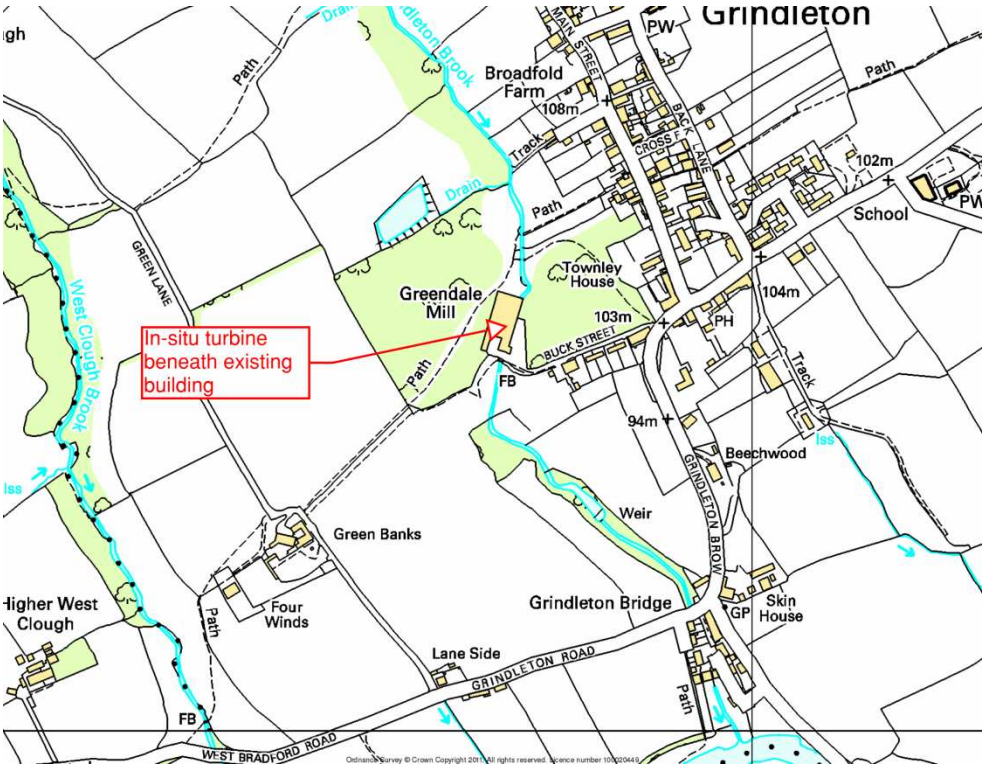
# Site 21: Greendale Mill, Grindleton

## Site Assessment

Figure 1 Map showing general layout




This building was a cotton weaving mill built in the late 1860s, and was steam and water-powered. There is an adjacent mill pond, though this is no longer owned by the mill. The Greendale Mill complex is south west of Grindleton village. The mill comprises an altered range of stone built sheds with the beck within a culvert under its eastern side. On the western side there is a range of altered two and three storey structures, probably originally housing the mill engine and boiler house.

The potential scheme at this site involves piping a proportion of the beck beneath or along the east side of the mill and then through a turbine either beneath the mill building or below the car park of the complex before using the historic outflow to the beck.

Historically the entire beck would have been used to generate power, but modern ecological mitigation standards require some water to be left in the watercourse to maintain the habitat and allow species to migrate up and downstream. If this remains to be the case, it is likely to render this scheme unfeasible. If however, the Environment Agency is content for the operator to utilise the entire flow of Grindleton Brook, the scheme may be worth investigating further.

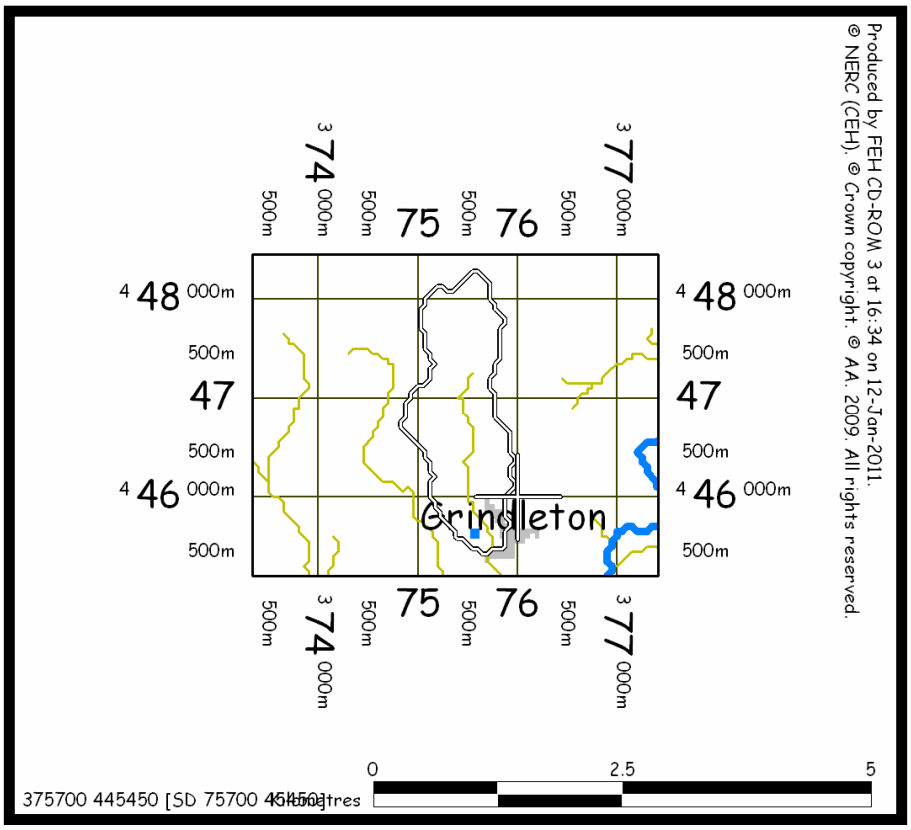
Figure 3 The stream flowing beneath the mill

Figure 4 The outlet from beneath the mill

Figure 5 The turbine pit with some machinery above in situ

# 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 | 375730, 445510 |
| Powerhouse Grid Reference | 375700, 445420 |
| Catchment Area | 2.0 km$^2$ |
| Annual Rainfall | 1365 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 | 0.053 | 0.00468 |
| January | 0.0866 | 0.0135 |
| February | 0.0627 | 0.01 |
| March | 0.0755 | 0.00987 |
| April | 0.0361 | 0.00607 |
| May | 0.0209 | 0.00377 |
| June | 0.0143 | 0.00282 |
| July | 0.0191 | 0.00382 |
| August | 0.0296 | 0.00314 |
| September | 0.0473 | 0.00625 |
| October | 0.0778 | 0.008 |
| November | 0.0762 | 0.00846 |
| December | 0.0899 | 0.00865 |

Table 2 Annual flow duration data

| Exceedance Probability | Flow Rate [m³/s] |
|---|---|
| 5 | 0.194 |
| 10 | 0.123 |
| 20 | 0.071 |
| 30 | 0.047 |
| 40 | 0.033 |
| 50 | 0.023 |
| 60 | 0.016 |
| 70 | 0.012 |
| 80 | 0.008 |
| 90 | 0.006 |
| 95 | 0.005 |
| 99 | 0.003 |

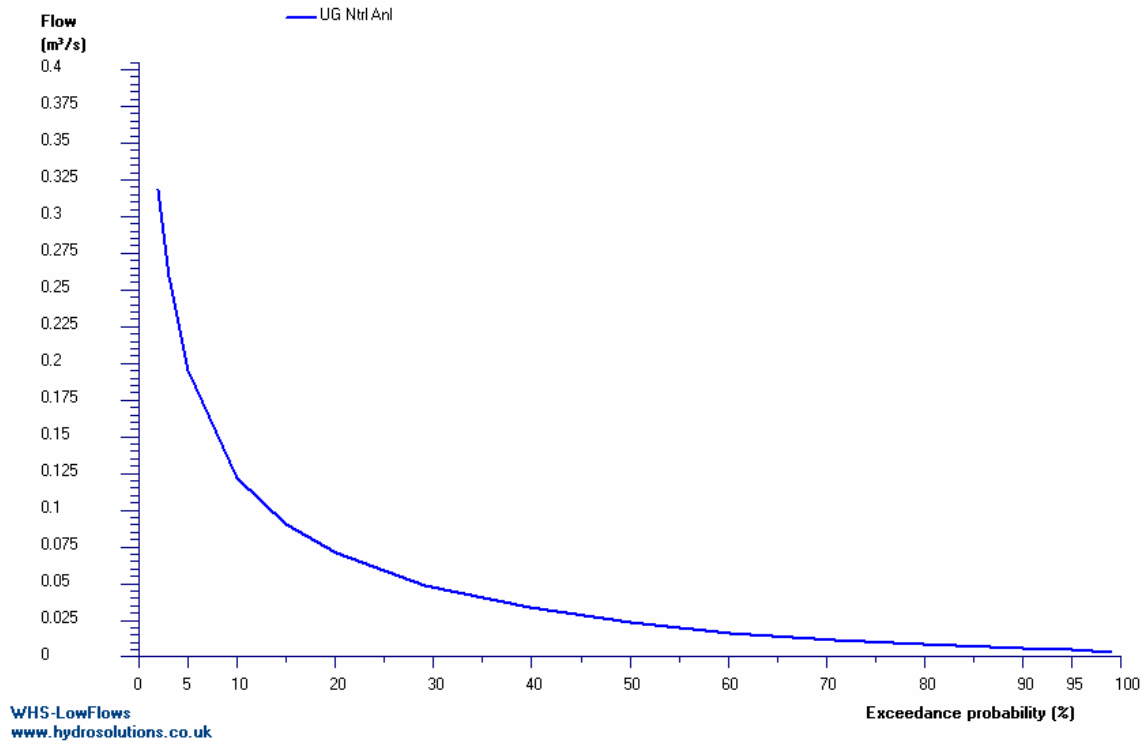



Figure 7 Annual flow duration curve produced using low flows software

# Hydropower Analysis

**Site:** Greendale Mill
**Run Date / Time:** 12 January 2011 at 16:49

**Mean Flow:** 0.048 m3/s
**Provisional Rated Flow:** 0.075 m3/s
**Residual Flow:** 0.006 m3/s
**Rated Flow:** 0.069 m3/s
**Gross Hydraulic Head:** 3.00 m
**Nett Hydraulic Head:** 2.85 m

| Applicable Turbines | Gross Annual Average Output | Nett Annual Average Output | Maximum Power Output | Rated Capacity | Minimum Operational Flow |
|---|---|---|---|---|---|
| Crossflow | 4.7 | 4.7 | 1.5 | 1.4 | 0.016 |
| | MWh | MWh | kW | kW | m3/s |

*No turbines operate with flow rates as low as the mean flow for Grindleton Beck. Therefore, design flow had to be artificially increased for the results shown above.*

**Site:** greendale wasdale
**Run Date / Time:** 08 April 2011 at 16:42

**Mean Flow:** 0.078 m3/s
**Provisional Rated Flow:** 0.11 m3/s
**Residual Flow:** 0.000 m3/s
**Rated Flow:** 0.11 m3/s
**Gross Hydraulic Head:** 3.00 m
**Nett Hydraulic Head:** 2.52 m

| Applicable Turbines | Gross Annual Average Output | Nett Annual Average Output | Maximum Power Output | Rated Capacity | Minimum Operational Flow |
|---|---|---|---|---|---|
| Crossflow | 7.5 | 7.2 | 2.2 | 2.0 | 0.016 |
| | MWh | MWh | kW | kW | m3/s |

If it were possible to utilise the entire flow of Grindleton Beck to generate power, then the maximum power generated would be approximately 2.0kW and the annual average energy produced would be 7.5MWh.

Table 3 Hydropower Analysis

| | |
|---|---|
| Gross Head [m] | 3 |
| Net Head [m] | 2.85 |
| Design Flow [$m^3/s$] | 0.07 $m^3/s$ |
| Rated Capacity [kW] | 1.4 kW |
| Average Annual Energy Output [MWh] | 4.7MWh |
| Average annual Carbon Dioxide offset | 10.8 tonnes |

# Impact Assessment

This site is within the Forest of Bowland AONB and has a Landscape Character Assessment of Undulating Lowland Farmland with Wooded Brooks.

Refurbishment of a scheme at Grindleton Mill has obvious historic benefits. Historically all the flow of Grindleton Brook was directed through the turbine, which may today have made this scheme economic. However, attitudes towards nature conservation have changed and only a proportion of the water is available for abstraction. Provision for fish migration should be made past the new intake.

## Statutory Requirements

It would be necessary to apply to the Environment Agency for an abstraction license and it is likely that planning permission would be required to construct an intake.

The complex is listed in the Historic Environment Records, and therefore any development should be discussed with the county archaeologist.

An ecologist will be able to advise on the extent of environmental investigations required.

## Budget Development Cost

The total budget cost for the whole scheme is **£77,350**. 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 not economically viable for this scheme to export energy to the grid. Instead, it would be consumed on site by the business.

Under the current government feed-in tariff regulations, hydropower schemes receive a generation tariff according to their rated capacity. Schemes less than 15kW receive 19.9p/kWh. This generation tariff is received regardless of how the electricity is used. The owner has indicated that the electricity would be used on site, thereby offsetting import costs. This increases the value of the generated electricity by the import tariff, which we have assumed is 5p/kWh.

In conclusion, the total value of the generated electricity would be 24.9p/kWh, giving an average annual value of approximately **£1080**.The simple payback time for this scheme is 72 years. If the entire beck could be harnessed to generate power, rather then a proportion, then the annual average revenue would increase to **£1867**and this would decrease the payback time to 41 years.

## Conclusion

It is likely that the potential is too small for a scheme here, although refurbishment of a scheme at Grindleton Mill does have obvious historic benefits. Historically, all the flow of Grindleton Brook was directed through the turbine, which may today make this scheme economic. However, attitudes towards nature conservation have changed and only a proportion of the water is available for abstraction.

## 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

Table 4 Development Budget Cost

**Budget Scheme Cost Estimate**
**Greendale Mill, Grindleton**

| ITEM | UNIT | QUANTITY | MIN | MAX |
|---|---|---|---|---|
| **Turbine** | | | | |
| Turbine Quotation | No | 1 | £10,000.00 | £12,500.00 |
| **Grid Connection** | | | | |
| Grid Connection | No | 1 | £0.00 | £0.00 |
| **Civils** | | | | |
| Concrete Works | $m^3$ | 20 | £10,000.00 | £12,500.00 |
| Fish Pass | $m^3$ | 0 | £0.00 | £0.00 |
| Metalwork | m | 1 | £2,000.00 | £2,500.00 |
| Fish Pass Length | m | 0 | £0.00 | £0.00 |
| Pipe Installation | m | | | |
| Rock | m | 15 | £1,650.00 | £2,062.50 |
| Gravels | m | 15 | £600.00 | £750.00 |
| Soft | m | 0 | £0.00 | £0.00 |
| Pipe Materials | No | 1 | £3,000.00 | £3,750.00 |
| Temporary Access | m | | | |
| Rock | m | 0 | £0.00 | £0.00 |
| Gravels | m | 0 | £0.00 | £0.00 |
| Soft | m | 0 | £0.00 | £0.00 |
| Temporary Access on Good Ground | m | 10 | £400.00 | £500.00 |
| **Powerhouse** | | | | |
| Powerhouse | kW | 5 | £15,000.00 | £18,750.00 |
| **Prelims** | | | | |
| Duration | Months | 2 | £6,000.00 | £7,500.00 |
| **Sub Total** | | | | |
| Sub Total | | | £48,650.00 | £60,812.50 |
| **Professional Fees** | | | | |
| Professional Fees | | | £7,297.50 | £12,162.50 |
| **Sub Total** | | | | |
| Sub Total | | | £55,947.50 | £72,975.00 |
| **Contingency** | | | | |
| Contingency | | | £11,189.50 | £14,595.00 |
| **GRAND TOTAL** | | | £67,137.00 | £87,570.00 |