

Avoncliff Weir Determination Report



Decision Statement

Water Resources Act 1991 (as amended) (WRA 1991) and the Environment Act 1995

We have received applications for licences for two competing hydropower schemes at Avoncliff weir, Avoncliff, Bradford on Avon, Wiltshire. The two competing hydropower schemes are located at North Mill (north side of the weir) and Weavers Mill (south side of the weir).

Applicant	Licence type	Application number
Mr Ewan EARL (North Mill applicant)	Transfer Impounding	NPS/WR/002511 NPS/WR/003126
Mr Martin TARRANT (Weavers Mill applicant)	Impounding	NPS/WR/001709

For reasons which are explained further in Appendix 1 (section 2), it is not possible for us to grant a licence to both schemes in this case. We have therefore compared the two schemes against a number of factors that we consider are relevant to this site and we have decided which of the two schemes is the most desirable in the public interest. Further information on our approach to this comparison is set out in our 'Competing hydropower schemes' guidance dated December 2012 (Appendix 2), to which full reference should be made. In summary, as set out in section 19 of that guidance —

“Every case will turn on its own merits. The Environment Agency will seek to grant those hydropower applications which are of greatest public benefit, bearing in mind their short and long-term effects on the local and national environment and the overall desirability of any particular scheme in the public interest, when considered against all other actual or potential proposals at the site.” The ultimate question for us in this case is which of the proposed schemes, if either, is it desirable, in the public interest, for us to license? Our role is to make decisions about the appropriate use of the site for the benefit of existing and future generations, bearing in mind that once approved and built, a hydropower scheme is likely to remain in situ for decades, perhaps for many generations. Our overall aim is to grant a licence which is of the greatest public benefit bearing in mind the short and long-term effect on the local and national environment and the overall desirability of the scheme in the public interest”.

In accordance with the Competing hydropower schemes guidance, we have had regard to the site specifics of each scheme and we have compared the schemes by reference to a number of factors. There are a number of points of comparison where we have weighed the

relative merits and de-merits of both schemes and we have concluded that overall (and in particular in four areas highlighted below) the Weavers Mill scheme is preferable to the North Mill scheme.

Accordingly, having considered the relevant information and data from both applicants, representations from members of the public, having had regard to our statutory duties and to our guidance and having taken advice from expert advisers (AMEC Environment and Infrastructure UK Ltd and Mott MacDonald) we refuse the North Mill applications numbers NPS/WR/002511 and NPS/WR/003126; and we grant a licence to the Weavers Mill applicant (application number NPS/WR/001709).

In summary we conclude that the Weavers Mill scheme is preferred because:

- **It could generate more electricity.**
- **It will use water more efficiently by generating more electricity per m³ of water used.**
- **It has a lower embedded carbon footprint.**
- **The carbon offset would be greater over its lifetime.**
- **It involves a lesser flood risk and is unlikely to require flood mitigation measures.**
- **Its visual impact on the landscape is less obtrusive.**

The Nature of This Report

The determination report comprises this decision statement together with the appendices listed below. In this decision statement we have set out our main reasons for concluding that Weavers Mill is the scheme demonstrating the greater benefit to both the public and the environment. We have additionally summarised how and why we have reached that conclusion.

Appendices

Appendix 1 – Describes in more detail a number of other factors and areas of comparison including those where we conclude there is no significant difference between the schemes. Additionally we have included relevant comments received from the applicants during the consultation on our minded to decision and our response to these comments. Further matters that are relevant to our decision including details of the applications, how we have advertised and consulted upon the applications and how we have had regard to our statutory duties and to the views of members of the public are also set out.

Appendix 2 - Competing hydropower schemes guidance December 2012

Appendix 3 – Flow data analysis October 2013

Appendix 4 – AMEC – Avoncliff Weir Comparison of Hydropower Schemes – February 2014

Appendix 5 – Mott MacDonald – Appraisal of Flood Levels at Avoncliff April 2013

Differentiating Factors

The Weavers Mill scheme is considered to be the most desirable scheme for the following main reasons:

1. Electricity generation

The applicants have chosen different turbine types for their proposed schemes at this weir: the North Mill scheme would use an Archimedes turbine, while the Weavers Mill scheme would use a Kaplan turbine.

We have been advised by AMEC using, among other things, the information and data supplied by each applicant, on the likely generation capability of each scheme.

AMEC carried out a comparison of the merits of Kaplan and Archimedes turbines in relation to the site, and this is provided in the AMEC report (Appendix 4). AMEC explain how they have taken head variation into account and the 'drowning out' effect caused by tail water level increases at the Avoncliff weir.

Following a visit to the place of manufacture of the Kaplan turbine to be installed the Weavers Mill applicant provided performance curves for two of his turbines. The general shape of the curves exhibit the behaviour we would expect to see for a well designed Kaplan turbine. We are satisfied that the Weavers Mill applicant would be able to manufacture an appropriately designed turbine to an acceptable standard.

Section 11 of Appendix 1 describes how the North Mill applicant's assessment of the water level data has changed over time and now closely correlates to that of the Weavers Mill applicant. From these data AMEC have derived the 'synthesised head duration curve' to use in calculating electricity generating potential estimates. This is a reasonable approach given the obvious similarities between the two sets of data.

The Avoncliff weir is prone to a quickly changing downstream water level. The physical characteristics and mode of operation of the Kaplan turbine mean that it is not as sensitive to the rising downstream water level to the same degree as the Archimedes turbine. The generating potential of the North Mill scheme would be severely compromised by a rising water level downstream of the weir thus 'drowning out' the lower portion of the two turbines. This would have the effect of reducing the efficiency and thus the generating potential of the Archimedes turbines at this site.

We conclude that the Weavers Mill scheme could generate 398MWh/year and the North Mill scheme could generate 363MWh/year. The Weavers Mill scheme has the potential to generate 35MWh/year more (approx 9.6%) electricity than the North Mill scheme.

Considering these figures in terms of average household consumption, this means that the Weavers Mill scheme could generate the equivalent typical household annual electricity consumption of 121 houses. The North Mill scheme could generate the equivalent typical household annual electricity consumption of 110 houses.

The fact that the Weavers Mill scheme could generate more electricity per year (and over its lifetime) is important to us because over the lifetime of the scheme this amounts to a greater carbon saving.

In addition, the Weavers Mill scheme makes more effective use of the available water resource by generating 3.02Wh/m^3 compared to the North Mill scheme generating 1.92Wh/m^3 . The Weavers Mill scheme proposes to use a maximum of $7.9\text{m}^3/\text{s}$ of water

compared to the North Mill scheme at 10.033m³/s of water. Weavers Mill proposes to use less water to generate more electricity than North Mill. By using less water than the North Mill scheme, the Weavers Mill scheme will allow more water to flow over the main river weir and better maintain the weir pool environment.

There is a small but significant difference in the estimated electricity generating potential of the two schemes. That difference amounts to 35MWh/year or the electricity consumption of 11 households annually. Over the lifetime of the scheme, this could amount to a significant additional amount of 'green' energy generated and accordingly, of carbon saved. We consider the Weavers Mill scheme to be preferable in terms of the estimated amount of electricity proposed to be generated.

In addition, as set out above, the Weavers Mill scheme makes more efficient use of the available water resources. Thus, even if it were the case that the two schemes generated equal amounts of electricity, we would prefer the Weavers Mill scheme because of its greater efficiency, in accordance with our aim of ensuring the optimum use of available water resources, as well as its other advantages (summarised below) in areas such as flood risk, carbon footprint and visual amenity.

The Weavers Mill scheme is preferred because:

- **It could generate more electricity.**
- **It will make more efficient use of available water resources, generating more electricity per m³ water.**

2. Carbon savings

Helping to mitigate the effects of climate change by encouraging the development of suitable hydropower schemes is important to us.

We conclude that the North Mill scheme will have a greater carbon footprint from manufacture and construction than the Weavers Mill scheme. This is due to the larger quantity of steel and concrete used in the construction of the North Mill scheme. The North Mill scheme is estimated to have an embedded carbon footprint from manufacture and construction of 80 tonnes CO_{2e} (carbon dioxide equivalent); and the Weavers Mill scheme 25 tonnes CO_{2e}.

Further carbon savings will arise from the Weavers Mill scheme as a result of its greater electricity generation potential over the lifetime of the scheme. On the basis of the current standard carbon intensity of grid electricity of 0.434kg CO_{2e}/kWh (DECC figures for generation-based average emissions), the amount of carbon saved would be about 173 tonnes CO_{2e} per annum for Weavers Mill and 157 tonnes CO_{2e} per annum for North Mill (i.e. an approx. 10% higher estimated saving of CO₂ for Weavers Mill). Licensing the scheme with the greatest potential for annual carbon savings is an important consideration and in the public interest.

Although the carbon intensity of UK electricity production may change in the future, based on current values the Weavers Mill scheme would offset 800 tonnes CO_{2e} more carbon than North Mill over the next 50 years (800 Tonnes Carbon = impact of driving 2.6 million miles in an average family car).

The Weavers Mill scheme is preferable because:

- **It has a lower embedded carbon footprint.**
- **The carbon offset would be greater over its lifetime.**

3. Flood Risk

Our flood risk mapping shows the area upstream of Avoncliff to be at risk of flooding. Both schemes involve new or altered structures within the watercourse and it is therefore necessary to consider their potential effect on flood risk.

We have carried out a flood level appraisal, which provides for a high-level assessment of the two schemes in order to facilitate a comparison between them for the purposes of the present licensing decision.

Mott MacDonald used the one dimension (1D) ISIS component of the hydraulic model (part of the Bradford-on-Avon Flood Modelling and Mapping project) as a 'baseline' scenario to appraise flood levels upstream of Avoncliff weir as a result of the two hydropower schemes. The two schemes were modelled independently to determine the impact on water levels upstream for a range of design flows (return periods 1 in 2 year to 1 in 1000 year inclusive).

Model runs were undertaken to assess the impacts of the two schemes. For each scheme, two model configurations were used in order to determine the maximum and minimum impact which each of the proposals is likely to have on flood levels. The configurations are:

- Considering the maximum constriction to the flow; assuming sluice gates are fully shut at high flows to protect the turbines; and
- Considering the minimum constriction to the flow; assuming sluice gates and turbines removed (as may occur during maintenance conditions).

Both schemes were tested for a range of flood events; i.e. 1 in 2, 5, 10, 20, 50, 75, 100, 200 and 1000 year events as well as the 1 in 100 year plus climate change event. This may also be expressed as a percentage for example; a 1 in 20 year flood event means there is a 5% risk of a flood event of that severity happening in any year.

The outputs from these model runs indicate the full range of impacts that each scheme could have on peak water levels during flood events.

The results indicate that the North Mill scheme would have the following impacts:

- Over the full range of events tested, the water level could increase by up to 20cm and decrease by up to 15cm immediately upstream of Avoncliff weir for the maximum restriction to the flow and minimum restriction to the flow scenarios respectively.
- Over the full range of events tested, the water level could increase by up to 10cm and decrease by up to 7cm in the main river closest to the rowing club for the scenarios of maximum restriction to the flow and minimum restriction to the flow respectively.

The results indicate that the Weavers Mill scheme would have the following impacts:

- Over the full range of events tested, the water level could increase by up to 1cm and decrease by up to 5cm immediately upstream of Avoncliff weir for the maximum restriction to the flow and minimum restriction to the flow scenarios respectively.
- Over the full range of events tested, the water level could increase by up to 1cm and decrease by up to 3cm in the main river closest to the rowing club for the scenarios of maximum restriction to the flow and minimum restriction to the flow respectively.

By installing one of the turbines in the existing weir the North Mill scheme would cause a constriction in the available width of weir. Consequently the North Mill scheme would present a reduction in flood flow capacity greater than the Weavers Mill scheme where the Kaplan turbine will be located below the existing weir crest level. The model results indicate that of the two schemes proposed the increase in water levels upstream of the weir at Avoncliff is greater for the North Mill scheme, hence there is greater potential for an increase in flood risk as a result of the North Mill scheme than there is for the Weavers Mill scheme.

The North Mill applicant has proposed allowing water to pass through the adjacent building as a means of flood flow mitigation. The proposal is to use an entrance to the “old waterwheel drive area below the mill”. The entrance is stated to be 1.5m by 2m in size. The North Mill applicant states that in the event of “high floods” the water level will overtop the side crest and water will be able to pass through the channel and therefore concludes that “high flows” will be able to pass through the mill structure. There are, however, several areas of concern for us in relation to this proposed means of flood flow relief:

- For a flood relief channel to operate effectively at North Mill, the river must have a gradient from upstream to downstream of the weir. The constriction caused by the downstream aqueduct and the effect of the confluence of the rivers Frome and Avon causes the river downstream of the weir to rise and back up effectively ‘drowning out’ the weir. By removing the gradient to such an extent, the proposed flood relief channel through the building would become ineffective.
- A flood relief channel could become blocked. Effective operation of such a system could not be guaranteed at all times when it is needed.
- The site specific circumstances at Avoncliff mean that it is likely that any effective flood mitigation could only be achieved using a package of measures, including construction of works on third party land.

As set out in the National Planning Policy Framework (NPPF), inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere.

In choosing between the two competing schemes we are comparing the intrinsic flood risk of each scheme. We consider that it is appropriate, in accordance with conventional flood risk

management practice, to seek to eliminate risk at source before considering mitigation measures. Flood risk should be avoided where possible and avoidance is preferable to mitigation in terms of the 'hierarchy' of flood risk management measures.

Properties in close proximity to the weir and located in the floodplain could be at greater risk of flooding as a result of the proposed North Mill scheme. For example, we are informed that River House (the property adjacent to Weavers Mill), in heavy rainfall during 2012 narrowly avoided flooding. We estimate that this event was a 1 in 5 year flood event. We have been informed that during the 1 in 20 year flood event of December 2013 River House flooded.

For the purposes of flood risk the flood level assessment indicates there is greater potential for an increase in flood risk as a result of the North Mill scheme than there is for the Weavers Mill scheme.

Representations were received expressing concern about flood risk from people in close proximity to the schemes and upstream in Bradford-on-Avon. We have given particular weight to the potential increase in flood risk to people and property in the vicinity of the weir and upstream at Bradford-on-Avon.

Here again we note that there is a range of factors in play, so that even if the potential increase in flood risk from the North Mill scheme was not a factor differentiating between the schemes, the Weavers Mill scheme would continue to be preferable on the grounds of greater electricity production, more efficient use of water, carbon savings and visual amenity.

We conclude that:

- **The North Mill scheme presents a greater potential to increase flood risk (increased likelihood and severity of flooding) than the Weavers Mill scheme.**
- **The Weavers Mill scheme is preferable because it is less likely to increase flood risk.**

4. Visual impact on the landscape

Avoncliff weir is located within the Cotswold Area of Outstanding Natural Beauty and a Local Wildlife Site. The North Mill scheme has a larger footprint (two turbines, one located in the weir) than the Weavers Mill scheme. The Archimedes screws together with associated infrastructure would be visible from local viewpoints, for example from the aqueduct; from along the Macmillan Way Long Distance Route and from within the Barton Farm Country Park. The Weavers Mill scheme will not be as visible as it is to be located below the level of the weir and largely hidden from local viewpoints.

The North Mill applicant has asserted that his scheme will be a point of interest and bring visitors to Avoncliff specifically to look at the Archimedes turbines and that his scheme could be described as improving visual amenity. We do not accept this because although his scheme would be visible from the aqueduct and local viewpoints he has confirmed that he

intends to encase the turbines in a mesh screen and thus the workings of the turbine would be largely obscured from view.


Additionally a number of representations expressed concern about visual impact; including those in close proximity to the schemes. We share these concerns and we have taken all of these representations into account and furthermore, in comparing the schemes, we have met the owner of the adjacent property to Weavers Mill. We expect these matters to be considered in more detail during the planning application process with the local authority; but as part of our comparison our view is that the North Mill scheme will have a greater visual impact on the local landscape.

We conclude that:

- **Due to its location and size the North Mill scheme will be more visible to members of the public and local residents than the Weavers Mill scheme.**
- **Therefore the Weavers Mill scheme is preferable to the North Mill scheme in terms of its visual impact on the landscape.**

Conclusion

We have compared the two proposed schemes using our Competing hydropower schemes guidance. We have concluded that overall the Weavers Mill scheme demonstrates the greater public benefit. Our conclusions take into account the short and long term effects of the scheme on the local and national environment and its overall desirability in the public interest.

Authorised by: Steve Jackson Position: National Permitting Service Manager	Date: 14 th February 2014	Signed: 
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