Alternative Energy Promotion Centre

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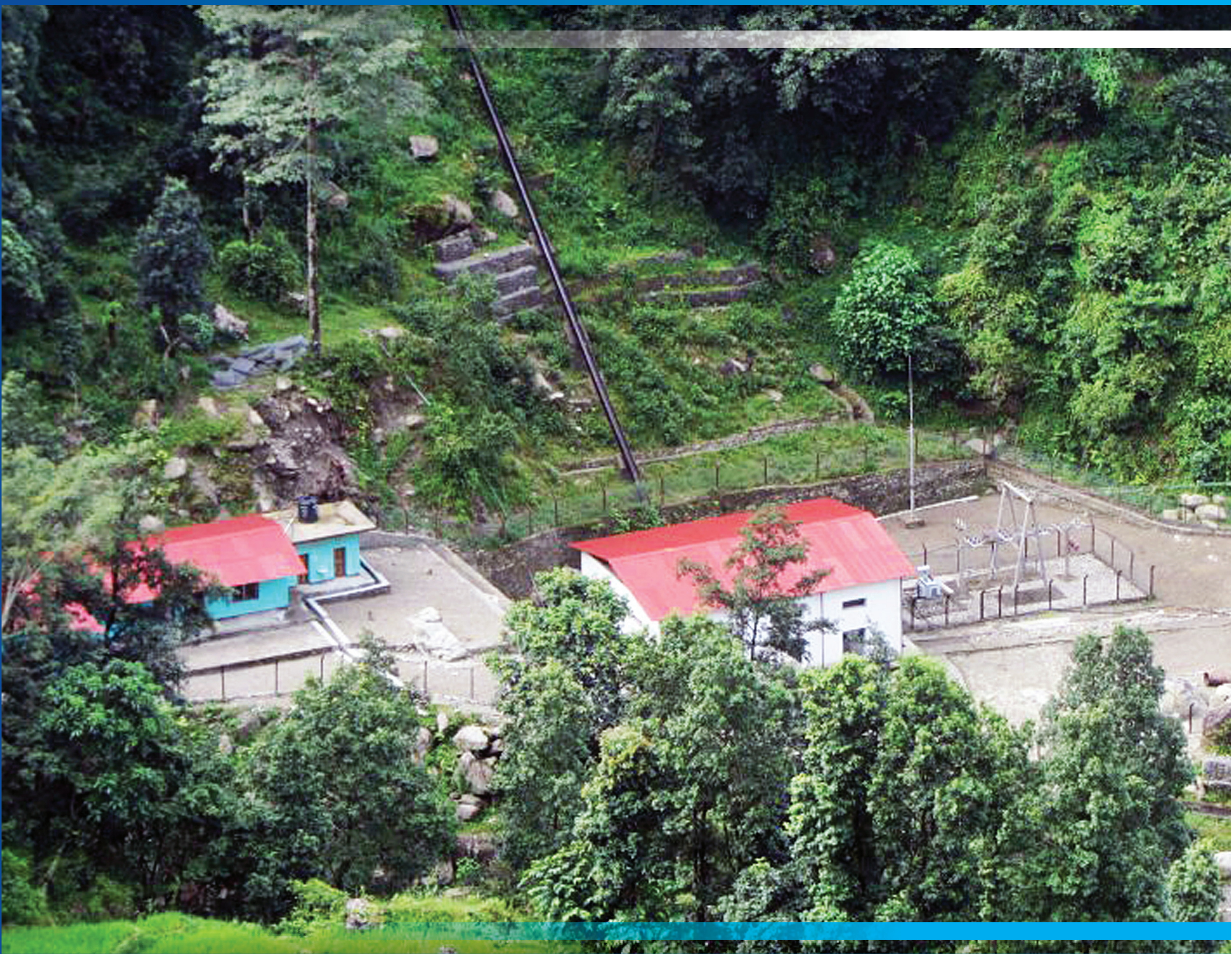
Guidelines for Detailed Feasibility Studies of Mini Hydropower Projects



June 2014

Alternative Energy Promotion Center

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ACKNOWLEDGEMENT

The Alternative Energy Promotion Centre (AEPC) under the Ministry of Science Technology and Environment has been promoting Renewable Energy to meet the energy needs of rural Nepal science its establishment in 1996.

These guidelines have been prepared to provide a basis for consultants to undertake detailed feasibility studies, including technical design, socio-economic data collection, risk analysis and financial analysis for mini hydropower projects promoted by the Alternative Energy Promotion Centre (AEPC). For the purpose of these guidelines, a mini-hydropower plant (MiniHP) is defined as a plant with the installed capacity greater than 100 kW up to 1000 kW. Before doing DFS the developer should have conducted a pre-feasibility study in which the water discharge at site and other technical parameters are measured. It is expected that the use of these guidelines will result in a standard approach to designing and reporting on detailed feasibility studies of new mini-hydropower projects.

I hope these guidelines will be useful not only to AEPC/NRREP but also to all other organizations working in the field of mini hydro. I further believe these guidelines will be good reference material to everyone interested mini hydro.

Lastly, I would like to extend my sincere thanks to all those involved in the production of this document. Special thanks goes to Mr. Pushpa Chitrakar and his team from Angel Consultancy. I extend my appreciation to Renewable Energy for Rural Livelihood and Community Electrification Sub-component of NRREP for their invaluable contribution in this regard.

I would also like to thank RERL programme of AEPC for publishing this document.

Ram Prasad Dhital

Officiating Executive Director

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ABBREVIATIONS

AC	Alternating Current
ACSR	Aluminium Conductor Steel Reinforced
AEPC	Alternative Energy Promotion Centre
amp	Ampere
amsl	Above mean sea level
AVR	Automatic Voltage Regulator
B/C	Benefit Cost Ratio
BM	Bench Marks
CAR	Catchment Area Ratio
CFUG	Community Forest Users' Group
CT	Current Transformer
DC	Direct Current
DDC	District Development Committee
DHM	Department of Hydrology and Meteorology
DoED	Department of Electricity Development
DWRC	District Water Resources Committee
EIA	Environmental Impact Assessment
ELC	Electric Load Controller
ESAP	Energy Sector Assistance Programme
FDC	Flow Duration Curve
FGD	Focus Group Discussion
GoN	Government of Nepal
GPS	Global Positioning System
GRP	Glass Reinforced Pipe
HDPP	High Density Polythene Pipe
HFL	High Flood Level
HH	House hold
HP	Hydropower
HSC	Hydrologically Similar Catchment
Hz	Hertz
ICIMOD	International Center for Integrated Mountain Development
IEE	Initial Environmental Examination
INGO	International Non-Governmental Organization

INPS	Integrated Nepal Power System
IPP	Independent Power Producer
IRR	Internal Rate of Return
km	Kilometer
kVA	Kilo-Volt ampere
kW	Kilo Watt
kWh	Kilo-Watt hour
l/s	Litre per second
m	Metre
m^3/s	Cubic meter per second
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MGSP	Mini-Grid Support Program
MIP	Medium Irrigation Project
mm	Milli-metre
MoEST	Ministry of Science,Technology and Environment
MoWR	Ministry of Water Resources
MW	Mega Watt
NEA	Nepal Electricity Authority
NGO	Non-Governmental Organization
NPV	Net Present Value
PPA	Power Purchase Agreement
PT	Potential Transformer
RCC	Reinforced Cement Concrete
RL	Reduced Level
VDC	Village Development Committee
WECS	Water and Energy Commission Secretariat

1 INTRODUCTION

1.1 General

These guidelines have been prepared to provide a basis for consultants to undertake detailed feasibility studies, including technical design, for mini hydropower projects supported by the Alternative Energy Promotion Centre (AEPC) of the Government of Nepal. For the purpose of these guidelines, a mini-hydropower plant (MiniHP) is defined as a plant generating electrical power greater than 100 kW upto1000 kW. Before conduction DFS the developer should have conducted pre-feasibility study in which the discharge measurement at site and other technical parameters be presented.

It is expected that the use of these guidelines will result in a standard approach to designing and reporting on detailed feasibility studies of new isolated as well as grid connected mini-hydropower projects. The overall objective of these guidelines is that mini-hydropower plants are built with appropriate quality and thus their failure rates are minimized. The specific objectives are as follows:

- Rural households are able to receive reliable and affordable electricity for household lighting and thus quality of life is improved
- Technically sound mini-hydropower projects are implemented
- MiniHPs are cost effective and financially viable so that private public partners are entered as business entities and external supports are not required for their operation and maintenance
- Safety issues are adequately addressed
- The plants are grid connectable so that local industries get assured supply of power and energy to a certain supply area and to the neighboring grids.
- Where feasible, multi-purpose projects that integrate hydropower with other uses of the water resources are promoted
- Enhancement in community awareness on GESI perspective and thus women, vulnerable community will be empowered
- Mini-hydropower projects will support in carbon reduction

As presented in a typical mini-hydropower project implementation schedule in Figure 1.1, the detailed design study of a mini hydropower project shall only be carried out after the project has been identified and initiated. A detailed feasibility study is the report written after the second site visit of a prospective MiniHP site following an assessment of information provided in the preliminary feasibility study. Thus, the detailed feasibility study should build upon the findings of the preliminary feasibility study. It should be noted that the detailed feasibility report is the final document on which the decision whether or not to implement the mini-hydropower plant is based. The report will also provide a basis for negotiation of loan from a financing institution for its development. The detailed feasibility study reports shall assist the developer in negotiating with potential contractors.

A multidisciplinary team of experienced technicians (engineers), environmentalists and socio-economists/ sociologists, who are familiar with mini-hydropower, are expected to undertake the detailed feasibility studies. Thus, the underlying technical, environmental and socio-economical principles are not discussed in detail in these guidelines.

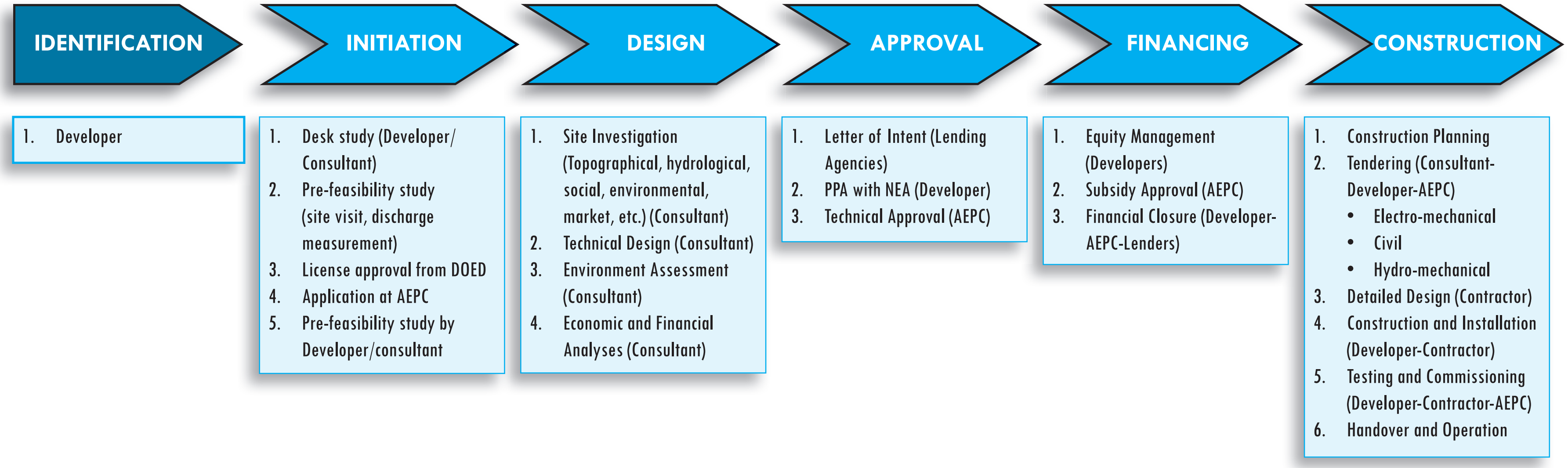


Figure 1.1: A typical Mini Hydropower Development Chart

It should be noted that the design engineer/consultant may propose alternative designs that are different than those based in the guidelines provided that:

- Such designs have sound technical basis,
- They are proven in the context of Nepal, and
- They are more cost effective than when the designs are based on the guidelines

The format for carrying out site work and subsequent analysis for detailed feasibility study is presented in Appendix D. All information required in the format should be filled in; where this is not possible, comments should be provided to justify the omission.

It is recommended to use a separate set of spreadsheets "Mini Hydro Design Tools" for assisting the design engineer in sizing appropriate structures and equipment for the chosen scheme. It should be noted that these tools are guidelines only and are not intended to replace sound engineering judgment. They should be used with caution to verify the design parameters based on site-specific conditions.

1.2 Objective and scope of works

The main objective of the Detailed Feasibility Study of Mini Hydropower Projects is to determine the technical feasibility and financial attractiveness of the project so that it can be implemented by a developer.

The scope of work under a detailed feasibility study includes:

- Study and review of reconnaissance or pre-feasibility study of the project prepared in earlier study
- Carry out hydrological, topographical, geological & geotechnical field survey and investigations. Collect information on existing infrastructure.
- Conduct socio-economic survey and environmental study of the project and supply area
- Study of multipurpose use of water resource
- Assessment of power & energy requirement and load demand forecast of the project area
- Assessment of power potential of the site and determination of optimum plant capacity
- Prepare layout, design and dimensioning of the components of the power plant on detailed feasibility study level
- Study of transmission line for power evacuation and for interconnection with mini grid or national grid
- Preparation of construction planning and scheduling
- Preparation of Bill of Quantities and project cost estimation
- Carry out financial analysis of the project
- Risk assessment of the project
- Project evaluation on implementation and recommendations for further action.

The detailed feasibility study report serves as the documented basis for decision making by the developers and for entering into contract for detailed design (if necessary) and construction. It is assumed that a turnkey contract is the basis for the detailed design and the construction. In a turnkey contract, the contractor has to complete the detailed design and have it approved before contractor starts construction work.

The detailed feasibility study report should provide following detailed information on the project.

1) Demand Survey
2) Supply analysis
3) Project layout and recommended specifications
4) Community benefit assessment
5) Financial analysis
6) Risk assessment

1.3 Application of Guidelines and Content

These guidelines are applicable for conducting Detailed Feasibility Studies of mini hydropower projects ranging from electrical power output greater than 100 kW upto 1000 kW supported by AEPC. The guidelines cover methods and sequence of preparation of the detailed feasibility study of mini hydro projects. Methods of conducting field survey & investigation, scope of design and analysis and economical and financial analyses have been elaborated. Standard formats for carrying out field survey & investigations as well as formats for preparing project costs have been recommended. Design Tools for design of typical hydraulic structures, hydrological analysis, load demand analysis and financial analysis of mini hydro projects are presented in excel sheets which will reduce the time for design and analysis part of the study and resulting in consistency in report preparation and presentation. Sample drawings on feasibility study level of mini hydro projects are illustrated.

The Guidelines consist of the following components:

- Field survey and investigations
- Design of project components and preparation of their cost
- Load demand analysis
- Financial analysis
- Socioeconomic study of the project area
- Risk assessments
- Environmental study
- Spreadsheet design aid for typical structures
- Spreadsheet models for determining hydrological flows and load demand analysis
- Guidelines on use of spreadsheets
- Formats for preparation of detailed feasibility study.
- Sample drawings of mini hydro projects

These guidelines does not cover aspects of operation and maintenance of mini hydropower projects.

1.4 Power Market

The power market of mini hydro projects in Nepal can be broadly divided into two categories depending upon interconnection of the plants.

1.4.1 Isolated Projects

Projects without national or local grid connection are categorized as Isolated Schemes. The power market will be the respective load centers to be supplied by the proposed mini hydro projects. These load centers in general exhibit the following characteristics:

- Energy uses are primarily for domestic lighting purpose,
- Peak power demands are in evening hours,
- Day time load share limited to milling of agro products and other minor commercial uses,
- The household consumers are scattered in wide area,
- The plant factors as well as load factors are generally low,
- Load promotion activities are identified /designed for increasing the load factors, which are essential for the financial viability of the project.

Installed capacities of isolated systems are governed mainly by the domestic demands. Non-lighting uses should ideally complement the lighting use. End uses are operated in such a way that they are operated during non-lighting hours without necessitating increase in the installed capacities. Other approaches to sizing a plant may also be proposed, if financial attractiveness can be demonstrated.

The maximum demand, load variation of a mini hydropower project shall be determined in the detailed feasibility study of the project. The optimum output based on hydrological parameters shall be determined during the detailed feasibility studies.

1.4.2 Grid Connected Projects

Mini hydropower projects with larger generation potential sites and/or with higher demands should be studied for interconnection with other generating facilities including national/central grid system. During the field survey, it is required to collect information on the adjacent power facilities and nearest transmission line. It should be investigated whether surplus power from the proposed project can be transmitted to the nearby local or national grids. The voltage level, distance from the new scheme, capacity of the transmission line to absorb the additional injected power etc., should be investigated. In case the peak load is relatively high, the possibility of tapping power from the National Grid/Local Grid shall also be considered. Grid connected schemes have better financial viability than isolated schemes as all the energy generated by the scheme can be sold to the grid operator.

The electricity tariff will have to be determined/ assessed both for supply in the local load centers and for supply to the grid operator. The purchase rate of grid operator might be less as he is supplied with only the surplus energy which will be secondary type of energy. If a guaranteed power can be supplied to the grid operator, a higher tariff can be negotiated.

1.5 Institutional Aspects

Assessment of Developer's capability and commitment to implement the scheme should be made by the Consultant. Financial and management abilities for implementation and operation of the project should be elaborated. Also the role of beneficiary/ community in the project implementation and operation should be clearly defined. The Developer must have overall knowledge of mini hydro development process and must be aware of the risks associated with it.

Institutions such as NGOs or government line agencies that are active in the project area and are likely to contribute in the implementation of the scheme should be contacted and their interest in the scheme and possible contributions should be mentioned in the report.

1.6 Policy issues

1.6.1 Hydropower development and the private sector

The Ministry of Water Resources, with the intention of promoting hydropower (up to 25 MW) through the private sector, has declared policies for the purchase of electricity by NEA from such projects as:

- NEA will buy all power produced by the private power plants up to 25MW of installed capacities based on the design discharges corresponding to 40% of exceedance (80% exceedance in case of projects in the range of 100kW-1000kW).
- PPA period is 25 years.
- Base year for energy tariff will be the Commercial Date of Operation.
- Differential tariff: For power plants up to 25 MW installed capacity, Rs. 4.8/kWh for wet months (Baishak-Mansir) and Rs. 8.4/kWh for the dry period of the year (Poush – Chaitra) with a flat annual escalation rate of 3% for five years.

1.6.2 Policy regarding Mini hydropower project

Hydropower Development Policy 2001 and Electricity Act 2065, state that no license shall be required for hydropower project up to a capacity of 1 MW. Such hydropower project shall be registered with the District Water Resources Committee (DWRC) prior to commencement of the works. Information of such registration shall be given to the Department of Electricity Development. The basis for registration of such projects shall be as determined by the Government of Nepal.

Section 3 of Electricity Act, 2065 has made a provision that a proponent does not require a license for survey, construction and operation of production/ transmission/ distribution of a hydropower project with installed capacities up to 1000 kW.

Section 21 of Electricity Act 2065 has also made a provision that a proponent does not require to pay any royalties on installed capacity or revenue of a hydropower project with an installed capacity up to 1000kW.

1.6.3 Application Process for Mini-hydro Project

The proponent should submit certain information before commencing the work of the project as prescribed in Clause 5 of the Directives on Licensing of Hydropower Projects 2068. Submittal shall be made to the Secretary of Ministry of Water Resources (MoWR) through the Department of Electricity Development (DoED).

1. If the proponent's application is for survey and development of the project, the proponent shall submit the following information to the DoED:
    a. A duly signed and stamped Application as per Schedule 1 of the Directive.
    b. Desk study of the proposed project which includes salient features (i.e. name of the water body), scope of work, detailed cost breakdown, hydrological analyses and work schedule
    c. Topographical map showing all the major components of the project (in scale of 1:25,000 or 1: 50,000) and project boundaries with Longitudes and Latitudes.
    d. Proponent's institutional registration certificate, bylaws and Niyamawali.
    e. Documents showing financial ability of the proponent's institution as per Clause 3
    f. Documents showing technical capabilities of the project as per Clause 4.
    g. Contact addresses of the proponent or his representative (name, address, telephone (office and resident), mobile number, fax number, Post Office Box number and an email address.
    h. Letter of recommendation addressed to DoED for project development (survey, production, transmission and distribution) from concerned VDC/ Municipality with a copy addressed to DWRC (District Water Resources Committee).

The Department will issue a license to the proponent if all the documents submitted have no objection to issue such a license.

On acquiring such a license for the development of the project, the proponent shall inform the DWRC about the license.

2. If the proponent's application is for survey, production, transmission and distribution, the proponent should submit the following to the DoED in addition to the information listed in (1) above:
    a. Schedule for completion of feasibility study report
    b. Construction work schedule
    c. Cost of development
    d. Letter of intent regarding Power Purchase Agreement (PPA) if sold to utility and/or a letter of intent regarding Power Sales Agreement if sold to consumers isolated from the National Grid, providing information on types and number of such consumers
    e. Financial evidence to support construction of the project.

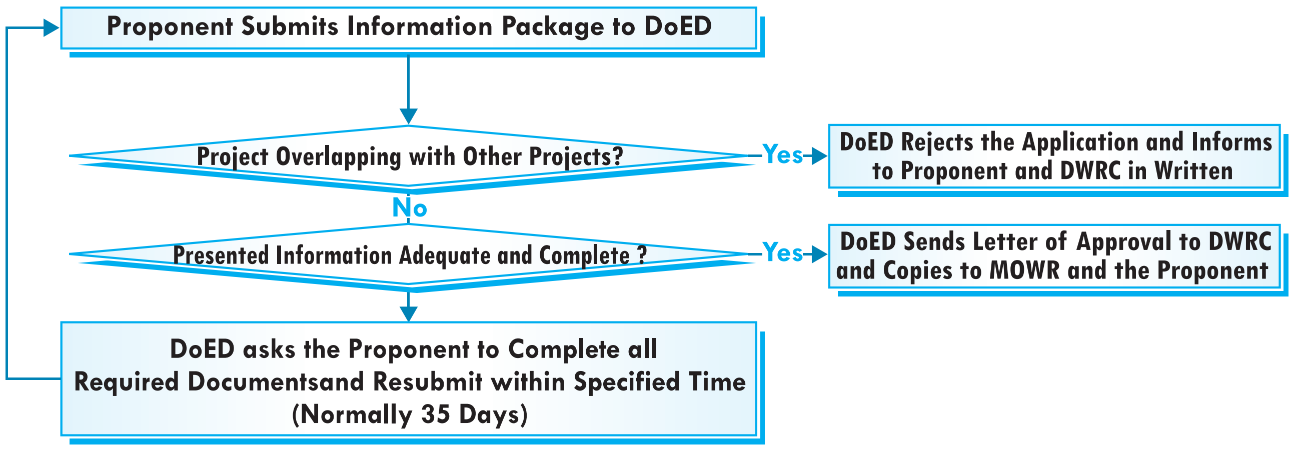


Figure 1.2: Licensing Processes for Mini Hydropower Projects

1.6.4 Renewable Energy Subsidy Policy 2069

Renewable Energy Subsidy Policy 2069 has provision of subsidy for mini hydropower projects up to 1000kW. For a mini hydropower project to be eligible for the subsidy, a detailed feasibility study should adequately address AEPC's policy issues. Currently, these issues include the following:

- Whether adverse environmental impacts are possible due to the implementation of the scheme.
- The project must be financially viable such that the return on equity at the applicable discount rate for the economic life is positive.
- The subsidy policy of AEPC for the study and implementation of the scheme should be mentioned in the relevant parts of the feasibility study.

Community/Cooperative owned Mini hydro

The subsidy for community/cooperative owned mini hydro off- grid projects above 100kW to 1000 kW (or 1 MW) projects be as follows:

Subsidy Category	Subsidy Amount in Rs.		
	Category "A" VDCs	Category "B" VDCs	Category "C" VDCs
Subsidy per household	20,000	18,000	16,000
Subsidy per kW	120,000	100,000	70,000
But, the maximum subsidy amount per kW including household subsidy will not exceed Rs. 220,000, Rs. 190,000 and Rs. 170,000 for Category "A", Category "B" and Category "C" VDCs respectively.			

Projects from 100kW to 500kW should connect at least 500 households or at least 5 households per kW to be eligible for the above mentioned subsidy amount. Similarly, projects from 500kW to 1000 kW should connect at least 1000 households or at least 5 households per kW to be eligible for subsidy

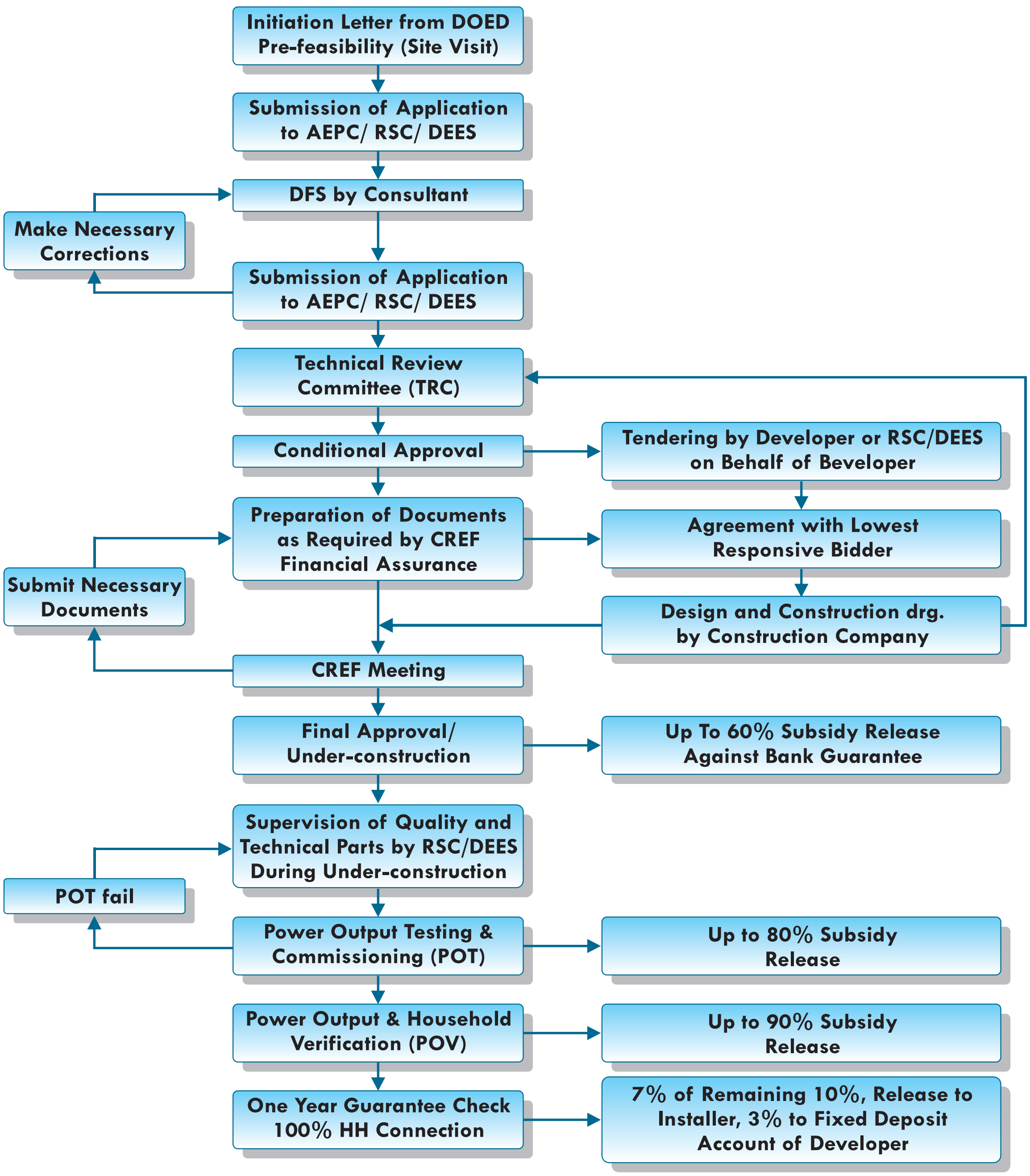
Mini Hydro connected to Grid

For mini hydro project connected to grid, the household subsidy will be provided based on number of households connected to the plant. The subsidy amount per household to be connected to grid will be Rs. 15,000

For schemes to be interconnected with the national grid operated by NEA, the Consultant should address and meet all the requirements of NEA for such schemes. The procedure of power purchase agreement (PPA) for the sale of surplus energy to NEA and its expected energy purchase rate should be used in the financial analysis of the project.

While determining the capacity of the project for the purpose of the subsidy to the project 10 kW to 100 kW, the basis shall be taken generally 200 watt and 400 watt at maximum. However, the developer may develop the project higher than that capacity. For more information on subsidy policy and mechanism one should refer to 'Renewable Energy Subsidy Policy, 2013' and 'Renewable Energy Subsidy Delivery Mechanism, 2013'.

Mini-Hydropower Development Flow Chart



1.7 Multipurpose Projects

Financial and economic viability of a hydro project is enhanced by integrating hydro generation with other uses of the water resource e.g. for the purpose of irrigation and water supply. Following configurations of multi-purpose use of water are being practiced:

- Feeding irrigation command area located downstream of the of the tailrace canal
- Use canal drops in the middle of the main canal of irrigation system
- Supply water for irrigation or water supply from the power canal or forebay
- Pumping water for irrigation or drinking water during off-peak period

For multi-purpose schemes, following concerns should be considered in the feasibility study:

- Apart from meeting the flow requirements for power generation, excess flows are available for the secondary purpose. For example, if the design flow required for power generation is less than the 80% exceedance flow (large river and low installed capacity), excess irrigation flows can be available during the irrigation demand period. If the command area is along the headrace alignment, irrigation flows can be made available by sizing the headrace canal to meet both demands (i.e. those for power generation and irrigation). If a pipe is used for headrace, flow control structures such as valves will be required at the irrigation outlets.
- If the command area is along the tailrace alignment, irrigation flows can be made available without increasing the conveyance capacity of the headrace. Realignment or extension of the canal length can be the only additional costs required.
- It may also be possible to accommodate irrigation flows or other non-hydropower flows with the same design flows or canal by water management practices. For example, irrigating during off-peak hours by either reducing the power output or closing the plant are viable options.
- The additional costs and incremental benefits from the secondary use should be demonstrated in multi-purpose projects. For example, the increase in the cost of the headrace canal to accommodate irrigation flows should be compared with the benefits due to increases in crop yields over the span of the power plant. If the accumulated benefits from the secondary uses over the life of the plant for a given discount rate as per the prevailing policy exceed the additional costs required to accommodate such uses, then multi-purpose projects can be justified.

Multiple uses of water resources should not be considered a threat to mini hydro projects. Infact, efforts should be made to seek technical and management solutions that encourage power generation and integrate other uses of water resources.

1.8 References

MiniHydro Survey and Design Tools is a set of design tools consisting a MS workbook for surveying and designing of mini hydropower projects, a set of typical mini hydropower drawings and a guideline manual for using the spreadsheets. These reference materials are enclosed in this publication. Updates on these tools are also available in the AEPC website.

2 SURVEY AND INVESTIGATIONS

2.1 General

The objective of field survey and investigation of a mini hydro project is to acquire necessary data and information of the identified hydropower site and the electricity supply area to carry out the technical feasibility and financial viability of the project. The detailed feasibility study of a project is carried out to meet the power demand and demand growth of a power market (service area) which has been established through a reconnaissance or pre-feasibility study of a particular hydropower site. At the detailed feasibility stage of study, it is understood that the service area has been defined to a reasonable extent and a matching potential hydro generation (with demand growth in consideration) site has been identified.

Generally, the following field survey and investigations are conducted for the detailed feasibility study of a mini hydropower project:

1) Topographical survey of the project for mapping of the site
2) Hydrological survey and data collection
3) Geological and Geotechnical investigations and studies
4) Environmental Study
5) Socioeconomic study

2.2 Approach & Methodology

Desk study, reconnaissance study, review of earlier studies, field survey and investigations; laboratory tests (if needed) and data analysis, topographical mapping, geological investigation, project design, power evacuation study, environmental study, quantity and cost estimation, construction planning and scheduling and financial analysis are the major steps envisaged in the detailed feasibility study of a mini hydropower project.

2.3 Topographic Survey and Mapping

2.3.1 Human resources, maps, and Survey Equipment

Human resources

A typical field survey team should consist of following human resources:

- hydropower engineer/civil engineer/hydrologist
- geologist
- topographical survey crew and
- environmentalist

Depending upon the size of the project, site conditions and experience of the team members, the survey team can be smaller. The joint team should evaluate the site conditions and define the project layout after walkover survey and finalize the site of all the major structures. The location of all the major structures should be noted by each team member on the available map from the earlier study or on the existing topographical map of the project site. It is recommended to use a GPS to record the coordinates of the selected major structure locations. Then, each member should carry out specific study in detail.

During the investigation of a mini hydro project, it is highly recommended that relatively a larger area shall be investigated before finalizing the project layout for detailed survey & investigation.

Maps

Topographic Maps prepared by the Survey Department of Government of Nepal available in the scales of 1:25,000 and 1:50,000 should be used as a basis for further topographic survey and mapping of the site. These days digitized topographical maps are also available for purchase from the Survey Department. Topographical maps provide important information of ground elevation, nature of river stretches/ bends, forest areas, cliff, agricultural land, slides, settlements, existing trails, roads, electricity lines etc., which are very useful for the survey team.

Contour maps from pre-feasibility or earlier study, if available, should be referred in the preliminary study and used for planning of subsequent field survey works.

Survey Equipment

Survey equipment required for topographical survey:

1) Global Positioning System (GPS)/ altimeter, compass
2) Total Station or Theodolite and Level Instrument
3) Prisms, survey staff (3m/ 5m), ranging rods in required numbers
4) Measuring tapes (3m/5 m, 50m/100m)
5) Chisel for engraving in rock/boulders, enamel paints (red or yellow), wooden pegs, concrete monuments with pegged nails etc.

2.3.2 Topographical Survey

The topographical surveying team evaluates the site conditions and define the project configuration at site. During the feasibility survey of the mini hydro some permanent marks along the alignment indicating the chainage and reduced level should be erected with concrete where the alignment change directions. After a walkover survey of the project site and finalizing the layout of the project and fixing the locations of major structural components (headworks, canal alignment, forebay, penstock alignment, powerhouse and tailrace alignment), the following works shall be carried out:

1) Establish control points and benchmarks.
2) Carry out close traverse survey to establish required ground control points at various locations in the project area.
3) Carry out topographical survey covering the complete project area. The major structural components should be surveyed in detail. Details of existing features like survey points, streams, forest area, high flood marks, test pits, river banks, cultivated land, foot trails, roads, houses, springs, ponds, electricity supply line, rocky cliff, landslide etc. should be surveyed for mapping.

4) Strip survey of water conveyance route (canal, aqueduct, siphon) with detailed cross sections of cross drainages across the headrace conveyance route (s) and penstock route with coverage of most promising alternatives to produce maps. The width of the survey corridor should be at least 15m on each side from the centre line of the canal alignment.

5) Some permanent marks along the alignment indicating the chainage and reduced level should be erected with concrete where the alignment change directions.

6) River cross section survey should be carried out both at intake and powerhouse/ tailrace sites covering at least 200m upstream and downstream at each site. The intervals should be 50m to 100m depending upon river conditions. High flood marks and existing water levels must be shown in the cross sections. Similarly, the detailed cross-section survey of sites of cross-drainage works shall also be carried out.

7) The survey may include impoundment or peaking pondage area, if any.

8) Access road alignment/distance from roadhead to project site, cross drainage locations should be noted and mentioned in report.

9) Conduct walkover survey along transmission routes using available 1:25,000 scale topo-sheets to compare with socio-environmental settings including forested areas to be crossed for potential alternatives. GPS shall be used for getting coordinates of the transmission line route.

10) The Bench Marks (BMs) reference points should be clearly defined in Topographic maps as well as in the report. The reduced level and co-ordinates shall preferably be transferred from the nearest permanent survey station (National Trigonometric Grid) established by the Department of Survey. Alternatively, benchmarks with an arbitrary reduced level (RL) will be adopted by using RLs from GPS or available topographical maps. A separate reference should be prepared and concrete monuments with embedded nails should be established, as BMs. BMs established on large boulders should be engraved in an encircled cross and the BM number also engraved as enamel paints disappear in a short period. D-cards (description cards) should be prepared for all control points of topographic survey. In addition, the photographs of the control points should be taken to include in the survey report.

11) At least three BMs should be established at headworks (diversion weir, intake and settling basin) site, forebay site and powerhouse site. BMs along headrace canal at an inverval of 1 km shall be established.

2.3.3 Mapping and Plotting

1) Preparation of contour map in 1:5000 scale with contour interval of 5m for the whole project area. All the features must be shown in the contour maps.

2) Preparation of contour maps in 1:200 with 1m contour intervals for diversion weir, intake, settling basin, forebay and spillway, penstock alignment, powerhouse and tailrace canal.

3) Other maps, cross-sections, profiles should be developed according to the scales of relevant drawings required for the detailed feasibility study.

4) Typical construction drawings should be provided by consultant in DFS report. Reinforcement should be provided in percentage.

Table 2.1: Scales of Drawings (Paper Size: A3 Paper)

S.N.	Types of Drawing	Scale	Counter Interval
1	Alternatives Considered	1:5000	5 m
2	General Arrangement of Selected Project	1:5000	
3	Headworks		
	a) General Arrangement	1:500	1 m
4	Diversion Weir and Intake		
	a) General Arrangement	1:200	1 m
	b) Elevations and Sections	1:100	
5	Settling Basin		
	a) Plan	1:200	1 m
	b) Section	1:100	
6	Headrace Water Conduit System		
	a) Plan & Longitudinal Profile	1:2000	2 m
	b) Section	1:200	
7	Forebay to tailrace		
	a) Plan and Profile	1:2000	2 m
	b) Section	1:200	
8	Forebay (Elevations and Sections 1:500)		
	a) Plan	1:200	1 m
	b) Section	1:100	
9	Powerhouse		
	a) General Arrangement	1:500	1 m
	b) Plan and Elevations	1:200	
	c) Sections	1:100	
10	Powerhouse –Switchyard Layout	1:500	
11	Cross Drainage Works		
	a) Plan	1:200	
	b) Sections	1:100	

2.3.4 Transmission Line (T/L) Survey

A walkover survey of transmission routes using available 1:25,000 or 1:50,000 scale topographic sheets should be carried out. The route of the transmission line should be plotted on the map. The GPS coordinates of distinct features and the bends should be recorded and indicated in the route map. Important physical and social/cultural/monumental features falling in the right of way of alignment should be noted down. Socio-environmental impacts of the transmission line (Primary distribution line depending upon actual power to be transmitted and the distance over which such power is to be distributed) should also be assessed. Transmission line can be measured by preparing the T/L profile from the topographical-map. The T/L should be surveyed to each load center.

2.3.5 Site Photographs

1) Photographs of the location of major structures such as weir axis, settling basin site, forebay and powerhouse with date should be taken from various points and angles. The weir axis should be photographed from upstream, downstream and with respect to BMs.

2) The headrace canal and penstock alignment photographs should be from a suitable distance in overlapping sequence from a single position. View from opposite bank is generally preferred.

3) Photographs of cross drainages, landslides, private land, forest, catchment area, test pits for construction materials, location of gauging station, flow measurement activity, load centers, transmission line route etc. should be taken.

4) These days video films of the site are also widely used which will help to check some features during design phase of the feasibility study.

5) While taking photograph of a particular site the coordinates of the site should be recorded and later transferred in the picture.

2.4 Hydrological Investigation

2.4.1 General

The optimum energy production by a mini hydropower is directly proportional to the available flow. The discharge of the plant should be designed at Q80 for isolated mode and Q40 for grid (National/ Local) connected.

Hydrological parameters of the potential sites shall be estimated as per prevailing standard methods. Hydrological parameters that are essential for designing a mini hydropower projects are:

- Long term mean monthly flows for determining installed capacities
- Flood flows for bypassing estimated floods safely
- Construction flood for preventing the project elements during construction

Most of the potential mini hydropower project site streams are ungauged and it is highly recommended that hydrological parameter estimations for such sites shall be based on a series of flow measurements. However gauge can be installed if required.

A preferable method for estimating such ungauged sites is to utilize methods developed for ungauged rivers based on available measured data of the same or neighbouring rivers. The measured data can be:

- Time series data measured by the Department of Hydrology and Meteorology of the same river or neighbouring rivers.
- Spot measurements of the considered river at intake and powerhouse sites.
- Calibrated gauge data of the considered river and corresponding flows.

During field investigations, information on low flows and high floods should be solicited from the senior natives of the project area. The minimum flow experienced and maximum flood marks should be interrogated and noted in the field book for their subsequent analysis. Uses of water in the upstream and downstream should be investigated and confirmed. Information on future program for the use of source river must be collected and water availability for power generation shall be confirmed.

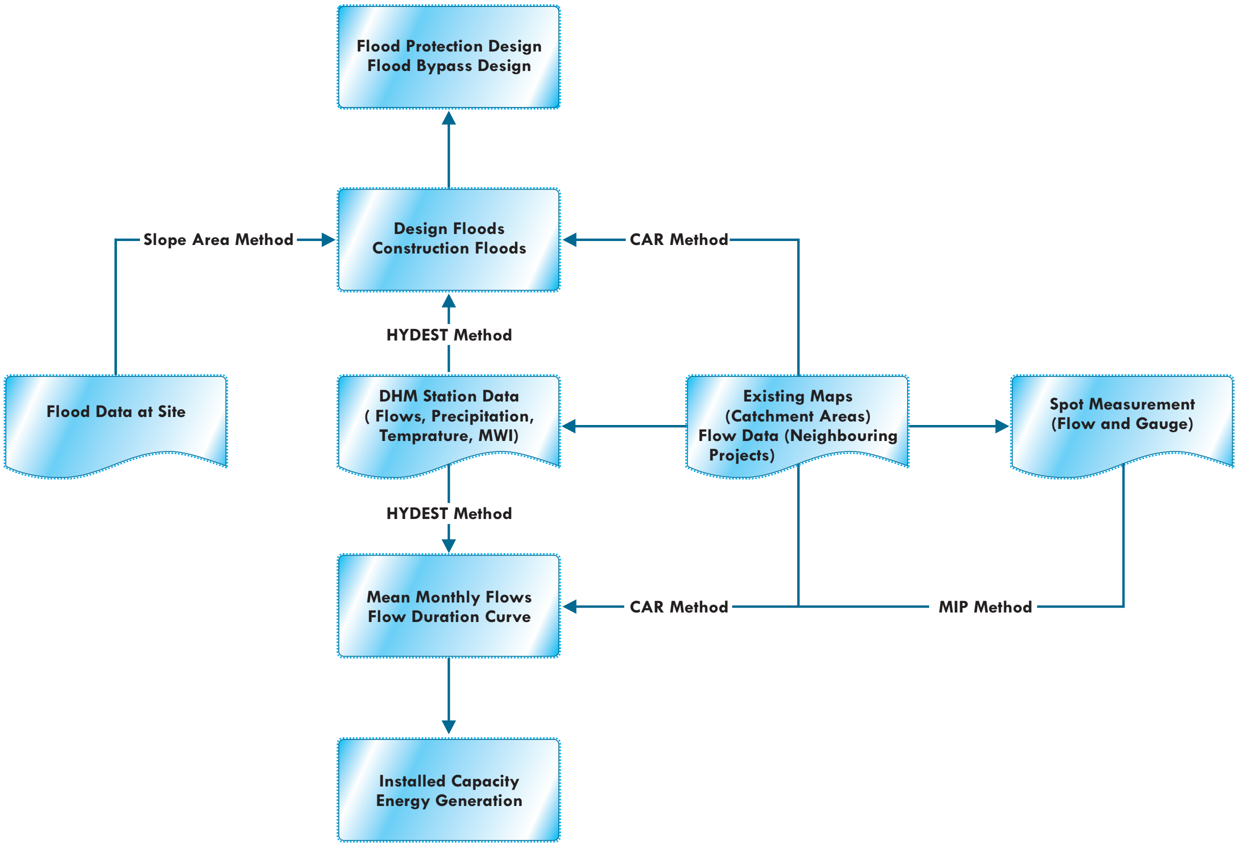


Figure 2.1: Hydrological Parameter Calculations and their uses in Mini Hydropower Projects

2.4.2 Stream flow measurement

Stream flow measurement is the process of measuring discharge (often expressed in m3/s or l/s and often measured in lean seasons) at a particular time at a particular point of a channel of water. Recommended methods of stream flow measurements for mini hydropower projects are:

1. Conductivity Method or Salt Dilution Method (up to 1500 l/s)
2. Current meter (from 1500 l/s onwards)

A site visit should be made between the months of November to May to measure low flow river discharge at the intake site and preferably at the powerhouse site.

Minimum of 3 sets of measurement at a time span of 1 month should be carried out.

2.4.3 Conductivity Method or Salt Dilution Method

Conductivity of water increases with its salt contents and temperature. Flow measurement using conductivity meter, also known as the "salt dilution method", involves pouring a known quantity of salt solution some distance upstream of gauging location (usually 30 to 100m) and measuring the change in conductivity as the salt wave approaches. The salt solution changes the conductivity of the river (as the salt wave travels downstream) and this change in conductivity can be related to the river flow if base line conductivity of the river, the type and amount of salt added and water temperature are known. As the salt wave passes the measurement location, the conductivity of the river returns to its original level (i.e. base line conductivity).

The salt dilution method is quick (generally less than 10 minute per set of measurement), easier to accomplish, reliable and relatively more accurate (less than 7% error) than other methods. This method is suitable for smaller fast flowing streams (up to 1500 l/s). The instrument and accessories are easier for carrying in remote places. In this method, the change of conductivity levels of the stream due to pouring of known quantity of predefined diluted salt (50-300gm per 100 l/s) are measured with a standardized conductivity meter (with known salt constant, k) at a regular interval (e.g., 5 seconds).

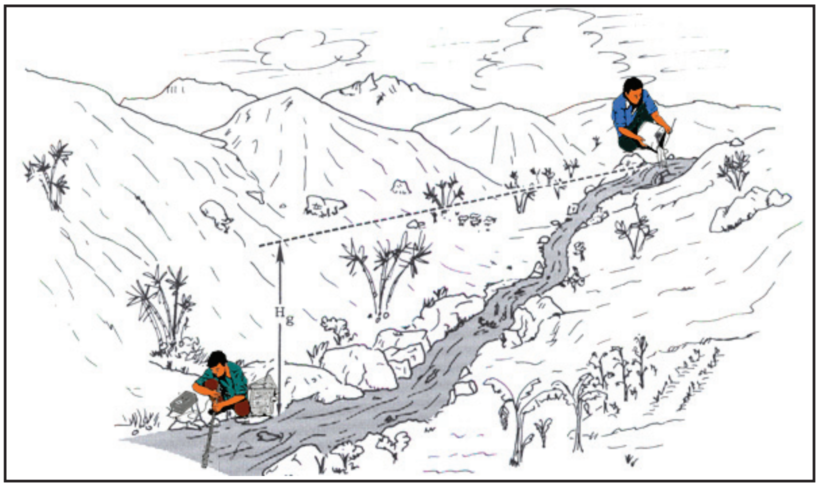


Figure 2.2: Salt Dilution Method

For accurate results, following conditions need to be ensured:

- The salt solution poured upstream must be completely mixed throughout the river cross section before it arrives at the measurement location.
- Stream should be as turbulent as possible.
- The stream section should not have large stagnant pools.
- There should not be any inflows into or outflows from the stream between the points where the salt solution is poured and where the measurements are taken Use of conductivity meter is not recommended to use during heavy raining and flood season.
- The conductivity meter probe should be submerged in fast flowing section of the river.
- The amount of salt stated in the packets is verified. The salt should also be dry and free flowing.
- The salt type / brand should be identical to the one that is used for calibrating the instrument.

Figure 2.3: HACH sensION5 and HANNA HI 933000 conductivity meters

2.4.4 Current Meter Measurement

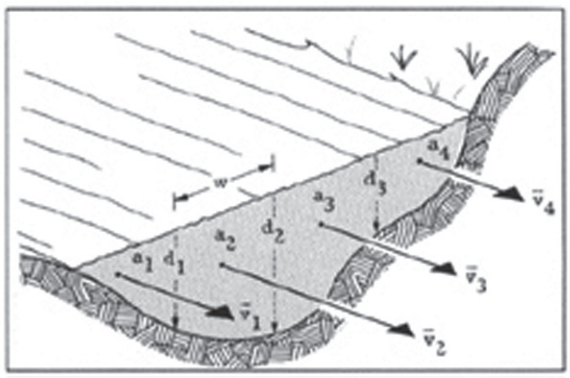
Current meters consist of a shaft with a propeller or cups connected to the end. The speed of propeller is related to the stream velocity at the location of the propeller. Current meters are supplied with their individual velocity formulae relating to their rotational speeds. Generally these devices are used to measure velocities from 0.2 to 5.0 m/s with a probable error of approximately 2%.

This is the most common method for measuring velocities at any depth in larger streams and rivers (Q>1500 l/s) which are not turbulent. Since most of the micro and mini hydropower projects in Nepal utilize less than 1500 l/s of water, and the use of current meter requires well-trained technicians, this method is recommended only for bigger schemes.

In case the velocity of a stream does not vary significantly, an average velocity at a depth of 0.6 of the depth of channel is measured and used as an average velocity. Alternatively, velocity of a deeper section where it is likely that the velocity changes considerably with the water depth, an average of velocities measured at 0.2d and 0.8d is considered as representing average velocity at that section. The average velocity is then multiplied by the cross sectional area of the flow to calculate discharge through that section.

$Q = A * v$

In case the velocities and depth at the considered location vary significantly, the cross section is divided into strips of parallel sections and discharge through these sections are calculated and summed to calculate the total discharge. This method is termed as Mean Section Method. The discharge based on the mean section method is:



$Q = a1v1+a2v2+.....anvn = \sum ai*vi$

Where,

Q = discharge (m3/s)

ai = mean section (m2) = (di-1+d1)/2*w for equally spaced widths

= [(di-1*wi-1) +(di*wi)] /2*w for unequally spaced widths.

wi = strip width

vi = velocity at the mid point of the considered strip = (vi+vi+1)/2, since velocities are taken at di.

There are two types of current meter readings commonly used at present. The traditional one gives revolutions in a specified time. Mean velocities in the given strips are calculated by using number of revolutions within specified time and given four instrument coefficients. Modern current meters are capable of calculating velocities directly.

2.4.5 Flow Estimation Method

The mean monthly flows mentioned in the pre-feasibility study should be verified at this stage by using methods (1) and (2):

(1) Medium Irrigation Project (MIP) Method

(2) Water and Energy Commission Secretariat (WECS)/Department of Hydrology and Meteorology (DHM) Method (HYDEST)

(3) Catchment Area Ratio (CAR) Method if required

2.4.5.1 MIP Method

The MIP method presents a technique for estimating the distribution of monthly flows throughout a year for ungauged locations. For application to ungauged sites, it is necessary to obtain one flow measurement in the low flow period from November to May.

- In the MIP Method, Nepal has been divided hydrologically into seven zones. Once the catchment area of the scheme, one flow measurement in the low flow period and the hydrological zone is identified, long-term average monthly flows can be determined by multiplying the unit hydrograph (of the concerned region) with the measured catchment area.
- Hydrological zone can be identified based on the location of the scheme in the hydrologically zoned map of Nepal.
- For catchment areas less than 100 km2, MIP method is used for better results.

2.4.5.2 WECS/DHM (Hydest) Method

- It is developed for predicting river flows for catchment areas larger than 100 km2 of ungauged rivers based on hydrological theories, empirical equations and statistics.
- In this method the total catchment area, areas between 5000m to 3000m are required as input.
- Flow contribution per unit area (km2) for 5000 to 3000m and from lower elevations, i.e., below 3000m is assumed to be in different proportion during flood. However, for long term average monthly flows, all areas below 5000m are assumed to contribute flows equally per km2 area.
- The monsoon wetness index can be read from a standard monsoon wetness index map (The map is presented in the Expert System, "Hydrology" Worksheet).
- The average monthly flows can be calculated by the equation:

  $Q_{mean,month}$ = C x (Area of Basin)^{A1} x (Area below 5000m +1)^{A2} x (Monsoon Wetness Index)^{A3}.

  Where, C, A1, A2 & A3 are coefficients of the different months and are presented in Table 2.2.
- The catchment area can be calculated from the topographical maps (maps that show contours) once the Intake location is identified..

Table 2.2: Prediction coefficients for long term average monthly flows

Month	Constant coefficient, C	Power, Area of basin (km^2), A_1	Power, Area of basin below 5000 m +1 (km^2), A_2	Power of Monsoon Wetness Index, A_3
January	0.01423	0	0.9777	0
February	0.01219	0	0.9766	0
March	0.009988	0	0.9948	0
April	0.007974	0	1.0435	0
May	0.008434	0	1.0898	0
June	0.006943	0.9968	0	0.2610
July	0.02123	0	1.0093	0.2523
August	0.02548	0	0.9963	0.2620
September	0.01677	0	0.9894	0.2878
October	0.009724	0	0.9880	0.2508
November	0.001760	0.9605	0	0.3910
December	0.001485	0.9536	0	0.3607

2.4.5.3 Catchment Area Ratio Method (CAR Method)

If the two catchments are hydrologically similar, extension of hydrological data for proposed site under study could be done simply by multiplying the available long term data at hydrologically similar catchments (HSC) with ratio of catchment areas and precipitations of base (proposed site under study) and index (HSC) stations. Precipitation and Weighted Catchment Area Ratio (PWCAR) is the most accurate method for estimating mean monthly flows for the desired location. Base station flows under this method are calculated as:

$$Qb = Qi*(Pb/Pi)*((Ai/Ab/Ai)_{>3000} + (Ai/Ab/Ai)_{<3000})/Ai$$

Where,

Q = discharge in m^3/s

P = annual precipitation in mm

A = drainage area in sq.km

Suffix 'b' stands for base station and i stands for index station. Suffix >3000 stands for areas above 3000m and <3000 stands for area under 3000m.

2.4.6 Flow Duration Curve (FDC)

FDC is a curve consisting of a plot of values of stream flow (daily, weekly or monthly) in order of magnitude as ordinates and percent of time as abscissa. The curve shows the flow equaled or exceeded for any desired percentage of time covered by the record. FDC should be used for calculating installed capacity of the plant corresponding to a desired exceedance.

Q% at 0%, 5%, 20%, 40%, 60%, 80%, 95% and 100% of exceedance should be calculated by using total area (ATotal), area below 5000m (A5000A) and monsoon wetness index (MWI) by using following equations:

$$\ln Q_{0\%} = -3.5346 + 0.9398 \cdot \ln(A5000A+1) + 0.3739 \cdot \ln(MWI)$$

$$\ln Q_{5\%} = -3.4978 + 0.9814 \cdot \ln(A5000A+1) + 0.2670 \cdot \ln(MWI)$$

$$\ln Q_{20\%} = -5.4357 + 0.9824 \cdot \ln(A\,Total) + 0.4408 \cdot \ln(MWI)$$

$$\ln Q_{40\%} = -5.9543 + 1.0070 \cdot \ln(A\,Total) + 0.3231 \cdot \ln(MWI)$$

$$\ln Q_{60\%} = -6.4846 + 1.0004 \cdot \ln(A\,Total) + 0.3016 \cdot \ln(MWI)$$

$$\ln Q_{80\%} = -4.8508 + 1.0375 \cdot \ln(A5000A+1) + 0.3739$$

$$\ln Q_{95\%} = -5.4716 + 1.0776 \cdot \ln(A5000A+1) + 0.3739$$

$$\sqrt{Q_{100\%}} = -0.09892 + 0.08149 \sqrt{(A5000A+1)}$$

The percentage of exceedances in between adjacent exceedances presented above are calculated by taking arithmetic mean of them. Q65% can be calculated as:

$$Q_{65\%}=Q_{80\%}+(P_{80\%}-P_{65\%})/(P_{80\%}-P_{60\%})*(Q_{60\%}-Q_{80\%})$$

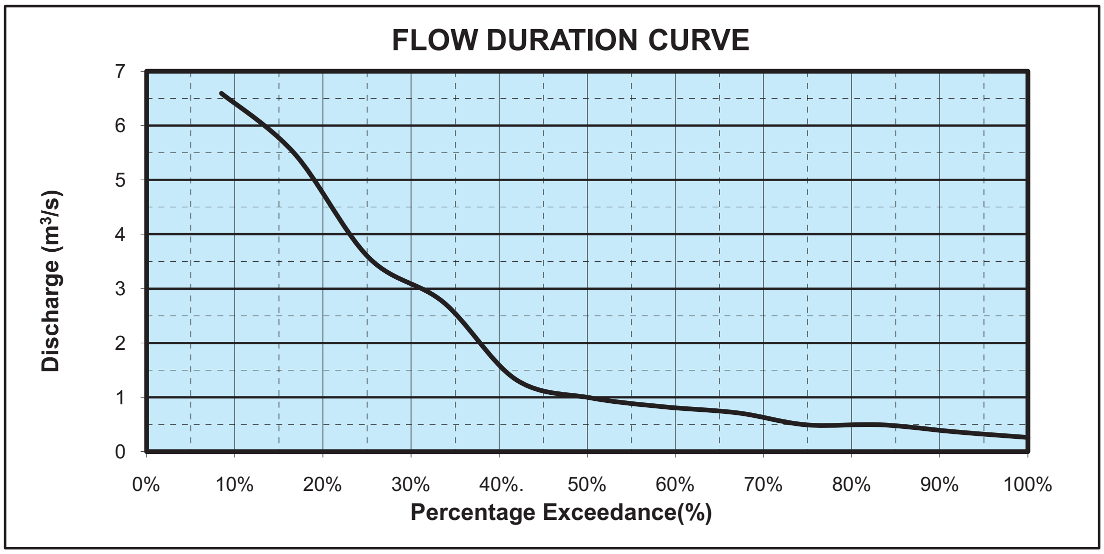


Figure 2.4: A Typical Flow Duration Curve

2.4.7 Flood Flows

The catchment area below 3000 m contour line is used for the estimation of floods of various return periods. 3000m elevation is believed to be the upper elevation that is influenced by the monsoon precipitation. This method has to be used with caution for catchments having significant areas above snowline. The 2-year and 100-year flood can be calculated using the following equations:

$$Q_{2\ daily} = 0.8154 \times (A3000A + 1)^{0.9527}$$

$$Q_{2\ inst} = 1.8767 \times (A3000A + 1)^{0.8783}$$

$$Q_{100\ daily} = 4.144 \times (A3000A + 1)^{0.8448}$$

$$Q_{100\ inst} = 14.630 \times (A3000A + 1)^{0.7342}$$

The construction flood should be considered as the highest monthly flows from November to

$$Q_F = e^{\left(\ln Q_2 + S \cdot \sigma_{\ln Q\ F}\right)}$$

$$\sigma_{\ln QF} = \frac{\ln\left(\frac{Q_{100}}{Q_2}\right)}{2.326}$$

May. Flood peak discharge, QF, for any other return periods can be calculated using:

Where, S is the standard normal variant for the chosen return period, from Table 2.3,

Table 2.3: Standard normal variants for flood

Return period (T) (yrs)	Standard normal variant (S)
2	0
5	0.842
10	1.282
20	1.645
50	2.054
100	2.326

2.5 Geology and Geotechnical Study

2.5.1 General

The detail feasibility study should cover the geological and geotechnical studies. Fairly larger area should be investigated upstream and downstream of the identified project site with different alternatives to arrive at most appropriate and economical layout. The site conditions should be evaluated from construction and operation point of view.

The main objectives of geological study of a mini hydro project can be summarized as:

- To obtain information on regional geology of the project area
- To study detailed geological conditions of locations of proposed hydraulic structures
- To prepare detailed engineering geological map (1:2,000), geological cross sections of the locations of major project structures like the dam axis.
- To investigate geomorphological condition of the project area
- To clarify the geology and stability condition of the canal and pipe alignment
- To assess the slope stability of the project areas
- To carry out construction material survey and testing in needed

2.5.2 Regional Geological Study

Following procedures should be carried out to investigate regional geological characteristics of the project:

1) Collect and review geological reports, maps and literatures on the regional basis in which the project area lies. Maps prepared by Department of Mines and Geology for the project area should be studied for general study and further study/ investigation should be taken up to meet the requirements based on specific site conditions and the nature and size of project.
2) Locate the project area in the regional geological map that reflects the rock types and regional geological structures in the project area in the scale 1:10,000 or in other scales available.

2.5.3 Investigation and Observation

2.5.3.1 Geological Map and Geomorphology of the major hydraulic structure

Geological map of the particular sites of major hydraulic structures in the scale 1:200 shall be prepared. Features to be noted in such a geological map include:

- rock outcrops
- rock type
- orientation of bedding and joint planes
- weathering condition of rock mass
- spacing of joint planes
- fracture intensity of rock
- landslides
- erosion of land mass by river, wind, glacier, etc.

- ground water condition
- type and nature of recent deposit such as alluvial deposit, colluvial deposit, glacial deposit, or any other type
- composition of deposited materials, degree of compaction, suitable for slope cutting
- permeability in recent deposit, and
- estimation of bearing capacity for foundation of hydraulic structures.

2.5.3.2 Collection of Geological and Geomorphological Information

Collection of geological and geomorphologic information should include rock type, orientation of bedding, joint planes, degree of weathering in case of rock out crops and geomorphic features should include the description on landslides - type and nature, active or passive, size, slope failure type, and vulnerability to the hydraulic structures.

2.5.4 Construction Material Survey

Construction material survey mainly consists of estimation of local construction materials at site and evaluation of their quality for construction purpose through laboratory tests.

Potential sites for borrowing local construction materials that are required for construction of civil structures shall be identified and marked in a proper map.

Types of deposits of fine and coarse aggregates are:

1) Alluvial deposit
2) Colluvial deposit
3) Other type of deposits

Following measures shall be taken while carrying out construction material surveys:

- Note the predominant rock types in boulder composition and estimate the quantity of aggregate formation after crushing the natural boulders.
- Measure the length and width of deposit and calculate the area of deposit.
- Confirm the thickness of deposit by digging pits in a density of one number in every 100 m2 in uniformly distributed deposit. Otherwise, increase the density of test pits to the required numbers in case of lateral changes in deposit. Size of test pit should be at least 2 m x 2 m and shape should be tapering at the bottom to avoid sidewall collapse.
- Quantify the volume of materials excavated from each pit and separate the different materials like sand, gravel and boulders in percentage by volume.
- Take an average of different type of construction materials from all test pits within an identified deposit.
- Confirm the total quantity of reserve for extraction of sand, gravel and boulders for production of aggregates.

2.6 Socio-economic Aspects

2.6.1 Introduction

The socio-economic data required for a mini hydropower development includes the collection of village profile data, identification of potential beneficiaries, load centres, economic and financial conditions of the beneficiaries and other relevant data.

2.6.2 Data/Information Requirement

For initiation of a mini hydropower project data/information specific to the project site needs to be collected. This has to be done through collection of information from the potential beneficiaries. The following information should be included.

2.6.2.1 General socioeconomic information

General socio economic information shall be collected for preparing baseline information of the project so that the indicators can be compared before and after the installation of the mini hydropower project. Following information shall be included in the baseline surveying:

1) ***Identification:*** Identification of the location of the Scheme and the beneficiary areas – specifically the load center where the Focus Group Discussion (FGD) is conducted.
2) ***Site Information:*** Information regarding the distance from the nearest road head and an airport to the project site and load centres.
3) ***Income Level:*** The income level of the households of the load centers has been categorized into High, Medium and Low levels as perceived by the participants of the FGD in the respective load center. This should be taken as the baseline information for comparison in subsequent periodic FGDs.
4) ***Economic Activities:*** Activities related to agriculture, livestock, cottage industry, remittance, agriculture production, industry and craft, business entities etc. should be recorded.
5) ***Infrastructure:*** The infrastructure available at the time of the FGD should be recorded under the Public Services heading.
6) ***Local Level Capacity:*** Local level capacity implies to the available trained work force within the beneficiary communities.
7) ***Education:*** Access to education and the annual dropout of students should be filled in.
8) ***Consumption of Energy:*** Consumption of different kinds of energy should be filled in.
9) ***Development activities:*** The development activities expected in the immediate future.
10) ***Willingness to Pay:*** The willingness to pay for electricity use as reported by the potential beneficiary during the FGD.

2.6.2.2 Load Demand Forecast: The load demand forecast shall be carried out based on the socio-economic Focus Group Discussion. The inputs for the load demand forecast are as follows:

1) ***Total number of households:*** The total number of households of the proposed load centers is estimated based on the response of the Focus Group.
2) ***Base Year population:*** The total population of the proposed load centers is estimated based on the VDC records and then verified by the Focus Group.

3) ***Average household size:*** The average household size has been calculated based on the number of households and the population of the load centers.

4) ***Income level of households:***
   - Low income group: households have been estimated on the basis of Focus Group response.
   - Middle income group: households have been estimated on the basis of Focus Group response.
   - High Income group: households have been estimated on the basis of Focus Group response.

5) ***Annual growth of the income groups:*** Annual growth of the income groups will either be based on the district level figures as far as possible or if not we will have to be satisfied with the national level figures. The national level figures are biased towards the richer city areas of the country. Therefore, such statistics may not properly reflect the conditions of the poor rural areas. Commercial establishment units are based on the responses of the Focus Group.

6) ***Industrial establishment units:*** Industrial establishment units are based on the responses of the Focus Group.

7) ***Street light units:*** Street light units are based on the responses of the Focus Group.

Based on the above mentioned data input the domestic, commercial, industrial and street light demand has been estimated.

2.6.2.3 Local administration including VDC, DDC and other organizations

An inventory of existing institutions and organizations in the load centers will be made based on the responses of VDCs, DDCs and the Focus Group.

2.6.2.4 Productive End Use Possibilities

End use possibilities should be accessed during the site visit and stated in the report. The primary use of mini-hydropower in isolated scheme in the rural context of the country is for household lighting. Thus, in order to optimise the use of the mini-hydropower plant and increase its financial viability, the installed capacity should be governed by household demand and end uses. The capacity of the project for the purpose of the subsidy shall be based 200 watt and 400 watt at maximum if end uses demands. However, the developer may develop the project higher than that capacity, provided that the financial viability can be demonstrated.

In order to access the power requirements, the number of beneficiary households, the average power demand per household and end uses should be determined based on discussions with the community or Focus Group Discussion. Attempts should be made to strike a balance between the technical aspects of the scheme and the demand of for electricity. Similarly, the type of end uses, their capacities and expected annual operating time based on local resources available and market opportunity should be determined. The prospective entrepreneurs willing to install the various end uses should be identified at the detailed feasibility stage. The DFS survey team should collect information from the field visit as shown in annex D2.

2.6.2.5 Gender Equality and Social Inclusion

Gender Equality and Social Inclusion is necessitated by the fact that an overwhelming number of citizens are systematically deprived of their fundamental human rights and their rights to development due to existing inequalities in Nepali society. GESI approach undertaken as development intervention challenges the old ways of working and endorses innovative measure to overcome the hurdles of gender inequality and social exclusion. This approach assesses the key issues hindering the agency, access and articulation of women, poor and socially excluded group in the participation and benefit sharing, and then devises strategy to address these issues. It plays a vital role to narrow down the existing gaps between women and men belonging to various social groups (vertically in social hierarchy and horizontally in gender hierarchy). Therefore GESI is an indispensible intervention approach widely applied for equal access and control on development inputs and its benefits provided by the nation or development projects. The DFS survey team should collect informations from the field visit as given in annex D3.

2.6.3 Community Benefit Assessment

Methods of qualitative and quantitative assessment of benefits of the project to the local communities shall be demonstrated based on socio-economic evaluation. This assessment will give the picture of what the local people will gain (direct & indirect benefits) from the development of the indigenous resource.

Indirect benefits begin to accrue only after the plant construction is completed and the actual production of electricity has started. These benefits are also known as the impacts of electrification. The expected benefits from electricity use are enumerated as follows:

a. Upliftment of Industrial and Commercial Activities

The industries and commercial enterprises that are presently based on imported fuel as their basic inputs are expected to switch over to electricity in their functioning. For example, diesel based mills will change over to more cheaper and reliable form of energy input, i.e. electricity. Moreover, the stable supply of electricity at reasonable price is expected to augment new ventures (such as furniture making, printing press etc.) using electricity as input in the project area.

b. Employment Creation

The implementation of the proposed project is expected to increase employment of skilled and unskilled local human resource during the construction and operation period of the power plant. Employment is further generated through increased hiring of laborers in the new industrial and commercial establishments that are likely to emerge after the introduction of electricity in the proposed load centers. Thus, the jobs created by the introduction of electricity would obviously increase the income level of the local population.

c. Cost Savings

Presently kerosene is being purchased by the rural folk for lighting purposes. The expenditure on kerosene is expected to be minimum once cheaper and more accessible electricity will substitute kerosene consumption.

d. Improved Infrastructure

The construction of trails/roads to the project site will allow greater economic mobility. The availability of telephone, and the movement of staff and other people lead to create markets, in the area covered by the power plant. However, depending upon the conditions of the target areas, not all of the indirect benefits listed above may convert into actual realization. Therefore, in order to assess the future indirect benefits present activities, future plans and the priority needs of the communities should be taken into consideration.

Direct benefit to the project includes income generation by selling electricity to the beneficiaries, end users within the community and bulk sale of electricity to the utility companies such as NEA.

2.7 Environmental Considerations

A hydropower project scheme entails change in the use of land and water. Magnitude of such change depends upon the selected site configuration and the capacity of the project.

Environment Protection Act, 1997 and Environment Protection Rule, 1997 do not make Environmental Impact Assessment (EIA) or Initial Environmental Examination (IEE) mandatory for hydropower project less than 1000 kW of installed capacity. Although the adverse environmental impacts of individual mini hydro project is generally not very significant, the aggregate effects of several such projects in vicinity could be of magnitude to cause adverse impact to the environment. Therefore, environmental impact due to implementation of such projects shall be considered in the detailed feasibility study of mini hydropower projects. Environmental Study for a mini hydropower project shall identify key impacts, predict magnitude, extent and duration of impacts as well as suggest monitoring and mitigation/enhancement of impacts for project sustainability. In this connection, the environmental considerations should meet the environmental guidelines of AEPC.

2.7.1 Baseline Data Collection of Existing Environmental Conditions

Baseline condition is defined as the description of existing condition at a point in time against which subsequent change can be examined, predicted and confirmed by monitoring. In other words, baseline condition provides the pre-project record.

Baseline study refers to the collection of background information on the existing physical, biological, socioeconomic and cultural environment of the proposed project area including changes that are expected.

For environmental assessment of the proposed project, the baseline conditions for the physical, biological, socio-economic, and cultural environment of the project area should be found out and documented for future records. The major categories of the environment likely to be included in environmental report of mini hydro are the following:

2.7.1.1 Physical Environment

a. **Topography:** general gradient of the river, slope of the river, general terrain condition of the project area
b. **Geology:** geological setting, status of geological stability or instability, characteristics of surface deposit, land slide and soil erosion
c. **Meteorology and Hydrology**
   i. meteorology: different climatic regimes, temperature, rainfall
   ii. hydrology: hydrological character, flow regimes, river discharge

2.7.1.2 Biological environment

Forest management practice, vegetation type and composition

2.7.1.3 Socio-economic and cultural environment

a. **Demography:** estimated population, population characteristic
b. **Social setting:** Social structure of community (cast, ethnicity, religion), social practice, housing pattern, settlement pattern in core and immediate area
c. **Gender issue:** role of women in society, their responsibility
d. **Infrastructure:** road, track, bridge, water supply system etc.
e. **Education:** literacy rate, education facility

f. **Community resource:** resource commonly used by community
g. **Economic characteristic:** income, expenditure, skill level, occupation, employment, market
h. **Health and sanitation:** health facility, institution, common diseases, sanitation condition
i. **Water use right:** existing and proposed consumptive and non-consumptive uses of river water
j. **Land use:** existing land use pattern (farmland, barren land, settlement, forest)

2.7.2 Methodology of Data Collection

Base line information can be collected from maps, reports and field study, questionnaire survey such as checklist, inventory and sampling depending upon the nature of the project. Primary data/ information related to the environmental attributes like air, noise level, water quality, data related to geomorphology are collected from field studies. A structural as well as semi structural questionnaire and group discussion, key informant interview with local persons is used for collection of primary information on socio-economic aspects. Ecological information is collected from field studies as well as secondary sources. The following methodology can be adopted for the data collection:

Desk Study

Collect information and data from maps, Central Bureau of Statistics (CBS) and Department of Hydrometeorology (DHM) data, district profile, VDC profile, published and unpublished literatures related to project, report of similar project elsewhere etc.

Field Work

The Study Team should visit the project area to observe, collect and analyze data/information of the project area. The works should be carried out using the following methods:

- Walkover survey
- Sampling
- Interviews/group discussion
- Checklist/questionnaire

Indicative component of physical, biological, socio-economic and cultural environment that are taken into account while recording the existing environmental condition of the project area are given below

Public Consultation

Public consultation refers to the process by which the concerns of local affected persons and others who have plausible stake in the environmental impacts of the project or activity are ascertained with a view to taking into account all the material concerns in the project or activity design as appropriate. A stakeholder is any individual, group, agency or organization affected by a project and/or with concern or interest in a development project and its outcomes, or in common resource impacted by a development project. A stakeholder should be treated as a "partner in development" and not as opponent of the project.

The list of prospective stakeholders includes some or all of the following. In every category, gender issue must be given proper consideration; both women and men should be represented in activities.

- Affected local individuals, communities or households
- Elected officials of concerned VDC/Municipality
- Concerned business people and entrepreneurs
- Local NGOs

- Local influential individuals from affected area, such as informal or traditional community heads, school teachers, healers, social and religious leaders and other notable women and men
- Health workers
- Social workers
- Project developer/proponent themselves

Generally speaking those most directly affected by a project are clearly among the key stakeholder-they are at the greatest risk, they feel the impacts most intensely, they benefit the most from opportunities; hence, they should be the first to be involved. Since local people will be stakeholder for most part of the life of a project, their involvement and participation from the beginning is crucial to project success. Therefore, at least one public consultation meeting should be conducted in the project area.

Data Analysis

The information and data collected from the fieldwork should be compiled and analyzed to establish the relation between the environmental impacts and their mitigation measures due to construction and operation of the proposed project. Based on the data analysis, conclusion shall be drawn on the resolution of environmental issues and practical action for environment protection of the project area.

2.7.3 Environmental Impacts of mini hydropower project

Magnitude of environmental impacts of mini hydropower project implementation depends upon the selected site configuration and the capacity of the project. A mini hydropower project covers relatively small area and has low impact on existing environment (positive or favorable and negative or unfavorable) in nature than larger projects. The environmental impact due to implementation of mini hydropower project construction activities are summarized in Table 2.4:

Table 2.4: Environmental Impacts of Mini hydropower project

Activity	Address Impact
Construction of diversion weir, approach canal, desander, headrace canal or headrace pipe, penstock, powerhouse, switchyard, project accessories, access road	**Physical environment** • Soil erosion and chances of landslide due to removal of tree and cutting existing slope and filling of loose excavated materials • Surface erosion from excavated material filling site • Change in land use pattern • Deterioration of surface water due to surface runoff from excavated site **Biological Environment** • Loss of forest and vegetation • Exploitation of none timber forest product **Socioeconomic Environment** • Acquisition of private as well as governmental land • Visual intrusion caused by construction activities • Destruction and destroyed recreational spots (e.g. water fall) and activities • Raised social issues from the migrated work force
Construction of transmission line	• Fragmentation of forest due to right of way clearing • Visual intrusion • Restricted private land acquisition
Operation of the project	**Physical Environment** • Landslide triggering from instability site • Deposition of sediment on dewatering zone due to flushing of desander **Biological Environment** • Barrier effect on migratory fish species from constructed weir • Barrier on wild life movement **Socio-economic and cultural environment** • Issue on downstream water right • Issue on public health

The environmental implication may be beneficial or adverse, but the main objective of impact identification is to specify area that are likely to be affected by the implementation of the project. Environmental work related to the mini hydro project starts at the time of detailed study of the proposal. At the same time potential environmental impact should be analyzed and predicted from analysis of field as well as secondarnny data of existing environment against development activities. A matrix should be developed showing environmental issues, impact, impact predictin, mitigation measures and mitigation cost as shown in annex D4.

3 TECHNICAL DESIGN AND ANALYSIS

3.1 General Features of Hydropower Projects

Most of the mini hydro schemes are of run-of-the-river types. In a run-of the-river scheme, the natural run-off of the source river is used for power generation in real time and no significant storage is envisaged. Therefore, the power generation in such projects depends directly on the available flow in the river.

A typical run-of-the-river project consists of a headwork, a conveyance system (headrace pipe or canal), desander, a forebay, penstock pipes connecting to the powerhouse, a switching and protection system and a transmission/distribution system. As far as possible preference should be given to construct the intake, desilting basin and forebay at the source adjacent to the river source and start the penstock right from there to reduce the overall cost. Categorically, they can be divided into civil work, hydro-mechanical work, electro-mechanical work, transmission/distribution system and the user segment (utilization). For a mini hydro based on Q80 double unit electro-mechanical equipment is recommended.

3.2 Human resources

A typical technical design team should consist of following human resources:

- Civil engineer
- Mechanical engineer
- Electrical engineer
- Structural engineer
- Draft person and
- Others as required

3.3 Civil Works

3.3.1 Headworks

A headworks consists of all structural components required for safe withdrawal of desired water from a source river into a canal/conduit. Weir, intake, protection works, desilting basin, forebay etc., are the main structural components. Preference should be given to construct structures like intake, desilting basin and forebay at the source adjacent to the river source and start the penstock right from there so as to minimize cost. Those structures should also be designed using M 25 reinforced concrete. Indicators of an ideal headworks can be summarized as:

1. Withdrawal of desired flows (i.e. Qdiverted and spilling in case of flood).
2. Sediment bypass of diversion structure (Continued sediment transportation along the river).
3. Debris bypass (Continued debris bypass without any accumulation).

4. Hazardous flood bypass with minimum detrimental effects.
5. Sediment control at intake by blocking/reducing sediment intake into the system.
6. Settling basin control (settling and flushing of finer sediments entered into the system through intakes or open canals).

3.3.2 Diversion Weir

A weir is a structure built across a river to raise the river water and store it for diverting a required flow towards the intake.

It is recommended that the weir be 5m to 20m d/s of side intake. This will assure that water is always available and there is no sediment deposition in front of the intake. A narrow river width with boulders is preferable for weir location.

Mini hydropower project weir shall be of permanent (concrete/stone masonry) or semi-permanent (Gabion weir with concrete/plastic core) or even temporary (not recommended).

In case a temporary weir shall be constructed, it should be used for diverting maximum flow of 1 m3/sec.

3.3.2.1 Temporary Weir

a) Temporary weir is constructed using boulders available at the site, stone masonry in mud mortars placed across a part or all of the river width.
b) It is simple and low cost but it is not possible to divert all of the river flow in dry season by this structure.
c) It is suitable only for the diversion of flows below 1 m3/sec

3.3.2.2 Semi Permanent Weir

a) Gabion structures can be used as semi permanent weir.
b) If there is no significant boulder movement along the river stretch at the intake area.
c) Differential settlements under the weir foundation resulting in uneven settlement. Semi permanent weir should tolerate some ground movement without significant damage on its body
d) As the gabion weirs are more vulnerable to damage by moving boulders, it cannot be used in the steep streams, which carry such boulders.
e) Seepage can be controlled by using an impermeable membrane.

3.3.2.3 Permanent weir

a) If flow is limited during dry season and river carries large boulders permanent weir may be built across the river.
b) The foundation of the permanent weir should be laid on rock foundation so as to avoid seepage/water piping and scouring problem.
c) These are constructed of mass concrete, stone masonry in cement mortar and using plum concrete. The surface should be constructed with abrasion resistant concrete.
d) A reinforced concrete surface layer may be provided to protect the weir body from damage by boulders moving in flood season.

e) A permanent weir should be considered in the following conditions, if:
   i) large boulders movement occurs in the river at the weir site.
   ii) the river bed is not eroding, aggrading or shifting course.
   iii) there is a scarcity of flow in dry season.
   iv) there is sufficient fund for construction.
   v) the site is not in remote areas.

f) Factors to be considered during design of weirs:
   i) If a weir across part of the river width is sufficient, it should not be extended across the entire width.
   ii) The weir length should allow safe passage of design flood.
   iii) The weir height should be as low as possible but should be such that the water level rises above the upper edge of the intake mouth.
   iv) The weir profile should be such that it is possible for the bed load to move the boulders to roll over it.

g) The weir design should include the following factors:
   i) Seepage control
   ii) Safety against scour
   iii) Safety on bearing capacity of the foundation
   iv) Stability against overturning and sliding

3.3.2.4 Undersluice

An undersluice bypasses sediment to the downstream of the weir preventing accumulation and subsequently entering into the conveyance system. It is provided close to the intake to flush out the sediments deposited in front of it and thus control the bed levels in its approach area. It should have following characteristics:

a) Maintain a guided and uniform flow in front of intake
b) Enable the intake to draw desired discharge during normal flow in the river with no or insignificant suspended sediments
c) Scour and sluice the sediment deposited in front of the intake
d) Pass the pre-monsoon flood and part of the high flood during monsoon.

3.3.3 Intake

An intake can be defined as a structure that diverts water from river or other water course to a conveyance system downstream of the intake. Side intake and bottom intake are the common types of river intakes that are used in Nepali hydropower schemes.

Conveyance Intake is an intake, which supplies water to a conveyance other than the pressure conduit to the turbine. Power Intake is an intake, which supplies water to the pressure conduit to the turbine.

3.3.3.1 Side Intake

A structure built along a river bank and in front of a canal / conduit end for diverting the required water safely is known as a side intake. Side intakes are simple, less expensive, easy to build and maintain.

3.3.3.2 Bottom/Drop/Tyrolean/Trench Intake

A structure built across and beneath a river for capturing water from the bed of a river and drops it directly in to a headrace is known as a bottom intake. They are mainly useful for areas having less sediment movement, steeper gradient, and surplus flow for continual flushing. Inaccessibility of trashrack throughout the monsoon season and exposure of the system to all the bed load even though only a small part of the water is drawn are the common drawbacks of drop intakes.

Side intakes are suitable for all types of river categories whereas the drop intake is recommended for rivers having longitudinal slopes more than 10% with relatively less sediment and excess flushing discharge. The side intake is generally of rectangular orifice type with a minimum submergence of 50mm. The side intake should be at:

- Straight river u/s & d/s of the intake.
- Alternatively, on the outer side of the bend to minimize sediment problems and maximize the assured supply of water.
- Relatively permanent river course.
- By the side of rock outcrops or large boulders for stability and strength.

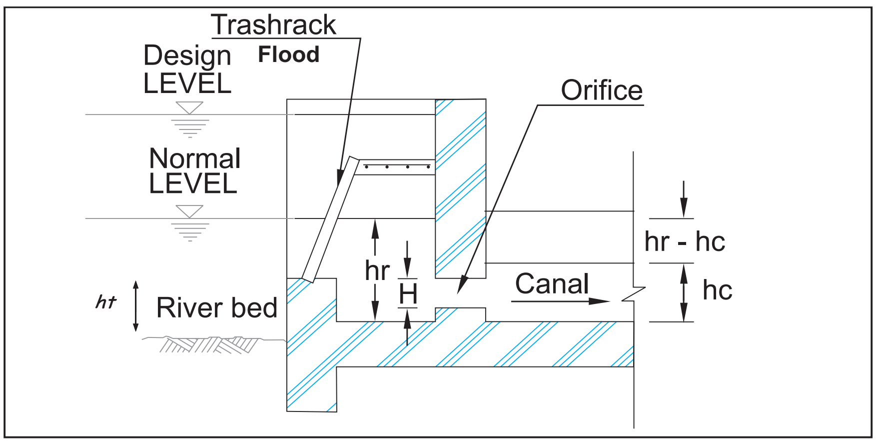


Figure 3.1: A Typical Side Intake

According to the flushing requirement and tentative losses, the intake has to be oversized to allocate an excess flow of 10% to 20% (or Qdiverted).

A coarse trashrack should be provided to prevent big boulders and floating logs from entering into the headrace system. Placing of trashrack at 3V:1H is considered to be the optimum option considering the combined effect of racking and hydraulic purposes

A gate/stop log should be provided to regulate flow (adjust/ close) during operation and maintenance.

To optimize downstream canal and other structures, a spillway should be provided close to the intake.

3.3.4 Sediment Handling Structures

Gravel trap and settling basin are the sediment handling structures at headworks. Forebay is the sediment handling structure provided at the end of the headrace system or at the start of the penstock system.

A settling basin traps sediment (gravel/sand/silt) from water and settles down in the basin for periodical flushing back to natural rivers. Since sediment is detrimental to civil and mechanical structures and elements, the specific size of specified percentage of sediment has to be trapped, settled, stored and flushed. This can only be achieved by reducing turbulence of the sediment carrying water. The turbulence can be reduced by constructing settling basins along the conveyance system. Since the settling basins are straight and have bigger flow areas, the transit velocity and turbulence are significantly reduced allowing the desired sediments to settle. The sediment thus settled has to be properly flushed back to the natural rivers.

Thus a settling basin:

1. Prevents blocking of headrace system assuring desired capacity of the system.
2. Prevents severe wearing of turbine runner and other parts.
3. Reduces the failure rate and O&M costs.

According to the location and function, a settling basin can be of following types:

1. Gravel Traps for settling particles of 2mm or bigger diameter.
2. Settling Basins for settling particles of 0.2mm or bigger diameter.
3. Forebays for settling similar to settling basin (optional) and smooth flow transition from open flow to closed flow.

Mini and small hydropower settling basins are of concrete (M20 or higher). However, for functionality, all settling basins should have following components:

1. Inlet Zone: An inlet zone upstream of the main settling zone is provided for gradual expansion of cross section from turbulent flow to smooth/laminar flow.
2. Settling Zone: A settling zone is the main part of a settling basin for settling, deposition, spilling flushing and trash removal.
3. Outlet Zone: An outlet zone facilitates gradual contraction of flow to normal condition.

A typical section of a settling basin with all the components (inlet, transition, settling and outlet zones) and accessories (spillway, gate) is presented in Figure below.

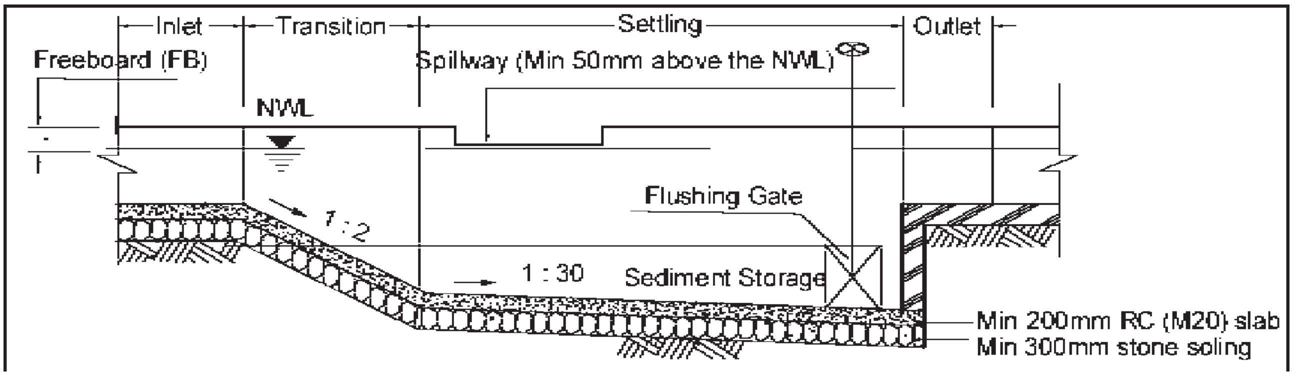


Figure 3.2: A Typical Setting Basin

The requirements for designing sediment settling basins are described below.

3.3.4.1 Gravel Trap

General requirements for designing a gravel trap are below:

1. Location: Close to intake and safe and in between intake and settling basin.
2. Dimensions: Sufficient to settle and flush gravel passing through upstream coarse trashrack.

3. Spilling: Sufficient spillway/vertical flushing pipe.
4. Spilling and flushing: back to the river.
5. Material: 1:4 cement stone masonry with 12mm thick 1:2 cement plastering on the waterside or structural concrete.
6. Recommended settling diameter and trap efficiency are 2mm and 90% respectively.
7. Sediment storage zone: Adequate storage for 12 hours minimum (flushing interval).
8. Drawdown: Drawdown discharge capacity should be at least 150% of the design discharge.
9. Aspect ratio (straight length to width ratio): 1.5 to 2 for micro-hydropower gravel trap. The recommended aspect ratio of mini and small hydropower gravel trap is 4.

3.3.4.2 Settling Basin

General requirements for designing a settling basin are outlined below:

1. Location: Close to gravel trap/Intake.
2. Dimensions: Sufficient to settle and flush the designed sediment size.
3. Spilling: Sufficient spillway/vertical flushing pipe (layout dependent).
4. Spilling and flushing: back to the river.
5. Material: 1:4 cement stone masonry with 12mm thick 1:2 plastering on the waterside or structural concrete.
6. Recommended settling diameter (trap efficiency) and head are presented in Table 13.1

Table 3.1: Settling diameter, trap efficiency and gross head

Gross Head (m)	Particles to settled (mm)	Trap Efficiency %
Up to 10m	0.50	(90%)
10 - 50m	0.30	(90%)
50 - 100m	0.25	(90%)
100 -300m	0.20	(90%)
>300m	0.15	(90%)

7. Sediment storage zone: Adequate storage for 12 hours (flushing interval)
8. Drawdown: Drawdown discharge capacity should be at least 150% of the design discharge.
9. Aspect ratio (straight length to width ratio): 4 to 10.

3.3.4.3 Forebay

Following criteria have been outlined for designing a forebay:

1. Dimensions and functions: Similar to settling basin if upstream system is of open type or the forebay functions as a combined settling basin cum forebay.
2. Submergence: Sufficient to prevent vortex (i.e. 1.5 * v2/2g).
3. Active Storage: At least 15 sec * Qd. Active storage capacity should be based on closing time of turbines.
4. Freeboard: 300mm or half the water depth whichever is less.
5. Drawdown: A drain pipe/Gate.
6. Spilling capacity: Minimum of spilling Qd during load rejection.

7. Fine Trashrack:
   a. At the entrance of the penstock
   b. Inclination: 3V:1H
   c. Bars: Placed along vertical direction for ease of racking.
   d. Clearance: 0.5 * nozzle diameter in case of Pelton or half the distance between runner blade in case of Crossflow/Francis.
   e. Velocity: 0.6 to 1 m/s
   f. Weight: =< 60kg (porter load) for transportation by porters.

3.3.5 Headrace/Tailrace cannel

A headrace or a tailrace can be defined as a conveyance system that conveys designed discharge from one point (e.g. intake) to another (e.g. forebay). Generally canal systems are used in all mini hydropower schemes whereas pipe systems or tunnel system are used for specific e.g. difficult terrain. A canal can be unlined (earthen) or lined (stone masonry or concrete). Rectangular and trapezoidal canal cross sections are mostly used profiles. Pipes used in MiniHP can be of HDPE or mild steel and it can be either open or buried.

Mild steel headrace-cum-penstock pipes is getting popularity in mini and small hydropower schemes in Nepal. Because of the easier sediment handling facility and better financial parameters, a layout with headrace-cum-penstock pipe has been adopted in many micro, mini and small hydropower projects in Nepal.

For computing head losses, Manning's equation is used for canal whereas Darcy-Weisbach equation is used for pipe.

General requirements for designing canal and pipe headrace systems are outlined below.

3.3.5.1 Canal

a) Capacity: The canal should be able to carry the design flow with adequate freeboard and escapes to spill excess flow. A canal should generally be designed to carry 110 to 120 % of the design discharge.

b) Velocity: Self-cleaning but non erosive (≥ 0.3m/s).

c) Unlined canal: In stable ground for Q ≤ 30 l/s

d) Lined canal: For higher discharge and unstable ground. Canals with 1:4 stone masonry or concrete are recommended. Care should be taken to minimize seepage loss and hence minimize the subsequent landslides.

e) Sufficient spillways and escapes as required.

f) Freeboard: Minimum of 300mm or half of water depth.

g) Stability and Safety against rock fall, landslide & storm runoff. A catch drain running along the conveyance canal is recommended for mini and small hydropower projects.

h) Optimum Canal Geometry: Rectangular or trapezoidal section for lined canal and trapezoidal section for unlined canal are recommended. Unequal settlement of lined trapezoidal canal should be prevented.

3.3.5.2 Pipe

a) PVC/HDPE/GRP: Buried at least 1m into ground.

b) Steel/Cast Iron: As pipe bridge at short crossings/landslides. They are also used for low pressure headrace and headrace-cum-penstock alignments.

c) Pipe inlet with trashracks for a pipe length of more than 50m.

d) Minimum submergence depth of $1.5*v^2/2g$ at upstream end.

e) Provision of air valves and wash outs where necessary.

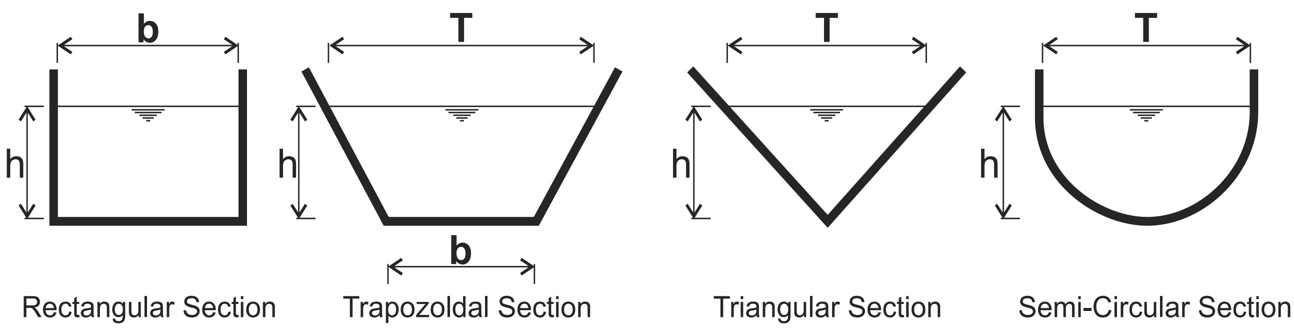


Figure 3.3: Typical Canal Cross Sections

3.3.6 Anchor Block

Anchor blocks are rigid structures that encase the penstock pipe and restrain its movement in all directions. These should be located at all vertical and horizontal bends along the penstock alignment. Furthermore, anchor blocks should be placed at sections where the exposed straight pipe length exceeds 30 m. The following additional criteria should be considered in the design of these structures:

The foundation should be adequate to accommodate the bearing pressure due to the block and the associated forces. Anchor blocks should be designed against overturning, sinking and sliding. The detailed design of anchor block including the reinforcement and plum concrete should be provided.

3.3.7 Powerhouse

The powerhouse supports and houses the generating units and their accessories. It provides passage of water through the turbines and tailrace. The powerhouse design and layout should satisfy good performance of the plant, economic construction and easy inspection and maintenance. The design and construction of the powerhouse should be made on the basis of data provided by equipment manufacturer. The structural design can be carried after the general layout and dimensions have been defined.

In mini hydropower plant, single floor type of powerhouse is recommended due to easiness in operation and maintenance. Generally number of units is minimized as electromechanical cost is high in comparison to civil cost of powerhouse. So, one or two units are recommended for mini hydro projects. For small units horizontal axis turbines are more suitable because it is easier to monitor all equipments in a single floor. Layout of a project should consist of turbine, generator, governor, regulating panels, low voltage control panels and service bay.

Requirements for Powerhouse Design is outlined below:

a. Location of powerhouse should be safe from flood.
b. Geological condition of powerhouse site should be satisfactory
c. Setting of turbine(in case of Francis turbine) should match with the suction head provided by the machine manufacturer
d. Tailrace should be free from the influence of design flood
e. Machine arrangement should be such that the width of powerhouse i.e. Span of overhead traveling crane be minimum
f. Service bay should be suitably sized to use for loading and unloading purpose,
g. Columns should be isolated from the machine foundation
h. Each Block of Machine foundation should be safe in sliding, overturning, and in bearing capacity.
i. Foundation stability should be checked in different load condition provided by the machine manufacturer especially during synchronous fault condition.

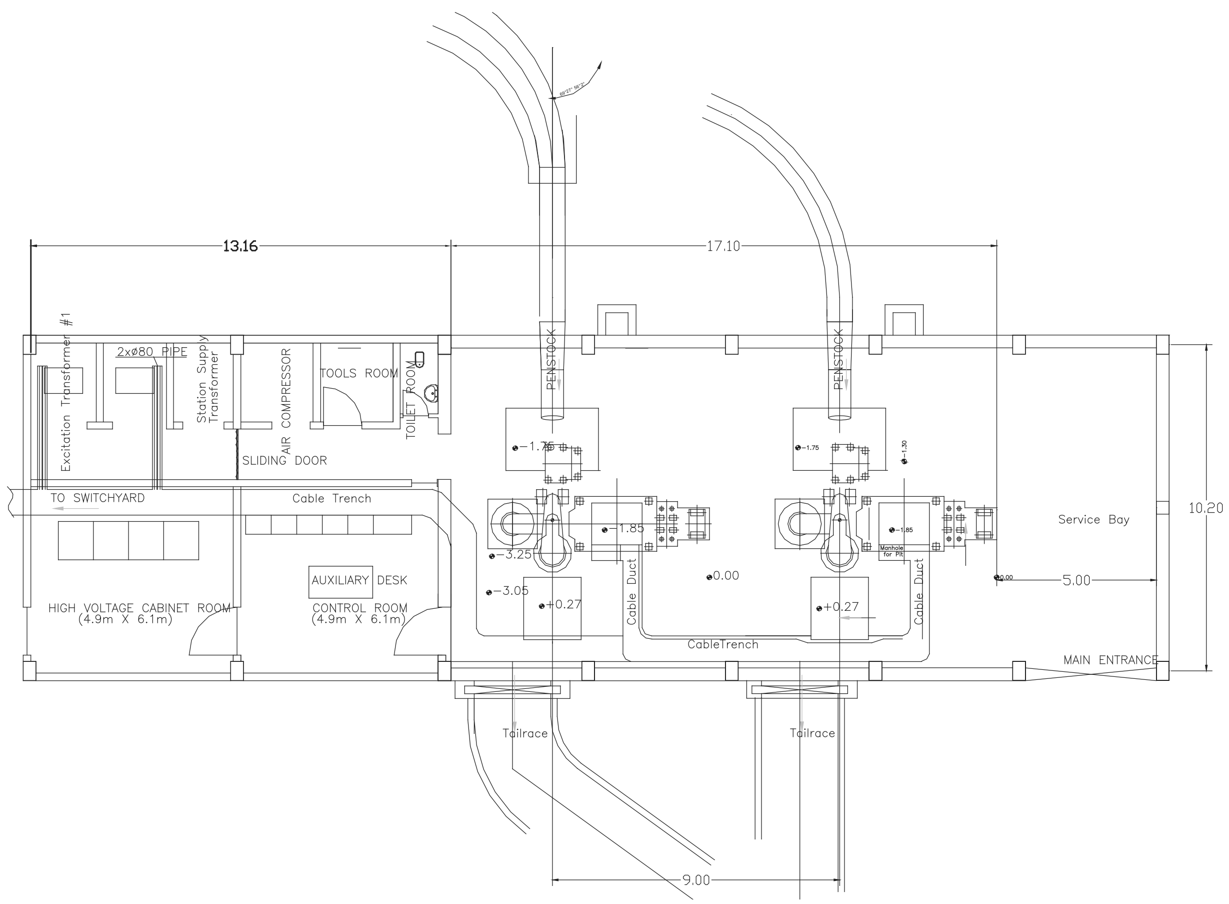


Figure 3.4: Typical Powerhouse Plan

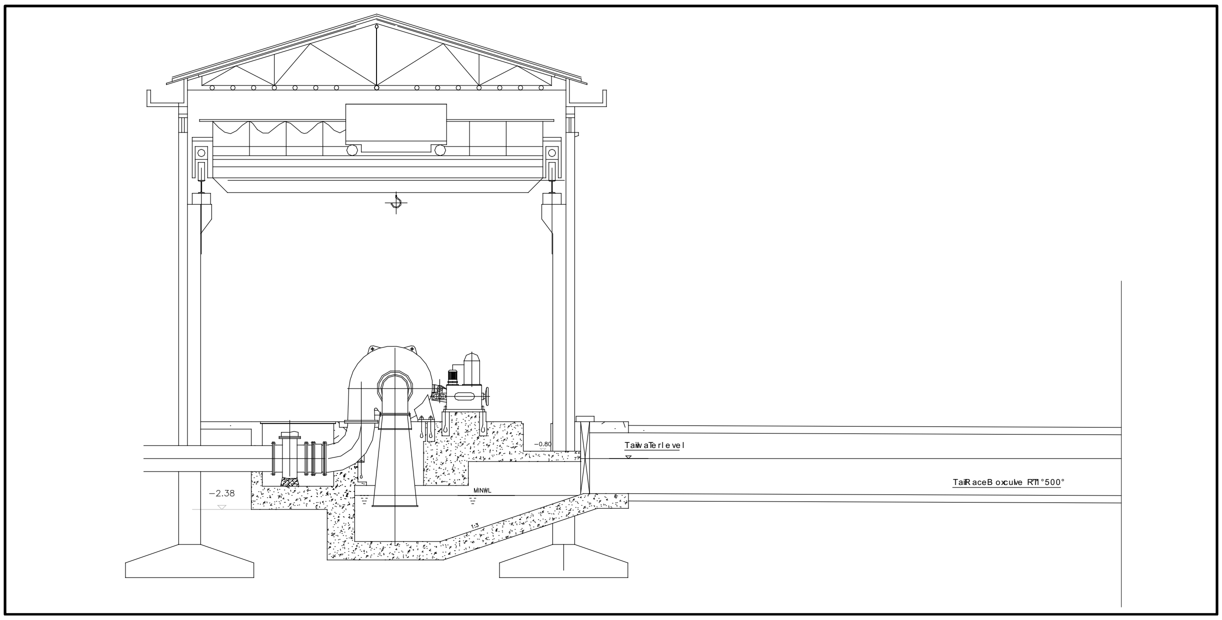


Figure 3.5: Typical Powerhouse Section

3.3.8 Machine Foundation

A machine foundation of a mini-hydro project is a gravity structure designed to transfer hydraulic forces from penstock, torque from rotating machines and gravity loads from generator, turbines and the foundation itself. Similar to an anchor block, the machine foundation should be stable against overturning, sliding and sinking/bearing. It is strongly recommended to refer to suppliers while dimensioning mini hydropower machine foundations.

The critical plane of a machine foundation depends on turbine axis and coupling types. A turbine axis (shaft) is perpendicular to the incoming flow for Crossflow, Pelton and Spiral case Francis turbines whereas it is parallel to the incoming flow for open flume Francis and other axial flow turbines. Coupling type (direct or belt drive) also determines a critical plane with respect to its stability. Stability along both these mutually perpendicular axes should be analyzed.

3.4 Hydro-mechanical Equipment

3.4.1 Penstock

A Penstock is a pressurized water conduit that conveys water under pressure to the turbine from a free water surface. This free water surface may be either surge chamber devices or a reservoir or Forebay. The penstocks should be as hydraulically efficient as practical to conserve available head, and structurally safe to prevent failure which would result in loss of life and property. An economic study will size a penstock from a monetary standpoint, but the final diameter should be determined from combined engineering and monetary considerations.

General requirements for penstock pipe are outlines below.

1. Material: Mild steel (tunnel lining, exposed and buried) and HDPE/GRP (buried) pipes should be used as penstock pipes. For mild steel pipes, flanged connections are recommended for low head up to 60m. In other cases, site welding is recommended. A combination of HDPE/GRP and mild steel can also be used.

2. For exposed (i.e., above ground) mild steel penstock alignment, a minimum clearance of 300 mm between the pipe and the ground should be provided for ease of maintenance and minimizing corrosion effects.

3. GRP/HDPE pipes should be buried to a minimum depth of 1 m. Similarly, if mild steel penstock pipes have to be buried, a minimum of 1 m burial depth should be maintained and corrosion protection measures such as high quality bituminous/epoxy paints should be applied. Due to higher risks of leakage, flange connected penstocks are not recommended to be buried.

4. The recommended initial trial internal diameter (D) can be calculated as:

   $D = 41 \times Q\ 0.38$ mm

   Where, Q = Design flow in l/s

5. Total headloss should not be more than 5% of the gross head. For higher losses it should be proven economically more feasible.

6. Anchor / Thrust blocks at every horizontal and vertical bend should be constructed.

7. Expansion joints should be placed immediately downstream of every anchor block for exposed mild steel penstock.

8. Instead of providing an expansion joint immediately upstream of turbine, a mechanical coupling is recommended for ease of maintenance and reduced force transmitted to the turbine casing.

3.4.2 Expansion Joints

Expansion Joints are installed in exposed penstocks between fixed point or anchors to permit longitudinal expansion, or contraction when changes in temperature occur and to permit slight rotation when conduits pass through two structures where differential settlement or deflection is anticipated. The expansion joints are located in between two anchor blocks generally downstream of uphill anchor block. This facilitates easy erection of pipes on slopes.

Expansion Joints should have sufficient strength and water tightness and should be constructed so as to satisfactorily perform their function against longitudinal expansion and contraction.

The expansion of the pipeline can be calculated as follows:

$\Delta L = \square \times \Delta T \times L$

Where,

L = Length of the pipe section, (m)

ΔL = Change in length due to expansion (m)

$\square$ = Coefficient of linear expansion of steel

= 12×10^{-6} m/m °C

ΔT = Change in temperature (°C)

To be safe, it would be recommended that the expansion joint can be capable of accommodating a length change of double this amount.

3.4.3 Branch Pipe

Depending on the number of units, a single penstock feeds, the penstock branching is defined as bifurcation when feeding two units, trifurcation when feeding three units and manifold when feeding a greater number of units by successive bifurcations. Branch pipes of bifurcating type are generally known as "Wye" pieces which may be symmetrical or asymmetrical. Preference should be given to symmetrical branches. For asymmetrical branches safe design calculations should be provided.

3.4.4 Gates

Hydraulic gates (vertical sliding/radial) are used for regulating the discharge for power generation. The different types of gates are used for regulation and flow control. For such small project vertical slide type gates with manual operating system is suitable and recommended for use. The rubber seals are used for preventing water leakage. The gates are manufactured from the following materials:

1) steel
2) wooden planks

The wooden plank's gates are used for small opening of water passage and small discharge while steel gates are used for bigger opening of water passage and larger discharge.

Gate design criterion

- The gates shall be designed for the hydrostatic and hydrodynamic forces taking into consideration forces arising from wave effects, seismic loads and ice formation wherever applicable.
- The additional water head to the static head to account for the sub-atmospheric pressure downstream of gates located in conduits/sluices should be specified to the designer.
- The gate is normally designed to close under its own weight with or without addition of ballast but sometimes it may require a positive thrust for closing, in which case hoist shall be suitable for that purpose.
- It shall be watertight, the maximum permissible leakage being not more than 5 litres/min/m length.
- It shall be capable of being raised or lowered by the hoist at the specified speed;
- Power operated gates shall normally be capable of operation by alternate means in case of power supply failure;
- If meant for regulation, it shall be capable of being held in position within the range of travel to pass the required discharge without cavitations and undue vibration

3.4.5 Stoplogs

Stoplogs are used for regulation of discharge at the time of gate's maintenance. Stoplogs may be made from steel, wood and concrete. Concrete blocks are not used for such small projects as stoplogs. If opening of water conduit is small then wooden type stoplogs are economical otherwise steel stoplogs are used.

3.4.6 Trashracks

A trashrack is a structure placed at an intake mouth to prevent floating logs and boulders entering into headrace. Coarse trashracks and fine trashracks are provided at the river intake and penstock intake respectively

Coarse trashrack should be made of vertical mild steel strips of 5mm*40mm to 5mm*75mm with a clear spacing not exceeding 75mm. The approach velocity should be less than 1.0 m/s. For transportation by porters in remote areas, the weight of a piece of trashrack should not exceed 60 kg. Placing of trashrack at 3V:1H is considered to be the optimum option considering the combined effect of racking and hydraulic purposes.

Fine trashrack differs with coarse trashrack in approach velocity and spacing between bars. The velocity should be 0.6 to 1 m/s and clearance should be 0.5 * nozzle diameter in case of Pelton or half the distance between runner blade in case of Crossflow/Francis.

The headloss through trashracks depends upon the shape, size and spacing of bars and velocity of flow. The head losses through the trashrack may be computed using the following formula (IS: 11388 – 1995):

$$h_r = k\left(\frac{t}{b}\right)^{1/8} \frac{v^2}{2g} \sin$$

Where,
h_r = loss of head through racks
t = thickness of rack bars
b = clear spacing between rack bars
v = velocity of flow through the trash rack
a = angle of bar inclination to the horizontal, and
k = factor depending on bar shape, determined in accordance figure below.

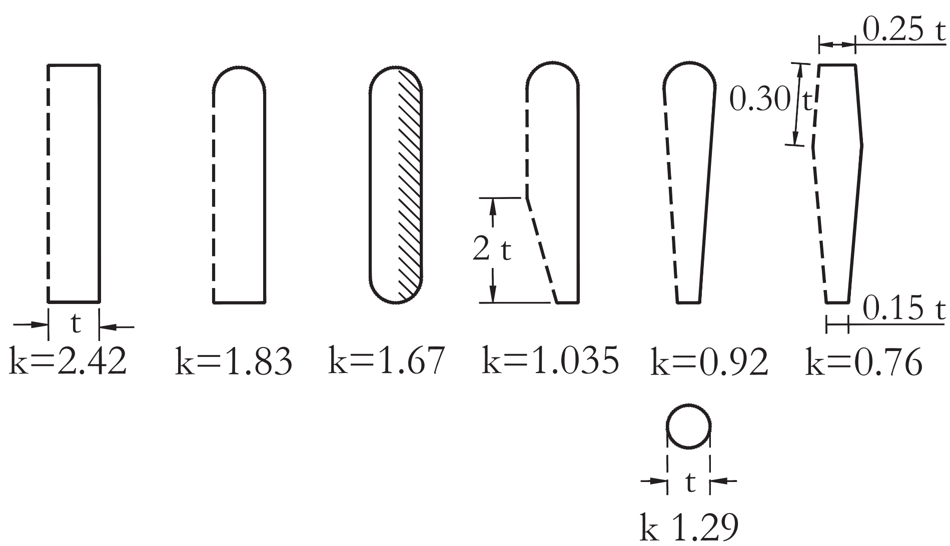
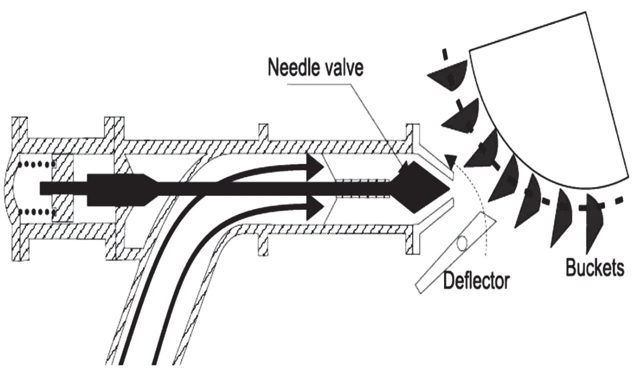
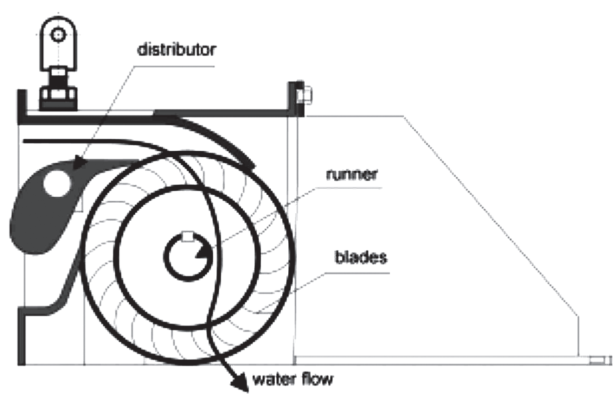


Figure 3.6:Values of trash rack coefficient for different bar shapes (IS: 11388 – 1995)

3.4.7 Turbine

A turbine converts potential energy of water to rotational mechanical energy. Cross-flow and Pelton turbines are the most commonly used turbines in Micro and mini hydropower plants. The size and type of turbine for a particular site depends on the net head and the design flow. Pelton turbines are suitable where the ratio of head to flow is high and Cross-flow turbines are suitable for high flow and low head schemes. The selection of the turbine type based on flow and head conditions are discussed below. It should be noted that for certain head and flow ranges both Pelton (multi-jet) and Cross-flow turbines may be appropriate. In such cases, the designer should consult with the manufacturer and make a decision based on availability, efficiency and costs. On a horizontal shaft Pelton turbine the maximum number of jets should be limited to 2 for ease of manufacturing. The number of jets can be higher for vertical shaft Pelton turbines. However, these require higher precision work in mounting the generator vertically on the turbine shaft and furthermore, in case of varying rotational speeds (RPM of the turbine and the generator), the belt drive arrangements (including those for mechanically coupled end uses) will be difficult.





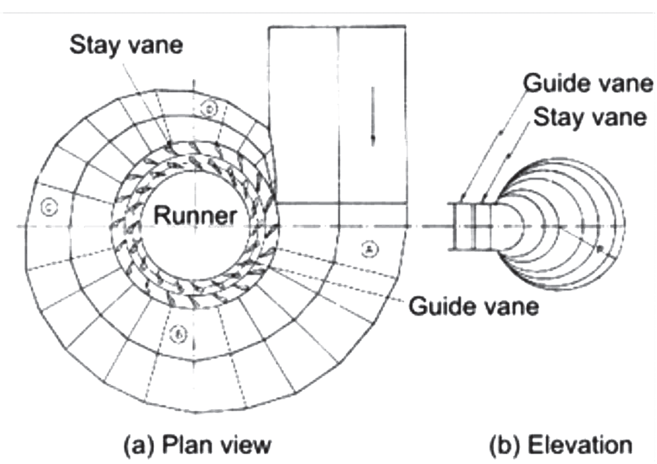


Figure 3.7:Typical mini hydropower turbines

3.4.7.1 Turbine type selection

In the present context, Pelton or Cross-flow or Francis turbines are used in micro and mini hydropower projects. Other options shall only be used if they can demonstrated to be both cost effective and proven in the Nepalese context. General guidelines for selecting micro and mini hydropower turbines are presented in Table 3.2. and fig. 3.8

Table 3.2: Turbine Selection Criter

High Head	Medium Head	Low Head
Pelton, Turgo	Cross-flow, multi jet Pelton, Turgo,	Cross flow
	Francis	Propeller, Kaplan

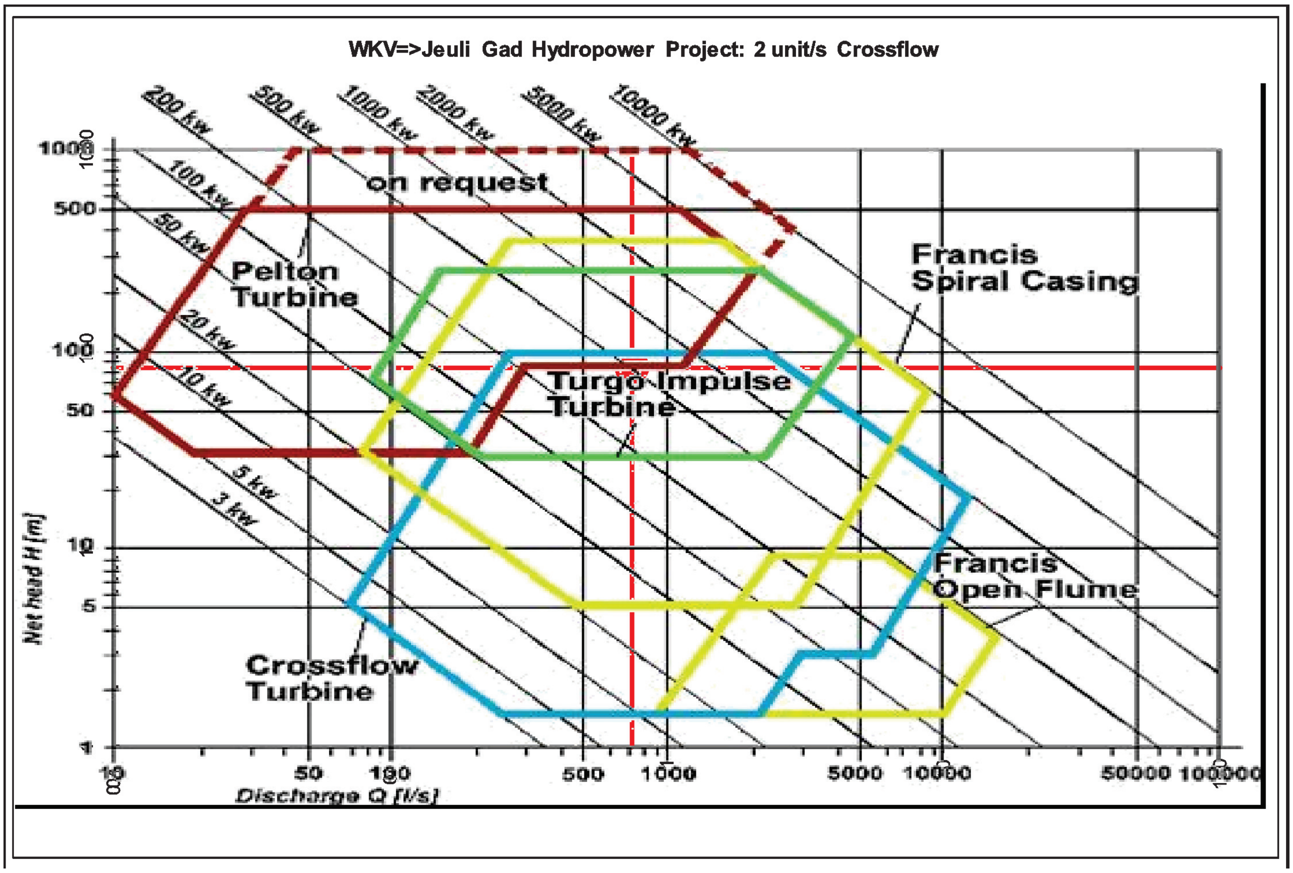


Figure 3.8: Turbine Selection Chart *Source: WKV Gmbh*

3.4.7.2 Classification of Turbines

Turbines are classified according to various parameters. The important ones are:

- According to the action of water on its blades (Impulse: Pelton; Reaction: Francis; Propeller, Kaplan).
- According to the name of the Inventors/originator (Pelton, Francis, Kaplan)
- According to direction of flow of water (Tangential flow – Pelton; Radial flow –Centrifugal; Axial flow – Kaplan; Mixed – Radial & Axial – Modern Francis)
- According to disposition of Turbine shaft (Horizontal shaft; Vertical Shaft)

- According to specific speed: The specific speed of a turbine is the speed of a geometrically similar turbine that would develop one brake horsepower under a head of one meter. Typical turbine types versus recommended specific speeds are given in Table 3.4.

Pelton Turbine

A Pelton turbine has one or more nozzles discharging jets of water which hit series of buckets mounted on the periphery of a circular disc. The principle of the Pelton turbine is to convert the kinetic energy of a jet of water into angular rotation of the buckets it strikes. The advantages and disadvantages of Pelton turbines are:

Advantages

- High efficiency
- Simple structure
- Easy to shut down w/ jet deflector
- Good part flow efficiency

Disadvantages

- Nozzle can be clogged
- High surge pressure
- Bucket profile difficult to fabricate

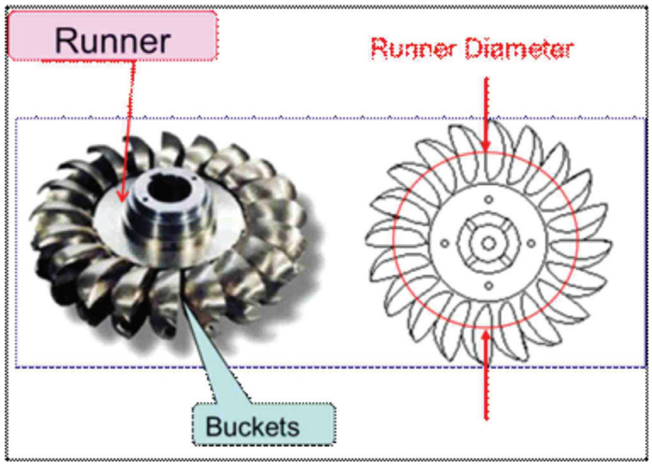


Figure 3.8.1:Typical Penton Runners

Sizing of Pelton Turbines

- Jet Velocity (vjet) m/s $v_{jet} = Cd\ x\sqrt{2 * g * H_{net}}$, where Cd = 0.96, H_{net} = net head.
- Nozzle diameter $d_{jet} = 0.54\ x \dfrac{\sqrt{Q}}{H_{net}^{0.25}}\ x \dfrac{1}{\sqrt{N_{jet}}}$ *1000, where Q = discharge per unit turbine, Njet = number of jets in one turbine.
- Pitch Circle Diameter, (PCD) mm (Normally Available micro hydropower Pelton diameters are 160 mm, 250 mm and 350 mm)

$$PCD = 60 * (0.5 * Cd * \sqrt{2 * g * Hnet})x \frac{1}{(\pi * rpmt)} * 1000,$$

where rpmt = turbine rpm, Cd = coeff. Of discharge.

- $\text{Pelton rpm} = \dfrac{38\ x \sqrt{H}}{D_{Pelton}} * 1000$

Crossflow Turbine

A Crossflow turbine has single horizontal drum-shaped runner in each unit. A rectangular adaptor directs the jet to the full length of the runner in this kind of turbine.

Advantages

- Easy to fabricate
- Easy to maintain

Disadvantages

- Low rotational speed so needs drive system

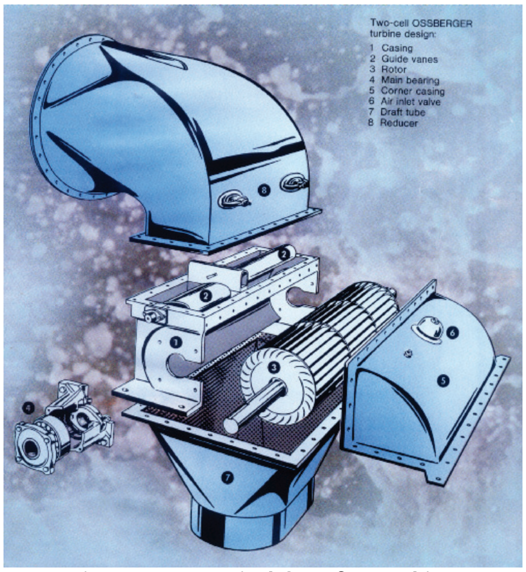


Figure 3.8.2: Typical Crossflow turbine

Sizing of T14 Crossflow Turbines

- Turbine rpm $rpm\ Cross\ Flow = 40 \times \frac{\sqrt{H_{net}}}{D_{runner}}$,

  Available D_{runner} = 300 mm

- Jet thickness t_{jet}=0.1 *D_{runner} to 0.2 *D_{runner}

- Runner width $b_o = \frac{Q_{max}}{Q_{ss} \times D_{runner} \times \sqrt{H}}$

  Where Q_{ss} = 0.8*Q_d

  b_o size is recommended to increase 20% higher of calculated size.

Francis Turbine

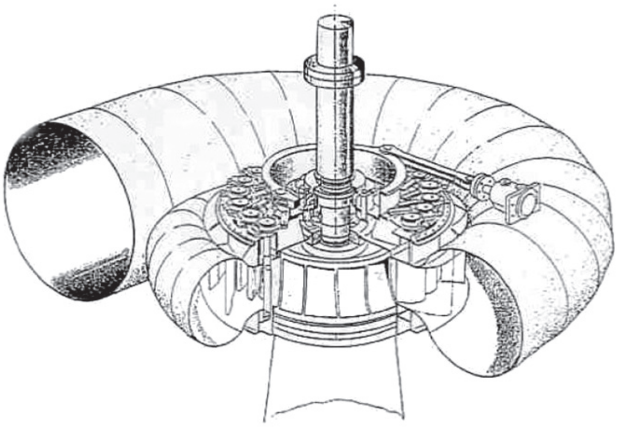
A Francis is a reaction turbine suitable for high flow low head. Francis turbines are sophisticated although it has higher efficiency over a wider range of flows.

Advantages

- Easy to fabricate
- Easy to maintain

Disadvantages

- Low rotational speed so needs drive system



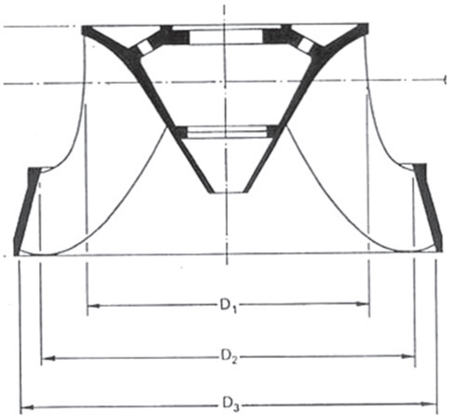


Figure 3.8.3: View and cross section of Francis runner

Sizing of Francis Turbines

- Ideal turbine rpm n' $rpm\ Francis = 1145 \times \frac{H^{0.15}}{Q^{0.5}}$
- Synchronous speed $nq = n \times \frac{Q^{0.5}}{H^{0.75}}$
- Runner diameter $D3 = 0.44 \times \frac{Q^{0.5}}{H^{0.05}}$
- Inlet diameter $D1 = D3 \times \left(\frac{1}{0.460 + 0.00829nq} \right)$
- Height of runner b= 0.5D3
- Height of runner guide vane (water passage height) $bt = D3 \times \left(\frac{-0.00702 + 0.00380nq}{0.460 + 0.00829nq} \right)$
- Spiral case dimensions:
  - A = (-0.0813+0.773 D3)*$nq^{0.1}$
  - B = (0.362+1.889 D3)*$nq^{0.1}$
  - C = (0.162+2.288 D3)*$nq^{0.1}$
- Draft tube dimensions:
  - P = 0.428+2.812 D3
  - Q = 0.273+0.670 D3
  - X = -0.568+2.741 D3

3.4.8 General Recommendations

The recommended net heads for maximum rotational speed (rpm) and efficiencies for different turbines and turbine specifications are presented in Table 3.3.

Table 3.3: Turbine specifications

Type	Net head (m)	Max RPM	Efficiency (n_t)
Pelton	More than 10m	1500	70 - 90%
T15 Crossflow	up to 80m	1500	65 - 78%
Francis		1500	80 - 93%

The consultant should provide performance characteristics curve for higher efficiency turbines as required by AEPC.

The type of turbine can be determined by its specific speed given by the following equation:

Sp Speed (without speed increaser) ns = Turbine rpm*√(1.4*PkW/Nturbines)/Hn5/4

Sp Speed (with speed increser) nsg = Sp Speed (no gear)* Turbine rpm / Generator rpm

Table 3.4: Turbine type vs. Specific speed ns (metric HP units) range

Turbine	Min n_s	Max n_s
Kaplan	270	1000
Francis	60	350
Pelton	8	72
Turgo	20	70
Crossflow	42	200

3.4.8.1 Governors

A governor adjusts the water flow to maintain the generating unit's speed and the system frequency. In addition, it maintains instant to instant balance between the turbine shaft power and electrical load at the generator terminal plus drive (if any) and generator losses. The hydraulic turbine governor should perform following functions:

1. Maintain and adjust unit speed before the unit goes on line
2. Maintain system frequency after synchronization by adjustment of the turbine output.
3. When operating on a system parallel with other units, to share load changes with the other units in a planned manner in response to system frequency error
4. To adjust the output of the unit in response to operator or other supervisory commands and
5. Protect the unit from an abnormal condition (e.g. condition of runaway speed following sudden load rejection etc) by initiating unit shutdown.

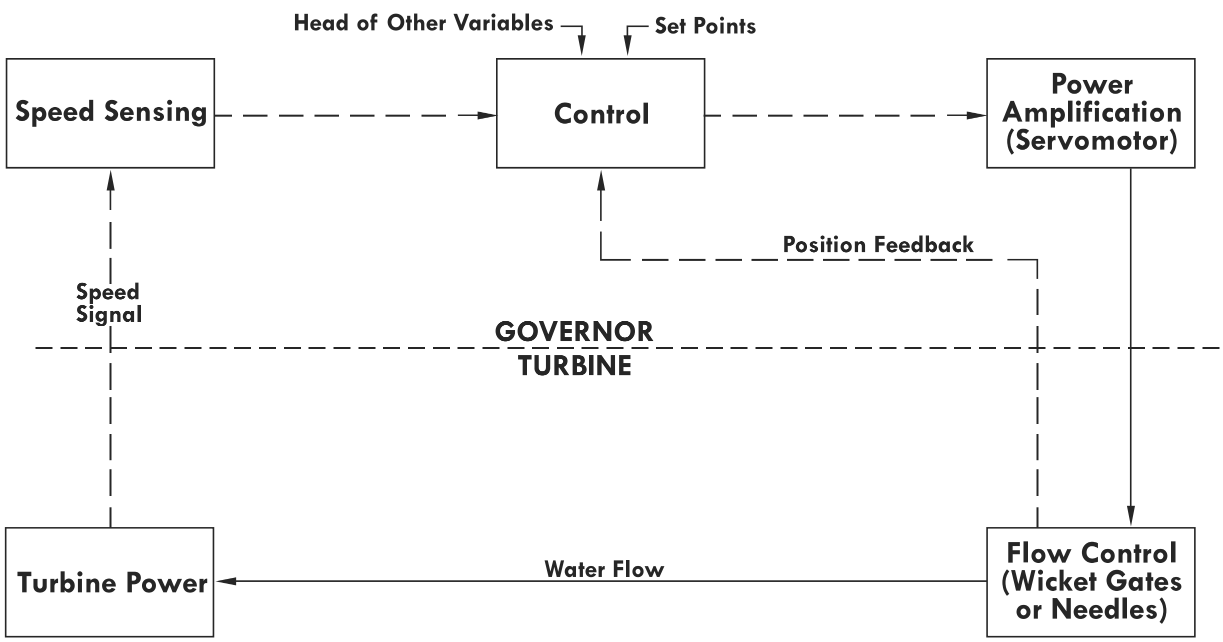


Figure 3.8.4: Basic Block Diagram of a governor

3.4.8.2 Inlet Valves

Valves are mechanical devices that control flow in conduits or piping systems. Closure valves installed at inlet of spiral casing or distributor pipes are used to shut off flow to the turbine and stop the unit if the turbine wicket gate or nozzles fail to close. These closure valves are called inlet valves or turbine shut-off valves. The most common types of valves are:

a. Butterfly Valves (should be used upto 250 m water head for mini/small hydro application)
b. Spherical Valves (should be used for high head application)

3.4.8.3 Drive System (Speed Increaser)

When the turbine and the generator both have the same rated speed and both can be placed so that their shafts are in line, direct coupling is the right solution. There occurs virtually no power loss with direct coupling and maintenance requirement is minimal. Turbine manufactures will recommend the type of coupling to be used, either rigid or flexible although a flexible coupling that can tolerate certain misalignment is usually recommended.

For mini hydropower plant, with Pelton, Turgo and Francis type turbines being common, the turbine runner shall be coupled directly to the generator's rotor with suitable bolting connection. In case of Cross flow and low speed Kaplan turbine, belt or gear drive (speed increaser) shall be used to match the synchronous speed of the generator.

Direct drive

This system is is used in the case where the shaft speeds are identical by using a flexible coupling to join the two shafts together directly. The advantages are low maintenance and low cost. The efficiency of direct coupling should be 98 – 99.5%.

Flat belt and pulleys

Modern flat belts run at high tension and are made of a strong inner band coated with a high friction material such as rubber. One pulley must have a slightly convex profile (crowned) which together with good alignment, keeps the belt in position in either vertical or horizontal use. The efficiency of flat belt should be 96 – 98%

Speed increaser types

Speed increasers according to the arrangement used in their construction are classified as:

a. Parallel-shaft using helical gears set on parallel axis and is especially attractive for medium power applications.
b. Bevel gears commonly limited to low power applications using spiral bevel gears for a 90° drive.
c. Belt speed increaser that is commonly used for small power application and offer maintenance facilities

3.5 Electrical Components

Electrical equipment consists of generator, transformer, switchgear equipment, control and protection devices, equipment for transmission and distribution system etc. Important considerations should be given while selecting these components. Apart from the considerations mentioned below, IEC Standards or British Standards or Indian Standards or standards issued by American National Standard Institute (ANSI) or any other equivalent International Standards can be adopted with proper justification.

3.5.1 Generator

3.5.1.1 Types and Selection

Induction or synchronous generators can be used to convert the mechanical energy output of the turbine into electrical energy. Most installations of mini hydro projects utilize synchronous generators.

The main advantage of a synchronous generator for mini hydroelectric plant applications is its capability to operate with either a lagging or leading power factor, by control of its excitation. Power factor values for synchronous generators are determined by the requirement of the local load, or the connecting electric utility system, or both, which commonly ranges between 0.8 and 0.95.

Furthermore, synchronous generator has ability to establish its own operating voltage. In case of grid connected or interconnected system, even if the interconnection is broken, the generator may still supply the local load. To utilize this advantage requires governor (accurate and responsive speed and power output control system) and automatic voltage regulator (voltage and reactive power control system).These increase the cost of the installation employing synchronous generator however.

The advantages of an induction generator are lower, initial and maintenance costs due to elimination of exciter, voltage regulator, and synchronizer. But it can not provide reactive power or voltage control as an isolated power source. Another disadvantage is its lower efficiency throughout the operating range. The induction generator draws its excitation (magnetizing) current from the electrical system.

It is recommended that for mini hydro projects (100 kW to 1000 kW), three phase synchronous generator should be used.

Following specifications shall be mentioned for mini hydropower synchronous generators:

(i)	Rated output	...kVA
(ii)	Power factor	0.8(lag)
(iii)	Frequency	50Hz
(iv)	No. of Phases	3
(v)	Rated voltage	...kV
(vi)	Range of voltage variation	± 2%(with electronic AVR)
(vii)	Range of frequency variation allowed	±5%
(viii)	Stator winding connection	star
(ix)	Speed	...rpm
(x)	Short Circuit ratio	not less than 1.0
(xi)	Inertia constant	in between 2 to 4
(xii)	Generator efficiency	92 – 97%
(xiii)	Generator cooling	open cooling

3.5.1.2 Generator capacity and power output rating

The generator should have sufficient continuous capacity to handle the maximum output available from the turbine (kW rating) at 100 percent gate opening without the generator exceeding its rated temperature rise.

Table 3.5: Generator rating factors

Maximum Ambient Temperature(°C)	20	25	30	35	40	45	50	55
A Temperature factor	1.1	1.08	1.06	1.03	1	0.96	0.92	0.88
Altitudes (m)	1000	1250	1500	1750	2000	2250	2500	2750
B Altitude Factor	1	0.98	0.96	0.945	0.93	0.915	0.9	0.88
Altitudes (m)	3000	3250	3500	3750	4000	4250	4500	
B Altitude Factor	0.86	0.845	0.83	0.815	0.8	0.785	0.77	
C Power Factor								0.8

$$\text{Generator kVA} = \frac{\text{Installed capacity per unit in kW}}{A \times B \times C}$$

If ELC is used, the generator is to be oversized upto 20% to take the consideration of harmonics introduced due to the use of thyristors (non-linear loads).

Up to 150 kW capacity, load control governing system (Electronic Load Controller- ELC) can be utilized in isolated systems using synchronous generators. There should be enough availability of water while using ELC. In addition, emergency shut off device is required to bring the machine to standstill in case ballast system fails for some reasons with no or part village load. For higher capacities of generators and/or grid-connected mode, flow control governors shall be used. The generator should have capability to withstand continuous over speed of 200 to 300% of rated turbine speed.

3.5.1.3 Generator voltage

The rated voltage of generator increases with power capacity. In case of mini hydro generators the standard generation voltages of 400 V, 690 V or 3300 V can be used after careful system design as a whole to arrive at technically sound least cost option.

3.5.1.4 Generator Speed

Hydraulic turbine-driven generators produce electrical energy by the transformation of potential energy through mechanical energy ultimately to electrical energy . The mechanical design of each generator must conform to the hydraulic requirements of its specific plant. Thus, in general, the speed of the generator should be compatible with turbine speed; if not, speed increasers need be used.

3.5.1.5 Insulation and temperature rise

Insulation class of generator windings shall conform as :

(i) Stator winding — class F

(ii) Rotor winding — class F

Temperature rise allowed are as follows:

(i) Stator winding — Class B temperature rise

(ii) Rotor winding — Class B temperature rise

3.5.1.6 Excitation System

Direct current field excitation is required for synchronous generators to produce excitation voltage. Brushless exciters are generally provided for smaller, higher speed generators. Larger, slower speed generators generally utilize static exciters with solid-state equipment (Thyristor) that converts alternating current to uni-directional direct current.

Automatic voltage regulators sense generator voltage and compare it with a reference value, and adjust the exciter output accordingly to reduce the difference to zero.

3.5.1.7 Generator Neutral Grounding

For mini hydro generators of capacity upto 1000 kW and generation voltage 400 V, neutrals of generators may be earthed directly to ground through an isolation switch. Generators of higher rating or higher generation voltage may be earthed through a resistance or a distribution transformer. In this case, the effective resistance should be such that the generator neutral current during a phase-to-ground is limited between 100 and 150 percent of the generator full-load current.

3.5.2 Transformers

3.5.2.1 Generator Transformer

To step up the generation voltage to the transmission voltage, transformers of following specifications should be used:

(i)	Type	3-phase, oil immersed, copper owned AVR with parallel operation
(ii)	Installation	outdoor
(iii)	Rated capacity	…kVA
(iv)	Rated H.V. winding voltage	…kV
(v)	Rated L.V. winding voltage	…kV
(vi)	Cooling	ONAN
(vii)	Rated frequency	50 Hz
(viii)	LV winding connection	Delta
(ix)	HV winding connection	Star
(x)	Vector Group Reference	YNd11 or YNd1
(xi)	No Load tap changer (on HV side)	
	Voltage variation range	+/- 2*2.5%
(xi)	Efficiency	not less than 98%
(xii)	Grounding	
	LV winding	- ungrounded
	HV winding	- solid

a. Rating

The full load kVA rating of the step-up transformer should be at least equal to the kVA rating of the generator or sum total of kVA ratings of all generators in case plant has two or more generators.

b. Transformer Voltage

Ratios and voltage ratings of transformers should conform to preferred ratings wherever possible. The transformer low-voltage winding rating should match the generator voltage rating and the high-voltage rating should be suitable for the voltage of the transmission system, to which it will be connected. In general, transformer ratios for the use in mini hydro projects are : 11/0.4 kV, 11/0.69 kV, 11/3.3 kV, 33/0.4 kV, 33/0.69 kV, 33/3.3 kV etc.

3.5.2.2 Station Transformer

Indoor, non-inflammable liquid- filled or dry-type transformer of suitable size station transformer should be installed. The transformer should meet the simultaneous maximum lighting load, simultaneous maximum load of station auxiliaries, battery charger plus around 20% spare capacity which may in general will be from 1 to 3 percent of the plant capacity, lower percentage value applying for bigger sizes plants and bigger percentage value applying for smaller plant size.

3.5.3 Switchgear equipment

The main purpose of switchgear is to protect the generators and to connect them to the utility system (grid) or isolated system. The generator breaker is used to connect or disconnect the generator from the power grid. Potential transformers (PTs) and current transformers (CTs) may be used to transform voltage and current values to suitable low voltage(mostly 110V) or low current(5Amp or 1Amp) value as required by metering and protection relays. PTs may not be required in some cases when generation voltage is 400V. Figure 2.12 shows a single-line diagram of a mini hydro plant with a single unit. The high voltage side is equipped with a line circuit breaker and a line disconnection switch with earthing switch, which disconnects the generating unit and main transformer from the transmission line. A station transformer provides power for the operation of auxiliary units. Some of the switchgear equipment can be designed as follows:

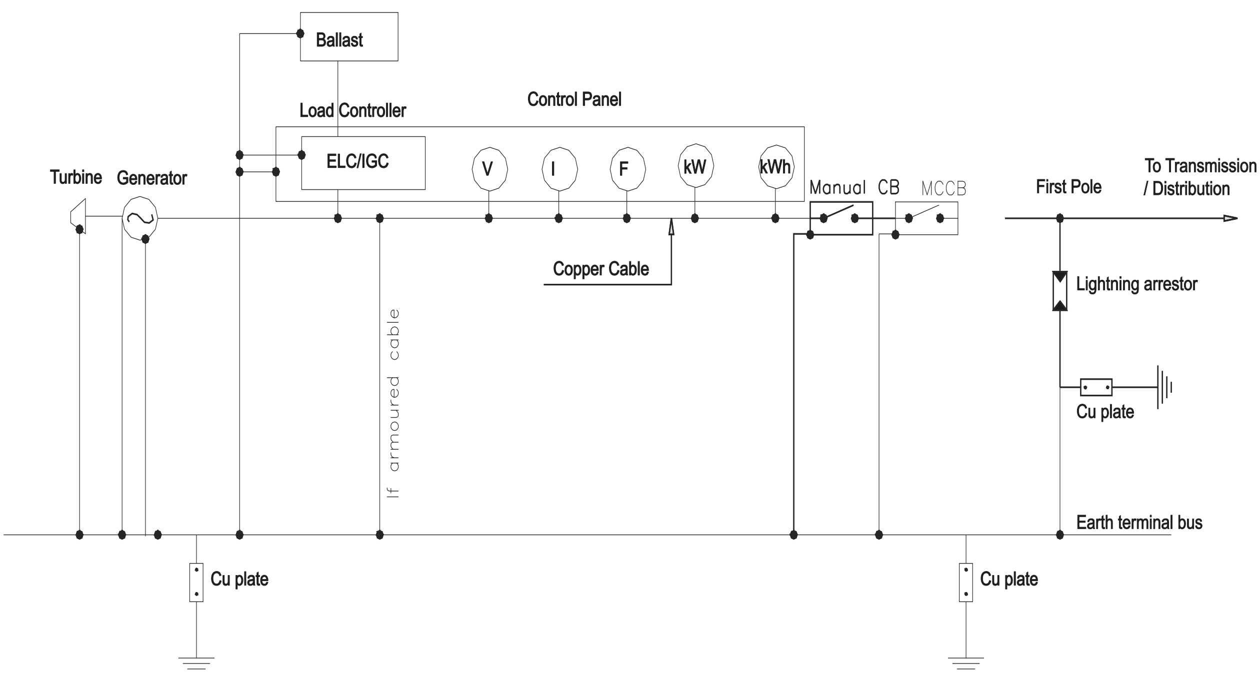
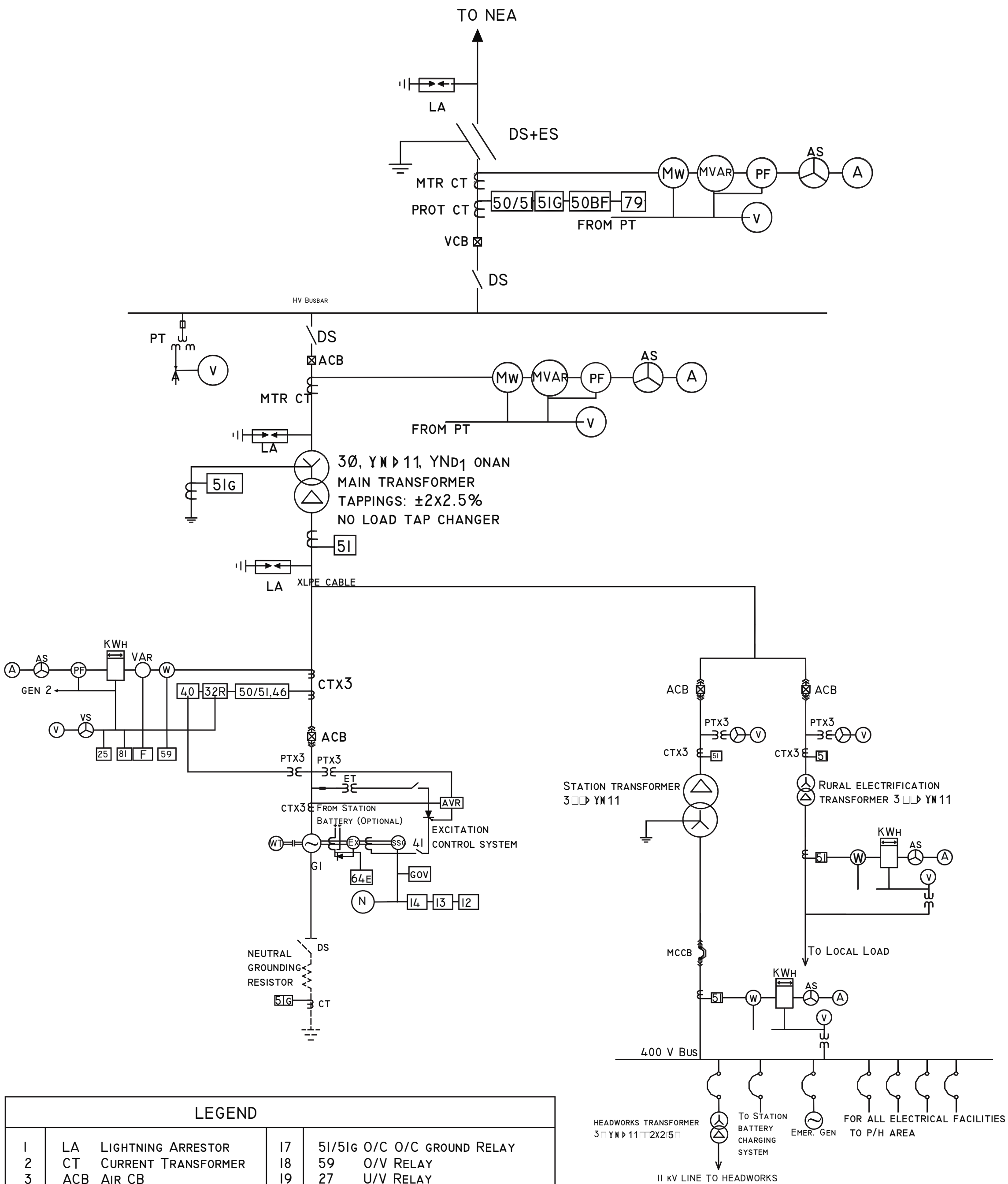


Figure 3.9: Single Line Diagram of a typical single Unit Mini Hydro Plant without grid connection



LEGEND

1	LA	Lightning Arrestor	17	51/51G	O/C O/C ground Relay
2	CT	Current Transformer	18	59	O/V Relay
3	ACB	Air CB	19	27	U/V Relay
4	SYNC	Synchronising Panel	20	GOV	Governor
5	W	Watt Meter	21	ET	Excitation Transformer
6	V	Volt Meter	22	F	Frequency Meter
7	A	Ameter	23	(symbol)	CT
8	PF	Power Factor Meter	24	(symbol)	DO Fuse
9	40	Loss of Excitation Relay	25	25	Synchrocheck Relay
10	32	Directional Relay	26	41	Field Circuit Switch
11	12	Over Speed Relay	27	46	Negative Sequence Relay
12	EX	Excitor	28	32R	Reverse Power Relay
13	41	Field Circuit Switch	30	81	Frequency Relay (Under/Over)
14	(symbol)	Generator	31	79	Auto Reclosing Relay
15	(symbol)	Disconnecting Switch	32	13	Synchronous Speed Device
			33	14	Under Speed Device

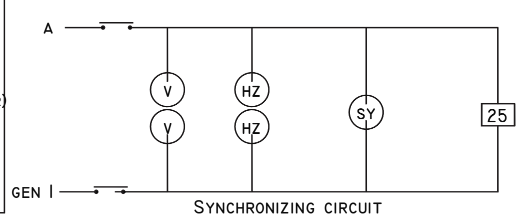


Figure 3.10: Single Line Diagram of a typical single Unit Mini Hydro Plant with grid connection

3.5.3.1 Circuit breakers and isolators

Different types of circuit breakers that can be used in Mini Hydro power stations are:

a. Air circuit breaker for 400 V, 690 V, 3.3 kV systems.

b. Vacuum circuit breaker for 3.3kV and 11 kV systems.

c. SF_6 Circuit Breaker/Vacuum Circuit Breaker for 33 kV systems.

The continuous current rating (I) of the circuit breaker can be calculated as:

I(Amp) ≥ Maximum power to be delivered(kW)/ (√3 * Line Voltage(kV) * Power Factor)

Both rated values of transient and subtransient reactances are used in computations for determining momentary rating and the interrupting ratings of circuit breakers. These should comply with the grid or distribution system requirements.

The continuous current of the isolators can be calculated same as that of circuit breakers.

3.5.3.2 Surge Arresters

Mini hydro stations should be equipped with suitably rated surge arresters to protect the equipment especially transformers and generators form lightning and switching surges. The interrupting current of surge arrestors should not be less than 10 kA. The voltage ratings of lightning arresters are:

System Voltage	Lightning arrester voltage rating
3.3 kV	3 kV
11 kV	9 kV
33 kV	30 kV

3.5.4 Control and Protection Systems

3.5.4.1 Control system

For mini hydro installations, sophisticated control system is not suggested. Simplicity of control is essential to keep total installed equipment cost as well as repair ,maintenance, , and test costs at a minimum. A simpler system would have greater reliability because of lesser failure probability with less number of components.

The control system should provide the following control modes:

a. Manual control of the individual components and systems from hard wired control panels located in the control room as well as near the respective units.

b. Automatic control of generating units from control panels located in the control room as well as near the respective units by PLC based unit controller.

3.5.4.2 Protection Systems

Protection system should be provided to isolate faulty systems as quickly as possible, to limit damage to plant and equipment and to maintain healthy systems in stable operating conditions. The protection system should ensure protection of people, protection of assets, security of supply and system stability. The system should feature a high degree of selectivity and discrimination between faulty and healthy circuits. Adequate protection systems should be provided for turbines, generators, transformers, and feeders.

a. Turbine Protection

The turbine should be protected in the following conditions:

- Bearing temperature extremely high/low
- Failure of governor
- Over speed
- Oil level of pressure oil tank low or high
- Regulating pond / reservoir water level below the setting etc.

b. Generator Protection

Generator should be protected with the following schemes:

- Loss of Field protection
- Reverse power protection (Must for grid/local grid interconnected palnts)
- Over fluxing protection
- Negative sequence /Phase unbalance protection.
- Over/Under voltage and over/under frequency protection.
- Phase over current protection and earth fault protection
- Out of synchronization protection
- Rotor earth fault protection
- Unbalanced loading etc.

c. Transformer Protection

The power transformers should be protected with the following schemes:

- Overcurrent and earth fault protection
- Oil temperature indicator with alarm
- Buchholz relay with alarm and trip contacts.
- Winding temperature indicator with alarm and trip contacts
- Magnetic Oil Level Gauge(MOLG) with low-level alarm.

d. Feeder Protection

- Three Phase Overcurrent
- Earth Fault Protection (Suited to local supply system)
- Voltage restrained overcurrent relay

3.5.5 Grounding

A safe grounding design has two objectives: to provide low impedance path for, out of balance current to earth under normal condition and, fault current without exceeding operating and equipment limits or adversely affecting continuity of service and to assure that a person in the vicinity of grounded facilities is not exposed to the danger of electric shock. After preliminary layouts of the dam, powerhouse, switchyard, tailrace have been made, desirable locations for ground mats can be determined. Grounding possibilities in these areas should be investigated, and the soil resistivity measured. Sufficient prospecting should be done to develop a suitable location for the ground mat coupled with a determination of average soil resistivity at the proposed location. The ground resistance of the mat should not be more than 1 Ohm in any case. Apart from ground resistance, the value of step and touch potential shall be within safe limits.

Copper is the most commonly used material for conductors in grounding design. Other materials such as copper-clad-steel, aluminium or steel may be used for grounding grid. But special attention should be given while using these materials, especially against corrosion.

3.5.6 Lighting system

Lighting system shall be provided for the entire plant including control room, covering all the buildings, switchyard, outdoor areas, roads, yards etc. Following lighting level shall be maintained

1.	Powerhouse M/C floor	100 lux
2.	Control Room	300 lux
3.	Equipment Rooms	100 lux
4.	Outdoor Switchyard	20 lux
5.	General/Roads/ Headworks area	10 lux

3.5.6.1 Normal AC lighting system

In this system, the lighting circuits shall be fed by the 400V, 3 phase, 4 wire normal AC supply available from the normal lighting distribution boards. All the lighting fixtures connected to this system shall be available as long as supply is available from normal source.

3.5.6.2 Emergency DC lighting system

During station emergency involving total AC failure, incandescent lamp DC lighting fixtures from 110 or 48 V DC supply shall be provided for movement of personnel in powerhouse building at strategic locations viz. near entrance, staircase, landings etc. and for lighting the control room and switchyard. A suitably rated battery charger with both float and boost charging mode for the above battery shall be installed.

3.5.7 Communication System

In mini hydropower stations, the communication link (usually a telephone link) between powerhouse and the dam area and with grid or distribution system should be established.

3.5.8 Modes of Mini hydropower station operation

3.5.8.1 Isolated Mode

For operation of mini hydropower projects in an isolated mode, the provision for black start facility of the plant is essential such that each mini hydro generator should be able to start on its own. In isolated mode, mini hydropower plants can be operated independent of existing grid and provide electrical power to the limited consumers. Typical drawing for isolated mode is shown in figure-2.13.

3.5.8.2 Interconnection with grid

When mini hydropower plant is to be connected with National Grid, NEA norms should be followed. For local grid connection, it should at least fulfill the following requirements:

a. Power evacuation study

Before connecting mini hydro power plant to the existing grid, necessary technical study for evaluating the impact on the grid due to new connection (power evacuation study) should be carried out. The connection of project should not result in the degradation of the quality of the grid. For this purpose, a comprehensive load flow study should be carried out taking account of the new project. Apart from load flow, fault calculation as well as transient stability study needs to be carried out with bigger sized Minihydro plants. Exact requirement may be stipulated by the utility grid on a rational bais. If the results of power evacuation study is to negative impact on the grid, either some modifications on the system configuration/technical requirements are desirable or selection of new interconnection point is essential.

b. Power Quality Standards:

Power Quality shall encompass quality of voltage(magnitude), frequency and the availability.

i. Frequency Variations

Mini hydropower projects should be designed and operated maintaining the system frequency within the limits of ±2.5% of 50 Hz.

ii. Voltage Variations

For on-grid, the voltage variation at any connection point should not exceed ±10%. For off-grid system, voltage variation during normal condition is acceptable upto ±5% and ±10% during short time contingency period (few minutes to an hour).

iii. Power Factor

Mini hydropower projects should maintain a power factor not less than 0.8 lagging at the the point of interconnection with the utility grid or shall inject specified amount of VAR as determined by the utility grid.

iv. Total Harmonic Distortion (THD)

As per IEEE 519 Standard, total harmonic of line-line voltage should not exceed 5%. This is required for the plant capacity above 300kVA.

v. Protection Requirements

The minimum protection at the interconnection point required for a mini hydropower projects connected to the grid will vary according to type, size, method of connection and earthing of the grid. It should have the following protection facilities for 33 or 11 kV systems:

- Three Phase Overcurrent
- Earth Fault Protection
- Others if necessary

vi. Equipment Short Circuit Rating

All Equipment at the connection point shall comply with the requirements given by the grid code.

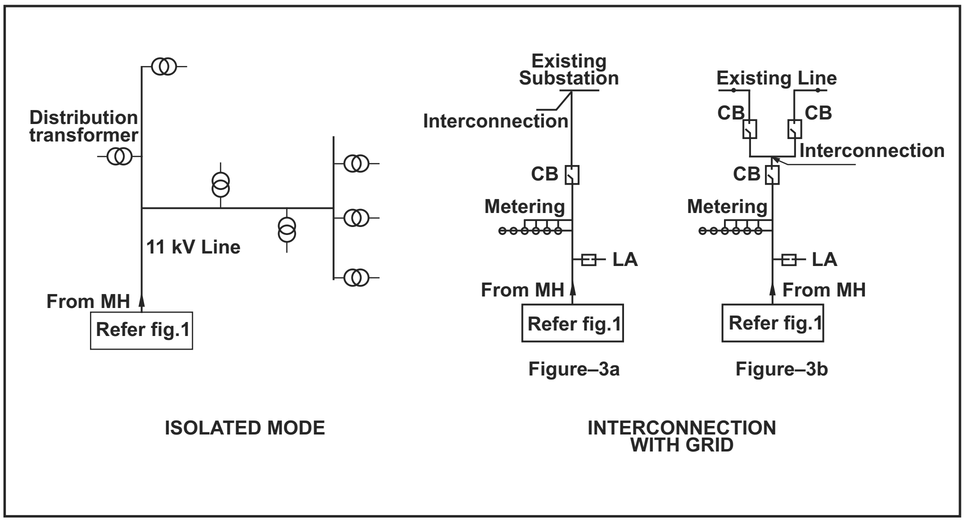


Figure 3.11: Station Operation Mode

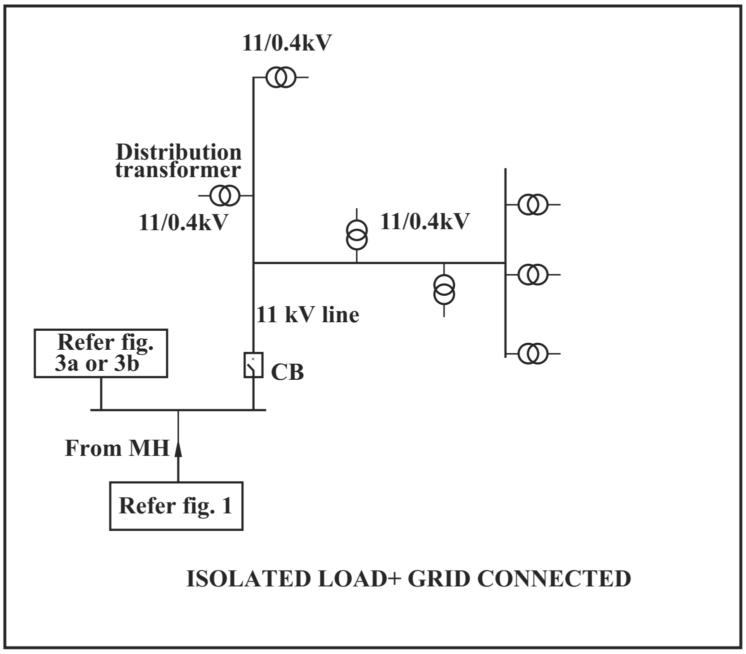


Figure 3.12: Station Operation in Mixed Mode

3.6 Transmission and Distribution

1. Transmission lines can either be buried or suspended overhead on poles. Overhead lines are more common as they are less expensive and easier to install. Overhead lines are also easy to repair and maintain. However, when the settlements are densely populated or heavy snowfall is expected during winters, underground transmission lines may be preferred. Underground systems require less maintenance, however cost per maintenance is much higher.

2. The design of transmission and distribution lines should be such that voltage drop at any distribution line end is limited to 10% of nominal value (11 kV or 33 kV line - 5%, distribution transformer plus LT line - 5%.)

3. The maximum transmission line-to-line voltage level permitted in isolated system is 11 kV. Distribution Transformers sizes should be carefully determined (keeping in mind diversity factor into account and

in a way that under no condition shall the power plant be overloaded). Oversizing the transformer on the basis of future load growth in clusters makes sense only if the plant size is such as to cater future load growth. This is to be noted that there are only few standard sizes of transformers available in the market and one has to sometime choose next higher rating just because exact size transformer is not available. For service connection, following voltage system should be used:

i) Low Tension supply

-230 V, single phase for loads upto 30 A

-400/230 V, three phase for loads more than 30A

ii) High Tension supply

11 kV and 33 kV three phase systems for load more than 100 kVA

4. ACSR conductors are generally used for overhead transmission lines.

Standard Conductor sizes to be used in 33 kV line is 100 sq. mm ACSR (DOG) and conductor size to be used in 11 kV line is 100 sq mm (DOG) or 50 sq. mm ACSR (RABBIT). Aerial bundled cables (ABC) may also be used for overhead lines if poles are expensive. ACSR conductors are available in various sizes and designations. Their properties are presented in the Table below.

Table 3.6: Sizes and designations of ACSR conductors used in mini hydro schemes

Name	Current rating in still air(A)	Resistance (Ω/km)	Inductive reactance at 50 Hz ad 50 cm spacing (Ω/km)	Approximate weight (Kg/km)
Squirrel	76	1.374	0.355	85
Gopher	85	1.098	0.349	106
Weasel	95	0.9116	0.345	128
Rabbit	135	0.5449	0.335	214
Otter	185	0.3434	0.328	339
Dog	205	0.2745	0.315	394

5. Armoured cables should be used for underground systems. PVC-insulated armoured cables may also be used but should be limited to short distribution lines, service lines, overhead distribution box (DB) connections and around the powerhouse. The provision of cable in mini-hydro scheme is highly discoursed unless there is possibility of ice loading in the transmission/distribution line, safety is critical measure and aesthetic is essential in tourism area. The comparison between cable and overhead line is given in table below.

Table 3.6: Comparison between overhead line and cable

Property	Overhead Line	Cable
Ease of installation	Simple	Difficult
T&D over long distances	Good	Poor
Use indoors and highly populated areas	Difficult	Very good
Visual impact	High	None
Reliability	Good	Very good
Complexity of repair	Good	Very good
Cost of material	Low	Very high
Cost of installation	Low	Very high

Source: westernpower

The specifications of armoured and unarmoured cable are presented in annex E.

6. The clearances of overhead conductors with ground, trees and other structures should maintained in accordance with the values presented in tables below

Table 3.7: Minimum Ground Clearances

S.N.	Voltage Level	Across Road (m)	Along Road (m)	Other places (m)
1.	above 230/400 V and below 11 kV	5.8	5.5	4.6
2.	11 kV to 33 kV	6.1	5.8	5.2

Table 3.8: Minimum Clearances between live wires and structures or trees.

S.N.	Voltage Level	Minimum Clearance (m)
1.	230/400 to 11 kV	1.25
2.	above 11 kV and upto 33 kV	2

Note: Maximum deflection of wire due to wind pressure should be considered while fixing the minimum clearances.

7. The minimum sag for cables up to 11 kV can be calculated by:

$$d = (L/172.8)^2$$

where, d= sag in m

L= length of span in m

Table 3.9: Sag for spans of overhead cables

Span (m)	20	30	40	50	60	80
Minimum sag (mm)	13	30	54	84	121	210

The value of sag should be included when determining the ground clearance of a transmission line.

8. Transmission poles should be made of hardwood, reinforced concrete, or galvanized steel. All poles carrying 11 kV and 33 kV circuits shall 11 meters high. Pre-stressed reinforced concrete poles are economical for the plain terrain. Steel telescopic poles are used at difficult hilly terrain. In case of wooden poles, only treated poles should be used. The basic span shall be maintained within the following limits:-

33 kV line: 50m to 55 m

11 kV line: 50m to 55 m

Suitable dimensions for the wooden poles which can be used for three-phase transmission are given in the following table.

Table 3.10: Pole specification for hardwood poles

Minimum length (m)	6	7	8	8.5	9
Maximum span (m)	35	35	35	35	35
Buried length (m)	1	1.2	1.5	1.7	2
Minimum top diameter (mm)	125	140	150	175	175
Minimum ground clearance (m)	4	4.6	5.5	5.8	6.1

9. Shackle insulators of appropriate voltage should be used I overall lines with voltages up to 1000 V. Stay insulators shall be provided on all stays sets along overhead lines of more than 1000 V. Insulator dimensions and appropriate conductors are listed in the table below.

Table 3.11: Insulator specifications

S.N.	Size	Dimensions	Weight	Corresponding conductor
1	Small	55 mm × 55 mm	200 gm	Squirrel, service wire
2	Medium	75 mm × 90 mm	600 gm	Gopher, weasel and rabbit
3	Large	100 mm × 110 mm	1300 gm	Dog

10. Pin, Disc, Strain are used for high-voltage transmission.
11. The operating voltage and span determine the minimum spacing of the conductors. Generally conductor spacing on the poles should be at least 300 mm in case of up to 400 V, 400 mm in case of 1000 V and 600 mm in case of 11 kV lines. For aluminium conductors in horizontal or triangular alignment, spacing is given by the formula:

    $$\text{Spacing} = \sqrt{(d + (V/150))}$$

    where, Spacing is in meters

    V= voltage in kV

    d = sag in meters

    In general, 70% should be added as a safety factor on the value calculated above.
12. A stay set should be provided at the first pole, at all poles set at an angle and at line ends. For safety and protection from storms, every fifth pole is generally stayed on both sides even if the poles are in a straight line.
13. Distribution lines and branches with more than 100 households or 10 kW should have a back-up breaker in a distribution box in order to be able to identify faults.
14. For easy maintenance and fault finding, the distribution system should be divided into different area separated by switches and fuses.
15. Drop-out fuses and gang-operated switches of suitable ratings shall be provided at high voltage points.
16. Distribution transformers should be oil-immersed, natural-cooled single and/or three-phase, suitable for outdoors installation on 11 kV and 33 kV, 50 Hz distribution systems. The design of transformers should conform to the latest edition of the appropriate IEC specifications and/or other recognised international standards.

Table 3.12: Features for distribution transformers

Type	Three-phase, 11/0.4 kV	Three-phase, 33/0.4 kV	Single-phase, 11/0.23 kV
Rated capacity			
Rated system voltage - Primary - Secondary	 11 kV 400/230 V	 33 kV 400/230 V	 11 kV 230 V
Highest system voltage - Primary - Secondary	 12 kV 440 V	 36kV 440 V	 12 kV 250 V
Rated Frequency	50 Hz	50 Hz	50 Hz
Connection - Primary - Secondary	 Delta Gnd. Wye	 Delta Gnd. Wye	 NA
Cooling System	ONAN	ONAN	ONAN
Vector group	Dyn 11	Dyn 11	NA
BIL for windings and bushings for primary side	75 kV	170 kV	75 kV
Withstand voltage, 50 Hz, 60S - Primary - Secondary	 28 kV 3 kV	 70 kV 3 kV	 28 kV 3 kV
Maximum allowable noise level at 3 metre hemispherical radius	<44 dB	<44 dB	<44 dB
Applicable standard	IEC	IEC	IEC

Lightning protection

1. Lightning arrestors should be provided for all current-carrying conductors at the start and end of transmission and distribution lines. Moreover, in lightning prone areas, lightning arrestors should be provided every 1000 m along high-tension lines and every 500 m along distribution lines.
2. Neutral lines should be placed on top of overhead low-tension lines. In lightning-prone areas neutral lines should be earthed approximately every 200 m using 2 m long, 25 mm diameter GI earth piping and GI wire/ strips or ACSR conductors with a minimum area of 20 mm^2.
3. Earthing should be provided at each lightning arrestor along the electrical lines, at the transformer body and at the transformer neutral on the secondary side of the distribution transformer. Earthing should be carried out using a minimum 600 mm × 600 mm × 3 mm ground plate of copper or GI piping/ strips with adequate depth, fill material and maintenance provisions (soaking, tightening connections, earth-resistance measurement) in order to achieve the least-resistance earth path for fault current and lightning strikes.
4. In lightning-prone zones, overhead ground wires shall be used to protect high-voltage transmission lines. This provision is not, however, recommended for low-voltage distribution networks.
5. Varistors should be used for better protection, especially for electronic equipment.

Service wire

Guidelines for service wire are discussed below.

1. Service wire should be doubly insulated: they should be PVC cable (concentric or multi-core) and additional voltage drops should not exceed 2%. Underground service connections should be either armoured cable or PVC cable in protective circuit.
2. Service wire should be of the same material as the line conductor (aluminium) to avoid the galvanic corrosion.
3. For spans exceeding 20 m, in consideration of the mechanical strength required, service wire of minimum 4-6 mm^2 (depending on the span) should be used for all lighting loads regardless of the actual power supply. However, if the distance (span) between a pole and a house is very short (i. e. less than 20 m), then a twin flat cable of 2.5 mm^2 can also be used.
4. A switch fuse unit (main unit) should be installed in each house.
5. The fuse of the main switch should be rated to protect against exceeding the maximum current ratings of the service connection.
6. To avoid overloading transformer and/ or plant, a load-limiting device (ECC, MCB or PTC) should be installed in each household.
7. Service wires should be clamped to poles to avoid creating tension in connections.

4 POWER AND ENERGY

4.1 Introduction

The purpose of developing a power plant is to generate energy. The amount of energy that can be generated from a power plant is dependent on the quantity of water flowing past a point per unit time and the head of the system plus the efficiency of the generating equipment and conveyance system. The annual total energy delivery capacity of a power plant is defined by the available discharge of the river for different period of time.

Probable monthly power and energy shall be calculated and presented in the detailed feasibility study report. Monthly energy shall be calculated in Nepali months in case of grid connected mini hydropower project mainly because NEA purchases bulk energy in Nepali months.

4.2 Estimation of Power Potential and Determination of Installed Capacity

The installed capacity of a project depends on the load demand of the power market and power potential of the river. An installed capacity of a power plant (P) can be calculated as:

$$P = 9.81 \times \square_t \times \square_g \times \square_d \times Q \times H_{net} \text{ (kW)}$$

Where,

- P = Power in kilowatt
- Q = Discharge in m^3/s
- H_{net} = Net head in meters
- $\square_t$ = Full Load Efficiency of turbine
- $\square_g$ = Full Load Efficiency of generator
- $\square_d$ = Efficiency of drive system

4.3 Outage

An off-grid mini hydropower project is generally in operation only during the period of adequate load and therefore plant outage mainly due to intentional stoppage of the plant is quite considerable. In case a mini hydropower project is grid connected, an outage including internal purposes shall be limited to 4%. In case the length of the transmission line is considerable (more than one kilometer), an additional energy losses along the transmission line shall be considered while calculating deemed energy to be supplied to the NEA grid.

4.4 Input Data

Hydrology: Average monthly discharge of the source river is used to calculate the power generation. The available flow for power generation shall be calculated by deducting downstream releases for environmental and for water supply, irrigation, water mills etc. from the available flow in the river. Specific requirement of downstream release shall be determined in the field investigation period. The prevailing mandatory environmental release is 10% of the minimum monthly river flow.

In case of isolated power plants the power and energy generation shall be worked out based on demand analysis.

Head losses: The total head loss in the headrace conveyance and penstock is calculated and deducted from the gross head to determine the net head or the rated head of the plant. Head losses consist of frictional head losses and turbulence head losses. The frictional head losses depend on the velocity of the flow and characteristics of the conveyance system whereas the turbulence head losses depend on the velocity and nature of the flow.

Head losses for mean monthly flows shall be calculated for estimating generated power and energy.

Equipment Efficiency: The efficiency of turbine, generator and power transformers are multiplied to get the overall efficiency of the plant. The efficiency of all the equipment contributing to overall efficiency vary with load and flow condition.

Other Assumptions: The following additional assumptions shall be made for the computation of the power and energy produced by the project:

- The minimum downstream release shall be taken as 10% of the minimum monthly inflow.
- The loss due to evaporation can be neglected
- The generation loss due to scheduled outage and station consumption can be considered as around 4% of generation of each month.
- In isolated schemes, daily load factor should be considered for determining the energy consumption.

4.5 Energy Computation

Estimation of mean monthly energy shall be calculated for each month. In case, the plant is grid connected, mean monthly energy shall be calculated in Nepali months. Mean monthly energy generation can be calculated as:

E (kWh) = no. of days in a month x 24 hours x power generation (P in kW)

An annual energy generation is the sum of all twelve months of the year.

5 PROJECT COST ESTIMATE

5.1 Introduction

Capitalized project cost consists of pre-construction costs, construction costs and financial costs. NEA generally pays its first payment only after the 4th month. Therefore, in a grid connected system, a working capital adequate for operating the plant for this period shall also be added in the capitalized cost. A typical capitalized cost of a mini hydropower project is presented in Table 5.1.

The costing of the project shall be carried out based on the project component quantities and unit rates derived from the corresponding district rates for the fiscal year. Wherever possible, the current costs of equipment and material also need to be obtained from manufacturers. Where these are not available, costs shall be calculated based on the similar projects carried out or current ongoing projects in Nepal.

Table 5.1: Summary of Cost

SN	Particulars
1	Pre-Operating Expenses
2	Civil Construction
3	Hydro-mechanical Works
4	Electro-mechanical
5	Transmission line & Interconnection
6	Land Lease & Purchase
7	Site Office & Camp Facilities
8	Office Equipment
9	Equipment
10	Infrastructure & Logistics
11	Environmental & Social Costs
12	Project Engineering, Management & Supervision
13	Insurance & Miscellaneous
14	Interest During Construction
15	Working Capital @ 20% of O&M
	Total before IDC & WC
	Total before WC
	Total including IDC & WC

5.2 Assumptions

The following criteria and assumptions are the basis of the cost estimate:

The cost estimate and financial analysis shall be carried out in Nepalese currency.

The US $ to NRs exchange rate shall be used for cost.

Price level
The cost estimate shall be made at the price level of the current fiscal year. All costs shall be first estimated on a per unit basis for each of the components and then amount arrived after multiplying with number. These shall be added to obtain the entire project cost. Lump sum costs shall be allocated for components where a detailed breakdown of costs is not available or worthwhile using judicious judgement.

Material price and labor cost
Material costs reflect real costs incurred at other projects of similar size or having similar scope of works. The prices shall be calculated based on the district rate for the current fiscal year. It shall be stated whether the bulk of the construction material, the steel items for headrace pipe and penstock work and all of the electromechanical equipment need to be imported or available in the local market.

It shall also be stated that whether skilled, semi-skilled and unskilled human resource can be obtained locally.

Indirect cost
The unit costs shall include profit, and overhead, which the contractor would charge. Along with that, Value Added Tax (VAT) will be applicable to all construction material procured. Therefore, VAT shall be included as per government norms in the relevant cost estimates.

5.3 General Methodology

The project shall be divided into a number of major components for the estimating process as follows:

- Pre-operating cost
- Main civil construction works
    - Temporary river diversion
    - weir, intake, canal, settling basin, forebay/spillway
    - headrace canal/pipe, saddle supports, and anchor blocks
    - powerhouse, and tailrace and outdoor switchyard
    - protection works
- Land and support: The cost components include land acquisition and lease, compensation to Forest Users' Committee, camp and other physical facilities, local development, access roads, if any, and environmental mitigation. This cost also shall include cost of relocation of existing infrastructure facilities that lie in the project construction site.
- Hydro-mechanical works
- Electrical and Mechanical equipment
    - turbines
    - generators
    - transformers
    - Electric Panels and Unit Control Boards

  - Governor
  - Indoor Switchgear and protection relays
  - Power, Control and communication cables
  - Cable Trays
  - Battery Charger Panel and Battery
  - auxiliary equipment
  - gates, valves and hoisting devices
  - switchyard equipment
- Transmission Line system (including transformers, LT lines etc)
- Value Added Tax (VAT)
- Physical and price contingencies
- Interest during construction
- Annual operation and maintenance (for financial analyses)

5.4 Cost Estimate of Civil Works

The estimating process for the civil construction works shall be as followings:

a. Development of unit rate of construction works based on designers' past experience with reasonable adjustments for the site specific conditions of the project. The construction method to be adopted and standard norms and practices of the country including prevailing market rates shall be given due consideration.

b. Division of the project area into a number of working fronts like headworks, settling basin / forebay, headrace pipe/penstock pipe, powerhouse and tailrace, etc.

c. Identification of distinct construction tasks or measurable pay items, such as overburden excavation, rock excavation, stone masonry, backfill work, concrete works, shuttering &scaffolding, steel reinforcement etc.

d. Quantity calculation of each item

e. Calculation of cost for each activity by multiplying quantity obtained in (d) by rates derived in (a).

f. Calculation of cost for each structure by summing up costs calculated in (e) of different works required for the structure.

5.4.1 Unit Rates/ Unit Prices

Unit rates should be derived for the major work items. Standard norms of practice and desingers' in-house experience shall be utilized in derivation of the unit rates. Wherever applicable, norms published by Ministry of Works and Physical Planning can be used. The prices of material and other equipment can be obtained from local market and also from projects under construction. A provision of 15~25% of the unit cost shall be adopted for overhead and profit. The following four sub-heads shall be estimated and the summation of these will be the rate of an item of works.

5.4.2 Labour Costs

For estimating purposes, the labour force is subdivided into five categories, namely unskilled, semi-skilled, skilled, highly skilled and supervisors. It shall be judged whether the work force required for the project will be available in the local areas or not. Normally, specific skilled labour will be hired from outside the project area. Labour costs should be based on the District Rate (Available from Office of the District Development Committee of every district and updated in the beginning of each fiscal year) of study year. However the rates of skilled as well as the unskilled labor in the construction area which prevails with district rate should be noted.

5.4.3 Cost of Equipment tools and Plants

For rate analysis purpose, equipment rates shall be derived from a widely used publication named "Cost Reference Guide for Construction Equipment".

5.4.4 Cost of Construction Material

It shall be assumed that major construction materials like cement, reinforcement steel, structural steels etc can be supplied from the nearest market or city center. Unit rates of construction materials should be derived from rates of local markets adding transportation cost and loading and uploading charges. Local construction materials like sand, aggregate and stones should be carefully analyzed. If these materials has to be transported or purchase from another vendor the rates should be accordingly. Specific materials like turbines, penstock pipes, gates which may be imported from India or overseas and their costs shall be calculated accordingly.

5.4.5 Overhead and profit

A profit at the rate of 10~15% shall be reasonable for the Contractors after allocating all charges of equipment, establishments etc. The overhead includes items such as office rent, camp facilities, power supply, depreciation of equipment, salaries of office staff, bank & insurance charges, etc. This overhead charge will be taken as 5~10% of the net cost of unit rate. Hence, a provision of 15~25% of unit cost can be adopted for overhead and profit.

5.5 Land and Support

Land and support include the following costs:

- Land acquisition and lease
- Compensation to Forest Users' Committee
- Camp facilities
- Local development
- Temporary access road
- Environmental mitigation

5.6 Pre-operating expenses

The pre-operating expenses include the cost of engineering and administration and developers cost.

5.6.1 Engineering, Construction Management, and Supervision

Real cost for engineering, construction management and supervision shall be calculated for covering the following items:

- detailed field investigations
- preparation of detailed construction drawings
- supervision of construction, transmission line, testing and commissioning
- management of procurement and transportation
- cost of the access road and the power house area development

- administration of construction materials
- measuring the work
- preparation of tender documents
- Management of procurement. transportation
- measuring the work and preparation of interim certificates
- cost of owner's and consultant's equipment, supplies, communication and transport

The prevailing practice is to allocate 6% of the total base cost to allow engineering, construction management and supervision costs.

5.6.2 Developer's Cost

The general practice of allowing 2% allowance of the base cost to cover owner's administration and other miscellaneous costs shall be considered.

5.7 Hydro mechanical works

The cost of Hydro-mechanical works such as conveyance pipe, penstock pipe, gates, trashracks, gates and stoplog shall be estimated from the information provided by the manufacturers/suppliers. Quotations from local manufacturers shall be solicited, as cost of hydromechanical equipment supplied by local fabricators may be cheaper compared to the imported one.

5.8 Electrical and Mechanical Equipment

The costs of the electrical and mechanical equipment should be estimated by a combination of methods including:

- Interpretation of quoted prices supplied by potential suppliers, mainly for the larger and more expensive equipment such as turbines, generators, power transformers, and main inlet valves.
- In-house estimates using established international prices and/or relationships for more routine items. The in-house information is based on years of collection of price data, and often elements the errors of variations of prices occurring due to changes in supply and demand.
- Percentage or lump sum provisions on a ratio basis based on experience, for lesser miscellaneous items.

The costs of the switchyard components may be based on:

- partly on quoted prices supplied by potential suppliers, and
- partly on in-house estimates using established international prices, and experience

5.9 Transmission Line

The cost of transmission line should be based on the current costs practiced in transmission line constructed by NEA or quotation of manufacturers/suppliers.

5.10 Value Added Tax (VAT)

In accordance with Government of Nepal's Rules, a Value Added Tax (VAT) of 13% is applied on the total civil construction cost and in the cost of hydro-mechanical works. VAT is exempted for electro-mechanical equipment by projects below 3 MW capacity.

5.11 Contingencies

The estimated costs should include physical contingencies which allow for unforeseen cost increases that may become necessary as more information is obtained and evaluated. In view of the extent of investigations and study, the following contingencies shall be considered:

- Civil Works - Surface & Infrastructure & General Items 10%
- Hydro- & Electromechanical and Transmission 5%

A price contingency of 4% of the construction cost shall be considered in the project estimate.

5.12 Interest During Construction (IDC)

Interest During Construction (IDC) is usually capitalized as part of the capitalized cost because it must be financed during construction and recovered through depreciation charges. IDC is the interest that is paid on the funds drawn down from loans taken to finance the projects. IDC is based on the debt-equity ratio, interest rate, construction period and cash flow disbursement. As stated earlier, need of a provision of working capital shall also be stated and allocated accordingly.

5.13 Annual operation and Maintenance Cost

The annual operation and maintenance (O & M) cost of a hydropower plant is generally adopted 1.5% to 3% of the total construction cost. It is less for larger plants and high for smaller plants. Alternatively this cost can be calculated with the breakdown of cost items. The cost items are:

- salary and benefits to the operation crew
- cost of materials
- cost of spare parts
- regular repair and maintenance cost
- insurance cost
- local development cost
- other costs

Experience of similar type of power plant is also an appropriate method to determine the annual operation & maintenance cost.

5.14 Project Cost

On the basis of the analysis described above, the cost of the Mini Hydropower Project shall be calculated. Financial cost of the Project includes applicable taxes and duties applicable to hydropower projects as per Nepal Government Rule, custom duty @1% of the price for import of electromechanical equipment, price contingency during construction and interest during construction on debt portion of the cost.

6 CONSTRUCTION PLANNING AND SCHEDULING

6.1 General

The feasibility study of a hydropower project essentially prepares the construction planning and scheduling of the project construction works. It is generally presented in a bar chart, critical path method diagram (CPM chart) or some computer programs like MS Project. The cash flow required for the project construction is calculated on the basis of cost required for construction of various project components. The construction plan and schedule lists out construction activities and work items of the project components in a vertical column and the time duration required for each activity or sub activity are shown in horizontal rows.

The construction phase of a mini hydro project starts after approval letter from DoED has been received by a developer and power market to supply the energy from the envisaged power plant has been established. In grid connected mini hydro projects the developer has to conclude a power purchase agreement with an electricity utility like the Nepal Electricity Authority.

6.2 Phases of Construction Activities

The construction schedule of a mini hydro project should covers the following items.

1. **Preconstruction schedule**

   The main activities of the preconstruction schedule are detail design of the project components, preparation of bid documents and selection of contractors for the construction works. Other activities in this phase are construction of access to the project site, arrangement of land for the project, establishment of construction power, appointment of contractors and suppliers and organization of project management group.

2. **Construction schedule**

   Based on the detailed design the volume of different works is determined and time required to complete the items are calculated. The time calculation is based on work volume and productivity of work depending upon construction technology. The sequence of work is also worked out. The construction works in a mini hydro project generally consist of the following works:

   - ***Preparatory works:*** Land acquisition, establishment of construction facilities, arrangement of borrow area of construction materials.
   - ***Civil works:*** River diversions works and construction of diversion facilities, desilting facilities, water conveyance system (headrace canal or conduits) forebay, penstock support and anchor blocks, powerhouse building and tailrace canal.
   - ***Hydromechanical works:*** Fabrication, transportation, erection and testing of gates, trash racks, penstock pipes etc. Generally, the civil works for these steel structures are completed and then the installation works are performed.
   - ***Electromechanical works:*** The electromechanical works are carried out after the civil works have been substantially completed. It is planned in such a way that the powerhouse civil work is completed first and the powerhouse building is handed over to the equipment installer. Possible interference between the contractors of these works needs to be coordinated by the project management to avoid conflicts and unnecessary delays.

- ***Transmission Line work:*** The transmission line work may be started slightly behind the civil works depending upon the transmission line length or time required to complete it. The transmission line construction must be ready before the testing of electromechanical equipment is to be carried out.
- ***Commissioning of Power Plant:*** The commissioning of the power plant can be completed after successful testing of the power plant facilities like testing of waterways, testing of generating equipment and charging of transmission line. The commercial generation of the project starts at after the commissioning of the power plant.

7 FINANCIAL ANALYSES

7.1 General

The power project must be technically feasible as well as financially viable. Apart from the technical, environmental and socio-economic aspects of the project, the financial analysis provides the most important indicators for the acceptability of the project for investment. The financial evaluation is aimed at giving potential investors an overview of the risks and benefits associated with financing the project. The analysis is based on the use of real time monetary values of the cost and benefit and makes use of market prices and, therefore, includes any taxes which will be levied on the factors of production and any subsidies, capital or operating costs, which may be received as part of the development. All costs are charged and all revenues credited to the analysis in the actual amounts expended or received at the time of expenditure. For this analysis the financial rate of return and cash flow is assessed from the perspective of a utility owner/operator.

The financial analysis is carried out by the usual discounted cash flow technique. The financial indicators are: the Internal Rate of Returns on Total Investment and Equity Investment, Net Present Value and Benefit Cost Ratio. The analysis is carried out in Nepalese Rupees (NRs.) as the price for the energy that will be sold from this project will be in NRs. The relevant specific parameters applied for the financial analysis in this study are the following:

7.2 Subsidy

The amount of applicable subsidies for implementing new and upgrading of existing Mini/micro-hydropower project are as per Renewable Energy Subsidy Policy, 2069 presented in subsidy section of chapter 1.

7.3 General Assumptions

Analysis Period: The analysis period starts with cash flow investment for project construction works which is distributed for each year of construction period generally 1.5 to 3 years. Then the cost and revenue are spread over the economic life of the plant from the date of commercial generation. Generally, 25 years can be adopted as the economic life of a mini hydro plant.

Reference Date: A reference date for costs, exchange rate and discounting is established on the date of project evaluation.

Investment Cost: The financial cost of project investment is made up of total construction cost with contingencies, price escalation, taxes, duties, value added tax and the interest during construction. Interest during construction is calculated with prevailing interest rate on the total investment. The format for the cost is presented in Format.

Operation & Maintenance (O&M) Costs: Annual operation and maintenance cost of the plant is made up of salary of staff, repair & maintenance cost, taxes and duties, overhead of the company, depreciation cost. The O&M cost is generally adopted as 1.5 to 3% of the project cost.

Insurance Premium: Annual insurance premium of the plant can be assumed to be 0.5 to 2.0 percent of the total financial cost of the project.

Financing Mix: The project is assumed to be developed with long term loan and equity investment of Developer with financing mix of loan and equity as appropriate. The medium term loan is assumed to carry the annual interest rate for the repayment period following commercial operation of the project. Interest during construction (IDC) has been capitalized.

Discount Rate: A discount rate has to be chosen and used to calculate the Net Present Value and the Benefit Cost Ratio of the project as well as to compare with the calculated IRR on Equity Investment. The choice of a discount rate should be based on the prevailing market interest rate – say 6 % on Capital cost minus subsidy.

Energy Benefits: Energy benefits of a project are based on the energy consumption in the supply area multiplied by the electricity tariff. The price of energy is generally based on prevailing tariff in similar projects or the electricity tariff of NEA.

In case of isolated scheme the tariff rate should be fixed by community for lighting and end use purpose. However financial parameters should be met. If the project is connected to the central grid of NEA the energy benefit from the project is calculated on the basis of a power purchase agreement between the Developer and NEA. The Developer can supply the monthly deemed energy under PPA. The prevailing practice of NEA is to purchase energy based differential tariff. NEA is tariff for Poush – Chaitra (dry energy) and the rest of the months (wet energy) are Rs 8.40/kWh and Rs. 4.80/kWh respectively. As presented in Table 4.1, NEA has also made a provision of 3% flat escalation on both the energies for five years.

Table 7.1: NEA Tariff and 3% escalation for five years

Year of Operation	1	2	3	4	5	6
Tariffs (NRs)						
dry season	8.40	8.65	8.90	9.16	9.41	9.66
wet season	4.80	4.94	5.09	5.23	5.38	5.52

Royalty: According to the Electricity Act, 2068, royalty on electricity production up to 1000kW is exempted.

Depreciation: The depreciation rate of 4 percent per annum has been applied by straight line method is used.

Tax Rate: As stipulated in the Electricity Act 2065, the applicable corporate tax rates for enterprises undertaking electricity generation are:

- VAT exemption for all equipment and spare parts required for the construction period. 1% Custom is applicable.
- Income Tax Act 2058 has made a provision that there shall be no income tax for the projects up to 1000 kW

7.4 Results of Financial Analysis:

Financial parameters for the base case (total investment) shall be:

- Positive NPV
- FIRR higher than the interest rate
- B/C ratio above 1.
- Debt Service Cover Ratio (DSCR) more than 1.

7.5 Sensitivity Analysis

It is essential to carry out sensitivity analysis to justify the project feasibility under various changes in the basic parameters which might influence the financial indicators of the project. The base case should be tested with possible changes in the basic parameters. The following cases should be tested for financial viability. A typical sensitivity parameter associated with financial risks of a mini hydropower project is presented in Table 7.3. The values given in the Table shall be adjusted according to the market conditions during negotiations with lending agencies.

Table 7.2: Sensitivity Parameters

Sensitivity Analysis
Change in discount rate From 8 to 16%
Change in interest 1 rate From 9 to 13%
Change in cost From -20 to 20%
Change in revenue from -15 to 5%

8 RISK ASSESSMENT

8.1 General

A mini hydro project shall be re-examined under reasonable range of alternative assumptions with regard to the underlying uncertainties of variables as listed under:

- Financial Risk
- Hydrological Risk
- Market Risk
- Construction Risk

Some of the risks are site specific and they should be assessed during the field investigation and design period. The detailed study shall collect and analyze adequate data/information associated with the risks as stated above. This will prevent harming the project construction as well as operation. Appropriate measures should be suggested in descriptive form by the consultant on risk management.

8.2 Financial Risk

The financial risks includes change in interest, change in item rates, change in project cost, change in legislation, change in exchange rate, change in construction period, etc. These risks shall be analyzed during negotiations with lenders. Sensitivity parameters for analyzing financial risks are presented in Table 7.3.

8.3 Hydrological Risk

Power generation from a run-of river scheme is directly related to the hydrology of the source river. Generally mean monthly flows are used for determining the monthly energy generation. Hydrology of rivers vary depending on the precipitation and other climatic conditions. Moreover, mini hydro projects are generally constructed in ungauged rivers/ streams and the flows generated through various indirect methods may not fully reliable. The revenue of the scheme should be checked under variable hydrological conditions. Decrease in revenue due to lower generation flows shall be considered in the financial analysis. A typical range can be -15% to +5% based on the reliability of hydrological data of the project.

8.4 Construction Risk

Risks related to construction are cost overrun due to delayed construction which causes increased IDC, advance loss of revenue due to late generation, increase in market price, penalty for late delivery of energy, geological risk, contractor's performance risk, force majeure risk (unforeseen conditions), etc. The probable degree of risks should be loaded by the Consultant in the sensitivity analysis.

8.5 Other Risks

Other risks in mini hydro development can be:

Environmental risk: Environmental risk are related to water rights, acquisition of land, relocation of existing structures (road, bridge, canal etc.), use of forest area etc. Information shall be collected by interacting with beneficiaries and people of project area. These data shall be analyzed and suitable mitigation measures shall be recommended in the detailed feasibility study. Timely negotiation and receiving permissions shall be made to avoid delay and interruption in construction and operation phase.

Political risk: Disturbances due to political instability lead uncertainty in a project implementation may result in delays and cost overrun. Assessment of such risk shall be carried out by qualitative methods.

Social risk: Social risks are associated with the implementation of project without proper consultation and consent of the people residing in the project areas. Timely interaction is recommended for minimizing such a risk. Social risk may arise due to excessive use of local resources (water, land, forest, construction materials, etc.) by the developer, intervention in the living style or tradition of the locals, etc. These risks shall be identified and adequate mitigation measures shall be recommended during the socio economic and environmental studies of a mini hydropower project.

9 FEASIBILITY REPORT STANDARD

9.1 General

The detailed feasibility study report shall be prepared in a concise manner with necessary project data/ information, analyses and designs, drawings, tables and annexes. The detailed feasibility shall have following three volumes:

VOLUME I: MAIN REPORT (A4)

VOLUME II: ANNEX (A4)

VOLUME III: DRAWINGS (A3)

9.2 Detailed Feasibility Study Report Format

VOLUME I: MAIN REPORT (A4)

EXECUTIVE SUMMARY

SALIENT FEATURES OF THE PROJECT

1. INTRODUCTION

- 1.1 Background
- 1.2 Power market
- 1.3 Previous studies
- 1.4 Project
- 1.5 Location and accessibility
- 1.6 Objectives and scope of study

2. TOPOGRAPHIC SURVEY AND MAPPING

- 2.1 Existing maps
- 2.2 Surveying
- 2.3 Topographic mapping

3. HYDROLOGY

- 3.1 General
- 3.2 Basin characteristics
- 3.3 Data available

3.4 Climatology and Meteorology

3.5 Stream flow

3.6 Hydrological analysis

3.6.1 MIP method

3.6.2 Catchment correlation method

3.6.3 HYDEST

3.6.4 Flow measurement

3.6.5 Summary of flow estimation

3.6.6 Mean monthly flows

3.6.7 Flow duration curve

3.6.8 Water sharing issues and riparian release

3.6.9 Available flow for power generation

3.6.10 Low flow

3.6.11 Extreme flood flows

4. GEOLOGY AND GEOTECHNICAL STUDY

4.1 General

4.2 Regional geology

4.3 Project geology

4.3.1 Rock types

4.3.2 Debris flow soil deposit

4.3.3 Alluvial soil deposit

4.3.4 Colluvium

4.3.5 Residual soil

4.3.6 Landslides

4.4 Geological descriptions of major project sites

4.4.1 Headworks

4.4.2 Waterways

4.4.3 Forebay

4.4.4 Penstock alignment

4.4.5 Powerhouse site

4.5 Construction materials

4.6 Geological problems

5. ALTERNATIVE STUDY

`

6. PROJECT CONFIGURATION

6.1 Headworks

6.1.1 Diversion weir

6.1.2 Intake

6.1.3 Gravel trap

6.2 Settling basin

6.3 Waterway pipe inlet

6.4 Waterway

6.5 Forebay

6.6 Penstock

6.7 Anchor blocks and saddle supports

6.8 Powerhouse and tailrace

6.9 Access road

7. POWER AND ENERGY OUTPUT

7.1 General

7.2 Energy generation

7.2.1 Power and energy benefits

7.3 Demand Analysis

8 HYDROMECHANICAL AND ELECTROMECHANICAL WORKS

8.1 Hydromechanical Works

8.2 Electromechanical Works

9. STUDY ON POWER TRANSMISSION

9.1 Transmission system

9.1.1 Transmission line

9.1.2 Interconnection

9.2 Distribution network

9.3 Load centres

10 ACESS CONDITION

11 ENVIRONMENTAL ASPECTS

12 PROJECT COST ESTIMATE

12.1 Cost estimates

12.2 Basis of cost estimate

12.3 Construction cost estimate

12.4 Operation and maintenance cost

13 PROJECT EVALUATION

13.1 General

13.2 Evaluation of the project

13.3 Assumptions

13.4 Financial analysis

13.5 Sensitivity analysis

13.6 Risk Analysis

13.6 Conclusion and Recommendations

14 CONSTRUCTION PLANNING AND SCHEDULING

14.1 Infrastructure

14.2 Construction power

14.3 Transportation of materials and equipment

14.3 Construction schedule of project works

14.4 Construction planning

14.5 Organization Structure

15 CONCLUSION AND RECOMMENDATIONS

15.1 Conclusions

15.2 Recommendations

VOLUME II: ANNEX (A4)

APPENDIX A TOPOGRAPHIC SURVEY

APPENDIC B FLOW MEASUREMENT DATA SHEET

APPENDIX C DESIGN

APPENDIC D COST ESTIMATION&FINANCIAL ANALYSIS

VOLUME III: DRAWINGS (A3)

APPENDIX E DRAWINGS

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11 ANNEXES

Annex A: Directives on licensing hydropower 2068

Annex B: Documents of required for tendering

Annex C: Bill of quantity (BOQ) sample

Annex D: Format for detail feasibility study of Mini-hydropower Project

Annex E: Sample drawing of Lipin Small Hydropower Projects, 1500 kW, Sindhupalchowk

Annex F: Specifications of Armoured and Unarmoured cable

ANNEX A

DIRECTIVES ON LICENSING HYDROPOWER 2068

अनुमतिपत्रको दरखास्त सम्बन्धी व्यवस्था:

(१) कुनै जलविद्युत आयोजनाको विकास गर्न चाहने प्रवर्द्धकले विद्युत उत्पादनको सर्वेक्षण अनुमतिपत्र प्राप्त गर्नको लागि देहाय बमोजिमको कागजातहरु सहित नियमावलीको अनुसूची–२ बमोजिमको ढाँचामा विभाग समक्ष दरखास्त दिनु पर्नेछ ।

(क) दरखास्तमा माग गरेको विद्युत उत्पादनको क्षमता अनुसारको अनुमतिपत्र दस्तुर बापतको रकम विभागको धरौटी खातामा जम्मा गरेको सक्कल रसिद,

(ख) नियमावलीको नियम ४ को (क), (ख), (ग) र (घ) बमोजिमको विवरणहरु (जस्तैः अध्ययन कार्यको (Detail cost breakdown) डिटेल कष्ट ब्रेक डाउन, कार्य तालिका, आयो जनाको हाईड्रोलोजिकल विश्लेषण आदि), खुल्ने गरी तयार पारेको डेस्क स्टडी रिपोर्टका साथै नापी विभागद्वारा प्रकाशित १:२५,००० वा १:५०,००० स्केलको स्थलरुप नक्शामा अक्षांश र देशान्तर खुल्ने गरी आयोजनाको क्षेत्र रेखात्कन गरिएको स्थलरुप नक्सा, (ग) संस्थाले दरखास्त दिंदा संस्थादर्ताको प्रमाणपत्र, स्थायी लेखा नम्वर र संस्थाको प्रबन्धपत्र तथा नियमावली,

(ङ) उपदफा ३ बमोजिम आर्थिक क्षमता प्रमाणित हुने कागजात विवरण,

(च) उपदफा ४ बमोजिम प्राविधिक क्षमता प्रमाणित हुने कागजात विवरण,

(छ) संयुक्त उपक्रमवाट आयोजनाको विकास गर्ने भए सो सम्बन्धी समझदारीपत्र वा संझौताको प्रमाणित प्रतिलिपि,

(झ) प्रवर्द्धक वा निजको तर्फवाट सम्पर्क गर्ने आधिकारिक व्यक्तिको विवरण, पत्राचार गर्ने स्पष्ट ठेगाना, सम्पर्क टेलिफोन नं. (कार्यालय, निवास,) मोबाइल नं., फ्याक्स नं.,पो.व.नं., तथा इमेल,

(२) कुनै आयोजनाको जडित क्षमता निर्धारण देहायको आधारमा गरिनेछ :

(क) विभागले अनुमतिपत्र माग गरिएको आयोजनाको जडित क्षमता निर्धारण गर्न प्रवर्द्धकले उपलब्ध गराएको हाइड्रोलोजिकल टाइम सिरिज डाटाको (Probability या Excedence) प्रोब्याबिलिटी अफ एक्सिडेन्स Q40 (क्यू फोर्टी) लाई आधार बनाउने छ ।

(ख) प्रवर्द्धकले पेश गरेको हाईड्रोलोजिकल तथ्यांक्त विभागमा उपलब्ध आधिकारिक तथ्यात्कसंग तात्विक रुपमा फरक परेको पाईएमा विभागमा उपलब्ध तथ्यांकलाई आधार मानी विभागले सम्बन्धित आयोजनाको जडित क्षमता निर्धारण गर्नेछ ।

(ग) प्रवर्द्धकले दरखास्तमा माग गरेको जडित क्षमता भन्दा विभागवाट निर्धारण भएको जडित क्षमता

बढी हुन आएमा विभागवाट निर्धारित जडित क्षमतालाई कायम गरी सोही बमोजिम अनुमतिपत्र दस्तुर बापतको धरौटी प्रवर्द्धकबाट प्राप्त भइसकेपछि मात्र विभागले आवश्यक कारवाही प्रारम्भ गर्नेछ ।

(घ) यसरी कुनै आयोजनाको जडित क्षमता निर्धारण गर्दा विभागले जलस्रोतको अधिकतम उपयोग, विद्युत बजारको उपलब्धता र लगानीको अधिकतम प्रतिफललाई नै मुख्य आधार मान्नेछ ।

(ङ) कुनै प्रवर्द्धकले उचित आधार सहित आयोजनाको जडित क्षमता वृद्धिको लागि दरखास्त दिएमा अनुमतिपत्र जारी भएको मितिदेखि त्यस्तो जडित क्षमता वृद्धि भएको मानी सोही अनुसारको दस्तुर बुझाउनु पर्नेछ ।

(३) प्रवर्द्धकले आफ्नो आर्थिक क्षमता वा हैसियत प्रस्तुत गर्न विभाग समक्ष निम्न कागजातहरु पेश गर्नु पर्नेछ :

(क) आयोजनाको कुल लागतको बीस प्रतिशत स्वपुजी (इक्वीटी) को हिसाबले हुन आउने रकमको कम्तिमा पाच प्रतिशत रकम बराबरको खुद सम्पत्ति (नेट वर्थ) रहेको प्रमाणित कागजात वा पछिल्लो छ महिनासम्म कायम रहेको आधिकारिक तरल सम्पत्तिको विवरण विभाग समक्ष पेश गर्नु पर्नेछ । यस्तो विवरण दर्तावाल चार्टर्ड एकाउन्टेन्टबाट प्रमाणित भएको तथा पछिल्लो आर्थिक वर्षको आधिकारिक लेखापरीक्षण प्रतिवेदन समेत समावेश भएको हुनुपर्नेछ ।

(ख) एक भन्दा बढी आयोजनाको सर्वेक्षण अनुमतिपत्रको लागि दरखास्त दिनेको हकमा त्यस्तो प्रवर्द्धकले माग गरेको थप आयोजना कार्यान्वयन गर्न सक्ने अतिरिक्त आर्थिक क्षमता ।

(ग) संयुक्त उपक्रम (जोईन्ट भेन्चर) द्वारा आयोजना विकास गर्ने भएमा आबद्ध संस्थाको सामुहिक आर्थिक क्षमता (खुद सम्पत्ति वा तरल सम्पत्ति) ।

(घ) संयुक्त उपक्रमवाट आयोजना विकास गरिने भएमा कानुन बमोजिम नयाा कम्पनी दर्ता गरेको प्रमाणित कागजातहरु ।

(४) प्रवर्द्धकले आफ्नो प्राविधिक क्षमता प्रस्तुत गर्न देहाय बमोजिमका कागजात विवरणहरु विभाग समक्ष पेश गर्नु पर्नेछ :

(क) प्रचलित कानून बमोजिम नेपालमा दर्ता भएको परामर्शदातृ संस्थासागको सम्झौतापत्र र परामर्शदातृ संस्थाको प्रबन्धपत्र तथा नियमावलीको प्रमाणित प्रतिलिपि ।

(ख) विदेशी परामर्शदातृ संस्था भएमा त्यस्तो संस्थाले नेपालमा दर्ता भएको कुनै परामर्शदातृ संस्थासंग आबद्ध भई कार्य गर्ने गरी गरेको सम्झौताका अतिरिक्त संस्था दर्ता भएको कागजातको प्रमाणित प्रतिलिपी ।

(ग) परामर्शदातृ संस्थावाट आयोजनाको कार्यमा संलग्न हुने प्राविधिकहरुको योग्यता तथा अनुभव खुल्ने कागजातहरु ।

(घ) परामर्शदातृ संस्थाले यस अघि जलविद्युत आयोजनाको सम्भाव्यता अध्ययन वा डिटेल डिजाईन वा डिटेल प्रोजेक्ट रिपोर्ट तयार गरेको अनुभव खुल्ने कागजातहरु ।

ANNEX B

DOCUMENTS REQUIRED FOR TENDERING

While preparing tender documents the owner/consultant should include following information.

Section I	Instruction to Bidders
Section II	Bidding Data
Section III	Sample forms of Bid
Section IV	General Condition of Contract
Section V	Special Condition of Contract
Section VI	Technical Specifications
Section VII	Sample Forms of Security
Section VIII	Bill of Quantities
Section IX	Drawings (as required)

ANNEX C

BILL OF QUANTITY (BOQ) SAMPLE

Alternative Energy Promotion Centre

FA 2.01: Summary of Cost x 1000

SN	Particulars	Cost in Rs	Cost in Rs x1000	%
1	Pre-Operating Expenses	-	-	
2	Civil Construction	-	-	
3	Metal Works	-	-	
4	Plant and Machinery	-	-	
5	Transmission line & Switchyard	-	-	
6	Land Purchased & Development	-	-	
7	Site Office Building	-	-	
8	Office Equipment	-	-	
9	Vehicle (if required)	-	-	
10	Infrastructure Development	-	-	
11	Environment Mitigation	-	-	
12	Project Sup, Engineering & Management	-	-	
13	Project Insurance	-	-	
14	Interest During Construction	-	-	
15	Working Capital @ 20% of O&M	-	-	
	Total before IDC & WC	**-**	**-**	
	Total before WC	**-**	**-**	
	Total including IDC & WC	**-**	**-**	

Total before IDC & Working Capital

Total Cost		
Cash Loan		
Equity		

Total including IDC

Total Cost		**100.00%**
Interest During Construction in Fin. Fees		
Total Loan w/o working capital		
Equity		

Total including IDC & Working Capital

Total Cost		**100.00%**
Working Capital		
Total Loan with working capital		
Equity		

Alternative Energy Promotion Centre

Financial Summary

SN	Descriptions	Rs	$
1	Project Capacity (MW)		
2	Energy Generation (GWh)		
	Dry Season (GWh)		
	Wet Season (GWh)		
	Plant Factor (%)		
3	PPA Base Rate (Rs / kWh)		-
	Dry Season (Rs / kWh)		-
	Wet Season (Rs / kWh)		-
	Escalation Rate (3% for 5 years)		
4	Total Project cost (x 1000 Rs)		-
	Pre-Operating Expenses		-

	Civil Construction: 0%		-
	Metal Works: 0%		-
	Plant and Machinery: 0%		-
	Transmission line & Switchyard: 0%		-
	Land Purchased & Development: 0%		-
	Site Office Building: 0%		-
	Office Equipment: 0%		-
	Vehicle: 0%		-
	Infrastructure Development: 0%		-
	Environment Mitigation: 0%		-
	Project Sup, Engineering & Management : 0%		-
	Project Insurance: 0%		-
	Interest During Construction: 0%		-
	Working Capital @ 20% of O&M: 0%		-
	Total before IDC & WC: 0%		-
	Total before WC: 0%		-
	Total including IDC & WC: 0%		-
5	Sources of Fund: 100%		-
	Equity: 0%		-
	Loan: 0%		-
6	Period of Construction & Disbursement		
	1st Year		
	2nd Year		
	3rd Year		
7	Loan Period (years)		
	(including 3 yrs construction & 10 yrs repayment)		
8	Bank Interest Rate (%)		
9	Operation & Mainentenace Cost (% of project cost)		
	Escalation Rate (per anum)		
10	Royalties		

	Royalty (energy) % up to 15 years of CoD		
	Royalty (energy) % after 15 years of CoD		
	Royalty(capacity) Rs./kW up to 15 years of CoD		-
	Royalty(capacity) Rs./kW after 15 years of CoD		-
11	Depreciaion		
12	Discounted Factor		
13	Tax Rate		
	1 - 7 Yrs (after CoD)		
	7 - 10 Yrs (after CoD)		
	After 10 Yrs (after CoD)		
14	Required Commercial Operation Date		
15	Major outputs		
	Internal Rate of Return on Project(FIRR)		
	Internal Rate of Return on Equity (EIRR)		
	Debt Service Coverage Ratio (DSCR)		
	NPV		-
	BC Ratio		

Summary of BoQ and Cost Estimates

S. No.	Description of Particulars	Total	%
A	CIVIL WORKS	-	
B	HYDROMECHANICAL WORKS	-	
C	ELECTROMECHANICAL EQUIPMENT & TRANSMISSION LINE	-	
D	OTHER COSTS	-	
F	FINANCIAL COSTS	-	
G	CAPITALIZED COST	-	
	Total Cost: Cr Rs.		

FA 2.03: Unit Rates: Materials

District Manpower Rate (8 hr/day)

S. No.	Manpower	District Rate (Rs/day)	Used Rate (Rs/day)	Hourly rate including over time (Rs/hr.)
1	Unskilled			-
2	Semiskilled			-
3	Skilled			-
4	Rebar man			-
5	Fitter			-
6	Driller			-
7	Blaster			-
8	Welder			-
9	Skilled Electrician			-
10	Unskilled Electrician			-
11	Senior Mechanic			-
12	Junior Mechanic			-
13	Mason			-
14	Carpenter			-
15	Fabricator			-
16	Nozzle man			-
17	Operator_(S_C)			-
18	Mixer Operator			-
19	Concrete finisher			-
20	Heavy Driver			-
21	Medium Driver			-
22	Light Driver			-
23	Excavator Operator			-
24	Light Equipment Operators			-
25	Plumber			-
26	Painter			-
27	Helpers for all Class			-

28	Skilled Supervisor			-
29	Unskilled Supervisor			-
30	Foreman			-
31	Surveyor			-
32	Security Guard			-
33	Office boy			-
34	Office store Asst..			-
35	Survey Asst..			-
36	Computer Operator			-
37	Khalasi Helper			-
38	Gas cutter Turner			-
	Facilities for project regular staff			
	Dashain Allowance @ 30days payment annually			
	12 days paid leave in a year			

Construction Material Rates inclusive of VAT at Project Site

S.No.	Materials	Unit	Rates (Rs)			Remarks
			At nearest roadhead	Transportation	Site	
1	Cement	Ton				
2	Reinforcement Steel	Ton				
3	Structural Steel	Ton				
4	2.2m lomg Rock Bolts (Ordinary Type) w 200m threading and 200x200x10mm plate and accessories					
a	20 mm Dia.	nr				
b	22 mm dia	nr				
c	25 mm dia	nr				
d	28 mm dia	nr				
e	32 mm dia	nr				
5	Rock Bolts (Expansion Type)	m				

6	Binding Wire (1.22mm dia)	kg				
7	24g C.G.I Sheet for Roofing	Bundle				
8	Mesh wire 10 SWG heavy quality	kg				
9	Selvage wire 8 SWG heavy quality	kg				
10	Binding wire 12 BWG medium quality	kg				
11	Gelatin incl security	kg				
12	Detonator	no				
13	Fuse Wire	roll				
14	Drill Bits(25 & 28 mm Dia)	pcs				
15	Drill Bits(36mm Dia)	pcs				
16	Drill rods (8' long)	pcs				
17	Drill rods (5' long)	pcs				
18	Cement capsule (M32 300 mm long)	no				
19	High Speed Diesel	lit				
20	Acetylene (DA) gas (6.4 Cum/Cylinder)	cylinder				
21	Oxygen Gas (14 Cum/Cylinder)	cylinder				
22	Super plasticizer (MBT)	kg				
23	Accelerator(RHEOBUILD 850)	kg				
24	Diesel	lit				
25	Mobil(Pneumatic oil)	lit				
26	Lubricant	Kg				
27	Gear oil	lit				
28	Hydraulic oil	lit				
29	Bearing grease	kg				
30	Engine oil	lit				
31	Transmission oil	lit				
32	PVC air Hose (1" dia.)	m				
33	Flexible Water Hose (2.5" dia.)	m				
34	Aggregates < 30 mm	m^3				
35	Aggregates < 20 mm	m^3				

36	Aggregates < 10 mm	m^3				
37	Sand	m^3				
38	Mixed Gravel	m3				
39	Vent Duct (600 mm dia)	m				
40	Rail Track (14 kg/m)	m				
41	Welding electrode (4mm, 3.2 mm, 2.5 mm)	pkt.				
42	Anchor Bar (2.2m long, Dia.= 25 mm)	nr				
43	Anchor Bar (2.2m long, Dia.= 20 mm)	nr				
44	Forepolling Steel bar(3m long, 32mm Dia)	nr				
45	Forepolling Steel bar (3m long, 25m Dia)	nr				
46	Forepolling Steel bar (3m long, 20m Dia)	nr				
47	Local Wood (Soft wood)	m^3				
48	Saal Wood	m^3				
49	P.V.C. water stop 230 mm wide	m				
50	Boulder stone	m^3				
51	Geotextile Filter	m^2				
52	Enamel Paint	lit				
53	Primer	lit				
54	Aluminum Paint	lit				
55	HDP Pipe (110 mm Dia.)	m				
56	G I Pipe (50 mm Dia.)	m				
57	HDP Pipe (25 mm Dia.)	m				
58	Packers	no				
59	nails(25-100mm)	kg				
60	Cleaning Tools	L/S				
61	Timber beams	m^3				
62	Steel Forms(3mm thick)	m^2				
63	Steel Forms (Gantry Type)	m^2				
64	Bearing Plates	No				
65	Strut and Bracing	L.s.				

66	Nuts and Bolts	no				
67	Galvanized Iron Pipe (15mm Dia.)	m				
68	Glass for Window	m^2				
69	Cement Paint	Kg				
70	Gum	Kg				
71	Nail	Kg				
72	Black Pipe 2" Diameter	m				
73	2 Inch HDPE Pipe	rm				
74	4 Inch HDPE Pipe	rm				
75	Block .2 x .2 x .4	No.				
76	Impervious Clay Material	m^3				
77	Pervious Material/River Gravel	m^3				
78	Petrol	1 Lit				
79	Kerosene	1 Lit				
80	Block (General)	No.				
81	Microsilica (20kg/m3)	kg				
82	Plasticizer (5.63kg/m3)	kg				
83	Water for Concrete (for 1m3)	LS				
84	Plywood	m^2				

Hire Rates (if required)of Construction Equipment and Plant (Excluding fuel but including operators)

S. No.	Equipment	Capacity	Hourly Hire Rate (Rs)	Charge for Operator and Helper(Rs)	Hourly Hire Rates/hr.
1	Excavator incl operators				
2	Loader (KLD)				
3	Tipper (6 Cum) incl operators				
4	Backhoe				
5	Vibrating Roller (JV 40)				
6	Generator (50GF)				
7	Generator 180kV				
8	Concrete Mixer (14/10)				

9	Rock Breaker				
10	Concrete Pump				
11	Vibrator				
12	Submersible Pump (3", 3 HP)				
13	Electric Air Compressor				
14	Welding Machine				
15	Diesel Air Compressor (XA 280)				
16	Water Pump				
17	Jeep 10 seater				
18	Total Station				
19	Auto Level				
20	Buckets and its accessories				
21	Hand Pneumatic Drill				
22	Locomotive				
23	Rock Shovel				
24	Grout Pump				
25	Shotcrete Machine				
26	Axial flow Exhaust Fan				
27	Hydraulic Lab. Crusher				

Alternative Energy Promotion Centre

FA 2.04: Unit Rates: Works

Item	Unit	Unit Rate
Item: 01. Site Clearance (Manual)	Sq. m.	
Item: 02. Site Clearance (Mechanized)	Sq. m.	
Item: 03. Tree felling and root digging (30~60 cm Girth)	1 no.	
Item: 04. Earthwork Excavation in Soft Soil including Haulage up to 5 m (Manual)	cu.m.	
Item: 04a. Earthwork Excavation in boulder mixed Soil including Haulage up to 100 m (Mechine)	cu.m.	
Item: 05. Earthwork Excavation in Hard Clay and Weathered Rock including Haulage up to 30 m (manual)	cu.m.	

Item: 06. Earthwork Excavation in Hard Rock by Chiseling including Haulage up to 30 m (manual)	cu.m.	
Item: 07. Earthwork in Backfilling by Common Material with Compaction (manual)	cu.m.	
Item: 08. Dry Stone Soling in Foundation with 30m Lead	cu.m.	
Item: 09. Open cut excavation in river bed material with 0.7km haulage	cu.m.	
Item: 10. Open cut excavation in boulder mixed soil with 0.7km haulage	cu.m.	
Item: 11. Open cut excavation in hard rock with 0.7km haulage	cu.m.	
Item: 12. Backfill (mechanized)	cu.m.	
Item: 13. M25 RCC Surface Concrete	cu.m.	
Item: 14. M20 RCC Surface Concrete	cu.m.	
Item: 15. M15 RCC Surface Concrete	cu.m.	
Item: 16. M10 RCC Surface Concrete	cu.m.	
Item: 17. Plum concrete M20 with 30% plum	cu.m.	
Item: 18. Formwork	sq. m	
Item: 19. Formwork (round)	sq. m	
Item: 20. P.V.C. water stop 230 mm wide (Type -B)	cu.m.	
Item: 21. Geotextile	m2	
Item: 22. Stone Riprap Works	cu.m.	
Item: 23. Stone Soling Works	cu.m.	
Item: 24. Stone Soling Works	cu.m.	
Item: 25. Stone Masonry in 1:4 cement mortar	cu.m.	
Item: 26. Stone Lining on top of Weir	cu.m.	
Item: 27. Gabion Works	cu.m.	
Item: 28. Dry Stone Masonry Works	cu.m.	
Item: 29. Reinforcement Steel	ton	
Item: 30. 100mm Blinding Concrete M10	cu.m.	
Item: 31. Cement Pointing in 1:3 Cement Mortar	100 .	
Item: 32. 12.5mm thick Cement plaster in 1:4 cement mortar	100 .	
Item: 33. 3mm thick neat Cement Punning	100	
Item: 34. 25mm thick 2 Coat Flooring Concrete	10	
Item: 35. Wood Work in Door/Windows Chaukhat	1 Cu.m.	

Item: 36. 1.5" thick Saalwood Door Shutter	2.114 .	
Item: 37. Glass Shutter for Windows	10 .	
Item: 38. Iron Work in Truss (2 inch Diameter Black Pipe)	10 r.m.	
Item: 39. CGI Sheet Roofing (26 Gauge)	10Sq.m.	
Item: 40. Two Coat White wash in inner walls	1 .	
Item: 41. Hand Rail Work (2" Dia. Black Pipe) for Staircase	10 rm.	
Item: 42. 2 Coats of Enamel Paint in Door/Windows	1 .	
Item: 43. 4" Diameter HDPE Pipe Laying	50 rm.	
Item: 44. Brick Masonry Work in 1:4 c/m	Cu.m.	
Item: 45. Care of Water During Construction at Headworks Site	Cu.m.	
Item: 46. Tunnel excavation (Size 3.5m X 3.75m) and haulage up to construction audit	Cu.m.	
Item: 47. 2m long Anchor Bar(20mm)	2m	
Item: 48. Forepoling with 3m long 32mm Dia. Steel Bar	3m	
Item: 49. Forepoling with 3m long 25mm Dia. Steel Bar	m	
Item: 50. Forepoling with 3m long 20mm Dia. Steel Bar	3m	
Item: 51. Structural Steel Support	ton	
Item: 52. Formwork Type F1	sq.m.	
Item: 53. Formwork Type F3	sq m	
Item: 54. Formwork round in tunnel	sqm	
Item: 55. Invert Cleaning	sqm	
Item: 56. Drilling of 2.5m long hole for Consolidation Grouting	m	
Item: 57. Consolidation Grouting	kg	
Item: 58. Backfill/mortar Grouting (Ratio of cement and sand 1:2)	Rs/kg	
Item: 59. Rock bolt 2.2m long 20mm diameter (Ordinary Type)	Rs/2.2m	
Item: 60. Rock bolt 2.2m long, 25mm diameter (Ordinary Type)	Rs/m	
Item: 61. Rock bolt: 2.2m long, 25mm diameter (Expansion Type)	Rs/m	
Item: 62. Reinforcement Steel (For Underground Works)	Per Ton	
Item: 63. Concrete M25 (Underground)	Per m3	
Item: 64. Concrete M20 (Underground)	Per m3	
Item: 65. Concrete M15 (Underground)	Cu.m.	

Item: 66. Concrete M10 (Underground)	Cu.m.	
Item: 67. Shotcrete (5cm thick)	Per m2	
Item: 68. Shotcrete (10cm thick)	Per m2	
Item: 69. Shotcrete (15cm thick)	Per m2	
Item: 70. Wiremesh for Shotcrete	Rs/m2	
Item: 71. P.V.C. water stop 20mm wide (B-Type):Underground	Rs/m	
Item: 72. Hydroseal with Accessories	Rs/m 2	
Item: 73. Roadway earthwork excavation including haulage and disposal up to 10m	m3	
Item: 74. Stone Masonry in Mud-mortar	m3	
Item: 75. Dry Stone Masonry in road drainage	m3	
Item: 76. Penstock pipe made of IS2062B, total	kg	
Item: 77. Gate, Stoplogs and other hydromechanical component as per IS2062B, total	kg	
Item: 78. Open cut excavation in medium rock with 0.7km haulage	m3	
Item:79. Tunnel mucking haulage @ average distance of 5km (1.5 Swelling factor)	m3	

Alternative Energy Promotion Centre

FA 2.05: Rate Analyses (Follow Government of Nepal Norms)

Typical example for rate analysis

Item: 01. Site Clearance (Manual)

	Description	No	Unit	Quantity	Unit Rate	Amount
1	**<u>Manpower</u>**					
	Foreman		hr.			
	Skilled		hr.			
	Unskilled		hr.			
					Sub Total	
	Sub Total of A					
2	Site clearance (machined)		Lum sum			
3	Sub Total of (2+3)					
4	**Contractors profit and overhead 15 % of Total A**					
	Rate per Unit (D+E)					

Item: 04a. Earthwork Excavation in boulder mixed Soil including Haulage up to 100 m (Machine)

	Description	No	Unit	Quantity	Unit Rate	Amount
1	**Manpower**					
	Skilled		hr.			-
	Unskilled		hr.			-
					Sub Total	-
2	**Materials**					
	Diesel		lit		-	-
	Lubricant		kg		-	-
	Hydraulic oil		lit.		-	-
	Mobil		lit.		-	-
					Sub Total	-
3	**Equipment**					
	Excavator incl operators		hr.			-
	Tipper (6 Cum) incl operators		hr.			-
					Sub Total	-
4	Sub Total of (1+2)					-
5	Overhead and Profit (0% of 3)					-
6	Sub Total of (3+4)					-
7	**Contractors profit and overhead 15 % of Total A**					
	Rate per Unit (5+6)					-

Item: 09. Open cut excavation in river bed material with __km haulage

	Description	No	Unit	Quantity	Unit Rate	Amount
1.	**Labor**					
	Surveyor	1	hr.		-	-
	Supervisor	1	hr.		-	-
	Tipper driver	1	hr.		-	-
	Tipper Helper	1	hr.		-	-
	Excavator Operator	1	hr.		-	-

	Excavator Helper	1	hr.		-	-
	Sub-Total					-
2	**Equipment**					
	Excavator	1	hr.		-	-
	Tipper	1	hr.		-	-
	Survey equipment	1	hr.		-	-
	Sub-Total					-
3	**Materials**					
	Diesel		lit		-	-
	Lubricant(Grease)		kg		-	-
	Mobile		lit.		-	-
	Sub-Total					-
	Total A					-
4	**Contractors profit and overhead 15 % of Total A**					
Grand Total						**-**

Item: 12. Backfill (mechanized) - cu.m.

	Description	No	Unit	Quantity	Unit Rate	Amount
1.	**Labor**					
	Backhoe Operator	1	hr.		-	-
	Backhoe helper	1	hr.		-	-
	Tipper driver	1	hr.		-	-
	Tipper helper	1	hr.		-	-
	Roller operator	1	hr.		-	-
	Sub-Total					-
2	**Equipment**					
	Backhoe	1	hr.		-	-
	Tipper	1	hr.		-	-
	Vibrator. tandem roller	1	hr.		-	-
	Sub-Total					-

3	**Materials**					
	Diesel		lit		-	-
	Lubricant		Kg.		-	-
	Sub-Total					-
	Total A					-
5	**Contractors profit and overhead 15 % of Total A**					
	Grand Total					-

Item: 13. M25 RCC Surface Concrete 1 - cu.m.

	Description	No	Unit	Quantity	Unit Rate	Amount
1	**Labor**					
	Supervisor	1	hr.		-	-
	Foreman	1	hr.		-	-
	Skilled Labor	1	hr.		-	-
	Unskilled labor	2	hr.		-	-
	Concrete mixer operator	1	hr.		-	-
	Concrete Pump Operator	1	hr.		-	-
	Concrete Pump Helpers	4	hr.		-	-
	Sub-Total					-
2	**Equipment**					
	Concrete Pump	1	hr.		-	-
	Concrete mixture	2	hr.		-	-
	Agitator	1	hr.			-
	Concrete vibrator	1	hr.		-	-
	Sub-Total					-
3	**Materials**					
	Portland Cement		kg		-	-
	Super Plasticizer		kg		-	-
	Sand		m^3		-	-
	Aggregate (20mm and down grade)		m^3		-	-

	Aggregate (10mm and down grade)		m^3		-	-
	Diesel		lit.		-	-
	Lubricant		Kg.		-	-
	Sub-Total					-
	Total A					-
5	**Contractors profit and overhead 15 % of Total A**					
	Grand Total					-

Alternative Energy Promotion Centre

Quantity Calculations

Bill of Quantity

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
A	**HEADWORKS**							**HEADWORKS TOTAL**	-	
1	**Site Clearance**	m^2								
								Total		
2	**Coffer Dam**									
2.01	Care of Water during construction	LS								
2.02	Excavation in boulder mixed soil	m^3								
2.03	Backfilling in embankment	m^3								
2.04	HDPE liner	m2								
2.05	Filter	m^3								
2.06	Random boulder riprap, 0.5m dia	m^3								
								Total	-	
3	**River Training**		reduction							
3.01	Care of Water during construction	LS								
3.02	Channel Excavation in boulder mixed soil	m^3								
3.03	U/s retaining wall									
a	Excavation in boulder mixed soil	m^3								
b	Compaction of soil	m^3								

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
c	Blinding	m^3								
d	Concrete (M20)	m^3								
e	Formworks	m^2								
f	Gabion boxes	m^3								
g	Reinforcement	ton								
h	Backfilling in embankment	m^3								
3.04	D/s retaining wall									
a	Compaction of soil	m^3								
b	Gabion boxes	m^3								
c	Backfilling in embankment	m^3								
								Total	**-**	
4	**Diversion Weir**									
4.01	Care of Water during construction	LS								
4.02	Excavation of cut off walls in boulder mixed soil	m^3								
4.03	Compaction of soil	m^3								
4.04	Stone soling	m^3								
4.05	Blinding Concrete	m^3								
4.06	Plum Concrete (M20, 30% plum)	m^3								
4.07	Boulder Concreting (M25, 80% boulder)	m^3								
4.08	Structural concrete (M25) - 4.05 - 4.06	m^3								
4.09	Formwork									
a	Weir section	m^2								
b	Cut-off	m^2								
4.10	Reinforcement	ton								
4.11	Backfilling in cutoff	m^3								
4.12	PVC Water-stop incl accessories	m								
4.13	Hydroseal	m^2								
4.14	Expansion joint sealant	m								

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
4.15	Weep holes	m								
4.16	10 no of 9m drilling for curtain grouting	m								
4.17	2 rows of 7nos 6m drilling for curtain grouting	m								
4.18	Cement for 9m curtain grouting (@400kg/hole)	ton								
4.19	Cement for 9m curtain grouting (@750kg/hole)	ton								
								Total	-	
5	**Weir upstream apron including cutoff wall**									
5.01	Care of Water during construction	LS								
5.02	Excavation of cut off walls in boulder mixed soil	m^3								
5.03	Compaction of soil	m^3								
5.04	Stone soling	m^3								
5.05	Blinding Concrete	m^3								
5.06	Structural concrete (M25)	m^3								
5.07	Formwork									
a	Weir section	m^2								
b	Cut-off	m^2								
5.08	Reinforcement	ton								
5.09	Backfilling in cutoff	m^3								
5.10	PVC Water-stop incl accessories	m								
5.11	Hydroseal	m^2								
5.12	Expansion joint sealant	m								
5.13	Boulder Lining, 0.5m dia min	m^3								
								Total	-	
6	**Weir downstream apron**									
6.01	Care of Water during construction	LS								
6.02	Compaction of soil	m^3								
6.03	Boulder Lining, 0.5m dia min	m^3								
								Total	-	

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
7	**Left bank wing wall**									
7.01	Care of Water during construction	LS								
7.02	Excavation of cut off walls in boulder mixed soil	m^3								
7.03	Compaction of soil	m^3								
7.04	Stone soling	m^3								
7.05	Blinding Concrete	m^3								
7.06	Structural concrete (M25)	m^3								
7.07	Formwork									
a	Elevations	m^2								
b	Sections	m^2								
7.08	Reinforcement	ton								
7.09	Backfilling in cutoff	m^3								
7.10	PVC Water-stop incl accessories	m								
7.11	Expansion joint sealant	m								
7.12	Hydroseal	m^2								
								Total	**-**	
8	**Non spilling Diversion Weir**									
8.01	Care of Water during construction	LS								
8.02	Excavation of cut off walls in boulder mixed soil	m^3								
8.03	Compaction of soil	m^3								
8.04	Stone soling	m^3								
8.05	Blinding Concrete	m^3								
8.06	Structural concrete (M25)									
a	Core Footing	m^3								
b	Core Wall	m^3								
8.07	Formwork									
a	Elevations	m^2								
b	Sections	m^2								

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
8.08	Reinforcement	ton								
8.09	Backfilling in cutoff with tunnel spoil	m^3								
8.10	PVC Water-stop incl accessories	m								
8.11	Expansion joint sealant	m								
8.12	Hydroseal	m^2								
8.13	Boulder Lining, 0.5m dia min	m^3								
								Total	**-**	
9	**Divide Wall, bed load hopper & under sluice**									
9.01	Care of Water during construction	LS								
9.02	Compaction of soil	m^3								
9.03	Stone soling	m^3								
9.04	2.2m long 25dia ordinary rock bolt at 2m c/c at hopper	no								
9.05	Blinding Concrete	m^3								
9.06	Structural concrete (M25) intake part	m^3								
a	Front Wall	m^3								
b	Front wall orifice deduction	m^3								
c	Base slab	m^3								
d	Base slab (sloping)	m^3								
e	Top slab	m^3								
f	Top slab beam	m^3								
9.07	Structural concrete (M25) divide wall & under sluice	m^3								
a	Base slab including cut off	m^3								
b	Divide wall 0,6m strip	m^3								
c	Divide wall remaining portion	m^3								
d	Divide wall manhole deduction	m^3								
e	Radial gate entrance deduction	m^3								
f	Divide wall 0,6m strip	m^3								
g	Spillway deduction	m^3								

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
h	Radial gate front wall and top slab	m^3								
i	Tie beams	m^3								
9.08	Formwork @ intake									
a	Front wall	m^2								
b	Curved piers	m^2								
c	Orifice deduction	m^2								
d	Orifice walls	m^2								
e	Orifice slabs	m^2								
f	Top slab including beams	m^2								
9.09	Formwork at divide wall & under sluice	m^2								
a	Divide walls	m^2								
b	Radial gate front wall and top slab	m^2								
c	Manhole	m^2								
d	Sections/Joints	m^2								
e	End curve of flushing channel	m^2								
9.10	Reinforcement	ton								
9.11	Backfilling in cutoff with tunnel spoil	m^3								
9.12	PVC Water-stop incl accessories	m								
9.13	Expansion joint sealant	m								
9.14	Hydroseal	m^2								
9.15	0.3 m thick Hard stone lining	m^3								
9.16	0.2 m thick Hard stone lining	m^3								
9.17	Boulder Lining, 1m dia	m^3								
								Total	-	
10	**Intake, gravel trap, spillway & flushing duct**									
10.01	Care of Water during construction	LS								
10.02	Excavation (60% rock & 40 boulder mixed soil)	m^3								
10.03	Blinding Concrete	m^3								
10.04	2.2m long 25dia ordinary rock bolt at 2m c/c GT	no								

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
10.05	2.2m long 25dia ordinary rock bolt at 2m c/c at alt intake	no								
10.05	Structural concrete (M25)									
a	Base slab under divide walls	m^3								
b	Base slab sloping part	m^3								
c	Base slab main basin	m^3								
d	Alt intake u/s wall	m^3								
e	Alt intake slab	m^3								
f	u/s side wall	m^3								
g	Less orifice opening	m^3								
h	Middle wall	m^3								
i	d/s side wall	m^3								
j	Less spillway	m^3								
k	Headwalls	m^3								
l	Abutment walls at flat base	m^3								
m	Abutment walls @ sloping	m^3								
n	Remaining 0.25m platform slab	m^3								
10.06	Formwork									
a	Base slab under divide walls	m^2								
b	Base slab sloping part	m^2								
c	Base slab main basin	m^2								
d	Alt intake u/s wall	m^2								
e	Alt intake slab	m^2								
f	u/s side wall (Alt intake side)	m^2								
g	u/s side wall (Gravel trap side)	m^2								
h	Less orifice opening	m^2								
i	Inner walls at trashrack areas	m^2								
j	Middle wall	m^2								
k	Middle wall @ sloping part	m^2								

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
l	d/s side wall	m^2								
m	Less spillway	m^2								
n	Headwalls: front wall	m^2								
o	Headwalls: d/s of trashrack	m^2								
p	Headwalls: in between gates	m^2								
q	Remaining 0.25m platform slab	m^2								
r	sections	m^2								
10.07	Reinforcement	ton								
10.08	Stone masonry in spillway areas	m^3								
10.09	Hardstone Lining, 0.3m dia min	m^3								
10.10	PVC Water-stop incl accessories	m								
10.11	Expansion joint sealant	m								
10.12	Hydroseal	m^2								
10.13	Hand rail									
10.14	Backfilling and surface preparations									
								Total	-	
11	**Settling Basin Transition Section & Bedload Excluder**									
11.01	Care of Water during construction	LS								
11.02	Excavation (60% rock & 40 boulder mixed soil)	m^3								
11.03	Blinding Concrete	m^3								
11.04	2.2m long 25dia ordinary rock bolt at 2m c/c	no								
11.04	Structural concrete (M25)									
a	Base slab under front wall	m^3								
b	Base slab sloping part under front wall	m^3								
c	Base slab: gravel flushing steel lined part	m^3								
d	Base slab: gravel flushing hard stone lining portion	m^3								
e	Gravel flushing steel lined wall: upstream	m^3								
f	Gravel flushing steel lined wall: middle wall	m^3								

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
g	Gravel flushing steel lined wall: down-stream wall	m^3								
h	Gravel flushing side wall at stone lining parts	m^3								
i	Top slab: gravel flushing channel	m^3								
j	Gravel flushing gate chamber walls	m^3								
k	Chamber platform slabs	m^3								
l	Main horizontal base slab	m^3								
m	Main sloping base slab	m^3								
n	Side Walls @ sloping part	m^3								
o	Side Walls @ flat part	m^3								
p	Divider walls	m^3								
q	Gravel entrance front wall	m^3								
r	Inlet gate middle piers	m^3								
s	Inlet gate side piers	m^3								
t	Inlet gate walls and platform	m^3								
11.05	Formwork									
a	Base slab under front wall	m^2								
b	Gravel flushing steel lined part elevations	m^2								
c	Gravel flushing slab	m^2								
d	Gravel flushing steel lined part sections	m^2								
e	Gravel flushing gate chamber walls	m^2								
f	Chamber platform slabs	m^2								
g	Side and middle walls	m^2								
h	Divider walls	m^2								
i	Gravel entrance front wall	m^2								
j	Inlet gate middle piers	m^2								
k	Sections (side walls)	m^2								
l	Sections (divide walls)	m^2								

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
11.06	Reinforcement	ton								
11.07	PVC Water-stop incl accessories	m								
11.08	Expansion joint sealant	m								
11.09	Hydroseal	m^2								
11.10	Hand rail									
11.11	Backfilling and surface preparations									
								Total	-	
12	Settling Basin at Parallel Section									
12.01	Care of Water during construction	LS								
12.02	Excavation (40% rock & 60% boulder mixed soil)	m^3								
12.03	Excavation (40% rock & 60% boulder mixed soil)	m^3								
12.03	Blinding Concrete	m^3								
12.04	2.2m long 25dia ordinary rock bolt at 2m c/c	no								
12.05	Structural concrete (M25)									
a	Base slab and walls	m^3								
b	Flushing channel	m^3								
c	Steps	m^3								
12.06	Plum concrete M15 with 30% plum backfilling	m^3								
12.07	Formwork									
a	Outer face of side walls	m^2								
b	Inner faces of all walls	m^2								
c	Divide Walls	m^2								
d	Flushing channel	m^2								
12.07	Reinforcement	ton								
12.08	PVC Water-stop incl accessories	m								
12.09	Expansion joint sealant	m								
12.10	Hydroseal	m^2								
12.11	Hand rail									

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
12.12	Boulder Lining, 0.5m dia min at kholsa	m^3								
12.13	River Training									
12.12	Backfilling and surface preparations									
								Total	-	
13	Forebay and Sediment Flushing Channel (till the end of bell mouth)									
13.01	Care of Water during construction	LS								
13.02	Excavation: (50% rock & 50% boulder mixed soil)	m^3								
13.03	Excavation: Flushing Culvert under forebey (100% rock)	m^3								
13.03	Blinding Concrete	m^3								
13.04	2.2m long 25dia ordinary rock bolt at 2m c/c	no								
13.04	Structural concrete (M25)									
a	Front walls incl base slab under them	m^3								
b	Sediment Flushing base slab	m^3								
c	Sediment flushing walls	m^3								
d	Sediment flushing open walls	m^3								
e	Sediment flushing top slab	m^3								
f	Sediment flushing end cut off	m^3								
g	Sediment gate platform walls	m^3								
h	Flat base slab at trashrack areas	m^3								
i	Sloping base slab	m^3								
j	Lowest base slab	m^3								
k	Deepest walls around bell mouth	m^3								
l	Less spillway	m^3								
m	Less tunnel inlet	m^3								
n	Walls at sloping portions	m^3								
o	Walls at flat parts	m^3								
p	Inlet gate smallest piers	m^3								
q	Inlet intermediate piers	m^3								

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
r	Inlet middle pier	m^3								
s	Remaining wall to platform	m^3								
t	Platform slab	m^3								
u	Vertical height of steps	m^3								
v	Headwalls	m^3								
w	Spillway Channel	m^3								
x	Remaining spillway walls	m^3								
y	Bellmouth portion	m^3								
z	Forebay roof slab	m^3								
aa	Forebay beams	m^3								
ab	Forebay columns	m^3								
13.05	Formwork									
a	Front walls incl base slab under them	m^2								
b	Sediment flushing outer walls	m^2								
c	Sediment flushing top slab	m^2								
d	Sediment flushing open walls	m^2								
e	Sediment flushing sections	m^2								
f	Sediment flushing end cut off	m^2								
g	Sediment gate platform walls	m^2								
h	Deepest walls around bell mouth	m^2								
i	Less tunnel inlet	m^2								
j	Less spillway	m^2								
k	Walls at sloping portions	m^2								
l	Walls at flat parts	m^2								
m	Inlet gate smallest piers	m^2								
n	Inlet intermediate piers	m^2								
o	Inlet middle pier	m^2								
p	Platform slab	m^2								
q	Vertical height of platform slab	m^2								

SN	Description	unit		L	B	H	Quantity	Unit Rate, NRs.	Amount, NRs.	Remarks
r	Headwalls	m^2								
s	Spillway	m^2								
t	Remaining spillway walls	m^2								
u	Bellmouth portion	m^2								
v	Forebay roof slab	m^2								
w	Forebay beams	m^2								
x	Forebay columns	m^2								
Y	Sections	m^2								
13.06	Reinforcement	ton								
13.07	PVC Water-stop incl accessories	m								
13.08	Expansion joint sealant	m								
13.09	Hydroseal	m^2								
13.10	Hand rail									
13.11	Backfilling and surface preparations									
								Total	-	

POWERHOUSE EQUIPMENT COST (UP TO THE SITES): AVERAGE COST BASED ON SIMILAR QUOTATIONS

SN	Description of Items	Unit	Quantity	Unit Price US $	Total Price US $	Manufacturer
1						
(a)	Horizontal Francis type axial flow turbine with runner guide vanes, draft tube, wicket gates, by pass valves with associated auxiliary and ancillary equipment incomplete set to develop rated output of __ kW at rated net head and rated discharge and capable of delivering of continuous maximum output of 10% more at rated net head and maximum discharge.	Set			-	
(b)	Digital Speed Governing equipment with actuator, servomotor, pilings, mountings, safety devices, hand wheel, motors, fittings, water level sensor and PLC Control complete set	Set			-	

SN	Description of Items	Unit	Quantity	Unit Price US $	Total Price US $	Manufacturer
(c)	Oil Pressure system for turbine, governor with two nos. of oil pumps (main and stand by) on the oil tank and one pressure oil accumulator with adequate nitrogen charged bladders including safety and indicating devices, valves, strainers, relays, instrument	Set			-	
(d)	Cooling water system with two pumps (main 2 sets and standby pumps), duplex filters, two non-return valves, required isolating valves, flow relays, pressure gauges, flow indicators, piping, generator bearings etc. in complete set.	Set			-	
(e)	Main Inlet valve with manual, electrical and hydraulic operated, branch pipe to connect with penstock and turbine with necessary control & operation arrangements, fittings, mountings and other ancillary equipment's in complete set	Set			-	
(f)	Fly wheel complete with protection system	Set			-	
2						
(a)	__ kVA, __kV, 50 Hz. 0.85 power factor with 10%continous overload capacity Synchronous generator, Brushless excitation system, self excited, self regulated, AVR, Automatic Power Factor Controller with base frame etc.. in complete set	Set			-	
(b)	__ kV Vacuum circuit breaker magnetic and thermal overcurrent protection withdrawal type and relay panel with necessary CT and PT to complete the scope of work.	Set			-	
(c)	Generator Control, Protection, Instrumentation and Annunciation Panel	Set			-	
(d)	Generator Neutral Grounding Panel	Set			-	
(e)	Generator LA, VT, Surge Capacitor, CT & PT Panel	Set			-	
(f)	AVR / Auto Power Factor Control Panel	Set			-	
(g)	Generator Automatic Synchronizing Panel complete with PT	Set			-	
3	**Following major parts to be supplied:**					
(a)	Turbine Control / Governor Panel with SCADA system computer control	Set			-	
(b)	Unit & Station Auxiliary Board	Set			-	

SN	Description of Items	Unit	Quantity	Unit Price US $	Total Price US $	Manufacturer
(c)	Station Auxiliary Transformer, Feeder Control Panel, 400V Breaker with Panel	Set			-	
(d)	DC distribution board with necessary control and protection	Set			-	
(e)	220 V DC, 500 AH, DC Maintenance free heavy duty industrial type battery & battery Charger	Set			-	
(f)	__ kV, 3 phase __ A, __ kA, SF6 circuit breaker complete with accessories	Set			-	
(g)	__ kV Transformer Breaker Panel complete with overcurrent relay, earth fault relay, differential relay,distance relay, synchro check relay (25), master trip relay, over voltage relay, metering devices indoor type	Set			-	
(h)	__ kVA, 50 Hz, 3 Phase, __/__ kV Setup Power Transformer (YNd11) with Bucholz relay, sudden gas pressure release valve, temperature rise relay with differential protection __ kV Disconnecting Switch with earthing facility	Set			-	
(i)	__ kVA, 50 Hz, 3 Phase __kV / __V Station Auxiliary Transformer, Dyn11	Set			-	
(j)	__ Ton Electrical Operated Overhead Traveling Crane with crane rails, fixing material complete set	Set			-	
(k)	__ kV Disconnecting Switch with earthing facility	Set			-	
(l)	__ kV Disconnecting Switch without earthing facility	Set			-	
(m)	__ kV, __ kA, Lightning arrester station type with surge monitor and counter	no			-	
(n)	__ kV, Current transformer complete set 75/1/1/1/1 A, 20VA, 0.5 , 5P20, 20 VA and for differential and distance relays CTs should have PS class	no			-	
(o)	__ kV, Potential transformer complete set with power fuse protection 132,000/√3/110/√3/110/√3, 3 P, 50 VA, 0.5 , 50VA	no			-	
(p)	Steel Gantry structures complete set for all outdoor equipment (LA, CT, PT, VCB, Station transformer, Lightning mast, Light post, DS, DSES, outgoing gantry)	Lot			-	
(q)	Bus bar, conductors, connectors complete set	Lot			-	
(r)	Post insulators, suspension (disc) insulators to complete the scope of work	Lot			-	

SN	Description of Items	Unit	Quantity	Unit Price US $	Total Price US $	Manufacturer
4	__ kV, __ kV Copper, armored power & Control Cables for Powerhouse & Switchyard Complete, Water level sensor cable and all termination and jointing kit to complete the scope of work	Lot			-	
5	Copper Earthing System (__ mm2 bare copper stranded and __ mm dia. __ m long copper clad steel spike) for Powerhouse and Switchyard Equipment to achieve 1 ohm earth resistance	Lot			-	
6	Station Lighting System	Lot			-	
7	Ventilation System	Lot			-	
8	Fire Extinguishing System	Lot			-	
9	Mandatory spares for 5 years of successful operation of Turbines, Generators, Control and annunciation panel, indoor & outdoor switchyard equipment and all auxiliaries as per manufacturer's recommendations	Lot			-	
10	Mandatory Maintenance Tools & Plants as per requirement and manufacturer's recommendations	Lot			-	
11	Spare runner (13% Cr, and 4% Ni) with jet deflector complete set	Lot			-	
12	__ kW Diesel Generator	Lot			-	
13	Erection, Testing, Commissioning, Training	Lot			-	
14	Delivery up to Project site	Lot			-	
	GRAND TOTAL IN US$ & $/kW			-	-	
	GRAND TOTAL IN NRs & NRs/kW			-	-	

INTERCONNECTION EQUIPMENT AT TINGLA SUB-STATION

SN	Description of Item	Unit	Quantity	Rate	Amount, US$	Manufacturer
1	__ kV, 3 phase __ A, __ kA, Outdoor SF6 circuit breaker complete with accessories	Set			-	
2	__ kV Line Breaker Panel complete with distance protection (21), directional over current relay , earth fault relay, breaker failure relay (50 BF), synchro check relay (25), master trip relay, with metering devices	Set			-	

SN	Description of Item	Unit	Quantity	Rate	Amount, US$	Manufacturer
3	__ kV __ A, (STC 3 sec), 25 kA , 3 phase Motorized Disconnecting Switch with and without earthing facility outdoor type and 110 VDC supply for motor	Set			-	
4	__ kV, 10 kA, Lightning arrester outdoor station type with surge monitor leakage current and surge counter	no			-	
5	__kV,50VA,132,000/√3/110/√3V/110/√3V Two core with 3P for Protection and 0.5 for metering outdoor capacitive voltage transformer complete with accessories.	Nos.			-	
6	protection cores with 5P20 class, two protection core with PS class and one metering core of 0.5 accuracy class outdoor current transformer complete with accessories.	Nos.			-	
7	__ kV, 75/1/1A, 132,000/√3/110/√3V/ 110/√3V outdoor combine current and voltage transformer with two metering cores each with 0.2 accuracy class for CT and set				-	
8	__ kV Post Insulator to complete the scope of work	Lot			-	
9	Insulator strings with tension set, connectors, brack strap to complete the scope of work	Lot			-	
10	Galvanized steel structure for one incoming, busbar gantry and equipment (e.g. CB, CT, PI, LA, isolators, combine metering equipment, PF, lightning mast, station transformer) supporting frame complete with bolts, nuts and all accessories.	Lot			-	
11	Galvanized steel structure for Lightning Mast around 20m tall for lightning protection for extended switchyard.	Lot			-	
12	110 V DC, 120 AH Maintenance free battery and battery charger	Set			-	
13	Busbars (bus tube) to match with the existing bus, conductors and different connectors to complete the specified scope of works.	Lot			-	
14	Low voltage power and control cables and necessary equipment to complete the work.	Lot			-	
15	Outdoor Lighting with suitable lamp post for extended switchyard.	Lot			-	
16	Necessary jointing kits	Lot			-	
17	Earthing System to connect all new switchyard equipment to an existing earth and also extend the new earth of required to achieve 1 ohm earth resistance.	Lot			-	
18	Static bi directional energy meter as per NEA standard with 0.2 accuracy class	Nos.			-	
19	Spare parts	Lot			-	

SN	Description of Item	Unit	Quantity	Rate	Amount, US$	Manufacturer
20	Supply and Delivery up to site	Lot			-	
21	Erection, testing and commissioning	Lot			-	
22	Civil work for above work	Lot			-	
	GRAND TOTAL IN US$				-	
	GRAND TOTAL IN NRs				-	

TRANSMISSION LINE UNIT COST

SN	Description of works	Unit	Quantity	Rate	Amount, US$	Manufacturer
1	Detail survey with preparation of plan and profile, sag calculation drawing preparation etc.	km				
2	Detail structural analysis (tower and foundation) with preparation of construction drawing using PLSCAD etc.	km				
3	Soil investigation work with preparation of detail report as per specification with all lab tests (1 common soil, 1 fissure rock, 2 hard rock)	km				
4	Earthwork excavation for tower foundation including backfilling with excavated soil	km				
5	Foundation work in different type of soil condition with necessary form work(1:1.5:3)	km				
6	Supply, delivery to required site for installation of galvanized steel lattice structure	km				
7	Supply, delivery, installation of ACSR WOLF conductor	km				
8	Supply, delivery, installation of OPGW earth wire Supply, delivery of Insulators, tension set assemblies, dampers, earthing, phasing and danger signs etc. complete set	km				
9	Supply, delivery of Insulators, tension set assemblies, dampers, earthing, phasing and danger signs etc. complete set	km				
10	Erection of tower	km				
11	Stringing of conductor three phase and earth wire with head loading of materials (conductor, insulator, hardware etc..) all complete	km				
12	Right of way cost	km				
	GRAND TOTAL IN US$					
	GRAND TOTAL IN NRs					

ANNEX D

FORMATS

ANNEX D1

LANDSLIDE IDENTIFICATION FORMAT

Name of the Landslide:		
Date:	Location No.:	Location: (E) (N)
Location Description:		

A. Rock Type, Structure and Strength

Lithology:

Geological Structures (major/minor):

Strength of Rock Mass:

Weathering:

Orientation of Discontinuities:

Bedding/Foliation: Joint 1: Joint 2: Joint 3:

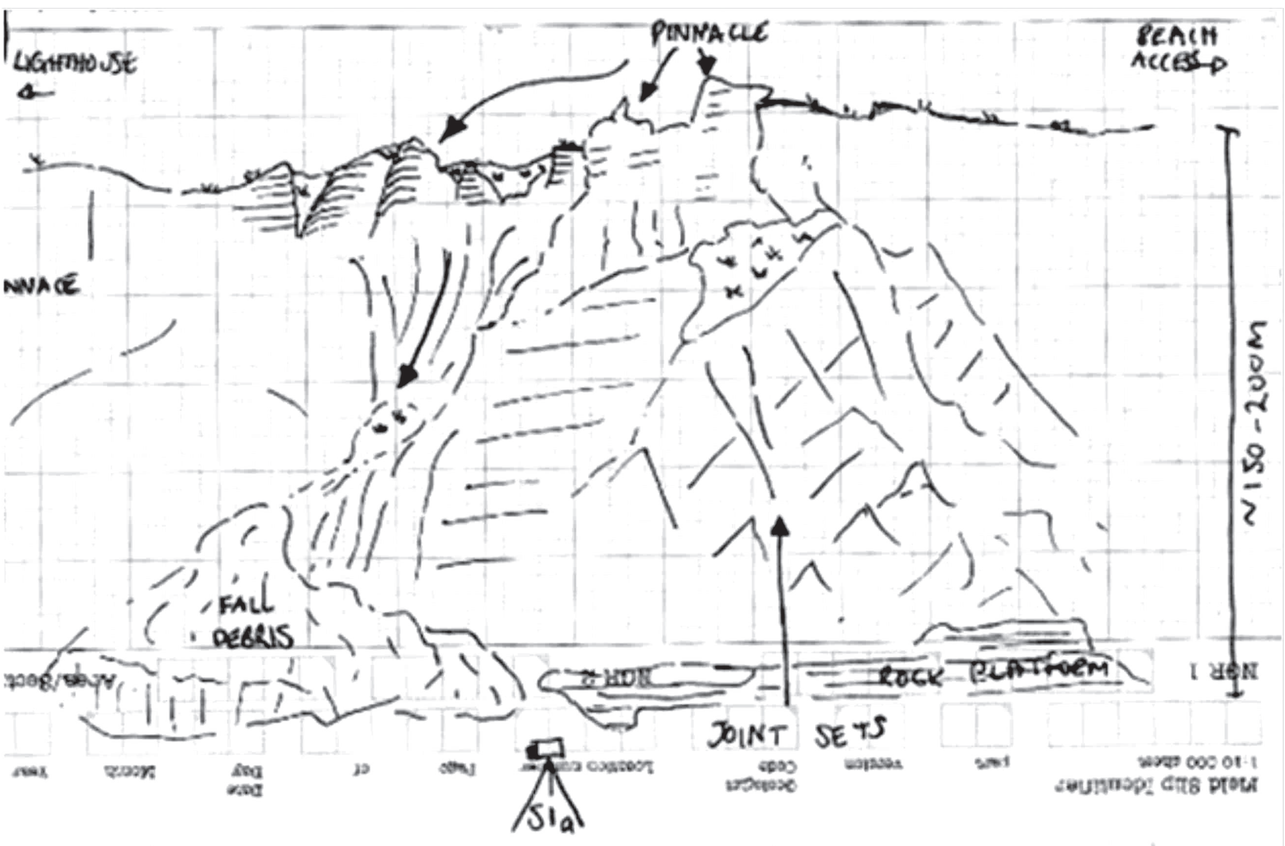
Random Joints:

B. Soil Type and Plasticity *Description:* *Depth of Soil:* *Plasticity:* *UCS Nomenclature:*
C. Slope Angle and Shape *Zone of Depletion:* *Zone of Accumulation:* *Left Flank:* *Right Flank:* *Shape:*
D. Drainage State and Level of Water Table *Seepage:*
E. History of Previous Landslides
F. Land Use (including vegetation type and change)

G. Remarks

H. Remedial Works

I. Sketch



ANNEX D2

PRODUCTIVE END USE FORMAT

फर्म १

स्थानीय मुख्य व्यक्तिहरू (गाविस सचिव, विद्यालय शिक्षक, व्यापारी, उद्यमी, सामुदायिक संगठन तथा संस्था) संग सोधिने प्रश्नावली (कम्तीमा ३ जनासंग सोध्ने)

१ **अन्तरवार्ता दिनेको नामः**

२ **ठेगानाः** फोन/मोबाइल नं.

३ **पेशाः**

४. **लघु/साना जलविद्युत आयोजनाको नाम :**

५. **लाभान्वित क्षेत्र :** जिल्ला ....

(क) गाविस १: वडा नं. ....

(ख) गाविस २: वडा नं. ....

(ग) गाविस ३: वडा नं...................

६. **लाभान्वित घरधुरी संख्या.......................**

७. **महिला घरमुली संख्या/म्ब्ल घरधुरी................**

८. **अनुमानित क्षमता (किलोवाट)................**

९. जलविद्युत आयोजना क्षेत्रमा संचालनमा रहेका उद्यम तथा आयमूलक क्रियाकलापमा आधारित समूहहरु के के छन् ?

क्र.सं.	उद्यम तथा आयमूलक क्रियाकलापहरुको नाम	स्वामित्व	वर्गीकरण(आयमूलक / लघु/ साना /मझौला)	ऊर्जाको स्रोत
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१०. लाभान्वित क्षेत्रमा हुने मुख्य विक्रियोग्य उत्पादनहरु (कृषि, वन, तथा खनिजमा आधारित) के के छन् ?

क्र.सं.	कृषि/पशुपालन उत्पादन	वनमा आधारित उत्पादन/ गैह्र काष्ठ जन्य	अन्य वस्तु तथा उत्पादनहरु
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११. लाभान्वित क्षेत्रमा अन्य सम्भावित सेवाहरु के के हुन सक्दछ ? (उदाहरण: होटल, सञ्चार, पर्यटन आदि)

क्र.सं.	सेवाहरु
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१२. मुख्य बजार केन्द्रहरु

बजारको नाम	ठेगाना	गाउँबाट कति टाढा छ ? कि.मी	कैफियत

१३. लाभान्वित क्षेत्रमा कस्ता खालका सम्भावित उद्यम/व्यवसाय र समूहहरु आधारित आयमूलक क्रियाकलाप बढी लाभदायक देखिन्छ र किन (अवसरहरु) ?

क.सं.	उद्यम/आयमूलक क्रियाकलापहरुको प्रकार	किन
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१४. उद्यम तथा समूहमा आधारित आयमूलक क्रियाकलाप संचालनका तथा विकासको लागि कस्तो पहल भएको छ र कसले गरेको छ ?

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१५. लाभान्वित क्षेत्रमा कस्ता खालका परम्परागत सिपहरु उपलब्ध छन् ?

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१६. लघु /साना जलविद्युत आयोजनाको लाभान्वित क्षेत्रमा विद्यालयहरुको विस्तृत विवरण

क.सं.	नाम	ठेगाना	तह	विद्यार्थी संख्या
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१७. लघु /साना जलविद्युत आयोजनाको लाभान्वित क्षेत्रमा स्वास्थ्य चौकी/क्लिनिक (सार्वजनिक/निजी) को विस्तृत विवरण

क्र.सं.	नाम	कार्यालय प्रमुख/प्रोपाइटर	ठेगाना
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१८. लघु /साना जलविद्युत आयोजनाको लाभान्वित क्षेत्रमा कुनै स्थानीय वित्तिय संस्थाहरु उपलब्ध छन् ? यदि छ भने कृपया खुलाउनुहोस् ।

क्र.सं.	स्थानीय वित्तिय संस्थाको नाम	ठेगाना	प्रकार (जस्तैः बैंक, सहकारी संस्था)
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१९. लघु /साना जलविद्युत आयोजनाको लाभान्वित क्षेत्रमा कस्ता खालका संस्थाले कस्तो प्रकारका सहयोगहरु समुदायमा प्रदान गरीरहेको छ ?

क्र.स	संस्थाको नाम	प्रदान गरिरहेको सेवाहरु

२०. लघु /साना जलविद्युत आयोजनाको लाभान्वित क्षेत्रमा सम्भावित उद्यम तथा उद्यमीहरुको सूची उल्लेख गर्नुहोस् वा बताउनुहोस् ?

क्र.स	सम्भावित उद्यमीहरुको नाम	छनौट गरिएको उद्यम तथा ब्यवसाय	कैफियत
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२१. पिछडिएको वर्ग तथा अन्यबाट आयमूलक क्रियाकलापहरु गर्ने इच्छुक व्यक्तिहरुको सूची बताउनुहोस्।

क.स	सम्भावित आयमूलक क्रियाकलापहरुको नाम	व्यक्ति तथा घरधुरीको नामवली	कैफियत
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प्रतिवेदन फाराम

व्यवसायिक अवसरको प्रतिवेदन

भाग क: लघु /साना जलविद्युत आयोजनाको लाभान्वित क्षेत्र र आयोजनाको जानकारी

यस भागमा नजिकका बजार केन्द्रहरु, स्थानीय वित्तिय संस्थाहरु, विद्यालयहरु र स्वास्थ्य चौकी/क्लिनिकको बारेमा जानकारी संलग्न गरिएको छ ।

मुख्य बजार केन्द्रहरु

क.स	बजारको नाम	ठेगाना	गाउँबाट कति टाढा छ ?	कैफियत

लघु/साना जलविद्युत आयोजनाको लाभान्वित क्षेत्रमा विद्यालयहरुको विस्तृत विवरण

क.सं.	नाम	ठेगाना	तह	विद्यार्थी संख्या
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लघु/साना जलविद्युत आयोजनाको लाभान्वित क्षेत्रमा स्वास्थ्य चौकी/क्लिनिक (सार्वजनिक/निजी) को विस्तृत विवरण

क.सं.	नाम	कार्यालय प्रमुख/प्रोपाइटर	ठेगाना

लघु/साना जलविद्युत आयोजनाका लाभान्वित क्षेत्रमा भएका स्थानीय वित्तिय संस्थाहरुको विवरण

क.सं.	स्थानीय वित्तिय संस्थाको नाम	ठेगाना	प्रकार (जस्तैः बैंक, सहकारी संस्था)

भाग खः लाभान्वित क्षेत्रमा उपलब्ध व्यवसासायिक सहयोग सेवाहरुको जानकारी

यस भागमा सहयोगी संस्थाहरु (गैह्र सरकारी संस्था/अन्तर्राष्ट्रिय गैह्र सरकारी संस्थाहरु), लघु, साना तथा मझौला उद्यमहरुको प्रवर्द्धनसंग सम्बन्धित आयोजनाहरु, स्थानीय व्यापारी तथा तिनका भूमिकाहरु संलग्न गरिएको छ ।

भाग गः व्यवसायिक अवसरहरु तथा सम्भावित उद्यमीहरु

ग.१ लाभान्वित क्षेत्रमा हुने मुख्य उत्पादनहरु (कृषि तथा वनमा आधारित) के के छन् ?

क्र.सं.	क्षेत्र	वस्तुको प्रकार	बचत/नपुग
१	कृषि उत्पादन		
२	पशुपालन उत्पादन		
३	वन उत्पादन (गैह्र काष्ठ जन्य)		
४	अन्य उत्पादन		

ग.२ लाभान्वित क्षेत्रमा अन्य सम्भावित सेवाहरु के के हुन सक्दछ ? (उदाहरणः होटल, सञ्चार, पर्यटन आदि)

ग.३ गाउँ बाहिर बेच्न वा व्यापार गर्न लगिने वस्तुहरु

गाउँ बाहिर जाने वस्तुहरु	कहाँ

ग.४ स्थानिय स्तरमा उत्पादन हुने तर वाहिर बाट खरिद गरिने वस्तुहरु

स्थानीय रुपमा उत्पादन हुने आयातीत वस्तुहरु	कहाँबाट

ग.५ लाभान्वित क्षेत्रमा कस्ता खालका सम्भावित उद्यम र आयमूलक क्रियाकलापमा आधारित समूहहरु बढी लाभदायक देखिन्छ र किन (अवसरहरु) ?

क्र.सं.	उद्यम/आयमूलक क्रियाकलापहरुको प्रकार	किन

ग.६ लाभान्वित क्षेत्रमा संचालित उद्यमहरु के के हन

उद्यमीको नाम	उद्यमको प्रकार	मुख्य उत्पादन	बजार	संचालन वर्ष

ग.७ लाभान्वित क्षेत्रमा उपलब्ध विशेष/परम्परागत सिपहरुको सूची

विशेष/परम्परागत सिपहरुको प्रकार	को संग यस्ता सिपहरु छन्

ग.८ उद्यम/आयमूलक क्रियाकलापहरुको विकासका लागि कस्ता पहलहरु भए

पहलहरु	कसबाट

ग.९ पिछडिएको वर्गको जनसंख्या (घरधुरी संख्या, पेशागत सिप, लोपोन्मुख समूह)

ग.१० लाभान्वित क्षेत्रमा सम्भावित तथा इच्छुक उद्यमीहरुको सूची

सम्भावित तथा उद्यमीहरुको नाम	सम्भावित उद्यमहरु	क्षमता	संचालन समय

ग.११ पिछडिएको वर्ग तथा अन्यबाट माग गरिएका आयमूलक कार्य गर्ने व्यक्ति तथा घरधुरीको सूची

सम्भावित तथा रुची राखेका आयमूलक क्रियाकलाप संचालन गर्न चाहने उपभोक्ताहरुको नाम	DAG प्रकार (जाती, गरीब, महिला)	सम्भावित आयमूलक क्रियाकलापहरु

ANNEX D3

GESI FORMAT

S.N.	Name of Beneficiaries	Sex (M/F)	VDC	District	Ethnicity/ Caste								Class				Social Status					Physical Condtion		Remarks
					DT	DH	JT	JH	B/C/T	Madh	Mus	Oth	PP	P	M	S	SW	DAG	NCV	CV	EG	P/M	HIV/AIDs	

Terminology

Caste and Ethnicity

DT – Dalit (Terai)
DH – Dalit (Hill)
JT – Janjati (Terai)
JH – Janajati (Hill)
B/C/T – Brahmin/Chetri/Thakuri
Madh – Madhesi
Mus – Muslim
Oth – Others

Class

PP	-	Pro-poor	Food sufficiency less than 3 month, survive on daily wages
P	-	Poor	Food sufficieny for 3-6 month, rest to be managed from daily wages
M	-	Medium	Food sufficient for 6-9 month
S	-	Sampanna	Food sufficiency for whole year

Social Status

SW	-	Single Women
NCV	-	Natural calamities victim
EG	-	Endanger Group
DAG	-	Disadvantage group
CV	-	Conflictt Victim

Physical Status

P/M	-	Physcal/Mental
DA	-	Differently able

Note: For More information refer AEPC, Gender Equality and Social Inclusion Mainstreaming Plan

ANNEX D4

TYPICAL ENVIRONMENT IMPACT ASSESSMENT

S.N.	Environmental Issues	Impacts	Impact Prediction			Proposed Mitigation Measures	Mitigation Cost (Rs)
	Adverse Impact		Magnitude	Extent	Duration		
1.	**Physical Environment**						
1.1	**Construction phase**						
1.1.1	Topography change	Damage to local topography forms	M	S	ST	No mitigation measures	
1.1.2	Land use change	Conversion of other land use to built structure	M	S	ST	Minimum land will be used whereas possible	
1.1.3	Change in land stability, erosion and sedimentation due to construction related activities	Increase in land instability	L	S	ST	Surface excavation works will be controlled Excavated slope will be stabilized through bioengineering technique	
		Increase in sedimentation and erosion due to construction	L	S	ST	All excavated materials will be disposed properly Disposal of excavated loose materials along water pathway will be prohibited	
1.2	**Operation phase**						
1.2.1	Change in river flow and river morphology	Alteration of river morphology and river flow in the dewatering zone	L	S	LT	10% residual environmental flow will be released	
1.2.2	Erosion at tail race	Increase erosion in downstream of dam and tail race	L	S	LT	Civil protection structure will be provided below dam and tailrace	

2.	**Biological environment**						
2.1	**Construction phase**						
2.1.1	Loss and fragmentation of forest and vegetation	Loss of forest vegetation	L	S	ST	Forest and vegetation will be felled only to the required by pegging the area and numbering the tree Compensatory afforestation of the felled pole sized tree as prevailing governmental law	
		Fragmentation of forest vegetation	M	S	ST	No specific mitigation measures	
2.1.2	Loss of wildlife and wild life habitat	Loss of wildlife and wild life habitat due to human influence	L	S	ST	Forest and vegetation will be felled only to the required by pegging the area and numbering the tree Project staff and workforce will be instructed not visit the forest area	
2.2	**Operation phase**						
2.2.1	Threat to wildlife on downstream	Threat may come on wildlife due to sudden release of water from weir at the time of load rejection time	L	S	LT	Established early siren system	
3.	**Socio-economic Environment**						
3.1	**Construction phase**						
3.1.1	Land and property acquisition	Loss of private land and property	M	S	LT	To mitigate the impacts of permanent land and property acquisition, a compensatory approach will be taken at replacement costs. All the required lands for permanent acquisition will be settled by bilateral negotiation and temporary land will be taken in lease.	
		Loss of agricultural production	M	S	LT	Cash compensation will be provided for loosed agricultural product from permanent acquired land	
3.1.2	Construction workforce related influence on community health, law and order situation	Increase communicable disease	M	S	ST	Regular checkup of migrated labor Increase awareness program	
		Conflict between workforce and local	M	S	LT	Will organize regular ethical behavioral programs to outside workers before work session to respect local people, their culture Will discourage alcohol consumption in public places outside the camp area	

3.1.3	Gender discrimination on employment	Biasness on selection of employment	L	S	ST	Equal opportunity will be given to male and female in the employment	
3.1.4	Child discrimination risk	Employment under aged child	L	S	ST	Under aged child will not be employed for the construction jobs	
3.2	**Operation Phase**						
3.2.1	Dewatering effect of river diversion to existing and proposed water use right	Reduce water level in dewatering zone	M	S	LT	Early information system will be established in downstream	
4.	**Beneficial impact**						
4.1	**Construction phase**						
4.1.1	Employment opportunity	Chances of local employment	L	S	ST	Emphasis will be given to local people in priority basis	
4.1.2	Environmental enhancement	Improvement of local services and facility	L	S	ST	The local communities of the affected VDC will be provided with environmental enhancement package as to the severity of impact to enhance their local service facilities	
4.2	**Operation phase**						
4.2.1	Rural electrification	Change lighting energy use	H	S	LT	Rural electrification program will be programmed	
4.2.2	Increase agro-based industries	Establishment of small agro-industries	H	S	LT	Priority will be given in rural small agro-based industry	

ANNEX D5

FORMAT FOR DETAIL FEASIBILITY STUDY OF MINI-HYDROPOWER PROJECT

This format is intended for use in conducting detailed feasibility studies for proposed mini-hydropower project. A preliminary feasibility study should have already been completed at this stage. The green shaded portion should be filled.

1 General

Name of Project:

Ownership: Community

Location:

VDC: Village:

District:

Comments:

Date of site visit:

From: 10 Nov.2013 To: 20 Dec.2013

UC Chairperson / Developer:

Address:

Contact No.:

Is chairperson of users community/Developer same as in preliminary survey? YES

Comment :

DF study team leader: Signature:

Team members:

Hydropower Engineer: Signature:

Geologist: Signature:

Environmentalist: Signature:

Survey Crew: Signature:

Signature:

2 Desk study/verification of preliminary study in topo map

Location of intake (X,Y):	Amsl:	1050	m
Location of forbay (X,Y):	Amsl:	1045	m
Location of powerhouse (X,Y):	Amsl:	998	m

Head:	47	m	
Discharge:	1.3	m^3/s	(From WECS or secondary infromation)
Power:	459.81	kW	(assuming 5% head loss)

Note:
1. The name of the scheme should be same as mentioned in the preliminary feasibility study format. If a different name is assigned, the reasons should be stated so that confusions can be avoided
2. If the developer is different than the pre-feasibility study, this should be explained/commented on.

3 Site Information

How was the site reached?

4 hours	from roadhead. Name of roadhead:	Ghurmi
1 days	from airfield. Name of airfield:	Lamidanda
2 days	for a loaded porter to reach the site from	Roadhead

Comment if other infromation is different than in premilinary feasiility study:

4 Hydrology

Measured flow at intake, **Q**$_{i}$:	1450	lps	14	Nov.	2013
	1320	lps	15	Jan.	2014
	1110	lps	16	Mar.	2015

Method used to measure the flow: Current meter method

Design Discarge Q_d: Q80 1300 lps

Upstream flows abstraction (within 2 hours if any), Q_{up}: YES

If yes, measured flow: 150 lps

Type of water use: Improve Water Mill

Upstream flows abstraction (within 2 hours if any), Q_{up}: YES

If yes, measured flow: 150 lps

Type of water use: Drinking water

Irrigation practice in the area: Seasonal

5 Socio-economic Details

5.1 Economic Activities

S.N.	Product	Units	Annual Prod./income	Remarks
1	Rice			
2	Maize			
3	Wheat			
4	Millet			
5	Oilseed			
6	Buckwheat			
7	Potatoes			
8	Other agricultural products			
9	Income level of HH			
9.1	Ward/group			
9.2	Ward/group			
9.3	Ward/group			
9.4	Ward/group			
10	Annual growth of income groups			Based on district figure
11	Cottage industries			
12	Remitance			
13				

Note: 1 pathi (local) = 40 kg Convert any local units to standard unit

5.2 Infrastructure

S.N.	Infrastructure	Yes/No	Distance from PH	Remarks
1	Post Office	YES		
2	Primary School	YES		
3	Lower Sec. School	YES		
4	Higher Sec. school	YES		
5	Plus Two School	YES		
6	Health Post	YES		
7	Bank	NO		
8	Police post	NO		
9	VDC office	YES		

S.N.	Infrastructure	Yes/No	Distance from PH	Remarks
10	Telephone network at PH	NO		
11	Agric. Assistance	YES		
12	Rural road	NO		
13	Other			

5.3 Availability of local people

SN	Type	No. Of HH	HH Members	Remarks
1	Dalit			
2	Ethnic			
3	Other			
4	Single women			
5	Disadvantaged group			
6	Poor			
7	Conflict affected			
8	Marginalized group			

5.4 Education and trained human resources

S.N.	Education Level	No. of HH	HH Members	Remarks
1	University			
2	Plus two			
3	SLC Pass			
4	Trade			
5	Secondary School			
6	Primary School			
7	Literate			
8	Illiterate			
9	Trained Manpower			
	Civil			
	Mechanical			
	Electrical			
	Manager			

5.5 Consumption of Energy

S.N.	Energy Source	Unit	Rs. per Unit	Conversion to kg or litre	Remarks
1	Firewood				
2	Kerosene				
3	Diesel				
4	Others - specify				

5.6 Load Demand Forecast

S.N.	Type	No.	Load demand (kW)	Remarks
1	Avg. HH size & Load Demang	**#DIV/0!**		In proposed load centre
2	Popoulation			VDC record
3	No. of HH			
4	Curret Diesel operated Mills/units			
5	Industrial establishment units			
6	Street light units			
7	DDC/VDC			
8	Commercial Establishments			
8.1	Small scale industries			
8.2	Workshop			
8.3	Handicraft			
8.4				
	Total		0	

6 Environmental Aspects

6.1 Baseline data collection

S.N.	Particular	Information on	Remarks
1	**Physical Environment**		
1.1	Topography	General gradient of the river:	
		Slope of the river:	
		General terrain condition of the project area:	

S.N.	Particular	Information on	Remarks
1.2	Geology	Geological setting:	
		Status of geological stability or instability:	
		Characteristics of surface deposit:	
		Landslide and soil erosion:	
1.3	Metrology	Different climatic regimes:	
		Temperature:	
		Rainfall:	
1.4	Hydrology	Hydrological character:	
		Flow regimes:	
		River discharge:	
2	**Biological Environment**	Forest management practice:	
		Vegetation type and composition:	
3	**Socio-economic and cultural Environment**		
3.1	Demography	Estimated population:	
		Population characteristic:	
3.2	Social setting	Social structure of community (cast, ethnicity, religion):	
		social practice:	
		Housing pattern:	
		Settlement pattern in core and immediate area:	
0.1	Gender issues	Role of women in society and their responsibility:	
0.2	Infracstructure	road/track/bridge:	
		Water supply system:	
0.1	Education	literacy rate, education facility:	
0.2	Economic characterstices	income/expenditure	
		Skill level:	
		Occupation:	
		Employment:	
0.1	Health and sanitation	health facility/institution:	
		Common diseases/sanitation condition	
0.1	Water use right	Existing and proposed consumptive and non-consumptive uses of river water:	
0.2	Land use	Existing land use pattern (farmland, barren land, settlement, forest):	

6.2 Environmental Impact and Mitigation Measures

S.N	Environmental issues	Impacts	Impact prediction			Proposed mitigation measures
			Magnitude	extent	Duration	
1	**Physical Environment**					
1.1	**Construction phase**					
1.1.1	Topography change	Damage to local topography forms				
1.1.2	Land use change	Conversion of other land use to built structure				
1.1.3	Change in land stability, erosion and sedimentation due to construction related activities	Increase in land instability				
		Increase in sedimentation and erosion due to construction				
1.2	**Operation phase**					
1.2.1	Change in river flow and river morphology	Alteration of river morphology and river flow in the dewatering zone				
1.2.2	Erosion at tail race	Increase erosion in downstream of dam and tail race				
2	**Biological environment**					
2.1	**Construction phase**					
2.1.1	Loss and fragmentation of forest and vegetation	Loss of forest vegetation				
		Fragmentation of forest vegetation				
2.1.2	Loss of wildlife and wild life habitat	Loss of wildlife and wild life habitat due to human influence				
2.2	**Operation phase**					
2.2.1	Threat to wildlife on downstream	Threat may come on wildlife due to sudden release of water from weir at the time of load rejection time				

S.N	Environmental issues	Impacts	Impact prediction			Proposed mitigation measures
			Magnitude	extent	Duration	
3	**Socio-economic Environment**					
3.1	**Construction phase**					
3.1.1	Land and property acquisition	Loss of private land and property				
		Loss of agricultural production				
3.1.2	Construction workforce related influence on community health, law and order situation	Increase communicable disease				
		Conflict between workforce and local				
3.1.3	Gender discrimination on employment	Biasness on selection of employment				
3.1.4	Child discrimination risk	Employment under aged child				
3.2	**Operation Phase**					
3.2.1	Dewatering effect of river diversion to existing and proposed water use right	Reduce water level in dewatering zone				
4	**Beneficial impact**					
4.1	**Construction phase**					
4.1.1	Employment opportunity	Chances of local employment				
4.1.2	Environmental enhancement	Improvement of local services and facility				
4.2	**Operation phase**					
4.2.1	Rural electrification	Change lighting energy use				
4.2.2	Increase agro-based industries	Establishment of small agro- industries				

7 Geology and Geotechnical informations

7.1 Geological and geomorphological information

S.N.	Particular	Information on civil constriction parts	Remarks
1	**Geological information**		
1.1	Rock type	Intake:	
		Gravel Trap:	
		De-settling basin:	
		Headrace cannel:	
		Forebay:	
		Pebstock alignment:	
		Powerhouse:	
		Tailrace:	
1.2	Orientation of bedding and joint planes	Intake:	
		Gravel Trap:	
		De-settling basin:	
		Headrace cannel:	
		Forebay:	
		Pebstock alignment:	
		Powerhouse:	
		Tailrace:	
1.2	Degree of weathering in case of rock out crops	Intake:	
		Gravel Trap:	
		De-settling basin:	
		Headrace cannel:	
		Forebay:	
		Pebstock alignment:	
		Powerhouse:	
		Tailrace:	
1.4	Fracturation intensity of rock	Intake	
		Gravel Trap:	
		De-settling basin:	
		Headrace cannel:	
		Forebay:	
		Pebstock alignment:	
		Powerhouse:	
		Tailrace:	

S.N.	Particular	Information on civil constriction parts	Remarks
2	**Geomorphic information**		
2.1	Landslide type and nature		
2.2	Landslide active and passive		
2.3	Slope failure type		
2.4	Land movement		
2.5	Erosion of land mass by river, wind, glacier		
2.6	Vulnerability to the hydraulic structures		

7.2 Construction material survey

S.N.	Type	Units	Quantity	Remarks
1	Alluvial deposits			
2	Cullivial deposits			
3	Other types of deposit			
4	Predominant rock type in boulder complsiotion			
5	Sand from unformly distrubuted exavated pit			
6	Gravel from unformly distrubuted exavated pit			
7	Boulder from unifromly didtributed excavated pit			
8	Local Material	Units	Rates	
8.01	Cement at project area			
8.02	Sand			
8.03	Block stone			
8.04	Bond stone			
8.05	Coarse aggregate			
8.06	Wood			
8.07	Unskilled labour	Md		
8.08	Mason	Md		
8.09	Carpenter	Md		
8.10	Technician	Md		
8.11	Kerosene	litre		
8.12	Diesel	litre		
9	Nearesrt local vendor for local material			

8 Techniclal Specification

Source stream:

Diversion weir

GPS Coordinate (X,Y): Amsl: 1050

Type: Permanant

Length: 10 m

Intake location

GPS Coordinate (X,Y): Amsl: 1051

Type: Side Intake

A gate/stop log provided to regulate flow is required: YES

Comment:

Spillway provided close to the intake: YES

Comment:

Headrace

Open canal lengths & corresponding chainages: 400 m

Type:	Section	0 350	Stone masonry	Rectangular
	Section	350 400	RCC	Trapazoidal

Headrace pipe lengths & corresponding chainages: 200 m

Section 400 600

Totlal headrace length 600 m

Head loss: 5 m

Unstable lengths requiring stabilisation: 100 m Section 400

Comment:

Gravel trap Location

GPS Coordinate (X,Y): Amsl: 1050

Distance from intake: 100 m Type: Stone masonry

Flushing location & description: ....

Are ground protection measures required at gravel trap? YES

Comment:

Settling basin

GPS Coordinate (X,Y): Amsl: 1050

Distance from intake: 100 m Type: RCC

Flushing location & description: ....

Are ground protection measures required at settling basin? YES

Comment:

Forebay

GPS Coordinate (X,Y): Amsl: 1046

Distance from intake: 100 m Type: RCC

Flushing location & description: ....

Are ground protection measures required at forebay? YES

Comment:

Penstock

Total length:	60	m
Grosss head, H_{gross}:	47	m
No of Vertical bends:	3	Nos.
No of Horizontal bends:	0	Nos.

Comment:

PH site

GPS Coordinate (X,Y): Amsl: 997

Above annual flood level of the river:	8	m
Distance from powerhouse to river bank / tailrace exit point:	7	m

Are ground protection measures required at powerhouse?	YES
Comment:	
Description of location:	

Transmission line length

Length of single phase:	m
Length of three phase:	m
Length of 11 kV:	m
Length of Composite line:	m

Is part of the scheme alignment or some structureslocated on private land?

Specify alignment/structures that are located on private land:

1	2
3	4

Is (are) the land owner(s) willing to have the alignment/structures on their land

Comments:

Comments on significant changes that have been made form the pre-feasibility study:

9 Power Calculation

Grosss head, H_{gross}:	47	m
Design discharge Q_{80}:	1.3	m^3/s
Net Head, H_{net}:	44.65	m
Effeciency of turbine:	0.85	Francis
Effeciency of generator:	0.96	
Effeciency of drive system:	0.98	Direct coupling
Acceleration due to gravity, g:	9.81	
Designed Power:	**455.35**	**kW**

10 Multipurpose Projects

Can multiple uses of water resources be promoted in this project? YES

Besides power generation, other uses are: Drinking water

Modifications required in the scheme layout or components to incorporate multiple uses of the water resources:

11 Power Market and Grid Connection

Modes of mini-hydropower station operation Interconnetion with grid

Nearest NEA grid point:

Distance from site: km

Plans to extend the grid in porject site direction in the next 5 years: YES

Extention of grid upto: in 3 years

Distance from site: km

Other Mini/Micro-hydropower Projects in the area

S.N.	Name	Location	kW	Dist. PH to PH (km)	Remarks
1					
2					
3					
4					
5					

Possibility of synchronization: YES

Is community/developer aware of synchronization? NO

Is both party willing for synchronization? YES

12 Agro-processing market

Is agroprocessing mills provided in the project area? YES

12.1 List of mills, diesel or water powered, within 5 km radius or 2 hour walk of the power house.

S.N.	Location & distance from the powerhouse	Water or Diesel operated	Estimated annual volume of grains processed	Remarks
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

13 Electrical Market

13.1 Villages to be electrified

S.N.	Name of village	Location from Powerhouse (km)	No. of Houses	No. of HHs to be included
1				230
2				300
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

S.N.	Name of village	Location from Powerhouse (km)	No. of Houses	No. of HHs to be included
13				
14				
15				
16				
17				
18				
19				
20				
Total households (all villages)				
Total household to be included in the project (HH)				530

Daily electricity supply time:

From	4:00	am	To	7:00	am
From	###	noon	To	2:00	pm
From	5:00	am	To	12:00	midnight

Total operating hours/day:

Average subscribed power, S_P: 200 watts/household

Farthest village to be electrified from the powerhouse:

Distance of this village from power house: km

13.2 Nearest Villages excluded from electrificaion

S.N.	Name of village	Location from Powerhouse (km)	No. of Houses	Remarks
1				
2				
3				
4				
5				
6				
7				
8				
Total number of households			0	

13.3 Electrically driven end-uses

S.N.	Description	Location	Name & Address of the Entrepreneur	Expected Operating Time (am/pm)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Maximum power required for business load (add only if operating time conceeds)

14 Estimated Electrical income

14.1 Income from household electrification

Proposed household electricity tariff, T_f: 1 Rs/watt/month

Probable monthly income from household tariff, $I_1 = HH \times S_P \times T_f =$ 106000 Rs/month

14.2 Enduse income estimate

S.N.	Type	Operating hours/day	Power required (kW)	Operating days/month	Energy consumption/ month (kWh)	End use tariff (Rs/kWh)	Monthly Income
1		8	10	25	2000	10	20000
2					0		
3					0		
4					0		
5					0		
6					0		
Total monthly income							**20000**

Total electrical income from end use, $I_2 =$ 20000 Rs./month

Comments:

15 Total Income

Total Income of the project: **###** **Rs./month**

16 Management

Proposed name of Project:

Proposed ownership:

16.1 Key People in proposed plant

S.N.	Name	Role in the proposed MH Plant	Address	Remarks
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

Entrepreneurial spirit level: Medium

Planned community participation level: Medium

People with managerial /business skill: Fair

Manager already selected: NO

If yes, Name:

Experience:

Technical/mechanical repair skill: Good

If no, How will the manager be selected?

Operator already selected: NO

If yes, Name:

Experience:

Technical/mechanical repair skill: Good

Training required:

How was the operator selected?

If no, How will the manager be selected?

16.2 Probable organisational structure

16.3 Other Informations

Average household land holdings in area: 5 ropanies

Number of households migrated into the area in last 12 months:

Reasons:

Number of households migrated out the area in last 12 months:

Reasons:

Local strength/skill:

Tourist potential in the area YES

Comment:

General interest in Mini-HP in this place: Excellent

Understanding of dangers of electricity: Very good

Understanding about paying for electricity: Good

Understanding about tariff structure: Fair

Understanding of need for repair fund: Poor

Understanding about end use possibilities: Excellent

17 Transportation Rates

S.N.	Type		Unit	Rs./unit	Remarks
1	Truck/tractor				
2	Mule	Easy load			
		Difficult load			
3	Porter	Easy load			
		Difficult load			
4	Plane				
5	Helicopter				
6					
7					

Nearest major supply market for the project:

All weather road-head of the project site:

Fair weather road-head of the project site:

18 Estimated annual operation and maintenance cost

S.N	Operating costs	Amount/month (Rs.)	Remarks
1	Sallary manager	12000	
2	Sallary operator 1		
3	Sallary operator 2		
4	Sallary accountant		
5	Sallary other		
6	Sallary other		
7	Office expences		
8	Miscellaneous		
	Total monthly operating cost	**12000**	

Annual Operating costs, Rs.: 144000

Estimated annual maintenance cost, Rs.:

Total annual operation and Maintenance cost,Rs.: 144000

ANNEX E

SPECIFICATIONS OF ARMOURED AND UNARMOURED CABLE

Two core XLPE insulated Armoured & Unarmoured cable with Aluminium/Copper Conductor (IS : 7098-1)

Area	Insu-lation Thick-ness	Inner Thick-ness	Outer Thickness		Approx O.D.		Max. D.C. Resistance at 20° C		Current Rating					
			AR	UA	AR	UA			In Ground		In Duct		In Air	
mm²	mm	mm	mm	mm	mm	mm	Ohm/km		Amps		Amps		Amps	
	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ	Cu	AJ	Cu	AJ	Cu	AJ	Cu
1.5	0.7	0.3	1.24	1.8	13.0	11.0	-	12.1	-	33	-	30	-	29
2.5	0.7	0.3	1.24	1.8	14.0	12.0	-	7.41	-	43	-	39	-	39
4	0.7	0.3	1.24	1.8	15.0	13.0	7.41	4.61	43	56	39	50	39	51
6	0.7	0.3	1.24	1.8	16.0	14.0	4.61	3.08	55	71	50	64	50	64
10	0.7	0.3	1.24	1.8	18.0	15.0	3.08	1.83	74	92	64	83	67	88
16	0.7	0.3	1.4	1.8	17.0	15.0	1.91	1.15	91	116	82	104	88	113
25	0.9	0.3	1.4	2.0	19.0	18.0	1.2000	0.7270	120	152	108	137	117	153
25	0.9	0.3	1.4	2.0	21.0	20.0	0.8680	0.5240	143	180	129	162	145	186
50	1.0	0.3	1.4	2.0	24.0	22.0	0.6410	0.3870	167	218	150	196	176	226
70	1.1	0.3	1.4	2.0	27.0	26.0	0.4430	0.2680	204	264	184	238	221	284
95	1.1	0.4	1.56	2.2	30.0	29.0	0.3200	0.1930	245	314	221	283	271	348
120	1.2	0.4	1.56	2.2	33.0	32.0	0.2530	0.1530	278	357	250	321	316	402
150	1.4	0.4	1.72	2.2	36.0	35.0	0.2060	0.1240	315	403	284	363	362	461
185	1.6	0.5	1.72	2.4	40.0	39.0	0.1640	0.0991	356	453	320	408	420	533
240	1.7	0.5	1.88	2.6	43.0	42.0	0.1250	0.0754	407	518	366	466	497	633
300	1.8	0.6	2.04	2.8	50.0	48.0	0.1000	0.0601	463	583	417	525	578	732
400	1.8	0.6	2.36	3.0	56.0	54.0	0.0778	0.0470	528	658	475	592	678	841

Source: Janta Cable Industries Pvt. Ltd.

Three core XLPE insulated Armoured & Unarmoured cable with Aluminium/Copper Conductor (IS : 7098-1)

Area	Insu-lation Thick-ness	Inner Thick-ness	Outer Thickness		Approx O.D.		Max. D.C. Resistance at 20⁰ C		Current Rating					
			AR	UA	AR	UA			In Ground		In Duct		In Air	
mm^2	mm	mm	mm	mm	mm	mm	Ohm/km		Amps		Amps		Amps	
	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ	Cu	AJ	Cu	AJ	Cu	AJ	Cu
1.5	0.7	0.3	1.24	1.8	14	11	-	12.1	-	25	-	23	-	22
2.5	0.7	0.3	1.24	1.8	15	12	-	7.41	-	34	-	31	-	30
4	0.7	0.3	1.24	1.8	16	14	7.41	4.61	34	44	31	40	31	40
6	0.7	0.3	1.24	1.8	17	15	4.61	3.08	43	55	39	50	40	52
10	0.7	0.3	1.24	1.8	19	17	3.08	1.83	57	73	51	66	53	70
16	0.7	0.3	1.24	1.8	21	18	1.91	1.15	73	97	66	87	70	90
25	0.9	0.3	1.40	2.0	22	20	1.2000	0.7270	94	122	85	110	96	123
35	0.9	0.3	1.40	2.0	23	22	0.8680	0.5240	113	146	102	131	117	151
50	1.0	0.3	1.40	2.0	26	25	0.6410	0.3870	133	172	120	155	142	183
70	1.1	0.4	1.56	2.2	30	29	0.4430	0.2680	164	211	148	190	179	231
95	1.1	0.4	1.56	2.2	33	32	0.3200	0.1930	196	253	176	228	221	285
120	1.2	0.4	1.56	2.2	36	35	0.2530	0.1530	223	287	201	258	257	330
150	1.4	0.4	1.72	2.4	42	39	0.2060	0.1240	249	321	224	289	292	375
185	1.6	0.5	1.88	2.6	45	44	0.1640	0.0991	282	361	254	325	337	430
240	1.7	0.5	2.04	2.8	51	49	0.1250	0.0754	326	416	293	374	399	508
300	1.8	0.6	2.2	3.0	56	54	0.1000	0.0601	367	464	330	418	456	575
400	2.0	0.7	2.52	3.2	63	61	0.0778	0.0470	418	521	376	469	530	661

Source: Janta Cable Industries Pvt. Ltd.

Three and half core XLPE insulated Armoured & Unarmoured cable with Aluminium/Copper Conductor (IS : 7098-1)

Area	Insulation Thickness	Inner Thickness	Outer Thickness		Approx O.D.		Max. D.C. Resistance at 20° C		Current Rating					
			AR	UA	AR	UA			In Ground		In Duct		In Air	
mm²	mm	mm	mm	mm	mm	mm	Ohm/km		Amps		Amps		Amps	
	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ	Cu	AJ	Cu	AJ	Cu	AJ	Cu
25	0.9/0.7	0.3	1.40	2.0	23.0	22.0	1.2000	0.7270	94	122	85	110	96	123
35	0.9/0.7	0.3	1.40	2.0	25.0	24.0	0.8680	0.5240	113	146	102	131	117	151
50	1.0/0.9	0.3	1.40	2.0	28.0	27.0	0.6410	0.3870	133	172	120	155	142	183
70	1.1/0.9	0.3	1.56	2.2	33.0	32.0	0.4430	0.2680	164	211	148	190	179	231
95	1.1/1.0	0.4	1.56	2.2	36.0	35.0	0.3200	0.1930	196	253	176	228	221	285
120	1.2/1.1	0.4	1.72	2.2	40.0	39.0	0.2530	0.1530	223	287	201	258	257	330
150	1.4/1.1	0.4	1.72	2.4	45.0	43.0	0.2060	0.1240	249	321	224	289	292	375
185	1.6/1.1	0.5	1.88	2.6	50.0	48.0	0.1640	0.0991	282	361	254	325	337	430
240	1.7/1.2	0.5	2.04	2.8	56.0	55.0	0.1250	0.0754	326	416	293	374	399	508
300	1.8/1.4	0.6	2.2	3.0	61.0	60.0	0.1000	0.0601	367	464	330	418	456	575
400	2.0/1.6	0.7	2.52	3.4	69.0	68.0	0.0778	0.0470	418	521	376	469	530	661

Source: Janta Cable Industries Pvt. Ltd.

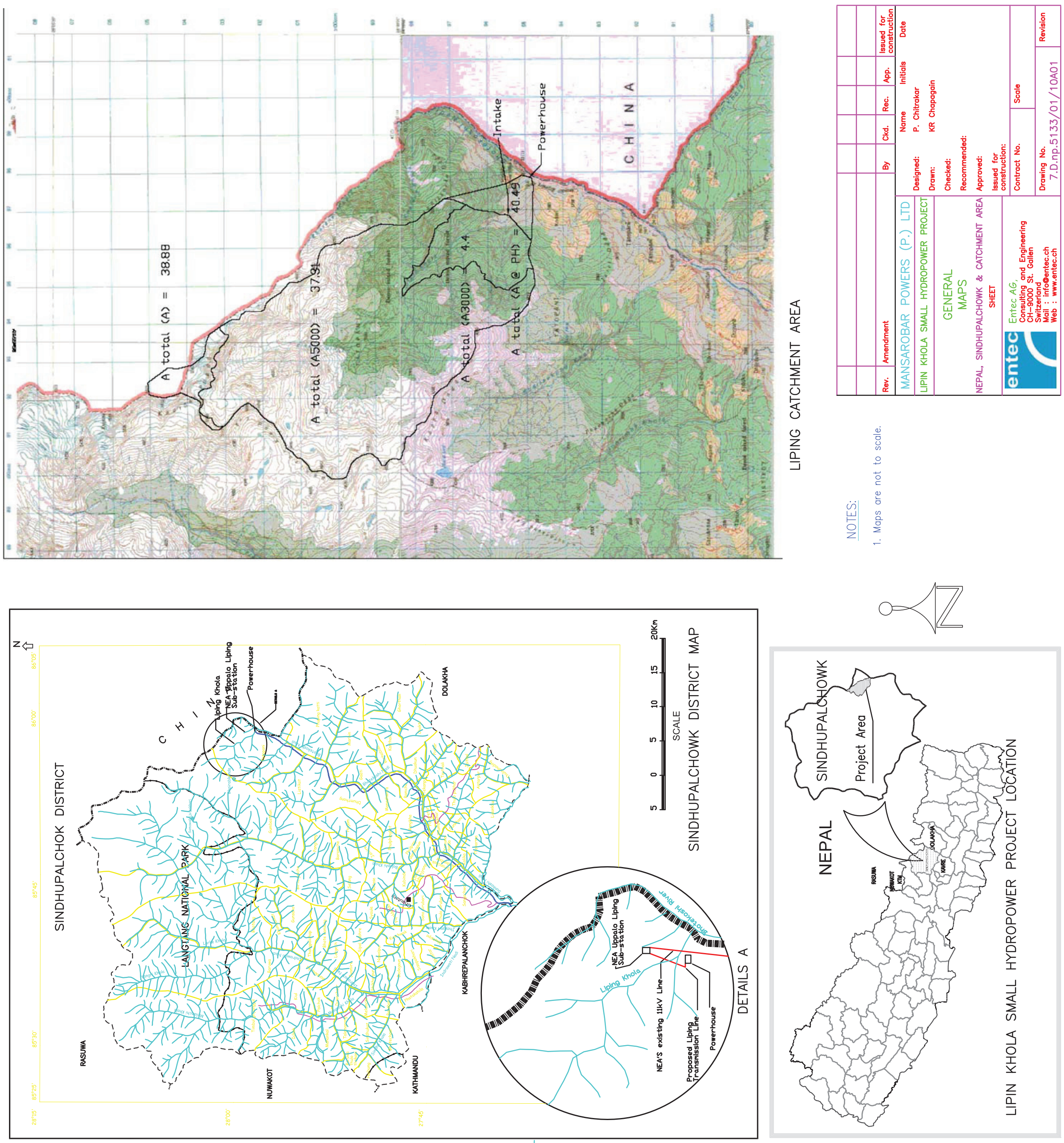
Four core XLPE insulated Armoured & Unarmoured cable with Aluminium/Copper Conductor (IS : 7098-1)

Area	Insu-lation Thick-ness	Inner Thick-ness	Outer Thickness		Approx O.D.		Max. D.C. Resistance at 20° C		Current Rating					
			AR	UA	AR	UA			In Ground		In Duct		In Air	
mm²	mm	mm	mm	mm	mm	mm	Ohm/km		Amps		Amps		Amps	
	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ/Cu	AJ	Cu	AJ	Cu	AJ	Cu	AJ	Cu
1.5	0.7	0.3	1.24	1.8	15.0	12.0	-	12.1	-	25	-	23	-	22
2.5	0.7	0.3	1.24	1.8	16.0	13.0	-	7.41	-	34	-	31	-	30
4	0.7	0.3	1.24	1.8	17.0	15.0	7.41	4.61	34	44	31	40	31	40
6	0.7	0.3	1.24	1.8	18.0	16.0	4.61	3.08	43	55	39	50	40	52
10	0.7	0.3	1.40	1.8	20.0	18.0	3.08	1.83	57	73	51	66	53	70
16	0.7	0.3	1.40	1.8	22.0	19.0	1.91	1.15	73	97	66	87	70	90
25	0.9	0.3	1.40	2.0	24.0	22.0	1.2000	0.7270	94	122	85	110	96	123
35	0.9	0.3	1.40	2.0	26.0	25.0	0.8680	0.5240	113	146	102	131	117	151
50	1.0	0.3	1.56	2.0	29.0	28.0	0.6410	0.3870	133	172	120	155	142	183
70	1.1	0.4	1.56	2.2	33.0	32.0	0.4430	0.2680	164	211	148	190	179	231
95	1.1	0.4	1.56	2.2	36.0	35.0	0.3200	0.1930	196	253	176	228	221	285
120	1.2	0.5	1.72	2.4	41.0	39.0	0.2530	0.1530	223	287	201	258	257	330
150	1.4	0.5	1.88	2.6	45.0	44.0	0.2060	0.1240	249	321	224	289	292	375
185	1.6	0.5	2.04	2.8	50.0	49.0	0.1640	0.0991	282	361	254	325	337	430
240	1.7	0.6	2.2	3.0	56.0	55.0	0.1250	0.0754	326	416	293	374	399	508
300	1.8	0.7	2.36	3.2	62.0	61.0	0.1000	0.0601	367	464	330	418	456	575
400	2.0	0.7	2.68	3.6	70.0	69.0	0.0778	0.0470	418	521	376	469	530	661

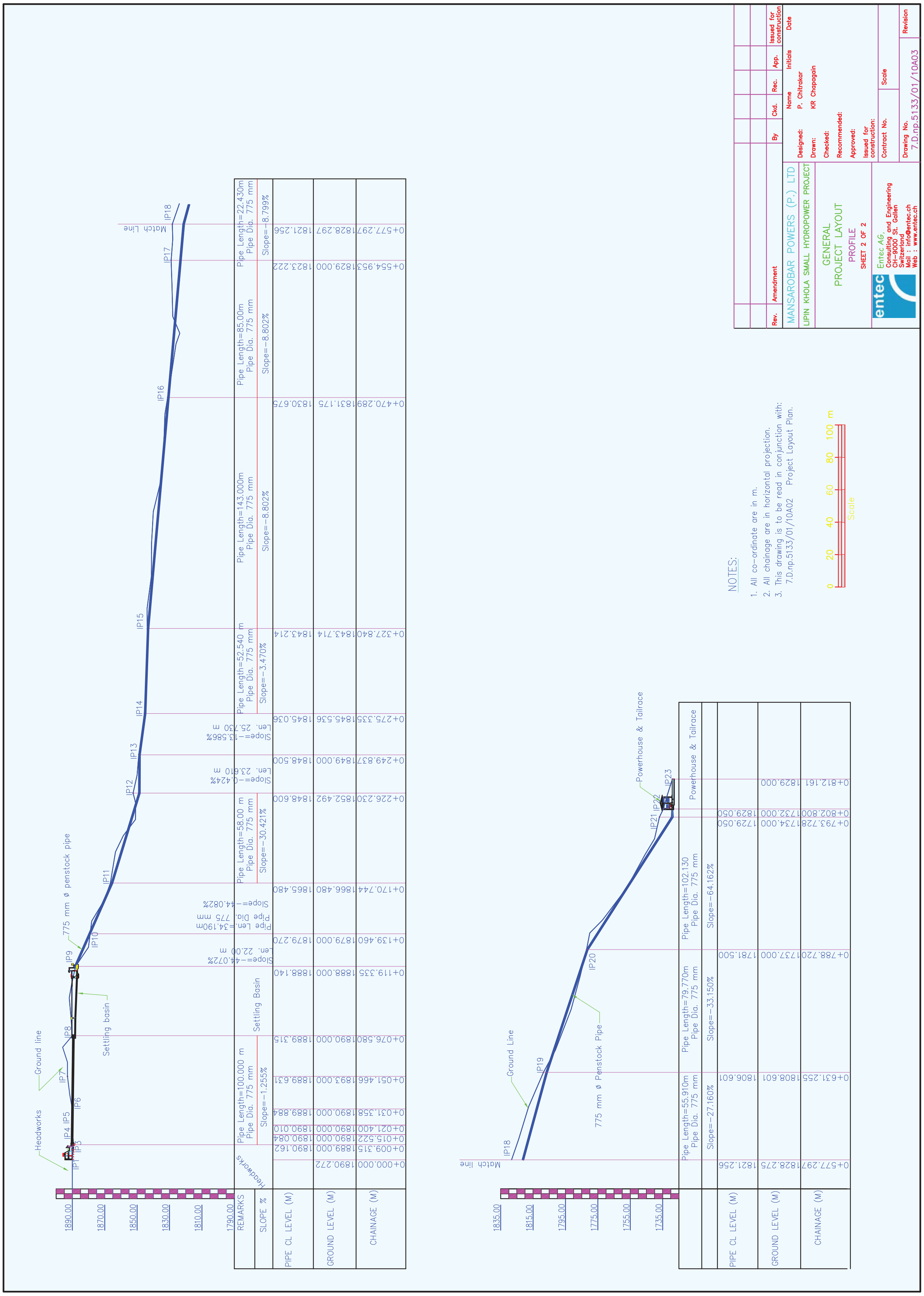
Source: Janta Cable Industries Pvt. Ltd.

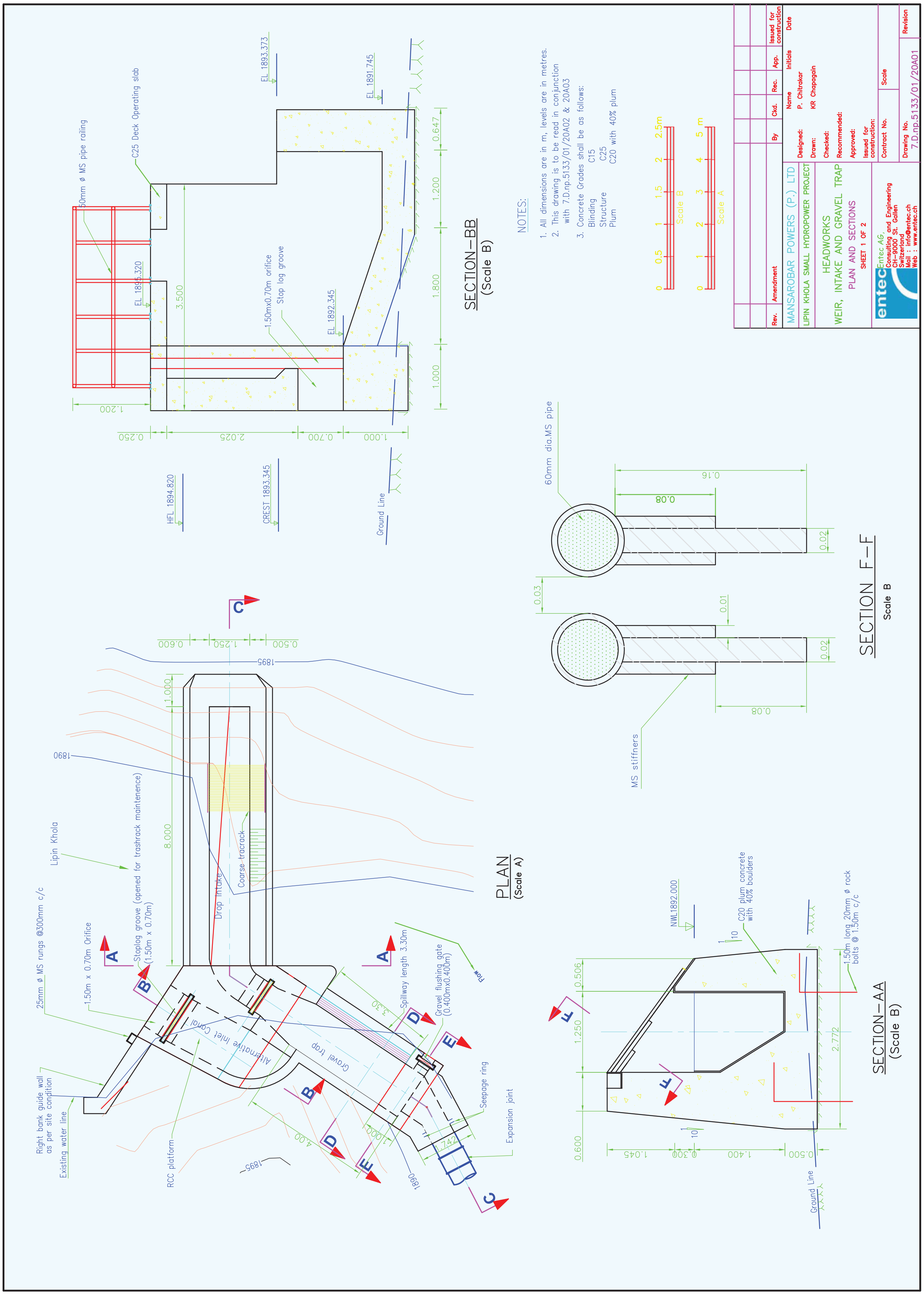
ANNEX F

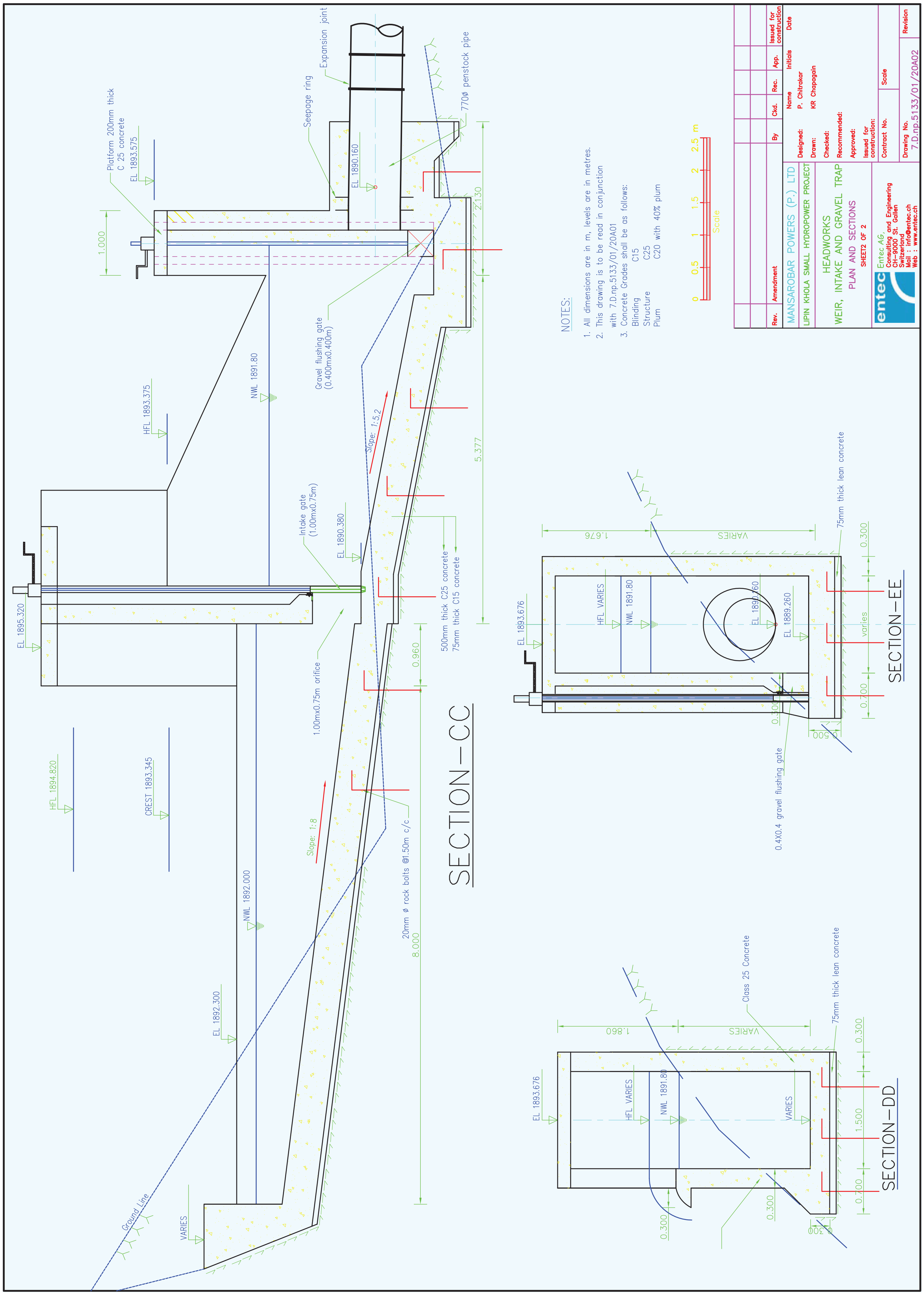
SAMPLE DRAWING OF LIPIN SMALL HYDROPOWER PROJECTS, 1500 KW, SINDHUPALCHOWK

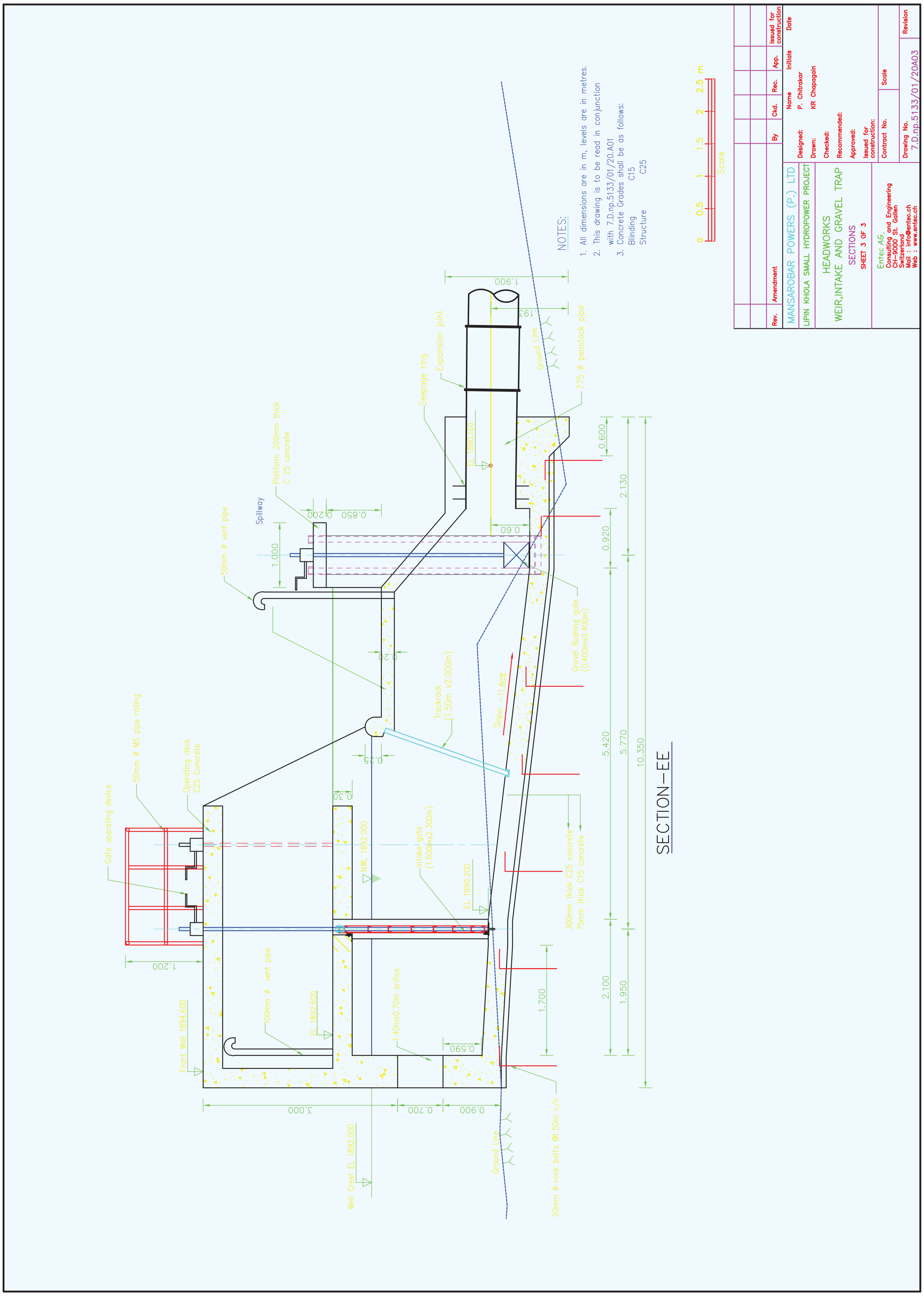


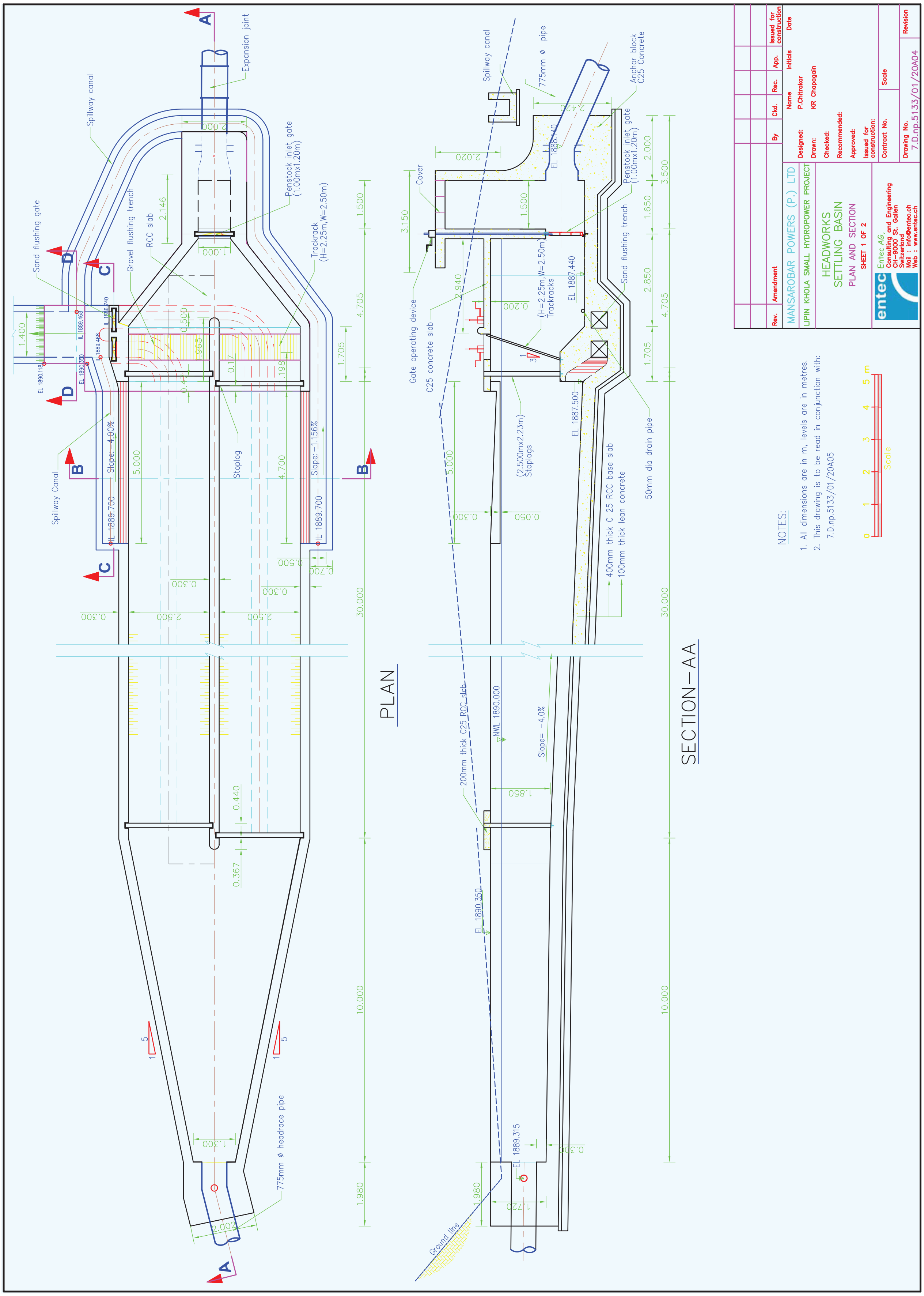
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
GENERAL PROJECT LAYOUT
PLAN
SHEET 1 OF 2
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
Drawing No. 7.D.np.5133/01/10A02
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Mail : info@entec.ch
Web : www.entec.ch
NOTES:
1. All co-ordinate are in m.
2. All chainage are in horizontal projection.
3. This drawing is to be read in conjunction with: 7.D.np.5133/01/10A05 Project Layout Profile
LEGEND:
Contour
Stream
Road
House
Boulder
River
Dropoff
Bridge
Track
Headworks
Settling Basin
775mm ø Headrace Pipe
Burried Penstock Pipe Length 30.0m
775mm ø Penstock pipe
Powerhouse
Lipin Khola

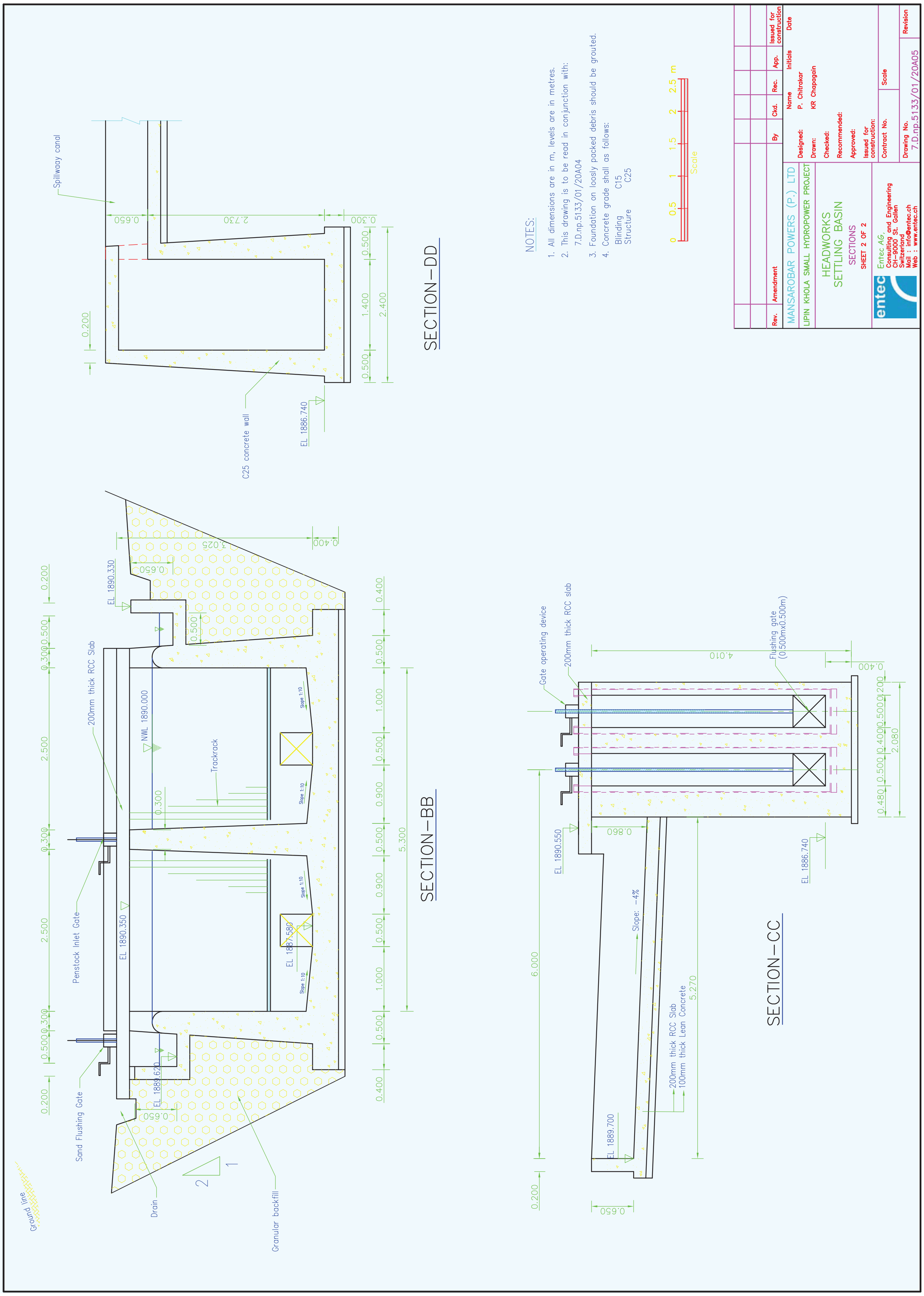

MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
GENERAL PROJECT LAYOUT
PROFILE
SHEET 2 OF 2
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Mail : info@entec.ch
Web : www.entec.ch
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
Drawing No. 7.D.np.5133/01/10A03
Revision
NOTES:
1. All co-ordinate are in m.
2. All chainage are in horizontal projection.
3. This drawing is to be read in conjunction with: 7.D.np.5133/01/10A02 Project Layout Plan.
Headworks
Ground line
Settling basin
775 mm ø penstock pipe
Match line
Powerhouse & Tailrace
775 mm ø Penstock Pipe
REMARKS
SLOPE %
PIPE CL LEVEL (M)
GROUND LEVEL (M)
CHAINAGE (M)

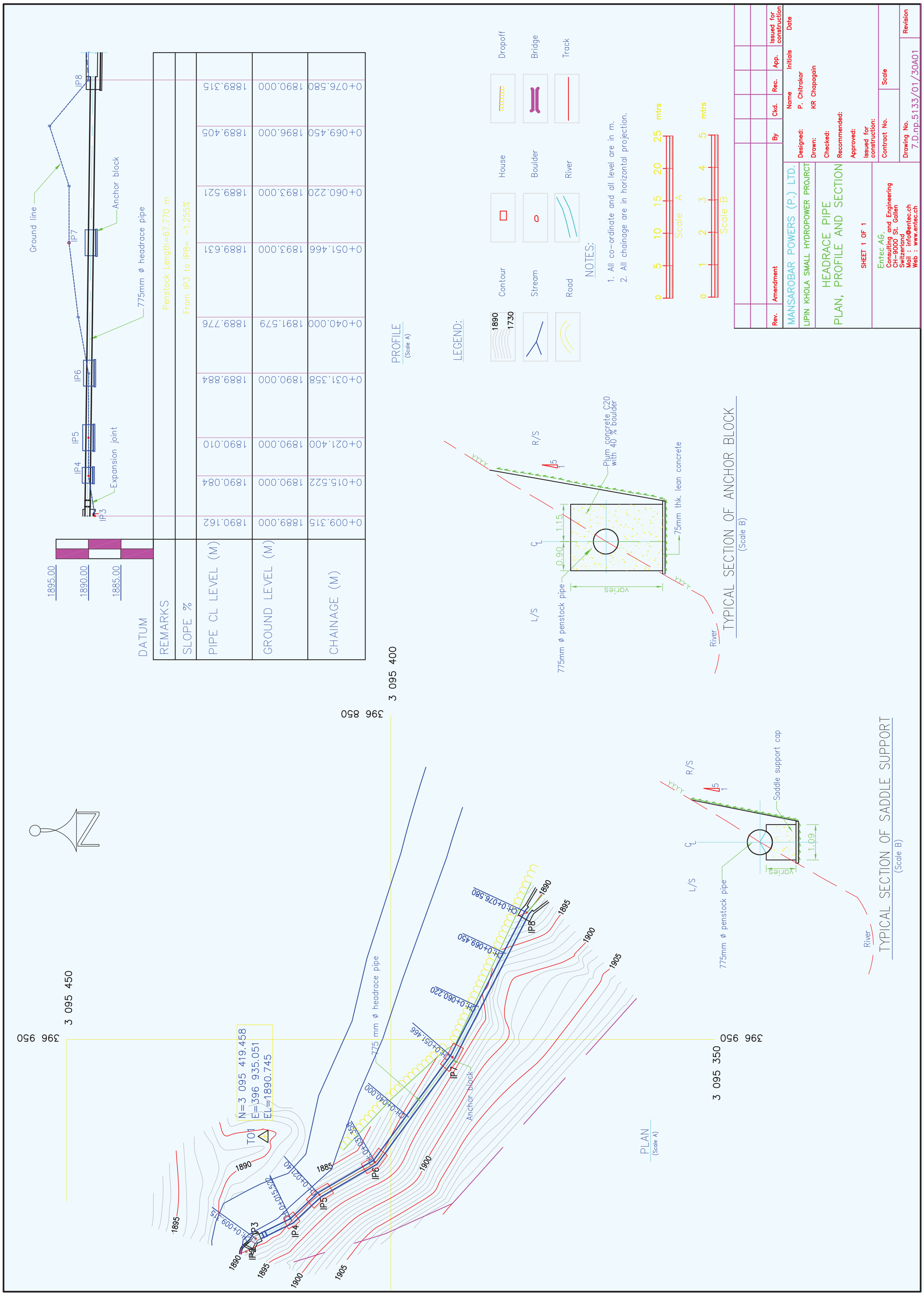

SECTION-BB
(Scale B)
PLAN
(Scale A)
SECTION F-F
Scale B
SECTION-AA
(Scale B)
NOTES:
1. All dimensions are in m, levels are in metres.
2. This drawing is to be read in conjunction with 7.D.np.5133/01/20A02 & 20A03
3. Concrete Grades shall be as follows:
Blinding C15
Structure C25
Plum C20 with 40% plum
C25 Deck Operating slab
60mm ø MS pipe railing
1.50mx0.70m orifice
Stop log groove
EL 1893.373
EL 1891.745
EL 1895.320
EL 1892.345
HFL 1894.820
CREST 1893.345
Ground Line
60mm dia.MS pipe
MS stiffners
Lipin Khola
25mm ø MS rungs @300mm c/c
1.50m x 0.70m Orifice
Stoplog groove (opened for trashrack maintenence) (1.50m x 0.70m)
Drop intake
Coarse trashrack
Spillway length 3.30m
Gravel flushing gate (0.400mx0.400m)
Flow
Gravel trap
Alternative Inlet Canal
Seepage ring
Expansion joint
RCC platform
Right bank guide wall as per site condition
Existing water line
NWL 1892.000
C20 plum concrete with 40% boulders
1.50m long 20mm ø rock bolts @ 1.50m c/c
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
HEADWORKS
WEIR, INTAKE AND GRAVEL TRAP
PLAN AND SECTIONS
SHEET 1 OF 2
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
Drawing No. 7.D.np.5133/01/20A01
Revision
entec
Entec AG Consulting and Engineering CH-9000 St. Gallen Switzerland
Mail : info@entec.ch
Web : www.entec.ch


SECTION-CC
SECTION-EE
SECTION-DD
NOTES:
1. All dimensions are in m, levels are in metres.
2. This drawing is to be read in conjunction with 7.D.np.5133/01/20A01
3. Concrete Grades shall be as follows:
Blinding C15
Structure C25
Plum C20 with 40% plum
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
HEADWORKS
WEIR, INTAKE AND GRAVEL TRAP
PLAN AND SECTIONS
SHEET2 OF 2
entec
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Designed: P. Chitrakar
Drawn: KR Chapagain
Drawing No. 7.D.np.5133/01/20A02
Platform 200mm thick C 25 concrete
Seepage ring
Expansion joint
770Ø penstock pipe
Gravel flushing gate (0.400mx0.400m)
Intake gate (1.00mx0.75m)
1.00mx0.75m orifice
500mm thick C25 concrete
75mm thick C15 concrete
20mm ø rock bolts @1.50m c/c
Ground Line
75mm thick lean concrete
Class 25 Concrete
0.4X0.4 gravel flushing gate
EL 1895.320
EL 1893.575
EL 1890.160
EL 1890.380
EL 1892.300
HFL 1894.820
HFL 1893.375
CREST 1893.345
NWL 1891.80
NWL 1892.000
EL 1893.676
EL 1889.260
Slope: 1:5.2
Slope: 1:8

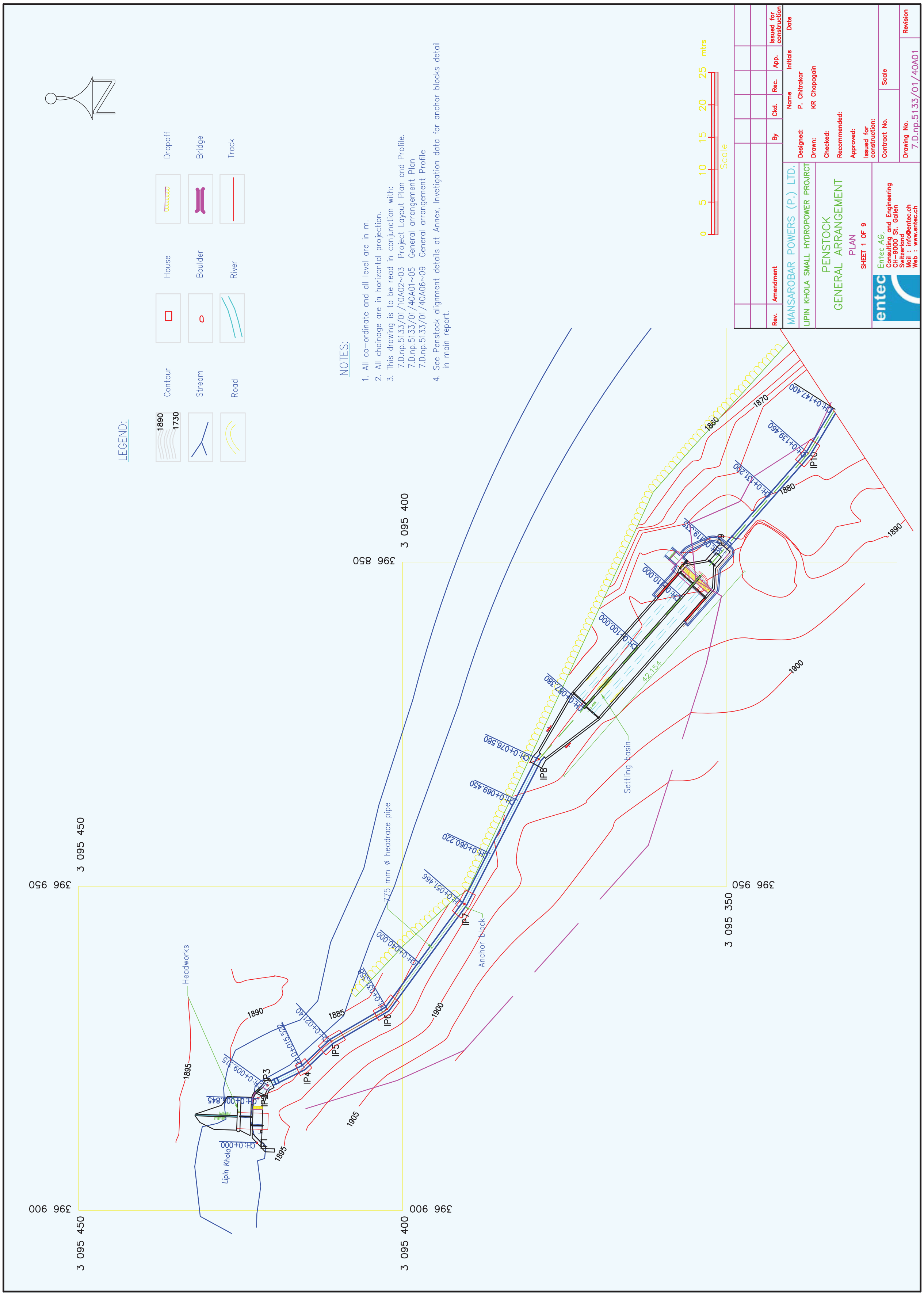

SECTION-EE
NOTES:
1. All dimensions are in m, levels are in metres.
2. This drawing is to be read in conjunction with 7.D.np.5133/01/20.A01
3. Concrete Grades shall be as follows:
Blinding C15
Structure C25
Scale
0 0.5 1 1.5 2 2.5 m
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
HEADWORKS
WEIR,INTAKE AND GRAVEL TRAP
SECTIONS
SHEET 3 OF 3
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Mail : info@entec.ch
Web : www.entec.ch
Rev. Amendment By Ckd. Rec. App. Issued for construction Date
Name Initials
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
Drawing No.
7.D.np.5133/01/20A03
Revision
Gate operating device
50mm ø MS pipe railing
Operating deck C25 Concrete
Front Wall 1894.600
100mm ø vent pipe
EL 1892.600
140mx0.70m orifice
Weir Crest EL 1892.000
Ground line
20mm ø rock bolts @1.50m c/c
NWL 1892.000
Intake gate (1.500mx2.300m)
EL 1890.200
300mm thick C25 concrete
75mm thick C15 concrete
Trashrack (1.50m x2.000m)
Slope -11.8m
Gravel flushing gate (0.400mx0.400m)
50mm ø vent pipe
Spillway
Platform 200mm thick C 25 concrete
Seepage ring
Expansion joint
775 ø penstock pipe
EL 1890.160
3.000 0.700 0.900 1.200 2.100 1.950 1.700 0.590 0.30 0.25 0.20 5.420 5.770 10.350 0.920 2.130 0.600 0.60 0.850 0.200 1.000 1.900 1.193

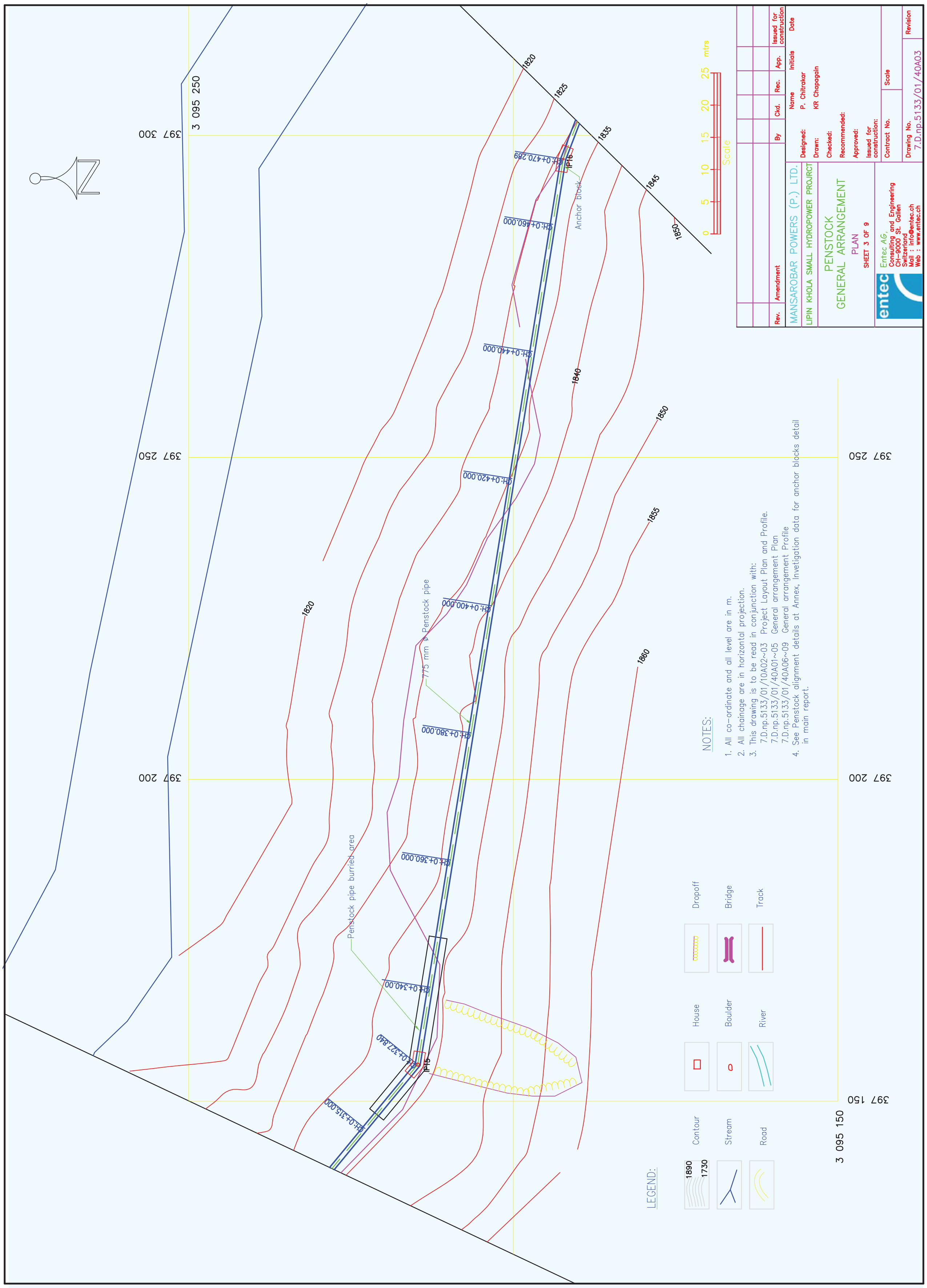

PLAN
SECTION–AA
Spillway canal
Sand flushing gate
Gravel flushing trench
RCC slab
Penstock inlet gate (1.00mx1.20m)
Trackrack (H=2.25m,W=2.50m)
Expansion joint
Stoplog
Spillway Canal
775mm ø headrace pipe
775mm ø pipe
Gate operating device
Cover
C25 concrete slab
Anchor block C25 Concrete
Sand flushing trench
(2.500mx2.23m) Stoplogs
(H=2.25m,W=2.50m) Trackracks
400mm thick C 25 RCC base slab
100mm thick lean concrete
50mm dia drain pipe
200mm thick C25 RCC slab
NWL 1890.000
Ground line
NOTES:
1. All dimensions are in m, levels are in metres.
2. This drawing is to be read in conjunction with: 7.D.np.5133/01/20A05
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
HEADWORKS
SETTLING BASIN
PLAN AND SECTION
SHEET 1 OF 2
Drawing No. 7.D.np.5133/01/20A04

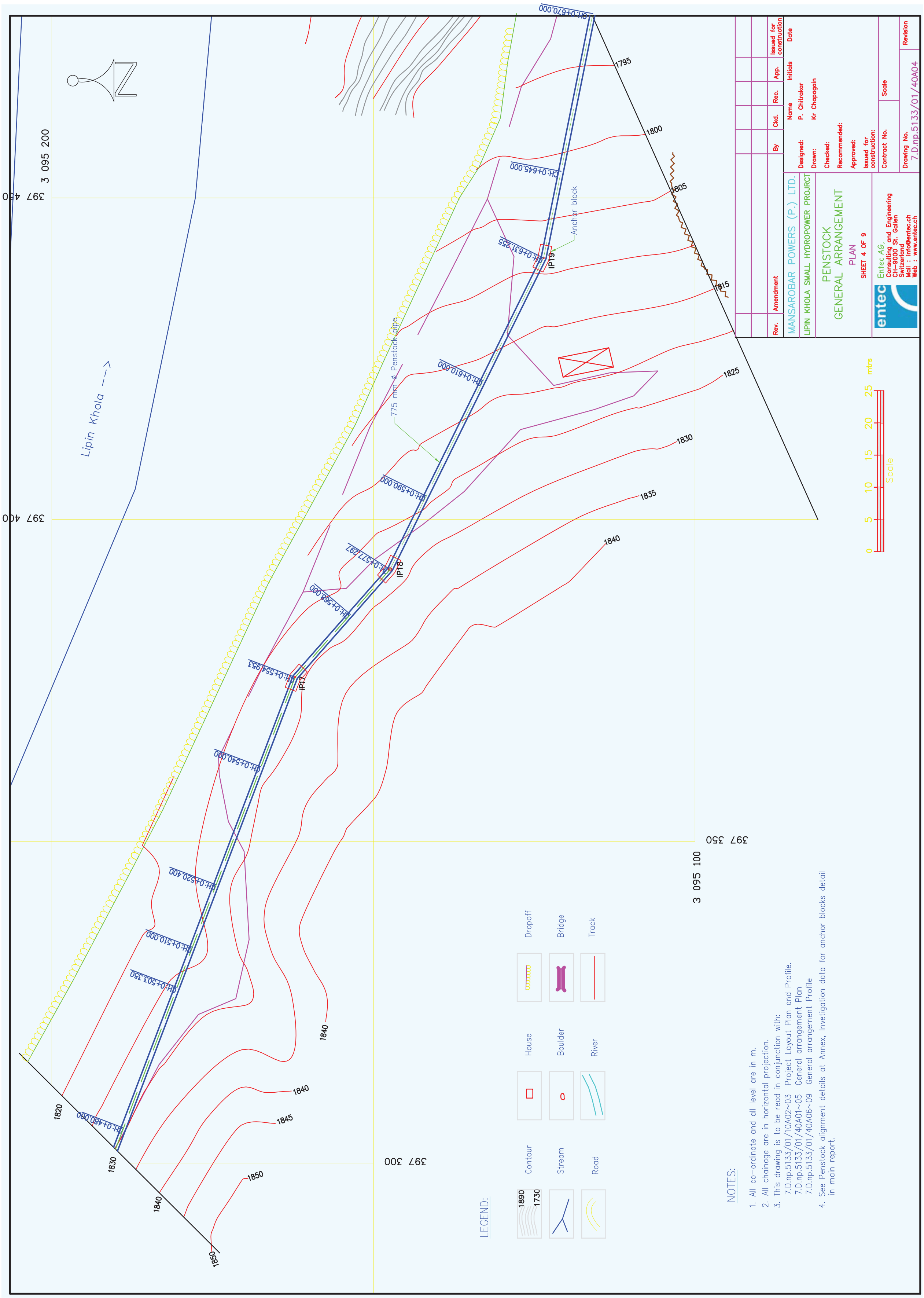

SECTION–DD
SECTION–BB
SECTION–CC
Spillway canal
C25 concrete wall
EL 1886.740
NOTES:
1. All dimensions are in m, levels are in metres.
2. This drawing is to be read in conjunction with: 7.D.np.5133/01/20A04
3. Foundation on loosly packed debris should be grouted.
4. Concrete grade shall as follows:
Blinding C15
Structure C25
Scale
Sand Flushing Gate
Penstock Inlet Gate
200mm thick RCC Slab
Trackrack
NWL 1890.000
EL 1890.350
EL 1890.330
Drain
Granular backfill
Ground line
Gate operating device
200mm thick RCC slab
Flushing gate (0.500mx0.500m)
EL 1890.550
EL 1889.700
Slope: -4%
200mm thick RCC Slab
100mm thick Lean Concrete
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
HEADWORKS
SETTLING BASIN
SECTIONS
SHEET 2 OF 2
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Drawing No.
7.D.np.5133/01/20A05

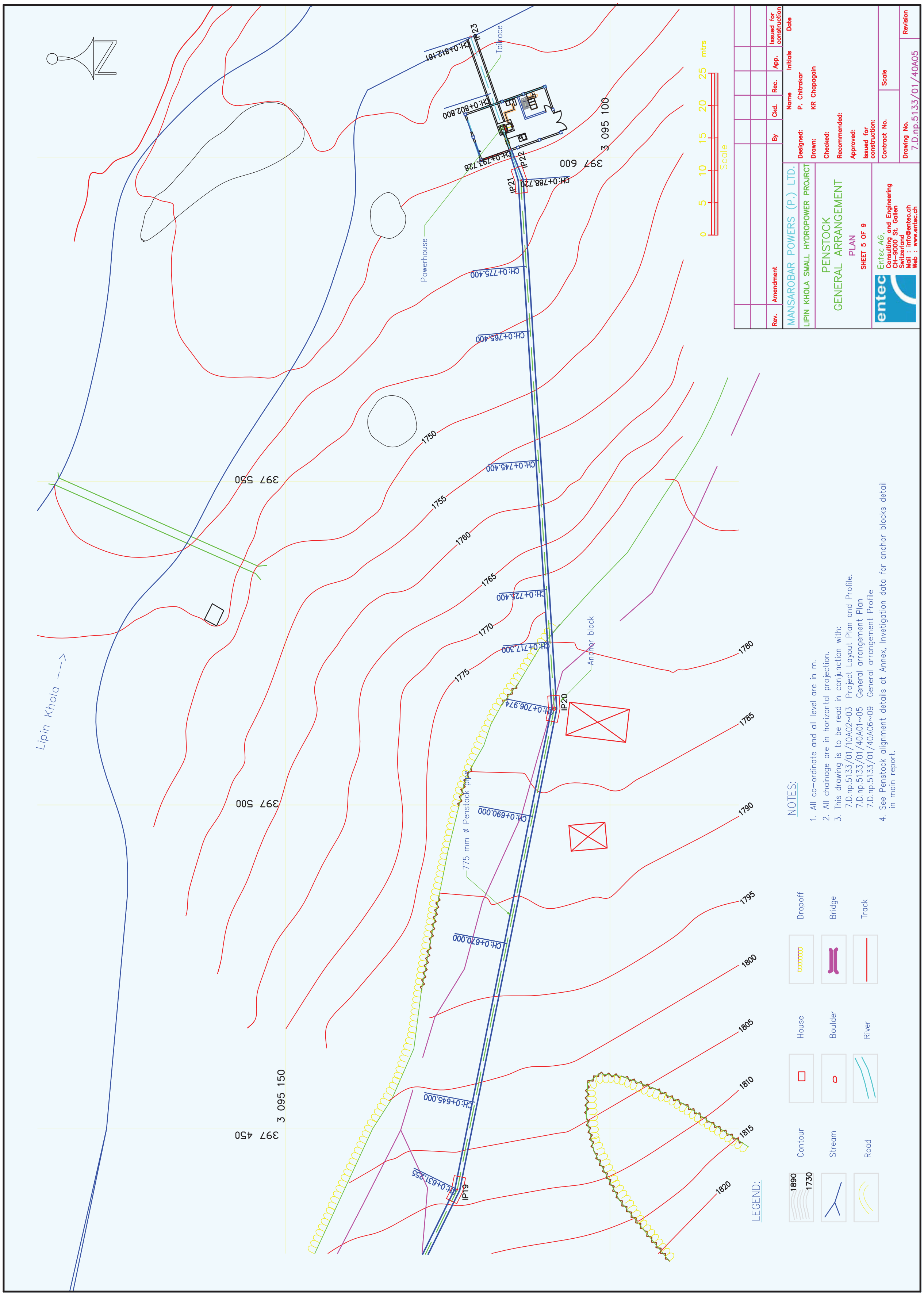


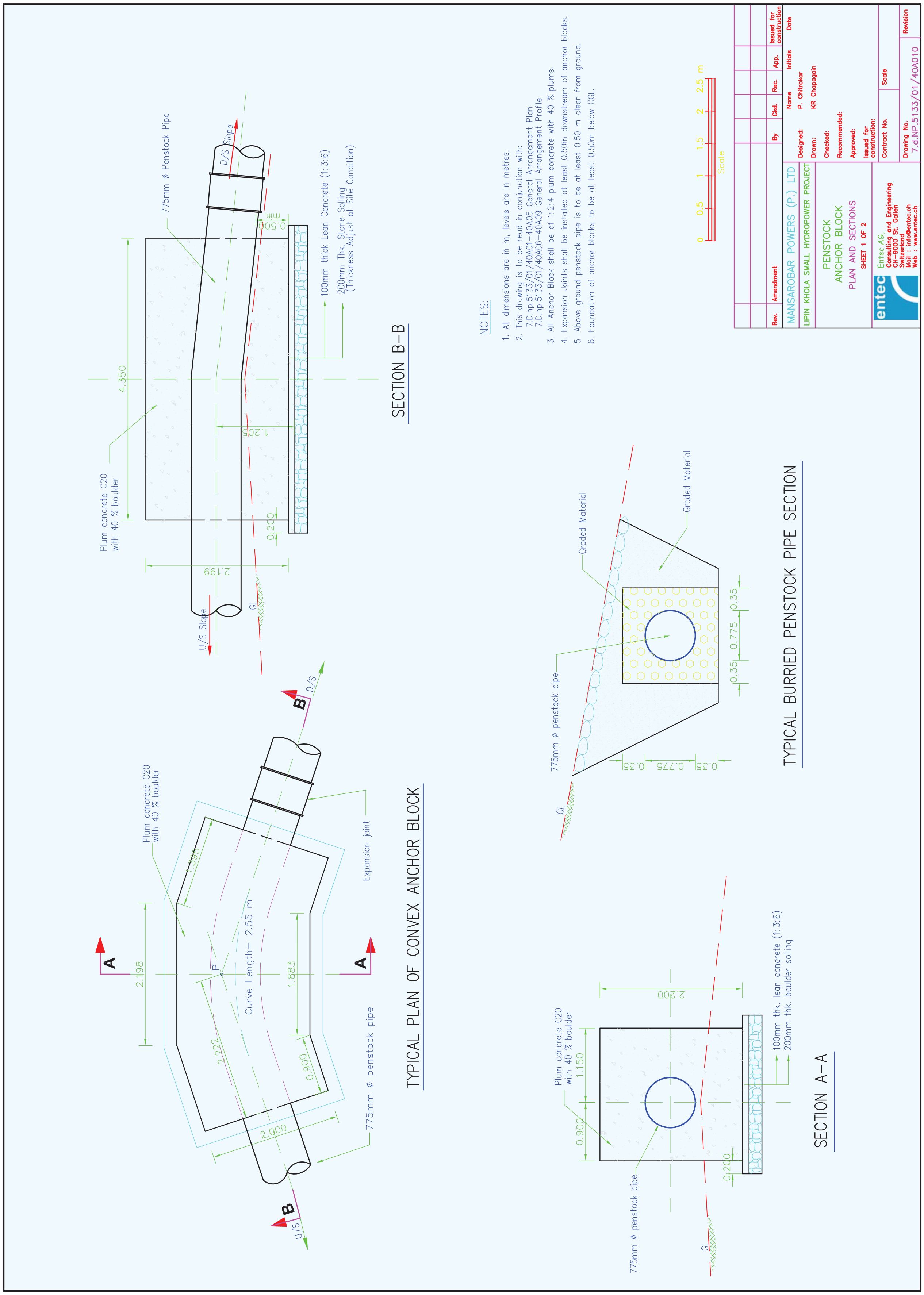
CHAINAGE (M)	GROUND LEVEL (M)	PIPE CL LEVEL (M)
0+009.315	1889.000	1890.162
0+015.522	1890.000	1890.084
0+021.400	1890.000	1890.010
0+031.358	1890.000	1889.884
0+040.000	1891.579	1889.776
0+051.466	1893.000	1889.631
0+060.220	1893.000	1889.521
0+069.450	1896.000	1889.405
0+076.580	1890.000	1889.315

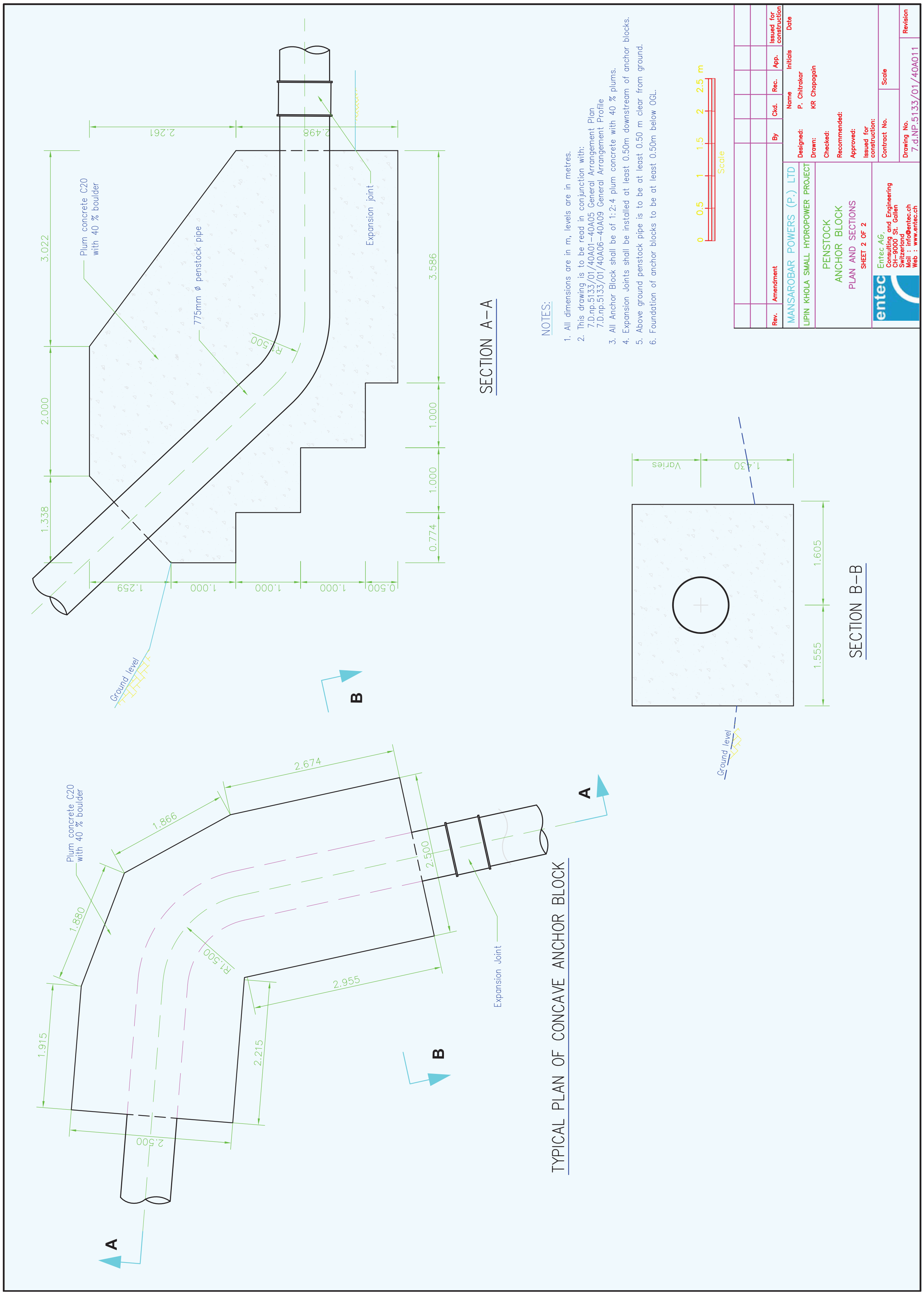

LEGEND:
Contour
1890
1730
Stream
Road
House
Boulder
River
Dropoff
Bridge
Track
NOTES:
1. All co-ordinate and all level are in m.
2. All chainage are in horizontal projection.
3. This drawing is to be read in conjunction with:
7.D.np.5133/01/10A02~03 Project Layout Plan and Profile.
7.D.np.5133/01/40A01~05 General arrangement Plan
7.D.np.5133/01/40A06~09 General arrangement Profile
4. See Penstock alignment details at Annex, investigation data for anchor blocks detail in main report.
Scale
0 5 10 15 20 25 mtrs
Headworks
Lipin Khola
775 mm ø headrace pipe
Anchor block
Settling basin
3 095 450
3 095 400
3 095 350
396 900
396 950
396 850
1885
1890
1895
1900
1905
1860
1870
1880
CH-0+000
CH-0+147.400
CH-0+139.460
CH-0+100.000
CH-0+076.580
CH-0+069.450
CH-0+060.220
CH-0+051.466
CH-0+040.000
IP1
IP4
IP5
IP6
IP7
IP8
IP10
Rev.
Amendment
By
Ckd.
Rec.
App.
Issued for construction
Date
MANSAROBAR POWERS (P.) LTD.
LIPIN KHOLA SMALL HYDROPOWER PROJECT
PENSTOCK
GENERAL ARRANGEMENT
PLAN
SHEET 1 OF 9
Name
Initials
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
entec
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Mail : info@entec.ch
Web : www.entec.ch
Drawing No.
Revision
7.D.np.5133/01/40A01

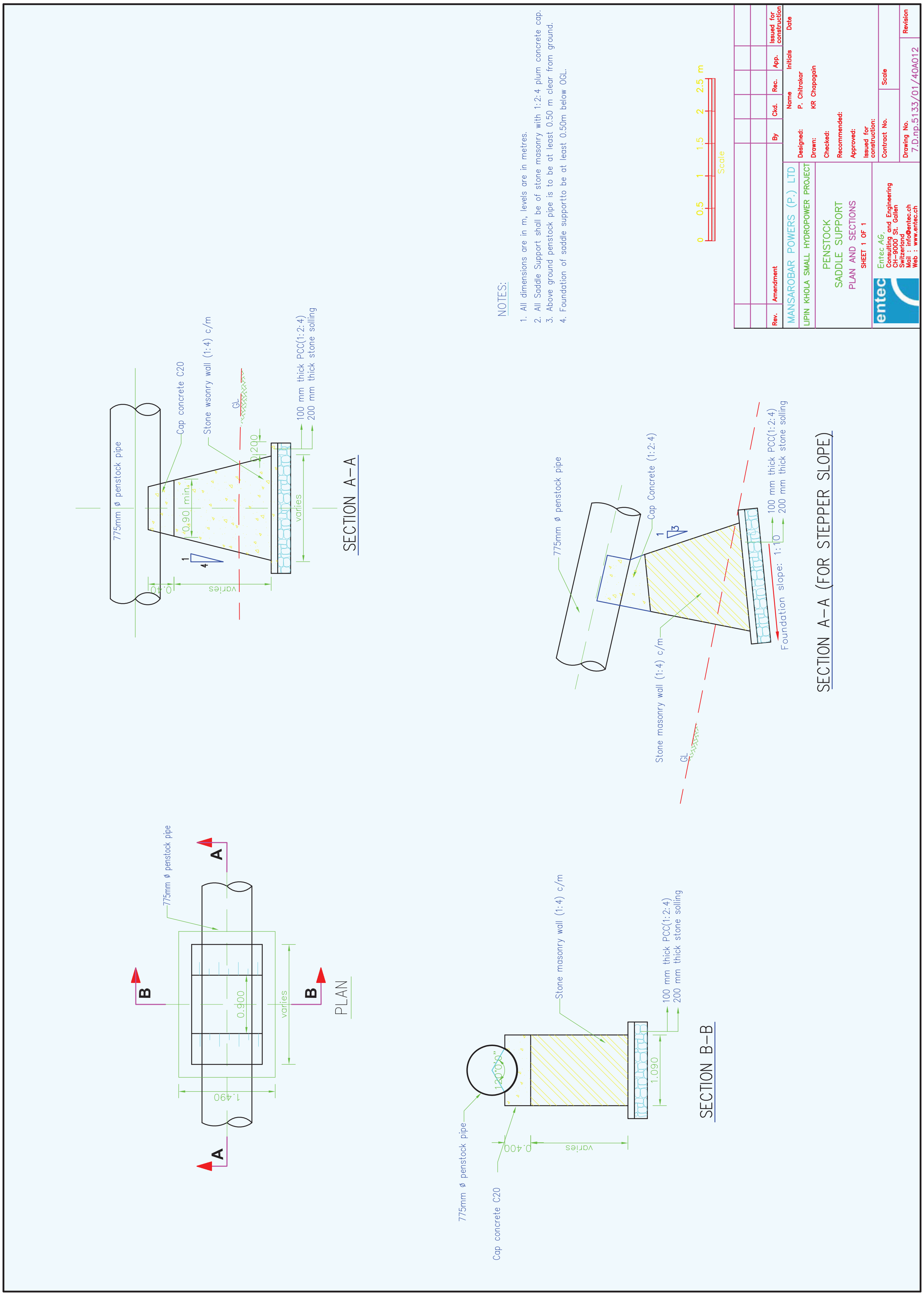

NOTES:
1. All co-ordinate and all level are in m.
2. All chainage are in horizontal projection.
3. This drawing is to be read in conjunction with:
7.D.np.5133/01/10A02~03 Project Layout Plan and Profile.
7.D.np.5133/01/40A01~05 General arrangement Plan
7.D.np.5133/01/40A06~09 General arrangement Profile
4. See Penstock alignment details at Annex, Investigation data for anchor blocks detail in main report.
LEGEND:
Contour
Stream
Road
House
Boulder
River
Dropoff
Bridge
Track
MANSAROBAR POWERS (P.) LTD.
LIPIN KHOLA SMALL HYDROPOWER PROJECT
PENSTOCK GENERAL ARRANGEMENT PLAN
SHEET 3 OF 9
Entec AG Consulting and Engineering
Drawing No. 7.D.np.5133/01/40A03
Penstock pipe burried area
775 mm ⌀ Penstock pipe
Anchor block
397 300
397 250
397 200
397 150
3 095 250
3 095 150

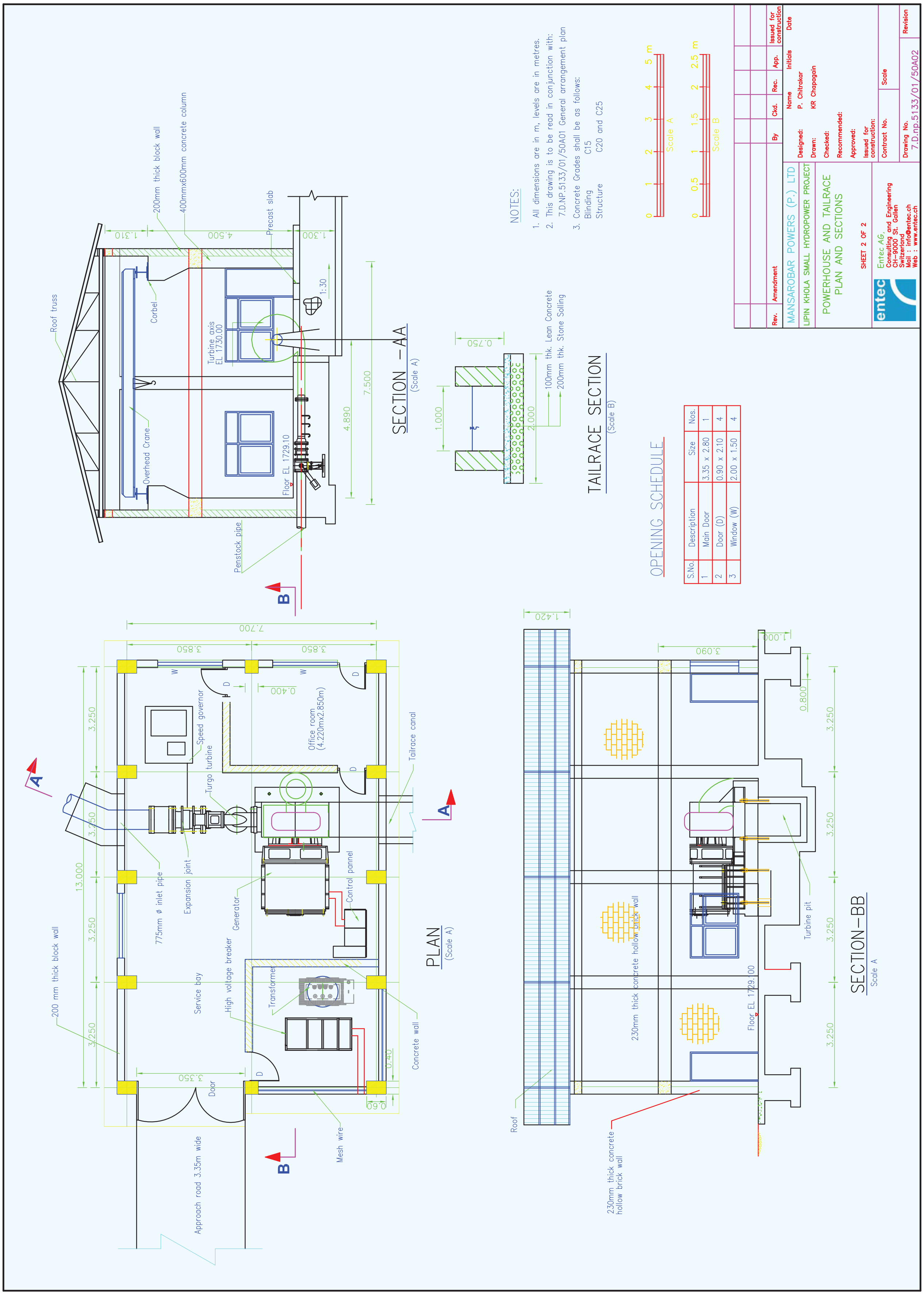

Lipin Khola
Penstock pipe
Anchor block
IP17
IP18
IP19
LEGEND:
Contour
House
Dropoff
Stream
Boulder
Bridge
Road
River
Track
NOTES:
1. All co-ordinate and all level are in m.
2. All chainage are in horizontal projection.
3. This drawing is to be read in conjunction with:
7.D.np.5133/01/10A02~03 Project Layout Plan and Profile.
7.D.np.5133/01/40A01~05 General arrangement Plan
7.D.np.5133/01/40A06~09 General arrangement Profile
4. See Penstock alignment details at Annex, Invetigation data for anchor blocks detail in main report.
Scale
mtrs
Rev.
Amendment
By
Ckd.
Rec.
App.
Issued for construction
MANSAROBAR POWERS (P.) LTD.
LIPIN KHOLA SMALL HYDROPOWER PROJRCT
PENSTOCK
GENERAL ARRANGEMENT
PLAN
SHEET 4 OF 9
entec
Entec AG,
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Mail : info@entec.ch
Web : www.entec.ch
Name
Initials
Date
Designed: P. Chitrakar
Drawn: Kr Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
Drawing No.
7.D.np.5133/01/40A04
Revision

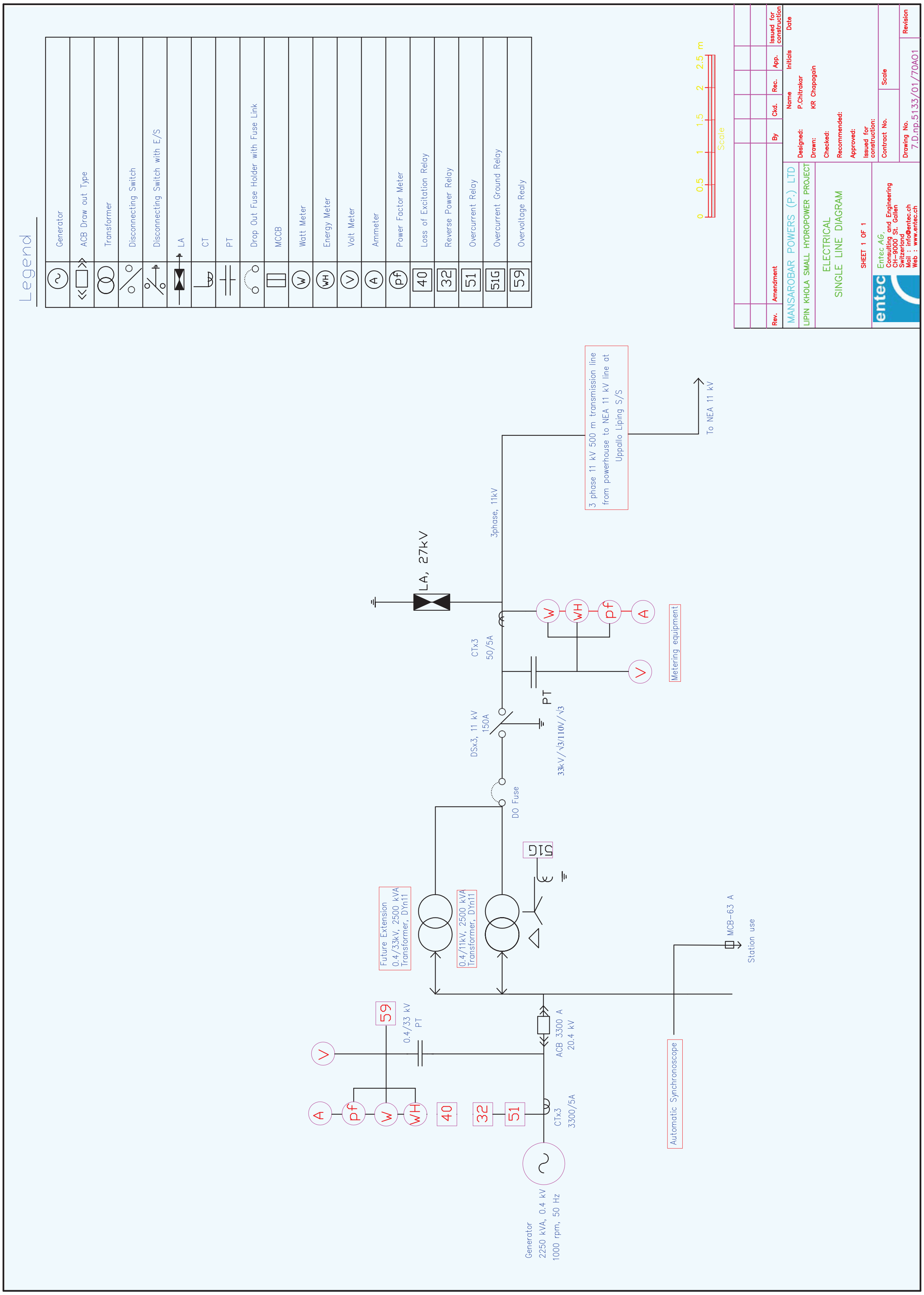

MANSAROBAR POWERS (P.) LTD.
LIPIN KHOLA SMALL HYDROPOWER PROJECT
PENSTOCK
GENERAL ARRANGEMENT
PLAN
SHEET 5 OF 9
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
Drawing No. 7.D.np.5133/01/40A05
Revision
Rev. Amendment By Ckd. Rec. App. Issued for construction Date
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Mail : info@entec.ch
Web : www.entec.ch
NOTES:
1. All co-ordinate and all level are in m.
2. All chainage are in horizontal projection.
3. This drawing is to be read in conjunction with:
7.D.np.5133/01/10A02~03 Project Layout Plan and Profile.
7.D.np.5133/01/40A01~05 General arrangement Plan
7.D.np.5133/01/40A06~09 General arrangement Profile
4. See Penstock alignment details at Annex, Investigation data for anchor blocks detail in main report.
LEGEND:
Contour
Stream
Road
House
Boulder
River
Dropoff
Bridge
Track
Scale 0 5 10 15 20 25 mtrs
Lipin Khola -->
Powerhouse
Tailrace
Anchor block
775 mm ø Penstock pipe
IP19
IP20
IP21
IP22
IP23
3 095 100
3 095 150
397 450
397 500
397 550
397 600

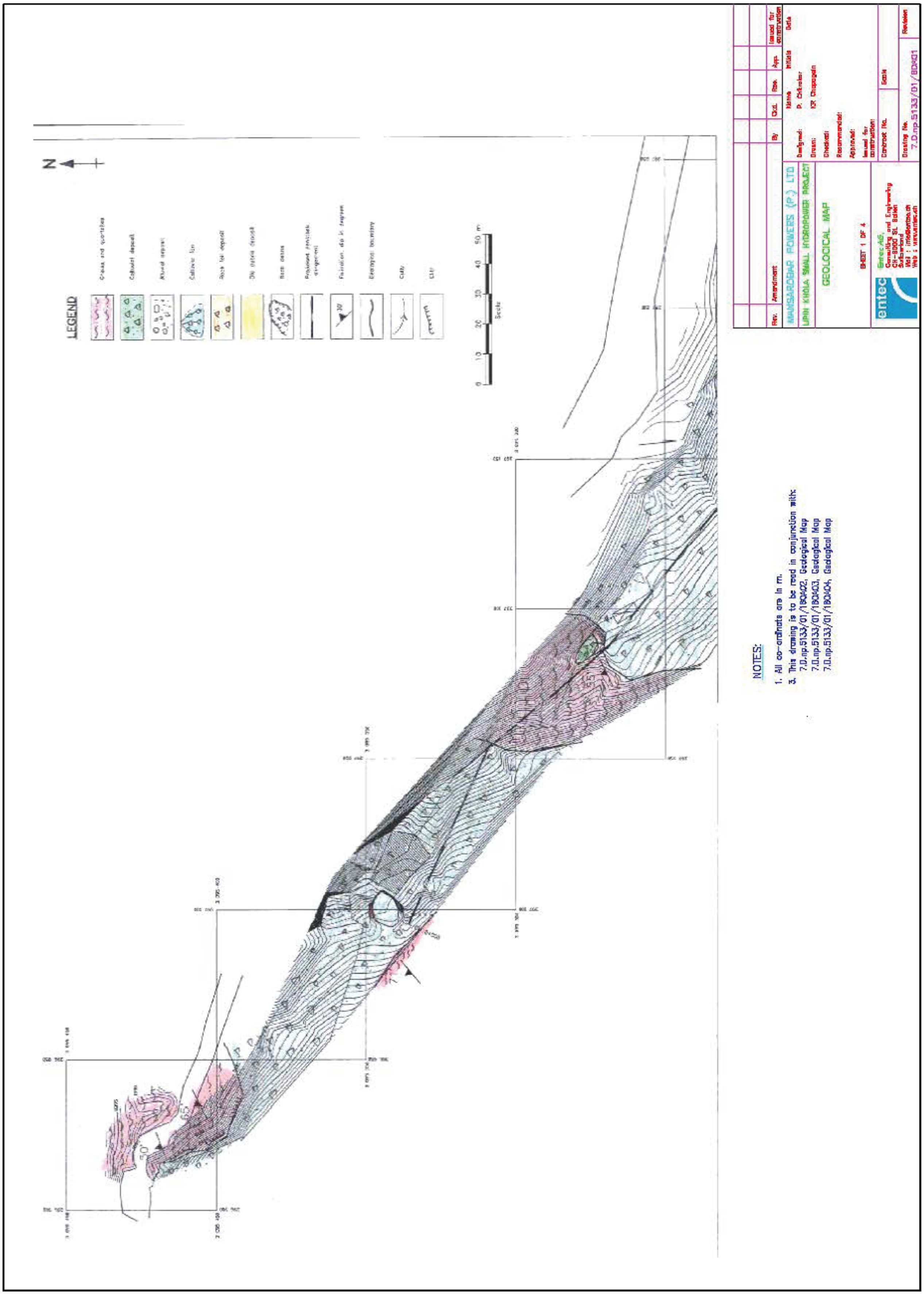

SECTION B-B
775mm ø Penstock Pipe
Plum concrete C20 with 40 % boulder
100mm thick Lean Concrete (1:3:6)
200mm Thk. Stone Soling (Thickness Adjust at Site Condition)
U/S Slope
D/S Slope
GL
4.350
1.205
2.199
0.200
0.500 min
TYPICAL PLAN OF CONVEX ANCHOR BLOCK
Curve Length= 2.55 m
775mm ø penstock pipe
Expansion joint
2.198
1.883
2.222
0.900
2.000
IP
NOTES:
1. All dimensions are in m, levels are in metres.
2. This drawing is to be read in conjunction with:
7.D.np.5133/01/40A01-40A05 General Arrangement Plan
7.D.np.5133/01/40A06-40A09 General Arrangement Profile
3. All Anchor Block shall be of 1:2:4 plum concrete with 40 % plums.
4. Expansion Joints shall be installed at least 0.50m downstream of anchor blocks.
5. Above ground penstock pipe is to be at least 0.50 m clear from ground.
6. Foundation of anchor blocks to be at least 0.50m below OGL.
TYPICAL BURRIED PENSTOCK PIPE SECTION
Graded Material
775mm ø penstock pipe
0.35
0.775
SECTION A-A
100mm thk. lean concrete (1:3:6)
200mm thk. boulder solling
2.200
1.150
0.900
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
PENSTOCK ANCHOR BLOCK PLAN AND SECTIONS
SHEET 1 OF 2
Designed: P. Chitrakar
Drawn: KR Chapagain
Entec AG Consulting and Engineering
Drawing No. 7.d.NP.5133/01/40A010

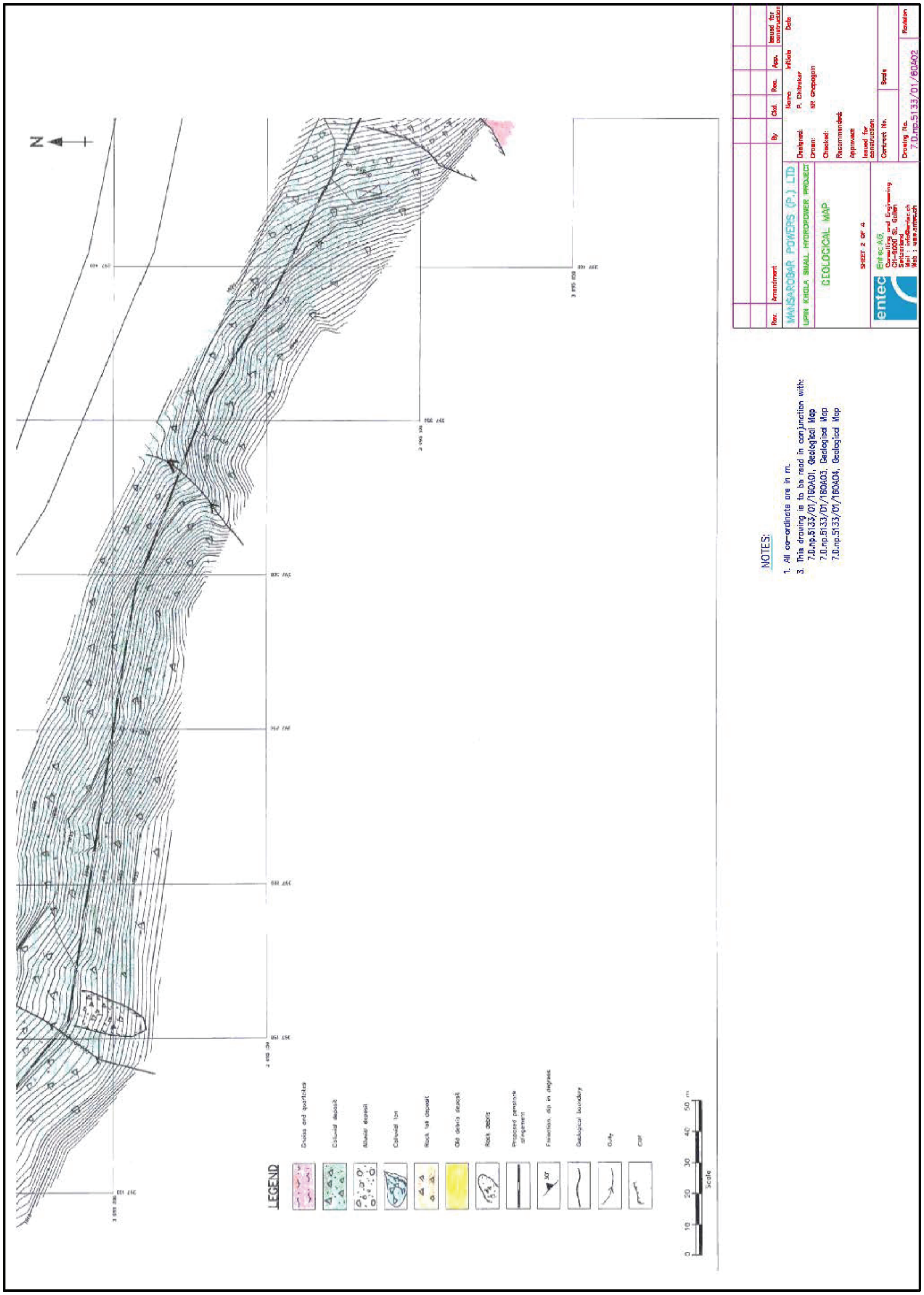

SECTION A–A
Plum concrete C20 with 40 % boulder
775mm ø penstock pipe
Expansion joint
Ground level
R1.900
2.261
2.498
3.022
2.000
1.338
3.586
1.000
1.000
0.774
1.259
1.000
1.000
1.000
0.500
SECTION B–B
Varies
1.430
1.605
1.555
Ground level
TYPICAL PLAN OF CONCAVE ANCHOR BLOCK
Plum concrete C20 with 40 % boulder
Expansion Joint
R1.500
2.674
1.866
1.880
1.915
2.500
2.955
2.215
2.500
A
B
NOTES:
1. All dimensions are in m, levels are in metres.
2. This drawing is to be read in conjunction with:
7.D.np.5133/01/40A01–40A05 General Arrangement Plan
7.D.np.5133/01/40A06–40A09 General Arrangement Profile
3. All Anchor Block shall be of 1:2:4 plum concrete with 40 % plums.
4. Expansion Joints shall be installed at least 0.50m downstream of anchor blocks.
5. Above ground penstock pipe is to be at least 0.50 m clear from ground.
6. Foundation of anchor blocks to be at least 0.50m below OGL.
0 0.5 1 1.5 2 2.5 m
Scale
Rev. Amendment By Ckd. Rec. App. Issued for construction
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
PENSTOCK
ANCHOR BLOCK
PLAN AND SECTIONS
SHEET 2 OF 2
Name Initials Date
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
entec
Entec AG,
Consulting and Engineering
CH–9000 St. Gallen
Switzerland
Mail : info@entec.ch
Web : www.entec.ch
Drawing No.
7.d.NP.5133/01/40A011
Revision

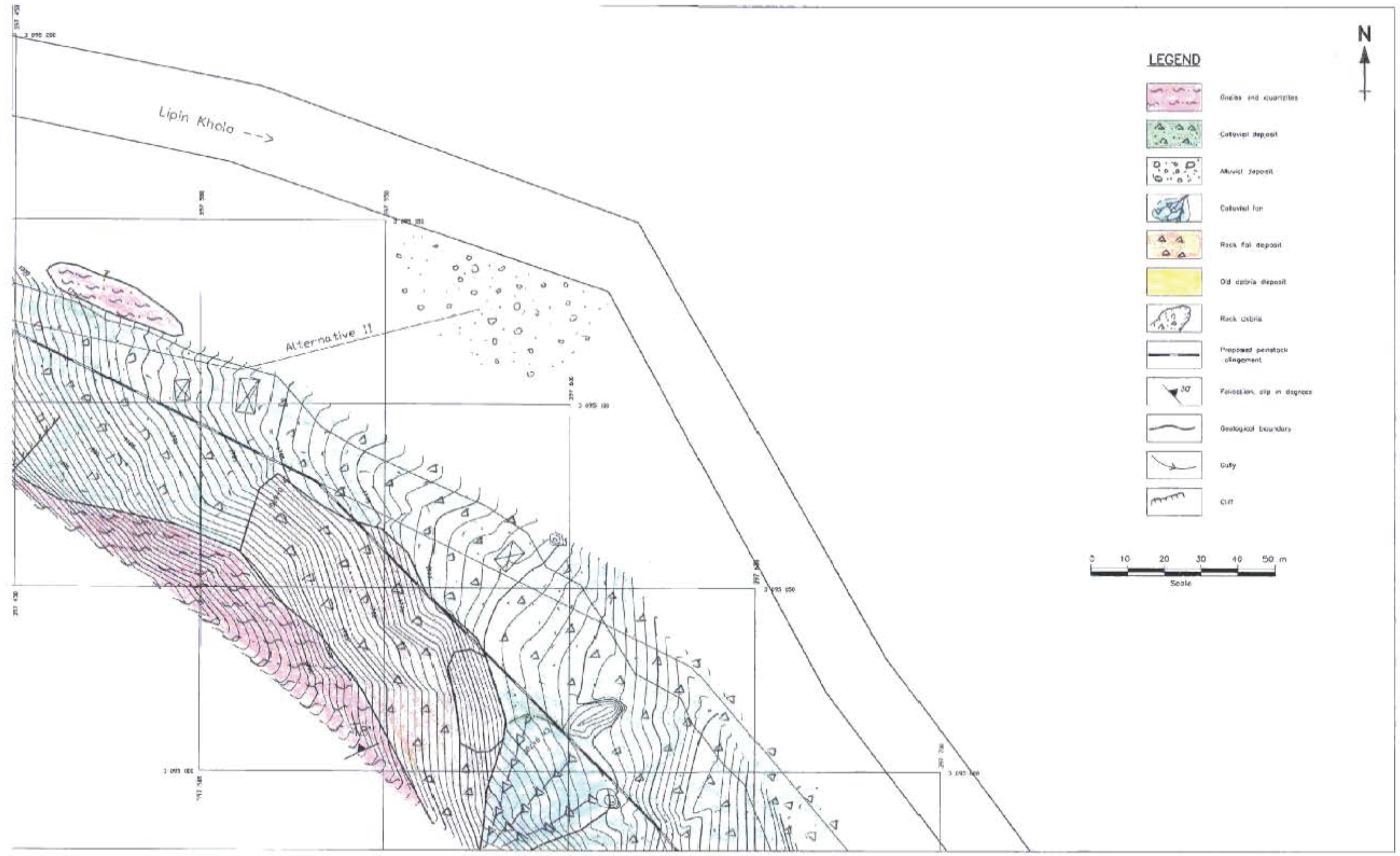

PLAN
SECTION A-A
SECTION B-B
SECTION A-A (FOR STEPPER SLOPE)
775mm ø penstock pipe
Cap concrete C20
Stone masonry wall (1:4) c/m
100 mm thick PCC(1:2:4)
200 mm thick stone soling
Cap Concrete (1:2:4)
Foundation slope: 1:10
GL
varies
0.900
1.490
1.090
0.400
NOTES:
1. All dimensions are in m, levels are in metres.
2. All Saddle Support shall be of stone masonry with 1:2:4 plum concrete cap.
3. Above ground penstock pipe is to be at least 0.50 m clear from ground.
4. Foundation of saddle supportto be at least 0.50m below OGL.
Scale
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
PENSTOCK
SADDLE SUPPORT
PLAN AND SECTIONS
SHEET 1 OF 1
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Drawing No. 7.D.np.5133/01/40A012
Revision


SECTION – AA
(Scale A)
Roof truss
200mm thick block wall
400mmx600mm concrete column
Precast slab
Corbel
Overhead Crane
Turbine axis EL 1730.00
Floor EL 1729.10
Penstock pipe
1:30
7.500
4.890
1.310
4.500
1.300
PLAN
(Scale A)
200 mm thick block wall
775mm ø inlet pipe
Expansion joint
Speed governor
Turgo turbine
Generator
Control pannel
Office room (4.220mx2.850m)
Tailrace canal
Service bay
High voltage breaker
Transformer
Concrete wall
Door
Mesh wire
Approach road 3.35m wide
13.000
3.250
7.700
3.850
3.350
TAILRACE SECTION
(Scale B)
100mm thk. Lean Concrete
200mm thk. Stone Soling
1.000
0.750
2.000
OPENING SCHEDULE
S.No. | Description | Size | Nos.
1 | Main Door | 3.35 x 2.80 | 1
2 | Door (D) | 0.90 x 2.10 | 4
3 | Window (W) | 2.00 x 1.50 | 4
SECTION–BB
Scale A
Roof
230mm thick concrete hollow brick wall
Turbine pit
Floor EL 1729.00
1.420
3.090
1.000
0.800
NOTES:
1. All dimensions are in m, levels are in metres.
2. This drawing is to be read in conjunction with: 7.D.NP.5133/01/50A01 General arrangement plan
3. Concrete Grades shall be as follows:
Blinding C15
Structure C20 and C25
Scale A
Scale B
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
POWERHOUSE AND TAILRACE PLAN AND SECTIONS
SHEET 2 OF 2
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Mail : info@entec.ch
Web : www.entec.ch
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
Drawing No.
7.D.np.5133/01/50A02
Revision


Legend
Generator
ACB Draw out Type
Transformer
Disconnecting Switch
Disconnecting Switch with E/S
LA
CT
PT
Drop Out Fuse Holder with Fuse Link
MCCB
Watt Meter
Energy Meter
Volt Meter
Ammeter
Power Factor Meter
Loss of Excitation Relay
Reverse Power Relay
Overcurrent Relay
Overcurrent Ground Relay
Overvoltage Realy
Generator 2250 kVA, 0.4 kV 1000 rpm, 50 Hz
CTx3 3300/5A
ACB 3300 A 20.4 kV
0.4/33 kV PT
Automatic Synchronoscope
Future Extension 0.4/33kV, 2500 kVA Transformer, DYn11
0.4/11kV, 2500 kVA Transformer, DYn11
MCB-63 A
Station use
DO Fuse
DSx3, 11 kV 150A
33kV/√3/110V/√3
PT
CTx3 50/5A
Metering equipment
LA, 27kV
3phase, 11kV
3 phase 11 kV 500 m transmission line from powerhouse to NEA 11 kV line at Uppallo Liping S/S
To NEA 11 kV
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
ELECTRICAL SINGLE LINE DIAGRAM
SHEET 1 OF 1
Designed: P.Chitrakar
Drawn: KR Chapagain
Entec AG, Consulting and Engineering
Drawing No. 7.D.np.5133/01/70A01


N
LEGEND
Gneiss and quartzites
Colluvial deposit
Alluvial deposit
Colluvial fan
Rock fall deposit
Old debris deposit
Rock debris
Proposed penstock alignment
Foliation, dip in degrees
Geological boundary
Gully
Cliff
0 10 20 30 40 50 m
Scale
NOTES:
1. All co-ordinates are in m.
3. This drawing is to be read in conjunction with:
7.D.np.5133/01/180A02, Geological Map
7.D.np.5133/01/180A03, Geological Map
7.D.np.5133/01/180A04, Geological Map
Rev. Amendment By Ckd. Rse. App. Issued for construction
MANSAROBAR POWERS (P.) LTD
UPIN KHOLA SMALL HYDROPOWER PROJECT
GEOLOGICAL MAP
SHEET 1 OF 4
Name Initials Date
Designed: P. Chitrakar
Drawn: KR Chapagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
Drawing No.
7.D.np.5133/01/180A01
Revision
entec
Entec AG, Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Mail : info@entec.ch
Web : www.entec.ch


N
NOTES:
1. All co-ordinate are in m.
3. This drawing is to be read in conjunction with:
7.D.np.5133/01/160A01, Geological Map
7.D.np.5133/01/160A03, Geological Map
7.D.np.5133/01/160A04, Geological Map
LEGEND
Gneiss and quartzites
Colluvial deposit
Alluvial deposit
Colluvial fan
Rock fall deposit
Old debris deposit
Rock debris
Proposed penstock alignment
Foliation, dip in degrees
Geological boundary
Gully
Cliff
0 10 20 30 40 50 m
Scale
Rev. Amendment By Ckd. Rec. App. Issued for construction
MANSAROBAR POWERS (P.) LTD
UPIN KHOLA SMALL HYDROPOWER PROJECT
GEOLOGICAL MAP
SHEET 2 OF 4
Name Initials Date
Designed: P. Chitrakar
Drawn: KR Chepagain
Checked:
Recommended:
Approved:
Issued for construction:
Contract No.
Scale
entec
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Drawing No.
7.D.np.5133/01/60402
Revision



NOTES:

1. All co-ordinate are in m.
3. This drawing is to be read in conjunction with:
   7.D.np.5133/01/160A01, Geological Map
   7.D.np.5133/01/160A02, Geological Map
   7.D.np.5133/01/160A04, Geological Map

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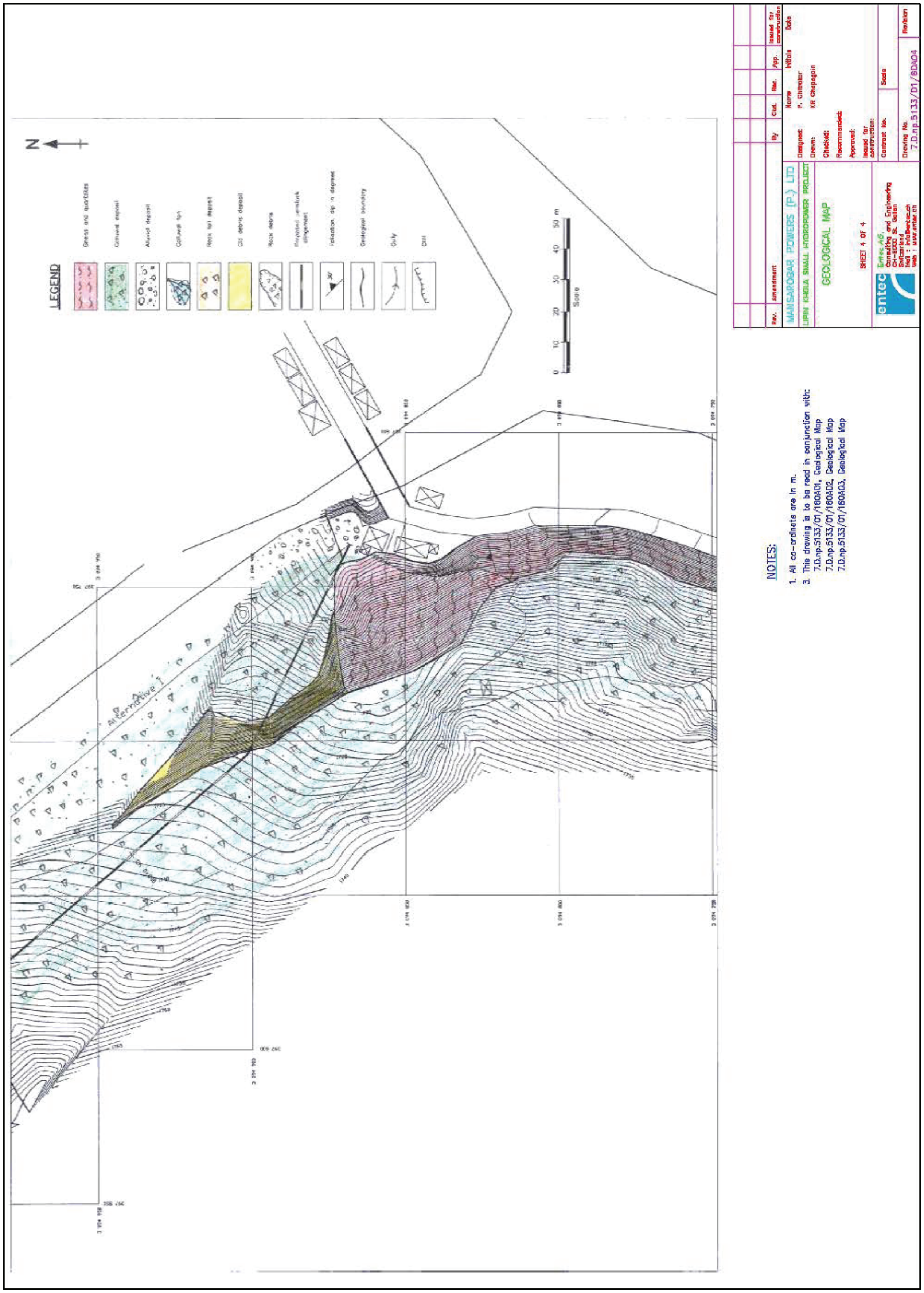
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
GEOLOGICAL MAP
SHEET 3 OF 4

entec
Entec AG
Consulting and Engineering
CH-9000 St. Gallen
Switzerland
Mail : info@entec.ch
Web : www.entec.ch

	Name	Initials	Date
Designed:	P. Chitrakar		
Drawn:	KR Chapagain		
Checked:			
Recommended:			
Approved:			
Issued for constructions			
Contract No.		Scale	
Drawing No. 7.D.np.5133/01/60A03		Revision	


LEGEND
Gneiss and quartzites
Colluvial deposit
Alluvial deposit
Colluvial fan
Rock fall deposit
Old debris deposit
Rock debris
Projected penstock alignment
Foliation dip in degrees
Geological boundary
Gully
Cliff
Scale
Alternative 1
NOTES:
1. All co-ordinate are in m.
3. This drawing is to be read in conjunction with:
7.D.np.5133/01/160A01, Geological Map
7.D.np.5133/01/160A02, Geological Map
7.D.np.5133/01/160A03, Geological Map
MANSAROBAR POWERS (P.) LTD
LIPIN KHOLA SMALL HYDROPOWER PROJECT
GEOLOGICAL MAP
SHEET 4 OF 4
Designed: P. Chitrakar
Drawn: KR Ghapagain
Checked:
Recommended:
Approved:
Drawing No.
7.D.np.5133/D1/60A04
entec

Contact Details

Alternative Energy Promotion Centre
Khumaltar height, Lalitpur, Nepal
Tel: +977-1-5539237, 5548468, 5539390, 5539391
Fax: 977-1-5542397, Email: rerl@aepc.gov.np
www.aepc.org.np