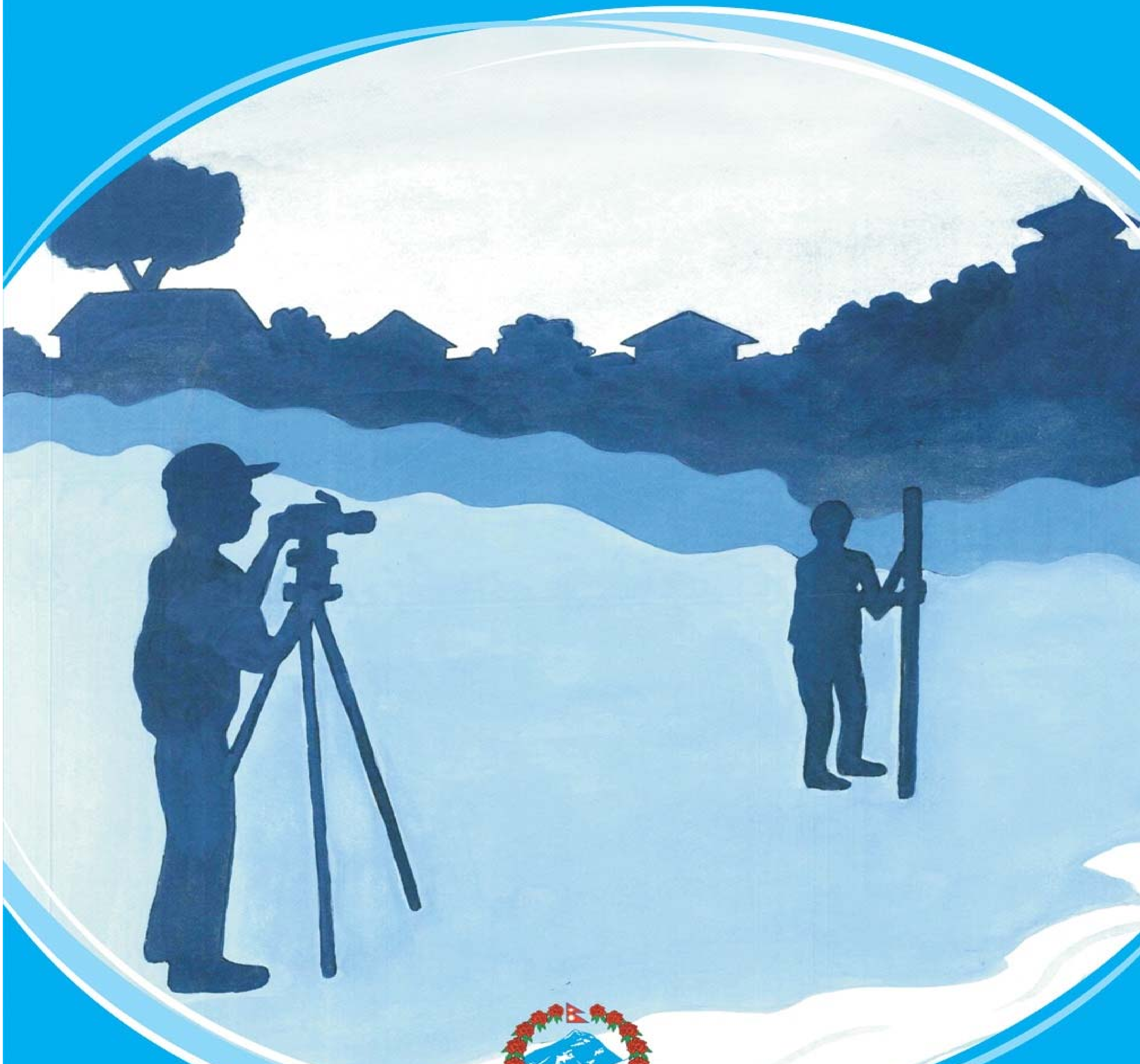
GUIDELINES FOR DETAILED FEASIBILITY STUDIES OF MICRO-HYDRO PROJECTS



Government of Nepal
Ministry of Energy, Water Resources and Irrigation
Alternative Energy Promotion Centre (AEPC)

GUIDELINES FOR
DETAILED FEASIBILITY STUDY OF MICRO-HYDRO PROJECTS

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PREFACE

The Alternative Energy Promotion Centre (AEPC) was established in 1996. It has been executing the national Rural and Renewable Energy Program (NRREP) since July 16, 2012 with single program modality. Support to micro/mini hydropower development under Community Electrification Sub-Component (CESC) has been one of the major activities of the programme within the NRREP.

AEPC has been preparing various guidelines, standards and manuals for assisting prospective micro/mini hydropower projects. Prevailing standards, guidelines and manuals are the basis for development of micro/mini hydropower projects in Nepal. In the course of accreditation for Green Climate Fund (GCF), AEPC supported projects needs to be fulfilled Environment and Social Safeguard (ESS) issues. For fulfilling the ESS, AEPC/CESC initiated updating existing Guidelines for Detail Feasibility Study of Micro-Hydro Projects.

I would like to express thanks to Global Engineering Associates Pvt. Ltd., Lalitpur and the CESC, CCU and other colleagues from AEPC for their contributions to the updating of the guideline. I would like to thank all those who directly and indirectly helped in updating this guideline.

Ram Prasad Dhital
Executive Director
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Abbreviations

AEPC	Alternative Energy Promotion Centre
ACSR	Aluminium conductor steel reinforced (electrical conductor cable type)
AVR	Automatic voltage regulator
BPC	Butwal Power Company Ltd.
DANIDA	Danish International Development Agency
DCS	Development & Consulting Services, a joint venture of UMN and HMGN
DFS	Detailed feasibility study
ECC	Electronic circuit cut-out
ELC	Electronic load controller
ESAP	Energy Sector Assistance Programme
HDPE	High-density polyethylene
HH	Household
HRC	High Rupturing Capacity
GoN	Government of Nepal
HP	Horsepower
HRC	High rupturing capacity
IGC	Induction generator controller
ITDG	Intermediate Technology Development Group
kVA	kilo-volt ampere
kW	kilowatt
lps	litres per second
m	metre
mm	millimetre
MCB	Miniature circuit breaker
MHP	Micro-hydropower project
MS	Mild steel
NEA	Nepal Electricity Authority
NRREP	National Rural and Renewable Energy Programme
PTC	Positive temperature coefficient
RCC	Reinforced cement concrete
VDC	Village development committee

CHAPTER ONE: GENERAL INTRODUCTION

1. Background

These guidelines were prepared to for consultants undertaking detailed feasibility studies (DFSs), including of technical design, for micro-hydropower projects (MHPs) supported by the Alternative Energy Promotion Centre (AEPC) of the Government of Nepal (GoN). They cover both micro- (10-100 kW) and pico- (up to 10 kW) hydropower projects.

It is expected that the use of these guidelines will result in the adoption of a standard approach to designing and reporting on such studies. Their overall objective is to see good-quality MHPs with minimal failure rates built. Their specific objectives are as follows:

- Rural households will receive reliable and affordable electricity for household lighting and thus experience an improvement in quality of life.
- Technically sound MHPs will be implemented.
- MHPs will be cost-effective and financially viable so that external support for their operation and maintenance is not needed.
- Safety issues will be adequately addressed
- MHPs will promote some end-uses based on available local resources and markets.
- Where feasible, multipurpose projects that integrate hydropower with other uses of the water resources will be promoted.
- Communities will be more aware about gender equality and social inclusion (GESI) and women and the vulnerable will be empowered.
- Carbon emissions will be rescued.

A DFS report is the report written after the second visit to a prospective MHP site following an assessment of the information provided by a preliminary feasibility study. Thus, the DFS should build upon the findings of the preliminary feasibility study. It is the final document, the one upon which the decision whether or not to implement the proposed MHP is based.

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

A separate Micro-hydro Design Aid spreadsheet programme has been developed and updated to assist the design engineer in sizing appropriate structures and equipment for a selected scheme. These are guidelines only and are not intended to replace sound engineering judgement. They should be used with caution to verify the design parameters based on site-specific conditions.

It should be noted that the design engineer/consultant may propose designs different from those in these guidelines provided that such designs meet these qualifications:

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

The six key issues that the study should cover are as follows.

1. Technical viability
2. Power demand and end-use possibilities
3. Project costs and finances
4. Institutional aspects
5. Policy issues
6. Possibilities for the multiple use of water

Each issue is discussed below. Chapter 2 discusses the technical and socio-economic aspects that should be covered during the site survey while Chapter 3 presents technical design considerations. The standards and requirements of a detailed feasibility report are discussed in Chapter 4. References are included in Chapter 5. The format for site surveys, examples of typical drawings, and cost estimation are presented in appendices B, C and D respectively.

Since it is expected that a multidisciplinary team of experienced technicians (engineers) and socio-economists/sociologists familiar with micro-hydropower will undertake each study, underlying technical and socio-economical principles are not discussed in detail.

1.1 Technical Viability

The DFS report should clearly demonstrate the technical viability of the scheme should be clearly by comparing it with alternative sites and/or alternative technology as far as practicable. This information should include the design flow and head; the length, type and dimensions of waterways and structures; and the specifications of equipment, accessories and protection devices as well as their operation and maintenance requirements. The available flow and head are not only the factors which should govern the size of the scheme. The technical design should also meet the demands of the beneficiaries for electricity.

The contractor should be able to quote a price for the implementation of the scheme based on the DFS report and a reconnaissance visit to the site. Furthermore, he or she should be able to construct (or supervise the construction of) the structures and install equipment with minor modifications to suit site conditions. Detailed construction drawings are not essential but the basis for working drawings should be incorporated in the report. Guidelines and requirements for technical viability and the standard of the report are discussed in Chapters 3 and 4 respectively.

1.2 Power Demand and End-Use Possibilities

The demand for power and end-use possibilities should be assessed during the site visit and stated in the report. The primary use of micro-hydropower in rural areas is household lighting. Thus, in order to optimise the use of an MHP (and thus increase its financial viability), the installed capacity should be governed by household demand. Other, non-lighting end-uses should ideally complement the lighting use. If other end-uses fall during non-lighting hours, the size of the scheme need not be unnecessarily increased. At any given time, the total capacity of end-uses under operation should be limited to the installed capacity, which is governed by the demand for lighting. That said, other approaches to sizing the plant will be entertained if financial viability is demonstrated.

To assess total power requirements, the number of beneficiary households and the average power demand per household should be determined through discussions with the community. Their demands should be balanced with the technical aspects of the scheme. The types of end-uses, their energy demands, and the expected annual operating time given the local resources and market opportunities available should also be determined. Prospective entrepreneurs willing to install the various end-uses should be identified in the DFS report.

1.3 Project Costs and Finances

The total implementation cost of the proposed technical design should be determined based on the prevailing rates for material, equipment, labour and transport in the concerned district. Site-specific rates should be used if they differ from or there are no district rates and special remarks and suitable references provided. Annual costs such as salaries for operators and plant maintenance as well as annual income should also be determined.

Based on discussions with the community members and the prospective developer, the consultant should suggest how the scheme is to be financed (e.g., loan, community contribution/equity and/or external support). Finally, the financial viability of the scheme as per the AEPC's policy requirements (i.e., positive net present value of equity at a discount rate of 6%) should be demonstrated.

1.4 Institutional Aspects

The commitment of the developer and community to implement the scheme and their ability to own and manage the plant should be assessed by the consultant. The assessment should include the general perception of micro-hydropower and electricity of the developer and the community, the need for operation and maintenance, and financial viability.

Any institutions, such as NGOs or government line agencies, which are active in the project area and are likely to contribute to the implementation of the scheme, should be contacted and the nature of their potential assistance documented.

1.5 Policy Issues

The DFS report should also adequately address the AEPC's policy issues regarding the eligibility of an MHP for subsidy support. Currently, these include the following:

- There should be no or limited adverse environmental impacts.
- The return on equity and an economic life of 15 years should be positive.
- The subsidies currently mandated by the GoN follow.

Table 1.1: Subsidies as per Renewable Energy Subsidy Policy 2073

Subsidy Distribution	**Subsidy Amount (Rs.)**			
(A) Based on capacity (kW)	Very remote area (Dolpa, Mugu, Humla)	RMs in 'Ka' areas	RMs in 'Kha' areas	RMs in 'Ga' areas
>10 – 1000 kW				
Distribution (per Households)	35,000	32,000	30,000	28,000
Generation-Equipment per kW	125,000	95,000	85,000	80,000
Generation-Civil per kW	80,000	30,000	25,000	20,000
The maximum subsidies per kW for households in 'Very remote' 'Ka', 'Kha' and 'Ga' areas are Rs. 382,000; Rs. 285,000; Rs. 260,000; and Rs. 240,000 respectively. Five households per kW will be considered for distribution subsidy.				
(B) Based on consumed energy (kWh)				
Consumed energy (kWh)	55%	50%	45%	40%
	Subsidy based on consumed energy shall be provided up to 5 years from the date of commissioning.			
Up to 10 kW	Installed capacity	**Subsidy Amount (Rs.)**		
		'Ka' areas	Kha' areas	'Ga' areas
Distribution (per HHs)	Upto 10 kW capacity	11,500	10,500	10,000
Generation (per kW)	Upto 10 kW capacity	10,500	60,000	50,000
	Upto 5 kW capacity	10,000	85,000	75,000
In case of projects upto 5 kW capacity, the maximum subsidies per kW for households in 'Ka', 'Kha' and 'Ga' areas are Rs. 185,000; Rs. 165,000; and Rs. 150,000 respectively. In case of projects greater than 5 kW and upto 10 kW capacity, the maximum subsidies per kW for households in 'Ka', 'Kha' and 'Ga' areas are Rs. 210,000; Rs. 190,000; and Rs. 175,000 respectively. In case of single generation, (electrification of temples, community radio stations, hospitals and similar institutional and community uses), only the per kW generation subsidy mentioned in above table is provided.				

Source: Renewable Energy Subsidy Policy, 2073

For details, see the Renewable Energy Subsidy Policy of 2073 and Subsidy Delivery Mechanism of 2073. As policy requirements may change, consultants should contact the AEPC office regarding the policies applicable at the time the study is conducted.

1.6 Multi Purpose Projects

Multipurpose MHPs are those that use water for reasons other than power generation, such as irrigation or drinking water supply. For example, if the headrace or the tailrace of a MHP is also used for irrigation, that plant can be considered a multipurpose plant. Where the topography is suitable, using tailrace discharge for irrigation could create an ideal multipurpose project if the alignment or length of the tailrace is designed suitably to serve a significant command area. Pumping water for irrigation during off-peak hours is another example of increasing the number of end-uses and promoting the non-hydropower use of water.

As discussed in the pre-feasibility study guidelines, the DFS should consider the following issues in its exploration of the possibility of the multiple use of water resources:

- Apart from meeting the flow requirements for power generation, excess flows should be available for secondary purposes. For example, if the design flow required for power generation is less than the 11-month exceedance flow (the river is large and installed capacity low), excess flow may be available for irrigation. If the command area is along the headrace alignment, irrigation flow can be made available by sizing the headrace canal to meet both demands (i.e., power generation and irrigation). If a pipe is used for the headrace, flow-control structures such as valves will be required at irrigation outlet points.
- If the command area lies 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 may be the only additional cost required.
- It may also be possible to accommodate irrigation or other non-hydropower flows with the same design flows using water management practices like irrigating during off-peak hours by either reducing the power output or closing the plant.
- The additional costs of and the incremental benefits from the secondary uses should be demonstrated in the DFS report. For example, the increase in the cost of a headrace canal which accommodates irrigation flows should be compared to the expected annual benefits due to increases in crop yields over the life span of the MHP. If the accumulated benefits at the discount rate current at the time of the study (15 years and 6% at present) exceeds the additional costs, then multipurpose projects can be justified.

It should be noted that the current AEPC policy encourages multipurpose projects: “Multipurpose power-irrigation-drinking water projects will be preferential projects for subsidy funding. Efforts should be made to seek technical and management solutions that encourage power generation and integrate other uses of the water resources.”

CHAPTER TWO: SITE SURVEY

2. Survey Requirements

Adequate and accurate survey work is vital to implementing a sustainable MHP. It should address both the technical and socio-economic issues of the project area.

The basis for the information that is to be compiled during the site visit is presented in Appendix B. The consultant should also note down other site-specific issues that are essential for the implementation of the scheme.

2.1 Technical Aspects

The technical survey should be conducted so that the locations of various structures can be shown in drawings and later constructed on the ground. It should verify the findings of the preliminary feasibility study and provide more accurate measurements, as is explained below.

2.2 Site Selection

The selection of an appropriate site depends on two factors: stream flow and topography. The power available from a MHP is a function of both the flow and the head and the head depends on the topography. An MHP is technically viable only if, together, the head and the flow meet the demands of the targeted community. Under normal circumstances, the lowest seasonal flow of the river should be used to calculate the power. While designers have little control over the flow available, they do have some control over topography: they can choose different alignments for the intake, headrace and penstock and they can modify the local topography through excavation, the implementation of soil stability enhancement measures and/or the construction of structures.

The surveyor should consider the physical advantages of the site point and contemplate the practical design and construction of alternative layouts. Each layout will require the construction of different components on different parts of the potential site; these should be noted. Features that may affect the design of the scheme, such as slope stability and land use and ownership should also be noted and a sketch map of each potential site plan made.

The DFS should closely examine each of the layouts identified during the preliminary survey and accurately locate each component in the site plan. The location of the intake is the key component, so the surveyor should consider it with the utmost attention.

Once all alternatives have been planned in detail, the most suitable layout should be chosen using, aside from the cost, the following criteria:

- The combination of head and flow must generate the required minimum power output.
- Preference should be given to the layout with simplest design and construction.
- The shorter the alignment of an MHP, the fewer construction materials it requires and thereby the less money and time it requires to construct. The powerhouse should be as close as possible to the load centre.

- Technical parameters such as overall slope stability, flood risks, and other site-specific issues should be considered.

Since slope stability of slopes affects the design of all components of an MHP, it should be analysed thoroughly, particularly in the following key areas:

- Above and below the proposed canal routes
- Below the proposed location of the settling basin or forebay
- Along the proposed penstock alignment
- Above and below the proposed powerhouse location

Unstable slopes can weaken support foundations through landslide or collapse or damage structures through falling debris. The following features of a slope or rock face indicate slope stability:

- Thick vegetative cover, including trees standing vertically.
- Straight, even slope profile
- Rock surfaces covered with moss, lichen or a weathered skin
- Hard, impermeable rock
- Rock with no or few joints
- Closed rock joints
- Well-packed debris, with fine material packed into voids between coarse material
- Well-established trees and shrubs
- No active gullies (although a stable gully system may be present)

A thorough investigation of slope will influence the design of the whole scheme, particularly the location of principal structures and should keep in mind two guidelines:

- Never construct on fill, that is, land which has been built-up or filled using excavated material.
- Avoid the location of structures close to landslide zones.

2.3 Flow Measurement and Hydrology

- The mean monthly flows reported in the pre-feasibility study should be verified using either the Medium Irrigation Project (MIP) method and/or the Hydest method, depending on the catchment area. A site visit should be made between the months of November and April to measure the river discharge at the intake site. If the mean monthly flows estimated at this stage are lower than those reported in the preliminary feasibility study, the design discharge (and thus the installed capacity) should be lowered accordingly. Note that as called for in the “Flow Verification Guidelines,” the design discharge should be available at least 11 months a year.

Table 2.1 Flow-measuring equipment

Equipment	Preferred limit (lps)	Acceptable limit (lps)
Bucket	Up to 10	Up to 30
Conductivity meter	Up to 500	Up to 1500
Current meter	Above 200	As per equipment specification

- Conductivity meter should be calibrated at least once every six months.
- Three sets of consistent measurements (within 10%) should be provided for discharge.
- The catchment area at the intake location reported in the pre-feasibility study should be verified based on available topographical maps.
- As for the pre-feasibility study, if the catchment area at the intake exceeds 100 km^2, then flow measurements and mean monthly flow estimation using the MIP method are not mandatory as flow requirements for MHPs during the low-flow season are ensured due to the catchment size. In such cases the Hydest method should be used to estimate monthly available flow.

2.4 Survey Equipment, Marking on Site and Photographs

The equipment recommended for site survey is presented in Table 2.2. Since there can be a significant time gap between the detailed survey and the construction of the scheme, permanent markings should be made and photographs should be taken at the locations of key structures so that the contractor/installer can determine their locations and alignments with ease. Depending on the ground conditions, either driving wooden pegs into ground with the exposed end painted or painting nearby boulders or rock outcrops is appropriate. Paints, such as enamel, that are not easily worn off due to adverse weather conditions should be used. Guidelines for marking at the site and taking photographs are presented in Table 2.2.

Table 2.2: Equipment and markings for site survey

S.N.	Area	Survey Equipment	Markings and Photographs
1.	Intake site	Level machine with GPS and tape or theodolite or equipment with similar accuracy	Enamel paints on permanent boulders and rock outcrops at river banks Photograph of the intake area
2.	Headrace alignment	Level machine with GPS and tape or theodolite or equipment with similar accuracy	Wooden pegs along the alignment at 10–20 m intervals and along bends Photograph showing the entire alignment as well as any site-

			specific features such as crossings and siphons
3.	Penstock alignment	Level machine with GPS and tape or theodolite or equipment with similar accuracy	Wooden pegs at the anchor block locations and at 10–20 m intervals along the alignment Photograph showing the penstock alignment
4.	Powerhouse site	Level machine with GPS and tape or theodolite or equipment with similar accuracy	Wooden pegs or marking on boulders Photograph of the powerhouse
5.	Tailrace	Level machine with GPS and tape or theodolite or equipment with similar accuracy	Wooden pegs or marking of boulders along the alignment at 10–20 m intervals Photograph of the tailrace alignment if is not visible in the powerhouse photograph
6.	Transmission and/or distribution lines	Compass and tape or GPS	Photograph showing the overall transmission and/or distribution lines

Note: For schemes up to 10 kW of installed capacity, the survey from intake to tailrace may be conducted using an Abney level and a tape, but the use of GPS is recommended in all cases.

2.5 Socio-economic aspects

The socio-economic survey should generally follow the format provided in Appendix B. The technical findings should be discussed with the developer and the community so that the alignment and locations of structures are clear to them.

Water right issues and tariff rates should be discussed and entrepreneurs interested in establishing end-uses should be identified and their requirements discussed. It is important for the survey team to spend time with the community and to explain the various aspects of the scheme in order to facilitate community mobilisation during the construction phase.

2.6 Possibility of multipurpose projects

The site survey should explore the possibility of multipurpose projects including aligning the headrace or tailrace through cultivated land to serve as an irrigation canal and the possibility of establishing a drinking water supply system using the forebay. If such projects appear feasible, they should be discussed with community members and the additional costs and benefits explained.

2.7 Gender Equity and Social inclusion

GESI been mainstreamed into the AEPC by including it in the development objective, in each of the immediate objectives, in relevant outputs and activities, and in indicators, targets and monitoring. The Renewable Energy Subsidy Policy of 2073 provides additional subsidies for single women, disadvantaged groups, the poor, the conflict-affected and marginalized groups, so the designer should collect data on all such groups.

2.8 Environment and Social Safeguard Aspect

Environment and social safeguard (ESS) have been mainstreamed in each community-based project including micro hydropower projects. In the context of accreditation to Green Climate Fund, each community-based projects needs to be assessed from ESS policy of AEPC. Relevant data are collected from survey format (Refer Appendix-A) which critically examines ESS issues and categorises the project based on risk potential risk.

After assessment of potential risk and impact profile, the project should be categorized A, B or C. Consequently, relevant recommendation should be made for carrying EIA or IEE if the project falls under category A or B respectively. If the project falls under category C, Environmental and Social Management Plan (ESMP) should be prepared.

CHAPTER THREE: TECHNICAL DESIGN

3. Component Design

The technical design of a MHP consists of civil, mechanical and electrical components, all of which are discussed in this chapter. Sample drawings are also included and more detailed drawings are presented in Appendix C. The spreadsheet programme Microhydro Design Aid prepared in conjunction with these guidelines can be used to make and/or check technical designs.

3.1 Civil Components

Civil structures are used for the waterways of an MHP. Although they are a major part of a project, they are often accorded little importance, and, as a result, MHPs frequently suffer from waterway problems. While the design of civil structures cannot be completely standardised as there are always topographical variations in the sites in which they are built, standard approaches able to deal with site-specific conditions can be developed. The ideal layout of a scheme will select appropriate sites for civil structures. Since civil structures are interdependent, civil design is an iterative process.

Site selection and layout, overall stability issues and the design of civil structures are described in detail in the "Civil Works Guidelines for Micro-Hydropower in Nepal" prepared by BPC Hydro-consult and Practical Action and accompanied by a Microhydro Civil Design spreadsheet programme. For this reason, only the guiding principles are discussed below.

3.1.1 Intake

The first criterion in selecting an intake is to ensure that the site conditions allow for the required quantity of water to be withdrawn from the river and channelled into the waterways of the MHP with minimal structural intervention during the low-flow season. The second criterion is to ensure that excess flow into the intake can be limited during the high-flow season.

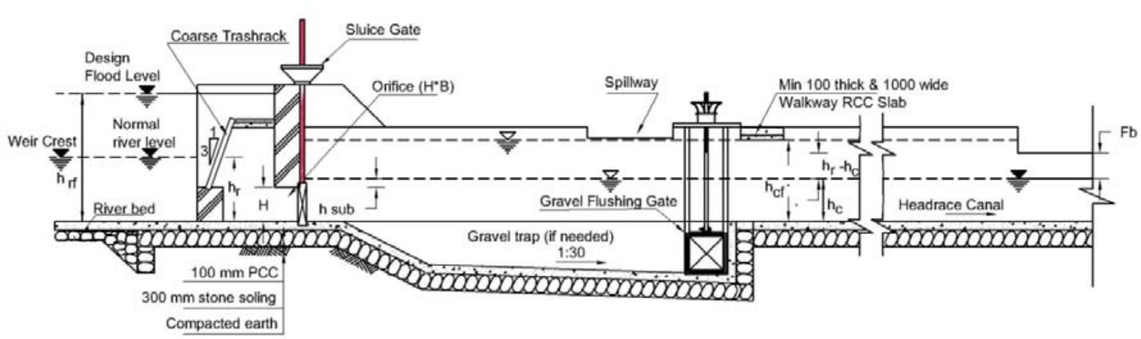


Figure 3.1: Cross-sectional view of the intake area

If the intake has to be located at a river bend, it must be in a stable area, and it should be at the outer bend to limit sediment deposition and to ensure flow availability during the dry season. Rock out-crops or large boulders that offer natural protection to the intake structure should be taken advantage of.

Poor design and/or location will limit the output and effectiveness of a micro-hydro project. Remedial work to correct poor initial design may cost far more than the extra cost of ensuring a good design in the first place. Further considerations for the design of the intake are as follows:

1. The intake should be sized to accommodate flows of 10–20% over the design flow so that the water levels in the sand trap and forebay are always sufficient. Note that in case of multipurpose projects that need to accommodate additional flows for secondary uses (e.g., irrigation flows), the intake should be sized accordingly.

2. The intake should be a rectangular orifice if site conditions permit as this type of intake, when appropriately sized, both allows the design flow into the waterways but also limits excess flow during floods. The intake orifice should be fully submerged during the dry season in order to provide the full design flow. The spreadsheet programme will help the designer check the orifice size for various design flow conditions.

3. In rivers that do not have significant floods or where the site conditions do not permit the placing of an orifice (e.g. high flood walls are required), extending the headrace canal is another option.

4. A bottom intake may be selected where there is no significant sediment movement along the river bed, the longitudinal river slope is relatively steep (e.g. at least 1:10), and excess flow is available for flushing even during the dry season. The spreadsheet programme will help the designer check the various parameters of the bottom intake.

5. Regardless of the type of intake chosen, a coarse trash rack should be placed at the intake mouth to prevent floating logs and boulders from entering the headrace canal. The bars in the trash rack should be spaced should be such that any gravel that enters the system can be transported by the headrace to the downstream flushing structure, such as a gravel trap.

6. A control/sluice gate should be provided at the intake so that the system can be easily closed for repair and maintenance as and when required. The control gate placed at the intake should be protected from damage by floods and boulders. Stop logs can be used in pico-hydro projects.

7. A first spillway should be provided as close as possible to the intake so that excess flows can be diverted away from the system as early as possible.

3.1.2 Weir

A diversion weir may be required at the intake to divert adequate flow towards the intake during the low-flow season but it adequate flow is available without it, a weir is not essential.

As a weir receives the direct impact of a flood, it is the most vulnerable civil structure in an MHP. The first choice of the designer should be a permanent structure, but depending on the site condition and other circumstances the designer can choose a semi-permanent (gabion structure, the most commonly used these days) or even a temporary structure.

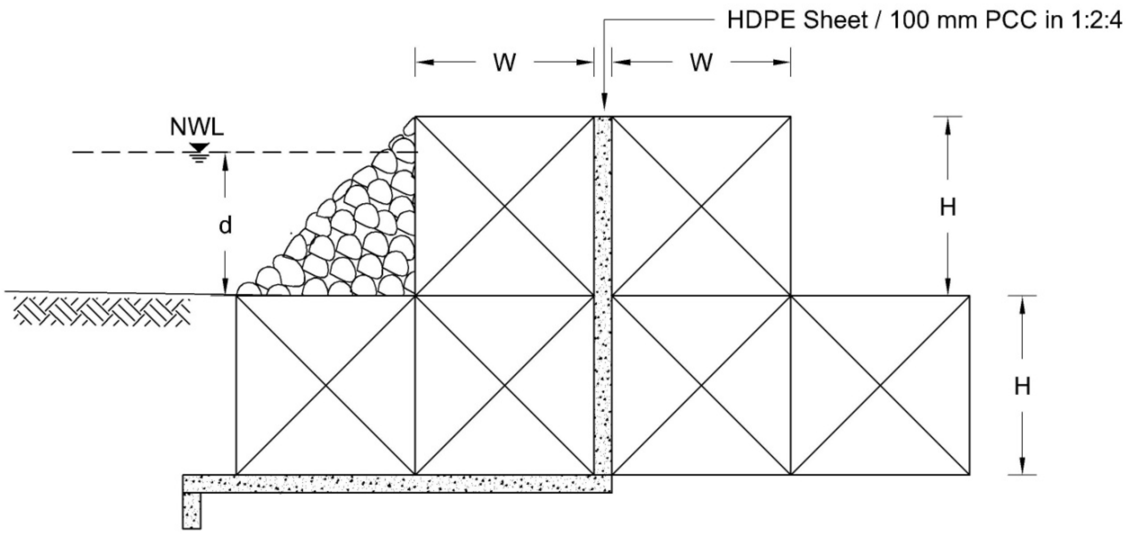


Figure 3.2 (A): Cross-sectional view of a gabion weir

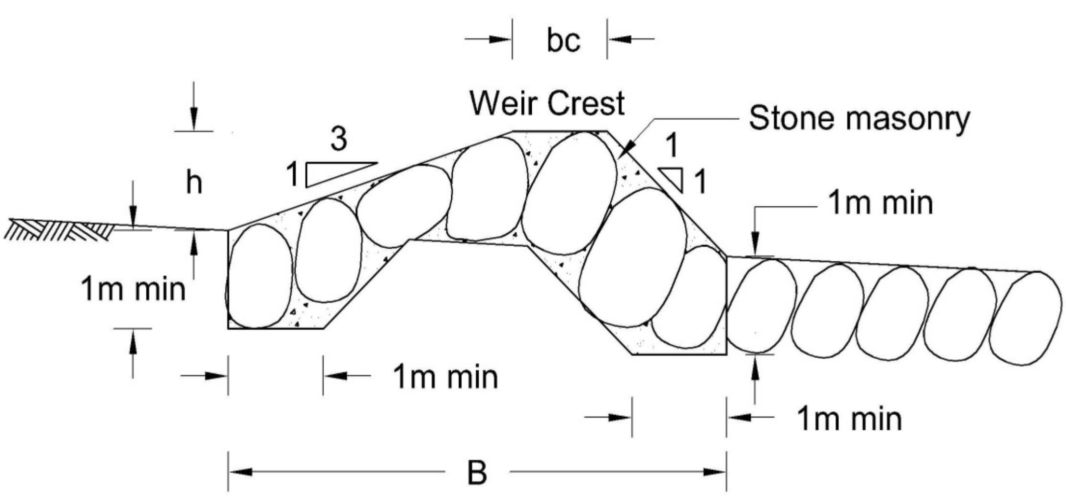


Figure 3.2 (B): Cross-sectional view of stone masonry weir

The length the weir projects into a river should be kept to a minimum. Unless it is essential to ensure flow adequacy, the entire river should not be obstructed. Other considerations regarding the design of a weir are as follows:

1. The height of the weir should be such that the water level rises above the upper edge of the intake mouth. In the case of an orifice intake, the weir height should be such that the orifice is always submerged during the dry season.

2. The weir profile should allow the bed load to move and boulders to roll over it.

3. A permanent weir should be designed so it will not overturn, lift or slide during high flows and floods.

3.1.3 Headrace

Based on the topography and site conditions either an open canal or low-pressure pipes (or combination of these) should be used as the headrace. The first choice for a headrace is an open canal as it is generally more cost-effective than other options. Pipes should be used at crossings, where the ground is unstable and/or steep, and at other locations where open canals are not possible. Further considerations for the design of the headrace are as follows:

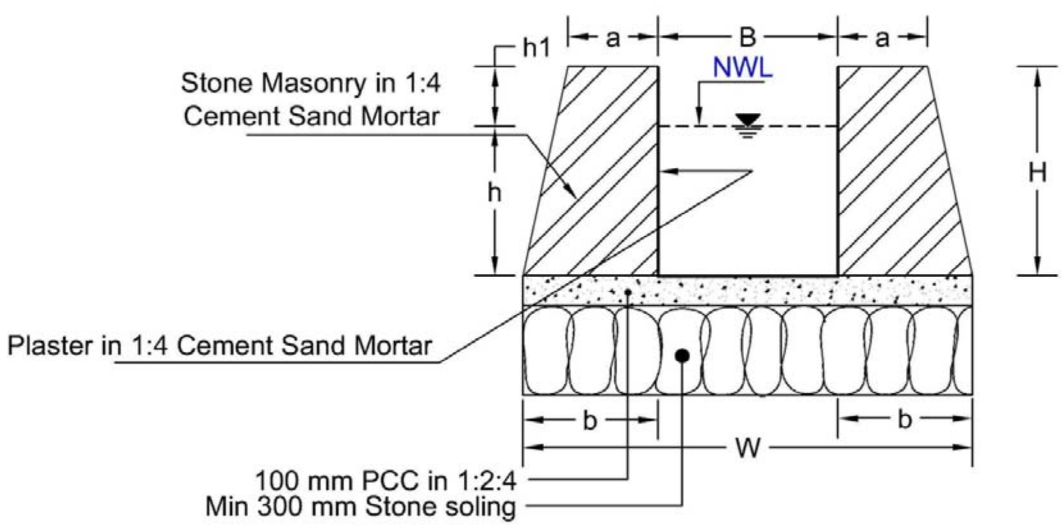


Figure 3.3: Headrace canal section

1. The flow velocities in both open canals and pipes should be sufficient to carry gravel and sediments to the gravel trap and the settling basin respectively. Particles should not be trapped along the headrace alignment. To minimise sediment deposition, the velocity in the headrace between the settling basin and the forebay, should not be less than 0.3 m/s.

2. Excessive velocity should also be avoided, as it causes canal walls to erode.

3. Unlined (earthen) canal may be used only along stable headrace alignments with design flows of less than 30 l/s. For larger flows, lined headrace canals should be used. They should be constructed with stone masonry with a cement-sand mortar ratio of 1:4 (1:4 c/s mortar). The insides of the canal should be plastered with the same mortar ratio along with punning. As a reinforced concrete canal is expensive, it should be used only along a short stretch of the alignment such as at crossings or where there is limited ground movement.

4. Spillways and escapes should be provided along the headrace canal alignment upstream of locations where it is likely to be blocked (e.g. where slides and rock falls occur) or if uphill runoff is likely to augment flow.

5. A minimum freeboard of 300 mm or half of the water depth (d/2) during design flow, whichever is lower, should be provided for headrace canals.

6. If HDPE or similar quality headrace pipes are used, they should be either buried or covered to a minimum depth of 1 m for safety reasons and protection against thermal and ultraviolet degradation.

7. The headrace of a multipurpose project that needs to accommodate additional flows for its secondary uses should be sized accordingly.

3.1.4 Crossings

Crossings are structures that convey flow over streams and gullies or other unstable terrain subject to landslide and erosion. Crossings generally occur along canal and penstock alignments. Depending upon their length and nature, different types of structure are suitable. Pipe crossings (MS pipe for short distances and HDPE pipe with catenary wire for longer ones), culverts, causeways, and siphons are some examples of crossing structure. Whatever the structure is, it should be safe and economic and able to convey the design discharge.

3.1.5 Gravel Trap and Settling Basin

A settling basin is essential for all MHPs since every river carries some sediment and all sediment is detrimental to turbines. A gravel trap needs to be incorporated only if the river carries significant gravel during the monsoon season. The following criteria should be considered in the site selection and design of these structures.

3.1.6 Gravel Trap

1. The structure should be located in a safe place but as close to the intake as possible so that gravel is not carried for a long distance.

2. Since the size of the gravel trap should be sufficient to settle any gravel that enters into the intake, the spacing of the bars of the coarse trash rack should be considered while sizing it.

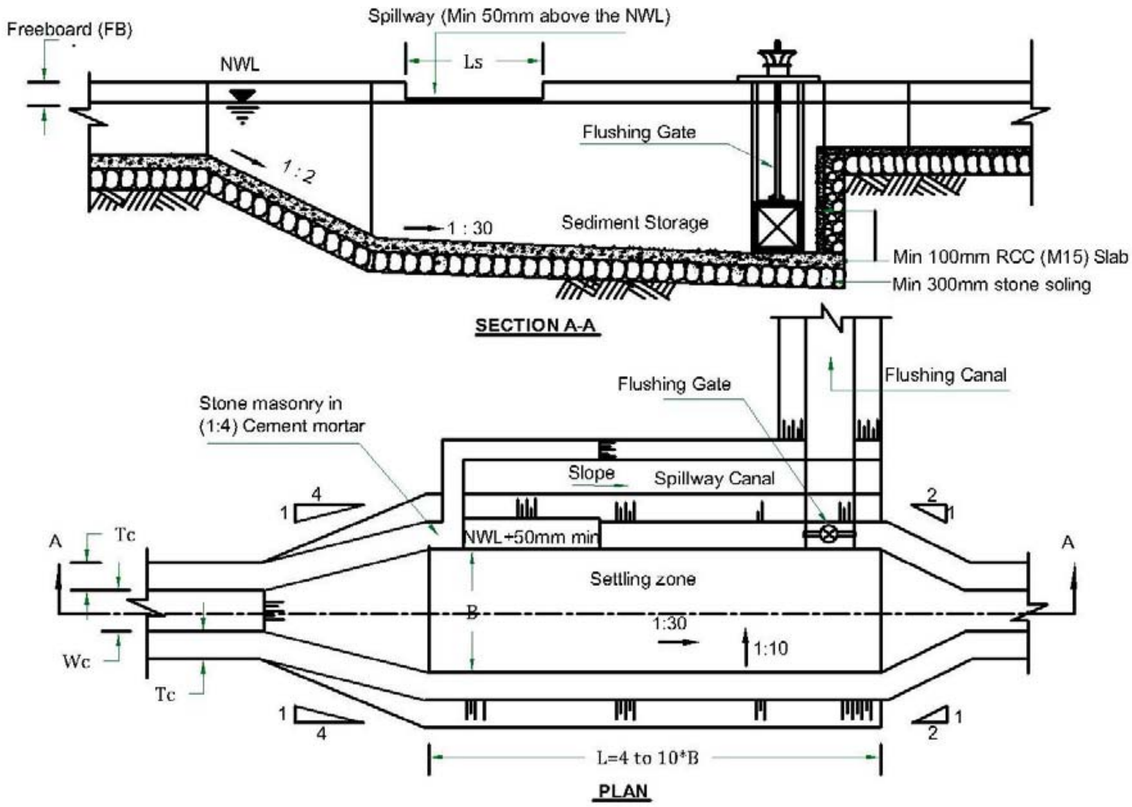


Figure 3.4: Plan and cross-section of a gravel trap

3. The longitudinal bed slope of a gravel trap should not be less than 1:30 for lateral intakes and 1:20 for streambed intakes. The bed of the gravel trap should have a trough-like shape in order to facilitate sediment flushing. A sill at the end of the gravel trap should be used to prevent sand from being washed into the headrace canal/pipe.

4. A flushing arrangement should be provided to flush out gravel deposited in the gravel trap.

5. A spillway should be incorporated and sized to spill either the design flow or the flood flow that enters the system, depending on whether there are other spillways upstream.

6. The overflow and flushing exits should lead back to the river without undermining the foundations of the headrace or the gravel trap or causing ground erosion.

The gravel trap should have walls of RCC or 1:4 c/s mortar masonry and an RCC base slab in order to reduce the problem of partial settlement. The water-retaining surfaces of the gravel trap should be plastered to 12 mm thickness using 1:4 c/s mortar with punning.

3.1.7 *Settling Basin*

1. The settling basin should be located as close to the gravel trap as possible. Where there is adequate space, it should be combined with the gravel trap to minimise costs.

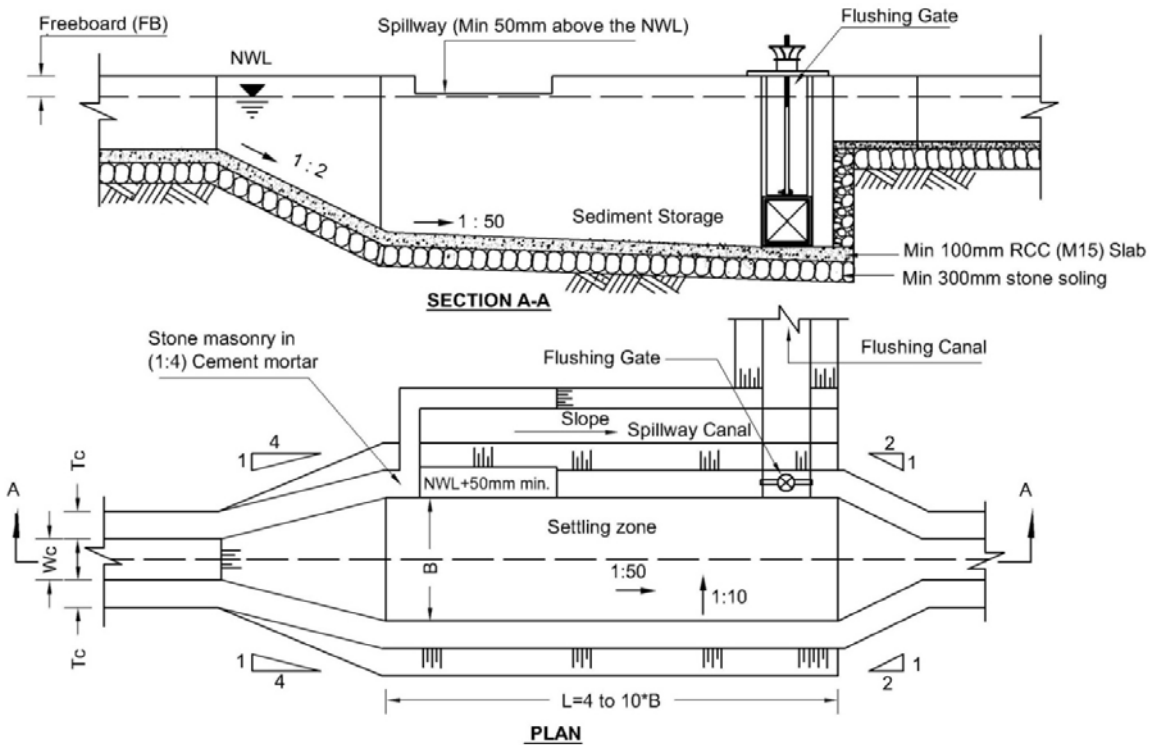


Figure 3.5: Plan and section of a settling basin

2. A net head of less than 10 m should have a settling basin sized to settle particles 0.3–0.5 mm in diameter. For a 10–100 m net head, 90% of particles 0.3 mm or greater should settle in the basin. For heads in excess of 100 m, 90% of particles up to 0.2 mm should settle.
3. The inlet zone of the settling basin should be expanded gradually as it meets the settling zone so that flow in the settling basin is evenly distributed. An expansion ratio of 1:5 is recommended or a weir may be incorporated. The contraction towards the outlet zone may be shorter, i.e., a 1:2 ratio.
4. The straight length-to-width (aspect) ratio of the settling zone should be 1:4-10. A longitudinal divide wall may be incorporated to improve the aspect ratio.
5. The storage volume of the basin should be adequate to flush high sediment loads twice a day (a 12-hour sediment storage capacity).
6. Flushing arrangement should be provided to flush the sediment deposited in the basin. The flushing arrangement should be such that when the flushing gate or cone is fully opened, the water level in the basin should decrease even with the incoming design flow (i.e. rapid draw-down).

7. If flood or excess flows can reach the settling basin, such as may be the case when the sand trap is combined with the gravel trap, a spillway should be incorporated and sized adequately.
8. The overflow and flushing exits should be led back to the river without undermining the foundations of the headrace and the settling basin or causing ground erosion.

The sand trap should have walls of RCC or 1:4 c/s mortar masonry and an RCC base slab in order to reduce the problem of partial settlement. The water-retaining surfaces of the sand trap should be plastered to 12 mm thickness using 1:4 c/s mortar with punning.

3.1.8 Forebay

The forebay is a basin at the end of the headrace which allows for the transition from open-channel to pressure-flow conditions. The following criteria should be considered in its design:

1. For a short headrace alignment up to 100 m where there is no sediment inflow from outside, the forebay and settling basin can be combined. For long headrace alignment, the forebay should be sized to allow for the secondary settlement of particles.
2. The penstock should be placed so there is adequate submergence depth to convey the design flow without causing a vortex (air entrainment).
3. As far as practicable, the size of the forebay should be such that the active volume above the penstock pipe is adequate to store 15 seconds of design flow without spilling.
4. A 300 mm freeboard should be provided.

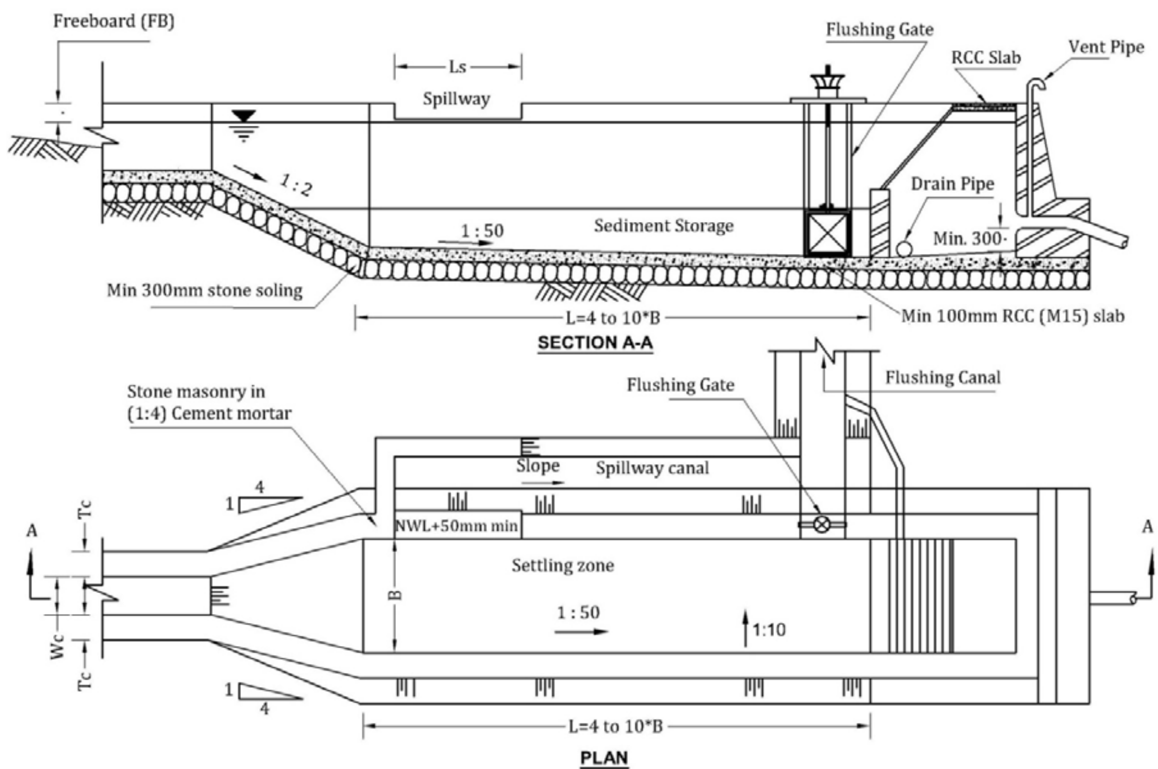


Figure 3.6: Plan and section of a forebay

5. A drain pipe should be incorporated so that the forebay tank can be fully emptied for maintenance work, especially if it is not possible to do so from the penstock pipe.

6. Flushing arrangement should be provided to flush the sediment deposited in the basin. The flushing arrangement should be such that when the flushing gate or cone is fully opened, the water level in the basin should decrease even with the incoming design flow (i.e. rapid draw-down).

7. A spillway should be incorporated and sized to spill the design flow (or flood flow if the system conveys flood flows to this point) without undermining structures or causing ground erosion along its route. This is essential since when the turbine is suddenly shut down and flow through the penstock is stopped, the flow will spill over from the forebay.

8. A fine trash rack should be provided at the entrance of the penstock. The trash rack should be laid at a vertical-horizontal slope of 3:1 slope for optimum hydraulic efficiency and ease of operation. The velocity through the trash rack should be 0.6–1.0 m/s.

The forebay should have walls of RCC or 1:4 c/s mortar masonry and an RCC base slab in order to reduce the problem of partial settlement. The water-retaining surfaces of the forebay should be plastered to 12 mm thickness using 1:4 c/s mortar with punning.

In case of multipurpose projects that need to accommodate additional flows for secondary uses till the forebay, this structure should be sized accordingly. However, if possible, additional flows for secondary uses should be diverted upstream of the forebay or settling basin so that the size of these structures need not be increased.

3.1.9 Support Piers

Support piers are short columns that support the exposed lengths of penstock pipes so that they do not sag due their own weight and that of the water they transport. The piers should allow movement parallel to the penstock alignment to accommodate thermal expansion and contraction but restrict vertical and sideways movement of the pipe. The following criteria should be considered in the design of these structures:

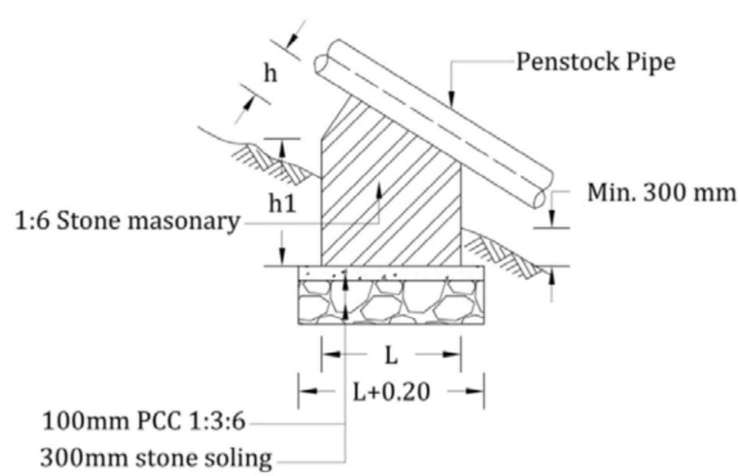


Figure 3.7: Support pier

1. Support piers should be designed to prevent overturning, sliding and sinking.

2. A minimum foundation depth of 300 mm should be provided. Similarly, a minimum ground clearance of 300 mm should be provided in order to reduce the corrosive effect due to soil contact.

3. Friction against the pipe and piers, which causes pipe wear, should be mitigated by, for example, placing a metal plate on top of the support pier and then a durable HDPE sheet on the plate.

4. The spacing of the support piers will depend on the pipe diameter, thickness, and quality of steel (see Table A1-1 in Appendix A).

5. A base plate designed at 120° of the penstock diameter should be installed at the support piers. HDPE sheeting should be placed between the penstock pipe and base plate.

6. For a steep penstock alignment (i.e. a 1:2 horizontal-vertical ratio), a C-clamp should be incorporated to control the vertical and sideway movements of the penstock pipe and for ease of installation. These clamps should not be tightened to the penstock since this action restrains pipe movement due to temperature effects.

Support piers should generally be constructed of stone masonry with1:6 c/s mortar. Other types of piers such as steel structures may be considered if they can be justified technically (e.g. to accommodate ground movement) or their cost-effectiveness can be demonstrated.

3.1.10 Anchor blocks

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. An anchor block should also be provided immediately upstream of the powerhouse in order to minimize forces on turbine housing. 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:

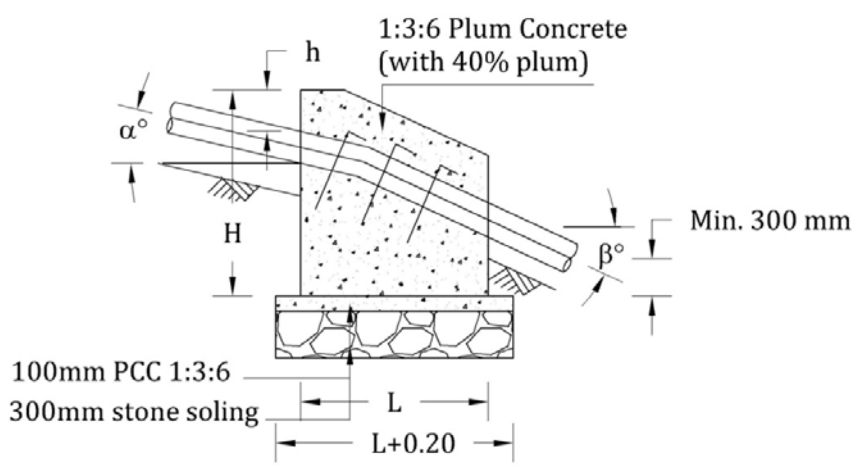


Figure 3.8: Anchor block

1. The foundation should be adequate to accommodate the bearing pressure due to the block and associated forces.
2. Anchor blocks should be designed to prevent overturning and sliding.
3. A minimum foundation depth of 300 mm should be provided. Similarly, a minimum ground clearance of 300 mm should be provided in order to reduce the corrosive effect of soil contact.
4. For installed capacities larger than 20 kW or a gross head higher than 60 m, detailed calculations accounting for the surge head should be included in the design of individual blocks. The "Civil Works Guidelines" should be referred to for a detailed design and rules of thumb for the sizing of anchor blocks.
5. Where site conditions allow, the first anchor block should be combined with the forebay.

3.1.11 Powerhouse

The main purpose of the powerhouse building is to protect electro-mechanical equipment from adverse weather, allow for easy access for operations, and prevent mishandling of the equipment by unauthorised persons. The following factors should be considered in the design and sizing of the powerhouse:

1. The structure should be waterproof so that rainfall cannot damage equipment.
2. Adequate lighting and ventilation should be provided.
3. It should be spacious enough to easily access all equipment. If agro-processing units are to be installed in the powerhouse, the space should accommodate not just them but also a number of consumers and their grain.
4. An operator's room should be provided in the powerhouse.

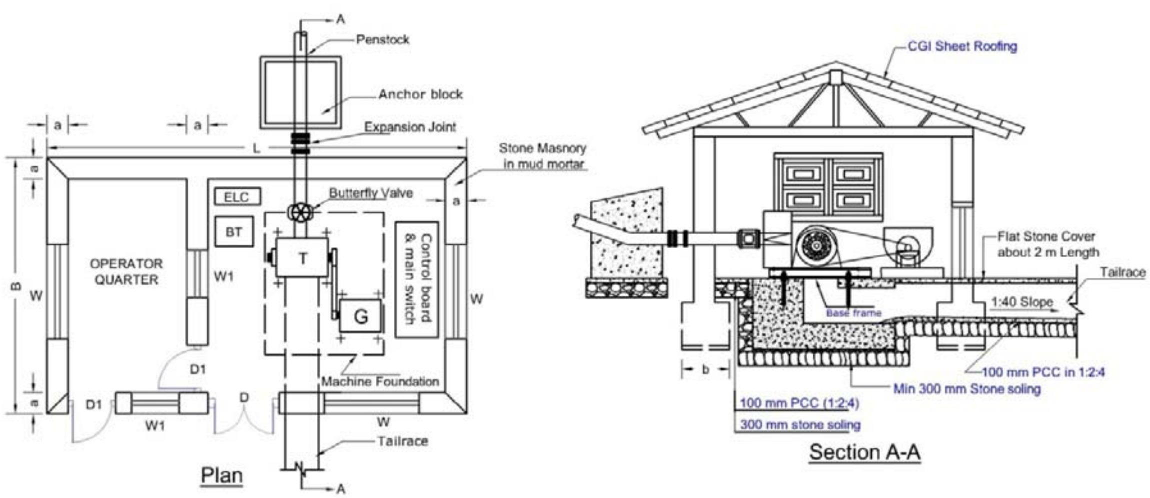


Figure 3.9: Powerhouse

3.1.12 Machine Foundation

The machine foundation of an MHP is a gravity structure designed to transfer hydraulic forces from the penstock, torque from rotating machines and gravity loads from the generator, the turbines and the foundation itself.

1. The machine foundation should be stable enough to prevent overturning, sliding and sinking/bearing. It should be of the standard dimensions recommended by suppliers.
2. The critical plane of a machine foundation depends on the turbine axis and coupling types. The turbine axis (shaft) is perpendicular to the incoming flow for cross-flow, pelton and spiral Francis turbines and parallel to the incoming flow for open-flume Francis and other axial-flow turbines. The coupling type (direct or belt drive) also impacts the stability of the critical plane. The stability of both the turbine axis and the coupling type should be analysed.

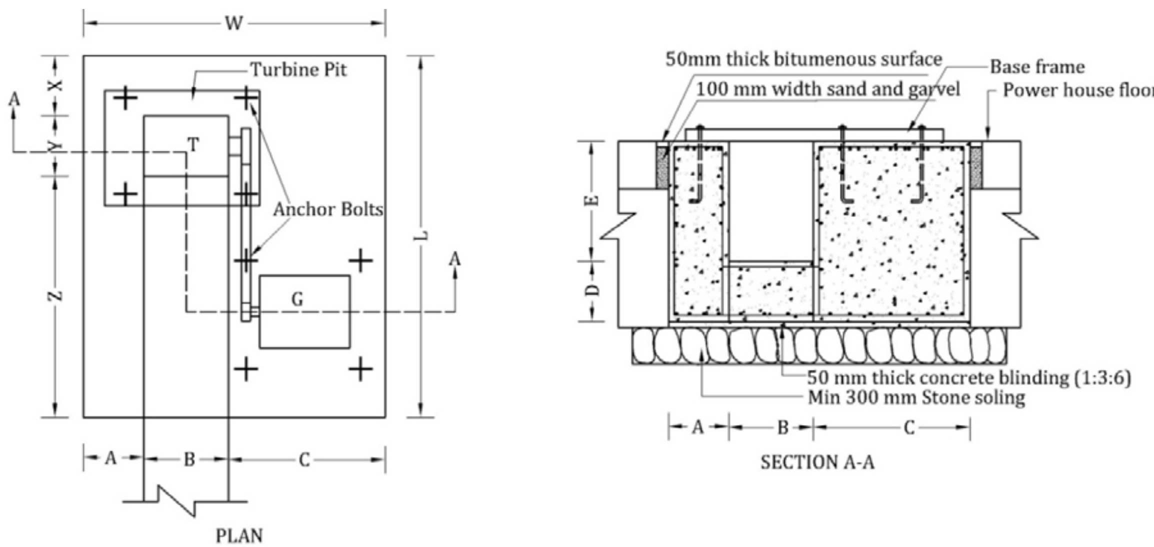


Figure 3.10: Machine foundation

Where,

A = at least 400 mm B= width of turbine C= length/breadth of generator base frame

E = at least 400 mm F= water level at tailrace at design discharge + min. 500 mm

F = Minimum distance of rod from outer wall (250 mm)

- A minimum of six anchor bars 20 mm in diameter and 700 mm long are to be used to fix the base frame to the machine foundation
- TOR steel bars 10 mm in diameter are to be used for reinforcement
- The maximum spacing should be 150 mm in the turbine pit and 200 mm for other faces. The lap length shall be at least 400 mm.
- The minimum reinforcement cover shall be 50 mm thick.
- The concrete shall be a 1:1.5:3 mix.

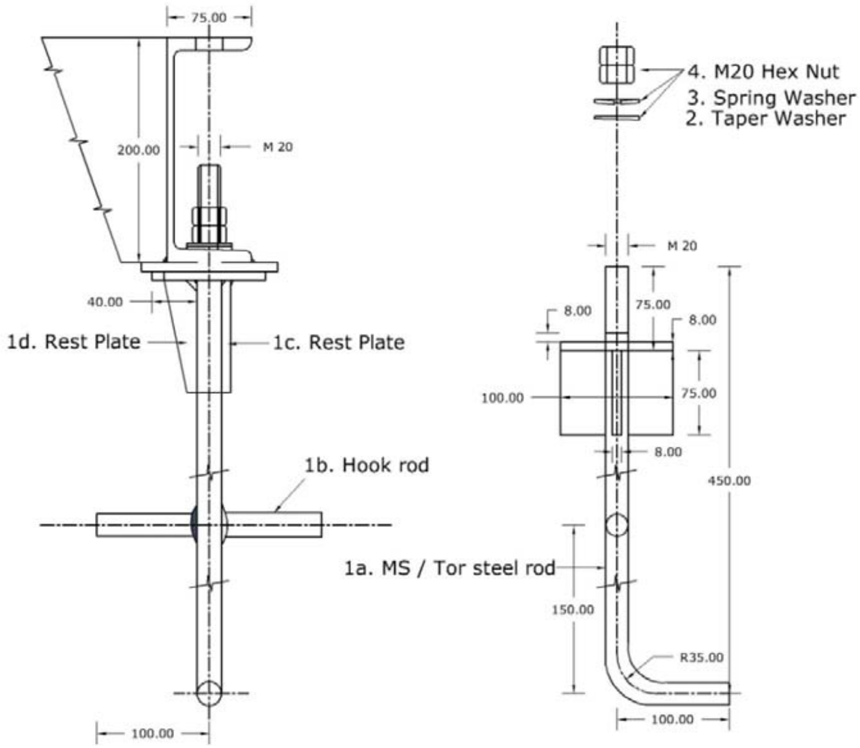


Figure 3.11: Sectional view of foundation bolt

For details about design process, refer to the “Civil Works Guidelines.”

3.1.13 Tailrace

Based on the topography of the site, either an open canal or a pipe should be used for the tailrace. The design considerations for the tailrace are similar to those for the headrace although the ground profile can be steeper. The tailrace should be able to divert flows from the turbines to the river (or nearby gully) without undermining the powerhouse foundation, the hill slope or the riverbank.

3.1.14 Stop Logs

Stop logs made of hardwood (e.g. sal) can be used as a control gate at intake for pico-hydro projects with design flows less than 50 l/s. The following criteria should be considered:

1. The minimum thickness of stop logs should be 50 mm.
2. The width of the stop-log groove should be equal to the plank thickness plus an extra 20 mm for clearance.
3. The minimum depth of the groove should be 80 mm.

3.2 Mechanical equipments

The trash rack, penstock pipe, turbine and power transmission systems are the major mechanical components of an MHP. The selection of mechanical components of appropriate type, size and material has significant effects on the power generation and durability of the scheme. Replacing poorly performing mechanical components is very costly so they should be selected carefully. This section gives some basic guidelines on their selection.

3.2.1 Trashrack

Trashracks are placed at an intake to prevent logs, boulders and other large waterborne objects from enter the waterways and at the forebay to prevent leaves, twigs and branches from entering the penstock. The following factors should be considered in designing and sizing a trashrack:

1. The trashrack should be fabricated from MS bars or plates. The coarse trashrack for an intake should be robust enough to withstand impacts from logs and boulders during the monsoon seasons.
2. The bars of the trashrack should be placed vertically (not horizontally) to facilitate raking.
3. Bars should be spaced as follows:

Intake: 50–150 mm, depending on the capacity of the initial headrace to carry gravel up to the gravel trap.

Forebay: Half the nozzle diameter for a pelton turbine and half the distance between the runner blades for a cross-flow turbine.

4. The velocity through the fine trashrack should be 0.6–1.0 m/s. For the coarse trashrack, the velocity is governed by the type of intake structure (e.g., concrete, stone masonry, etc.) and not the spacing between the bars, which does not cause significant flow obstruction.

5. Each section of the trashrack should be limited to 60 kg for transportability. If the total weight exceeds 60 kg, the trash rack should be fabricated in two or more sections.

3.2.2 Penstock Pipe

The penstock pipe conveys water under pressure from the forebay to the turbine. MS and HDPE pipes are widely used as penstocks in Nepal. The penstock alignment should be chosen so that a significant head can be gained in a short distance so that it is still possible to lay the penstock and build support and anchor blocks on the ground. The number of bends on the alignment should be kept to a minimum so that the number of anchor blocks and the head

loss can both be minimized. For and exposed (i.e., aboveground) penstock alignment, a clearance of 300 mm between the pipe and the ground should be provided in order to facilitate maintenance and minimize corrosive effects.

The selection of the diameter should be based on the following considerations:

1. Select the initial diameter based on the following empirical equation:

   $$D = 41 \times Q^{0.38}$$

   Where,

   D = Internal diameter of pipe in mm

   Q = Design flow in l/s

   Note that this equation gives a conservative diameter for pipe lengths less than 100 m.

2. Then check for head loss in the pipe. The total head loss should be limited to 5–10% of the gross head. For HDPE pipes, the nearest available larger diameter should be chosen.
3. Various iterations should be performed so that the head loss is limited to 5–10% and the diameter is neither over- nor under-sized.

The thickness of the penstock pipe depends on the pipe material, the fabrication method used and the type of turbine installed. For a detailed description of the selection of pipe thickness, the “Civil Works Guidelines” should be referred to.

Table 3.2: Standard length and diameter of penstock pipes

SN	Inside Diameter (mm)	Type of Pipe	Available Size
1	OD- 2*thickness	Ready-made	Outer diameter: 114, 140, 165, 193 & 219 mm Thickness: See table in Appendix A Length: 6 m
2	175	Sheet-rolled	Size: 1220 mm x 2240 mm Thickness: 3, 3.5, 4, & 4.5 mm
3	200		
4	.....		

Note:

- Sheet-rolled pipe may also be used for making pipe smaller than 175 mm in diameter.
- The diameter of a sheet-rolled pipe should be a multiple of 25 mm.
- To facilitate manual transportation each section of penstock pipe shall be 3 m for ready-made and 2.4 m for sheet-rolled pipe.

Table 3.3: Standard flange dimensions

S.N.	Penstock Diameter (mm)	Thickness (mm)	Width (mm)
1	Up to 400	10	50
2	More than 400	16	60-65

- Flat gaskets 6 mm thick or 'O' rings 10 mm in diameter should be used in between flanges
- For bend pipes, the bend angle should be 9-12°# from the centre of the bend

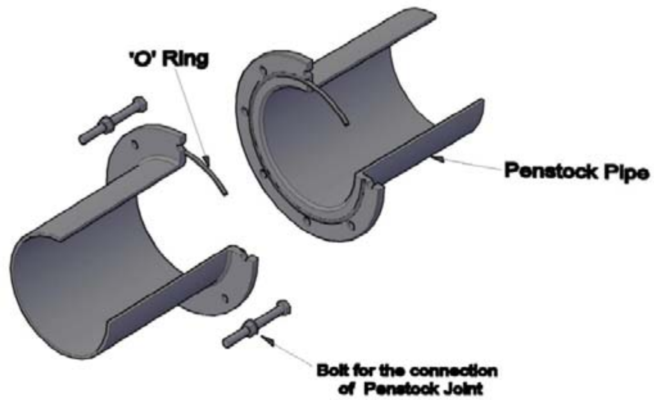


Figure 3.12: Flange connection of penstock pipe

Note that if HDPE pipes are used as penstock pipes, they should be buried to a minimum depth of 1 m. If MS pipes are used, they should also be buried to a minimum depth of 1 m but only after corrosion-protection measures such as painting them with high-quality bituminous paints are taken. Since the risk of leakage is high, flange-connected penstocks should not be placed underground.

3.2.3 Expansion Joints

The exposed sections of penstock pipes are subject to temperature changes (heating and cooling causes the pipes to expand and contract, thereby creating stress as the penstock pipes are rigidly fixed at both ends by the anchor blocks. Expansion joints are essential for accommodating such pipe movement. One joint should be located downstream of the forebay as well as downstream of every anchor block along exposed sections. Joints are not needed for buried sections as temperature differences are not significant.

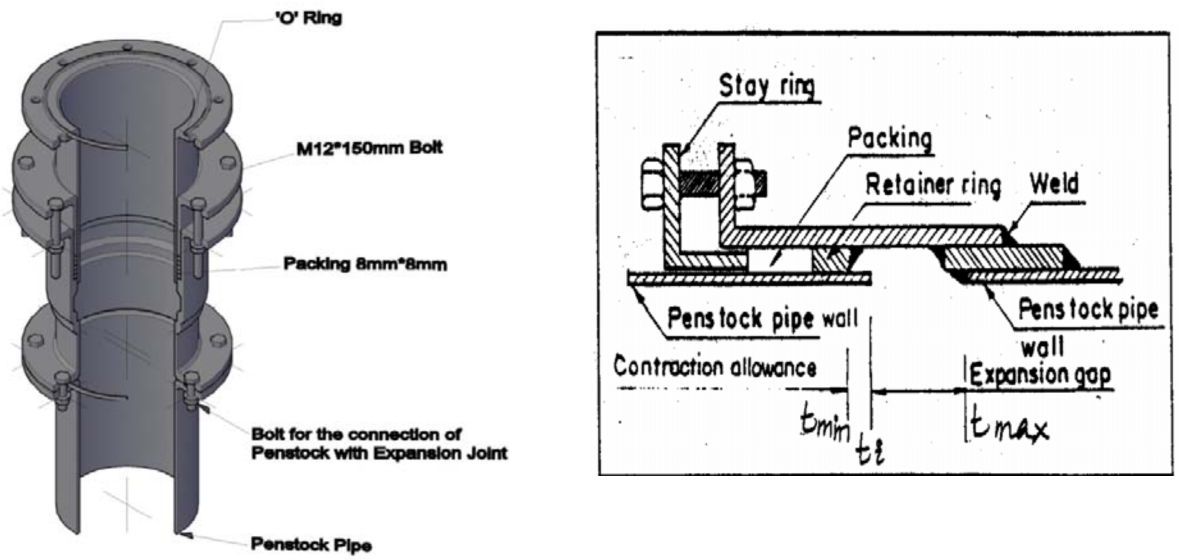


Figure 3.13: Sectional view of expansion joint

For flange-connected penstocks, if the distance between the last anchor block and the machine foundation is less than 10 m, there is no need for an expansion joint because the changes in pipe size can be accommodated by the gaskets between the flanges. However, a joint can be installed if installing it facilitates the installation of the turbine. Alternatively, a mechanical coupling can be used between the anchor block and turbine to facilitate turbine maintenance. The expansion joint or mechanical coupling between the last anchor block and the machine foundation should be placed outside the powerhouse.

3.2.4 Valves

Valves are used to stop or regulate the flow of water in penstock pipes and nozzles. Because they are costly and may fail, the fewest possible number should be installed. The following factors should be considered while locating and selecting valves:

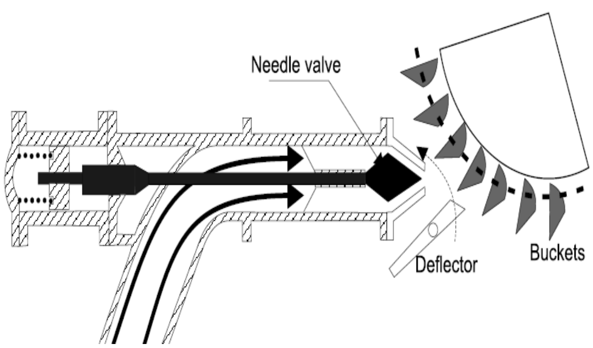
1. Emptying the flow in the penstock without letting in air causes negative pressure inside and a pipe may even collapse. Such a condition can occur if a gate is placed at the entrance of the penstock and it is closed suddenly or if the trashrack becomes blocked very quickly, thereby obstructing flow into the pipe. To introduce air during such conditions, an air vent should be installed within 1 m length from the start of the penstock pipe.
2. A stop valve should be placed at the turbine inlet or manifold. A gear-operated butterfly valve is recommended.
3. Spear valves should be used to regulate flow to a pelton turbine, but they should not be as stop valves. Instead, a separate stop valve should be installed.
4. Valves made from bronze or brass are preferred but cast iron may be used as an alternative.

3.2.5 Turbines

Cross-flow and pelton turbines are the most commonly used turbines in MHPs. The size and type of a turbine 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-low head schemes. In certain head and flow ranges both types may be appropriate, so the choice should be based on availability, efficiency and cost. A head of less 6 m may result in the need for large turbines diameters to generate more than 15 kW of power and thereby may not be financially feasible.

A pelton turbine with a horizontal shaft should have no more than two jets to manufacture. While a pelton turbine with a vertical shaft can have more than two jets, such turbines require more precision work both in mounting the generator vertically on the turbine shaft and, in the case of different rotational speeds of the turbine and the generator, the belt drives (including those for mechanically coupled end uses) will be difficult to arrange.

The capacity of a turbine should not exceed the rated capacity of a plant for generator protection. Its valve of the turbine should be adjusted with a mechanical stopper to ensure that it produces the rated power output.



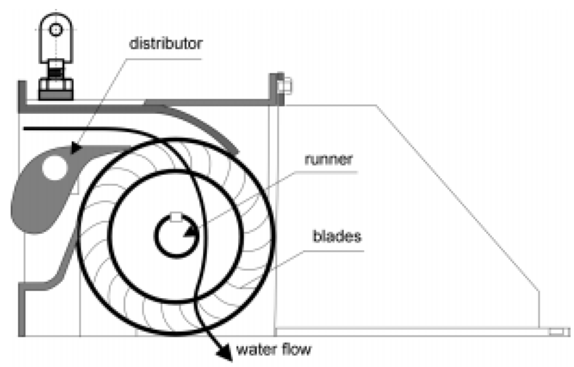


Figure 3.14: Parts of a pelton turbine

3.2.6 Selection of Turbine Type

Pelton, cross-flow or Francis turbines are those used in MHPs. Other options shall only be used if they are cost-effective, not available in Nepal and proven in Nepalese context. General Guidelines for selecting micro and mini hydropower turbines are presented in Table 2.4 below.

Table 2.4: Turbine Selection Criteria

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

Pelton Turbine

A pelton turbine has one or more nozzles, each of which discharge jets of water which hit a series of buckets mounted on the periphery of a circular disc. It converts the kinetic energy of a jet of water into the angular rotation of the buckets it strikes.

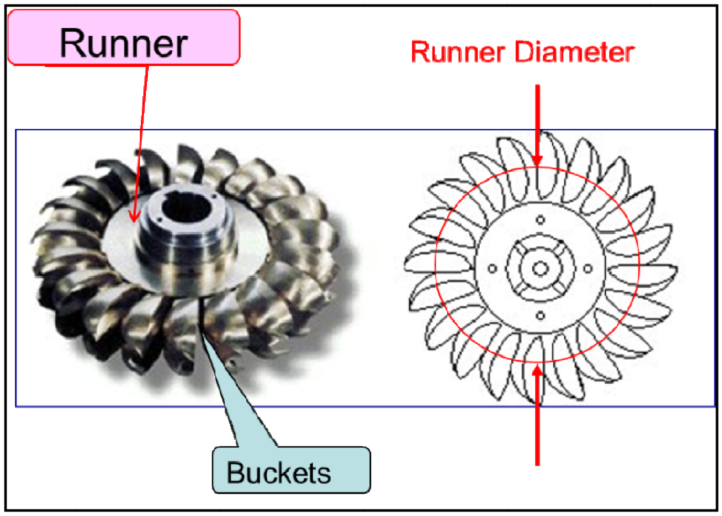


Figure 3.15: Pelton bucket

Sizing of Pelton Turbines

- Jet Velocity (vjet) m/s

$$v_{jet} = Cd \ x \sqrt{2 * g * H_{net}} \ ,$$

Where, Cd = 0.96, Z

H_{net} = net head.

- Nozzle diameter $d_{jet} = 0.54 \ x \ \frac{\sqrt{Q}}{H_{net}^{0.25}} \ x \ \frac{1}{\sqrt{N_{jet}}}$ *1000

Where,

Q = discharge per turbine and N_{jet} = number of jets per turbine.

- Pitch circle diameter (PCD) mm (Available 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 = coefficient of discharge.

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

Cross-flow Turbine

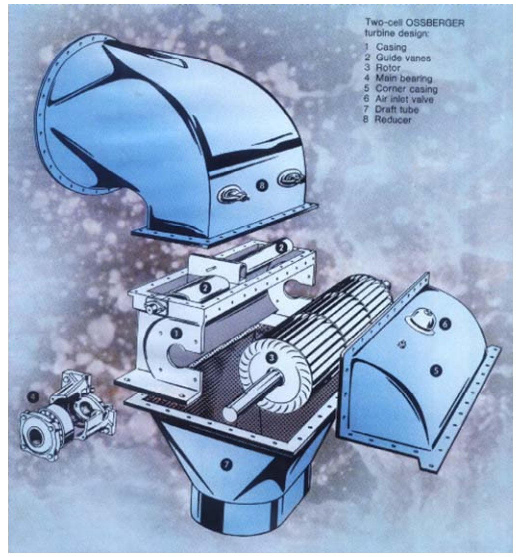


Figure 3.16: Parts of Cross flow Turbine

A cross-flow turbine has a 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.

Sizing of T15 Cross-flow Turbines

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

  Available D_{runner} = 300 mm

- Jet thickness t_{jet}= 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 turbine is a reaction turbine suitable for high-flow low to medium head schemes. Francis turbines are sophisticated although it has high efficiency over a wider range of flows.

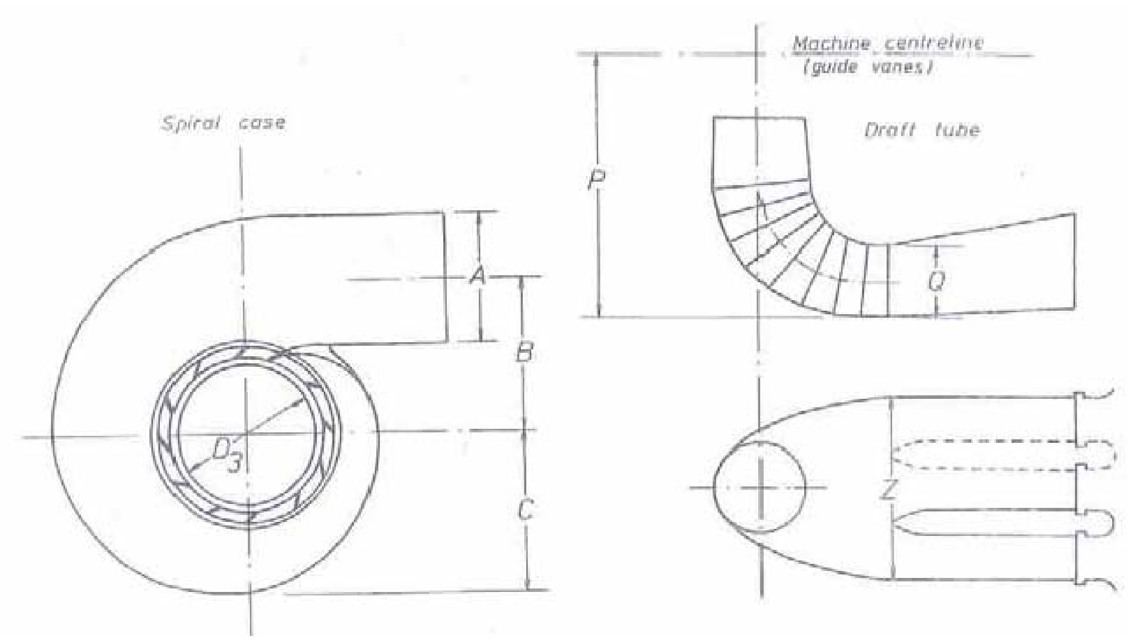


Figure 3.17: Parts of francis turbine

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

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 below.

Table 3.3: Turbine specifications

Type	Capacity (kW)	Efficiency (η_t)	Net head (m)	Max. RPM
Pelton	10 – 50	70 - 75%	More than 50 m	1500
	50 –100	75 - 80 %		
T12 cross- flow	10 – 50	60 - 72%	Up to 50 m	900
	50 – 100	65 - 72%		
T15 cross- flow	10 – 50	60 - 75%	Up to 80m	1500
	50 – 100	70 - 78%		
Francis	–	80 – 85 %	More than 10 m	1500

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

$$n_s = 3.65 * n_{turb.} * \frac{Q^{0.5}}{H^{0.75}}$$

Where,

Q = Designed discharge (m^3/s)

H = Gross head (m)

n_{turb}= Speed of the turbine (RPM)

Table 3.4: Ranges of specific speeds (n_s in metric HP units) for different turbine types

Turbine	Minimum n_s	Maximum n_s
Kaplan	270	1000
Francis	60	350
Pelton	8	72
Cross-flow	42	170

Where there are overlaps between cross-flow and pelton turbines, preference should be given to pelton turbines as their efficiency (for both overall and partial loads) is higher. Note that in an exceptional case, the value of ns may exceed the range given above; in this case, two or more units are needed.

3.2.7 Drive System

The drive system comprises the generator shaft, turbine shaft, bearings, couplings, pulleys, belts and other components used to change the speed or orientation of the drive. The function of the drive system is to transmit power from the turbine to the generator shaft in the required direction and at the required speed. The following factors should be considered while selecting the drive system:

3.2.7.1 Direct Coupled Drive System

- Preference should be given to direct coupling as it is compact and simple and efficiency approaches 98.5 to 99%.

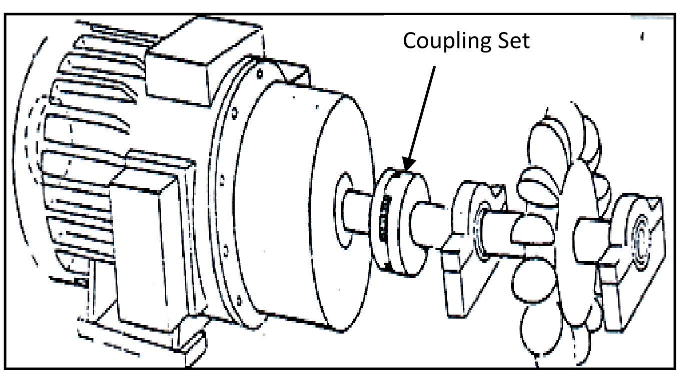


Figure 3.18: Direct coupling system

- Both the turbine and the generator should be bolted to concrete foundation and necessary arrangements should be made to bring both shafts to the same height.
- The alignments of all shafts should be correct to prevent the failure of couplings or bearings.
- Flexible in-line coupling should be provided as shaft alignment is never perfect.

3.2.7.2 Pulley and Belt System

Flat Belt

- For plants with an installed capacity greater than 10 kW, high-quality, efficient synthetic flat belts should be used. (Only endless belts are acceptable; using leather as a fraction layer in combination with a synthetic belt is also acceptable.) The efficiency of a flat belt is approximately 98–98.5%.
- The shafts of the generator and the turbine must be parallel to each other.
- The generator should be mounted on slide rails to obtain enough belt tension.
- The direction of rotation should pull the lower part of the belt.

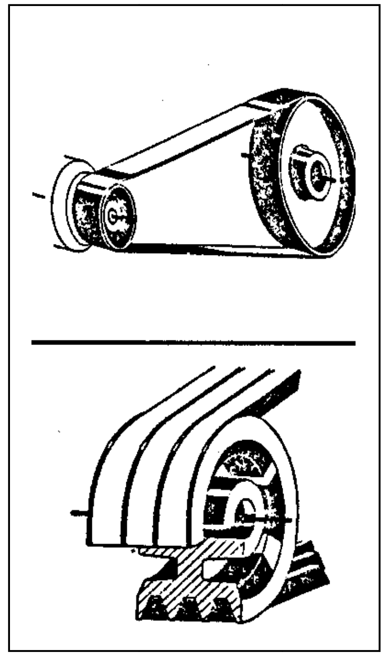


Figure 3.19: Flat belt with pulley

Wedge Belt

A wedge belt enables a belt to carry higher horsepower loads with minimum stretch, resulting in better stability. It gives superior flexibility and better traction, and is wear-resistant. The flexibility improves efficiency, as less energy is wasted in the internal friction caused by continually bending the belt. This gain in efficiency reduces the amount of heat generated and a cooler-running belt lasts longer. A wedge belt can be bent into concave paths by external idlers and can wrap any number of driven pulleys; it is limited only by its power capacity. The ability to bend the belt at the designer's whim allows it to take a complex or serpentine path. Wedge belts ensure uniform load transfer to cords, thereby preventing power loss and premature belt failure. Wedge belts can be used as an alternative for flat belts. The efficiency of a wedge belt is around 96%.

Figure 3.20: Wedge belt and pulley

V-Belts

- For plants with an installed capacity less 10 kW, V-belts are recommended. The efficiency of a V-belt is approximately 96%.
- The shafts of the generator and the turbine must be parallel to each other.
- The generator should be mounted on slide rails to obtain appropriate belt tension.
- The direction of rotation should pull the lower part of the belt.

Table 3.5: V-belt specifications

Belt cross-section	Power to be transmitted (kW)	Power to be transmitted (hp)	Recommended minimum pulley pitch dia. (mm)	Belt top width, W (mm)	Belt thickness, T (mm)
A	0.75 – 3.75	1 – 5	75	13	8
B	2 – 15	3 – 20	125	17	11
C	7.5 – 75	10 – 100	200	22	14
D	22.5 – 150	30 – 200	350	32	19

Source: Dunlop MAXRATE V-belt catalogue, India

Note: The distance required for the belts should be determined based on the size of the scheme and the RPM ratio in consultation with the manufacturer. This information is useful for the layout in the powerhouse.

3.3 Electrical components

Electrical systems are the most sensitive components of an MHP. They consist of the generator, control system, transmission system, distribution system, earthing, poles, and power limiting devices. Optimum power generation and the performance of a scheme depend upon the appropriate design and selection of electrical systems and components.

3.3.1 Generator

There are two types of generator: synchronous and induction (asynchronous). Induction generators are inexpensive and appropriate for small schemes. For large schemes, the induction generator is generally not used as it has problems supplying large inductive loads such as asynchronous motors, welding transformers and magnetic ballasts (choke). Synchronous generators are readily available in single-phase (e. g. up to 15-kVA) and three-phase generators. Induction generators, in contrast are not readily available as an off-the-shelf product in the Nepali market, so they need to be adapted from properly sized induction motors and the right excitation capacitors need to be connected.

An electronic load controller (ELC) is used to manage the power output of a synchronous generator such that the sum total of the village load and the ballast load always equals the power generated. To control an induction generator an induction generator controller (IGC) is used; it keeps the generated voltage constant. Conventional flow-control systems such as

electro-mechanical governors can also be used to control power output. The advantage of an electro-mechanical governor is that the discharge can be regulated, so additional flows are not wasted as they are in the case of both ELCs and IGCs). Governors are not commonly used in MHPs because of they are expensive and difficult to maintain.

- **Selection of Generator Size and Type**

Table below presents guidelines for the selection of the phase and type of generator.

Table 3.6: Phase and type of generator

Size of scheme	Up to 10 kW	Above 10 kW
Type of generator and phase	Synchronous or induction, single- or three-phase	Synchronous, three-phase only

Induction generators are generally less expensive and simpler than synchronous ones for low installed capacity. However, they are less reliable for starting motors as they cannot supply reactive power. Thus, if it is planned to use an MHP to power motors, a synchronous generator should be selected.

Factors affecting the size of a generator are temperature, altitude, the ELC correction factor and the power factor of the load. The de-rating coefficients used to allow for the above-mentioned factors are presented in Table 3.7.

Table 3.7: Generator-rating factors

SN	Max. Ambient Temperature (in °C)	20	25	30	35	40	45	50	55
A	Temperature Factor	1.10	1.08	1.06	1.03	1.00	0.96	0.92	0.88
	Altitudes	1000	1250	1500	1750	2000	2250	2500	2750
B	Altitude Factor	1.00	0.98	0.96	0.945	0.93	0.915	0.90	0.88
	Altitudes	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	ELC Correction Factor								0.83
D	Power Factor		When load is incandescent light bulbs only						1.0
			When load includes some CFL, tube lights, and other inductive loads						0.8

- **Sizing of an Synchronous Generator**

The stepwise procedure for selecting the size of a synchronous generator is as follows:

1 Use a power factor of 0.8 (assuming that the load includes tube lights and other inductive loads).

2 Use the appropriate values of the controller correction factor, altitude, and temperature factor in Table 3.7.

3 The size of the generator can be calculated from the formula below, where the factors A, B, C, D are found in Table 3.8.

$$\text{Generator kVA} = \frac{\text{Installed Capacity in kW}}{A \times B \times C \times D} \times \text{Safety Factor}$$

4 When the size of the generator is calculated using the above formula, a safety factor of 30% should be used (i.e. multiply the generator kVA calculated in step 3 by 1.3) to allow for these conditions:

a) The output of the turbine could be higher than expected.

b) If large motors (> 10% of generator size) are supplied by the generator, the generator should be able to handle the starting current.

c) The generator is always running at full load when using an ELC.

- **Sizing of an Induction Generator**

The stepwise procedure for selecting the size of an induction generator is as follows**:**

1) Use the values of the altitude and temperature factor found in Table 3.8.

2) The size of the generator can be calculated using the formula below, where the factors A and B are taken from Table 3.8.

$$\text{Induction Generator kW} = \frac{\text{Installed Capacity in kW}}{A \times B} \times \text{Safety Factor}$$

Note that in this case the ELC factor (C) and the power factor (D) are not required. Also it should be noted that the generator rating should not exceed 80% of the electrical motor rating (rated voltage and current).

3) As is the case with a synchronous generator, when the size of the induction generator is calculated using the above formula, a safety factor of 30% should be used.

- **Synchronous Generator Rotational Speed**

The rotational speed of a synchronous generator is determined using the following equation:

$$Rotational\ speed\ (in\ RPM) = \frac{120f}{P}$$

Where,

RPM is revolutions per minute

f is the frequency of the system in Hertz (Hz) which is 50 Hz for electrical systems in Asia and Europe.

P is the number of poles of the generator and is always even. In Nepal a four-pole generator is often used, a fact which results in a rotational speed of 1500 RPM. Two-pole generators are not used because of they require a lot of maintenance and produce less than optimum technical parameters. Six-pole generators (1000 RPM) are also eschewed because they are expensive.

- **Induction Generator Rotational Speed**

The rotational speed of an induction generator is determined using the following equation:

$$Rotational\ speed\ (in\ RPM) = \frac{120f}{P}(1+s)$$

Where,

P and f are as same as for a synchronous generator and

$$s = \frac{Ns - N}{Ns}$$

s is the slip of the generator

N_s is the synchronous speed, i.e. $Ns(in\ RPM) = \frac{120f}{P}$

N is the rated rotor speed of the induction motor. The value of N is given on the generator nameplate.

Note that the value of Ns always exceeds N (i.e., slip is always positive in the above equation)

- **Additional Generator Selection Guidelines**

Additional factors that should be considered while selecting generator size follow.

1. Only brushless self-excited self-regulated generators should be used for MHPs larger than 10 kW.
2. Use of a squirrel-cage induction generator should be limited to plants with an installed capacity less than 10 kW.
3. A compounding transformer-type voltage regulation system shall regulate the voltage to within a deviation of ± 5% from no to full load.
4. Generators fitted with electronic AVR must regulate the voltage to with a deviation of ± 2% from no to full load.
5. The single largest motor to be started in the system must not exceed 25% and 35% of plant capacity for induction synchronous generators respectively.
6. A soft-start or star-delta starter mechanism is recommended for motor loads exceeding 10 hp.

3.3.2 Powerhouse / Control System

Electrical installation in the powerhouse should display good workmanship and meet the standards presented below. As choices of devices and accessories in a powerhouse have significant cost implications, the guidelines below are comprehensive.

Cable Size

1. To ensure good connections, only copper cables should be used in the powerhouse.
2. Cables connecting various pieces of equipment should be double insulated for additional protection. Single-insulated cables can be used if they are inserted in pipes or conduits.
3. To accommodate vibrations, only multi-stranded cables should be connected to the generator.
4. If aluminum cable is used between the main switch and the first pole or transformer, cable shoes or reducer sockets should be used at the main switch.
5. The size of the neutral conductor from the generator to the IGC/ELC/ELC-extension should be equal to that of line conductors since the ELC introduces high neutral currents.
6. Cable shoes should be used at connection points in the powerhouse.
7. Cables used in the powerhouse should be the same at that of rated capacity of the generator.
8. Armored cables should be used for underground systems. PVC-insulated armoured cables may also be used for the underground system but should be limited to short distribution lines, service lines, overhead distribution box connections and in and around the powerhouse

Switch

1. To protect the system from a sustained overload or a fault in the distribution line, a metal clad main switch with high-rupturing capacity fuses should be installed.
2. The switchgear should comprise a moulded case circuit breaker (MCCB) or, for handling small currents, a miniature circuit breaker (MCB) for connecting and disconnecting the generator from the local grid. The breaking capacity in the case of a MCCB should not be less than 15 kA. In the case of a MCB it should not be less than 10 kA.
3. The powerhouse supply should have one TPN (three-phase plus neutral) MCB.

Monitoring

1. Devices to monitor the main current, generator voltage, frequency and ballast voltage should be installed. For plants above 10 kW, a kW power meter should also be installed.
2. One energy meter should be installed toward the village-load side. The energy meter should be as per the specification provided by AEPC.

Protection

1. Devices to protect against over- and under-voltage and over- and under-frequency should be installed in all plants with synchronous generators. For plants with capacities less than 10 kW, voltage protection is optional. An induction generator should be protected at least from over-voltage.
2. Overload protection at the powerhouse should be provided on all plants.

Control System (Ballast and ELC)

1. The controller ballast heater rating should be 20% higher than the plant capacity (in kW) in case of an ELC. However in the case of an ELC-extension, the thyristor rating shall be based on 60% of plant capacity. The thyristor-controlled ballast size shall be 60%*1.2 times the plant capacity and the fixed load (uncontrolled ballast) shall be 40% of the plant capacity.

2. Ballast heaters should be the resistive type and may either be immersion or space heaters or combination of both. Heaters must be safely earthed and protected against corrosion. Immersion heaters should be immersed in a separate MS tank.

3. The generator controller should regulate the frequency to within a deviation of ± 5%.

4. All cables should be protected by appropriately-sized HRC fuses (not Kit-Kat).

5. Installation of a float switch in the ballast tank to notify the operator is recommended.

3.3.3 Earthing

Because personal safety is the first priority in earthing issues, achieving equi-potential in dangerous zones is more important than achieving low earth resistances. Suitable means of ensuring safety include equi-potential loops and meshed earthing system. The installation of equi-potential loops around individual houses in the community is also recommended.

Where safe and reliable equi-potential bonding exists for a group of houses with meshed earthing systems, including reinforced concrete floors, earthing systems might be interconnected with nearby lightning earthing, a measure which can prevent the development of dangerous step voltage funnels.

Where equi-potential conditions are not reliably fulfilled, keeping the greatest possible distance (at least 10 m) between lightning and consumer earthing is recommended.

Number of Earthings

1. A 10 mm^2 copper wire or 20 mm^2 galvanized iron (GI) wire/strip should be embedded in the powerhouse foundation and terminated in a terminal bus on the powerhouse wall at a height of 30 cm from the floor. Metal roofing and the penstock, turbine, generator body, control panel body, ballast tank and other metal parts must be connected to that terminal bus (equipment earthing) in a continuous loop.
2. The generator neutral should be earthed separately.
3. The lightning arrestors at the first pole near the powerhouse should be earthed separately.

The above discussed three earthings should be carried out separately at a distance of at least 2.5 m between each.

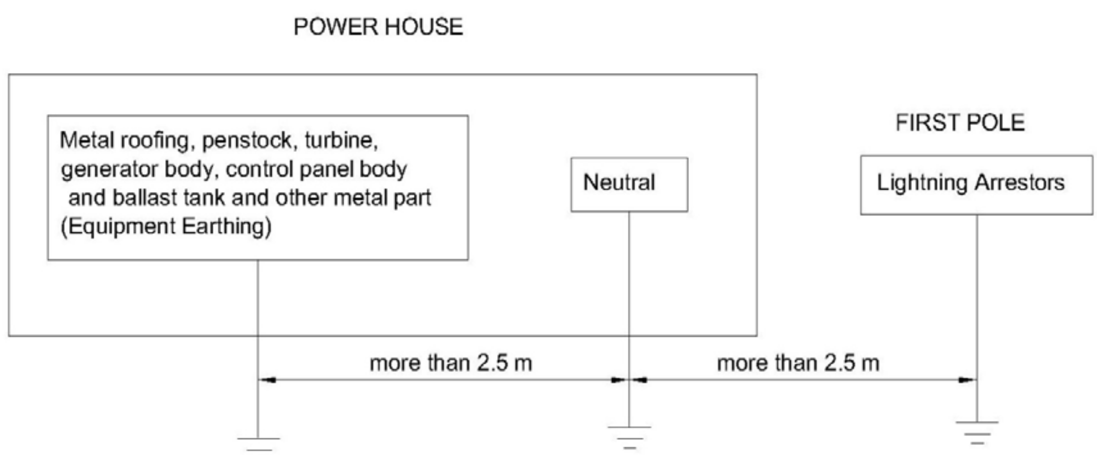


Figure 3.21: Powerhouse Earthing Arrangement

Type of Earthing

Copper-Plate Earthing

1. Brass or copper connections should be used in all earthings and copper earthing plates or equivalent GI pipes should be buried in a trench at a minimum depth of 2.5 m.
2. Earth electrodes should be copper plates with dimensions at least 600mmX600mmX3mm.
3. The first 1 m of material covering an earthing plate should consist of fine clay mixed with layers of charcoal and salt.
4. The best place for earthing is a location where the soil is moist and clayey.
4. Earth wire should be of 8 SWG copper.
5. Exposed sections of the earth wire should be inserted in a GI pipe.

Cylindrical Earthing

1. The copper-plated electrode should be 2,000 mm long and have a minimum diameter of 15 mm. The chemical-filled electrode should be the same length and have a diameter of 80 mm.
2. A hole with a diameter of 150 mm and a length of 2,100 mm should be bored in the ground.
3. Two 25 kg bags of black bill (a carbon-based conductive chemical) should be inserted around all sides of the copper-plated electrode.
4. The copper-plated electrode and conductor chemical should be properly covered by cast steel earthing hand hole of dimension 300 mm x 300 mm.

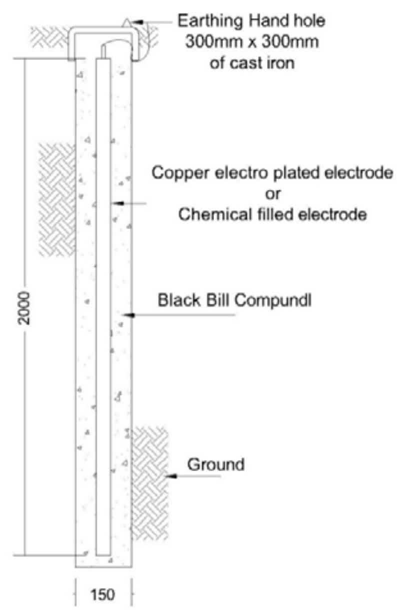


Figure 3.22: Cylindrical earthing

Measures to avoid corrosion include the following:

- Reinforcement steel in concrete can be connected to copper.
- Reinforcement steel in concrete can be connected to a steel or galvanized steel earthing system; such a connection should be above ground
- Bare or galvanized steel must never be connected to copper under the ground. Earthing systems should be made either of steel or galvanized steel or of copper, but not a mixture of both.
- The use of underground clamps is to be minimized and they must be made of compatible materials.

The best place for an earthing is a location where the soil is moist and clayey. At the powerhouse it is a good idea to put the earthing system below the tailrace water level, where moisture is higher than elsewhere. Typical values for soil resistance are provided in Table 3.8.

Table 3.8: Typical values for soil resistance

Type of Soil	Moderate Climate, Rainfall (>500 mm/year)		Desert Climate, Rainfall (<250 mm/year)
	Typical Value (Ωm)	Range of Measured Values (Ωm)	Range of Measured Values (Ωm)
Clay	10	5-20	10-1000
Porous limestone	50	30-100	50-300
Sandstone	100	30-300	>1000
Quartz, marble, carbonaceous limestone	300	30-300	>1000
Granite	1000	-	-
Slate, petrification, gneiss, volcanic rock	2000	-	-

Source: ABB/BS7430:1991, BS 7430:1991 and DIN VDE 0228

Transformer Earthing

Transformer earthing should arranged as shown below.

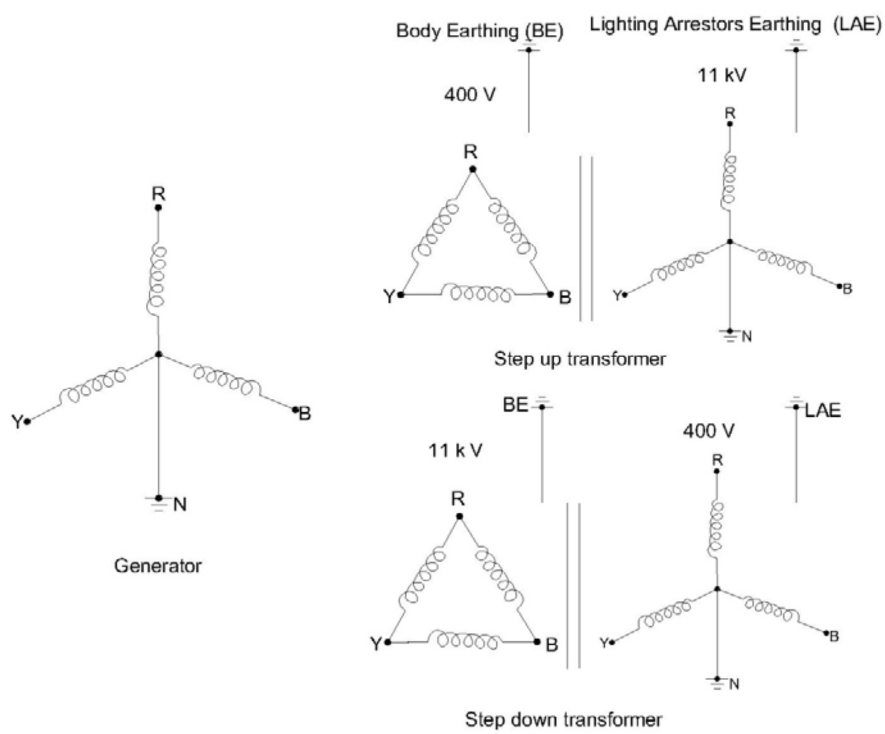


Figure 3.23: Transformer earthing

3.3.4 *Transmission and distribution system*

1. Transmission lines can be either buried or suspended overhead on poles. Overhead lines are more common as they are less expensive, easy to install, and to repair and maintain. However, when houses are densely located or heavy snowfall is expected during winters, underground transmission lines may be a better alternative. If properly installed and protected, such require little maintenance.
2. The design of transmission and distribution lines should be such that the voltage at the farthest point of any distribution feeder should not be below 90% of nominal value.
3. ACSR conductors are generally used for overhead transmission lines in MHP schemes. Aerial bundled cables (ABC) and their accessories may also be used for overhead lines. ACSR conductors are available in various sizes and designations as shown in Table 3.8 below.

Table 3.8: Sizes and designations of ACSR conductors used in MHPs

ACSR Code No.	Type of ACSR	Calculated Resistance At 20 º C Max. (Ohm/km)	Current Rating Max. (Amps)	Nominal Aluminium Area (mm^2)	Inductive Reactance (Ohm/km)	Weight (kg/km)
1	Squirrel	1.374	76	20	0.355	80
2	Gopher	1.098	85	25	0.349	106
3	Weasel	0.9116	95	30	0.345	128
4	Rabbit	0.5449	135	50	0.335	214
5	Otter	0.3434	185	80	0.328	339
6	Dog	0.2745	205	100	0.315	394

Source: Technical Catalogue, Trishakti Cables

The spreadsheet program provided may be used to check whether the selected ACSR sizes are adequate for the load and distances of the transmission/distribution lines.

4. a) The vertical clearance of overhead conductors should be chosen in accordance to Table 3.9.

Table 3.9: Minimum vertical clearance for overhead conductors

Place	Low-Tension	High-Tension (1-11kv)
Away from a road	4.5 m	5 m
Next to a road	5 m	5.5 m
Across a road	5.5 m	6 m

b) A horizontal clearance of at least 1.2 m shall be observed in all cases.

5. The minimum sag for cables up to 11kV can be calculated by the following formula:

$$d = \left(\frac{L}{172.8} \right)^2$$

Where, d = sag (in m)
L= length of span (in m)

Table 3.10: Minimum sags for selected spans of overhead cable

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

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

6. Transmission poles should be made of hardwood, reinforced concrete, or galvanized steel. Suitable dimensions for wooden poles for three-phase transmission are given in Table 3.11.

Table 3.11: Pole specification for hardwood poles

Minimum length (m)	6.0	7.0	8.0	8.5	9.0
Maximum span (m)	35	35	35	35	35
Buried length (m)	1.0	1.2	1.5	1.7	2.0
Min. top diameter (mm)	125	140	150	175	175
Min. ground clearance (m)	4.0	4.6	5.5	5.8	6.1

7. Shackle insulators with appropriate voltage ratings should be used for overhead lines with voltages up to 1,000 V. For overhead liens with voltages greater than 1,000 V, stay insulators shall be provided on all stay sets. The insulator dimensions and conductors to use are listed in Table 3.12.

Table 3.12: Insulator specifications

S. N	**Size**	**Dimension**	**Weight**	**Conductor**
1	Small	55 mm X 55 mm	200 gm	Squirrel, service wire
2	Medium	75 mm X 90 mm	600 gm	Gopher, weasel and rabbit
3	Large	100 mm X 110 mm	1300 gm	Dog

8. Steel pole should be used as provided for by the Nepal Electricity Authority.

9. Pin, disc, strain and post insulators must be used for high-voltage transmission.

10. The voltage and span of an overhead line determine the minimum spacing of the conductors. Generally, conductor spacing on the poles should be at least 300 mm in the case of a transmission voltage up to 400 V, 400 mm in the case of a 1,000-V line and 600 mm in case of 11-kV line. For aluminum conductors in a horizontal or triangular alignment the spacing is determined using this formula:

$$Spacing = \sqrt{d + \frac{V}{150}}$$

Where, Spacing is in meters

V = Voltage (in kV)

d = Sag (in m)

Generally 70% should be added to the value calculated above as a safety factor.

11. A stay set should be provided at the first pole, at all poles at an angle and at the end of a line. For safety and to provide protection from storms, every fifth pole is generally stayed on both sides even if the poles are in a straight line.

12. Lightning arrestors should be provided for all current-carrying conductors at the start and end of transmission and distribution lines. They also should be provided at intervals of 1000 m along high-tension lines and, in lightning-prone areas, every 500 m along distribution lines.

13. For overhead low-tension lines, the neutral line should be placed on top. In lightning-prone areas the neutral line should be earthed approximately every 200 m using GI earth pipes each 2 m long and 25 mm in diameter and at least 20 sq. mm of GI wire/strips or ACSR conductor.

14. Earthing should be provided at each lightning arrestor along the electrical lines as well as at the transformer body and transformer neutral on the secondary side of the distribution transformer. Earthing should be carried out using a copper ground plate of at least 600 mm x 600 mm x 3 mm or a GI pipe/strip buried at an adequate depth with proper fill material and maintenance provisions (soaking, tightening connections, earth resistance measurement) in order to achieve the least-resistance earth path for faulty current and lightning strikes.

15. Distribution lines/branches with more than 100 households or 10 kW should have a back-up breaker in a distribution box in order to discriminate faults.

16. For easy management and trouble-shooting of faults, the distribution system should be divided into groups separated by switches and fuses.

3.3.5 *Service wire*

The guidelines for service wires are discussed below.

1. Service wires should be double insulated: they should be PVC cable (concentric or multi-core) and additional voltage drop should not exceed 2%. Underground service connections should be either armoured cable or PVC cable in a protective circuit.

2. Service wires should be made of the same material as the line conductor (aluminum) to avoid galvanic corrosion.

3. Taking into consideration mechanical strength, concentric cable with a 6 sq.mm should be used for lighting loads regardless of the actual power supply.

4. A switch fuse unit (main switch) should be installed in each house.

5. The fuse of the main switch should be rated in order to protect against exceeding the maximum current ratings of both service and house wiring.

6. To avoid overloading, a load-limiting device (ECC, MCB or PTC) should be installed in each household.

7. Service wires should be clamped to poles to avoid tension in connections.

CHAPTER FOUR: REPORT STANDARD

4. Report Format

The DFS report should cover the technical viability of an MHP as well as power demand and end-use possibilities, project costs and other financial aspects, institutional aspects and policy issues as discussed in Chapter 1. The format and contents of the report are presented below.

The report should be as brief as possible while still containing all the information required. Furthermore, the field data collection sheets (Appendix B.) should be filled in as possilbe. The report should cover the following issues:

i. Salient Features

At the start of the report, the salient features of the proposed MHP should be listed. They should include all the parameters below as well as any pertinent site-specific parameters.

General

Name of Project	: Name
Source River/Stream	: Name
Location of Powerhouse	: Ward No. /Rural Municipality/Municipality/District
Locations of Load Centres	: Ward Nos. (Village name) /Rural Municipality/Municipality/District
No. of Households	: No.
Average Subscribed Power	: Watt/HH
Ownership	: Community/Cooperative/Private/PPP
Accessibility	: Approx. km from nearest road head

Technical

GPS Coordinates	: **Intake.** X, Y, Z coordinates **Powerhouse,** X, Y, Z coordinates
Measured Flow	: lps
Flow Measured Date	: day/month/year
Designed Discharge	: lps (11 months exceedance flow)
Gross Head	: m
Net Head	: m (head loss = %)
Design Power	: kW
Overall Efficiency	: %
Length of Headrace	: m (canal/pipe)
Penstock Pipe	: ....m long, ...mm Ø and ....mm thick (kgf/cm^2 if HDPE)
Penstock Type	: MS/HDPE
Powerhouse	: length (m) x breadth (m) (inner dimensions)
Turbine Type	: Cross-Flow/Pelton/Francis/Other
Turbine RPM	: Revolutions per minute

Driving system	: Belt drive/Direct coupling
Generator Size	: kVA; one-/three-phase
Generator Type	: Induction/Synchronous (brush/brushless)
Controller Type	: kW; IGC/ELC/Governor
Ballast Load	: kW ballast heaters

Transmission/Distribution Network:

High-Tension (11-kV) Line	: m
Low-Tension Line	: m (for both one and three phase)
Composite Line (HT + LT)	: m
Poles	: no. ; wooden/steel
Transformers	:
Step Up	: No. ; kVA ; one/three-phase
Step Down	: No. ; kVA ; one/three-phase

Ethnic Groups

Brahmin/Chhetri	: __HH (no.)
Others	: __HH
Ethnic (*janajati*)	: __HH
Dalit	: __HH
Single Women	: __HH
Disadvantaged/Marginalised	: __HH
Conflict-Affected	: __HH

Finances

Total Project Cost	: Rs.
Cost per kW	: Rs.

Sources of Financing

Community Contribution	:
Cash	: Rs. (Rs. per household)
Kind	: Rs.

Subsidy	: Rs.
Rural Municipality/Municipality investment	: Rs.
Other investments from government institutions	: Rs.
Loan	: Rs.
Others	: Rs.

Proposed Tariff	:
Lighting	: Rs. /Watt/Unit
Productive End-Uses/Businesses	: Rs. /Unit
Mechanical Running in PH	: Rs./Running Hours

IRR	: %
NPV (@ 6% Discount Rate)	: Rs.
NPV (@ 12 % Discount Rate)	: Rs.
B/C Ratio	:
Payback Period	: Years
Annuity Payment on Loan	: Rs.
Loan Maturity Period	: Years

ii. Summary

A brief summary of the report including the main findings, conclusions and recommendations of the study should be included. This section should clearly state whether or not the project is technically and financially feasible and whether or not it is recommended for implementation.

iii. Background

Information regarding the need or demand for the DFS should be discussed, as should the location of the site, its distance from the nearest road head, the nearest supply centre for construction materials, the time of the site visit and the list of the professional staff involved. The objective, scope and limitations of the study should also be discussed in this section.

iv. Methodology

The methodology employed to undertake the study should be briefly discussed. This section should include a description of equipment used to undertake the survey and flow measurement, a brief discussion of the community meetings that were organised during the site visit, the sources of socio-economic data, and a statement about how the information collected during the site visit was analysed.

v. Power/Lighting Demand

This section should briefly discuss how the installed capacity was determined based on the demand for electricity. The number of households to be electrified and the average power allocation per household should be stated. Adjustments for any future expansion and for system losses should also be discussed.

vi. End-Use Possibilities

The types of end-uses that are projected and the capacity, operating hours, annual days of operation of each should be presented as shown in Table 4.1 below. The annual load factor from all these end-uses should be calculated.

Table 4.1: End-Use Possibilities

SN	End-use	Power required (kW)	Operation period	
			Time/day (am, pm)	Days/month
1	Huller	3	10 am – 2 pm	15
2	Grinder	4	2 pm – 5 pm	10
3	Oil expulsion	5	10 am – 2 pm	10
4	Bakery	3	6 am – 9 am	25
5	Battery charging	2	11 pm – 4 am	20
6	*Lokta*-processing	5	2 pm – 5 pm	25
7	Video hall	2	4 pm – 9 pm	7
8	Noodles-processing	3	10 am – 2 pm	21
9	Computer institute	2	11 am – 4 pm	25
10	Electronic shop	2	8 am – 6 pm	25
11	......			
12	......			

The proposed end-uses should also be justified in terms of the market opportunities and local resources available (e.g., agro-products, dairy, etc.). For example, if an agro-processing plant is listed, the size of both the command area and the agricultural yield at the site as well as the presence of other plants (e.g., diesel mills) should be considered. A list of potential entrepreneurs and locations for each end-use should also be provided.

vii. Best Available Technology (BAT)

As per the resource availability and electricity demand, a comparative analysis of best available technology e.g. hydropower, solar, wind, gasifier should be done. Based on least cost (preferably life-cycle unit cost) the best available technology is selected to assess in details.

viii. Environment and Social Safeguard (ESS) Aspect

As discussed in section 2.5, any environmental and social risk should be properly dealt with potential remedial measures. After assessing potential risk associated, the project should be categorized A, B or C. Consequently, relevant recommendation should be made for carrying EIA or IEE if the project falls under category A or B respectively. If the project falls under category C, Environmental and Social Management Plan (ESMP) should be prepared.

ix. Multiple Use of Water

As discussed in Section 1.6, the multiple use of water in a multipurpose project should be described. The nature of the water uses, the modifications in design required and the expected

additional benefits from the secondary uses (e.g., number of households served with piped water, hectares of land irrigable, etc.) should also be discussed in this section.

x. Technical Design

This section should present the various components of the scheme in this sequence: the intake, the powerhouse. the tailrace and transmission/distribution lines. Sub-sections should be used to discuss each. The technical aspects that should be covered in the text and the corresponding drawings required are presented in Table 4.2. The technical design (i.e., text and drawings) should be in enough detail that a competent contractor would be able to quote a price for its implementation within a reasonable margin of error. Furthermore, based solely on the report, the contractor should be able to construct (or supervise the construction of) the structures and install the equipment specified, making only minor modifications to suit site conditions. It should be noted that detailed construction drawings are not essential but the basis for working drawings should be incorporated. Examples of the drawings required are presented in Appendix A so that the design engineer is aware of the nature and level of details to include.

Table 4.2: Technical Requirements for Detailed Feasibility Study of a Micro Hydro Project

Drawing	Description	Corresponding Details in Report
a. Map of project area	Show the project area, including that covered by distribution, using published maps (e.g., trekking maps, district maps, etc.)	Mention the location of the project, distance from road head, routes to site and villages covered by the distribution network.
b. General layout of the scheme	Show the locations of all major components, from intake to powerhouse/tailrace.	Describe the layout briefly.
c. Longitudinal profile of the scheme	Show the profile with levels from intake to powerhouse. *Note: Not mandatory for schemes with less than 5 kW installed capacity*.	
d. General layout plan of the headworks	Show the locations of the weir, intake, bank protection structures, etc.	
e. Intake details	Show a plan and sections of the weir, intake and other structures. Show dimensions, ground and water levels (normal & flood), especially at the intake so that the hydraulics can be cross-checked.	Describe key structures--their types and modes of operations; present flood considerations.
f. Gravel trap, settling basin, forebay, and spillways	Show a plan and sections of these structures. Show water and ground levels and the types and dimensions of structures (length, width and thickness). Show gates, spillways and flushing arrangements should be shown. An experienced contractor should be able to	Describe the location, dimensions and type of each structure. Mention operational aspects such as emptying frequency and sediment-flushing mechanisms in the settling basin.

	construct the structures based on these drawings.	
g. Crossings	Show a plan and sectional details of crossings. Include details about both the obstacle and the construction of the proposed structure.	Describe the locations, dimensions and types of all crossings. Describe their alignment, need, basis of selection, and any precautions that need to be taken.
h. Headrace	Show representative canal sections including ground and water levels, dimensions and side slopes. Show one section for each typical stretch. Also indicate the type of canal (e.g., stone masonry with cement mortar) and the longitudinal slope. In short, provide all the information needed so that the hydraulics can be checked. If a headrace pipe is used, show its type and dimensions as well as burial details for each representative section.	Provide the dimensions and types of canal/pipe. Describe the alignment and locations of additional spillways.
i. Penstock	Show the penstock profile including ground levels, pipe alignment and locations of anchor blocks. Mention pipe thickness and, if it is flange-connected, show details dimensions of the flanges and the number and diameters of bolts.	Mention the type of pipe, diameter, thickness, total weight, and individual lengths. Describe the alignment.
j. Anchor blocks and support piers	Show plans and cross-sections of all anchor blocks. Show one support pier for each straight section of pipe length. For both structures, show ground levels and pipe and/or deflection angles.	Mention the locations, numbers and types of anchor blocks and support piers.
k. Powerhouse and tailrace	Show a general layout plan and cross-sections of the powerhouse detailed enough that a contractor could build it. Include door and window openings, the depth of foundations, walls, roofing, etc. Ensure that there is adequate space for all the equipment and for operators to walk around. Show separate plans and cross-sections of the machine foundation. It should match the proposed electromechanical units, e.g., if a belt drive is mentioned, the machine foundation should not show direct coupling. *Note: this drawing is not mandatory for schemes with less than 5 kW installed capacity.* Requirements for the tailrace are similar.	Mention the dimensions and location of the power house as well as the type of wall and roofing materials used and any specific features. Mention the overall dimensions and type of structure of the the machine foundation. See above.

l. Trash rack	Show the position of the coarse trash rack at the intake and the fine trash rack at forebay. Mention the spacing between and the size of bars. *Note: this drawing is not mandatory for schemes with less than 5 kW installed capacity.*	Mention the overall size of the trash rack, the angle at which it will be installed and the type of bars used.
m. Gates, flush cones and other flow-control structures	Show the dimensions, positions and functions of these structures. *Note: this drawing is not mandatory for schemes with less than 5 kW installed capacity.*	Describe the gates and their operational procedures.
n. Expansion joints	Show the locations of these joints in the penstock profile drawings.	Mention the locations and number of joints.
o. Turbine	Show the turbine coupled (direct or with a belt drive) with the generator in plan and section (at least one) in the powerhouse drawing. *Note: this drawing is not mandatory for schemes with less than 5 kW installed capacity.*	Mention the type of turbine and indicate the shaft power it requires as well as its overall efficiency. For a pelton turbine, mention the number of jets.
p. End-uses	If end-uses (milling, grinding, etc.) are installed in the powerhouse, show the drive connections (line-shaft, belt) and the equipment in the plan for the powerhouse.	Report requirements were discussed separately in Section vi above.
q. Generator	Include the same information as for a turbine for drawing. *Note: this drawing is not mandatory for schemes with less than 5 kW installed capacity.*	Mention the capacity and type of the generator and these specifications: Voltage, phase, rated speed, frequency, power factor, runaway speed, efficiency, insulation, enclosure, lubrication, bearings life (in hours) and type of excitation system. Also mention the factors (altitude, temperature, ELC, power factor) considered while sizing the capacity of the generator.
r. Main Circuit Diagram of the Powerhouse	Give an overview of the electrical system in a single line diagram including the following: ❖ All connecting points between the components (generator, ELC/ELC-extension/IGC, ballast, control panel, MCCB, lightning arrestors) ❖ Earthing connections (generator-neutral, equipment and lightning arrestors) ❖ General specification of the equipment ❖ Size of the copper cables ❖ Size of the MCCB/MCB	**Load controller (ELC/ELC-Extension/IGC**): Mention detailed specifications. **Ballast:** Mention the type and size of the ballast and the capacity of the tank. **Control and protection system**: Describe briefly the control and protection system implemented in the scheme. Give brief description of the measuring (current, voltage, frequency, kW, kWh meter) and the protection instruments (OV, UV, OF, UF, OC, EF) instruments incorporated

	❖ Sizes of the fuses	in the control panel. Provide the specifications of the panel board. **Voltage-regulating system (AVR):** Describe the system and its operational characteristics. **Switchgear**: Mention the type, size and capacity of the breaker. **Cable/Wire**: Mention type and size of the cable to be used for connecting electrical equipment in the powerhouse. Describe the powerhouse wiring, including the size of the cable and the protection system adopted. **Earthing**: Explain the earthing system implemented in the powerhouse, mentioning the type and number of earthings.
s. Transmission/Distribution Diagram	Give an overview of the transmission/distribution system in a single line diagram that includes the following details: • Locations of transformers, switch and fuses, earthing points, and lightning arrestors • Distances between two nodes • Sizes and types of the cables/wire • Subscribed load at each node during peak hours • Name of the village at each load point • Size of the transformers and switch/fuse unit • Type of system (1- or 3-phase) *For schemes with less than 5 kW installed capacity, the transmission/distribution lines may be included in the general layout plan.*	**Transformer**: Provides detailed specifications. **Type of system**: Identify the type. **Conductor**: Mention the type, size and length of the conductor. **Voltage drop**: Mention the voltage drop at each node of the distribution system. **Poles**: Provide detailed specifications (type, size, number, etc.). **Stay sets**: Mention the number required. **Lightning arrestors/Earthing**: Mention the type, size and number of lightning arrestors and earthings required. **Insulators/D-clamp**: Mention the type, size and number needed. **Service wire/cable**: Mention the type, size and length of the wire/cable and the length required per household. **Load-limiting device**: Describe the load-limiting device to be installed in households **Switch/Fuse unit**: Mention the type, size and number of switch/fuse unit installed at the branch points of the distribution system.

xi. Hydrology

The catchment area, elevation of the scheme (both the intake and the powerhouse), the 11-month exceedance flows based on both the MIP and flow measurement methods, and the equipments used should be mentioned. The estimated mean monthly flows for all 12 months (MIP method) should be presented in a table in this section, while flow measurement data sheet should be appended at the end of the report.

The mean monthly flows estimated at this stage should be compared to those in the preliminary feasibility report and any significant differences discussed.

xii. Socio-Economic Status

The number of beneficiaries, ethnic composition, and general socio-economic condition of the area as well as existing and possible future end-uses should be discussed. If certain areas in the vicinity of the project area are excluded from the beneficiary groups, a justification for their exclusion (e.g., technical difficulty, unwillingness of the households to participate, etc.) should be stated. Sub-headings should be used for clarity. If the socio-economic findings of the DFS are significantly different those of the pre-feasibility study, an explanation should be provided.

xiii. Management

The ownership of the scheme and the proposed management structure should be discussed. This section should also state whether or not the developer has the capacity to manage the plant and the type of training and support that may be required to enhance his or her managerial skills.

xiv. Project Costs, Income and Financial Analysis

The estimated total project cost should be presented. It should include a summary of the detailed bill of quantities, mentioning the costs for the major components of the scheme (intake to transmission/distribution line). The detailed bill of quantities should be appended. A summary of costs (rates for local labour, material and transport/portering) and the basis on which these figures were arrived should also be presented. A much as possible, district rates should be used; if they are not, a justification or clarification must be provided. The formats for the cost summary and detailed bill of quantities are found in Appendix D.

Annual operation and maintenance costs, including the number of staff required should also be included, as should the estimated annual income, including income from both lighting and end-uses. How these figures were arrived at should be explained.

Finally, the financial viability of the scheme should be demonstrated. The net present value of equity investment at a discount rate of 6% and 12% and an economic life of 15 years should

be calculated. A cash flow table should be presented and the internal rate of return of the project should be calculated.

In the case of multipurpose projects, the additional costs to accommodate secondary water uses and projected annual benefits and costs should also be calculated.

xv. Policy Issues

This section should address the policy issues covered in Section 1.5. Whether or not each policy issue is met by the proposed plant should be clearly stated.

xvi. Comments

Any differences between the design parameters of the detailed and the preliminary feasibility studies should be explained. Any further comments that are essential for demonstrating the feasibility or unfeasibility of the scheme but do not fit in other sections should be included here.

xvii. Conclusions and Recommendations

This section should briefly summarise and conclude the study and provide recommendations for the construction and operation phases. Conclusions and recommendations should be related to or justified by the text of the report and the data in the format provided. Based on the technical analysis and financial figures, a clear recommendation about whether or not to proceed to the construction phase should be provided.

xviii. Appendixes

Filled-in detailed feasibility formats, drawings, photographs, a flow measurement data sheet, a detailed bill of quantity (BOQ), financial analysis and any other information that is relevant to demonstrating the feasibility of the scheme should be appended at the end of the report or included as a separate volume.

REFERENCES

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2. Allen R. Inversin (1986), Micro-Hydropower Sourcebook, A Practical Guide to Design and Implementation in Developing Countries, NRECA International Foundation, 1800 Massachusetts Avenue N. W., Washington, DC 20036.

3. AEPC (2069), Subsidy Policy for Renewable Energy

4. AEPC (2070), Subsidy Delivery Mechanism

5. AEPC/MGSP Publication (2004), Guidelines for Preliminary Feasibility Studies of Micro-hydro Projects

6. AEPC/MGSP (2005), Reference Micro-hydropower Standard

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8. AEPC/REF (2008), Micro Hydro Power Output and Household Verification Guidelines

9. BPC Hydroconsult, Intermediate Technology Development Group (ITDG), Kathmandu, Nepal (2002), Civil Works Guidelines for Micro-Hydropower in Nepal.

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11. ITDG, Electrical Guidelines for Micro-hydro Electric Installation.

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14. ITDG/Nepal (1999), Management Guidelines for Isolated Micro-hydro Plants in Nepal.

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16. Thake, Jeremy (2000), The Pelton Turbine Manual Design, Manufacture, Installation of Small Scale Hydropower, Published by ITDG,

APPENDICES

Appendix A: Reference Tables for Technical Design

Appendix B: Format for Detailed Feasibility Studies of Prospective Micro Hydro Projects

Appendix C: Typical Drawings of Micro-Hydro Projects

Appendix D: Project Costs and Bill of Quantities (BoQ)

Appendix E: Analysis of Best Available Technology (BAT)

Appendix F: Environmental and Social Management Plan (ESMP) Format

Appendix A: Reference Tables for Technical Design

Table A1_1: Support piers spacing (Centre to centre horizontal length in meters)

EFFECTIVE PIPE WALL	PLAIN PIPE				PIPE WITH WEAR PLATES			
THICKNESS, $T_{effective}$ (MM):								
320 N/mm2 STEEL	1.3	1.9	2.6	3.9	1.3	1.9	2.6	3.9
410N/mm2 STEEL	1	1.5	2	3	1	1.5	2	3
(a) Totel head								
h_{total} < 100 m								
100 mm dia	2	3.2	4	4.7	2	3.2	4	4.7
200 mm dia	4.1	6	7.3	8.3	4.1	6	7.3	8.3
300 mm dia	2.5	5.7	8.6	10.5	4.9	7	8.6	10.5
400 mm dia	1.4	2.6	5.8	11.7	5.1	7.4	9.1	11.7
500 mm dia	_	2.1	3.7	8.7	4.1	7.5	9.3	12
(b) 100 < h total <150 m								
100 mm dia	1.9	3.1	4	4.7	1.9	3.1	4	4.7
200 mm dia	3.9	5.8	7.1	8.3	3.9	5.8	7.1	8.3
300 mm dia	2.5	5.7	8.2	10.5	4.4	6.7	8.2	10.5
400 mm dia	1.4	2.6	5.8	11.2	4.4	6.9	8.6	11.2
500 mm dia	_	2.1	3.7	8.7	4	6.8	8.7	11.5
(c) 150 < h_{total} <200 m								
100 mm dia		2.3	3.5	4.7		2.3	3.5	4.7
200 mm dia	3.7	5	6.5	8.3	2.7	5	6.5	8.3
300 mm dia	2.5	5.7	7.6	10.1	3.2	5.8	7.6	10.1
400 mm dia	1.4	2.6	5.8	11.2	3	6	7.9	10.6
500 mm dia	_	2.1	3.7	8.7	2	5.8	7.9	10.7
(d) 200 < h_{total} <250 m								
100 mm dia		1.8	3.1	4.7		1.8	3.1	4.7
200 mm dia	1.8	4.4	6	8.3	1.8	4.4	6	8.3
300 mm dia	2.1	5.2	7	9.7	2.1	5.2	7	9.7
400 mm dia		2.6	5.8	10.1	_	5.1	7.2	10.1
500 mm dia	_	2.1	3.7	8.7	_	4.7	7.1	10.1

Source: Civil Design Guidelines

Notes:

- Applies only to steel penstocks welded or flanged to British Standard (minimum flange thickness = 16 mm). In other cases use one support pier for each individual pipe length, with the pier in the middle.
- Wear plates to be of same thickness as pipe wall, and welded on all edges, covering bottom 180° of pipe. The length should be enough to extend at least 0.5 times the pipe diameter beyond each side of the support pier.
- Interpolate between the above values for intermediate pipe diameters, wall thicknesses or steel grades

Appendix A1-2 a: High Density Polyethylene Pipe Standard Pipe Dimensions

Outside Diameter mm	SERIES II		SERIES III		SERIES IV		SERIES V	
	Working Pressure 2.5Kgf/cm sq.		Working Pressure 4Kgf/cm sq.		Working Pressure 6Kgf/cm sq.		Working Pressure 10Kgf/cm sq.	
	Wall Thickness		Wall Thickness		Wall Thickness		Wall Thickness	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
16 mm							2.0'	2.4
20mm 1/2"							2.3	2.8
25mm 3/4							2.8	3.3
32mm 1"					2.3	2.8	3.6	4.3
4cmm 1.25"			2.0'	2.4	2.9	3.4	4.5	5.2
50mm 1.5"			2.4	2.9	3.6	4.2	5.6	6.4
63mm 2"	2.0'	2.4	3.0'	3.5	4.5	5.2	7.1	8.1
75mm 2.5"	2.3	2.8	3.6	4.3	5.3	6.1	8.4	9.5
90mm 3"	2.8	3.3	4.4	5.2	6.4	7.3	10.1	11.4
110mm 4"	3.4	4.0'	5.0'	5.8	7.8	8.8	12.4	13.9
125mm 4.5"	3.9	4.5	6.0'	6.8	8.9	10.8	14.1	15.7
140mm 5"	4.3	5.0'	6.8	7.7	9.9	11.1	15.8	17.6
160mm 6"	4.9	5.6	7.8	8.8	11.3	12.7	18	20
180mm 7"	5.6	6.4	8.7	9.8	12.8	14.3	20.3	22.6
200mm 8"	6.2	7.1	9.7	10.9	14.2	15.9	225	25
225mm 9"	6.9	7.8	10.9	12.2	15.9	17.7	25.4	82.2
250mm 10"	7.7	8.8	12.1	13.6	17.7	19.7	28.2	31.3
280mm 11"	8.6	9.7	13.5	15.1	19.8	22	31.5	34.5
315mm 12"	9.7	10.8	15.2	17	22.3	24.8	36.4	39.2
355mm 14"	10.9	12.2	17.1	19.1	25.1	27.9	39.9	44.1
00mm16"	12.3	13.8	19.3	21.5	28.3	31.4	45	40.7

Source: Nepal Polythene & plastic Industries Pvt. Ltd.

Appendix A1-2 b: High Density Polyethylene Pipe Standard Pipe Dimensions

	SERIES		SERIES		SERIES		SERIES	
Outside	Working Pressure		Working Pressure		Working Pressure		Working Pressure	
Diameter	2.5Kgf/cm sq.		4Kgf/cm sq.		6Kgf/cm sq.		10Kgf/cm sq.	
mm	Wall Thickness		Wall Thickness		Wall Thickness		Wall Thickness	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
16 mm							2.0	2.4
20mm							2.3	2.8
25mm							2.8	3.3
32mm					2.3	2.8	3.6	4.3
4c mm			2.0	2.4	2.9	3.4	4.5	5.2
50mm			2.4	2.9	3.6	4.2	5.6	6.4
63mm	2.0	2.4	3.0'	3.5	4.5	5.2	7.1	8.1
75mm	2.3	2.8	3.6	4.3	5.3	6.1	8.4	9.5
90mm	2.8	3.3	4.4	5.2	6.4	7.3	10.1	11.4
110mm	3.4	4.0'	5.0'	5.8	7.8	8.8	12.4	13.9
125mm	3.9	4.5	6.0'	6.8	8.9	10.8	14.1	15.7
140mm	4.3	5.0'	6.8	7.7	9.9	11.1	15.8	17.6
160mm	4.9	5.6	7.8	8.8	11.3	12.7	18	20
180mm	5.6	6.4	8.7	9.8	12.8	14.3	20.3	22.6
200mm	6.2	7.1	9.7	10.9	14.2	15.9	22.5	25
225mm	6.9	7.8	10.9	12.2	15.9	17.7	25.4	28.2
250mm	7.7	8.8	12.1	13.6	17.7	19.7	28.2	31.3

Source: Panchakanya Plastic Ind. P. Ltd.

Appendix A1-3 PVC Pipe Standard Pipe Dimensions

	Class-1		Class-2		Class-3		Class-4	
Outside	Working Pressure		Working Pressure		Working Pressure		Working Pressure	
Diameter	2.5Kgf/cm sq.		4Kgf/cm sq.		6Kgf/cm sq.		10Kgf/cm sq.	
mm	Wall Thickness		Wall Thickness		Wall Thickness		Wall Thickness	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
20mm							1.1	1.5
25mm							1.4	1.8
32mm							1.8	2.2
4c mm					1.4	1.8	2.2	2.7
50mm					1.7	2.1	2.8	3.3
63mm			1.5	1.9	2.2	2.7	3.5	4.1
75mm			1.8	2.2	2.6	3.1	4.2	4.9
90mm	1.3	1.7	2.1	2.6	3.1	3.7	5	5.7
110mm	1.6	2	2.5	3	3.7	4.3	6.1	7
140mm	2	2.4	3.2	3.8	4.8	5.5	7.7	8.7
160mm	2.3	2.8	3.7	4.3	5.4	6.2	8.8	9.9
180mm	2.6	3.1	4.2	4.9	6.1	7	9.9	11.1
200mm	2.9	3.4	4.6	5.3	6.8	7.7	11	12.3

Source: Panchakanya Plastic Ind. P. Ltd.

Appendix A1-4a: Galvanized and Black Steel Pipe Standard Pipe Dimensions

Type	Normal Bore		Wall Thickness	Appox. OD	Weight of Black Pipe Plain End		Weight of Galvanized Pipe Threaded & Socketed	
Class	mm	Inch	mm	mm	Kg/m	m/M.T	Kg/m	m/M.T
LIGHT 'A'	15	1/2'	2	21.3	0.92	1050	1.01	990
	20	3/4'	2.35	26.3	1.41	709	1.48	676
	25	1'	2.65	33.7	2.01	498	2.11	474
	32	1¼	2.65	42.4	2.58	388	2.72	355
	40	1½	2.9	48.3	3.25	308	3.41	281
	50	2	2.9	60.3	4.11	243	4.33	222
	65	2½	3.25	76.2	5.8	172	6.11	156
	80	3	3.25	88.9	6.81	147	7.21	133
	100	4	3.65	114.3	9.89	101	10.49	91
MEDIUM 'B'	15	1/2'	2.65	21.3	1.22	820	1.28	781
	20	3/4'	2.65	26.9	1.58	633	1.65	606
	25	1	3.25	33.7	2.44	410	2.54	394
	32	1¼	3.25	42.4	3.14	318	3.27	292
	40	1½	3.25	48.3	3.61	277	3.77	254
	50	2	3.65	60.3	5.1	196	5.32	179
	65	2½	3.65	76.2	0.51	154	6.82	140
	80	3	4.05	88.9	8.47	118	8.87	107
	100	4	4.5	144.3	12.1	83	12.69	75
	125	5	4.85	139.7	16.2	62	16.95	55
	150	6	4.85	165.1	19.2	52	20	47
HEAVY 'C'	20	3/4'	3.25	26.9	1.9	526	1.97	508
	25	1	405	3370	297	336	3.07	326
	32	1¼	4.05	42.4	3.84	260	3.97	239
	40	1½	4.05	48.3	4.43	226	459	207
	50	2	4.5	60.3	6.17	162	6.39	148
	65	2½	4.5	76.2	7.9	127	8.21	115
	80	3	4.85	88.9	10.1	99	10.52	90
	100	4	5.4	114.3	14.4	69	15.44	63
	125	5	5.4	139.7	17.8	56	18.52	51
	150	6	5.4	165.1	21.2	47	22.22	42
	200mm GALVANISED AND BLACK STEEL PIPES (Detailed specification on request)							
	200	8	5.2	219.1	27.71	36	29.2	32
	200	8	6	219.1	31.82	31	33.2	28

Source: Hulas steel Industries. Pvt. Ltd.

Appendix A1-4b: Hipco Structural Pipe Standard Pipe Dimensions

Nominal Bore		Outside Diameter	Class	Thickness	Weight (Black Pipes)	Area of Cr. Section	Moment of Inertia	Section Modulus	Radius of Gyration
mm	Inch	mm		mm	Kg/m	cm	cm	cm	cm
15	1/2'	21.3	L	2	0.96	1.21	0.57	0.54	0.69
			M	2.65	0.22	1.55	0.69	0.65	0.67
20	3/4'	26.9	H	3.25	0.45	1.84	0.77	0.73	0.65
			L	2.35	0.42	1.81	1.38	1.02	0.87
			M	2.65	0.58	2.02	1.5	1.12	0.86
25	1	33.7	H	3.25	0.9	2.41	1.72	1.28	0.84
			L	2.65	2.04	2.58	3.14	1.86	0.1
			M	3.25	2.46	3.11	365	2.16	0.08
32	1¼	42.4	H	4.05	2.99	3.77	4.22	2.51	0.06
			L	2.65	2.61	3.31	6.57	3.1	41
			M	3.25	3.15	4	7.71	3.64	39
			H	4.05	3.86	4.88	9.07	4.28	0.36
40	1½	48.3	L	2.9	3.27	4.14	10.7	4.43	0.61
			M	3.25	3.61	4.6	11.73	4.86	0.6
			H	4.05	4.43	5.63	13.9	5.75	0.57
50	2	6.3	LI	2.9	4.14	5.23	21.59	7.16	2.03
			L2	3.25	4.57	5.82	23.77	7.89	2.02
			M	3.65	5.1	6.5	26.17	8.68	201
			H	4.5	6.17	7.89	30.9	1020	1.98
65	2½	76.1	L	3.25	5.84	7.44	49.44	13	2.58
			M	3.65	653	8.31	5465	14.4	2.56
			H	4.5	7.92	10.1	65.12	17.1	254
80	3	88.9	L	3.25	6.86	8.74	80.31	18.07	3.03
			M	4.05	8.48	10.8	97.38	21.91	3
			H	4.85	10.01	12.8	11346	25.53	2.98
100	4	114.3	L	3.65	9.97	12.7	194.39	34.01	3.91
			M	4.5	12.1	15.5	234.32	41	3.89
			H	5.4	14.5	18.5	274.54	48.04	386
125	5	139.7	L	4.5	14.9	19.1	437.2	62.59	4.78
			M	4.85	16.2	20.5	467.64	66.95	4.77
			H	5.4	17.9	22.8	514.49	73.66	4.75
150	6	165.1	L	4.5	17.8	22.7	732.57	88.74	5.68
			M	4.85	19.2	24.4	784.49	95.03	5.67
			H	5.4	21.2	27.1	864.69	104.75	5.65
175	7	193.7	L	4.85	22.6	28.7	1284	133	6.68
			M	5.4	25	31.9	1416.96	146.3	6.66
			H	5.9	27.3	34.8	1536.11	159	6.64
200	8	219.1	L	4.85	25.7	32.6	1874.06	171.07	7.58
			M	5.6	29.4	37.6	2141.59	195.49	7.55
			H	5.9	31	39.5	2247	205.11	7.54

Source: Hulas steel Industries. Pvt. Ltd.

Appendix B: Format for Detailed Feasibility Studies of Prospective Micro Hydro Projects

Format for Detailed Feasibility Studies of Prospective Mini/Micro-hydro Projects

This format is intended for use in conducting detailed feasibility studies for proposed mini/micro-hydro plants. A Pre-feasibility study should have already been completed at this stage. The survey team should take a copy of the filled preliminary feasibility study format so that comparisons can be made at site and any differences be recorded.

1. General

Name of Scheme: ………………………..…………………….……………………..

Location: Municipality/Rural Municipality: ……………………… Village: ………………..

State:………………………………

Coordinates: ………………………………………………………..…. (X, Y, Z)

Comments: ……………………………………………………………………………

……………………………………………………………………..……………………..

Date of site visit: ………………………………………………………………………

UC Chairman / Developer: ………………………………………………………..

Address:

Is UC Chairman / Developer same as in Pre-feasibility study?

Yes ( ) No ( )

Comments: …………………………………………………………………………..

………………………………………………………………………………………….

Study team leader: Name: ………………………………… Signature: …………….…

Team members: 1. Name:……………………………… 2. Name: ………………………

3. Name: ……………. ………………… 4. Name: ……………………..…

Persons Interviewed, address	Was this person also interviewed during pre-feasibility survey?	

2. Selection of best available technology

Hydropower: Is there hydro potential? Yes( ), No( )

If yes, (a) Monthly average flow (Q11) ……………lps

(b) Monthly average flow (Q40) ……………lps

(c) Available head (Hd) ………………m

Wind: Is there wind potential? Yes( ), No( )

If yes, (a) Daily average speed ……………m/s (b) Monthly average speed ……………m/s

(c) Availability of land for wind mill ……………(ha or m2)

(d) Types of potential land: public ( ), private ( ), other ( )…………………..

(e) Unit cost of land: ………………. (NRs/Ha or NRs./m2)

Solar: Is there solar potential? Yes( ), No( )

If yes, (a) Average irradiation ……………kWh/m2 (b) Availability of land for solar panel…………(Ha or m2)

(c) Types of potential land: public ( ), private ( ), other ( )…………………..

(d) Unit cost of land: ……………….. (NRs/Ha or NRs./m2)

Gasifier: Is there biomass potential? Yes( ), No( )

If yes, (a) Daily/monthly/annual average wood availability ……………m3

(b) Availability of land for harvesting wood……………(Ha or m2)

(c) Types of potential land: public ( ), private ( ),

(d) Unit cost of land: ……………….. (NRs/Ha or NRs./m2)

If multiple use of water is possible (i.e., multipurpose projects, the details should be provided here. Note that given the site conditions to the extent possible multipurpose projects should be proposed so that the water resources can be optimally used. Furthermore, the current AEPC policy is favourable to multipurpose projects as the cost ceilings for subsidy are not applicable for such cases.

3. Choosing best available technology

(a) Hydropower ( ) Reason: ………………………………………

(b) Wind ( ) Reason: ………………………………………

(c) Solar ( ) Reason: ………………………………………

(c) Gasifier ( ) Reason: ………………………………………

Any water right conflict that could arise from the implementation of the scheme should be mentioned here.

If other conflicts are foreseen, these should be stated here.

4. Site Information

How was the site reached?

…………. hours/days walk from road head. Name of road head: ………………

………… hours/day walk from airfield. Name of airfield: ………………………..

Time for loaded porter to reach the site form……… road head /airfield

………… hours /days

Comment if other site information is different than in preliminary feasibility study:
………………………..………………………………………………………………
………………………………………………………………………………………..

5. Technical Specifications

Fill in all of the technical information and provide appropriate comments as necessary, especially in the slope stability issues.

Source stream: …………………. Intake location: ………………

Elevation: ………………….. masl

Headrace: Open canal lengths & corresponding chainages: …………..……..

Headrace pipe lengths & corresponding chainage: ………….

From m………………………………………………

Unstable lengths requiring stabilization: ……………m

Gravel trap: Location: ………………..m, the from intake

Flushing location & description:

Are ground protection measures required? Yes( ) No ( )

Settling basin: ……………………..m, from the intake

Flushing location & description: …………………………………….

Are ground protection measures required? Yes( ) No ( )

Forebay: …………………m, from the intake

Flushing location & description: …………………………………………..

……………………………………………………………………………………

Are ground protection measures required? Yes( ) No ( )

Penstock: Total length: …………..m; No of Vertical bends: ……………

No of Horizontal bends: ……………Gross head, **H_{gross}:** ………………….m.

Powerhouse site: Description of location: ………………….……………..

………………………………………………………………………………………

Elevation: ………………. masl; ……. m above annual flood level of the river.

Distance from powerhouse to river bank / tailrace exit point: ……………….. m

Are ground protection measures required at powerhouse?

Yes ( ) No ( )

Transmission and distribution line: Length:…………………..m

Will part of the scheme alignment or some structures have to be located on private land? Yes ( ) No ( )

If yes, specify alignment/structures that will have to be located on private land: ………………………………………………………..

Is (are) the land owner(s) willing to have the alignment/structures on their land? Yes ( ) No ( )

Comments: ………………………………………………………………………

……………………………………………………………………………………

Comments on significant changes that have been made form the pre-feasibility survey: …………………………………………….

6. Hydrology

Measured flow at intake, **Q_i =** …………………. l/s

Method used to measure the flow: ………………………………

(Attach data sheet & calculations)

Date of flow measurement: ……………………………………

If there are water diversions (e.g., irrigation) close to the intake. i.e. within 2 hours walking distance, the flow diverted at these locations should also be measured and used to determine the 11-month exceedance flow based on MIP.

Upstream flows abstraction (if any), Q_{up}: ………………………… (l/s)

Specify water use (drinking water, irrigation etc): irrigation…….

Downstream water use: Q_d: ………… (l/s),

Specify water use (drinking water, irrigation etc): ………………………….

Irrigation practices in the area (seasonal, year round, rotational etc.): … Seasonal………………………………………………………………………

11 months exceedance flow based on Q_i + Q_{up} and MIP, **Q_{11}:** ……… (l/s),

Based on the survey measurements and data, state the number of individual bends required along the penstock alignment in the space provided.

Modifications required for multi-purpose projects should be briefly discussed here. For example, if irrigation flows is to be provided from the headrace, its sectional area will have be increased, irrigation outlets may be required at different points along the alignment etc.

Estimate the maximum power available (P_{max}) from the 11-month available flow. The value for the overall efficiency of the system η should be based on the efficiencies of the individual component (e.g., penstock, turbine, generator & transformer).

A general plan from the intake to the powerhouse and tailrace should be drawn at site for comparison with the survey drawings, which would be prepared later. Although, this drawing need not be in scale, the waterway lengths and locations of the structures should be mentioned.

Refer to the CESC Flow Verification Guidelines for the methodology regarding the use of MIP method to estimate the monthly flows. Note that if flows are abstracted upstream of the intake, these should also be measured and included to determine the 11 months exceedance flow calculations based on MIP method.

Similarly, when calculating the 11-month available flow for power generation, the upstream abstraction and the downstream demands should be deducted.

11 months available flow, $Q_{avail} = \mathbf{Q_{11-}} - (Q_{up} + Q_d)$ l/s

Will there be any water right conflict due to the implementation of the scheme? Yes ( )   No ( )

Comments on water right issues: none…………

Other possible conflicts due to the implementation of the scheme: none

7. Multipurpose Projects

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

Yes ( )   No ( )

If yes, besides power generation, other uses are:

Irrigation ( )   Drinking water ( )   Others (specify): ………………

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

Tailrace water can be used for irrigation..……………………………………

8. Installed Capacity and Layouts

Estimated maximum available power:

$\mathbf{P_{max} = \eta \times (H_{gross} \times Q_{avail})/100}$ = ………………… kW

Draw a general sketch (plan) of the scheme from the intake to the tailrace (i.e., birds eye view) in the box below;

Draw a general layout plan of the transmission/distribution areas from the powerhouse;

If multiple use of water is possible (i.e., multipurpose projects, the details should be provided here. Note that given the site conditions to the extent possible multipurpose projects should be proposed so that the water resources can be optimally used. Furthermore, the current AEPC policy is favourable to multipurpose projects as the cost ceilings for subsidy are not applicable for such cases.

Any water right conflict that could arise from the implementation of the scheme should be mentioned here.

If other conflicts are foreseen, these should be stated here.

Include names of all villages (or wards), distances and corresponding number of houses that are proposed to be electrified

Estimate the average power requirements per household and lighting hours based on discussions with the community and the power output possible given the flow and head conditions. The probable lighting hours (morning and evening) should be stated in the space provided.

Similarly, a sketch of the transmission / distribution line should be included in the box provided.

8.1 Villages to be electrified

Name of Village	Location from Powerhouse (km)	No. of Houses	Nos. to be included
Total households to be included in the MHP, **B =**			

Daily electricity supply time: from ……………AM to ……………AM

………… PM to …………….PM

Total hours/day:

Average subscribed power, **F =** …………… watts/household

Name of the farthest village, from the powerhouse, to be electrified: ……………………………

Distance of this village to the power house = ………………..km

Nearest Villages from powerhouse excluded from electrification:

Name	Location from MHP Site	No of Houses
Total households in non-participating villages, $\mathbf{A_n}$ =		

Domestic Loads:

Total probable domestic load = (**F** x **B**)/1000 = **G =**…………….. kW

Compared to the pre-feasibility study, has this probable domestic load increased or decreased.? …………………………………

Reasons / Comments: …..…………………………………….…….….………..……….

The total probable domestic load is calculated by multiplying the total number of households to be electrified

9. Electricity Market

Electrically driven end uses:

S.N.	Description	Location	Name & Address of the Entrepreneur	Expected Operating Time (am/pm)	Power Required (kW)
1					
2					
3					
4					
Maximum power required for business load, $\mathbf{J_1}$ = **(Add only if operating time coincide)**					

Mechanically Driven end uses:

S.N.	Description	Location	Name & Address of the Entrepreneur	Expected Operating Time (am/pm)	Power Required (kW)
1					
2					
3					
4					
Maximum power required for business load, J_2= **(Add only if operating time coincide)**					

Note: *All business loads should generally be operated during non-lighting hours. Maximum business load should be limited to total domestic load.*

Additional business likely after 3 years:

Type of Business	Location	Power kW	Comments

Peak load (M_p) on the system should generally be equal to the total probable domestic load (G) calculated earlier. In the exceptional case if the peak load is different such as due high end uses these should be explained and the financial viability justified in the report as discussed earlier.

Design plant capacity should be calculated by adding 25% to the peak load. This allows for 10% transmission/distribution losses and 15% for future requirements such as increased household power demands and additional connections.

Compare $\mathbf{M_d}$ with the available maximum power, $\mathbf{P_{max}}$, on Section 4. If $\mathbf{M_d}$ is greater than $\mathbf{P_{max}}$ the system needs to be re-designed by decreasing the number of households to be electrified and/or the average household subscribed power. Another possibility is to deduct the 15% power allocated for future expansion.

Note the end point of the NEA grid nearest to the site and the direct distance (not the walking distance) to this point from the site. Also comment on any known proposals to extend the grid in a direction, which brings it closer to the site for the next 5 years, how close, this will bring it to the scheme site, and the source of the information. Comment, if necessary on the reliability of this information.

10. Total System Loads

Total probable load on system:

Peak load on the system = $\mathbf{M_p}$ **=………………..** kW

$\mathbf{M_p}$ **should generally be equal to G.**

Explain if M_p is different than G: ……………………………………

…………………………………………………………………………….

Design plant capacity of the project = $\mathbf{M_p + 0.1M_p = M_d}$ = ……… kW

Comments: …………..………………………………….……….…………

Is $\mathbf{M_d}$ less than or equal to estimated maximum power, $\mathbf{P_{max}}$**?**

Yes( ) No( )

If yes, $Q_{design} = 100 \times M_d / (H_{gross} \times \eta)$ = ……………… l/s

If No, decrease the number of households to be electrified, average subscribed power, and/or deduct 15% allocated for future expansion.

$\mathbf{M_d}$ **= …………….** kW

$Q_{design} = 100 \times M_d / (H_{gross} \times \eta)$ = ……………… (l/s)

Based on discussions with the community members, developer and the entrepreneurs, the end uses should be fixed. Then the power requirements of these end uses as well as the operating time should be estimated. The maximum power required for business load should be calculated by adding the individual business loads only if the operating hours coincide. Thus the combinations of various loads may have to be calculated to determine the maximum business load. Depending on whether the proposed business is mechanically or electrically operated, the tables above should be filled in accordingly.

Note that the business loads should generally operate during the non-lighting hours and the maximum business load should be limited to the probable business load. Financial viability should be demonstrated if the business loads exceed the peak domestic load.

If there are possibilities for additional end uses that could be developed after 3 year, these should be included in the table above.

11. NEA Electrical Grid

Nearest NEA grid point: ……………..Distance from site: ………….. km

Plans to extend the grid in this direction in the next 5 years?

Yes( ) No ( )

To where? ……………………… How far from site? ………. km

Source: ……………….……………………………

Comment: ………………………………………….

List other mini/micro-hydro plants and mills within a 5 km radius or 2-hours walk from the powerhouse, whether diesel or water powered. Note the distance from the MHP powerhouse to the mill in approximate minutes of walking time for an average local person carrying a load of grain. This information may be available from secondary sources such as the "Micro hydro data of Nepal" in which case they should be verified during the site visit.

12. Other MHPs in Area

Location	Size (kW)	Distance (km)	Monthly Tariff (Rs./watt)	Comments

Note the monthly tariff charged for electricity at each MHP, which provides electricity. If the tariff is a multi-level tariff note the rate common to the greatest number of consumers and provide details of other rates in the comments section. Note also the milling tariff for the grains shown.

13. Estimated Electrical Income

Proposed household electricity tariff, T_f:……………….. Rs/watt/month

Probable monthly income from household tariff,

$S_1 = B \times F \times T_f$ =………… Rs/month

End use income estimate from sales of electricity/power

S.N.	Type	Operating hours/day	Power required (kW)	Energy consumption/ year (kWh)	End use tariff (Rs/kWh)	Yearly income (Rs)
1						
2						
3						
4						
5						
			Total			

Total income from end uses, S_2 = ……………………….. **Rs./yr**

Comment: …………………………………………………………………

14. Agro-processing Market

Is milling to be provided in this MHP scheme? Yes ( ) No( )

If milling is to be provided as part of the MHP scheme, tick the "Yes" box and complete this section.

14.1 Agro-processing Mills in Area

List all mills, whether diesel or water powered, within a 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
1			
2			
3			
4			
5			
6			

List all mills, whether diesel or water powered, within a 5 km radius or 2 hour walk of the power house. Note the distance from the MHP power house to the mill in approximate minutes of walking time for an average local person carrying a load of grain, eg. 30 mins.

Consideration must be given to the effect of other mills nearby and the likelihood that existing mills will continue to be patronised unless the proposed MHP is more convenient or offers cheaper milling rates.

14.2 Monthly Milling Income from the scheme

Column	1	2	3	4
Grain	Monthly Milling Volume	Rate Rs./ Pathi	Monthly Income 1 x 2	Comments
Rice	V_r =	R_r =		
Maize	V_m =	R_m =		
Wheat	V_w =	R_w =		
Millet	V_l =	R_l =		
Oilseed	V_o =	R_o =		
Other ……..	V_x =	R_x =		
Total milling income, S_3 =				Rs.

Comment: ……………………………………..……………………………...
………………………..…..…………………………….…..….……….………

Total the production likely to go to this mill from all villages, V_r, V_m, V_w, V_l, V_o and V_x. These are the totals, which will be used to estimate milling income of the scheme. The milling rates should be based on the prevailing rates in the nearby schemes and discussions with the community, developer and the entrepreneurs.

Total all the individual grain milling incomes to give a total monthly milling income, S_3.

When calculating the total estimated income add the income from sales of electricity to households (S_1) and sales of electricity to business loads (S_2) if the businesses are owned by other entrepreneurs and not the developer. This is because the entrepreneur does not hand over the income from the end uses to the developer
If the developer owns the end uses, then add the income from sales of electricity to households (S_1) and the income from the operation of businesses (S_3) but not the sales of electricity to the businesses (S_2) because the developer does not need to pay for the electricity that is consumed from his power plant.

15. Estimated Total Income

Total probable monthly income from MHP:

$S_t = S_1 + S_2$ = Rs …………………… if the milling & other end uses are operated by the entrepreneurs other than the developer

$S_t = S_1 + S_3$ = Rs… ……….……… if the milling & other end uses are operated by the developer

Note that while calculating the total monthly income, the sales of electricity to end uses and the income both should not be added.

16. Enabling Environment

Item	Excellent	V. Good	Good	Fair	Poor	Comments
General interest in MHP in this place						
Understanding of dangers of electricity						
Understanding about paying for electricity						
Understanding about tariff structure						
Understanding of need for repair fund						
Understanding about end use possibilities						

Other Comments: ……………………..………………………………………..
…………………………………………………………………………

Rate the interest and understanding of plant owner / UC chairperson / local project lead person, have in micro-hydro plants in general. Also rate:-

- the general understanding of the dangers of electricity and precautions needed to be taken, eg. repair only by qualified tradesmen, keep children away, don't touch wires together, use proper plugs
- the concept of paying for electricity consumption (ie. the need to cover the costs involved in producing electricity - operators salary, repair and maintenance, depreciation etc.)
- the proposed tariff structure, ie. do people understand that different levels of electricity subscription will have different rates and why
- the understanding of the need to establish an equipment maintenance fund to cover recurring maintenance, future repairs and eventual replacement of machinery
- the local interest in end use possibilities (milling, small industries such as metal fabrication, noodles, fruit drying, bakery etc.) rather than being satisfied with lighting only
Comments should be made whenever interest or understanding is rated "Excellent", "Fair" or "Poor".

17. Management

17.1 Proposed ownership

Note the type of ownership proposed for the scheme; Private means the local equity is totally provided by an individual and the individual also organises any loan component, the MHP will be operated as a business for profit; Company means a group of private individuals organising together to operate the MHP as a business for profit; Cooperative means a group of communities organizing together to operate MHP as both business & cooperative manner; Community means a group representative of the community to be served by the MHP collects the equity and organises the financing of the MHP and will operate it on behalf of the community. Also include proposed name of managing organisation if known.

Private ( ) Company ( ) Cooperative ( ) Community ( )

Proposed Name of project: ……………………………………………….

Name of Owner: ……………………..

Comment: ……………………..………..………………………………………..

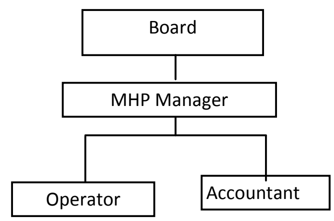
17.2 Key People in proposed plant

List the key people involved in the project and their role (e.g., developer, entrepreneur etc.)

Name	Role in the proposed MH Plant	Comments

17.3 Probable organisational structure

Draw a simple sketch of the proposed organisational structure, eg.



Estimate the level of entrepreneurial ability of the management compared with other business people of the area.

Entrepreneurial spirit level:- High( ) Medium( ) Low ( )

Assess the anticipated level of community participation in the MHP scheme, i.e. is the community involved in setting the tariff rate, making policy decisions? such as how to punish payment defaulters etc. Comment as necessary.

Planned community participation level:

High( ) Medium( ) Low( ) None( )

18. Socio-economic Details

18.1 Agricultural Products / Natural Resources

List the main products of the area, both agricultural and other natural resources ,e.g., forestry. The project area should include the distribution area or the MHP and up to 2 hours of walk form the agro processing units. Some of the main agricultural products common to rural areas of Nepal are already listed. Note the annual production of the product in the market area and the units being used, eg. muri, pathi, kg., litres. Note conversion factor of pathi into kg in the area.

Compare the annual production figures of this table with the monthly milling volume estimated earlier. The values here should not be less than the annual milling volume estimated to be processed from the proposed MHP.

Product	Units	Annual Prod.	Comments
Rice			
Maize			
Wheat			
Millet			
Oilseed			
Buckwheat			
Potatoes			
………….			
………….			

Note: **1 pathi (local) = 3 kg, 1 muri= 20 pathi**

Ethnicity and Social information of the beneficiaries (use additional sheets if necessary)

क.सं	उपभोक्ताको नाम	लिङ्ग (म/पु)	गा.वि.स	जिल्ला	जात/ जनजाति								वर्ग				सामाजिक स्तर					शारिरीक अवस्था		कैफियत
					त.द	द	त.ज	ज	ब्रा/क्षे/ठ	म	मु	अ	अ.ग	ग	म	स	ए.म	बि.पि	लो.ज	पि.व	द्व.पि	शा मा	एच.आई.भी	

शव्दावालिहरु

जात/जनजाति

त.द.	तराई दलित
दलित	पहाडि दलित
त.ज.	तराई जनजाति
ज.	पहाडि जनजाति
ब्रा./क्षे./ठ.	ब्रामण/क्षेत्री/ठकुरी
म.	मधेशि
मु.	मुशलमान
अ.	अन्य नेपाल सरकारले पहिचान नगरेका जातजातिहरु

सामाजिक स्तर

ए. म.	एकल महिला
बि.पि.	बिपत्ति पिडित
लो.ज.	लोपोन्मुख जनजाति
पि.व.	पिछडिएका वर्ग
द्व.पि.	द्वन्द पिडित

शारीरिक अवस्था

शा.मा.	शारिरीक / मानसिक अशक्तता
एच.आई. भी.	

वर्ग

अ.ग.	अति गरीब	३ महिना सम्म खान पुग्ने
ग.	गरीब	६ महिना सम्म खान पुग्ने
म	मध्यम बर्ग	६ देखि ९ महिना सम्म खान पुग्ने
स	सम्पन्न	बर्षभरि पुग्ने

Education Level

Education Level	No. of HH	HH Members	Comments
University			
Plus two			
SLC Pass			
Trade			
Secondary School			
Primary School			
Literate			
Illiterate			
Total			

List the distribution of education level across the market area with both the number of households and the total number of individuals at each level. Levels are:-

- University - completed a degree course
- Plus two – has passed plus two or intermediate level.
- SLC Pass - has passed SLC exam.
- Trade - has recognised trade for which they have studied or been apprenticed, eg. auto mechanic, machinist, electrician, goldsmith, tailor
- Secondary school - has completed some years of secondary school
- Primary school - completed primary school
- Literate - can read and write
- Illiterate - cannot read and write - includes infants below school age

The total households will not be the same as $\mathbf{A_i}$ because most households will have more than one education level

Energy Source

Energy Source	Unit	Rs. per Unit	Conversion to kg or litre or kWh or Wp	Comments
Firewood				
Kerosene				
Solar Home System				
LPG				
Pico hydro/ Peltric set				
Others - specify				

List the rates for major energy sources in the project area. Also note the units used, eg. bari for firewood, litre etc. and convert these to more conventional units such as kg for firewood and litre for kerosene. Cost per unit for the resource in the market area should include transport costs into the area.

Facilities

Facilities	Y	N	Distance from MHP	Comments
Post Office				
Primary School				
Lower Sec. School				
Higher Sec. school				
Plus Two School				
Health Post				
Bank				Type …...……………….
Police post				
Rural Municipality office				
Cooperative				
Mill				
Telephone				
Agro Business				
Other…				

Check “Y” or “N” (for yes or no) against the facilities found in the market area and note the distance from the MHP power house. Add any other important facilities in the area.

If there is a phone in the region list the phone number in the space provided.

Miscellaneous

Average household land holdings in area: 10 ropanies

Number of households migrated into the area in last 12 months: No …..

Reasons: ……………………………………………………………………………

Number of households migrated out of the area in the last year: ……….

Reasons: ……………………………………………………………………………

………………………………………………………………………………………

NGOs or GOs in area:

What are they doing? …………...

………………………………………………………………………………………

Status and role of women: Positive, Participative

Interest of women in the MHP: very positive, supportive………………….....

..……………………………………………………………………………………

Local strengths / skills: …………………………

………………………………………………………………………………………

Tourist potential in area, Yes( ) No( ) ………………………………

Other Comments, if any: ……………………………………………………….

……………………………………………………………………………………….

List any Govt. Organisations or NGOs working in the area, and note the type of work they are doing, eg. drinking water installation, non-formal education, community development etc

Comment on the status of women in the market area and what roles they occupy in community life. Note any prominent leadership positions by women.

Note also the general interest shown by women in the coming of a MHP - are they supportive? Why or why not.

Comment on strengths or skills in the community, which are under-utilised or can be used more for community development.

Note if there is any tourism potential for the area and comment as necessary.

Note here any other comments related to socio-economic matters which could affect the project or be useful as baseline information in determining the impact of

19. Rates applicable at the project area

Local Material Rates

Description	Unit	Rs./unit	Comments
Sand			
Block stone			
Bond stone			
Coarse aggregate			
Wood			
Unskilled labour	Md		
Mason	Md		
Carpenter	Md		
Technician	Md		
Kerosene	litre		
Diesel	litre		
Cement	Bag		

Transportation Rates

Type	Unit	Rs./unit	Comments
Truck/tractor			
Mule - easy load - difficult			
Porter - easy load - difficult			
Public transport			
Hired vehicle			
Plane			
Helicopter			

Nearest major supply market for the project: …………………………………

All weather road-head of the project site: ……………………………………

Fair weather road-head of the project site: ……………………………………

Note that the transport rate for a truck or tractor is to bring material/equipment from the nearest major supply town to the roadhead. Give rates per kg. if possible

For mules and porters the rates given should be for transport from the roadhead to the MHP site. Note different rates for easy and difficult loads if a local distinction is made. If possible, rate units should also be kg here.

Rates for plane and helicopter transport should only be given if this is the most inexpensive form of transport to site, or there are special circumstances. Comment as needed.

Add other important rates in the space provided if considered necessary.

Estimated Annual Operation and Maintenance cost

Operating costs	Amount/month (RS)	Comments
Salary - manager		
Salary – operator 1		
Salary – operator 2		
Salary – accountant		
Salary – others		
Salary – others		
Office expenses		
Miscellaneous		
Total monthly operating cost		

Annual Operating costs: Rs …………………………

Estimated annual maintenance cost: ………% of total project cost

Rs. …………………………..

Total operation and Maintenance cost: **Rs. ………………………..**

List the human resources costs required to run the plant. Note that the manpower of MH plants is also based on the size of the plant and the distribution area covered.

All salaries of people employed by the MHP - manager, operators, accountant should be estimated based on nearby MHP plants or the prevailing rates in the community for similar type of work (e.g., school teacher, government employee etc.)

If this is a community owned scheme based on discussions at site, state also the cash contribution by participating households as well as the labour contribution in terms of person days as well as in rupee amount.

Since the project cost will be determined at a later stage the loan amount cannot be fixed at site. However, the survey team should inform the developer that there may be a need for a bank loan if the subsidy and the equity amount are less than the total project cost.

20. Equity contribution by developer and loan requirements:

Cash contribution: Total Rs……………………………

And Rs. ………………../household if Community owned

Labour contribution: ……….. persons/day= Rs…………………

In case of insufficient funds the developer will:

✐Increase the equity contribution to meet the balance

Withdraw a bank loan for the balance

Net Present Value (NPV) of investment at ……% rate and 15 years of plant life is: Positive ( ) Negative ( )

NPV value is Rs: ………………………………

Based on the total equity for the project, annual O & M costs, 4% discount rate and 15 years of economical life, calculate the net present value (NPV) of the equity. A spreadsheet program has been provided for this purpose. Note that the total equity should include both "cash" and "labour (kind)" contributions. The conversion of labour contribution into cash value should be made based on the prevailing labour rates of the site.

21. Environmental and Social Aspects

21.1 Please mark the area having adverse impact by the project implementation

(Applicable to Mini/Micro Hydro above 10 kW capacity kW)

A. Protected area ( ) B. Community forest ( )

C. Government forest ( ) D. Religious forest ( )

E. Leasehold forest ( ) F. Private Forest ( )

G. Cultural heritage/religious site ( ) H. National park ( )

I. Buffer zone ( ) J. Conservation Area ( )

K. Area used by indigenous people ( ) L. Wildlife Sanctuary ( )

M. Wetland ( ) N. Unique or aesthetically valuable land or water form ( )

O. Range of endangered or threatened animals and birds ( )

P. Not any ( )………………………………

Please brief in short about the tools and procedure used to determine the impacts.

…………………………………………………………………………………………….
…………………………………………………………………………………………

21.2 Project impact on biodiversity conservation & sustainable management of living natural resources. (Applicable to Mini/Micro Hydro above 10kW capacity)

SN		*Yes*	*No*	*If Yes, action for reducing risk*
1.	*Short -term construction impacts such as soil erosion*, deterioration of water and air quality, noise and vibration from construction equipment			
2.	Disturbance of large areas due to material quarry			
3.	Impounding of a long river stretch			
4.	Dryness (less than 50% of dry season mean flow) over a long downstream river stretch?			
5.	Construction of permanent access road near or through forests			
6.	Clearing of large forested area for ancillary facilities and access road			
7.	Creation of barriers for migratory land animals			
8.	Loss of precious ecological values due to flooding of agricultural/forest areas, and wild lands and wildlife habitat; destruction of fish spawning/breeding and nursery grounds?			
9.	Deterioration of downstream water quality due to anoxic water from the reservoir and sediments due to soil erosion			
10.	Loss or destruction of unique or aesthetically valuable land or water forms			
11.	Loss of productive land			
12.	Is there a landslide exposure risk to Micro/Mini Hydro Component			
13.	Will tailrace and overflow be routed so as to not cause erosion damage			

21.2.1 Please rate the likelihood consequences of the impacts

A. Insignificant ( ) B. Minor ( )

C. Moderate ( ) D. Major ( )

E. Critical ( )

For the purpose of siting of project components, give preference to the lands that are already converted or degraded or are not significant from the biodiversity or agro-biodiversity point of view.

Local residents of the project area are informed well before the project is commissioned regarding the placement of project structures and alterations proposed to the natural environment and developer has received consent for that also. Rate any flood risks that may occur with particular attention to past history of floods. If any past flood would have caused damage to any of the proposed MHP structures listed,

Note the availability of local people or people who are currently living away from the area but willing to return if a suitable opportunity arises with managerial and/or business operation experience, eg. have successfully operated a small business. Note if a person has already been selected to manage the scheme and the type of experience they have had. If someone has not already been selected comment on how they will be selected. Also note down whether training requirements are essential for the manager and operators (if already identified) and briefly describe the type of training required.

21.3 Project impacts on Human Rights

(Applicable to Mini/Micro Hydro above 10 kW capacity kW)

SN	Projects impacts	Yes	No
1.	Disproportionate impacts on the poor, women, children or other vulnerable groups		
2.	Uncontrolled human migration into the area due to sub-project		
3.	Adverse impacts on enjoyment of the human rights of the affected population and particularly of marginalized groups		
4.	Opportunity provided to local communities or individuals to raise concerns regarding the project during the stakeholder engagement process		
5.	Impact on livelihood of vulnerable group of people or community		

Strictly avoid projects that involve any sort of "livelihood threat" to the local communities reliant on specific natural resource and the specific community is not willing to give up using those resources.
Strictly avoid projects that involve any sort of demolition or relocation of physical resource that holds cultural, historic or ethnic significance and the community using it don't give consent for that.
If the natural or physical resources discussed above are noted, the community shall be informed about the changes expected after project implementation, anticipated impacts and compensation measures. Once the specific community provides consent for that it shall be documented separately as the "Vulnerable Community Development Plan" and the project implementation unit shall acknowledge it separately.

21.3.1 Please rate the likelihood consequences of the impacts

A. Insignificant ( ) B. Minor ( )
C. Moderate ( ) D. Major ( )
E. Critical ( )

21.4 Capacity Building

1.	Are the local people available in the project area have business skill or managerial skill?		
2.	Are the local people available in the project area with technical/mechanical repair skills		
3.	Does the human resources available in the project needed any type of capacity building trainings?		
4.	Will the manager and operator for the project selected through Community decision?		
5.	Has the project selected the manager and operator needed for the Project?		

Note : If the project manager and operator are already selected, please state the Name and Experience of the selected candidate as well describe the type of trainings required for the selected candidates

Name of selected Manager: ………………………………… Experience……………………..

Name of selected operator1: …………………………………Experience……………………..

Name of selected operator2: …………………………………Experience……………………..

Trainings any………………………………………………………………………………………

21.5 Impacts on labour and working Conditions.

(Applicable to Mini/Micro Hydro above 10 kW capacity)

SN	Project Impacts	Yes	No
1.	Risks and vulnerabilities related to occupational health and safety during project construction and operation		
2.	Project potentiality of requirement of migrant workers to construct or implement it		
3.	Social conflicts if workers from other regions or countries are hired		
4.	Risk of child exploitation or abuse linked to the project		
5.	Equal wages for female and male workers for same work		
6.	Timely payment		
7.	Insurance for workers		

Ensure ergonomically safe construction works and provide protective gears to the construction workers during work.
Ensure adequacy of basic amenities like safe drinking water, rest-rooms and change rooms.
Employment of staff in a project will ensure the highest level of gender balance to the extent possible.
Ensure there is no discrimination regarding the remuneration of men and women employed for the project in comparable positions. Women are privileged with associated maternity and medical exemptions.

Conduct age verification of the construction worker before employing them for any purpose.

21.5.1 Please rate the likelihood consequences of the impacts

A. Insignificant ( ) B. Minor ( )

C. Moderate ( ) D. Major ( )

E. Critical ( )

21.6 Impacts on Community Health Safety and Security

(Applicable to Mini/Micro Hydro above 10 kW capacity)

SN	Project Impacts	Yes	No
1.	Community health and safety risks due to the transport, storage, and use and/or disposal of materials likely to create physical, chemical and biological hazards		
2.	Risks to community safety due to both accidental and natural hazards during project construction, operation and decommissioning		

Human waste from project sites will be contained at site itself and their surface/sub-surface drainage should be prevented. Construction wastes from project sites will be contained appropriately at site and no leakages to the outside environment are ensured.

21.6.1 Please rate the likelihood consequences of the impacts

A. Insignificant ( ) B. Minor ( )

C. Moderate ( ) D. Major ( )

E. Critical ( )

21.7 Impacts on Land acquisition and involuntary resettlement

(Applicable to Mini/Micro Hydro above 10 kW capacity)

S.N	Projects impacts	Yes	No
1.	Project be constructed in private land		
2.	Project be constructed in public land		
3.	Project be constructed in government land		
4.	Project be constructed in leasehold land		
5.	Other types of land		
6.	Physical relocation of people, more than 100		
7.	Physical relocation of people, 25 to100		
8.	Mode of land procurement - Voluntary		
9.	Mode of land procurement - Involuntary		
10.	Impact on access to natural resources and areas used by Affected Communities resulting in Economic displacement		
11.	Impact on livelihood of land donor		

Strictly avoid projects that involve any involuntary resettlement of the affected families.

Strictly avoid projects that involve any sort of “livelihood threat” due to construction of project structures on the arable land belonging to specific families.

21.7.1 Please rate the likelihood consequences of the impacts

A. Insignificant ( ) B. Minor ( )

C. Moderate ( ) D. Major ( )

E. Critical ( )

21.8 Resource efficiency and pollution prevention

(Applicable to Mini/Micro Hydro above 10 kW capacity)

SN	Project Impacts	Yes	No
1.	Water pollution due to wastewater discharge		
2.	Deterioration of air quality due to air pollutant emission		
3.	Noise pollution		
3.	Solid Waste Management		
4.	Hazardous waste generation		
5.	Reduction of GHG emission due to project implementation		

Natural living resources will be protected to the extent possible. If not, efforts shall be put to recreate the natural environment.

Preventive actions shall be taken towards pollution. If the preventive measures are not possible, pollution arising from the project site will be contained at the site and treatment will be done, if required.

Strictly avoid any project activity that involves GHG emission post project execution.

Strictly avoid project activity that increased vulnerability of a community to the climate induced disasters

21.8.1 Please rate the likelihood consequences of the impacts

A. Insignificant ( ) B. Minor ( )

C. Moderate ( ) D. Major ( )

E. Critical ( )

22. Project categorization based on the potential risk and impact profile

(*Please categorize the project based on above impact profile)*

Category A [ ]

Projects with the potential to cause significant adverse social and/or environmental impacts that are diverse, irreversible or unprecedented. Note: As per Schedule 2 of EPR 1997.

So, as per the above impact profile the project falls on ***Category A,*** *so recommended to conduct Environmental Impact Analysis (EIA) and prepare Resettlement Action Plan (RAP) of the project.*

Category B [ ]

Projects with the potential to cause limited adverse social and/or environmental impacts that are few in number, generally site-specific, largely reversible, and readily addressed through mitigation measures. Note: As per Schedule 1 of EPR 1997.

So, as per the above impact profile, the project falls on ***Category B,*** *so recommended to conduct Initial Environmental Examination (IEE) and prepare Abbreviated Resettlement Action Plan (ARAP) of the project.*

Category C [ ]

Projects that include activities with minimal or no risks of adverse social and environmental consequences

So, as per the above impact profile, the project falls on ***Category C.*** *However the project has minimal environmental impact. To mitigate the impacts and for enhancing beneficial impacts, so recommended to prepare Environmental and Social Management Plan (ESMP).*

A……..

B……

Confirmation from Developer and Surveyor:

User Committee/Developer

Name: ………………………………………….

Position: ………………………………………….

Signature: ………………………………………….

Date: ………………………………………….

Survey Consulting firms:

Name: ………………………………………….

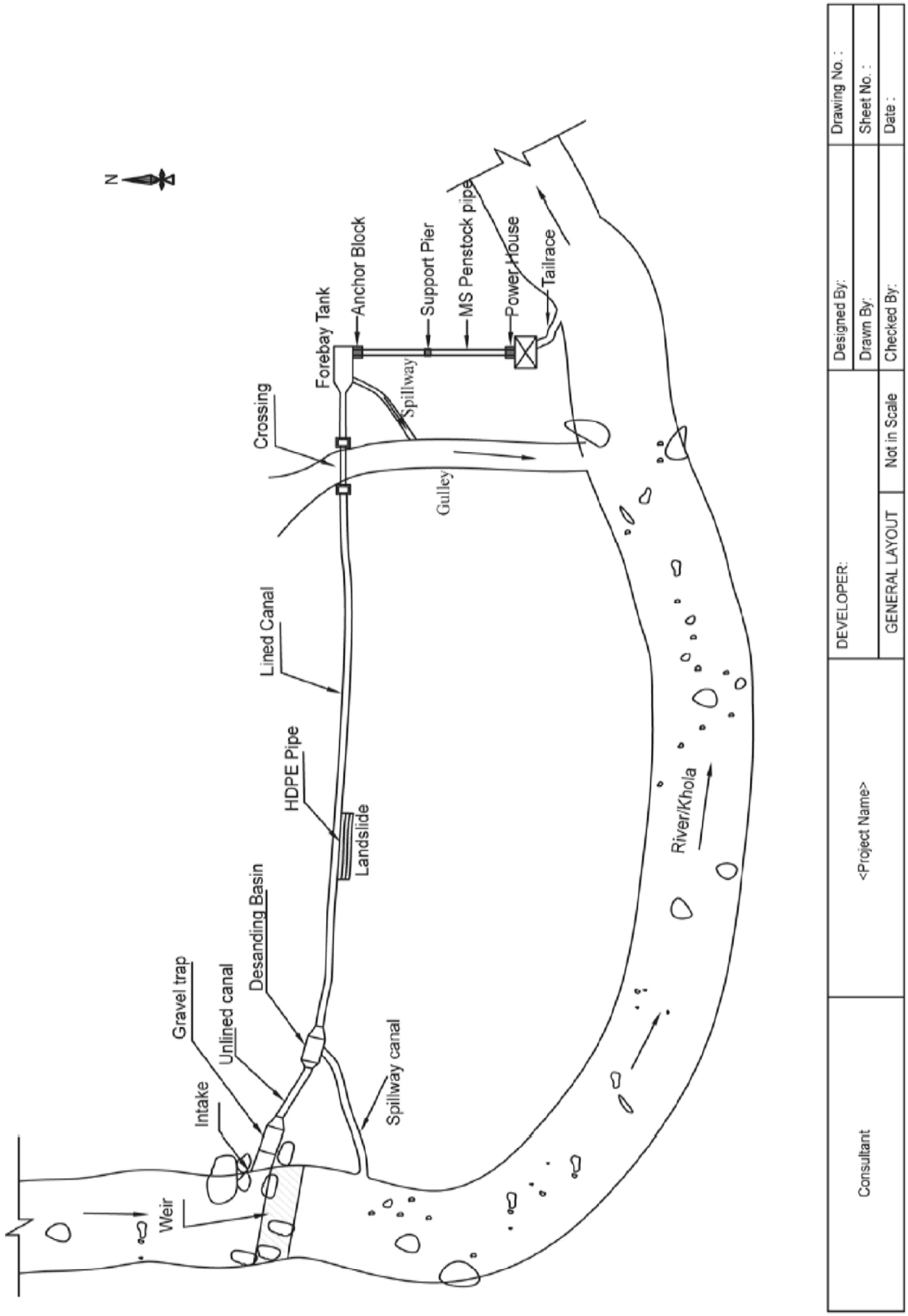
Position: ………………………………………….

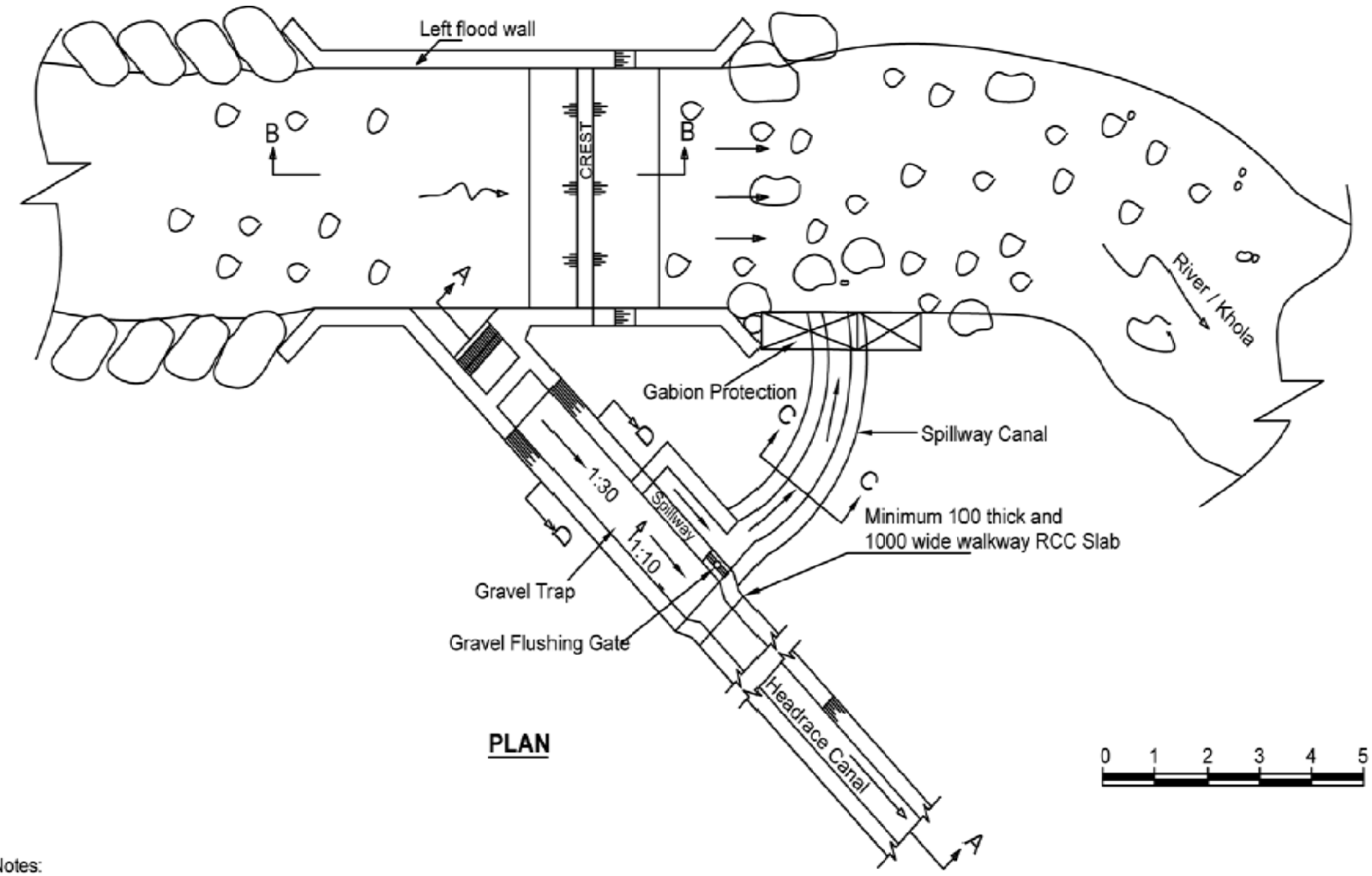
Signature: ………………………………………….

Date: ………………………………………….

Office stamp: ………………………………………….

Appendix C: Typical Drawings of Micro-Hydro Projects


N
Intake
Gravel trap
Unlined canal
Desanding Basin
Weir
Spillway canal
HDPE Pipe
Landslide
Lined Canal
Crossing
Gulley
Forebay Tank
Spillway
Anchor Block
Support Pier
MS Penstock pipe
Power House
Tailrace
River/Khola
Consultant
<Project Name>
DEVELOPER:
GENERAL LAYOUT
Not in Scale
Designed By:
Drawn By:
Checked By:
Drawing No. :
Sheet No. :
Date :

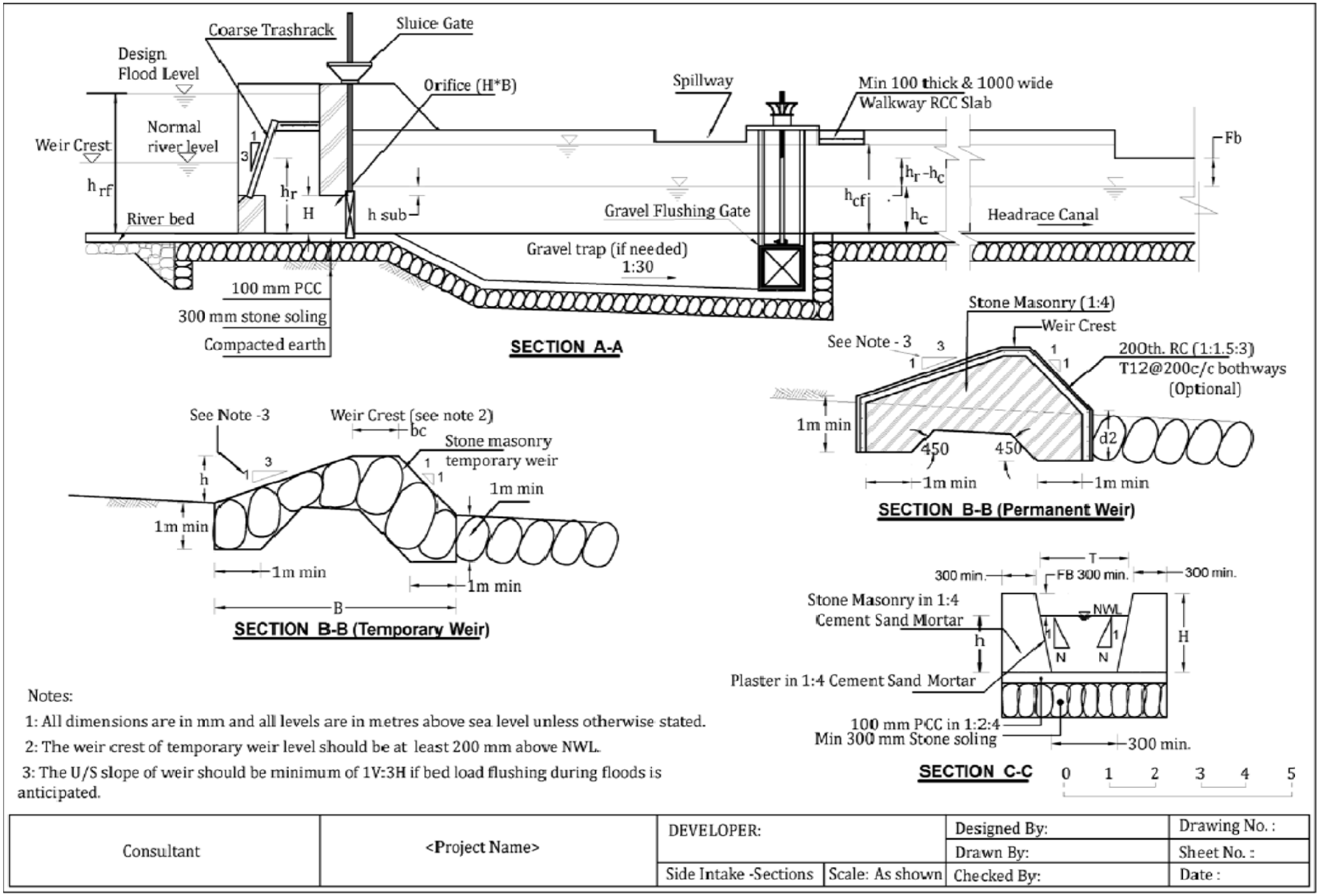


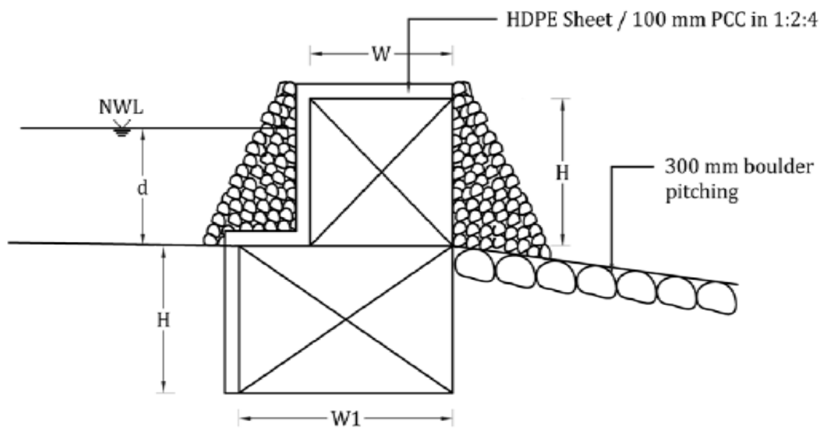
PLAN

Notes:

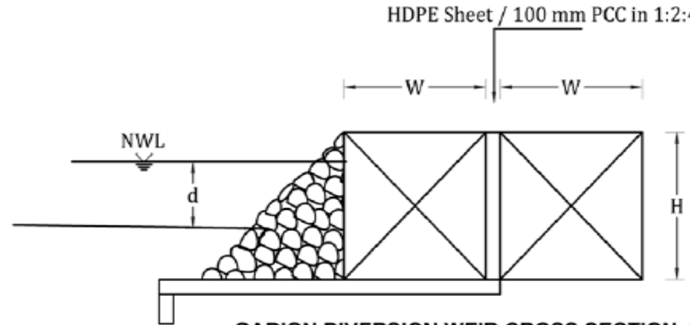
1: All dimensions are in mm and all levels are in metres above sea level unless otherwise stated.

Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Side Intake Plan	Scale: As shown	Checked By:	Date :

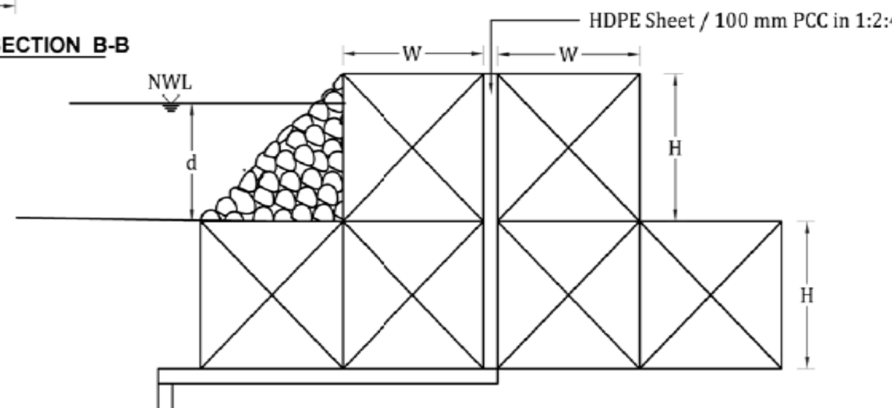

Coarse Trashrack
Sluice Gate
Design Flood Level
Orifice (H*B)
Spillway
Min 100 thick & 1000 wide Walkway RCC Slab
Fb
Weir Crest
Normal river level
h rf
hr
H
h sub
River bed
Gravel Flushing Gate
hcf
hr -hc
hc
Headrace Canal
Gravel trap (if needed)
1:30
100 mm PCC
300 mm stone soling
Compacted earth
SECTION A-A
Stone Masonry (1:4)
Weir Crest
See Note - 3
200th. RC (1:1.5:3)
T12@200c/c bothways
(Optional)
1m min
d2
450
450
1m min
1m min
SECTION B-B (Permanent Weir)
See Note -3
Weir Crest (see note 2)
bc
Stone masonry temporary weir
h
1m min
1m min
1m min
1m min
B
SECTION B-B (Temporary Weir)
T
300 min.
FB 300 min.
300 min.
Stone Masonry in 1:4 Cement Sand Mortar
NWL
h
H
N
N
Plaster in 1:4 Cement Sand Mortar
100 mm PCC in 1:2:4
Min 300 mm Stone soling
300 min.
SECTION C-C
0 1 2 3 4 5
Notes:
1: All dimensions are in mm and all levels are in metres above sea level unless otherwise stated.
2: The weir crest of temporary weir level should be at least 200 mm above NWL.
3: The U/S slope of weir should be minimum of 1V:3H if bed load flushing during floods is anticipated.
Consultant
<Project Name>
DEVELOPER:
Side Intake -Sections
Scale: As shown
Designed By:
Drawn By:
Checked By:
Drawing No. :
Sheet No. :
Date :



GABION DIVERSION WEIR CROSS SECTION B-B



GABION DIVERSION WEIR CROSS SECTION B-B



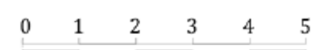
GABION DIVERSION WEIR CROSS SECTION B-B

Notes:

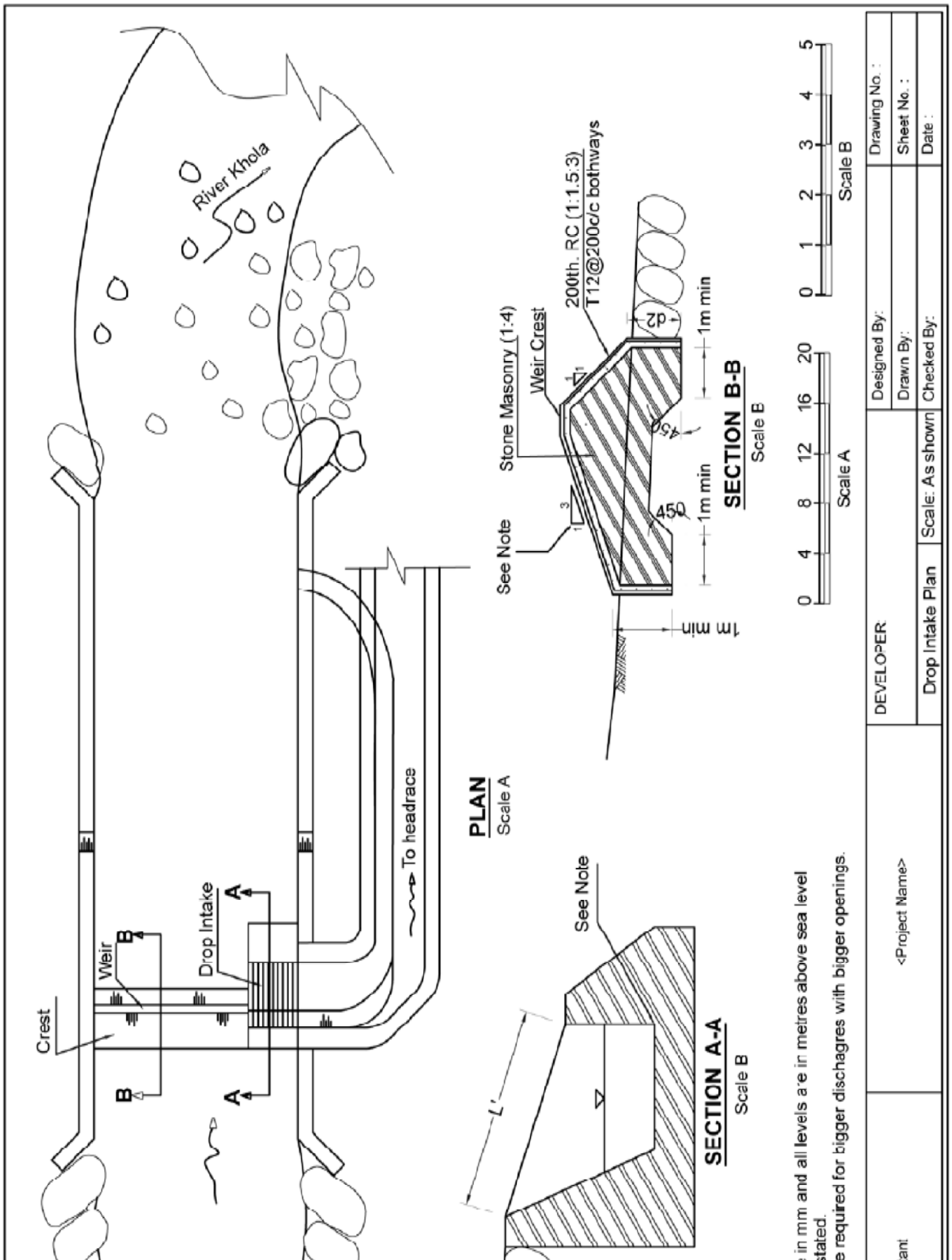
1: All dimensions are in mm and all levels are in metres above sea level unless otherwise stated.

2: The weir crest of temporary weir level should be at least 200 mm above NWL.

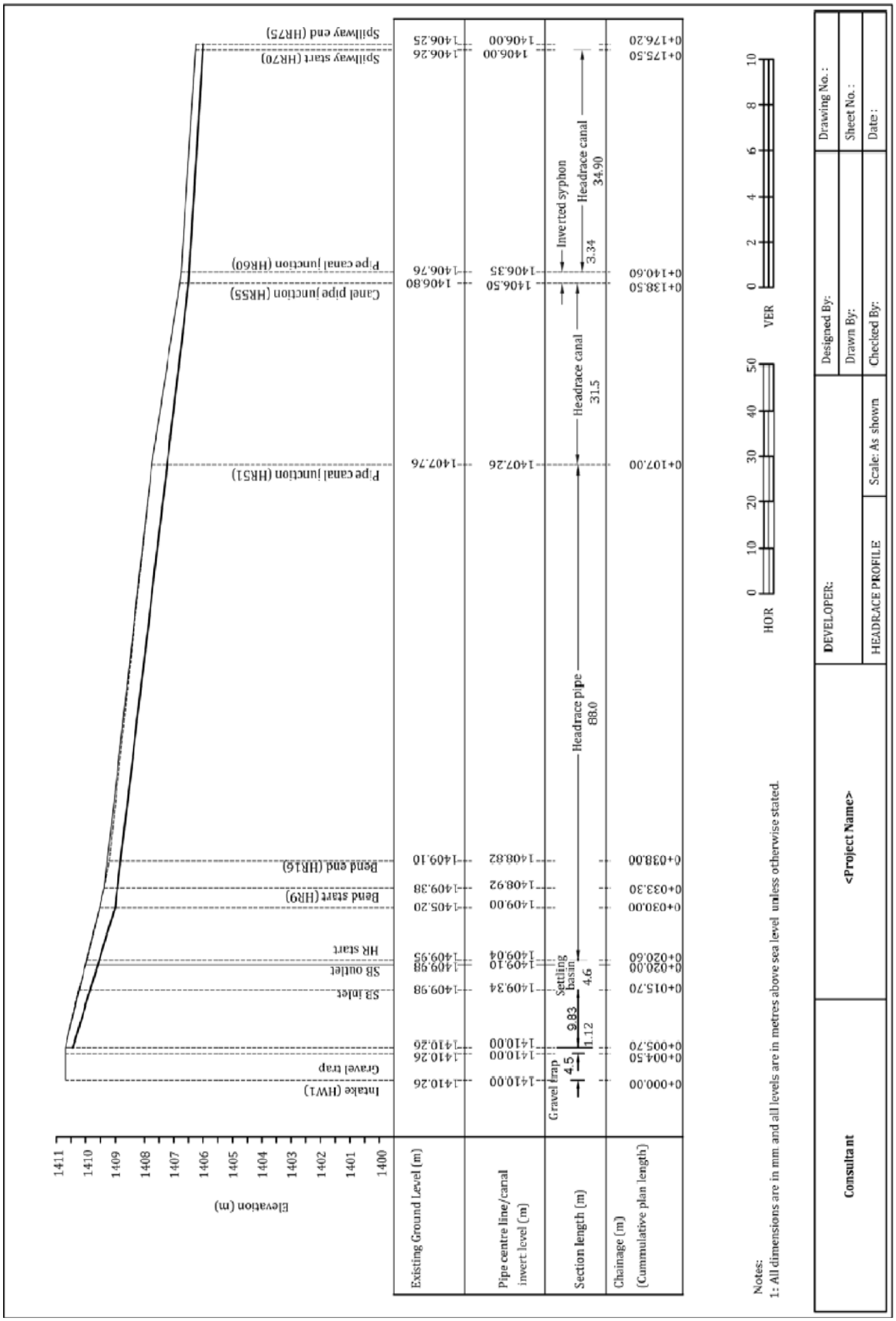
3: The U/S slope of weir should be minimum of 1V:3H if bed load flushing during floods is anticipated.

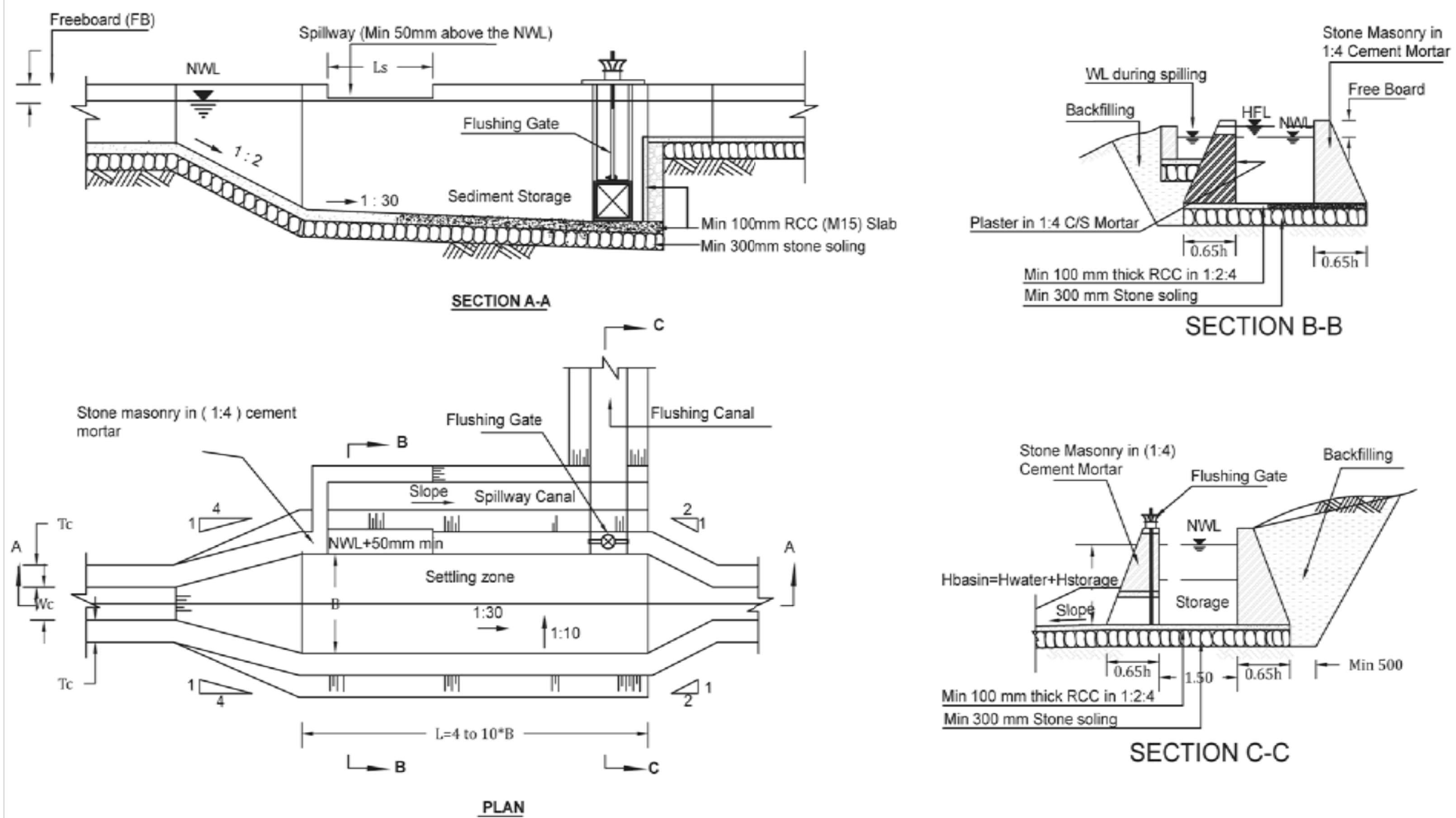


Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Side Intake -Sections	Scale: As shown	Checked By:	Date :



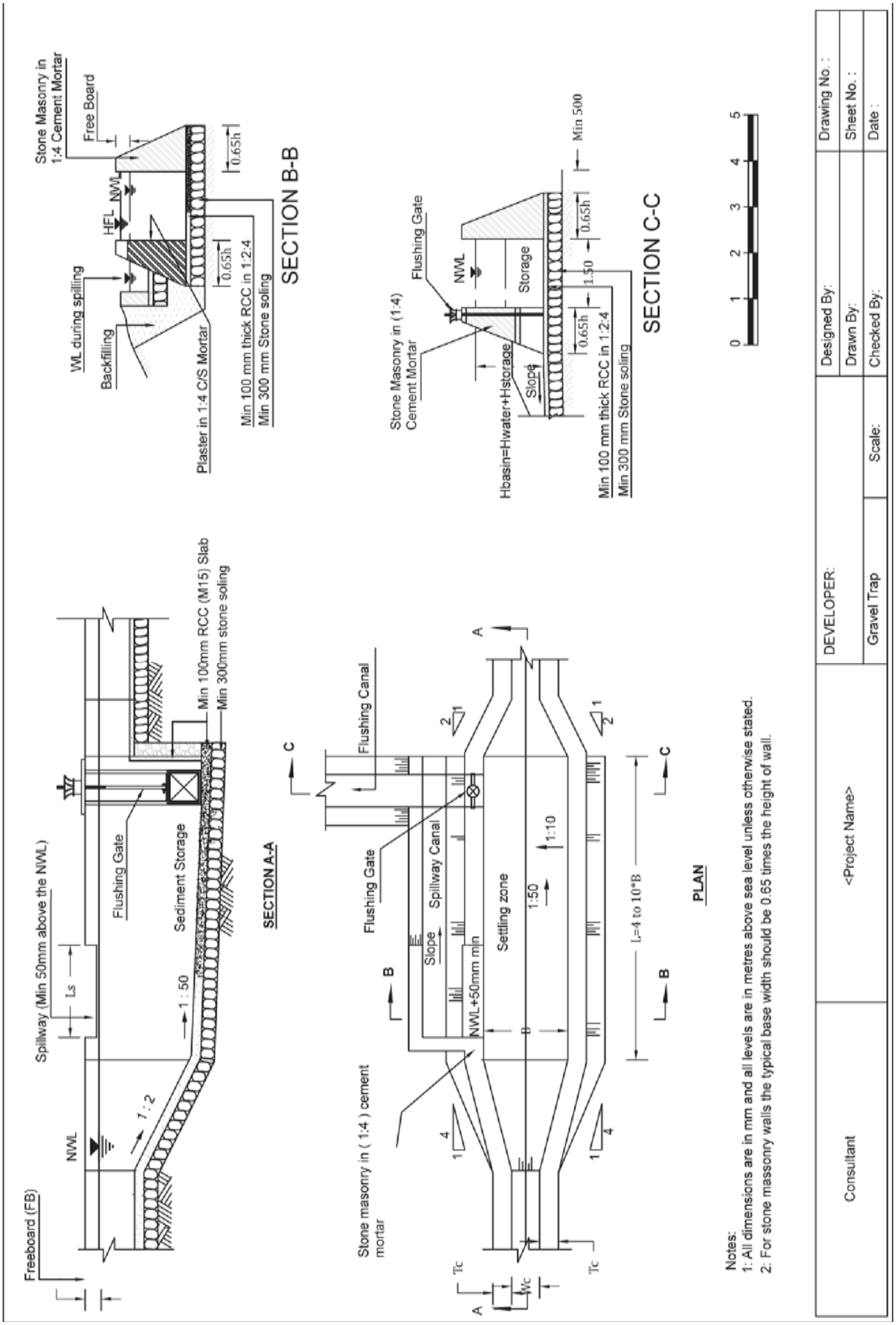
River Khola
Crest
Weir
Drop Intake
B
A
To headrace
PLAN
Scale A
See Note
SECTION A-A
Scale B
L'
See Note
Stone Masonry (1:4)
Weir Crest
200th. RC (1:1.5:3)
T12@200c/c bothways
d2
1m min
450
450
1m min
1m min
SECTION B-B
Scale B
0 4 8 12 16 20
Scale A
0 1 2 3 4 5
Scale B
Notes:
1: All dimensions are in mm and all levels are in metres above sea level unless otherwise stated.
2: Steel lining may be required for bigger dischagres with bigger openings.
Consultant
<Project Name>
DEVELOPER:
Drop Intake Plan
Scale: As shown
Designed By:
Drawn By:
Checked By:
Drawing No. :
Sheet No. :
Date :

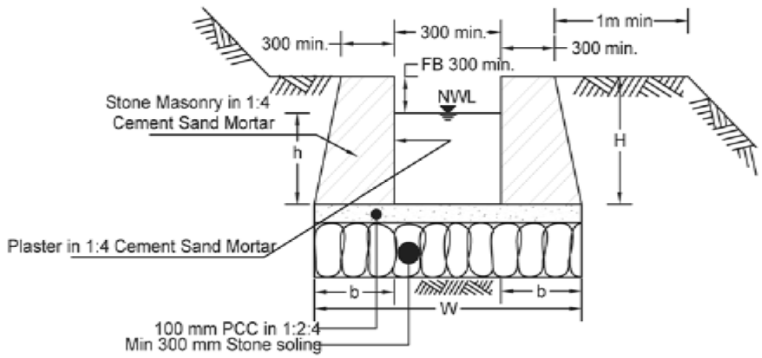

Elevation (m)
Existing Ground Level (m)
Pipe centre line/canal invert level (m)
Section length (m)
Chainage (m) (Cummulative plan length)
Intake (HW1)
Gravel trap
SB inlet
SB outlet
HR start
Bend start (HR9)
Bend end (HR16)
Pipe canal junction (HR51)
Canal pipe junction (HR55)
Pipe canal junction (HR60)
Spillway start (HR70)
Spillway end (HR75)
Gravel trap
Settling basin
Headrace pipe
88.0
Headrace canal
31.5
Inverted syphon
3.34
Headrace canal
34.90
HOR
VER
Notes:
1: All dimensions are in mm and all levels are in metres above sea level unless otherwise stated.
Consultant
<Project Name>
DEVELOPER:
HEADRACE PROFILE
Scale: As shown
Designed By:
Drawn By:
Checked By:
Drawing No. :
Sheet No. :
Date :



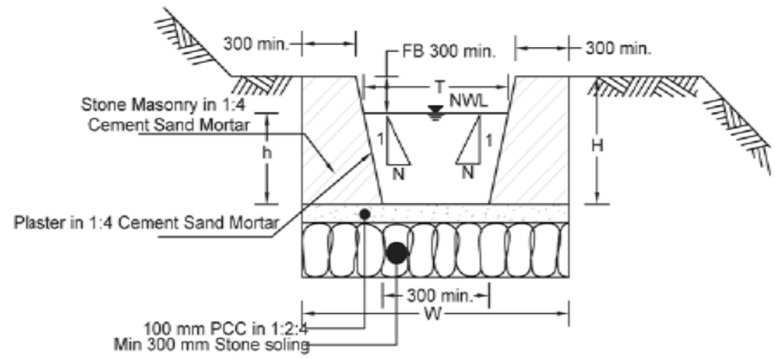
Notes:
1: All dimensions are in mm and all levels are in metres above sea level unless otherwise stated.
2: For stone massonry walls the typical base width should be 0.65 times the height of wall.

Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Gravel Trap	Scale:	Checked By:	Date :

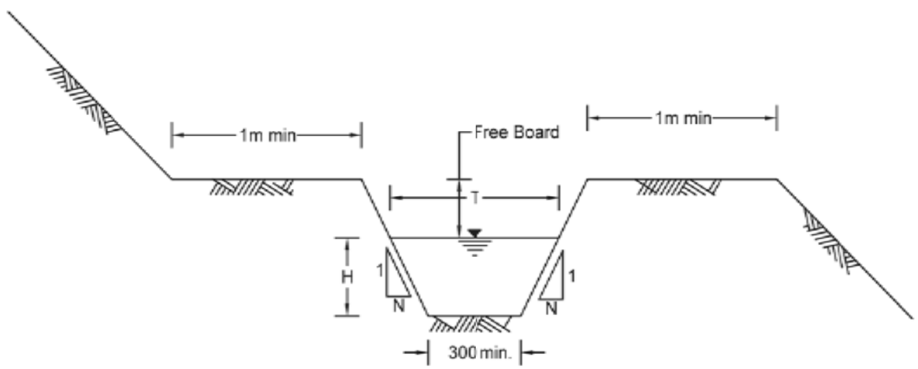

Freeboard (FB)
NWL
Spillway (Min 50mm above the NWL)
Ls
1 : 2
1 : 50
Flushing Gate
Sediment Storage
Min 100mm RCC (M15) Slab
Min 300mm stone soling
SECTION A-A
Stone masonry in (1:4) cement mortar
Flushing Gate
Spillway Canal
Flushing Canal
Slope
NWL+50mm min
Settling zone
1:50
1:10
B
L=4 to 10*B
PLAN
Tc
Wc
A
B
C
Notes:
1: All dimensions are in mm and all levels are in metres above sea level unless otherwise stated.
2: For stone massonry walls the typical base width should be 0.65 times the height of wall.
Stone Masonry in 1:4 Cement Mortar
Free Board
WL during spilling
Backfilling
HFL
NWL
Plaster in 1:4 C/S Mortar
Min 100 mm thick RCC in 1:2:4
Min 300 mm Stone soling
0.65h
SECTION B-B
Stone Masonry in (1:4) Cement Mortar
Flushing Gate
NWL
Storage
Slope
Hbasin=Hwater+Hstorage
Min 100 mm thick RCC in 1:2:4
Min 300 mm Stone soling
0.65h
1.50
Min 500
SECTION C-C
0 1 2 3 4 5
Consultant
<Project Name>
DEVELOPER:
Gravel Trap
Scale:
Designed By:
Drawn By:
Checked By:
Drawing No. :
Sheet No. :
Date :



LINED CANAL



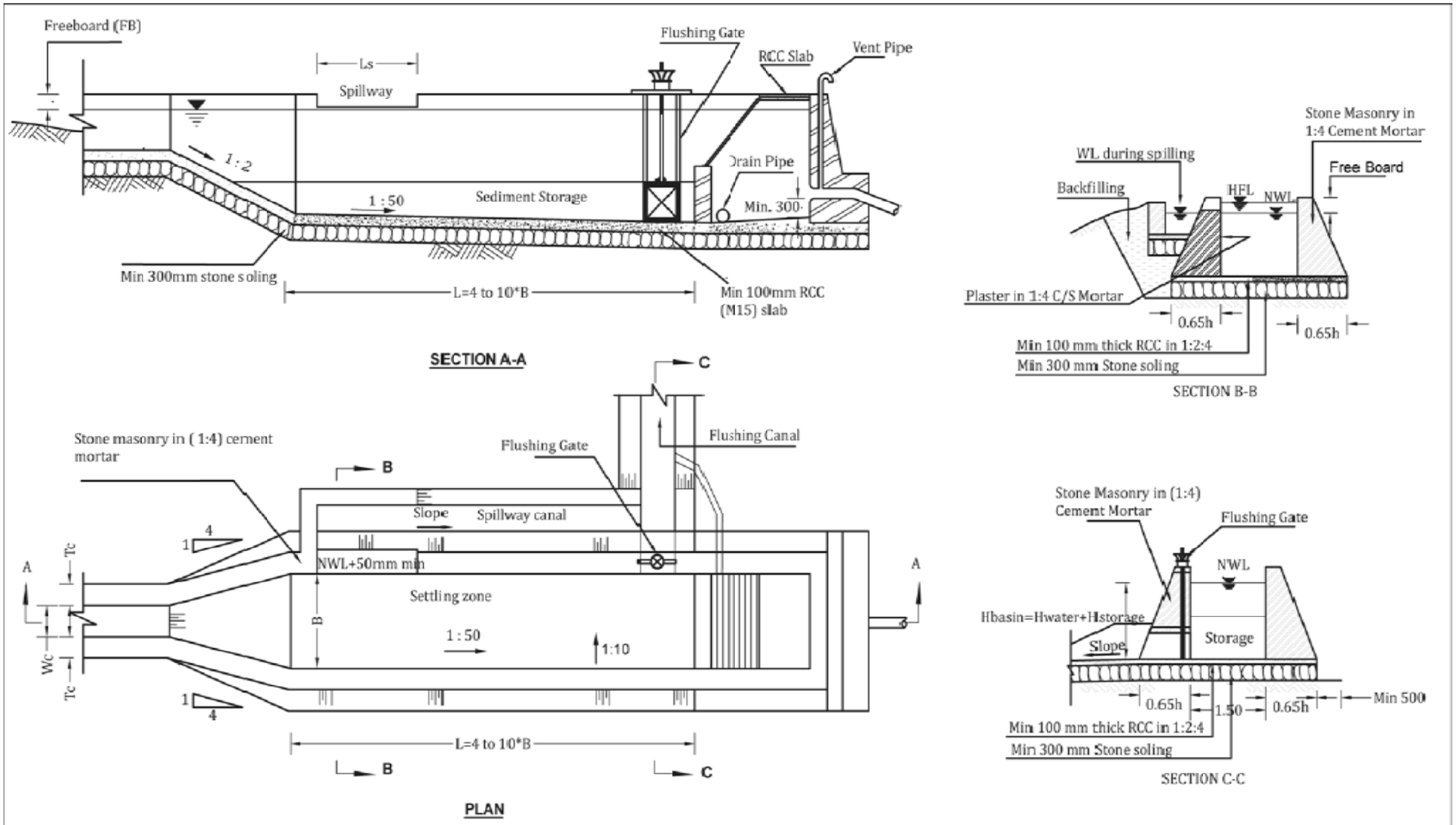
LINED CANAL



UN LINED CANAL

Notes:
1: All dimensions are in m and all levels are in metres above sea level unless otherwise stated.
2: For stone massonry walls the min. base width should be 0.65 times the height of wall.
3: Free Board half of water depth / 300mm minimum.

Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Headrace Canal	Scale: As Shown	Checked By:	Date :

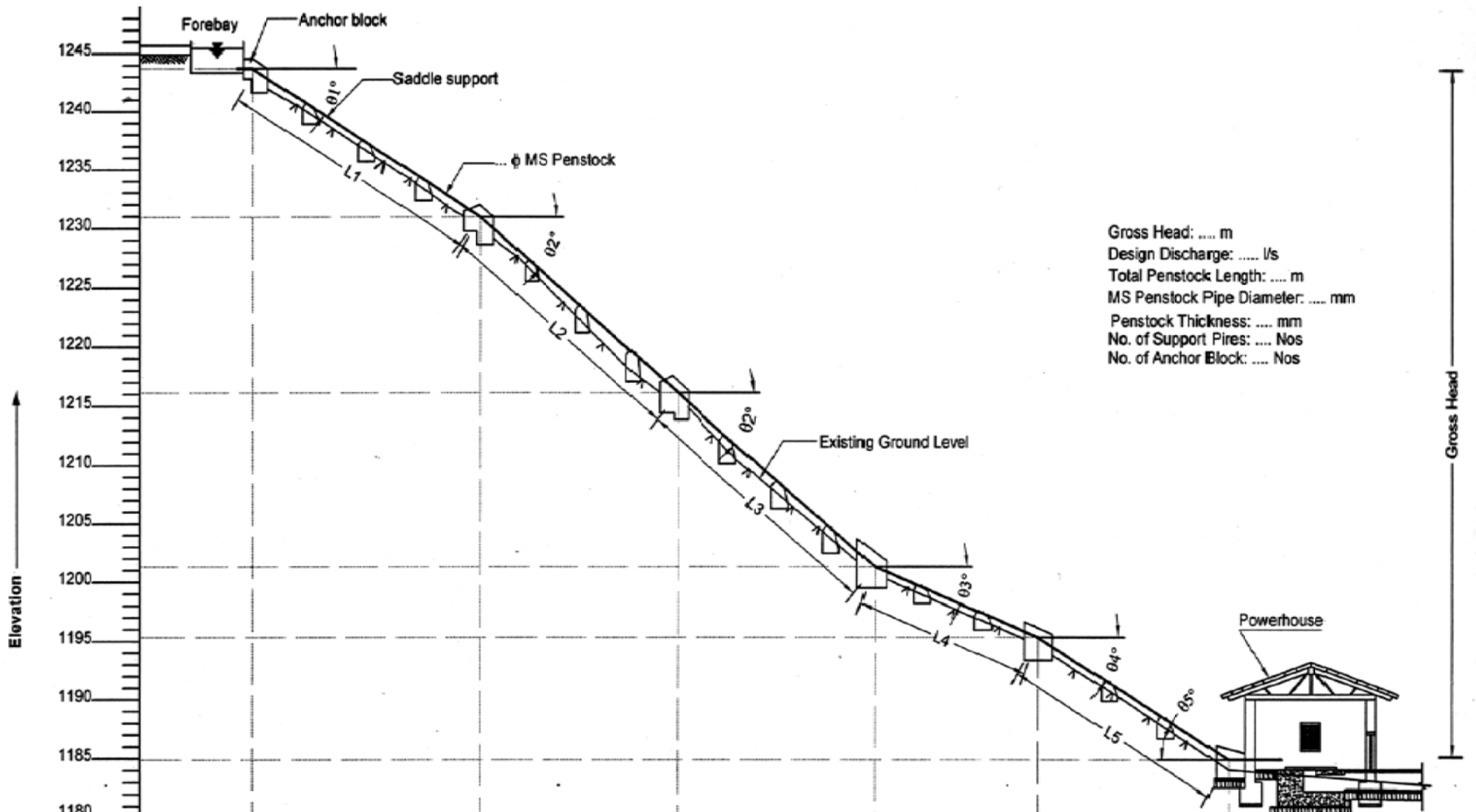


Notes:

1: All dimensions are in mm and all levels are in metres above sea level unless otherwise stated.

2: For stone massonry walls the minimum base width should be 0.65 times the height of wall.

Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Forebay	Scale: As shown	Checked By:	Date :



Chainage (m)	0.00	24.45	27.91	31.43	32.00	38.26
Original Gr. Level	1152.00	1133.00	1130.99	1126.51	1122.96	1118.30
Formation Level	1152.43	1133.41	1129.81	1126.01	1125.42	1118.71

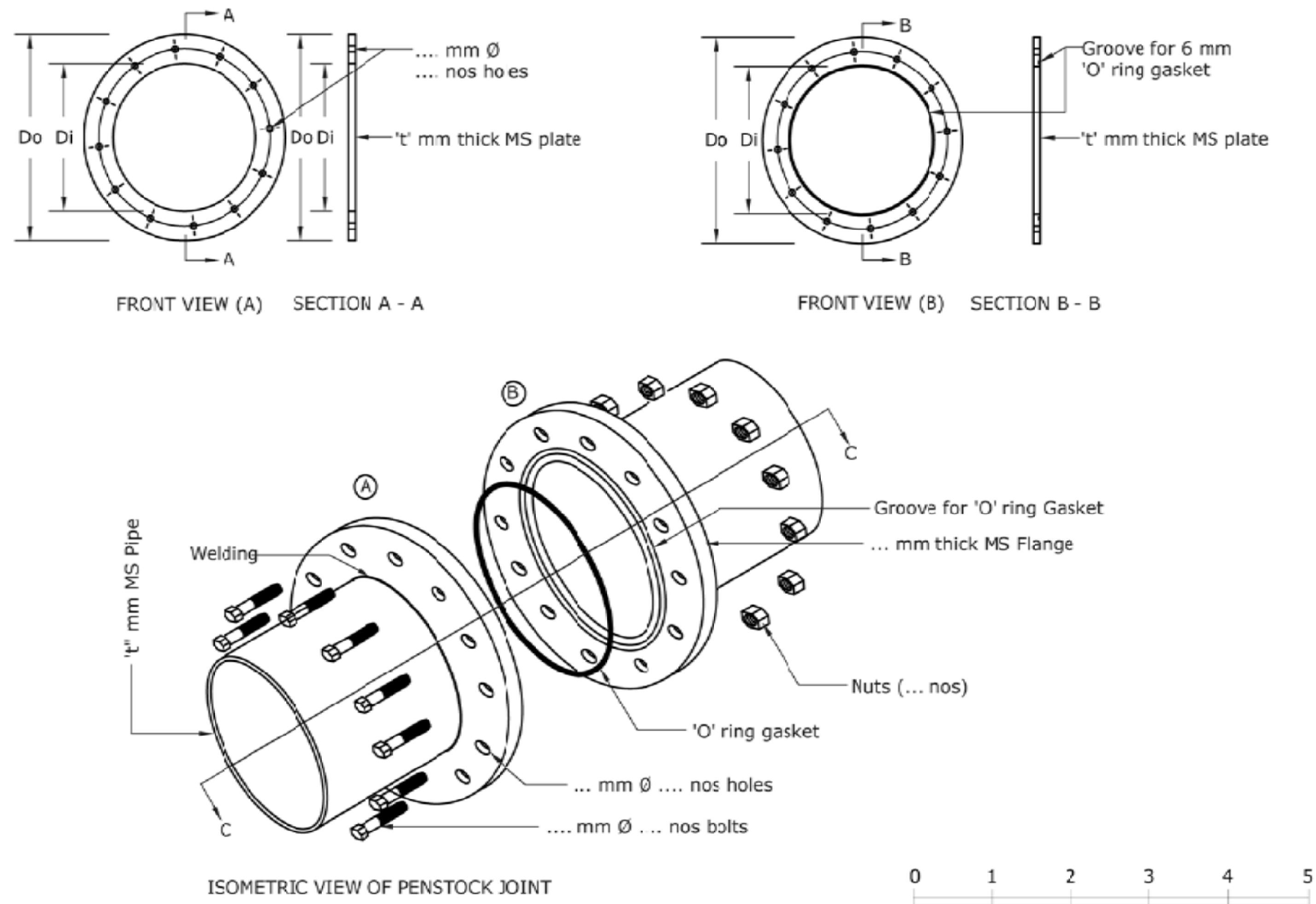
SCALE

0 5 10 15 20 25 M

Notes:

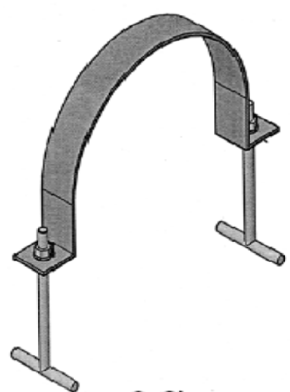
1. All dimensions are in mm and all levels are in metres above sea level unless otherwise stated.

Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Penstock Alignment	Scale: As shown	Checked By:	Date :

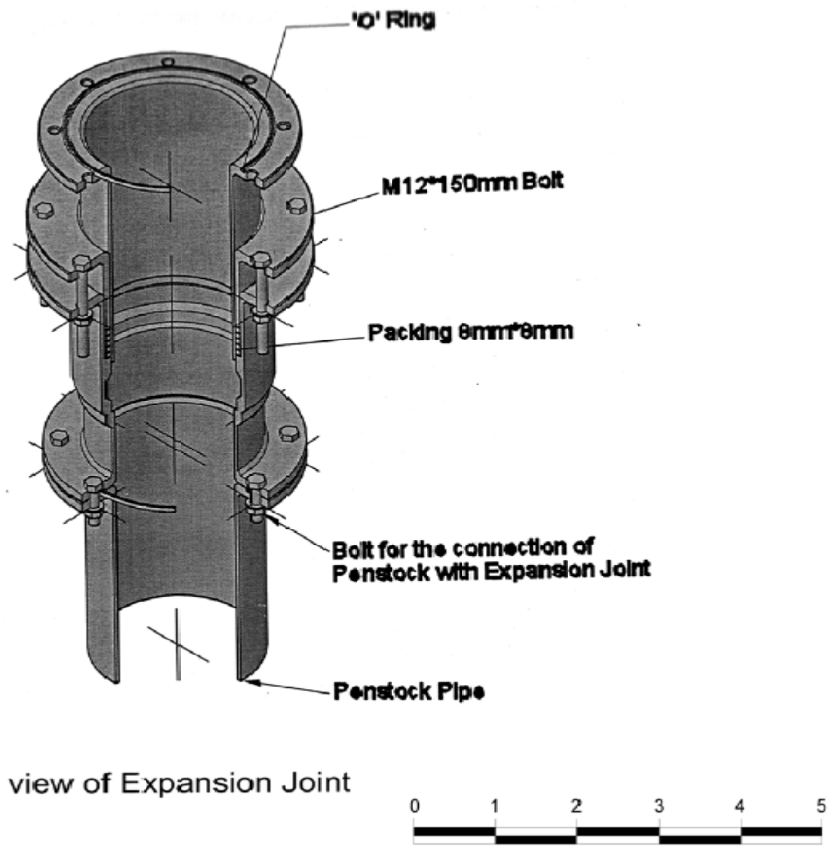


1. All dimension are in m unless otherwise specified in the drawing.

Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		PENSTOCK DETAILS	Scale:	Checked By:	Date :

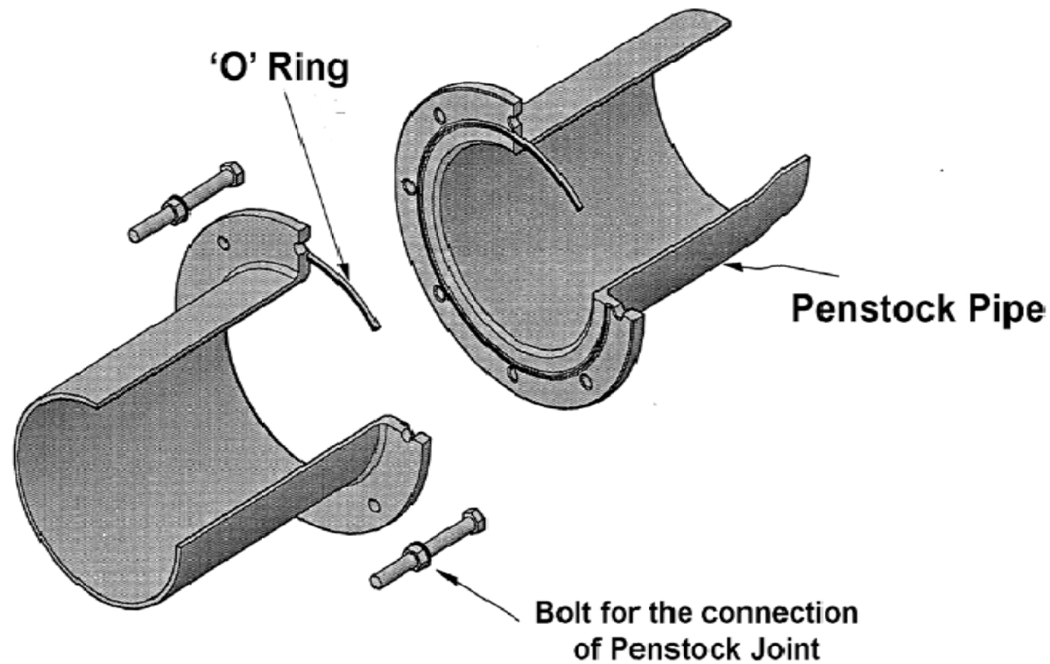


C-Clamp



Sectional view of Expansion Joint

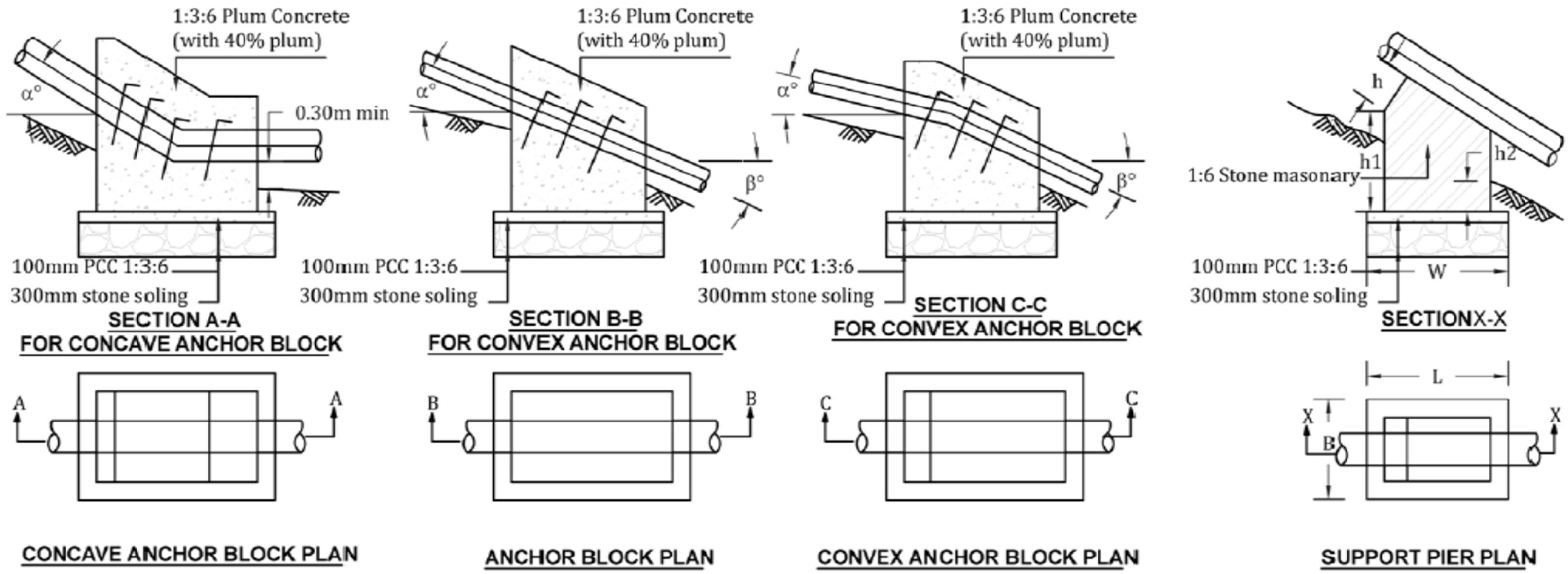
Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Expansion Joints	Not in Scale	Checked By:	Date :

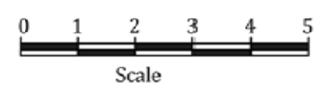


Section C - C
Penstock Pipe Details

0 1 2 3 4 5

Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Section of Penstock Details	Not in Scale	Checked By:	Date :

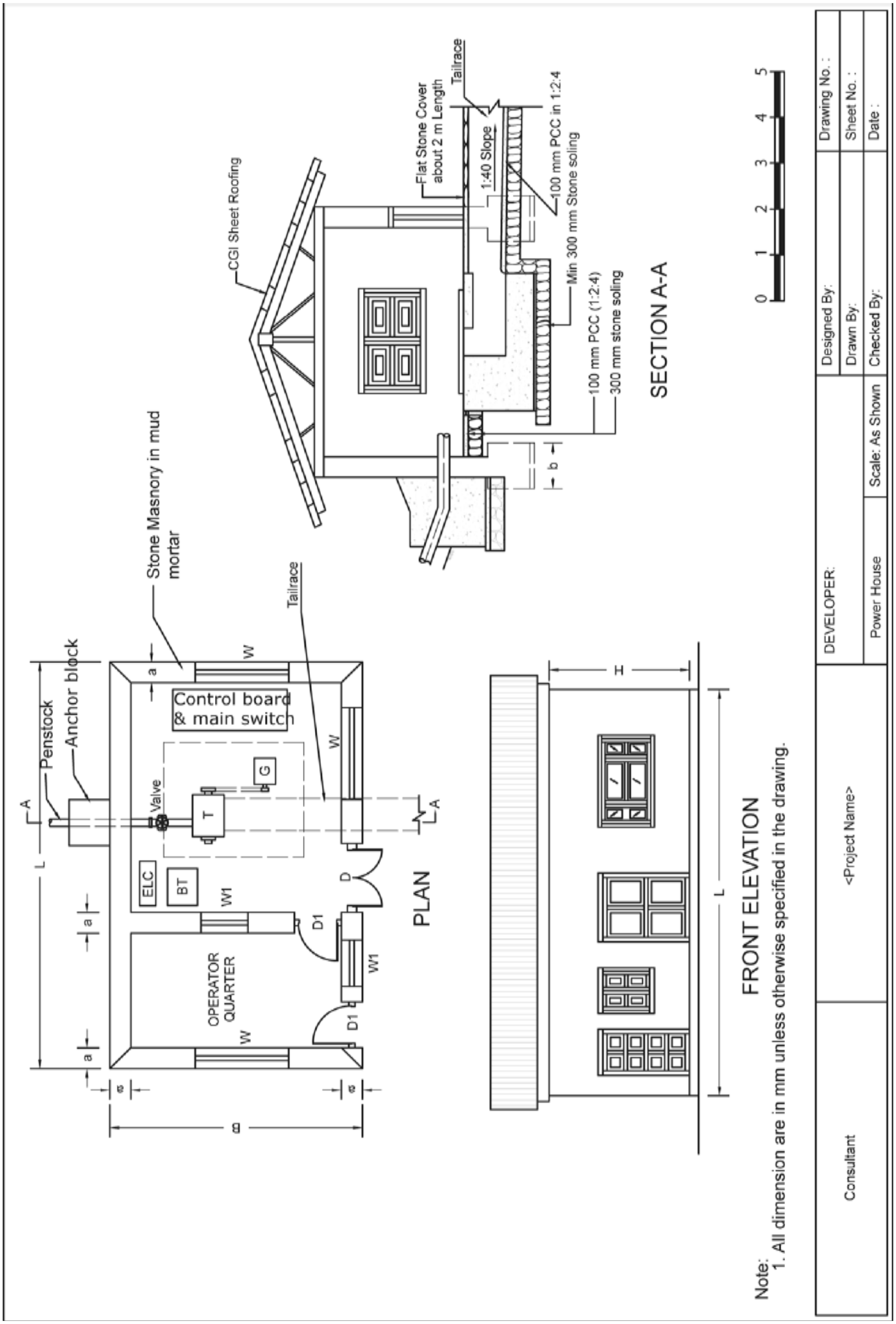




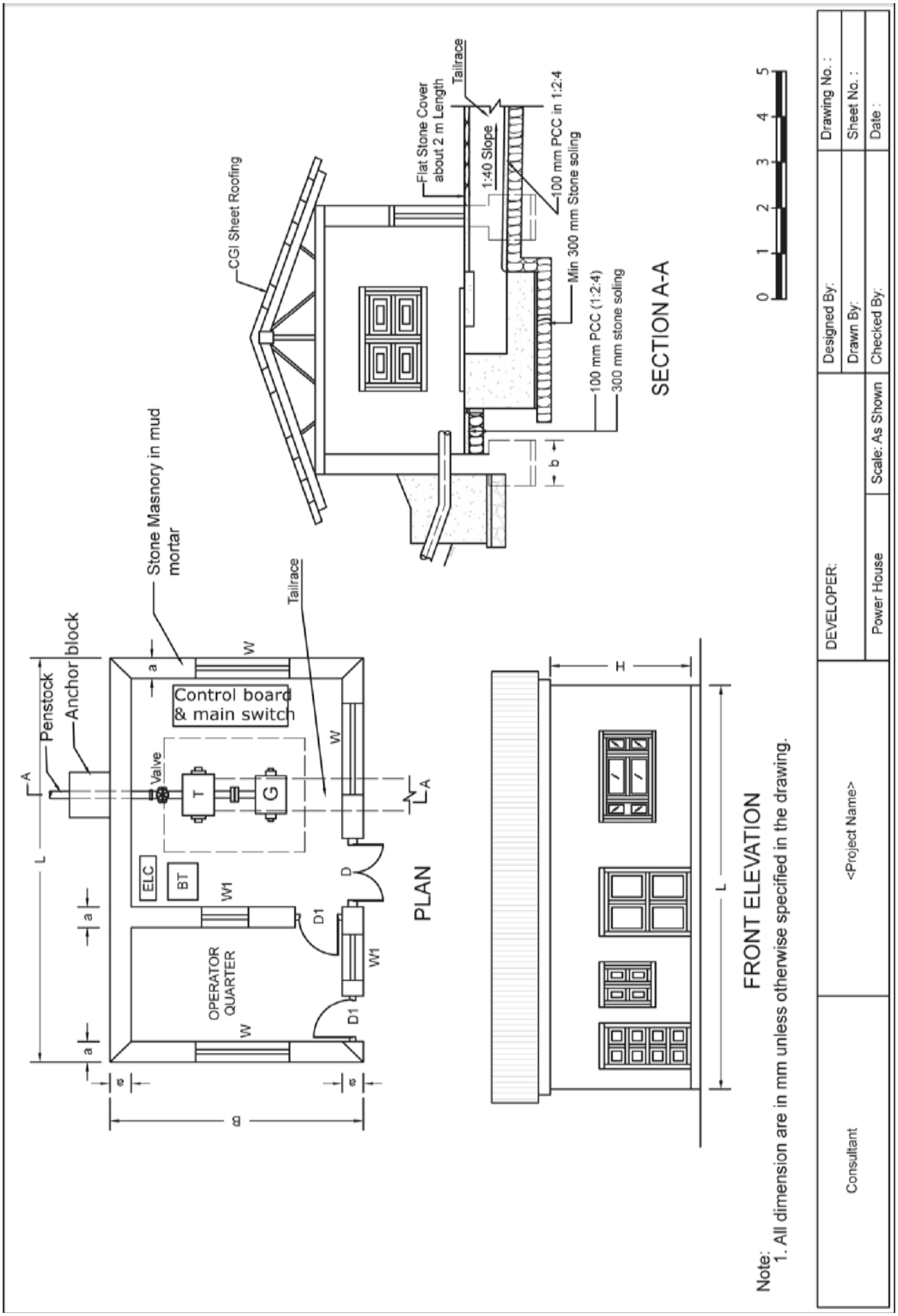
Note:

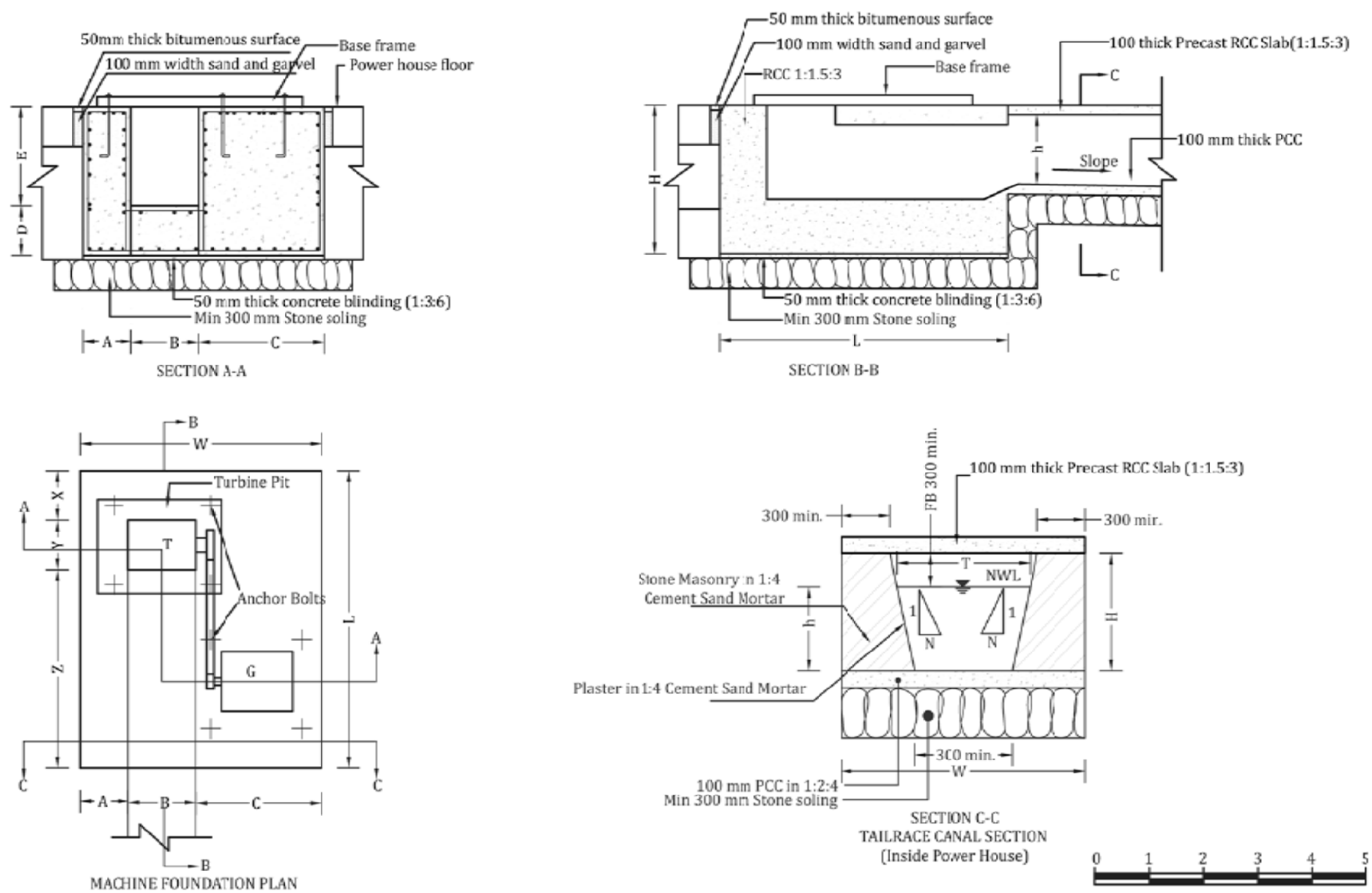
1. All dimension are in m unless otherwise specified in the drawing.

Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Anchor block & Support Pier	Scale:	Checked By:	Date :



Penstock
Anchor block
Stone Masnory in mud mortar
Control board & main switch
Valve
T
G
Tailrace
ELC
BT
OPERATOR QUARTER
W
W1
D
D1
a
L
B
A
PLAN
CGI Sheet Roofing
Flat Stone Cover about 2 m Length
Tailrace
1:40 Slope
100 mm PCC in 1:2:4
Min 300 mm Stone soling
100 mm PCC (1:2:4)
300 mm stone soling
b
SECTION A-A
0 1 2 3 4 5
H
FRONT ELEVATION
Note:
1. All dimension are in mm unless otherwise specified in the drawing.
Consultant
<Project Name>
DEVELOPER:
Power House
Scale: As Shown
Designed By:
Drawn By:
Checked By:
Drawing No. :
Sheet No. :
Date :

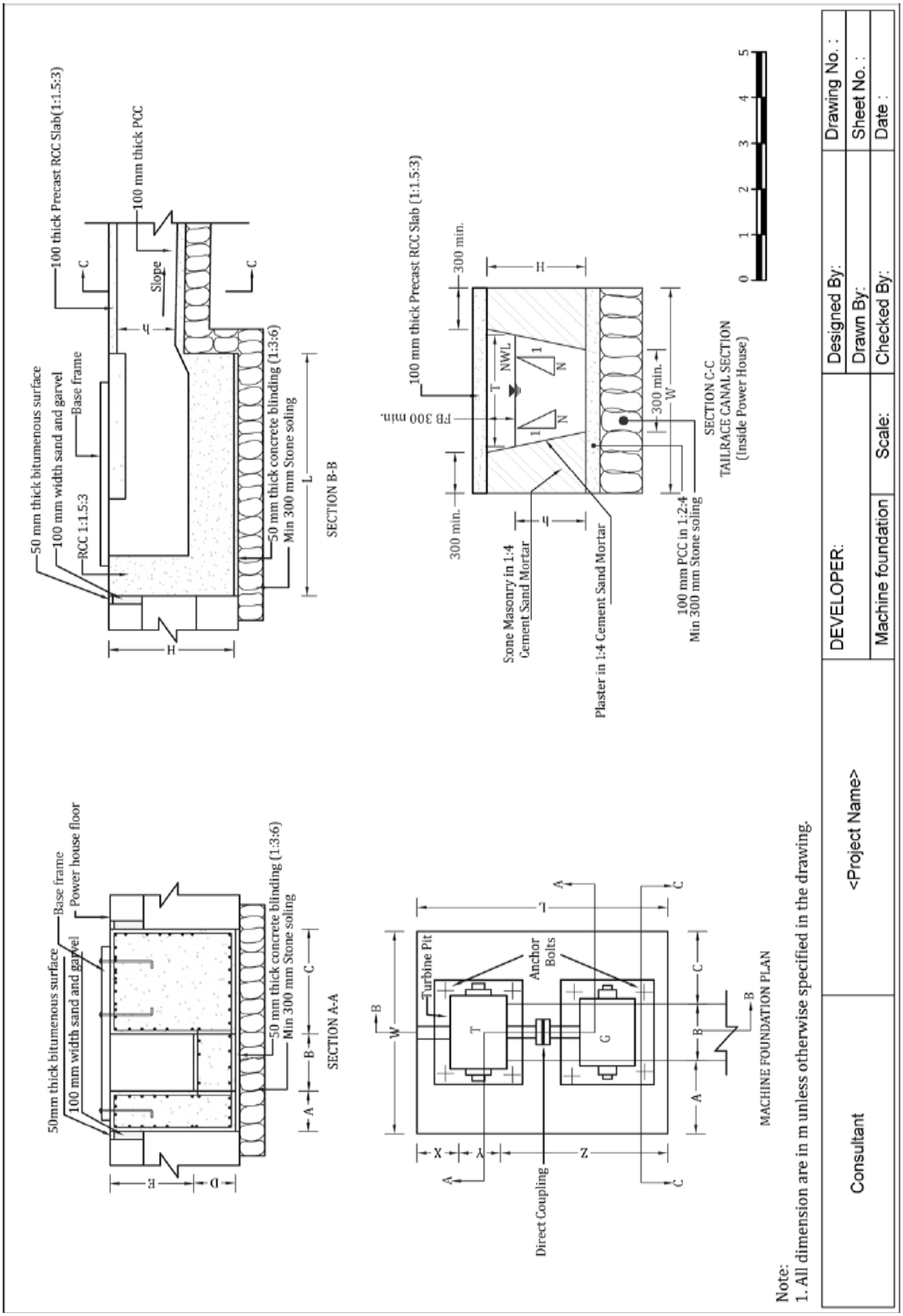

Penstock
Anchor block
Stone Masnory in mud mortar
Tailrace
Control board & main switch
Valve
T
G
ELC
BT
OPERATOR QUARTER
W
W1
D
D1
PLAN
CGI Sheet Roofing
Flat Stone Cover about 2 m Length
Tailrace
1:40 Slope
100 mm PCC in 1:2:4
Min 300 mm Stone soling
100 mm PCC (1:2:4)
300 mm stone soling
SECTION A-A
FRONT ELEVATION
Note:
1. All dimension are in mm unless otherwise specified in the drawing.
Consultant
<Project Name>
DEVELOPER:
Power House
Designed By:
Drawn By:
Checked By:
Scale: As Shown
Drawing No. :
Sheet No. :
Date :

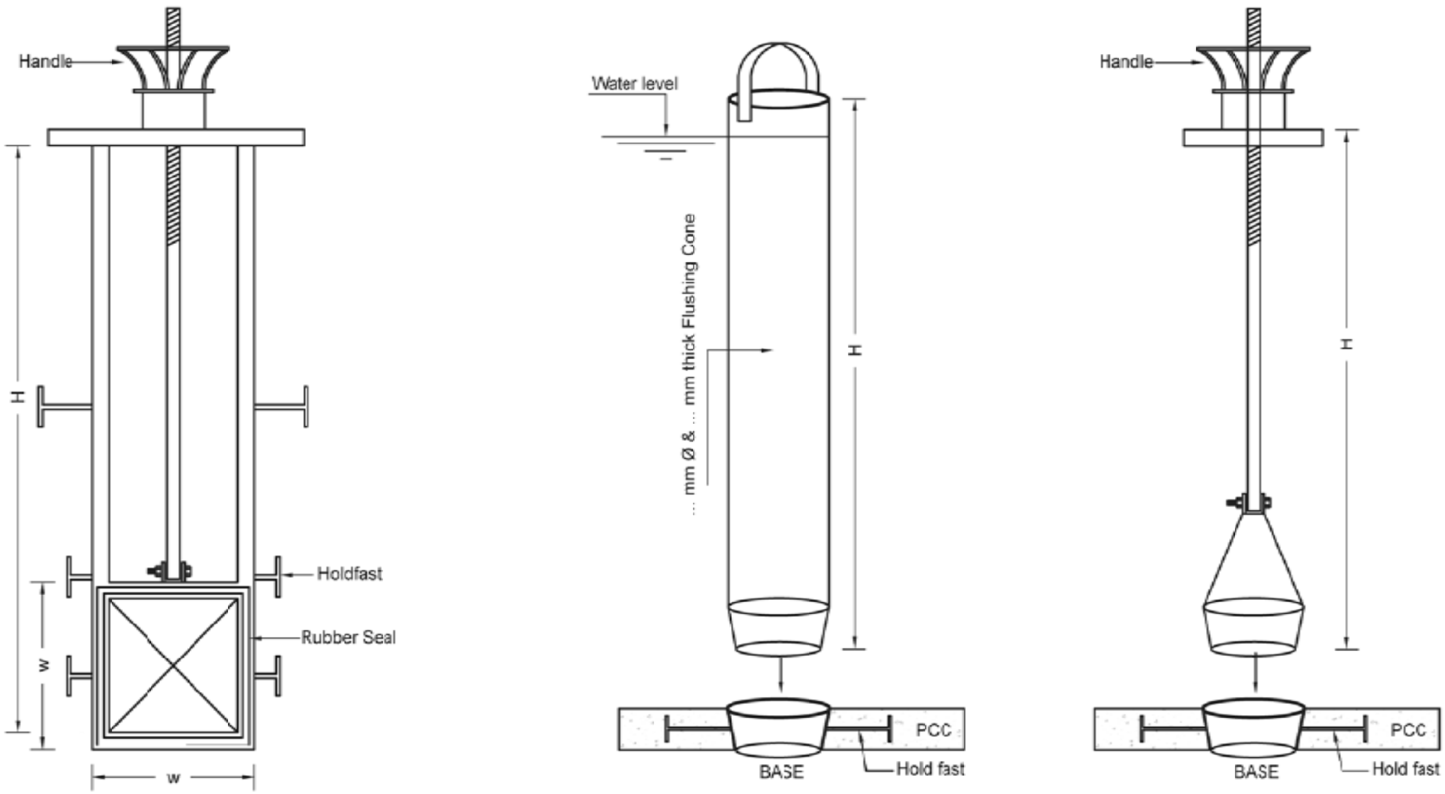


Note:

1. All dimension are in m unless otherwise specified in the drawing.

Consultant	<Project Name>	DEVELOPER:		Desigred By:	Drawing No. :
				Drawn By:	Sheet No. :
		Machine foundation	Scale:	Checked By:	Date :


50mm thick bitumenous surface
100 mm width sand and garvel
Base frame
Power house floor
50 mm thick concrete blinding (1:3:6)
Min 300 mm Stone soling
SECTION A-A
MACHINE FOUNDATION PLAN
Turbine Pit
Anchor Bolts
Direct Coupling
T
G
50 mm thick bitumenous surface
100 mm width sand and garvel
Base frame
RCC 1:1.5:3
100 thick Precast RCC Slab(1:1.5:3)
100 mm thick PCC
Slope
50 mm thick concrete blinding (1:3:6)
Min 300 mm Stone soling
SECTION B-B
100 mm thick Precast RCC Slab (1:1.5:3)
300 min.
FB 300 min.
NWL
Stone Masonry in 1:4
Cement Sand Mortar
Plaster in 1:4 Cement Sand Mortar
100 mm PCC in 1:2:4
Min 300 mm Stone soling
SECTION C-C
TAILRACE CANAL SECTION
(Inside Power House)
Note:
1. All dimension are in m unless otherwise specified in the drawing.
Consultant
<Project Name>
DEVELOPER:
Machine foundation
Designed By:
Drawn By:
Checked By:
Scale:
Drawing No. :
Sheet No. :
Date :

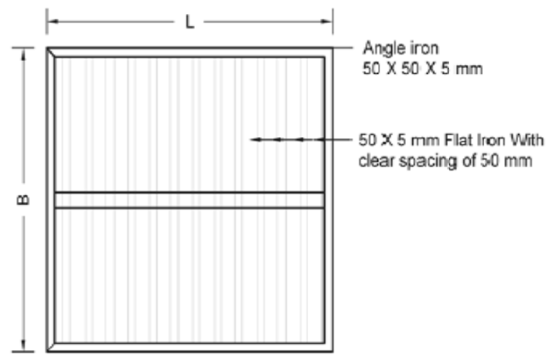


FLUSHING GATE FLUSHING CONE FLUSHING CONE

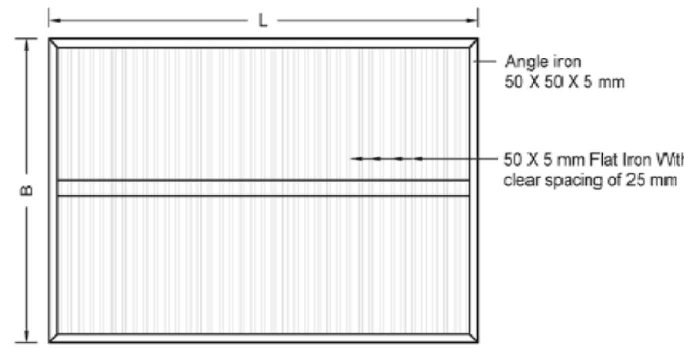
Note:

1. All dimension are in m unless otherwise specified in the drawing.

Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		SLUICE GATE / FLUSHING CONE	Scale:	Checked By:	Date :



COURSE TRASHRACK FOR INTAKE

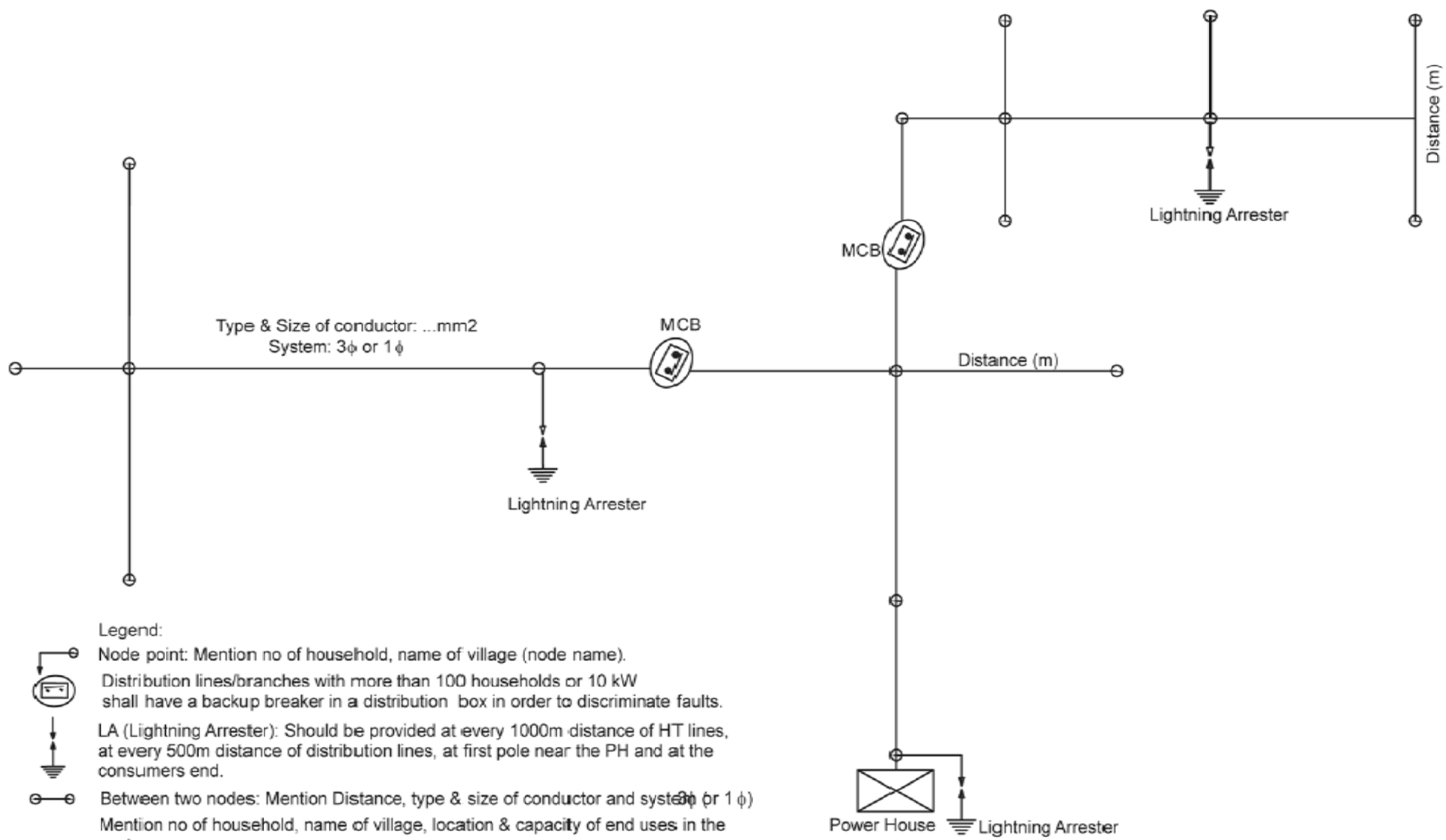


FINE TRASHRACK FOR FOREBAY

Note:

1. All dimension are in m unless otherwise specified in the drawing.

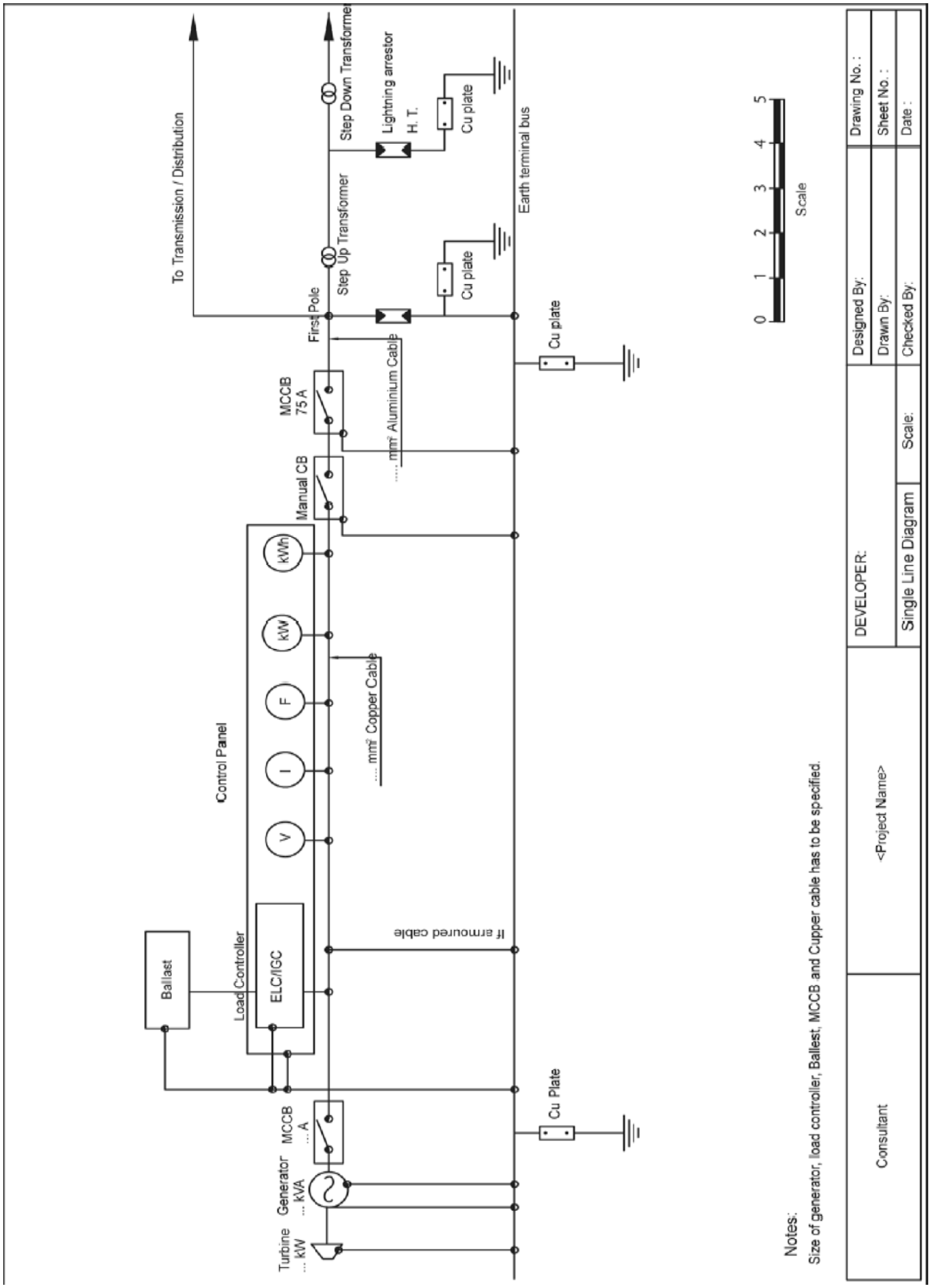
Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		TRASHRACK	Scale:	Checked By:	Date :



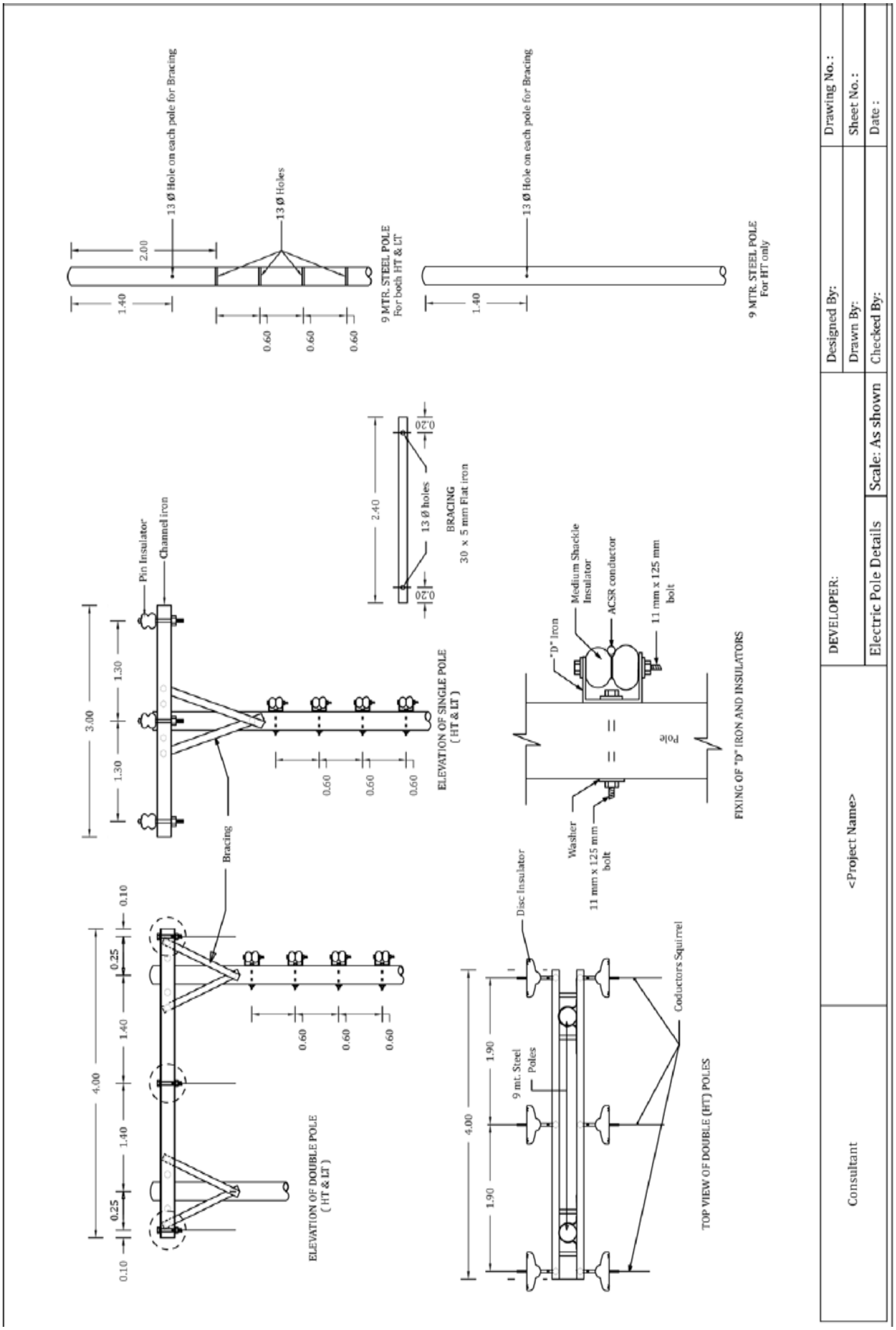
Legend:

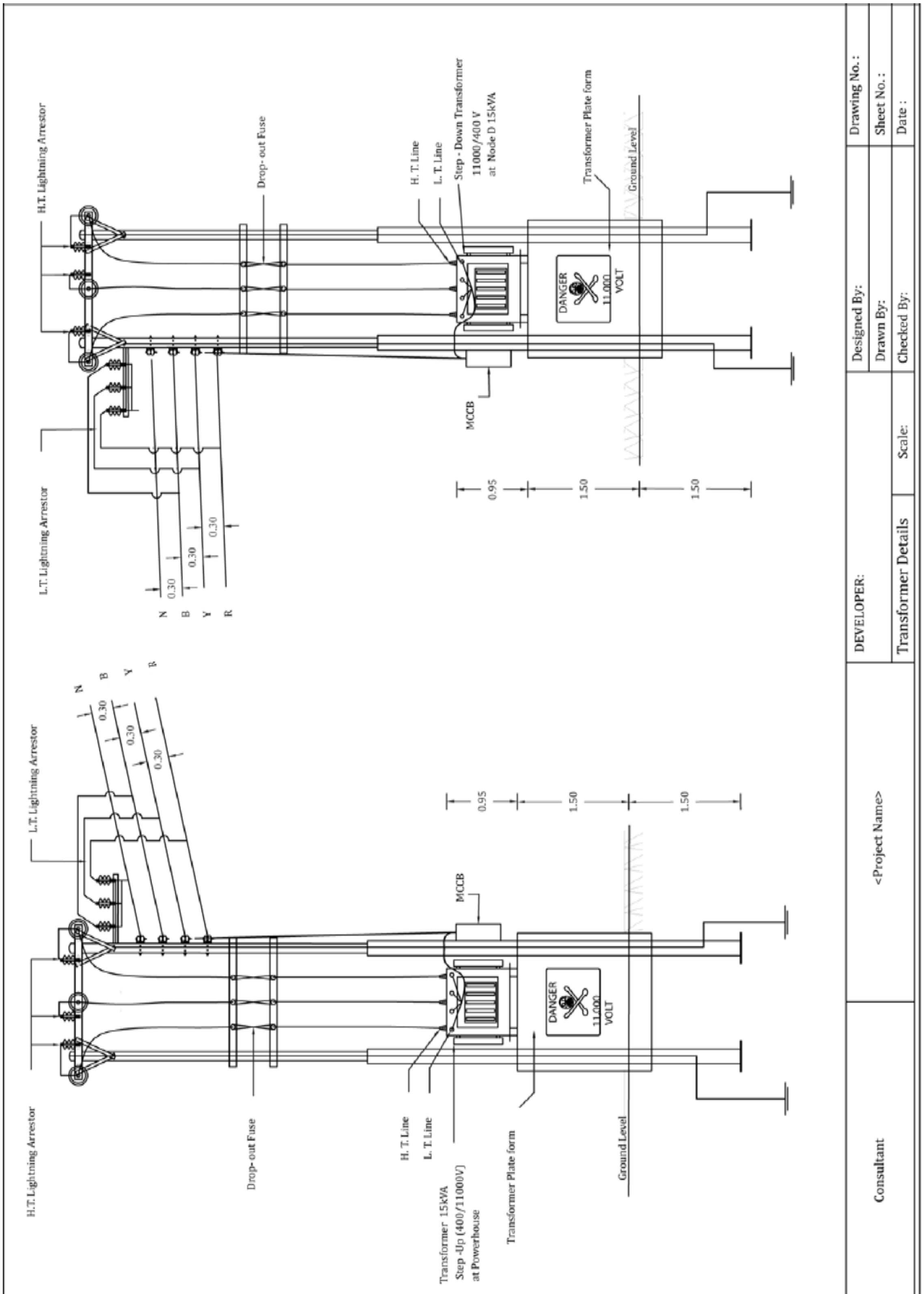
- Node point: Mention no of household, name of village (node name).
- Distribution lines/branches with more than 100 households or 10 kW shall have a backup breaker in a distribution box in order to discriminate faults.
- LA (Lightning Arrester): Should be provided at every 1000m distance of HT lines, at every 500m distance of distribution lines, at first pole near the PH and at the consumers end.
- Between two nodes: Mention Distance, type & size of conductor and system (3ϕ or 1ϕ)
- Mention no of household, name of village, location & capacity of end uses in the system

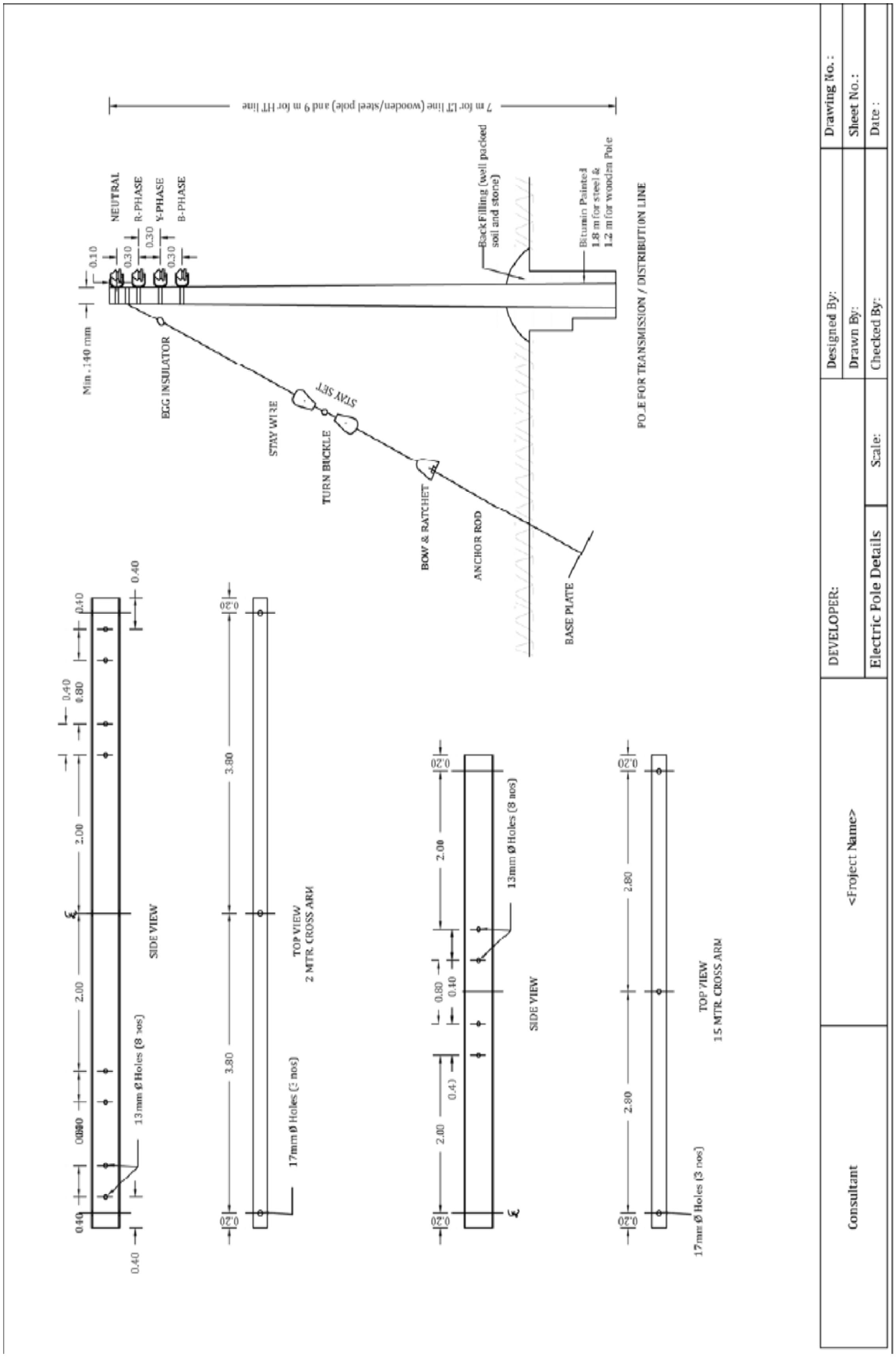
Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Transmission & Distribution	Scale:	Checked By:	Date :

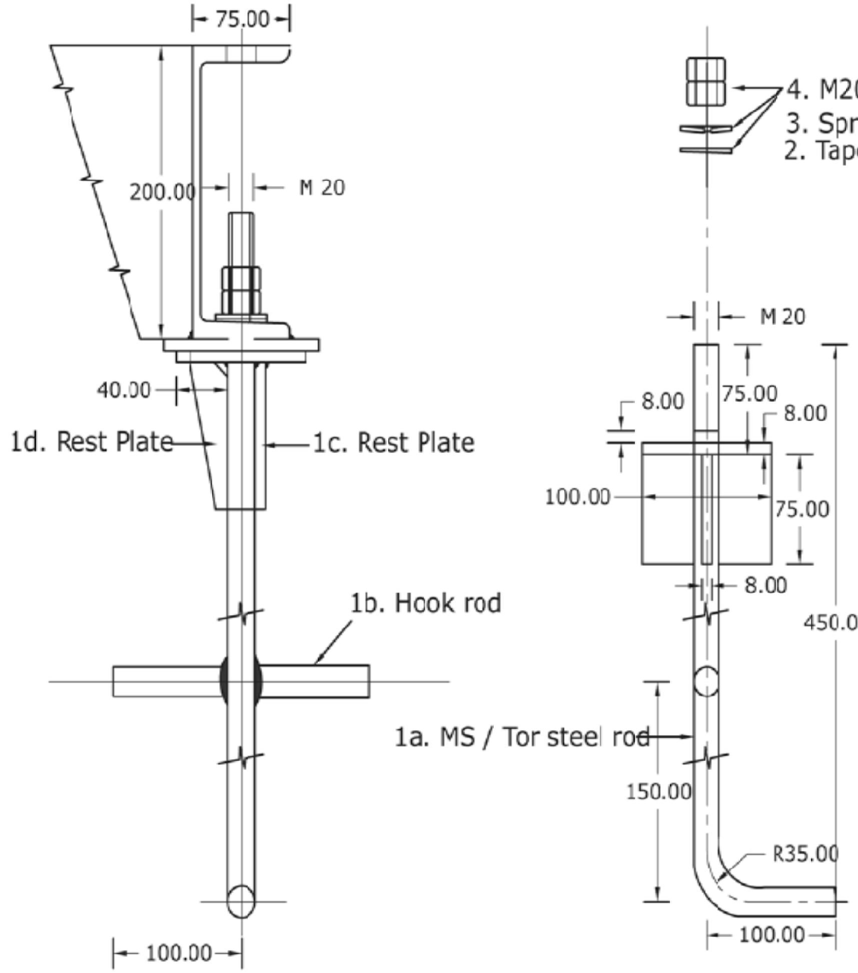


To Transmission / Distribution
Step Down Transformer
Lightning arrestor
H. T.
Cu plate
Step Up Transformer
Cu plate
Earth terminal bus
First Pole
Cu plate
MCCB
75 A
.... mm² Aluminium Cable
Manual CB
kWh
kW
F
I
V
Control Panel
..... mm² Copper Cable
If armoured cable
Ballast
Load Controller
ELC/IGC
Turbine
... kW
Generator
... kVA
MCCB
... A
Cu Plate
0 1 2 3 4 5
Scale
Notes:
Size of generator, load controller, Ballest, MCCB and Cupper cable has to be specified.
Consultant
<Project Name>
DEVELOPER:
Single Line Diagram
Scale:
Designed By:
Drawn By:
Checked By:
Drawing No. :
Sheet No. :
Date :


ELEVATION OF DOUBLE POLE (HT & LT)
ELEVATION OF SINGLE POLE (HT & LT)
TOP VIEW OF DOUBLE (HT) POLES
FIXING OF "D" IRON AND INSULATORS
BRACING 30 x 5 mm Flat iron
9 MTR. STEEL POLE For both HT & LT
9 MTR. STEEL POLE For HT only
13 Ø Hole on each pole for Bracing
13 Ø Holes
13 Ø holes
Pin Insulator
Channel iron
Bracing
Disc Insulator
Coductors Squirrel
9 mt. Steel Poles
Washer
11 mm x 125 mm bolt
"D" Iron
Medium Shackle Insulator
ACSR conductor
Pole
Consultant
<Project Name>
DEVELOPER:
Electric Pole Details
Scale: As shown
Designed By:
Drawn By:
Checked By:
Drawing No. :
Sheet No. :
Date :


H.T. Lightning Arrestor
L.T. Lightning Arrestor
Drop- out Fuse
H. T. Line
L. T. Line
Transformer 15kVA
Step -Up (400/11000V)
at Powerhouse
Transformer Plate form
Ground Level
MCCB
DANGER
11,000
VOLT
N
B
Y
R
0.30
0.95
1.50
Step - Down Transformer
11000/400 V
at Node D 15kVA
Consultant
<Project Name>
DEVELOPER:
Transformer Details
Scale:
Designed By:
Drawn By:
Checked By:
Drawing No. :
Sheet No. :
Date :


7 m for LT line (wooden/steel pole) and 9 m for HT line
NEUTRAL
R-PHASE
Y-PHASE
B-PHASE
Min. 140 mm
EGG INSULATOR
STAY WIRE
STAY SET
TURN BUCKLE
BOW & RATCHET
ANCHOR ROD
BASE PLATE
Back Filling (well packed soil and stone)
Bitumin Painted 1.8 m for steel & 1.2 m for wooden Pole
POLE FOR TRANSMISSION / DISTRIBUTION LINE
SIDE VIEW
13mm Ø Holes (8 nos)
TOP VIEW 2 MTR. CROSS ARM
17mm Ø Holes (3 nos)
SIDE VIEW
13mm Ø Holes (8 nos)
TOP VIEW 15 MTR. CROSS ARM
17mm Ø Holes (3 nos)
Consultant
<Project Name>
DEVELOPER:
Electric Pole Details
Designed By:
Drawn By:
Checked By:
Scale:
Drawing No. :
Sheet No.:
Date :



Pos No.	Specification	Size	Qty.	Remark
4	Hex. nut	MS M 20	2	
3	Spring washer	Spring steel M20	1	
2	Taper washer	MS M20	1	
Ie	Rest plate	Ms Plate 8*100*100mm	1	
Id	Rib	MS Flate 8*40*75mm	1	
Ic	Rib	MS flate 8*75*100mm	1	
Ib	Hook rod	MS/Tor steel Rod M20*90mm	2	
Ia	Anchor Rod	MS/Tor steel Rod dia 22*535mm	8	
I	Anchor Bolt	MS/Tor steel Rod dia 22*450mm	8	Set or as per plant size designed

0 1 2 3 4 5

1. All dimension are in mm unless otherwise specified in the drawing.

Consultant	<Project Name>	DEVELOPER:		Designed By:	Drawing No. :
				Drawn By:	Sheet No. :
		Anchor Bolt Details	Scale:	Checked By:	Date :

Appendix D: Project Costs and Bill of Quantities

PROJECT COSTS & BILL OF QUANTITY (BOQ)

1. Unit Rate

The unit rate using for rate analysis shall be specify as follows:

S.N.	Particulars	Unit	Price(Rs.)	Remarks
1	Skilled Labour	day		
2	Unskilled Labour	day		
3	Dressed stone	Cum		
4	Non dressed stone	Cum		
5	Aggregates	Cum		
6	Sand	Cum		
7	Cement	bag		
8	Reinforcement Bar	Kg		
9	Mud	Cum		
10	Bindig wire	Kg		
11	G.I. Wire	Kg		
12	CGI Sheet 26 Gauge	Bundle		
13	Plain G I Sheet	m		
14	8 mm dia screw type nail/nut bolt	pcs		
15	J hook with nut and washer	pcs		
16	Bitumen washer	pcs		
17	Wood for door and window	cft		
18	Hold fast 250 mm	pcs		
19	Screw	pcs		
20	Hinge 150 mm	pcs		
21	Bolts (250& 300 mm)	pcs		
22	Locking set	pcs		
23	Handles	pcs		
24	4 mm thick glass	Sqft		
25	Wooden pole	pcs		
26	Flag stone	pcs		
27	Brick	pcs		
28	3 mm Ply wood	Cum		
29	Nail	Kg		
30	Polyethylene/Bitumen sheet	Roll		
31	------			
32	------			

Note: Rate analysis shall be done on the basis of district rates (special remarks shall be provided in case of difference than the district rate) and standard norms.

2. Project Cost Summary Format

SN	Components	Amount (Rs)			Share (%)	Remarks
		Local	Non-local	Total		
1	Civil works					
2	Mechanical works					
3	Electrical works					
4	Tools & spare parts					
5	Packing & transportation					
6	Supervision, Installation, testing & commissioning					
	Sub-total					
	13% VAT in non local cost					
	Contingency (3-5%)*					
	Total Project Cost					
	Cost per kW					

* 3% for bigger size and 5% for smaller size projects

3. Financial Analysis Outputs

SN	Financial Indicators	Output	Remarks
1	Internal Rate of Return (IRR)		
2	Benefit Cost Ratio (B/C Ratio)		
3	Net Present Value (NPV@6%)		
4	Net Present Value (NPV@12%)		
5	Payback Period (Years)		

4. Sources of Financing

SN	Source	Amount (Rs)	Share (%)	Remarks
1	AEPC/NRREP Subsidy			
2	VDC Support			
3	DDC Support			
4	Community contribution			
	Local labour & material			
	Cash contribution			
5	Bank loan			
6	Others			
	Total Project Cost			

5. Possible Sources of Income

5.1. From Household Tariff

SN	Power (kW)	No. of Households	Total Electricity Consumption	Tariff Rate (Rs)	Amount (Rs)
Total Income from H/H Consumers					

5.2. From Possible Productive End-uses

SN	End Use	Capacity (kW)	Operating Hours/year	Total Unit (kWh)	Tariff Rate	Amount (Rs)
1						
2						
3						
Total Income from Productive End-uses						

6. Possible Expenditure

SN	Description	Quantity	Unit	Rate	Amount (Rs)	Remarks
1	**Salary**					
	Manager					
	Operator I					
	Operator II					
	Accountant (if any)					
	....					
2	Office Expenses					
3	Repair & Maintenance					
4	HR Development (Training etc.)					
5	Loan Repayment					
6	Miscellaneous					
Total Annual Expenditure						

A. Component Cost Summary Format

SN	Description	Amount (Rs)	Share (%)	Remarks
I	**Civil Works**			
1.1	Headworks (Intake, weir & protection works)			
1.2	Gravel Trap (if provided)			
1.3	Desilting basin with spillway			
1.4	Headrace Canal			
1.5	Forebay with spillway			
1.6	Support piers			
1.7	Anchor Blocks			
1.8	Power House			
1.9	Machine foundation & Tailrace			
1.10	Crossing (if any)			
1.11	Environmental and social safeguard cost (if any)			
	Sub-total (I)			
II	**Mechanical Works**			
	Turbine & Accessories			
	Valve			
	Power transmission			
	Penstock Pipe & Accessories			
	Sub-total (II)			
III	**Electrical Works**			
	Generator and Accessories			
	Control and Protection System			
	Power Cable and Wiring			
	Conductor			
	Fittings			
	Pole			
	Transformer			
	Sub-total (III)			
IV	**Tools & Spare Parts**			
	Sub-total (IV)			
V	**Packing & Transportation**			
	Sub-total (V)			
VI	**Supervision, Installation & Testing/ Commissioning**			
	Sub-total (VI)			
VII	**Total Trainings**			
	Sub-total (VII)			
VIII	**End-uses (if applicable)**			
	Sub-total (VII)			
	Grand Total (I-VIII)			

B. BILL OF QUANTITY (BOQ)

I. CIVIL WORKS

1. Headworks (Intake/weir/protection)

SN	Description	Unit	Qty	Rate	Amount
1.1	Site Clearance	LS			
1.2	Excavation work (under water)	Cum			
1.3	Stone Soling	Cum			
1.4	Concreting 1:2:4	Cum			
1.5	Bar work (10 mm dia. Bar)	kg			
1.6	Stone masonry in 1:4 c/s mortar	Cum			
1.7	1:4 c/s plastering	Sqm			
1.8	Gabion Construction	Cum			
	......				
	....				
1.9	Course Trashrack	Nos			
1.10	Flow Control Gate *(with specification)*	Nos			
	Total - 1				
	Cement (50 kg bag)	Bag			

2. Gravel trap (if provided)

SN	Description	Unit	Qty	Rate	Amount
2.1	Site clearance	Sqm			
2.2	Excavation work	Cum			
2.3	Stone soling	Cum			
2.4	Concreting 1:2:4	Cum			
2.5	Reinforcement steel	Kg			
2.6	Stone masonry in 1:4 c/s mortar	Cum			
2.7	1:4 c/s plastering with punning	Sqm			
2.8	Flushing gate *(with specification)*	Set			
2.9	Trash rack *(with specification)*	Set			
	Total - 2				
	Cement (50 kg bag)	Bag			

3. **Headrace Canal**

SN	Description	Unit	Qty	Rate	Amount
3.1	Site clearance	Sqm			
3.2	Excavation work in	Cum			
	a. Ordinary soil				
	b. Mixed soil				
	c. Rock				
3.3	Stone Soling	Cum			
3.4	Concreting 1:2:4	Cum			
3.5	Reinforcement steel (if required)	Kg			
3.6	Stone masonry in 1:4 c/s mortar	Cum			
3.7	1:4 c/s plastering	Sqm			
3.8	Centering & Shuttering	Sqm			
3.9	HDPE pipe (if required)	m			
3.10	Gabion work (if required)	Cum			
3.11	Others				
	Total - 3				
	Cement 50 kg bag	Bag			

4. **Desilting Basin**

SN	Description	Unit	Qty	Rate	Amount
4.1	Site clearance	Sqm			
4.2	Excavation work	Cum			
4.3	Stone soling	Cum			
4.4	Concreting 1:2:4	Cum			
4.5	Reinforcement steel	Kg			
4.6	Stone masonry in 1:4 c/s mortar	Cum			
4.7	1:4 c/s plastering with punning	Sqm			
4.8	Flushing gate *(with specification)*	Nos			
	Total - 4				
	Cement (50 kg bag)	Bag			

5. Forebay Tank

SN	Description	Unit	Qty	Rate	Amount
5.1	Site clearance	Sqm			
5.2	Excavation work	Cum			
5.3	Stone soling	Cum			
5.4	Concreting 1:2:4	Cum			
5.5	Reinforcement steel	Kg			
5.6	Stone masonry in 1:4 c/s mortar	Cum			
5.7	1:4 c/s plastering with punning	Sqm			
5.8	Flushing gate *(with specification)*	Nos			
5.9	Trash rack *(with specification)*	Set			
	Total - 5				
	Cement (50 kg bag)	Bag			

6. Anchor Block (......... Nos.)

SN	Description	Unit	Qty	Rate	Amount
6.1	Excavation work	Cum			
6.2	Stone soling	Cum			
6.3	1:3:6 PCC with 40% plum & nominal bar	Cum			
6.4	Reinforcement steel	Kg			
6.5	Dry stone masonry	Cum			
6.6	Centering & shuttering	Sqm			
	Total - 6				
	Cement (50 kg bag)				

7. Support Piers (....... Nos.)

SN	Description	Unit	Qty	Rate	Amount
7.1	Excavation work	Cum			
7.2	Stone soling	Cum			
7.3	Concreting 1:3:6	Cum			
7.4	Stone masonry in 1:6 c/m	Cum			
7.5	Base plate	Set			
7.6	Anchor bolt, nut and washer	Sqm			
7.7	HDPE /tarpoline sheet	m			
	Total - 7				
	Cement (50 kg bag)				

8. Powerhouse Building

SN	Description	Unit	Qty	Rate	Amount
8.1	Site clearance				
8.2	Excavation work	Cum			
8.3	Stone soling	Cum			
8.4	1:2:4 PCC	Cum			
8.5	Stone masonry in mud mortar	Cum			
8.6	Plaster with 1:6 c/s mortar	Sqm			
8.7	Pointing with 1:3 c/s mortar	Sqm			
8.8	Doors and Windows				
8.8.1	Sal wood work door & window frame	Cft			
8.8.2	Sal wood door shutter	Sqft			
8.8.3	Sal wood window Shutter	Sqft			
8.8.4	4 mm thick glass for window	Sqft			
8.8.5	Miscellaneous (Hing, Locker, Handle, Screw, Nail etc.)	L.S.			
8.9	Sal wood for roofing truss	Cft			
8.10	26 SWG CGI sheet roofing	Sqm			
8.11	CGI sheet ridging	Rm			
8.12	Paint on door and window	Sqm			
8.13	White wash on walls	Sqm			
	Total - 8				
	Cement (50 kg bag)				

9. Machine Foundation and Tailrace Canal

SN	Description	Unit	Qty	Rate	Amount
9.1	Excavation work	Cum			
9.2	Stone soling	Cum			
9.3	Dry Stone masonry	Cum			
9.4	Concreting 1:1.5:3	Cum			
9.5	Reinforcement Steel	Kg			
9.5	Plastering in 1:4 c/s mortar	Sqm			
9.6	Centering& Shuttering	Sqm			
9.7	Stone masonry in 1:4 c/s mortar	Cum			
	Total - 9				
				Sub-total-I	

10. Crossings

SN	Description	Unit	Qty	Rate	Amount
10.1	Excavation work	Cum			
10.2	Stone soling	Cum			
10.3	Dry Stone masonry	Cum			
10.4	Concreting 1:1.5:3	Cum			
10.5	Reinforcement Steel	Kg			
10.5	Plastering in 1:4 c/s mortar	Sqm			
10.6	Centering& Shuttering	Sqm			
10.7	Stone masonry in 1:4 c/s mortar	Cum			
	Total - 10				
				Sub-total-I	

11. Environmental and Social Safeguard Cost

SN	Description	Unit	Qty	Rate	Amount
11.1					
11.2					
11.3					
11.4					
11.5					
11.5					
11.6					
11.7					
	Total - 11				
				Sub-total-I	

II. MECHANICAL WORKS

SN	Description	Unit	Qty	Rate	Amount
1	**Turbine & Accessories**				
1.1	Turbine: Cross flow/pelton/... of size	Set			
1.2	Turbine base frame	Set			
1.3	Foundation bolt with nut &washer	Set			
1.4	Adaptor	Set			
1.5	Pressure guage				
	Total -1				
2	**Valve**				
	Butterfly valve, ... mm dia.	Set			
	Total -2				
3	**Power transmission**				
3.1	Pulley on turbine dia. ...... mm	Nos			
3.2	Pulley on generator dia. .....mm	Nos			
3.3	Belt	Set			
	Or, direct coupling				
	Total-3				
4	**Penstock Pipe & Accessories**				
4.1	Penstock pipe (MS/HDPE)				
	.... mm dia. .... mm thick	m			
	.... mm dia. .... kgf/cm^2	m			
4.2	O-ring	m			
4.3	Nut and bolt for penstock	Nos.			
4.5	Vent pipe ...... mm with fittings				
4.6	Bell mouth	Nos			
4.7	Bend pipe	Nos			
4.8	Expansion joints, ...mm dia.	Set			
4.9	Painting	Sqm			
	Total-4				
				Sub-total-II	

III. ELECTRICAL WORKS

SN	Description	Unit	Qty	Rate	Amount
1	**Generator and Accessories**				
1.1	**Generator:** Type: .... Phase: .... kVA: .... Voltage: .... RPM: .... Frequency: ....Hz	Set			
1.2	Generator Base frame with nut/bolts	Set			
	Total-1				
2	**Control and Protection System**				
2.1	ELC/IGC with control panel & accessories Capacity : ....kW Phase:	Set			
2.2	Ballast unit: Ballast tank: size .... Ballast heater: .... kW (........ nos.)	Set			
2.3	Main switch: Type: .... Phase:........ Capacity: ..... A	Set			
2.4	MCCB: Type: .... Phase:........ Capacity: ..... A	Set			
2.5	Digital Energy Meter as per AEPC specification	Set			
2.6	Insulation tape RYBN	Nos			
2.7	Earthing System Type: .... Size:	Set			
2.8	Earthing wire 8 SWG, copper	m			
2.9	Salt	Kg			
2.10	Coal	Bag			
	Or, other appropriate subsitute				
2.11	Lightning arrestor				
	For LT line .... kV	Nos.			
	For HT line .... kV	Nos.			
2.12	Backup breaker (MCCB/MCB) in distribution system				
	Total-2				
3	**Power Cable and Wiring**				
3.1	Power cable				
	Copper Type: .... Size: ....mm^2 core:	m			
	Aluminium Type: .... Size: ....mm^2 core:	m			
3.2	Power house wiring	LS			
	Multi strand insulated copper cable 2.5 mm^2	Roll			
	Power socket/ switch/bulb	Nos			
3.3	Insulation tape	Nos.			
3.4	Load limiting devices for H/H (MCB etc.)	Nos.			
	Total-3				

4	**Conductor**				
4.1	Dog	km			
4.2	Rabbit	km			
4.3	Weasel	km			
4.4	Gopher	km			
4.5	Squirrel	km			
4.6	Service wire 6mm^2, Type................	m			
4.7	Aerial Bundled Cable (ABC)	km			
	Total-4				
5	**Fittings**				
5.1	D-iron, nut/bolt & insulator for LT line	Set			
5.2	Pin insulator & fittings for 11 KV	Set			
5.3	Disc insulator & fittings for 11 KV	Set			
5.4	Stay set size	Set			
5.5	Stay wire size/dia.	m			
	Total-5				
6	**Pole**				
6.1	Steel pole Type: ...., length .... m, Wt. ..... Kg	Nos.			
6.2	Wooden pole Type ...., length .... m	Nos.			
6.3	Cross arms & fittings, size.........., Wt. .. Kg	Set			
6.4	Bitumen paint	ltr			
	Total-6				
7	**Transformer**				
7.1	Step- Up Transformer Size: .... kVA, Phase	Nos.			
7.2	Step Down Transformer Size: .... kVA, Phase	Nos.			
7.3	DO fuse	Set			
7.4	DO fuse operating rod	Nos.			
	Total-7				
				Sub-total - III	

IV. TOOLS AND SPARE PARTS

SN	Description	Unit	Qty	Rate	Cost
1	**Tools**				
1.1	Clamp meter	Nos			
1.2	Open wrench	Set			
1.3	Ring wrench	Set			
1.4	Allen key wrench	Set			
1.5	Screw driver	Set			
1.6	Hammer 2.5 lb	Nos			
1.7	Insulation tape	Nos			
	.....				
	.....				
	Total (1)				

2	**Spare Parts**				
2.1	Turbine bearings	Nos.			
2.2	Belts	Set			
2.3	Nut/bolts	Nos.			
2.4	Gaskets	m			
2.5	Panel meters	Nos.			
2.6	Generator rectifiers	Nos.			
2.7	HRC Fuse & other fuse (uses)	Nos.			
2.8	Thyristers	Nos.			
2.9	Insulators	Nos.			
2.10	Conductors	m			
2.11	AVR	Set			
	Total (2)				
				Sub-total-IV	

V. Packing and Transportation

SN	Description	Unit	Qty	Rate	Cost
1	**Preparation & Packing**	L.S.			
2	**Transportation**				
2.1	By truck	Kg			
2.2	By plane/helicopter	Kg			
2.3	By mule/porter				
	Easy load	kg			
	Un-easy load	kg			
				Sub-total-V	

VI. Installation and Testing/commissioning Work

SN	Description	Unit	Qty	Rate	Cost
1	**Civil Component**				
	Supervision	MD			
2	**Mechanical Component**				
2.1	Unskilled labour	MD			
2.2	Mechanical technician	MD			
2.3	Supervision	MD			
3	**Electrical Component**				
3.1	Unskilled labour	MD			
3.2	Electrical technician	MD			
3.3	Supervision	MD			
4	**Testing and Commissioning**				
4.1	Civil components	MD			
4.2	Mechanical components	MD			
4.3	Electrical components	MD			
				Sub-total-VI	

VII. Training

SN	Description	Unit	Qty	Rate	Cost
1	Management training	Person	1		
2	Operator Training	Person	2		
				Sub-total-VII	

VIII. End Uses (if Applicable)

SN	Description	Unit	Qty	Rate	Cost
1	**Agro-processing**				
1.1	Grinding	Set			
1.2	Hulling	Set			
1.3	Oil-expelling	Set			
2	**Bakery**	Set			
3	**Computer institute**	Set			
4	**Furniture**	Set			
	....				
	....				
				Sub-total-VIII	

Appendix E: Analysis of Best Available Technology (BAT)

Comparison of Different Technologies: Best Available Technology (BAT)

S.N.	Particulars	Hydropower Option	Solar Option	Wind Option	Biomass Option	Technological Choice (Rank)	Remarks
1	Unit Generation Cost (Rs./kWh)						
2	Discount Rate (i)						
3	Investment Rs. Million (P)						
4	Annual Income (Rs.)						
5	O& M Cost						
6	Project Life (n)						
7	NPV (Rs.)						
8	IRR @ 6% discount rate						
9	IRR @ market price						
10	Pay Back Period (Years)						

Appendix E: Environmental and Social Management Plan (ESMP) Format

ENVIRONMENTAL AND SOCIAL MITIGATION MEASURES

S.N.	Environmental/Social Impacts	Mitigation Measures	Time of Action	Estimated Mitigation Cost (NRs.)	Responsibility
1.0 Construction Phase					
1.1					
1.2					
1.3					
1.4					
1.5					
1.6					
2.0 Operation Phase					
2.1					
2.2					
2.3					
2.4					
2.5					
2.6					
2.7					
2.8					

Environmental and Social Monitoring Plan

S.N.	Indicators	Methods	Frequency/Time	Place	Monitoring Authority	Monitoring Cost (NRs.)
1.1 Construction Phase						
1.1.1						
1.1.2						
1.1.3						
1.1.4						
1.1.5						
1.1.6						
1.2 Operation Phase						
1.2.1						
1.2.2						
1.2.3						
1.2.4						
1.2.5						
1.2.6						
1.2.7						
1.2.8						