

Natural Resources Wales

**Salmon For Tomorrow 2 –
Llanfair Talhaiarn**

Llanfair TH Design Philosophy

290013-ARP-CP-LF-GE-0001

P03 | 22 September 2023

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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1 Introduction

1.1 Overview

Natural Resources Wales (NRW) have appointed Ove Arup and Partners (Arup) to appraise and design fish passage improvements as part of the Salmon for Tomorrow 2 programme. This programme comprises sites located across Wales with works comprising of a mix of new fish pass installations and weir removals. The project is funded by Welsh Government are aiming to improve spawning along 1500 km of waterways which is currently being impeded by weir structures.

This report provides information regarding the design of one of these sites: Llanfair Talhaiarn on the River Elwy previously providing flows to a mill race. The original weir is thought to be around 200 years old. It has been raised or modified multiple times since then, and is in very poor condition.

This report is intended to outline the basis of design based on current understanding and work to date, and is to be updated once further information is available and design work carried out.

1.2 Client Brief

The project brief provided by NRW is as per the extract below:

‘Complete detailed design for weir removal and, if the design necessitates, a design for mitigation downstream of the weir that adopts the principles of green engineering.’

1.3 Site

The weir is located on the River Elwy, situated at Ordnance Survey national grid reference (NGR) SH 93052 70474. Upstream of the weir are the School Lane Bridge and the A544 Road Bridge, Figure 2. The weir was previously used to supply a mill on the right-hand (East) bank, but now serves no operational purpose. The weir is limiting migration to over 20km of salmonoid spawning habitat upstream (NRW, 2021).



Figure 1: Location of Llanfair TH weir

The weir is in very poor condition having been heavily degraded and is collapsing in some locations. On the left (West) side of the river there are signs of undercutting. Deterioration is also noticeable throughout the rest of the structure, albeit less advanced. The weir has been observed to deteriorate from the start of the design process to the current time. The central fish pass has five steps each of around 0.5m and is not thought to function well, limiting which species and which size of fish can migrate upstream. The poor condition of the weir may cause attraction flows away from the fish pass.

Although the weir is still impounding water, it is expected that the centre and right channels in particular will eventually fail in the same way as the left. A large flood event could cause collapse of the structure. The consequences of such a failure are outside the scope of this and previous studies. It should be noted that only a visual inspection was conducted and it was not invasive.



Figure 2 .View of weir from downstream, taken by topographic surveyors, extracted from the Weir Condition Assessment (August 2020).



Figure 3: Photo of weir taken during August 2020 site visit



Figure 4. View of weir from upstream, taken by topographic surveyors, extracted from the WCA(August 2020).



Figure 5. Evidence of undercutting under the upstream left weir channel, extracted from the WCA (August 2020).

Along the left-hand bank runs a public footpath alongside agricultural fields and along the right is a semi natural woodland which is not immediately accessible. These accessibility challenges are considered later in the report.

Downstream of the weir is a waste water treatment works on the right-hand side, and directly upstream is a disused leat leading to a private property which has been blocked off. There are no abstraction or impoundment licenses on the site, however it should be noted that unlicensed abstraction up to 20 m³/d are permitted by current legislation.

2 Baseline Information

Multiple sources of information and other assessments have been carried out, and those are summarised in this section.

It should be noted that no drawings or as-built records of the structure are available.

2.1 Hydraulic model

A 1D-2D hydraulic model was provided which was updated in 2020, was supplied and run giving results which were within expected/typical values and gave confidence that it could be used in further modelling. A detailed topographic survey of the weir itself was provided with the model, as well as cross sections at certain locations from 485m upstream to 150m downstream. The chainage starts at 0m as shown in **Error! Reference source not found.** and this naming convention is utilised throughout this report. Further, a survey of the weir was conducted and several cross sections produced. The purpose of the survey was to extend the modelled reach in both directions. Updates to the model are described in section 3.

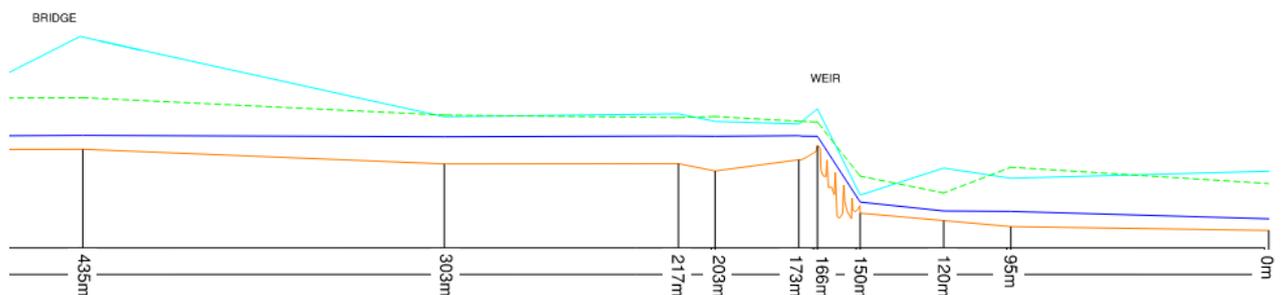


Figure 6. Chainages up the river

2.2 Previous design work

AECOM previously undertook work at this location resulting in a proposed outline design, provided to Arup at the start of the existing commission. This included retaining the wing walls on either side of the weir, regrading the existing channel at a gradient of 1:150 (a distance of 435m), and construction of a check weir at approximately 370m chainage. The proposed regrading was modelled in the baseline model provided.

The following deliverables were provided.

- Llanfair Modelling Report and FCA, Aecom [April 2021],
- Llanfair Hydromorphology Technical Note, Aecom [September 2020],
- Weir Condition Assessment, Aecom [October 2020],
- Llanfair WFD Screening Assessment, Aecom [March 2020],
- Llanfair TH Aquatic PEA, Aecom [October 2020],

- Llanfair TH Terrestrial PEA, Aecom [October 2020], and
- Design Philosophy, Aecom [April 2021].

The Llanfair Terrestrial Preliminary Environmental Assessment (PEA) undertaken by Aecom [October 2020], noted Himalayan Balsam, an invasive species, across the site. Any works which take place must consider treatment of the plants.

2.3 Subsequent assessments

The following assessments have already been issued by Arup in relation to the project:

- Design Progression Report
- Detriment assessment
- Silt sampling technical note

LiDAR was acquired for a larger length of river, both 2.5km upstream and downstream of the topographic survey extent, in order to ascertain the context of the existing weir extent.

Due to the large trees on the banks of the river, and the requirement to only remove trees where absolutely necessary, a Bluesky National Tree Map dataset was obtained for the site. This was compared with photos to identify which trees may need removal during the construction phase. Subsequently, an arboricultural survey was carried out which recommended works to be carried out to the trees around the weir and check weir.

To support detailed design, another topographic survey was carried out in August 2022.

2.4 Flood Risk

The weir is located within flood zones 2 and 3. After the village of Llanfair TH was flooded in February 2020, Arup was appointed under a separate commission by Conwy Borough Council to write a Flood Investigation Report in October 2020. The investigation gave no mention to the weir, thus it can be assumed that there is no flood risk arising due to the weir.

According to the Weir Condition Assessment (2020), although the impact on flood risk due to the weir was not assessed, the risk would be relatively minor as the local flood plain has a high level of connectivity to the river. Thus currently, flood flows will be bypassing the weir.

Flood modelling has shown that the removal of the weir will increase flood depths downstream of the weir for three landowners, and negotiations are ongoing regarding detriment mitigation. Flood modelling is covered in the flood modelling report 290013-ARP-CP-LF-RP-CX-0004.

The construction Risk Assessments and Method Statements should implement safe systems of work to include consideration of flood forecasts, inclement weather and local river levels during construction.



Figure 7: Flood Zone map, extracted from NRW flood risk maps (2021)

2.5 Environmental Constraints

A Preliminary Ecological Appraisal (PEA) has been conducted for the site and was informed by a desk study and a site visit (August 2020). The key recommendations from the report are:

- The Scheme would not result in any negative effects to the Coedydd Derw Elwy SSSI due to the distance (>800m) and fact that the Site is located downstream of the SSSI, shown in Figure 8.
- Habitats Regulations Assessment would not be necessary.
- Potential further survey/assessment was recommended for the following species depending on the nature and extent of temporary works, and location of site compound and associated access:
 - Otter (a subsequent survey found evidence of otters was found in multiple locations on both sides of the river, including potential lying up spots)
 - Water vole;
 - Badger (a subsequent survey found no evidence of badgers)
 - Breeding kingfisher (including dipper);

- Roosting bats (should any tree removal/management be required for river access);
- Great crested newt (if access to the river is from the south);
- Invasive non-native species.
- Further surveys are also recommended in regards to direct and indirect negative effects on the following species:
 - Birds (wintering and breeding);
 - Notable mammals – specifically hedgehog and brown hare; and,
 - Foraging bats.
- The PEA should be reviewed if the final works locations impacts ancient woodland to the South of the river, shown in Figure 8.
- Should noise and visual impacts be a result of the final design and if ancient woodland will potentially be impacted, a habitat condition assessment and woodland flora survey would potentially be required. This may involve a biodiversity net gain assessment should any habitat be lost.
- Works within the ancient woodland habitat should be avoided completely as suitable mitigation cannot be provided

Species-specific surveys are to be carried out prior to construction and an invasives species management plan will also be produced.

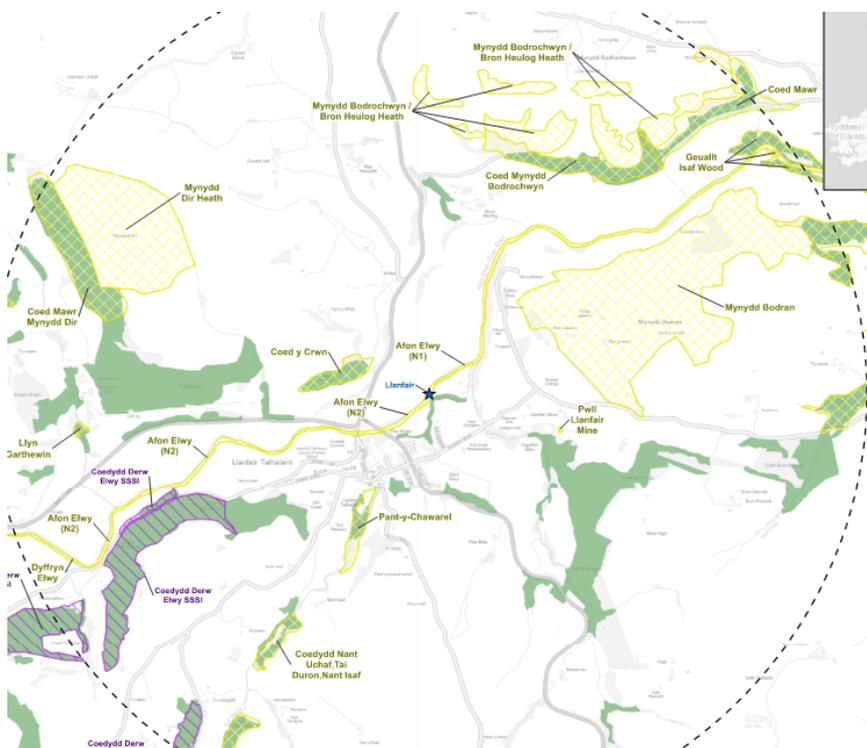


Figure 8: Extents of ancient woodland (green hatch) and SSSI (purple hatch)

2.6 Utilities

A utilities search had previously been carried out at this site by Aecom and since by Arup (November 2021), see Figure 10 and Figure 11 . Of note, a buried water main was located approximately 45m downstream of the Bridge. The depth of the 4-inch diameter pipe is unknown. The presence of the water main was confirmed on site by Arup (February 2022), who identified 3 concrete markers on the banks, Figure 12.

Two outfalls on the right-hand side are shown on the DCWW mapping. A headwall was identified a combined outfall (Figure 9) approximately 40m downstream of the weir toe on a site visit. It is set back from the river channel and was heavily silted in front of the headwall apron.



Figure 9: Headwall identified downstream of weir

The surface water outfall was not located.

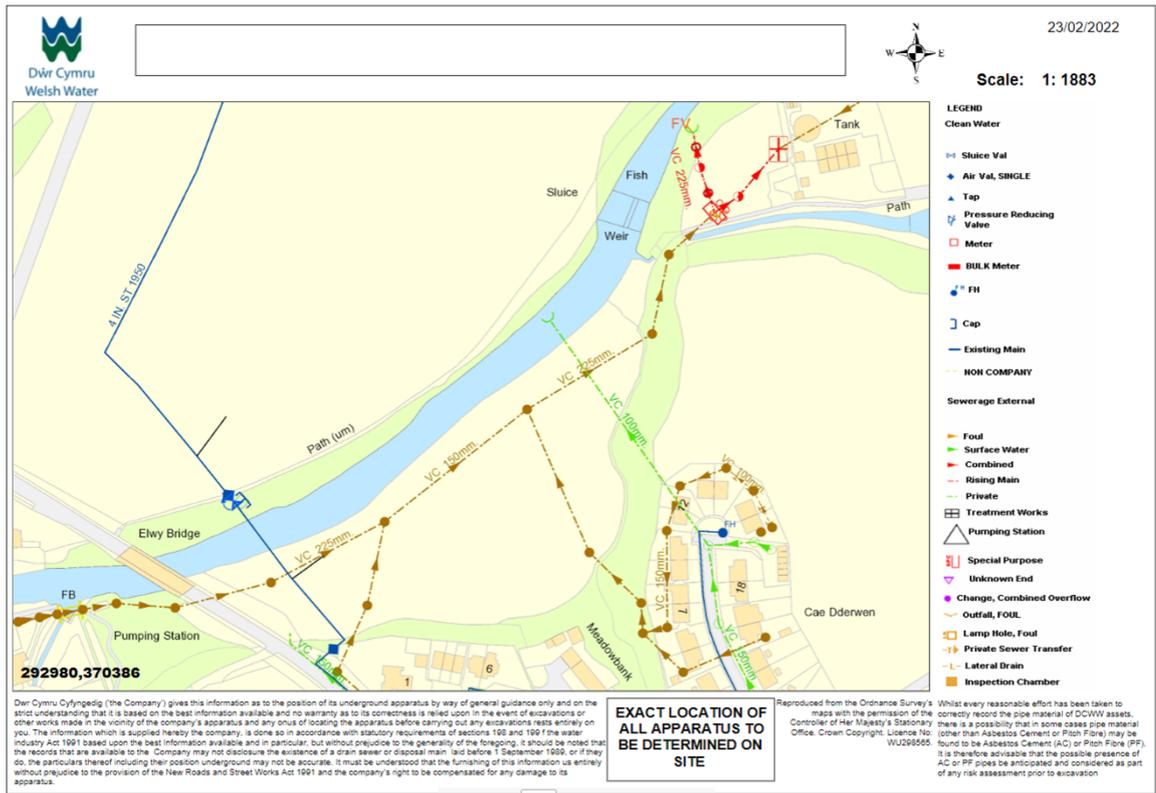


Figure 10: Welsh Water utilities search

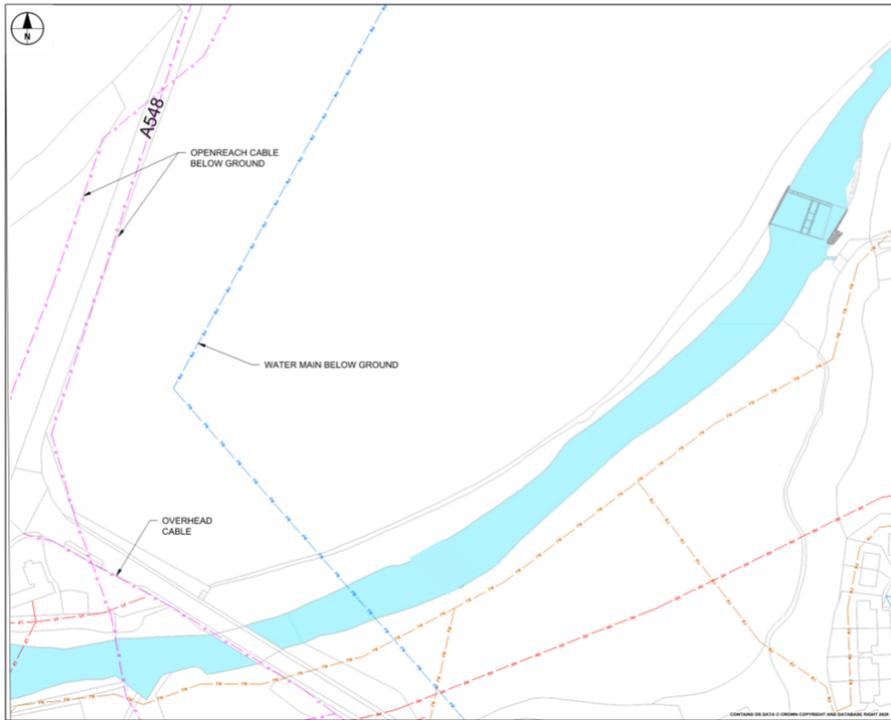


Figure 11: Extended combined utilities mapping



Figure 12: Marker posts indicating presence of buried Welsh Water pipe

2.7 Interfaces

Land ownership details are held by NRW, who are leading on engagement.

Access will be made to the left-hand bank through the farmer's field which will require temporary relocation of the public footpath. This shall be considered further with NRW's estates and the appointed contractor.

On the right-hand bank is a historical abstraction point which used to feed a mill, however the leat has since been blocked off and is no longer functional. NRW have agreed with the landowner that the leat will be left as existing.

Initial discussions have taken place between the project team and Conwy Council who own the two bridges upstream of the weir. They expressed concern regarding the potential for increased scour risk at the bridge, and that if the risk was increased they would prefer full scour aprons to be installed. Model results show a minimal increase in velocities following weir removal and discussions are ongoing with the council.

3 Options Development

Arup reviewed the AECOM design and proposed several changes. These were set out in *290013-ARP-CP-LF-RP-CX-0001 Design Progression Report* (Arup, 2022) where the decision made between designs which involved increased bed disturbance and those with minimal engineering was described.

A key change is that Arup propose that the wing walls on both banks can be removed. This is possible due to the shallow gradients on either bank and initial geotechnical assessment. The advantage of removing the wing walls is that NRW would have no on-site assets to maintain. There will also be no reliance on existing structures within the permanent design and the demolition should be easier to plan.

Following issue of the design progression report, sketches and a site visit on 16/02/2022, it was agreed to progress with the proposed design.

4 Proposed Design

The proposed design is full removal of the weir and wing walls. This includes the following components:

- The concrete weir, base and wing walls will be demolished. There is uncertainty over the composition of the weir due to the lack of record drawings.
- Once removed, the wing walls are to be regraded at a suitable slope angle (likely between 1 in 2 and 1 in 3). Protection will be added to these slopes to reduce the risk of excessive erosion and slippage of the bank.
- The leat on the right-hand bank will be retained and left open
- Due to the lack of information regarding the construction of the weir, it may be prudent to use an observational approach during wing wall removal. The stability of the slope would be assessed throughout demolition whilst the wing wall is removed in stages from the top. This

may result in some of the wing wall being left in or other support added. Any instability can be assumed at this stage to be localised to the riverbank.

- There will be one blockstone check weir, 10m downstream of the DCWW water main.
- Reprofilng of material in the channel is to be minimised. This is to allow the material to redistribute naturally whilst minimising in-river working. Material directly upstream of the weir will be excavated as necessary to allow for removal of the weir. Sampling and testing of the material in accordance with waste disposal regulations has confirmed that the material is suitable for onsite reuse.
- Riverbed material will be able to move freely over time downstream of the check weir.
- Toe stabilisation of either rip rap or rock roll is required at the check weir location and at the weir location. The riverbanks will be graded with biodegradable coir matting for erosion protection around the check weir banks.
- Banks are to naturally re-grade over time following weir removal, following the conclusion drawn in a geotechnical initial assessment of the weir removal option (Arup, 2022). This is possible due to the topography of the site. There is however, a risk of slope instability during construction and in the following years. NRW would need to monitor the area over several years and allow for reactive mitigation works were risks to materialise.
- Downstream of the weir, the eroded left hand bankside will be reprofiled to minimise future erosion. Brush will be used to reinstate the bank and to be sourced from the coppicing of one small tree upstream and a larger tree downstream as well as the removal of a tree on the opposing bank's gravel bed. By coppicing, the roots will remain in the bank for stability but the above ground portion of the trees will be removed as they are currently deflecting water flow and promoting erosion. A layer of gravel will be taken from the gravel bar opposite the eroded riverbank and willow harvested from a sustainable source downstream. This area would be fenced off to allow the vegetation to establish and stabilise the riverbank.
- The existing gate by the weir will be relocated downstream to allow access to the left hand side gravel bar for gravel seeding, from the Nant Barrog trap, in the future.
- There will be some tree removal and coppicing across the scheme to enable access at the check weir and to the right bank at the weir. One in-channel tree downstream of the weir will also be removed to minimise the risk of future bank erosion. The design and construction access seeks to minimise impacts upon trees as far as practicable.

4.1 Design Criteria

4.1.1 Weir removal

The weir removal design will utilise the principles outlined in the CIRIA C763 *River weirs: Design, maintenance, modification and removal* guidance document.

The long profile of the river has been assessed using the hydraulic model cross section and LiDAR to determine the natural gradient of the river. In the long term, it is anticipated that the river will reprofile its bed to match this condition.

4.1.2 Check Weirs

Due to the proximity of the buried water main and the A544 bridge upstream, it is proposed to construct a check weir structure downstream of this infrastructure.

The check weir will be formed of blockstone arranged in an upstream arc and will be buried to the anticipated level of the regraded riverbed. The check weir will provide a visible early warning against scour propagating upstream and prevent knickpoint progression upstream of this point which may expose the buried water main and/or the bridge foundations.

Another check weir structure was previously considered at the crest location of the existing weir, however, it was not found to reduce the risk of excessive regrading post construction and was not protecting any upstream structures. Therefore, a monitoring regime, which would be necessary with or without the inclusion of a check weir, would be able to suitably inform NRW operatives.

The check weir has been designed in accordance with CIRIA 683 The Rock Manual, and CIRIA C742 Manual on scour at bridges and other hydraulic structures. They will be designed to resist loading caused by river flows, including the effects of scour. Flows have been derived from hydraulic modelling results and the blockstones will be designed to act individually. Debris loading will not be considered as the majority is likely to pass over the structure in floods.

Shield's calculations were carried out to determine the characteristic grain size at various locations within the river, detailed in the Design Progression Report (Arup, 2022). The channel requires boulders approximately sized to 0.3m to keep particle movement to a minimum.

4.1.3 Bank Protection

The 1D hydraulic model provides cross sectional average velocities which does not provide detailed information of likely patterns of erosion across the river channel. A geomorphologist's professional judgement and experience has been used to determine the likely locations most at risk of erosion and the likely river response to weir removal.

NRW have indicated that they would not like gabion baskets to be used as part of the design from a durability and aesthetic perspective, and that the use of concrete should be minimised.

NRW have requested erosion protection to make use of natural materials where possible. There are significant tree works anticipated to support the weir removal, along with an established source of willow downstream of the site, which could provide site-won material for natural riverbank protection.

The protection to be provided for the banks is to be designed for 1 in 20-year flow.

4.1.4 Tree Removal

To facilitate the removal of the weir, it is currently anticipated that:

- Four trees require removal.
- Four trees require coppicing.
- One tree group requires coppicing.
- Two work exclusion zones are recommended to protect retained trees.

4.2 Buildability

It is anticipated that an early contractor involvement report will be produced to support the detailed design of the scheme.

A construction compound is expected to be in the farmer's field near the junction of the A544 and A548. An access track will then be used to get from the field to the weir, utilising bog mats or similar. As there is currently public access to the weir along this route, alternative access or a safe crossing of the access track will need to be facilitated.

It is expected that the sequence of works will be as follows:

- Tree removal and coppicing,
- Infill works to left-hand bank downstream of the weir,
- Construction of upstream check weir and associated bank protection,
- Install temporary works to facilitate weir removal, likely to involve either half- or full width of the river being dewatered,
- Removal of bed material upstream of the weir to facilitate construction access. This can be placed in-river downstream of the weir.
- Remove weir structure – expected to be in two halves with flows diverted in one half of the river whilst demolition takes place in the other,
- Construct bank protection at weir location,
- Reinstate site and carry out landscaping and / or replanting works as necessary.

The proposed design has looked to minimise the amount of in river working by allowing bed material to regrade naturally rather than creating an artificial slope.

This will also minimise the quantities of imported materials required. The waste classification testing of the bed material confirm that the material can be used on site rather than requiring offsite disposal.

4.3 Maintenance

Due to the mobile nature of the river geomorphology, the design cannot eliminate the risk of increased bed regrading post weir removal, however the impact can be mitigated through a monitoring plan. Following weir removal, although there will be no inspection or maintenance needed of the weir, the check weir should be inspected periodically and after large storms by NRW for a period of at least 5 years. This is anticipated to consist of a visual inspection following periods of high river flows and a topographic survey of control points at 1-, 3- and 5-years post weir removal. Where the weir was located will also need to be monitored in a similar manner.

The bank protection installed at the banks of the check weir and where the weir was, will also need to be inspected. It should be acknowledged that there is a risk of slope instability during construction and in the longer term. This inspection regime will be detailed by Arup in coordination with operatives at a later stage.

Reactive mitigation works in response to risks materialising should also be planned. Risks are detailed in the risk assessments which have been compiled over the design process.

4.4 Consents and Permissions

In order to be constructed, the works will require the licences and agreements noted in .

Table 1: Consents and permissions required

Permission	Responsibility	Note
Permanent Flood Risk Activity Permit (FRAP)	Arup	
Temporary FRAP	Contractor	
Impoundment licence	Arup	Likely 6 month timescale, includes FCA and WFDa
Landowner agreement	NRW	To cover compound and access on left-hand bank, and weir removal on right-hand bank
Species-specific licences	TBC	TBC following surveys

INNS management plan	Arup / Contractor	Management plan by Arup, contractor to put specific arrangements in place
F10	NRW	Notify HSE of works
Felling licence	NRW / Contractor	To be confirmed

5 Key Risks & Opportunities

5.1 Risks and constraints

A project risk register (290013-ARP-XX-LF-PG-RA-0001) has been produced by Arup and NRW identifying key risks and proposed mitigation. The highest scoring risks following mitigation were:

- Contractor pricing for the scheme exceeding NRW’s budget.
- Unknown construction details of the weir and / or ground conditions.
- Excessive bank erosion following construction.

A design hazard register is also in place and will be updated throughout the project. Key risks include:

- Stability of the existing structures during demolition. There are no as-builts available so this will require careful temporary works planning by the contractor.
- In-river working, including the risks of flooding in high flow events, which will require management and monitoring by the contractor.
- Lifting operations into the river for the blockstone check weir.
- Plant / pedestrian interaction, in particular on the public footpath where used for access. Vehicle movements should be minimised and separation measures put in place.
- Unknown exact location and depth of DCWW water pipe 10m U/S of regrading start. Contractor to commission survey to confirm the exact location of the pipe and its depth.
- Himalayan Balsam on site thus the Contractor is to work to an invasive species management plan. Material is to be disposed of suitably and work is to be carried out to suitable RAMS.

Key construction constraints include:

- The construction period being limited by in-stream working requirements, to be confirmed by NRW.

- Limited access to the right-hand bank

5.2 Opportunities

Additional opportunities could include:

- Improvements to the public realm in the local area such as upgrading the footpath and disabled access to the gravel bar downstream of the weir on the left hand bank.
- Inclusion of benches / picnic table following the works.
- Various opportunities for enhancements were given in the PEA, including the installation of bat or bird boxes; kingfisher or dipper habitat creation or creation of log piles as species refuges.
- Re-use of materials on site instead of offsite disposal.

6 References

Aecom (2021), Llanfair Modelling Report and FCA

Aecom (2021), Hydromorphology Technical Note

Aecom (2021), Llanfair WFD Screening Assessment

Aecom (2020), Weir Condition Assessment

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