500 kW LUNANA MINI HYDROPOWER PROJECT

DETAILED PROJECT REPORT

VOLUME 0: EXECUTIVE SUMMARY

DRUK GREEN CONSULTANCY
PROJECTS DEPARTMENT
DRUK GREEN POWER CORPORATION LIMITED

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EXECUTIVE SUMMARY

1. Introduction

Lunana Gewog under Gasa Dzongkhag lies in the extreme northwest region of Bhutan with a total area of 1,716.26 km^2. It consists of five Chiwogs with thirteen (13) villages. The total number of household excluding the institutions is 198 and according to the National Population and Housing Census 2017 (NPHC-2017), the Gewog has a total population of 699. The villages are spread along Phochhu valley and lie at an elevations ranging from El. 3,000 m to 4,180 m. The entire area falls under the national protected area and biological corridor of Jigme Dorji National Park. Except for Ramina village, rest of Lunana does not have motor road connectivity and it takes more than a week on foot to travel from the nearest road head. For lighting homes, the government has provided people with solar home lighting system. Besides solar home lighting system, people also depend on non-renewable energy resources for daily energy needs such as firewood, kerosene and liquid petroleum gas. Excessive dependence on firewood that are used for cooking and heating purpose has led to a rapid depletion of tree coverage in the national park.

Due to high and rugged mountainous terrain exceeding El. 5,000 m, it was found not feasible to extend grid power supply to Lunana. Moreover, grid extension will have significant environmental impacts as it will pass through national park over 97 km: grid extension is estimated to cost Nu. 426 million and would also be of poor reliability due to long length over high altitudes. In view of intermittent nature of power supply, solar and wind turbines are also not feasible. Therefore, the only acceptable option for reliable electricity for Lunana is through development of mini hydropower plant: further, Chuzachhu river is the only stable nearby river on which such an option is possible.

Based on the request of Department of Renewable Energy (DRE), DPR study of Lunana Mini Hydropower Project has been conducted by Druk Green Consultancy (DGC) in close coordination with DRE, for providing off-grid electricity supply to Lunana community and institutions. The salient feature of the project is attached as **Annexure I.**

2. Topographical Survey and Mapping

The topographical survey of the project has been carried out by establishing three control points using local bench mark. The whole project area of interest comprising head works, Head Race system, forebay cum desilting tank, penstock alignment and Power House and Tail Race Channel have been surveyed at 1 m contour interval and at 1:2,500 scale. Also, the

longitudinal and cross sectional survey of Chuzachhu has been carried out. The topographical map and sections in requisite scale have been used for project layout and design.

3. Geology and Construction Materials

The general geology of the project site comprise of glacier moraine with dense to very dense clasts of granite gneiss with sandy matrix of fluvio-glacial deposit.

The intake and associated structures have been located in a stable area without any risk of slope stability of abutments. The Head Race Pipe has been aligned on relatively gentle and stable topography and the surface geology of entire 986 m length has been mapped in detail. The retaining structures and cross drainage arrangement have been suggested wherever required as per site conditions. The forebay cum desilter has been located on relatively flat and stable topography. The slope erosional features observed near the forebay cum desilter need to be mitigated with dry masonry wall. The surplus escape and silt flushing discharge will be evacuated through channel and piped system along a natural depression. The penstock has been aligned along a stable slope ranging from 35° to 39°. The Power House is on stable and relatively flat topography. The foundation of the Power House will be on alluvium formation and therefore, adequate drainage measures have been provided in the Power House area to drain out seepage water.

The potential river shoal and sand quarry sites have been identified to meet the required construction materials for the project. Sufficient quantity of river sand and boulders are available in close vicinity of the project site.

4. Project Alternatives

The potential hydropower sites in Lunana valley starting from Pangrizampachhu near Shangsha village in the south to Thanza village in the north have been studied to identify the best site for hydropower development. Based on detailed site survey, estimated power demand of 500 kW and also taking into account the location of major load centers, the site at Chuzachhu has been assessed to be the only feasible one. Other sites such as at Pangrizampachhu and Drangsochhu were not found feasible due to lower discharge and head. The project layout map of the finally selected site at Chuzachhu is as presented in **Annexure II** and some photographs along with superimposed layout and marking of major features is provided at **Annexure III.**

5. Hydrology and Power Potential Study

The catchment area of Chuzachhu at the intake site is 55 km² and is mainly fed by glacier melt and glacial lakes. Due to the lack of measured flow data of Chuzachhu, the inflow data of Samdingkha gauging station of Phochhu has been used for the purpose of establishing water availability supplemented by observed discharge data taken by DGPC's team in October 2019. The minimum river discharge is about 0.90 m^3/s. The river discharge of Chuzachhu taken using current meter in October 2019 was 2.50 m^3/s. The average minimum and maximum temperature is –3.75 °C and 9.81°C respectively. The estimated design flood based on rainfall at Thanza met station is 100 m^3/s and the diversion flood is estimated as 5 m^3/s.

The power demand survey and analysis has been carried out based on field survey data and information received from relevant agencies. The estimated total power demand for electrification of 173 households in 10 villages and institutes (existing and upcoming) is about 500 kW without considering Wachey village. To provide firm power of 500 kW, the firm design discharge required is 0. 72 m^3/s considering net head of 88.62 m and overall efficiency of machine of 80%. The parameters that have been considered in computing power potential is as shown Table 1**:**

Table 1: Parameters for power potential study

Parameters	Values	Unit
Full Supply Level at forebay cum desilter	4,217.00	masl
Machine Centerline	4,123.50	masl
Gross Head	93.5	m
Head Loss	4.48	m
Net Head	88.62	m
Combined Efficiency	80	%
Design Discharge	0.72	m^3/s

The installed capacity of the project has been determined at 500 kW with estimated firm annual design energy of 4.38 GWh.

6. Civil Engineering Structures

The Civil Engineering structures for the project comprises of the following:

- RRM coffer dam of maximum height of 2.60 m with 1,000.00 mm diameter (OD) HDPE pipe for temporary diversion of 5.0 m^3/s design discharge.
- Trench weir of 8.5 m (L) x 0.60 m (B) with intake chamber provided with regulating gate and spillway arrangement.
- Shingle excluder gate of 0.30 m x 0.30 m in intake chamber for flushing of shingles.
- HDPE Head Race Pipe of 630.00 mm diameter (OD) of 986 m long to convey discharge of 0.83 m^3/s to the forebay cum desilting tank.
- Forebay cum desilter of 25.00 m (L), 2.5 m (B) and depth varying from 2.65 m to 3.50 m provided with silt flushing gate, surplus escape arrangement and fine screen.
- Steel penstock pipe of 182 m length, 530 mm diameter (ID) supported on anchor and saddle blocks conveying design discharge of 0.72 m^3/s to the surface Power House.
- Surface Power House of 14.00 m (L) x 8.00 m (B) x 5.00 m (H).
- Tail Race Channel of 55.00 m length and size of 1.0 m (B) x 1.0 m (H).

7. Electro Mechanical Equipment

The Power House shall accommodate two horizontal Pelton turbines having rated output of 250 kW each under the design head of 88.62 m at 750 rpm synchronous speed. The Main Inlet Valve will be butterfly valve. The synchronous generator of horizontal shaft is rated 362 kVA with power output capacity of 250 kW at 0.8 power factor, 50 Hz frequency and at 415 V. Two generating transformers (three phase), each rated 312.5 kVA shall step-up the generated voltage for transmission at 33 kV for distribution.

8. Hydro Mechanical Equipment

The following are the major Hydro-Mechanical equipment designed for safe and efficient operation of the project:

- A set of horizontal type trash rack bay of size 0.6 m x 8.5 m in the trench weir.
- One number of vertical type slide gate of size 0.6 m x 1.2 m with screw hoist at the intake for flow regulation.
- One number manually operated butterfly valve of internal diameter 0.6 m at the inlet of HRP pipe.

- A vertical type slide gate of size 0.3 m x 0.3 m for flushing out shingles from the intake chamber.
- A set of trash rack bay of size 2.7 m x 3.1 m inclined at 80 degree with horizontal at the forebay cum desilter.
- A vertical type slide gate of size 0.3 m x 0.3 m at the end of forebay cum desilter for flushing silt.
- A double disc gate valve of internal diameter 0.53 m at the start of penstock.
- Two number vertical lift slide gates of size 0.9 m x 1.0 m at the TRC to isolate the units.

9. Infrastructure and Construction Facilities

A suitable site on the right bank of Chuzachhu has been identified for setting up of construction camp, site office and the construction facility. The muck disposal areas have been identified nearby the excavation sites to reduce the lead distance or reuse the material for backfill of trenches.

10. Construction Method, Equipment Planning and Schedule

The construction method, equipment planning and construction schedule have been framed taking into account the various challenges associated with accessibility and high altitude. The winter months in Lunana from November until April is extremely cold with minimum recorded temperature of up to -15 degree Celsius. Accordingly, the working period of 6 months starting from May to October has been considered for planning and construction scheduling with working duration of 8 hours per day. As the construction works coincide with the monsoon months and considering the available rainfall data of Thanza, the work progress of 80% has been considered in framing project schedule. Moreover, the concreting works are not recommended below 5 degree Celsius as per IS 7861 Part 2 due to restrictions in concrete shrinkage and setting time.

In view of the site specific challenges and limited working period, most works are planned to be carried out using fuel driven equipment and deployment of light weight construction machineries to ease transportation and mobilization. Some of the construction equipment proposed are mini-excavators, stone crusher, tractor, Pionjar breakers, concrete mixers, welding sets, dewatering pumps, power chainsaws, mini-diesel generator and max puller – most of which can be transported by heavy lift helicopter. The total estimated weight of the above construction equipment is about 8.0 MT.

The entire project works are planned to be completed in about 334 days including testing and commissioning of Electro-Mechanical equipment. The construction will spread over two working seasons. While the actual works are scheduled from the month of May, some of the machineries and construction materials are planned to be mobilized around March and April in order to gain time for the main works. The project schedule has been prepared using Labour Material Coefficient (LMC 2017) of Bhutan Schedule of Rates and has been developed in Primavera P6. The construction schedule is attached as **Annexure IV.**

The manpower planning has been carried out with the intent to complete all major civil works in the first working season so as to reduce re-mobilization of manpower during the second working season. The overall manpower of all categories works out to about 83 including 9 personnel of the project management team.

The transportation of construction equipment, materials for civil, HM and EM are mostly planned to be air lifted by helicopter in order to allow adequate facilitation of required items at all work fronts except for items such as fuel due to safety regulations. Further, the entire cement, estimated at 278 MT, for the project construction is planned to be carried by horses/yaks since the cost comparison indicates cheaper rate of cement transportation by horses by a factor of about 5. The total weight of materials, including food items for personnel, needed to be transported by helicopter and horse/yaks works out to about 390 MT and 292 MT respectively. 5,840 trips to be made by horses/yaks can be managed by existing resources in Laya, Lunana, Sephu ,Khatoed, Khamaed and Goenshari without severely impacting transporting of regular supplies to the area.

11. Power Transmission and Distribution

The power generated at 415 V from the power plant will be stepped up to 33 kV for transmission and distribution to different villages of Lunana. Two scenarios have been studied for the transmission and distribution - including and excluding Wachey village. The total line length including electrification of Wachey village is about 32 km and excluding Wachey village is about 23 km. The total transmission and distribution cost is higher by about 32.40 % when Wachey village is included.

12. Environmental and Social Impact Assessment

As mandated by the Environmental Assessment Act 2000 and Regulation of Environmental Clearance of Projects, 2016, a full-fledged Environmental and Social Impact Assessment

(ESIA) has been undertaken for the extended areas of the proposed project. ESIA has been prepared based on the endorsed Terms of Reference of the National Environment Commission Secretariat (NECS).

The baseline data for impact assessment was collected both through field survey and through secondary sources. The project lies in alpine region with broadleaf mixed with conifer forest types. The area is mainly dominated with shrubs and alpine scrubs. The project area falls within the multipurpose zone of Jigme Dorji National Park. An assessment of the biological environment of the project area recorded one floral with near threatened status and two faunal species with endangered status (as per IUCN). No fish species has been observed in the Chuzachhu.

The socio-economic survey through household interviews of Dotag, Tenchoe & Tshozhong was carried out to understand the socio-economic condition of the people. Additionally, the permanent residents of the villagers were consulted to seek their views on the Project. The total land required for the project is 79.53 acres including 68.33 acres for transmission and distribution line. Most of the project components including transmission and distribution line falls in State Reserve Forest Land, except for the part of Right of Way (RoW) for transmission and distribution line which falls in private land (about 1.0 acre), which can be mitigated during the construction phase.

To manage the risks associated with project activities on various aspects of environment such as land use, biological (flora and fauna) and physical (air, noise, surface water quality), an Environmental Management Plan (EMP) along with detailed Environmental Monitoring Program has been prepared. Nu. 5.00 million has been allocated to mitigate the impacts associated with the project.

Environmental valuation and greenhouse gas emission assessment carried out for the project indicates that the project is beneficial in terms of carbon dioxide sequestration and reducing pressure on existing natural resources. Environmental Risk Assessment has been carried out to assess risk associated with project activities to human, environment and social. Evaluating impacts and benefits of the project, the assessment indicates that it has significant positive benefits. It will provide reliable source of energy for cooking, heating and lighting. It will reduce dependence on firewood: with 502 tonnes of firewood or 519 trees estimated to be saved annually. The electrification will help improve health and sanitation of people. It will also help people save more time, where they can allocate additional time for other household chores. It will also reduce migration of the people thus improving border security.

13. Project Cost

The project cost has been estimated on the basis of detailed design and drawings prepared at the level of Detailed Project Report. The unit rate analysis has been carried out based on market survey, Labour and Material Coefficients 2017 Civil (LMC – 2017) and Bhutan Schedule of Rate 2018 Civil (BSR – 2018) and adjusted for these site. The guidelines for preparation of project estimates for River Valley Projects and Guidelines for working out unit rate cost of the construction equipment used for river valley projects, India have been used to derive the hourly use rate of equipment and machinery. Further, the budgetary offers have been received from relevant firms in Nepal and Bhutan for helicopter services for transportation of construction machinery, equipment and materials. The lowest competitive rate of Nu. 537 per kg has been adopted in computing the rate analysis and also for working out the transportation cost using helicopter. In view of high altitude, remoteness of site, harsh weather condition and exorbitantly high living cost, labour wages have been accordingly escalated by a factor of about 4 to 5 times compared to the market rate in Punakha and Gasa. The adopted labour wages is comparable to the existing wages being paid by the contractor in Lunana working for various infrastructure projects. The reasonable overhead charges and contractor's profit have been considered in the rate analysis.

The total cost of the project is estimated at Nu. 605.24 million and Nu. 662.93 million without and with Wachey village electrification respectively at December 2019 prices. The abstract of project cost is as shown in Table 2:

Table 2: Abstract of Project Cost

Item Description	Estimated Cost (Million Nu.)
Civil and HM Works	244.80
EM Works	145.73
Establishment Cost	13.00
Tools & Plants	1.40
Environmental Cost	5.00
Miscellaneous Cost	17.37
Sub-Total	427.30
Transmission and Distribution without Wachey village connection	177.93
Transmission and Distribution with Wachey village connection	235.62

Item Description	Estimated Cost (Million Nu.)
Total Cost without Wachey village connection	**605.24**
Total Cost with Wachey village connection	**662.93**

14. Financial and Economic Evaluation

The financial evaluation has been worked out considering three different scenarios:

Case I : As per BEA guidelines for domestic tariff determination
Case II : Fully funded by the government as grant
Case III : Adjusted transportation cost

Table 3: Levelized Tariff

Without Wachey (Nu./kWh)			With Wachey (Nu./kWh)		
Case I	**Case II**	**Case III**	**Case I**	**Case II**	**Case III**
20.70	6.24	4.12	22.68	6.83	4.37

The Levelized Tariff (LT) for Case I is high as it is based on domestic tariff regulation where cost of capital, interest on working capital, tax and O&M cost. However, LT for Case II and III is comparatively low as the total project cost is expected to be fully financed by the government without the expectation of any returns, taxes and obligations. The Case III tariff is based on adjustment of high transportation costs of Nu. 246.22 million for this remote location and taking transportation cost of Nu. 42.37 million that would generally apply to such projects.

The domestic tariff for rural households is Nu. 2.68/unit up to 500 kWh consumption. Further, highlanders are provided free electricity up to 200 units. The LT for Case II of Nu. 6.24/unit and Nu. 6.83/unit is much higher compared to the existing domestic tariff of Nu. 2.68/unit.

Though the LT in Cases I and II are much higher compared to the existing domestic tariff mainly due to small size project, transportation and challenging conditions, the socio-economic, political and environmental benefits to the local community due to the project is substantial.

15. Conclusions and Recommendations

Lunana Mini Hydropower Project with an installed capacity of 500 kW and annual design energy of 4.38 GWh has been designed as a pure run-off the river. The project has been investigated and studied at the level of DPR following relevant guidelines and international best practices. The major project components have been suitably located and optimized to best suit the topographical and geological conditions of the project area. In view of the project being located in high altitude exceeding El. 4,000 m, various technical measures and interventions have been considered and incorporated in the design specifications and methodology including scheduling of construction and commissioning of the project.

The project, due to its small size and remote location, has negligible socio-environmental impacts. In fact, with the commissioning of the mini hydropower project in Lunana, it would bring about immense positive benefits to the populace in terms of clean and reliable form of electricity for lighting, cooking and heating that would reduce dependence on firewood, thereby supporting in conservation of forest and protection of upper catchment of Punatsangchhu basin. With the advent of clean and renewable electricity in the village homes of Lunana, it would significantly change the living conditions and standards of the people with better health and sanitation, and more available working hours especially for women for investment in other important chores. Providing such modern and basic amenities like reliable electricity in the region which are located closer to the national border, would encourage local communities to stay in their ancestral home which is strategically essential for maintaining border security and also discourage rural-urban migration.

The project has been assessed to be technically feasible for construction though the project cost due to its remoteness and high transportation is much higher compared to other similar size projects in other locations. In view of the above stated reasons, and most importantly to enable socio-economic development of the remote communities located close to the northern border, it is therefore recommended to consider development of the project.

Quality Assurance Plan

In our continuing efforts to provide quality and completeness to our assignments, we are instituting a Quality Assurance Plan for our important works. This is an ongoing work and suggestions and recommendations are welcome. For this assignment, we have attached a Note to the Main Report, the QAP. We have recorded the qualification and experience of assigned experts, checklist of the Terms of Reference of the assignment; list of standards, codes, guidelines used and adherence to these.

Annexure 1

Salient Features

A. GENERAL	
Location	
Country	Bhutan
Dzongkhag	Gasa
River	Chuzachhu
Nearest Village	Tenchoe
Location of Intake (local coordinate)	X= 41317.87 Y= 420648.07 Z= 4,235.00
Location of Powerhouse (local coordinate)	X= 42155.08 Y= 420046.59 Z= 4,125.00
B. HYDROLOGY	
Catchment Area	55.0 km^2
Minimum Firm Flow	0.9 m^3/s
C. CIVIL WORKS	
Trench Weir	
Size & Shape	Rectangular
Size	8.5 m (L) x 0.6 m (B)
River Bed Level at Centre	El. 4,235.00 m
Service Gate Size	0.6 m (W) x 1.2 m (H)
Shingle Flushing Gate	0.3 m (W) x 0.3 m (H)
Head Race Pipe	
Diameter	630.0 mm (OD)
Length	986.0 m
Material	HDPE (PE 63 grade, PN 2.5, DN-630, average thickness 20.65 mm)
Design Discharge including 15% for silt flushing	0.83 m^3/s

Forebay cum Desilter	
Type	RCC Surface Structure
Size Including Transition	31.0 m (L) x 2.5 m (B) x 2.65 to 3.50 m (H)
Forebay cum Desilter Top	El. 4,217.5 m
Full Supply Level (FSL)	El. 4,217.0 m
Crest Level (Surplus Escape)	El. 4,217.05 m
Crest Length (Surplus Escape)	5.0 m
Design Discharge (Surplus Escape)	0.72 m^3/s
Surplus Escape Channel	11.5 m (L) x 1.0 m (B)
Surplus Escape Outfall	El. 4,119.0 m
Penstock	
Type & Shape	MS Pipe (E250 A)
Design Discharge	0.72 m^3/s
Number	1 No.
Main Penstock	530.0 mm diameter (ID), 182.0 m length & 8.0 mm thick
Branch Penstock	350.0 mm diameter (ID), 18.0 m length & 8.0 mm thick
Velocity	3.3 m/s
CL of Penstock at Intake Chamber	El. 4,213.6 m
Powerhouse	
Type	Surface Powerhouse
Size	14.0 m (L) x 8.0 m (B) x 5 m (H), H from M/c Floor level
Center Line of Turbine	El. 4,123.5 m
Machine Floor Level	El. 4,122.7 m
Maximum Tail Water Level	El. 4,121.9 m
Tail Race Channel	
Type	Open Channel
Number	1 No.
Shape & Size	Rectangular, 1.0 m (W) x 1.0 m (H)

Length Slope	55.0 m 1 in 300	
TRC Outfall (Invert)	El. 4,121.1 m	
D. ELECTRO MECHANICAL EQUIPMENT		
Turbine		
Type of Turbine	Three (3) Jet Horizontal Pelton	
Number of Turbine	Two (2)	
Rated Head	88.62 m	
Rated Output	1 x 250 kW (Per Turbine)	
Rated Speed	750 rpm	
Efficiency	87.92 %	
Generator		
Type of Generator	Synchronous, Cylindrical rotating type	
Rated Power	362 kVA	
Power Factor	0.8 lagging	
Generation Voltage	415 V	
Number of Phases	Three (3)	
Frequency	50 Hz	
Type of Cooling	Air cooled	
Efficiency	91.00%	
E. POWER DISTRIBUTION		
	Excluding Wachey	**Including Wachey**
Type	Overhead	Overhead
Transmission Distribution Voltage	33 kV	33 kV
Total Line Length	23 km	32 km
Conductor Type	Rabbit	Rabbit
Total no. of Villages to be Electrified	10	11
Total no. of Household (excluding institutions)	173	187

F. POWER GENERATION	
Design Discharge	0.72 m^3/s
Gross Head	93.5 m
Head Loss	4.88 m
Design Head	88.62 m
Firm Power	500 kW
Firm Annual Energy	4.38 GWh
Annual PLF	100%
G. CONSTRUCTION SCHEDULE	
Construction Period	12 months (Two Seasons)

H. PROJECT COST (MILLION NU.)

	Excluding Wachey	Including Wachey
Total Cost	605.82	663.55
i. Civil & HM Cost	245.30	245.30
ii. Electromechanical Cost	145.73	145.73
iii. Power Transmission & Distribution Cost	178.01	235.74
iv. Per kW Cost	1.21	1.33

I. LEVELIZED TARIFF (NU./KWh)

Excluding Wachey			Including Wachey		
Case I	**Case II**	**Case III**	**Case I**	**Case II**	**Case III**
20.72	6.24	4.14	22.70	6.84	4.38

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. ALL ELEVATION ARE IN METERS.

FOR DPR PURPOSE ONLY

CLIENT		DEPARTMENT OF RENEWABLE ENERGY MINISTRY OF ECONOMIC AFFAIRS
CONSULTANT		DRUK GREEN CONSULTANCY DRUK GREEN POWER CORPORATION LTD.

	NAME	SIGN
DESIGNED BY	TSHERING DHANJIT SINGER	
DRAWN BY	JIGME WANGMO	
REVIEWED BY	TASHI DORJEE (HS)	
APPROVED BY		
DATE:-	JANUARY -2020	
SHEET SIZE A1	SCALE	1:40000

PROJECT

LUNANA MINI HYDROPOWER PROJECT (500 kW)

DRAWING TITLE

PROJECT LAYOUT PLAN

DGPC/DGC/LMHP/CIVIL-01

REV	SHEET

Annexure III

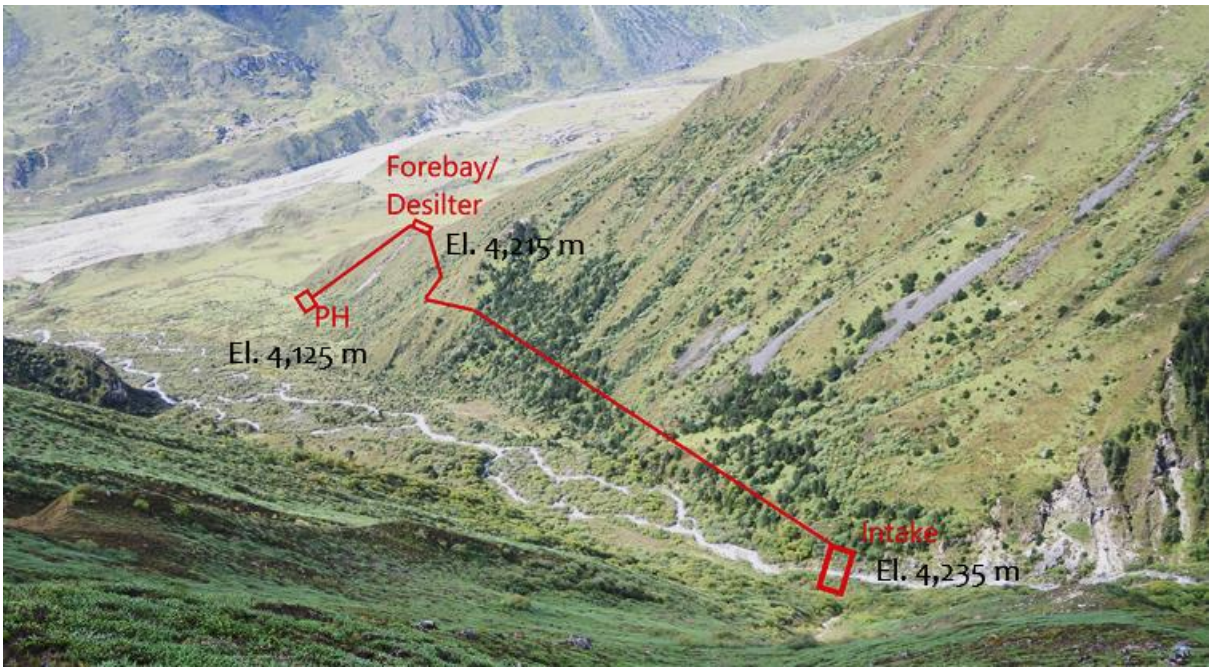


Figure 1: Project Layout

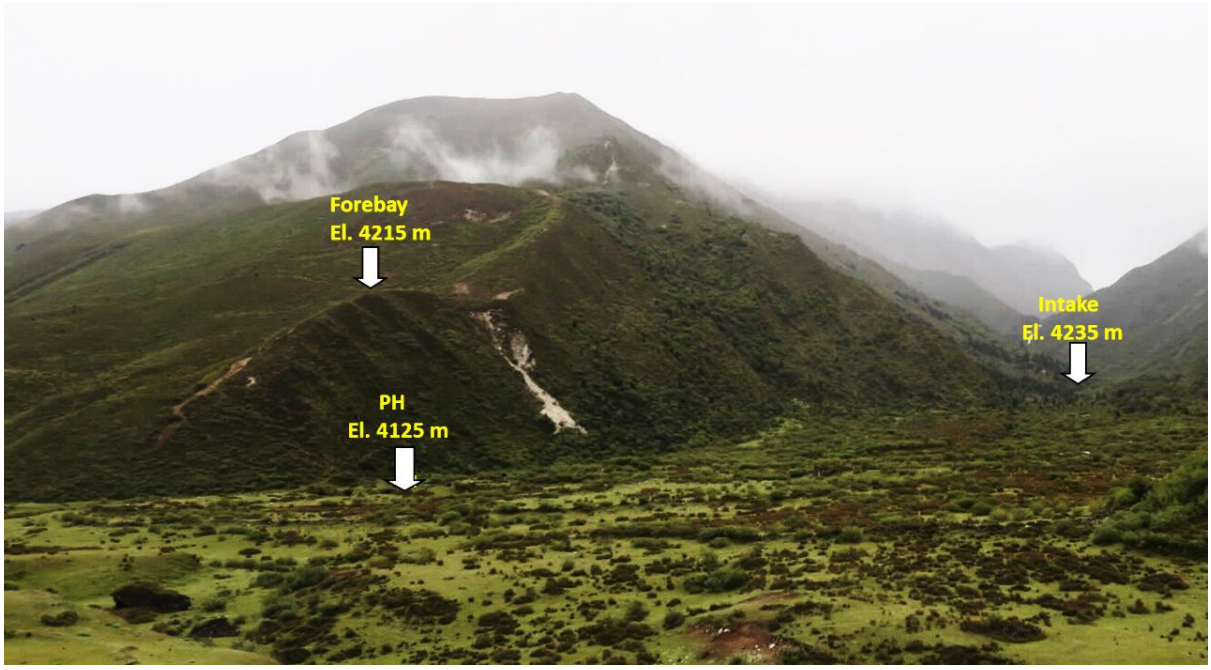
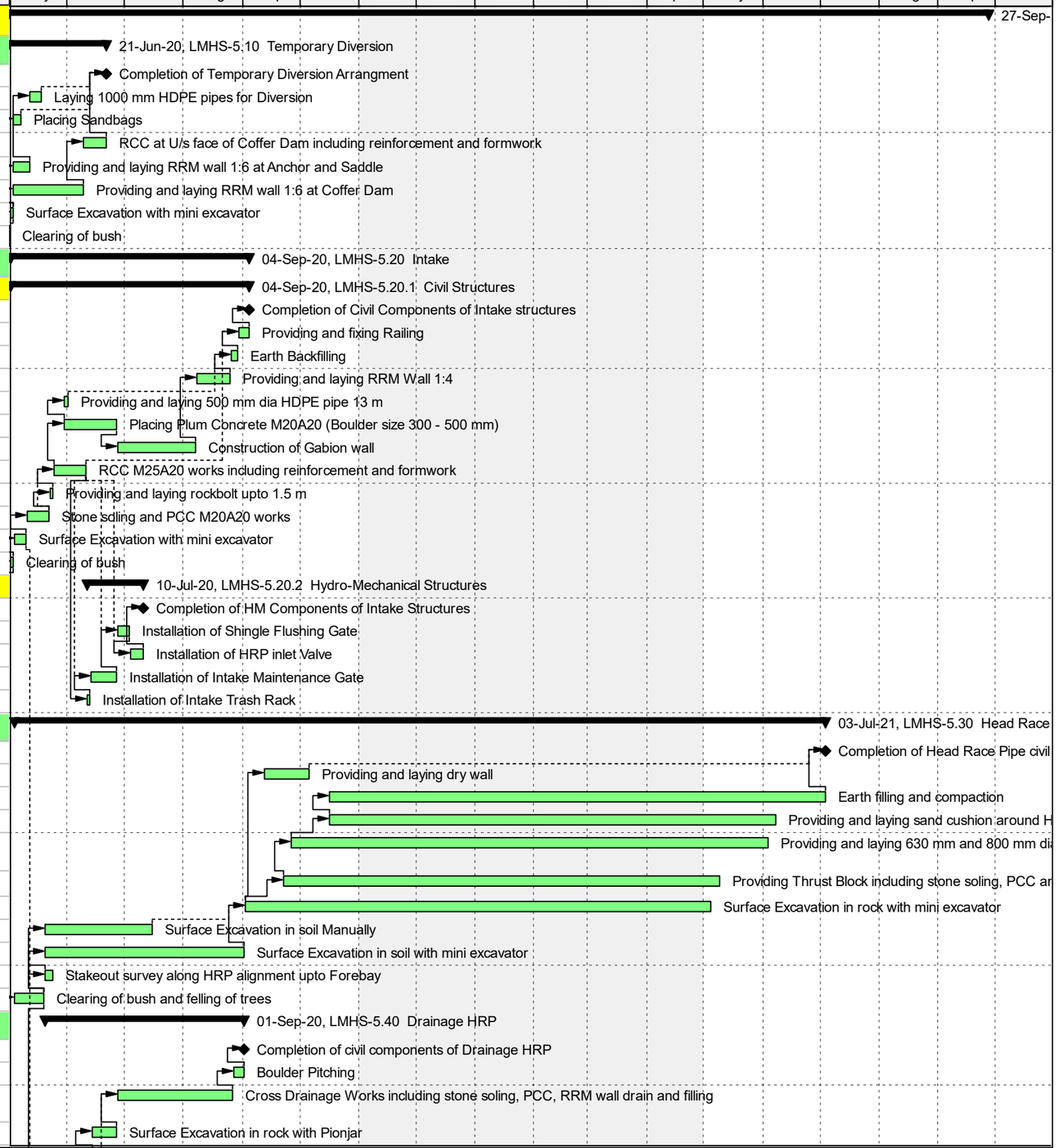


Figure 2: Location of Main Project Components

DETAILED PROJECT REPORT
Lunana Mini Hydropower Project

Activity ID	Activity Name	Original Duration	Start	Finish
LMHS-5	**500 kW Lunana Mini Hydro Scheme**	334	01-May-20	27-Sep-21
LMHS-5.10	**Temporary Diversion**	52	01-May-20	21-Jun-20
TD0080	Completion of Temporary Diversion Arrangment	0		21-Jun-20
TD0070	Laying 1000 mm HDPE pipes for Diversion	6	12-May-20	18-May-20
TD0060	Placing Sandbags	4	03-May-20	07-May-20
TD0050	RCC at U/s face of Coffer Dam including reinforcement and formwork	12	09-Jun-20	21-Jun-20
TD0040	Providing and laying RRM wall 1:6 at Anchor and Saddle	9	03-May-20	12-May-20
TD0030	Providing and laying RRM wall 1:6 at Coffer Dam	37	03-May-20	09-Jun-20
TD0020	Surface Excavation with mini excavator	2	02-May-20	03-May-20
TD0010	Clearing of bush	1	01-May-20	01-May-20
LMHS-5.20	**Intake**	126	02-May-20	04-Sep-20
LMHS-5.20.1	**Civil Structures**	126	02-May-20	04-Sep-20
IS0100	Completion of Civil Components of Intake structures	0		04-Sep-20
IS0090	Providing and fixing Railing	6	30-Aug-20	04-Sep-20
IS0080	Earth Backfilling	4	26-Aug-20	29-Aug-20
IS0070	Providing and laying RRM Wall 1:4	18	08-Aug-20	25-Aug-20
IS0061	Providing and laying 500 mm dia HDPE pipe 13 m	3	30-May-20	01-Jun-20
IS0060	Placing Plum Concrete M20A20 (Boulder size 300 - 500 mm)	28	30-May-20	26-Jun-20
IS0050	Construction of Gabion wall	42	27-Jun-20	07-Aug-20
IS0040	RCC M25A20 works including reinforcement and formwork	17	25-May-20	10-Jun-20
IS0031	Providing and laying rockbolt upto 1.5 m	2	23-May-20	24-May-20
IS0030	Stone soling and PCC M20A20 works	12	11-May-20	22-May-20
IS0020	Surface Excavation with mini excavator	7	04-May-20	10-May-20
IS0010	Clearing of bush	2	02-May-20	03-May-20
LMHS-5.20.2	**Hydro-Mechanical Structures**	30	11-Jun-20	10-Jul-20
ISHM0050	Completion of HM Components of Intake Structures	0		10-Jul-20
ISHM0040	Installation of Shingle Flushing Gate	7	27-Jun-20	03-Jul-20
ISHM0030	Installation of HRP inlet Valve	7	04-Jul-20	10-Jul-20
ISHM0020	Installation of Intake Maintenance Gate	14	13-Jun-20	26-Jun-20
ISHM0010	Installation of Intake Trash Rack	2	11-Jun-20	12-Jun-20
LMHS-5.30	**Head Race Pipe**	245	04-May-20	03-Jul-21
HRP0100	Completion of Head Race Pipe civil components	0		03-Jul-21
HRP0090	Providing and laying dry wall	24	12-Sep-20	05-Oct-20
HRP0080	Earth filling and compaction	80	16-Oct-20	03-Jul-21
HRP0070	Providing and laying sand cushion around HRP	54	16-Oct-20	07-Jun-21
HRP0060	Providing and laying 630 mm and 800 mm dia HDPE pipe including jointing	70	26-Sep-20	03-Jun-21
HRP0050	Providing Thrust Block including stone soling, PCC and Plum Concrete	49	22-Sep-20	09-May-21
HRP0040	Surface Excavation in rock with mini excavator	64	02-Sep-20	04-May-21
HRP0030	Surface Excavation in soil Manually	57	20-May-20	15-Jul-20
HRP0020	Surface Excavation in soil with mini excavator	105	20-May-20	01-Sep-20
HRP0011	Stakeout survey along HRP alignment upto Forebay	5	20-May-20	24-May-20
HRP0010	Clearing of bush and felling of trees	16	04-May-20	19-May-20
LMHS-5.40	**Drainage HRP**	105	20-May-20	01-Sep-20
DHRP0080	Completion of civil components of Drainage HRP	0		01-Sep-20
DHRP0070	Boulder Pitching	6	27-Aug-20	01-Sep-20
DHRP0060	Cross Drainage Works including stone soling, PCC, RRM wall drain and filling	61	27-Jun-20	26-Aug-20
DHRP0050	Surface Excavation in rock with Pionjar	13	14-Jun-20	26-Jun-20



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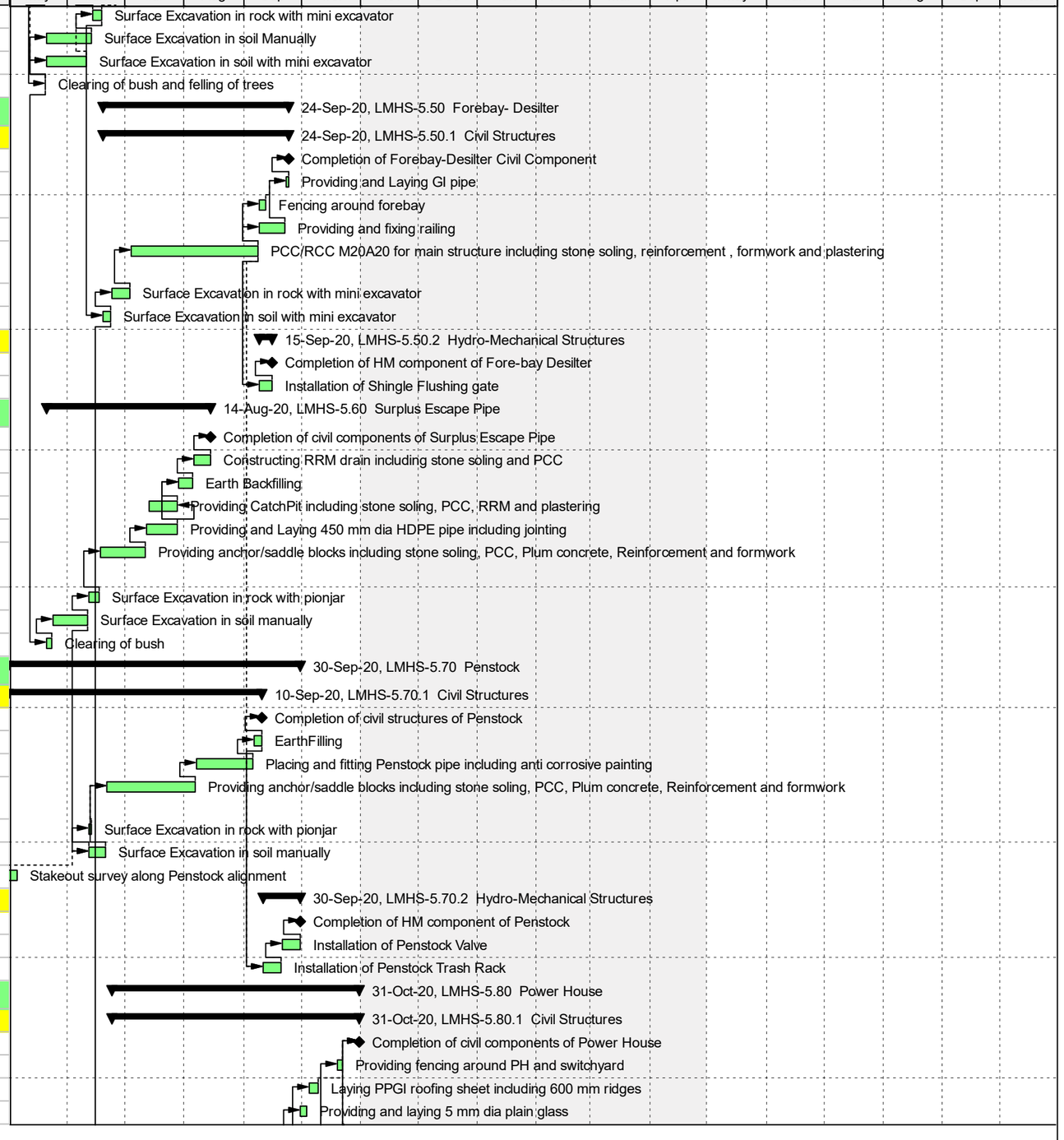
DETAILED PROJECT REPORT
Lunana Mini Hydropower Project

Activity ID	Activity Name	Original Duration	Start	Finish
DHRP0040	Surface Excavation in rock with mini excavator	5	14-Jun-20	18-Jun-20
DHRP0030	Surface Excavation in soil Manually	24	21-May-20	13-Jun-20
DHRP0020	Surface Excavation in soil with mini excavator	21	21-May-20	10-Jun-20
DHRP0010	Clearing of bush and felling of trees	1	20-May-20	20-May-20
LMHS-5.50	**Forebay- Desilter**	98	19-Jun-20	24-Sep-20
LMHS-5.50.1	**Civil Structures**	98	19-Jun-20	24-Sep-20
F-DC0070	Completion of Forebay-Desilter Civil Component	0		24-Sep-20
F-DC0060	Providing and Laying GI pipe	2	23-Sep-20	24-Sep-20
F-DC0050	Fencing around forebay	4	09-Sep-20	12-Sep-20
F-DC0040	Providing and fixing railing	14	09-Sep-20	22-Sep-20
F-DC0030	PCC/RCC M20A20 for main structure including stone soling, reinforcement , formwork and plastering	67	04-Jul-20	08-Sep-20
F-DC0020	Surface Excavation in rock with mini excavator	10	24-Jun-20	03-Jul-20
F-DC0010	Surface Excavation in soil with mini excavator	5	19-Jun-20	23-Jun-20
LMHS-5.50.2	**Hydro-Mechanical Structures**	7	09-Sep-20	15-Sep-20
F-DCHMC	Completion of HM component of Fore-bay Desilter	0		15-Sep-20
F-DCHMC	Installation of Shingle Flushing gate	7	09-Sep-20	15-Sep-20
LMHS-5.60	**Surplus Escape Pipe**	86	21-May-20	14-Aug-20
SEP0080	Completion of civil components of Surplus Escape Pipe	0		14-Aug-20
SEP0070	Constructing RRM drain including stone soling and PCC	9	06-Aug-20	14-Aug-20
SEP0060	Earth Backfilling	8	29-Jul-20	05-Aug-20
SEP0050	Providing CatchPit including stone soling, PCC, RRM and plastering	16	13-Jul-20	28-Jul-20
SEP0042	Providing and Laying 450 mm dia HDPE pipe including jointing	17	12-Jul-20	28-Jul-20
SEP0040	Providing anchor/saddle blocks including stone soling, PCC, Plum concrete, Reinforcement and formwork	24	18-Jun-20	11-Jul-20
SEP0030	Surface Excavation in rock with pionjar	6	12-Jun-20	17-Jun-20
SEP0020	Surface Excavation in soil manually	19	24-May-20	11-Jun-20
SEP0010	Clearing of bush	3	21-May-20	23-May-20
LMHS-5.70	**Penstock**	153	01-May-20	30-Sep-20
LMHS-5.70.1	**Civil Structures**	133	01-May-20	10-Sep-20
PS0040	Completion of civil structures of Penstock	0		10-Sep-20
PS0031	EarthFilling	5	06-Sep-20	10-Sep-20
PS0030	Placing and fitting Penstock pipe including anti corrosive painting	30	07-Aug-20	05-Sep-20
PS0020	Providing anchor/saddle blocks including stone soling, PCC, Plum concrete, Reinforcement and formwork	47	21-Jun-20	06-Aug-20
PS0011	Surface Excavation in rock with pionjar	2	12-Jun-20	13-Jun-20
PS0010	Surface Excavation in soil manually	9	12-Jun-20	20-Jun-20
PS0009	Stakeout survey along Penstock alignment	5	01-May-20	05-May-20
LMHS-5.70.2	**Hydro-Mechanical Structures**	20	11-Sep-20	30-Sep-20
PSHM0030	Completion of HM component of Penstock	0		30-Sep-20
PSHM0020	Installation of Penstock Valve	10	21-Sep-20	30-Sep-20
PSHM0010	Installation of Penstock Trash Rack	10	11-Sep-20	20-Sep-20
LMHS-5.80	**Power House**	130	24-Jun-20	31-Oct-20
LMHS-5.80.1	**Civil Structures**	130	24-Jun-20	31-Oct-20
PH0090	Completion of civil components of Power House	0		31-Oct-20
PH0071	Providing fencing around PH and switchyard	3	20-Oct-20	22-Oct-20
PH0050	Laying PPGI roofing sheet including 600 mm ridges	5	05-Oct-20	09-Oct-20
PH0044	Providing and laying 5 mm dia plain glass	4	30-Sep-20	03-Oct-20



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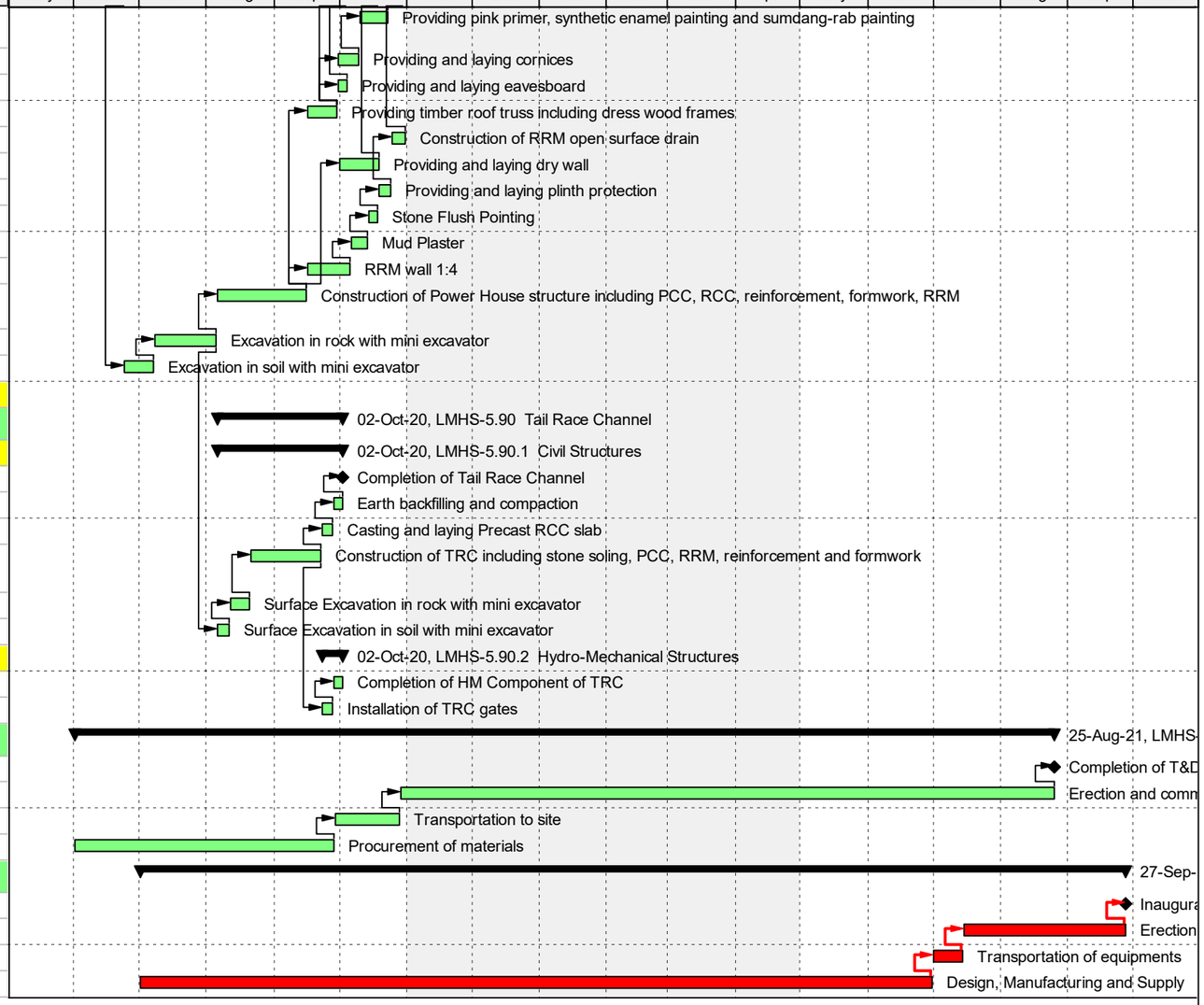
Activity ID	Activity Name	Original Duration	Start	Finish
PH0043	Providing pink primer, synthetic enamel painting and sumdang-rab painting	14	10-Oct-20	23-Oct-20
PH0042	Providing and laying cornices	10	30-Sep-20	09-Oct-20
PH0041	Providing and laying eavesboard	5	30-Sep-20	04-Oct-20
PH0040	Providing timber roof truss including dress wood frames	14	16-Sep-20	29-Sep-20
PH0037	Construction of RRM open surface drain	7	25-Oct-20	31-Oct-20
PH0036	Providing and laying dry wall	19	01-Oct-20	19-Oct-20
PH0035	Providing and laying plinth protection	6	19-Oct-20	24-Oct-20
PH0033	Stone Flush Pointing	5	14-Oct-20	18-Oct-20
PH0032	Mud Plaster	8	06-Oct-20	13-Oct-20
PH0031	RRM wall 1:4	20	16-Sep-20	05-Oct-20
PH0030	Construction of Power House structure including PCC, RCC, reinforcement, formwork, RRM	41	06-Aug-20	15-Sep-20
PH0020	Excavation in rock with mini excavator	29	08-Jul-20	05-Aug-20
PH0010	Excavation in soil with mini excavator	14	24-Jun-20	07-Jul-20
LMHS-5.80.3	**Hydro-Mechanical Structures**	0		
LMHS-5.90	**Tail Race Channel**	58	06-Aug-20	02-Oct-20
LMHS-5.90.1	**Civil Structures**	58	06-Aug-20	02-Oct-20
TRC0060	Completion of Tail Race Channel	0		02-Oct-20
TRC0050	Earth backfilling and compaction	5	28-Sep-20	02-Oct-20
TRC0040	Casting and laying Precast RCC slab	5	23-Sep-20	27-Sep-20
TRC0030	Construction of TRC including stone soling, PCC, RRM, reinforcement and formwork	33	21-Aug-20	22-Sep-20
TRC0020	Surface Excavation in rock with mini excavator	9	12-Aug-20	20-Aug-20
TRC0010	Surface Excavation in soil with mini excavator	6	06-Aug-20	11-Aug-20
LMHS-5.90.2	**Hydro-Mechanical Structures**	10	23-Sep-20	02-Oct-20
TRCHM0(	Completion of HM Component of TRC	5	28-Sep-20	02-Oct-20
TRCHM0(	Installation of TRC gates	5	23-Sep-20	27-Sep-20
LMHS-5.100	**Transmission and Distribution**	270	01-Jun-20	25-Aug-21
T&D0040	Completion of T&D works	0		25-Aug-21
T&D0030	Erection and commissioning	120	29-Oct-20	25-Aug-21
T&D0020	Transportation to site	30	29-Sep-20	28-Oct-20
T&D0010	Procurement of materials	120	01-Jun-20*	28-Sep-20
LMHS-5.110	**Electro-Mechanical**	273	01-Jul-20	27-Sep-21
E&M0040	Inauguration Date	0		27-Sep-21
E&M0030	Erection, Testing and Commissioning	75	15-Jul-21	27-Sep-21
E&M0020	Transportation of equipments	14	01-Jul-21	14-Jul-21
E&M0010	Design, Manufacturing and Supply	365	01-Jul-20*	30-Jun-21



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