CHAPTER 3
Data Collection and the Design Process

As discussed in Chapter 2, in order to design an MHP plant properly, it is necessary first to collect information and data about such things as the power required, the capabilities and keenness of the recipient communities/entrepreneurs, and the potential of the site. This data and information are collected from sources that include the promoters or owners of the plant, other persons or individuals who are or have been working in the area, and, most importantly; through site visits, discussions, meetings, and surveys. In the following sections the main topics for which information and data need to be collected and analysed are discussed, together with the methodology and sources that can be used.

3.1 Information Collection before the Site Visit

Considerable information should be collected before first travelling to the site. This information should also be useful for making travel and accommodation arrangements. If possible, information should be obtained about the site, the local community, the economy, the water source (or sources), the weather, and the social conditions. The main source of information would normally be the entrepreneur or representatives of the community pursuing installation of the plant; i.e., the people who have approached the organization to conduct the survey. Other possible sources are personnel from non-government organizations (NGOs) working in the area, or employees of banks, schools, or other offices working and living in the area. Although it might be quite difficult to find such a person (or people), an effort should made because information from them is likely to be less biased. Although further visits to the site and proper surveys will be necessary, this pre-visit information can facilitate many aspects of the visit and may even decrease the length of time needed at the site. The contact people may also be helpful in making arrangements for the trip and stay.

A form similar to that shown in Annex I may be used for collecting information. This form includes sections on location of the site; travel route, mode, and distance; contact persons in the area; accommodation arrangements; some ideas about the number and type of consumers; the social and economic situation; and, of course, some description of the water source, terrain, and climate. While collecting such information, it should be kept in mind that the person being interviewed may have little knowledge of technical subjects and questions should be phrased simply so they can be easily understood and should be repeated if necessary. Even so, the information obtained may not be totally accurate.

3.2 Preparations for the Site Visit

During the visit, a number of surveys and other tasks will have to be performed. Preparations need to be made for these, and equipment and other items acquired and carried to the site. The tasks to be prepared include the following.

- Arrival and stay in the Project area
- Meetings with community members/leaders/representatives, entrepreneurs
- Reconnaissance survey
- Survey of demand
- Preliminary site survey
- Preparation of sketches/maps
- Photography at the site

The first matter to be determined is the timing of the visit, which should be convenient from the point of view of travel, stay, and working at the site. It should be during a dry period (not too much rain) and not too hot or too cold. Otherwise, work at the site may be difficult. In Nepal the convenient period for surveys (including measuring minimum flow) is between February and May. The optimum period may be different in other countries and/or sub-regions of the HKH area. Appropriate information needs to be obtained from the people of the area, the Meteorology Department of the country, and other sources.

Usually two persons should travel to the site, especially during the first visit: a qualified and experienced surveyor and an assistant. They should be able to get along with each other and work well together. Later, however, it should be possible to locate and engage one or more local persons to assist in the survey work and other tasks such as organizing meetings.

It is not easy to estimate the time needed for completing all the surveys, meetings, and layout design. For an experienced surveyor, the minimum time needed would be three days, excluding travel time, if the site is easy, the community helpful, and adequate information has been collected before the visit. In general, however, at least five to seven days should be allowed for the first visit and preliminary survey.

3.2.1 Survey and Other Related Equipment

It would be very useful to acquire maps for the project area with topographical contours on a scale of 1:50,000 or better. Such maps are not easily available for some countries of the Himalayan region, but they are generally available for Nepal.

The choice of survey material to be carried to the site depends partly on the decision made on the methodology to be used for flow measurement (see section 3.8). It is both expensive and embarrassing to have to return to the office to collect necessary equipment, thus a check list should be prepared beforehand showing the equipment needed. A typical check list is shown in Annex 2. Most of the equipment, especially the delicate optical equipment, needs to be packed properly for transportation to the site.

Proper clothing is also important: shoes, caps, glasses, and gloves are needed. Warm clothes and a sleeping bag are also essential. Thus attention should be paid to packing the appropriate personal belongings for the trip; taking into account the weight limitation, since in general all luggage has to be carried by somebody.

3.3 Arrival at the Site

After arriving and settling down at the site or village, where the team is to stay, safely and with all equipment intact, the first thing to be done is to contact the people who are to look after the team and make arrangements for their stay, meetings, and survey. The actual work can only start when the team has established these contacts, is comfortably settled into lodgings, and arrangements have been made for further travel to the villages of beneficiaries and the site.

The second important task is to try to contact those directly concerned and discuss with them the work plan for the next few days. These initial meetings should also be helpful in assessing how keen the community or the entrepreneur and his partners/supporters are about the installation, and how much help/assistance they are prepared to offer to the team. The message should always be that this is their project and the team has come to assist.

For a community owned and/or managed plant, the third task is to organize a meeting of representatives of different ethnic/caste/religious/and economic groups and anyone else who would like to attend. The main objective of this first meeting is to meet the potential beneficiaries and assess their keenness, capability, and willingness to assist and work for the installation. Overall, the following aspects should be covered.

- Know and meet the various groups and build rapport and trust.
- Explain why the team has come.
- Provide as much information as possible about the proposed MHP plant and explain the need for the local community to be involved in such things as decision-making, surveys, installation, management, operation, and repairs, as well as any other contributions.
- Collect additional information about such things as the site, stream, consumers, previous surveys.

- Assess the keenness and capacity of the potential beneficiaries through their responses to what they are being told (avoid asking direct questions).
- Sense any inter-community conflicts: social, economic, related to land/water, etc.
- Ask how beneficial the group thinks the MHP would be for the community and what they themselves would be able to do.
- Ask if they have any fears or misgivings about potential negative effects of the MHP plant: land use, diversion of water, effect on their *ghatta*(s).
- Ask if potential beneficiaries really want an MHP for electricity and if they are willing to contribute in cash and kind to have it installed.
- Ask how much power they think is needed.
- Ask who would be the manager of the plant, whether the participants would trust such a person, and whether they think he is competent and experienced enough to do the job.
- Ask if the potential beneficiaries think it would be appropriate to form a committee to look after both the installation and operation of the plant; and if so who would be the proper people to work as members of the committee. (The actual committee may be formed later after more thorough consultations and assessment of the leading people.)
- Ask the participants to identify four to five suitably qualified people to assist in the survey work. Such persons should be interviewed later and, if found suitable and willing to assist, should be assigned some tasks.

This meeting should be treated as a preliminary meeting and most of the discussion should be informal. The community leaders should not be given the impression that the team is following some pre-planned course. At the same time, some notes may be taken of facts related to the assessment.

It would be useful to hold a similar type of meeting for an entrepreneur-owned plant. The main objective in this case would be to judge the reaction of the people towards the plant, and whether the owner was capable of dealing with the issues and concerns raised by the community members. The entrepreneur might be asked to organize such a meeting himself.

3.4 Reconnaissance Survey

This survey involves visual inspection of the site for a few hours to become familiar with the prevailing conditions and gain some idea about such things as the flow, elevation (whether the slope is gentle or steep and allows more or less head), terrain, vegetation, land uses, and water uses. Photographs of the site, stream, terrain, and likely location of the civil structures may also be taken. Some community representatives and helpers should accompany the survey team to discuss the following.

- Whether any previous survey had been conducted; and, if yes, what were the results? Did any one have records? Even if proper records of a previous survey are available and thought reliable, it is still necessary to perform a survey, but it might be possible to shorten some aspects of the survey and layout design.
- Had any sites already been considered or identified for, say, the powerhouse/mill, forebay, power canal, and intake?
- General items such as who owned the land where the powerhouse was proposed, would the intake be suitable, and was there a proper location for digging/constructing a canal?

Some very rough estimates of flow may be made using the float method, for example. The terrain should be inspected for possible siting of the powerhouse, forebay, canal, and intake. Some idea about the availability of head can also be obtained, using, for example, an altimeter, thus enabling a very rough calculation of the power potential of the site.

The main objective of the reconnaissance survey is to become familiar with the site, consider or evaluate locations for the main components, and make a very rough estimate of the potential of the site.

3.5 Comprehensive Meeting with the Beneficiary Groups

At this stage, the survey team should have a very rough idea of the demand for power (through discussions before the site visit and during the preliminary meeting) and the power potential (from a previous or reconnaissance survey). Looking at the site, very rough estimates of costs can also be made. With these figures in mind , this is the time to hold a more comprehensive and decisive meeting with community members, leaders, and representatives of different ethnic/economic groups. Women representatives should be included if at all possible. The main objective of the meeting is to discuss and clarify all major background aspects, such as demand, power, costs, funding, contributions and other support, some technical details, other end uses, management, tariffs, incomes, repair and maintenance, and back-stopping. The team members should facilitate the discussions rather than lead them, and make the community feel that they are talking about their own plant/property, its benefits, and the necessary effort and responsibilities.

All known information should be presented at the meeting and discussion encouraged. The team members should observe and assess the possibility of cooperation and working together between the different ethnic and other groups; try to identify any real conflicts within the groups; and assess the keenness and ability of potential beneficiaries to participate in and contribute to the installation and later manage and operate the plant successfully.

Assessment should also be made of whether most of the consumers are willing or able to pay for the electricity. The technical and managerial capabilities of the community nominees may also be assessed. Conflicts or different views relating to the land on which the plant and its components are to be situated must also be discussed and assessed. The required level of income and tariffs and the types of tariff (fixed, metered, other) and their implications should also be discussed and conclusions drawn if possible. The advantages of having a significant net positive income that can be used to improve the plant and its services in the long run should also be explained. If appropriate, formation of a Users' Committee to look after the arrangements should be facilitated at this stage. Some suggestions or ideas from the villagers about industrial applications may also be discussed, evaluated, and finalised if possible.

It may be necessary to interrupt the survey or even recommend abandoning the installation plans if it becomes clear during the meeting that the capabilities or interest of the community are limited or serious conflicts exist about, say, water or land use. The meeting, for example, may become unruly or even break up.

3.6 Demand Survey

This survey is mainly concerned with the counting of households and other potential consumers (shops, lodges, offices, temples, schools, industry), who are ready to commit themselves to receive power and pay for it, and with calculating the total demand for power. The survey can be conducted before the comprehensive meeting or even before the reconnaissance survey, but it is better to take up this detailed work after the first decision to go ahead has been made.

The usual form of tariff for low-cost plants is a fixed rate based on power to be used or connected, with current limiting devices to ensure that the power used is kept within the limits. The power needs of each consumer are calculated in terms of the number of light bulbs or tube lights, radios, TVs , fans, and other pieces of equipment to be connected and their wattage rating. The forms shown in Annexes 3 to 7 can be used to record the power needs of customers (rounded up to the next highest 50 or 100 watts). Industrial uses discussed and agreed upon by the community may also be added. The figures are added together to give a final figure for the present total power needed, allowing for power losses in the transmission and distribution lines. This final figure is the minimum present power demand and, if the power potential of the site is significantly less than this value then the installation process would have to be abandoned.

If the plant under consideration is entrepreneur owned; then the power needs for electricity and/or agro-processing may be estimated in a similar way and the minimum power demand computed.

Usually, after discussions with the community, the figure for the power demand will be increased in order to cater to the needs for the immediate future (next 1-2 years) when other residents in the area ask for connections. An assessment of such future demand should be made and added to the minimum power demand to give the desirable power capacity of the plant. The additional future demand is usually between 10 and 50 per cent of the current minimum demand. The desirable power capacity should be taken as the rated power of the MHP plant to be designed and installed.

The survey of demand should be accurate and thorough, as it is not usually repeated at the time of the detailed site survey. If considered necessary, however, some reliable community members may be requested to carry out a more thorough survey later.

3.7 Preliminary Site Survey

The survey includes flow measurement when the flow is at a minimum (in the dry season); determination or selection of the head needed to generate the required rated power; flow measurement, land survey, and measurement of heights (heads),* slopes, and distances to locate the powerhouse, forebay, power canal, and intake so that the rated power can be generated. These surveys and measurements are described below.

3.8 Flow Measurement

The method of flow measurement to be used for a particular stream depends mainly on the volume of flow and whether it is turbulent or calm. Very few natural streams are non-turbulent, especially in mountainous terrain, except for smaller sections. The following methods are usually appropriate in the developing countries for measurement of flow of mountain streams.

1) The bucket method:	for flows up to 20 l/s.
2) The velocity-area method using	for larger streams (flow>20 l/s) with a depth of
a) a flow meter	at least 10 cm at the deepest point
b) a float	for any volume of flow in a calmer (less turbu-
lent) stream	
3) The weir method:	for larger streams (flow>50 l/s), a rectangular or triangular weir can be used.
4) The salt dilution method:	for all streams with smaller flows

* It is important to ensure that all height measurements are made using a completely vertical measuring rod or tape. A simple plumb line (a small heavy weight hung on one end of a string) can be used to check that the measuring line is vertical.

The following general rules should be followed.

- The location for the flow measurement should be chosen carefully so that the depth of the stream is adequate, measurements can be made easily, and flow is not diverted by being broken up into sections or seeping underground to rejoin the main flow somewhere downstream.
- The timing of the measurement should also be such that the flow is steady (not changing significantly) during the period in which measurements are made.
- It is useful to measure the flow by at least two different methods so that the results are more reliable. If the difference in the values obtained by two different methods is more than 20 per cent, something may be wrong. Either the flow is changing, or at least one of the measuring methods has not been performed properly.
- Flow measurement using a float is not very accurate and its use should be confined to the initial rough measurements.

The different methods of flow measurement are described briefly below. These descriptions should be adequate for surveyors who are already familiar with the concept of flow and its measurement. However, those who are totally new to the subject might find it difficult to make accurate measurements using the brief descriptions. Novices are advised to learn the methods from other experienced persons or, if this is not possible, to read more detailed textbooks on the subject.

3.8.1 The Bucket Method

This is a very simple and accurate method if the flow is relatively small (say <20 l/s). A bucket or other container of known size is used as a measure (Figure 3.1). All the water in the stream is diverted into the container through a pipe or a trough and the time taken to fill the container is measured. The flow, Q, is given by:

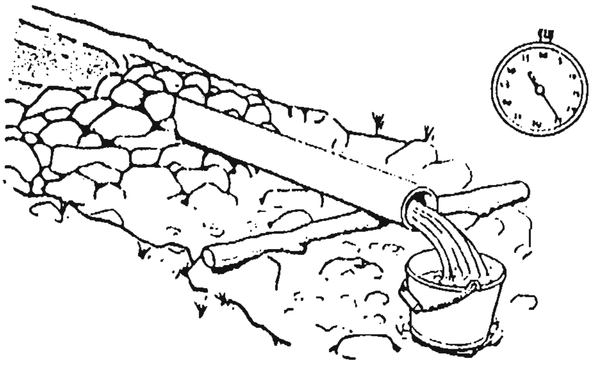

Figure 3.1: The Bucket Method

$$Q\,(l/s) = \frac{\textit{volume of container in litres}}{\textit{no. of seconds to fill it}}$$

Care must be taken to channel all the flow into the container. Usually, a dam is built around the pipe and the area is temporarily sealed with earth, plastic/rubber sheets, stones, or similar, to prevent leakage. If possible, in order to obtain reasonable accuracy, the capacity of the container should be such that it takes more than five seconds to fill.

3.8.2 The Velocity-Area Method

a. Using a Flow meter

This method is quite useful and reasonably accurate if a proper flow measuring instrument is available. The basic technique is illustrated in Figure 3.2. A suitable point is selected carefully along the stream; the cross-sectional area at this point is divided into different sections; the width, depth, and profile are used to calculate the area of each section; and the average velocity of each section is measured by a current meter (flow meter) held at its centre. The average flow is calculated using the general formula for flow, Q:

$$Q = \sum a_i \times v_i = a_1 \times v_1 + a_2 \times v_2 + a_3 \times v_3 + \ldots\ldots$$

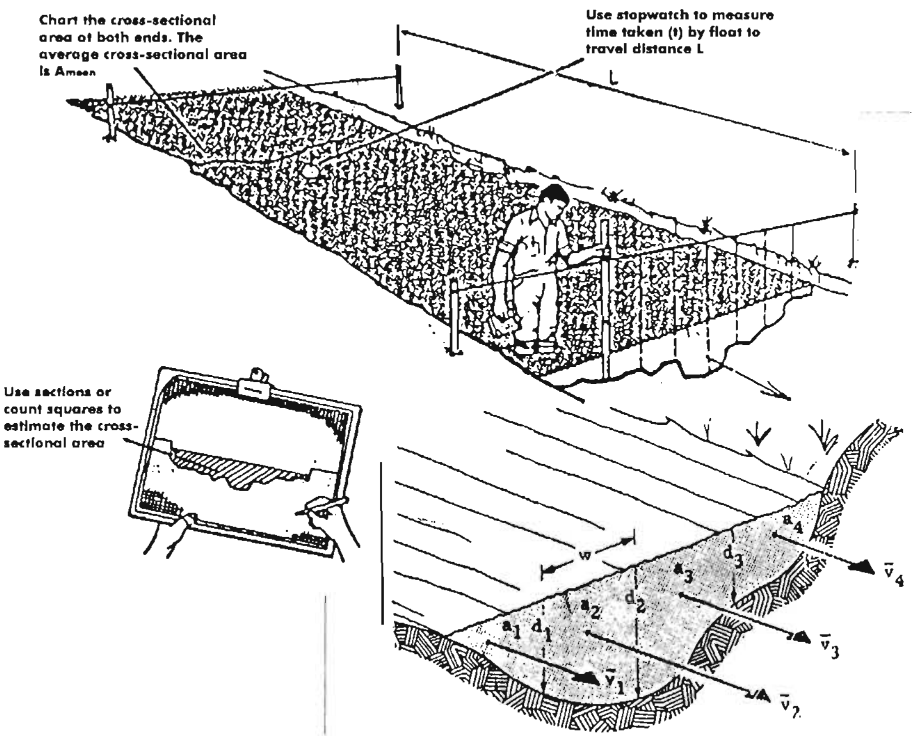

Figure 3.2: Velocity-Area Method Using a Flow Meter

The sub areas can be calculated as if the sections were trapezoid using

$$A = average\ depth\ (d)\ x\ width\ (w) = \frac{d_1 + d_2}{2}\ x\ w$$

or by counting squares on squared paper using an outline of the cross-section profile.

There are many types of flow/current meter available that are light and quite easy to carry (see for example Figure 3.3), although they are somewhat expensive.

An appropriate location must be selected, preferably along a straight and non-turbulent length of the stream. Both the stream bed and the width should be reasonably uniform and not covered with protruding materials such as rocks. The water should be adequate for most of the cross-section; and the mean depth should be at least 100mm, preferably more.

Elaborate instructions and tables are provided with the current meters to enable proper and accurate calculation of the velocity. The depth at which the rotor must be located is also specified. The preferred depth for many types of meters is 0.6 of the total depth of water at that point. Many meters are mounted on measuring rods so that the depth can be measured at the same time as the flow, and the rotor can be located easily at the requisite depth.

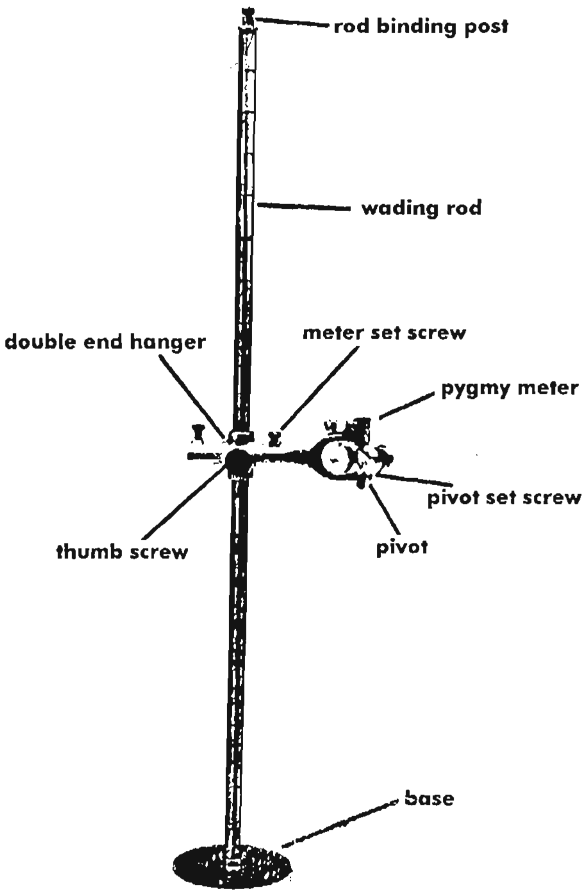

Figure 3.3: A Typical Current/Flow Meter

b. Using a Float

This method is similar to the above, but the flow is measured using a small floating object rather than a flow meter. The object chosen should float partially submerged in the water and can be a piece of light wood or a more elaborate, specially constructed float like those shown in Figure 3.4. The float is placed at the centre of the stream and the time taken for it to travel a certain distance (or the distance covered in a certain time) is measured. The surface velocity (V_s) of the water at the centre of the stream is given by:

$$V_s \text{ m/s} = \text{Distance travelled by float (m)/Time taken(s)}$$

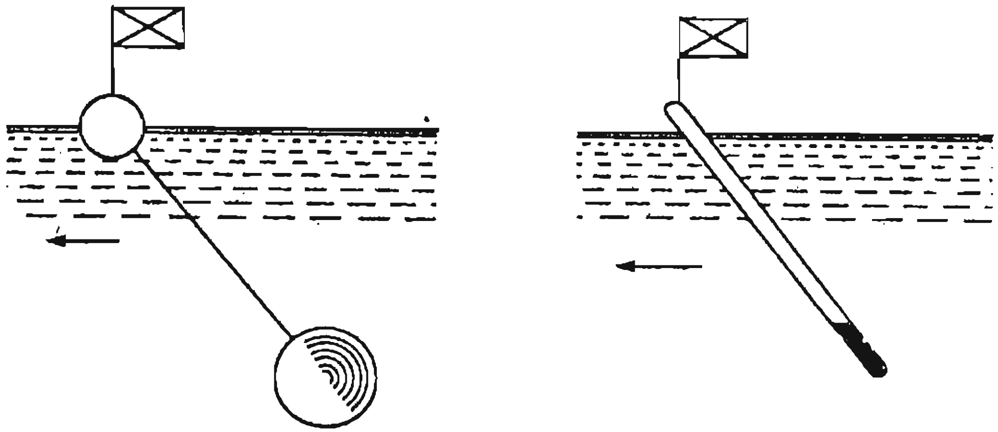

Figure 3.4: Some Proper Floats

V_s is not the average velocity of the stream since the water moves at a slower speed near the banks and the bottom of the stream. A correction factor 'C' needs to be introduced to determine the average velocity, $\overline{V}$, of the stream.

$$i.e., \overline{V} = C \times V_s$$

C varies between 0.4 and 0.95 depending on the conditions.

For example;	for shallow turbulent streams	C = 0.45
	for small regular streams with a smooth bed	C = 0.65
	for large, slow, clear streams	C = 0.75
	for large, deep streams with a smooth bed	C = 0.85

The cross-sectional area of the stream (A) is calculated by measuring the depth at different points along the chosen cross-section as explained in the previous section and Figure 3.2. The flow, Q, is then calculated as follows.

$$Q = \bar{V} \times A = C \times V_s \times A$$

The accuracy of measurements by this method may be quite low with a possible error of ± 50 per cent, or even higher, and other methods of measurement should be used as far as possible. The accuracy can be improved through experience by comparing the flow measurements obtained using different methods and thus learning to choose the correct value for the correcting factor C.

3.8.3 The Weir Method

Many types of weir can be used to measure the flow in streams. The method of measuring, two different types of weir, and the equations used to calculate the flow Q, are shown in Figure 3.5. The most convenient weir is the rectangular type, mainly because it can be constructed from wood on site if an amateur carpenter is available. If the weir has been made properly, the flow measurement can be accurate within ± 5 per cent. However, it is unlikely that this level of accuracy will be achieved in most practical situations.

This weir can measure flows of between 10 and 400 l/s. The length, L, of the weir should be at least three times the height of the flow h (see Figure 3.5). Furthermore, h should be large enough to be measured accurately (about 50mm or more) but not more than 0.5m. The following precautions need to be taken when measuring the flow.

- The crest of the weir should have a reasonably sharp edge
- The water flow over the weir should fall; i.e., the water level in the downstream channel should be considerably lower than the crest
- The crest of the weir should be at least 2h higher than the upstream bed.
- The crest should be as horizontal as possible so that the head, h, is constant along the length of the crest.
- The area surrounding the weir should be well sealed so that all flow passes over the crest.
- The head, h, should be measured as accurately as possible and the measuring rod should be installed at a distance of about 4h upstream from the crest (Figure 3.5)

Another useful weir is the 90° triangular notch (commonly called a V-notch, Figure 3.5). This is a more convenient measuring weir than the rectangular weir having just one dimension (90° angle). It needs to be produced accurately in a workshop, but it is more suitable for measuring small flows, and a small version can easily be carried to the site and fixed to wooden planks *in situ* for measurements of flows of between three and 300l/s.

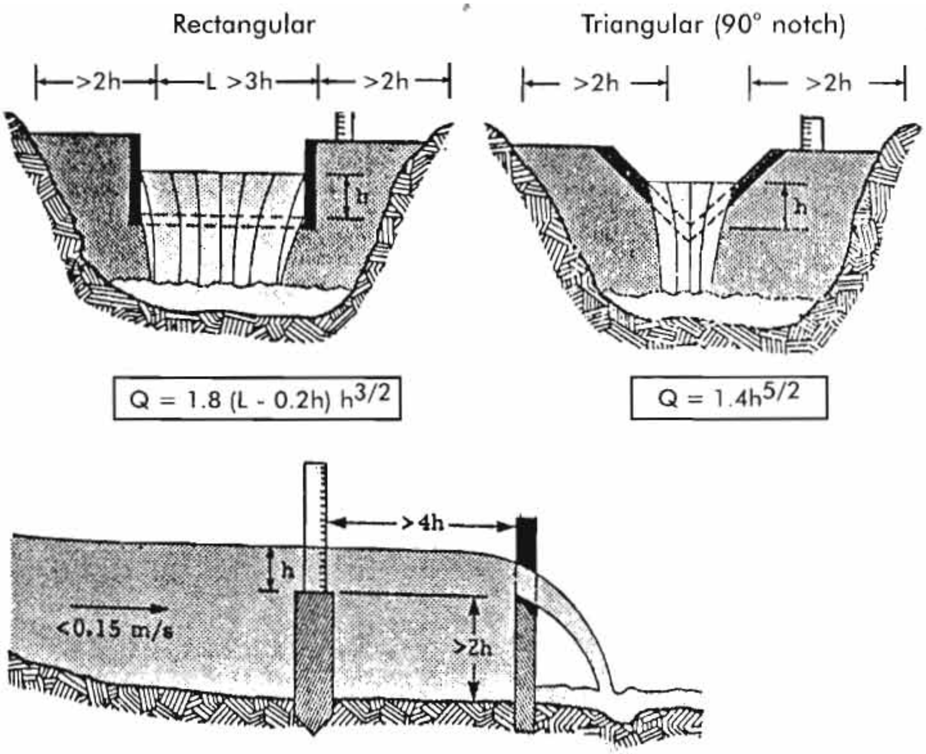

Figure 3.5: Flow Measurement Using a Weir

3.8.4 The Salt-Dilution Method

This method of flow measurement is proving to be quite convenient, accurate, and quick for small, shallow, and turbulent mountain streams. The way in which the measurement is made is illustrated in Figure 3.6. If the conductivity meter is well calibrated and the measurement is carried out properly, the accuracy should be better than ± 7 per cent; which is quite acceptable for MHP schemes. The meter used to measure the conductivity of the water is a small device that can be carried around quite easily. Such meters cost between 50 and 400 US$.

The method is as follows. A known weight of pure dry salt is completely dissolved in a bucket full of water. The water is mixed with the stream water as quickly as possible, but without muddying the water severely, at a pre-selected location. The probe of the conductivity meter is immersed about 30 - 50m downstream near to the bed and centre of the stream and conductivity readings are taken every five or 10 seconds. The readings will rise, reach a peak, and fall back to the base level, over a period of time. Usually two people are needed to take and record the readings.

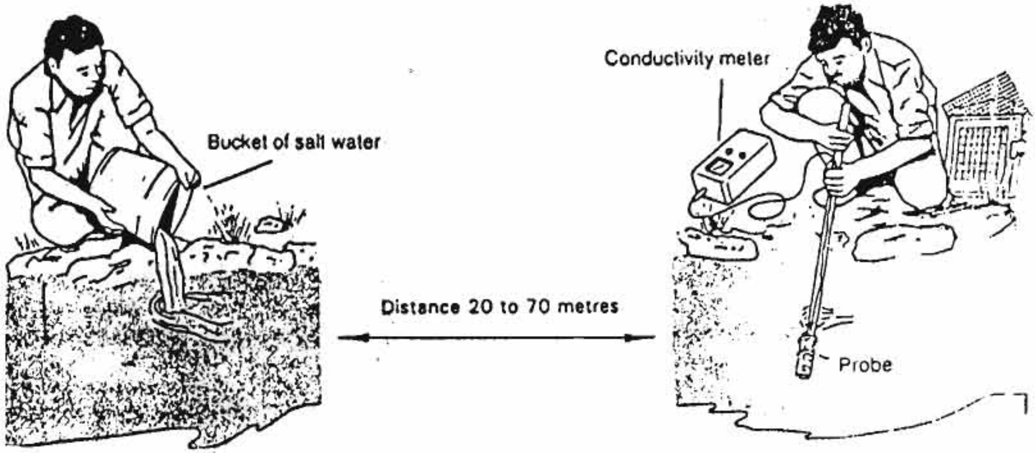

Figure 3.6: Flow Measurement Using the Salt Dilution Method

The readings are taken continuously until the conductivity values have returned to normal (which means that all the salt water has passed the probe). A graph of change in conductivity with time is plotted, and the area under the curves calculated (Figure 3.7). If graph paper is used, the area can be calculated easily by counting the squares. The temperature of the stream should also be measured. The flow, Q, is then calculated using the following equation.

$$Q\,(m^3/s) = \frac{\text{Mass of salt }(kg)}{\text{Conversion factor } k\ (kg/m3/ohm-1)\ x \text{ area under the curve } (ohm^{-1}s)}$$

The conversion factor, k, depends on the temperature, and its value is given in the manual for the conductivity meter. More detailed instructions for flow measurement are also provided in the manuals.

The following points should be kept in mind when using the salt-dilution method and the conductivity meter.

- The curve should be smooth and have an adequate peak. It should not be distorted. If it is distorted in the way shown in the examples in Figure3.7, follow the instructions given to achieve a good curve.
- The measurement process should be repeated two or three times to achieve reliable results (if the results do not match, recalibrate the instrument or contact the supplier).
- An electronic integrator is also available which can calculate the area automatically when the readings are fed into it. However, this may be an unnecessary additional

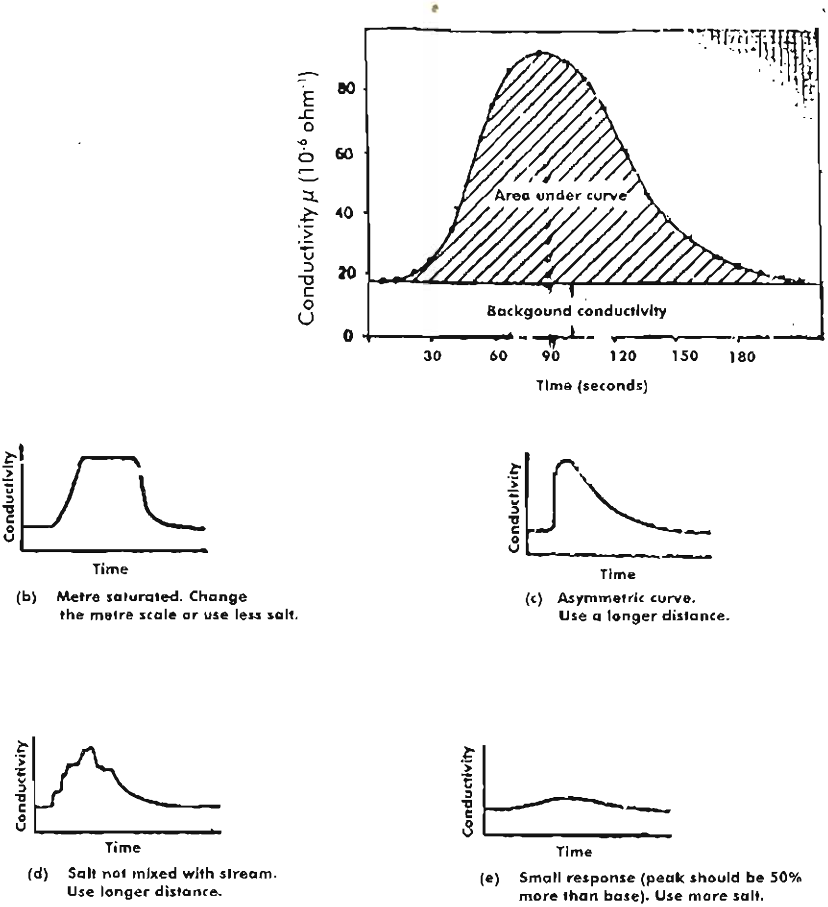

Figure 3.7: Typical Curves Showing the Change in Conductivity Over Time (The Ideal Curve is Shown, Together with Typical Distorted Curves and Recommendations for Corrective Measures)

expenditure if the measurements are not taken frequently. In any case the curve should still be plotted so that its shape can be checked.

- The method is suitable for small flows and fast streams. If the stream is too shallow or very fast then the results may be misleading. Therefore, a relatively calm section of the stream should be selected for measurements.
- Use about 100g of salt for every 0.1 m^3/s of flow.
- The distance between the place where the salt is added and the place where the probe is inserted should be between 30 and 50 metres.
- Sometimes a coefficient is written on the probe which must be applied to the equation to get the correct value of flow.

3.9 Determining the Head

As explained earlier, the final head is determined by the location of the powerhouse and the forebay, which also determine the route of the canal and intake. The surveyor should first calculate the value of gross head required from the simplified power equation; i.e., $h_g = P/5Q$ where P is the total power required, that is the minimum present power demand plus losses, and Q is the flow. The surveyor then starts by tentatively selecting a suitable site for the powerhouse and the forebay and measuring the height and distance between the two. If the height of the forebay above the base (floor) of the powerhouse is adequate, the ground is stable, and the route for the penstock is relatively short, he may then proceed to find a suitable route for the power canal and the site for the intake. If any of these conditions are not fulfilled, then he must look for a new site for the component in question and repeat the process for all the other components. He may have to accept a smaller or larger head than originally desired as a result of limitations on siting possibilities for the major components. Thus the process of 'determining the head' involves a lot of surveying including measurement of distances (both horizontal and along a slope), heights, and angles and bends. At the same time, the geological and other conditions of the selected locations must also be examined and evaluated to ensure that they are fit for constructing such structures and that no natural or human/animal damage will result.

Some experts suggest performing the process in reverse; that is selecting a suitable site for the intake first, then siting the canal, forebay, penstock, and powerhouse in that order. For this it is necessary to first have some idea of the area where the MHP plant and its components are to be located. This method may be more appropriate if the value of the head is not so critical. Whichever method is followed, it is certain that the survey and selection process will have to be repeated many times, selecting the location of one component, siting the others, encountering problems, starting with another location, and so on.

The necessary and desirable characteristics for the locations of each of the civil structures are described in the following sections.

Powerhouse and Forebay

- The powerhouse must be easily accessible and near to the consumption centres.
- An adequate area must be available for all the facilities and mechanical units proposed.
- The location must be firm and not threatened by landslides, falling stones, floods, or similar.
- The location must lie above the 50-year flood level of the stream.
- It must be possible to construct a tailrace easily to carry the water leaving the turbine to the stream.

- The requisite land for the powerhouse, penstock, and forebay must be available or easily acquired.
- (If cost is a crucial factor or only a small area is available, then for small plants for an electricity scheme the possibility may also be explored of constructing a robust portable structure to cover just the turbine and generator.)
- The location of the powerhouse and the forebay should provide the desirable head.
- As the penstock is an expensive component it should be as short as possible and its path should be straight and without serious obstructions (protrusions and depressions). Thus the slope needs to be fairly steep.
- The path of the penstock should also be on firm ground and not liable to slip as a result of heavy rains, landslides, or similar.

If both the available flow and the available head are more than necessary; then it would be advisable to increase the head and minimise the design flow. This approach reduces the cost of mechanical equipment and transportation. However, by increasing the gross head, the length of the canal will increase which makes it more vulnerable to damage, the length of penstock would also increase but the diameter will decrease.

Power Canal

The third site to select and survey is the path of the power canal from the proposed forebay to the intake. The considerations include the following.

- The path should be stable and not threatened by storm gulleys, landslides, falling rocks, or similar.
- The construction of the canal must be feasible and not too expensive.
- The path should not contain obstructions that would hinder construction, make construction expensive, or shorten the life of the canal (avoid, for example, a vertical or near vertical cliff, a large storm gully, or terrain susceptible to erosion or landslides). If such a situation exists, then the construction of the canal is seen as the most serious problem; and the best approach would be to select a suitable route for the canal first on any side of the stream and then select the sites for the intake, forebay, and powerhouse.
- Sometimes an aquaduct (covered if necessary to prevent damage from falling stones) or a pipe may be used for part of the route of the canal to cross a gulley or a depression (Figure 3.8). Similarly, the possibility may also be explored of building a canal or installing a pipe around a large rock or other obstruction (on the hillside), if the rock is in the way of the normal path of the canal. This approach would be advisable since in many situations it may not be possible to locate a terrain without any obstructions or other problems.

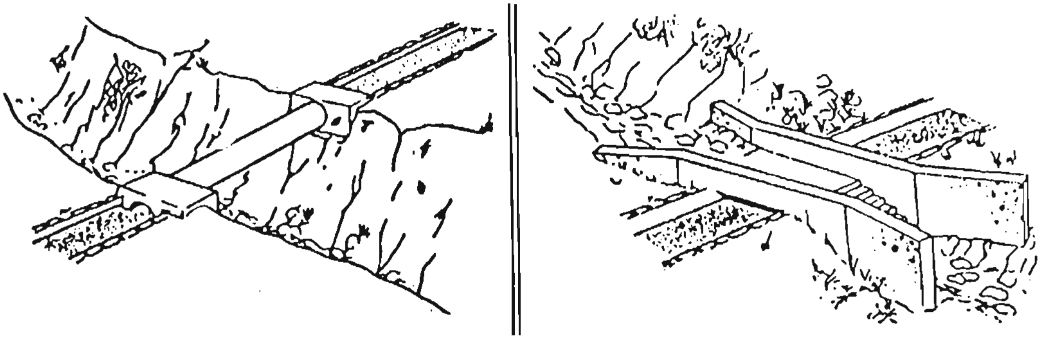

Figure 3.8: Different Choices for Parts of a Canal and Crossing

- Different types of construction for different sections of the canal may also be tentatively decided at this stage depending upon the geological conditions (extent of erosion, greenery, obstructions, and similar).
- Usually, the power canal should be constructed in such a way that only a minimum amount of rainwater enters it. To achieve this, a drainage channel should be provided wherever necessary and possible. In addition, more spillways may be provided at appropriate locations to prevent damage to the canal and forebay as a result of additional flow caused by rainwater.
- The canal path should have a small gradient. A gradient of two to four metres per km (1:125 to 1:250) is considered adequate for earthen channels. If the number of bends is large, or the cross-section is non-uniform over the whole length, then the gradient may be increased slightly to compensate for the losses and to ensure that the velocities in the canal are within the permissible range, as shown below for different soil types.

Type of Soil	Velocity Range
Sand	0.3 - 0.4 m/s
Sandy loam	0.4 - 0.6 m/s
Clayey loam	0.6 - 0.8 m/s
Clay	0.8 - 2.0 m/s

Intake

Some suitable and unsuitable locations for an intake are illustrated in Figure 3.9.

- Usually the site of the intake should be suitable to accommodate the construction of a weir downstream of the intake mouth.
- The intake should be sited at a place where the stream is relatively permanent; for example, flowing over bedrock and not prone to accumulation of silt.

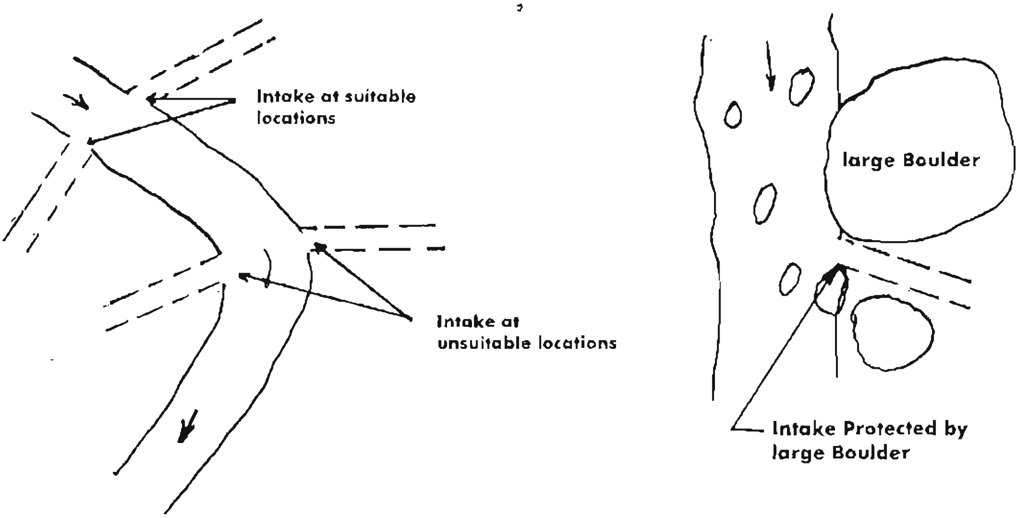

Figure 3.9: Suitable and Unsuitable Locations for an Intake

- The stream should not have a large gradient upstream of the intake.
- The stream should be relatively straight both upstream and downstream of the intake to avoid damage from sharply turning flood waters. If really necessary, the intake may be placed on the outside of a bend; but not on the inside. However, if the silt load in the stream is high, this may also be a problem.
- Sometimes the intake can be protected by locating it under or downstream of a large boulder.

Weir

Two types of natural and temporary weir are illustrated in Figure 3.10.

- A weir may not be needed if the inherent features of the stream automatically divert adequate water to the intake during the dry season (a natural weir).
- Sometimes, a temporary weir or partial diversion dam can be built for smaller schemes which is washed away during the high floods and rebuilt easily during the low-flow period when it is really needed (Figure 3.10b).
- Since considerable silt or gravel is likely to accumulate at the foot of the weir, it should be constructed about 50 metres or so downstream of the intake.
- A permanent weir can also be build from gabions, stone masonry, or concrete, depending upon the level of high flows and the amount of debris carried during such periods.

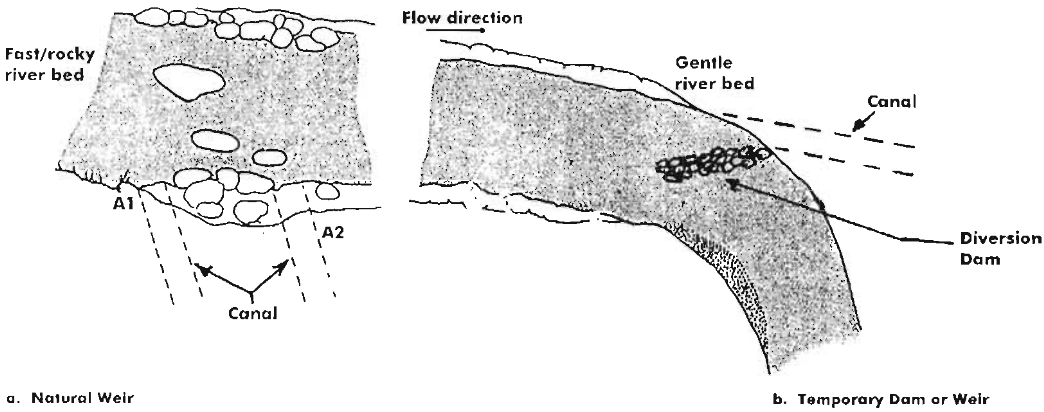

Figure 3.10: A Natural Weir and a Temporary Diversion Dam

3.10 Measuring the Head

Once suitable locations have been selected for all the civil structures, the available head and the distances between these structures should be measured. The head can be measured using one or two of the following methods.

3.10.1 Using a Clinometer (Abney Level)

The clinometer (also called an Abney level) is a smaller version of a line level and is used to measure vertical angles. If possible it should incorporate a range finder. It is used to measure the angle of the slope and this is used to calculate the gross head. The method is illustrated in Figure 3.11. The accuracy available from this rather small and cheap instrument is better than ± 5 per cent for measuring the head. The other equipment needed is a measuring tape (30m), two strong sticks of equal length (~1.5m long) and marking pins or pegs.

Procedure

1. Place one stick/ranging rod at the starting point of the survey, for example, the location of the turbine base in the powerhouse, and the second stick at the first intermediate point, less than 30 metres away.
2. Measure the straight sloping distance, L_1, between the tops of the sticks and record.
3. Place the Abney level on top of the first stick and sight the top of the second; turn the spirit level until the bubble is at the centre of the split eyepiece and record the measured angle a_1.
4. Move the first stick to the next location along the route of the penstock, preferably less than 30m away.

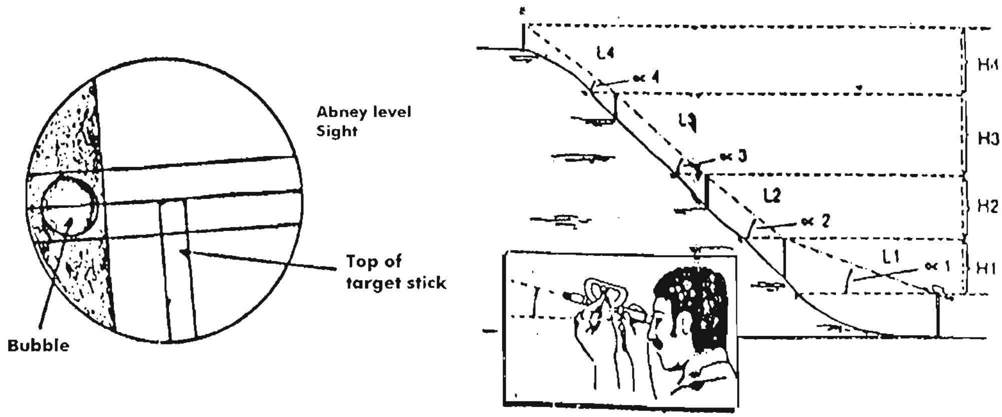

Figure 3.11: Measuring the Head with an Abney Level

5. Repeat operations 2 and 3 from the second stick aiming at the new position of the first stick; record the slope distance L_2 and angle a_2.
6. Move the second stick to the next position along the penstock and repeat operations 2-5, until the base of the forebay is reached.

Table 3: Sample Record Sheet for Abney Level Measurement

Positions	Distance between Positions (m)	Angle α between positions	H = L x sin α	Remarks
1 & 2	L_1 =	α_1 =	h_1 =	
2 & 3	L_2 =	α_2 =	h_2 =	
3 & 4	L_3 =	α_3 =	h_3 =	
Total head (m) = $h_1 + h_2 + h_3 + \ldots\ldots$				

3.10.2 Using a Water-Filled Tube

This is one of the simplest and cheapest methods for measuring small heads. The method is illustrated in Figure 3.12. The equipment needed is a 20m long, transparent plastic tube with a diameter of about 10-12mm, two graded rods, a measuring tape, and some marking pins/pegs. Usually, two people are needed to take the measurements. This method can be quite accurate if the surveyors are experienced. However, it should be repeated three or more times to ensure that no mistakes have been made.

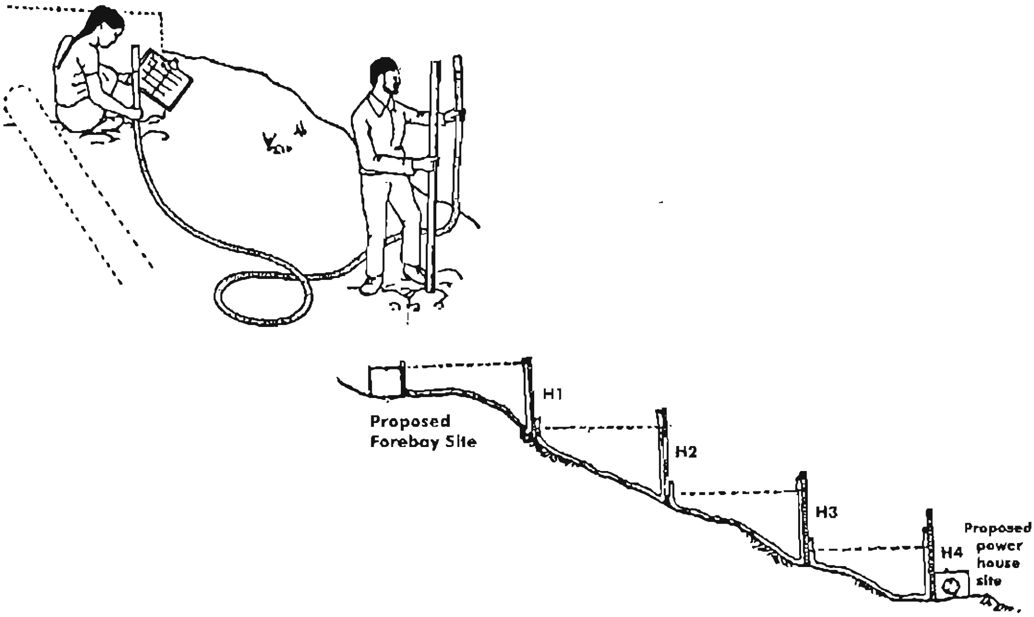

Figure 3.12: Measuring the Head Using a Water-Filled Tube

Procedure

1. Starting from the site of the forebay, fill the plastic tube with sediment free water. You should hold one end of the pipe while your assistant holds the other end, both about shoulder high. Remove all bubbles by stroking various parts of the uncoiled tube.
2. Ask your assistant to walk slowly down the hill along the path of the proposed route of the penstock; he should keep raising his end of the pipe while you slowly lower yours to ensure that water does not spill from either end of the pipe. The assistant should stop when your end of the pipe nearly reaches the ground.
3. Measure the heights of water in the pipe above ground level using the graded rods (h_1 and h_2) and the horizontal distance L_1. Mark both positions (1 and 2) with pegs and record all the readings on the record sheet.
4. Direct your assistant to stay in the same position and lower his end of the pipe while you move to a new position below him (position 3) along the penstock route, raising your end of the pipe until the water level reaches about head high at your end and nearly touches the ground at your assistant's end.
5. Read and record the new readings at positions 2 and 3, and measure the distance between the points along the slope. Record the readings.
6. Repeat the process until one of you reaches the base mark for the turbine.

Record Sheet for Water Tube Measurements					
Positions	1st height above ground	2nd height above ground	Difference h (m)	distance L (m)	Remarks
1 - 2 2 - 3 3 - 4					
Total			Head =	Distance =	

3.10.3 Using a Water-Filled Tube with a Pressure Gauge

This method is similar to the one described above but can be simpler, since an aneroid pressure gauge is used to measure the pressure and thus the head.

The procedure for the measurements is also similar, but the water height above the ground is only measured at the higher position, and a pressure reading is taken at the lower position. The record sheet is similar to that shown above except that the second entry for the height is replaced by a pressure reading, which is later converted into a height reading.

Some important points should be noted.

1. The pressure gauge should be frequently and properly calibrated in the office or *in situ*.
2. Air bubbles must be completely removed from the tube.
3. The measurements should be repeated two or three times.

If the surveyor can perform the water-filled tube method properly there is no need to use the pressure gauge method, which incorporates an additional instrument and which may be inaccurate.

3.10.4 Using an Altimeter

Conventional aneroid type barometers or altimeters are usually difficult to use and can be quite inaccurate. The new digital altimeters are easy to use and cheaper (~200-500 US$) and can be used for initial and rough measurements, especially for large heads (<100m). The method of measurement with an altimeter simply involves taking the readings wherever needed, say at the site of the turbine, the forebay, and the intake, and using the differences in readings to calculate the head, gradient, and other desired quantities. It must be remembered that the accuracy of readings is affected by changes in altitude atmospheric pressure, and temperature. Therefore, another more accurate method would have to be used to measure the height later. For this reason, altimeters are not very popular.

3.10.5 Other Methods

There are many other methods that can be used to measure the head and professional surveyors would have no problem using them. For example, a simple plank to which a spirit level has been attached can be used together with two graded rods to measure height differences between two positions. This equipment is heavy and cumbersome to use, however. Similarly, more accurate and expensive levels and theodolites can be used, but these require considerable practice and skill to master. Consequently, the Abney level and water-filled tube methods, which are fairly accurate, cheap, and easy to use, are probably the best methods for MHP schemes with heads of less than 100m.

3.11 Methods Used for Other Surveys

The other surveys to be carried out while visiting a prospective MHP site are distance measurements, both horizontal and along slopes, and land/area surveys that can be used to prepare or update sketches or maps for future use. The two dimensional (area) surveys also include measurements of distances, slopes, and angles; which have to be integrated to prepare two- or even three-dimensional maps and to calculate the lengths of such things as canals and transmission lines.

Distances are usually measured using tapes or 'chains'. The latter are sturdier than tapes in rough field conditions. Bends or turns can be measured on the ground or by using an optical instrument such as an Abney level. Some pegs or pins are also needed that can be driven into the ground to mark the various points (starting points, end points, intermediate points) from which distances have been measured and readings taken. The readings and markings are recorded in measurement books and reproduced on drawing sheets to prepare maps of the area. The maps may also include elevation readings such as topographic maps.

It is not possible to describe all the techniques for performing these surveys in a manual of this size. However, reasonable common sense and some prior familiarity with the equipment and methods should be sufficient to enable surveyors to take the measurements. For example, any one surveying should know how to measure a straight distance between two points, or to measure an angle between two straight lines using methods of geometry.

3.12 Examples

The following section provides examples of the way in which surveys are conducted, the design flow chosen, and the head determined in a hypothetical MHP project.

Example 3.1

A survey conducted to assess the demand concluded that at least 26kW power was required at present to meet the existing demands of about 200 interested consumers. However, there were about 75 additional prospective consumers who, if eventually connected, would need additional peak power of 8kW. The flow measurement indicated that 180 l/s water was available during the dry season; it was learned that the flow can fall below this value in some dry seasons. Discussions with the community members indicated that a minimum of 30 l/s must be allowed to flow in the stream at all times and not be diverted for the MHP plant.

The following decisions need to be taken at this stage.

What should the design flow be; and what is the minimum and desirable head?

Decision Methodology

Design Flow. The measured flow is 180 l/s from which 30 l/s need to be deducted. Thus the design flow (Q_d) should be 150 l/s, or lower as the flow may decrease even further during some dry seasons. Some of the options available are as follow.

a) Use the available figure of 150 l/s and be prepared to accept lower power for one or two months in some dry seasons in future.

b) Wait for further surveys to see if a higher but viable gross head (h_g) is available so that the flow can be reduced easily while still achieving the power required from the higher head.

c) If the survey of demand and discussions with the community indicate that it would not be a serious problem to accept less peak power (less than the required value but equivalent to or higher than the minimum value) during the three to four months of the dry season, an even higher value of flow, say 180 l/s, could be selected for Q_d (but it would not be advisable to go higher than this value).

The Minimum and Desirable Head

The minimum (acceptable) power, P; is 26kW, and the design flow, Q, is taken as 150 l/s, i.e., 0.15 m^3/s. The minimum desirable gross head h_g is given by:

$$h_g = P/5Q = 26/5 \times 0.150 = 34.7 \text{ or } 35 \text{ metres}$$

This simple equation should incorporate all the losses (including the head loss). If a lower flow value, for example 120 l/s, is used then

$$h_g = 26/5 \times 0.12 = 43 \text{ metres}$$

If the desirable value of power is used then

$$h_g = (26+8)/5 \times 0.12 = 57 \text{ metres}$$

Therefore, the maximum head that would be needed is 57 metres, and the minimum acceptable head would be 35 metres.

Although some idea about the available head might have been gained during the reconnaissance survey, a good decision would be to complete the preliminary survey to determine the head range that is easily available without having to extend the canal too far.

Example 3.2

The preliminary survey of the site has revealed that, with the given location of the powerhouse, there are two possible locations for the forebay and other allied upstream structures, including the canal and the intake. The two possibilities give:

i) h_g = 32m, the length of the penstock is 48 metres and the length of the canal is about 650 metres; and
ii) h_g = 48m, the length of the penstock is 73 metres and the length of the canal is 1,100 metres.

How do we go about deciding the design flow and design gross head?

Decision Methodology

It appears to be inadvisable to shift the location of the powerhouse because the land is easily available and accessible. The location is also suitable for extending the transmission lines and disturbance to the surrounding lands is minimal. Thus the main decisions that need to be taken are the values to use for the head and flow.

For most practical purposes it is useful to have a high head and low flow. This would suggest choosing the second possibility with a head of 48m. But the canal for this option is too long. Using a design flow of 120 l/s (the most suitable value), the power from the second option would be:

$$P = 5Q\,h_g = 5 \times 0.12 \times 48 = 28.8kW$$

It might be advisable to re-survey the route of the canal to judge whether such a long canal would actually be sufficiently stable in the long run. The geological conditions might also be investigated to ascertain whether there could be any possibility of slip, excessive run-off (rainwater flow) from the top, or other such problems. If the canal route is fairly safe and if any minor vulnerable sections can be stabilised using concrete or good retaining walls, then this choice might be made.

If the canal site appears vulnerable, then the first option should be examined. The desirable flow value of 120 l/s would not give the required power with this smaller head. The power ,P, with a flow of 150 l/s would be

$$P = 5 \times 0.15 \times 32 = 24kW$$

Thus the available power is still not adequate and we would have to consider whether to accept this value for the power that is not much lower than the minimum needed (26kW). The plant can still be designed for a higher output, say 30kW; which it would be able to generate for six to eight months of the year; but the consumers would have to accept having less power for the remaining period. It is clear, however, that the chances of increasing the power supply in the future are slim. One suggestion would be to have a meeting with the communities/recipients and discuss both options; particularly the last, and arrive at a consensus through discussions. It might even be necessary to have two meetings, one at a later date. The aspects to be determined should be considered in the following order.

1. Pursue the first option of using h_g = 48m and investigate the canal more thoroughly to assess its suitability. If the site is not judged to be suitable, then
2. the option of generating 24kW should be examined in more detail and discussions held with the communities to discover whether they would be happy in the long run with this low value of power. If this was not possible; then
3. consider the third option of installing a larger (~30kW) plant and accepting less power for a few months. Again the community should be encouraged to decide after identifying the possibilities and discussing the implications.
4. If this last option is not acceptable to the community; then the recommendation from the surveyors should be not to go ahead with the installation.

Note. This example was deliberately presented in this way to illustrate that such surveys and the ensuing decisions are almost never straightforward or just a problem of simple mathematical calculations.

3.13 Survey for the Transmission Lines

After the location of the powerhouse has been fixed (and is not likely to be changed), a survey should be carried out to fix the route of the transmission lines and measure their lengths. This survey mostly involves measurement of distances and sometimes heights if hills are to be crossed. The main figures to be calculated are the lengths of the wires to be installed and the numbers of other allied equipment such as poles, insulators, and lightning arresters.

The figures for the lengths will also be used when calculating the costs.

The following points should be kept in mind when designing the layout for the transmission lines.

1. Ideally, the transmission lines should travel along straight lines to minimise costs and avoid lateral loads on the poles. This is rarely possible, however, especially as it may be necessary to avoid such things as patches of cultivated land, a group of trees, or houses. Still, the basic principle should be to avoid bends and diversions as far as possible.
2. If the lines are to pass through areas of cultivated land, the poles must be located on the banks between two pieces of land so that they are relatively safe and farmers' lands are not affected.
3. Crossing of the transmission lines through thick forest should be avoided, if really necessary then the path of the lines should be cleared of trees.

3.14 Preparation of Sketches

During and after completing the survey, it is necessary to prepare sketches of the area for reference as well as for the future work of survey and installation. It is also advisable to mark the locations of the sites on the ground with pegs or other such materials. The sketches will have to be improved later and proper drawings prepared. It is desirable to prepare the following sketches.

1. An overall sketch of the area (say on a scale of 1:10,000) showing the relevant portion of the stream and the nearby beneficiary settlements. The distances between the main features should also be included. Some heights may be mentioned, but detailed contours are not needed. An example is shown in Figure 3.13.
2. A more detailed sketch of the MHP location which includes the powerhouse, penstock, forebay, power canal, intake, and relevant portion of the river. The scale should be around 1:1,000. The contour lines traversing the main components should be shown together with the altitude values if possible. Otherwise, only the altitude values (absolute or relative) may be shown for the main locations and important sub-locations.

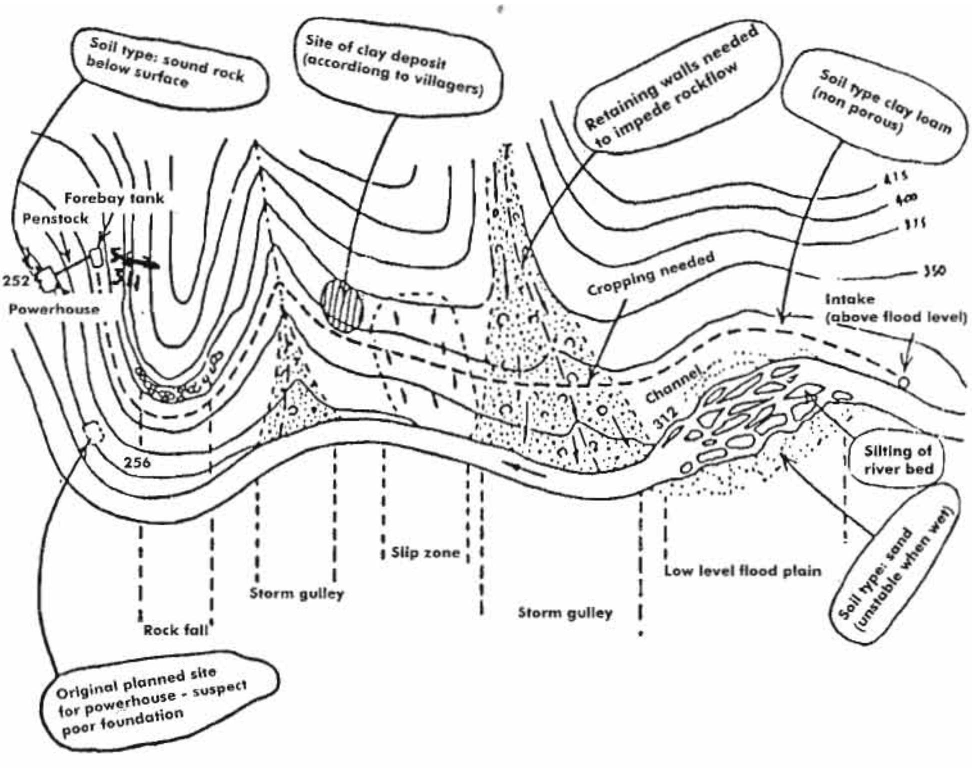

Figure 3.13: A Typical Sketch of the MHP Site and Settlements

3. The results of the survey for the transmission lines should also be shown, either separately or superimposed on the first sketch. It is desirable to have a separate sketch since the transmission lines are affected by land and topographical features such as cultivated land and the boundaries between fields, forest, and high intervening hills. The lengths of the transmission lines can be written next to the relevant lines.

   If possible, these sketches should be redrawn to give drawings of reasonable quality so that they can be used later for detailed survey and installation.

3.15 Organizing a Second Meeting

After most of the survey has been completed, and some rough calculations of the power potential and rough estimates of the costs made, it would be useful for community-owned projects to have another meeting with most of the members of the community. Participation in the meeting should be as full and have a wide a range as possible. Participants should be informed about the costs, possible problems or shortcomings, and possible end uses. It would be useful to facilitate the formation of a Users' Committee at this time. The points to be covered include the following.

- Describe again the work involved and the responsibilities, duties, and possible problems to be faced by the communities in the management of the plant.
- Prepare and agree upon a draft of an agreement between the community and the sponsor(s).
- Discuss the possibility of other end uses, including agro-processing, saw mill, and workshops, with the aim of using power during the daytime off-peak period. Adequate information should be provided on the costs, power needs, and methods of operation and maintenance for, and possible incomes from, such machinery. If electricity is to be the main output of the plant, it may be more beneficial and even cost-effective to use electrical motors situated at convenient locations to drive the industrial units.
- Identify key persons/leaders of different communities/groups for further consultation in future.
- Discuss further the other uses of the water (present as well as future ones) and assess any signs of conflict or differences of opinion. Try to assist in resolving such differences.
- Discuss tariffs for domestic, commercial, and industrial uses and put forward suggestions.
- Work out some initial figures for incomes, expenditure, and net incomes for the benefit of the users/owners.
- Inform the users how such incomes could be used in the best interests of the plant, its services, and its benefits to the community.
- Facilitate the formation of a User or Management Committee with a few members (about five); comprising those who are most interested in and informed about the installation and operation.

The main objective of the meeting is to motivate the community and make them aware of the benefits of the MHP plant, as well as the effort, organization, and hard work that will be needed to make it a success.

3.16 Other Aspects to be Covered During the Preliminary Survey

A number of other aspects should be considered, surveyed, assessed and/or analysed so that conclusions can be drawn or opinions formed about the probability of success of the plant (in terms of such factors as income, service, and long-term performance). These aspects include the following. They mainly apply to community owned or managed plants, but some aspects are also relevant to entrepreneur owned plants.

Assessment of the Community

The community needs to be assessed with regard to the following.

- How keen most of the community members are for the MHP and electricity; and their willingness to actively support and work for the survey, installation, etc of the plant. As discussed earlier, ideally the community members or leaders should themselves initiate any efforts to install a plant in their area. Sometimes, however, the promoting agencies may also initiate activities leading to a possible installation. In both cases, but more so in the second case, the communities and their leaders have to be motivated to provide assistance and contribution right from the beginning. The interest of the communities and their leaders in supporting and contributing to the installation is an indicator for the likely level of success of the plant after it comes into operation. This assessment should be made more or less informally through dialogue, discussions, and meetings. The level of support and assistance provided during the survey is another indicator of the general level of enthusiasm for the plant.
- Conflicts within the communities and/or between different communities; and whether the different groups would be able to collaborate with each other. Other uses of water such as for irrigation, washing, and drinking, should also be examined and opinions formed. Similarly, there may be differences of opinion regarding the use of the land for the powerhouse, channels, and other components. The main concern is whether one or more communities would be able to work together to make both the installation and the operation of the plant a success.
- Potential within the community (or of certain members who need to be identified) for business sense, management, and technical operations. Questions should be asked about business experience (keeping shops/lodges, buying/selling agricultural commodities) and about technical experience related to water mills (*ghatta*(s)), diesel mills, transport, or other machinery. These investigations should be helpful for identifying prospective operators or even managers. The assessment should also be undertaken, mainly through discussions with shop owners, traders, and community leaders.
- The various discussions may also be formal, but more authentic information can usually be gathered through informal discussions in tea shops or other social places with different people.
- Finally the capability of the households to pay the initial installation charges, including the wiring from the pole to the bulbs within the houses, should be assessed. These charges may be as much as a few thousand rupees. Clearly, there will be many families who would find it difficult to pay for the connection immediately. However, the main point to discover is whether a large proportion of the potential customers (say 70 per cent or more) falls into this category, since this would indicate a serious problem. During the survey of the households, some idea should be obtained about total incomes (particularly cash incomes) and a figure arrived at as to how many customers

would ask for connections immediately after the powerhouse begins to supply electricity.

3.17 Environmental Aspects of an MHP

A small-scale run-of-the-river type MHP plant installed in a remote area is probably the least harmful option environmentally for providing power to a community. This includes construction, operation, and the materials used for construction. Nevertheless, some negative environmental impact is possible; especially if the plant is not properly designed or installed. Most potential problems relate to flow of water from the stream to the forebay through the canal, or to the powerhouse through the penstock. The following possibilities should be investigated and precautionary measures taken.

- Seepage of water from the canal, forebay, or penstock can cause damage to downstream lands or houses, or lead to erosion and/or landslides. Such seepage should be minimised and a drainage system provided wherever possible.
- Breaching of the canal could cause more serious damage in a short time to land or crops. Proper design and construction of the canal is again the answer.
- Since the flow in such channels is usually quite low, the damage is almost never excessive. Equally, the villagers/communities are capable of repairing any damage quite quickly. Nevertheless, it would not be good if a canal were to break down frequently. Thus the design, construction, and maintenance should be adequate.
- It may be necessary to cut some trees or bushes to construct the powerhouse, the civil structures, and the transmission lines. Although this damage is never extensive or even significant, care should be exercised to fell the minimum number of trees or bushes; and to choose the route for the canal and transmission lines accordingly.
- Some minor environmental problems may be encountered if the flow in the original stream becomes very low or it dries up completely. Although the dried up portion of the stream may be of a very short length, usually less than one km, it may be inconvenient for people who use it for drinking and washing. The riverine life may also be adversely affected. The following precautionary measures are advisable.

    - A minimum prescribed flow should be left in the stream even if this means reducing the power output.
    - If it is necessary to divert most of the water for power generation, a study should be made of whether the effect on fish or other important riverine life would be severe.
    - Find out how many people/families take water from the dried up portion of the stream for their normal daily needs; and whether they would face difficulties.

3.18 Financial Analysis and Viability

When the preliminary surveys are complete and the layout has been finalised, the costs, both capital and running costs, should be calculated[1].

All costs must be included: the electro-mechanical equipment; civil works, construction materials, labour, transportation, tools, spares, and so on. The expenditures for which cash payment must be made should be listed separately from contributions or acquisitions in kind such as free labour, free construction materials, free land, and so on.

The running costs should mainly include the salaries of the manager and operators, consumables and spares (grease, brushes for generator, bearing set), and cleaning and maintenance of the canal and civil works.

An attempt should then be made to estimate the income from the sale of electricity to various consumers (domestic, commercial, social/services, industrial). The net income can then be calculated. The minimum acceptable net income for entrepreneur owned plants should be 20 per cent of the capital investment (simple payback period 5 years or less)[2]

Such high incomes are usually not possible for community-owned and managed plants which are mainly intended to generate electricity for lighting and other domestic uses (such as radio and TV). A net income of about five per cent of the capital would usually be considered satisfactory and viable for such plants, and the income would mainly be used for major repairs and replacement of parts. However, if a loan is to be repaid, then the yearly installment should also be included in the running expenses and the tariffs must be fixed so that the cash income is sufficient for the loan repayment and to provide a net income.

It should be made clear to everyone concerned that the figures are only estimates; and the actual expenditure and income may differ considerably from these. The more experienced and qualified the surveyors and estimators are, the more accurate the estimates will be.

1 It is not necessary or even convenient to make all these calculations on the site. This can be done in the office. However, it is necessary to pass on these figures to the community or entrepreneur as soon as possible to assist them in making decisions and arranging the required funds.

2 Some experts have suggested fairly complex mathematical methods for financial analysis. While these methods may be necessary or useful for large investors/plants, they are usually beyond the capacities of ordinary local entrepreneurs and are of little use to them.

It should be emphasised again, that an effort should be made to use the maximum amount of energy available from the plant to give an increased income without any additional investment. Possible end uses and industries should be discussed with the entrepreneurs or community leaders. An extra effort will be needed to collect and provide information about such things as equipment, costs, operational techniques, training available, and income estimates. Prospective entrepreneurs may also need information about possible sources of funding and procedures for getting loans. All these additional but necessary efforts are worthwhile for the promoters since they can lead to increased financial viability of the plants and a good name for this environmentally friendly energy source for inaccessible and underdeveloped mountain areas.

3.19 Survey or Feasibility Report

The final outcome of the site visit, surveys, and assessments is a feasibility or survey report which includes the data, sketches/drawings, results, estimates, and conclusions. This report may be prepared at the site or in the office after returning from the site, and the final findings and conclusions should be about whether the plant is viable technically, financially and/or in terms of service. Almost all the information and data that have been collected should be included in the report.

A typical report would include the following.

- Location and description of the project area
- Economic situation and social conditions
- Description of site including settlements, population, households, and shops (include sketch/map)
- Main communities and lead persons
- Survey of demand: data-analysis, estimate of power demand (minimum and desirable values) including possible and committed industrial end uses
- Reconnaissance survey and results (include sketch/map)
- Results of meetings and discussions with entrepreneurs and community members/ leaders. Results of assessment (keenness, capabilities, cooperation, conflicts, economic and technical abilities)
- Preliminary survey and results of
    - flow measurement
    - geological aspects/problems
    - layout survey and head measurements
    - location of civil structures and sizes (head, penstock length, forebay size, canal length, intake size and type/structural details, weir type and size), include sketches/ drawings

- Specific features or problems of the site/layout
- Is desirable or minimum power available? comments and recommendations on whether to go ahead
- Other important aspects, for example water uses, environmental aspects, and social conditions and suggestions (for example funding to provide cheaper connections to poorer families)
- Survey for transmission lines, distances, sizes, losses
- Costs, incomes, and financial analysis
- Conclusions and specific suggestions

Although there are many topics to be covered, it is advisable to make the main report short (less than 20 pages). Some forms completed during the survey and other papers can be included as annexes. The data in the Initial Inquiry Form can be corrected and provided in some way and other sketches and tables and such like also included if necessary.

If the constraints on size permit, a few photographs of the site, especially those identifying locations of civil structures, should also be included in the report.