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RAJAMUDI
MINI HYDROELECTRIC PROJECT
2 x 25 kW

DETAILED PROJECT REPORT

for

UNIDO Regional Centre for Small Hydropower

August 2006

PREFACE

UNIDO (United Nations Industrial Development Organisation), through its project No.US/IND/03/002 has established a Regional Centre for Small Hydro Power in Thiruvananthapuram, Kerala, India, on 4 April 2003. at the Energy Management Centre, under Department of Power, Government of Kerala, UNIDO Regional Centre (RC) would like to ensure that this project, initially designed for a period of three years, paves the way for several micro, mini and small hydro projects to be implemented in Kerala, rest of India and in the South Asia region.

The aims and objectives of establishing this project is to further strengthen the Small Hydro Power related activities of the Energy Management Centre. With the establishment of the Centre, several renewable energy related awareness building and training programmes were conducted, to promote and accelerate sustainable development. It will facilitate the design of cost effective Renewable Energy Technologies using locally manufactured equipment, materials, labour, and organizing consultancy services on comprehensive aspects of renewable energy systems and small hydropower development.

One of the planned activities of the UNIDO Regional Centre project is to develop bankable Detailed Project Reports during the three years of the initial duration of the project.

One of the envisaged specific activities of the Regional Centre is developing programmes and projects related to the development of SHP for promoting and accelerating sustainable development through creating replicable income generating activity models and Community Development Centres (CDC) for remote rural areas. The RC kicked-off such an endeavour in Mankulam, an un-electrified Panchayath in Kerala, which is an agricultural resource rich village in the Idukki district, devoid of communication facilities. This is done in association with the local self Government of this Panchayath.

During 2001, with the objective of generating power for the lighting needs of the local community, the Panchayath initiated implementation of a 100 kW micro hydropower scheme at Pampumkayam, with a catchment area of 8 sq. km. The Honourable Minister for Power, Govt. of Kerala, inaugurated the project for power supply in October 2004.

The initiative of the Regional centre, with the help of Energy Management Centre the Investigation for reconnaissance and site visits to various mini hydropower projects have been made. The following potential sites have been further identified and detailed investigation completed. The schemes are

1. Kozhiyilakuthu	-	Mankulam Grama Panchayath (Report Completed)
2. Kilikkalthodu	-	Mankulam Grama Panchayath (Report Completed)
3. Padivathil	-	Naranammozhi Panchayath (Ranni Block) Report Completed
4. Panamkudantha	-	Naranammozhi Panchayath (Ranni Block) Report Completed
5. Rasathikuthu		Mannamkandam Panchayath (Adimaly Block) Report Completed

The Rajamudi Mini Hydro Electric Project is in Rajamudi thodu, flows to Uppu thodu in Periyar Basin and is located in Udumbanchola Taluk. The capacity of the scheme is 250 KW with an annual energy generation of 1.18Mu.

After making site visits, reconnaissance studies and conducting topographical investigation works it is seen that the scheme is technically feasible. Thereafter, detailed study has been made and report prepared. As per the report the cost of generation from this project is Rs2.90/Unit. Therefore this project is deemed financially viable.

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RAJAMUDI MHP

PART – I
GENERAL REPORT

CHAPTER - I

SALIENT FEATURES

1. Location		
1.1	*State*	Kerala
1.2	*District*	Idukki
1.3	*Thaluk*	Udumpanchola
1.4	*Panchayath*	Vathikkudy
1.5	*Access*	(25 km). Vazhathopu → Karimpan →
	a. Road	Uppukandam → Manippara → Vathikkudy →
		Rajamudy → 1km to project site
	b. Rail	Kochi
	c. Airport	Kochi
	d. Harbour	Kochi
1.6	*Geographical Co-ordinates*	
	Latitude	77°01'50" E
	Longitude	9°52'30" N
2. River		
2.1	*River*	Rajamudy Thodu a tributary of Upputhodu stream
2.2	*Basin*	Periyar
3. Hydrology		
3.1	*Catchment Area*	5.68 sq. km.
3.2	*Mean annual rainfall*	3600mm
4. Component Structures		
4.1	*Diversion Structure*	
	i. Type	Gravity Weir with un-gated overflow portion
	ii. Length of weir	21m
	(a) Overflow portion	15m
	(b) Non Overflow portion	6 m length (3 each on both side)
	iii. Deepest Bed Level	101.00
	iv. Excavated level	100.50
	v. Top width of non -overflow portion	1.00 m
	vi. Shape of the overflow portion	Ogee (Parabolic with vertical u/s face)
	vii. FSL	+104.00
	viii. Height of Weir at deepest bed level at overflow portion	3.50 m

	ix. Top level of Non-overflow portion	+106.00
4.2	***Intake***	
	i. Location	Right Bank
	ii. C/L level at intake	102.50
	iii. Size of Intake pipe	0.25m dia
	iv. Bell mouth height	0.80 m
	v. Control of gate	Manually operated screw type gate with rack and pinion arrangement
4.3	***River sluice***	
	• Location	Right bank
	• Diameter	300 mm
	• Centre line elevation of river sluice	101.75
	• Control Arrangement	Manually operated screw type lift gate
4.5	***Penstock pipe***	
	• Location	Bifurcating from the end of Penstock
	• Diameter	250 mm
	• Length	265m
	• Maximum Velocity	2.22m/sec
	• Shell Thickness	8mm
	• Design discharge	$0.117 m^3/sec$
4.6	***Power House***	
	i. Type	Over Ground
	ii. Head (Net Head)	67.50m
	iii. Elevation of C/L of turbine	+32.00
	iv. Floor level of M/C hall	+31.50
	v. Tail water level (normal)	+31.00
	vi. Size	
	i. Length	6.0 m
	ii. Width	6.0 m
	iii. *Height*	4 m
	iv. Installed Capacity	50 kW
	v. Turbine type	Cross flow turbine
	vi. No. of units & capacity	2 x 25kW
4.7	***Tail Race Channel***	
	i. Shape	Rectangular with rubble masonry sidewalls
	ii. Length	15 m
	iii. Size	0.75m x 0.75m
	iv. Sill level of channel at exit	+31.00

4.8	*Power Evacuation* i. Transmission lines	Power Generated will be transmitted through 11kV line for 1 km length
5. Power Benefits		
5.1	*Annual Energy generation*	033 Mu
6. Financial		
6.1	Total Cost of project	Rs. 50.00 Lakhs (incl. of transmission cost)
6.2	Cost per kW installed	Rs. 100000 /-
6.3	Cost of generation/ unit	Rs. 2.37 (incl. of transmission)

Chapter - II
INTRODUCTION

This micro hydel project, proposed at Rajamudy, is going to be implemented by Idukki District Panchayath. The project is situated near to Idukki HE Project (within 25 km). There are around 200 families in the area, It is a scattered population spread over the whole area. The only solution for supplying uninterrupted power supply is to have an independent electricity generating station in the area. Idukki District is having a large no of streams. Already there are some micro hydel stations up to 1000 kW capacity have been studied and is in advanced stage for consideration. Rajamudy stream is a second order stream with a maximum head potential of about 72 m. The design head after deducting the losses comes to 67.50m The capacity of the scheme is estimated as 50 kW. There is every possibility for electricity demand to get increased in future. Hence the investigation, selection of sites etc. are made in many other project sites also near to that area.

This scheme is designed as a run off the river scheme with no storage. The power generated in the scheme will be fed to KSEB grid through the 11 kV line. The average energy availability from this scheme have been worked out and will be 0.33 Mu

Exposed rock available is through out the stream. An overflow type weir is proposed to be located in the stream at about 30m away from the cart track. The spilled water will not make any problem because the water emerges after energy dissipation. The project will not cause any forest submergence or any environmental problem since the total area is in private land. The proposed weir having a height of 4.0 m from the river bed level. The Intake position is fixed at right bank in the Non-overflow block. A. Scour sluice is also provided to remove silt accumulated in the reservoir. Regarding the water conductor system a penstock having a length of 265m is proposed. The power house location also fully in private land. The tail water is let in to the same river. This project envisages 11kV power evacuation line of around 1 km to distribution locations
The capacity of the scheme is 2 x25 kW. The capacity is selected after detailed study of the availability of water in the stream and from the rain fall records of Vazhathopu rain gauge station.

Investigation of the site has been done and many alternatives have been studied for fixing the weir location. The weir is fixed at a suitable location 30 mts above the present pedestrian track, which is the apt location for the construction of weir.

The turbine selected is Hori: Francis turbine to suit the available head and discharge. The machines selected are with denomination of 2 x 25kW, as this is the optimum size, which can cater to a lean flow in the dry seasons as well.

The total estimated cost of the project is 50 Lakhs and cost per kWh is Rs. 2.37 with a pay back period of 11 years. This is economically viable and better to implement at the earliest. A simple intake with vertical lift gate is proposed on the right bank of the river through the non-overflow portion of the weir.

.An approach road up to the powerhouse site of about 300mts is to be constructed after acquisition.

The main components of the structures of the project are

1. Concrete weir of length 21m. The overflow portion is 15m and Non-overflow portion of 4m & 2m on both left and right bank.
2. A gated intake having an opening of 1.0x1.0m is provided at the Right bank, through the non-overflow portion.
3. A gated out let arrangement having 50cm diameter is also provided to remove silt accumulated in the reservoir portion.
4. The main water conductor system is a penstock having a dia of 25cm and thickness 8mm having a length of 265 m is to be provided and bifurcated near to the powerhouse.
5. A powerhouse having a size of 6x6x4 m is to be provided
9. A tailrace channel of length 18 m have to be cut and lined for the safe flow of water back to the river without being affected by the high flood conditions.

Chapter III

SURVEY AND INVESTIGATION

1. Topographical surveys

EMC has conducted a reconnaissance and preliminary investigation study was first conducted to ascertain the feasibility for establishing a micro hydel scheme, near Rajamudy either as a stand-alone station or connected to the grid. Based on the feasibility report different options studied so as to utilize the full power potential of the stream basin in future. Accordingly the detailed investigation for the scheme was carried out. As elaborate investigation was not required for a micro hydel scheme, the investigations were restricted to selection of an ideal site for weir, water conductor system, PH & tail-race. The whole project features are located within an area of one hectare; the detailed survey was completed within a week's period. The contour map for the entire project area was prepared including the small water spread area. Investigation as to the number of people in the locality to be benefited, availability of construction materials, working seasons, the labour availability, infrastructure facilities existing in the area, were conducted and explained in this report at respective places.

2. Survey on availability of materials

The streambed is fully on Rock. Some rock excavations may be required at the right bank to locate the intake pipe. Hence the excavated rubbles/ cobbles and coarse aggregates obtained from the project area itself can be utilised for concrete works. All other materials required for civil construction work has to be brought from outside.

3. Property survey

The total extend of project area will be around 1 Ha only. There is no homestead within this area and hence no problem of any eviction. The land belongs to private persons/Panchayath. This project is going to face minimum hurdles once the Panchayath is involved in the land acquisition process. The boundaries of the project area can be easily demarcated at the site for easy transfer of lands.

Chapter IV

HYDROLOGY

Surface water

Catchment Area

This stream is a first order stream in nature and having a drainage area of **5.68 sq. km.** The whole catchment area lies approximately at 800.00m above MSL. Rajamudy stream is a tributary of Upputhodu stream, which joins with Periyar at Karimpan.

Existing use

The area, through which this stream flows, is being used for cultivation of cash crops. Water at different location are diverted and used for watering the cash crops. Being a run off the river micro hydel scheme, the water after generation is left into the same stream.

Rainfall data

The scheme catchment experiences both south west monsoon and north east monsoon. No rain gauge station is established in the project area. The nearest rain gauge station is at Vazhathoppu, Idukki. The average annual rainfall at Idukki is 3600 mm, assumed based on the rainfall data. Monthly rainfall readings for the period from 6/1992 to 05/2003 collected from Vazhathoppu is shown in Table - 2

Climatological Data

As stated no climatological station is established here. Idukki station and Rajamudy are situated approximately in the same altitude. Hence the climatological data such as temperature, humidity, rate of evaporation etc, are calculated from Idukki and is taken as reliable data for this scheme.

Gauge and discharge data

Since there is no river gauge established at the site there is no inflow data for this stream available for Idukki reservoir. Since this project site is approximately in the same elevation of Idukki, the flow details proportionate to the catchment are arrived at after effecting necessary empirical correlation for the first order characteristics of the stream.

Sediment Analysis

This scheme is mainly envisaged as a run off the river scheme. Also the terrain upstream of the weir is almost flat with very gentle slope. Hence the study of silt load is not done. However in the design of the diversion weir provision is made for flushing out the silt through a river sluice located at the Right bank Non-overflow portion. Periodic removal of silt can also be done during the lean season

Flood Estimation

As there are no past records of the basin available, flood studies of the catchment has been made based on the CWC method `Detailed Approach for Design Flood Estimation For Small Catchment`. A flood of frequency 25 years is considered for the basin. A synthetic unit hydrograph (SUHG) of `1 hour duration` has been developed or the basin from the known parameters such as catchment area (A),length of longest main stream along the river course(L),equivalent stream slope (S_{eq}) etc: Ordinates of the SUHG has been worked out as per the formulae applicable for Sub Zone 5(b), Kerala State, Fig 1 shows the 1-hr synthetic hydrograph developed for the basin.

The design storm duration is adopted as $1.1 \times t_p$, which gives higher value of flood peak. Design storm duration worked out to 4 hours. Point rainfall and aerial rainfall are computed from the maps and tables furnished by the CWC for sub Zone 5(b). The point rainfall with a frequency of 25-yr 24-hr for the basin is found to be 240 mm. Using the conversion factor furnished by CWC, 25-yr 4hr point rainfall for the basin works out to 126 mm.

For converting the point rainfall to aerial rainfall, the aerial reduction factor is found to be negligibly small and hence not considered for calculation purpose. 25-year, 4-hr aerial rainfall is therefore is taken as 126 mm. Catchment Area-5.68 sq. km, Length of stream-6.38 km, S_{eq}-40.46 m / km

The above 25-year 4-hr rainfall is split in to 1-hourly rainfall increments using the time distribution coefficients of areal rainfall. A design loss rate of 0.19cm / hr as recommended for Kerala is applied to get effective rainfall. Effective rainfall increments are tabulated below.

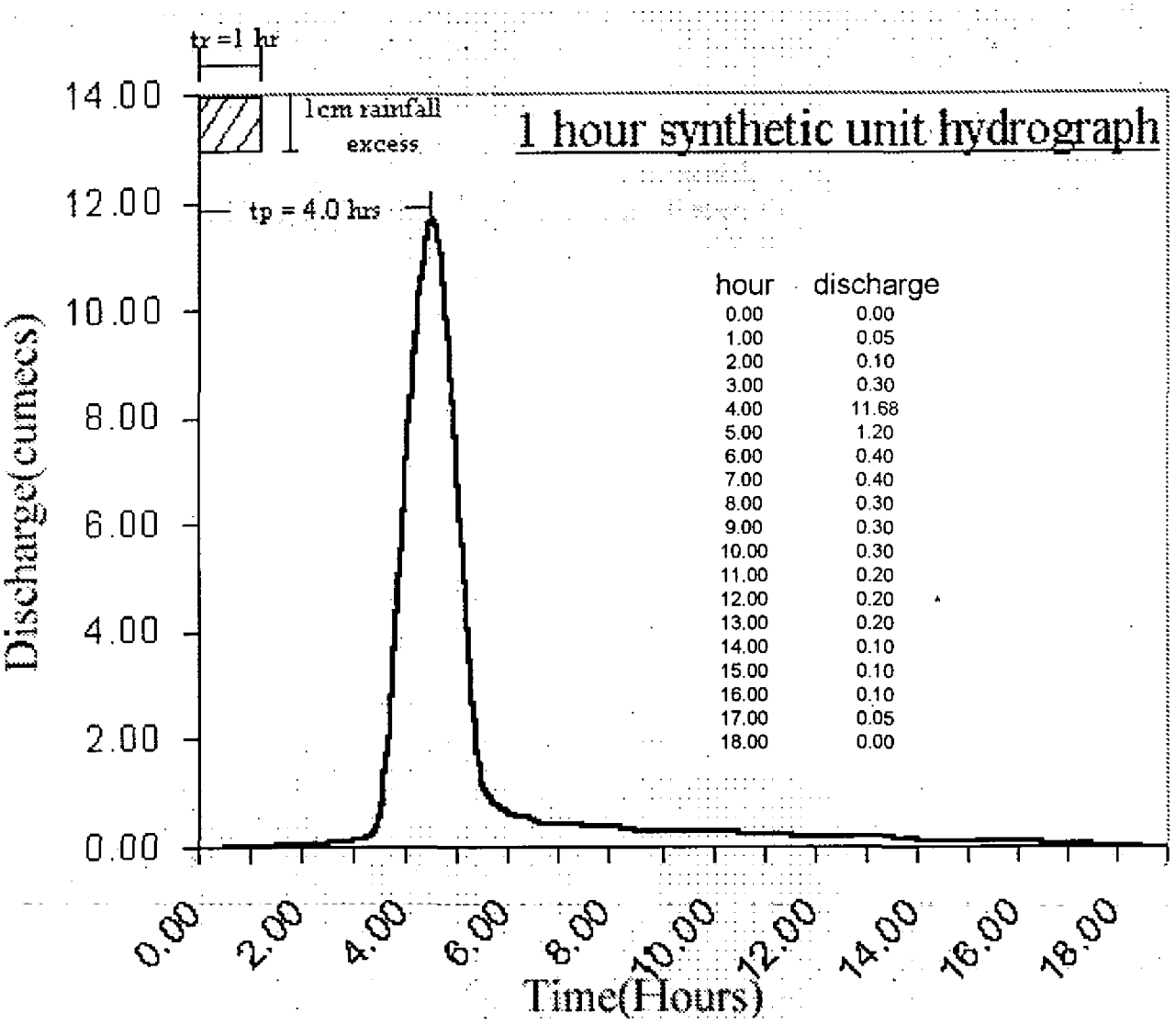


Fig. 1 - One hour synthetic unit hydrograph

Table.1- (Hourly rainfall increments)

Duration (hours)	Distribution coefficients	Storm Rainfall (mm)	Rainfall increments (cm)	Effective rainfall Increments (cm)
1	**2**	**3**	**4**	**5**
1	0.57	71.82	7.18	6.99
2	0.81	102.06	3.02	2.83
3	0.94	118.44	1.64	1.45
4	1.00	126.00	0.76	0.57

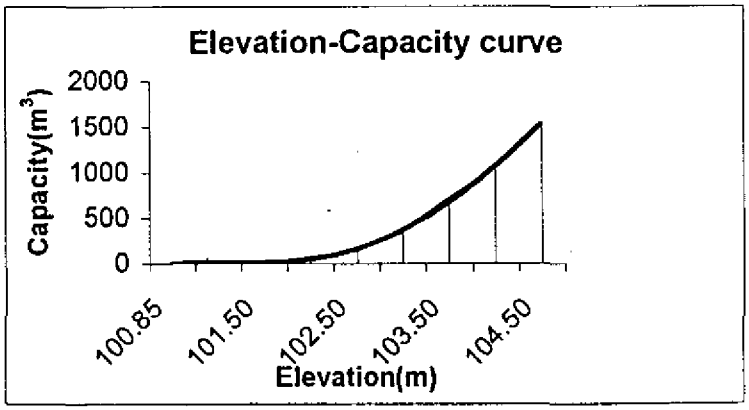
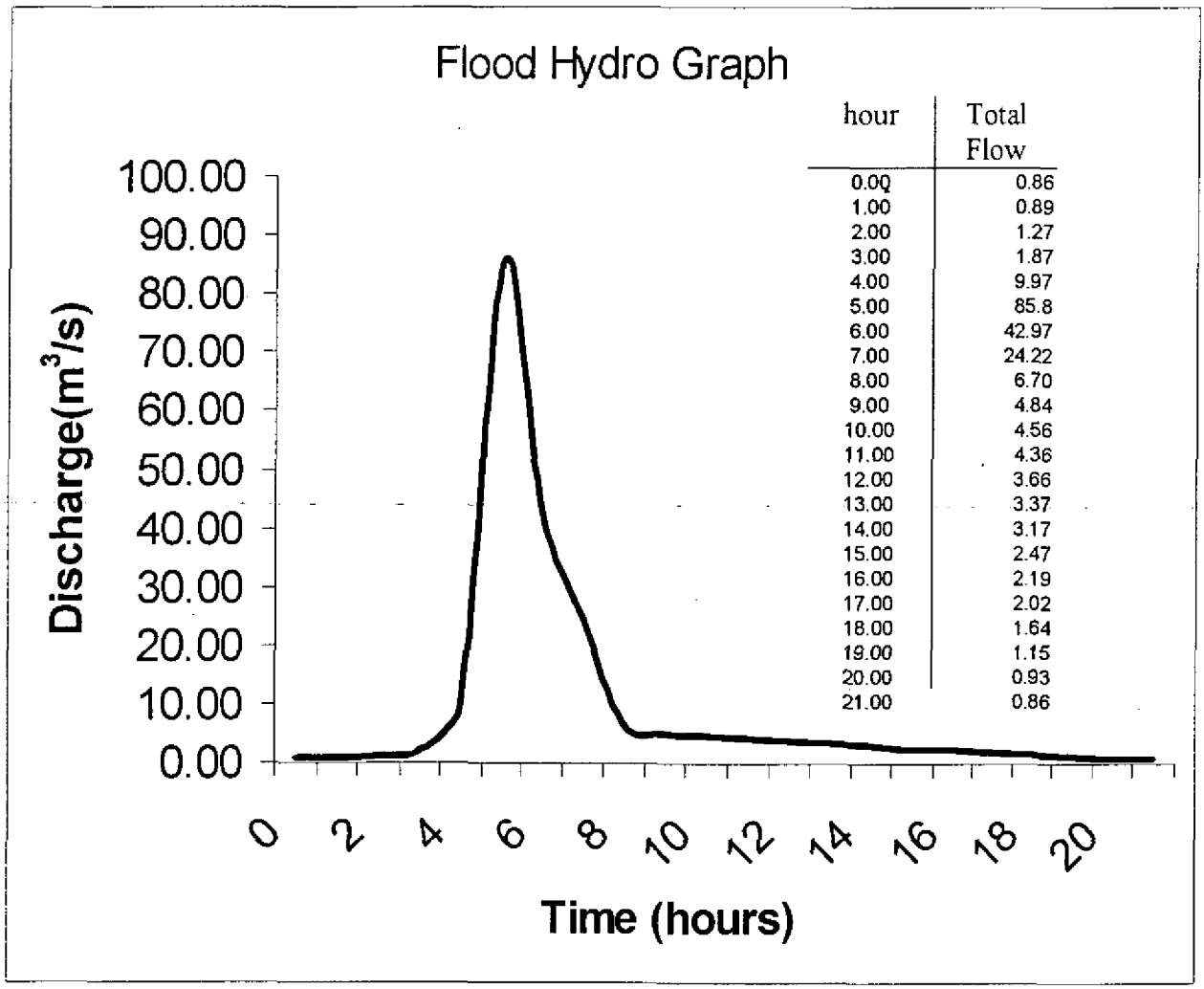


Fig. 2 - Elevation-Capacity curve

Computation of flood peak

The design base flow is taken as 0.15 cumecs per sq. km as recommended by CWC. A flood hydrograph (Fig 3) is developed for the basin after arriving the critical 1-hr effective rainfall sequence. The peak flood discharge is estimated as 85.8 cumecs.



hour	Total Flow
0.00	0.86
1.00	0.89
2.00	1.27
3.00	1.87
4.00	9.97
5.00	85.8
6.00	42.97
7.00	24.22
8.00	6.70
9.00	4.84
10.00	4.56
11.00	4.36
12.00	3.66
13.00	3.37
14.00	3.17
15.00	2.47
16.00	2.19
17.00	2.02
18.00	1.64
19.00	1.15
20.00	0.93
21.00	0.86

Fig. 3 - Flood Hydrograph

Water Quality

Chemical analysis of the water in the stream is not carried out. But this water is being used by the local people for domestic purpose as well as irrigation. This stream flows down to join with the Periyar river finally. In the lower reaches of Periyar river the KSEB had implemented a major Hydro electric project called Lower Periyar Hydro electric Project (180MW) necessary test has been done while implementation of the project and no adverse effect is noted in water quality.

Water utilisation

The water in the stream is presently being used by the local public for their agricultural needs. An allocation of 50% of the water in the stream is made to cater agriculture. On observing the present condition of the river it is seen that water is available in good quantity during monsoon period and very small quantity during summer months. During summer season the water will be let into the stream for the use of public. Therefore no hindrance will be brought down on the inhabitants after commissioning of the scheme.

Table – 2. Monthly Rainfall readings in mm from 1992-93 to 2002-03 of Vazhathoppu

	June	July	August	September	October	November	December	January	February	March	April	May	Yearly Total
1992-93	359.50	464.70	986.00	332.50	342.20	195.00	146.80	0.00	0.00	0.00	326.20	51.20	**3204.10**
1993-84	583.50	1154.70	832.50	866.00	180.00	86.20	60.00	0.00	0.00	30.50	94.70	0.00	**3888.10**
1984-95	1057.50	2020.00	516.20	498.20	426.00	0.00	0.00	0.00	0.00	38.70	0.00	546.20	**5102.80**
1995-96	1016.10	1184.40	1325.20	121.10	326.20	139.90	0.00	0.00	100.00	90.00	118.70	45.00	**4466.60**
1996-97	1659.00	1410.00	837.50	43.50	294.20	124.60	0.00	0.00	3.70	0.00	184.30	346.65	**4903.45**
1997-98	1189.40	1672.50	977.80	569.10	376.90	371.40	4.00	0.00	96.50	63.50	161.30	292.20	**5774.60**
1998-99	990.20	1490.00	1100.20	371.80	692.50	230.20	58.50	27.20	49.50	0.00	302.20	216.20	**5528.50**
1999-00	1459.80	1642.20	971.00	446.00	693.50	300.80	0.00	54.50	29.400	44.80	229.80	523.00	**6382.40**
2000-01	888.00	1433.70	1194.90	753.20	340.50	204.20	0.00	34.30	28.50	42.50	409.70	109.80	**5439.30**
2001-02	958.30	1375.50	852.20	690.20	476.50	116.50	19.60	2.00	1.50	88.50	220.00	256.30	**5057.10**
2002-03	506.00	1823.25	991.00	490.00	399.50	328.00	153.20	2.00	1.20	73.50	94.00	132.00	**4993.65**
Average	**970.0**	**1425.5**	**962.2**	**471.1**	**413.5**	**190.6**	**40.2**	**10.9**	**27.1**	**42.9**	**194.6**	**229.0**	***4977.50***

Table – 3 - Monthly inflow of Rajamudy Catchment in m^3/sec

Year	June	July	August	September	October	November	December	January	February	March	April	May
1987-88	0.651	0.807	1.213	0.597	0.594	0.150	0.205	0.000	0.000	0.000	0.385	0.019
1988-89	1.070	2.049	1.477	1.288	0.319	0.158	0.106	0.000	0.000	0.03	0.174	0.000
1989-90	1.285	3.187	0.338	0.935	0.774	0.000	0.000	0.000	0.000	0.050	0.000	0.132
1990-91	1.587	2.129	2.382	0.225	0.586	0.260	0.000	0.000	0.199	0.162	0.120	0.041
1991-92	3.105	2.154	1.517	0.081	0.533	0.233	0.000	0.000	0.007	0.000	0.345	0.318
1992-93	2.152	3.065	1.392	1.078	0.691	0.303	0.002	0.000	0.196	0.116	0.305	0.205
1993-94	1.470	2.222	2.010	0.702	0.865	0.435	0.107	0.000	0.100	0.000	0.371	0.095
1994-95	2.181	3.028	1.790	0.850	1.279	0.373	0.000	0.000	0.035	0.005	0.438	0.524
1995-96	1.375	2.117	1.381	1.420	0.621	0.385	0.000	0.063	0.058	0.078	0.473	0.100
1996-97	1.298	2.297	1.547	1.215	0.865	0.219	0.030	0.000	0.003	0.101	0.213	0.235
1997-98	0.648	2.307	1.197	0.918	0.725	0.615	0.138	0.000	0.002	0.113	0.176	0.029
Average	***1.239***	***2.006***	***1.160***	***0.520***	***0.367***	***0.076***	***0.052***	***0.000***	***0.035***	***0.058***	***0.104***	***0.135***

Chapter - V
Geology

Regional Geology

This micro hydel scheme is located in the mountain region of Western Ghats of Kerala. The geological information about Western Ghats in that the formation consists mostly of Archean gneiss and charnokite. This mountain is classified as a region of high stability and the moments in the mountain has ceased long years ago.

Geology at site

Being a micro hydel scheme no geological exploration work has been done at the project site. Riverbed and both sides of the banks are covered with exposed rock. Also at the river course rock is exposed the weir location.

The proposed penstock route is partly rock and partly on earth. However as the pipe will be having a diameter of 200 mm (finally) only it is not significant whether the terrain is rocky. The pipe will be anchored on rocks and supported by saddle blocks. Powerhouse is located on the right bank of the stream. Rock is exposed in the area very near to the stream but otherwise the site consists of earth mixed with boulders. Earth cover over the rock is of the order of 2 m. The machines proposed to be housed in the PH building are of the order of 2x25kW. So major vertical or dynamic loading is not expected.

Chapter - VI

ENVIRONMENT AND ECOLOGY

The land is the project area are of private ownershio. There will be no problem for acquisition if Panchayath can arrange to get the lands transferred to the project. The procurement of materials can be arranged as and when required. Therefore no additional area required for project construction. Another advantage is that from the weir to power house the water is carried through penstock pipe and there fore the disturbance to the area is negligible. As such no special environmental and ecological study is necessary for the project. No quarry operation is to be carried out near to the area.

Chapter - VII

Need and Necessity of the project

7.1 *Present Development*

The Kerala State Electricity Board is the main utility in Kerala for the generation, transmission and distribution of electricity. For meeting the demand, apart from own generation, KSEB is importing power from Central Power Generating Stations as well as power generated by NTPC, BSES and other private parties. Even then KSEB can't meet the full requirement of the state's power needs. .

To bridge the demand supply gap, KSEB is taking measure by concentrating for major HE Projects and SHPs with local bodies and other power development sectors/agencies. Since the interest for taking lengthy isolated transmission line work is remote, villages will remain un-electrified and the local people will be deprived of the benefit of power.

The social impact in taking up the implementation of small, mini and micro-hydel scheme by the local bodies (Panchayath) is that power supply to isolated areas within the Panchayath can be effected at lesser cost, limiting the transmission and distribution lines within the village area.

This Mini hydel project, proposed at Rajamudy, is one of the schemes identified to be taken up under the control of UNIDO(RC). The project is situated near to Idukki HE Project (within 20 km). There are around 200 families in the area, most of them are tribal. It is a scattered population spread over the whole area with no electric connection. The only solution to this problem is to have an independent electricity generating station in the area. Rajamudy stream is a second order stream with a head potential of 70 m. The installed capacity assessed to cater the needs of the local area-people and also to connect to KSEB grid. There is every possibility for electricity demand to get increased in future.

Proposed Development

This scheme is designed as a run off the river scheme with no storage. The power generated will be distributed to the local people in the village. Surplus power generated in the subsequent stages will be fed to KSEB grid through the 11 kV line.

The average power availability from this scheme will be for 12 months with 6 months full generating capacity. For two months we can run the power station with 10% over load. The energy generation worked out as 0.33 MUnits /Year

No transmission system is intended for this project. The transmission line will be limited to extending the existing 11 kV line by the KSEB. A network of distribution system will be developed for domestic supply.

CHAPTER - VIII

CONSTRUCTION MATERIALS AND PROGRAMME

(a) Materials

For the construction of this project, the materials that are locally available as well as materials to be transported from elsewhere in the State can be utilised.

Source and availability

Rubble is available at the project site. An aggregate processing plant is proposed to be established near the Power House site. The coarse aggregates and fine aggregates can be produced at the plant using the rubble quarried here. Even though river sand is available in some part of the river, in the light of the environmental impact, as for as possible sand mining can be avoided. Hence crushed sand is proposed for construction purpose.

The project area is accessible through road and there will be no difficulty to convey Cement and Steel materials by Lorry. Tor-steel for reinforcement of concrete and steel plates for the fabrication of control gates, sluice gates, trash-racks and Penstock pipe and structural steel section for switchyard, etc can be brought from Pathanamthitta or Kochi by lorry.

Turbines and generating equipments if to be imported, these can be shipped to Cochin Port. From there, these items can be brought to site by lorry.

(b) Programme of Construction

An earthen road is branching from the tarred Upputhodu up to the weir site for a length of 500 m. This road can be developed for the project purpose. No separate colonies are proposed during construction period, since it is a micro hydel scheme.

Rajamudy Mini Scheme is proposed to be constructed under the guidance of UNIDO-RC and the work can be executed on contract basis. The proposed execution will be either a turnkey contract or separate contract for civil work, Fabrication & Erection of Gates, Penstock, Purchase and erection of Hydro mechanical Equipment etc. The quality control and the supervision for the entire work will be under the guidance of UNIDO-RC.

A Bar chart showing the starting and completion of various activities connected with the implementation of this project is attached with this project report.

The main activities involved are

1. Project Sanction including Finance
2. Marking Project Profile and fixing boundaries
3. Detailed design of the component Structures
4. Land acquisition
5. Preparation of tender documents
6. Tendering and award of Contract
7. Preliminary works, Access roads and infrastructure facilities.
8. Procurement of construction materials
9. Excavation of weir and intake.
10. Excavation of Penstock and anchor block.
11. Excavation of Power House, Tail Race and Switch Yard etc.
12. Concreting of weir
13. 1st Stage Concreting and roofing of Power House
14. Concreting of Anchor block and Erection of Penstock
15. Concreting of Tail Race & Switch yard
16. Supply and erection of T & G equipments, substation equipments etc
17. Erection of Machinery 1st stage
18. PH second stage concreting
19. Supply and erection of Gates and valves.
20. Fabrication and erection of Penstock
21. Final Erection of Machines
22. Construction of 11 KV transmission line.
23. Testing, Balancing & Commissioning

It is targeted to complete the construction activities, erection of T & G equipments and conduct trial running of the generators within 15 months from the date of awarding contract.

Multi-face activities are proposed. All the civil construction works will be carried out simultaneously to achieve the target. The entire activities of the project implementation will have to be monitored by an expert Team of Engineers.

CHAPTER - IX

COST OF THE PROJECT

Abstract of Costs

		In Rs. Lakhs
I	Civil Works	
	A. Preliminary (Land, Building, roads etc.)	2.75
	B. Works – Diversion structures, Water conductor System, Powerhouse and Tail Race etc.	23.50
II	Electrical Works	0
	i. Power plant equipments, accessories switchyard equipment	12.00
	ii. Transmission lines	4.00
III	Establishment charges including Project Management, Audit and Accounts, Running cost of vehicles, Welfare to workers, Inspection of UNIDO and other Experts and Officials, Maintenance of roads during the construction period, Camp equipments, forest and other clearances etc.	5.50
IV	Contingencies, consultancy, quality control, etc.	2.25
	Total	**50.00**
V	Year wise planning	
	The project is proposed to be implemented within 18 months.	
	Expenditure for 1st year	Rs. 30 lakhs
	Expenditure for 2nd year	Rs. 20.00 lakhs
	Total	**Rs. 50.00 lakhs**

CHAPTER - X

BENEFITS AND FINANCIAL ASPECTS

Rajamudy Micro Hydel Project proposed to be implemented under the guidance of UNIDO-RC for the generation of energy to meet the power requirements of the State.

Direct benefit of this project is the availability of 0.33 Mu of hydro energy after deducting auxiliary consumption (1%). This will be an added advantage for the State in meeting the energy requirement of the State.

For the analysis of the financial viability of this project the following calculations are made.

1. Deprecation of the component structures of project and average depreciation constant
2. Interest to be accrued on the capital during the period of construction. This amount is to be capitalised at the end of project construction.
3. Annual recurring expenses include (a) Interest 10% (b) Depreciation 2.3% (c) O&M charges 1.0% etc.
4. Dividend on Equity is 10%
5. Equity/ Loan ratio 25:75

The cost of generation of energy is found to be Rs 2.37/kWh. A financial analysis statement showing the capital expenditure, phasing of expenditure, recurring expenditure, cost of generation etc prepared and attached.

FINANCIAL ANALYSIS STATEMENT

Name of Project: - Rajamudy MHP

Installed Capacity - 50 kW

Total Cost of project = Rs. 50 Lakhs

Period of implementation of project: 2 years

Source of financing of project: 25% Equity, 75% loan

Equity = 12.5 say, Rs. 12.5 Lakhs Loan = 37.5 say, Rs. 37.5 Lakhs

Phasing of expenditure	**25% Equity**	**75% loan**	**Total**
1st Year	Rs. 12.5 Lakhs	Rs. 17.5 Lakhs	Rs. 30 Lakhs
2nd Year	Rs. 0 Lakhs	Rs. 20 Lakhs	Rs. 20 Lakhs

Interest on loan = 10%

Interest during Construction

1st Year =	17.5x(10%)/2 = 0.88 Lakhs
2nd Year =	20x(10%)/2+17.5x10% = 2.75 Lakhs
Total =	***3.625 Lakhs***

Interest during construction is capitalized. Hence total loan = Rs.41.125 Lakhs

Total cost of project on completion will be 12.5 + 41.125 = Rs. 53.625 Lakhs

i.e., Cost per M.W = Rs. 1072.5 Lakhs

Incentives and subsidies available from MNES.

1. Capital subsidy - Least of the below amounts.

a. 20% of project cost i.e., Rs. 10 Lakhs [or]

b. 75 Lakhs+12.5 Lakhs/MW i.e., Rs. 75.625 Lakhs

i.e., The subsidy eligible will be Rs. 10 Lakhs

This subsidy will be paid to financial institution providing the loan on commissioning the project. Hence the loan amount to be repaid is = 41.125 - 10 = 31.125 say Rs.31.2 Lakhs

Annual recurring expenses

(a) Interest on loan @ 10 % p.a = Rs. 3.12 Lakhs

(b) Operation and maintenance expenses @ 1% of Project cost = Rs. 0.5 Lakhs

(c) Depreciation @ 2.3% of project cost = Rs. 1.15 Lakhs

(d) Dividend on Equity at 10% = Rs. 1.25 Lakhs

(e) Total expenses = Rs. 6.02 Lakhs

Total power generated from the project = 0.33 Mu

Deducting

i. Power for auxiliary use @ 1% of generation = 0.0033 say, 0.01 Mu

Net power available = 0.32 Mu

Cost of generation of power per unit = 6.02/[0.32x10] = Rs. 1.89

If the loan amount is to be repaid in 11 years time, 5% of the loan amount is to be paid back every year; therefore repayment amount = Rs. 1.56 Lakhs

The total recurring cost per year will be = [6.02+1.56] = Rs. 7.58 Lakhs

Hence unit rate of power generation per unit =7.58/[0.32x10] = Rs. 2.37

The repayment and interest are to be made at a flat rate of [3.12 + 1.56] = Rs. 4.68 Lakhs (every year for complete repayment of loan + interest by 11 years)

Calculation of pay back period and cash flow statement.

Year from commencement of the project	Sum of expenditure (Loan) at the beginning of the year in Rs. Crores	Yearly capital expenditure through equity in Rs Crores.	Yearly capital expenditure through loan in Rs. Crores	Interest @10% of col{2} +interest @5% of col{4}	O/M cost +depreciated expenses in Rs. Crores	Net Power Available for company in Mu	Gross revenue @ in Rs Crores	Return on Equity	Net revenue col{8} -col{6}-col{9}	Annual surplus +ve or -ve (col.{10}-col.{5})	Sum of expenditure (Loan) at the end of year col.{2} + col.{4} -col.{11}
{1}	{2}	{3}	{4}	{5}	{6}	{7}	{8}	{9}	{10}	{11}	{12}
I	0.00	0.13	0.18	0.01						-0.01	0.18
II	0.18	0.00	0.20	0.03						-0.03	0.41
1	0.31	0.00	0.00	0.03	0.02	0.32	0.08	0.01	0.05	0.02	0.30
2	0.30	0.00	0.00	0.03	0.02	0.32	0.08	0.01	0.05	0.02	0.28
3	0.28	0.00	0.00	0.03	0.02	0.32	0.08	0.01	0.05	0.02	0.26
4	0.26	0.00	0.00	0.03	0.02	0.32	0.08	0.01	0.05	0.02	0.24
5	0.24	0.00	0.00	0.02	0.02	0.32	0.08	0.01	0.05	0.02	0.22
6	0.22	0.00	0.00	0.02	0.02	0.32	0.08	0.01	0.05	0.03	0.19
7	0.19	0.00	0.00	0.02	0.02	0.32	0.08	0.01	0.05	0.03	0.16
8	0.16	0.00	0.00	0.02	0.02	0.32	0.08	0.01	0.05	0.03	0.13
9	0.13	0.00	0.00	0.01	0.02	0.32	0.08	0.01	0.05	0.03	0.10
10	0.10	0.00	0.00	0.01	0.02	0.32	0.08	0.01	0.05	0.04	0.06
11	0.06	0.00	0.00	0.01	0.02	0.32	0.08	0.01	0.05	0.04	0.02
12	0.02	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.05	0.04	0.00
13	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.05	0.05	0.00
14	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
15	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
16	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
17	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
18	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
19	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
20	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
21	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
22	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
23	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
24	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00
25	0.00	0.00	0.00	0.00	0.02	0.32	0.08	0.01	0.04	0.04	0.00

RAJAMUDI MHP

PART – II
DESIGN REPORT

CHAPTER - XI

WATER & POWER STUDIES

Rajamudy micro hydel scheme envisages utilisation of water in the streamlet called Upputhodu of second order in nature for power generation of 50 kW. The scheme is designed as a run off the river scheme with small storage to meet demand during peak hours.

Even though the potential of this project location will be near 100kW, owing to the factor that the water from the river is utilised for agricultural and other purposes by local people, the capacity of the scheme is being fixed at 50% lower than the potential at 50 kW.

There is no rain gauge station available in the project area. The nearest rain guage station available is at Vazhathope maintained by KSEB. Monthly rain fall details of this station since 1981 is attached. The average rainfall in the area comes to 3600mm from the isobars published in the water atlas.

1.	Full reservoir level	-	+104.00
2.	Bed level of stream at weir site	-	+101.00
3.	M.D.D.L	-	+
4.	Level of c/l of runner	-	+32.00
5.	Max Head available	-	72.00 m
6.	Net design head allowing a head loss of 8 m	-	67.50 m

For a Power requirement of 1 kW

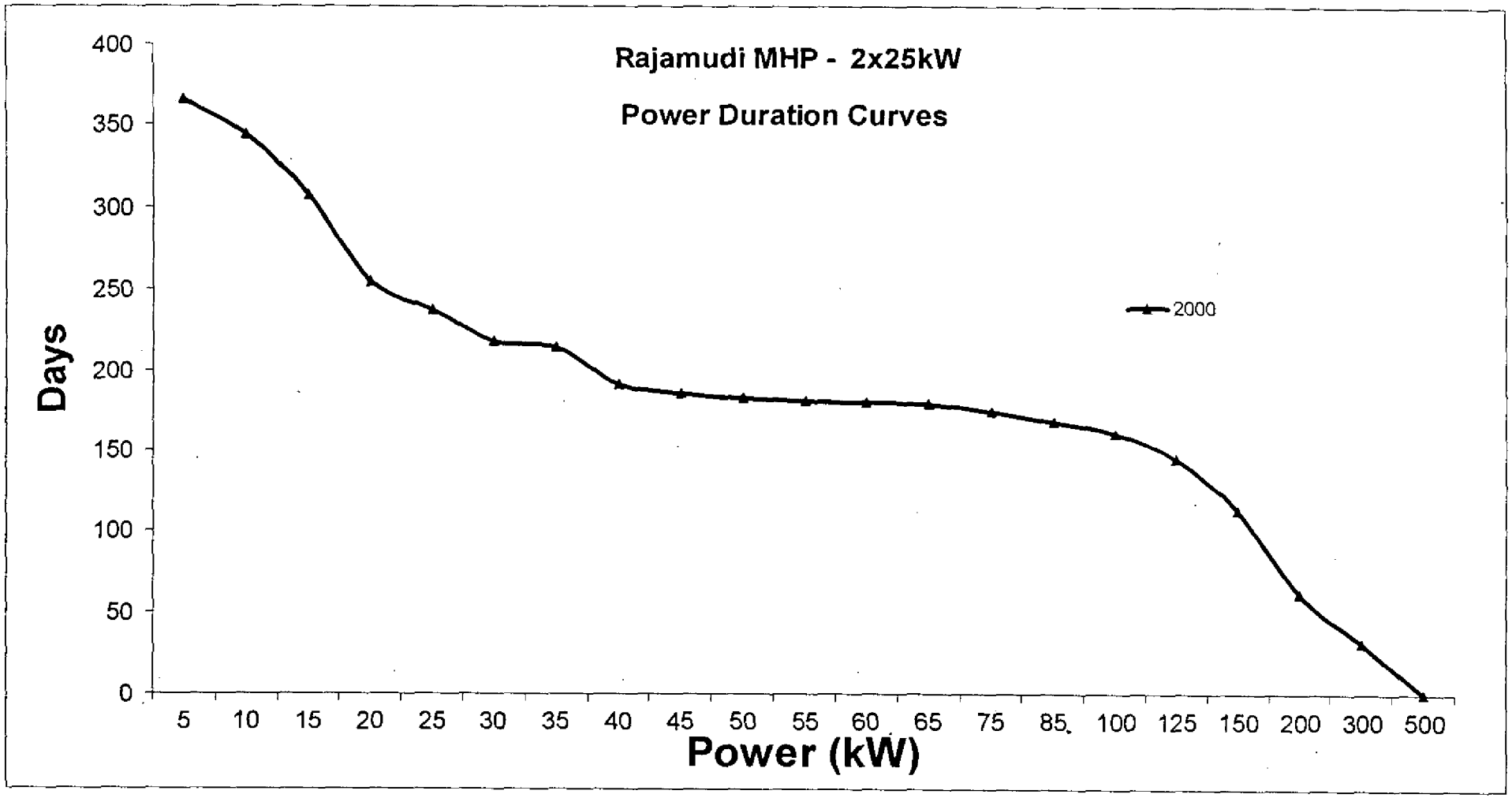
Power, $P = 7.Q.H$

$1 = 7 \times Q \times H$

$H = 67.5$ m

Then power draft, $Q = \frac{1}{7 \times 67.5} = 0.002116 m^3/s$

Accordingly the discharge requirement at 50kW with 10% overload capability will be $0.117 m^3/s$. The power generation possible from this scheme on a 50% dependable year will be 0.33Mu. The power duration curve of 50% dependable year 2000 is given below.


Rajamudi MHP - 2x25kW
Power Duration Curves
Days
Power (kW)
2000
400
350
300
250
200
150
100
50
0
5
10
15
20
25
30
35
40
45
50
55
60
65
75
85
100
125
150
200
300
500

CHAPTER - XII

DESIGN CRITERIA OF MAJOR COMPONENTS OF SCHEME

2.1 General

The Rajmudy micro hydel scheme is designed as a run of the river scheme with the following main project components.

Gravity weir

The weir is constructed across the Upputhodu stream, at about 20 m upstream of the footbridge. This concrete structure will be having an ungated overflow section for a length of 15m and overflow sections of 3m length on either side. Flood Discharge capacity of the spillway is 100m^3 /sec. Total length of the weir is 21m and protected on either banks with DR masonry. Though the scheme is designed as a run of the river scheme, a storage of 911 m^3 is provided to run the station during lean period as well as to function as a peaking station depending up on the future load demand. The station can have a capacity of 100kW with the available water. But, owing to the Though the present installed capacity will be only 15 kW, the weir is designed considering the future expansion and so as to enhance the station capacity up to 100 kW.

Water conductor system

a) a trash rack structure constructed on the right bank in front of the intake and river sluice
b) River sluice of dia 300 mm to pass through the silt, settling down near the intake end.
c) An intake located at elevation +102.5m.
d) Intake pipe of diameter 250 mm and length 265m, bifurcating into 150 mm dia pipes near power house.

Powerhouse

A surface powerhouse of size 6m x 6m to house two generating equipment of capacity 25 kW each.

Tailrace

A tailrace channel of length 18m to discharge the tail water back into the stream is provided.

2.1 WEIR

The weir is designed as a concrete gravity structure with a spillway in the stream course. The top width of the weir is fixed as 1m. Since rock is exposed on the right bank and to a certain extent at the bed, it is expected that firm rock is available at +100.50m at the spillway portion.

As mentioned in the earlier chapters the spillway crest level is fixed at +104.00m.The maximum height of weir at the overflow portion is 3.5m. From the flood hydrograph, the maximum flood discharge is worked out as 86 m^3/sec.

Taking C_d as 2.2, k_p=0.1, L=15m and
Q=86 m^3/sec,

L_c=L-2.k_p. H_d.

$Q = C_d . L_c . H_d^{3/2}$

H_d =1.89m, say **1.92m.**

L_c = 15-2x0.1x1.92=14.62m.

$Q = 2.2x14.62x1.92^{3/2}$ = 86 m^3/sec.

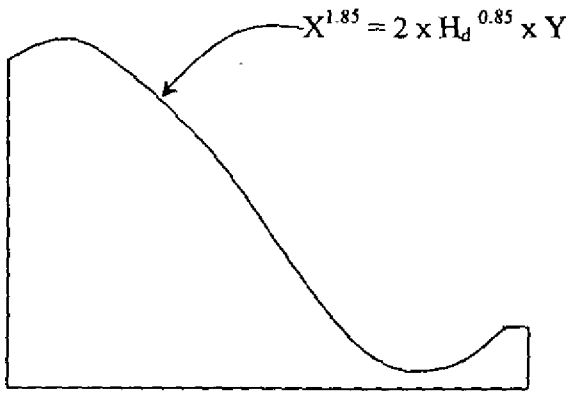
So length of spillway = 15m, design head = 1.92m and flood discharge = 86m^3/sec

Weir Profile

The upstream face of the weir is kept vertical.

Downstream Profile

$X_n = K H_d^{n-1} Y$



Equation for the Ogee profile for upstream face vertical → $X^{1.85} = 2 \times H_d^{0.85} \times Y$

$\frac{H_e}{H_d}$ is taken as 1

$$Y = \frac{X^{1.85}}{2 \times H_d^{0.85}}$$

$$\frac{dy}{dx} = 1.85 \times \frac{X^{0.85}}{2\ H_d^{0.85}}$$

Equating $\frac{dy}{dx} = \frac{1}{0.7}$, we get X = 3.14 and Y = 2.43 → Co-ordinates of point of tangency.

D/s slope of the weir below the point of tangency is given a slope of 0.70 H to 1 V.

Coordinates of Ogee Profile:

X	0.5	1.00	1.50	2.00	2.50	3.14
Y	0.08	0.29	0.62	1.05	1.58	2.43

Upstream Profile:

Equation for upstream profile

$$Y = \frac{0.724(X + 0.27H_d)^{1.85}}{H_d^{0.85}} + 0.126\ H_d - 0.4315 H_d^{0.375}(X+0.27H_d)^{0.625}$$

Coordinates :

X	0	-0.20	-0.40	-0.51
Y	0	0.026	0.11	0.237

Calculation for maximum depth of Tail water

Bed level of spillway is taken as 101.00m

Flood discharge (frequency- 25years) = 86 m^3 / sec

Overflow length of spillway = 15 m

Maximum head over the spillway = 1.92m

Q, discharge / unit width = C_d x 1 x $H_d^{1.5}$ = 5.86 m^3 / m width

$q = v \times d_1$

$v = \sqrt{2 \times 9.81 (H - 0.5 \times H_d)} = 8.9$ m / sec

$d_1 = q / v = 0.66$ m

$$d_2 = \frac{-d_1}{2} + \sqrt{\left(\left(2q^2/gd_1\right) + d_1^2/4\right)} = 2.78\text{m}$$

Maximum tail water level = 101.00m + 2.78 m = 103.78 m.

Training wall

Actual head and design head are taken as the same.

Upper nappe profile for $H/H_d = 1$

X / H_d	X (m)	Y / H_d	Y (m)
-1.00	-1.92	-0.941	1.81
-0.80	-1.54	-0.932	-1.79
-0.60	-1.15	-0.913	-1.75
-0.40	-0.76	-0.890	-1.71
-0.20	-0.38	-0.855	-1.64
0.00	0.00	-0.805	-1.55
0.20	0.38	-0.735	-1.41
0.40	0.76	-0.647	-1.24
0.60	1.15	-0.539	-1.03
0.80	1.54	-0.389	-0.74
1.00	1.92	-0.202	-0.39
1.20	2.3	0.015	0.029
1.40	2.68	0.266	0.51
1.60	3.07	0.521	1.00
1.80	3.47	0.860	1.65

Elevation of non-overflow section – 104 m + 1.92 m = 105.92m

Provide top elevation of non-overflow section as 106.00 m.

Training wall is provided for a length 8.4 m, on either side with elevation varying from 106.00m to 104.00m in steps ((2.50m – 106m,1.5 m-105 m, 4.4 m- 104 m.)).

Stilling Basin:

The design parameters for the type of stilling basin is worked out as follows

Velocity of flow = 8.9 m / sec

D_1= 0.66m

D_2 = 2.78 m

Froude number = V / (g xd_1) = 3.49

As the Froude no. is between 2.5 and 4.5 Type I Stilling Basin is selected.

From USBR Graph (Page 295) $L / D_2 = 5.1$

L=5.1 x 2.78 = 14.17

Length of stilling basin = 15m.

End sill etc is to be provided as for type I stilling basin. However to reduce the initial cost, construction of the entire length of stilling basin is not proposed in the first stage of development. Instead 5.00-m length of stilling basin will be constructed during the fist stage of development. The stilling basin floor is proposed to be of with big boulder packing and leveled over with a lean concrete mix of 1:3:6 to reduce the cost of construction. The training wall is also provided for a length of 5.00 m on either side, in the first stage.

Stability Analysis for Weir Section

Top width of the weir (assumed) , a = 1.00 m

Height of weir, H = 4.50 m

Height of foot bridge above spill way crest, H_b = 1.43 m

Uplift pressure factor, c = 0.33

Average shear strength of concrete, q = 70.00 t/m^2

Specific weight of water, w = 1.000 t/m^3

Specific weight of weir material, s = 2.300 t/m^3

Specific weight of silt submerged, γ_{sub} = 0.480 t/m^3

Specific weight of silt saturated, γ_{sat} = 1.480 t/m^3

Specific weight of soil fill at d/s, γ_{fill} = 1.600 t/m^3

Coefficient of friction between base and soil/rock, μ =0.600

Base width

Assumed base width of weir, *b* = 3.150 m

Height: base width ratio = 0.7

Maximum height of water at u/s, h = 4.500

Tail water depth d/s = 1.000

Height of silt deposit at u/s, h_s = 0.500 m

Height of silt deposit at d/s, h_s' = 1.000 m

Height of soil fill at d/s at non-overflow section part, h_{sf}=1.500m

Angle of internal friction of soil fill at d/s Non-overflow section (deg) = 30

Coefficient of internal friction of soil fill at d/s Non-overflow section, K_{af}=0.333

Angle of internal friction of silt (deg) = 27

Coefficient of internal friction of silt, K_a = 0.376

case -1:Reservoir full with silt at upstream and no tail water or silt at downstream

Item no and description	equation	forces(t/unit length)		lever arm (m)	Moments (t-m/unit length)	
		vertical	horizontal		A.Cw (+ve)	Cw (-ve)
1) weight of Weir, W_1 =	a)	16.301		2.100	34.233	
½Hbs + ½$H_b$as =	b)	1.645		2.817	4.632	
2)water pressure P_{hw} = ½w(h^2-H^2)			10.125	1.500		15.188
3)silt pressure P_s = ½$K_a\gamma_{sub}$ h_s^2			0.023	0.167		0.004
4) Soil fill pressure, *(Horizl)*, P_{sf} = ½$K_{af}\gamma_{fill}h_{sf}^2$			-0.600	0.500	0.300	
Vertl, P_{sfv} =½$\gamma_{fill}h_{sf}$b'		1.260		0.350	0.441	
5) uplift pressure, U	½bcwh	-2.339		2.100		4.912
				SUM	39.606	-20.103

ΣV =16.867 ΣH = 9.548 ΣM = 19.503

Distance of point of intersection of resultant with base from toe, χ= $\Sigma M/\Sigma V$ = 1.156

Factor of safety against sliding =$\mu\Sigma V)/\Sigma H$ = 1.060 **SAFE**

Shear friction factor = ($\mu\Sigma V$+ *bq*)/ΣH = 24.155 **SAFE**

Eccentricity, e = b/2-χ= 0.419 **SAFE**

Factor of safety against overturning =$\Sigma M^{(+ve)}/\Sigma M^{(-ve)}$ = 1.970 **SAFE**

Stability Analysis for (Overflow Section)

Top width of the weir (assumed),a =0.00m

Height of dam, H =3.50m

Uplift pressure factor, c = 0.50

Average shear strength of concrete, q =70.00 t/m^2

Base width

Assumed base width of weir, *b* = 4.400 m

Height: base width ratio=1.257

Maximum height of water at u/s, h =3.500

Tail water depth d/s = 1.000

Height of silt deposit at u/s,h_s =0.500

Height of silt deposit at d/s,h_s' =1.000

Angle of internal friction of silt(rad) = 0.471

Coefficient of internal friction of silt, K_a=0.376

Case :Reservoir full with silt at upstream and no tail water or silt at downstream

Item no and description	equation	forces(t/unit length)		lever arm (m)	Moments (t-m/unit length)		
		vertical	horizontal		A.Cw(+ve)	Cw(-ve)	
1) weight of Weir, W_1	½Hbs	17.710		2.933	51.949		
2)water pressure P_{hw}	½wh^2		6.125	1.167		7.146	
3)silt pressure P_s	½$K_a\gamma_{sub}h_s^2$		0.023	0.167		0.004	
5) uplift pressure, U	½bcwh	-3.850		2.933		11.293	
		ΣV =	13.860	SUM	51.949	-18.443	
		ΣH =	6.148	ΣM =	33.506		

Distance of point of intersection of resultant with base from toe, χ =ΣM/ΣV = 2.417

Factor of safety against sliding =μΣV)/ΣH =1.353 SAFE

Shear friction factor = (μΣV+ *bq*)/□H = 51.454 SAFE

Eccentricity, e = b/2-χ= -0.217 SAFE

Factor of safety against overturning =$\Sigma M^{(+ve)}/\Sigma M^{(-ve)}$ = 2.817 SAFE

Water Conductor System.

Maximum water level = 104.00 m (spillway crest)

C/L of intake =102.50 m

Dia. Of pipe =250mm

Gross Head = 72 m

Net Head = 67.50 m

P = 7 QH kW

Q = 50/(7 x 67.50) cumecs = 0.106 cumecs

With 250 mm dia pipe, C. S. Area = 0.05 m^2

V = 0.20/0.05 = 4.00 m / sec.

By providing 250-mm dia pipe, velocity of flow in the pipe will be limited to less than 3m/s. This velocity limitation will reduce head loss.

a) Design of Trash rack

Opening area ,Ae = penstock area/ C_c x cos θ

Cc = 0.7 for low head intakes

A_e = 0.05 / (0.7 x 1) 0 = 0- axis horizontal

= 0.07 m^2

As the axis is horizontal, height of opening $H_e = h_1 + h_2 = D + 2\ b$, where `D` = 250 mm

Profile of ellipse (top & bottom),in case of transition from rectangular to circular section

Is $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ where a = 1.1 D & b = 0.29 D

Length of transition `a` = 1.1 x 0.25 = 0.275 m

`b` = 0.29 x0.25 = 0.07 m.

He = 0.25 + 2 x 0.07 = 0.39 m

Width of transition = 0.07 / 0.39 = 0.20 m

Size of intake opening - bell mouth ≈ 0.39 m x 0.20 m or say 0.40 m x 0.20 m.

Minimum water cover above bell mouth = 0.30 x He ≈ 0.30 x 0.40 = 0.12 m

Elevation of C/L of pipe = 102.5 m.

Minimum drawdown level (MDDL) = 102.50 + 0.12 = 102.62 m

Bottom elevation of bell mouth =102.50 –0.20 = 102.30 m

Radius of trash rack should not be less than 0.8 He. ie.0.8x0.4 = 0.32 m

Also radius of trash rack should not be less than 1.428b, ie.1.428x0.2 = 0.29 m

4 side panels of size 1m x 1.75 m (2 nos. each) and 1 top panel of size 2m x 1 m with a frame made up of 50 mm angle iron, covering the inlet cone and the sluice outlet. The panels will be with 16 mm steel bars, sieve size being ~ 50 mm^2. The bars are welded to the outer frame made up of angle irons. The panels will be inserted into the slot provided in the concrete, with one upon the other. The top panel is of removable type for cleaning.

Penstock - Design details.

The installed capacity of the scheme is fixed as 50 kW. The dam is designed with storage to utilize for maximum generation (50 kW) during lean season and peak hours. With the same intention an intake pipe of 250 mm dia is proposed to be embedded in the dam body The penstock pipe will be extended for a length of 50 m from the intake weir up to the existing irrigation structure. The penstock pipe is to be buried while crossing the jeep road near the irrigation weir.

Rectangular openings will be provided in the weir for (i) river sluice and (ii) for taking the inlet cone (rectangular to circular for connecting the penstock).

The present proposal is for providing 250 mm dia MS or GI standard pipe with a suitable sluice valve at the starting point (for penstock maintenance etc.).

Three horizontal bends and 3 vertical bends are proposed in the penstock route. Welded joints are preferred due to less leakage/ maintenance associated with them.

Total length of pipe = 265m

Dia of Penstock = 0.25m

P = k. Q. H = say 7.Q.H

Thickness of pipe:

$t = 50 \times PD/\sigma$

where $\sigma = 3500/2 = 3500 kg/cm^2$.

= 50 x 75 x 0.25/1750 = 0.54 mm

Add $1/16^{th}$ of an inch for corrosion compensation = 0.54 + 0.16 = 0.64 mm

For easiness for site fabrication, handling etc, select a pipe of nominal thickness of 6 mm.

Head loss in penstock

Full supply level of reservoir = +104.00

C/L level of turbine = +32.00

Gross Head= 104.0-32.0 = 72.00

Diameter of the penstock = 0.25 m, Length of the penstock = 265 m

Velocity of flow through the penstock, v = 2.22 m/s

Velocity head = $\frac{v^2}{2g} = 0.252$

(a) Loss of head at bell mouth entry in forebay $h_e = k_e \frac{v^2}{2g}$

$k_e = 0.16$

$\therefore h_e = 0.16 \times 0.252 = 0.04$ m

(b) Loss of head due to friction, $h_f = \frac{f.l.v^2}{2gd}$

$f = 0.0125$ (for steel pipe with smooth surface)

$$h_f = \frac{0.0125 \times 265 \times 2.22^2}{2 \times 9.81 \times 0.25} = 3.34 \text{ m}$$

(c) Loss of head due to bends

i. Vertical bends - on Main Penstock (3 Nos.)

$$h_b = \frac{v^2}{2g} \sum k_b$$

	Angle of bend(°)	k - value
1.	7	0.021
2.	37.7	0.193
3.	19.8	0.059

Head loss due to vertical bends = (0.021+0.193+059) x 0.252 = 0.07m

ii. Horizontal bends

There are two horizontal bends in the main penstock.

Sl No.	Angle of bend(°)	k - value
1.	5	0.015
2.	15	0.045
3.	2	0.006

Total head loss due to horizontal bends = (0.015+0.045+0.006) x 0.252 = 0.02m

(d) Loss of head due to gradual contraction at PH end.

$$h_{gc} = 0.2 \frac{v^2}{2g} = 0.2 \times 0.252 = 0.05 \text{ m}$$

(e) Loss of head due to butterfly valve

$h_v = k_v \frac{v^2}{2g}$, k_v is taken as 0.18, h_v= 0.18 x 0.252 = 0.05 m

(f) Bifurcation losses

$$h_{br} = 0.8 \frac{v^2}{2g} = 0.8 \times 0.252 = 0.20 \text{ m}$$

Total head loss in penstock = 0.04+3.34+0.07+0.02+0.05+0.05+0.20= 3.76m

Net Head = 72.0-3.76 = 68.24 m.

Adding any other losses the total head loss is taken as 67.50m for design purpose.

Gates:

Two gates with rack & pinion lifting mechanism is proposed for the penstock intake cone and for the river sluice for cleaning the debris, silt etc.

The size of the gate is 40 cm x 40 cm with 6 mm plates with a boss welded at the top for providing the rack & pinion arrangement of ~ 1m length.

Weight of 2 nos. of gates with lifting mechanism = 50 kg

Powerhouse

For making the final design of Powerhouse, details from the manufacturer / supplier is necessary. In the absence of foundation details etc, a tentative design is made here which will be modified on getting details from the supplier.

Powerhouse will be located at about 260 m downstream of the weir, on the right bank of the stream. In the first stage development of the scheme, a powerhouse to house a T & G set of 25 kW capacity will be constructed with provision for future expansion.

Elevation of C/L of runner	= +32.00 m
Spillway crest level	= +104.00 m
MDDL	= +102.62 m
Maximum head	= 72.00 m
Minimum head	= 70.62 m
Design head	= 67.50 m.
Design discharge	= 0.117 m^3 / sec

The powerhouse building proper will be having a floor area of 6 m x 6m. Side walls will be of 23 cm thick brick work in cm 1:5 and height 2.80m. RCC footings of size 0.8m x 0.8m will be provided to columns, with RR masonry in CM 1:4 for foundation and basement of walls. The roof will be of sloping type with RCC, 7.5 cm thick. A collapsible shutter of 2.0 m wide and 2.1 m in height is proposed at the entrance. During future expansion and installation of additional units, this collapsible gate will be removed and another building unit attached. The sloping roof is proposed with the idea of installing a Solar PV system during lean season. A machine foundation of size 1.5m x 1.5 m is given in the absence of other details. Drains will be provided inside the powerhouse and connected to tailrace channel.

Tailrace Channel

The water coming out after generation will be let back in to the same stream. No separate major structure is proposed for the channel. The channel will be of length 18 m with a width of 0.75m.

RAJAMUDI MHP

PART – III
COST ESTIMATE

CHAPTER - XIII
COST ESTIMATE CRITERIA

The estimate of cost of this project is prepared following the guide lines for the preparations of project estimates for hydro electric project" issued by the Central Electricity Authority. All the estimates under the detailed head "Civil works" are based on quantities worked out from detailed survey and preliminary design of component structure of the project. The project is proposed to be executed either on "turnkey execution basis" or separate contract arrangements. As such the rates are worked out as detailed below

1. **Labour rates:** The current labour rates followed in the department is "Schedule of rates 2004.
2. **Rates for materials**: As stated in Chapter VI construction materials, such as rubble, coarse and fine aggregates are produced locally. Since sand mining in rivers is prohibited, crushed sand is proposed for the work and is being produced in the crushing plant. Non-levy cement only will be available for this work. Cost of cement at railhead at Kochi is taken and the cost at site is arrived by road transportation. Similarly, the tor steel structural steel, steel for Penstock pipes are to be procured from steel yard at Kochi and transported to site by rail and road.
3. **Rate for conveyance**: For manual head load conveyance the rates are taken from the present Schedule of rates. For lorry transport, the usual rate prevailing in this area is considered Special transportation charges are worked out and provided in the estimate for conveyance of Penstock pipes, trash-rack structures, vertical lift gates, hoists etc, as these items are very heavy and require extra care for transportation.
4. **Use rate for construction equipments**: Mechanised work is proposed for earthwork excavation, rock blasting, concreting etc. The use rate for various construction equipments are worked based on the present day value of machines and the output (capacity) of equipments as given by the manufactures of equipments.
5. **Electro-Mechanical part:** The estimate for electro-mechanical item, is worked out based on the budgetary offer received from reputed firms, manufacturing these item. For the

transportation the rates are worked out separately taking into account the difficulty of the job.

6. **Estimate for transmission lines:** The estimate for the transmission lines is worked out based on the standard rate collected from the Chief Engineer, Transmission. KSEBoard.

For all civil works the contractor's profit @ 10% and overhead charges @ 10 % are provided. Amenities to labour @ 30% is provided for labour part of the item, as stipulated in the guidelines.

CHAPTER - XIV

COST ESTIMATE – CIVIL WORKS

Sl No	Item	Unit	Rate	Amount in Lakhs
1	**Weir & Intake**			
1.1	Clearing the site	2000 m^2	170/100m^2	0.034
1.2	Temporary diversion arrangements	LS		0.150
1.3	Common excavation for foundation of weir, Energy dissipating arrangements etc.	40 m^3	150/m^3	0.060
1.4	Rock excavation for foundation of weir, Energy dissipating arrangements etc.	50 m^3	300/m^3	0.150
1.5	Foundation preparation	85 m^2	520/10m^2	0.044
1.6	Cement concrete C_{40}-M_{150} for the foundation of overflow, non overflow, intake, body of overflow portion etc.	65 m^3	3500/m^3	2.275
1.7	Cement concrete C_{20}-M_{200} for overflow, intake energy dissipating arrangements and training walls including piers & beams of intake	40 m^3	3600/m^3	1.440
1.8	Providing contraction joints with copper sealing strips	18 m	2650/m	0.477
1.9	Providing reinforcement rods for the foundation of weir, spill way training walls, ogee portion, etc.	1.6 Tons	50000/T	0.800
1.10	Fabricating and installing intake gates, and river sluices etc including erection.	2 Nos	LS	1.000
1.11	Contingencies			0.070
	Sub Total			**6.500**
2	**Penstock**			
2.1	Common excavation for track cutting, saddle supports, anchor blocks etc	130	150/m^3	0.195

2.2	Rock excavation	50	300/m^3	0.150
2.3	Cement concrete C20-M_{200} for saddle supports and anchor blocks	10 m^3	3600 / m^3	0.360
2.4	Providing reinforcements for the concrete works	1T	50000/T	0.500
2.5	Fabrication and transportation of Penstock pipes :			
	Straight pipes	11T	80000/T	8.800
	Expansion joint pipes	0.5 T	80000/T	0.400
	Bend pipe	0.7 T	85000/T	0.595
2.6	Erection of Penstock pipes including x-ray testing etc	12 Ton	6000 /T	0.720
2.7	Painting the pipes	210 m^2	600/10m^2	0.126
2.8	Contingencies			0.154
	Sub Total			**12.000**
3	**Power House**			
3.0	Clearing of site & Site levelling	500 m^2	175/100m^2	0.009
3.1	Common excavation for P.H Building and machine foundation	80 m^3	150/m^3	0.120
3.2	Rock excavation for P.H. Building and machine foundation	50 m^3	300/m^3	0.150
3.3	Cement concrete M_{20} C_{40} for the foundation of column	1m^3	3500/ m^3	0.035
3.4	Cement concrete M_{20} C_{20} for columns, roof slabs etc in Power House building	8 m^3	3600/ m^3	0.288
3.5	Cement concrete M_{20} C_{40} for machine foundation and raft	10 m^3	3400/m^3	0.340
3.6	R. R masonry in CM 1:5 for the foundation and basement of Power House building	12 m^3	1800/m^3	0.216
3.7	Brick masonry walls in CM 1:5 for the Power House building walls	50 m^3	2850/ m^3	1.425

3.8	Supplying and fixing steel doors, windows and ventilation with glazed shutters and other fittings		Ls	0.400
3.9	Providing reinforcements to concrete bend tied and placed in position.	1.6T	45000/T	0.720
3.10	Finishing works like Plastering, Painting, etc including rolling shutters and doors		Ls	0.700
3.11	Providing water supply and sanitary facility in PH building		Ls	0.100
3.12	Providing Electrification inside, the power house and switch yard		Ls	0.200
3.13	Contingencies		Ls	0.087
	Sub Total			**4.790**
4	**Tailrace Channel**			
4.1	Clearing site		Ls	0.001
4.2	Earthwork excavation in ordinary soil, mixed with boulders	15 m^3	150/m^3	0.023
4.3	Rock excavation	3 m^3	300/m^3	0.009
4.4	Concreting the bottom and sides of tail race channel	4.5 m^3	3500/m^3	0.158
4.5	Contingencies			0.020
	Sub Total			**0.210**
Grand Total (Civil Works)				**23.500**

CHAPTER - XV

COST ESTIMATE – ELECTRICAL WORKS

Specifications

Turbine	Horizontal Pelton
Number of units and rating	2 Nos. 25kW
Rated turbine out put	58 kW
Continuous overload capacity	10 %

	Item	Amount (Rs Lakhs)
1.	**E & M Equipments and auxiliaries**	
1.	Cost of Design, manufacture, tests at manufacturers works, supply, delivery at site, erection and commissioning of hydro turbine generating sets and auxiliaries as per the above requirements and as per standard specification, including Civil and structural works of switchyard including Earthment, lighting arrester. Switchyard accessories, connection hardware, communication and fire fighting equipments. Emergency lighting, ventilation and air-conditioning of control room, cable ducts, power cable Termination kits and all other accessories as per specification etc. complete including taxes, duties, insurance and provision of escalation etc.	12.00
	Sub Total	**12.00**

2	**Transmission works**	
2.1	Constructing 11 kV line from the switchyard of power house to distribution locations = 1 km @ Rs. 4 lakhs/km	4.0
	Sub Total	**4.00**

CHAPTER – XVI

COST ESTIMATE –DEVELOPMENTAL WORKS

a . Preliminary

	Item	Amount (Rs Lakhs)
i	Construction of approach roads 0.5 km @ Rs 2.5 Lakhs/km	1.25
ii.	Construction of temporary office building, Dormitory preliminaries etc.	2.50
iii.	Establishment charges including Project Management, Audit and Accounts, Running cost of vehicles, Welfare to workers, Inspection of UNIDO and other Experts and Officials, Maintenance of roads during the construction period, Camp equipments, forest and other clearances etc.	3.00
iv.	Contingencies, consultancy, quality control, etc.	2.25
	Total	**9.00**

b. Cost of land

The forest land required for the project may be taken on long-term lease from Forest.

	Item	Amount (Rs Lakhs)
1	Private land required – 0.25 Ha	1.50
	Total	**1.50**

CHAPTER - XVII

ABSTRACT OF ESTIMATE

I. Civil Works – water diversion works, water conductor system, Power House and tailrace channel

i.	Weir	→	Rs. 6,50,000.00	
ii.	Penstock pipe	→	Rs.12,00,000.00	
iii.	Powerhouse civil works	→	Rs. 4,79,000.00	
iv.	Tailrace channel	→	Rs. 21,000.00	
	Total			**Rs. 23.50 Lakhs**

II. Powerhouse T&G Equipments, Switchyard

i. Electromechanical Equipments = **Rs. 12.00 Lakhs**

III Transmission of power

i. Transmission line works and LT distribution = **Rs. 4.00 Lakhs**

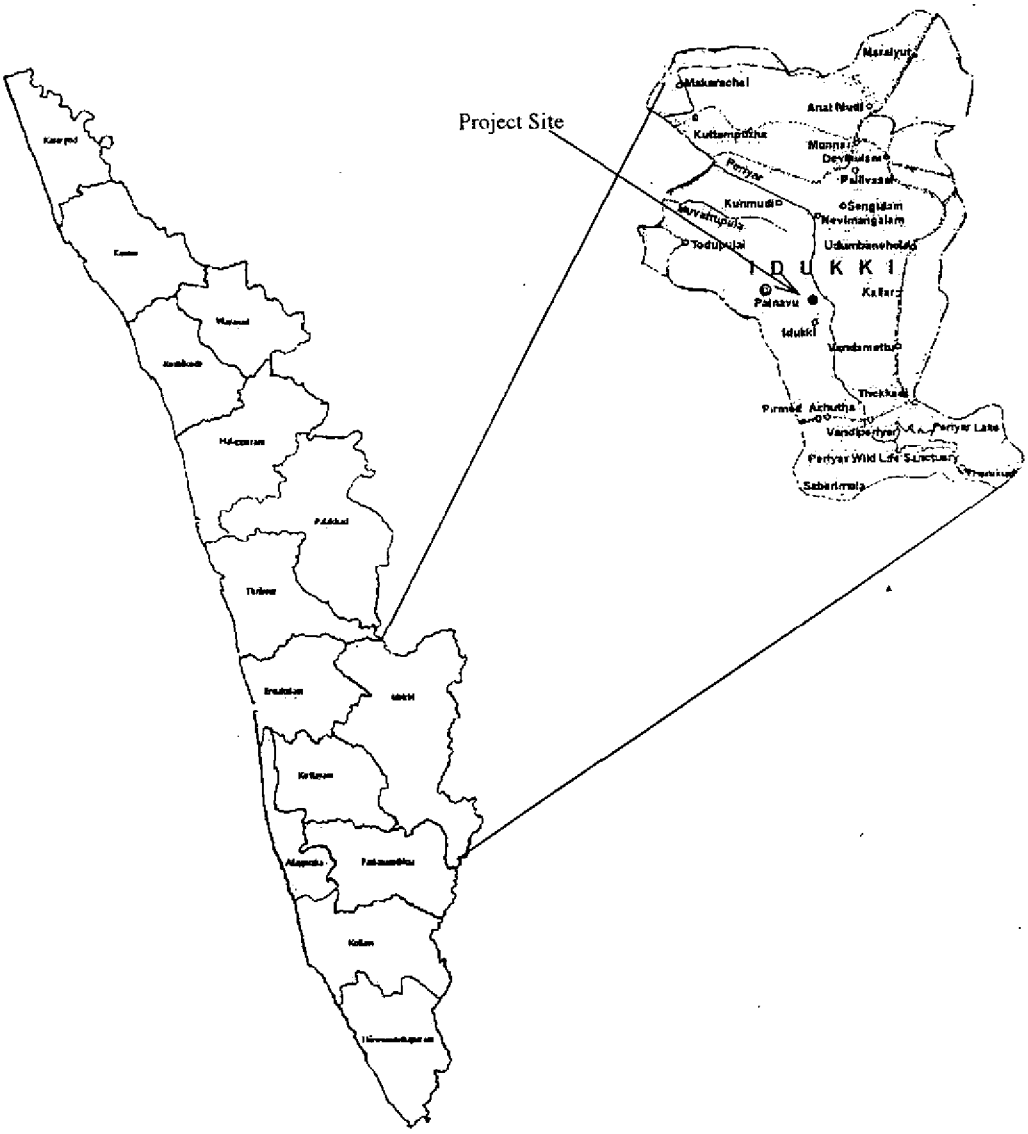
IV Developmental Works

i. Preliminary expenses, cost of land & buildings = **Rs. 10.50 Lakhs**

GRAND TOTAL **Rs. 50.00 Lakhs**

RAJAMUDI MHP

PART – IV
DRAWINGS



Project Report Drawing

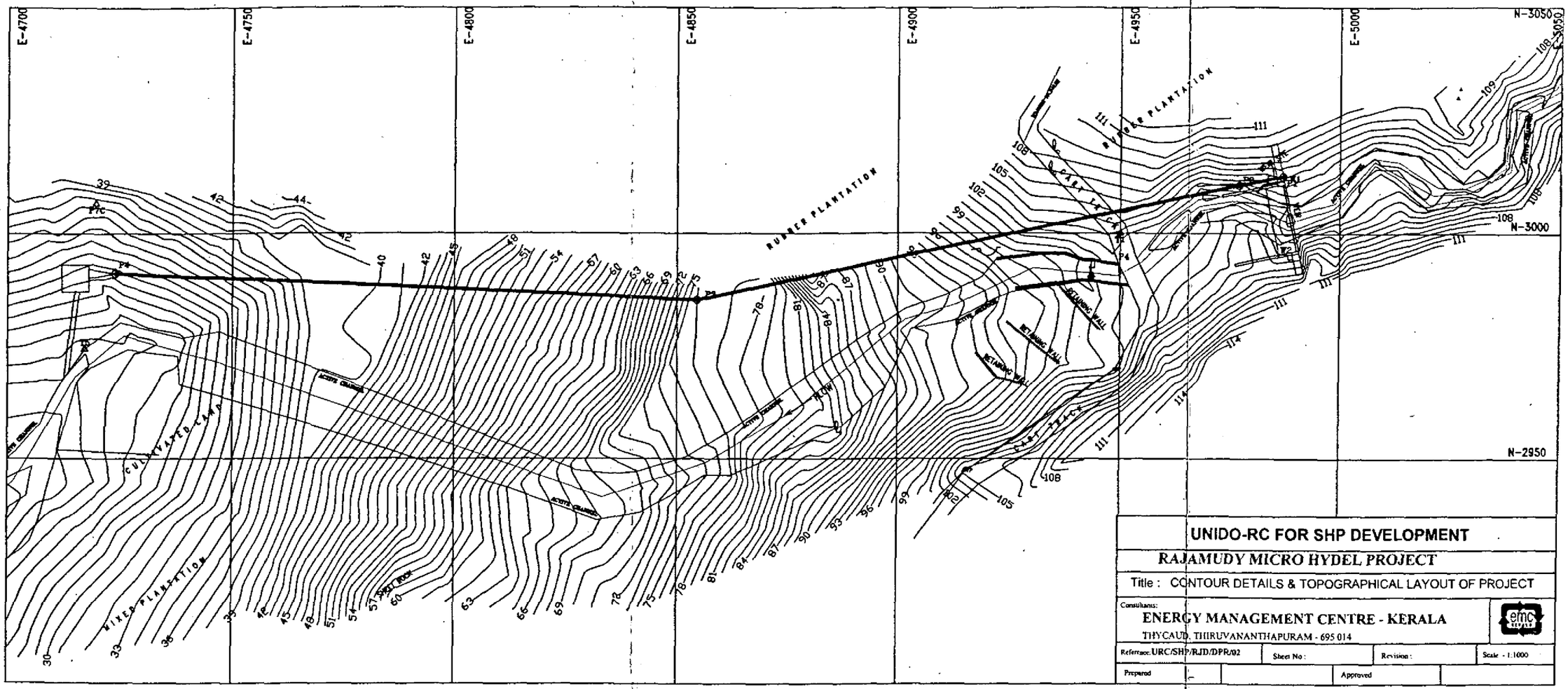
UNIDO-RC FOR SHP DEVELOPMENT

RAJAMUDY SMALL HYDEL PROJECT

Title : INDEX MAP

Consultants: **ENERGY MANAGEMENT CENTRE – KERALA**
THYCAUD, THIRUVANANTHAPURAM - 695 014

Reference: URC/SHP/RJD/DPR/01	Sheet No.	Revision:	Scale: NS
Prepared:		Approved	



UNIDO-RC FOR SHP DEVELOPMENT

RAJAMUDY MICRO HYDEL PROJECT

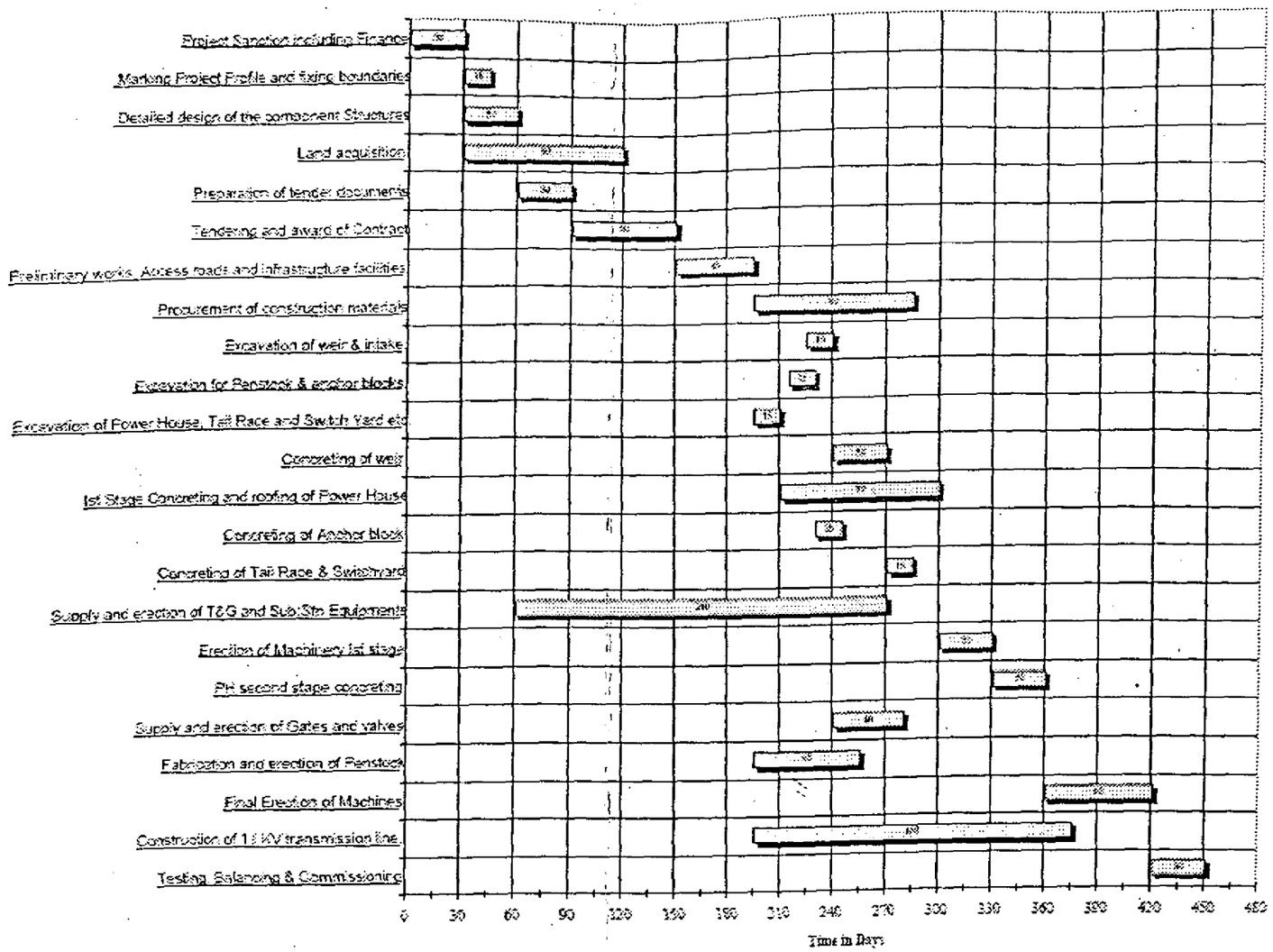
Title : CONTOUR DETAILS & TOPOGRAPHICAL LAYOUT OF PROJECT

Consultants:
ENERGY MANAGEMENT CENTRE - KERALA
THYCAUD, THIRUVANANTHAPURAM - 695 014

Referrace: URC/SHP/RJD/DPR/02	Sheet No :	Revision :	Scale - 1:1000
Prepared		Approved	

BAR CHART

Construction of Rajamudy MHP (2x25 kW)



Project Report Drawing

UNIDO-RC FOR SHP DEVELOPMENT			
RAJAMUDY MICRO HYDEL PROJECT			
Title : PROJECT SCHEDULE			
Consultants: **ENERGY MANAGEMENT CENTRE – KERALA** THYCAUD, THIRUVANANTHAPURAM - 695 014			emc
Reference: URC/SHP/RJD/DPR/03	Sheet No.	Revision:	Scale: NS
Prepared:		Approved	