Assessing micro-hydro potential for two hypothetical rivers

This exercise aims to assess the initial issues to be considered in finding a location for a micro-hydro site. It looks at two hypothetical sites and allows a comparison by working out basic sizing parameters and siting issues.

Time needed

To complete this exercise, you will need 1 hour 10 minutes

- Stage 1) To explain and break into groups (5 minutes)
- Stage 1) To do the exercise (40 minutes)
- Stage 1) To collate (5 minutes)
- Stage 1) Group discussion (20 minutes)

Films that accompany this exercise

- 'Introduction to small hydro power' (disc 1)
- 'Setting up a small hydro project' (disc 1)

To make this exercise meaningful you should consider both these films 'required viewing'.

Number of people or groups

If numbers allow, you should split attendees into groups of two to four.

Materials needed

- Print outs of **Table 1**, the two **site descriptions** and the **worksheet** for each group. (You can simply re-draw Table 1 on a large sheet if that's easier.)
- A calculator for each group.
- Flip chart or white board for recording final group discussion.

Running the exercise

Stage 1) Grouping and explaining (5 mins)

Begin by explaining to the group that you are going to look at the early-stage issues to be considered in finding a location for a micro-hydro scheme. Key data from two hypothetical sites will be used for some basic calculations on sizing and energy output, followed by a discussion of the non-technical issues. Split the group into several smaller groups to suit overall numbers. Each group will be doing the same tasks, with a whole group discussion at the end to compare results and to discuss any actual local sites that the group may know of.

Stage 2) Carrying out the exercise (40 mins)

1) Hand out to each group the worksheets for both sites and ask the groups to work through the accompanying exercises 1-3 (20 mins).
2) Hand out to each group the site descriptions and ask them to consider the final discussion task (4). Ask each group to nominate someone to record the key points on a flip chart (20 mins).

Stage 3) Collating results (5 mins)

At the end of the 40 minutes, stick up **Table 1** (below) on the wall or flip chart and fill in the values using the results of one of the groups, then compare these with results from the other groups.

Stage 4) Potential costs and income, and discussion

Begin by asking the group what are the key differences immediately apparent between the two Flow Duration Curves. Choose each group in turn to feedback a key point from their concluding discussions (Task 4) on the two potential sites. Record the key points around pros and cons of each location, gaps in information and next steps.

If the group has any potential locations for micro-hydro sites within their own community, a brief discussion could then be held covering the range of issues just discussed for the hypothetical sites. A typical preliminary site assessment would typically cover:

- the existence of a suitable waterfall or weir and a turbine site
- a consistent flow of water at a usable head
- the likely acceptability of diverting water to a turbine
- suitable site access for construction equipment
- a nearby demand for electricity, or the prospect of a grid connection at reasonable cost
- the social and environmental impact on the local area
- land ownership and/or the prospect of securing or leasing land for the scheme at a reasonable cost
- an initial indication of design power and annual energy output

Table 1

Print this table out very large, or simply copy it onto a sheet of flipchart paper. It needs to be big enough for everyone to read. The shaded boxes are the ones you will fill in during the course of this exercise.

Site	Rushwater River	Torrent River
Head	_ _ _ _ _ _ m	_ _ _ _ _ _ m
Mean flow rate	_ _ _ _ _ _ m^3/s	_ _ _ _ _ _ m^3/s
Peak system power	_ _ _ _ _ _ kW	_ _ _ _ _ _ kW
Annual output	_ _ _ _ _ _ kWh	_ _ _ _ _ _ kWh
Total annual value of feed-in tariff	£ _ _ _ _ _ _	£ _ _ _ _ _ _

Micro-hydro terms

Flow duration curve
This is a plotted line showing how flow is distributed over a period (usually a year). The vertical axis gives the flow, the horizontal axis gives the percentage of the year that the flow exceeds the value given on the y-axis. A 'flatter' curve (characterising a heavily spring-fed river) is preferable to a steeply sloping one, and means that the total annual flow will be spread more evenly over the year, giving useful flow for a longer period, and less severe floods.

Head
This describes the vertical drop through which the water falls between the intake source and the turbine outflow. Prior to site surveys, an initial indication of head between two points can be obtained from standard OS map contour lines, which show height differences of 10m.

Flow rate
This is the volume of water flowing down the watercourse, usually measured in cubic metres per second. It is generally better to have more head than more flow, since this keeps the equipment smaller. (**NB** the Environment Agency's 1,300 gauging stations measure the flow in the UK's most significant rivers and streams. This data can be obtained from the Centre for Ecology and Hydrology in Wallingford. Data for 200 sites is available at **www.nwl.ac.uk/ih/nrfa**)

Design flow
This is the water flow at which the turbine is designed to operate. It will usually be around 75% of the average flow of the river, in order to obtain a reasonable 'load factor' typically between 50-70%.

Load factor
This is a measure of how much the turbine could generate continuously operating at maximum capacity over the course of a year compared to how much it actually generates over the course of a year. For example, a 50% load factor assumes that the turbine will generate over one year an amount equal to that if it had been operating at maximum capacity for half a year (0.5 x 8760 hours).

Peak system power
The maximum rating of the turbine output in kW

Annual output
The total output of the turbine over the course of one year in kWh

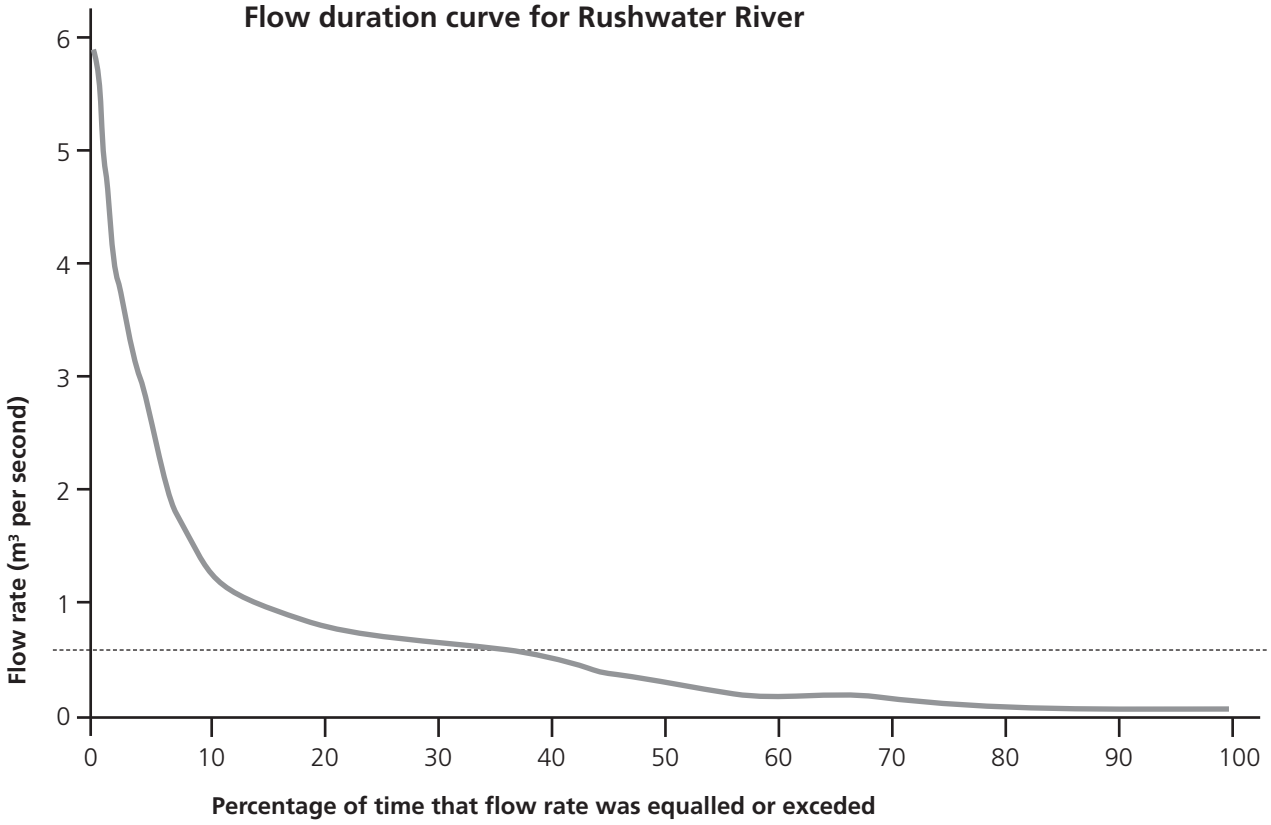
Further information is available from the British Hydro Association: **www.british-hydro.org**

Site description 1: **Rushwater River**

The first site is on the Rushwater River, adjacent to a wooded hilly area. The site is on the bank of the river and is part of a large estate privately owned by a local landowner, although fishing rights are subject to a long-term lease held by the local angling club. That stretch of the river bank is accessed by a small track which joins a tarmac road linking the landowner's property to the nearest main road. The landowner's property is the nearest house to the proposed hydro site at approximately 1km away.

The river itself is designated a Site of Special Scientific Interest due to the diversity of species along its length, including some ranked as nationally scarce. The location also falls within an Area of Outstanding Natural Beauty (AONB) and the woodland opposite the proposed hydro plant is a well-known beauty spot popular with walkers.

The group has obtained historical flow data from the National River Flow Archive website and has plotted a Flow Duration Curve – shown below.



The data indicates that the mean flow rate of the river is 0.53 m^3 per second. They have also concluded that, in order to achieve a decent 'head' of water, a near-horizontal 'leat' (channel) around 150m in length would need to be constructed to channel water from an upstream weir to the 'forebay' tank, from which point an 80m penstock (pipe) would then also need to be constructed to convey the water to the turbine site, creating a total 'head' of 11m.

Worksheet (for both rivers)

A small community group wishes to increase the amount of renewable energy generation in their area and has identified two locations near their village as being potentially suitable for micro-hydro sites. Using the following key parameters for the two sites (site 1, Rushwater River and site 2, Torrent River), work through the exercises 1-4 below.

Key site information (see 'Micro-hydro terms' for definitions)

Rushwater River	**Torrent River**
Head = 11 m	Head = 2.5 m
Mean Flow Rate = 0.53 m3	Mean Flow Rate = 1.85 m3
All generated electricity to be exported to grid (i.e. no buildings on site)	Annual electricity demand from buildings on site = 40,000 kWh Cost of electricity imports from grid = 13p/kWh

1) Using the figures for Head and Mean Flow Rate, calculate the Peak System Power as follows:

Head	**Design flow** use 0.75 x mean flow rate	**Peak system power (kW)** = head x design flow x 7
_ _ _ _ _ _ _ _ _ _ m	_ _ _ _ _ _ _ _ _ _ m^3/s	_ _ _ _ _ _ _ _ _ _ kW

2) Calculate the estimated annual energy yield, based on a 50% load factor, and work out what this would equate to in terms of the annual electricity demand of an average home, and the associated CO_2 savings .

Annual Output = peak system power x 0.5 x 8760	**Equivalent number of homes supplied** = annual output ÷ 4,100	**Annual CO_2 savings** = peak system power annual output x 0.542 ÷ 1,000
_ _ _ _ _ _ _ _ _ _ kWh	_ _ _ _ _ _ _ _ _ _ homes	_ _ _ _ _ _ _ _ _ _ tonnes

3) Work out the total potential revenue from the feed-in tariff, using the table of tariffs below

Annual output from exercise 2 above	**Annual income from generation tariff** = **[A]** x generation tariff from Table 2	**Savings from avoided electricity costs** = zero as none used on site	**Income from export tariff** = **[A]** x export tariff from Table 2	**Total annual value of feed-in tariff** = **[B]** + **[C]** + **[D]**
[A] _ _ _ _ _ kWh	**[B]** £ _ _ _ _ _	**[C]** £ _ _ _ _ _	**[D]** £ _ _ _ _ _	£ _ _ _ _ _

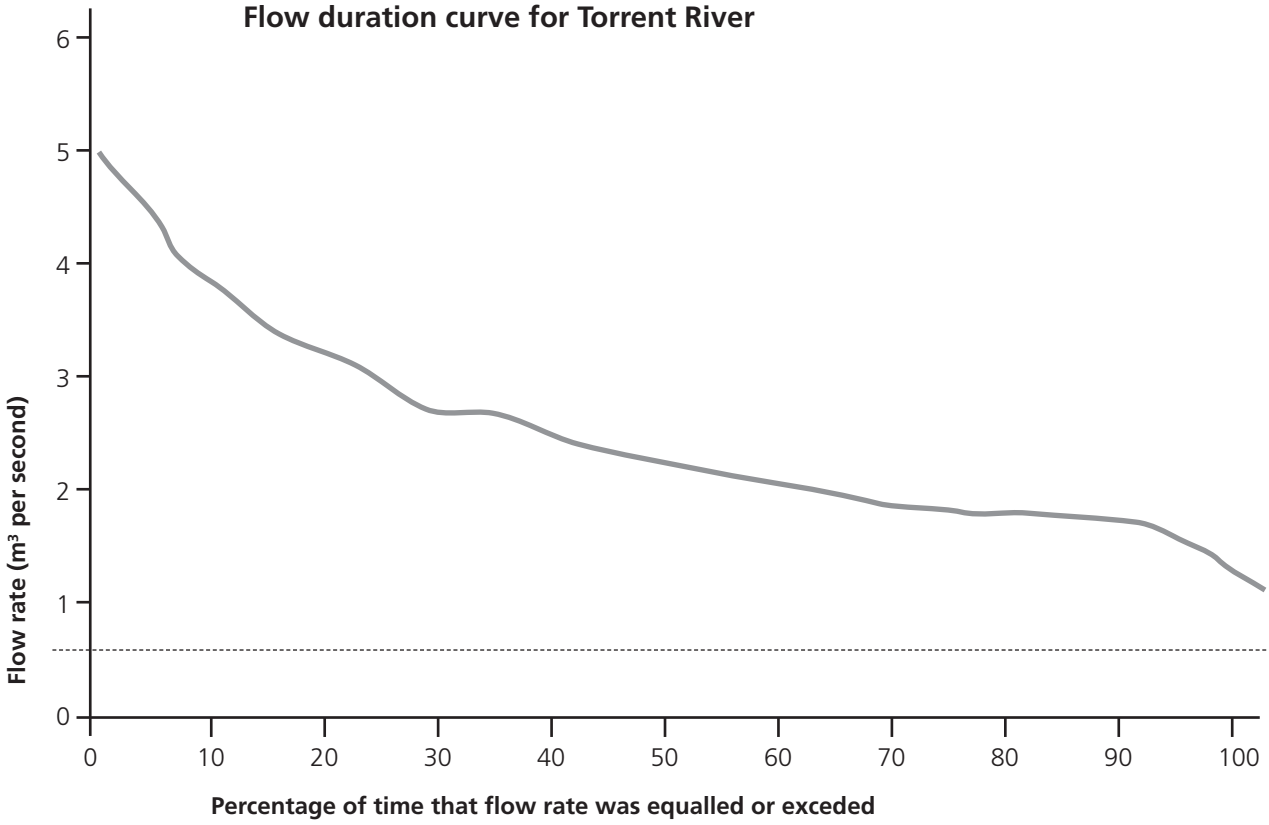
Feed-in tariff values for hydro power	**Scale of system**	**Generation tariff**	**Export tariff**
	up to 15kW	£0.199/kWh	£0.03/kWh
	15–100kW	£0.178/kWh	£0.03/kWh
	100kW to 2MW	£0.11/kWh	£0.03/kWh
	2–5MW	£0.045/kWh	£0.03/kWh

4) Now read through the handout describing the site. Briefly discuss the pros and cons that could arise with the proposed project and suggest ways to tackle any barriers. What actions should you take and what key information should you find out **before** commissioning a feasibility study?

The second site is on a different river, the Torrent, and consists of an old disused water mill. The site is owned by a charity which promotes outdoor pursuits for young disadvantaged people and the mill forms part of a larger building and adjacent cottages used by the charity for overnight accommodation, running courses and catering.

The main building is Grade II listed and this and the cottages are currently heated by electric storage heaters. The charity is very concerned about excessive electricity bills and the prospect of future increases. Last year's total electricity bill was over £5,000 for a consumption of 40,000 kWh.

The group has also obtained historical flow data from the National River Flow Archive website and has plotted a Flow Duration Curve – shown below.



The group has noticed that the maximum flow rate is similar to the Rushwater River site, but that the mean flow rate of the river is 1.85m³ per second. A refurbishment project would probably re-use the old weir, which has a potential head of around 2.5m, and means that almost no canal or approach pipework is required.