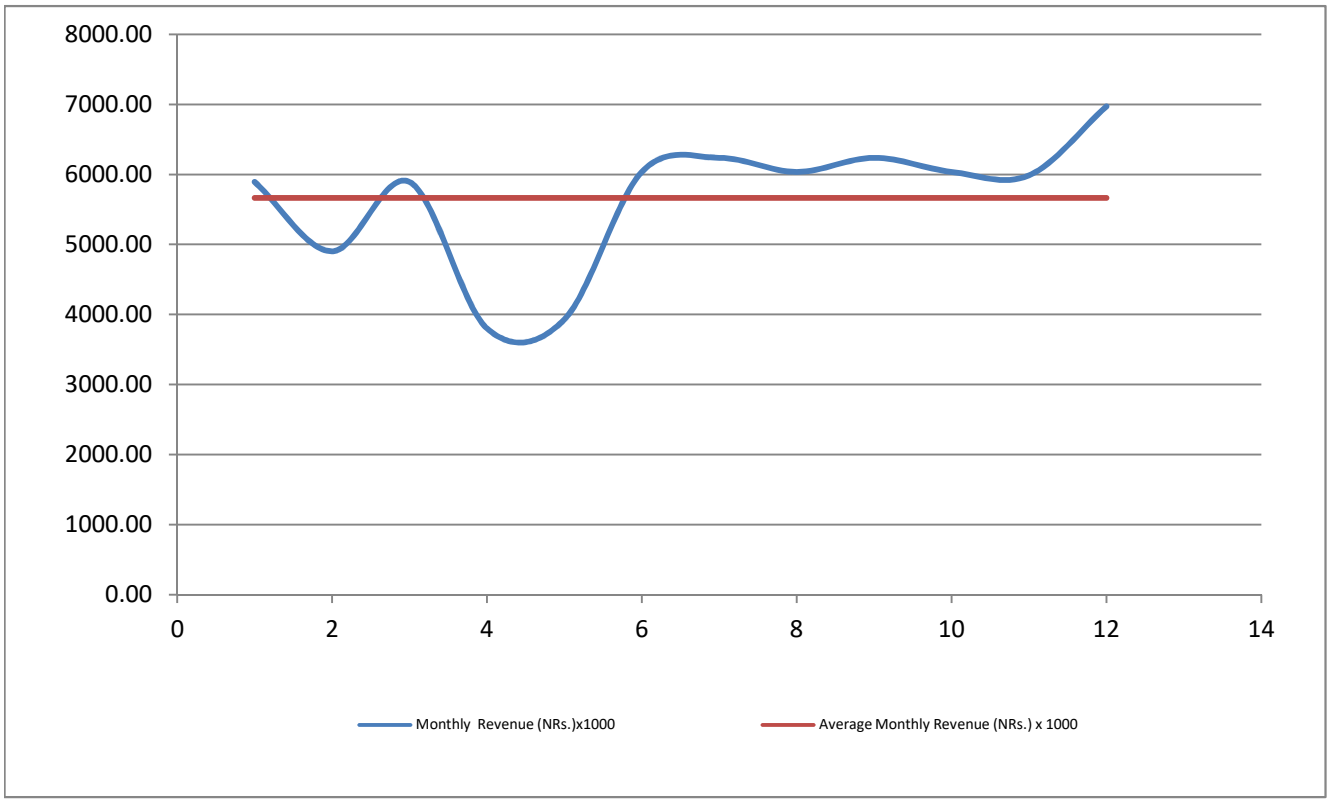


Table: Summary of Monthly and Average Monthly Revenue From the Project

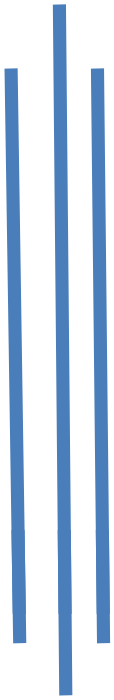
S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	5894.62	5664.93	
2	February	4903.96	5664.93	
3	March	5894.62	5664.93	
4	April	3804.80	5664.93	
5	May	3931.62	5664.93	
6	June	6037.29	5664.93	
7	July	6238.53	5664.93	
8	August	6037.29	5664.93	
9	September	6238.53	5664.93	
10	October	6037.29	5664.93	
11	November	5987.83	5664.93	
12	December	6972.74	5664.93	
	Total	67979.11	67979.11	

Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	586.15		
2	Bank Loan (70%)	410.308	(Million NRs.)	
3	Equity Investment (30%)	175.846	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	-87.5	(Million NRs.)	
6	IRR	7.88%		
7	B/C	0.86		
8	Least Cost of Energy (LCOE)	6.05	NRs./kWh	
9	Return on Equity (RoE)	-0.46%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	66.78	(Million NRs.)	

Desk Study Report of Mai Kharka Khola Mini Hydropower Project
Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk



Submitted To:

Jugal Rural Municipality,Sindhupalchowk

Submitted By:
Epsom Engineering Consultancy Pvt. Ltd.
Kalanki, Kathmandau

July 1, 2018

ACKNOWLEDGEMENTS

Its our great pleasure to work with Jugal Rural Municipality,Sindhupalchowk for Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk.

We would like to thank all the team of Jugal Rural Municipality,Sindhupalchowk for their support during the accomplishment of this study.

We would also like to thank to our study team for their valuable time for the accomplishment of the study.

It is expected that this study will pave the foundation for the development of hydropower projects in Jugal Rural Municipality,Sindhupalchowk.

Khimananda Kandel
Managing Director
Epsom Engineering Consultancy Pvt. Ltd.
Kalanki, Kathmandau
khimanandakandel@yahoo.com
9851070202

SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Mai Kharka Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindhupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.8199, Lattitude= 27.9669	
Powerhouse Coordinate	:	Longitude = 85.7961, Lattitude= 27.9679	
Access			
Location of Nearest Roadhe	:	Balephi Khola Intake	
Distance from Roadhead	:	7	
Hydrology			
Catchment Area	:	3.6	km2
Q40 /(Adopted)Discharge	:	0.176	m3/s
Power and Energy			
Gross Head	:	754	m
Efficiency %	:	0.85	%
Power at Q40	:	996	kW
Total Annual Energy at Q45	:	6.18	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	2232	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	5.67	m
Breadth	:	3	m
Height	:	1.14	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.65	m
Height of Canal	:	0.49	m
Forebay			
Length (m)	:	12	m
Breadth (m)	:	2	m
Height (m)	:	1.25	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	2890	m
Internal diameter (d)	:	400	mm
Thickness (mm)	:	21.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	1478	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 498 kW Capacity	
Gross Head	:	754	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2	
Height	:	0.49	

Grid Connection

Transmission voltage	:	11 kV	
Line length	:	11	kM
Connection point	:	Pangtang (Sherpa Gaun)	
	:		

Power Transformer

Number of unit	:	1	
Rating	:	1500	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 750	kVA
Rated Voltage	:	0.4	kV
Rated Frequency	:	50	Hz

Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period	:	18	Months

Economic and Financial Indicators

Project cost	:	306.21	Million (NRs.)
Annual Revenue	:	37.41	Million (NRs.)
Internal rate of return (IRR)	:	8.60	%
B/C Ratio	:	0.91	
Net present value (at 10% discount rate)	:	-30.42	Million (NRs.)
Cost per kW	:	2900.38	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

Following general assumptions have been made in this study.

1. All DoED license issued and power generated sites for more than 100 kW Installed capacity are avoided in this study.

2. Rivers with discharge more than 5 m3/s at 65% Probability of Exceedence are not studied for power generation. In general, large rivers are not considered in this study.

3. In general, Projects sites have been avoided for head less than 40 m.

4. Discharge of the river is estimated by using Hydest Method, Modified Hydest Method and model generated by using DHM monthly data. The average of the three methods have been adopted in flow estimation.

5. New_LocClim (Local Climate Estimator Software) have been used for the estimation of precipitation data.

6. Total headloss in waterways is taken as 10% of the total head available from Intake to Powerhouse.

7. Overall Efficiency of the proposed project is taken as 85% .

8. This study is completely based on desk study. District level coordination meeting is arranged in District Coordination Committees to the possible extent.

9. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel (email: khimanandakandel@yahoo.com)

Limitations:

1. It was not possible to carry out the detailed site survey of the Project because of ToR and Budgetory Limitations. So, Basically secondary data are used for the preparation of the report after making site

2. The project sites have been identified for 40% probability of flow exceedence.

3. The study area seems to have limited hydro resources and in this study optimization of available resources have been made. Regarding the development of storage type projects, it seems very high size dam which seems infeasible in case of such small streams.

STUDY METHODOLOGY

The study methodology includes the following.

1. Field Visit was made for the stream for the potential hydro development sites.

2. Field Survey was made by using GPS to find out headworks, headrace alignment and Powerhouse.

3. The possibility of developing Reservoir type of project was also surveyed and it was found it is not possible to develop Reservoir sites for such small streams.

4. Field level meeting was made with the leaders of Rural Municipality and the villagers.

5. The Surveyed data were analyzed and Plotted.

6. Hydrological study of the project was made by using Hydropower Guru Software Developed by Er. Khimananda Kandel (khimanandakandel@yahoo.com, 9851070202).

7. The project was designed and report was generated by using Hydropower Studio Model developed by Er. Khimananda Kandel (khimanandakandel@yahoo.com, 9851070202).

8. Reports for possible mini hydropower sites were generated in this study.

APPROACH FOR COST ESTIMATION

Following approach have been made for the estimation of cost estimation.

1. Length of headrace, penstock, distance from existing or proposed substation, nearest roadhead and distance of sand availability was found out by using GIS Map, Google Earth and available maps.

2. Approximate design/sizing of headrace, desanding basin, forebay and penstock pipe (diameter and thickness) is made for the identified alternatives.

3. 11 kV or 33 kV transmission line is proposed for power transmission and unit cost of 11 kV and 33 kV transmission line is prepared by including the cost of swithching station.

4. Water to wire cost is taken as certain dollar per kW.

5. It is assumed that the main construction materials and equipments will be delivered from stations namely; Birtamode, Itahari, Mirchaiya, Bardibas, Hetauda, Narayangadh, Kathmandu, Pokhara, Butwal, Bhaluwang, Tulsipur and Atariya.

6. Government standard has been followed for the estimation of rate of material. For generalizing the study, the rate of materials at Baglung district is taken as base rate and rate has been increased by certain percentage for remote districts with remoteness factor provision in cost estimate model.

7. For remote districts like Humla, Dolpa and Mugu district provision for transportation by air is also considered.

8. Revenue estimation for July to November, tariff rate is taken as Rs. 4.8 / Unit and for December to June Rs. 8.4/Unit is Considered. Tariff rate for revenue generation is increased by 3% per annum for 8 consecutive years and after this the tariff rate is fixed as constant as per the NEA tariff provision for small hydropower projects.

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12. Physical contingencies for Civil, Electro Mechanical (Water to Wire), Penstock/Hydromechanical are taken as 10%, 2.5 % and 5% respectively. Similarly VAT/Tax is taken as 13% and in case of Electromechanical items (Water to Wire) tax is taken as 1% .

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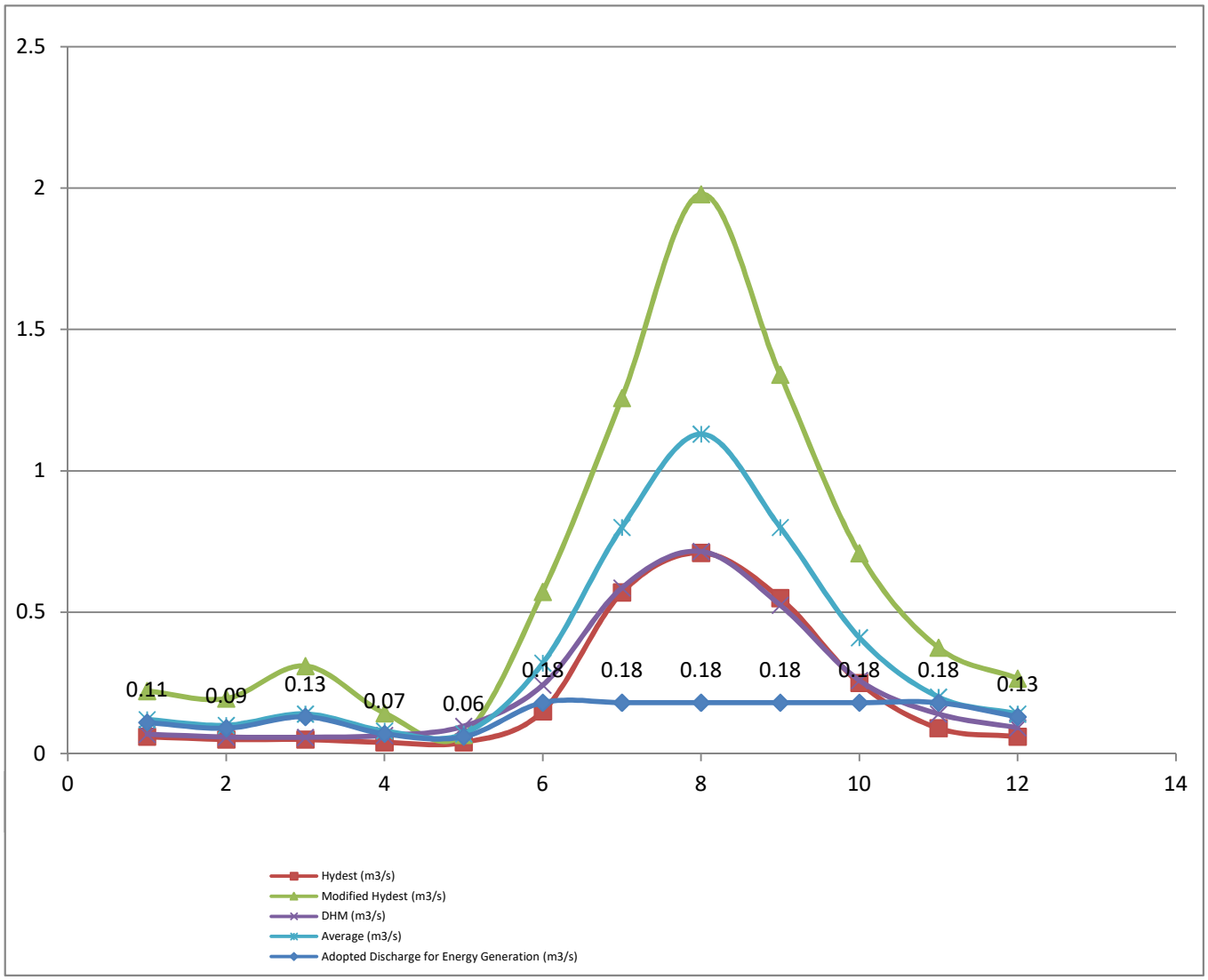
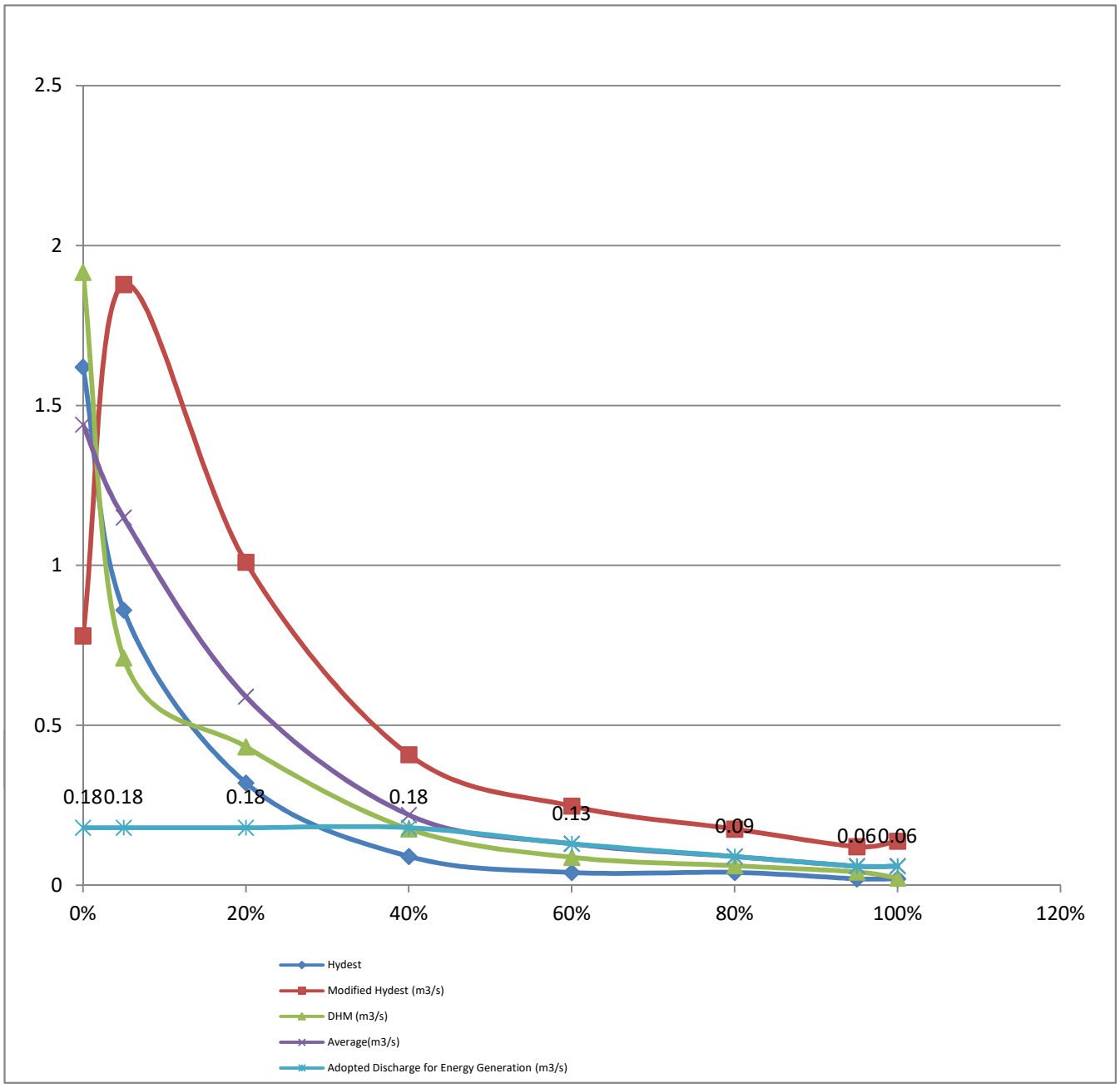
Available and Design Discharge in the River



e and Design Flow (m3/s) in the Stream

S.N.	Month	Discharge in River (m3/s)	Discharge for Power Generation (m3/s)	Remarks
1	January	0.12	0.108	
2	Febrauary	0.1	0.09	
3	March	0.14	0.126	
4	April	0.08	0.07	
5	May	0.07	0.06	
6	June	0.32	0.18	
7	July	0.8	0.18	
8	August	1.13	0.18	
9	September	0.8	0.18	
10	October	0.41	0.18	
11	November	0.2	0.18	
12	December	0.14	0.126	

Flow Duration Curve of the River



e and Design Flow (m3/s) in the Stream

S.N.	Probability of Exceedence (%age)	Hydest (m3/s)	Modified Hydest (m3/s)	DHM (m3/s)
1	0%	1.62	0.78	1.92
2	5%	0.86	1.88	0.71
3	20%	0.32	1.01	0.43
4	40%	0.09	0.41	0.18
5	60%	0.04	0.25	0.09
6	80%	0.04	0.18	0.06
7	95%	0.02	0.12	0.04
8	100%	0.02	0.14	0.02

Adopted Rate of Materials and Items at Project Site

Table : Adopted Rate of Materials and Items at Project Site

S.N.	Particulars	Unit Rate	Unit	Remarks
1	Cement (Ordinary Portland Cement)	750.00	Bag	VAT Additional
2	Sand	3,626.06	m3	At Project Site
3	Agreegate	2,209.15	m3	At Project Site
4	Stone	1,955.00	m3	At Project Site
5	Cutting Bending and Fixing Reinforcement Bars	119.43	kg	At Project Site
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12	Stone Masonry in 1:6 Cement Mortar	5,566.00	Cum	At Project Site
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16	Wooden Formwork	514.59	m2	At Project Site
17	20 mm thick Plastering	585.66	m2	At Project Site
18	12.5 mm thick Plastering	459.59	m2	At Project Site
19	CGI Roofing	508.07	m2	At Project Site
20	33 kV kV Transmission Line cost per kM	1,860,338.28	kM	At Project Site
21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5583197.278	
1.2	Desanding Basin	1.2	776473.5474	
1.3	Headrace Power Canal	1.3		
1.4	Cross Drainage Works	1.4	7613576.245	
1.5	Forebay Basin/Spillway	1.5	776473.5474	
1.6	Penstock and Hydro Mechanical (Metal Parts)	1.6	76135762.45	
1.7	Anchor Block and Support Pier	1.7	38067881.22	
1.8	Powerhouuse and Tailrace	1.8		
	Sub-Total NRs.		137640261.2	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	2.1	47061000	
3	TRANSMISSION LINE			
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	4.1	5000000	
4.2	Construction Camp Establishment	4.2	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	5.1	5000000	
	Sub-total		217964982.3	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	6.1	10898249.11	
	Sub Total 1-6		228863231.4	
7	Contigencies	7.1	18208562.09	
8	VAT 1-6 (6 Inclusive of VAT)	8.1	26330830.15	
9	Interest During Construction	9.1	32808314.84	
10	TOTAL ESTIMATED COST (NRs)	10.1	306210938.5	
	Cost per kW (1 US$ = NRs. 106)		2900.38	
	Cost per kW in NRs.		**307440.7**	

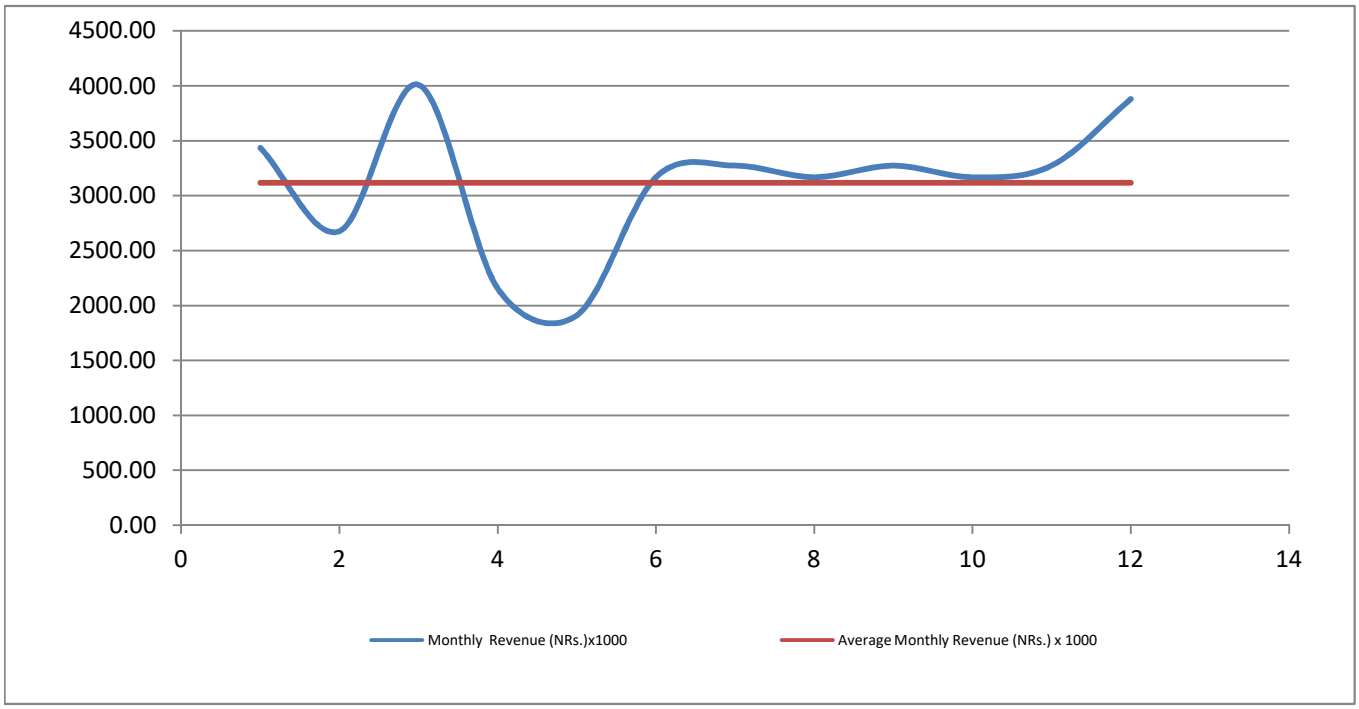

Table: Summary of Monthly and Average Monthly Revenue From the Project

S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	3436.66	3117.34	
2	February	2678.24	3117.34	
3	March	4010.37	3117.34	
4	April	2155.51	3117.34	
5	May	1912.38	3117.34	
6	June	3169.50	3117.34	
7	July	3275.15	3117.34	
8	August	3169.50	3117.34	
9	September	3275.15	3117.34	
10	October	3169.50	3117.34	
11	November	3275.15	3117.34	
12	December	3881.00	3117.34	
	Total	37408.11	37408.08	

Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	306.21	(Million NRs.)	
2	Bank Loan (70%)	214.348	(Million NRs.)	
3	Equity Investment (30%)	91.863	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	-30.42	(Million NRs.)	
6	IRR	8.60%		
7	B/C	0.91		
8	Least Cost of Energy (LCOE)	5.81	NRs./kWh	
9	Return on Equity (RoE)	8.37%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	34.88	(Million NRs.)	

Desk Study Report of Duskul Khola Mini Hydropower Project

Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk

Submitted To:

Jugal Rural Municipality,Sindhupalchowk

Submitted By:

Epsom Engineering Consultancy Pvt. Ltd.

Kalanki, Kathmandau

July 2, 2018

ACKNOWLEDGEMENTS

Its our great pleasure to work with Jugal Rural Municipality,Sindhupalchowk for Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk.

We would like to thank all the team of Jugal Rural Municipality,Sindhupalchowk for their support during the accomplishment of this study.

We would also like to thank to our study team for their valuable time for the accomplishment of the study.

It is expected that this study will pave the foundation for the development of hydropower projects in Jugal Rural Municipality,Sindhupalchowk.

Khimananda Kandel
Managing Director
Epsom Engineering Consultancy Pvt. Ltd.
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9851070202

SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Duskul Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindhupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.7581, Lattitude= 27.9779	
Powerhouse Coordinate	:	Longitude = 85.7888, Lattitude= 27.9923	
Access			
Location of Nearest Roadhead	:	Balephi Khola Intake	
Distance from Roadhead	:	9	
Hydrology			
Catchment Area	:	9.38	km2
Q40 /(Adopted) Discharge	:	0.459	m3/s
Power and Energy			
Gross Head	:	811	m
Efficiency %	:	0.85	%
Power at Q40	:	2794	kW
Total Annual Energy at Q45	:	16.315	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	2536	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	14.67	m
Breadth	:	3	m
Height	:	2.03	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.95	m
Height of Canal	:	0.7125	m
Forebay			
Particle Size to be Settled	:	0.3	mm
Length (m)	:	20	m
Breadth (m)	:	2.5	m
Height (m)	:	1.69	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	3750	m
Internal diameter (d)	:	550	mm
Thickness (mm)	:	30.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	1725	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 1397 kW Capacity	
Gross Head	:	811	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2.5	
Height	:	0.7125	

Grid Connection

Transmission voltage	:	11 kV	
Connection point	:	14	kM
Line length	:	Pangtang (Sherpa Gaun)	

Power Transformer

Number of unit	:	1	
Rating	:	4200	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 2100	kVA
Rated Voltage	:	0.4	kV

Rated Frequency	:	50	Hz
Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period	:	18	Months

Economic and Financial Indicators

Project cost	:	701.57	Million (NRs.)
Annual Revenue	:	103.05	Million (NRs.)
Internal rate of return (IRR)	:	0.11	%
B/C Ratio	:	1.04	
Net present value (at 10% discount rate)	:	27.84	Million (NRs.)
Cost per kW	:	2368.87	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

Following general assumptions have been made in this study.

1. All DoED license issued and power generated sites for more than 100 kW Installed capacity are avoided in this study.

2. Rivers with discharge more than 5 m3/s at 65% Probability of Exceedence are not studied for power generation. In general, large rivers are not considered in this study.

3. In general, Projects sites have been avoided for head less than 40 m.

4. Discharge of the river is estimated by using Hydest Method, Modified Hydest Method and model generated by using DHM monthly data. The average of the three methods have been adopted in flow estimation.

5. New_LocClim (Local Climate Estimator Software) have been used for the estimation of precipitation data.

6. Total headloss in waterways is taken as 10% of the total head available from Intake to Powerhouse.

7. Overall Efficiency of the proposed project is taken as 85% .

8. This study is completely based on desk study. District level coordination meeting is arranged in District Coordination Committees to the possible extent.

9. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel (email: khimanandakandel@yahoo.com)

Limitations:

1. It was not possible to carry out the detailed site survey of the Project because of ToR and Budgetory Limitations. So, Basically secondary data are used for the preparation of the report after making site visit.

2. The project sites have been identified for 40% probability of flow exceedence.

3. The study area seems to have limited hydro resources and in this study optimization of available resources have been made. Regarding the development of storage type projects, it seems very high size dam which seems infeasible in case of such small streams.

STUDY METHODOLOGY

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1. Field Visit was made for the stream for the potential hydro development sites.

2. Field Survey was made by using GPS to find out headworks, headrace alignment and Powerhouse.

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Following approach have been made for the estimation of cost estimation.

1. Length of headrace, penstock, distance from existing or proposed substation, nearest roadhead and distance of sand availability was found out by using GIS Map, Google Earth and available maps.

2. Approximate design/sizing of headrace, desanding basin, forebay and penstock pipe (diameter and thickness) is made for the identified alternatives.

3. 11 kV or 33 kV transmission line is proposed for power transmission and unit cost of 11 kV and 33 kV transmission line is prepared by including the cost of swithching station.

4. Water to wire cost is taken as certain dollar per kW.

5. It is assumed that the main construction materials and equipments will be delivered from stations namely; Birtamode, Itahari, Mirchaiya, Bardibas, Hetauda, Narayangadh, Kathmandu, Pokhara, Butwal, Bhaluwang, Tulsipur and Atariya.

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Available and Design Discharge in the River

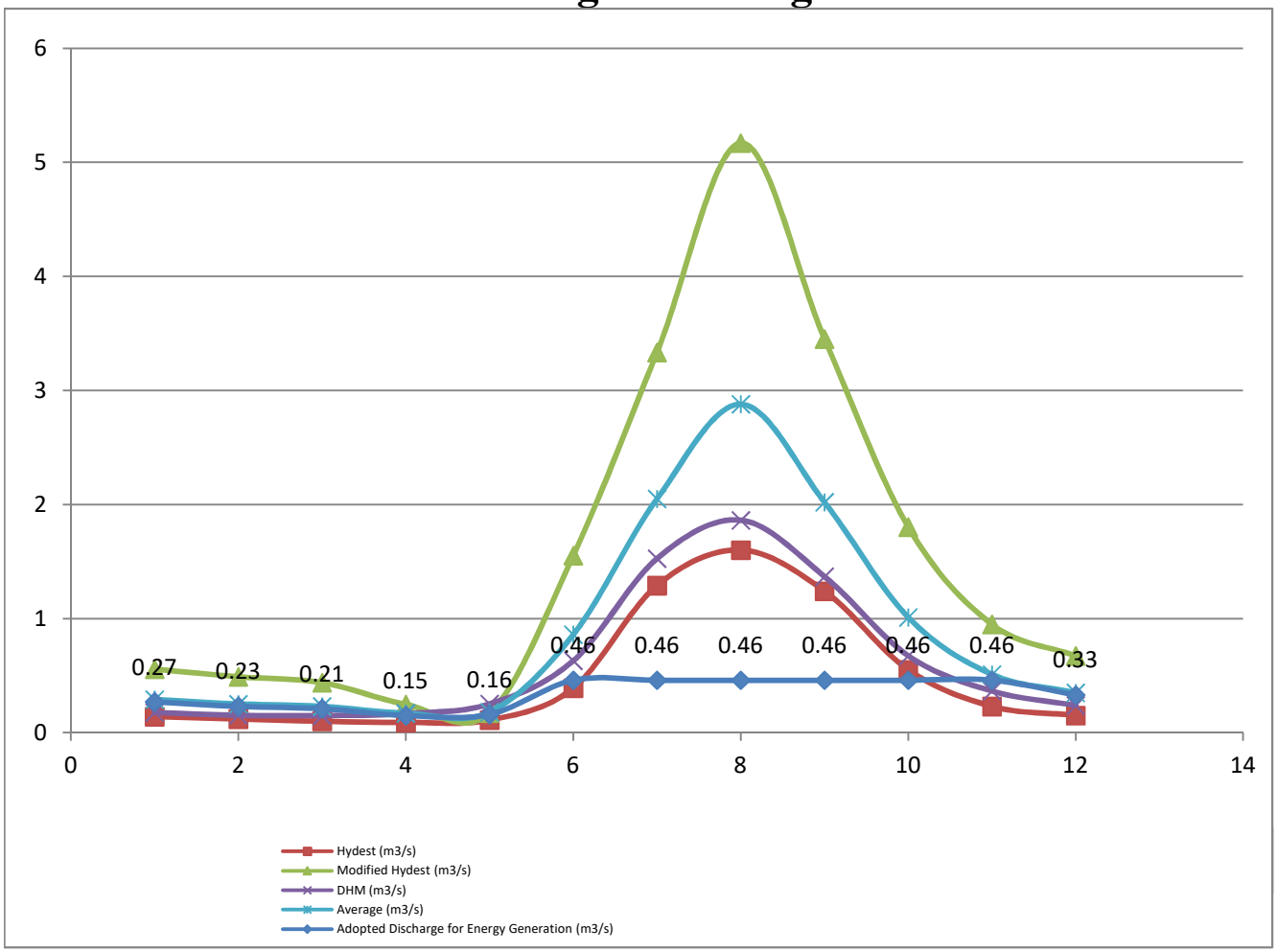


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N.	Month	Discharge in River (m3/s)	Discharge for Power Generation (m3/s)	Remarks
1	January	0.29	0.261	
2	Febrauary	0.25	0.225	
3	March	0.23	0.207	
4	April	0.17	0.15	
5	May	0.18	0.16	
6	June	0.86	0.46	
7	July	2.05	0.46	
8	August	2.88	0.46	
9	September	2.02	0.46	
10	October	1.01	0.46	
11	November	0.51	0.459	
12	December	0.35	0.315	

Flow Duration Curve of the River

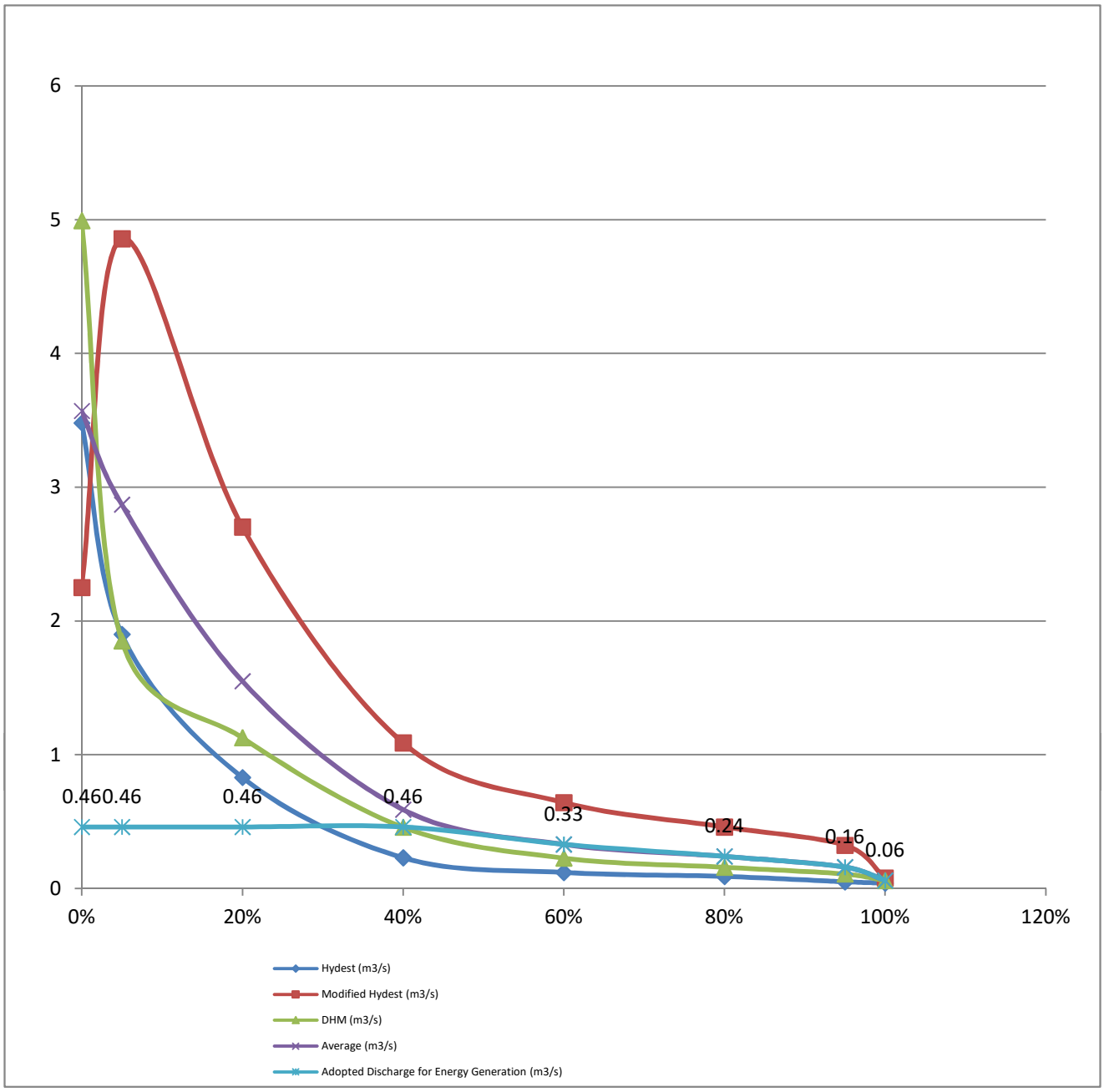


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N.	Probability of Exceedence (%age)	Hydest (m3/s)	Modified Hydest (m3/s)	DHM (m3/s)
1	0%	3.48	2.25	4.99
2	5%	1.9	4.86	1.85
3	20%	0.83	2.7	1.13
4	40%	0.23	1.09	0.46
5	60%	0.12	0.64	0.23
6	80%	0.09	0.46	0.16
7	95%	0.05	0.32	0.11
8	100%	0.04	0.08	0.06

Adopted Rate of Materials and Items at Project Site

Table : Adopted Rate of Materials and Items at Project Site

S.N.	Particulars	Unit Rate	Unit	Remarks
1	Cement (Ordinary Portland Cement)	750.00	Bag	At Project Site
2	Sand	3,626.06	m3	At Project Site
3	Agreegate	2,209.15	m3	At Project Site
4	Stone	1,955.00	m3	At Project Site
5	Cutting Bending and Fixing Reinforcement Bars	119.43	kg	At Project Site
6	Penstock Fabrication	180.36	kg	At Project Site
7	Gabion Making with material and filling	4,938.68	m3	At Project Site
8	Earthwork in Excavation	533.03	Cum	At Project Site
9	Earthwork in Backfilling	355.35	Cum	At Project Site
10	Dry Stone Soling	3,732.90	Cum	At Project Site
11	Stone Masonry in 1:4 cement mortar	12,658.31	Cum	At Project Site
12	Stone Masonry in 1:6 Cement Mortar	11,827.46	Cum	At Project Site
13	PCC(1:3:6) in Foundation	12,385.95	Cum	At Project Site
14	PCC (1:2:4) in Structures	15,400.08	Cum	At Project Site
15	PCC (1:1.5:3) in Structures	17,067.09	Cum	At Project Site
16	Wooden Formwork	514.59	m2	At Project Site
17	20 mm thick Plastering	585.66	m2	At Project Site
18	12.5 mm thick Plastering	459.59	m2	At Project Site
19	CGI Roofing	508.34	m2	At Project Site
20	33 kV kV Transmission Line cost per kM	1,860,338.28	kM	At Project Site
21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5583197.278	
1.2	Desanding Basin	1.2	1280872.091	
1.3	Headrace Power Canal	1.3	0	
1.4	Cross Drainage Works	1.4	19656630.97	
1.5	Forebay Basin/Spillway	1.5	1280872.091	
1.6	Penstock and Hydro Mechanical (M	1.6	196566309.7	
1.7	Anchor Block and Support Pier	1.7	98283154.87	
1.7	Powerhouuse and Tailrace	1.8	8687001.152	
	Sub-Total NRs.		331338038.2	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	2.1	132016500	
3	TRANSMISSION LINE			
3.1	33 Kv Transmission line to Substation	3.1	28544735.9	
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	4.1	5000000	
4.2	Site Facilities with Operators' Village	4.2	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	5.1	5000000	
	Sub-total		502199274.1	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	6.1	25109963.7	
	Sub Total 1-6		527309237.8	
7	Contigencies	7.1	41402449.49	
8	VAT 1-6 (6 Inclusive of VAT)	8.1	57694489.85	
9	Interest During Construction	9.1	75168741.26	
10	TOTAL ESTIMATED COST (NRs)	10.1	701574918.4	
	Cost per kW (1 US$ = NRs. 106)		2368.87	
	Cost per kW in NRs.		**251100.54**	

Revenue of the Project

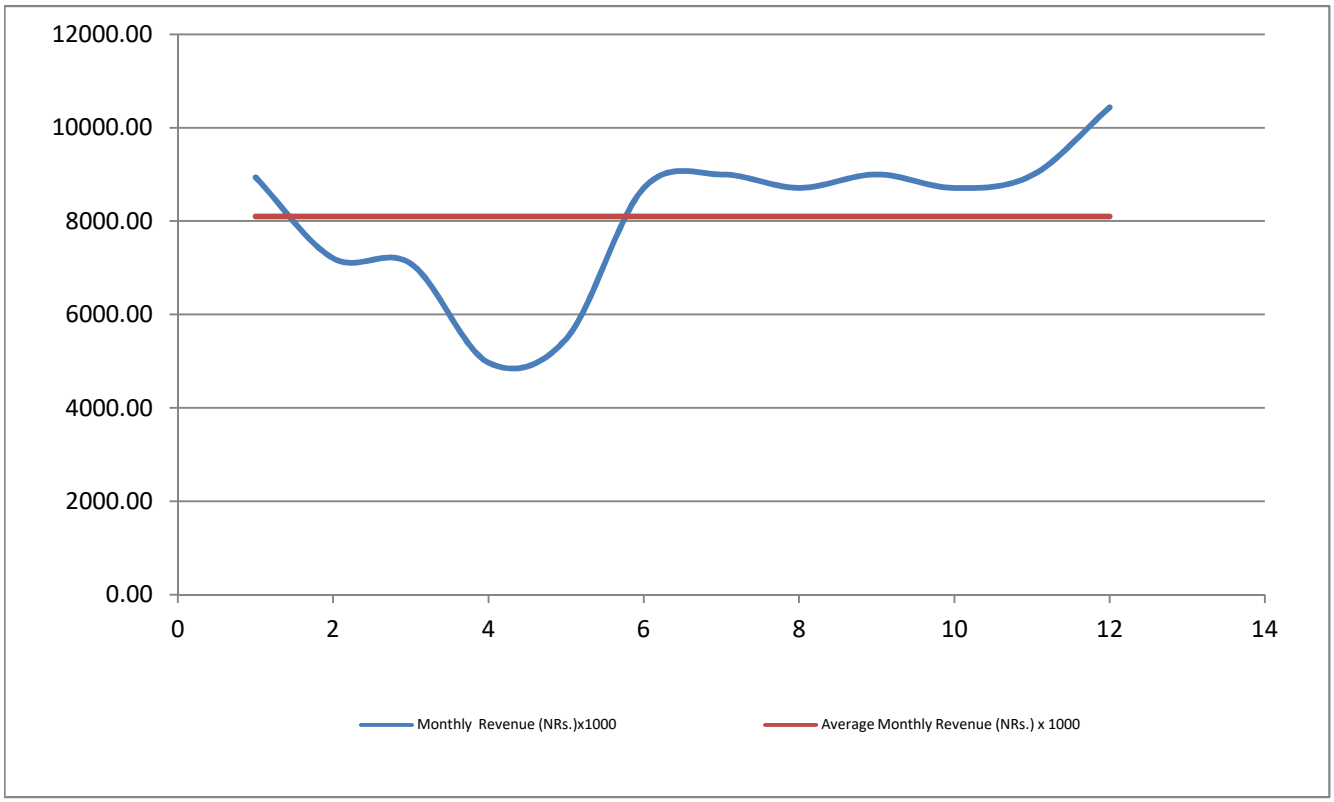


Table: Summary of Monthly and Average Monthly Revenue From the Project

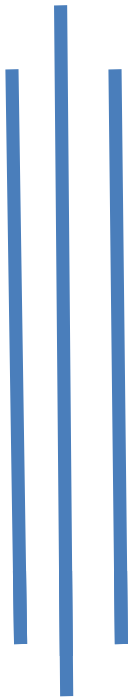
S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	8937.55	8101.41	
2	February	7203.35	8101.41	
3	March	7087.05	8101.41	
4	April	4969.64	8101.41	
5	May	5478.40	8101.41	
6	June	8709.12	8101.41	
7	July	8999.42	8101.41	
8	August	8709.12	8101.41	
9	September	8999.42	8101.41	
10	October	8709.12	8101.41	
11	November	8980.14	8101.41	
12	December	10434.61	8101.41	
	Total	97216.94	97216.95	

Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	701.57		
2	Bank Loan (70%)	491.102	(Million NRs.)	
3	Equity Investment (30%)	210.472	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	27.84	(Million NRs.)	
6	IRR	10.54%		
7	B/C	1.04		
8	Least Cost of Energy (LCOE)	5.04	NRs./kWh	
9	Return on Equity (RoE)	11.53%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	79.92	(Million NRs.)	

Desk Study Report of Tamrang Khola Mini Hydropower Project
Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk



Submitted To:

Jugal Rural Municipality,Sindhupalchowk

Submitted By:
Epsom Engineering Consultancy Pvt. Ltd.
Kalanki, Kathmandau

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Name of the Project	:	Tamrang Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.7518, Lattitude= 28.0067	
Powerhouse Coordinate	:	Longitude = 85.7786, Lattitude= 28.0197	
Access			
Location of Nearest Roadhead	:	Balephi Khola Intake	
Distance from Roadhead	:	12	
Hydrology			
Catchment Area	:	6.9	km2
Q40 /(Adopted)Discharge	:	0.337	m3/s
Power and Energy			
Gross Head	:	822	m
Efficiency %	:	0.85	%
Power at Q40	:	2079	kW
Total Annual Energy at Q45	:	12.69	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	2871	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	10.67	m
Breadth	:	3	m
Height	:	1.69	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.85	m
Height of Canal	:	0.64	m
Forebay			
Particle Size to be Settled	:	0.3	mm
Length (m)	:	15	m
Breadth (m)	:	2.5	m

Height (m)	:	1.53	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	3860	m
Internal diameter (d)	:	500	mm
Thickness (mm)	:	28.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	2049	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 1039.5 kW Capacity	
Gross Head	:	822	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2.5	
Height	:	0.64	

Grid Connection

Transmission voltage	:	11 kV	
Line length	:	17	kM
Connection point	:	Pangtang (Sherpa Gaun)	

Power Transformer

Number of unit	:	1	
Rating	:	3100	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 1600	kVA

Rated Voltage	:	0.4	kV
Rated Frequency	:	50	Hz
Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period	:	18	Months

Economic and Financial Indicators

Project cost	:	603.30	Million (NRs.)
Annual Revenue	:	76.72	Million (NRs.)
Internal rate of return (IRR)	:	9.23	%
B/C Ratio	:	0.95	
Net present value (at 10% discount rate)	:	-33.55	Million (NRs.)
Cost per kW	:	2737.62	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

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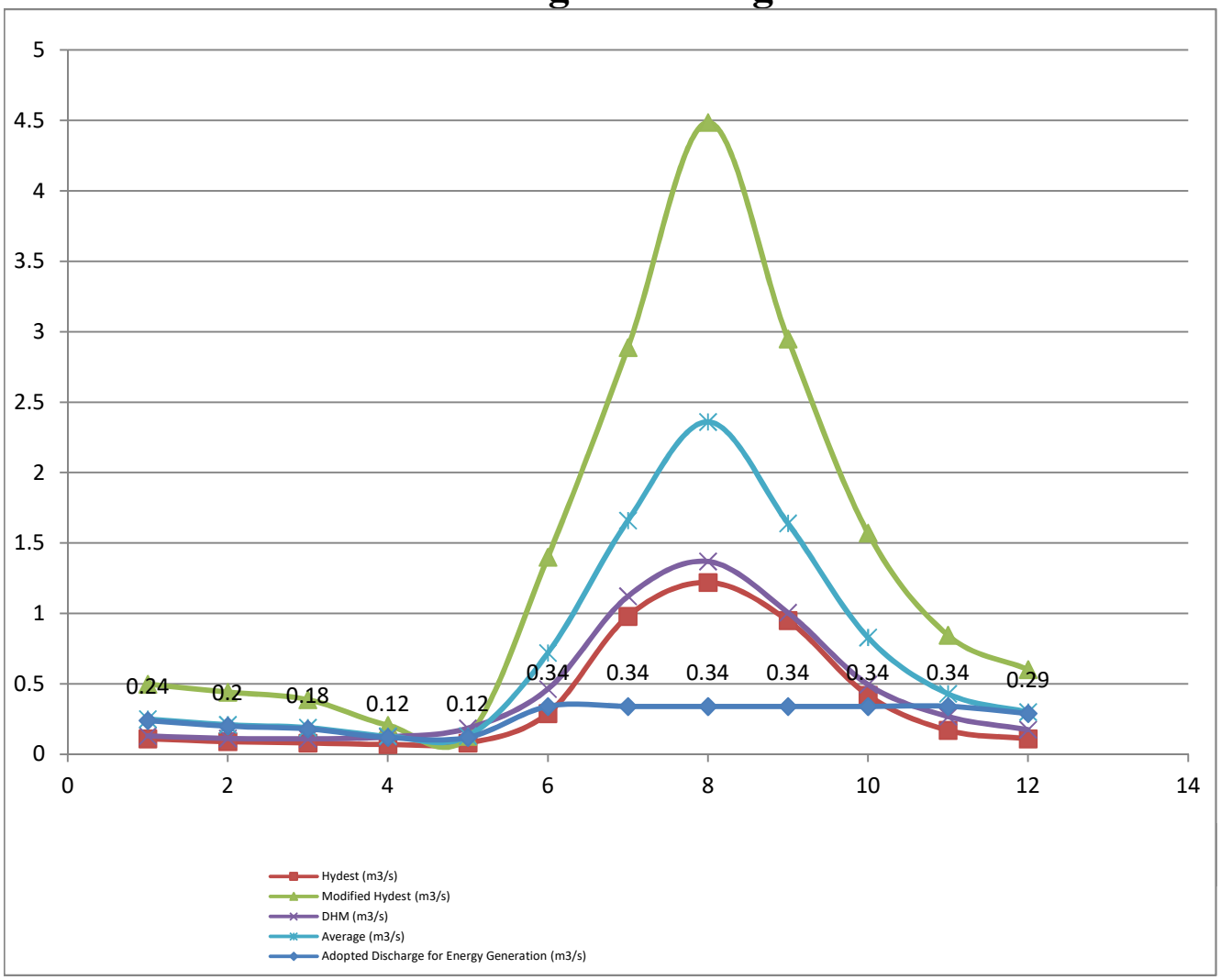

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3	March	0.19	0.171	
4	April	0.13	0.117	
5	May	0.13	0.117	
6	June	0.72	0.34	
7	July	1.66	0.34	
8	August	2.36	0.34	
9	September	1.64	0.34	
10	October	0.83	0.34	
11	November	0.43	0.34	
12	December	0.3	0.27	

Flow Duration Curve of the River

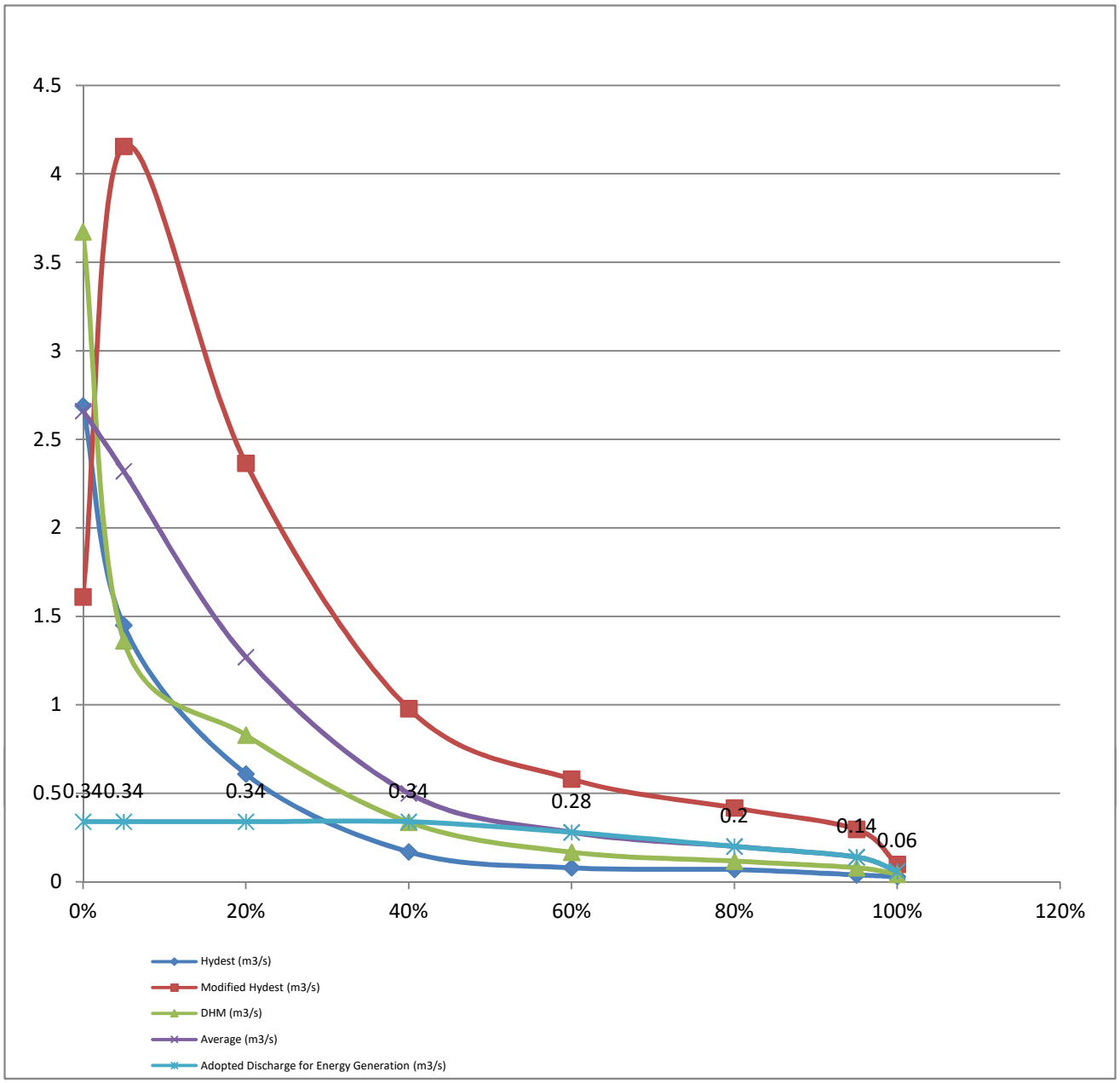


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N	Probability of Exceedence (%age)	Hydest (m3/s)	Modified Hydest (m3/s)	DHM (m3/s)
1	0%	2.69	1.61	3.67
2	5%	1.45	4.16	1.36
3	20%	0.61	2.37	0.83
4	40%	0.17	0.98	0.34
5	60%	0.08	0.58	0.17
6	80%	0.07	0.42	0.12
7	95%	0.04	0.3	0.08
8	100%	0.03	0.1	0.04

Adopted Rate of Materials and Items at Project Site

Table : Adopted Rate of Materials and Items at Project Site

S.N	Particulars	Unit Rate	Unit	Remarks
1	Cement (Ordinary Portland Cement)	750.00	Bag	At Project Site
2	Sand	3,740.46	m3	At Project Site
3	Agreegate	2,209.15	m3	At Project Site
4	Stone	1,955.00	m3	At Project Site
5	Cutting Bending and Fixing Reinforcement Bars	119.43	kg	At Project Site
6	Penstock Fabrication	180.36	kg	At Project Site
7	Gabion Making with material and filling	4,938.68	m3	At Project Site
8	Earthwork in Excavation	533.03	Cum	At Project Site
9	Earthwork in Backfilling	355.35	Cum	At Project Site
10	Dry Stone Soling	3,732.90	Cum	At Project Site
11	Stone Masonry in 1:4 cement mortar	12,717.51	Cum	At Project Site
12	Stone Masonry in 1:6 Cement Mortar	11,889.29	Cum	At Project Site
13	PCC(1:3:6) in Foundation	12,447.79	Cum	At Project Site
14	PCC (1:2:4) in Structures	15,458.63	Cum	At Project Site
15	PCC (1:1.5:3) in Structures	17,123.00	Cum	At Project Site
16	Wooden Formwork	514.59	m2	At Project Site
17	20 mm thick Plastering	588.56	m2	At Project Site
18	12.5 mm thick Plastering	461.51	m2	At Project Site
19	CGI Roofing	508.73	m2	At Project Site
20	33 kV kV Transmission Line cost per kM	1,860,338.28	kM	At Project Site
21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5595842.825	
1.2	Desanding Basin	1.2	985074.3309	
1.3	Headrace Power Canal	1.3		
1	Cross Drainage Works	1.4	16930963.02	
2	Forebay Basin/Spillway	1.5	985074.3309	
2	Penstock and Hydro Mechanical (M	1.6	169309630.2	
2	Anchor Block and Support Pier	1.7	84654815.08	
2	Powerhouuse and Tailrace	1.8		
	Sub-Total NRs.		287174188.1	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	1.9	98232750	
3	TRANSMISSION LINE			
3.1	33 Kv Transmission line to Substation	1.1	34125750.73	
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	1.11	5000000	
4	Site Facilities with Operators' Village	1.12	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	1.13	5000000	
	Sub-total		429832688.9	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	0.05	21491634.44	
	Sub Total 1-6		451324323.3	
7	Contigencies		36058688.54	
8	VAT 1-6 (6 Inclusive of VAT)		51277163.29	
9	Interest During Construction		64639221.02	
10	TOTAL ESTIMATED COST (NRs)		603299396.1	
	Cost per kW (1 US$ = NRs. 106)		2737.62	
	Cost per kW in NRs.		**290187.3**	

Revenue of the Project

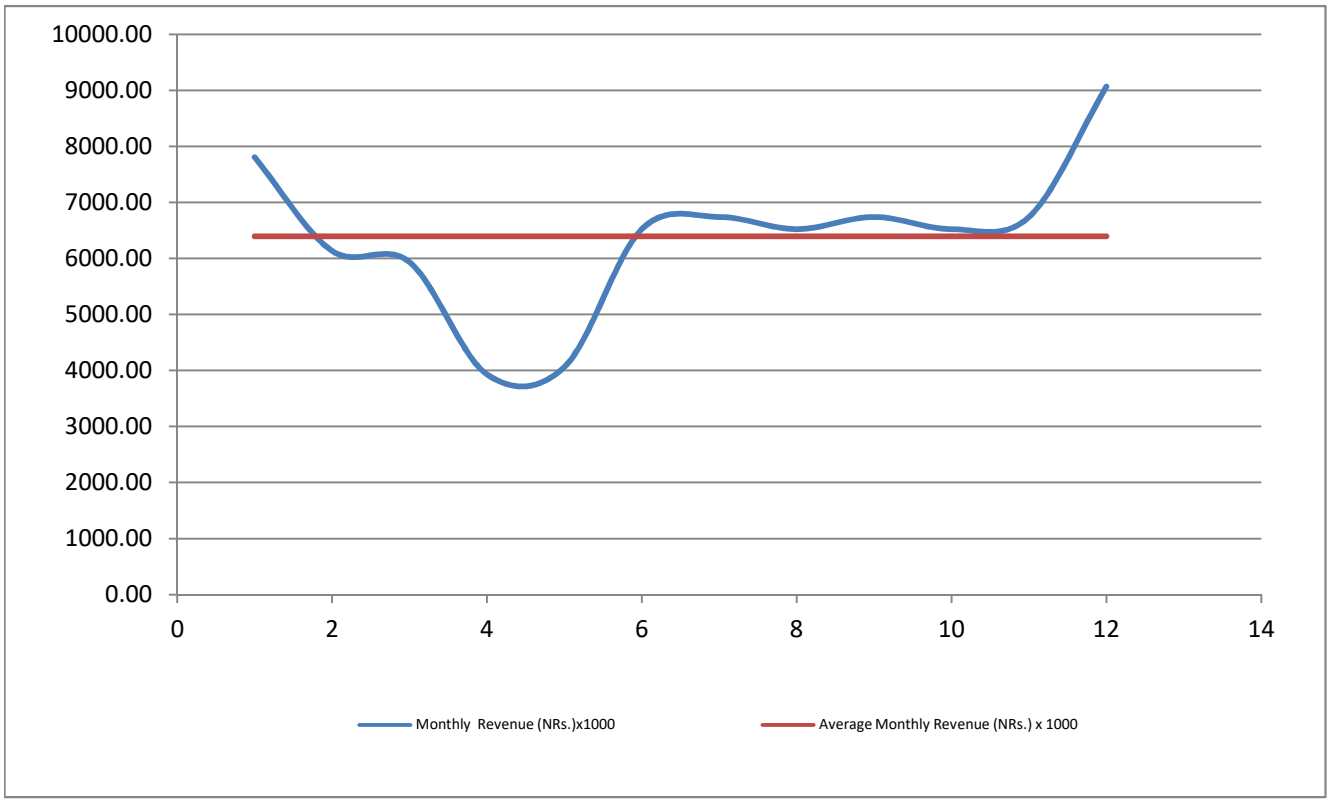


Table: Summary of Monthly and Average Monthly Revenue From the Project

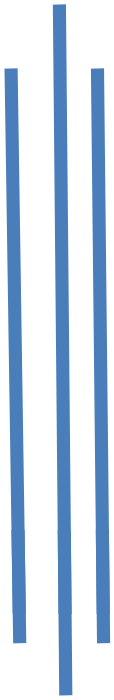
S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	7807.00	6393.57	
2	February	6135.21	6393.57	
3	March	5934.00	6393.57	
4	April	3929.99	6393.57	
5	May	4060.99	6393.57	
6	June	6522.51	6393.57	
7	July	6739.93	6393.57	
8	August	6522.51	6393.57	
9	September	6739.93	6393.57	
10	October	6522.51	6393.57	
11	November	6739.93	6393.57	
12	December	9068.37	6393.57	
	Total	76722.86	76722.86	

Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	603.30		
2	Bank Loan (70%)	422.31	(Million NRs.)	
3	Equity Investment (30%)	180.99	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	-33.55	(Million NRs.)	
6	IRR	9.23%		
7	B/C	0.95		
8	Least Cost of Energy (LCOE)	5.57	NRs./kWh	
9	Return on Equity (RoE)	12.57%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	68.73	(Million NRs.)	

Desk Study Report of Herang Khola Mini Hydropower Project
Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk



Submitted To:

Jugal Rural Municipality,Sindhupalchowk

Submitted By:
Epsom Engineering Consultancy Pvt. Ltd.
Kalanki, Kathmandau

July 1, 2018

ACKNOWLEDGEMENTS

Its our great pleasure to work with Jugal Rural Municipality,Sindhupalchowk for Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk.

We would like to thank all the team of Jugal Rural Municipality,Sindhupalchowk for their support during the accomplishment of this study.

We would also like to thank to our study team for their valuable time for the accomplishment of the study.

It is expected that this study will pave the foundation for the development of hydropower projects in Jugal Rural Municipality,Sindhupalchowk.

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9851070202

SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Herang Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindhupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.799, Lattitude= 28.0541	
Powerhouse Coordinate	:	Longitude = 85.7808, Lattitude= 28.0394	
Access			
Location of Nearest Roadhe	:	Balephi Khola Intake	
Distance from Roadhead	:	16	
Hydrology			
Catchment Area	:	6.16	km2
Q40 /(Adopted)Discharge	:	0.301	m3/s
Power and Energy			
Gross Head	:	1050	m
Efficiency %	:	0.85	%
Power at Q40	:	2372	kW
Total Annual Energy at Q45	:	14.864	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	3280	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	9.67	m
Breadth	:	3	m
Height	:	1.57	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.8	m
Height of Canal	:	0.60	m
Forebay			
Length (m)	:	15	m
Breadth (m)	:	2	m
Height (m)	:	1.47	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	3390	m
Internal diameter (d)	:	450	mm
Thickness (mm)	:	32.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	2230	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 1186 kW Capacity	
Gross Head	:	1050	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2	
Height	:	0.6	

Grid Connection

Transmission voltage	:	11 kV	
Line length	:	20	kM
Connection point	:	Pangtang (Sherpa Gaun)	
	:		

Power Transformer

Number of unit	:	1	
Rating	:	3600	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 1800	kVA
Rated Voltage	:	0.4	kV
Rated Frequency	:	50	Hz

Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period	:	18	Months

Economic and Financial Indicators

Project cost	:	613.85	Million (NRs.)
Annual Revenue	:	91.22	Million (NRs.)
Internal rate of return (IRR)	:	11.61	%
B/C Ratio	:	1.11	
Net present value (at 10% discount rate)	:	74.10	Million (NRs.)
Cost per kW	:	2441.41	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

Following general assumptions have been made in this study.

1. All DoED license issued and power generated sites for more than 100 kW Installed capacity are avoided in this study.

2. Rivers with discharge more than 5 m3/s at 65% Probability of Exceedence are not studied for power generation. In general, large rivers are not considered in this study.

3. In general, Projects sites have been avoided for head less than 40 m.

4. Discharge of the river is estimated by using Hydest Method, Modified Hydest Method and model generated by using DHM monthly data. The average of the three methods have been adopted in flow estimation.

5. New_LocClim (Local Climate Estimator Software) have been used for the estimation of precipitation data.

6. Total headloss in waterways is taken as 10% of the total head available from Intake to Powerhouse.

7. Overall Efficiency of the proposed project is taken as 85% .

8. This study is completely based on desk study. District level coordination meeting is arranged in District Coordination Committees to the possible extent.

9. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel (email: khimanandakandel@yahoo.com)

Limitations:

1. It was not possible to carry out the detailed site survey of the Project because of ToR and Budgetory Limitations. So, Basically secondary data are used for the preparation of the report after making site

2. The project sites have been identified for 40% probability of flow exceedence.

3. The study area seems to have limited hydro resources and in this study optimization of available resources have been made. Regarding the development of storage type projects, it seems very high size dam which seems infeasible in case of such small streams.

STUDY METHODOLOGY

The study methodology includes the following.

1. Field Visit was made for the stream for the potential hydro development sites.

2. Field Survey was made by using GPS to find out headworks, headrace alignment and Powerhouse.

3. The possibility of developing Reservoir type of project was also surveyed and it was found it is not possible to develop Reservoir sites for such small streams.

4. Field level meeting was made with the leaders of Rural Municipality and the villagers.

5. The Surveyed data were analyzed and Plotted.

6. Hydrological study of the project was made by using Hydropower Guru Software Developed by Er. Khimananda Kandel (khimanandakandel@yahoo.com, 9851070202).

7. The project was designed and report was generated by using Hydropower Studio Model developed by Er. Khimananda Kandel (khimanandakandel@yahoo.com, 9851070202).

8. Reports for possible mini hydropower sites were generated in this study.

APPROACH FOR COST ESTIMATION

Following approach have been made for the estimation of cost estimation.

1. Length of headrace, penstock, distance from existing or proposed substation, nearest roadhead and distance of sand availability was found out by using GIS Map, Google Earth and available maps.

2. Approximate design/sizing of headrace, desanding basin, forebay and penstock pipe (diameter and thickness) is made for the identified alternatives.

3. 11 kV or 33 kV transmission line is proposed for power transmission and unit cost of 11 kV and 33 kV transmission line is prepared by including the cost of swithching station.

4. Water to wire cost is taken as certain dollar per kW.

5. It is assumed that the main construction materials and equipments will be delivered from stations namely; Birtamode, Itahari, Mirchaiya, Bardibas, Hetauda, Narayangadh, Kathmandu, Pokhara, Butwal, Bhaluwang, Tulsipur and Atariya.

6. Government standard has been followed for the estimation of rate of material. For generalizing the study, the rate of materials at Baglung district is taken as base rate and rate has been increased by certain percentage for remote districts with remoteness factor provision in cost estimate model.

7. For remote districts like Humla, Dolpa and Mugu district provision for transportation by air is also considered.

8. Revenue estimation for July to November, tariff rate is taken as Rs. 4.8 / Unit and for December to June Rs. 8.4/Unit is Considered. Tariff rate for revenue generation is increased by 3% per annum for 8 consecutive years and after this the tariff rate is fixed as constant as per the NEA tariff provision for small hydropower projects.

9. Insurance cost is taken as 0.3% of total project cost annually. Royalty is taken as per the hydropower policy of Nepal.

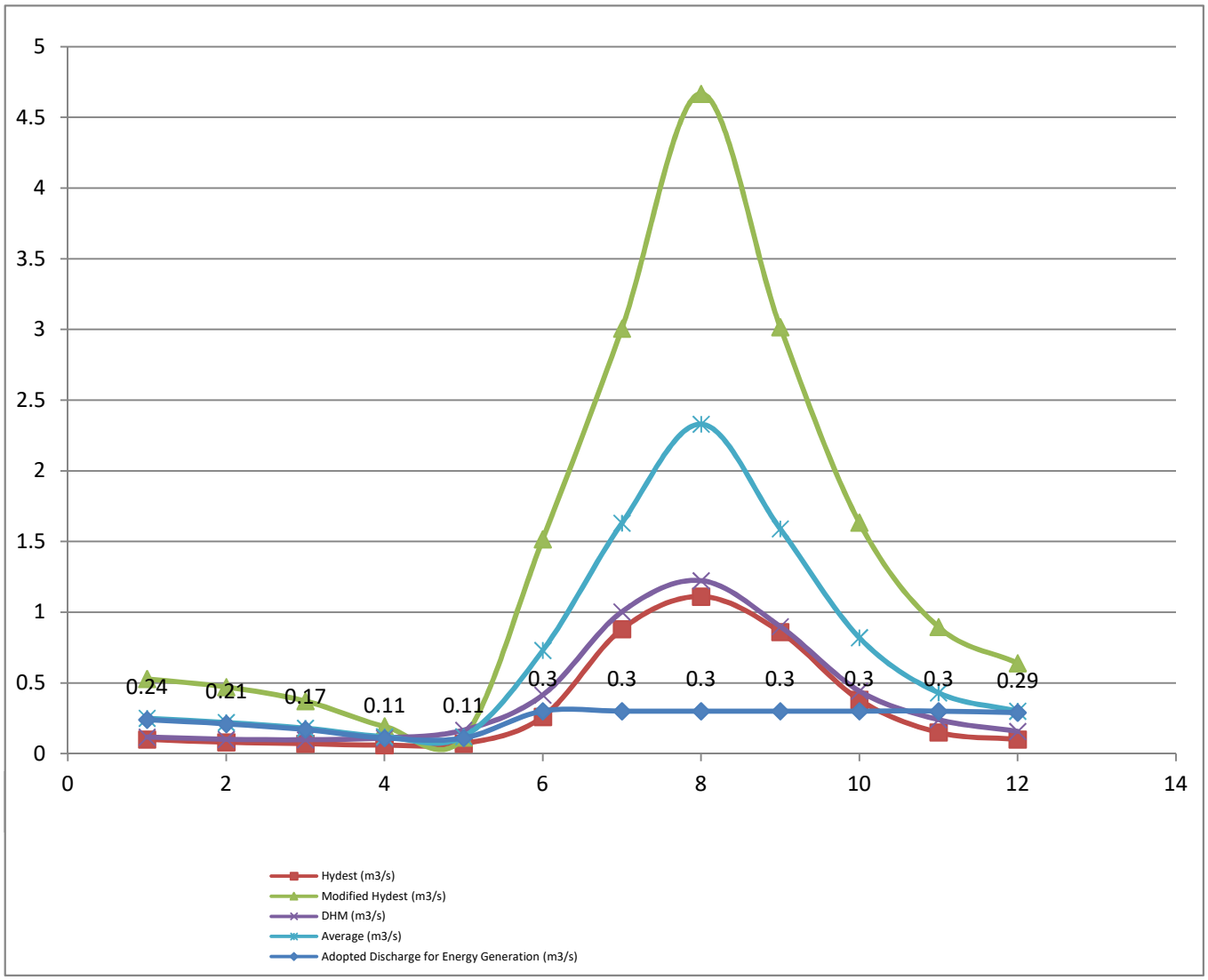
10. Financial parameters have been presented for all investment and equity investment options.

11. Hydropower project is compared with Solar power plant by using Least Cost of Energy (LCoE) mehtod.

12. Physical contingencies for Civil, Electro Mechanical (Water to Wire), Penstock/Hydromechanical are taken as 10%, 2.5 % and 5% respectively. Similarly VAT/Tax is taken as 13% and in case of Electromechanical items (Water to Wire) tax is taken as 1% .

13. Brief Summary report has been generated by using Hydropower Studio Model developed by Er. Khimananda Kandel.

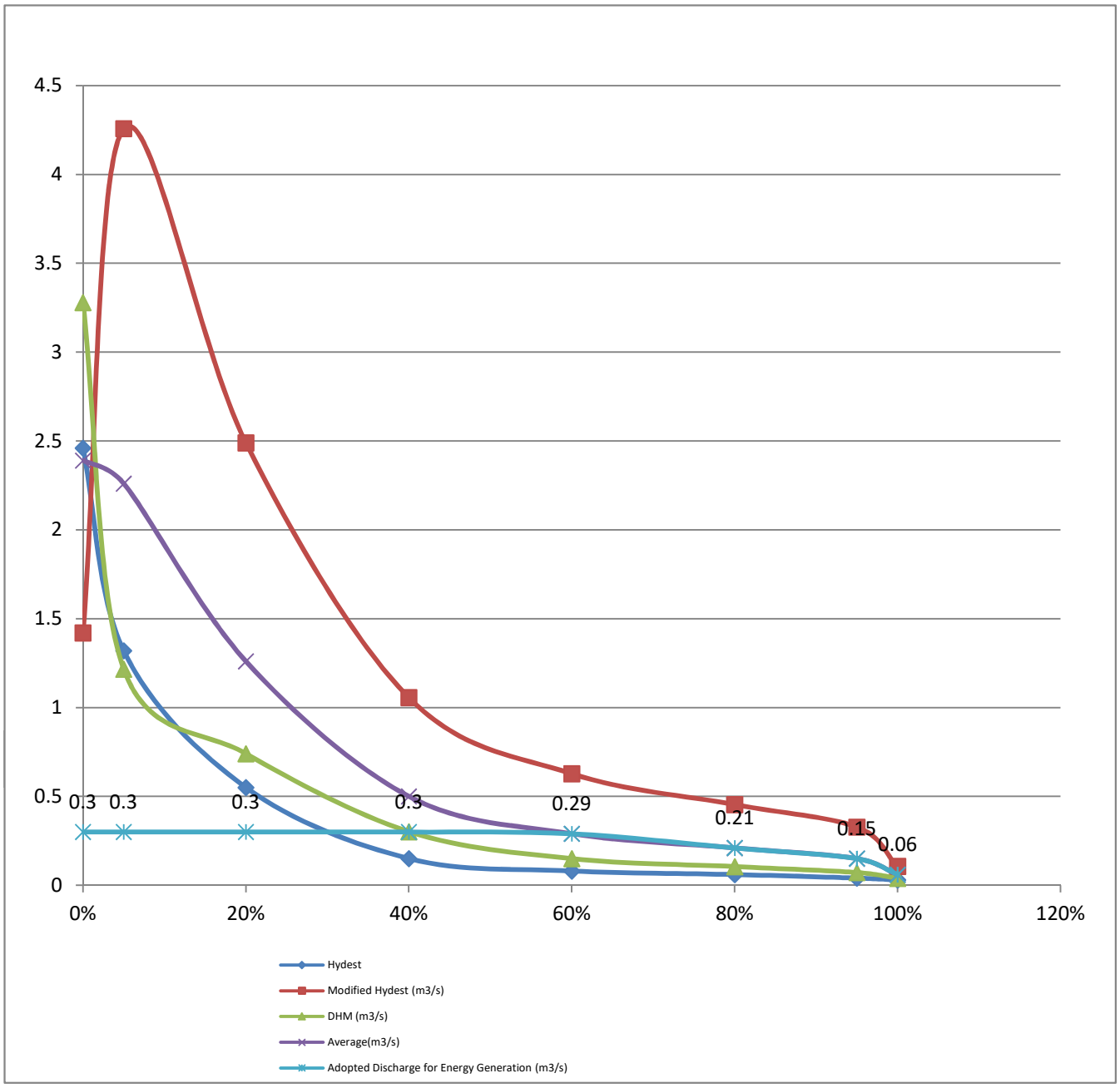
Available and Design Discharge in the River



e and Design Flow (m3/s) in the Stream

S.N.	Month	Discharge in River (m3/s)	Discharge for Power Generation (m3/s)	Remarks
1	January	0.25	0.225	
2	Febrauary	0.22	0.198	
3	March	0.18	0.162	
4	April	0.12	0.108	
5	May	0.12	0.108	
6	June	0.73	0.3	
7	July	1.63	0.3	
8	August	2.33	0.3	
9	September	1.59	0.3	
10	October	0.82	0.3	
11	November	0.43	0.3	
12	December	0.3	0.27	

Flow Duration Curve of the River



e and Design Flow (m3/s) in the Stream

S.N.	Probability of Exceedence (%age)	Hydest (m3/s)	Modified Hydest (m3/s)	DHM (m3/s)
1	0%	2.46	1.42	3.28
2	5%	1.32	4.26	1.22
3	20%	0.55	2.49	0.74
4	40%	0.15	1.06	0.3
5	60%	0.08	0.63	0.15
6	80%	0.06	0.45	0.1
7	95%	0.04	0.33	0.07
8	100%	0.03	0.11	0.04

Adopted Rate of Materials and Items at Project Site

Table : Adopted Rate of Materials and Items at Project Site

S.N.	Particulars	Unit Rate	Unit	Remarks
1	Cement (Ordinary Portland Cement)	750.00	Bag	VAT Additional
2	Sand	3,912.06	m3	At Project Site
3	Agreegate	2,209.15	m3	At Project Site
4	Stone	1,955.00	m3	At Project Site
5	Cutting Bending and Fixing Reinforcement Bars	119.43	kg	At Project Site
6	Penstock Fabrication	181.05	kg	At Project Site
7	Gabion Making with material and filling	4,938.68	m3	At Project Site
8	Earthwork in Excavation	533.03	Cum	At Project Site
9	Earthwork in Backfilling	355.35	Cum	At Project Site
10	Dry Stone Soling	3,732.90	Cum	At Project Site
11	Stone Masonry in 1:4 cement mortar	12,806.32	Cum	At Project Site
12	Stone Masonry in 1:6 Cement Mortar	5,566.00	Cum	At Project Site
13	PCC(1:3:6) in Foundation	12,540.53	Cum	At Project Site
14	PCC (1:2:4) in Structures	15,546.44	Cum	At Project Site
15	PCC (1:1.5:3) in Structures	17,206.87	Cum	At Project Site
16	Wooden Formwork	514.59	m2	At Project Site
17	20 mm thick Plastering	592.90	m2	At Project Site
18	12.5 mm thick Plastering	464.39	m2	At Project Site
19	CGI Roofing	509.26	m2	At Project Site
20	33 kV kV Transmission Line cost per kM	1,863,463.35	kM	At Project Site
21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5614811.146	
1.2	Desanding Basin	1.2	943428.3201	
1.3	Headrace Power Canal	1.3		
1.4	Cross Drainage Works	1.4	16318516.36	
1.5	Forebay Basin/Spillway	1.5	943428.3201	
1.6	Penstock and Hydro Mechanical (Metal Parts)	1.6	163185163.6	
1.7	Anchor Block and Support Pier	1.7	81592581.79	
1.8	Powerhouuse and Tailrace	1.8		
	Sub-Total NRs.		277350342.7	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	2.1	112077000	
3	TRANSMISSION LINE			
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	4.1	5000000	
4.2	Construction Camp Establishment	4.2	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	5.1	5000000	
	Sub-total		439496609.8	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	6.1	21974830.49	
	Sub Total 1-6		461471440.3	
7	Contigencies	7.1	35752905.68	
8	VAT 1-6 (6 Inclusive of VAT)	8.1	50853693.97	
9	Interest During Construction	9.1	65769364.79	
10	TOTAL ESTIMATED COST (NRs)	10.1	613847404.7	
	Cost per kW (1 US$ = NRs. 106)		2441.41	
	Cost per kW in NRs.		**258788.96**	

Revenue of the Project

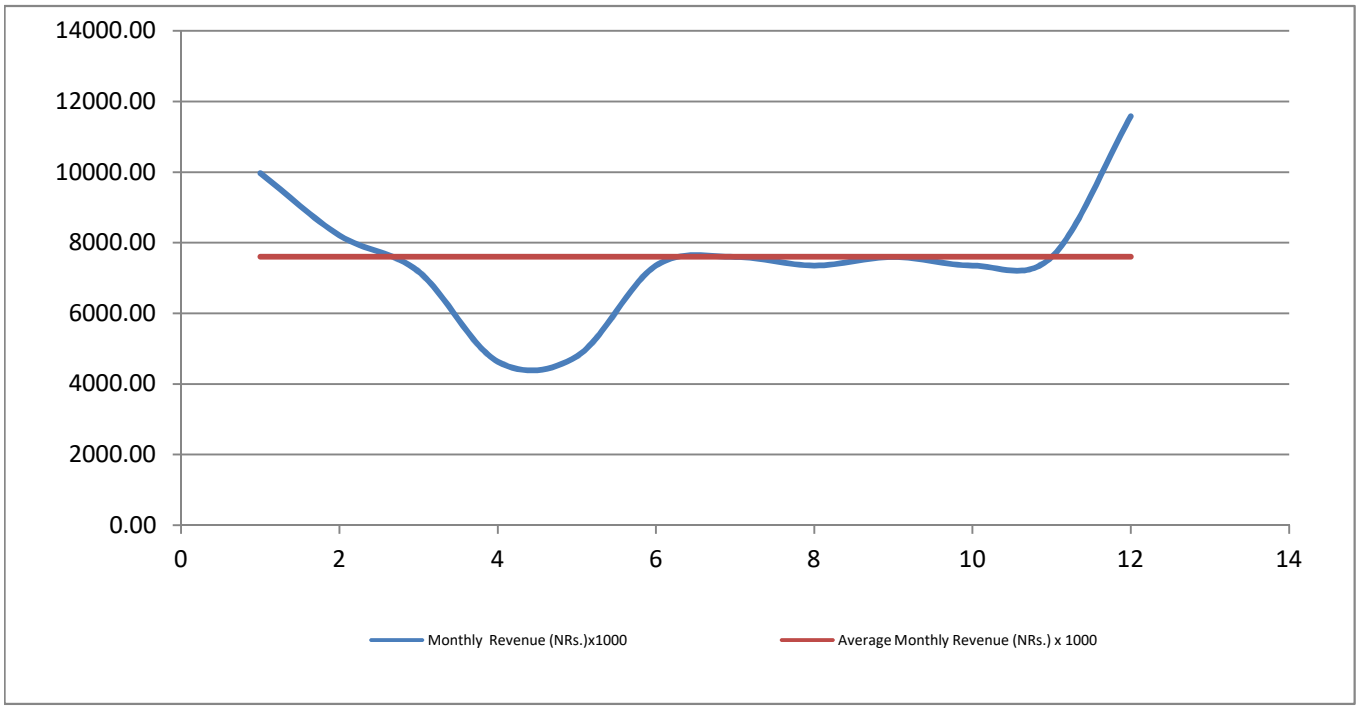


Table: Summary of Monthly and Average Monthly Revenue From the Project

S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	9972.49	7601.55	
2	February	8208.35	7601.55	
3	March	7182.67	7601.55	
4	April	4632.16	7601.55	
5	May	4786.57	7601.55	
6	June	7352.99	7601.55	
7	July	7598.09	7601.55	
8	August	7352.99	7601.55	
9	September	7598.09	7601.55	
10	October	7352.99	7601.55	
11	November	7598.09	7601.55	
12	December	11583.13	7601.55	
	Total	91218.61	91218.60	

Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	613.85	(Million NRs.)	
2	Bank Loan (70%)	429.693	(Million NRs.)	
3	Equity Investment (30%)	184.154	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	74.1	(Million NRs.)	
6	IRR	11.61%		
7	B/C	1.11		
8	Least Cost of Energy (LCOE)	4.84	NRs./kWh	
9	Return on Equity (RoE)	13.50%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	69.93	(Million NRs.)	

Desk Study Report of Teka Ghatte Khola Mini Hydropower Project

Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk

Submitted To:

Jugal Rural Municipality,Sindhupalchowk

Submitted By:

Epsom Engineering Consultancy Pvt. Ltd.

Kalanki, Kathmandau

July 1, 2018

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Khimananda Kandel
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9851070202

SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Teka Ghatte Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindhupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.799, Lattitude= 28.0541	
Powerhouse Coordinate	:	Longitude = 85.7806, Lattitude= 28.0398	
Access			
Location of Nearest Roadhead	:	Balephi Khola Intake	
Distance from Roadhead	:	17	
Hydrology			
Catchment Area	:	5.65	km2
Q40 /(Adopted) Discharge	:	0.276	m3/s
Power and Energy			
Gross Head	:	1050	m
Efficiency %	:	0.85	%
Power at Q40	:	2175	kW
Total Annual Energy at Q45	:	13.812	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	3280	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	9	m
Breadth	:	3	m
Height	:	1.49	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.8	m
Height of Canal	:	0.6	m
Forebay			
Particle Size to be Settled	:	0.3	mm
Length (m)	:	15	m
Breadth (m)	:	2	m
Height (m)	:	1.43	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	3080	m
Internal diameter (d)	:	450	mm
Thickness (mm)	:	32.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	2230	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 1087.5 kW Capacity	
Gross Head	:	1050	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2	
Height	:	0.6	

Grid Connection

Transmission voltage	:	11 kV	
Connection point	:	20	kM
Line length	:	Pangtang (Sherpa Gaun)	

Power Transformer

Number of unit	:	1	
Rating	:	3300	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 1650	kVA
Rated Voltage	:	0.4	kV

Rated Frequency	:	50	Hz
Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period	:	18	Months

Economic and Financial Indicators

Project cost	:	556.39	Million (NRs.)
Annual Revenue	:	89.71	Million (NRs.)
Internal rate of return (IRR)	:	0.12	%
B/C Ratio	:	1.14	
Net present value (at 10% discount rate)	:	83.18	Million (NRs.)
Cost per kW	:	2413.33	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

Following general assumptions have been made in this study.

1. All DoED license issued and power generated sites for more than 100 kW Installed capacity are avoided in this study.

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3. 11 kV or 33 kV transmission line is proposed for power transmission and unit cost of 11 kV and 33 kV transmission line is prepared by including the cost of swithching station.

4. Water to wire cost is taken as certain dollar per kW.

5. It is assumed that the main construction materials and equipments will be delivered from stations namely; Birtamode, Itahari, Mirchaiya, Bardibas, Hetauda, Narayangadh, Kathmandu, Pokhara, Butwal, Bhaluwang, Tulsipur and Atariya.

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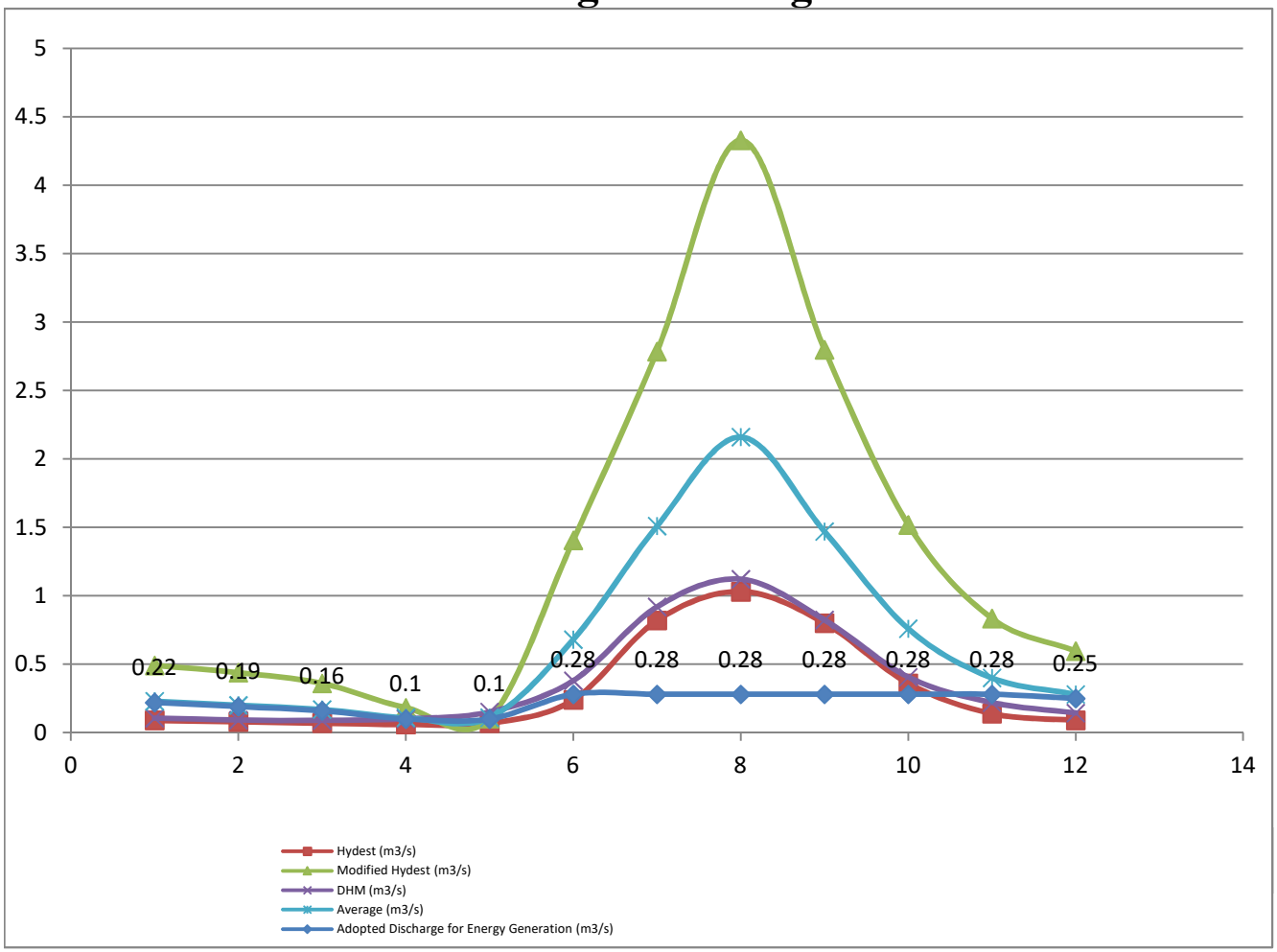


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N.	Month	Discharge in River (m3/s)	Discharge for Power Generation (m3/s)	Remarks
1	January	0.23	0.207	
2	Febrauary	0.2	0.18	
3	March	0.17	0.153	
4	April	0.11	0.099	
5	May	0.11	0.099	
6	June	0.68	0.28	
7	July	1.51	0.28	
8	August	2.16	0.28	
9	September	1.47	0.28	
10	October	0.76	0.28	
11	November	0.4	0.28	
12	December	0.28	0.25	

Flow Duration Curve of the River

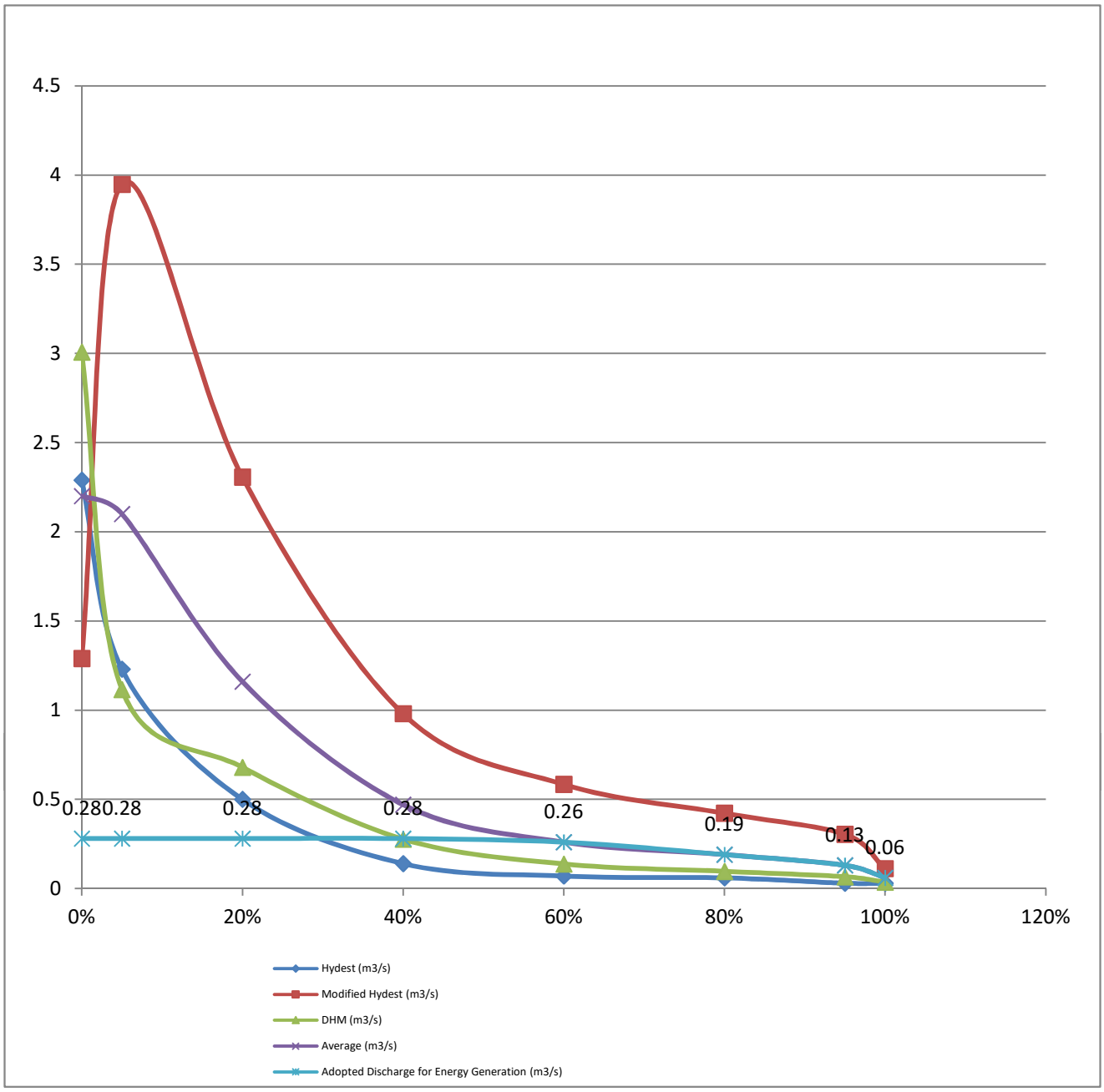


Table 1 : Summary of Available and Design Flow (m3/s) in the Stream

S.N.	Probability of Exceedence (%age)	Hydest (m3/s)	Modified Hydest (m3/s)	DHM (m3/s)
1	0%	2.29	1.29	3.01
2	5%	1.23	3.95	1.12
3	20%	0.5	2.31	0.68
4	40%	0.14	0.98	0.28
5	60%	0.07	0.58	0.14
6	80%	0.06	0.42	0.1
7	95%	0.03	0.3	0.07
8	100%	0.03	0.11	0.04

Adopted Rate of Materials and Items at Project Site

Table : Adopted Rate of Materials and Items at Project Site

S.N.	Particulars	Unit Rate	Unit	Remarks
1	Cement (Ordinary Portland Cement)	750.00	Bag	At Project Site
2	Sand	3,912.06	m3	At Project Site
3	Agreegate	2,209.15	m3	At Project Site
4	Stone	1,955.00	m3	At Project Site
5	Cutting Bending and Fixing Reinforcement Bars	119.43	kg	At Project Site
6	Penstock Fabrication	181.05	kg	At Project Site
7	Gabion Making with material and filling	4,938.68	m3	At Project Site
8	Earthwork in Excavation	533.03	Cum	At Project Site
9	Earthwork in Backfilling	355.35	Cum	At Project Site
10	Dry Stone Soling	3,732.90	Cum	At Project Site
11	Stone Masonry in 1:4 cement mortar	12,806.32	Cum	At Project Site
12	Stone Masonry in 1:6 Cement Mortar	11,982.04	Cum	At Project Site
13	PCC(1:3:6) in Foundation	12,540.53	Cum	At Project Site
14	PCC (1:2:4) in Structures	15,546.44	Cum	At Project Site
15	PCC (1:1.5:3) in Structures	17,206.87	Cum	At Project Site
16	Wooden Formwork	514.59	m2	At Project Site
17	20 mm thick Plastering	592.90	m2	At Project Site
18	12.5 mm thick Plastering	464.39	m2	At Project Site
19	CGI Roofing	509.39	m2	At Project Site
20	33 kV kV Transmission Line cost per kM	1,863,463.35	kM	At Project Site
21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5614811.146	
1.2	Desanding Basin	1.2	912021.3088	
1.3	Headrace Power Canal	1.3	0	
1.4	Cross Drainage Works	1.4	14355089.05	
1.5	Forebay Basin/Spillway	1.5	912021.3088	
1.6	Penstock and Hydro Mechanical (M	1.6	143550890.5	
1.7	Anchor Block and Support Pier	1.7	71775445.24	
1.7	Powerhouuse and Tailrace	1.8	8752463.4	
	Sub-Total NRs.		245872741.9	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	2.1	102768750	
3	TRANSMISSION LINE			
3.1	33 Kv Transmission line to Substation	3.1	39769267.04	
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	4.1	5000000	
4.2	Site Facilities with Operators' Village	4.2	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	5.1	5000000	
	Sub-total		398710759	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	6.1	19935537.95	
	Sub Total 1-6		418646296.9	
7	Contigencies	7.1	32168510.09	
8	VAT 1-6 (6 Inclusive of VAT)	8.1	45965368.66	
9	Interest During Construction	9.1	59613621.08	
10	TOTAL ESTIMATED COST (NRs)	10.1	556393796.8	
	Cost per kW (1 US$ = NRs. 106)		2413.33	
	Cost per kW in NRs.		**255813.24**	

Revenue of the Project

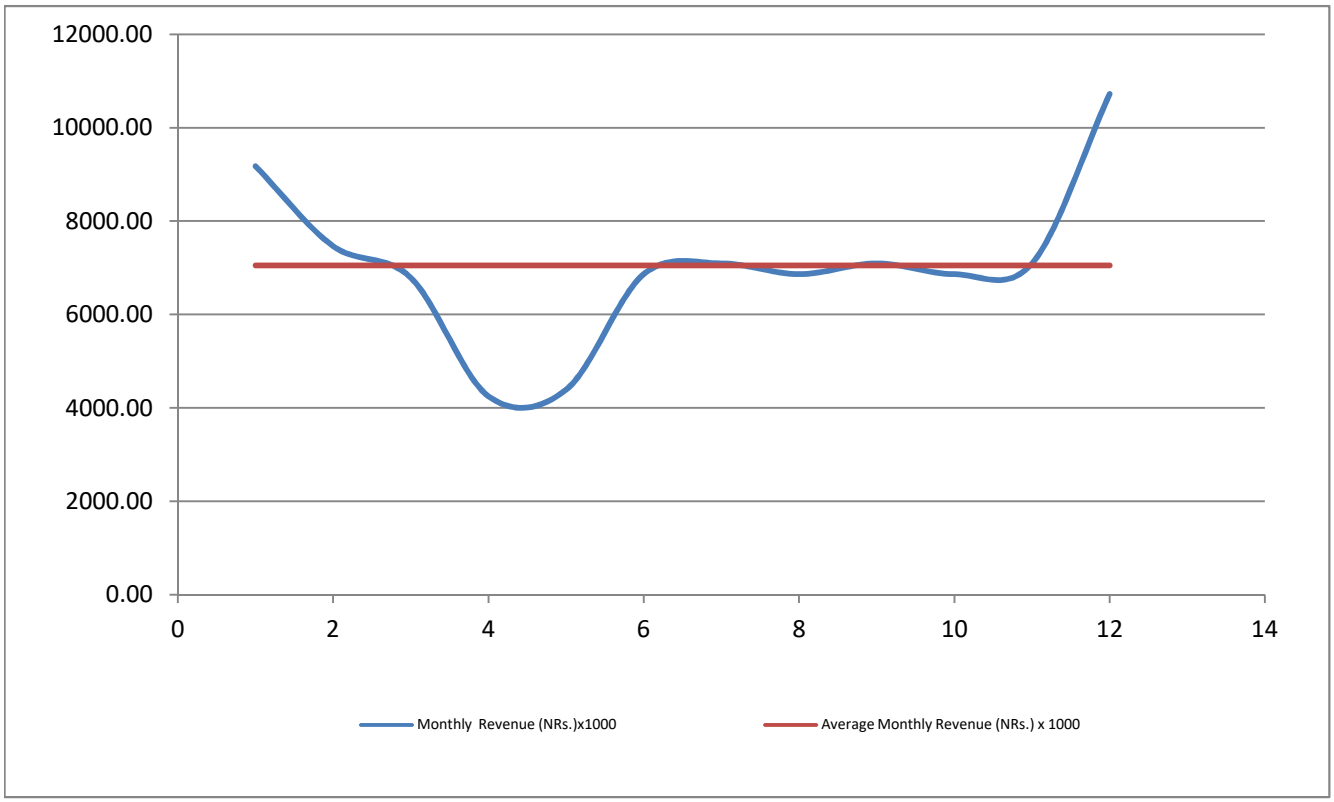


Table: Summary of Monthly and Average Monthly Revenue From the Project

S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	9173.79	7052.48	
2	February	7461.18	7052.48	
3	March	6783.32	7052.48	
4	April	4245.70	7052.48	
5	May	4387.22	7052.48	
6	June	6861.54	7052.48	
7	July	7090.26	7052.48	
8	August	6861.54	7052.48	
9	September	7090.26	7052.48	
10	October	6861.54	7052.48	
11	November	7090.26	7052.48	
12	December	10723.10	7052.48	
	Total	84629.71	84629.71	

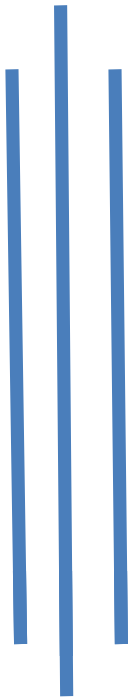
Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	556.39		
2	Bank Loan (70%)	389.476	(Million NRs.)	
3	Equity Investment (30%)	166.918	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	83.18	(Million NRs.)	
6	IRR	11.98%		
7	B/C	1.14		
8	Least Cost of Energy (LCOE)	4.72	NRs./kWh	
9	Return on Equity (RoE)	14.19%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	63.39	(Million NRs.)	

Desk Study Report of Golche Khola Mini Hydropower Project

Jugal Rural Municipality, Sindhupalchowk

Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk



Submitted To:

Jugal Rural Municipality,Sindhupalchowk

Submitted By:

Epsom Engineering Consultancy Pvt. Ltd.

Kalanki, Kathmandau

July 1, 2018

ACKNOWLEDGEMENTS

Its our great pleasure to work with Jugal Rural Municipality,Sindhupalchowk for Hydropower Master Plan Study of Jugal Rural Municipality, Sindhupalchowk.

We would like to thank all the team of Jugal Rural Municipality,Sindhupalchowk for their support during the accomplishment of this study.

We would also like to thank to our study team for their valuable time for the accomplishment of the study.

It is expected that this study will pave the foundation for the development of hydropower projects in Jugal Rural Municipality,Sindhupalchowk.

Khimananda Kandel
Managing Director
Epsom Engineering Consultancy Pvt. Ltd.
Kalanki, Kathmandau
khimanandakandel@yahoo.com
9851070202

SALIENT FEATURES

General		Particulars	Remarks
Name of the Project	:	Golche Khola Mini Hydropower Project	
Project location	:	Jugal Rural Municipality, Sindupalchowk	
Province No:	:	3	
Intake Coordinate	:	Longitude = 85.7269, Lattitude= 27.8933	
Powerhouse Coordinate	:	Longitude = 85.7577, Lattitude= 27.8947	
Access			
Location of Nearest Roadhead	:	Balephi Khola Intake	
Distance from Roadhead	:	2	
Hydrology			
Catchment Area	:	9.9	km2
Q40 /(Adopted)Discharge	:	0.484	m3/s
Power and Energy			
Gross Head	:	559	m
Efficiency %	:	0.85	%
Power at Q40	:	2030	kW
Total Annual Energy at Q45	:	10.98	GWh
Weir /Intake			
Type of Weir	:	Concrete Gravity Type	
RL of Intake	:	1661	m
Type of Intake	:	Rectangular Orifice Type	
Desanding Basin			
Particle Size to be Settled	:	0.2	mm
Length	:	15.33	m
Breadth	:	3	m
Height	:	2.1	m
Headrace Canal			
Length of Canal	:	100	m
Width of Canal	:	0.95	m
Height of Canal	:	0.71	m
Forebay			
Particle Size to be Settled	:	0.3	mm
Length (m)	:	20	m
Breadth (m)	:	2.5	m

Height (m)	:	1.72	m

Penstock

Type	:	Surface Type, Steel	
Length (m)	:	3580	m
Internal diameter (d)	:	550	mm
Thickness (mm)	:	22.00	mm

Powerhouse

Type	:	Surface Type, Steel	
Approximate Size	:	18.40 m x 10.22 m	
Reduced Level	:	1102	

Turbine

Type	:	Pelton	
Number of units	:	2	
Turbine rated capacity	:	2 x 1015 kW Capacity	
Gross Head	:	559	m
Rated turbine efficiency	:	0.89	%

Tailrace Canal

Type	:	Rectangular	
Breadth	:	2.5	
Height	:	0.71	

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Transmission voltage	:	11 kV	
Line length	:	4	kM
Connection point	:	Pangtang (Sherpa Gaun)	

Power Transformer

Number of unit	:	1	
Rating	:	3000	kVA
Number of phase	:	3	
Frequency	:	50	Hz
Primary (l.V. side)	:	0.4	kV
Secondary (H.V. side)	:	33	kV

Generator

No. of units	:	2	
Type	:	3-phase, synchronous	
Rated Power	:	2 x 1500	kVA

Rated Voltage	:	0.4	kV
Rated Frequency	:	50	Hz
Rated Power factor	:	0.8	lagging
Rated Efficiency	:	0.94	%
Excitation system	:	Brushless	

Construction Period	:	18	Months

Economic and Financial Indicators

Project cost	:	507.80	Million (NRs.)
Annual Revenue	:	64.62	Million (NRs.)
Internal rate of return (IRR)	:	9.18	%
B/C Ratio	:	0.95	
Net present value (at 10% discount rate)	:	-29.89	Million (NRs.)
Cost per kW	:	2359.9	US$

ASSUMPTIONS AND LIMITATIONS

Assumptions:

Following general assumptions have been made in this study.

1. All DoED license issued and power generated sites for more than 100 kW Installed capacity are avoided in this study.
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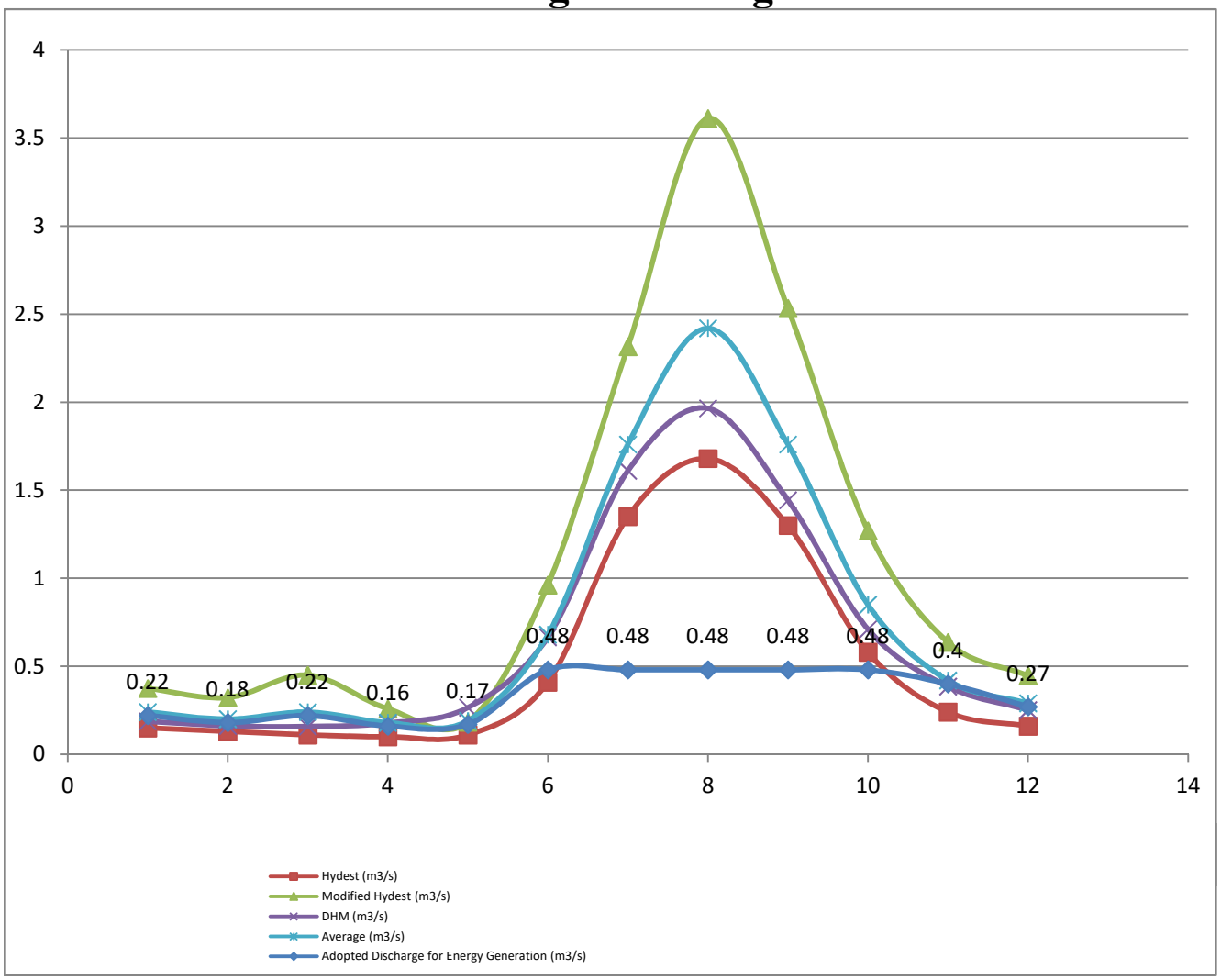

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6	June	0.68	0.48	
7	July	1.76	0.48	
8	August	2.42	0.48	
9	September	1.76	0.48	
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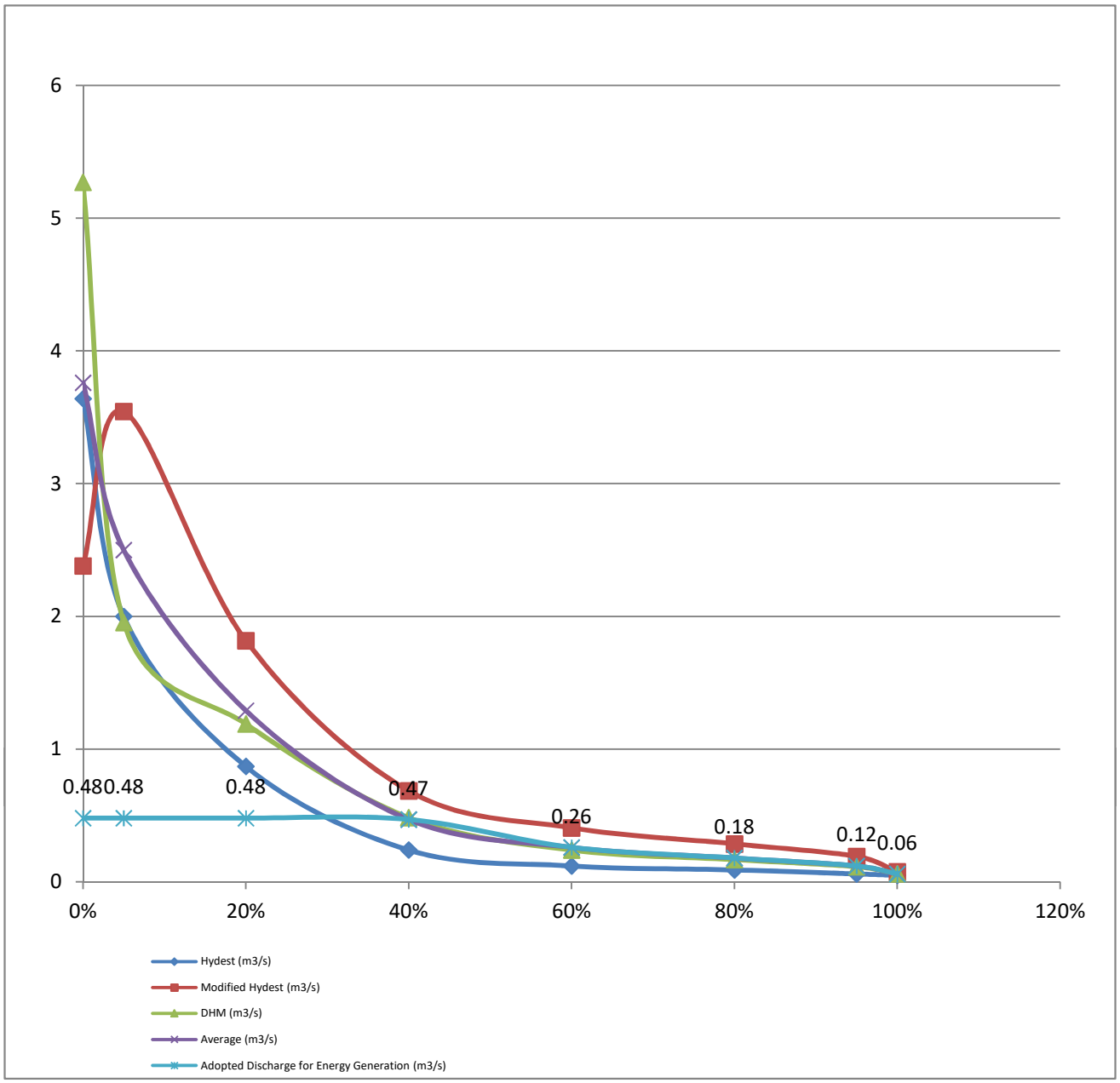

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3	20%	0.87	1.82	1.19
4	40%	0.24	0.69	0.48
5	60%	0.12	0.41	0.24
6	80%	0.09	0.29	0.17
7	95%	0.06	0.19	0.11
8	100%	0.05	0.08	0.06

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21	Powerhouse Generating Equipments all (Turbine, Generator, Governer, Valves, Switchyard and Power Transformer all)	$450.00	per kW	

Summary of Cost Estimate

SN	ITEM DESCRIPTION	Table No.	Amount NRs. (Alternative I)	Remarks
1	CIVIL WORKS			
1.1	Headworks	1.1	5576874.505	
1.2	Desanding Basin	1.2	1350717.22	
1.3	Headrace Power Canal	1.3		
1	Cross Drainage Works	1.4	14372753.75	
2	Forebay Basin/Spillway	1.5	1350717.22	
2	Penstock and Hydro Mechanical (M	1.6	143727537.5	
2	Anchor Block and Support Pier	1.7	71863768.74	
2	Powerhouuse and Tailrace	1.8		
	Sub-Total NRs.		246917159.2	
2	ELECTRO-MECHANICAL EQUIPMENT			
2.1	Power house equipment	1.9	95917500	
3	TRANSMISSION LINE			
3.1	33 Kv Transmission line to Substation	1.1	9953853.408	
4	ROAD AND SITE FACILITIES			
4.1	Project /or Access Road	1.11	5000000	
4	Site Facilities with Operators' Village	1.12	300000	
	Sub-Total NRs.		5300000	
5	ENVIRONMENTAL COSTS			
5.1	Environmental costs and compensation	1.13	5000000	
	Sub-total		363088512.6	
6	ENGINEERING & ADMINISTRATION COSTS			
6.1	Detailed Design, construction management, and administration cost	0.05	18154425.63	
	Sub Total 1-6		381242938.2	
7	Contigencies		30432788.65	
8	VAT 1-6 (6 Inclusive of VAT)		41719992	
9	Interest During Construction		54407486.27	
10	TOTAL ESTIMATED COST (NRs)		507803205.2	
	Cost per kW (1 US$ = NRs. 106)		2359.9	
	Cost per kW in NRs.		**250149.36**	

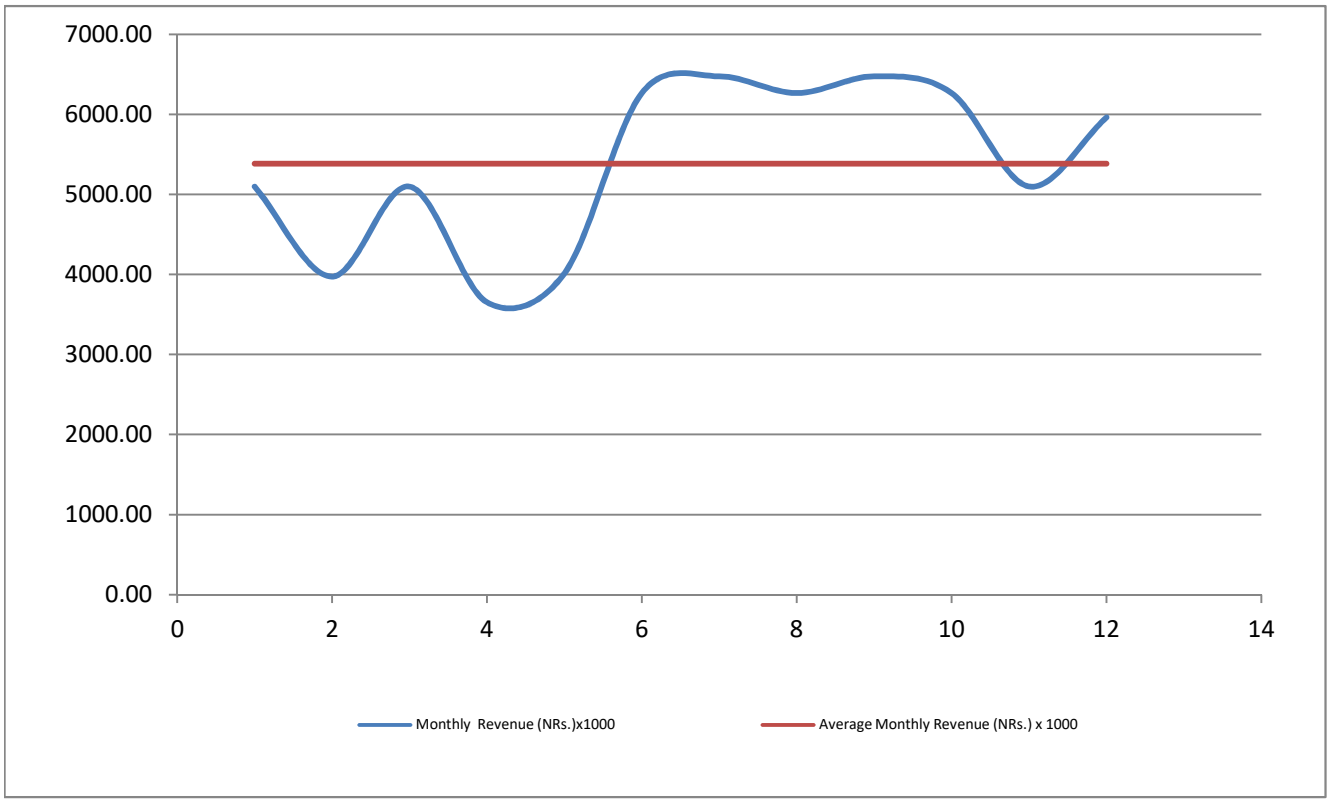

Table: Summary of Monthly and Average Monthly Revenue From the Project

S.N.	Month	Monthly Revenue (NRs.)x1000	Average Monthly Revenue (NRs.) x 1000	Remarks
1	January	5095.92	5385.37	
2	February	3972.63	5385.37	
3	March	5095.92	5385.37	
4	April	3652.39	5385.37	
5	May	4010.37	5385.37	
6	June	6264.35	5385.37	
7	July	6473.16	5385.37	
8	August	6264.35	5385.37	
9	September	6473.16	5385.37	
10	October	6264.35	5385.37	
11	November	5097.53	5385.37	
12	December	5960.30	5385.37	
	Total	64624.42	64624.42	

Financial Analysis

SN	Particular	Output	Unit	Remarks
1	Total Project Cost	507.80		
2	Bank Loan (70%)	355.462	(Million NRs.)	
3	Equity Investment (30%)	152.341	(Million NRs.)	
4	Bank Interest Rate Considered	10.00%		
5	NPV	-29.89	(Million NRs.)	
6	IRR	9.18%		
7	B/C	0.95		
8	Least Cost of Energy (LCOE)	5.42	NRs./kWh	
9	Return on Equity (RoE)	14.98%		
10	Loan Payment (Years)	10		
11	Annuity of Loan	57.85	(Million NRs.)	