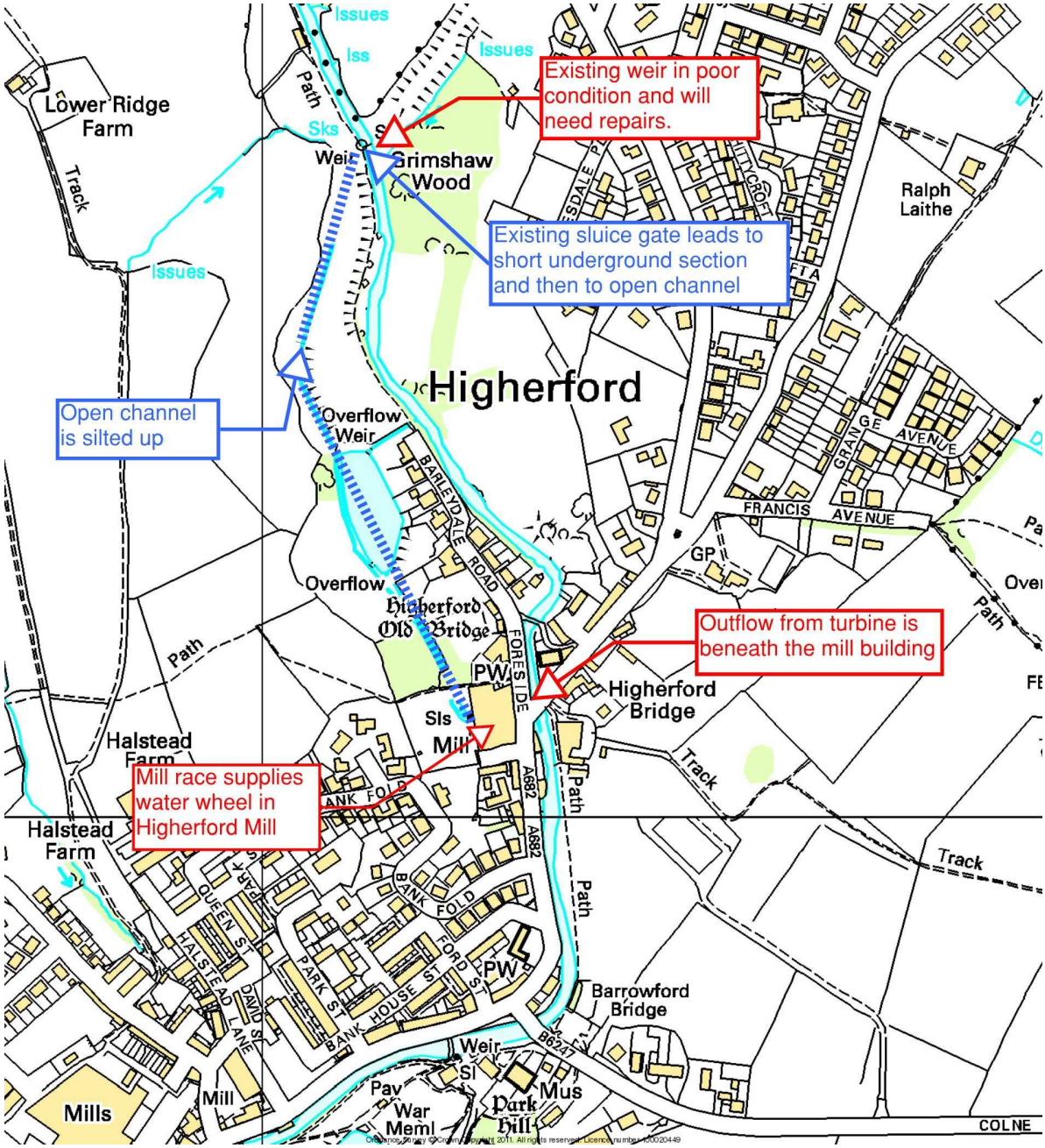
Site 11: Higherford Mill, Barrowford

Site Assessment

Figure 1 Map showing general layout



Restoration of this mill building is well under way, and the Heritage Trust is interested in furthering this restoration via the installation of a working water wheel. The main objective is to restore the mill, rather than maximise the economic hydro potential at this site. However, other technologies have been assessed as part of this study.

Much of the infrastructure is in place already at this site, though it is need of repair. The weir is not in a good condition; however, some water still flows into the intake.

The site is Grade II listed and was built in 1824 as a spinning mill. The mill ceased to function as a mill in the early 1970s. Substantial parts of the water courses survive (see photos). Upstream, near Grimshaw Wood, are the remains of a weir on Pendle Water. Sluice and filter bars are intact and access an underground race. The race runs partly underground from here to a mill pond located to the rear of Barleydale Road. At this point the race separates into two channels, with the higher by-passing the pond.

Figure 2 The remains of the intake weir

Figure 3 The sluice gate at the intake weir

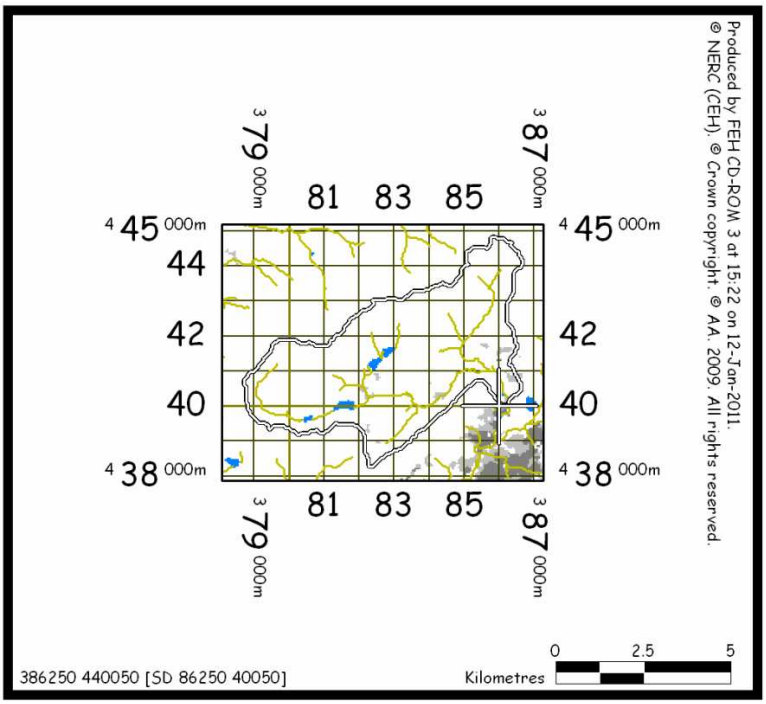
Figure 4 the discharge from beneath the mill

Figure 5 The leat from the intake weir to the mill is silted up

Beyond, the two races are again underground. They re-appear above the mill, and run to sluices that fed the wheel. Most of the controls, gearing and gates remain in situ. The position of the headwater suggests a high breast fed wheel. The tailrace can be seen as an arched opening, slightly upstream of Barrowford Bridge. The mill is also within a conservation area.

Catchment Analysis

Figure 6 Catchment boundary defined by Flood Estimation Handbook Software



The Flood Estimation Handbook software is used to determine the following catchment descriptors, for the proposed intake location, selected during the site visit.

Intake Grid Reference	386100, 440620
Powerhouse Grid Reference	386213, 440070
Catchment Area	25.6 km^2
Annual Rainfall	1398 mm

Annual Flow Statistics

Low Flows software is used to produce a Flow Duration Curve (FDC), which demonstrates how the river flow varies throughout the year. It presents the percentage time of the year each flow rate is exceeded. A particular notation is used to refer to FDC flow rates; e.g. 'Q_{95}' refers to the flow rate which is exceeded 95% of the year.

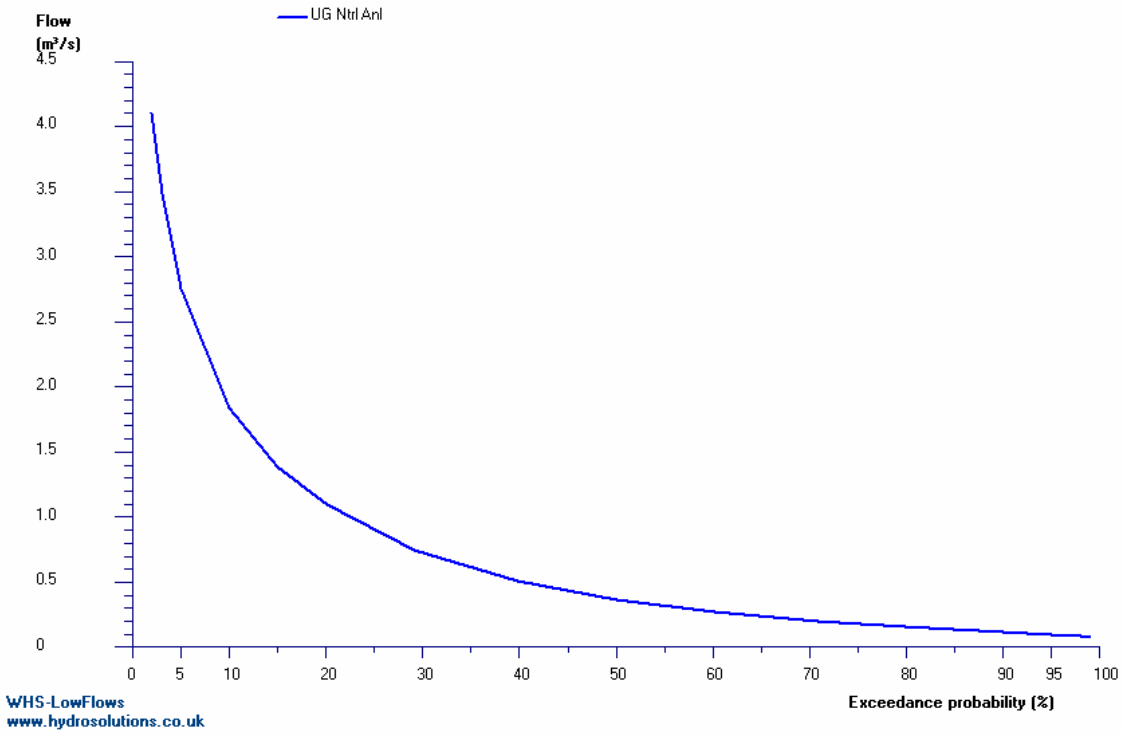
Table 1 Mean flow rate and flow rate at Q_{95}

Period	Mean Flow Rate [m³/s]	Flow Rate at Q_{95} [m³/s]
Annual	0.776	0.1
January	1.35	0.216
February	0.933	0.174
March	0.958	0.181
April	0.565	0.126
May	0.372	0.1
June	0.302	0.0822
July	0.299	0.0808
August	0.47	0.0836
September	0.562	0.0884
October	0.958	0.123
November	1.149	0.14
December	1.394	0.176

Table 1 Annual flow duration data

Exceedance Probability	Flow Rate [m³/s]
5	2.812
10	1.886
20	1.12
30	0.74
40	0.516
50	0.376
60	0.281
70	0.213
80	0.16
90	0.119
95	0.1
99	0.077

Figure 7 Annual flow duration curve produced using low flows software



Hydropower Analysis

Site: Higherford Mill
Run Date / Time: 12 January 2011 at 15:50

Mean Flow: 0.67 m3/s
Provisional Rated Flow: 0.74 m3/s
Residual Flow: 0.074 m3/s
Rated Flow: 0.67 m3/s
Gross Hydraulic Head: 5.50 m
Nett Hydraulic Head: 5.22 m

Applicable Turbines	Gross Annual Average Output	Nett Annual Average Output	Maximum Power Output	Rated Capacity	Minimum Operational Flow
Propellor	86.1	85.2	29.9	28.7	0.51
Crossflow	110.2	109.1	27.3	25.6	0.17
	MWh	MWh	kW	kW	m3/s

Hands off flow = Q95

A breast-shot water wheel is likely to produce less power than the turbine scenarios detailed above, but a maximum power of 25 kW may be achievable. It is recommended that a millwright specialist is consulted to investigate this further and get an accurate prediction of the power potential. A waterwheel has historically been used at this site, plus the Heritage Trust see many advantages to a wheel, including: high visual appeal for visitors, no screening required, relative ease of construction, and being very suitable for the existing site layout.

Table 3 Hydropower Analysis for suitable turbines

Gross Head [m]	5.5 m
Net Head [m]	5.2 m
Design Flow [m^3/s]	0.7 m^3/s
Rated Capacity [kW]	25 kW
Average Annual Energy Output [MWh]	100MWh
Average annual Carbon Dioxide offset	43 tonnes

Impact Assessment

The mill building is within Higherford conservation area, but is outside the Forest of Bowland Area of Outstanding Natural Beauty. The general Landscape Character Assessment states that the mill and second half of the millrace are Industrial Foothills and Valleys, and the rest of the millrace to the weir as Moorland Fringe.

An ecologist will need to be consulted to advice on the extent of environmental assessment required, including the clearing out of silt and vegetation from the mill race.

Statutory Requirements

In-river works will be required to rebuild the weir, and the Environment Agency will need to be consulted in order to acquire consent for this, as well as to apply for an abstraction and impoundment licence. It is likely that a fish pass will be required on the new weir. Work in the river will only be allowed between May and September. Planning permission is likely to be required for the repair of the weir. The site is Grade II listed, and is within a conservation area.

Budget Development Cost

The total budget cost for the whole scheme is **£341,475**. It should be noted that the civil works costs can vary considerably as material costs fluctuate. Likewise, mechanical and electrical (M&E) equipment costs vary in accordance with demand. Professional fees should be considered subject to change, as the scope of licensing and planning requirements are not yet defined. Consequently the budget estimate at this stage should be considered accurate to plus or minus 20%.

Revenue and Simple Payback Period

It is unlikely that a grid connection is required for this scheme, and instead the energy will be used on site at the Higherford Mill. The simple payback can therefore be worked out according to the electricity bills saved by the mill trust. An estimate of the grid connection cost has been acquired however, assuming that a Propeller, screw turbine or Crossflow turbine is used.

Under the current government feed-in tariff regulations, hydropower schemes receive a generation tariff according to their rated capacity. Schemes between 15 kW and 100 MW receive 17.8p/kWh. This generation tariff is received regardless of how the electricity is used. The current base value of electricity per kilowatt hour on top of this has been assumed as 3p/kW.

In conclusion, if a grid connection were acquired, the total value of the generated electricity would be 20.8 p/kWh, giving an average annual value of approximately **£20,800.** The simple payback, taken as the budget scheme cost divided by the annual value of electricity generated, is **16years**.

Conclusion

This scheme presents a great opportunity for the Heritage Trust to continue with their restoration of the Higherford Mill by re-instating the mill wheel. The weir will require some reconstruction, and the leat will need to be dug out along its entire length. Some stretches have historically run beneath ground. These sections will need to be investigated and potentially replaced. Some internal work will be required and these aspects are well underway already. A hydro scheme would be of great benefit to the Higherford Mill complex by providing cheap low carbon electricity and potentially providing small but long-term and sustainable revenue.

Table 4 Development Budget Cost

Budget Scheme Cost Estimate
Higherford Mill, Barrowford

ITEM	UNIT	QUANTITY	MIN	MAX
Turbine				
Turbine Quotation	No	1	£30,000.00	£37,500.00
Grid Connection				
Grid Connection	No	1	£0.00	£5,000.00
(existing 3 phase supply to mill)				
Civils				
Weir	m^3	25	£12,500.00	£15,625.00
Fish Pass	m^3	20	£10,000.00	£12,500.00
Weir Screen Length	m	15	£30,000.00	£37,500.00
Fish Pass Length	m	5	£10,000.00	£12,500.00
Mill Race	m			
Rock	m	0	£0.00	£0.00
Gravels	m	500	£20,000.00	£25,000.00
Soft	m	350	£19,250.00	£24,062.50
Pipe Materials	No	1	£0.00	£0.00
Temporary Access	m			
Rock	m	0	£0.00	£0.00
Gravels	m	400	£32,000.00	£40,000.00
Soft	m	250	£13,750.00	£17,187.50
Temporary Access on Good Ground	m	50	£2,000.00	£2,500.00
Powerhouse				
Powerhouse	kW	25	£15,000.00	£18,750.00
Prelims				
Duration	Months	6	£18,000.00	£22,500.00
Sub Total				
Sub Total			£212,500.00	£270,625.00
Professional Fees				
Professional Fees			£31,875.00	£54,125.00
Sub Total				
Sub Total			£244,375.00	£324,750.00
Contingency				
Contingency			£48,875.00	£64,950.00
GRAND TOTAL			£293,250.00	£389,700.00

Further Information

This site report is produced by Inter Hydro Technology on behalf of Forest of Bowland AONB, and funded by a partnership including Lancashire County Council, Lancaster & District Local Strategic Partnership, Pendle Borough Council and Ribble Valley Local Strategic Partnership.

This site report should be read in conjunction with the rest of the Forest of Bowland AONB Hydro Feasibility Study which can be downloaded at

http://www.forestofbowland.com/climatechange#hydro