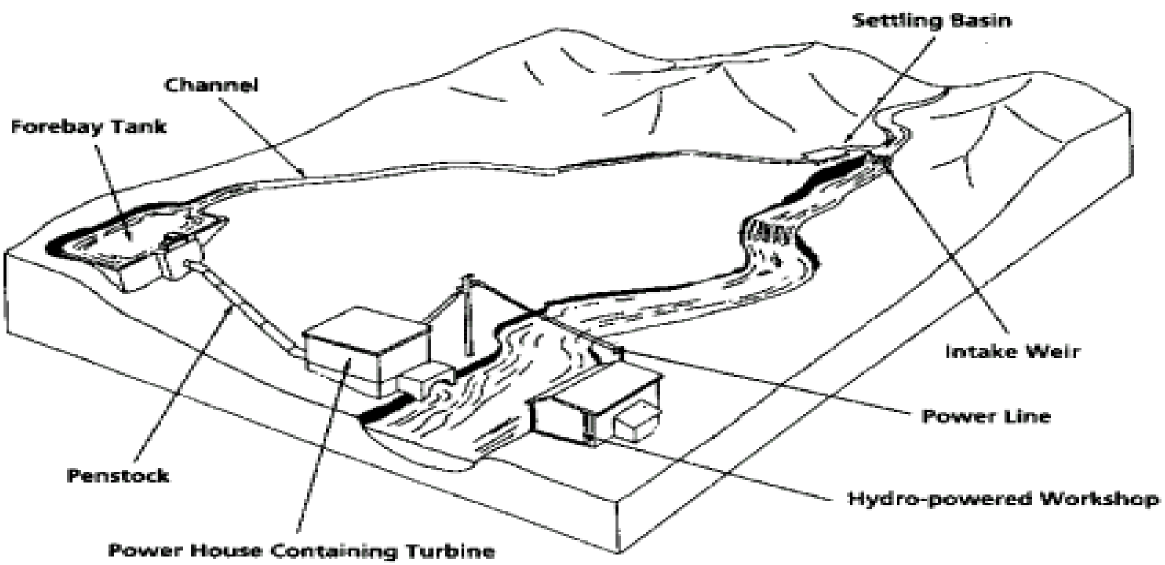
Sagar Mozumder
Lecturer, ESDM, DIU

Some features of Hydro Power Plant

- **Intake**
- **Leat (channel)**
- **Silt Basin**
- **Spillway**
- **Forebay Tank**
- **Penstock**
- **Powerhouse**
- **Tailrace**



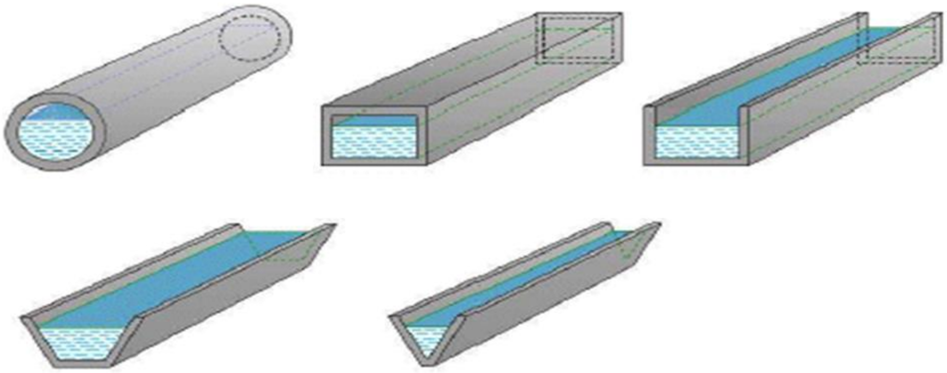
The diagram shows a typical micro-hydro scheme. Water from a stream or river is channelled into a tank and then released downhill through a pipe (or 'penstock'). When it reaches the bottom, the water drives a turbine that generates power. The amount of power produced depends on the distance the water falls before it hits the turbine and the number of litres per second flowing through the system. The turbine produces electricity or can be used to drive machinery directly.

Screen – Intake

Prevents debris and fish from entering the turbine
Situated at the entrance to the inlet of the turbine or leat

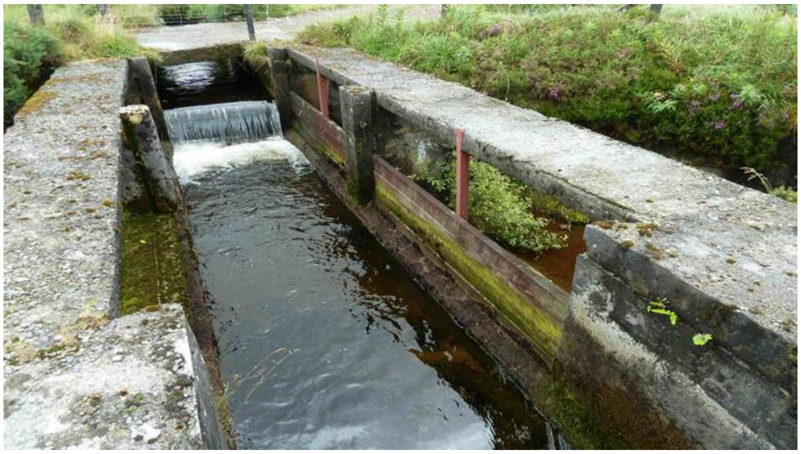
Leat

- A leat is an open channel
  - Less expensive than pipes
  - Can make use of existing channels at old mill sites
- Different types
  - Simple Earth Channel
  - Lined Channel (Brick, Block)
  - Concrete Capped channel
  - Sealed channel



Spillways

- Flood protection for the leat
- Over topping of the channel will cause damage to the channel
- Spillway portion of the leat at a lower level
- Above the normal operating level of the leat

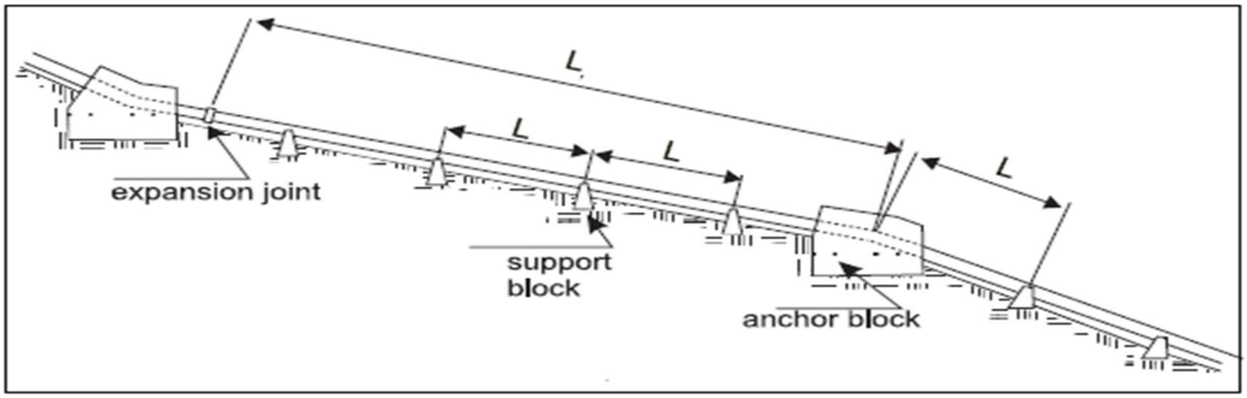


Silt Basin and Forebay Tanks

- Silt is abrasive and will damage the turbine
- Silt needs to be settled out of the flow of water
- A silt basin is used to slow the water and allow the silt to settle
- A forebay tank is a silt basin with the addition of a trash rack and penstock inlet.

Penstock

- Carries the water under pressure to the turbines
- Three important design considerations
  - Design Pressure
  - Diameter required to minimise friction losses
  - Cost of installation, repair and maintenance



Tail race

The tail race containing tail water, is a channel that carries water away from a hydroelectric plant or water wheel. The water in this channel has already been used to rotate turbine blades or the water wheel itself. This water has served its purpose, and leaves the power generation unit or water wheel area.

Sagar Mozumder
Lecturer, ESDM, DIU

Hydropower formulas

The **power output of a dam** is calculated using the potential energy of the water and can be found using the following hydropower formula:

$$P = \eta \times \rho \times g \times h \times Q$$

where:

- P is the power output, measured in Watts;
- η is the efficiency of the turbine;
- ρ is the density of water, taken as 998 kg/m^3 (you can change it in *advanced mode*);
- g is the acceleration of gravity, equal to 9.81 m/s^2 (you can change it in *advanced mode*);
- h is the head, or the usable fall height, expressed in units of length (meters or feet);
- Q is the discharge (also called the flow rate), calculated as `Q = A × v`;
- A is the cross-sectional area of the channel;
- v is the flow velocity.

Run-of-river installations and tidal power stations take advantage of the kinetic energy of the flow, so the formula is slightly different:

$$P = 0.5 \times \eta \times \rho \times Q \times v^2$$

The **efficiency** of the turbine is the ratio of available energy of water to the actual power output of the turbine. It's usually expressed as a percentage. The efficiencies of such turbines can reach up to 59.3%, as they're limited by the **Betz limit**.

Hydro turbine calculations: an example

Let's assume you want to build a dam on a small river. The cross-sectional area of the channel is 150 m^2, and the speed of the river is 2 m/s. The height of the dam is 15 m.

1. Calculate the discharge: `Q = A × v = 150 × 2 = 300 m³/s`.

   `2 = 300 m³/s`.
2. Find the efficiency of your hydro turbine. We can assume it's equal to 80%.
3. Find the power output of the dam with the hydropower formula:

`P = η × ρ × g × h × Q = 0.8 × 998 × 9.81 × 15 × 300 = 35,245,368 W ≈` **`35,245 kW`**

For example, let's assume you get paid $0.08 per kWh power for your electricity. The dam will be operating 150 days a year. After 365 days, you're going to secure the following revenue:

`revenue = $0.08 × 35,245 × 24 × 150 =` **`$10,147,561`**