Archimedean Screw Hydropower installation at Ludford Mill

DESIGN & ACCESS STATEMENT

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Introduction

Ludford Mill stands on the south bank of the River Teme at Ludford in Shropshire, facing the town of Ludlow on the north bank. Ludford Weir is parabolic or horseshoe in plan, with its crest curving downstream towards each bank. At the centre or apex of the weir is a fish pass. The proposed site is on the right or south arm of the weir where it abuts Ludford Mill.

A Design Study was carried out in 2011 by Mann Power Consulting Ltd which considered the potential for hydropower generation at this weir using an Archimedean screw turbine. A pre-application enquiry was made in 2011 to Shropshire Council, and discussions were reopened again in early 2014, with conservation oficer Rachel Parry.

The applicant is now a community co-operative which wishes to proceed with this project in the terms described in the present proposal. Directors of the co-operative include the owners and occupiers of Ludford Mill and the adjacent property Bell House. The scheme is to be developed in collaboration with the weir's owner, Teme Weirs Trust, which will lease land to and derive income from the scheme to further its conservation programme.

Figure 1: Proposed site at south bank, viewed from Ludford Mill

Completion of this project will create a supply of renewable energy into the local distribution network, with revenue from the generation and sale of this electricity. In mitigation, the project includes an improvement to eel and lamprey passage at the weir by the provision of a new specialised pass, and potentially improves upstream and downstream migrating fish of other species, by moderating the flows into the existing pass. This will help to ameliorate a perceived problem posed by the weir at Ludford as a barrier to the free migration of fish.

The present document serves as a Design & Access Statement, containing the following information, complemented by supporting material:

- Description of location
- Description of proposal
- Evaluation
- Involvement
- Design
- Overview of the Archimedean screw turbine

Description of location

As the Teme passes eastwards around Ludlow, it flows over several weirs, each created to provide a head of water to power the watermills which once operated here. Immediately downstream of Ludford Bridge stands Ludford Weir. This is parabolic or horseshoe in plan, with its crest curving downstream towards each bank: this shape allowed the weir to direct water towards mills at both banks. A weir of some form is understood to have stood on approximately this site since the thirteenth century, though it may originally have been a straight crest powering only one mill. Like other local weirs, this structure is now owned by Teme Weirs Trust which seeks to conserve these mouments to Ludlow's early industrial past.

At the centre or apex of the weir is a fish pass of Larinier design (i.e. containing a slope of metal baffles). This was constructed during major restoration of the weir in 2002, to improve the opportunity for migratory salmon and trout to ascend the weir during their annual run up the river. Above the pass is a large boulder, placed there to keep the pass clear of large flotsam. To the right of the fish pass, a low spot created on the crest serves as a slide to improve passage by canoes. The crest of the weir is not uniform but varies somewhat in height, with high spots particularly at the downstream ends: this variation is particularly visible during low flows, when much of the crest becomes dry.

On the left or north bank of the weir, the former Hockey's Mill has been converted to residential use. A sluice gate exists here but is not opened by Teme Weirs Trust except to flush out gravels after flood events.

On the right or south bank, Ludford Mill is occupied as a private residence: its exterior, structure, and some of its machinery remain broadly in their historical form, though the machinery is inoperable. During weir restoration, the mill's intake at the river was rebuilt to prevent flooding, with a small sluice now allowing only a sweetening flow to the millpond behind.

As the right arm of the weir approaches Ludford Mill, it rises to its widest and highest point, as an enlarged "lump" which remains dry more often than the rest of the weir crest (Figure 1, Figure 5). This area underwent restoration in 2002 with further works in 2013. The core of concrete was finished with embedded rough-cut stones to give the impression of an irregularly pebbled weir. The weir itself ends here, with a small overspill consisting of

removal stop-boards bridging a gap before meeting the bank retaining wall before Ludford Mill (Figure 6, Figure 7). There is a flood wall (built in 2002) in front of the mill itself, with an opening below water level which admits the sweetening flow through the mill, except when the owner closes the sluice against flood flows.

The area described above – consisting of part of the enlarged southernmost end of the weir, the adjacent overspill channel, and the intake surrounded by the yard parapet walls - is the area to be occupied by the proposed development (Figure 5, Figure 6, Figure 7). This is the smallest fooptrint which can efficiently be harnessed for hydropower at this weir while minimising impacts on the natural environment using an Archimedean screw turbine.

The weir and the mill are listed structures and lie within the Ludlow Conservation Area (see Heritage Statement). The weir occupies what are likely to be considered important views from Ludford Bridge and Old Street, including views of the medieval bridge. The Mill is not visible in views of the bridge, but is likely to be considered an important constituent element in some views of the weir (Figure 2, Figure 3, Figure 4). Access to the site is over the applicant's property, and no public access or rights of way are implicated.

Figure 2: Proposed site – principal view across river from Old Street

Figure 3: View from Ludford Bridge – proposed site at right of weir

Figure 4: Another view from Ludford Bridge

Figure 5: Proposed site – southernmost end of weir – close-up, from downstream

Figure 6: Top of proposed site - view of channel upstream – yard wall to be rebuilt

Figure 7: Reverse view looking down slope of weir – mill flood parapet to right

Figure 8: Failing bank wall at corner below mill to be cut back/realigned in concrete

Figure 9: Mill yard – low wall and gate at driveway to be permanently removed

Figure 10: Mill yard - tree to be removed, river parapet wall to be removed/reinstated

Description of proposal

Figure 11: Screw turbine with a mesh cover, during installation

Please refer to the submitted drawings.

The Archimedean screw turbine is essentially a cylinder of spiral blades which rotates upon bearings at each end. The weight of the water passing down the screw will cause it to turn, thereby harnessing the energy within the falling water. This energy will be converted into electricity by a generator connected via a gearbox at the upper end of the screw.

It is proposed to excavate an area beside and within the south end of the weir to create a concrete chamber for the Archimedean screw turbine. The material to be removed would include the end of the weir together with the stopboard channel (Figure 5, Figure 7), the protruding curved section of the failing bank retaining wall at the corner of the mill (Figure 8), the bed below these locations (consisting of concrete skim over gravels and possibly some bedrock) and the gravels which have accumulated in the river immediately above.

The turbine would be installed here at an inclination of ~22 degrees from horizontal, descending to the lower water, with the result that the lower half of the bladed section was below water at both ends of the turbine. The dimensions of the screw turbine most viable at this site and scaled to efficiently harness the resource available will be approximately 2.5m in diameter. The machinery above this (gearbox and generator) will be enclosed within a walled enclosure covered by decking, to minimise noise emissions and to protect the machinery from frequent flood levels. Subject to conservation preferences, one of a number of forms of visual screening is proposed to mask visibility of the screw turbine itself from public viewpoints. Drawings depict a curtain wall and a form of wooden covering.

A new automatic sluice gate would be installed at the entrance to the turbine. This would both provide failsafe shutdown and ensure that no water would be taken when water availability fell below an agreed level. At the water level, a screen of galvanized-steel horizontal bars proposed to be at ~100mm spacings (precise spacings to be determined by EA) will be set before the sluice gate to exclude debris and larger mammals.

The quantity of the diverted flow, and the retention of an adequate flow in the existing channels, must be sanctioned by the granting of an impoundment or abstraction licence by the EA. Adherence to the flows prescribed is a central condition of the licence, and therefore of the operation of the scheme. This licence has been applied for after pre-application discussion over some years, and negotiations on its conditions are proceeding.

Electrical controls for the system must also be housed within a robust and secure enclosure, and this is proposed to stand on the bank behind the yard wall of Ludford Mill. This can be given any exterior finish – see drawings for proposed appearance with board cladding and sloped roof, following the aesthetic of a robust garden shed.

Excavation of the works will yield an amount of spoil. The majority of this material will be river gravel and silt deposited at the weir by the Teme. Spoil from this riverbank location is considered highly unlikely to raise contamination issues. Spoil will where possible be redistributed by the contractors under direction from the applicant at suitable areas which are available within the applicant's property, used to improve river habitat locally under the direction of the Environment Agency (EA) and/or Natural England (NE - as considered in geomorphological consultant's report), used in the new construction itself, or otherwise disposed of offsite.

Remediation of the site, at any point in the future when the applicant might wish to cease operation, will be a straightforward process. The electrical and mechanical components can all be detached and removed for reclamation/recycling. New channels can be backfilled to restore a surface profile similar to that seen today. If required, redundant wing walls can be cut back to the grade of the weir face. Alterations which are likely not to be reversed are the new eel pass, whose continued presence is likely to be desirable for the purposes of optimising eel movement in the river, and the improved washout gate.

Figure 12: Screw turbines of various sizes in the factory, with and without covers

Electrical connection

The electricity generated will be connected into the local 3-phase grid network supply. The site has a three-phase electrical connection which was sized purposely to accommodate connection of the proposed system. Connection involves running a 3-phase cable from the generator control system in the powerhouse shed to a connection point nearby in the Mill, and installing the necessary metering and safety protection equipment. The cable will be buried at regulation depth across a short distance of paved yard, fully within the applicant's property, and will have no impact on visual or other amenity.

Systems of this scale must be connected under G59 regulations. This will require the applicant to obtain formal approval from the DNO with whom discussions will be opened.

System operation

The amount of water to be abstracted from the river must be controlled to comply with the conditions set out in EA licences and consents to ensure that ecological, fisheries, and other water interests are not compromised. See Environmental Sustainability Assessment.

This is achieved by fitting a level sensor close to the intake, which will measure the precise water level upstream of the screw. The agreed level will serve as a lower threshold point at which operation must cease to preserve an agreed minimum flow in the main river. If the flow falls below the minimum level, the automatic sluice gate is de-energised and falls closed to stop operation.

The automatic sluice gate will be located at the intake chamber just before the screw. The gate will be operated through an actuator controlled directly by an electronic control system which fulfils a number of functions:

1. Automatic system startup and G59-certified mains connection.
2. Automatic control of upstream water level.
3. Maximises the system output with the available water.
4. Automatic shutdown in the event of mains failure, system failure, or low water level.
5. System monitoring and reporting.

The water leaving the turbine will be directed smoothly back into the river at a velocity suitable to preserve the adjacent attraction flow signalling fish towards the fish pass. A sufficient cross-sectional area in the outflow channel is available to achieve this.

Evaluation

Design & Access Statement methodology seeks in part to ensure that developments are responses to their context, rather than impositions of pre-defined design. However it must be recognised that the construction of a renewable energy generating facility must be driven in the first instance by identifying a potential site which possesses sufficient natural resource to justify such a project. This is particularly the case with low-head hydropower, where such resource exists only at points where a fall in the river can be harnessed. Exploiting the fall created by an existing weir avoids the construction of a new weir elsewhere, an alternative which is now rarely possible to justify in environmental terms.

Evaluation, in the terms of the present development, subsists therefore in having identified that this location is particularly suited to hydropower. At the same time, the nature of this site within the river means that it is suited to no competing use which is more appropriate, more preferable, or incompatible with the hydropower proposal.

Through a process of appropriate consultation and responsive detailing, the present design has been elaborated to realise the site's potential, balancing the maximum benefit with minimum of adverse impact. Design of a hydropower installation to suit this site is therefore a clear response to context. (For generic considerations of hydropower siting and layout, see the appended "Principles of hydropower layout".)

Other turbine positions were considered and discounted due to their unviability or their potentially greater greater environmental impact. Opting to install the system so as to abstract water just upstream of the weir and return it just below will minimise the depleted reach - a key aspect in minimising the impact of ecological changes whilst getting the most from the natural resource.

During its licensing process, the EA consults widely on the implications of such proposals. As the EA has already been broadly favourable in its licensing response, it is not proposed to duplicate details of this process in the present document, beyond alluding to the case made in the accompanying Hydrology and Environmental Sustainability Assessments.

Commencement of works is also conditional upon gaining further EA consent for the proposed works in the river at the time in question, and gaining EA acceptance of the eel

pass detailing. Neither of these will be contentious given the designs which are being presented, founded on wide experience of best practice as implemented at other sites.

Wider environmental, social and economic benefits from the proposed development are clear: in terms of a long-term source of renewable electricity generation which will displace an equivalent amount of carbon-emitting generation and thus contribute to mitigating climate change, benefitting all aspects. However, the proposed development also includes an eel pass and improvement of conditions for the existing fish pass, which will improve accessibility of the Teme above Ludford, adding further benefit to the improvements made this year at Lingen Bridge upstream. This is accepted by the EA as an environmental, social and economic benefit, in terms of its contribution not only to the resilience of the respective fish populations, but consequently also to increased public participation in and expenditure upon angling in the catchment above this site.

Renewable energy as a planning consideration

Clearly this installation is primarily aimed at the generation of green energy and sits firmly within the context of policy at national, formerly at regional, and increasingly at local levels.

National Policy

Climate Change Act 2008: This Act puts into statute the UK's targets to reduce carbon dioxide emissions through domestic and international action by at least 80 per cent by 2050 and 26-32 per cent by 2020, against a 1990 baseline. (Information from DEFRA)

DECC Renewable Energy Strategy 2009. This clearly expresses the potential contribution which central government expects small hydropower to make to national renewable energy expansion.

DECC Microgeneration Strategy 2011. This reiterates the government's expectation that the development of new small and micro renewables installations must form an important part of national renewable energy provision.

DCLG National Planning Policy Framework (DCLG 2012). Indicative of the present government's intentions, post-regionalism, this document maintains a core planning principle that: "planning policies and decisions should enable the reuse of existing resources, such as through the conversion of existing buildings, and encourage, rather than restrict, the use of renewable resources (for example, by the development of

renewable energy)" and an objective that "the planning system should aim to… secure, consistent with the Government's published objectives, radical reductions in greenhouse gas emissions, through… active support for… the delivery of renewable and low-carbon energy infrastructure".

NPPF further proposes that "local planning authorities should recognise the responsibility on all communities to contribute to energy generation from renewable or low-carbon sources. They should… have a positive strategy to promote energy from renewable and low-carbon sources… [and] design their policies to maximise renewable and low-carbon energy development while ensuring that adverse impacts are addressed satisfactorily… When determining planning applications, local planning authorities should apply the presumption in favour of sustainable development and… not require applicants for energy development to demonstrate the overall need for renewable or low-carbon energy and also recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions; and [should] approve the application if its impacts are (or can be made) acceptable."

NPPF 17 states as a Core Principle that: "planning should… support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change… and encourage the use of renewable resources (for example, by the development of renewable energy)". LPAs "should not require applicants for energy development to demonstrate the overall need for renewable or low carbon energy and also recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions; and… approve the application if its impacts are (or can be made) acceptable" (NPPF 98).

NPPF 97 states that planning authorities "should support community-led initiatives for renewable and low carbon energy". The present application is for precisely such a community development.

NPPF 97 further states that planning authorities "should consider identifying suitable areas for renewable and low carbon energy sources". The policy clearly derives from a concern with windpower development, and for hydropower it is generally impractical to earmark "areas" in that sense. Opportunities for hydropower in most authorities are

concentrated at run-of-river sites, which are confined to, albeit distributed along, the corridor of the river valleys. Some authorities have conducted area-wide studies to try to pinpoint potential hydropower locations. However micro-hydro schemes are typically progressed by a specific local landowner or interest group, and their development tends only to proceed when interest and motivation occur for a specific site, and at a point in time when economic factors such as tariffs are favourable to the development of the potential at that site.

Indicators of scale (from former (-2011) Regional Policy)

Even though regional-level plans have now been revoked, until alternative targets are set, the research which went into regional plans may continue to provide an indicative guideline as to the scale of renewable energy development within this region which will be required to meet national commitments. The former Government Office for the West Midlands (GOWM) sought to quantify potential for its Regional Spatial Strategy (RSS) targets for renewable energy. The research for this included a study by Halcrow (Renewable Energy Prospects for the West Midlands, 2001) which estimated that the region could raise its hydropower output from a status quo of 3 to as much as 7 or even 10 GWh/year, assuming very optimistically that all potential capacity would be realised. This was critiqued in 2004 by West Midlands Observatory (West Midlands Regional Energy Strategy, 2004) as follows (p.53):

- For reasons of topography all **hydro** developments in the Region will be small scale and, for the most part, "run of river" systems. The resource within the region is therefore very limited and is unlikely to exceed the estimate of 7GWh/year estimated in the Halcrow Report. Smaller schemes are more feasible with far less environmental impact and there are many disused water mills that may offer the possibility of relatively straightforward and economic electricity generation.
- Hydro-electric schemes are much more site specific than wind schemes. It is likely that all hydro developments in the Region will be incorporated into existing weirs and so will not involve the construction of impoundment dams or long penstocks. There are a number of other potential schemes, in the 50–500kW range, in the West Midlands which are likely to be commercially viable and are either under development or developers have outline plans

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Here it was still considered “likely” that “full development of resource” would occur due to favourable economics; though, since that date, the Feed-In Tariff has passed its peak and is now undergoing reduction.

The present proposal, at around 0.175 GWh/year, would contribute 2.5% of the predicted total potential output across the region, or 4.4% of the additional new output which was considered to be needed to put the region on track to meet its anticipated production targets from hydropower alone. Any progress towards a significant increase in hydropower in Shopshire is likely to be made by an accumulation of relatively small steps.

Local Policy

Shropshire Council has signed up to the Nottingham Declaration on Climate Change, under which local authorities acknowledge the increasing impact that climate change will have on their communities and commit to tackling the causes and effects.

The authority has taken steps to promote renewables on its own properties, though hydro has not yet played a part in this. Local councillors have enlisted support in the recent past for a smaller community development at Neen Sollars, and other schemes have gone live, but realisation of hydro potential across the authority area has not been. In the south of the county, given the sensitivities of the Shropshire Hills AONB to wind power development, the LPA has had to limit its proactive support for wind technology, and here think instead in terms of promoting energy conservation and "more compatible" forms of renewables. Addressing Climate Change by developing appropriate small-scale renewables is identified as a key issue for the AONB, with an emphasis on increasing renewable output without impacting the special qualities of the AONB, and on community initiatives (Shropshire Hills AONB: Management Plan 2014-2019, p.35 and policy CS13). The present proposal for a community-led contribution to non-wind capacity at Ludlow, lying within the zone of influence of the AONB, is an opportunity to support this intent.

The high numbers of historic buildings in Shropshire have led the authority to adopt a strategy dealing with the sustainable energy needs of communities in historic urban areas (SECHURBA project, 2011-: http://www.shropshire.gov.uk/media/997575/Shropshire-Historic-Community-Guidance-final-pdf.pdf). While the strategy did not itemise hydropower as a potential response, the widespread existence of historic mills and weirs, and the fact that these are exactly the sites where run-of-river hydropower is still a technically feasible option, makes the adoption of hydropower at old mill sites one of the most immediately logical means of reconciling the historic built environment with low-carbon energy projects.

Ludlow's Place Plan (2012, 2013), in its Infrastructure and Investment Delivery Framework for Ludlow, identifies hydropower as being an "aspirational" opportunity: "the Town Council recognise the potential for energy production from the Teme Weir". The present project brings forward the means of realising this aspiration in a sympathetic design.
https://shropshire.gov.uk/media/832417/ludlow-and-surrounding-area-place-plan-2013-2014-reduced.pdf

The authority's Local Development Framework is supported by the 2006-2026 Core Strategy (2011: https://shropshire.gov.uk/media/830904/shropshire-core-strategy-2011-reduced.pdf) of which Objective 9 is to "promote a low carbon Shropshire, delivering development which mitigates, and adapts to, the effects of climate change, including flood risk, by promoting… the generation of energy from renewable sources."

CS6 Sustainable Design and Development Principles: "…to achieve an inclusive an accessible environment which respects and enhances local distinctiveness and which mitigates and adapts to climate change", all development must "[meet] the minimum criteria set out in the sustainability checklist [such that] energy efficiency and renewable energy generation are adequately addressed and improved where possible." To be sustainable, it is required that a new development such as this one "protects, restores, conserves and enhances the natural, built and historic environment and is appropriate in scale, density, pattern and design taking into account the local context and character."

CS8 Facilities, Services and Infrastructure Provision: [Sustainable development] will be assisted by… positively encouraging infrastructure, where this has no significant adverse impact on recognised environmental assets, that mitigates and adapts to climate change, including decentralised, low carbon and renewable energy generation." Within this theme, "a positive approach to alternative energy sources using decentralised, renewable or low carbon technologies recognises that [off-mains demand] is a problem that particularly affects rural Shropshire, but is also an issue that Shropshire has the natural resources to help address and should do so wherever possible" (CS 4.105). One way to offset this off-grid carbon burden is by increasing the supply of renewable electricity to on-grid demands, and the Teme is one of those natural resources which can deliver this.

The effectiveness of policies CS6 and CS8 is to be monitored by indicators which include "Renewable energy capacity installed by type". The proposed development will contribute materially to the authority's hydropower capacity.

CS9 foresees larger developments making an infrastructure contribution through projects which may include renewables facilities. It is not at present intended that the hydropower project would be funded via this route, though this could be a possibility for the applicant to consider if developers were to come forward.

CS16 supports development that promotes opportunities for accessing, understanding and engaging with Shropshire's landscape, cultural and historic assets (CS 6.32). The hydropower project could conceivably contribute to this in terms of interpretative signage explaining the significance of the Teme weirs in Ludlow's industrial development, if the local authority were to allow such signage to occupy a position beside Old Street at a public viewpoint overlooking Ludford Weir.

CS17 Environmental Networks: "Development [should] protect, enhance, expand and connect Shropshire's environmental assets." Appropriate Assessment for European Habitats Directive (CS 7.10) in relation to the Teme SSSI will be conducted by the EA, as lead authority for main rivers, via its hydropower licensing process, which is already in progress for this development. Through that process, it has been submitted that the development as designed poses low or negligible risk of detrimental ecological impacts, and confers a new positive benefit in terms of improved passage for eels and lampreys, as well as improving the efficiency of the existing fish pass - to the benefit of salmon, trout, grayling and other species. The proposal therefore enhances rather than reducing connectivity between natural sites (CS 7.4). As regards specific impacts on the listed structures, please see further below.

CS18 Water Management: "Planning applications [must be] in accordance with the tests contained in PPS25, and have regard to the SFRAs for Shropshire"; they must be "designed to be safe"; and "FRAs should be proportionate to the level of flood risk, scale, nature and location of the proposed development, as identified within the SFRAs." The development is designed as an in-river structure, and a proportionate Flood Risk Assessment has been submitted to the Environment Agency (EA) as part of the licensing process (see accompanying document entitled Environmental Sustainability Assessment). The development does not culvert existing flow channels (CS 7.16) incurring increased flood risk (its new additional channel is a net increase in conveyance when operating, but in flood conditions it is intentionally closed); and the existing small culvert providing sweetening flow through the Mil itself, while not susceptible to being deculverted, is likewise actively closed off in flood events. The development will be fully compliant with EU Water Framework Directive (CS 7.18), a requirement which is ensured by the mandatory EA licences being issued only after the proposal has been formally assessed by the EA via its hydropower licensing process.

Losses and benefits

The principal loss is that of part of the structure of Ludford Weir (see Heritage Statement below). Consideration of the loss of those elements will determine whether their impact on views represents in turn an unacceptable loss of visual amenity.

The proposal's primary benefit is renewable energy, as above.

The installation will return the weir site to a productive use which is analogous to its historic prior role in water power. The proposal uses machinery which is an efficient contemporary equivalent of the waterwheel equipment which was historically present at Ludlow's mills.

Natural environment aspects have been treated at length in seeking the necessary impoundment licence from the EA. A principal benefit of the proposal is that it resolves a longstanding problem identified by the EA in terms of eel passage in the Teme, which is a river heavily affected by the presence of numerous weir obstructions. 2014 has seen further improvement with fish and eel passage being added upstream at Lingen Bridge, so the potentially accessible catchment upstream which can be served by the proposed improvements is now even greater.

The proposal will not be detrimental to habitats or wildlife in its construction or operation. For full details of the specific consideration which has already been given to aquatic and bankside habitat in receiving approval from the EA, please refer to the reports submitted herewith, and headline comments below (under Biodiversity Statement).

The small-scale works involved do not threaten geological assets.

The proposed scheme is in keeping with Landscape Character, on the basis that the site's existing use is as a water control structure and that the weir and its mills have been used for water power for many centuries and survive as a visual reminder of this use. Water power is resumed here in a contemporary form. While valued landscapes are often intended to avoid coalescence of urbanised centres and to protect the individual character of discrete settlements, this scheme does not threaten these aims, as no significant loss of townscape is involved and overall appearance is largely conserved.

Impacts upon living conditions, employment, highways, and infrastructure are not implicated in this small-hydropower proposal. The proposal occupies a small footprint of water-control infrastructure which will not foreseeably be suitable for other uses, and therefore has minimal impact in terms of reserving space from other uses. While river valleys may present problems for the effective and acceptable siting of wind power, it is precisely such topography which allows a small-scale hydropower installation to be discreetly incorporated into the landscape at an appropriate fall in the land.

On the question of site remediation, as above, the proposal consists largely of a channel which can be backfilled, and machinery which can be removed and very largely recycled. Construction and operation should create no land contamination, and the profile of the site can be restored if the scheme were to cease operation in future. A planning condition requiring this would be acceptable.

In summary, it is submitted that the proposal may be viewed favourably, as being a proportionate use of the natural resource in the landscape at one of the most appropriate points where that resource may be exploited, without unacceptably diminishing the public amenity of the wider landscape character or valuable features. Indeed, improving passage for eels and fish will contribute to population sustainability, which in turn will enhance opportunities for angling as a public benefit of the wider catchment and enjoyment of its landscapes.

(Please refer also to the submitted Environmental Sustainability Assessment, ecological survey, fisheries survey and Construction Method Statement.)

Involvement

The present Design & Access Statement reflects the outcome of discussions to date.

Consultation with the Environment Agency (EA)

Consultation on factors affecting the water environment and its riverbank context has been undertaken with the EA as part of a pre-application for the licences and consents which are a mandatory requirement for such schemes (see below). Environmental impacts of the scheme will be constrained by the conditions attached to the permissions on the licence. The EA licensing process has been informed by the applicant's assessment of ecological issues and Flood Risk as set out in the accompanying Environmental Sustainability Assessment. Formal application has been made for EA licensing, and should be determined within 4 months of the validation date (August 2014), during which time any additional concerns raised by the EA must be fully addressed through further consultation. The following paragraphs summarise how the EA is involved in this process.

Division of regulation between Planning Authorities and the EA

Hydropower schemes vary greatly in their size and their implications for development control. Low-head micro-hydropower schemes may be at the lower end of the size range, but their typical situation is the lowland river environment where the proposed location may be considered visually or ecologically sensitive.

Environmental considerations receive detailed attention during the process of obtaining an abstraction and/or impoundment licence, which is a legal prerequisite to this project (as to almost all such schemes). The EA approaches statutory consultees including Natural England and is a competent authority to undertake Appropriate Assessment under the Habitats Regulations. The EA considers flood risk, water resource, fisheries, recreation, ecology and biodiversity. The EA issues consents for works in rivers and for any identified flood defence or land drainage impacts of new schemes. Principal legislation includes Water Resources Act 1991, Water Act 2003, and subsequent amendments.

The EA as a consultee to planning

The EA also has a role as a statutory consultee to the planning process in these matters. It is usual for the EA to require planning conditions which *inter alia* prevent the operation of the scheme unless the appropriate (abstraction and/or impoundment) licence has been issued (see licences, below).

The EA formerly favoured "parallel tracking" of licensing with planning, though this is now less favoured. The EA undertakes to appoint an account manager for the proposed scheme as a single point of contact in the EA. In the interests of avoiding unnecessary duplication and delay, the planning authority is encouraged to seek early contact with the relevant EA account manager, to understand the EA's timescales, input points, preferred ownership of joint regulatory activities, and status of all work already done to address any concerns which may be mutual. Please contact the EA or Mann Power to establish which EA account manager has been assigned to this project.

EA internal guidance to its planning liaison officers has emphasised that work should not be duplicated between the EA and planning, but exactly how these considerations will be allocated will be determined by the EA on a case-by-case basis. When the EA is consulted at planning, it aims in principle to return no objection, having adequately addressed regulatory concerns under the grant of appropriate EA licences and consents – these concerns having been set out and discussed during the EA pre-application.

The EA works to a statutory 4-month timescale for licensing, and to a 2-month timescale for the additional consents described. Any parallel processing must take this into account. For this project, the 4-month licensing period is due to complete in December. Documents reviewed by the EA for the licensing application will have also been circulated to staff in the EA's Partnerships and Strategic Overview team who will be consulted again via the planning application.

The applicant typically wishes to establish that scheme design is acceptable to the EA (at least in principle) as early as possible, independently of the planning application. This is because the parameters of the scheme design which are influenced by EA preferences during the licensing process (hydrology, fisheries screening requirements) are more crucial to deciding the technical viability of the scheme than other aspects regulated primarily via the planning process. The logical progression is from tentative investigation, to agreeing

appropriate mitigation, to establishing viability, to confirming finalised design. Due consultation is required at each stage. Each of these stages gives a developer confidence to commit additional investment to the development.

Abstraction or Impoundment licence/s

A formal application was lodged with the EA in August 2014, after pre-application consultation in 2011-12 and 2013-14. This should be validated during August and determined by December. During this period, any additional concerns raised by the EA must be fully addressed. Based on the layout of the scheme, the EA has decided that only an Impoundment type of licence is required, and no Abstraction licence.

EA licences attach a number of conditions to the development (namely the protection of other water users' rights in the river as well as environmental issues discussed in the Environmental Sustainability Assessment). When determining the licence, the EA makes a decision whether the scheme context justifies advertising the application in the local press. In the present case, advertising will take place.

Fish pass approval

Installation or modification of a technical-type fish pass must be individually approved by the EA prior to operation. In the present case, as the Larinier fish pass will not be changed, this does not apply. While the EA fish pass approval process is not invoked in the same way for the eel/lamprey pass measures, pre-app discussions with EA Fisheries will be continued to refine the exact technical details of these elements. However the location and physical form are unlikely to change, and the submitted drawings are closely indicative of the form and position of the proposed structures.

Works-in-river consents

Also referred to as Flood Defence consent (in main rivers), one or more consents of this type will be required from the EA for the hydro project, as for all works to be carried out within or close to a watercourse. EA consents consider the temporary impacts on the river of all construction works to be carried out for the scheme, for example by the potential release of concrete or oils during construction; and also the permanent impacts of the operation of the scheme.

The consent application requires describing the fine detail and timings of the scheme's construction, and it is therefore often most appropriate to postpone this until the planning decision has been made (when final design and timings have been agreed). The consent will be considered by the EA's local Partnerships and Strategic Overview team (formerly Development Control & Flood Risk / ADFR), which also responds also as a statutory consultee to the planning process.

Consultation with English Heritage

English Heritage was consulted in 2011, and recommended discussion with the local authority Conservation officers on proposed impacts to the listed structures. This was undertaken in 2011 and 2014.

Consultation with Natural England

Natural England (NE) is a statutory consultee for the River Teme SSSI and is consulted by the EA during its licensing process. NE has also been consulted directly at two stages in the project, and its responses have been taken into account in design (see Environmental Sustainability Assessment).

Other work undertaken in relation to ecological considerations

The site has been surveyed by an independent ecologist and by specialist fish and fisheries consultants (see reports).

Community involvement

This renewable generation project is advanced by a community co-operative which includes the riparian owners of the adjacent historic properties under terms which benefit the owner of the weir. This is the most appropriate way of harnessing the historic structures and natural resources of the mill weir to provide an income stream to support the owners' stewardship of these assets - and by thus sustaining their ongoing upkeep, to benefit to the wider public. The applicant group has sought to promote wider interest in the project by leafletting locally and by addressing public meetings, including presenting to a meeting of Ludford Parish Council (Ludford Conference Centre, 30th September 2013).

The common benefit to the community's river users in terms of angling is at the forefront of the EA's concerns when considering applications for the necessary licences. The scheme

promotes the movement of fish in the Teme catchment, and thereby the resilience of fish populations into the future, which confers a net benefit upon angling and the wider public.

Consultation with the local planning authority

Planning pre-application was sought and advice received that the proposal was in the first instance likely to be of greatest interest in terms of Conservation. Discussion has been held with Conservation officer Rachael Parry in 2011 and 2014.

Listed Building Consent

The proposal will require Listed Building Consent as it affects the setting of various listed buildings and the structure of at least one. A heritage statement is included below.

Navigation/boating/canoeing

The proposed scheme will not hinder canoeing on this stretch of the River Teme. Other forms of navigation do not apply at this weir site.

Public rights of way

No public rights of way are implicated.

Construction access

Road access is from Park Road via a private driveway.

Trees

As the only trees involved are a smaller ornamental non-native tree and shrubs to be removed from a private garden, no formal arboricultural work has been done.

Design

Description of the design should be read in conjunction with drawings and plans provided.

Use

The installation is primarily aimed at the generation of green energy, and sits firmly within the context of policy at national, formerly at regional, and increasingly at local levels, promoting the development of decentralised low-carbon energy production.

The installation's electrical output will be spread over most of the different flow conditions in the Teme, and will continue round the clock in such periods. However there will be no output when the river flow is too low. The system therefore responds to the challenge of sustainable decentralised generation in a manner proportionate and appropriate to the natural resource at this site, while at the same time maintaining or improving passage for fish via measures approved by EA Fisheries and in keeping with the EA's aspirations.

Amount

Efficient use of land and infrastructure includes the exploitation of existing resources and structures, as is proposed here at a site where weirs already exist and water management already takes place.

The proposal does not support occupancy, and has no implications for occupation density, nor does it risk opportunistic conversion to other uses.

A hydropower scheme may foreseeably act as a further attraction encouraging some additional sightseers to view from public viewpoints, but it is not credible that this will materially increase the present volume of traffic or car parking in the vicinity. Visually masking the system would further reduce this attraction.

The system is designed to supply electricity to the National Grid and to do so in a way which makes most efficient use of the available water resource having regard to environmental concerns which are regulated by the licence granted by the EA. On balance, the scheme is efficient and proportionate to the need to generate renewable electricity at a site where natural resources are available to do so (here, water flow and a fall in the land).

Layout

Water power was the original *raison d'être* of the weir at Ludford, whose surviving parabolic form was created to serve mills at both banks of the river. Water power is reinstated by the proposed scheme, in a manner and to an extent in keeping with the site's present condition and status.

The defining characteristics of the proposed site are the presence of a suitable flow in the watercourse and the head available in terms of the descent at the weir. This site is one where the viable amount of head can be exploited on the spot where the water is abstracted without having to lead the water out of the watercourse over any great distance. This prioritises returning the water to the river as soon as possible, minimising the 'depleted reach' of watercourse so that only the weir itself is deprived of water. The sizing and layout of the turbine has been designed with the intention of making a modest and low-impact use of the available resources: the flow of the Teme, and the fall at this spot.

A wide-spaced screen before the turbine will allow all but the largest debris items to pass through the turbine. The form and sizing of the intake, screen and channel are all directly dictated by the amount of flow being taken, a technical necessity for efficient design of the scheme to use the water resource available at the site. To ensure that environmental concerns are prioritised, design was informed by a full consultation process with the EA via their abstraction and impoundment licensing regime.

Flood risk to, and arising from, the proposed development is dealt with more fully in an assessment in the Environmental Sustainability Assessment document. All elements relate to the routing of water within the river, and must therefore lie within the flood corridor. In short, it is a technical necessity for the system to be located at and/or within the river itself. While the scheme is clearly water-compatible, it also constitutes an exception to non-development in the flood plain as infrastructure development whose location there is essential to its operation.

In layout terms, design is dictated by the functional purpose of the hydropower installation as in-river structure. The positioning of the control equipment (within the powerhouse) places it at an appropriate height to escape submersion during predicted floods, the generating equipment (above the screw) is housed in an enclosure which confers protection to a certain flood level, while other parts of the system are designed for submersion. The generator enclosure serves to enclose components of the machinery - it

secures, protects, and creates an aesthetically plain envelope around what would otherwise be exposed machinery. It also acts to minimise the emission of machinery noise.

The sluice gate design includes automatic failsafe shutdown of the system at excessive flows. At moderate flows, when the system is operating, the turbines act as a new path to flow between the sections of the flood corridor immediately above and below the weir.

The mechanical elements of the installation are relatively superficial to the landscape and are removable at decommissioning in future. At that point, the civil works - open concrete chambers - created for the screw and intake may either be suitably dammed/infilled, reutilised for new purposes relating to river management, or cut away and removed. These requirements contrast favourably with alternative scheme designs for such a site, using competing types of turbine such as Kaplan or siphon types. These could involve visible pipework or deeper excavation and pressure tubes formed within massive concrete.

G59 electrical connection will involve insulated cable buried and routed discreetly beneath the mill front yard to the connection point which is at that corner of the adjacent mill cellar.

Among low-head micro-hydro options, the Environment Agency has most frequently cited the Archimedean screw as an example of potentially environmentally-sustainable technology. The Environment Agency's requirements for the scheme to be considered sustainable include accommodating measures for fish passage which must satisfy the specifications of the EA in improving the opportunities for fish to ascend the river. This ensures that migrating fish of all species remain able to pass upstream of this site.

Scale

The footprint of the built elements (turbine installation, washout gate, eel pass, and powerhouse) will be approximately 100m^2, in addition to the area of riverbank changed to form the intake bay. The height of the generator enclosure is proposed as level with the existing parapet wall to maintain this level of flood exclusion. The powerhouse shed is sized only to fit the necessary equipment, and is located behind the yard walls, minimising its presence in public views. (See drawing for AOD levels and dimensions.)

The turbine's presence in terms of shape and size is driven by technical considerations – it is the direct result of designing to optimise efficient use of the natural resource in the proposed location. The Archimedean screw turbine represents technical optimisation of an

ancient technology, resulting in a more than corresponding increase in efficiency and output. While screw turbines are larger in size than other turbines which might compete technically at such a site, their size is in fact a positive choice in terms of ecological impact. Not only fish, but also ecologically-important woody river debris and suspended particles, can pass safely downstream through the spacious slowly-rotating chambers of the screw. The proposed system is therefore proportionate to its context.

Landscaping

The development is primarily a structural change to built structures within the river. The garden area of Ludford Mill will not be changed, and there are no wider impacts to landform or landscape. It is intended to maintain the private drive from Park Road in its present condition. The bank immediately adjacent to the hydropower development consists of a small front yard at Ludford Mill (Figure 9). This will be modified to serve as construction access.

Appearance

The turbine system and structures necessary to its mounting and operation will not be closely or easily visible from viewpoints outside the immediate vicinity, due to the distance from all accessible public viewpoints and the screening effect of trees within the river corridor. However, the conservation officer has also emphasised a preference for masking the machinery.

The screw turbine is typically supplied in a muted shade of green, but another colour may be specified if this is conditioned. However it is proposed that the turbine itself will be roofed over with a solid visual screen such as wooden planking so that it is not visible. Where new screening walls are visible from viewpoints outside the property these will be finished in stonework of a material and form matching the existing riverbank walls which they abut. It is expected that samples would be submitted by the contractor.

All steelwork elements will be either galvanised or painted. Furthermore it is proposed that those which must rise above horizontal sight lines – such as the hydraulic rams, sluice gate and its frame – will be clad with vertical wood boards in a natural finish, to provide a finish best harmonising with the surrounding context without detracting from their technical function.

Proposed Materials

Element	Material
Structural walls	Formed R/C, faced with stone masonry where visible
Top covering (as visual/acoustic/weather screen)	Wooden decking or boards in natural finish
Archimedean screw turbine (and trough beneath)	Mild steel, painted green RAL6007; rubber extrusions
Turbine support substructure and channel	Poured R/concrete (at or below water level)
Grouting of components to channel base & sides	Poured concrete (at or below water level)
Mesh walkways and safety covers	Galvanized or painted mild steel (as flat deck)
Sluice gates and frames	Galvanized mild steel (clad in natural wood board)
Coarse debris screens	Galvanized mild steel (at water level)
Washout sluice gate	Galvanized mild steel (below water level)
Stop boards (temporary/occasional use)	Unpainted treated timber (below water level)
Eel pass substrate	Proprietary peg tile in black plastic (below water level)
Cabling (buried, wherever possible)	Black waterproof plastic-sheathed copper cable
Powerhouse shed (in yard), walls	Horizontal timber siding, over single-leaf blockwork
Powerhouse shed (in yard), roof	Single slope, felt roof or similar
Handrail fencing, where necessary	post-and-rail, unpainted timber or black painted steel

Paint specifications for all elements are subject to agreement.

Access

Access considerations are atypical in this planning application, as the proposal is for an engineering installation, and one which operates unattended except at maintenance visits.

Access to and around the site is fully within the applicant's property. There is no existing public access to the development area, and this will remain unaffected by the proposed scheme once in operation. As an engineering infrastructure installation, the proposed development requires no ingress except for periodic maintenance inspection and engineering access. Maintenance access to the vicinity of the hydropower installation will be undertaken by, or arranged with, the occupant of the mill, representing the applicant. Similarly, the installation will also permit continued access to the riverbank/weir by EA personnel by arrangement with the landowner, as at present.

The scheme's utility and benefits to the local area, community, and wider society lie not in direct public access to or use of its structures, but principally in its contribution to renewable generation targets - while also benefitting fish populations as described.

Construction Access

Please refer to submitted plan showing the footprint of the proposed construction site as a red line, the location of the construction compound, and the vehicular access via the residential drive from Park Road.

While heavy equipment is being used during the construction phase, no unauthorised persons will be permitted into the red line area. Notices will be posted to reflect this and unauthorised access will be monitored.

Supporting statements for planning applications

Flood Risk Assessment *(see also Environmental Sustainability Assessment document)*

DCLG 2011 proposes an objective to "avoid inappropriate development in areas at risk of flooding by… where development is necessary, making it safe without increasing flood risk elsewhere". While developers in Flood Zones 2 and 3 are required to provide evidence of the sequential test and exception test "where appropriate", the present proposal is a case where this is not necessary, in that run-of-river hydropower developments must and can only be situated within the watercourse and/or flood plain. A hydropower scheme therefore logically constitutes water-compatible development. Its location is a matter of technical functionality. (While it also fulfils an infrastructure function as a power generation facility, capable of passing sequential test, NPPF guidance clarifies this to the effect that LPAs "should not use a sequential approach" for renewables infrastructure.)

While the proposal is therefore indeed in a location likely to be affected by current and future flooding, nonetheless in fact it creates low risk in relation to flooding. This is due firstly to the small scale of the proposed reduction in flood plain capacity (predominantly due to the enclosure around the generator) in the light of the creation of additional capacity (new lowered inverts); secondly, to the small area within which the proposal changes river flow; thirdly, to the flood-resilient design of the installation itself.

Full details of this case are presented in a Flood Risk Assessment section within the submitted Environmental Sustainability Assessment. Those observations should satisfy the policy's requirement in the present case for site-specific Flood Risk Assessment (FRA) as a proposal in Flood Zone 3. The same case has been made to EA Water Resources and their internal consultees in EA Partnerships and Strategic Overview (formerly Flood Defence), and will be reviewed again by the latter when the applicant seeks to gain EA works consents which are mandatory prior to construction.

The proposal creates no surface water or other drainage requirements. No water services are included. The structure itself consists of a channel designed to convey water, and its upper surfaces (wooden decking, tops of concrete, steel mesh walkways) drain directly into this channel, just as the stonework of the adjacent bank drains to the river at present.

Environmental Assessment (re EIA)

For hydropower projects of this scale, EIA regulations are not invoked except where there are grounds of special site sensitivity (EIA Regs 1999 Schedule 2). In the 40 schemes around the UK where the present author has had involvement at planning stage, this exception has only arisen in a case where the site fell within a SSSI/SAC where there was significant residual concern for a risk of harm to the interest features.

At this site, potential concerns have been set out by Natural England and have been duly addressed via the Environment Agency Impoundment licensing process. Therefore in the present case it is inferred that EIA will not be invoked, and that no formal Environmental Statement is consequently required.

For a micro-hydropower development of this limited scale, using Archimedean screw technology which is acceptable to the Environment Agency, the submitted Environmental Sustainability Assessment is typically accepted as an adequate assessment. Furthermore, the scheme is already regulated in terms of potential impacts on the natural environment, in that it is subject to mandatory EA licensing before it can be built or operated.

Heritage Statement

Sources consulted include Shropshire Historic Environment Record (HER), British Listed Buildings online, historic photographs and OS maps, and historical information and weir restoration plans in the possession of Teme Weirs Trust.

Statement of significance

Ludford Mill is listed Grade II (1202857, 1954). A previous mill here was demolished and the mill built its surviving form in the seventeenth century. It is a surviving example of a seventeenth-century watermill of a form and construction likely to be representative of other local mills now lost. It is now a private residence. Since the listing it has suffered fire damage and undergone some internal refurbishment. The listing features are unchanged.

Immediately upstream of the mill, an area forming a front yard overlooks the river, its bank retained by a masonry wall extended upwards as a parapet (Figure 10). This yard area now fronts the driveway with a low stone parapet wall and garden gate of recent date (Figure 9) and abuts the Mill to the east and the garden wall of Bell House to the west. The stone bank retaining wall and parapet walls are apparently modern: photos from the 1850s-1890s (http://collections.vam.ac.uk/item/O216420/ludlow-mill-below-ludford-bridge-photograph-francis-frith/ and others) show this space as instead being occupied down to water level by a building of apparent early-modern timbered construction. The yard is surfaced with broken stone paving and rubble/gravel and this ground is likely to consist of demolition debris from the preceding structure.

During weir restoration by Teme Weirs Trust (2002, below), a masonry flood wall was added in front of the mill, allowing a small flow to enter the mill via a sluice, and the area thus enclosed was covered with decking. The manual sluice can be operated by the occupant of Ludford Mill to stop inflow during floods.

Below this area, to the northeast, an irregular area of paved ground outside the outer corner of the mill building is retained by a repaired and deteriorating bank wall of brickwork and masonry which is visibly undercut at present by flowing water (Figure 8). This wall has permanently stood in flowing water and is thus among the elements most likely to have been subject to continous repair during the Mill's operational life.

The mill stands at the southern end of Ludford Weir. This is a horseshoe or parabolic weir of some 145m total length, which itself is also listed Grade II (1241119, 1993) though in separate ownership. The weir is listed as a monolithic entity without specific details of interest ("medieval origins; stone rubble, with vertical coursing"). The weir has since been subjected to extensive renovation by its owner Teme Weirs Trust, which included the construction of a Larinier fish pass at the apex of the weir (2002). While it is understood that there has been a weir at this approximate location since at least the fourteenth century, the surviving structure of the weir is likely to be more recent. Medieval weirs were often of less permanent construction, for example constructed of stakes and hurdles with or without retained stone infill. Weirs frequently collapsed, being rebuilt when required, as long as an imperative persisted to operate the mill, or to provide other services (e.g. fish-trapping, protection of river crossings). The surviving masonry form of many weirs dates from the eighteenth century. Ludford Weir has historically been repaired, most recently in 2002 - when extensive restoration was carried out to missing and failing parts using concrete with an inlaid stone finish (South Shropshire planning consent SS/1/00/11368/LB) - and in 2013, when further repairs in a similar style were undertaken at the southernmost end. A photo from the 1850s-1870s (http://collections.vam.ac.uk/item/O216420/ludlow-mill-below-ludford-bridge-photograph-francis-frith/) shows the weir with narrower profile and parts of a timber skeleton exposed.

Between the weir and the mill is an overspill crest. This consists of a stack of plain wooden boards, of modern date, which can be inserted and withdrawn by hand by the occupant of Ludford Mill to control water levels.

The other end of the weir was formerly the site of Hockey's Mill or Old Street Mill, whose successor is a residential building. Here is now located a modern manual sluice gate (installed in 2002) which is operated by Teme Weirs Trust to remove accumulated material from the weir after floods.

The weir appears in views from Ludford Bridge and Old Street, including views of the medieval bridge itself which is listed Grade I (1281983, 1954) and a Schedued Ancient Monument (1003012, formerly SA73). The Mill is not visible in views of the bridge, but is a constituent element in some views of the weir. The weir contributes variety to the form of the river and may be considered an element of interest in the Ludlow Conservation Area.

Bell House is a former inn which is listed Grade II* (1202820, 1954) and now a private residence. This property stands in grounds adjacent to Ludford Mill and is separated from the proposed installation site by its garden, trees, and rear garden wall at a higher level. Downstream on the opposite riverbank, 18 Temeside is listed Grade II (1212040, 1954). This property is separated from the proposed site by the river and by rear gardens.

Other listed buildings further afield are outside the area of influence of the present proposal.

The occupants of Ludford Mill and Bell House are directors of the applicant co-operative.

Impact

The proposed development necessitates removing part of Ludford Weir and replacing this with a new structure. The development as proposed also removes some riverbank retaining walls in the curtilage of Ludford Mill and replacing these with a new structure. The listed interest features of Ludford Mill are unchanged by the proposal.

The new structures will appear in views of Ludford Weir and Ludford Mill, and thus have a visual impact on their setting. The new structures will not appear in views of Ludford Bridge, Bell House or 18 Temeside or other buildings of interest, and will not modify their setting nor affect their features directly.

Detailed proposal

The present development proposes to remove a section of the weir at its southernmost extremity, but otherwise does not propose to further modify the structure. The proposed change to the weir would remove a portion of its fabric which amounts to ~2% of the length of the structure. The portion to be removed has been heavily repaired in recent years in concrete, detailed in a free (if sympathetic) interpretation of some older surviving portions, and is without specific or unique architectural features of note. The overspill crest at the end of the weir, consisting of plain boards of modern date, is to be removed; its function will be replaced with an automated equivalent a little upstream allowing greater control.

The proposal also involves removal of some bank retaining walls relating to Ludford Mill and their replacement with more stable contemporary engineered structures.

The bank wall and driveway wall of the front yard area will be removed for construction access. The wall and garden gate to the driveway will not be reinstated, leaving the yard area open to and accessible from the private drive. No changes will be made to the garden wall abutting Bell House or to Ludford Mill. The yard contains an ornamental palm tree and shrubs which will be permanently removed (Figure 9, Figure 10). The powerhouse shed will be built within this yard, close to the garden wall to Bell House (see drawings). The retaining wall and its parapet at the bank will be reinstated upon completion of works, except where the new concrete works inherit this function. After works the ground level of the yard will be restored and surface improved where necessary with a suitable treatment.

At the outermost corner of the mill, it is proposed to cut back the failing bank retaining wall and replace with a watertight reinforced concrete substructure as part of the works supporting the screw turbine. This will eliminate the undercutting of the bank, and will thus offer better protection against future instability of the mill itself. Faces of the new concrete works which are visible in external views of the property will be finished in stone laid to match the existing surfaces.

These works will be continued southwards/upstream as reinforced concrete wall. The parapet formed by the stone floodwall (2002) and its modern wooden decking (Figure 1) will not be removed or physically changed, but the new concrete works will be formed directly against the front of the modern floodwall. The new concrete will then turn westward to be formed along the line of the bank retaining wall below the yard. In excavation below ground level, a reinforced concrete bed will be laid to form a rectangular channel, with flat slabs at a lower level and at an upper level, connected by a sloped descent where the screw turbine will be installed. The channel will be completed on its west side by a reinforced concrete curtain wall, to be faced on its visible north-western side with stonework matched to that of the Mill and its area walls. Behind the curtain wall, a reinforced concrete slab will be formed over the upper end of the channel to bear the generator which extends from the top end of the screw. This machinery will be enclosed by a stone-clad screen parapet and a wooden decking cover with access hatch.

Ground conditions and archaeological potential

An archaeological watching brief in 2012, during remediation works after a fire within the Mill, noted that bedrock was encountered a short distance beneath the mill cellar, sloping down northwards towards the river channel. Ground investigation in 2002 for the weir restoration works noted that in the area of construction now proposed – i.e. at the foot of

the overspill sluice, north and west of the mill cellar – the bedrock was encountered at a correspondingly greater depth (here some 2m), being overlaid with gravels which had been capped with concrete during previous works to the weir. The weir itself is believed to be founded on an exposed bedrock shelf, outcrops of which appear in early photographs.

In the proposed area of works, there is therefore some potential for identifying remains of previous engineering structures which may have been capable of surviving permanent inundation, as well as for exposing surviving remains of historic fabric within the removed section of the weir itself. An archaeological watching brief during the new works is therefore likely to be appropriate.

Mitigation

The question may be asked why it is not preferable to simply reinstate the original mill machinery and layout, and thus to minimise change to the surviving historic structures. Indeed, in some cases, this is an option which might be considered. This very much depends, not only on what has survived and how it has been altered, but on what new conditions apply to protection of the environment, and finally on the changed economics of waterpower. Mills were formerly operated without prioritising the sustainability of future fish populations, without regard to impact on SSSI interest features, without the need to manage flows so as to comply with EA Water Framework Directive, and so forth. Small watermills operating in previous centuries were scaled to the needs of specific industrial processes which favoured modest base levels of output and often seasonal demands. Generating electricity for sale into the grid may favour a rather different profile of activity.

The proposed design at Ludford was arrived at after first considering what designs might instead make use of the spaces and/or machinery within Ludford Mill. The surviving historic machinery is incomplete and would require extensive and expensive refurbishment in order to create a scheme which, even so, would be too small to be financially viable as a community project. To create a viable scheme, the intakes and water structures within the mill would have to be significantly enlarged and remodelled, and it would be difficult to achieve without increasing flood risk to the residential property. Consultation with the EA concluded that its preferences lay with a scheme outside the mill in the proposed location and of the proposed form. This was because the proposed design removes the water from the river over the least distance and does not route fish through the dark culverted wheelpits of the mill. In principle, routing flow through the mill itself to use the water at the

historic wheelpits would also require the scheme to build a new fishpass inside the mill, which would be a physical impossibility without substantial demolition and remodelling.

The proposed design thus moves the installation to the front of the mill. This has been mitigated for in design by specifying outline forms and finishes to match those adjacent.

On balance, the scheme which is put forward represents the best compromise between exploiting the mill's historic water resource and retaining the greatest value in the historic structures - losing none of the form of the mill itself, at a cost of a small portion of the weir.

Benefits

The proposal is for a community renewable energy scheme, which is to be evaluated in its own right against the authority's wider planning criteria in the Design & Access Statement. This section relates therefore only to specific benefits in terms of heritage assets.

Weirs which are no longer supported by the conservation budget of a related mill or other heritage asset will face an increasingly uncertain future. As barriers to the natural form of a river, their continued existence is in conflict, in principle, with the EA's interpretation of EU Water Framework Directive, such that there is not a regulatory imperative to maintain them. For owners of weirs, who may in the past have incurred little expense in minor maintenance, costs will increase as the EA receives increased powers to require modifications, to meet changing requirements to reduce the impact of the presence of the structures. Ownership of a weir is therefore ever more likely to become a burden, and intervening to maintain the structure will become increasingly difficult to justify where there are no returns from so doing.

Ludlow is fortunate in having the benefit of an organisation, Teme Weirs Trust, which is dedicated to the conservation of the local weirs and their ecology and which has been very active in restoration of the weirs. Such initiatives are nationally rare, and even where they have existed, circumstances may not support their survival over the long term. This is in part because weirs in isolation, unlike historic buildings or estates, cannot easily generate funds directly. It is not usually practicable to charge for access, as the primary amenity is visual and is often available at no charge. Weirs lie predominantly underwater, so that their structure itself often is not or is only partly visible. For all that their effect contributes to visual enjoyment of the river landscape, isolated weirs as heritage assets are highly unlikely to be self-sustaining.

This creates a problem for heritage management in a time of financial pressure. If budgets do not increase, the adhoc funding available to any given heritage project is likely to decline, given the increasing number of historic assets, their increasing age, and the increasing standards and costs which conservation requires. The need for heritage assets themselves to "work" to contribute to funding their own conservation is now widely recognised, for example in the operation of English Heritage and in recent proposals for the re-establishment of its assets under a charity (J. Larkin (2014): http://www.pia-journal.co.uk/article/view/pia.451/596).

There is one way in which weirs can make a clear and direct economic contribution to their continued conservation, and indeed this should not come as a surprise given that the creation of mill weirs (at whatever remove in time) occurred as an industrial investment for purely economic purposes. Mill weirs were built to create a head of water to power the machinery of watermills. Where conditions still exist to exploit this head for commercial benefit, this can be the source of an income stream. The principal means to achieving this is now the installation of a micro-hydropower system. This is what is proposed at Ludford.

An Archimedean screw has technical merits (including robustness and longevity), but its principal advantage lies in the fact that it provides a downstream route for fish. Other smaller and faster turbine types must install screens to filter out fish; therefore the water which passes through them is temporarily "lost" to the river and to migratory fish.

The proposed scheme presents an opportunity to attribute a funding responsibility for improvements to the weir, which are now necessitated by its presence as a continued obstruction to the free movement of fish species. This is because a hydropower scheme such as that proposed can afford to provide mitigation in terms of installing an eel and lamprey pass to meet latest regulatory requirements, and creating a positive improvement in the operating conditions for the existing Larinier fish pass. Without such a scheme, these improvements would otherwise have to be funded independently out of existing budgets, most likely by Teme Weirs Trust or its successor, or by the local authority.

An argument may also be made that the reintroduction of water power at this site creates a positive benefit to the setting of Ludford Mill and Ludford Weir. Postcard views present an apparently tranquil scene which is redolent of inactivity, masking the impressive power of the river and the historic uses for which it was harnessed by weirs and mills such as these.

Likewise the current appearance of the mill as a discreet residential property does not evoke the industrious activity which brought these structures into being and sustained their survival over many centuries. The reinstatement of a water power facility gives focus to this history, returning a significance to the mill and weir which is poorly revealed at present.

Biodiversity Statement

The planning application takes account of the fact that local authorities may call for submission of a biodiversity statement. This page therefore stands as a statement, stating response to generic questions as follows:

"Extent and location of habitats and features that could be affected"

- River Teme SSSI http://www.sssi.naturalengland.org.uk/citation/citation_photo/2000102.pdf
- Terrestrial habitats: hard masonry and concrete features only - no impact
- BAP priority deciduous woodland, downstream, is separated form the site by the Mill property
- Teme Bank SSSI, upstream, has no connectivity to the site – no implications
- The Teme catchment is a priority area for Catchment Sensitive Farming – no implications

"Likely impacts to designations/priority habitat"

- Only the Teme SSSI designation is relevant here; via the Environment Agency Impoundment licensing process a submission has been made that there is no detrimental impact on the interest features, a conclusion which is supported by the relevant specialist reports in terms of fish species and terrestrial ecology. It is submitted that the development confers net benefit to fish species of interest, due to improved passage, and no detriment to other interest features.
- No connection to or impact upon BAP priority habitat or unconnected terrestrial SSSI (Teme Bank)

"How alternative designs and locations have been considered"

- this weir complex is the only locally-viable location for hydropower, and this site is the most efficient and most productive potential layout option within the complex; the designer has been commissioned as supplier of the environmentally best option among hydropower technologies; alternative layouts and larger systems were considered early on which were discarded as being more impactful upon the natural environment as well as upon the listed structure. Hydropower is less visually intrusive to the wider landscape than a corresponding amount of wind or solar power.

"How adverse impacts will be avoided"

- see attached Environmental Sustainability Assessment for principles of design which aims to satisfy the ecological requirements of the Environmental Agency and other consultees
- see ecological report for assessment and mitigation re other habitats

"How any unavoidable impacts will be mitigated or reduced"

- ditto

"How impacts that cannot be avoided or mitigated will be compensated"

- ditto

"Any proposals for enhancements of biodiversity (this is particularly relevant and desired for Major Developments and other large developments)"

- this development is of a small scale, and located by technical necessity within the constraints of a residential area; but again: see ecological report for proposals

"These reports may form part of a wider Environmental Impact Assessment"

- this development is of a small scale which does not require full-scale EIA under the regulations

"Reports may not be required where applicants are able to provide pre-application correspondence from Natural England which confirms that they are satisfied that the proposal will not have an adverse impact on any SAC, SPA, SSSI OR RAMSAR"

- reports are submitted. Natural England is a statutory consultee as regards the Teme SSSI, and has been consulted on the proposals via the Environment Agency Impoundment licensing process.

For further detail, the reader is referred to the attached document entitled Environmental Sustainability Assessment and the ecological consultant's site report.

Overview of the Archimedean screw turbine

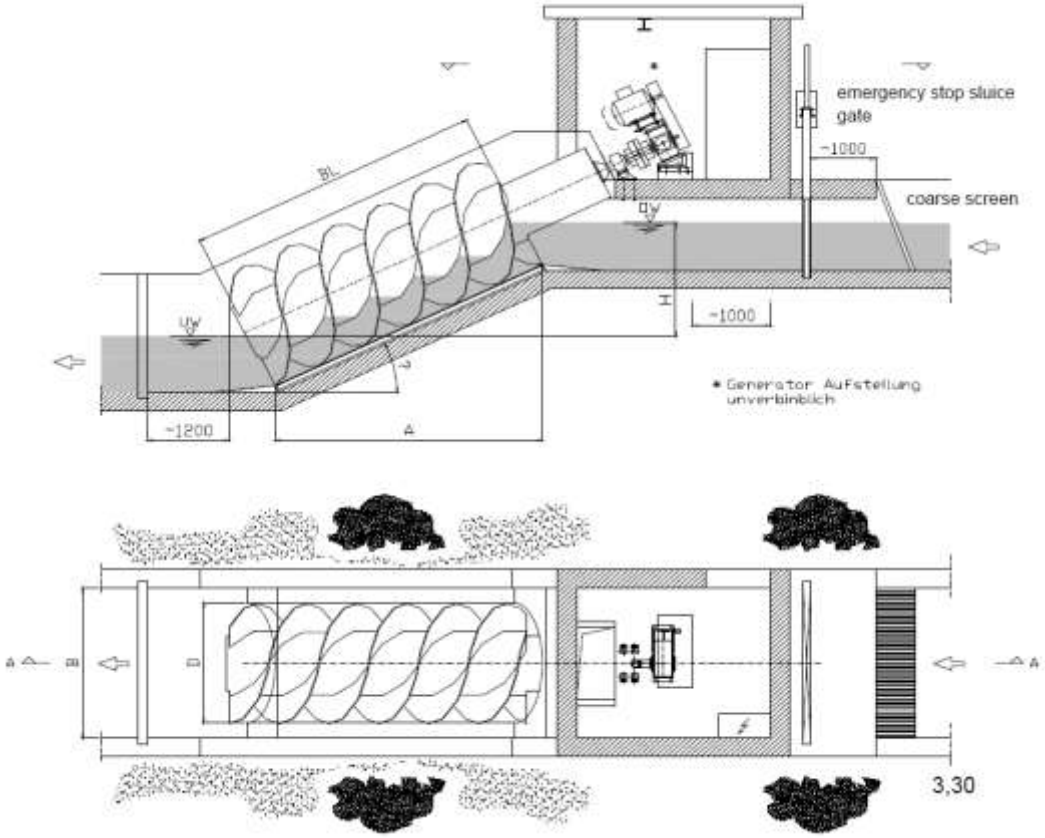


Figure 13: Archimedean screw hydropower system – generic layout sketch

Figure 14: Larger screw (behind footbridge) installed at Mapledurham Mill, Reading

The concept of the Archimedean screw has been known since ancient times, when it was first used as a water pump, with the screw rotating to lift water uphill. The potential of inverting this process has now been realised, by allowing water to fall by gravity into the chambers of the screw. The system then rotates, allowing potential energy to be extracted from the water and fed through a gearbox to power a generator to export electricity.

The turbine structure is similar to an extremely large hardware screw, which commonly consists of a single blade rotating round a central core (single helix). The modern hydrodynamic turbine consists of a triple or quadruple helix, combining large open water chambers with a slow speed of rotation, which avoids any pressure change in the water. Fish can therefore simply enter the screw at the top, and pass through the screw unharmed at the bottom. Extensive testing has been carried out to prove just how fish-friendly the machine is, with over 1000 successful passages of live fish of various species and sizes. These tests were carried out and fully documented by independent experts Fishtek Consulting Ltd.[1]. As there is no need to exclude fish, only a very coarse screen is required, which allows leaves, sticks and other debris to pass through without causing blockages and the subsequent loss of output that other turbines would suffer.

The top of the screw is connected via a flexible coupling to a gearbox, to increase the speed to close to 1500rpm, and then through a final drive to the generator. An electrical control system controls the flow of water to the screw via a sluice gate, monitors the output of the generator, and ensures that the correct frequency and voltage are maintained at all times.

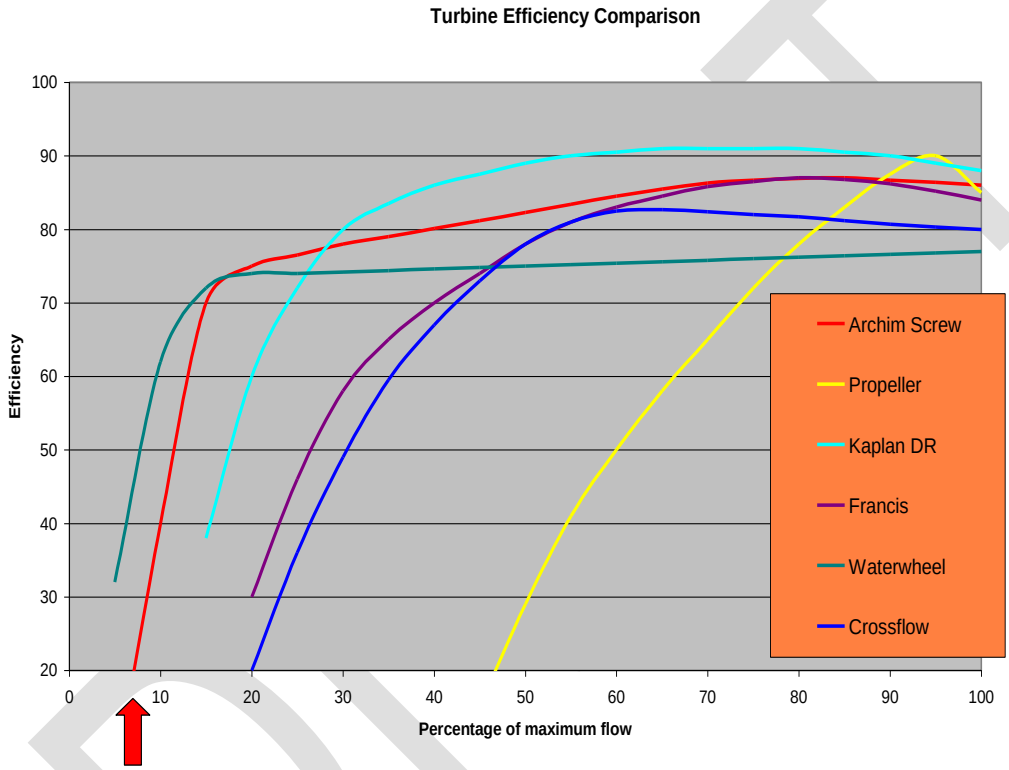
Efficiency comparison

The Archimedean screw is recognised not only for its potentially fish-friendly design, but for its performance among competing designs as increasing flow affects efficiency (below).

The Archimedean screw reaches efficiencies of up to 86%, providing a comparable electrical output to alternative systems, but with a lower capital cost and maintenance overhead. The omission of fine screening, together with a low water velocity and low pressure throughout the system, means that the net head available for generation is very close to the gross head at the site. In addition, full flow capacity is maintained through the screw even when the gross head is reduced during times of high water. These factors can all have a significant impact on the actual annual generation possible from a particular site.

A thorough assessment of the actual performance of an operating system was carried out by independent consultants Nick Bard Hydro Systems[2], which proved that the performance matched that predicted by the manufacturer.

When estimating the energy delivered over the course of the year, it is most important to consider the effect of changing head and flow on efficiency. Favourable performance of the screw in this respect is reflected in the energy capture calculations provided to the client.



References

1 Archimedean Screw Fish Passage Test Results, Fishtek, Sept 2007 et seq. http://www.mannpower-hydro.co.uk/research.php

2 River Dart Hydro Performance Assessment, Nick Bard Hydro Services, June 2007. http://www.mannpower-hydro.co.uk/research.php