**<u>Benson Weir Refurbishment Impoundment Licence Continuation Sheet</u>**

**<u>D Harmer 17/08/2023</u>**

| | |
|---|---|
| *This File:* | |
| Benson Weir Impoundment Licence Continuation Sheet | ENV0003198C-JAC-ZZ-00-PT-Z-0002 |
| *Related Files:* | |
| Benson Weir Impoundment Licence Pre Application PART D Form | ENV0003198C-JAC-ZZ-00-PT-Z-0001 |

| Section | Answer Text |
|---|---|
| D7.1 | <u>Benson Weir Fish Pass Permanent</u><br>A Technical Fish Pass is to be built "mid-channel" through an existing overspill fixed crest weir. This will permanently lower the fixed crest at this section of the weir. The current fixed crest is set to level 44.19mAOD where the lowest fixed crest of the new Fish Pass being set to 43.45mAOD. Please see drawings ENV0003198C-JAC-SF-00-DR-C-1515-Demolition Details and ENV0003198C-JAC-SF-00-DR-C-1530-Fish Pass Long Sections Through Fish Pass (Brush & Baffles).<br><br><u>Benson Weir Fish Pass Temporary*</u><br>For the temporary state, a dam (in the form of sheet piles) will prevent water spilling into the dry working area. The arrangement of the piles can be seen in ENV0003198C-JAC-SF-00-DR-C-1520 Fish Pass General Arrangement. The spill level of the piles will be approx. 45.00mAOD. This is higher than the current fixed crest and water will be diverted either side of the sheet piles.<br><br><u>Benson Weir "Limpet" Dams</u><br>In order to remove and replace the existing large radial gates, temporary works in the form of a “Limpet Dam” are needed to dam water from passing through gate bays. See Section 6 of the “Benson Weir - Outline Buildability Statement” for details.<br><br><u>Benson Weir Ton Bag Dams</u><br>In order to remove and replace the small radial gates and walkway supports, temporary works in the form of ton bags and plastic sheeting are needed to create dry working areas and divert flows. See Section 6 of the “Benson Weir - Outline Buildability Statement” for details.<br><br>A sketch of the impounding works are shown on drawing. ENV0003198C-JAC-ZZ-00-SK-C-0002-Benson Weir Impounding Structures. |
| D8.4 | <u>Benson Weir Fish Pass Permanent</u><br>43.45mAOD (lower than existing)<br><br><u>Benson Weir Fish Pass Temporary</u><br>45.00mAOD (estimated) |

| | |
|---|---|
| | Benson Weir "Limpet" Dams<br>45.00mAOD (estimated)<br><br>Benson Weir Ton Bag Dams<br>45.00mAOD (estimated)<br><br>Limpet dams and Ton Bags will be removed prior to overflow occurring. |
| D8.5 | Impoundment works will divert flows rather than store. |
| D10.2 | A FRAP application will be made in due course |

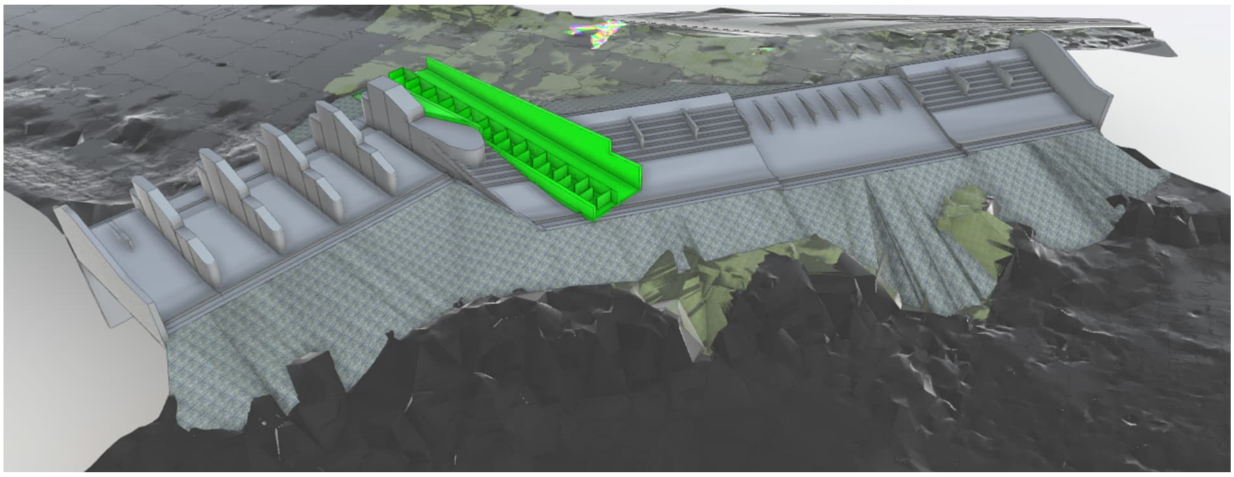
# Benson

## Weir Refurbishment

# 1. Introduction

Benson Weir is located on the River Thames in the village of Benson just south of Oxford. The complex comprises of Weir A and Weir B. Weir A consists of two small hand radial gates and four large hand radial gates. Weir B consists of 8 small hand radial gates and two over falls. The Thames path crosses over the weir complex on a suspended walkway.

This buildability statement outlines the construction process for the refurbishment of the weir at Benson.



# 2. Main site compound and satellite compound

## a. Main Compound

The proposed main compound will be located about 1km upriver from the weir in a farmer's field adjacent to the river. There is a break in the tree line along the riverbank giving good unrestricted access to the river. There is an access track straight from the main road, A4074 Henley Road. See Figure 1 and 2 below.


Figure 1. General Location Plan

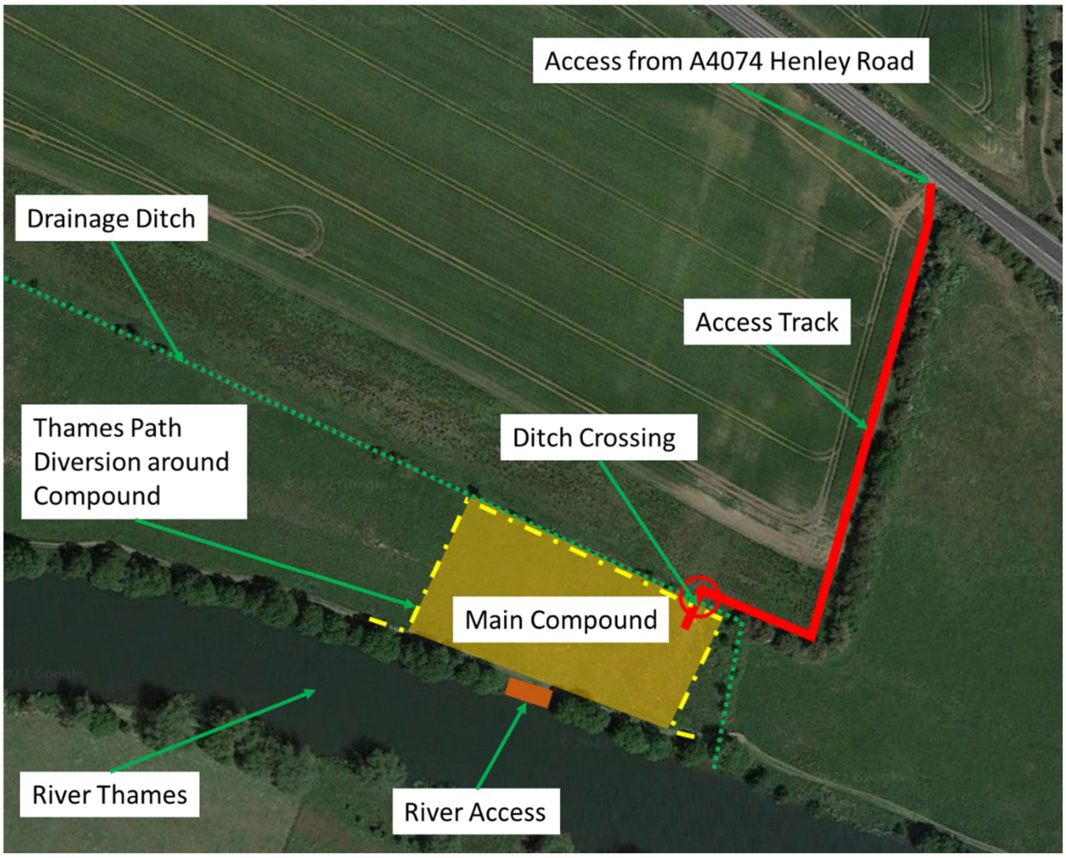


Figure 2. Main Compound Plan

Figure 1 above shows a wider view of the area including the weir complex and both the main and satellite compounds.

Figure 2 shows a closer view of the proposed main compound. The access track will be formed from crushed stone or matting similar to that shown below in Figure 3. A gate will be installed on the entrance set back from the road to maintain security to the compound but also the landowners remaining land.

Figure 3. Track matting example

There is a drainage ditch which runs through the area and will require a crossing point similar to Figure 4 below. This could be left at the end for the landowner as they currently don't have access across the ditch in this location.

Figure 4. Piped ditch crossing example

A request will be made to divert the Thames Path around the compound to remove the risk of plant moving around when loading and unloading marine plant on the river side.

The river access will look similar to that shown below in Figure 5 from our recent Black Potts project in Windsor.

Figure 5. Black Potts River Access

**b. Satellite Compound and Worksite Access**

The satellite compound is proposed to be located in a plot of land directly adjacent to the EA car park by the weir complex. It can be seen in Figure 6 below. This Satellite compound will allow access to the work site as well as being a location for small material deliveries and welfare. Concrete will be delivered here and is covered in section 7.3 below. All substantial deliveries like the gates and Rock armour will be delivered to the main compound and bought down the river.

Access to the work site will be either via the walkway or from the satellite compound via marine access. Which option will depend on the work that is taking place and whether the walkway is in the process of being replaced?

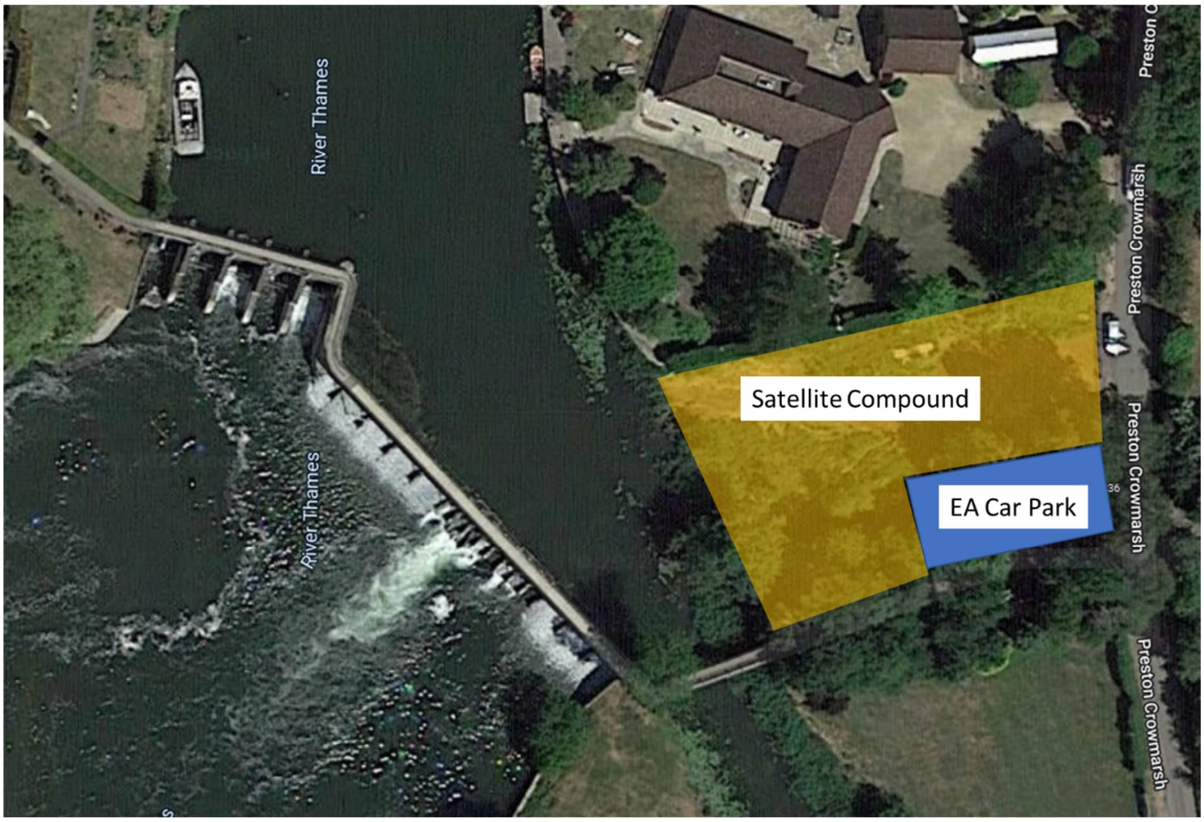



Figure 6. Satellite Compound Plan

## 3. Thames Path

During Construction it will be necessary to close and divert the Thames path in two locations. The first location is where the main compound is proposed. Currently the Thames path runs along the river bank and we would propose to divert this around the compound to mitigate the risk to the public of the plant moving around in that location loading and unloading the supply barge.

The second location is where the Thames Path crosses Benson Weir itself. This part of the path would need to be closed for the duration of the project to again avoid risk to members of the public during construction and especially when the walkway is being replaced. The diversion would be approximately 1.9m and a 37min walk to Wallingford Bridge as shown in Figure 7 below

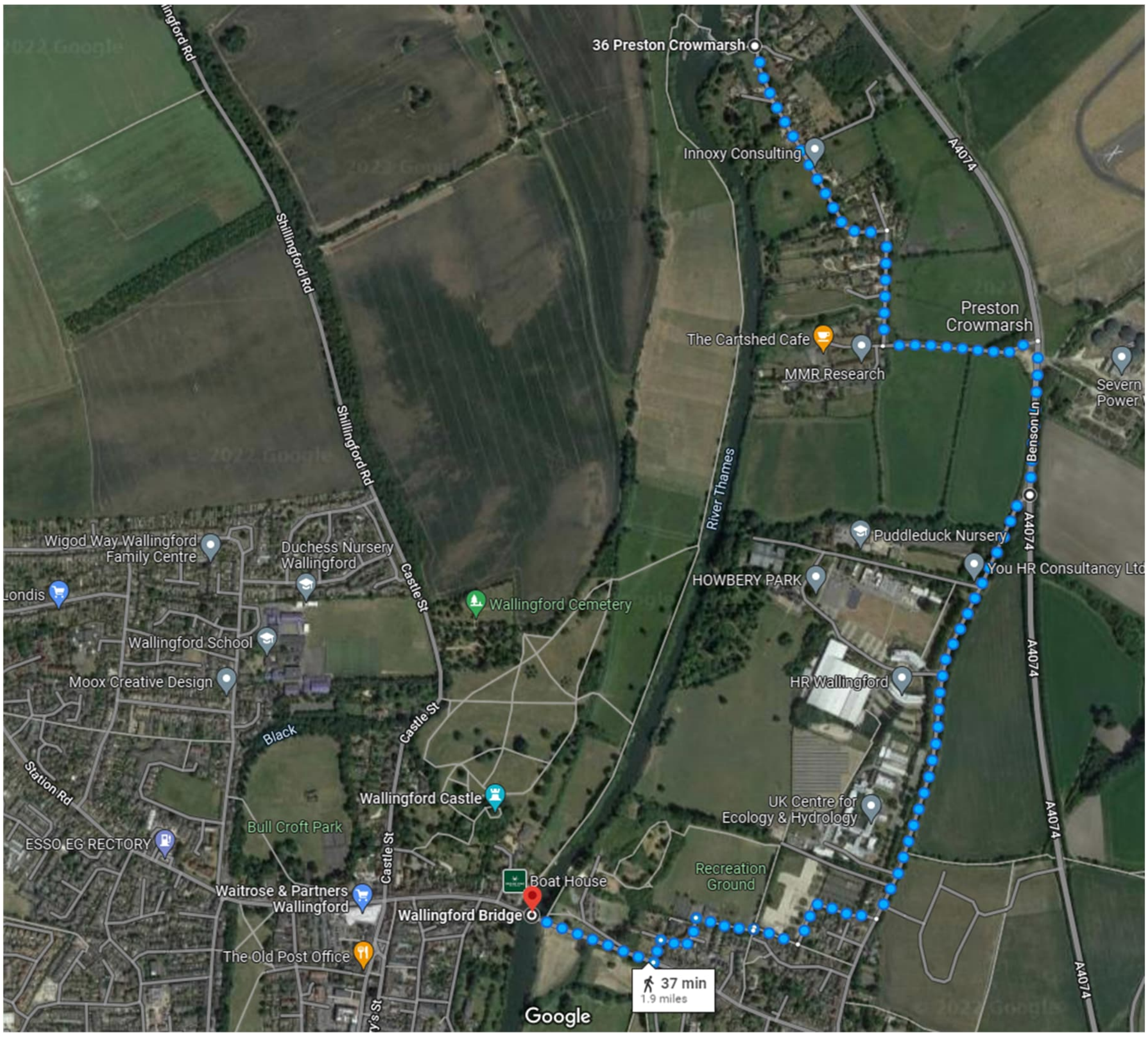


Figure 7. Proposed Thames Path Diversion Route

# 4. Plant and Material Movement

The majority of plant and materials will be loaded on to the supply barge at the main compound and taken down river to the works. The supply barge will be similar to that shown below in Figure 8, which is currently in use on our Godstow project. It is made up from 9 Link floats with 2 of them being spud leg units. The Spud legs are used for additional stability when moored up. The barge below can carry 40t at anyone time. The configuration can also be changed to allow for greater capacity if and when required. The configuration below should be adequate to move most of the materials to site including the new gates, walkway section and sheet piles. We may opt to increase the barge size when transporting the rock armour to reduce the number of journeys.


Figure 8. Proposed supply barge with push boat/tug

A large excavator, 25t+, will be used to load the barge in the main compound. Loose material such as the rock armour will be loaded into skips on the barge similar to that sown below in Figure 9. These boat skips can carry up to 6000l or 12000kg.

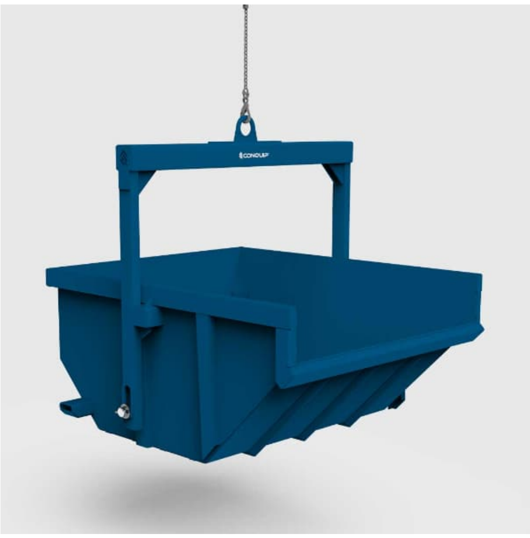


Figure 9. Example of a boat skip

Small materials and concrete will be delivered to the satellite compound. Before being transferred to the works site

## 5. Crane Barge

We plan to service the works with a 70t crane sat on a barge moored alongside the weir. The crane will be used in the replacement of the gates and walkways as well as the contraction of the fish pass including piling. It will also be used for excavation and placement of the rock armour. The crane will sit of a barge like that seen in Figure 10. The is a mock-up for another project of a barge carrying a 70t crawler crane with lattice boom.

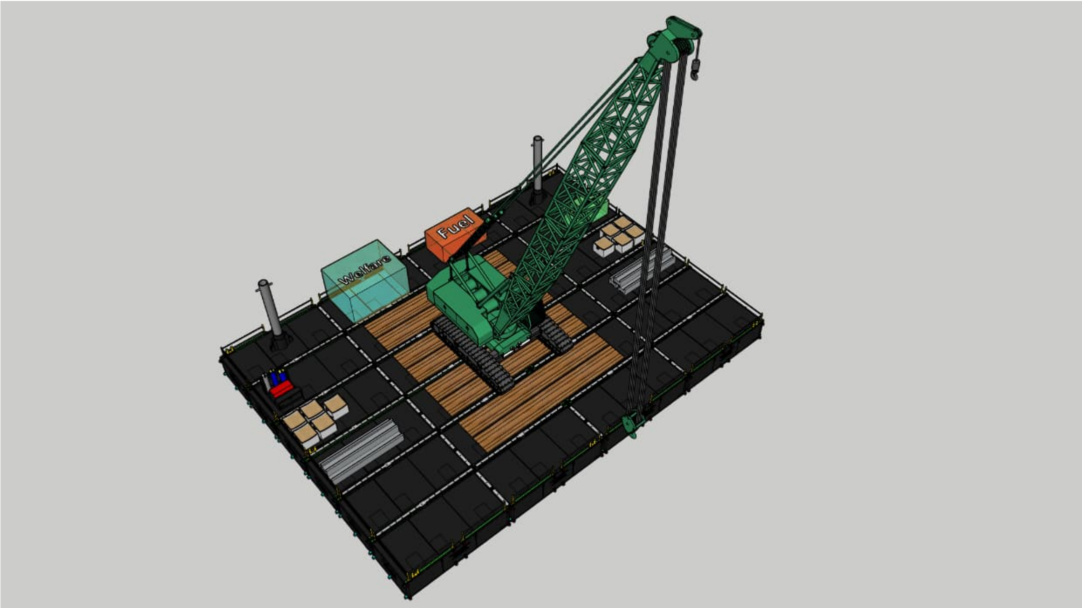



Figure 10. Mock-up of a barge with 70t crawler crane

# 6. Weir Gate and Walkway Replacement

1. Large Radial Gates + 2 small radial gates to the west of the complex

The large radial gates will be replaced one at a time. Temporary works will be installed up stream to stank of the flow of water through each bay. The temporary works will be designed to be reused for all the large weir gates including on the other 4 weir replacement schemes. Please see sketch below in Figure 11. The is a basic view of the Temporary works attached to the piers on the upstream side.

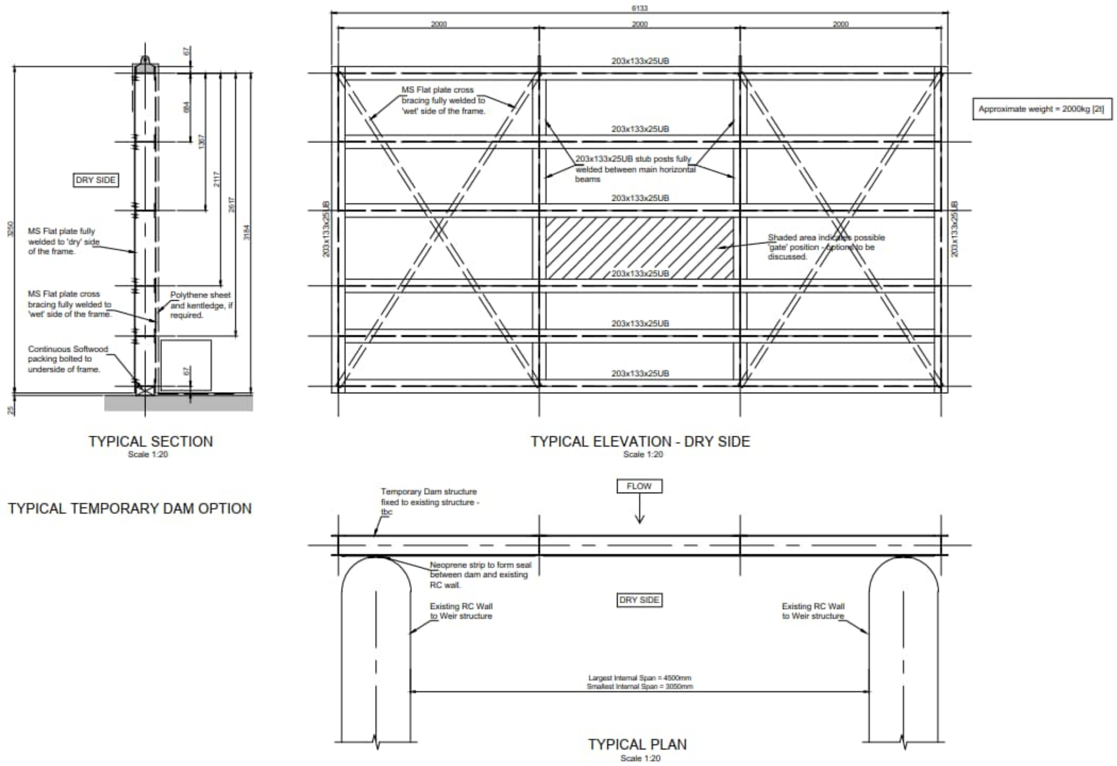



Figure 11. Proposed for upstream temporary works

The water downstream is shallow so the proposal on the downstream side of the works would be to closed off using jumbo back of aggregate / sand wrapped in thick polythene placed on the concrete apron. See Figure 12 below for a sketch and some photos of a previous example


Figure 12. Bulk bag sketch and example photo's

2. Small Radial Gates

The small gates will be replaced at the same time using the above Jumbo bag temporary works to divert water around the gates while they are replaced.

3. Walkway

The walkway will be replaced as the works progresses. The walkway is not required to be removed for the replacement of the gates, but it would be a significate benefit, so it is proposed to remove and replace sections of the walkway as the gate replacement works progresses. The walkway forms part of the Themes Path but for the duration of the works will be closed. See section 3 above.

## 7. Fish Pass

1. Sheet Piles

The sheet piles for the fish pass will be installed using a piling attachment on the crane. The piles will be transported down river from the main compound. The use of a piling gate may be required. The piles will be installed higher then finished level to be used as temporary works.

On completion of the fishpass the piles will be cut off to finished level. This may need to be done with divers depending on the final level required.

2. Demolition of existing structure and excavation

The construction of the new fish pass requires sections of the existing structure to be demolished or altered. This work will be carried out by saw cutting the concrete then breaking it out using machine mounted or remotely operated breakers. Any excavated material will be removed via the supply barge back to the main compound and mucked away.

3. Concrete

Concrete for the construction of the fish pass will be delivered to the satellite compound and then delivered to the work face using concrete skips and the crane. Concrete wash out facilities will be provided in the satellite compound.

## 8. Rock Armour

As part of the design there is rock armour to be placed both upstream and downstream of the weir structure. This will inevitably require some excavation works to get down to formation. This excavation works will take place using a clam shell attachment on the crane, which will be sited on the upstream side of the weir. The excavated material will be loaded into a hopper barge and taken back to the main compound where it will be allowed to dry and then mucked away. Any remaining excavation works can be carried out using a 9t Excavator with a long reach arm sitting on a flat top barge. See Figure 13 below for an example of a 9t Long Reach Excavator.


Figure 13. 9t long reach excavator

The placement of the rock will be done using the crane. The first layer of rock will be placed in prefilled bag similar to that shown in Figure 14 below. These bags make it easier to place the stone and also negate the need for a Terram layer. Tops layers of rock will be placed using a rock grab on the crane.

Figure 14. Rock filled bags being used at Black Potts Weir

# National Environmental Assessment and Sustainability

# Environmental Action Plan

| | |
|---|---|
| **Project name** | Benson Weir Refurbishment FBC |
| **Project 1B1S reference** | ENV0003198C |
| **Area** | Eastern Hub |
| **Date** | 20/06/23 |
| **Version number** | C03 |
| **Author** | Amanda Baker |

## Revision history

| Revision date | Summary of changes | Author | Version number |
|---|---|---|---|
| 10/05/2023 | For EA Review and Comment | Amanda Baker | P01 |
| 25/05/2023 | Minor updates to include details surrounding vegetation clearance, fish rescue and updates to heritage section | Lindsay Perry | P02 |
| 20/06/23 | Final update to include hawthorn hedge removal and reinstatement | Lindsay Perry | C03 |

## EAP Approvals

| Name | Signature | Title | Date | Version |
|---|---|---|---|---|
| Shauket Khan | SK | Benson Weir EAP | 10/05/2023 | P01 |
| Shauket Khan | SK | Benson Weir EAP | 12/06/2023 | P02 |
| Shauket Khan | SK | Benson Weir EAP | 20/06/23 | C03 |

## Distribution

| Name | Title | Date | Version |
|---|---|---|---|
| Jo Fernandez | NEAS | | |
| Paul Warrington | Project Manager | | |
| | | | |

# Contents

# Introduction

This Environmental Action Plan (EAP) has been developed specifically for the proposed works (the 'scheme') at Benson Weir, located on the River Thames in Oxfordshire (Grid Reference: SU 614 912, Figure 1). The scheme is required to eliminate any inherent health and safety risks associated with operating the existing structures whilst extending its operational life and control of the watercourse. In addition, the construction of a fish pass in this location is expected to remove barriers to free migration and isolation of fish populations on the river; contributing to the Environment Agency's Water Framework Directive (WFD) objectives.

The EAP summarises the actions required to implement the environmental mitigation and outcomes identified specifically for this scheme and is supported by the Designers Risk Assessment, Non-Statutory Environmental Report and the Tree Protection and Removals Plan appended to this document.

It details the roles and responsibilities for environmental action / management of those involved in the works. Where appropriate the actions detailed in the table below has a named person who is responsible for ensuring that the action is implemented. It is ultimately the contractor's responsibility for ensuring the EAP commitments are delivered.

These actions form part of the contract documentation and must be adhered to.

## Schedule of Works

Benson Weir refurbishment works: reference BAM Programme BAU.5330-32811-OBC-01-Rev 2.

Starting date September 2023; with pre-construction surveys prior to enabling works and site clearance scheduled for March 2024.

Planned completion September 2025.

## Limitations of the Report

It should be noted that pre-construction ecological surveys have been recommended as an action in the EAP, and the contractors must consult with the project ecologist prior to any work being undertaken. The Preliminary Ecological Appraisal (PEA) and any other supporting information regarding protected species and habitats have been appended to this report.

A Habitat Suitability Index (H.S.I) assessment has been carried out (Jacobs, May 2021) and there are no suitable water bodies within 500m of the scheme boundary suitable to support great crested newts.

The following pre-construction ecological surveys are scheduled for September 2023 and will include:

- A search for badger setts
- An inspection for otter resting places
- Mapping of non-native invasive species
- Inspections for reptile and amphibian places of refuge (hibernacula)
- An assessment of trees for their potential to support roosting bats; and
- Nesting bird checks (if any vegetation clearance is proposed between 1st February and 1st September 2024). This will include specific consideration of a known breeding pair of Mute swans near the weir.

Tree protection zones will be plotted onto an appended Tree Removals and Protection plan. Prior to any works being undertaken within close proximity to trees the scheme arboriculturist must be consulted to avoid impacts upon the root protection areas.

The northern end of the Benson weir walkway is within the Preston Crowmarsh Conservation Area. The Local Authority Conservation Officer will be notified ahead of the works, though they would not be expected to impact on the Conservation Area.

# Completing the Environmental Action Plan

**The EAP is a live document and will be updated at appropriate times as the scheme progresses.** The EAP will be completed by the project's Environmental Advisor (or other suitably experienced person).

## Environmental Responsibilities

The EAP only identifies the site-specific environmental risks and management required prior, during and post construction of the schemes. The appointed contractor is responsible for implementing good environmental practice on site, in line with their own Environmental Management Systems (EMS), including but not limited to:

- Dust suppression measures;
- Noise management;
- Waste management;
- Vehicle maintenance and management;
- Pollution prevention and control;
- Response procedures e.g. services strike, contaminated land; and
- Hazardous materials handling and storage.

## Roles

### The Environmental Clerk of Works (ECW)

The ECW is responsible for inspecting the project during construction to ensure that the environmental aspects of the contract are being achieved in an environmentally sensitive manner. The ECW will provide regular reports to NEAS and the Project Manager on environmental matters, including monitoring all items listed in the EAP. The ECW will be the first point of call regarding environmental questions relating to the site works and will be responsible for providing tool box talks and briefings to the Contractor during the construction works. They will also update the EAP with progress against managing outstanding environmental risks and be responsible for distributing this around the team. The ECW will be responsible for ensuring that appropriate Environment Agency staff are consulted and their comments taken into account in any revised MS (e.g. NEAS, fisheries, biodiversity, environment management).

### Site supervisor

The site supervisor is responsible for ensuring that the works are completed as per the technical requirements and for notifying the project team (including the ECW) of any changes to the designs or technical requirements.

### Contractor

The Contractor is responsible for providing the Project Team with an updated programme of forthcoming activities and provide method statements (as required) for review and check against the objectives within the EAP. The Contractor is ultimately responsible for complying with the actions in the EAP and ensuring that the site is managed in a way that minimises the impacts to the environment.

### ECC Project Manager

The ECC Project Manager is responsible for helping to manage the contract and providing the team with updates on general progress and any design or construction changes. The ECC Project Manager will allow adequate time for these reviews between drafting the MS and undertaking the work on site.

Each action in the table below has **one** named person who is responsible for ensuring that the action is implemented. It is ultimately the contractor's responsibility for ensuring the EAP commitments, which may include planning conditions, are delivered.

## Environmental Incident Reporting system

All environmental incidents must be reported to the Environment Agency Incident Hotline 0800 80 70 60 as per the Environmental Incident Reporting Poster at the earliest opportunity and then to the ECC Project Manager, Site Supervisor, Environment Agency Project Manager and Environment Agency NEAS Environmental Project Manager. In addition, near misses must be reported via the hotline where there was/is the potential for a significant impact and where lessons can be learned.

## Changing the EAP

Any changes made to the proposed construction methodology and approach will be assessed to consider whether there are new environmental effects or changes to those identified in the PEIR and appropriate mitigation applied via the Environmental Action Plan (EAP). The EAP would be amended to take account of any such changes and the contractor would need to ensure that the EAP has been agreed with NEAS prior to any works commencing.

# Summary of Scope of Works

### Site Setting

Benson Weir (centred around Grid Ref: SU 614912. Figure 1 and Plate 1) is in a semi-rural setting on the edge of the large village of Benson in South Oxfordshire. It is a tranquil area with generally low levels of noise. Residential properties line the river in this location with mature gardens and landing stages forming the riverbanks. The weir connects the lock island in the west to a small peninsular in the east. This peninsular is open grassland lined along the banks with mature trees. From here there is a connection by footbridge across the Mill Leat to the eastern bank of the Thames. The footpath on this side is heavily wooded. However, in general there are few mature trees on the eastern side of the weir except directly opposite the Mill Leat.

**Plate 1**: Benson Weir


**Figure 1**: Location of Benson Weir

**Scheme Proposal**

The proposed scheme involves the following:

- Replacing 14 steel gates like for like, re-designed to meet current codes and standards. Including improvement of the design such as removing cross bracing that is prone to trap debris and introduction of nappe breakers.

- Upgrading of Mechanical and Electrical (M&E) equipment. New operational equipment (Drives & Headworks). New actuator with control panel and button operating system for large radial gates. Small radial gates to have a new system which retains manual handling while introducing option to use portable hand electric winder (110V)

- Complete replacement of all support steel work and walkways.

- Repair and refurbishment of elements of the sub-structure. Including introduction of erosion protection (riprap/rock armour); and

- Installation of a technical fish pass (baffle-brush) on the existing fixed crest, located mid-weir.

**Access Routes and Compounds**

The proposed main compound will be located less than 1km upriver from the weir in a farmer's field adjacent to the river. There is a break in the tree line along the riverbank giving good unrestricted access to the river. There is an access track straight from the main road, A4074 Henley Road. See Figure 2 below.

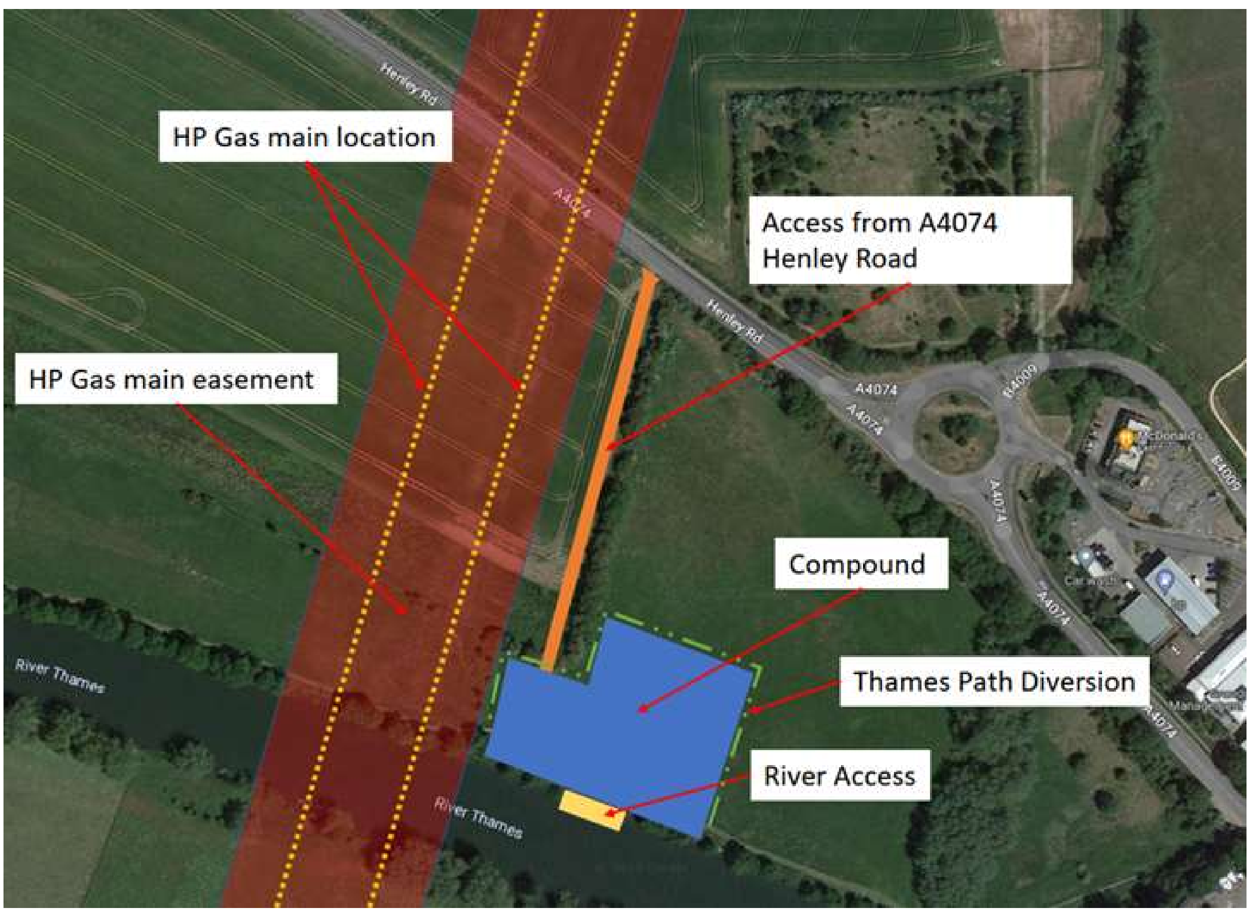



**Figure 2**: Site layout

## Relevant Contact Details

| | |
|---|---|
| **Project Sponsor** | Peter Collins |
| **Project Executive** | Nick Leishman |
| **Project Manager** | Paul Warrington |
| **NEAS** | Jo Fernandez |
| **ECW** | TBC |
| **Contractor** | BAM |
| **Site Supervisor** | TBC |

# Environmental Action Plan

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| **A. Pre-construction** | | | | | | |
| **A0. Approvals** | | | | | | |
| A0.1 | Prevent unforeseen environmental effects | Any changes to construction method or construction details (compared with the Works Information) to be discussed with Site Supervisor. If required, further agreement with NEAS, PM, SODC. | EECPM | | | |
| A0.2 | To secure necessary permissions for proposed works | Undertake consultation with appropriate stakeholders (Oxfordshire County Council, South Oxfordshire District Council) sufficient to secure exemptions / approvals, including a Traffic Regulation Order (TRO) from OCC for the Benson walkway closure if not already in place. | To be confirmed | | | |
| A0.3 | Compliance with the requirements of the EAP | Appoint Environmental Clerk of Works to act as a point of contact for environmental concerns and ensure implementation and audit of the EAP. | EA PM | | | |
| **A1. Human Population** | | | | | | |
| A1.1 | To communicate information about the proposed works to relevant stakeholders | Undertake consultation with affected landowners and residents to advise of the proposed nature and timing of | EA Estates | | Advertisements placed in relevant journal | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
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| | and local residents and minimise disruption to nearby residential and commercial receptors. | the works, access arrangements, and to decide on the location of the site compound area. | | | | |
| | | Notice of entry to be issued at least 7 days before the works to all affected landowners. | EA Estates | | No further action | |
| A1.2 | To ensure public and contractor safety | All service plans to be reviewed prior to attending site | EA PM | Contractor to review service plans and carry out services searches | Site investigations carried out by the Contractor | |
| **A2. Landscape, Land Use and Amenity** | | | | | | |
| A2.1 | To protect the landscape character. | Record the condition of the site prior to any works being undertaken. Undertake a pre-works condition survey (including photos) of site compound / works area and any access tracks / roads.<br><br>Agree site reinstatement including any planting locations | Contractor | Photographic survey by contractor prior to temporary and accommodation works. Photos to be shared to project team and landowner.<br><br>Landscape plan: ENV0003198C-JAC-XX-00-SK-EN-0001 | | |
| A2.2 | To provide continuing safe access along existing non-motorised user (NMU) routes | Ensure works will minimise impact on PRoW and Thames Path (*that crosses Benson Weir and the main works compound*). | Environment Co-Ordinator/ Contractor | https://www.nationaltrail.co.uk/en_GB/short-routes/benson-weir-footway- | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
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| | | Pedestrian and cycle routes will not require closure but traffic management and/or fencing of the working areas will be undertaken.<br>At Benson Weir the path will be diverted away from the works and over Wallingford Bridge, utilising the existing diversion.<br>At the main compound the path will be diverted around the compound fence and across the access track requiring a banksman to direct members of the public safely. | | closed-jan-2023-ongoing/ | | |
| A2.3 | To maintain public safety around the works area. | A fenced off working area will be provided around each location of the works listed above to ensure that members of the public are kept a safe distance from the works. | Contractor | Site compound and access route: ENV0003198C-JAC-ZZ-00-DR-C-1003 | | |
| **A3. Flora and Fauna** | | | | | | |
| A3.1 | To prevent any harm to species or habitats | An Environmental Clerk of Works (ECW) to be appointed for onsite advice and supervision as required, in advance of the works commencing. The programme of works will be established prior to work starting and the ECW will identify when they need to be | Contractor and ECW. | | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
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| | | onsite and ecological management actions required.<br>A pre-start meeting will be held with the ECW and contractor prior to works beginning. | | | | |
| | | Contractor to abide by the locations agreed to with ECW. | Contractor | | | |
| A3.2 | To avoid impacts on reptiles (as protected by the (Wildlife & Countryside Act, 1981 as amended) | A walkover survey to identify any potential habitat / hibernacula for reptiles within the footprint of the investigation to be undertaken by a qualified Ecologist in advance of any works commencing onsite. | Project Ecologist / ECW | | | |
| | | If required and depending on programme, habitat manipulation ahead of site mobilisation - 48 hours before commencing and in bright, warm weather strim and rake off vegetation down to 150mm, 24 hours before commencing strim the vegetation down to 50mm and rake off cuttings.<br><br>ECW to be suitably qualified to oversee the clearance of | Contractor working with ECW who will advise accordingly. | Site Plan: ENV0003198C-JAC-ZZ-00-DR-C-1000.<br>Tree Removals and Protection Plan: see Appendix C.<br>Ecological Schedule: see Appendix D | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
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| | | vegetation and working with reptiles.<br><br>ECW to oversee all vegetation clearance. Vegetation clearance to take place within timeframes shown on Ecological Schedule and in accordance with Tree Removals and Protection Plan and Site Plan showing the temporary site compounds and access routes.<br><br>ECW to deliver toolbox talk to all contractors. | | | | |
| A3.3 | To avoid impacts on badgers (Wildlife & Countryside Act, 1981 as amended) | Walkover survey to identify any badger setts within 20m of the proposed works/access routes and site compounds in advance of any works commencing onsite. If present, a mitigation strategy should be agreed with Natural England prior to the works beginning. | Project Ecologist / ECW | | | |
| A3.4 | To avoid impacts on amphibians (Wildlife & Countryside Act, 1981 as amended) | A walkover survey to identify any potential habitat / hibnernacula for amphibians within the footprint of the works (including access routes and site compounds) to be undertaken by a qualified Ecologist in advance | Project Ecologist / ECW | | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
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| | | of any works commencing onsite. | | | | |
| A3.5 | To avoid impacts on nesting birds (Wildlife & Countryside Act, 1981 as amended) | Vegetation clearance should be undertaken well in advance of the nesting bird season (generally considered to be end February to end of August), which would deter breeding within the vicinity of the works. Where this is not possible, measures to deter birds from nesting could be deployed, which would require further consideration.<br><br>If any scrub or trees need removing within the breeding bird season (March – August inclusive) then a check for nesting birds should be undertaken by a suitably qualified Ecologist within 24 hours of the works commencing. If an active nest is found, mitigation will include retaining the vegetation until the young have fledged. Buffer zones of 5-10m should be retained around retained vegetation known to support nesting birds. | Project Ecologist / ECW | BS 5837:2012 Trees in relation to design, demolition & construction | Pair of Mute swans recorded near/adjacent to weir structure (local interest/concern that works could disturb nesting/breeding) | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| A3.6 | Minimise impacts to aquatic habitats and species | Confirm locations where works in/ close to water course are required and agree timing/ working method with EA Fisheries team. BAM to agree timings and discuss with the EA once known. | Contractor | | | |
| A3.7 | To avoid impacts on trees, bats and nesting birds (Wildlife & Countryside Act, 1981 as amended) | Mark out root protection area (of at least canopy size) around trees adjacent to access routes and/or site compound, and no works to be undertaken (or materials / equipment stored) within these zones. | Project Ecologist / ECW/Project Arboriculturist | BS 5837:2012 Trees in relation to design, demolition & construction | If signs of bats are found then the ECW and bat ecologist will need to advise on the best working methods or the need for a protected species licence. | |
| A3.8 | To avoid impacts on bats (Wildlife & Countryside Act, 1981 as amended). | Avoid any trees and hedgerows with potential for bats.<br>If trees are to be trimmed, an Arboriculturist or an Ecologist will need to be present to check for any crevices or other potential habitat for bats.<br>Works should be carried out only during the day to avoid disturbance. | Contractor Project Arboriculturist / Project Ecologist / ECW | | Install temporary fencing or tape around trees, at or wider than the canopy (see action A3.6 above). Tool-box talk for all site operatives to be provided by ECW. | |
| A3.9 | To avoid impacts on trees / hedgerow (Wildlife & Countryside Act, 1981 as amended) | Ref: A3.6 The arboricultuist will advise on site of the root protection area to be protected.<br><br>Prior to starting works, ensure that South Oxfordshire | Contractor | BS 5837:2012 Trees in relation to design, demolition & construction | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
| --- | --- | --- | --- | --- | --- | --- |
| | | District Council have agreed to works which could impact upon trees. This agreement must be documented in writing. | | Tree Removals and Protection Plan: ENV0003198C-JAC-XX-00-SK-EN-0001 | | |
| A3.10 | To prevent spread of invasive non-native plant species (INNS) | If INNS are positively identified within the vicinity of the works and/or access routes during the pre-construction site walkover, agree appropriate methodology/mitigation in accordance with best practice.<br><br>No spread during construction | ECW/Contractor | Contractor to include in site RAMS (if applicable) | Toolbox talk detailing steps to take if invasive species are found. | |
| **A4. Water Environment** | | | | | | |
| A4.1 | Minimise pollution risk to controlled surface water. | A Flood Risk Activity Permit FRAP) is required for any works within 8m of the riverbank or 5m of a culvert (Method Statements will need to be prepared to support the works). | Contractor | https://www.gov.uk/government/publications/excluded-flood-risk-activities-environmental-permits/excluded-flood-risk-activities#site-investigation-boreholes-and-trial-pits | The FRAP will be submitted at detailed design prior to construction commencing. The FRAP will cover the temporary works (coffer damming) and the permanent impact caused by the introduction of a technical fish pass. | |
| A4.2 | Minimise pollution risk to controlled surface water. | Produce a method statement prior to works detailing pollution prevention | Contractor | | Contractor RAMS to detail methods | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | measures to be employed onsite. | | | Email from EA Fisheries to confirm approach to any de-watering/in-channel activities in addition to the RAMs<br>Method Statements shall include how potentially contaminated materials would be segregated and stored in an impervious bunded area to prevent contamination of groundwater or land.<br>Known or suspected contaminated stockpiles would be tested to ensure that no cross-contamination results | |
| A4.3 | To protect existing riverbed habitat and material | Produce a method statement detailing how the existing bed material will be protected OR removed, stored and reinstated to be agreed with the EA Fisheries and Biodiversity Team. | | | | |
| A4.4 | Minimise impacts to aquatic habitats and associate species | Agree working method for any temporary works in-channel with EA Fisheries team including silt management methods and any monitoring requirements. | Contractor | | | |
| A4.5 | To control run-off | A construction site drainage system shall be provided to prevent pollution of surface or groundwater. | Contractor | | A Method Statement will be produced which includes measures to ensure that no pollution pathways are created between the construction site and the watercourses via overland flow during rainfall events. | |
| A4.6 | Minimise impacts to aquatic habitats and associated species | Any piling operations should be scheduled so that disturbances to migration and spawning periods (March-November) are minimised to the satisfaction of the Environment Agency | Contractor | | | |
| A4.7 | Minimise impacts to aquatic habitats and associated species | Where mobile water retention techniques or cofferdams are used, measures should be sequenced so that a | Contractor | | Measures to be agreed with relevant Environment Agency FBG officers. | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | minimum of 50% of the river is available for migratory fish | | | | |
| **A5. Heritage and Archaeology** | | | | | | |
| A5.1 | Minimise risk to known and potential heritage and archaeology | A Written Scheme of Investigation (WSI) will be submitted to the Oxfordshire County Archaeologist for an archaeological watching brief in relation to construction of the satellite compound.<br><br>An archaeological contractor registered at the Chartered Institute for Archaeologists will need to be appointed to prepare the WSI and undertake the specified works.<br><br>Medium to high potential for buried archaeology to be impacted within the satellite compound only. | Contractor | | At the time of writing (May 2023) BAM have appointed JMHS to undertake the WSI and the Watching Brief and the WSI has been issued to the Oxfordshire County Archaeologist for comment. | |
| **A6. Soils and Geology** | | | | | | |
| A6.0 | Minimise impact of contamination in soils | Contractors required to develop a Site Waste Management Plan (SWMP) and Materials Management Plan (MMP)<br>produced in accordance with CLAIRE 'Definition of Waste' Code | Contractor | | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| A6.1 | Reduce potential risk of degrading topsoil (site compounds and access routes) | Establish on-site access routes and remove topsoil from areas likely to see significant vehicle activity. | Contractor | BAM Outline Buildability Statement | | |
| **A7. Noise and Vibration** | | | | | | |
| A7.1 | Identify and minimise potential damage from vibration | Examine visually any buildings within 50m of works likely to generate vibration to establish if the buildings they are structurally sound. If buildings could be structurally unsound the undertake a structural survey and a vibration impact risk assessment. | Contractor | ENV0003198C-JAC-ZZ-00-AS-EN-0001 | | |
| A7.2 | Control of noise and minimise risk of nuisance | Consult with the Local Authority to determine whether they require a Section 61 consent for the works. | Contractor | | | |
| A7.3 | Minimise complaints during construction | Inform local residents and other stakeholders in advance of the works and provide a 24-hour complaint hotline. | Contractor | | | |
| **B. During Construction** | | | | | | |
| **B1. Human Population** | | | | | | |
| B1.1 | To minimise disruption to the local community | Put in place forewarning methods to keep landowners and tenants informed of progress of the works. E.g. signage, council advertising works near NMU routes. | Contractor | EA Estates | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | Keep landowners and tenants [and public] informed of progress of the works through direct discussions. | Contractor | | | |
| B1.2 | To minimise disruption to the local community | Work within defined working hours only.<br>Keep working area tidy and compact.<br>Provide appropriate signage.<br>Keep number of construction plant accessing the works to a minimum.<br>Install and check fencing to ensure it is fit for purpose. | Contractor | | | |
| B1.3 | Minimise impacts to air quality | Static plant (e.g. lighting masts) must be connected to mains where practicable to avoid the use of diesel-powered machinery.<br>Modern machinery and/or machinery with DPFs (Diesel Particulate Filter) must be used in order to limit pollutants released into the surrounding environment. A 'No idling policy' of all machinery and vehicles on site to be enforced.<br>All plant must be properly maintained and throttled down or switched off when not in use. | Contractor | | | |
| **B2. Landscape, Land Use and Amenity** | | | | | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| B2.1 | To provide continuing safe access along existing non-motorised user. | Ensure that clear signage and enforcement is maintained throughout the works. Exclusion fencing and/or banksman (to direct pedestrians safely across the footbridge/weir) must be in place throughout the works. | Contractor | | | |
| B2.2 | Minimise impact on landscape character and visual amenity. | Site to be kept tidy and working area to be screened (heras fencing with reusable brown or black tarp). Site compound / satellite compound to be appropriately fenced to minimise visual impact. | Contractor | | | |
| **B3. Flora and Fauna** | | | | | | |
| B3.1 | To protect retained hedgerows, trees and vegetation | Ensure tree protection measures are maintained throughout construction<br>Drills and machinery must stay outside the tree protection zone of any tree (as agreed during site setup).<br><br>ECW to oversee all vegetation clearance. Vegetation clearance to take place within timeframes shown on Ecological Schedule and in accordance with Tree Removals and Protection Plan and Site Plan showing the temporary site | Contractor | BS 5837:2012 Trees in relation to design, demolition & construction<br>Site Plan: ENV0003198C-JAC-ZZ-00-DR-C-1000.<br>Tree Removals and Protection Plan: see Appendix C.<br>Ecological Schedule: see Appendix D<br>Landscape Plan | On site monitoring will ensure protection measures and the method statement are being implemented correctly, at agreed intervals before and during the construction phase of the project. | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | compounds and access routes.<br><br>A section of hawthorn hedge will need to be removed with type 1 matting placed over the top, to accommodate the access track at the main works compound. The section of hedge will need to be replanted after the track is reinstated, in accordance with the Landscape Plan. | | | | |
| B3.2 | To avoid impacts on badgers | See A3.4 above<br>Excavations to be covered at night to prevent entrapment<br><br>If badgers are found, stop works and consult the ECW. | Contractor and ECW | | | |
| B3.3 | To avoid impacts on reptiles / amphibians | See A3.5 above | Contractor and ECW | | | |
| | | If a species is found, stop works and consult the ECW. | ECW | | | |
| B3.4 | To avoid impacts on nesting birds | If active nests are found on site, works need to stop within exclusion zone until advised by ECW. | ECW / Contractor | | | |
| B3.5 | Prevent the spread of invasive non-native species | Compliance with section 14 of the Wildlife and Countryside Act 1981. Good biosecurity practices should be followed | Contractor | http://www.nonnativespecies.org/ | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | by all staff with training and facilities provided to allow the check-clean-dry approach to biosecurity to be followed | | checkcleandry/index.cfm | | |
| B3.6 | To minimise disturbance to bats | No night-time working and ensure tree protection measures are retained throughout the works to prevent disturbance to potential roosting and foraging habitat<br><br>Minimise the use of artificial lighting during the works; if required ensure lighting is directed towards works and away from vegetation/river corridor. | Contractor | | https://www.bats.org.uk/our-work/buildings-planning-and-development/lighting | |
| B3.7 | Minimise impacts on water quality and aquatic species | A fish rescue plan should be in place in case fish are stranded during coffer dam installation and dewatering during construction.<br>Fish rescue will be undertaken by a recommended qualified fish rescue specialist as required under a Section 27a authorisation of the Salmon and Freshwater Fisheries Act (1975). | Contractor (Recommended qualified fish rescue specialist) | | | |
| **B4. Water Environment** | | | | | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| B4.1 | Minimise pollution risk to controlled surface water | Pollution prevention measures to be employed as appropriate. Method Statement to be followed to prevent pollution of watercourse.<br>Compliance with permit conditions | Contractor | https://www.gov.uk/guidance/pollution-prevention-for-businesses | | |
| B4.2 | Minimise pollution risk to controlled groundwater | Implement agreed precautionary measures and/or specific method statement requirements. | Contractor | | | |
| **B5. Heritage and Archaeology** | | | | | | |
| B5.1 | Minimise damage to unrecorded remains, if encountered during works | Archaeological watching brief to be undertaken during all ground reduction operations, including topsoil stripping, that have the potential to damage or truncate archaeological remains<br>within the satellite compound in accordance with approved WSI. | Contractor | | | |
| **B6. Soils and Geology** | | | | | | |
| B6.1 | Minimise soil degradation | Removal and storage of topsoil from site compounds/working areas; in accordance with Materials Management Plan. Reinstated following demobilisation of the area(s). | Contractor | | Any stockpiles to be labelled/stored in accordance with MMP. | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| B6.2 | Ensure excavated/ disturbed contaminated land is dealt with correctly (if required) | Create segregated stockpiles.<br><br>Carry out chemical testing/ analysis including upon made and re-worked soils to identify any contamination. | Contractor | | | |
| B6.3 | Agree appropriate remediation/ disposal/ re-use measures (if required) | Compliance with the proposals outlined within the method statement / Scope | EA | | | |
| B6.4 | Comply with agreed remediation measures/ disposal/ re-use (if required) | Action B6.3 as required. | Contractor | | | |
| **B7. Noise and Vibration** | | | | | | |
| B7.1 | Best Practicable Means followed | Routine measures developed for construction sites would be implemented considering the use of Best Practicable Means (BPM) under Section 72 of CoPA 1974 and good practice under BS 5228 Part 1: Noise and Part 2: Vibration. These include, but are not limited to:<br><br>• Restriction of working hours limited to the construction standard working hours set out by the South Oxfordshire District Council to 07:30 to 18:00 Monday to Friday, Saturdays from 08:00 to 13:00 and, no | Contractor | Control measures can be found in the Benson Weir FBC Noise and Vibration Assessment:<br>ENV0003198C-JAC-ZZ-00-AS-EN-0001 | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | working on Sundays or Public Holidays;<br>• Programming the works to restrict impacts to the minimum possible time;<br>• Keeping local residents and property owners fully informed about the nature and timing of the works, including traffic controls, via such means as newsletters or individual contact, where appropriate;<br>• Having a representative available on site during working hours to answer queries or address any concerns expressed;<br>• All workers on site, including sub-contractors, self-employed staff and employees must be made aware of the need to keep noise and disruption to a minimum from building works, equipment, plant and machinery, radios, music, vehicles or any other sources<br>• Handling of all materials in a manner which minimises noise, including minimising drop | | | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | heights into hoppers and lorries<br>• The quietest available plant or machinery should be used where practicable. For example, any diesel generators brought to site or to be used at the site compounds should be super-silenced or sound reduced models fitted with acoustic enclosures or any pneumatic tools fitted with silencers or mufflers, wherever practicable;<br>• Placing equipment, plant and generators facing away from the sensitive receptors, as far as practical, including any generators used to supply power to the construction compounds.<br>• Ensure that all plant and equipment is properly maintained and operated in accordance with manufacturers' recommendations and in such a manner as to avoid causing excessive noise; | | | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | • Start-up plant and equipment sequentially rather than all together;<br>• Ensure that equipment is shut down when not in use for a period longer than 5 minutes;<br>• Acoustic barriers consisting of site materials such as bricks, earth mounds or movable noise barriers for construction should be considered when noise cannot be sufficiently reduced by careful siting of noise sources<br>• Since the satellite compound location is proposed directly adjacent to the land of a residential property on Preston Crowmarsh, provision of temporary construction site hoarding panels should be installed around the area of the proposed satellite compound.<br>• Consideration of alternative work methodologies which produce lower noise outputs so that noise and vibration levels are kept to a minimum, e.g. Using | | | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | rotary piling wherever possible to minimise the impact from vibratory piling;<br>• Using smaller plant items when operating in close proximity to sensitive receptors to minimise the vibration levels and;<br>• No vehicles will wait or queue on public highways with engines running and care will be taken when unloading deliveries. | | | | |
| B7.2 | Mitigation measures maintained | Undertake daily checks of the efficiency of any adopted mitigation for noise or vibration. | Contractor | Control measures can be found in the Benson Weir FBC Noise and Vibration Assessment:<br>ENV0003198C-JAC-ZZ-00-AS-EN-0001 | | |
| B7.3 | Stakeholder liaison | Ensure stakeholder liaison is continued, especially to inform of changes to schedule or of overrunning works. | Contractor | | | |
| **C. Post-Construction** | | | | | | |
| **C1. Landscape, Land Use and Amenity** | | | | | | |
| C1.1 | To reinstate access / use across the area. | Clear, tidy and remove all waste materials from site. | Contractor | Landscape plan: | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | Ensure all working area demarcation fencing is removed, the site is reinstated to the satisfaction of the landowner (and County Council PRoW Officer where relevant), and a post-works condition survey is completed (including photos) of site compound / works area and any access tracks / roads.<br><br>Deliver habitat/vegetation mitigation in line with agreed reinstatement plans. | | ENV0003198C-JAC-XX-00-SK-EN-0001 | | |
| C1.2 | Minimise disruption to the local community – landowners, businesses etc. | Notify local landowners, business users etc. of the completion of the works | EA Estates | | | |
| **C2. Heritage and Archaeology** | | | | | | |
| C2.1 | To inform relevant parties if archaeological remains are encountered during excavation | The appointed archaeological contractor will prepare a report on the watching brief undertaken within the satellite compound.<br><br>The report will be submitted to the Oxfordshire County Archaeologist for inclusion within the Oxfordshire Historic Environment Record (HER) and placed on OASIS for | Contractor | | | |

| Ref. No. | Objective | Action | Responsibility | Reference to further information | Progress and Further Action | Sign off and date |
|---|---|---|---|---|---|---|
| | | inclusion on the Archaeological Data Service. | | | | |

# Appendix A. Preliminary Ecological Appraisal

ENV0003198C-JAC-ZZ-00-RP-EN-0004

# Appendix B. H.S.I Survey Report

ENV0003198C-JAC-ZZ-00-RP-EN-0005

# Appendix C.  Tree Removals & Protection Plan

ENV0003198C-JAC-XX-00-SK-EN-0001

# Appendix D. Ecological Schedule

ENV0003198C-JAC-XX-00-TN-EN-0001

# Environmental audit record

| | | | |
|---|---|---|---|
| Project | | Project ref.: | |
| Project Manager: | | NEAS EPM: | |
| Location | | Grid reference | |

### Site Visit Audit Details

| | | | | | |
|---|---|---|---|---|---|
| Visit During/Post Construction: | | Date of Visit: | | Time of Visit: | |
| Audit Officer: | | Photos taken (y/n): | | Referenced to Pre-Photos(y/n): | |

**Does the Site Supervisor have an up to date copy of the EAP? Yes / No**

# General comments

**Benson Weir Refurbishment Impoundment Licence Continuation Sheet**

**D Harmer 17/08/2023**

| | |
|---|---|
| *This File:* | |
| Benson Weir Impoundment Licence Continuation Sheet | ENV0003198C-JAC-ZZ-00-PT-Z-0002 |
| *Related Files:* | |
| Benson Weir Impoundment Licence Pre Application PART D Form | ENV0003198C-JAC-ZZ-00-PT-Z-0001 |

| Section | Answer Text |
|---|---|
| D7.1 | Benson Weir Fish Pass Permanent<br>A Technical Fish Pass is to be built "mid-channel" through an existing overspill fixed crest weir. This will permanently lower the fixed crest at this section of the weir. The current fixed crest is set to level 44.19mAOD where the lowest fixed crest of the new Fish Pass being set to 43.45mAOD. Please see drawings ENV0003198C-JAC-SF-00-DR-C-1515-Demolition Details and ENV0003198C-JAC-SF-00-DR-C-1530-Fish Pass Long Sections Through Fish Pass (Brush & Baffles).<br><br>Benson Weir Fish Pass Temporary*<br>For the temporary state, a dam (in the form of sheet piles) will prevent water spilling into the dry working area. The arrangement of the piles can be seen in ENV0003198C-JAC-SF-00-DR-C-1520 Fish Pass General Arrangement. The spill level of the piles will be approx. 45.00mAOD. This is higher than the current fixed crest and water will be diverted either side of the sheet piles.<br><br>Benson Weir "Limpet" Dams<br>In order to remove and replace the existing large radial gates, temporary works in the form of a "Limpet Dam" are needed to dam water from passing through gate bays. See Section 6 of the "Benson Weir - Outline Buildability Statement" for details.<br><br>Benson Weir Ton Bag Dams<br>In order to remove and replace the small radial gates and walkway supports, temporary works in the form of ton bags and plastic sheeting are needed to create dry working areas and divert flows. See Section 6 of the "Benson Weir - Outline Buildability Statement" for details.<br><br>A sketch of the impounding works are shown on drawing. ENV0003198C-JAC-ZZ-00-SK-C-0002-Benson Weir Impounding Structures. |
| D8.4 | Benson Weir Fish Pass Permanent<br>43.45mAOD (lower than existing)<br><br>Benson Weir Fish Pass Temporary<br>45.00mAOD (estimated) |

| | |
|---|---|
| | Benson Weir "Limpet" Dams<br>45.00mAOD (estimated)<br><br>Benson Weir Ton Bag Dams<br>45.00mAOD (estimated)<br><br>Limpet dams and Ton Bags will be removed prior to overflow occurring. |
| D8.5 | Impoundment works will divert flows rather than store. |
| D10.2 | A FRAP application will be made in due course |

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# Benson Weir Fish Pass Modelling

Document no: ENV0003198C-JAC-ZZ-00-RP-HY-0002
Revision no: P01

Environment Agency
ENV0003198C

Benson Weir Refurbishment
29 March 2023

## Benson Weir Fish Pass Modelling

| | | | |
|---|---|---|---|
| Client name: | Environment Agency | | |
| Project name: | Benson Weir Refurbishment | | |
| Client reference: | ENV0003198C | Project no: | B550C067 |
| Document no: | ENV0003198C-JAC-ZZ-00-RP-HY-0002 | Project manager: | Shauket Khan |
| Revision no: | P01 | Prepared by: | Charles Grice/Chris Weeks |
| Date: | 29 March 2023 | File name: | ENV0003198C-JAC-ZZ-00-RP-HY-0002.docx |
| Doc status: | S3 | | |

## Document history and status

| Revision | Date | Description | Author | Checked | Reviewed | Approved |
|---|---|---|---|---|---|---|
| P01 | 29/03/23 | Draft for comment | CG | CW | KV/DH | SYK |
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| | | | | | | |

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# Contents



# Appendices

## Tables



## Figures

# 1. Introduction

This report provides details of the modelling undertaken at Benson Weir to understand the potential impacts of temporary works whilst sets of radial gates are replaced and temporary/permanent works for the proposed fish pass. The assessment is based on hydraulic modelling, using the Environment Agency (EA) approved 1D2D model of the Thames[1]. The model domain covers the Thames from Sandford Lock to Reading Bridge. The model extent and location of the Benson Weir is detailed in Figure 1-1.

The flood model was also configured to be used as a low flow model to understand the impact of the proposed fish pass under low flow conditions.

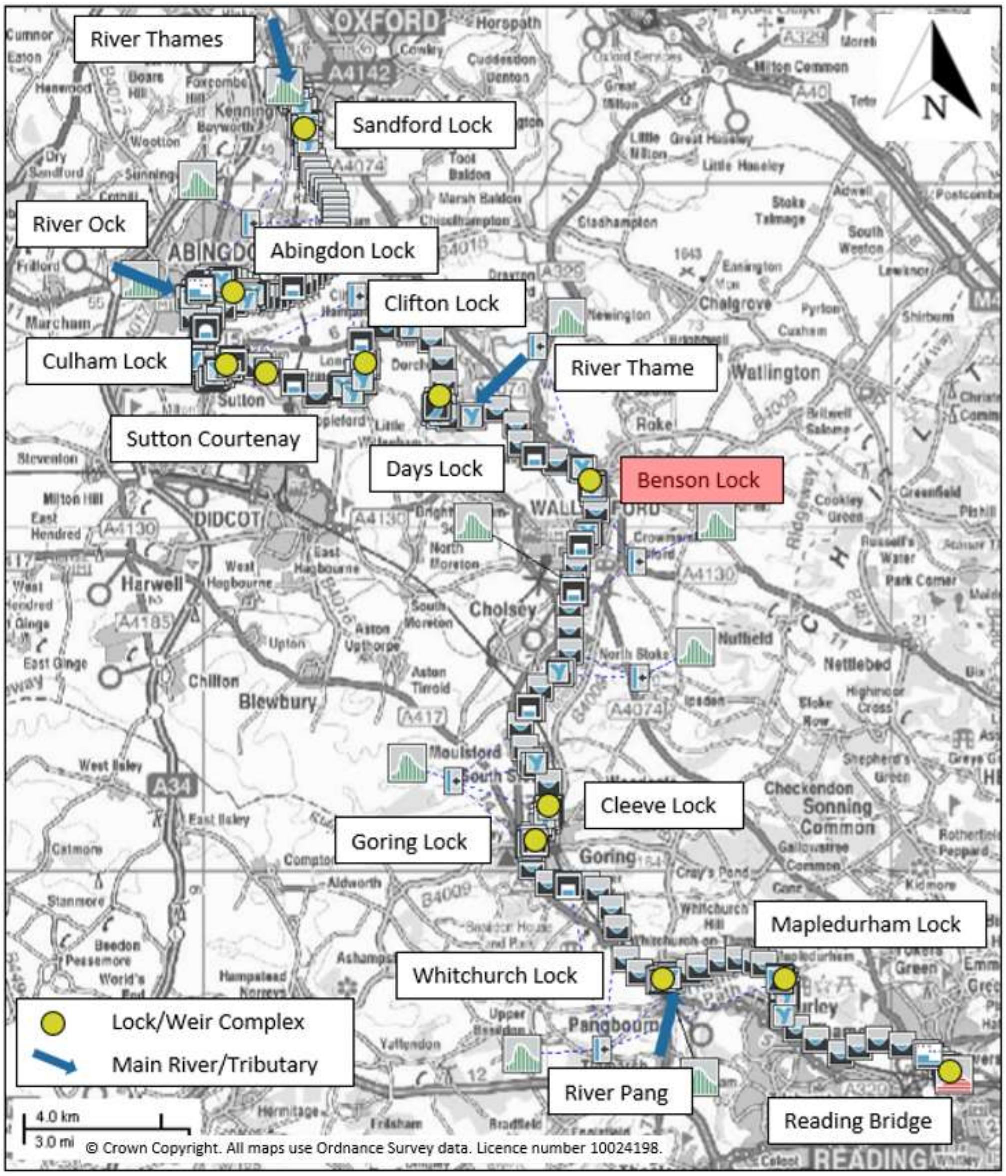



**Figure 1-1. Location plan and model extent**

[1] Abingdon Flood Schemes - River Thames Modelling Report, CH2M, June 2017

## 1.1 Report structure

This report is structured as follow:

- Chapter 2 provides a summary of the existing 2017 1D2D model, the re-runs undertaken for this study using newer software versions and comparison of re-runs with the 2017 results.
- Chapter 3 describes the modelled scenarios used to assess the potential impacts of temporary works (removal of gate bays and sections of weir) during gate replacement and construction of the proposed fish pass.
- Chapter 4 comment on the model sensitivity test undertaken to reflect the proposed reduction of the gate 'side cills' which would be bolted to the pier walls for future gate replacement.
- Chapter 5 describes the changes to the model to represent the proposed fish pass and comparison to baseline under flood flow conditions
- Chapter 6 covers the proposed fish pass modelling and comparison to baseline for low flow conditions.
- Chapter 7 provides concluding remarks from the modelling.

Chapters 3, 4 and 5 provide tables which compare the maximum river water levels for each scenario tested with the baseline results. The river locations and model nodes reported in the tables are detailed Figure 1-2.


| Ref | Node | Description |
|---|---|---|
| 1 | 43.076 | D/S Culham Lock |
| 2 | 43.001 | U/S Clifton Lock |
| 3 | 42.100 | D/S Clifton Lock |
| 4 | 42.001 | U/S Days Weir |
| 5 | 41.134 | D/S Days Weir |
| 6 | 41.114 | Thame confluence |
| 7 | 41.044 | D/S Wallingford Road |
| 8a | 41.017D | 770m U/S Benson Weir |
| 8 | 41.001 | U/S Benson Weir |
| 9 | 40.040X | D/S Benson Weir |
| 9a | 40.032X | 200m D/S Benson Weir |
| 10 | 40.001X | U/S High Street |
| 11 | WBypassU | U/S Winterbrook Bridge |
| 12 | 40.068 | U/S Moulsford Railway |
| 13 | 40.002 | U/S Cleeve Weir |
| 14 | 39.013 | D/S Cleeve Weir |
| 15 | 38.091 | U/S Gatehamton Railway |
| 16 | 38.002 | U/S Whitchurch |
| 17 | 37.075 | Whitchurch Bridge |
| 18 | 37.002 | U/S Mapledurham Lock |
| 19 | 36.149 | D/S Mapledurham Lock |
| 20 | 36.032 | Caversham Bridge |

**Figure 1-2. Reported 1D model node locations**

# 2. Existing model

## 2.1 Model overview

The existing model study was completed in June 2017, which produced a standard 1D2D flood model based on a 10m grid. The model was calibrated to the January 2003, July 2007, November 2012 and Winter 2013/14 events, where the model predicted water levels within +/- 0.15m for 78 out of 88 observed flood records. The model provided flood maps and design water levels for the 50%, 20%, 10%, 5%, 3.3%, 2%, 1.3%, 1%, 0.5%, 0.1% AEP events, and the 1% AEP event with climate change of 25%, 35% and 70%.

## 2.2 Software version

The existing model was based on the software versions of flood modeller available at that time. To increase the model run times for this assessment the following changes were made to the model:

- Run using the latest versions of the software (latest version as of the time of this assessment).
- 2D output format changed from DAT to XMDF (more efficient).
- Model end time reduced to 204 hours from 300 hours, the original modelling represented receding hydrographs, the original results were checked, and the selected 204 hours end time is after the model peak in the 1D and 2D domains.
- Mass balance corrector switched off for re-run, TUFLOW manual states the command is no longer required or recommended with the latest software versions.

The software versions used for the 2017 study and this assessment are detailed in Table 2-1

**Table 2-1. Software Versions**

| Study date | Flood Modeller | TUFLOW |
|---|---|---|
| Existing model 2017 | 4.2 (double precision) | 2016-03-AC-iDP-w64 |
| Benson Weir assessment 2022 | 6.1 (double precision) | 2020-10-AF-iDP-w64 |

## 2.3 Comparison of baseline results using newer software versions

To understand any impacts to the results when using the new software versions, the baseline events were re-run. Table 2-2 provides a summary of the maximum and minimum changes in the peak 1D river water levels for all model nodes (new version minus the original version) and the differences upstream and downstream of Benson Weir. The differences for the 50% to 1% AEP events are small and assumed to be attributed to improvements in the modelling software. The model re-runs have improved the overall mass balance for all AEP events (refer to Appendix B).

For the 0.5% and 0.1% AEP events, the differences between the existing 2017 results and the re-runs are larger but only at localised locations within the model. The 2017 study reported problems with the model for the extreme flows (1% AEP with climate change and the 0.1% AEP event) and used different models which applied a simplified 1D model schematisation around Benson, Goring, Whitchurch and Mapledurham Locks. The model re-runs used the base model for the 0.5% AEP and the simplified model for the 0.1% AEP (i.e. same models used as the 2017 study), although the re-runs have shown to improve the mass balance (due to the new software versions), stability issues are partly re-introduced using the new software version for the 0.5% and 0.1% AEP events.

Figure 2-1, Figure 2-2 and Figure 2-3, show the water level time series at the model nodes which report the largest differences for the 0.5% (max difference) and 0.1% AEP (max and min difference). For the purpose of assessing scenarios at Benson Weir, the re-run of the models shows no stability issues for the water levels at Benson, as shown in the comparisons upstream (Figure 2-4) and downstream (Figure 2-5) of Benson Weir for the 0.5% and 0.1% AEP events. Based on the location of the stability problem for the 0.5% AEP, the model results for the 0.5% AEP are considered appropriate for testing scenarios at Benson Weir. For the 0.1% AEP the results should be used with caution, given the oscillations in water levels during peak flows which occur at multiple locations throughout the model.

**Table 2-2. Summary of peak level differences between software versions**

| AEP | Maximum change (m) All Nodes | Minimum change (m) All Nodes | Difference u/s Benson (m) | Difference d/s Benson (m) |
|---|---|---|---|---|
| 50% (2-year) | 0.01 | -0.04 | -0.02 | -0.03 |
| 20% (5-year) | 0.01 | -0.02 | 0.00 | 0.00 |
| 10% (10-year) | 0.03 | -0.01 | 0.02 | 0.02 |
| 5% (20-year) | 0.01 | -0.03 | 0.00 | 0.00 |
| 3.3% (30-year) | 0.01 | -0.02 | -0.01 | -0.01 |
| 2% (50-year) | 0.00 | -0.02 | -0.01 | -0.01 |
| 1.3% (75-year) | 0.04 | -0.01 | 0.03 | 0.03 |
| 1% (100-year) | 0.05 | -0.01 | 0.02 | 0.02 |
| 0.5% (200-year) | 0.19 | -0.02 | 0.01 | 0.01 |
| 0.1% (1000-year) | 0.23 | -0.11 | -0.07 | -0.07 |

Figure 2-1 shows the water levels downstream of Whitchurch Lock (node 37.056) which reports the highest difference for the 0.5% AEP event. The time series shows oscillations in the 0.5% AEP re-run results which are not present for the 0.1% AEP events, as the simplified model is used. The 0.5% AEP event could be re-run using the simplified model to stabilise the results in this area.

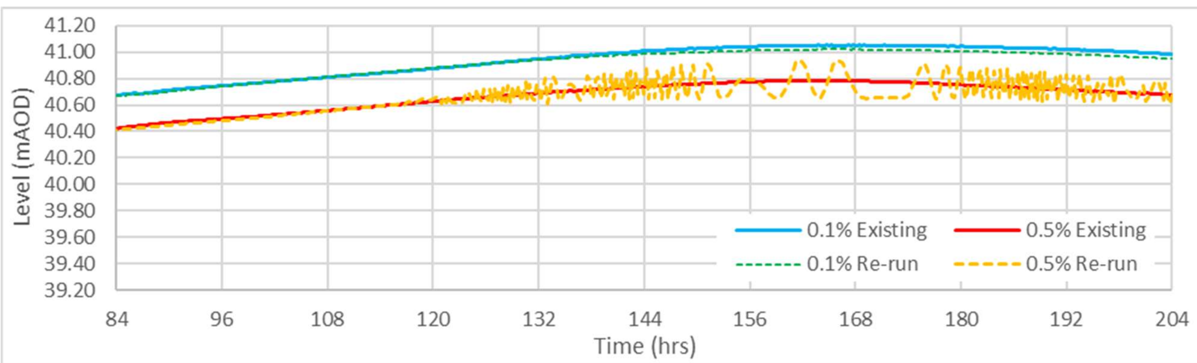



**Figure 2-1. Comparison of 2017 and 2022 re-run – 0.5% maximum difference**

Figure 2-2 shows the maximum difference for the 0.1% AEP event, which is located downstream of Tollgate Road at Culham Lock (node 43.076). At this location, the re-run shows oscillations in the results, note that the 0.5% AEP results are similar for the 2017 and re-run. This area was not covered by the simplified model and more analysis of the results would be required improve the results in this location.

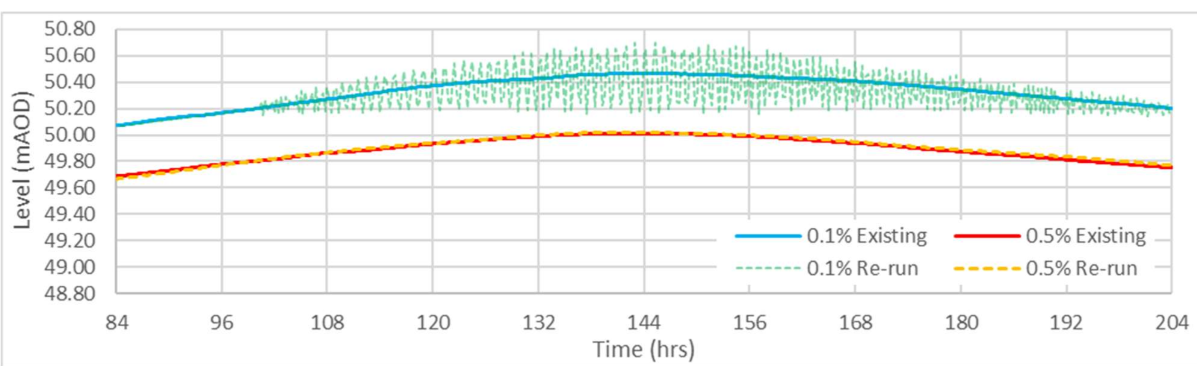



**Figure 2-2. Comparison of 2017 and 2022 re-run – 0.1% maximum difference**

Figure 2-3 shows the minimum difference for the 0.1% AEP event, which is located downstream of Goring Lock (node 39d.127A). At this location the water levels profile is smoother for the re-run.

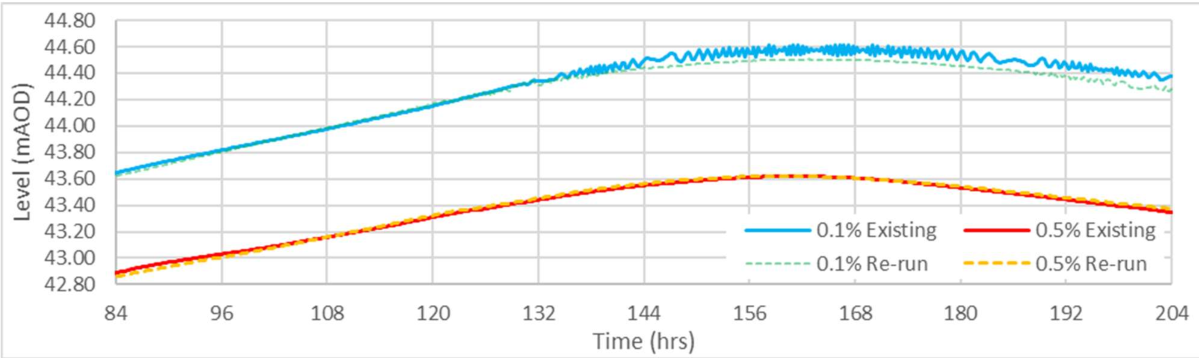



**Figure 2-3. Comparison of 2017 and 2022 re-run – 0.1% minimum difference**

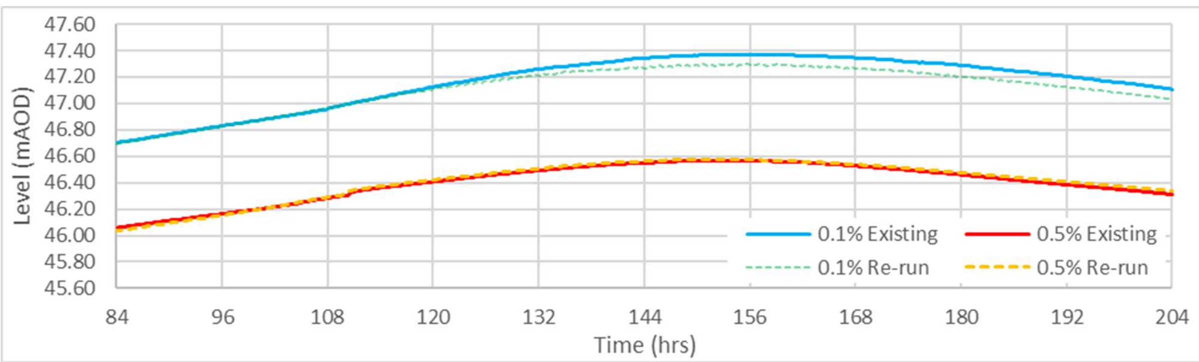



**Figure 2-4. Comparison of 2017 and 2022 re-run - upstream of Benson Weir**

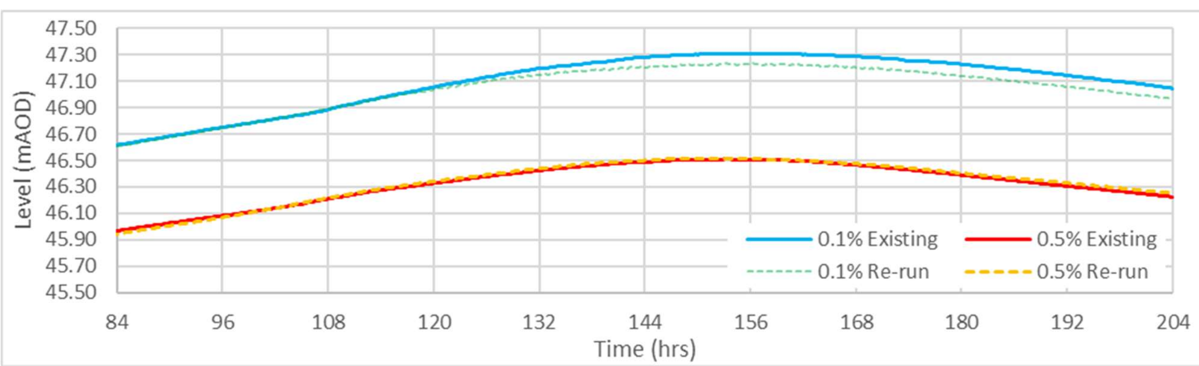



**Figure 2-5. Comparison of 2017 and 2022 re-run - downstream of Benson Weir**

# 3. Temporary Works (Flood Modelling)

## 3.1 Existing structures at Benson Weir

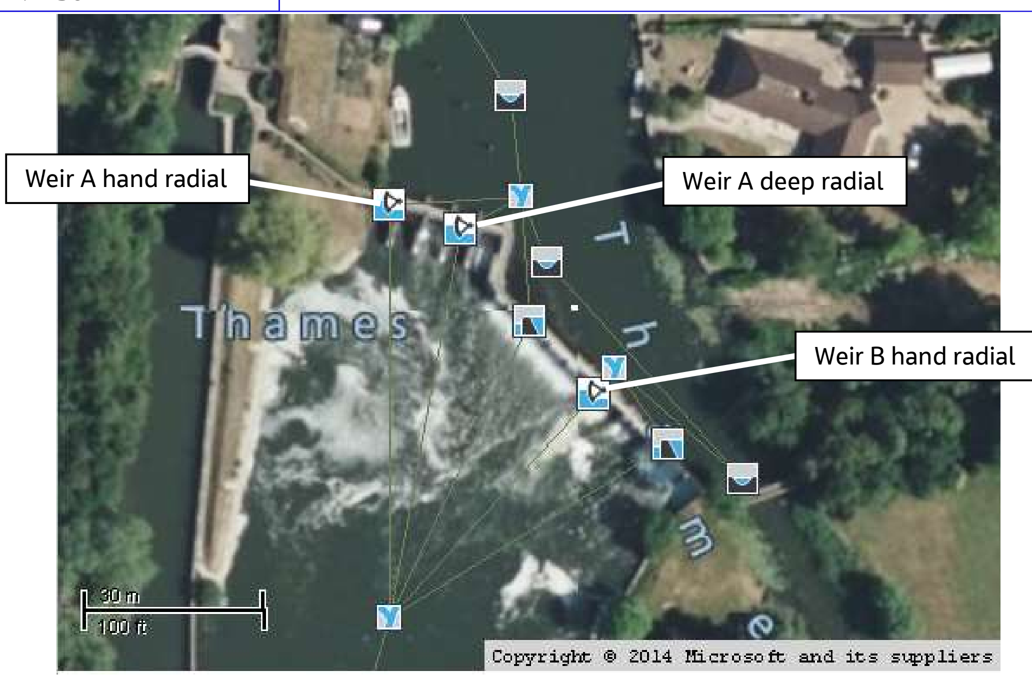
The weir and gated structures at Benson Weir complex are detailed in Table 3-1. The baseline flood model represents the movable gates at lock complexes as either fully open or with a set of logical rules. The rules which monitor the water levels upstream of the lock are set open or close to maintain a target water level. At Benson Weir, the deep radial gates have logical rules, and the smaller hand radial gate are set fully open. Table 3-2 provides a summary of the gate operation which are applied for all modelled scenarios.

**Table 3-1. Benson Weir structure details (extracted from model)**

| Structure | Model Node | Number of gates | Invert (mAOD) | Weir/individual Gate width (m) | Gate Height (m) |
|---|---|---|---|---|---|
| Weir A hand radial gates | 41.HRAU | 2 | 43.431 | 1.81 | 0.729 |
| Weir A deep radial gates | 41.DRU | 4 | 42.136 | 3.81 | 2.054 |
| Weir B weir | 41.OFAU | n/a | 44.110 | 20.30 | n/a |
| Weir B radial gates | 41.HRBU | 8 | 43.431 | 1.83 | 0.762 |
| Weir B weir | 41.OFBU | n/a | 44.110 | 12.55 | n/a |

**Table 3-2. Benson Weir moveable structures (extracted from model)**

| Structure and Node | Baseline Model |
|---|---|
| Weir A hand radial gates (2No.)<br>Node 41.HRAU | Fully open (opening = 1.419m) |
| Weir A deep radial gates (4No.)<br>Node 41.DRU | Logical rules for flood model with target water levels between 44.15mAOD and 44.30mAOD (SHWL = 44.19).<br>Maximum opening of 4.174m which occurs for all events |
| Weir B radial gates (8No.)<br>Node 41.HRBU | Fully open (opening = 1.419m) |



## 3.2 Temporary Works scenarios modelled

Temporary works scenarios have been modelled to represent the closure/damming to sets of gate bays for gate replacement and a cofferdam at the weir during the construction phase of the fish pass.

Scenario A1/2 (tested 1 or 2 gates replaced at a time) and Scenario B (pairs of gates replaced) represent the gate replacement works with the model. The scenarios assume the gate bays are to be completely removed from the model i.e., if the gates are dammed off, the top of the dam would be higher than the highest water levels predicted from the flood modelling, so no flows can occur at the location.

Scenario A1 represents replacement of the deep radial gates at Weir A (node 41.DRU), which have been applied by reducing the number of gates from 4 to 3 and for Scenario A2 the number of gates has been reduced from 4 to 2. Scenario B represents replacement of the hand radial gates at Weir B (node 41.HRBU), which have been applied by reducing the number of gates from 8 to 6. Removal of the 2 hand radial gates at Weir A has not been modelled, given the gates sizes are similar to the hand radial gates at Weir B, it would provide similar results as Scenario B.

Scenario C represent the temporary works during the construction of the fish pass. The modelling assumes a cofferdam which obstructs 50% of the existing 20.3m wide weir (node 41.OFAU located between the gates at Weir A and B). It is assumed the top of the cofferdam would be higher than the highest water levels predicted from the flood modelling, so no flows can occur at this location.

Table 3-3 provides a summary of the temporary works scenarios modelled, the modelling uses the same baseline datafile and the changes to the structures are applied using Flood Modeller IED files.

**Table 3-3. Temporary works scenarios**

| Scenario | Description of model schematisation | IED file used to represent temporary works |
|---|---|---|
| Scenario A1 | Weir A deep radial gates reduced from 4 to 3 | BensonWeirA_Close_1_Gate.ied |
| Scenario A2 | Weir A deep radial gates reduced from 4 to 2 | BensonWeirA_Close_2_Gates.ied |
| Scenario B | Weir B hand radial gates reduced from 8 to 6 | BensonWeirB_Close_2_Gates.ied |
| Scenario C | Width of weir reduced from 20.3m to 10.15m | BensonWeirB_Overfall_50pcBlocked.ied |

## 3.3 Scenario A1: Weir A 1 deep radial gate blocked

The maximum river water levels predicted from the modelling and comparison between the baseline and blocked Weir A radial gate scenario (1 gate blocked) are detailed in Table 3-4 (50% to 3.3% AEP) and Table 3-5 (2% AEP to 1% AEP+31%) at the selected locations detailed in Figure 1-2

Maps which show the differences in the maximum floodplain water levels are detailed in Figure 3-1 (50% and 20% AEP), Figure 3-2 (10% and 5% AEP), Figure 3-3 (3.3% and 2% AEP), Figure 3-4 (1.3% and 1% AEP), Figure 3-5 (0.5% AEP and 0.1% AEP) and Figure 3-6 (1% AEP+31%). The maps indicate areas of no/negligible changes to peak water levels as light green shading, reductions in water levels are shaded greens/blues and increases in water levels are shaded yellow/orange/purples. Areas which no longer flood are shaded black and new areas of flooding are shaded red.

The modelling predicts negligible differences downstream of Benson Weir for all AEP events. The largest increase in water level of 0.05m is predicted immediately upstream of Benson Weir for the 50% AEP with 0.04m for the 20% and 1% AEP.

The floodplain maps show the largest water level increase to occur for the 50% AEP event (up to 0.09m), locally on the right bank floodplain at Benson Weir. The maps show the areas of floodplain increase to extend upstream to Wallingford Bridge. Figure 3-7 shows zoomed in maps for the 50%, 10% and 1% AEP events, which show the largest changes to floodplain water levels. The modelling predicts flood depths at properties on the left bank at Benson Weir to increase up to 0.03m (1% AEP).

**Table 3-4. Scenario A1: Peak water levels and differences to baseline (50% AEP to 3.3% AEP)**

| Ref | Location | 50% AEP | | | 20% AEP | | | 10% AEP | | | 5% AEP | | | 3.3% AEP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base (mAOD) | Scen A1 (mAOD) | Diff (m) | Base (mAOD) | Scen A1 (mAOD) | Diff (m) | Base (mAOD) | Scen A1 (mAOD) | Diff (m) | Base (mAOD) | Scen A1 (mAOD) | Diff (m) | Base (mAOD) | Scen A1 (mAOD) | Diff (m) |
| 1 | D/S Culham Lock | 48.82 | 48.82 | 0.00 | 49.10 | 49.10 | 0.00 | 49.27 | 49.27 | 0.00 | 49.43 | 49.43 | 0.00 | 49.53 | 49.53 | 0.00 |
| 2 | U/S Clifton Lock | 48.09 | 48.09 | 0.00 | 48.28 | 48.28 | 0.00 | 48.40 | 48.40 | 0.00 | 48.53 | 48.53 | 0.00 | 48.61 | 48.61 | 0.00 |
| 3 | D/S Clifton Lock | 47.53 | 47.53 | 0.00 | 47.88 | 47.88 | 0.00 | 48.10 | 48.10 | 0.00 | 48.29 | 48.29 | 0.00 | 48.41 | 48.41 | 0.00 |
| 4 | U/S Days Weir | 46.54 | 46.54 | 0.00 | 46.84 | 46.85 | 0.01 | 47.07 | 47.08 | 0.01 | 47.26 | 47.26 | 0.00 | 47.39 | 47.39 | 0.00 |
| 5 | D/S Days Weir | 46.33 | 46.33 | 0.00 | 46.66 | 46.67 | 0.01 | 46.94 | 46.95 | 0.01 | 47.15 | 47.15 | 0.00 | 47.28 | 47.29 | 0.01 |
| 6 | Thame confluence | 46.17 | 46.17 | 0.00 | 46.50 | 46.51 | 0.01 | 46.80 | 46.81 | 0.01 | 47.01 | 47.02 | 0.01 | 47.16 | 47.16 | 0.00 |
| 7 | D/S Wallingford Road | 45.44 | 45.45 | 0.01 | 45.71 | 45.72 | 0.01 | 45.94 | 45.96 | 0.02 | 46.09 | 46.10 | 0.01 | 46.20 | 46.21 | 0.01 |
| 8a | 770m u/s of Benson | 45.12 | 45.15 | 0.03 | 45.41 | 45.43 | 0.02 | 45.65 | 45.67 | 0.02 | 45.81 | 45.83 | 0.02 | 45.93 | 45.95 | 0.02 |
| 8 | U/S Benson Weir | 44.94 | 44.99 | 0.05 | 45.26 | 45.30 | 0.04 | 45.51 | 45.54 | 0.03 | 45.67 | 45.70 | 0.03 | 45.79 | 45.82 | 0.03 |
| 9 | D/S Benson Weir | 44.77 | 44.78 | 0.01 | 45.13 | 45.13 | 0.00 | 45.38 | 45.39 | 0.01 | 45.56 | 45.56 | 0.00 | 45.68 | 45.69 | 0.01 |
| 9a | 200m d/s Benson | 44.69 | 44.69 | 0.00 | 45.03 | 45.03 | 0.00 | 45.29 | 45.29 | 0.00 | 45.46 | 45.46 | 0.00 | 45.59 | 45.59 | 0.00 |
| 10 | U/S High Street | 44.51 | 44.51 | 0.00 | 44.86 | 44.86 | 0.00 | 45.12 | 45.12 | 0.00 | 45.29 | 45.29 | 0.00 | 45.41 | 45.41 | 0.00 |
| 11 | U/S Winterbrook Bridge | 43.90 | 43.90 | 0.00 | 44.23 | 44.23 | 0.00 | 44.48 | 44.48 | 0.00 | 44.65 | 44.65 | 0.00 | 44.77 | 44.77 | 0.00 |
| 12 | U/S Moulsford Railway | 43.26 | 43.26 | 0.00 | 43.53 | 43.53 | 0.00 | 43.74 | 43.74 | 0.00 | 43.90 | 43.90 | 0.00 | 44.02 | 44.02 | 0.00 |
| 13 | U/S Cleeve Weir | 42.67 | 42.67 | 0.00 | 42.80 | 42.80 | 0.00 | 42.89 | 42.89 | 0.00 | 43.03 | 43.03 | 0.00 | 43.13 | 43.13 | 0.00 |
| 14 | D/S Cleeve Weir | 42.06 | 42.06 | 0.00 | 42.27 | 42.27 | 0.00 | 42.48 | 42.48 | 0.00 | 42.67 | 42.67 | 0.00 | 42.81 | 42.81 | 0.00 |
| 15 | U/S Gatehamton Railway | 41.04 | 41.04 | 0.00 | 41.55 | 41.55 | 0.00 | 41.89 | 41.89 | 0.00 | 42.11 | 42.11 | 0.00 | 42.27 | 42.27 | 0.00 |
| 16 | U/S Whitchurch | 39.99 | 39.99 | 0.00 | 40.29 | 40.29 | 0.00 | 40.43 | 40.43 | 0.00 | 40.53 | 40.53 | 0.00 | 40.59 | 40.59 | 0.00 |
| 17 | Whitchurch Bridge | 39.71 | 39.71 | 0.00 | 39.93 | 39.93 | 0.00 | 40.08 | 40.08 | 0.00 | 40.18 | 40.18 | 0.00 | 40.25 | 40.25 | 0.00 |
| 18 | U/S Mapledurham Lock | 39.04 | 39.04 | 0.00 | 39.18 | 39.18 | 0.00 | 39.28 | 39.28 | 0.00 | 39.35 | 39.35 | 0.00 | 39.40 | 39.41 | 0.01 |
| 19 | D/S Mapledurham Lock | 38.49 | 38.48 | -0.01 | 38.75 | 38.75 | 0.00 | 38.93 | 38.93 | 0.00 | 39.04 | 39.04 | 0.00 | 39.11 | 39.11 | 0.00 |
| 20 | Caversham Bridge | 36.92 | 36.92 | 0.00 | 37.22 | 37.22 | 0.00 | 37.47 | 37.47 | 0.00 | 37.63 | 37.63 | 0.00 | 37.76 | 37.76 | 0.00 |

**Table 3-5. Scenario A1: Peak water levels and differences to baseline (2% to 0.1% AEP, 1% AEP +31%)**

| Ref | 2% AEP | | | 1.3% AEP | | | 1% AEP | | | 0.5% AEP | | | 0.1% AEP | | | 1% AEP +31% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Base (mAOD) | Scen A1 (mAOD) | Diff (m) | Base (mAOD) | Scen A1 (mAOD) | Diff (m) | Base (mAOD) | Scen A1 (mAOD) | Diff (m) | Base (mAOD) | Scen A1 (mAOD) | Diff (m) | Base (mAOD) | Scen A1 (mAOD) | Diff (m) | Base (mAOD) | Scen A1 (mAOD) | Diff (m) |
| 1 | 49.66 | 49.66 | 0.00 | 49.78 | 49.78 | 0.00 | 49.86 | 49.86 | 0.00 | 50.02 | 50.02 | 0.00 | 50.70 | 50.70 | 0.00 | 50.43 | 50.43 | 0.00 |
| 2 | 48.72 | 48.72 | 0.00 | 48.84 | 48.84 | 0.00 | 48.90 | 48.90 | 0.00 | 49.03 | 49.03 | 0.00 | 49.47 | 49.47 | 0.00 | 49.29 | 49.29 | 0.00 |
| 3 | 48.53 | 48.54 | 0.01 | 48.66 | 48.66 | 0.00 | 48.72 | 48.72 | 0.00 | 48.85 | 48.85 | 0.00 | 49.22 | 49.22 | 0.00 | 49.08 | 49.08 | 0.00 |
| 4 | 47.53 | 47.54 | 0.01 | 47.72 | 47.73 | 0.01 | 47.80 | 47.81 | 0.01 | 47.96 | 47.96 | 0.00 | 48.40 | 48.41 | 0.01 | 48.18 | 48.18 | 0.00 |
| 5 | 47.43 | 47.43 | 0.00 | 47.62 | 47.62 | 0.00 | 47.71 | 47.71 | 0.00 | 47.88 | 47.88 | 0.00 | 48.30 | 48.30 | 0.00 | 48.08 | 48.08 | 0.00 |
| 6 | 47.30 | 47.31 | 0.01 | 47.51 | 47.51 | 0.00 | 47.60 | 47.60 | 0.00 | 47.78 | 47.78 | 0.00 | 48.23 | 48.23 | 0.00 | 47.99 | 47.99 | 0.00 |
| 7 | 46.34 | 46.35 | 0.01 | 46.56 | 46.57 | 0.01 | 46.68 | 46.69 | 0.01 | 46.92 | 46.92 | 0.00 | 47.54 | 47.55 | 0.01 | 47.19 | 47.19 | 0.00 |
| 8a | 46.08 | 46.09 | 0.01 | 46.32 | 46.32 | 0.00 | 46.44 | 46.46 | 0.02 | 46.68 | 46.69 | 0.01 | 47.30 | 47.30 | 0.00 | 46.93 | 46.93 | 0.00 |
| 8 | 45.94 | 45.96 | 0.02 | 46.18 | 46.20 | 0.02 | 46.30 | 46.34 | 0.04 | 46.58 | 46.58 | 0.00 | 47.30 | 47.31 | 0.01 | 46.92 | 46.93 | 0.01 |
| 9 | 45.84 | 45.85 | 0.01 | 46.10 | 46.10 | 0.00 | 46.23 | 46.24 | 0.01 | 46.52 | 46.52 | 0.00 | 47.24 | 47.25 | 0.01 | 46.84 | 46.85 | 0.01 |
| 9a | 45.75 | 45.75 | 0.00 | 46.01 | 46.01 | 0.00 | 46.15 | 46.15 | 0.00 | 46.44 | 46.45 | 0.01 | 47.18 | 47.19 | 0.01 | 46.78 | 46.78 | 0.00 |
| 10 | 45.57 | 45.57 | 0.00 | 45.81 | 45.81 | 0.00 | 45.93 | 45.93 | 0.00 | 46.19 | 46.19 | 0.00 | 46.83 | 46.83 | 0.00 | 46.48 | 46.48 | 0.00 |
| 11 | 44.92 | 44.92 | 0.00 | 45.15 | 45.15 | 0.00 | 45.28 | 45.28 | 0.00 | 45.55 | 45.55 | 0.00 | 46.23 | 46.23 | 0.00 | 45.87 | 45.87 | 0.00 |
| 12 | 44.17 | 44.17 | 0.00 | 44.41 | 44.41 | 0.00 | 44.55 | 44.55 | 0.00 | 44.84 | 44.84 | 0.00 | 45.59 | 45.59 | 0.00 | 45.18 | 45.18 | 0.00 |
| 13 | 43.28 | 43.28 | 0.00 | 43.52 | 43.52 | 0.00 | 43.66 | 43.66 | 0.00 | 44.00 | 44.00 | 0.00 | 44.79 | 44.79 | 0.00 | 44.36 | 44.36 | 0.00 |
| 14 | 42.99 | 42.99 | 0.00 | 43.28 | 43.28 | 0.00 | 43.45 | 43.45 | 0.00 | 43.82 | 43.82 | 0.00 | 44.71 | 44.71 | 0.00 | 44.23 | 44.23 | 0.00 |
| 15 | 42.47 | 42.47 | 0.00 | 42.76 | 42.76 | 0.00 | 42.93 | 42.93 | 0.00 | 43.28 | 43.28 | 0.00 | 44.15 | 44.15 | 0.00 | 43.68 | 43.68 | 0.00 |
| 16 | 40.67 | 40.67 | 0.00 | 40.79 | 40.79 | 0.00 | 40.86 | 40.86 | 0.00 | 41.08 | 41.08 | 0.00 | 41.28 | 41.28 | 0.00 | 41.11 | 41.11 | 0.00 |
| 17 | 40.33 | 40.33 | 0.00 | 40.46 | 40.46 | 0.00 | 40.56 | 40.56 | 0.00 | 40.84 | 40.84 | 0.00 | 40.98 | 40.98 | 0.00 | 40.80 | 40.80 | 0.00 |
| 18 | 39.47 | 39.47 | 0.00 | 39.58 | 39.58 | 0.00 | 39.66 | 39.66 | 0.00 | 39.86 | 39.86 | 0.00 | 40.08 | 40.08 | 0.00 | 39.90 | 39.90 | 0.00 |
| 19 | 39.20 | 39.20 | 0.00 | 39.33 | 39.33 | 0.00 | 39.41 | 39.41 | 0.00 | 39.58 | 39.58 | 0.00 | 39.87 | 39.87 | 0.00 | 39.68 | 39.68 | 0.00 |
| 20 | 37.91 | 37.91 | 0.00 | 38.10 | 38.10 | 0.00 | 38.19 | 38.19 | 0.00 | 38.34 | 38.34 | 0.00 | 38.67 | 38.68 | 0.01 | 38.50 | 38.50 | 0.00 |

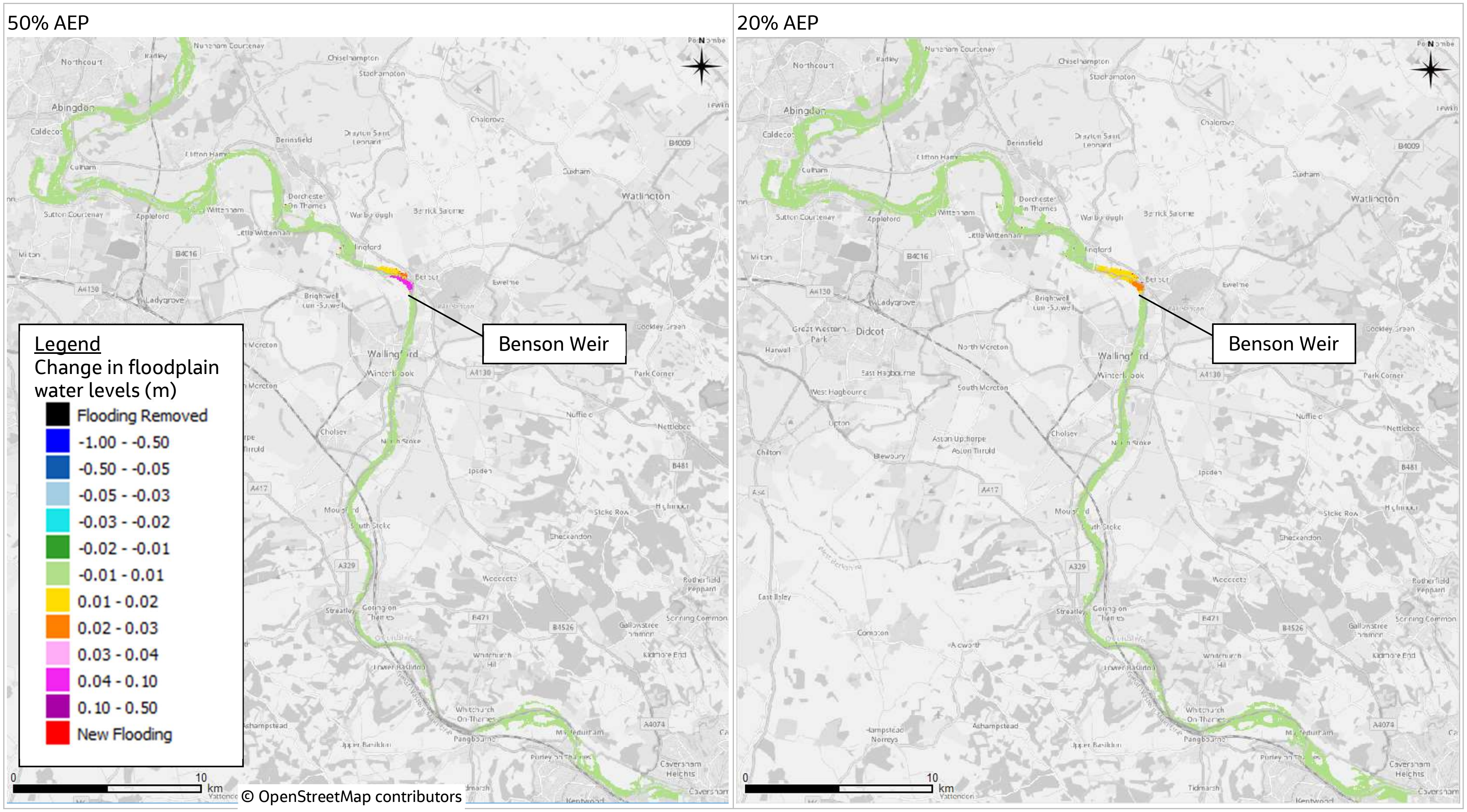



**Figure 3-1 Scenario A1: Changes to floodplain maximum water levels (50% and 20% AEP)**


**Figure 3-2 Scenario A1: Changes to floodplain maximum water levels (10% and 5% AEP)**


**Figure 3-3 Scenario A1: Changes to floodplain maximum water levels (3.3% and 2% AEP)**


**Figure 3-4 Scenario A1: Changes to floodplain maximum water levels (1.3% and 1% AEP)**


**Figure 3-5 Scenario A1: Changes to floodplain maximum water levels (0.5% and 0.1% AEP)**

1% AEP +31%

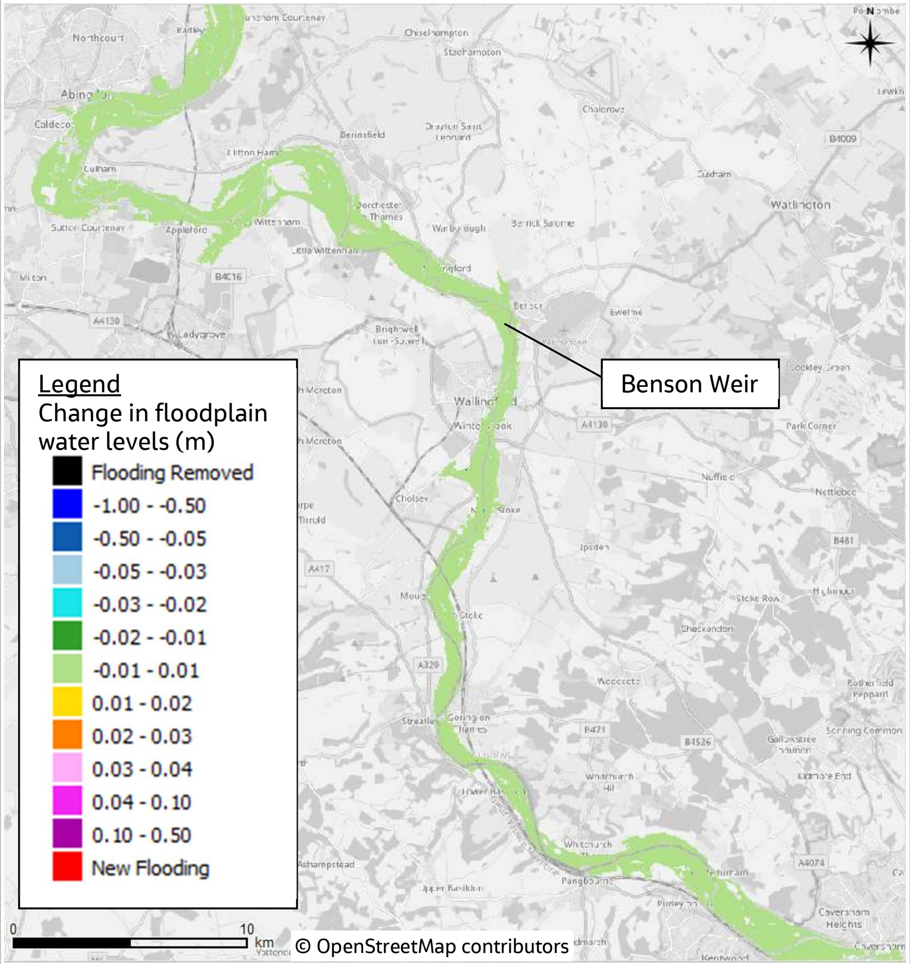



**Figure 3-6 Scenario A1: Changes to floodplain maximum water levels (1% AEP +31%)**

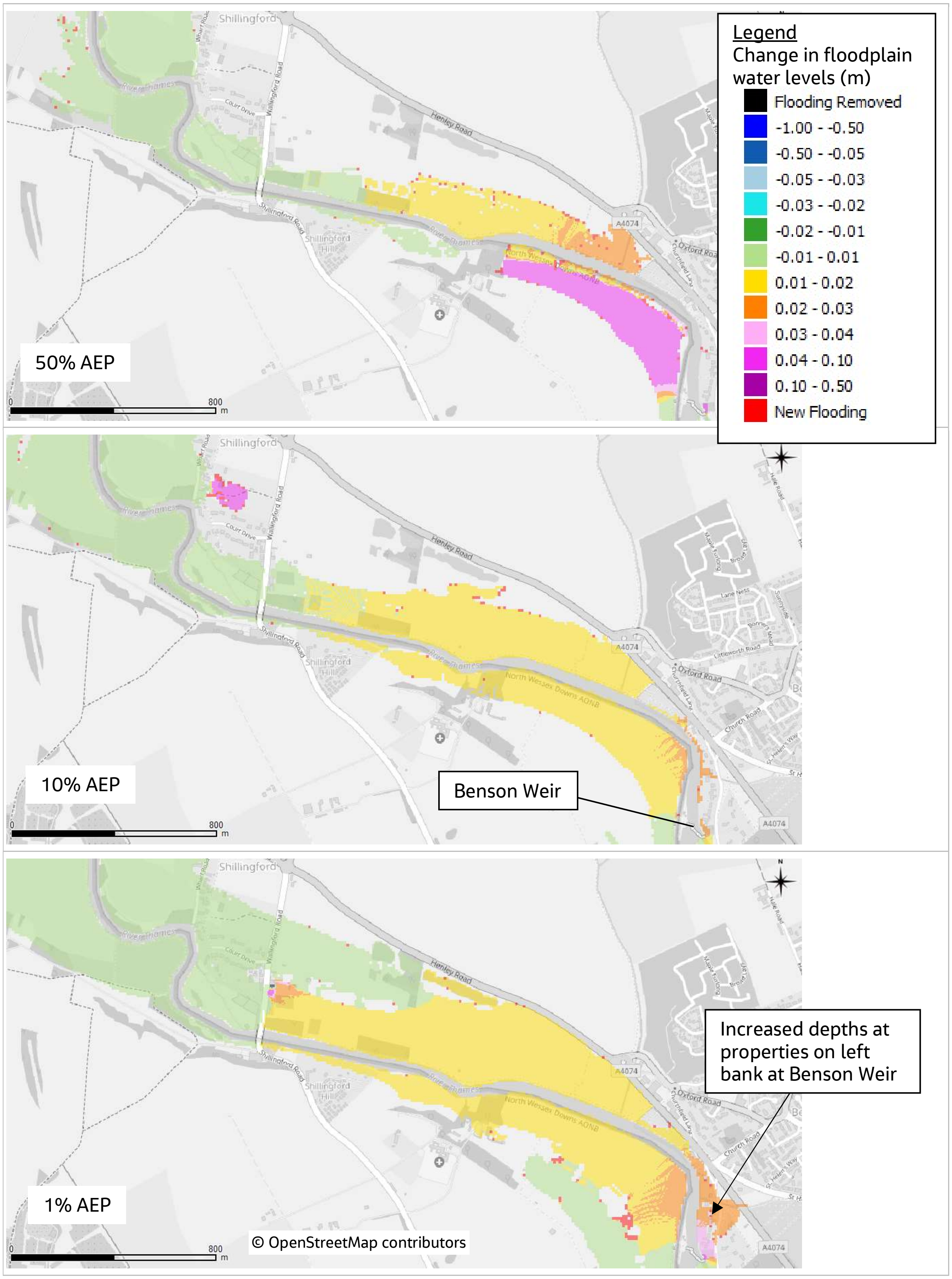



**Figure 3-7 Scenario A1: Changes to floodplain max water levels (50%,10% and 1% AEP zoomed in)**

## 3.4 Scenario A2: Weir A 2 deep radial gates blocked

The maximum river water levels predicted from the modelling and comparison between the baseline and blocked Weir A radial gates scenario (2 gates blocked) are detailed in Table 3-6 (50% to 3.3% AEP) and Table 3-7 (2% AEP to 1% AEP+31%) at the selected locations detailed in Figure 1-2.

Maps which show the differences in the maximum floodplain water levels are detailed Figure 3-8 (50% and 20% AEP), Figure 3-9 (10% and 5% AEP), Figure 3-10 (3.3% and 2% AEP), Figure 3-11 (1.3% and 1% AEP), Figure 3-12 (0.5% AEP and 0.1% AEP) and Figure 3-13 (1% AEP+31%). The maps are generated from the maximum 2D water level grids from scenario minus the baseline. The maps indicate areas of no/negligible changes to peak water levels as light green shading, reductions in water levels are shaded greens/blues and increases in water levels are shaded yellow/orange/purples. Areas which no longer flood are shaded black and new areas of flooding are shaded red.

The modelling predicts negligible differences downstream of Benson Weir for all AEP events. Upstream of Benson Weir, Scenario A shows higher increases in water levels when compared to Scenario A1. The largest increase in water level of 0.11m is predicted immediately upstream of Benson Weir for the 50% AEP. The largest increase at Benson Weir for the 20% to 1% AEP is 0.08m to 0.05m.

The floodplain maps show the largest floodplain level increase to occur for the 50% AEP event (up to 0.22m), locally on the right bank floodplain at Benson Weir The modelling predicts the impacts to extend upstream to Days Weir, with the largest increase at the River Thame confluence of 0.02m for the 20% and 10% AEP events. Figure 3-14 details a zoomed in flood level difference for the 20% AEP events (highest increase in water level at the Thame confluence).

The modelling predicts flood depths at properties on the left bank at Benson Weir to increase up to 0.06m (1% AEP).

For the higher flow events (0.5%, 0.1% and 1% AEP +31%) the modelling predicts negligible differences at Benson Weir.

**Table 3-6. Scenario A2: Peak water levels and differences to baseline (50% AEP to 3.3% AEP)**

| Ref | Location | 50% AEP | | | 20% AEP | | | 10% AEP | | | 5% AEP | | | 3.3% AEP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base (mAOD) | Scen A2 (mAOD) | Diff (m) | Base (mAOD) | Scen A2 (mAOD) | Diff (m) | Base (mAOD) | Scen A2 (mAOD) | Diff (m) | Base (mAOD) | Scen A2 (mAOD) | Diff (m) | Base (mAOD) | Scen A2 (mAOD) | Diff (m) |
| 1 | D/S Culham Lock | 48.82 | 48.82 | 0.00 | 49.10 | 49.10 | 0.00 | 49.27 | 49.27 | 0.00 | 49.43 | 49.43 | 0.00 | 49.53 | 49.53 | 0.00 |
| 2 | U/S Clifton Lock | 48.09 | 48.09 | 0.00 | 48.28 | 48.28 | 0.00 | 48.40 | 48.40 | 0.00 | 48.53 | 48.53 | 0.00 | 48.61 | 48.61 | 0.00 |
| 3 | D/S Clifton Lock | 47.53 | 47.53 | 0.00 | 47.88 | 47.88 | 0.00 | 48.10 | 48.10 | 0.00 | 48.29 | 48.29 | 0.00 | 48.41 | 48.41 | 0.00 |
| 4 | U/S Days Weir | 46.54 | 46.55 | 0.01 | 46.84 | 46.85 | 0.01 | 47.07 | 47.09 | 0.02 | 47.26 | 47.27 | 0.01 | 47.39 | 47.39 | 0.00 |
| 5 | D/S Days Weir | 46.33 | 46.34 | 0.01 | 46.66 | 46.67 | 0.01 | 46.94 | 46.96 | 0.02 | 47.15 | 47.16 | 0.01 | 47.28 | 47.29 | 0.01 |
| 6 | Thame confluence | 46.17 | 46.18 | 0.01 | 46.50 | 46.52 | 0.02 | 46.80 | 46.82 | 0.02 | 47.01 | 47.02 | 0.01 | 47.16 | 47.17 | 0.01 |
| 7 | D/S Wallingford Road | 45.44 | 45.46 | 0.02 | 45.71 | 45.74 | 0.03 | 45.94 | 45.97 | 0.03 | 46.09 | 46.12 | 0.03 | 46.20 | 46.23 | 0.03 |
| 8a | 770m u/s of Benson | 45.12 | 45.19 | 0.07 | 45.41 | 45.46 | 0.05 | 45.65 | 45.70 | 0.05 | 45.81 | 45.85 | 0.04 | 45.93 | 45.97 | 0.04 |
| 8 | U/S Benson Weir | 44.94 | 45.05 | 0.11 | 45.26 | 45.34 | 0.08 | 45.51 | 45.58 | 0.07 | 45.67 | 45.74 | 0.07 | 45.79 | 45.85 | 0.06 |
| 9 | D/S Benson Weir | 44.77 | 44.79 | 0.02 | 45.13 | 45.13 | 0.00 | 45.38 | 45.39 | 0.01 | 45.56 | 45.56 | 0.00 | 45.68 | 45.69 | 0.01 |
| 9a | 200m d/s Benson | 44.69 | 44.69 | 0.00 | 45.03 | 45.03 | 0.00 | 45.29 | 45.29 | 0.00 | 45.46 | 45.46 | 0.00 | 45.59 | 45.59 | 0.00 |
| 10 | U/S High Street | 44.51 | 44.51 | 0.00 | 44.86 | 44.86 | 0.00 | 45.12 | 45.12 | 0.00 | 45.29 | 45.29 | 0.00 | 45.41 | 45.41 | 0.00 |
| 11 | U/S Winterbrook Bridge | 43.90 | 43.90 | 0.00 | 44.23 | 44.23 | 0.00 | 44.48 | 44.48 | 0.00 | 44.65 | 44.65 | 0.00 | 44.77 | 44.77 | 0.00 |
| 12 | U/S Moulsford Railway | 43.26 | 43.26 | 0.00 | 43.53 | 43.53 | 0.00 | 43.74 | 43.74 | 0.00 | 43.90 | 43.90 | 0.00 | 44.02 | 44.02 | 0.00 |
| 13 | U/S Cleeve Weir | 42.67 | 42.67 | 0.00 | 42.80 | 42.80 | 0.00 | 42.89 | 42.89 | 0.00 | 43.03 | 43.03 | 0.00 | 43.13 | 43.13 | 0.00 |
| 14 | D/S Cleeve Weir | 42.06 | 42.06 | 0.00 | 42.27 | 42.27 | 0.00 | 42.48 | 42.48 | 0.00 | 42.67 | 42.67 | 0.00 | 42.81 | 42.81 | 0.00 |
| 15 | U/S Gatehamton Railway | 41.04 | 41.04 | 0.00 | 41.55 | 41.55 | 0.00 | 41.89 | 41.89 | 0.00 | 42.11 | 42.11 | 0.00 | 42.27 | 42.27 | 0.00 |
| 16 | U/S Whitchurch | 39.99 | 39.99 | 0.00 | 40.29 | 40.29 | 0.00 | 40.43 | 40.43 | 0.00 | 40.53 | 40.53 | 0.00 | 40.59 | 40.59 | 0.00 |
| 17 | Whitchurch Bridge | 39.71 | 39.71 | 0.00 | 39.93 | 39.93 | 0.00 | 40.08 | 40.08 | 0.00 | 40.18 | 40.18 | 0.00 | 40.25 | 40.25 | 0.00 |
| 18 | U/S Mapledurham Lock | 39.04 | 39.04 | 0.00 | 39.18 | 39.18 | 0.00 | 39.28 | 39.28 | 0.00 | 39.35 | 39.35 | 0.00 | 39.40 | 39.41 | 0.01 |
| 19 | D/S Mapledurham Lock | 38.49 | 38.49 | 0.00 | 38.75 | 38.75 | 0.00 | 38.93 | 38.93 | 0.00 | 39.04 | 39.04 | 0.00 | 39.11 | 39.11 | 0.00 |
| 20 | Caversham Bridge | 36.92 | 36.92 | 0.00 | 37.22 | 37.22 | 0.00 | 37.47 | 37.47 | 0.00 | 37.63 | 37.63 | 0.00 | 37.76 | 37.76 | 0.00 |

**Table 3-7. Scenario A2: Peak water levels and differences to baseline (2% to 0.1% AEP, 1% AEP +31%)**

| Ref | 2% AEP | | | 1.3% AEP | | | 1% AEP | | | 0.5% AEP | | | 0.1% AEP | | | 1% AEP +31% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Base (mAOD) | Scen A2 (mAOD) | Diff (m) | Base (mAOD) | Scen A2 (mAOD) | Diff (m) | Base (mAOD) | Scen A2 (mAOD) | Diff (m) | Base (mAOD) | Scen A2 (mAOD) | Diff (m) | Base (mAOD) | Scen A2 (mAOD) | Diff (m) | Base (mAOD) | Scen A2 (mAOD) | Diff (m) |
| 1 | 49.66 | 49.66 | 0.00 | 49.78 | 49.78 | 0.00 | 49.86 | 49.86 | 0.00 | 50.02 | 50.02 | 0.00 | 50.70 | 50.70 | 0.00 | 50.43 | 50.43 | 0.00 |
| 2 | 48.72 | 48.72 | 0.00 | 48.84 | 48.84 | 0.00 | 48.90 | 48.90 | 0.00 | 49.03 | 49.03 | 0.00 | 49.47 | 49.47 | 0.00 | 49.29 | 49.29 | 0.00 |
| 3 | 48.53 | 48.54 | 0.01 | 48.66 | 48.66 | 0.00 | 48.72 | 48.72 | 0.00 | 48.85 | 48.85 | 0.00 | 49.22 | 49.22 | 0.00 | 49.08 | 49.08 | 0.00 |
| 4 | 47.53 | 47.54 | 0.01 | 47.72 | 47.73 | 0.01 | 47.80 | 47.81 | 0.01 | 47.96 | 47.96 | 0.00 | 48.40 | 48.41 | 0.01 | 48.18 | 48.18 | 0.00 |
| 5 | 47.43 | 47.44 | 0.01 | 47.62 | 47.63 | 0.01 | 47.71 | 47.71 | 0.00 | 47.88 | 47.88 | 0.00 | 48.30 | 48.30 | 0.00 | 48.08 | 48.08 | 0.00 |
| 6 | 47.30 | 47.31 | 0.01 | 47.51 | 47.51 | 0.00 | 47.60 | 47.60 | 0.00 | 47.78 | 47.78 | 0.00 | 48.23 | 48.23 | 0.00 | 47.99 | 47.99 | 0.00 |
| 7 | 46.34 | 46.36 | 0.02 | 46.56 | 46.57 | 0.01 | 46.68 | 46.70 | 0.02 | 46.92 | 46.92 | 0.00 | 47.54 | 47.55 | 0.01 | 47.19 | 47.20 | 0.01 |
| 8a | 46.08 | 46.11 | 0.03 | 46.32 | 46.33 | 0.01 | 46.44 | 46.46 | 0.02 | 46.68 | 46.69 | 0.01 | 47.30 | 47.29 | -0.01 | 46.93 | 46.93 | 0.00 |
| 8 | 45.94 | 45.99 | 0.05 | 46.18 | 46.22 | 0.04 | 46.30 | 46.35 | 0.05 | 46.58 | 46.59 | 0.01 | 47.30 | 47.32 | 0.02 | 46.92 | 46.93 | 0.01 |
| 9 | 45.84 | 45.85 | 0.01 | 46.10 | 46.10 | 0.00 | 46.23 | 46.24 | 0.01 | 46.52 | 46.52 | 0.00 | 47.24 | 47.24 | 0.00 | 46.84 | 46.85 | 0.01 |
| 9a | 45.75 | 45.75 | 0.00 | 46.01 | 46.01 | 0.00 | 46.15 | 46.15 | 0.00 | 46.44 | 46.45 | 0.01 | 47.18 | 47.18 | 0.00 | 46.78 | 46.78 | 0.00 |
| 10 | 45.57 | 45.57 | 0.00 | 45.81 | 45.81 | 0.00 | 45.93 | 45.93 | 0.00 | 46.19 | 46.19 | 0.00 | 46.83 | 46.83 | 0.00 | 46.48 | 46.48 | 0.00 |
| 11 | 44.92 | 44.92 | 0.00 | 45.15 | 45.15 | 0.00 | 45.28 | 45.28 | 0.00 | 45.55 | 45.55 | 0.00 | 46.23 | 46.23 | 0.00 | 45.87 | 45.87 | 0.00 |
| 12 | 44.17 | 44.17 | 0.00 | 44.41 | 44.41 | 0.00 | 44.55 | 44.55 | 0.00 | 44.84 | 44.84 | 0.00 | 45.59 | 45.59 | 0.00 | 45.18 | 45.18 | 0.00 |
| 13 | 43.28 | 43.28 | 0.00 | 43.52 | 43.52 | 0.00 | 43.66 | 43.66 | 0.00 | 44.00 | 44.00 | 0.00 | 44.79 | 44.79 | 0.00 | 44.36 | 44.36 | 0.00 |
| 14 | 42.99 | 42.99 | 0.00 | 43.28 | 43.28 | 0.00 | 43.45 | 43.45 | 0.00 | 43.82 | 43.82 | 0.00 | 44.71 | 44.71 | 0.00 | 44.23 | 44.23 | 0.00 |
| 15 | 42.47 | 42.47 | 0.00 | 42.76 | 42.76 | 0.00 | 42.93 | 42.93 | 0.00 | 43.28 | 43.28 | 0.00 | 44.15 | 44.14 | -0.01 | 43.68 | 43.68 | 0.00 |
| 16 | 40.67 | 40.67 | 0.00 | 40.79 | 40.79 | 0.00 | 40.86 | 40.86 | 0.00 | 41.08 | 41.08 | 0.00 | 41.28 | 41.28 | 0.00 | 41.11 | 41.11 | 0.00 |
| 17 | 40.33 | 40.33 | 0.00 | 40.46 | 40.46 | 0.00 | 40.56 | 40.56 | 0.00 | 40.84 | 40.84 | 0.00 | 40.98 | 40.98 | 0.00 | 40.80 | 40.80 | 0.00 |
| 18 | 39.47 | 39.47 | 0.00 | 39.58 | 39.58 | 0.00 | 39.66 | 39.66 | 0.00 | 39.86 | 39.86 | 0.00 | 40.08 | 40.08 | 0.00 | 39.90 | 39.90 | 0.00 |
| 19 | 39.20 | 39.20 | 0.00 | 39.33 | 39.33 | 0.00 | 39.41 | 39.41 | 0.00 | 39.58 | 39.58 | 0.00 | 39.87 | 39.87 | 0.00 | 39.68 | 39.68 | 0.00 |
| 20 | 37.91 | 37.91 | 0.00 | 38.10 | 38.10 | 0.00 | 38.19 | 38.19 | 0.00 | 38.34 | 38.34 | 0.00 | 38.67 | 38.67 | 0.00 | 38.50 | 38.50 | 0.00 |


**Figure 3-8. Scenario A2: Changes to floodplain maximum water levels (50% and 20% AEP)**


**Figure 3-9. Scenario A2: Changes to floodplain maximum water levels (10% and 5% AEP)**


**Figure 3-10. Scenario A2: Changes to floodplain maximum water levels (3.3% and 2% AEP)**

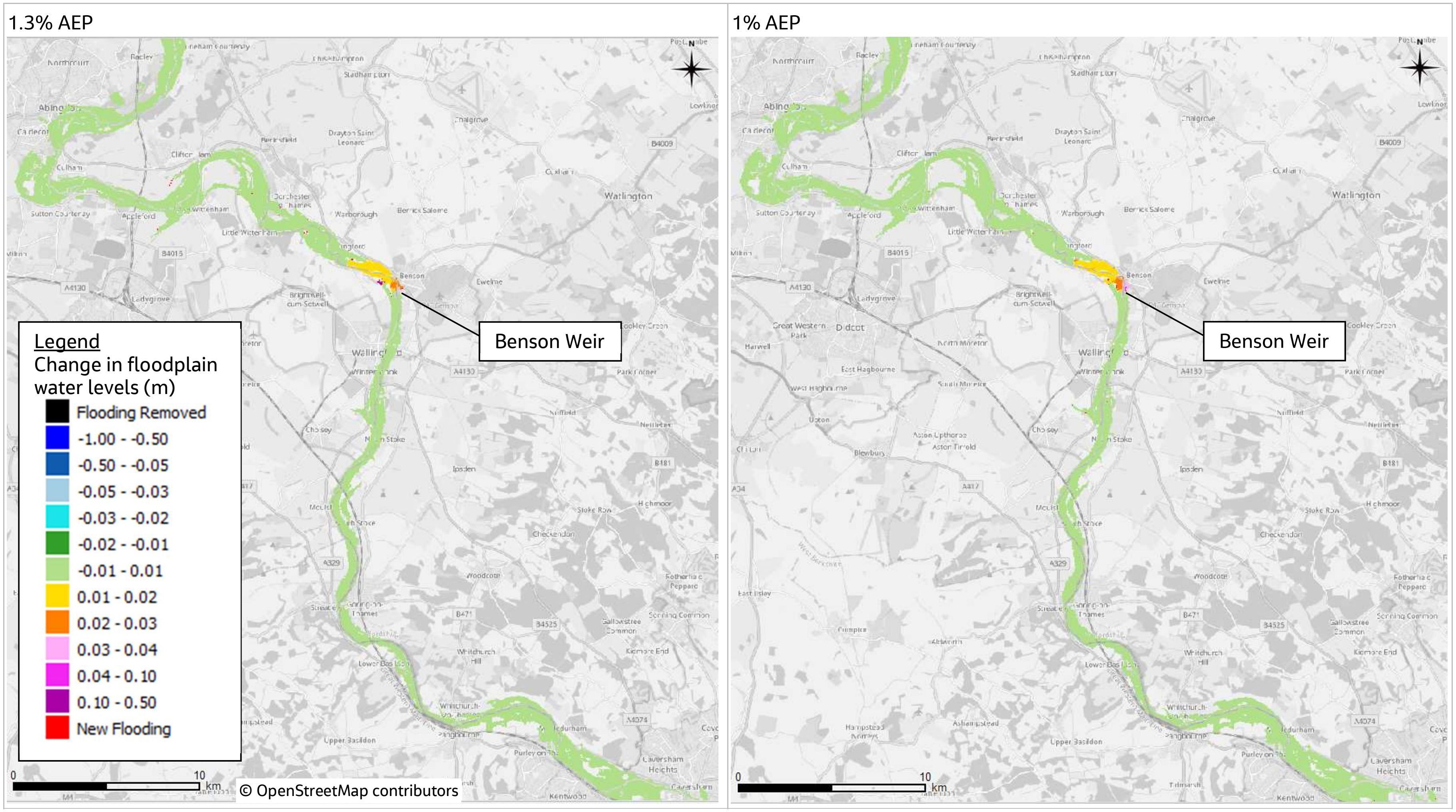



**Figure 3-11. Scenario A2: Changes to floodplain maximum water levels (1.3% and 1% AEP)**

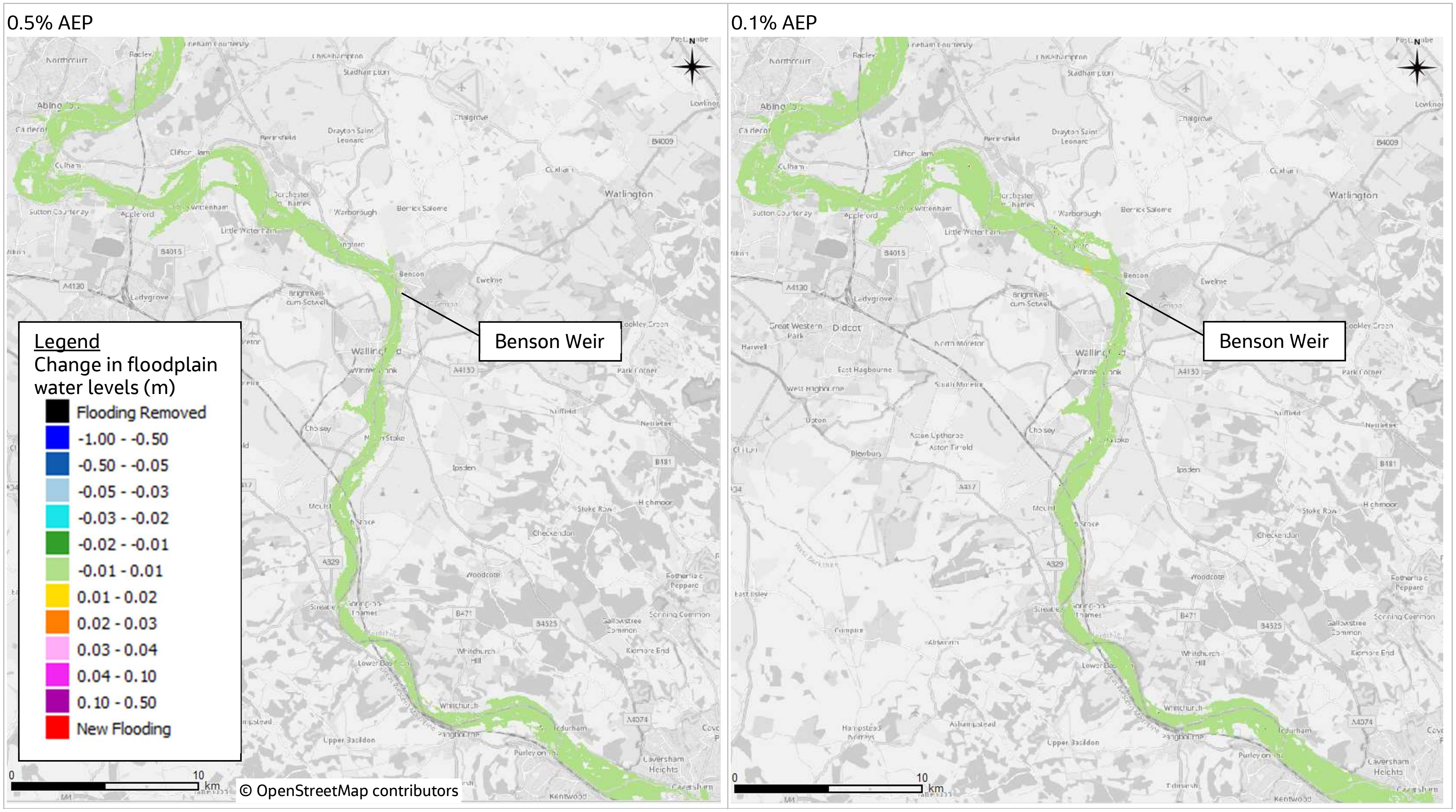



**Figure 3-12. Scenario A2: Changes to floodplain maximum water levels (0.5% and 0.1% AEP)**

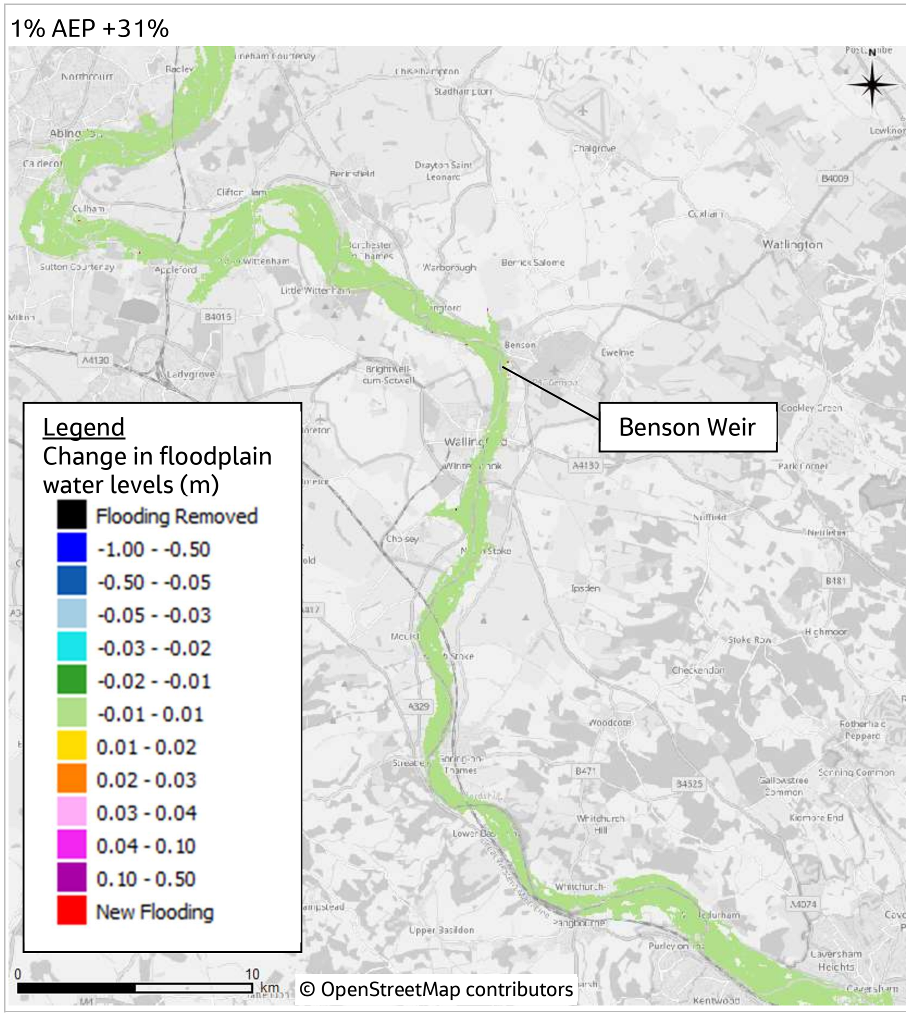



**Figure 3-13. Scenario A2: Changes to floodplain maximum water levels (1% AEP + 31%)**

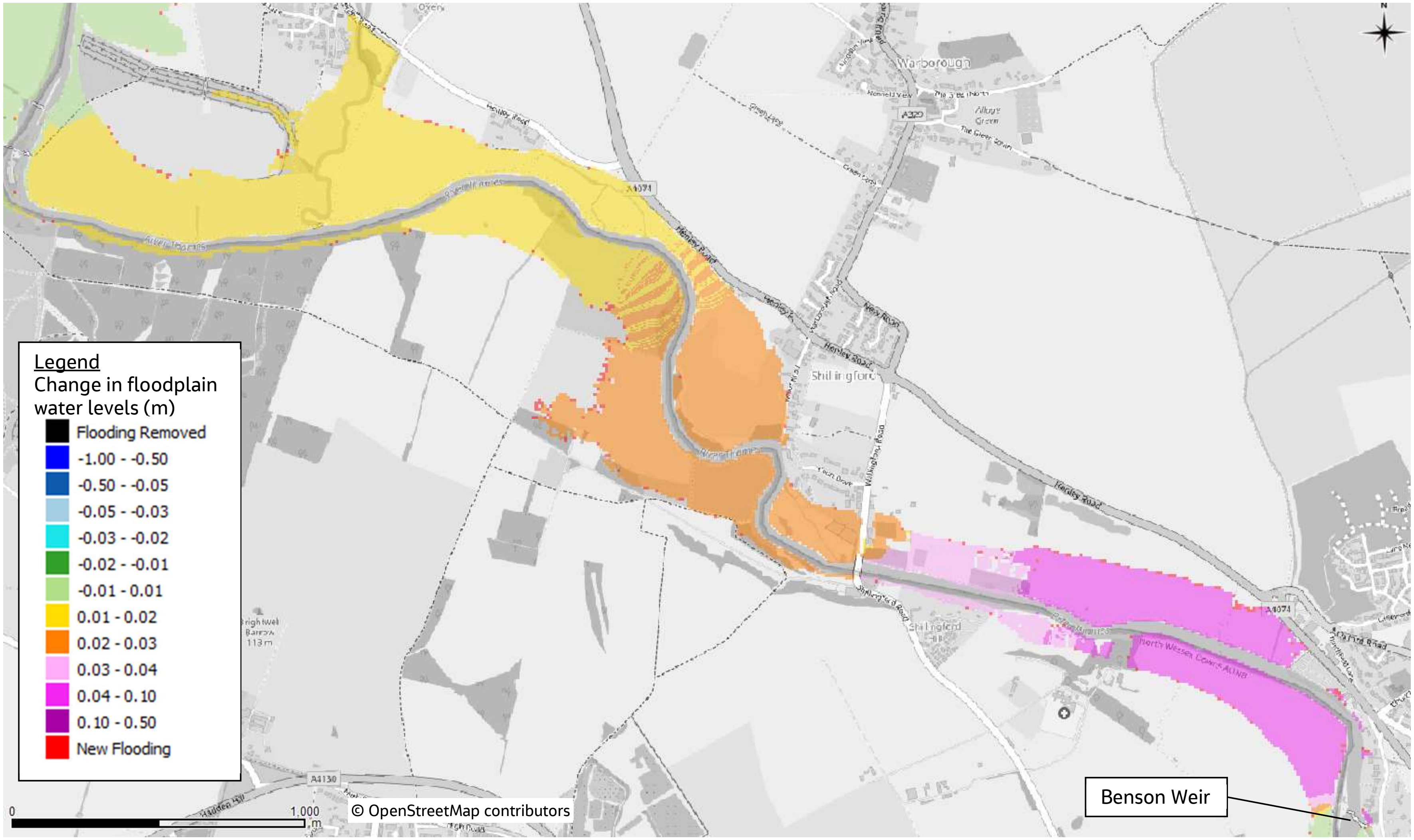



**Figure 3-14. Scenario A2: Changes to floodplain maximum water levels (20% AEP zoomed in)**

## 3.5 Scenario B: Weir B 2 hand radial gates blocked

The maximum river water levels predicted from the modelling and comparison between the baseline and blocked Weir B radial gates scenario are detailed in Table 3-8 (50% to 3.3% AEP) and Table 3-9 (2% AEP to 1% AEP+31%) at the selected locations detailed in Figure 1-2

Maps which show the differences in the maximum floodplain water levels are detailed in Figure 3-15 (50% and 20% AEP), Figure 3-16 (10% and 5% AEP), Figure 3-17 (3.3% and 2% AEP), Figure 3-18 (1.3% and 1% AEP) , Figure 3-19 (0.5% AEP and 0.1% AEP) and Figure 3-20 (1% AEP+31%). The maps indicate areas of no/negligible changes to peak water levels as light green shading, reductions in water levels are shaded greens/blues and increases in water levels are shaded yellow/orange/purples. Areas which no longer flood are shaded black and new areas of flooding are shaded red.

The modelling predicts negligible differences all AEP events. The changes in floodplain peak water level is only predicted for the 50% AEP event, where there is up to 0.02m increase on the right bank active floodplain at Benson Weir. Otherwise, the modelling predicts no/negligible changes to peak water levels (as indicated on the maps which show light green shading throughout the model).

**Table 3-8. Scenario B: Peak water levels and differences to baseline (50% AEP to 3.3% AEP)**

| Ref | Location | 50% AEP | | | 20% AEP | | | 10% AEP | | | 5% AEP | | | 3.3% AEP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base (mAOD) | Scen B (mAOD) | Diff (m) | Base (mAOD) | Scen B (mAOD) | Diff (m) | Base (mAOD) | Scen B (mAOD) | Diff (m) | Base (mAOD) | Scen B (mAOD) | Diff (m) | Base (mAOD) | Scen B (mAOD) | Diff (m) |
| 1 | D/S Culham Lock | 48.82 | 48.82 | 0.00 | 49.10 | 49.10 | 0.00 | 49.27 | 49.27 | 0.00 | 49.43 | 49.43 | 0.00 | 49.53 | 49.53 | 0.00 |
| 2 | U/S Clifton Lock | 48.09 | 48.09 | 0.00 | 48.28 | 48.28 | 0.00 | 48.40 | 48.40 | 0.00 | 48.53 | 48.53 | 0.00 | 48.61 | 48.61 | 0.00 |
| 3 | D/S Clifton Lock | 47.53 | 47.53 | 0.00 | 47.88 | 47.88 | 0.00 | 48.10 | 48.10 | 0.00 | 48.29 | 48.29 | 0.00 | 48.41 | 48.41 | 0.00 |
| 4 | U/S Days Weir | 46.54 | 46.54 | 0.00 | 46.84 | 46.84 | 0.00 | 47.07 | 47.08 | 0.01 | 47.26 | 47.26 | 0.00 | 47.39 | 47.39 | 0.00 |
| 5 | D/S Days Weir | 46.33 | 46.33 | 0.00 | 46.66 | 46.66 | 0.00 | 46.94 | 46.94 | 0.00 | 47.15 | 47.15 | 0.00 | 47.28 | 47.29 | 0.01 |
| 6 | Thame confluence | 46.17 | 46.17 | 0.00 | 46.50 | 46.50 | 0.00 | 46.80 | 46.80 | 0.00 | 47.01 | 47.01 | 0.00 | 47.16 | 47.16 | 0.00 |
| 7 | D/S Wallingford Road | 45.44 | 45.44 | 0.00 | 45.71 | 45.71 | 0.00 | 45.94 | 45.94 | 0.00 | 46.09 | 46.09 | 0.00 | 46.20 | 46.20 | 0.00 |
| 8a | 770m u/s of Benson | 45.12 | 45.13 | 0.01 | 45.41 | 45.41 | 0.00 | 45.65 | 45.66 | 0.01 | 45.81 | 45.82 | 0.01 | 45.93 | 45.94 | 0.01 |
| 8 | U/S Benson Weir | 44.94 | 44.95 | 0.01 | 45.26 | 45.27 | 0.01 | 45.51 | 45.51 | 0.00 | 45.67 | 45.68 | 0.01 | 45.79 | 45.80 | 0.01 |
| 9 | D/S Benson Weir | 44.77 | 44.78 | 0.01 | 45.13 | 45.13 | 0.00 | 45.38 | 45.38 | 0.00 | 45.56 | 45.56 | 0.00 | 45.68 | 45.69 | 0.01 |
| 9a | 200m d/s Benson | 44.69 | 44.69 | 0.00 | 45.03 | 45.03 | 0.00 | 45.29 | 45.29 | 0.00 | 45.46 | 45.46 | 0.00 | 45.59 | 45.59 | 0.00 |
| 10 | U/S High Street | 44.51 | 44.51 | 0.00 | 44.86 | 44.86 | 0.00 | 45.12 | 45.12 | 0.00 | 45.29 | 45.29 | 0.00 | 45.41 | 45.41 | 0.00 |
| 11 | U/S Winterbrook Bridge | 43.90 | 43.90 | 0.00 | 44.23 | 44.23 | 0.00 | 44.48 | 44.48 | 0.00 | 44.65 | 44.65 | 0.00 | 44.77 | 44.77 | 0.00 |
| 12 | U/S Moulsford Railway | 43.26 | 43.26 | 0.00 | 43.53 | 43.53 | 0.00 | 43.74 | 43.74 | 0.00 | 43.90 | 43.90 | 0.00 | 44.02 | 44.02 | 0.00 |
| 13 | U/S Cleeve Weir | 42.67 | 42.67 | 0.00 | 42.80 | 42.80 | 0.00 | 42.89 | 42.89 | 0.00 | 43.03 | 43.03 | 0.00 | 43.13 | 43.13 | 0.00 |
| 14 | D/S Cleeve Weir | 42.06 | 42.06 | 0.00 | 42.27 | 42.27 | 0.00 | 42.48 | 42.48 | 0.00 | 42.67 | 42.67 | 0.00 | 42.81 | 42.81 | 0.00 |
| 15 | U/S Gatehamton Railway | 41.04 | 41.04 | 0.00 | 41.55 | 41.55 | 0.00 | 41.89 | 41.89 | 0.00 | 42.11 | 42.11 | 0.00 | 42.27 | 42.27 | 0.00 |
| 16 | U/S Whitchurch | 39.99 | 39.99 | 0.00 | 40.29 | 40.29 | 0.00 | 40.43 | 40.43 | 0.00 | 40.53 | 40.53 | 0.00 | 40.59 | 40.59 | 0.00 |
| 17 | Whitchurch Bridge | 39.71 | 39.71 | 0.00 | 39.93 | 39.93 | 0.00 | 40.08 | 40.08 | 0.00 | 40.18 | 40.18 | 0.00 | 40.25 | 40.25 | 0.00 |
| 18 | U/S Mapledurham Lock | 39.04 | 39.04 | 0.00 | 39.18 | 39.18 | 0.00 | 39.28 | 39.28 | 0.00 | 39.35 | 39.35 | 0.00 | 39.40 | 39.40 | 0.00 |
| 19 | D/S Mapledurham Lock | 38.49 | 38.49 | 0.00 | 38.75 | 38.75 | 0.00 | 38.93 | 38.93 | 0.00 | 39.04 | 39.04 | 0.00 | 39.11 | 39.11 | 0.00 |
| 20 | Caversham Bridge | 36.92 | 36.92 | 0.00 | 37.22 | 37.22 | 0.00 | 37.47 | 37.47 | 0.00 | 37.63 | 37.63 | 0.00 | 37.76 | 37.76 | 0.00 |

**Table 3-9. Scenario B: Peak water levels and differences to baseline (2% to 0.1% AEP, 1% AEP +31%)**

| Ref | 2% AEP | | | 1.3% AEP | | | 1% AEP | | | 0.5% AEP | | | 0.1% AEP | | | 1% AEP +31% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Base (mAOD) | Scen B (mAOD) | Diff (m) | Base (mAOD) | Scen B (mAOD) | Diff (m) | Base (mAOD) | Scen B (mAOD) | Diff (m) | Base (mAOD) | Scen B (mAOD) | Diff (m) | Base (mAOD) | Scen B (mAOD) | Diff (m) | Base (mAOD) | Scen B (mAOD) | Diff (m) |
| 1 | 49.66 | 49.66 | 0.00 | 49.78 | 49.78 | 0.00 | 49.86 | 49.86 | 0.00 | 50.02 | 50.02 | 0.00 | 50.70 | 50.70 | 0.00 | 50.43 | 50.43 | 0.00 |
| 2 | 48.72 | 48.72 | 0.00 | 48.84 | 48.84 | 0.00 | 48.90 | 48.90 | 0.00 | 49.03 | 49.03 | 0.00 | 49.47 | 49.47 | 0.00 | 49.29 | 49.29 | 0.00 |
| 3 | 48.53 | 48.54 | 0.01 | 48.66 | 48.66 | 0.00 | 48.72 | 48.72 | 0.00 | 48.85 | 48.85 | 0.00 | 49.22 | 49.22 | 0.00 | 49.08 | 49.08 | 0.00 |
| 4 | 47.53 | 47.54 | 0.01 | 47.72 | 47.72 | 0.00 | 47.80 | 47.81 | 0.01 | 47.96 | 47.96 | 0.00 | 48.40 | 48.41 | 0.01 | 48.18 | 48.18 | 0.00 |
| 5 | 47.43 | 47.43 | 0.00 | 47.62 | 47.62 | 0.00 | 47.71 | 47.71 | 0.00 | 47.88 | 47.88 | 0.00 | 48.30 | 48.30 | 0.00 | 48.08 | 48.08 | 0.00 |
| 6 | 47.30 | 47.30 | 0.00 | 47.51 | 47.51 | 0.00 | 47.60 | 47.60 | 0.00 | 47.78 | 47.78 | 0.00 | 48.23 | 48.23 | 0.00 | 47.99 | 47.99 | 0.00 |
| 7 | 46.34 | 46.34 | 0.00 | 46.56 | 46.56 | 0.00 | 46.68 | 46.68 | 0.00 | 46.92 | 46.92 | 0.00 | 47.54 | 47.55 | 0.01 | 47.19 | 47.19 | 0.00 |
| 8a | 46.08 | 46.08 | 0.00 | 46.32 | 46.32 | 0.00 | 46.44 | 46.44 | 0.00 | 46.68 | 46.69 | 0.01 | 47.30 | 47.30 | 0.00 | 46.93 | 46.93 | 0.00 |
| 8 | 45.94 | 45.95 | 0.01 | 46.18 | 46.18 | 0.00 | 46.30 | 46.31 | 0.01 | 46.58 | 46.58 | 0.00 | 47.30 | 47.31 | 0.01 | 46.92 | 46.92 | 0.00 |
| 9 | 45.84 | 45.85 | 0.01 | 46.10 | 46.10 | 0.00 | 46.23 | 46.23 | 0.00 | 46.52 | 46.52 | 0.00 | 47.24 | 47.24 | 0.00 | 46.84 | 46.84 | 0.00 |
| 9a | 45.75 | 45.75 | 0.00 | 46.01 | 46.01 | 0.00 | 46.15 | 46.15 | 0.00 | 46.44 | 46.45 | 0.01 | 47.18 | 47.18 | 0.00 | 46.78 | 46.78 | 0.00 |
| 10 | 45.57 | 45.57 | 0.00 | 45.81 | 45.81 | 0.00 | 45.93 | 45.93 | 0.00 | 46.19 | 46.19 | 0.00 | 46.83 | 46.83 | 0.00 | 46.48 | 46.48 | 0.00 |
| 11 | 44.92 | 44.92 | 0.00 | 45.15 | 45.15 | 0.00 | 45.28 | 45.28 | 0.00 | 45.55 | 45.55 | 0.00 | 46.23 | 46.23 | 0.00 | 45.87 | 45.87 | 0.00 |
| 12 | 44.17 | 44.17 | 0.00 | 44.41 | 44.41 | 0.00 | 44.55 | 44.55 | 0.00 | 44.84 | 44.84 | 0.00 | 45.59 | 45.59 | 0.00 | 45.18 | 45.18 | 0.00 |
| 13 | 43.28 | 43.28 | 0.00 | 43.52 | 43.52 | 0.00 | 43.66 | 43.66 | 0.00 | 44.00 | 44.00 | 0.00 | 44.79 | 44.79 | 0.00 | 44.36 | 44.36 | 0.00 |
| 14 | 42.99 | 42.99 | 0.00 | 43.28 | 43.28 | 0.00 | 43.45 | 43.45 | 0.00 | 43.82 | 43.82 | 0.00 | 44.71 | 44.72 | 0.01 | 44.23 | 44.23 | 0.00 |
| 15 | 42.47 | 42.47 | 0.00 | 42.76 | 42.76 | 0.00 | 42.93 | 42.93 | 0.00 | 43.28 | 43.28 | 0.00 | 44.15 | 44.15 | 0.00 | 43.68 | 43.68 | 0.00 |
| 16 | 40.67 | 40.67 | 0.00 | 40.79 | 40.79 | 0.00 | 40.86 | 40.86 | 0.00 | 41.08 | 41.08 | 0.00 | 41.28 | 41.28 | 0.00 | 41.11 | 41.11 | 0.00 |
| 17 | 40.33 | 40.33 | 0.00 | 40.46 | 40.46 | 0.00 | 40.56 | 40.56 | 0.00 | 40.84 | 40.84 | 0.00 | 40.98 | 40.98 | 0.00 | 40.80 | 40.80 | 0.00 |
| 18 | 39.47 | 39.47 | 0.00 | 39.58 | 39.58 | 0.00 | 39.66 | 39.66 | 0.00 | 39.86 | 39.86 | 0.00 | 40.08 | 40.08 | 0.00 | 39.90 | 39.90 | 0.00 |
| 19 | 39.20 | 39.20 | 0.00 | 39.33 | 39.33 | 0.00 | 39.41 | 39.41 | 0.00 | 39.58 | 39.58 | 0.00 | 39.87 | 39.87 | 0.00 | 39.68 | 39.68 | 0.00 |
| 20 | 37.91 | 37.91 | 0.00 | 38.10 | 38.10 | 0.00 | 38.19 | 38.19 | 0.00 | 38.34 | 38.34 | 0.00 | 38.67 | 38.68 | 0.01 | 38.50 | 38.50 | 0.00 |


**Figure 3-15. Scenario B: Changes to floodplain maximum water levels (50% and 20% AEP)**


**Figure 3-16. Scenario B: Changes to floodplain maximum water levels (10% and 5% AEP)**


**Figure 3-17. Scenario B: Changes to floodplain maximum water levels (3.3% and 2% AEP)**

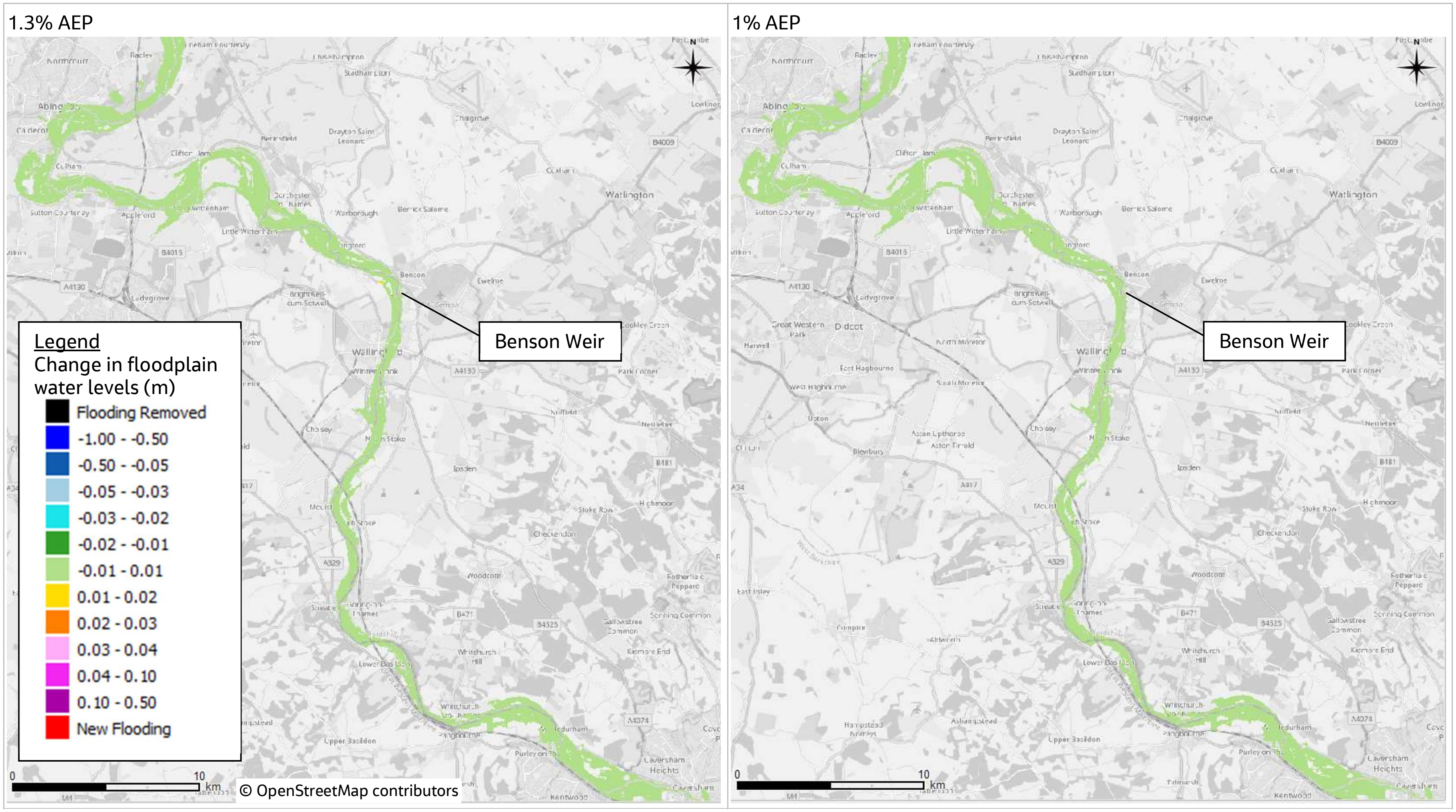



**Figure 3-18. Scenario B: Changes to floodplain maximum water levels (1.3% and 1% AEP)**

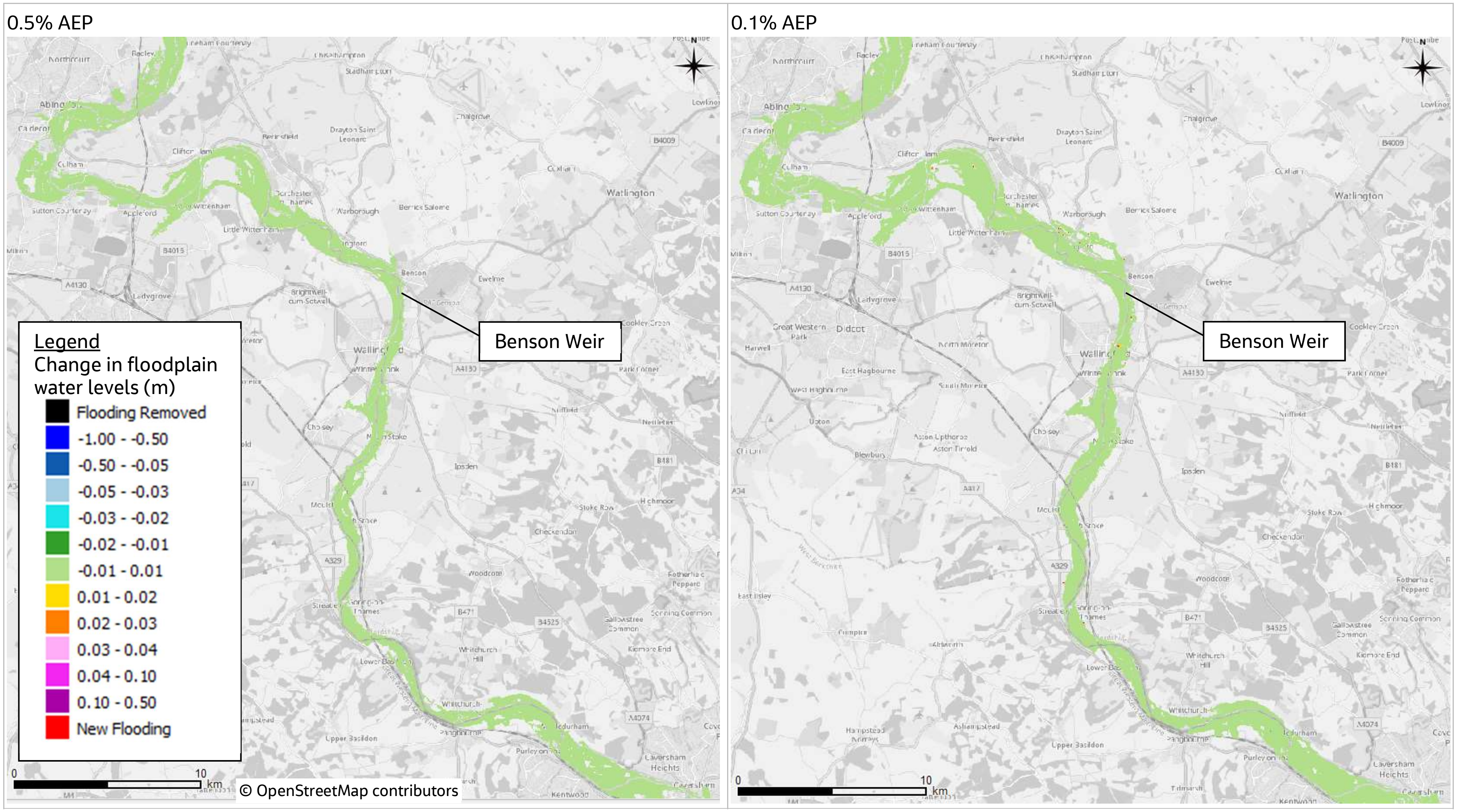



**Figure 3-19. Scenario B: Changes to floodplain maximum water levels (0.5% and 0.1% AEP)**


**Figure 3-20. Scenario B: Changes to floodplain maximum water levels (1% AEP + 31%)**

## 3.6 Scenario C: Weir B overfall weir 50% blocked

The maximum river water levels predicted from the modelling and comparison between the baseline and 50% weir blockage scenario are detailed in Table 3-10 (50% to 3.3% AEP) and Table 3-11 (2% AEP to 1% AEP+31%) at the selected locations detailed in Figure 1-2

Maps which show the differences in the maximum floodplain water levels are detailed in Figure 3-21 (50% and 20% AEP), Figure 3-22 (10% and 5% AEP), Figure 3-23 (3.3% and 2% AEP), Figure 3-24 (1.3% and 1% AEP) , Figure 3-25 (0.5% AEP and 0.1% AEP) Figure 3-26 (1% AEP+31%). The maps indicate areas of no/negligible changes to peak water levels as light green shading, reductions in water levels are shaded greens/blues and increases in water levels are shaded yellow/orange/purples. Areas which no longer flood are shaded black and new areas of flooding are shaded red.

The modelling predicts the largest increase in river water level to occur locally upstream of Benson Weir of 0.05m for the 1% AEP event, all other modelled events predict an increase of 0.01/0.02m. The reason for the larger increase for 1% AEP is due to the operating mode of the deep radial gates. Under baseline conditions the 1% AEP maximum water level is 0.01m below the bottom of the fully open radial gate (structure operates in a drowned weir mode). For Scenario C, the small water level increase reaches the gate and the model switches to a drowned gate mode, which reduces the flow through the structure and increases the water level.

The floodplain maps show the largest water level increase to occur for the 50% AEP event (up to 0.04m), locally on the right bank floodplain at Benson Weir. The largest impact area is for the 1% AEP, the maps show levels to increase upstream to Wallingford Bridge.

**Table 3-10. Scenario C: Peak water levels and differences to baseline (50% AEP to 3.3% AEP)**

| Ref | Location | 50% AEP | | | 20% AEP | | | 10% AEP | | | 5% AEP | | | 3.3% AEP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base (mAOD) | Scen C (mAOD) | Diff (m) | Base (mAOD) | Scen C (mAOD) | Diff (m) | Base (mAOD) | Scen C (mAOD) | Diff (m) | Base (mAOD) | Scen C (mAOD) | Diff (m) | Base (mAOD) | Scen C (mAOD) | Diff (m) |
| 1 | D/S Culham Lock | 48.82 | 48.82 | 0.00 | 49.10 | 49.10 | 0.00 | 49.27 | 49.27 | 0.00 | 49.43 | 49.43 | 0.00 | 49.53 | 49.53 | 0.00 |
| 2 | U/S Clifton Lock | 48.09 | 48.09 | 0.00 | 48.28 | 48.28 | 0.00 | 48.40 | 48.40 | 0.00 | 48.53 | 48.53 | 0.00 | 48.61 | 48.61 | 0.00 |
| 3 | D/S Clifton Lock | 47.53 | 47.53 | 0.00 | 47.88 | 47.88 | 0.00 | 48.10 | 48.10 | 0.00 | 48.29 | 48.29 | 0.00 | 48.41 | 48.41 | 0.00 |
| 4 | U/S Days Weir | 46.54 | 46.54 | 0.00 | 46.84 | 46.84 | 0.00 | 47.07 | 47.08 | 0.01 | 47.26 | 47.27 | 0.01 | 47.39 | 47.39 | 0.00 |
| 5 | D/S Days Weir | 46.33 | 46.33 | 0.00 | 46.66 | 46.66 | 0.00 | 46.94 | 46.95 | 0.01 | 47.15 | 47.15 | 0.00 | 47.28 | 47.29 | 0.01 |
| 6 | Thame confluence | 46.17 | 46.17 | 0.00 | 46.50 | 46.50 | 0.00 | 46.80 | 46.81 | 0.01 | 47.01 | 47.02 | 0.01 | 47.16 | 47.16 | 0.00 |
| 7 | D/S Wallingford Road | 45.44 | 45.44 | 0.00 | 45.71 | 45.72 | 0.01 | 45.94 | 45.95 | 0.01 | 46.09 | 46.10 | 0.01 | 46.20 | 46.21 | 0.01 |
| 8a | 770m u/s of Benson | 45.12 | 45.14 | 0.02 | 45.41 | 45.42 | 0.01 | 45.65 | 45.67 | 0.02 | 45.81 | 45.83 | 0.02 | 45.93 | 45.94 | 0.01 |
| 8 | U/S Benson Weir | 44.94 | 44.96 | 0.02 | 45.26 | 45.28 | 0.02 | 45.51 | 45.53 | 0.02 | 45.67 | 45.70 | 0.03 | 45.79 | 45.81 | 0.02 |
| 9 | D/S Benson Weir | 44.77 | 44.78 | 0.01 | 45.13 | 45.13 | 0.00 | 45.38 | 45.39 | 0.01 | 45.56 | 45.56 | 0.00 | 45.68 | 45.69 | 0.01 |
| 9a | 200m d/s Benson | 44.69 | 44.69 | 0.00 | 45.03 | 45.03 | 0.00 | 45.29 | 45.29 | 0.00 | 45.46 | 45.46 | 0.00 | 45.59 | 45.59 | 0.00 |
| 10 | U/S High Street | 44.51 | 44.51 | 0.00 | 44.86 | 44.86 | 0.00 | 45.12 | 45.12 | 0.00 | 45.29 | 45.29 | 0.00 | 45.41 | 45.41 | 0.00 |
| 11 | U/S Winterbrook Bridge | 43.90 | 43.90 | 0.00 | 44.23 | 44.23 | 0.00 | 44.48 | 44.48 | 0.00 | 44.65 | 44.65 | 0.00 | 44.77 | 44.77 | 0.00 |
| 12 | U/S Moulsford Railway | 43.26 | 43.26 | 0.00 | 43.53 | 43.53 | 0.00 | 43.74 | 43.74 | 0.00 | 43.90 | 43.90 | 0.00 | 44.02 | 44.02 | 0.00 |
| 13 | U/S Cleeve Weir | 42.67 | 42.67 | 0.00 | 42.80 | 42.80 | 0.00 | 42.89 | 42.89 | 0.00 | 43.03 | 43.03 | 0.00 | 43.13 | 43.13 | 0.00 |
| 14 | D/S Cleeve Weir | 42.06 | 42.06 | 0.00 | 42.27 | 42.27 | 0.00 | 42.48 | 42.48 | 0.00 | 42.67 | 42.67 | 0.00 | 42.81 | 42.81 | 0.00 |
| 15 | U/S Gatehamton Railway | 41.04 | 41.04 | 0.00 | 41.55 | 41.55 | 0.00 | 41.89 | 41.89 | 0.00 | 42.11 | 42.11 | 0.00 | 42.27 | 42.27 | 0.00 |
| 16 | U/S Whitchurch | 39.99 | 39.99 | 0.00 | 40.29 | 40.29 | 0.00 | 40.43 | 40.43 | 0.00 | 40.53 | 40.53 | 0.00 | 40.59 | 40.59 | 0.00 |
| 17 | Whitchurch Bridge | 39.71 | 39.71 | 0.00 | 39.93 | 39.93 | 0.00 | 40.08 | 40.08 | 0.00 | 40.18 | 40.18 | 0.00 | 40.25 | 40.25 | 0.00 |
| 18 | U/S Mapledurham Lock | 39.04 | 39.04 | 0.00 | 39.18 | 39.18 | 0.00 | 39.28 | 39.28 | 0.00 | 39.35 | 39.35 | 0.00 | 39.40 | 39.40 | 0.00 |
| 19 | D/S Mapledurham Lock | 38.49 | 38.49 | 0.00 | 38.75 | 38.75 | 0.00 | 38.93 | 38.93 | 0.00 | 39.04 | 39.04 | 0.00 | 39.11 | 39.11 | 0.00 |
| 20 | Caversham Bridge | 36.92 | 36.92 | 0.00 | 37.22 | 37.22 | 0.00 | 37.47 | 37.47 | 0.00 | 37.63 | 37.63 | 0.00 | 37.76 | 37.76 | 0.00 |

**Table 3-11. Scenario C: Peak water levels and differences to baseline (2% to 0.1% AEP, 1% AEP +31%)**

| Ref | 2% AEP | | | 1.3% AEP | | | 1% AEP | | | 0.5% AEP | | | 0.1% AEP | | | 1% AEP +31% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Base (mAOD) | Scen C (mAOD) | Diff (m) | Base (mAOD) | Scen C (mAOD) | Diff (m) | Base (mAOD) | Scen C (mAOD) | Diff (m) | Base (mAOD) | Scen C (mAOD) | Diff (m) | Base (mAOD) | Scen C (mAOD) | Diff (m) | Base (mAOD) | Scen C (mAOD) | Diff (m) |
| 1 | 49.66 | 49.66 | 0.00 | 49.78 | 49.78 | 0.00 | 49.86 | 49.86 | 0.00 | 50.02 | 50.02 | 0.00 | 50.70 | 50.70 | 0.00 | 50.43 | 50.43 | 0.00 |
| 2 | 48.72 | 48.72 | 0.00 | 48.84 | 48.84 | 0.00 | 48.90 | 48.90 | 0.00 | 49.03 | 49.03 | 0.00 | 49.47 | 49.47 | 0.00 | 49.29 | 49.29 | 0.00 |
| 3 | 48.53 | 48.54 | 0.01 | 48.66 | 48.66 | 0.00 | 48.72 | 48.72 | 0.00 | 48.85 | 48.85 | 0.00 | 49.22 | 49.22 | 0.00 | 49.08 | 49.08 | 0.00 |
| 4 | 47.53 | 47.54 | 0.01 | 47.72 | 47.73 | 0.01 | 47.80 | 47.81 | 0.01 | 47.96 | 47.96 | 0.00 | 48.40 | 48.41 | 0.01 | 48.18 | 48.18 | 0.00 |
| 5 | 47.43 | 47.43 | 0.00 | 47.62 | 47.62 | 0.00 | 47.71 | 47.71 | 0.00 | 47.88 | 47.88 | 0.00 | 48.30 | 48.30 | 0.00 | 48.08 | 48.08 | 0.00 |
| 6 | 47.30 | 47.31 | 0.01 | 47.51 | 47.51 | 0.00 | 47.60 | 47.60 | 0.00 | 47.78 | 47.78 | 0.00 | 48.23 | 48.23 | 0.00 | 47.99 | 47.99 | 0.00 |
| 7 | 46.34 | 46.35 | 0.01 | 46.56 | 46.57 | 0.01 | 46.68 | 46.69 | 0.01 | 46.92 | 46.92 | 0.00 | 47.54 | 47.55 | 0.01 | 47.19 | 47.20 | 0.01 |
| 8a | 46.08 | 46.09 | 0.01 | 46.32 | 46.32 | 0.00 | 46.44 | 46.46 | 0.02 | 46.68 | 46.69 | 0.01 | 47.30 | 47.29 | -0.01 | 46.93 | 46.93 | 0.00 |
| 8 | 45.94 | 45.96 | 0.02 | 46.18 | 46.19 | 0.01 | 46.30 | 46.34 | 0.04 | 46.58 | 46.59 | 0.01 | 47.30 | 47.32 | 0.02 | 46.92 | 46.94 | 0.02 |
| 9 | 45.84 | 45.85 | 0.01 | 46.10 | 46.10 | 0.00 | 46.23 | 46.24 | 0.01 | 46.52 | 46.52 | 0.00 | 47.24 | 47.24 | 0.00 | 46.84 | 46.85 | 0.01 |
| 9a | 45.75 | 45.75 | 0.00 | 46.01 | 46.01 | 0.00 | 46.15 | 46.16 | 0.01 | 46.44 | 46.45 | 0.01 | 47.18 | 47.18 | 0.00 | 46.78 | 46.78 | 0.00 |
| 10 | 45.57 | 45.57 | 0.00 | 45.81 | 45.81 | 0.00 | 45.93 | 45.93 | 0.00 | 46.19 | 46.19 | 0.00 | 46.83 | 46.82 | -0.01 | 46.48 | 46.48 | 0.00 |
| 11 | 44.92 | 44.92 | 0.00 | 45.15 | 45.15 | 0.00 | 45.28 | 45.28 | 0.00 | 45.55 | 45.55 | 0.00 | 46.23 | 46.23 | 0.00 | 45.87 | 45.87 | 0.00 |
| 12 | 44.17 | 44.17 | 0.00 | 44.41 | 44.41 | 0.00 | 44.55 | 44.55 | 0.00 | 44.84 | 44.84 | 0.00 | 45.59 | 45.59 | 0.00 | 45.18 | 45.18 | 0.00 |
| 13 | 43.28 | 43.28 | 0.00 | 43.52 | 43.52 | 0.00 | 43.66 | 43.66 | 0.00 | 44.00 | 44.00 | 0.00 | 44.79 | 44.79 | 0.00 | 44.36 | 44.36 | 0.00 |
| 14 | 42.99 | 42.99 | 0.00 | 43.28 | 43.28 | 0.00 | 43.45 | 43.45 | 0.00 | 43.82 | 43.82 | 0.00 | 44.71 | 44.71 | 0.00 | 44.23 | 44.23 | 0.00 |
| 15 | 42.47 | 42.47 | 0.00 | 42.76 | 42.76 | 0.00 | 42.93 | 42.93 | 0.00 | 43.28 | 43.28 | 0.00 | 44.15 | 44.14 | -0.01 | 43.68 | 43.68 | 0.00 |
| 16 | 40.67 | 40.67 | 0.00 | 40.79 | 40.79 | 0.00 | 40.86 | 40.86 | 0.00 | 41.08 | 41.08 | 0.00 | 41.28 | 41.28 | 0.00 | 41.11 | 41.11 | 0.00 |
| 17 | 40.33 | 40.33 | 0.00 | 40.46 | 40.46 | 0.00 | 40.56 | 40.56 | 0.00 | 40.84 | 40.84 | 0.00 | 40.98 | 40.98 | 0.00 | 40.80 | 40.80 | 0.00 |
| 18 | 39.47 | 39.47 | 0.00 | 39.58 | 39.58 | 0.00 | 39.66 | 39.66 | 0.00 | 39.86 | 39.86 | 0.00 | 40.08 | 40.08 | 0.00 | 39.90 | 39.90 | 0.00 |
| 19 | 39.20 | 39.20 | 0.00 | 39.33 | 39.33 | 0.00 | 39.41 | 39.41 | 0.00 | 39.58 | 39.58 | 0.00 | 39.87 | 39.87 | 0.00 | 39.68 | 39.68 | 0.00 |
| 20 | 37.91 | 37.91 | 0.00 | 38.10 | 38.10 | 0.00 | 38.19 | 38.19 | 0.00 | 38.34 | 38.34 | 0.00 | 38.67 | 38.67 | 0.00 | 38.50 | 38.50 | 0.00 |


**Figure 3-21. Scenario C: Changes to floodplain maximum water levels (50% and 20% AEP)**


**Figure 3-22. Scenario C: Changes to floodplain maximum water levels (10% and 5% AEP)**


**Figure 3-23. Scenario C: Changes to floodplain maximum water levels (3.3% and 2% AEP)**


**Figure 3-24. Scenario C: Changes to floodplain maximum water levels (1.3% and 1% AEP)**


**Figure 3-25. Scenario C: Changes to floodplain maximum water levels (0.5% and 0.1% AEP)**

1% AEP +31%

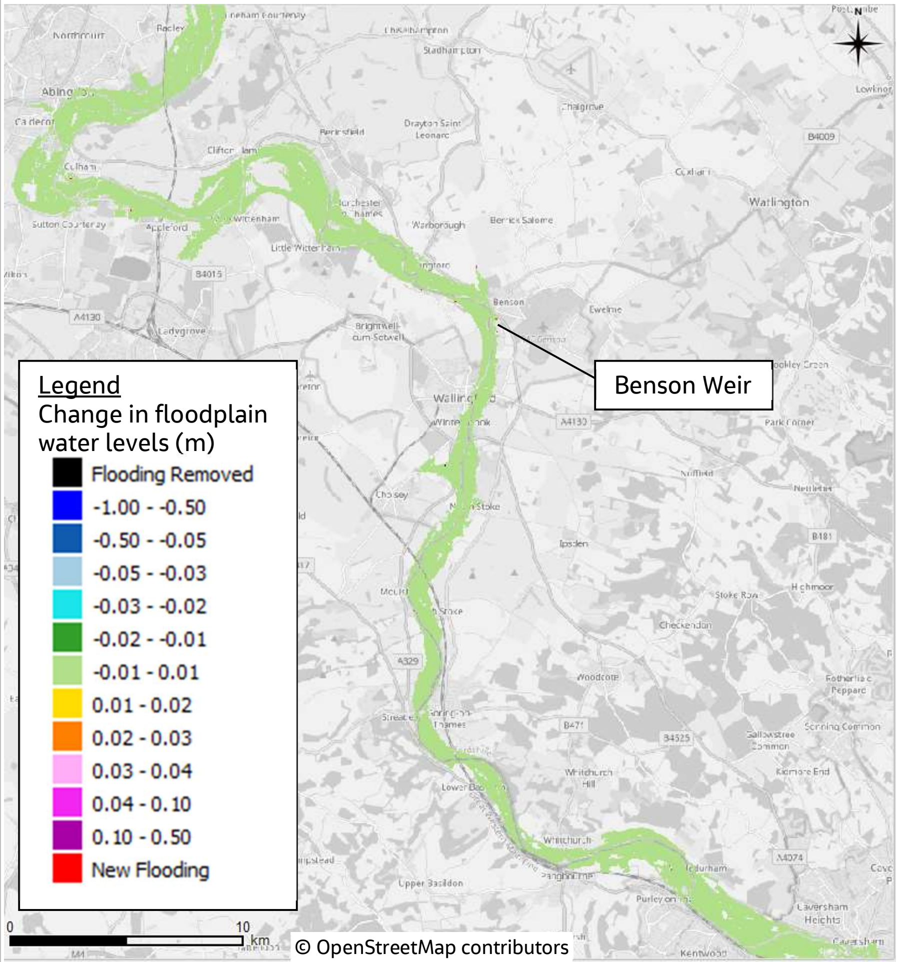



**Figure 3-26. Scenario C: Changes to floodplain maximum water levels (1% AEP + 31%)**

# 4. Gate width sensitivity testing

As a sensitivity test, the model has been run with each individual gate at Benson Weir reduced by 0.09m (Weir A hand and deep radials and Weir B hand radials). The reduction reflects proposed 'side cills' which would be bolted to the pier walls for future gate replacement. This is considered a worst-case scenario as all gate widths have been reduced for the test, whereas the replacement is proposed for only the Weir A gates. The test has been run for the 10%, 5% and 1% AEP events.

The maximum river water levels predicted from the modelling and comparison between the baseline and reduced gate width are detailed in Table 4-1 at the selected locations detailed in Figure 1-2. The modelling predicts negligible impacts to the maximum water levels. Table 4-2 shows the peak 'river flow' is slightly reduced by 0.6m$^3$/s, 0.7m$^3$/s and 1.3m$^3$/s for the events tested with the reduced gate width. The river flow component reduction is less than 1% of the total flow that passes through Benson Weir (river and floodplain flow).

Maps which show the differences in the maximum floodplain water levels are detailed in Figure 4-1. The modelling predicts no/negligible changes to peak water levels (as indicated on the maps which show light green shading throughout the model).

**Table 4-1. Peak water levels and differences to baseline, gate width reduction**

| Ref | Location | 10% AEP | | | 5% AEP | | | 1% AEP | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Base (mAOD) | Reduced (mAOD) | Diff (m) | Base (mAOD) | Reduced (mAOD) | Diff (m) | Base (mAOD) | Reduced (mAOD) | Diff (m) |
| 1 | D/S Culham Lock | 49.27 | 49.27 | 0.00 | 49.43 | 49.43 | 0.00 | 49.86 | 49.86 | 0.00 |
| 2 | U/S Clifton Lock | 48.40 | 48.40 | 0.00 | 48.53 | 48.53 | 0.00 | 48.90 | 48.90 | 0.00 |
| 3 | D/S Clifton Lock | 48.10 | 48.10 | 0.00 | 48.29 | 48.29 | 0.00 | 48.72 | 48.72 | 0.00 |
| 4 | U/S Days Weir | 47.07 | 47.08 | 0.01 | 47.26 | 47.26 | 0.00 | 47.80 | 47.81 | 0.01 |
| 5 | D/S Days Weir | 46.94 | 46.94 | 0.00 | 47.15 | 47.15 | 0.00 | 47.71 | 47.71 | 0.00 |
| 6 | Thame confluence | 46.80 | 46.80 | 0.00 | 47.01 | 47.01 | 0.00 | 47.60 | 47.60 | 0.00 |
| 7 | D/S Wallingford Road | 45.94 | 45.94 | 0.00 | 46.09 | 46.09 | 0.00 | 46.68 | 46.68 | 0.00 |
| 8a | 770m u/s of Benson | 45.65 | 45.65 | 0.00 | 45.81 | 45.82 | 0.01 | 46.44 | 46.44 | 0.00 |
| 8 | U/S Benson Weir | 45.51 | 45.51 | 0.00 | 45.67 | 45.68 | 0.01 | 46.30 | 46.30 | 0.00 |
| 9 | D/S Benson Weir | 45.38 | 45.38 | 0.00 | 45.56 | 45.56 | 0.00 | 46.23 | 46.23 | 0.00 |
| 9a | 200m d/s Benson | 45.29 | 45.29 | 0.00 | 45.46 | 45.46 | 0.00 | 46.15 | 46.15 | 0.00 |
| 10 | U/S High Street | 45.12 | 45.12 | 0.00 | 45.29 | 45.29 | 0.00 | 45.93 | 45.93 | 0.00 |
| 11 | U/S Winterbrook Bridge | 44.48 | 44.48 | 0.00 | 44.65 | 44.65 | 0.00 | 45.28 | 45.28 | 0.00 |
| 12 | U/S Moulsford Railway | 43.74 | 43.74 | 0.00 | 43.90 | 43.90 | 0.00 | 44.55 | 44.55 | 0.00 |
| 13 | U/S Cleeve Weir | 42.89 | 42.89 | 0.00 | 43.03 | 43.03 | 0.00 | 43.66 | 43.66 | 0.00 |
| 14 | D/S Cleeve Weir | 42.48 | 42.48 | 0.00 | 42.67 | 42.67 | 0.00 | 43.45 | 43.45 | 0.00 |
| 15 | U/S Gatehamton Railway | 41.89 | 41.89 | 0.00 | 42.11 | 42.11 | 0.00 | 42.93 | 42.93 | 0.00 |
| 16 | U/S Whitchurch | 40.43 | 40.43 | 0.00 | 40.53 | 40.53 | 0.00 | 40.86 | 40.86 | 0.00 |
| 17 | Whitchurch Bridge | 40.08 | 40.08 | 0.00 | 40.18 | 40.18 | 0.00 | 40.56 | 40.56 | 0.00 |
| 18 | U/S Mapledurham Lock | 39.28 | 39.28 | 0.00 | 39.35 | 39.35 | 0.00 | 39.66 | 39.66 | 0.00 |
| 19 | D/S Mapledurham Lock | 38.93 | 38.93 | 0.00 | 39.04 | 39.04 | 0.00 | 39.41 | 39.41 | 0.00 |
| 20 | Caversham Bridge | 37.47 | 37.47 | 0.00 | 37.63 | 37.63 | 0.00 | 38.19 | 38.19 | 0.00 |

**Table 4-2. Peak flow comparison, gate width reduction**

| AEP | Peak flows and comparison ($m^3/s$) | | | |
|---|---|---|---|---|
| | Total flow at Benson Weir (river and floodplain) | River flow Baseline | River flow gate width reduced | Difference in river flow |
| 10% AEP | 243 | 184.1 | 183.5 | -0.6 |
| 5% AEP | 261 | 190.1 | 189.4 | -0.7 |
| 1% AEP | 337 | 213.3 | 212.0 | -1.3 |

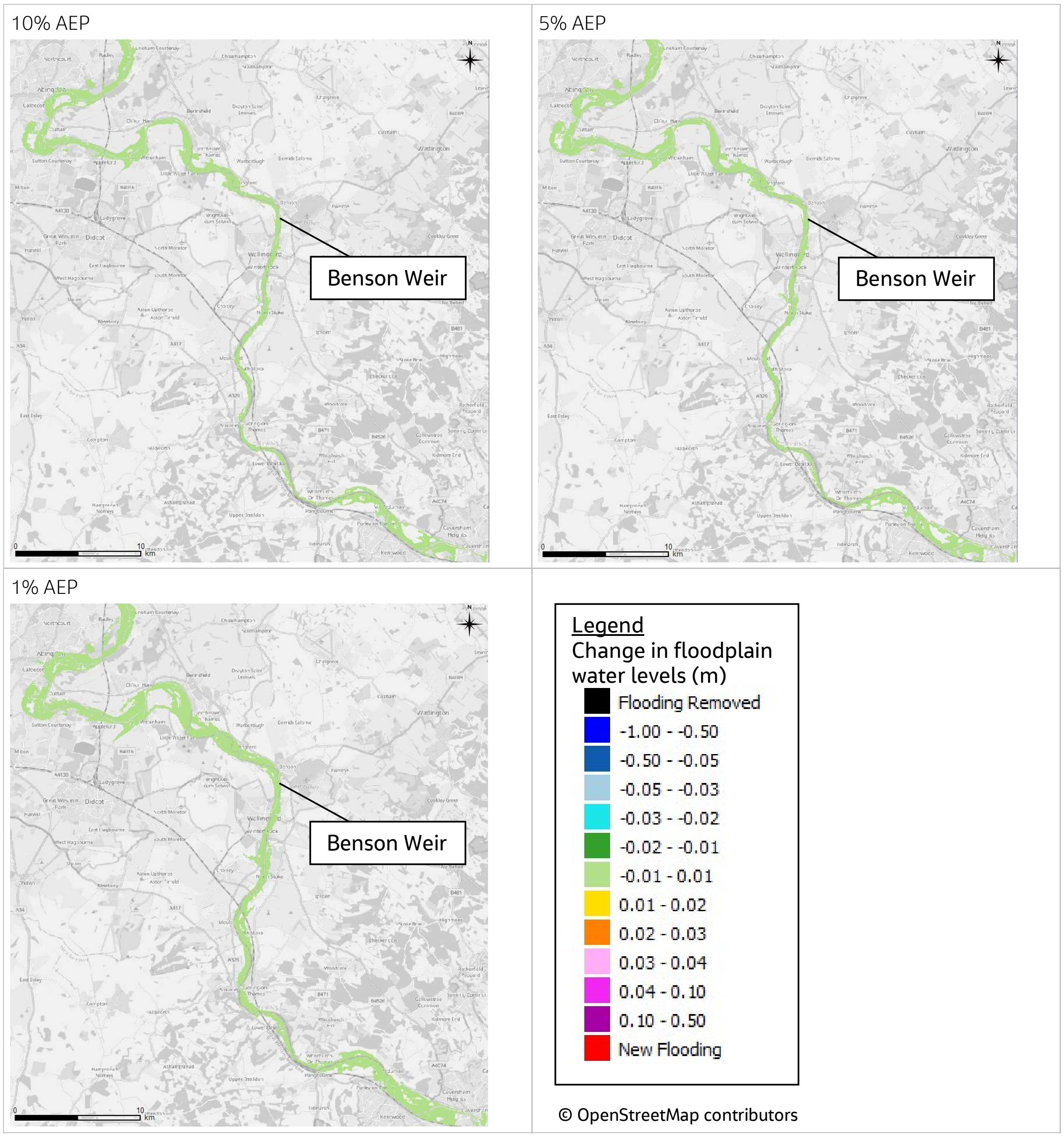



**Figure 4-1. Changes to floodplain maximum water levels, gate width reduction**

The modelled water levels upstream of Benson Weir for the baseline and gate width reduction test are detailed Figure 4-2 (10% AEP), Figure 4-3 (5% AEP) and Figure 4-4 (1% AEP). The time series show similar water levels during peak flows and slightly higher levels at low flows e.g., at time 20 hours water levels are up to 0.02m higher for the gate width reduction.

Figure 4-5 (10% AEP), Figure 4-6 (5% AEP) and Figure 4-7 (1% AEP) show the flows within the river (i.e. which pass via the gates and weirs at Benson) for the for the baseline and gate width reduction test. The modelling predicts negligible changes in flows over the design flood events tested.

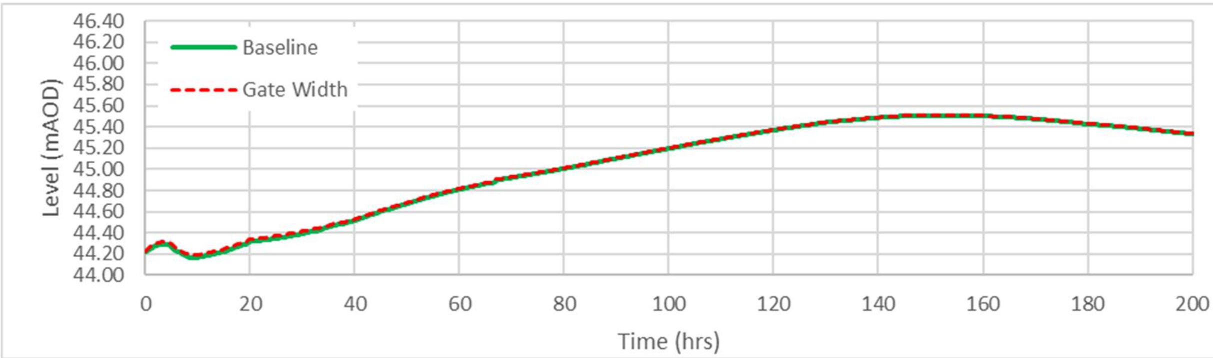



**Figure 4-2. Water levels at Benson Weir, gate width reduction – 10% AEP**

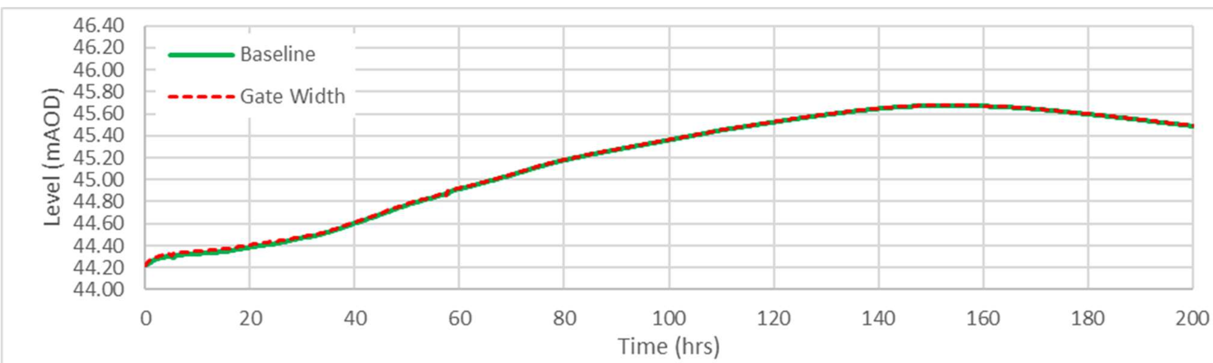



**Figure 4-3. Water levels at Benson Weir, gate width reduction – 5% AEP**

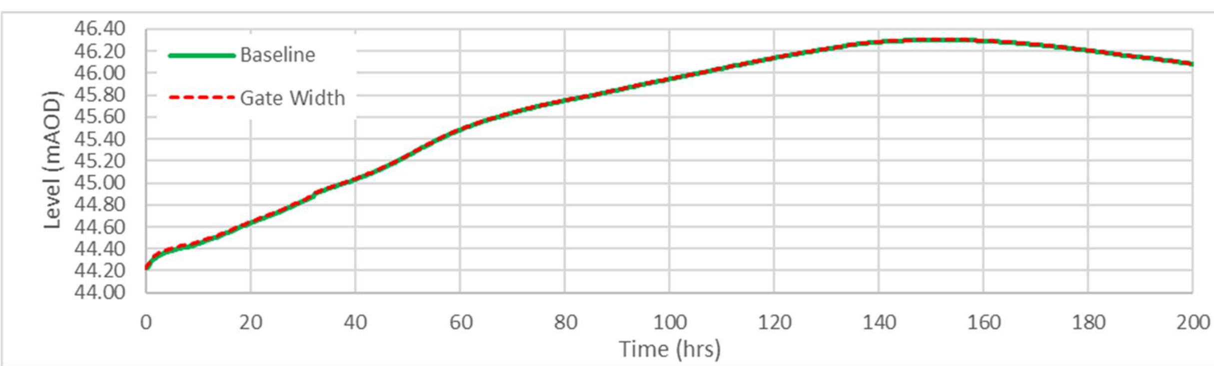



**Figure 4-4. Water levels at Benson Weir, gate width reduction – 1% AEP**

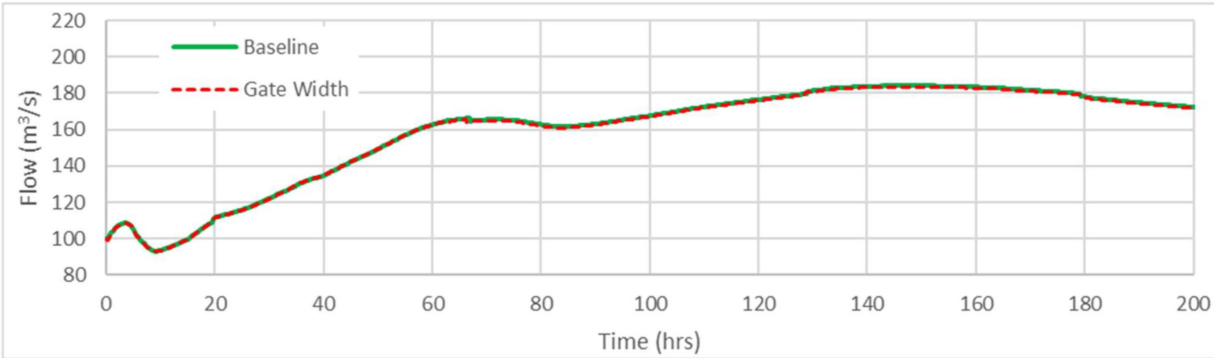



**Figure 4-5. River flow at Benson Weir, gate width reduction – 10% AEP**

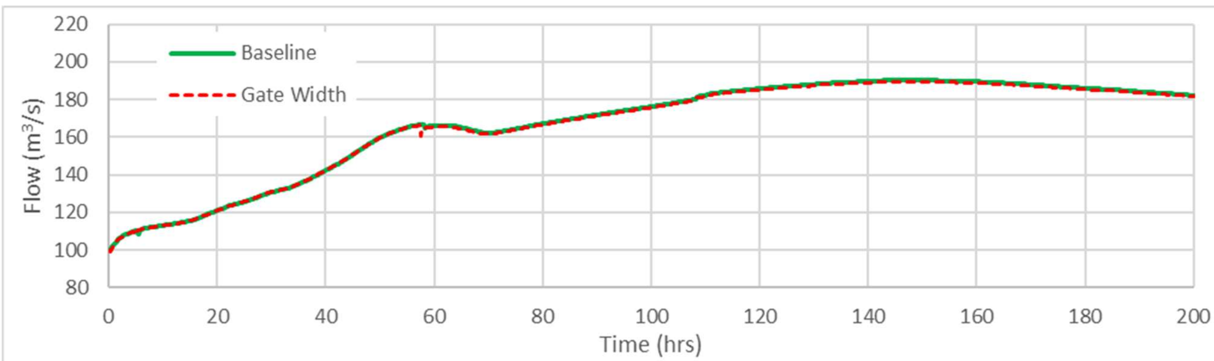



**Figure 4-6. River flow at Benson Weir, gate width reduction – 5% AEP**

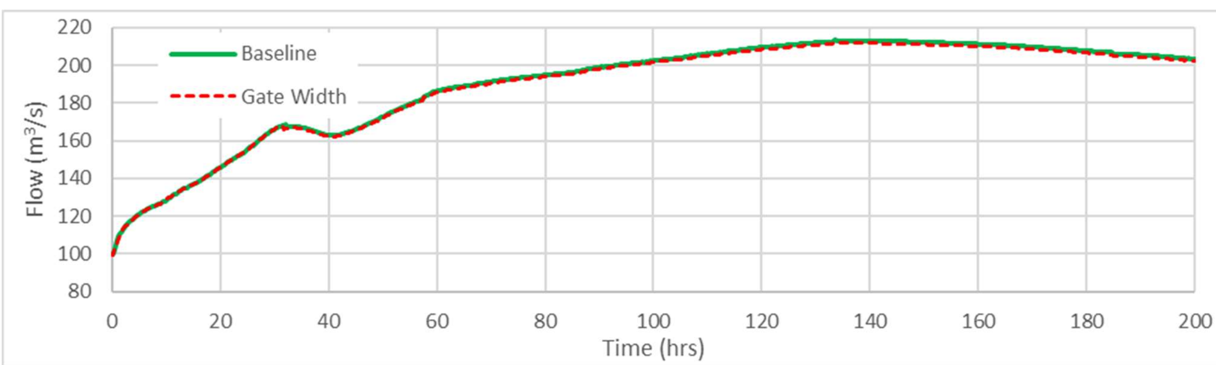



**Figure 4-7. River flow at Benson Weir, gate width reduction – 1% AEP**

# 5. Fish Pass Modelling (Flood Modelling)

The model schematisation was adjusted to represent the proposed fish pass as detailed in Figure 5-1. The width of the existing weir has been reduced by 5.75m to accommodate the fish pass which is modelled as a 5.75m wide spill unit with crest levels which represent the baffle, brush, and divider sections of the fish pass. The width of the cross section which represents the channel adjacent to Weir A has also been reduced to accommodate the fish pass.

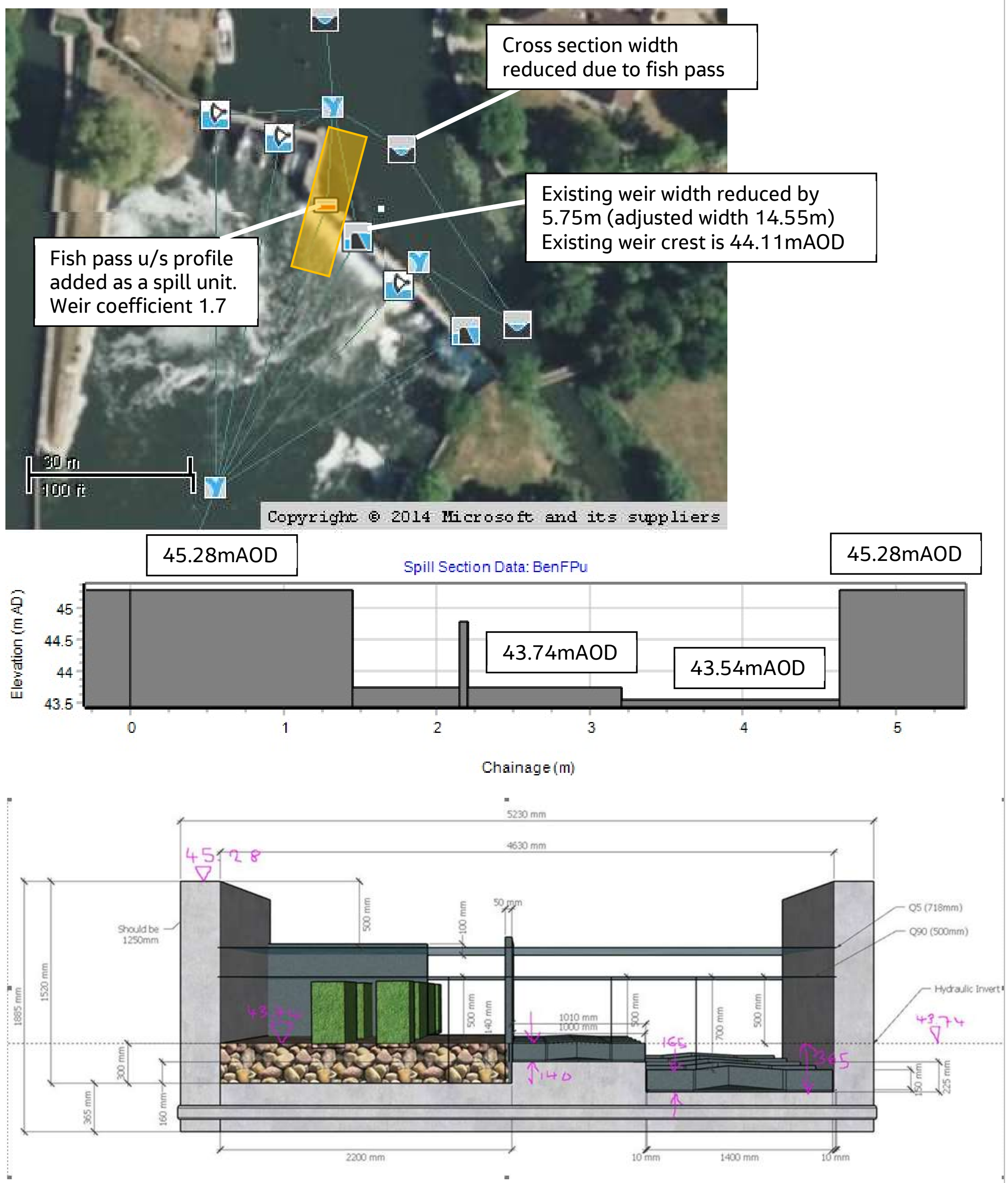



Figure 5-1. Fish pass model schematisation

The maximum river water levels predicted from the modelling and comparison between the baseline and fish pass scenario are detailed in Table 5-1 (50% to 3.3% AEP) and Table 3-11 (2% AEP to 1% AEP+31%) at the selected locations detailed in Figure 1-2. Maps which show the differences in the maximum floodplain water levels are detailed in Figure 5-2 (50% and 20% AEP), Figure 5-3 (10% and 5% AEP), Figure 5-4 (3.3% and 2% AEP), Figure 5-5 (1.3% and 1% AEP) , Figure 5-6 (0.5% AEP and 0.1% AEP) and Figure 5-7 (1% AEP+31%).

The modelling predicts negligible differences for the 50% to 1% AEP and 1% AEP +31%. The 0.5% AEP event showed a localised reduction of 0.05m immediately upstream of the weir. The 0.1% AEP event predicts an increase of 0.02m which extends downstream to the High Street bridge at Wallingford. The model is starting to show some oscillations in water level for the 0.1% AEP at the High Street bridge, which could be influencing the results.

Overall, the modelling predicts no/negligible changes to peak water levels (as indicated on the maps which show light green shading throughout the model), although there is some uncertainty with the 0.1% AEP model results.

**Table 5-1. Fish Pass: Peak water levels and differences to baseline (50% AEP to 3.3% AEP)**

| Ref | Location | 50% AEP | | | 20% AEP | | | 10% AEP | | | 5% AEP | | | 3.3% AEP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base (mAOD) | FP (mAOD) | Diff (m) | Base (mAOD) | FP (mAOD) | Diff (m) | Base (mAOD) | FP (mAOD) | Diff (m) | Base (mAOD) | FP (mAOD) | Diff (m) | Base (mAOD) | FP (mAOD) | Diff (m) |
| 1 | D/S Culham Lock | 48.82 | 48.82 | 0.00 | 49.10 | 49.10 | 0.00 | 49.27 | 49.27 | 0.00 | 49.43 | 49.43 | 0.00 | 49.53 | 49.53 | 0.00 |
| 2 | U/S Clifton Lock | 48.09 | 48.09 | 0.00 | 48.28 | 48.28 | 0.00 | 48.40 | 48.40 | 0.00 | 48.53 | 48.53 | 0.00 | 48.61 | 48.61 | 0.00 |
| 3 | D/S Clifton Lock | 47.53 | 47.53 | 0.00 | 47.88 | 47.88 | 0.00 | 48.10 | 48.10 | 0.00 | 48.29 | 48.29 | 0.00 | 48.41 | 48.41 | 0.00 |
| 4 | U/S Days Weir | 46.54 | 46.54 | 0.00 | 46.84 | 46.84 | 0.00 | 47.07 | 47.07 | 0.00 | 47.26 | 47.26 | 0.00 | 47.39 | 47.39 | 0.00 |
| 5 | D/S Days Weir | 46.33 | 46.33 | 0.00 | 46.66 | 46.66 | 0.00 | 46.94 | 46.94 | 0.00 | 47.15 | 47.15 | 0.00 | 47.28 | 47.28 | 0.00 |
| 6 | Thame confluence | 46.17 | 46.17 | 0.00 | 46.50 | 46.50 | 0.00 | 46.80 | 46.80 | 0.00 | 47.01 | 47.01 | 0.00 | 47.16 | 47.15 | -0.01 |
| 7 | D/S Wallingford Road | 45.44 | 45.44 | 0.00 | 45.71 | 45.71 | 0.00 | 45.94 | 45.94 | 0.00 | 46.09 | 46.09 | 0.00 | 46.20 | 46.20 | 0.00 |
| 8a | 770m u/s of Benson | 45.12 | 45.12 | 0.00 | 45.41 | 45.41 | 0.00 | 45.65 | 45.65 | 0.00 | 45.81 | 45.81 | 0.00 | 45.93 | 45.93 | 0.00 |
| 8 | U/S Benson Weir | 44.94 | 44.94 | 0.00 | 45.26 | 45.26 | 0.00 | 45.51 | 45.51 | 0.00 | 45.67 | 45.67 | 0.00 | 45.79 | 45.79 | 0.00 |
| 9 | D/S Benson Weir | 44.77 | 44.77 | 0.00 | 45.13 | 45.13 | 0.00 | 45.38 | 45.38 | 0.00 | 45.56 | 45.56 | 0.00 | 45.68 | 45.68 | 0.00 |
| 9a | 200m d/s Benson | 44.69 | 44.69 | 0.00 | 45.03 | 45.03 | 0.00 | 45.29 | 45.29 | 0.00 | 45.46 | 45.46 | 0.00 | 45.59 | 45.59 | 0.00 |
| 10 | U/S High Street | 44.51 | 44.51 | 0.00 | 44.86 | 44.86 | 0.00 | 45.12 | 45.12 | 0.00 | 45.29 | 45.29 | 0.00 | 45.41 | 45.41 | 0.00 |
| 11 | U/S Winterbrook Bridge | 43.90 | 43.90 | 0.00 | 44.23 | 44.23 | 0.00 | 44.48 | 44.48 | 0.00 | 44.65 | 44.65 | 0.00 | 44.77 | 44.77 | 0.00 |
| 12 | U/S Moulsford Railway | 43.26 | 43.26 | 0.00 | 43.53 | 43.53 | 0.00 | 43.74 | 43.74 | 0.00 | 43.90 | 43.90 | 0.00 | 44.02 | 44.02 | 0.00 |
| 13 | U/S Cleeve Weir | 42.67 | 42.67 | 0.00 | 42.80 | 42.80 | 0.00 | 42.89 | 42.89 | 0.00 | 43.03 | 43.03 | 0.00 | 43.13 | 43.13 | 0.00 |
| 14 | D/S Cleeve Weir | 42.06 | 42.06 | 0.00 | 42.27 | 42.27 | 0.00 | 42.48 | 42.48 | 0.00 | 42.67 | 42.67 | 0.00 | 42.81 | 42.81 | 0.00 |
| 15 | U/S Gatehamton Railway | 41.04 | 41.04 | 0.00 | 41.55 | 41.55 | 0.00 | 41.89 | 41.89 | 0.00 | 42.11 | 42.11 | 0.00 | 42.27 | 42.27 | 0.00 |
| 16 | U/S Whitchurch | 39.99 | 39.99 | 0.00 | 40.29 | 40.29 | 0.00 | 40.43 | 40.43 | 0.00 | 40.53 | 40.53 | 0.00 | 40.59 | 40.59 | 0.00 |
| 17 | Whitchurch Bridge | 39.71 | 39.71 | 0.00 | 39.93 | 39.93 | 0.00 | 40.08 | 40.08 | 0.00 | 40.18 | 40.18 | 0.00 | 40.25 | 40.25 | 0.00 |
| 18 | U/S Mapledurham Lock | 39.04 | 39.04 | 0.00 | 39.18 | 39.18 | 0.00 | 39.28 | 39.28 | 0.00 | 39.35 | 39.35 | 0.00 | 39.40 | 39.40 | 0.00 |
| 19 | D/S Mapledurham Lock | 38.49 | 38.49 | 0.00 | 38.75 | 38.75 | 0.00 | 38.93 | 38.93 | 0.00 | 39.04 | 39.04 | 0.00 | 39.11 | 39.11 | 0.00 |
| 20 | Caversham Bridge | 36.92 | 36.92 | 0.00 | 37.22 | 37.22 | 0.00 | 37.47 | 37.47 | 0.00 | 37.63 | 37.63 | 0.00 | 37.76 | 37.76 | 0.00 |

**Table 5-2. Fish Pass: Peak water levels and differences to baseline (2% to 0.1% AEP, 1% AEP +31%)**

| Ref | 2% AEP | | | 1.3% AEP | | | 1% AEP | | | 0.5% AEP | | | 0.1% AEP | | | 1% AEP +31% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Base (mAOD) | FP (mAOD) | Diff (m) | Base (mAOD) | FP (mAOD) | Diff (m) | Base (mAOD) | FP (mAOD) | Diff (m) | Base (mAOD) | FP (mAOD) | Diff (m) | Base (mAOD) | FP (mAOD) | Diff (m) | Base (mAOD) | FP (mAOD) | Diff (m) |
| 1 | 49.66 | 49.66 | 0.00 | 49.78 | 49.78 | 0.00 | 49.86 | 49.86 | 0.00 | 50.02 | 50.02 | 0.00 | 50.70 | 50.70 | 0.00 | 50.43 | 50.43 | 0.00 |
| 2 | 48.72 | 48.72 | 0.00 | 48.84 | 48.84 | 0.00 | 48.90 | 48.90 | 0.00 | 49.03 | 49.03 | 0.00 | 49.47 | 49.47 | 0.00 | 49.29 | 49.29 | 0.00 |
| 3 | 48.53 | 48.53 | 0.00 | 48.66 | 48.66 | 0.00 | 48.72 | 48.72 | 0.00 | 48.85 | 48.85 | 0.00 | 49.22 | 49.22 | 0.00 | 49.08 | 49.08 | 0.00 |
| 4 | 47.53 | 47.53 | 0.00 | 47.72 | 47.72 | 0.00 | 47.80 | 47.80 | 0.00 | 47.96 | 47.96 | 0.00 | 48.40 | 48.41 | 0.01 | 48.18 | 48.18 | 0.00 |
| 5 | 47.43 | 47.43 | 0.00 | 47.62 | 47.62 | 0.00 | 47.71 | 47.71 | 0.00 | 47.88 | 47.88 | 0.00 | 48.30 | 48.30 | 0.00 | 48.08 | 48.08 | 0.00 |
| 6 | 47.30 | 47.30 | 0.00 | 47.51 | 47.51 | 0.00 | 47.60 | 47.60 | 0.00 | 47.78 | 47.78 | 0.00 | 48.23 | 48.23 | 0.00 | 47.99 | 47.99 | 0.00 |
| 7 | 46.34 | 46.34 | 0.00 | 46.56 | 46.56 | 0.00 | 46.68 | 46.67 | -0.01 | 46.92 | 46.91 | -0.01 | 47.54 | 47.55 | 0.01 | 47.19 | 47.19 | 0.00 |
| 8a | 46.08 | 46.08 | 0.00 | 46.32 | 46.31 | -0.01 | 46.44 | 46.44 | 0.00 | 46.68 | 46.69 | 0.01 | 47.30 | 47.31 | 0.01 | 46.93 | 46.93 | 0.00 |
| 8 | 45.94 | 45.93 | -0.01 | 46.18 | 46.17 | -0.01 | 46.30 | 46.29 | -0.01 | 46.58 | 46.53 | -0.05 | 47.30 | 47.32 | 0.02 | 46.92 | 46.92 | 0.00 |
| 9 | 45.84 | 45.84 | 0.00 | 46.10 | 46.10 | 0.00 | 46.23 | 46.23 | 0.00 | 46.52 | 46.51 | -0.01 | 47.24 | 47.26 | 0.02 | 46.84 | 46.84 | 0.00 |
| 9a | 45.75 | 45.75 | 0.00 | 46.01 | 46.01 | 0.00 | 46.15 | 46.15 | 0.00 | 46.44 | 46.44 | 0.00 | 47.18 | 47.20 | 0.02 | 46.78 | 46.78 | 0.00 |
| 10 | 45.57 | 45.57 | 0.00 | 45.81 | 45.81 | 0.00 | 45.93 | 45.93 | 0.00 | 46.19 | 46.19 | 0.00 | 46.83 | 46.85 | 0.02 | 46.48 | 46.48 | 0.00 |
| 11 | 44.92 | 44.92 | 0.00 | 45.15 | 45.15 | 0.00 | 45.28 | 45.28 | 0.00 | 45.55 | 45.55 | 0.00 | 46.23 | 46.23 | 0.00 | 45.87 | 45.87 | 0.00 |
| 12 | 44.17 | 44.17 | 0.00 | 44.41 | 44.41 | 0.00 | 44.55 | 44.55 | 0.00 | 44.84 | 44.84 | 0.00 | 45.59 | 45.59 | 0.00 | 45.18 | 45.18 | 0.00 |
| 13 | 43.28 | 43.28 | 0.00 | 43.52 | 43.52 | 0.00 | 43.66 | 43.66 | 0.00 | 44.00 | 44.00 | 0.00 | 44.79 | 44.79 | 0.00 | 44.36 | 44.36 | 0.00 |
| 14 | 42.99 | 42.99 | 0.00 | 43.28 | 43.28 | 0.00 | 43.45 | 43.45 | 0.00 | 43.82 | 43.81 | -0.01 | 44.71 | 44.72 | 0.01 | 44.23 | 44.23 | 0.00 |
| 15 | 42.47 | 42.47 | 0.00 | 42.76 | 42.76 | 0.00 | 42.93 | 42.93 | 0.00 | 43.28 | 43.28 | 0.00 | 44.15 | 44.15 | 0.00 | 43.68 | 43.68 | 0.00 |
| 16 | 40.67 | 40.67 | 0.00 | 40.79 | 40.79 | 0.00 | 40.86 | 40.86 | 0.00 | 41.08 | 41.08 | 0.00 | 41.28 | 41.28 | 0.00 | 41.11 | 41.11 | 0.00 |
| 17 | 40.33 | 40.33 | 0.00 | 40.46 | 40.46 | 0.00 | 40.56 | 40.56 | 0.00 | 40.84 | 40.84 | 0.00 | 40.98 | 40.98 | 0.00 | 40.80 | 40.80 | 0.00 |
| 18 | 39.47 | 39.47 | 0.00 | 39.58 | 39.58 | 0.00 | 39.66 | 39.66 | 0.00 | 39.86 | 39.86 | 0.00 | 40.08 | 40.08 | 0.00 | 39.90 | 39.90 | 0.00 |
| 19 | 39.20 | 39.20 | 0.00 | 39.33 | 39.33 | 0.00 | 39.41 | 39.41 | 0.00 | 39.58 | 39.58 | 0.00 | 39.87 | 39.87 | 0.00 | 39.68 | 39.68 | 0.00 |
| 20 | 37.91 | 37.91 | 0.00 | 38.10 | 38.10 | 0.00 | 38.19 | 38.19 | 0.00 | 38.34 | 38.34 | 0.00 | 38.67 | 38.68 | 0.01 | 38.50 | 38.50 | 0.00 |


**Figure 5-2. Fish Pass: Changes to floodplain maximum water levels (50% and 20% AEP)**


**Figure 5-3. Fish Pass: Changes to floodplain maximum water levels (10% and 5% AEP)**


**Figure 5-4. Fish Pass: Changes to floodplain maximum water levels (3.3% and 2% AEP)**


**Figure 5-5. Fish Pass: Changes to floodplain maximum water levels (1.3% and 1% AEP)**

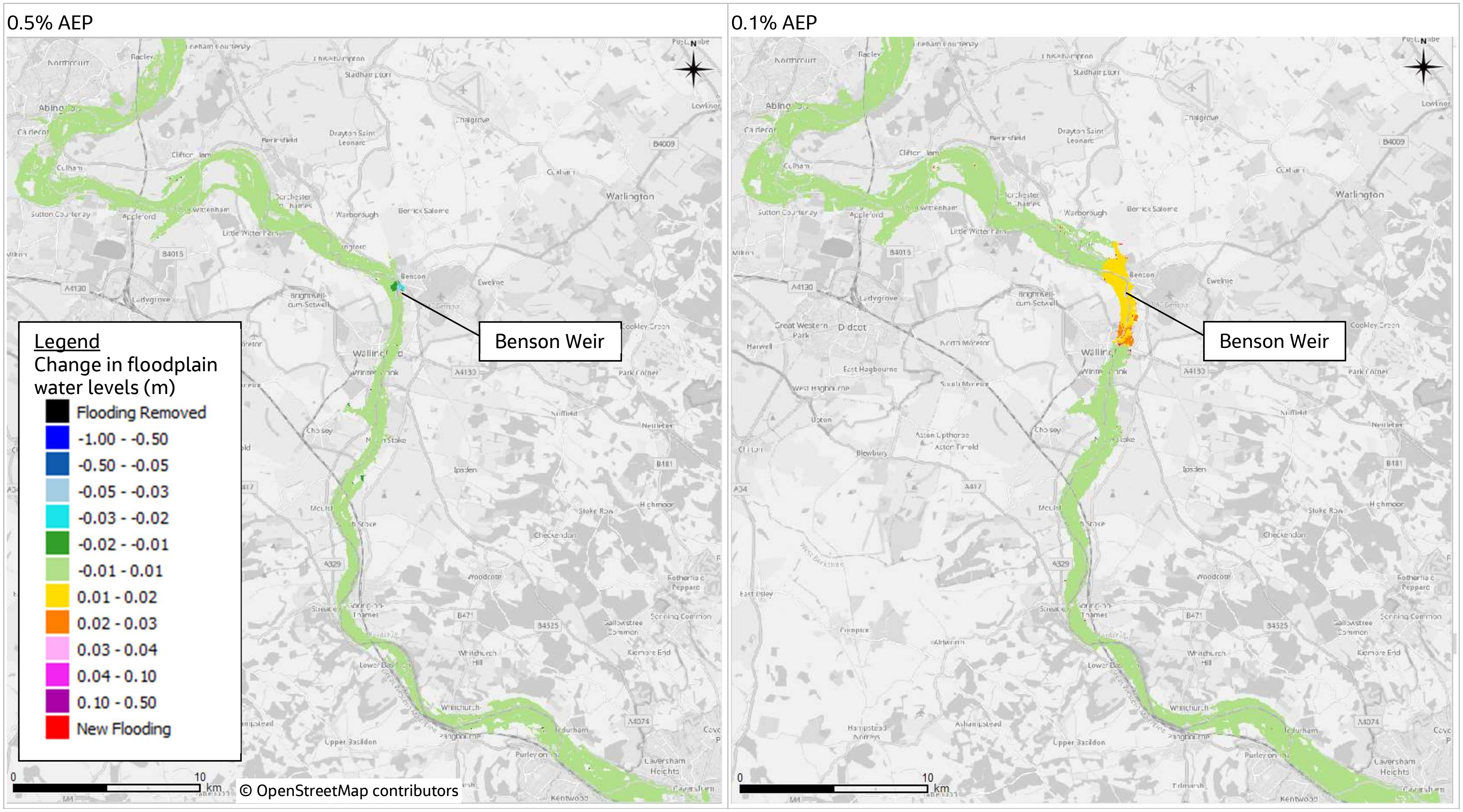



**Figure 5-6. Fish Pass: Changes to floodplain maximum water levels (0.5% and 0.1% AEP)**

1% AEP +31%

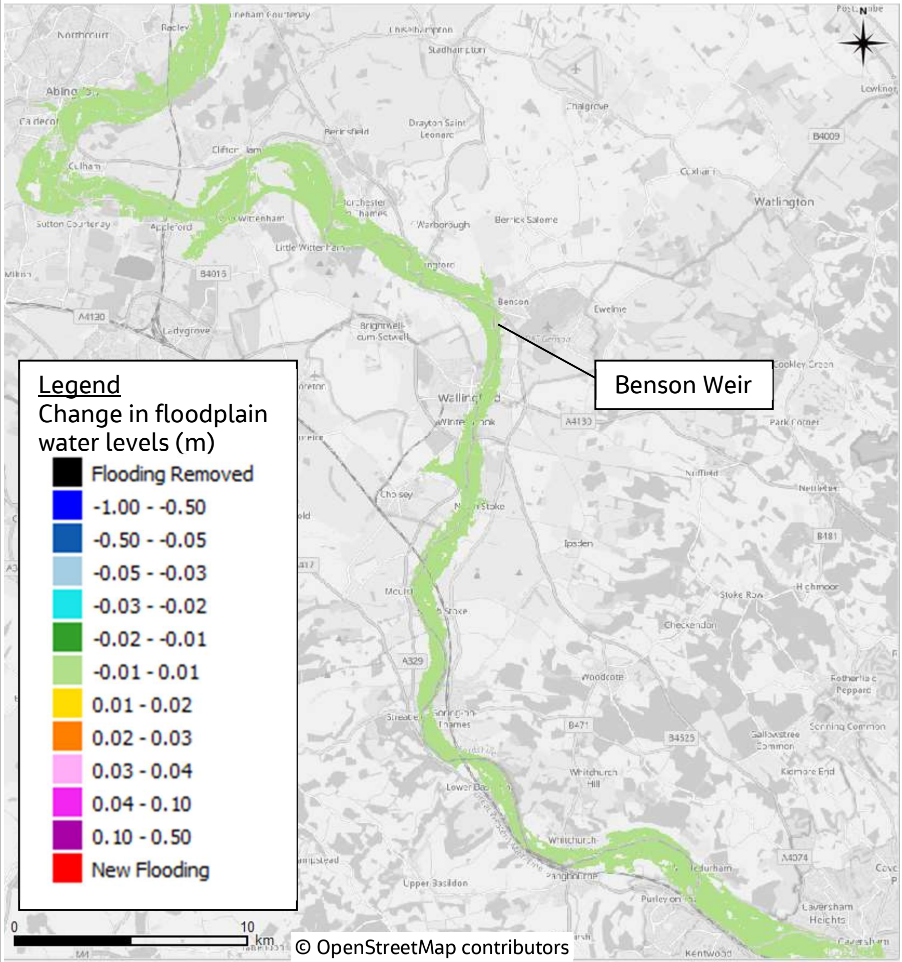



**Figure 5-7. Fish Pass: Changes to floodplain maximum water levels (1% AEP + 31%)**

# 6. Fish Pass (Low Flow Modelling)

To test the proposed fish pass under low flow conditions, a low flow model has been developed from the flood model. The model has been run for a range of low flows under baseline conditions and a scenario which represent the fish pass as a spill weir unit (as used in the flood modelling) and a rating curve based on data provided from the physical modelling[2].

## 6.1 Hydrometric data

Gauge data has been provided by the Environment Agency at Sutton Courtney, Days Weir and Wheatley (flow data) and Benson Weir (level data). The standard head water level (SHWL) and tail water level (STWL) at Benson Weir is 44.19mAODmAOD and 42.32mAOD (datum used for tail water levels 40.19mAOD).

### 6.1.1 Low flow estimates

Table 6-1 provides a summary of flow estimates ranging from Q5 to Q95 at Benson Weir. The flows were calculated using flow data from the flow records at Days Weir and Wheatley (Wheatley gauge is located on the River Thame, catchment area weighting was applied to derive flow estimates at the Thames confluence).

**Table 6-1. Low flow estimates upstream of Benson Weir**

| Percentile | Flow ($m^3/s$) |
|---|---|
| 5 | 118.00 |
| 10 | 82.90 |
| 20 | 52.10 |
| 50 | 19.40 |
| 70 | 10.50 |
| 90 | 5.40 |
| 95 | 4.30 |

### 6.1.2 Benson Weir water levels

Recorded levels for ‘daily mean stage’ have been provided at Benson Weir for December 1995 to September 2021. Figure 6-1 details the recorded daily mean water levels upstream (head) of Benson Weir (stage values added to SHWL datum). The Environment Agency also provided the equivalent ‘exceeding probabilities stages’ at Benson Weir (head and tail) which are summarised in Table 6-2.

[2] Benson_rating curves_1400_1000_0.08.xlsx, Dr.-Ing. Reinhard Hassinger, 16th Jan 2023

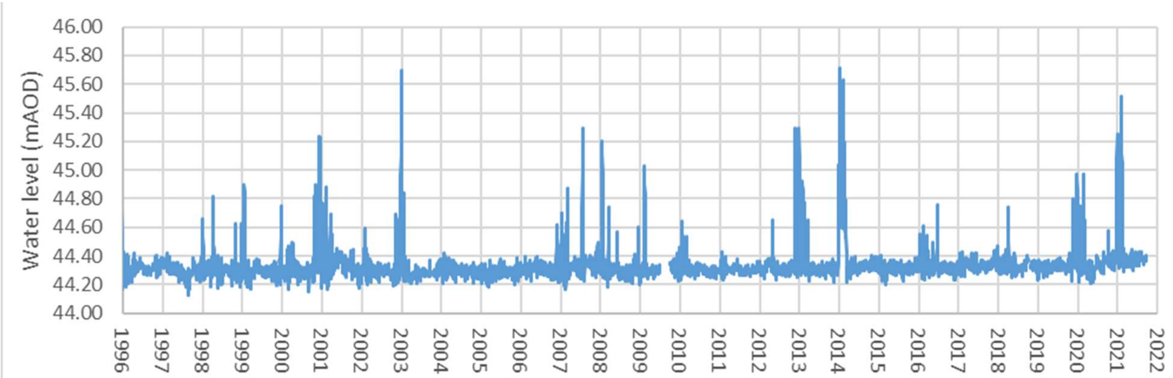



**Figure 6-1. Benson Weir recorded daily mean water level (head)**

**Table 6-2. Benson Weir exceeding probabilities**

| Percentile | Benson Weir head | | Benson Weir tail | |
|---|---|---|---|---|
| | Stage (m) | Level (mAOD) | Stage (m) | Level (mAOD) |
| 5 | 0.288 | 44.478 | 3.926 | 44.116 |
| 10 | 0.202 | 44.392 | 3.364 | 43.554 |
| 20 | 0.166 | 44.356 | 2.774 | 42.964 |
| 30 | 0.147 | 44.337 | 2.527 | 42.717 |
| 40 | 0.134 | 44.324 | 2.402 | 42.592 |
| 50 | 0.122 | 44.312 | 2.331 | 42.521 |
| 60 | 0.110 | 44.300 | 2.290 | 42.480 |
| 70 | 0.100 | 44.290 | 2.259 | 42.449 |
| 80 | 0.088 | 44.278 | 2.228 | 42.418 |
| 90 | 0.070 | 44.260 | 2.176 | 42.366 |
| 95 | 0.053 | 44.243 | 2.113 | 42.303 |
| 98 | 0.028 | 44.218 | 1.410 | 41.600 |
| 99 | 0.008 | 44.198 | 1.410 | 41.600 |
| Extreme Values | | | | |
| 99.50 | -0.007 | 44.183 | 1.410 | 41.600 |
| 99.90 | -0.038 | 44.152 | 1.410 | 41.600 |
| 99.95 | -0.056 | 44.134 | 1.410 | 41.600 |
| 99.99 | -0.115 | 44.075 | 0.000 | 40.190 |

## 6.2 Fish Pass low flow scenarios

The river Thames reach from Days Weir to Cleeve Lock has been extracted from the 1D flood model. The flows detailed in Table 6-1 are input to the model as upstream boundary conditions at Days Weir and a water level boundary of 41.42m applied downstream of Cleeve Lock (STWL).

The logical rules for the movable structures at Benson Weir have been represented using target lower/upper water levels based on an offset of 0.15m above the SHWL of 44.19mAOD (target water levels 44.34mAOD to 44.39mAOD). For each flow tested, the model will open/close gates until the water level is between the specified lower/upper water level band. A similar set of logical rules were applied at Cleeve Lock (based on Cleeve Lock SHWL of 42.32mAOD).

The model configuration detailed above was run to represent the baseline conditions.

The fish pass modelling assessed two scenarios which tested different methods to represent the fish pass. The low flow modelling tested using a spill unit, which is the identical approach used in the flood modelling (refer to section 5) and a rating curve based on the physical modelling. For both scenarios the width of the existing weir and cross section which represents the channel adjacent to Weir A has been reduced to accommodate the fish pass. The water level and flow data for the rating curve is detailed in Table 6-3, note that the rating curve approach was not used for the flood model as the physical modelled tested flows for Q5 – Q95.

**Table 6-3. Fish pass physical model water levels and flows**

| Percentile | Total Flow ($m^3/s$) | Physical model data at fish pass | |
|---|---|---|---|
| | | Water level (mAOD) | Fish pass flow ($m^3/s$) |
| 5 | 118.0 | 44.478 | 5.940 |
| 10 | 82.9 | 44.393 | 4.620 |
| 50 | 19.4 | 44.311 | 3.560 |
| 90 | 5.4 | 44.260 | 2.990 |
| 95 | 4.3 | 44.243 | 2.810 |

## 6.3 Fish Pass low flow results

Table 6-4 provides the modelled water levels and comparison to the SHWL for the baseline and fish pass scenarios. Figure 6-2 compares the Environment Agency lock exceeding probability headwater levels (black line) against the headwater levels for the modelled baseline (red line), fish pass represented as a spill (green line) and fish pass represented with the rating curve (orange line). This assumes that the percentile flow statistics can be directly aligned to the exceeding probability water levels.

The baseline results show that for the flow range tested, the operation of the moveable structures could be set to maintain the water level to the target band for flows between Q10 and Q70. For the larger Q5 flow, the model predicts all gates would need to be fully open to try and maintain the target level (the modelled water level is above the target level). For Q90 and Q95, the model predicts all gates to be fully closed as water levels are below the lower limit of the target water level i.e., water levels are now controlled by spilling over the top of the closed gates and fixed crest overfall weirs.

Both fish pass methods tested show similar results, the modelling predicts that for flows larger than Q70 the river flows are sufficient for the structures to control water levels to the target band. For flows smaller than Q70, the moveable structures would be fully closed, the model predicts water levels to be lower than the baseline (0.04/0.05m lower). However, the water levels for the fish pass scenarios are still above the SHWL (0.05m for Q90 and 0.03/0.02m for Q95).

**Table 6-4. Benson Weir water levels for low flows (model node = 41.001)**

| Exceeding probabilities | | | Modelled Water levels (mAOD) and difference to SHWL (m) | | | | | |
|---|---|---|---|---|---|---|---|---|
| Percentile | Water level (mAOD) | Total flow ($m^3/s$) | Baseline WL | Difference to SHWL (m) | Fish Pass (spill) | Difference to SHWL (m) | Fish Pass (rating) | Difference to SHWL (m) |
| 5 | 44.478 | 118.0 | 44.36 | 0.17 | 44.35 | 0.16 | 44.34 | 0.15 |
| 10 | 44.392 | 82.9 | 44.30 | 0.11 | 44.30 | 0.11 | 44.31 | 0.12 |
| 20 | 44.356 | 52.1 | 44.33 | 0.14 | 44.31 | 0.12 | 44.34 | 0.15 |
| 50 | 44.312 | 19.4 | 44.30 | 0.11 | 44.30 | 0.11 | 44.32 | 0.13 |
| 70 | 44.290 | 10.5 | 44.33 | 0.14 | 44.33 | 0.14 | 44.32 | 0.13 |
| 90 | 44.260 | 5.4 | 44.28 | 0.09 | 44.24 | 0.05 | 44.24 | 0.05 |
| 95 | 44.243 | 4.3 | 44.26 | 0.07 | 44.22 | 0.03 | 44.21 | 0.02 |

It is understood that lock keepers attempt to hold the water level around 6” (0.15m) above SHWL. The low flow model represents this situation using the logical rules to change gate openings to maintain the water level within the target band, which was taken as SHWL +0.10m to SHWL +0.15m.

As shown in Figure 6-2, the model predicts the water level to drop below the lower target band (SHWL +0.10m), for flows smaller than say Q85 for baseline, which reduces to around Q77 for the fish pass (note the model has not been run using flows between Q70 and Q90).

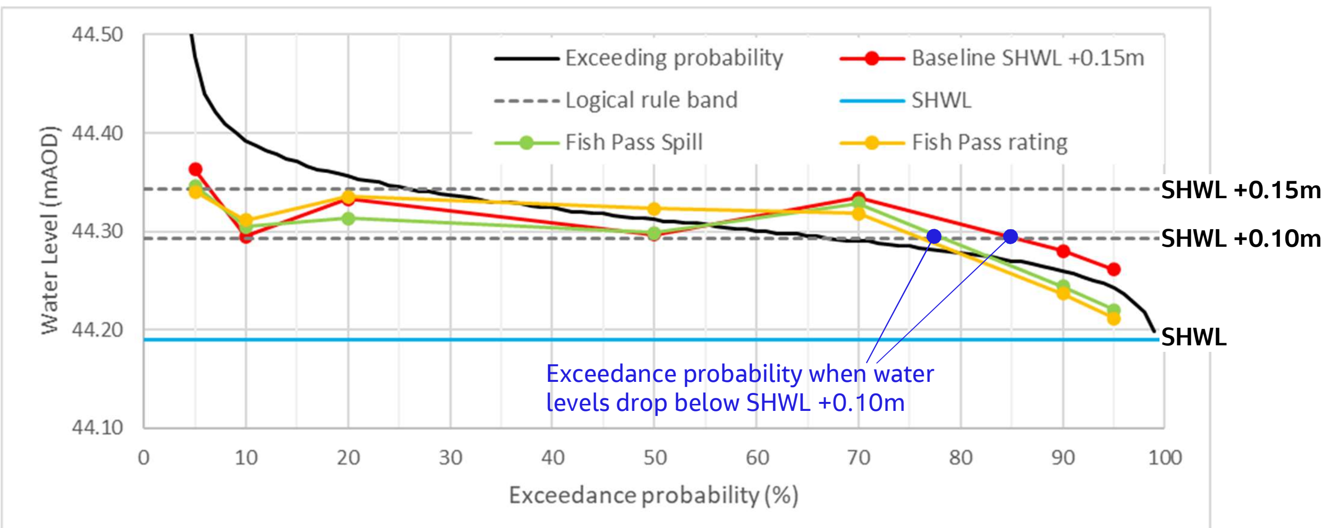



**Figure 6-2. Benson Weir comparison of headwater levels**

# 7. Concluding remarks

The existing 2017 hydraulic model developed for Thames (Sandford to Reading Bridge) has been re-used to assess the potential impacts of temporary works whilst sets of radial gates at Benson Weir are replaced and temporary/permanent works for the proposed fish pass.

The following conclusions can be drawn from the modelling

<u>Baseline modelling</u>

- To improve model run times for this assessment and future modelling (fish pass and temporary works modelling), the existing 2017 model baseline design events were re-run using the latest software versions with the mass balance corrector switched off.
- Comparison of the maximum water levels between the re-runs and 2017 results for the 50% to 1% AEP events show small differences, which are assumed to be attributed to improvements in the modelling software. The model re-runs have improved the overall mass balance for all AEP events.
- For the 0.5% and 0.1% AEP events, the differences between the existing 2017 results and the re-runs are larger at localised locations within the model.
- The 2017 study reported problems with the model for the extreme flows (1% AEP with climate change and the 0.1% AEP event) and used different models which applied a simplified 1D model schematisation around Benson, Goring, Whitchurch and Mapledurham Locks. The model re-runs used the base model for the 0.5% AEP and the simplified model for the 0.1% AEP (i.e., same models used as the 2017 study).
- Although the re-runs have shown to improve the mass balance (due to the new software versions), stability issues are partly re-introduced using the new software version for the 0.5% and 0.1% AEP events.
- Based on the location of the stability problem for the 0.5% AEP (Whitchurch Lock), the model results for the 0.5% AEP are considered appropriate for testing scenarios at Benson Weir. For the 0.1% AEP the results should be used with caution, given the oscillations in water levels during peak flows which occur at multiple locations throughout the model.
- Future studies which aim to improve the model should consider using the simplified model version for the 0.5% AEP event and review the locations of oscillations in levels/flow for the 0.1% AEP. Example methods to try and Improve the model could add additional roughness stability patches or reduce cross section spacings of the 1D model (interpolates or new sections).

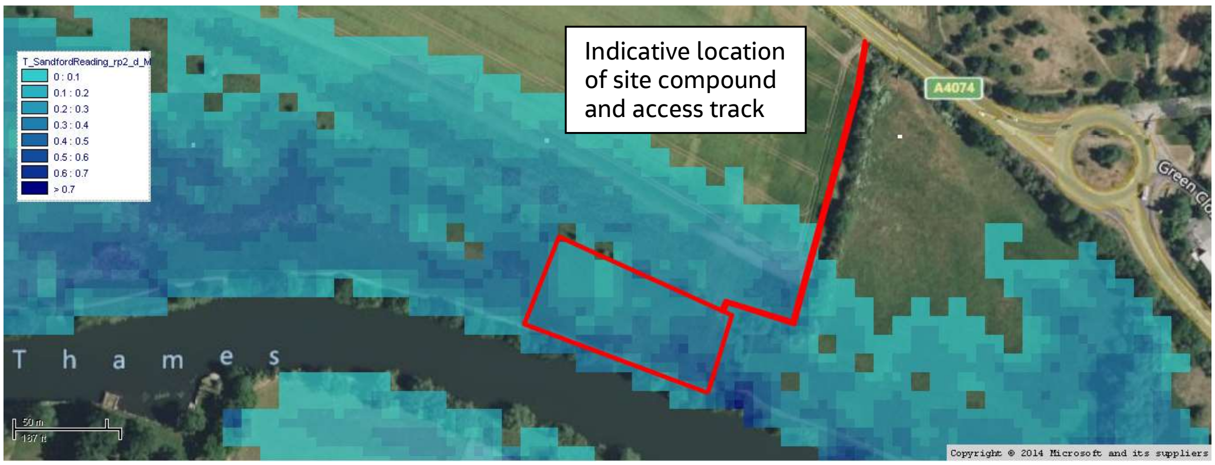
<u>Temporary works scenarios</u>

- Temporary works scenarios have been modelled to represent the closure/damming to sets of gate bays for gate replacement and a cofferdam at the weir during the construction phase of the fish pass.

- Scenario A1: full blockage of 1 deep radial gate at Weir A
  - Predicts negligible differences downstream of Benson Weir for all AEP events.
  - The largest increase in water level of 0.05m is predicted immediately upstream of Benson Weir for the 50% AEP with 0.04m for the 20% and 1% AEP
  - The floodplain maps show the largest floodplain level increase to occur for the 50% AEP event (up to 0.09m), locally on the right bank floodplain at Benson Weir. The modelling predicts flood depths at properties on the left bank at Benson Weir to increase up to 0.03m (1% AEP).
  - The modelling predicts the impacts to extend upstream to Wallingford Bridge.

- Scenario A2: full blockage of 2 deep radial gates at Weir A
  - Predicts negligible differences downstream of Benson Weir for all AEP events.
  - Upstream impacts are higher the Scenario A1
  - The largest increase in water level of 0.11m is predicted immediately upstream of Benson Weir for the 50% AEP. The largest increase at Benson Weir for the 20% to 1% AEP is 0.08m to 0.05m. For the higher flow events (0.5%, 0.1% and 1% AEP +31%) the modelling predicts negligible differences at Benson Weir.
  - The floodplain maps show the largest floodplain level increase to occur for the 50% AEP event (up to 0.22m), locally on the right bank floodplain at Benson Weir. The modelling predicts flood depths at properties on the left bank at Benson Weir to increase up to 0.06m (1% AEP).
  - The modelling predicts the impacts to extend upstream to Days Weir, with the largest increase at the River Thame confluence of 0.02m for the 20% and 10% AEP events.

- Scenario B: full blockage of 2 hand radial gates at Weir B
  - Predicts negligible differences all AEP events. The changes in floodplain peak water level are only predicted for the 50% AEP event, where there is up to 0.02m increase on the right bank active floodplain at Benson Weir.
- Scenario C: 50% blockage of the existing 20.3m wide weir
  - Predicts the largest increase in river water level to occur locally upstream of Benson Weir of 0.05m for the 1% AEP event, all other modelled events predict an increase of 0.01/0.02m.
- Site Compound: The site compound is located within the existing 50% AEP floodplain, where the model predicts floodplain depths up to 0.5m (for the 50% AEP) at the southern edge of the compound. The temporary works for the deep radial gates are predicted to further increase the 50% AEP flood depths at the compound area. Scenario A1 (1 deep radial gate blocked) predicts a further increase of 0.03m and Scenario A2 (2 deep radial gates blocked) a further increase of 0.06m.




Gate width sensitivity test

- As a sensitivity test, the model has been run with each induvial gate at Benson Weir reduced by 0.09m. This is considered a worst-case scenario as all gate widths have been reduced for the test, whereas the replacement is proposed for only the Weir A gates.
- The test has been run for the 10%, 5% and 1% AEP events and the modelling predicted negligible impacts to the maximum water levels.

Fish Pass

- Under flood conditions, the modelling predicts negligible differences for the 50% to 1% AEP and 1% AEP +31% events.
- The 0.5% AEP event showed a localised reduction of 0.05m immediately upstream of the weir.
- The 0.1% AEP event predicts an increase of 0.02m which extends downstream to the High Street bridge at Wallingford. The model is starting to show some oscillations in water level for the 0.1% AEP at the High Street bridge, which could be influencing the results.
- It is understood that lock keepers attempt to hold the water level around 6” (0.15m) above SHWL. The low flow model represents this situation using the logical rules to change gate openings to maintain the water level within the target band, which was taken as SHWL +0.10m to SHWL +0.15m.
- The model predicts the water level to drop below the lower target band (SHWL +0.10m), for flows smaller than say Q85 for baseline, which reduces to around Q77 for the fish pass (note the model has not been run using flows between Q70 and Q90).
- For the lower flows (smaller than the Q85 and Q77 stated above), once all the moveable structures are fully closed, the model predicts the fish pass water levels to be 0.04/0.05m lower than the current baseline. However, the water levels for the fish pass scenarios are still above the SHWL (0.05m for Q90 and 0.03/0.02m for Q95).

# 8. References

The following documents and reports have been referenced:


- Abingdon Flood Schemes - River Thames Modelling Report, CH2M, June 2017
- Benson_rating curves_1400_1000_0.08.xlsx, Dr.-Ing. Reinhard Hassinger, 16th Jan 2023

# Appendix A. Flood Modeller and TUFLOW key files

**Table A-1. Flood Modeller and TUFLOW files (baseline)**

| File | Baseline |
| --- | --- |
| Run (ief/tcf) and results name | T_SandfordReading_rp2<br>T_SandfordReading_rp5<br>T_SandfordReading_rp10<br>T_SandfordReading_rp20<br>T_SandfordReading_rp30<br>T_SandfordReading_rp50<br>T_SandfordReading_rp75<br>T_SandfordReading_rp100<br>T_SandfordReading_rp100cc31<br>T_SandfordReading_rp200<br>T_SandfordReading_rp1000 |
| 1D Datafile (same as 2017 study) | T_Ab_v16.DAT (50% AEP to 0.5% AEP) and T_Ab_v16e.DAT (0.1% AEP) |
| 1D Initial conditions | T_Ab_v16_100.iic |
| IED File (Event)<br><br>(same as 2017 study, apart from 100 year + 31%, based on latest guidance) | v2_Thames_2yr.IED<br>v1_Thames_5yr.IED<br>v1_Thames_20yr.IED<br>v1_Thames_30yr.IED<br>v1_Thames_50yr.IED<br>v2_Thames_10yr.IED<br>v2_Thames_75yr.IED<br>v2_Thames_100yr.IED<br>v2_Thames_100yr_31pc.IED<br>v2_Thames_200yr.IED<br>v2_Thames_1000yr.IED |
| IED File | - |
| TGC file (same as 2017 study) | TSM_v13.tgc (50% AEP to 0.5% AEP) and TSM_v13c.tgc (0.1% AEP) |
| TBC file (same as 2017 study) | TSM_v12.tbc (50% AEP to 0.5% AEP) and TSM_v12d.tbc (0.1% AEP) |
| TMF file (same as 2017 study) | Thames_Abingdon_v2.tmf |
| Time steps (same as 2017 study) | 1D 2.5 seconds and 2D 5 seconds |

**Table A-2. Flood Modeller and TUFLOW files (Scenario 1 of 2)**

| File | Scenario A1 | Scenario A2 | Scenario B | Scenario C |
|---|---|---|---|---|
| Run (ief/tcf) and results name | Benson_WeirA_1Removed_rp2<br>Benson_WeirA_1Removed_rp5<br>Benson_WeirA_1Removed_rp10<br>Benson_WeirA_1Removed_rp20<br>Benson_WeirA_1Removed_rp30<br>Benson_WeirA_1Removed_rp50<br>Benson_WeirA_1Removed_rp75<br>Benson_WeirA_1Removed_rp100<br>Benson_WeirA_1Removed_rp100cc31<br>Benson_WeirA_1Removed_rp200<br>Benson_WeirA_1Removed_rp1000 | Benson_WeirA_2Removed_rp2<br>Benson_WeirA_2Removed_rp5<br>Benson_WeirA_2Removed_rp10<br>Benson_WeirA_2Removed_rp20<br>Benson_WeirA_2Removed_rp30<br>Benson_WeirA_2Removed_rp50<br>Benson_WeirA_2Removed_rp75<br>Benson_WeirA_2Removed_rp100<br>Benson_WeirA_2Removed_rp100cc31<br>Benson_WeirA_2Removed_rp200<br>Benson_WeirA_2Removed_rp1000 | Benson_WeirB_2Removed_rp2<br>Benson_WeirB_2Removed_rp5<br>Benson_WeirB_2Removed_rp10<br>Benson_WeirB_2Removed_rp20<br>Benson_WeirB_2Removed_rp30<br>Benson_WeirB_2Removed_rp50<br>Benson_WeirB_2Removed_rp75<br>Benson_WeirB_2Removed_rp100<br>Benson_WeirB_2Removed_rp100cc31<br>Benson_WeirB_2Removed_rp200<br>Benson_WeirB_2Removed_rp1000 | Benson_WeirB_Overfall_rp2<br>Benson_WeirB_Overfall_rp5<br>Benson_WeirB_Overfall_rp10<br>Benson_WeirB_Overfall_rp20<br>Benson_WeirB_Overfall_rp30<br>Benson_WeirB_Overfall_rp50<br>Benson_WeirB_Overfall_rp75<br>Benson_WeirB_Overfall_rp100<br>Benson_WeirB_Overfall_rp100cc31<br>Benson_WeirB_Overfall_rp200<br>Benson_WeirB_Overfall_rp1000 |
| 1D Datafile (same as 2017 study) | T_Ab_v16.DAT (50% AEP to 0.5% AEP) and T_Ab_v16e.DAT (0.1% AEP and 1% AEP +31%) | | | |
| 1D Initial conditions | T_Ab_v16_100.iic | | | |
| IED File (Event) (same as 2017 study, apart from 100 year + 31%, based on latest guidance) | v2_Thames_2yr.IED, v1_Thames_5yr.IED<br>v1_Thames_20yr.IED, v1_Thames_30yr.IED<br>v1_Thames_50yr.IED, v2_Thames_10yr.IED<br>v2_Thames_75yr.IED, v2_Thames_100yr.IED<br>v2_Thames_100yr_31pc.IED<br>v2_Thames_200yr.IED, v2_Thames_1000yr.IED | | | |
| IED File (Gates) | BensonWeirA_Close_1_Gate | BensonWeirA_Close_2_Gates | BensonWeirB_Close_2_Gates | BensonWeirB_Overfall_50pcBlocked |
| TGC file (same as 2017 study) | TSM_v13.tgc (50% AEP to 0.5% AEP) and TSM_v13c.tgc (0.1% AEP) | | | |
| TBC file (same as 2017 study) | TSM_v12.tbc (50% AEP to 0.5% AEP) and TSM_v12d.tbc (0.1% AEP) | | | |
| TMF file (same as 2017 study) | Thames_Abingdon_v2.tmf | | | |
| Time steps (same as 2017 study) | 1D 2.5 seconds and 2D 5 seconds | | | |

**Table A-3. Flood Modeller and TUFLOW files (Scenario 2 of 2)**

| File | Gate width test | Fish Pass |
|---|---|---|
| Run (ief/tcf) and results name | T_SandfordReading_rp10_GateWidth<br>T_SandfordReading_rp20_GateWidth<br>T_SandfordReading_rp100_GateWidth | Benson_FishPass_v1_rp2<br>Benson_FishPass_v1_rp5<br>Benson_FishPass_v1_rp10<br>Benson_FishPass_v1_rp20<br>Benson_FishPass_v1_rp30<br>Benson_FishPass_v1_rp50<br>Benson_FishPass_v1_rp75<br>Benson_FishPass_v1_rp100<br>Benson_FishPass_v1_rp100cc31<br>Benson_FishPass_v1_rp200<br>Benson_FishPass_v1_rp1000 |
| 1D Datafile (same as 2017 study) | T_Ab_v16.DAT (50% AEP to 0.5% AEP) and<br>T_Ab_v16e.DAT (0.1% AEP and 1% AEP +31%) | T_Ab_v16_FishPass_v1.DAT (50% AEP to 0.5% AEP) and<br>T_Ab_v16e_FishPass_v1.DAT (0.1% AEP and 1% AEP +31%) |
| 1D Initial conditions | T_Ab_v16_100.iic | |
| IED File (Event) (same as 2017 study, apart from 100 year + 31%, based on latest guidance) | v2_Thames_2yr.IED, v1_Thames_5yr.IED<br>v1_Thames_20yr.IED, v1_Thames_30yr.IED<br>v1_Thames_50yr.IED, v2_Thames_10yr.IED<br>v2_Thames_75yr.IED, v2_Thames_100yr.IED<br>v2_Thames_100yr_31pc.IED<br>v2_Thames_200yr.IED, v2_Thames_1000yr.IED | |
| IED File (Gates) | BensonWeir_GateWidth.IED | N/A – updated DAT file incorporates the fish pass |
| TGC file (same as 2017 study) | TSM_v13.tgc (50% AEP to 0.5% AEP) and TSM_v13c.tgc (0.1% AEP) | |
| TBC file (same as 2017 study) | TSM_v12.tbc (50% AEP to 0.5% AEP) and TSM_v12d.tbc (0.1% AEP) | |
| TMF file (same as 2017 study) | Thames_Abingdon_v2.tmf | |
| Time steps (same as 2017 study) | 1D 2.5 seconds and 2D 5 seconds | |

# Appendix B. 1D2D Model performance

## B.1 1D Model

The models run well with 1D convergence similar to the original 2017 study. Figure B-1 shows the 1D convergence graphs for the 20%, 5%, 1% and 0.1% AEP events for the new 2022 baseline and Scenario A1/A2. Figure B-2 shows the 1D convergence graphs for Scenario B/C and Figure B-3 shows the 1D convergence graphs for the gate width reduction sensitivity test and the fish pass.

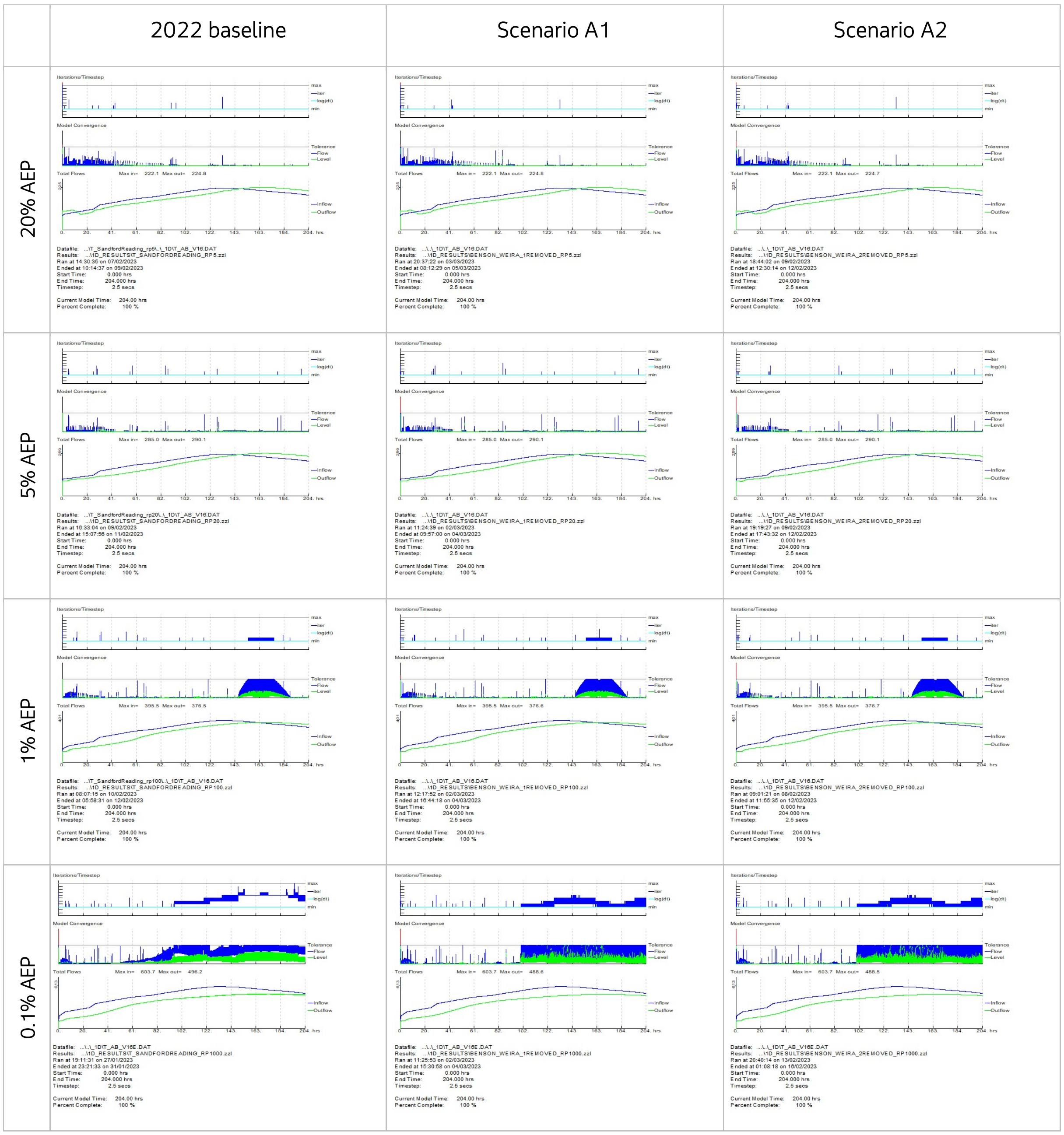



**Figure B-1. 1D model convergence graphs (baseline, Scenario A and B)**

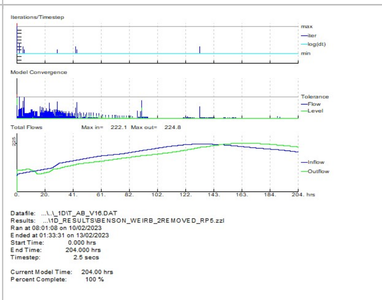
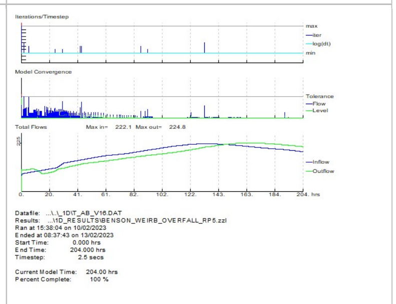
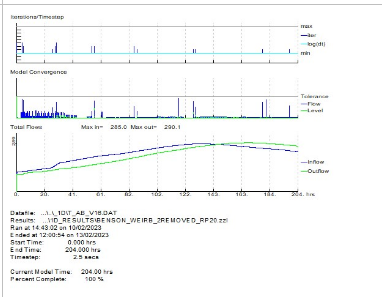
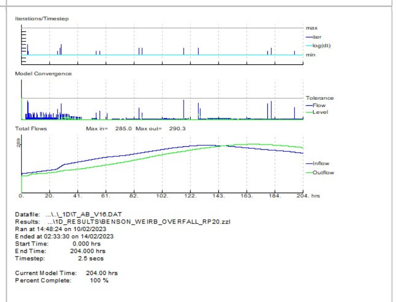
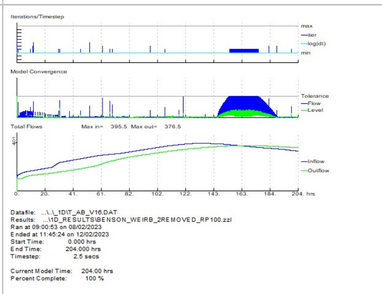
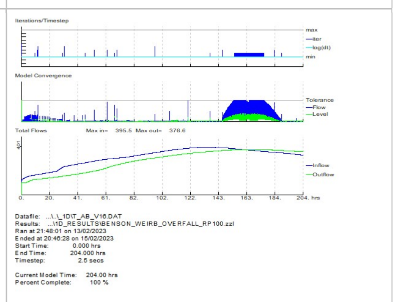
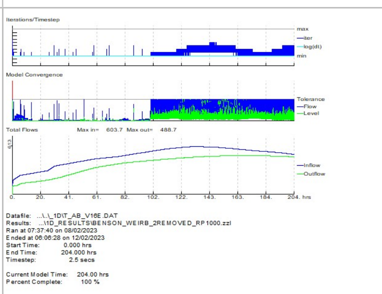
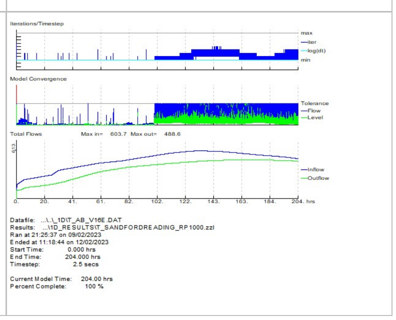
| | Scenario B | Scenario C |
|---|---|---|
| 20% AEP |  |  |
| 5% AEP |  |  |
| 1% AEP |  |  |
| 0.1% AEP |  |  |

**Figure B-2. 1D model convergence graphs (Scenario C and D)**

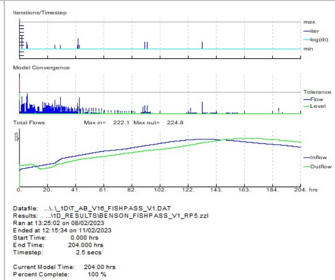
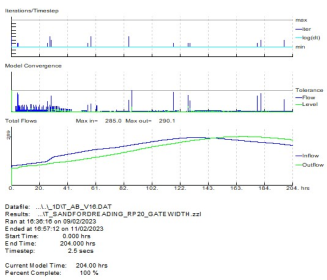
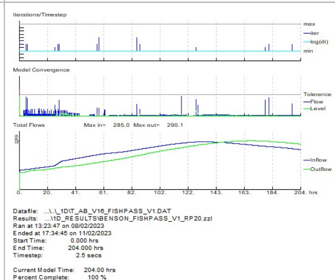
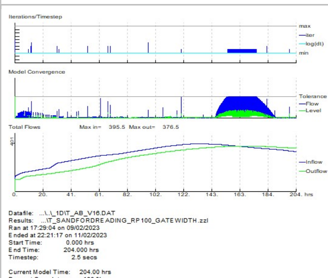
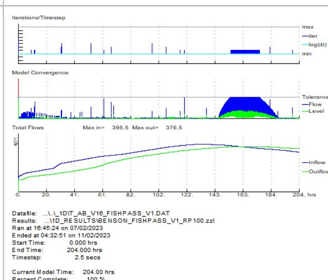
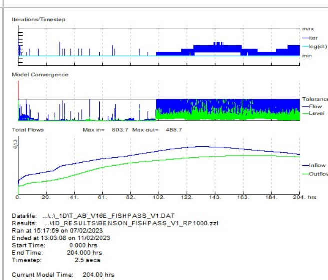
| | Gate width reduction | Fish Pass |
|---|---|---|
| 20% AEP | N/A |  |
| 5% AEP |  |  |
| 1% AEP |  |  |
| 0.1% AEP | N/A |  |

**Figure B-3. 1D model convergence graphs (Gate width reduction and fish pass)**

## B.2 2D Model

The 2D output of cumulative mass error are detailed in Figure B-4 (baseline, includes an inset from the 2017 modelling report), Figure B-5 (Scenario A1), Figure B-6 (Scenario A2), Figure B-7 (Scenario B), Figure B-8 (Scenario C), Figure B-9 (Gate Width) and Figure B-10 (Fish Pass).

The mass balance is within the +/-1% target and shows an improvement compared to the 2017 study, which is due to the new software versions and removal of the 'mass balance corrector' option.

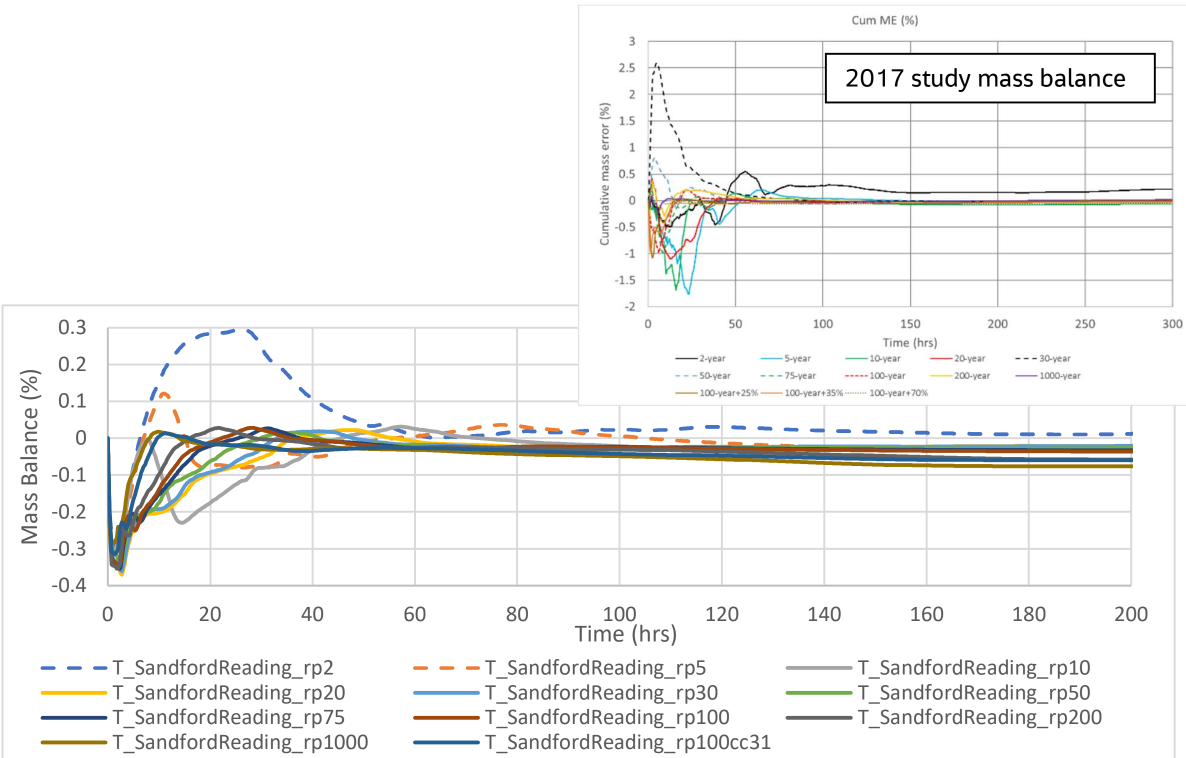



**Figure B-4. 2D Mass balance: 2022 baseline re-run**

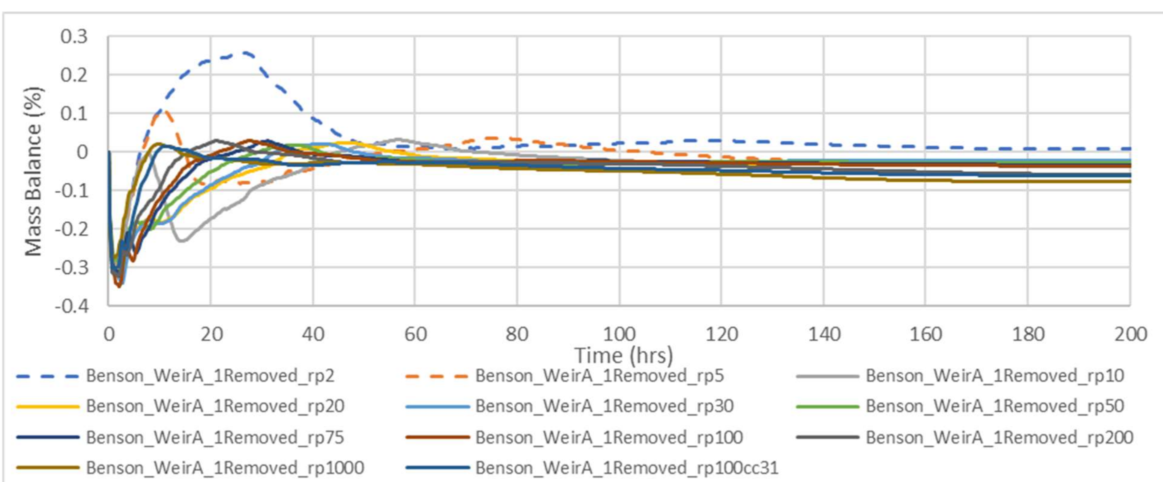



**Figure B-5. 2D Mass balance: Scenario A1**

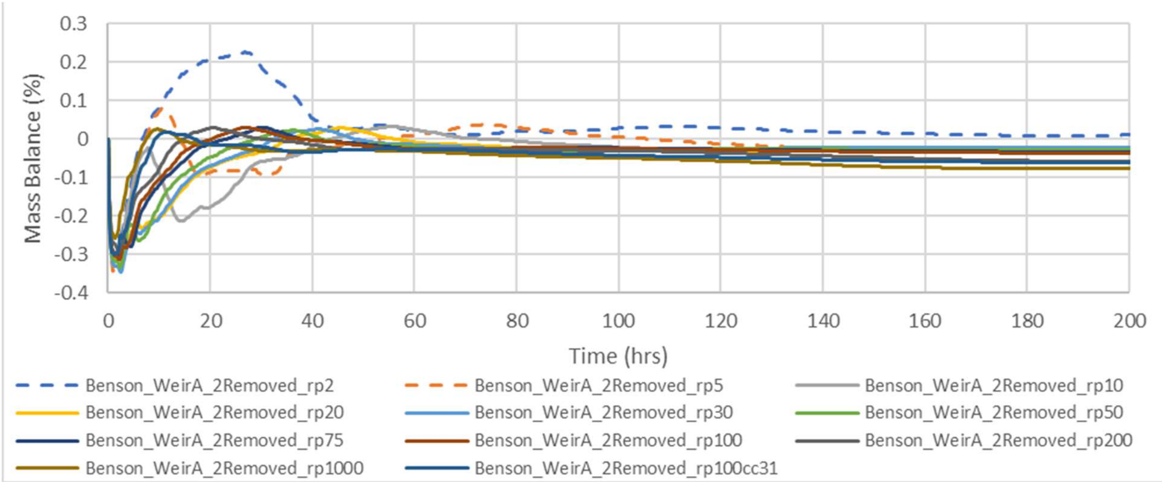



**Figure B-6. 2D Mass balance: Scenario A2**

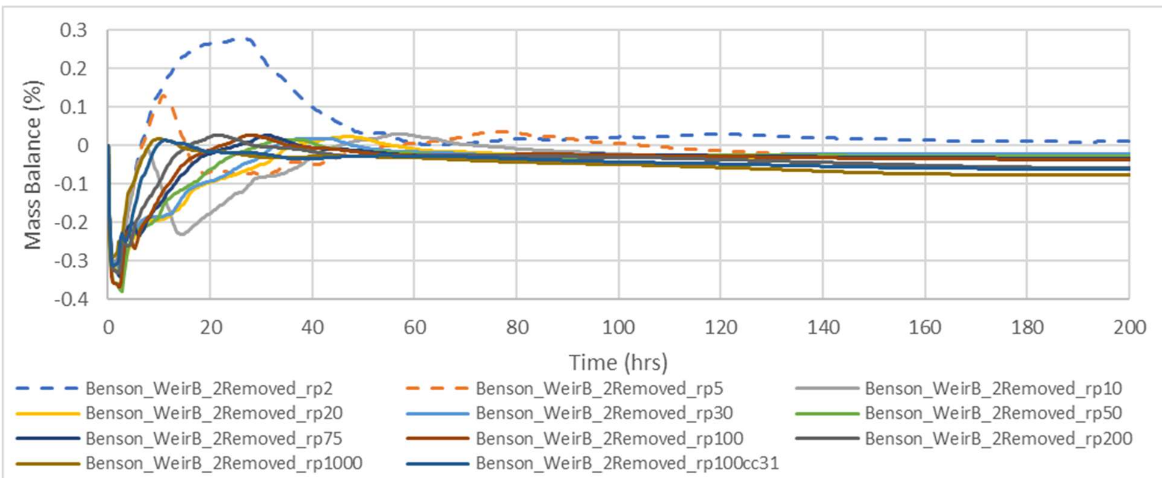



**Figure B-7. 2D Mass balance: Scenario B**

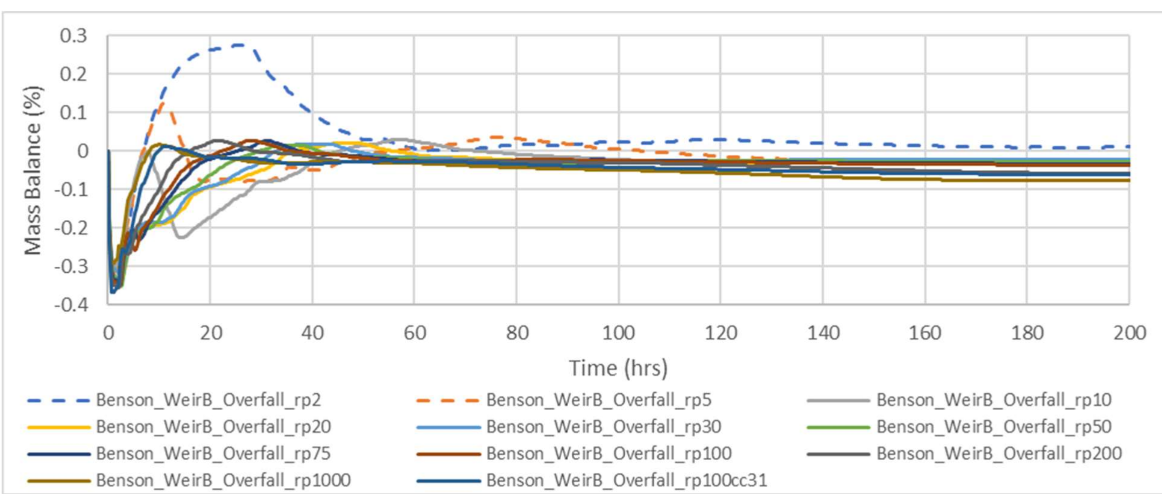



**Figure B-8. 2D Mass balance: Scenario C**

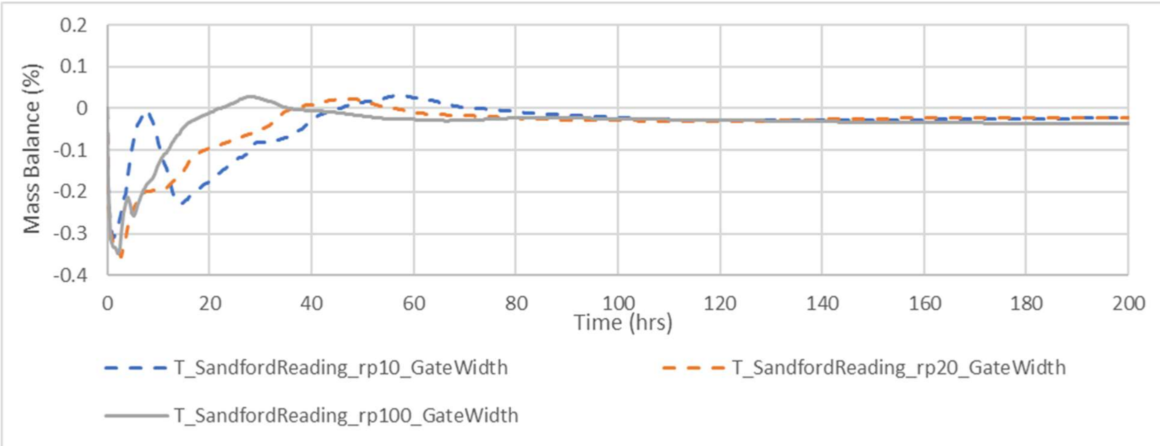



**Figure B-9. 2D Mass balance: Gate width reduction**

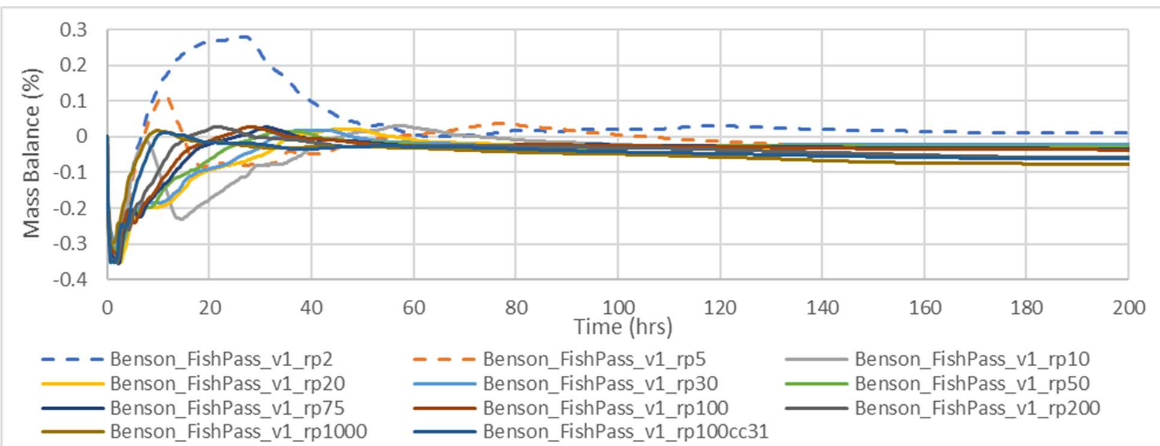
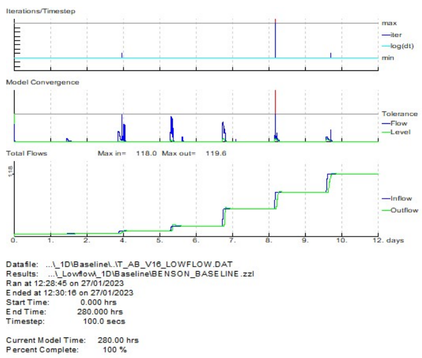
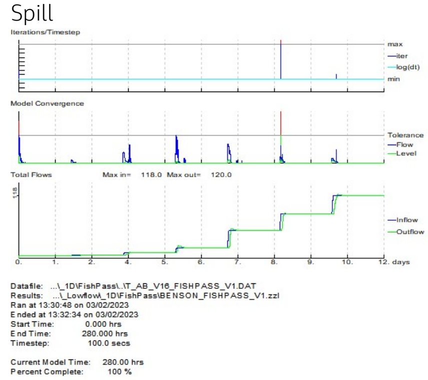
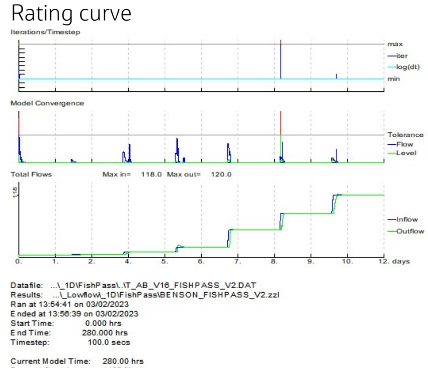



**Figure B-10. 2D Mass balance: Fish Pass**

# Appendix C. Low Flow Model

**Table C-1. Low Flow model files**

| File | Baseline | Fish Pass |
|---|---|---|
| Run (ief) and result name | Benson_Baseline.ief | T_Ab_v16_FishPass_v1.ief (spill method)<br>T_Ab_v16_FishPass_v2.ief (rating curve) |
| 1D Datafile | T_Ab_v16_LowFlow.DAT | T_Ab_v16_FishPass_v1.DAT (spill method)<br>T_Ab_v16_FishPass_v2.DAT (rating curve) |
| IED File for Benson Weir gate operation | BensonWeir_LowFlow.ied | |
| IED File for Cleeve Weir gate operation | CleeveWeir_LowFlow.ied | |
| Model Convergence | Baseline<br> | Spill<br><br>Rating curve<br> |

Environment Agency
Horizon House
Bristol
BS1 5AH

**Our reference:** WR - 184
**Your reference:** NPS/WR/040734
**Date:** 10/04/2024

Dear Paul,

## Acknowledgement of your application for a licence

Application number: NPS/WR/040734
Licence number: TH/039/0018/017

Thank you for your application for a new impounding works. I confirm that we have now assessed and accepted your application.

I also confirm that your application:

- began the formal decision process on 02/04/2024.
- will be decided by 02/08/2024 Note: there is no statutory determination date for Environment Agency applications, but the applicable statutory date has been included here ‘for information only.’
- Needs to be advertised. (We will do this for you by publishing a press notice in a local newspaper and on our website. You will need to pay the costs of advertising in a local newspaper, but we waive the £100 administration fee. We will send you an invoice setting out the advertising cost at the appropriate time.

If you have any questions about your application, please phone Gabrielle on 07387055943

Yours sincerely,

Gabrielle Pryor

Direct dial: 07387055943
Direct e-mail: Gabrielle.Pryor@environment-agency.gov.uk}

## Fish Pass Application – Supplementary Information

| | |
|---|---|
| Date: | 15 February 2023 |
| Project name: | Benson Weir Refurbishment (TWRP) |
| Project no: | ENV0003198 |
| Attention: | Fish Pass Panel |
| Company: | Environment Agency |
| Prepared by: | Ross Bransby |
| Reviewed by: | Shauket Khan |
| Document no: | ENV0003198-JAC-SF-00-TN-C-0007 |
| Revision no: | P01 |
| Copies to: | Stuart Manwaring & Darryl Clifton-Dey, Environment Agency |

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# SECTION ONE – Application Supplementary Information

**Section numbers match those on the Application for fish pass approval form.**

This note provides additional information to supplement that provided on the 'Application for fish pass approval' form (Ref. FP002). In addition, the following drawings are provided;

| | |
|---|---|
| ENV0003198C-JAC-SF-00-DR-C-1501 | Benson Weir Fish Pass Application Site Plan (Location Plan) |
| ENV0003198C-JAC-SF-00-DR-C-1513 | Fish Pass General Arrangement |
| ENV0003198C-JAC-SF-00-DR-C-1520 | Benson Weir Fish Pass Plan |
| ENV0003198C-JAC-SF-00-DR-C-1530 | Benson Weir Long Sections Through Fish Pass (Brush & Baffles) |
| ENV0003198C-JAC-SF-00-DR-C-1535 | Benson Weir Fish Pass Cross Sections - Sheet 1 of 2 |
| ENV0003198C-JAC-SF-00-DR-C-1536 | Benson Weir Fish Pass Cross Sections - Sheet 2 of 2 |

A percentage exceedance hydrograph is included in Section 10 of this document.

# 1. Site details

## 1.1 Site name

As application.

## 1.2 Grid ref

As application, plus;

Grid ref: SU613912. What3Words: cities.harshest.supplier. Closest postcode: OX10 6RY. County: Oxfordshire.

## 1.3 Watercourse

As application.

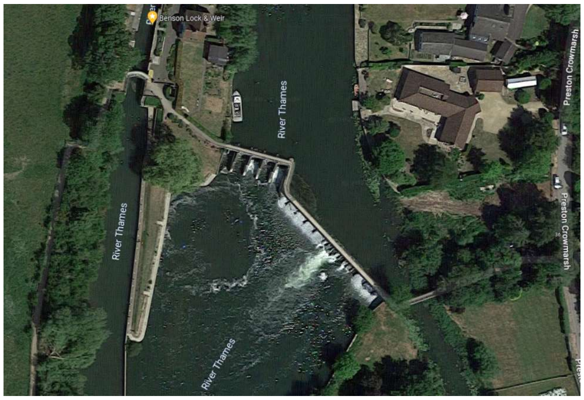
## 1.4 Site name

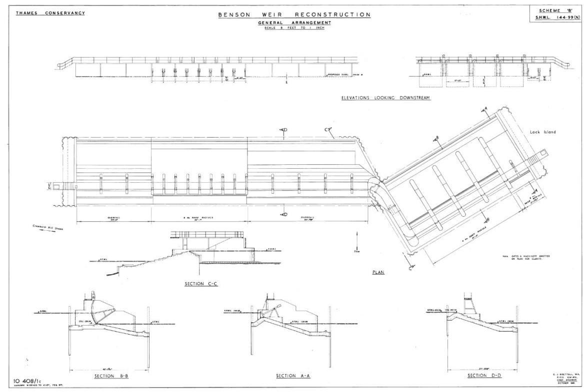
As application.

# 2. Details of the obstruction

## 2.1 What type of obstruction is the pass designed to overcome?

Weir / lock structure for navigation.




Standard Head Water Level (SHWL) is 44.19mAOD, Standard Tail Water Level (STWL) is 42.33mAOD.

Working from left to right there are;

- Side channel to old mill
- 3no. overspill bays with a crest level approximately 75mm below SHWL, 12m length
- 8no. hand radial gates with a crest level approximately 750mm below SHWL, 16m length
- 5no. overspill bays with a crest level approximately 75mm below SHWL, 20m length
- 4no. large radial gates with a crest level approximately 1,800mm below SHWL, 18m length
- 2no. hand radial gates with a crest level approximately 750mm below SHWL, 4m length
- Lock (navigation)

A public footpath (Thames Path) runs on the walkway over the weir (approx. 80m long).

## 2.2 What is the purpose of the obstruction?

As application.

## 2.3 Describe the obstruction, including any relevant control structures and associated channels

As application.

## 2.4 What is the overall length (in metres) of the crest of the obstruction?

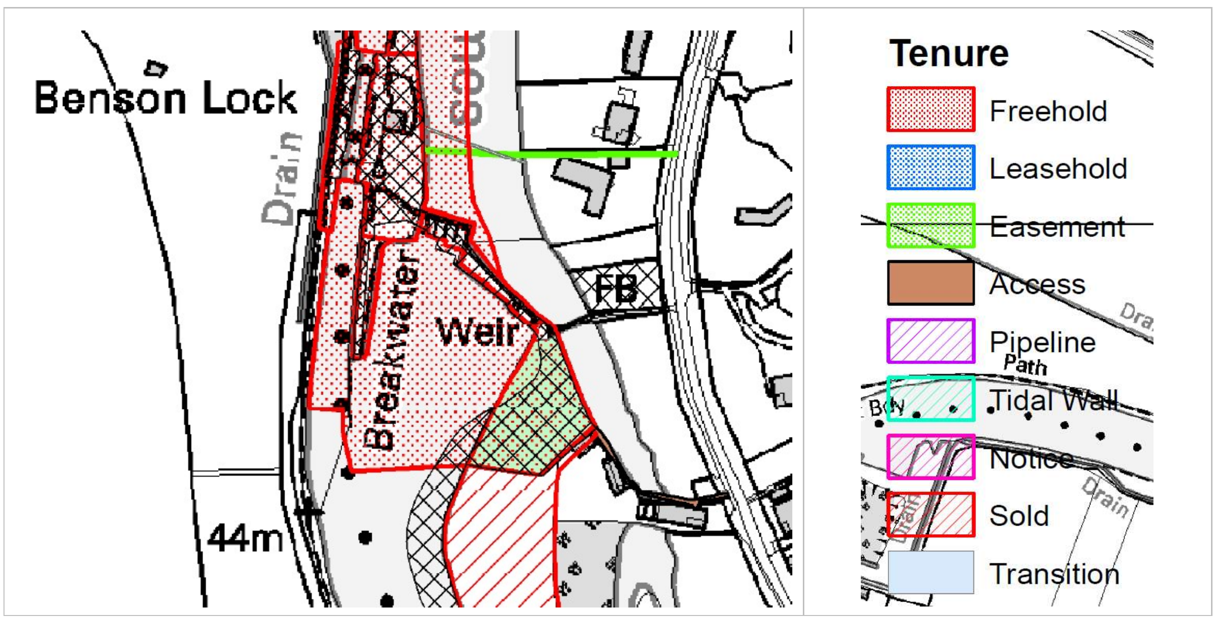
Total weir/walkway length is about 80m. The lengths of the individual weir section is detailed in 2.1 above.

## 2.5 What is the maximum difference between upstream and downstream water levels at the structure?

During higher flows the tail water level rises more than the head water level. Therefore the greatest head difference is at lower flows with a Q95 difference of 1.895m.

## 2.6 Who owns the obstruction and the riverbanks at the obstruction?

The obstruction, weir and lock, are owned and operated by the Environment Agency. The banks are owned by the Environment Agency, however, the majority of the mill island is privately owned.



# 3. Fish pass design and ownership details

## 3.1 Who has designed the fish pass?

The fish pass has been designed by Jacobs with support from Dr Reinhard Hassinger.

Dr Hassinger works for the University of Kessel, Germany, including in the Research Institute and Test Centre for Environmental Technology and Hydraulic Engineering. He is a world expert in the development of brush fish passes.

The first UK brush pass installation was at Porters Lock, Kent in 2010. This was designed by Halcrow (now Jacobs) working with Dr Hassinger. https://waterprojectsonline.com/wp-content/uploads/case_studies/2010/River-Medway-Canoe-Trail-2010.pdf

Laboratory testing of a baffle brush pass at the Universtity of Kessel.

## 3.2 Who will own and operate the fish pass?

The Environment Agency will own and operate the fish pass. APT contact Stuart Malaure.

## 3.3 Name the lead Environment Agency officer involved with this pass

The Area FBG team of Stuart Manwaring and Lizzie Rhymes have been involved, however, Darryl Clifton-Dey has been a key contact for the development of the fish pass at Benson Weir.

# 4. Fish species and period of migration

## 4.1 Provide details of the species the pass is designed for and identify other species at this site which the pass would benefit

As application.

## 4.2 Will the pass operate all year?

As application.

# 5. River discharge and water levels

## 5.1 Annual river discharge

Information as per application.

There is no flow gauging at Benson Weir. Values were therefore derived from a hydrology assessment using data from upstream and downstream gauging stations and taking into account upstream tributaries (and gauges on those tributaries) between Benson Weir and the next upstream flow gauging site (Days Weir). [Report ref: ENV0003198C-JAC-SF-00-RP-HY-0001]. See Section 10 for outline details of available data.

## 5.2 Range of river discharge the pass is expected to operate over

As application.

Being a site with gates to control upstream water level a relatively consistent head level is maintained for a wide range of flows. This optimises and increases the range of flows during which the pass is usable.

## 5.3 River water levels, above ordnance datum (mAOD), corresponding with the flows identified in 5.2

Using historical level gauge data from Benson Weir (15+ years), the percentage exceedance river levels shown in the table below were determined.

| Percentile Exceedance (%) | Head Level (mAOD) | Above SHWL (m) | Tail Level (mAOD) | Above STWL (m) | Difference Head/Tail (m) |
|---|---|---|---|---|---|
| 5.0 | 44.478 | 0.288 | 44.103 | 1.773 | 0.375 |
| 10.0 | 44.392 | 0.202 | 43.483 | 1.153 | 0.909 |
| 50.0 | 44.311 | 0.121 | 42.520 | 0.190 | 1.791 |
| 90.0 | 44.260 | 0.070 | 42.385 | 0.055 | 1.875 |
| 95.0 | 44.243 | 0.053 | 42.348 | 0.018 | 1.895 |

## 5.4 Is the fish pass for eel only?

As application.

# 6. Description of fish pass, operating flows, and intended operating periods

## 6.1 Type of fish pass

We are referring to the pass as a 'Hassinger Baffle Brush' pass.

## 6.2 Description of the fish pass

As application with supplementary information below.

The pass comprises the following element;

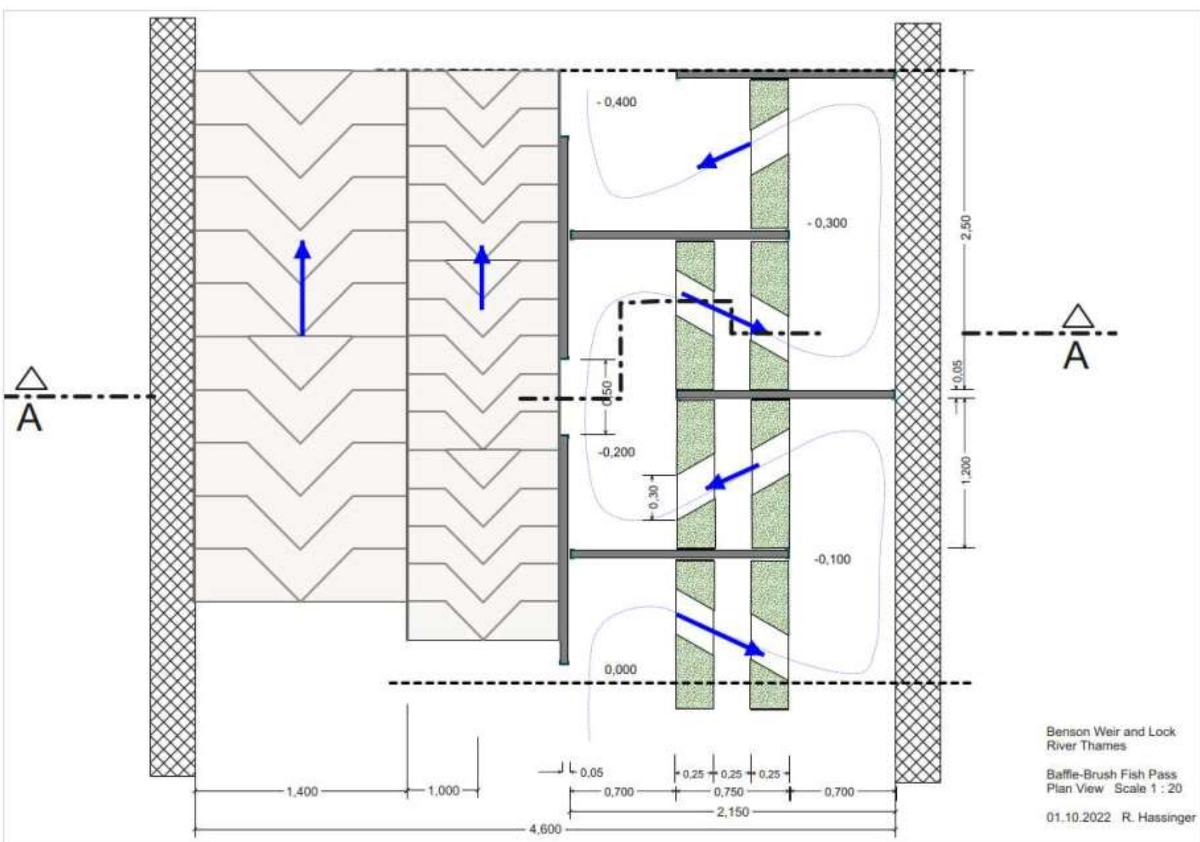
'Large' baffles section. Similar in style to the Larinier baffle but a different size and proportion. 1,400mm wide with 150mm high baffles.

'Medium' baffles section. Similar in style to the Larinier baffle but a different size and proportion. 1,000mm wide with 125mm high baffles.

Brush section using 500mm high brush blocks.

Due to some constraints at the site there is some variation from the standard brush design with a pass gradient of 1:12.5 (8%) and a series of dividing wall in the brush section. These provide a degree of separation between the baffle and brush sections but the primary purpose is to increase the effective length of that section of the pass resulting in effective gradient of the brush section of ~1:30.

An outline image is shown below.

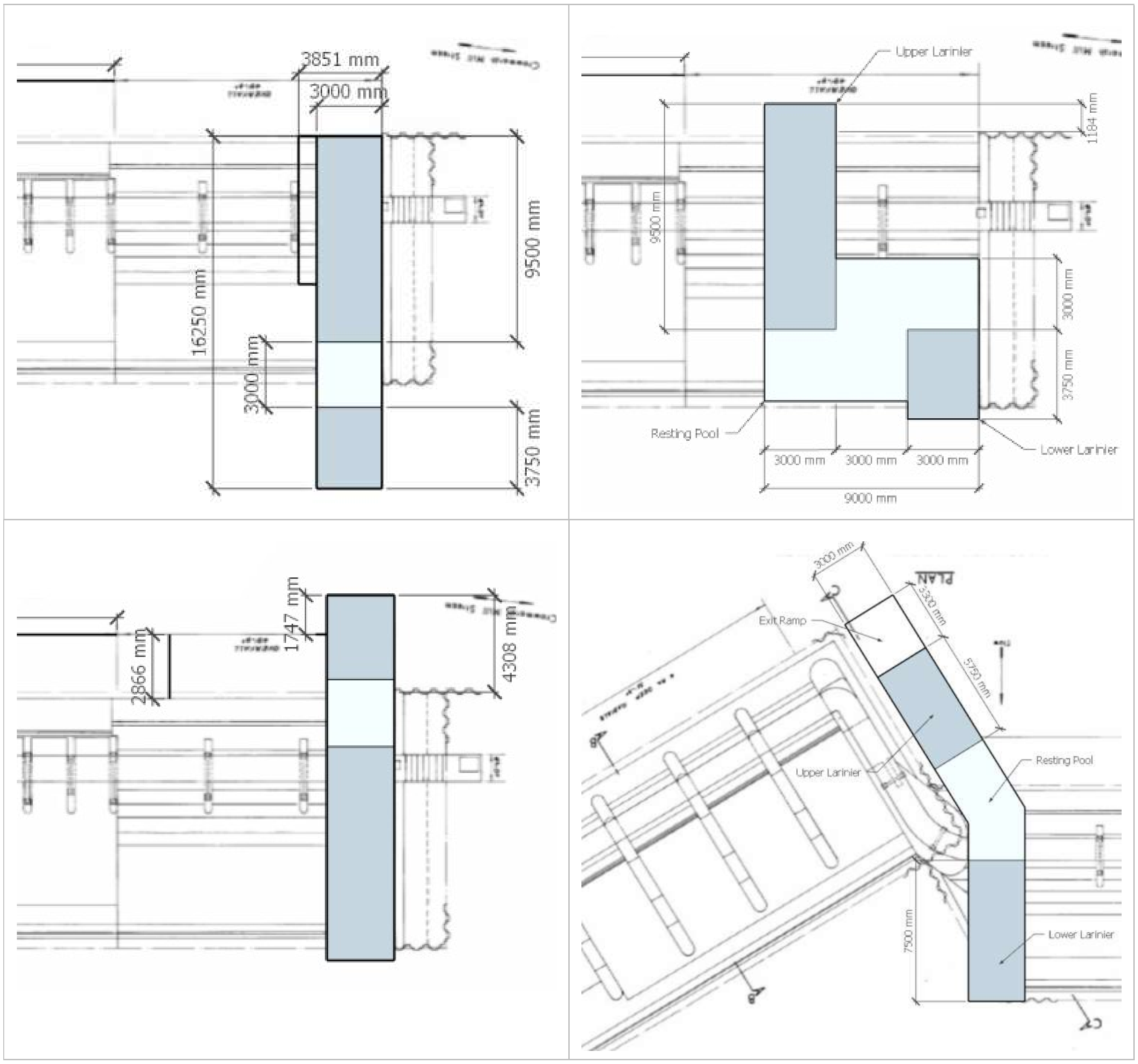



Further images are included in Section 2 of this note.

## 6.3 Explain why you plan to have the pass at the location you propose, and any factors that restrict where the pass can be located

As application.

Alternative pass arrangements considered. Primarily a Larinier pass on the true left bank with final image being a mid-channel Larinier. [Ref: ENV0003198C-JAC-SF-00-DS-C-0002].




## 6.4 How is the pass location and operation designed to make sure that fish are attracted to the fish pass across the intended river discharge operating range?

As application.

## 6.5 Describe how the operation of any nearby water - control structures may affect the performance of the pass

As application.

## 6.6 Does the fish pass include a pool pass?

As application.

## 6.7 Not applicable

n/a

## 6.8 Not applicable

n/a

## 6.9 Does the fish pass include a baffle pass?

As application.

## 6.10 Describe how the baffle pass will operate to allow fish to pass upstream, including the changing hydraulic conditions within it over the range of river discharge when the pass is expected to operate

See Section 11 Rating curve information of this report.

Also see Section 12.2 with details of the baffle design.

## 6.11 Give details of the operating conditions at the river discharge limits the baffle pass will operate at

Table headings in application have been used in non-standard way, the following apply;

- Flight 1 – brush pass
- Flight 2 – medium baffles
- Flight 3 – large baffles

## 6.12 Are resting pools required?

As application.

## 6.13 Not applicable

n/a

# 7. Eel passes

## 7.1 Type of eel pass

As application.

## 7.2 Description of eel pass

As application.

## 7.3 Is the eel pass pump fed?

As application.

## 7.4 Explain why you plan to have the eel pass at the location you propose, and any factors that restrict where the pass can be

As application.

## 7.5 Describe how nearby water - control structures may in any way affect the operation of the eel pass

As application.

## 7.6 In the table below, provide a summary of the operating conditions at the river discharge limits the eel pass will operate at

Flight 1 column has been used for the brush pass.

# 8. Monitoring and maintenance

## 8.1 Describe any proposals you have for monitoring the hydraulic and biological performance of the fish pass

As application.

## 8.2 Describe the procedures that you will have in place to maintain the structure and mechanisms of the pass

As application.

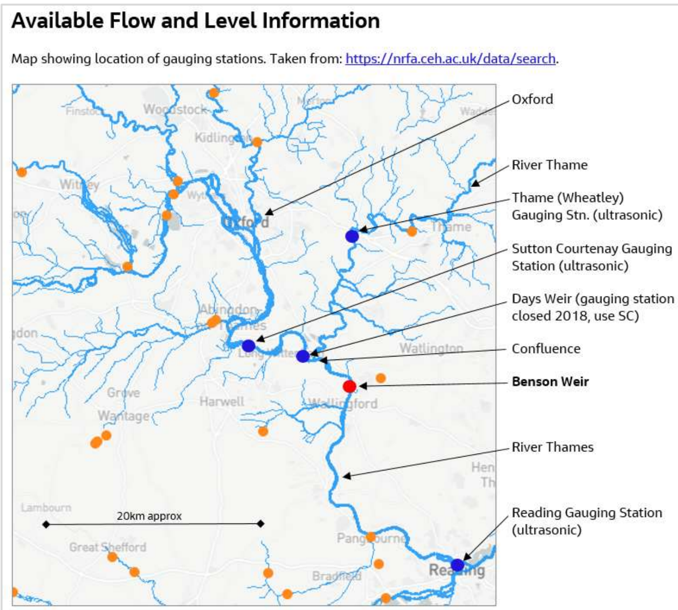
# 9. Supporting documents

As application.

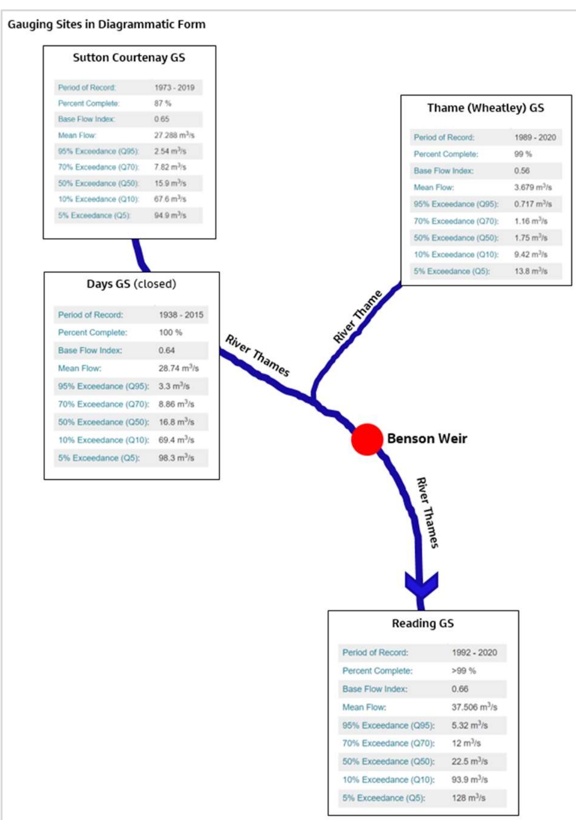
# SECTION TWO – Further Design Information

## 10. Annual river discharge hydrograph

Benson Weir is not a flow gauging site. In order to determine the flow at Benson a hydrometric assessment was undertaken using available data from sites; upstream, downstream and on tributaries. Relevant sites are shown on the plan below.

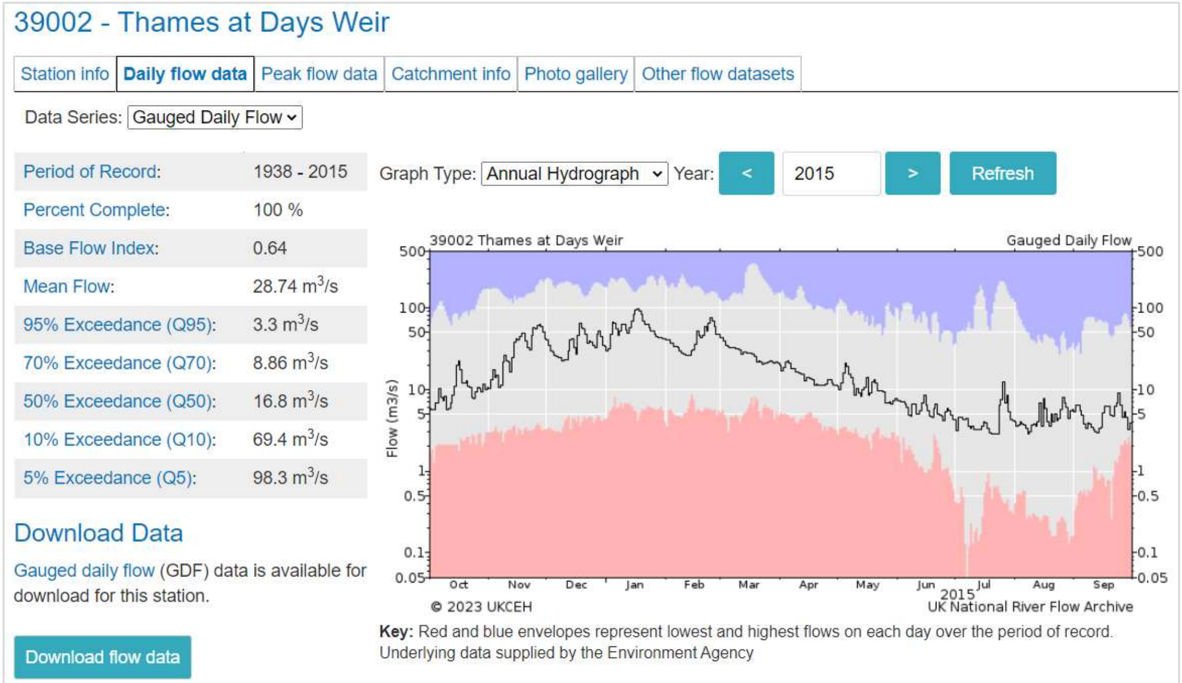


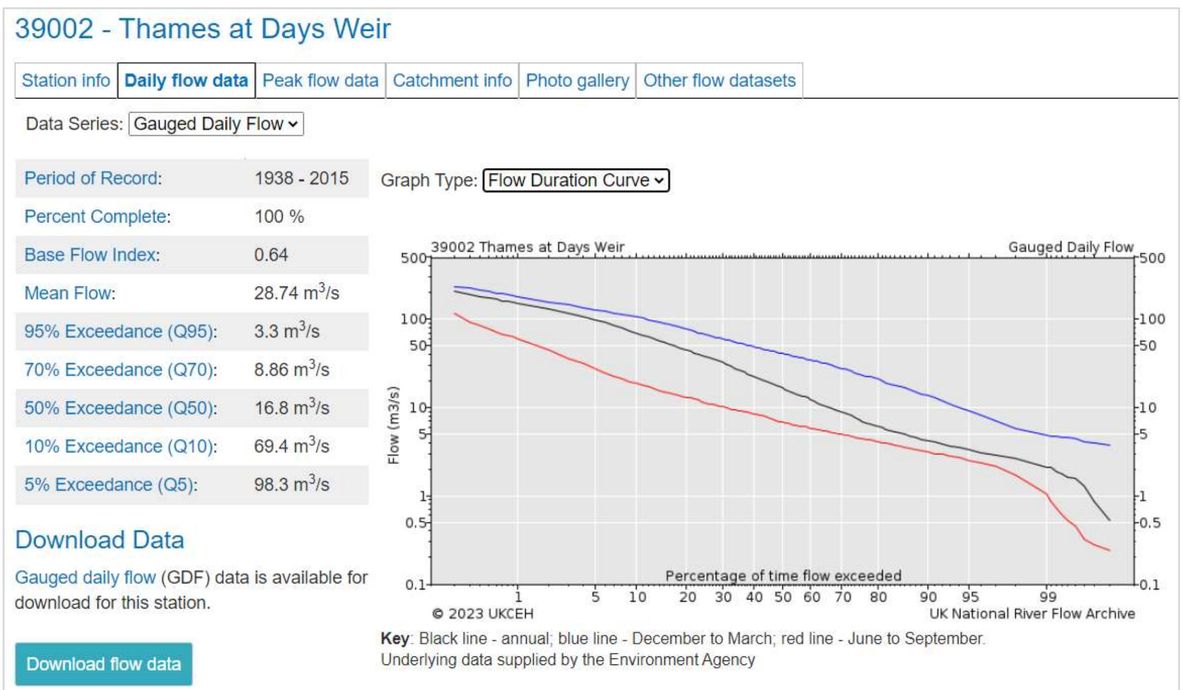

Location of flow gauging sites.




Schematic of principal data used.

The hydrographs for Days Weir (next upstream) and Reading (next downstream) have therefore been included below. Note there are tributaries which join the Thames between both these sites and Benson.



## 39130 - Thames at Reading

Station info | **Daily flow data** | Live data | Catchment info | Other flow datasets

Data Series: Gauged Daily Flow

| | |
|---|---|
| Period of Record: | 1992 - 2021 |
| Percent Complete: | 99 % |
| Base Flow Index: | 0.66 |
| Mean Flow: | 37.892 $m^3/s$ |
| 95% Exceedance (Q95): | 5.35 $m^3/s$ |
| 70% Exceedance (Q70): | 12.2 $m^3/s$ |
| 50% Exceedance (Q50): | 22.9 $m^3/s$ |
| 10% Exceedance (Q10): | 94.38 $m^3/s$ |
| 5% Exceedance (Q5): | 129 $m^3/s$ |

Graph Type: Annual Hydrograph Year: < 2015 > Refresh


**Key:** Red and blue envelopes represent lowest and highest flows on each day over the period of record.
Underlying data supplied by the Environment Agency

### Download Data

Gauged daily flow (GDF) data is available for download for this station.

Download flow data

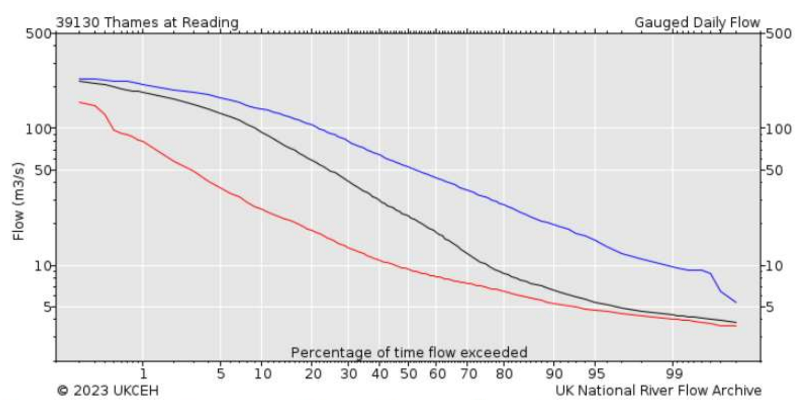
## 39130 - Thames at Reading

Station info | **Daily flow data** | Live data | Catchment info | Other flow datasets

Data Series: Gauged Daily Flow

| | |
|---|---|
| Period of Record: | 1992 - 2021 |
| Percent Complete: | 99 % |
| Base Flow Index: | 0.66 |
| Mean Flow: | 37.892 $m^3/s$ |
| 95% Exceedance (Q95): | 5.35 $m^3/s$ |
| 70% Exceedance (Q70): | 12.2 $m^3/s$ |
| 50% Exceedance (Q50): | 22.9 $m^3/s$ |
| 10% Exceedance (Q10): | 94.38 $m^3/s$ |
| 5% Exceedance (Q5): | 129 $m^3/s$ |

Graph Type: Flow Duration Curve




**Key**: Black line - annual; blue line - December to March; red line - June to September.
Underlying data supplied by the Environment Agency

### Download Data

Gauged daily flow (GDF) data is available for download for this station.

Download flow data

# 11. Rating curve information

Brush section:

| Calculation of the Stage-discharge Relationship | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| # | Water head m | Head of bristle layer m | Nominal overflow m | Overflow head* m | Overflow Discharge l/s | **Total Brush Discharge l/s** | Velocity in bristles m/s | Velocity in Overflow layer m/s | |
| 1 | 0.470 | 0.470 | | 0.000 | 0 | **249.4** | 0.442 | | |
| 2 | 0.500 | 0.470 | 0.03 | 0.030 | 10.62 | **260.0** | 0.433 | 0.295 | |
| 3 | 0.510 | 0.469 | 0.040 | 0.041 | 16.97 | **266.3** | 0.443 | 0.345 | |
| 4 | 0.520 | 0.468 | 0.050 | 0.052 | 24.24 | **273.6** | 0.444 | 0.388 | |
| 5 | 0.530 | 0.467 | 0.060 | 0.063 | 32.33 | **281.7** | 0.445 | 0.428 | |
| 6 | 0.540 | 0.466 | 0.070 | 0.074 | 41.15 | **290.5** | 0.446 | 0.463 | |
| 7 | 0.550 | 0.465 | 0.080 | 0.085 | 50.66 | **300.0** | 0.447 | 0.497 | |
| 8 | 0.560 | 0.464 | 0.090 | 0.096 | 60.81 | **310.2** | 0.448 | 0.528 | |
| 9 | 0.570 | 0.463 | 0.100 | 0.107 | 71.55 | **320.9** | 0.449 | 0.557 | |
| 10 | 0.580 | 0.462 | 0.110 | 0.118 | 82.87 | **332.2** | 0.450 | 0.585 | |
| 11 | 0.590 | 0.461 | 0.120 | 0.129 | 94.72 | **344.1** | 0.451 | 0.612 | |
| 12 | 0.600 | 0.460 | 0.130 | 0.140 | 107.09 | **356.5** | 0.452 | 0.637 | |
| 13 | 0.610 | 0.459 | 0.140 | 0.151 | 119.96 | **369.3** | 0.453 | 0.662 | |
| 14 | 0.620 | 0.458 | 0.150 | 0.162 | 133.30 | **382.7** | 0.454 | 0.686 | |
| 15 | 0.630 | 0.457 | 0.160 | 0.173 | 147.11 | **396.5** | 0.455 | 0.709 | |
| 16 | 0.640 | 0.456 | 0.170 | 0.184 | 161.36 | **410.7** | 0.456 | 0.731 | |
| 17 | 0.650 | 0.455 | 0.180 | 0.195 | 176.04 | **425.4** | 0.457 | 0.752 | |
| 18 | 0.660 | 0.454 | 0.190 | 0.206 | 191.14 | **440.5** | 0.458 | 0.773 | |
| 19 | 0.670 | 0.453 | 0.200 | 0.217 | 206.66 | **456.0** | 0.459 | 0.794 | |
| 20 | 0.680 | 0.452 | 0.210 | 0.228 | 222.57 | **471.9** | 0.460 | 0.813 | |
| 21 | 0.690 | 0.451 | 0.220 | 0.239 | 238.87 | **488.2** | 0.461 | 0.833 | |
| 22 | 0.700 | 0.450 | 0.230 | 0.250 | 255.55 | **504.9** | 0.462 | 0.852 | |
| Values for Duration Curve Points | | | | | | | | | |
| 24 | 0.718 | 0.448 | 0.248 | 0.270 | 286.50 | **535.9** | 0.464 | 0.885 | Q5 |
| 25 | 0.632 | 0.457 | 0.162 | 0.175 | 149.92 | **399.3** | 0.455 | 0.713 | Q10 |
| 26 | 0.551 | 0.465 | 0.081 | 0.086 | 51.65 | **301.0** | 0.447 | 0.500 | Q50 |
| 27 | 0.500 | 0.470 | 0.030 | 0.030 | 10.62 | **260.0** | 0.442 | 0.295 | Q90 |
| 28 | 0.483 | 0.472 | 0.013 | 0.011 | 2.46 | **251.8** | 0.441 | 0.181 | Q95 |

* The overflow head is increased by bending of the bristles
(10% of the additional nominal overflow head)

Cont.

Large baffles and medium baffles (highlighted rows show information for Q90 water level):

| Rating curve baffle section 2 (1400/700) | | | | | |
|---|---|---|---|---|---|
| Nr. | h | h/hbfl | lambda | v | Q |
| | m | [-] | [-] | m/s | l/s |
| 1 | 0.250 | 1.667 | 5.605 | 0.529 | 185.2 |
| 2 | 0.275 | 1.833 | 4.814 | 0.599 | 230.5 |
| 3 | 0.300 | 2.000 | 4.190 | 0.670 | 281.6 |
| 4 | 0.325 | 2.167 | 3.687 | 0.744 | 338.4 |
| 5 | 0.350 | 2.333 | 3.276 | 0.819 | 401.2 |
| 6 | 0.375 | 2.500 | 2.934 | 0.896 | 470.2 |
| 7 | 0.400 | 2.667 | 2.647 | 0.974 | 545.3 |
| 8 | 0.425 | 2.833 | 2.403 | 1.054 | 626.9 |
| 9 | 0.450 | 3.000 | 2.194 | 1.135 | 714.9 |
| 10 | 0.475 | 3.167 | 2.012 | 1.217 | 809.4 |
| 11 | 0.500 | 3.333 | 1.854 | 1.301 | 910.7 |
| 12 | 0.525 | 3.500 | 1.715 | 1.386 | 1018.7 |
| 13 | 0.550 | 3.667 | 1.592 | 1.472 | 1133.7 |
| 14 | 0.575 | 3.833 | 1.483 | 1.560 | 1255.6 |
| 15 | 0.600 | 4.000 | 1.386 | 1.648 | 1384.6 |
| 16 | 0.625 | 4.167 | 1.299 | 1.738 | 1520.8 |
| 17 | 0.650 | 4.333 | 1.220 | 1.829 | 1664.2 |
| 18 | 0.675 | 4.500 | 1.148 | 1.921 | 1815.0 |
| 19 | 0.700 | 4.667 | 1.084 | 2.013 | 1973.2 |
| 20 | 0.725 | 4.833 | 1.025 | 2.107 | 2138.9 |
| 21 | 0.750 | 5.000 | 0.971 | 2.202 | 2312.2 |
| 22 | 0.775 | 5.167 | 0.921 | 2.298 | 2493.1 |
| 23 | 0.800 | 5.333 | 0.876 | 2.394 | 2681.8 |
| Calculation for Duration Curve points | | | | | |
| Invert offset | | -0.2 | m | | |
| 24 | 0.918 | 6.120 | 0.703 | 2.863 | 3679.0 |
| 25 | 0.832 | 5.547 | 0.823 | 2.520 | 2934.7 |
| 26 | 0.751 | 5.007 | 0.969 | 2.206 | 2319.2 |
| 27 | 0.700 | 4.667 | 1.084 | 2.013 | 1973.2 |
| 28 | 0.683 | 4.553 | 1.127 | 1.950 | 1864.8 |

| Rating curve baffle section 1 (1000/500) | | | | | | |
|---|---|---|---|---|---|---|
| Nr. | h | h/hbfl | lambda | v | Q | |
| | m | [-] | [-] | m/s | l/s | |
| 1 | 0.250 | 2.000 | 4.190 | 0.612 | 153.0 | |
| 2 | 0.275 | 2.200 | 3.598 | 0.693 | 190.5 | |
| 3 | 0.300 | 2.400 | 3.132 | 0.775 | 232.6 | |
| 4 | 0.325 | 2.600 | 2.756 | 0.860 | 279.6 | |
| 5 | 0.350 | 2.800 | 2.449 | 0.947 | 331.5 | |
| 6 | 0.375 | 3.000 | 2.194 | 1.036 | 388.4 | |
| 7 | 0.400 | 3.200 | 1.979 | 1.126 | 450.5 | |
| 8 | 0.425 | 3.400 | 1.796 | 1.219 | 517.9 | |
| 9 | 0.450 | 3.600 | 1.640 | 1.312 | 590.6 | |
| 10 | 0.460 | 3.680 | 1.583 | 1.350 | 621.2 | |
| 11 | 0.470 | 3.760 | 1.530 | 1.389 | 652.6 | |
| 12 | 0.480 | 3.840 | 1.479 | 1.427 | 685.0 | |
| 13 | 0.490 | 3.920 | 1.431 | 1.466 | 718.2 | |
| 14 | 0.500 | 4.000 | 1.386 | 1.505 | 752.4 | |
| 15 | 0.510 | 4.080 | 1.343 | 1.544 | 787.4 | |
| 16 | 0.520 | 4.160 | 1.302 | 1.583 | 823.3 | |
| 17 | 0.530 | 4.240 | 1.263 | 1.623 | 860.1 | |
| 18 | 0.540 | 4.320 | 1.226 | 1.663 | 897.9 | |
| 19 | 0.550 | 4.400 | 1.190 | 1.703 | 936.6 | |
| 20 | 0.560 | 4.480 | 1.157 | 1.743 | 976.2 | |
| 21 | 0.570 | 4.560 | 1.124 | 1.784 | 1016.7 | |
| 22 | 0.580 | 4.640 | 1.094 | 1.824 | 1058.1 | |
| 23 | 0.590 | 4.720 | 1.064 | 1.865 | 1100.5 | |
| Calculation for Duration Curve points | | | | | | |
| Invert offset | | 0.000 | m | | | |
| 24 | 0.718 | 5.744 | 0.778 | 2.407 | 1728.0 | Q5 |
| 25 | 0.632 | 5.056 | 0.954 | 2.039 | 1288.9 | Q10 |
| 26 | 0.551 | 4.408 | 1.187 | 1.707 | 940.5 | Q50 |
| 27 | 0.500 | 4.000 | 1.386 | 1.505 | 752.4 | Q90 |
| 28 | 0.483 | 3.864 | 1.465 | 1.439 | 694.9 | Q95 |

Combined: (total pass)

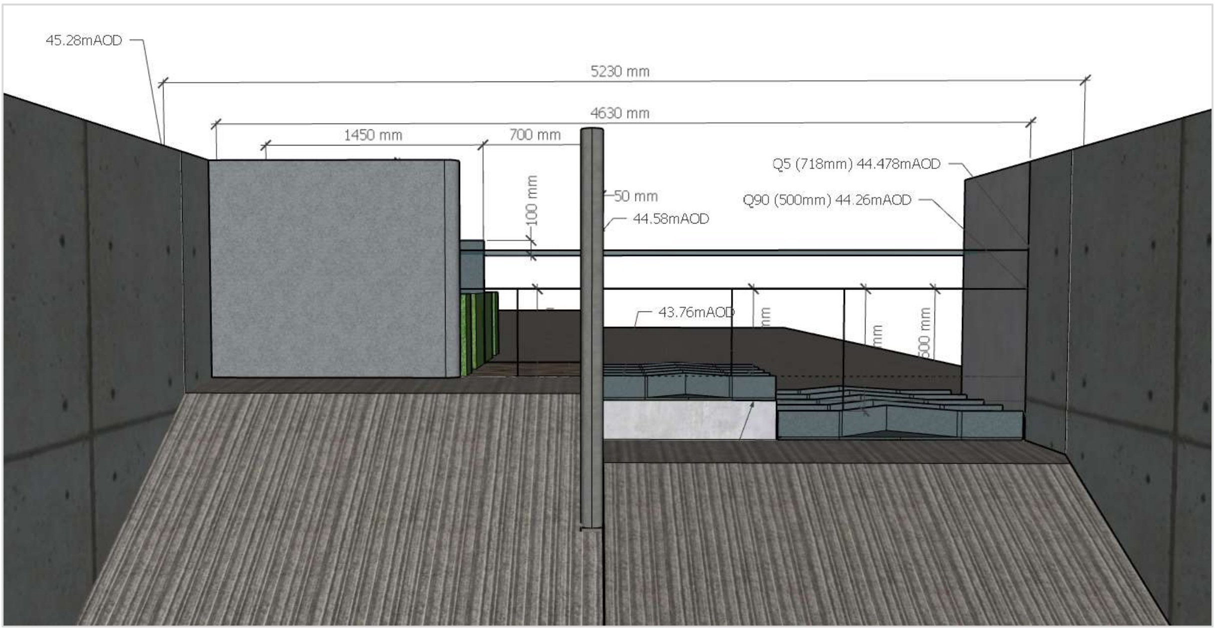
| Benson Weir and Lock | | | | | | | BRUSH & BAFFLE | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fish Pass | | | Inflow inver | 43.760 | mAOD | (design for Q90) | | | | |
| Summary of Discharges | | | | | | | | | | |
| | | | | | Discharges | | | | | |
| Percent. of Exceed. % | Duration of Exceedance days | River Discharge m³/s | Headpond level mAOD | Inflow head* m | Brush pass l/s | Baffle sec. 1 1000/500 l/s | Baffle. Sec. 2 1400/700 l/s | Discharge Fish Pass l/s | Discharge fish pass m³/s | % of flow going down fish pass |
| 5 | 18 | 118.0 | 44.478 | 0.718 | 536 | 1,728 | 3,679 | 5,943 | 5.94 | 5.04% |
| 10 | 37 | 82.9 | 44.392 | 0.632 | 399 | 1,289 | 2,935 | 4,623 | 4.62 | 5.58% |
| 50 | 183 | 19.4 | 44.311 | 0.551 | 301 | 940 | 2,319 | 3,561 | 3.56 | 18.35% |
| 90 | 329 | 5.4 | 44.260 | 0.500 | 260 | 752 | 1,973 | 2,986 | 2.99 | 55.29% |
| 95 | 347 | 4.3 | 44.243 | 0.483 | 252 | 695 | 1,865 | 2,811 | 2.81 | 65.38% |

* over inflow invert (designed for Q90)

# 12. Baffles, brushes and levels

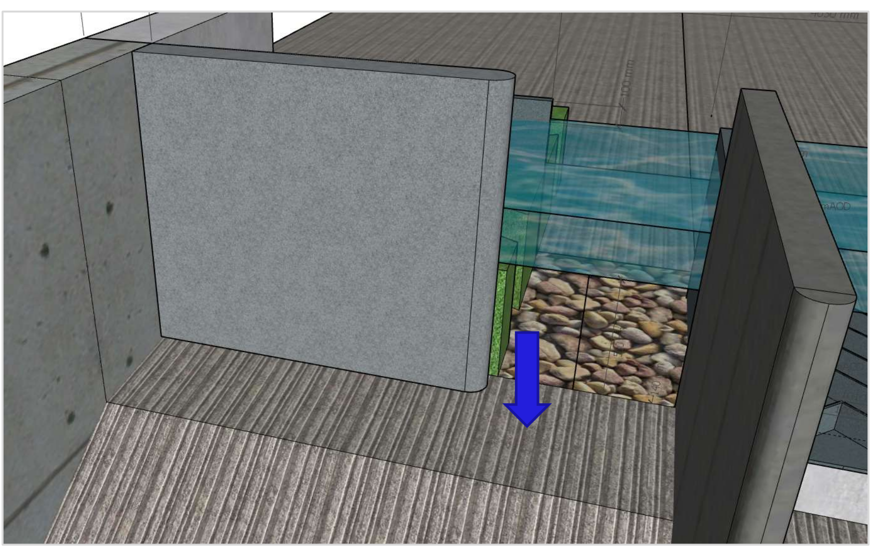
Detailed design is currently ongoing. The images below are from an initial 3D model used for concept design, however, it is not expected there will be any significant change from what is shown to final design (subject to requirements of fish pass panel).

General view of upstream end of pass. The central dividing wall will extend a couple of metres upstream.



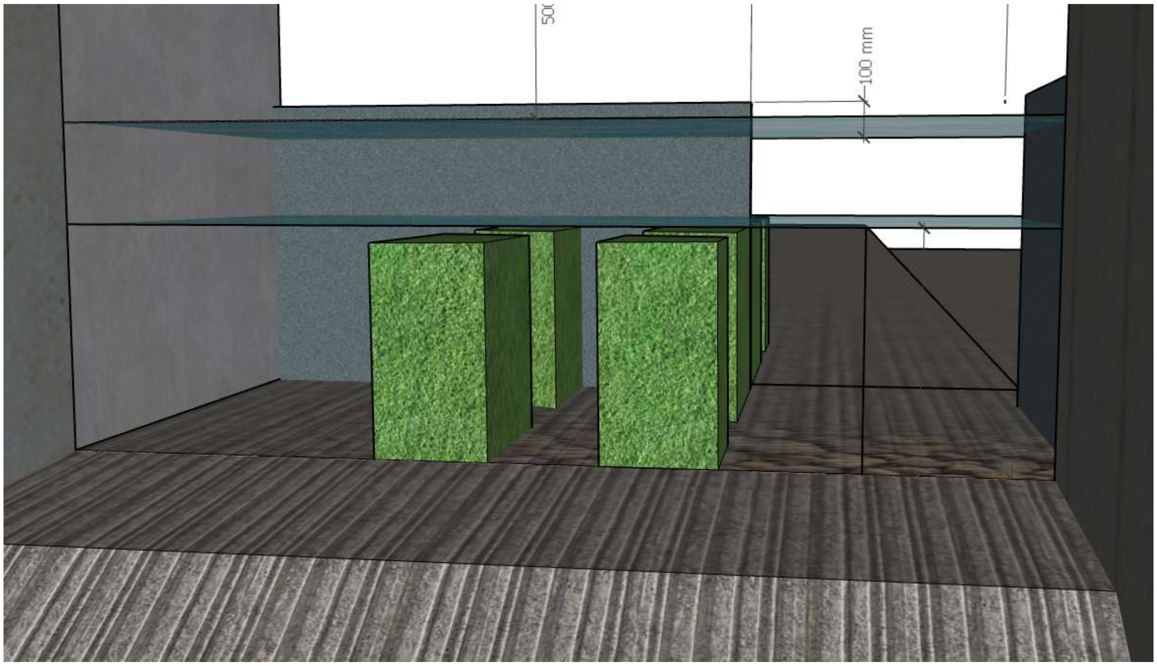

## 12.1 Brush section

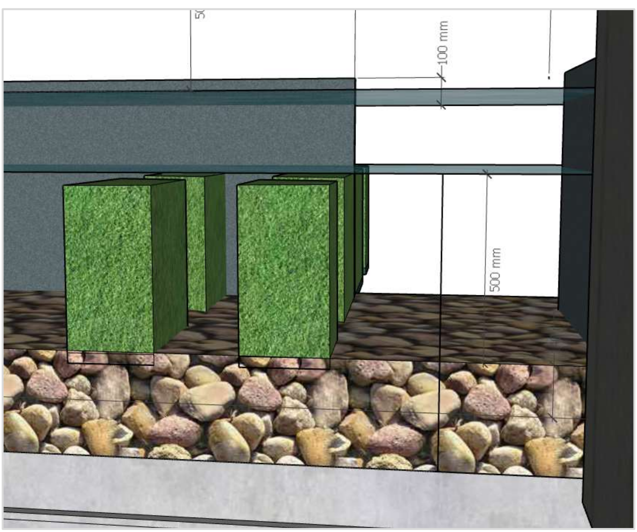
A 'hydraulic invert' level for the pass has been set 500mm below Q90 water level. The Q90 level is 44.26mAOD, so the upstream invert of the brush pass (horizontal concrete on image below shown by the arrow) is at 43.76mAOD.

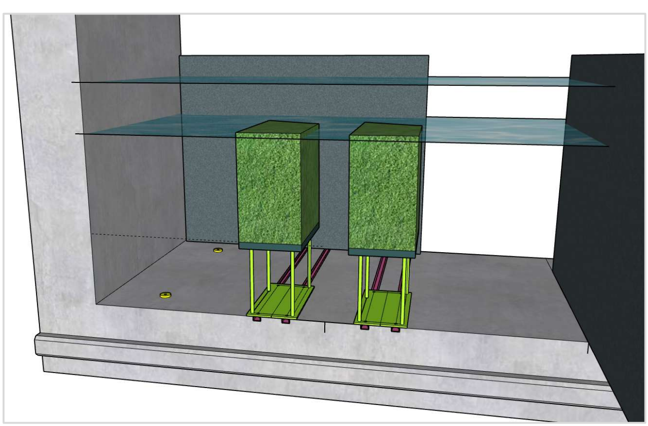


The brush blocks have a 30mm base with the bristles extending 470mm above the base. The blocks are mounted on threaded rod holding them above a 300mm thick gravel bed. The Q90 flow will be just over the top of the brushes.

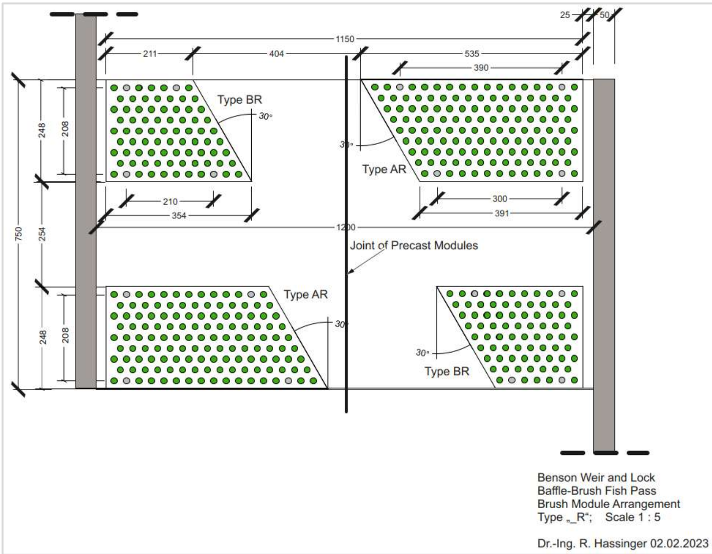
The second water level shown on the images below is the Q5 water level, this is 718mm above the hydraulic invert.



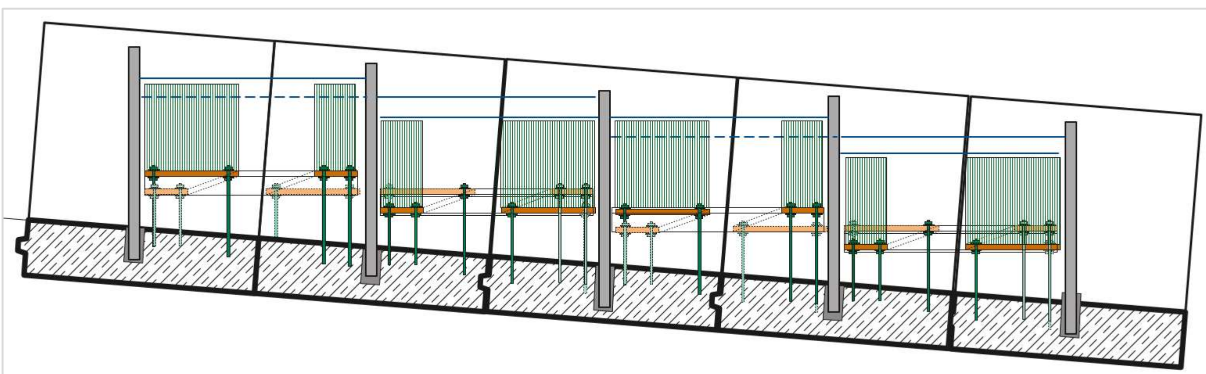



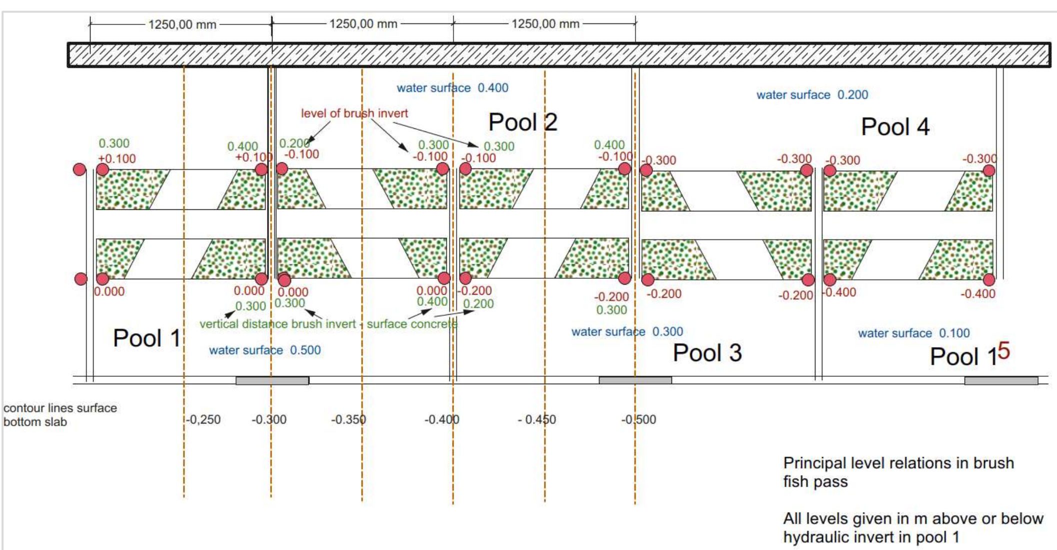



Below, layout of brush blocks on plan.



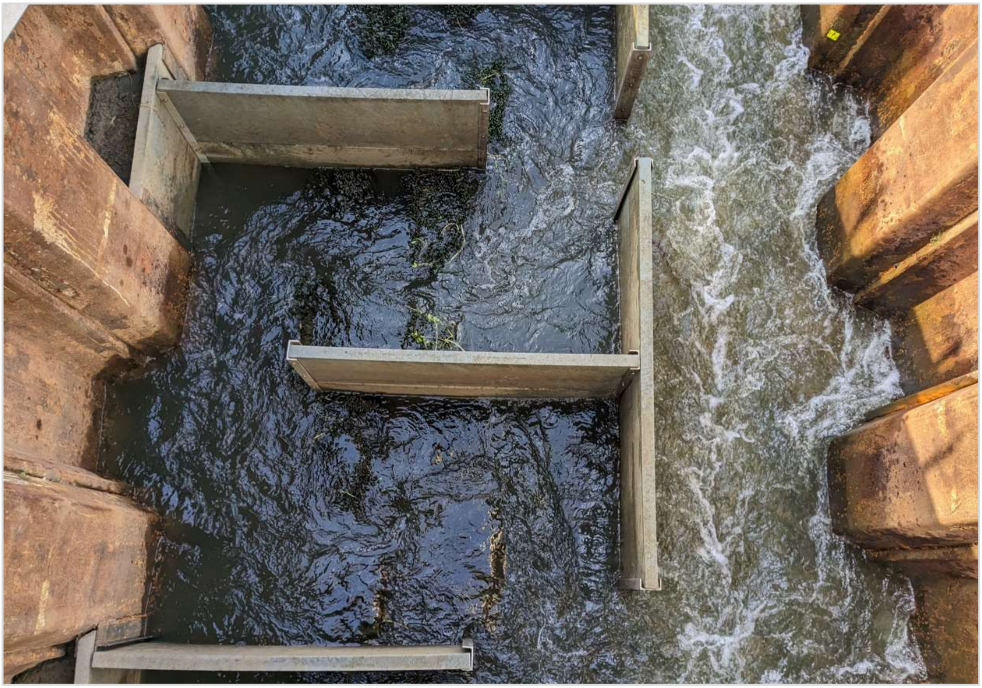

Long section through brush pass (300mm gravel layer now shown for clarity). Using the threaded mounts each brush block is set at an angle and different level to adjacent blocks so that there is a consistent gradient all the way down the pass.





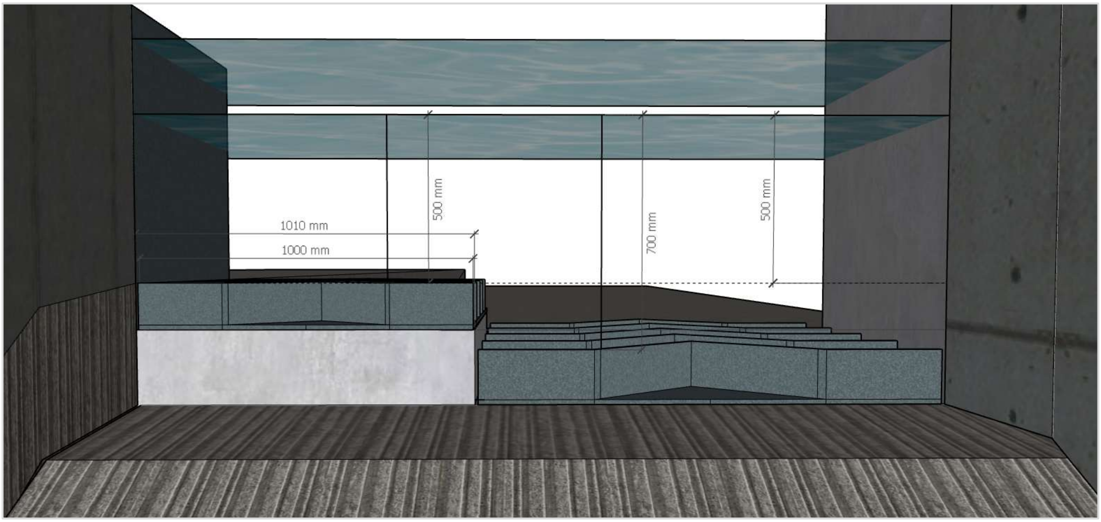
The dividing wall between the brush and baffle section has a series of gaps which allow fish to migrate between the different pass types. The significantly reduced velocities in the brush pass can act as a resting area for the baffle pass.

Photo of similar type pass installed at Walsham.



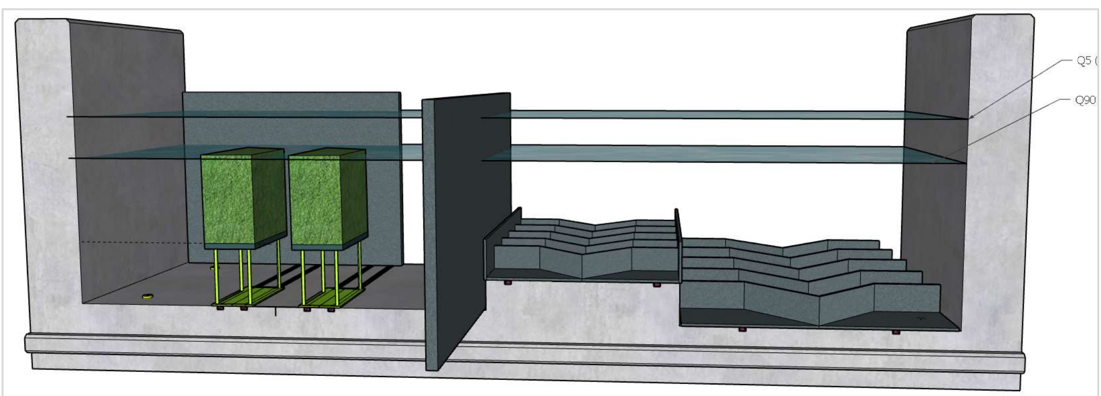
## 12.2 Baffle section

Indicative image of the upstream end of the baffle section of the pass.



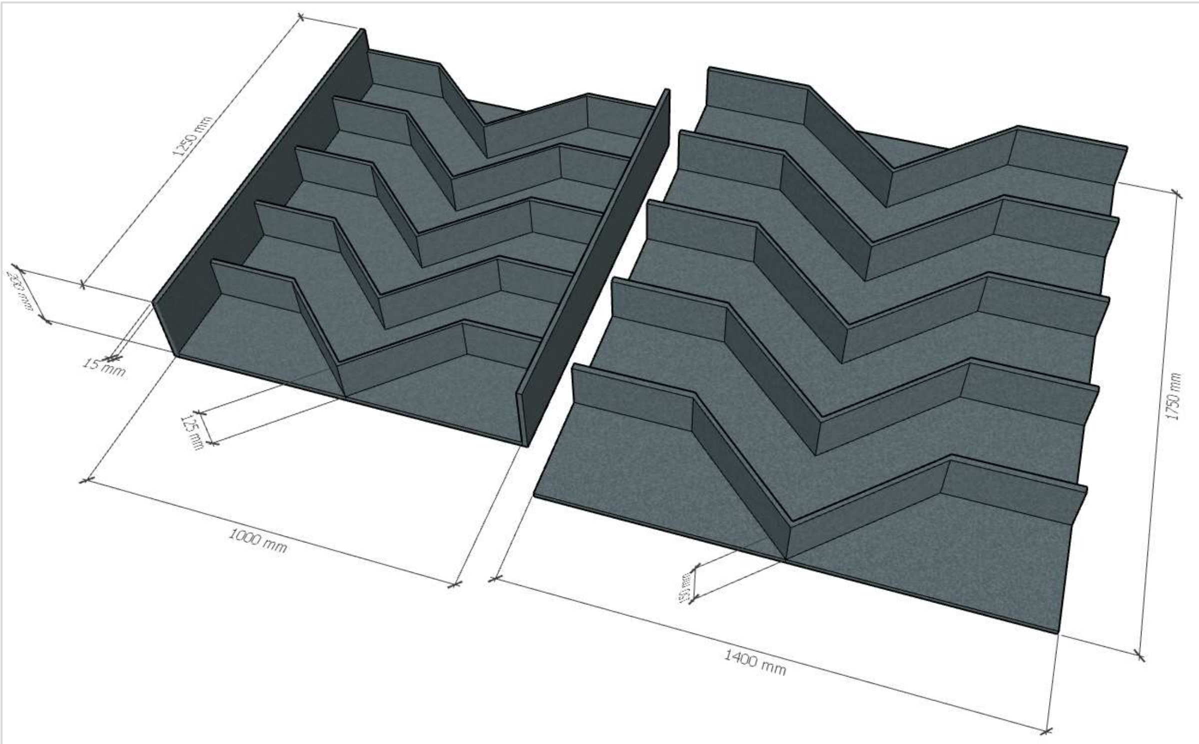

On the left are the medium baffles. The top of these is set at the 'hydraulic invert', i.e. the same level as the bottom of the brush blocks (43.76mAOD). At Q90 there is 500mm of water over the baffles.

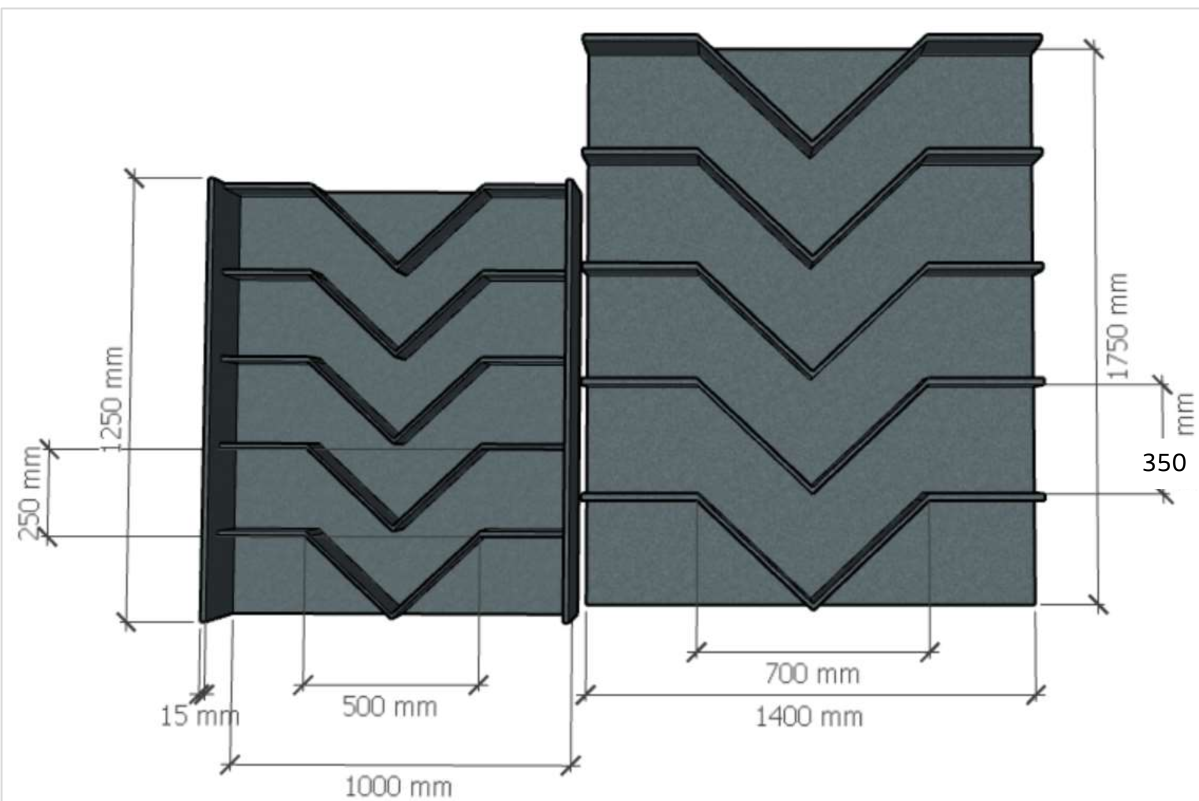
On the right are the large baffles. At Q90 there is 700mm of water over the top of these baffles. The level of the top of the top baffle is 43.56mAOD.




The dimensions (all in mm) of the baffle units is as follows.

| Dimenson | Medium baffle | Large baffle |
|---|---|---|
| Width | 1000 | 1400 |
| Length | 1250 | 1750 |
| Baffle height | 125 | 150 |
| Baffle spacing c/c | 250 | 350 |
| 'V' width (half unit width) | 500 | 700 |
| Side wall height | 200 | n/a |


1250 mm
15 mm
125 mm
1000 mm
1400 mm
1750 mm


1250 mm
250 mm
15 mm
500 mm
1000 mm
1750 mm
mm
350
700 mm
1400 mm

# 13. Design details

## 13.1 Position

The majority of initial options were on the true left bank (looking downstream). Generally the preferred location of a pass is adjacent to a bank as it makes them easier to find by species which travel along the edge of the watercourse.

However, there are a few restrictions at Benson which make this location difficult. First is a side channel to an old mill which is immediately upstream of the weir. It is therefore not possible for the fish pass to extend upstream of the weir without restricting flow and access to the mill channel.

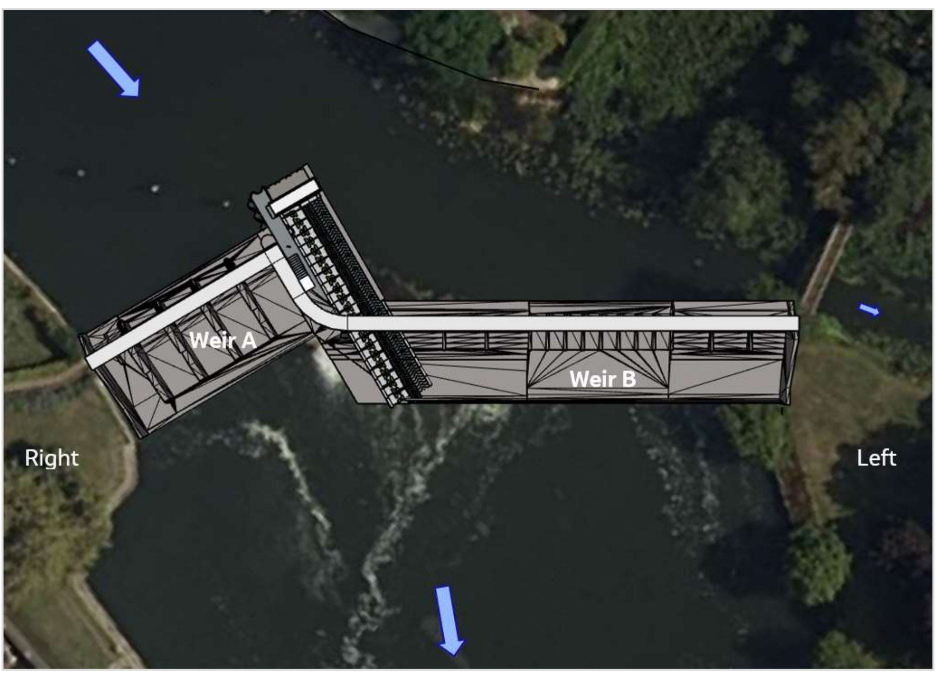
The entry (downstream end) of a fish pass should ideally be within a couple of metres of the toe of the weir. Working between these two restrictions the only space available is that if the weir itself, about 12m from the upstream to downstream pile lines at Benson (left hand side of Weir B).

Due to the head difference at Benson (~1.9m) and the limited available length it is not possible to have a single fish pass flight within the available space, rather some form of switchback arrangement with resting pools, etc. is required. This requires multiple weir bays to be taken out of action and used for fish passage.

Many options and arrangements were considered but no workable solution could be found within the confines of the left bank location. This included baffle passes (i.e. Larinier) and brush passes.

On the right bank are the gates of Weir A which are the main water level control gates. It was not considered appropriate to lose these operational capacity. A fish pass concept was therefore not developed against the right bank. The right bank is also the lock island so not continuous with the main river banks upstream and downstream.

Due to the above restrictions a centrally located pass was chosen.




Although not adjacent to a bank and so not the perfect location the mid channel position has a number of advantages. These include;

- The existing weir arrangement allows for a long (c.24m) pass.
- This is sufficient space to build a true multispecies baffle brush pass.

- The downstream end of the fish pass can be right on the toe of the weir.
- Access into the pass for routine maintenance can be achieved from main weir walkway (something which was more difficult on the left bank).
- The fish pass is fully within Environment Agency managed land.

## 13.2 Type of fish pass

The proposed fish pass is a combined 'baffle-brush' type pass as developed by Dr Hassinger of the University of Kessel, Germany. A number of baffle brush passes have already been constructed including at Sandford and Mapledurham. The design proposed for Benson is similar to that recently constructed at Walsham.

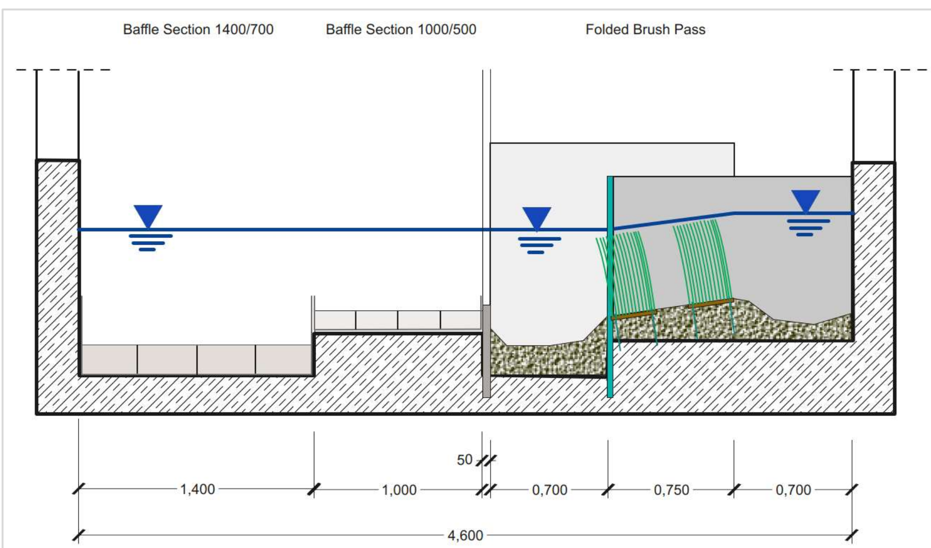
The baffle brush passes at Sandford and Mapledurham were constructed with a 1:20 gradient. However, due to the limitations on space at Benson a 1:12.5 gradient is required. The effective path length of the brush section is therefore increased with internal walls as has been done at the recently opened Walsham fish pass.

The proposed cross-section is shown in **Error! Reference source not found.**. Just over half the width is baffles with the other half being brushes. The total internal fish pass width is 4,600mm including a 50mm thick dividing wall.

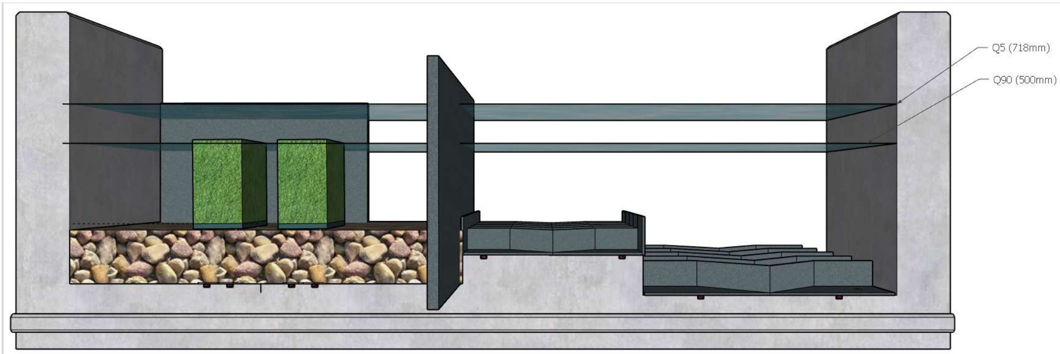
The baffle section has two sizes of baffle within it. A 1,400mm wide section with 150mm high baffles (and nominally 700mm depth of water) and a 1,000mm wide section with 125mm high baffles (and 500mm depth of water). The smaller baffles are therefore set on a raised section of the sub-structure.

The brush section has a series of dividing walls the brushes sit within. These dividing walls significantly increase the flow path length, effectively reducing the gradient of the brush pass.

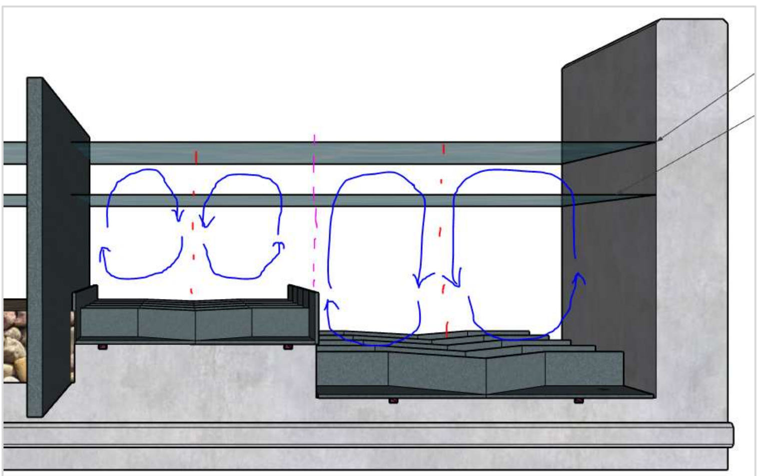
There is a degree of connectivity between the baffle and brush sections with a series of 500mm long gaps in the dividing wall between the two pass types. This allows fish in the baffle section to rest as required in the brush section.




*Note; since the section above was drawn the baffles and brushes have been flipped so are on opposite sides.*




The two baffle sections are at different levels with only a low dividing wall between the two. There has been a query about the interaction of currents between these two. A response on this is provided beneath the image below.



*"Each baffle section is a unit with a double secondary rotation. The current between the baffles is driven by the wedges of the baffles in -> out. This flow is guided to the top by the sidewalls which are at least 1,5 times the head of the baffles itself. This vertical flow at the sides has almost no component down the slope -> these are the corridors for the fish to migrate. For compensation there must be a flow to the centre (from both sides) close to the surface and after merging with the flow from the other side in the middle downward into the baffle interspace. There the downward current is divided into the both interspace flows outward. Each baffle section is a single system. Since the design water depths are different the height of the invert should be different to get a horizontal water surface in cross section.*

*With the flow the different water depth can't be seen. So, if the water flows nobody should think that something is not normal. The only visible distinction is the different aspect of flow pattern (stronger turbulence, stronger air entrainment) in the larger baffles. There is almost no water exchange between the baffle bands (only small compensating current if the water surface level is a bit different or if the inflow discharge is differing from the discharge in the baffle band).*

*We didn't test this in lab because this is a rather simple and sure conclusion derived from the equation of continuity.*

*If the tops of the baffles are at the same level the water depth in the baffle sections will differ from the ideal form which is a double square above the baffles. This would be odd in a hydraulic sense."*

*Dr Hassinger*

The larger baffles and deeper depths were desired in general to maximise the flow through the pass and achieve a reasonable proportion of the ADF through the pass.

## 13.3 Gradient

The gradient of the main structure is 1:12.5 or 8%. The baffle section of the pass has the same gradient. The brush section is built on the same slope but due to the extended flow path created by the dividing walls the effective gradient of the brush pass is approximatly1:30 (3.3%) (depends how the flow path is drawn – can vary between 1:25 and 1:35). The upstream ramp back down to bed level is at 1:2. At the downstream end of the weir apron there is a 1:5 rock ramp.

Gradient of baffle section - 1:12.5

Gradient of brush section - 1:30 (effective)

## 13.4 Layout

The design does not includes a resting pool. The reasons for this are the limited space available for the length of the pass and that the gradient and effective length of the brush section are sufficiently slow as not to require a resting pool. The spaces in the dividing wall between the two pass sections allows fish in the baffle section to migrate to the brush section if rest is required.

**Error! Reference source not found.** shows the baffle section on the left hand side of the pass and the brush on the right. It is planned to reverse this so that the baffles are on the right, closer to the main gates of Weir A.

## 13.5 Key dimensions

On plan the overall fish pass length is 28.1m; 23.8m for the main ramp and 4.3m for the upstream slope back to bed level. See Pass Schematic - Figure 1. The internal width of the pass is 4.6m. The pass has no changes of direction (i.e. is straight) and has no resting pool. The rock ramp down to the bed at the downstream end is approximately 6m long.

As a result of the dividing walls on the brush section of the pass the effective length of that element is 2.4x that of the baffle section, i.e. 57.1m long.

Two different size baffles are proposed. The larger are 1,400mm wide with 175mm high baffles. The smaller are 1,000mm wide with 125mm high baffles.

The brushes are 500mm tall.

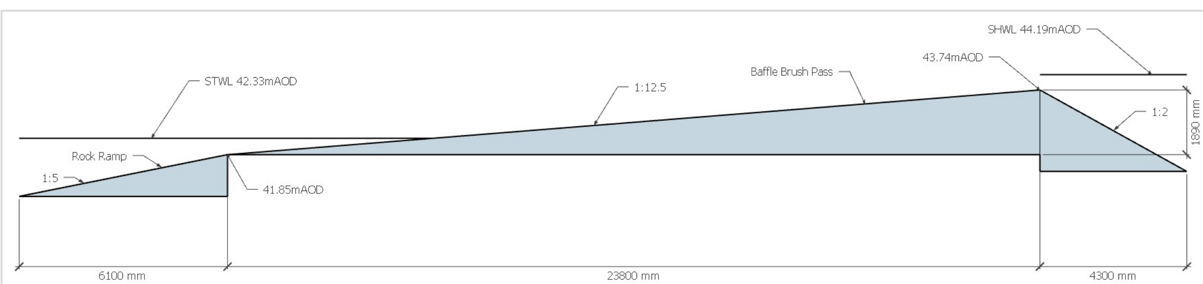



Figure 1 – Pass Schematic

## 13.6 Flows

Following work by Dr Hassinger the proposed fish pass cross-section is shown in **Error! Reference source not found.**. Under normal conditions (Q50) the flows over the baffles are deeper than may be expected in a normal Larinier with 700mm depth of water over the larger baffles and 500mm depth over the smaller baffles. This ratio of 4:1 water depth over the baffles to baffle height is optimum.

These deeper flows (compared to a standard Larinier) help increase the total flow through the pass resulting in almost 3,000 litres per second (3 cumecs) under normal flow conditions. The annual daily mean flow (ADF) is 34 cumecs so approximately 8.8% of the ADF is achieved.

### 13.7 Species

The advantage of this hybrid type of pass is the wide range of species it caters for. This includes; salmonids, coarse fish, eels and lamprey.

### 13.8 Maintenance

Baffle passes generally required relatively little maintenance and are reasonably self-cleansing, however, occasional debris clearance is required, particularly from the first few upstream baffles.

The brush section of the pass may accumulate more debris, however, depending upon the debris it may not affect its function. Any significant debris will need to be removed.

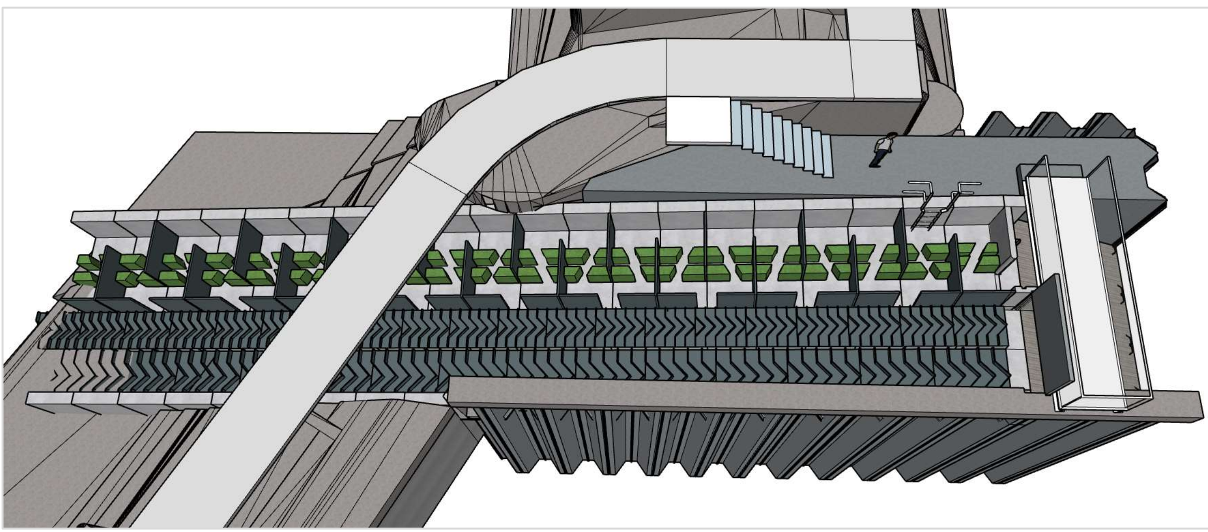
A debris boom will be included in the design to help deflect any debris towards the main weir gates where it should be flushed through.

For maintenance within the pass first the flows will need to be temporarily stopped. The best solution for water control is still being finalised but will likely be a penstock.

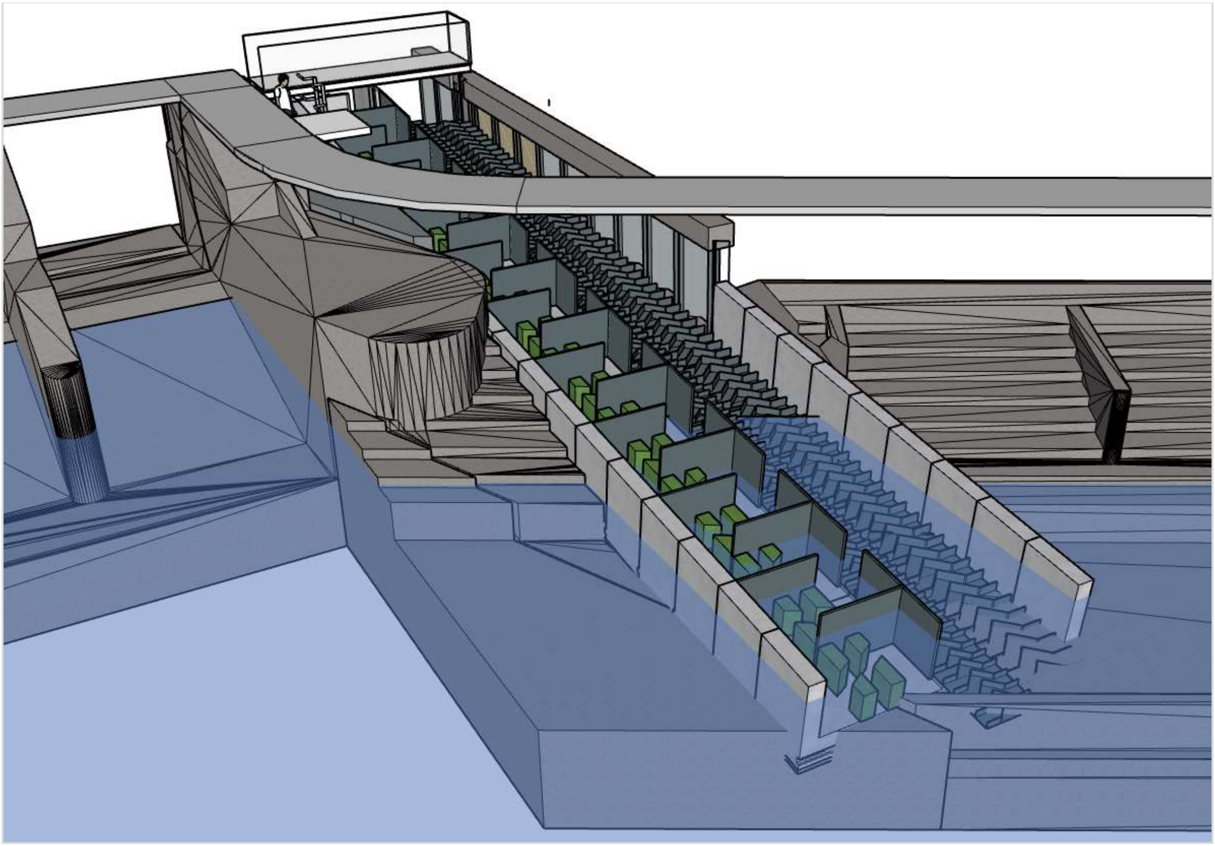
Safe pedestrian access will then be provided down into the fish pass.

## 14. Figures

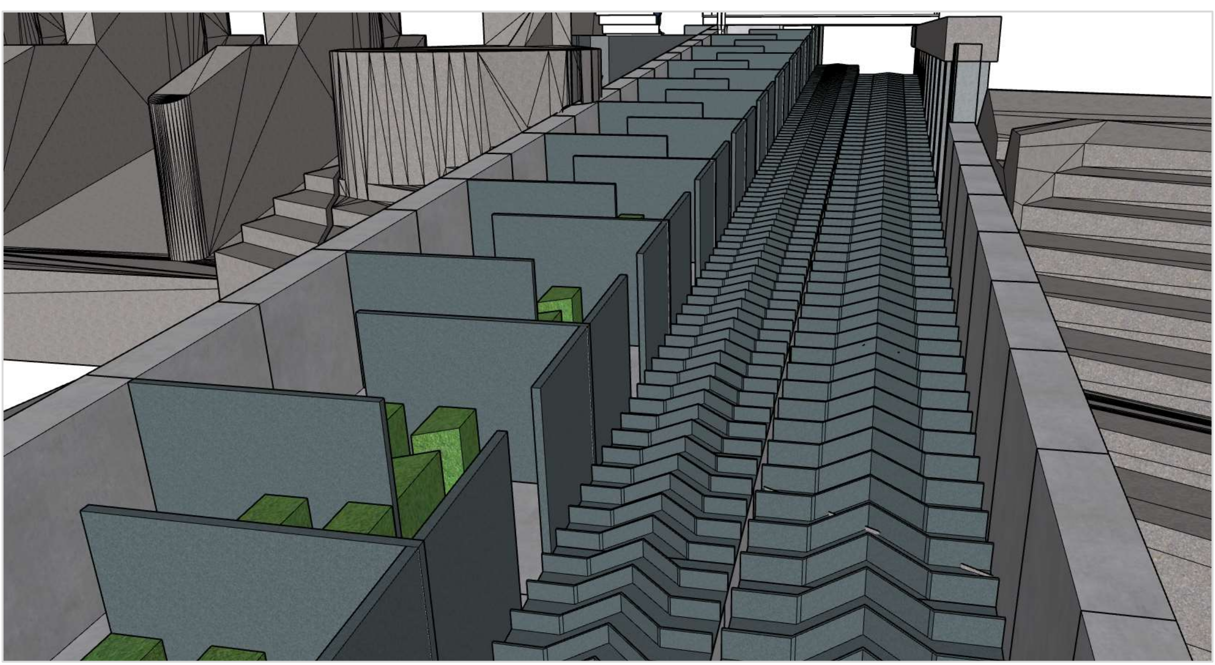
Below are various images of the Benson fish pass design. Please not that most of these were produced prior to the baffles and brushes being swapped sides. This was so the baffles are adjacent to the larger radial gates and that there was a better route to and into the structure for weaker species following the left bank.



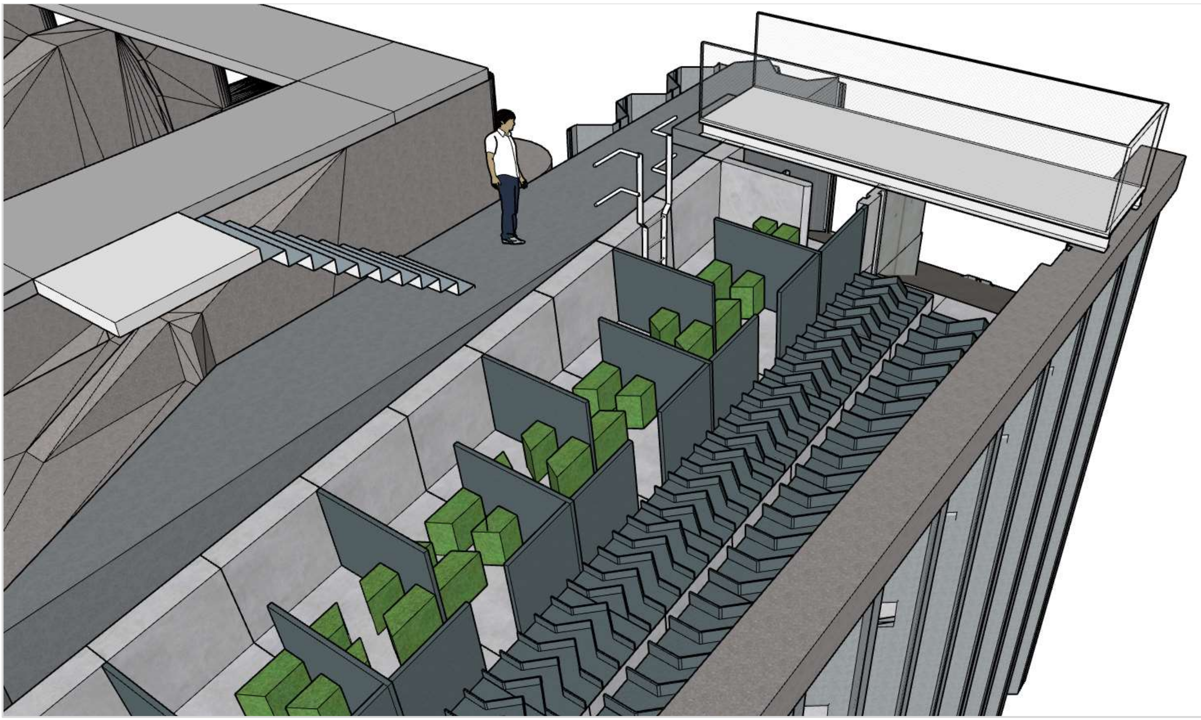
General view of pass, access off walkway and maintenance bridge across upstream end. As outlined above the baffle and brush sections will be switched so that the baffles are closer to the more significant flows of Weir A and that the brushes are closer for species tracking along the toe of the weir.



General view from downstream showing Standard Tail Water Level. Pass will be moved a metre or two downstream to minimise the restriction of the upstream channel.

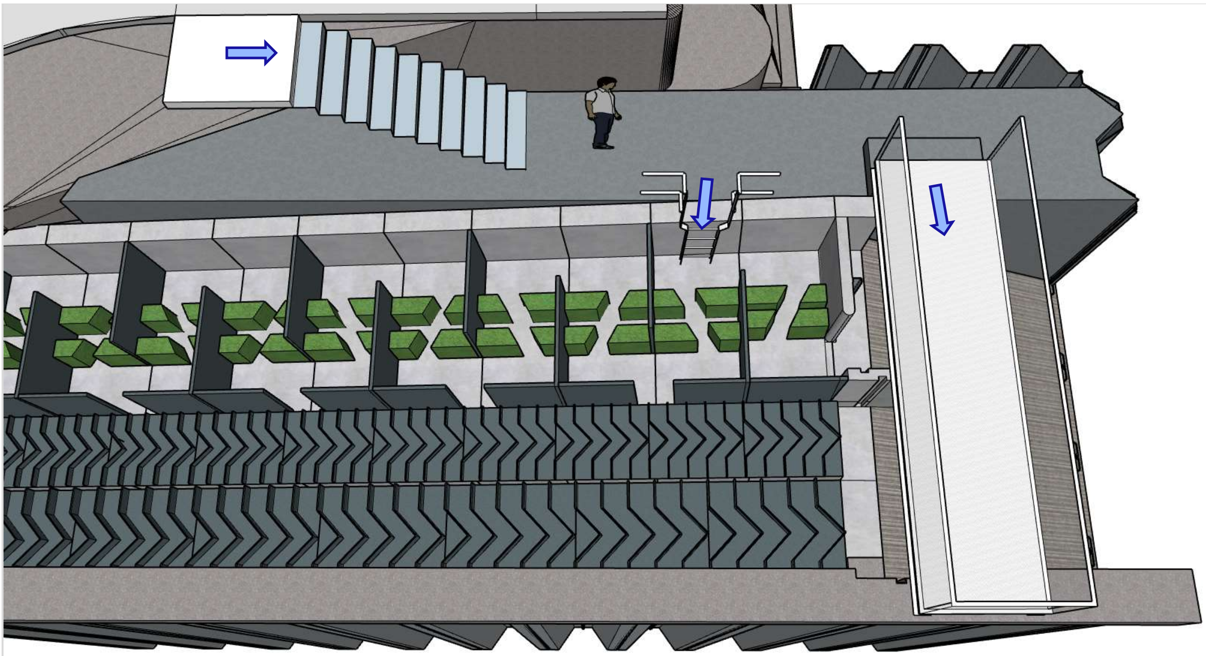


View of two-stage baffles and brush section with dividing walls.

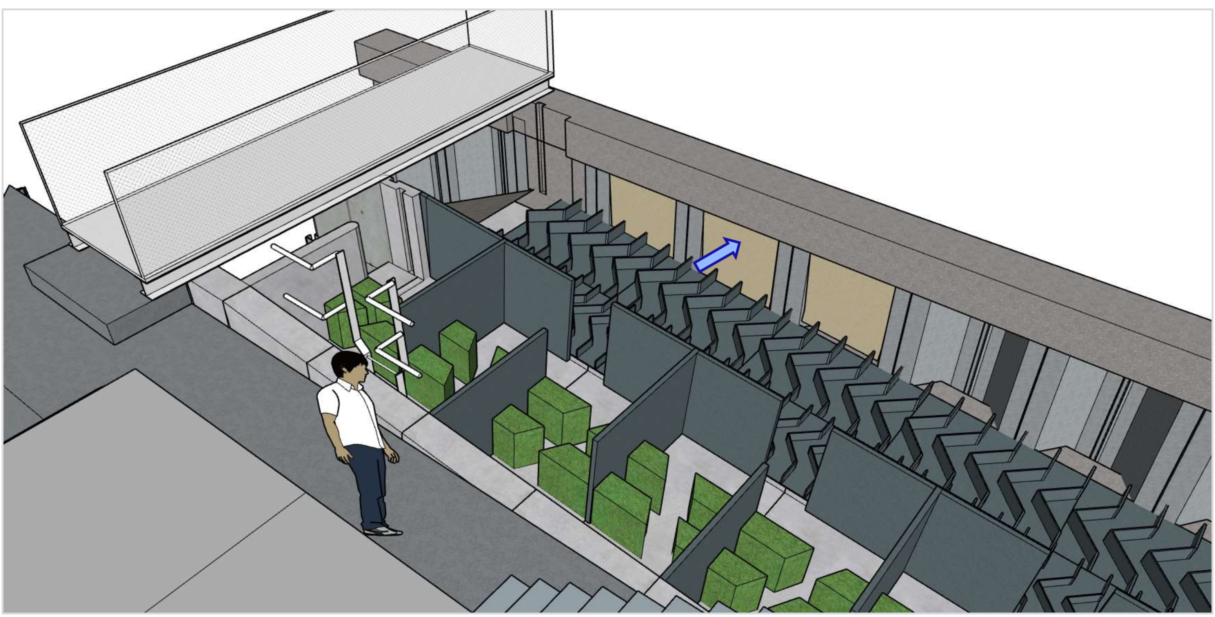


Maintenance access will be via a landing and step irons down from the main walkway (not ladder as shown). A couple of ladders/step irons or similar will be used to gain entry into the pass. The walkway over the pass is for the operation and maintenance of the penstock. The pass is constructed of pre-cast concrete units which will be made with all the required sockets for site installation of the fish pass furniture.

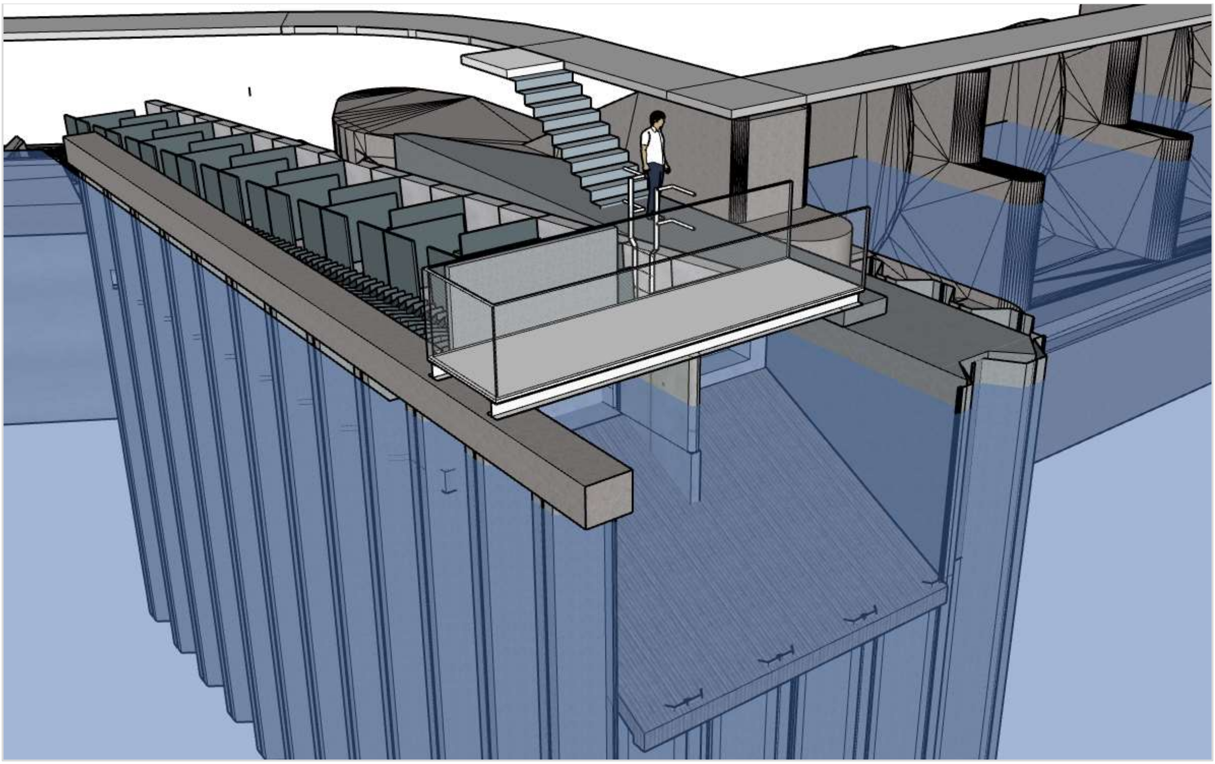
Aerial view of the upstream end of the fish pass with possible fish pass routes.



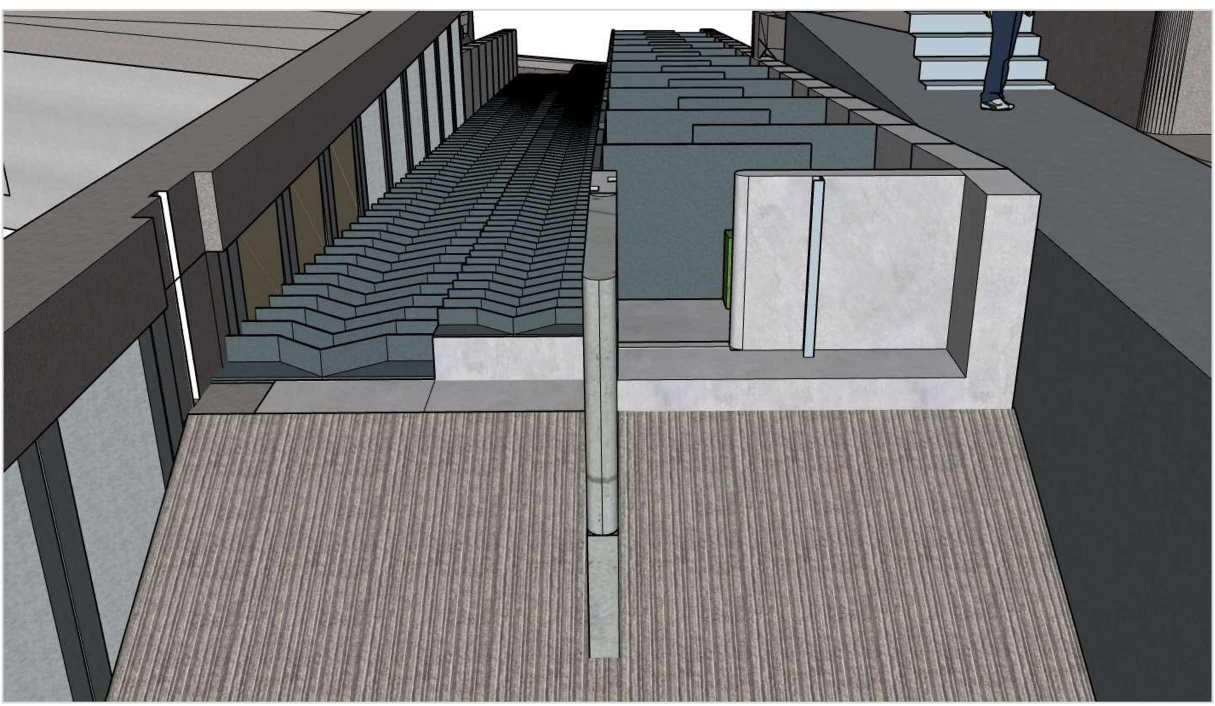
Maintenance access.



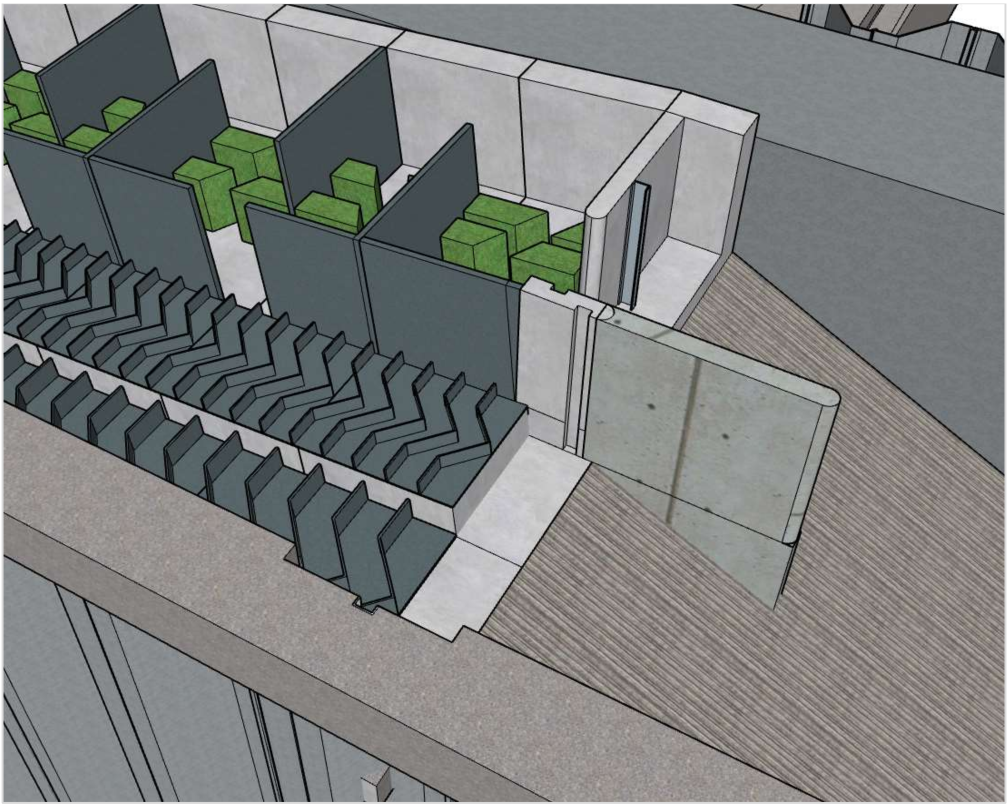
At the upstream end of the fish pass on the left side blanking plates will be put in the sheet pile in-pans to provide a linear surface (these will extend all the way down).



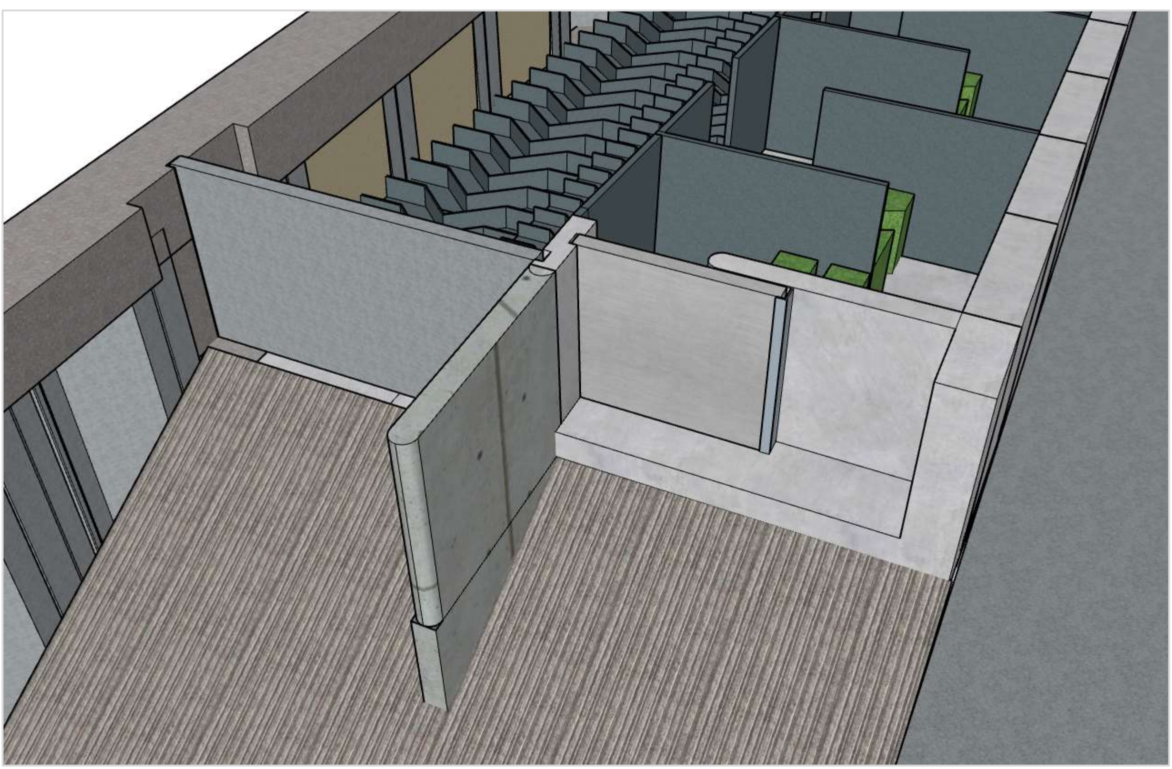
General view of upstream end of ass with Standard Head Water Level indicated.



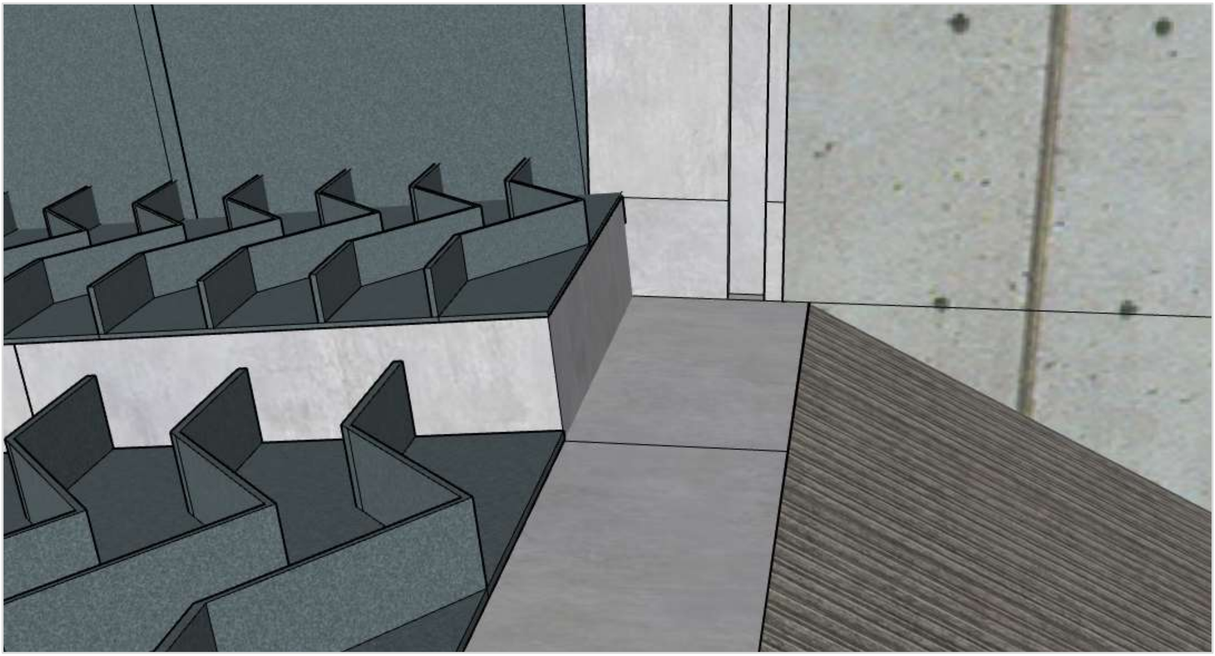
Top end of the fish pass. Left is two-stage baffle section and right brush section (has been reversed).



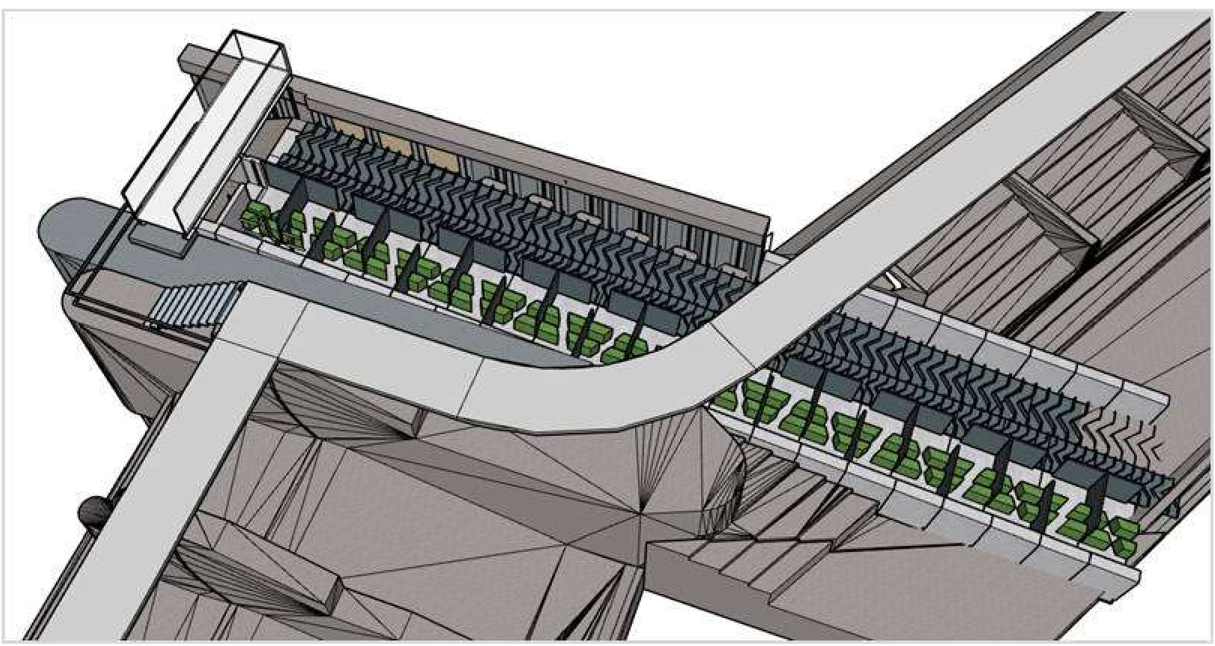
Central dividing wall extends about 2m upstream of the baffle/brush sections.



Upstream end of pass with penstock down and stoplogs installed.



The step at the upstream end of the smaller baffle section. A 45° angle will be put on this.



General view.

## Fish Pass Application – Response To Fish Pass Panel Questions

| | |
|---|---|
| Date: | 29 September 2023 |
| Project name: | Benson Weir Refurbishment (TWRP) |
| Project no: | ENV0003198C |
| Attention: | Area Fisheries Team |
| Company: | Environment Agency |
| Prepared by: | Ross Bransby |
| Reviewed by: | Shauket Khan |
| Document no: | ENV0003198C-JAC-SF-00-DS-C-0009 |
| Revision no: | P01 |
| Copies to: | Stuart Manwaring, Darryl Clifton-Dey, Environment Agency |

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# Purpose of Document & Background

An Application for fish pass approval (Form FP002) was submitted to the Environment Agency Fish Pass Panel in early 2023 (file ref: ENV0003198C-JAC-SF-00-DS-C-0006) for the proposed fish pass at Benson Weir. Accompanying this was a Supplementary Information document and a set of Drawings (as listed below).

| | |
|---|---|
| ENV0003198C-JAC-SF-00-DS-C-0007 | Fish Pass Application – Supplementary Information |
| ENV0003198C-JAC-SF-00-DR-C-1501 | Benson Weir Fish Pass Application Site Plan (Location Plan) |
| ENV0003198C-JAC-SF-00-DR-C-1513 | Fish Pass General Arrangement |
| ENV0003198C-JAC-SF-00-DR-C-1520 | Benson Weir Fish Pass Plan |
| ENV0003198C-JAC-SF-00-DR-C-1530 | Benson Weir Long Sections Through Fish Pass (Brush & Baffles) |
| ENV0003198C-JAC-SF-00-DR-C-1535 | Benson Weir Fish Pass Cross Sections - Sheet 1 of 2 |
| ENV0003198C-JAC-SF-00-DR-C-1536 | Benson Weir Fish Pass Cross Sections - Sheet 2 of 2 |

**In March 2023 Jacobs were notified that the design does not need to go back to the Fish Pass Panel (i.e. approved in principle), however, there were a number of queries which do need to be addressed prior to construction. The responses should go to the Area (Environment Agency Thames Area Fisheries Team) and the final sign-off is by the Area.**

This document works through the questions raised by the Fish Pass Panel and provides responses to each.

All Fish Pass Panel queries have been considered by Jacobs and in consultation with Darryl Clifton-Dey (Senior Technical Specialist, Environment Agency), and Dr Reinhard Hassinger (Former Head of the Research Institute and Test Centre for Environmental Technology and Hydraulic Engineering, University of Kassel and currently appointed as a sub-consultant to Jacobs as a technical specialist for the design of baffle-brush fish passes on the River Thames).

Jacobs is seeking Environment Agency Area (Fisheries Team) approval of the proposed design prior to the construction of Benson Weir Fish Pass (due to start during the first quarter of 2024).

# 1. Fish Pass Panel Comments

**Panel comments and points for Area consideration:**

A - The long section drawings show a step at the toe of the brush pass rather than a slope.
B - There is no downslope shown at the exit of the smaller baffle side of the pass.
C - There are some errors and inconsistencies in the application form and drawings:
    C1 - Table 5.2 - the fish pass does not need to operate to Q5 flows.

C2 - The proposed larger baffle heights are given as both 150mm and 175mm high in supplementary info and detailed drawings but 175mm in the app form.
C3 - The drawings do not all show the 125mm edge along the sides of the smaller baffles.
C4 - Drawings in the supplementary information show baffles and brush the opposite way round to what has been proposed.

D - Do we have any evidence of eel using brush passes at this slope?
E - There is no partition wall to help form an attraction jet below the last set of brushes.
F - The water levels provided in the form are extremely constant, however it looks like the design would be overtopped quite easily so it is recommended that these are double checked to ensure they are correct. A level exceedance table would be very useful.
G - As this is a novel design, it is recommended that the gaps in the dividing wall between the baffle and brush pass should be designed so that they can be shut off if shown to be detrimental to the operation of the pass.

**Panel Recommendation: Form and dimensions of the fish pass will be consistent with Provisional Approved Status, subject to:**

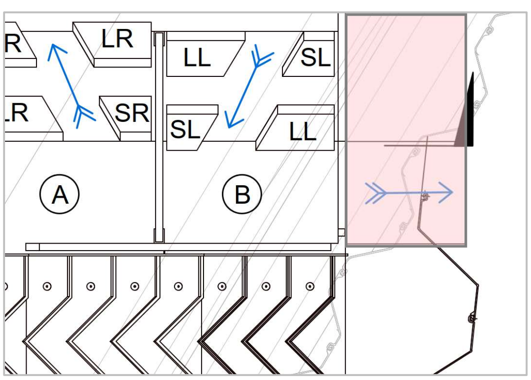
H - Correction of errors in the application form and drawings.
I - Monitoring to demonstrate that the hydraulic conditions within the pass are suitable for fish passage. This could be achieved via an initial desk-based assessment of the ability of fish to ascend the pass based on pass length, the velocities provided in the application and a consideration of fish swimming ability and followed by field monitoring of hydraulic conditions post-construction to ensure that velocities are as predicted. If this monitoring demonstrates, to the satisfaction of the Area team, that the pass functions as described in the application and that conditions are suitable for fish passage, then the pass will be consistent with Approved Status.

**This does not need to return to the Fish Pass Advisory Panel.**

# 2. Panel Comments and Points For Area Consideration - Responses to Comments

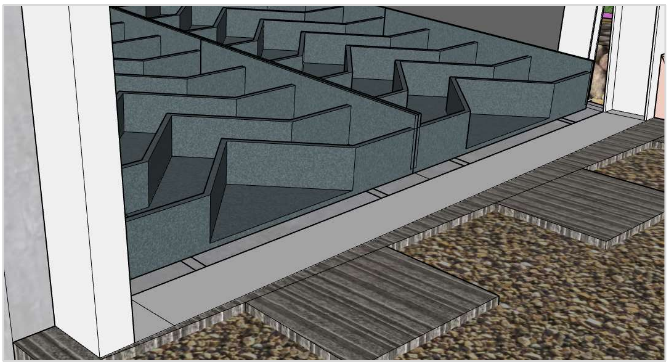
## 2.1 A - The long section drawings show a step at the toe of the brush pass rather than a slope

An additional section of concrete has been included at the bottom of the brush pass. As much as is possible the scour protection / rock ramp downstream of the weir pile line will be built up to this ramp.




## 2.2 B - There is no downslope shown at the exit of the smaller baffle side of the pass

Rather than having two different size sets of baffles with the smaller being set on a raised invert the two baffle units are now the same size (150mm height) and sit directly on the lowest invert concrete level. There is therefore no need for any downslope from any raised section of baffles.



## 2.3 C - There are some errors and inconsistencies in the application form and drawings:

### 2.3.1 C1 - Table 5.2 - the fish pass does not need to operate to Q5 flows.

**5.2 Range of river discharge the pass is expected to operate over**

| | Percentile exceedance | $m^3/s$ |
|---|---|---|
| Lowest flow | Q 95 | 4.30 |
| Highest flow | Q 5 | 118.00 |

Understood. The Q10 maximum operational river flow for the pass, is 82.9 $m^3/s$.

Full table:

| **QFLOW** | **River discharge ($m^3/s$)** |
|---|---|
| Q95 | 4.3 |
| Q90 | 5.4 |
| Q50 | 19.4 |
| **Q10** | **82.9** |
| Q5 | 118.0 |

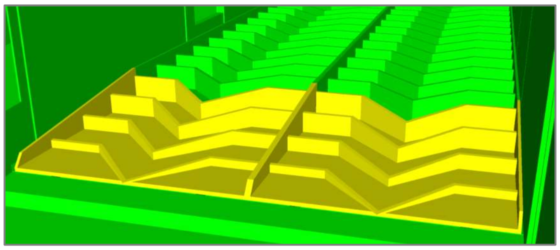
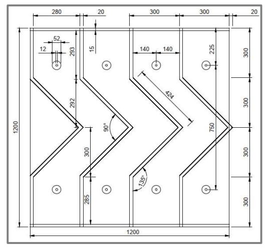
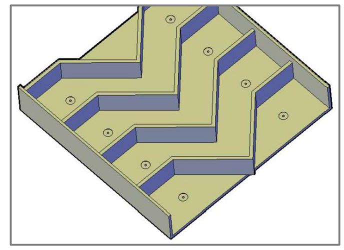
### 2.3.2 C2 - The proposed larger baffle heights are given as both 150mm and 175mm high in supplementary info and detailed drawings but 175mm in the app form.

Following the queries raised during the fish pass application process about the different height baffles, the design has now been revised and both sets of baffles are of the same size and at the same level.

They are 150mm high, at 300mm spacing down the pass and each unit is 1,200mm wide. The baffles are 20mm thick.

### 2.3.3 C3 - The drawings do not all show the 125mm edge along the sides of the smaller baffles.

The images from the 3D model used in the fish pass application did not show the edge plates on the small baffles. All baffles are now the same size (150mm high) and the primary 3D model and our fabrication drawings have edge plates on the baffles. This edge plate is 200mm total height, so extends 50mm above the baffles. Below; left – baffles in main Civils model, middle and right – fabrication details.

### 2.3.4 C4 - Drawings in the supplementary information show baffles and brush the opposite way round to what has been proposed.

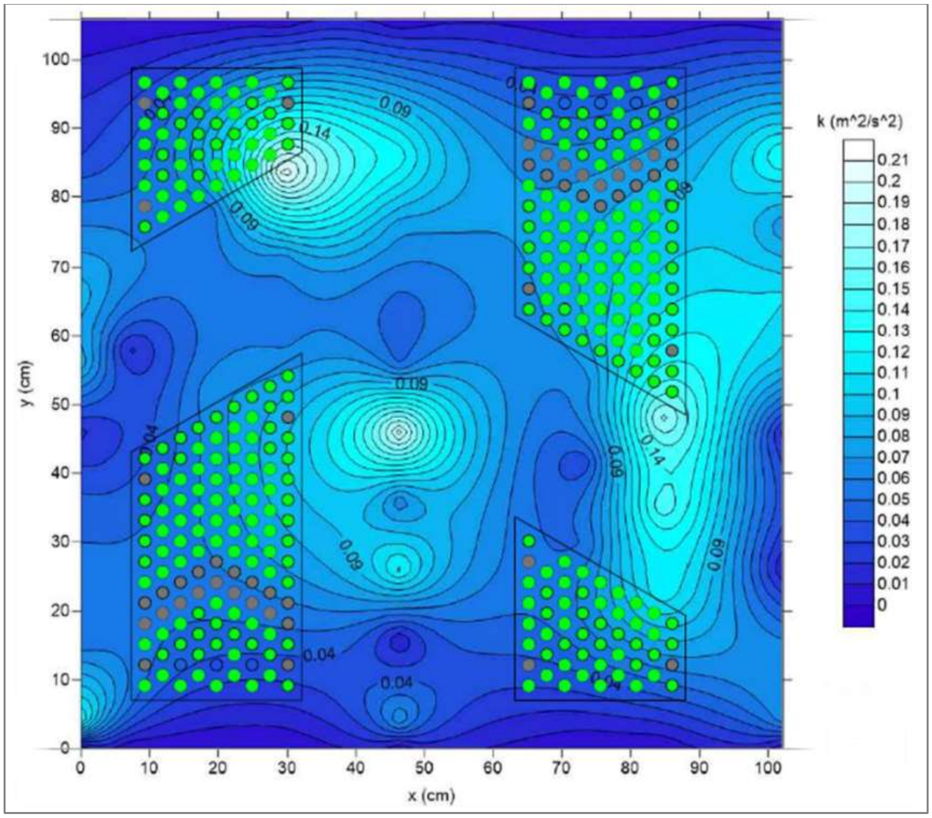
At the time of the fish pass application the baffles were shown on the left on the high level model and one of the details sheets. All models and drawings are now updated and show the baffles on the right and the brushes on the left.

This has been agreed as the best arrangement so that the baffles are closer to the main radial gates and that any weaker species tracking up the left bank and across the weir to the fish pass encounter the brush section first. This arrangement is also beneficial in terms of design and construction with the upper left section of the pass being constructed of sheet piles and the right-hand wall built from concrete, which better suites the baffles and the smooth channel required for this type of pass.

## 2.4 D - Do we have any evidence of eel using brush passes at this slope?

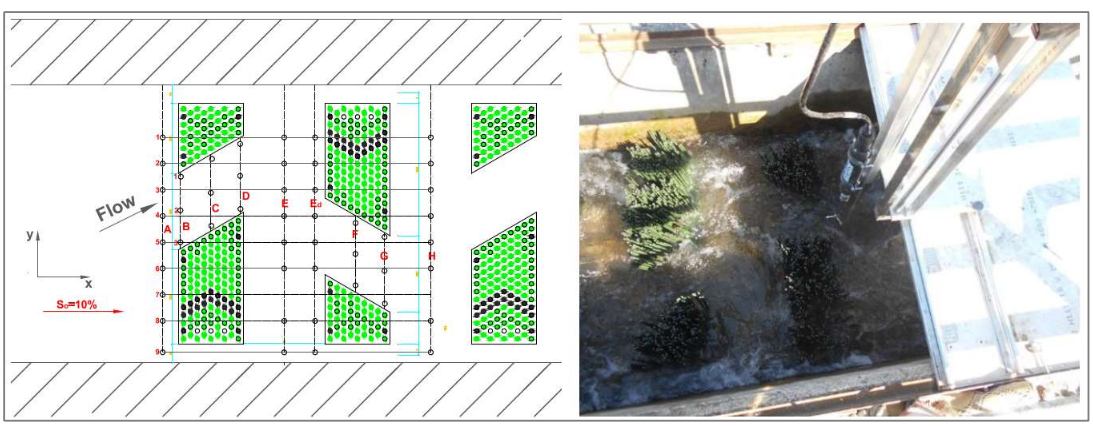
We are not aware of any scientific study proving the use of this type of pass by eels. However, the gravel bed, low velocity zones and general low velocity within the brush pass are considered to be suitable for eels to navigate the structure.

As indicated on the image below there are areas in and around the brushes with very low velocities and energies, which along with the gravel substrate is believed to provide good conditions for the passage of eel. The below energy/velocity measurements were obtained from a field study by S.Kucukali, R.Hassinger, B.Verep, T.Mutlu & D.Ozelci (*Flow and Turbulence Measurements in a Diagonal Brush Fish Pass: A Field Study*). The slope and arrangement are different to Benson but similar velocities are expected based on Dr Hassinger's experience and past laboratory work. The design at Benson replicates in part the recently constructed fish pass at Walsham Weir. It is planned that a site survey at Walsham will be carried out shortly by the Environment Agency to record the velocities at various points and depths throughout the brush pass.




The above image shows kinetic energy measured at mid depth. As can be seen there are various slack areas in and around the brushes which should be suitable for eel migration. A continuous route with velocities of less than 0.3m/s is possible up the brush pass.

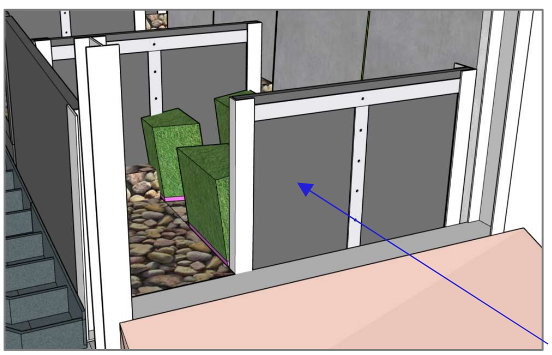
The velocities/energy were obtained from on site measurements from a brush pass using the setup shown below.




Top view of the brush fishway and the velocity measurement grid. The substrate within the pass is also rough with a wide range of interstices. This will aid the passage of many small species. (See image below - although at Benson it is planned to use a slightly larger size of rock – more gabion size, with some even larger rocks wedged under the brushes and in the base layer).

## 2.5 E - There is no partition wall to help form an attraction jet below the last set of brushes.

This was an omission from the drawing set provided to the panel. The design has been updated to include a final dividing wall which will provide the desired attraction flow.



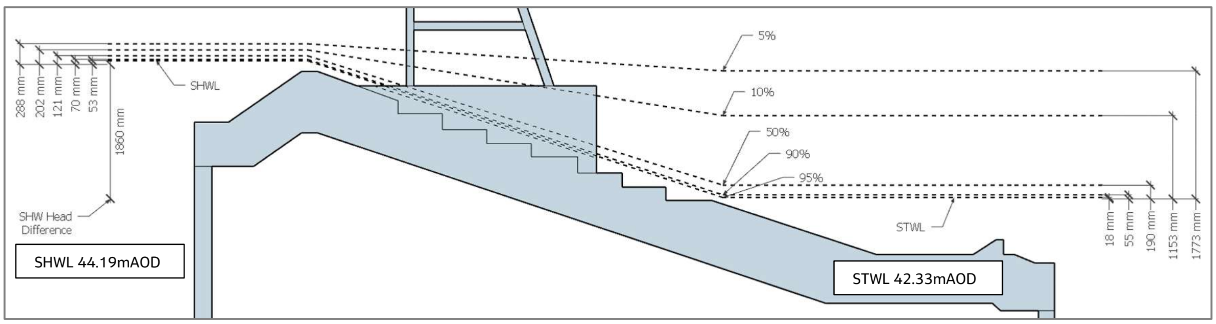
Final partition wall at end of brush pass.

## 2.6 F - The water levels provided in the form are extremely constant, however it looks like the design would be overtopped quite easily so it is recommended that these are double checked to ensure they are correct. A level exceedance table would be very useful.

The primary purpose of Benson Weir is to manage a consistent head water level to aid navigation. This is achieved by the lockkeeper actively managing gate operations throughout the day. As such, upstream water levels during the Qflow conditions of the fish pass design have a relatively narrow range. There is only a 0.15m difference in head water level between Q10 and Q95. This stable head level is a benefit for fish passage at control structures.

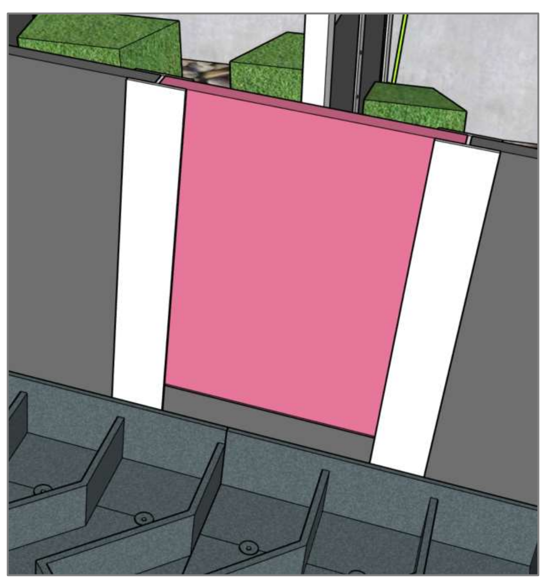
Using historical level gauge data from Benson Weir (15+ years), the percentage exceedance river levels shown in the table below were determined.

| Percentile Exceedance % | Head Stage (m above SHWL) | Head Level (mAOD) | Tail Stage (m above STWL) | Tail Level (mAOD) | Difference (head/tail) |
|---|---|---|---|---|---|
| 0.1 | 1.357 | 45.547 | 3.182 | 45.512 | 0.035 |
| 1.0 | 0.806 | 44.996 | 2.610 | 44.940 | 0.056 |
| 5.0 | 0.288 | 44.478 | 1.773 | 44.103 | 0.375 |
| **10.0** | **0.202** | **44.392** | **1.153** | **43.483** | **0.909** |
| **50.0** | **0.121** | **44.311** | **0.190** | **42.520** | **1.791** |
| **90.0** | **0.070** | **44.260** | **0.055** | **42.385** | **1.875** |
| **95.0** | **0.053** | **44.243** | **0.018** | **42.348** | **1.895** |
| 98.0 | 0.028 | 44.218 | -0.009 | 42.321 | 1.897 |
| 99.0 | 0.008 | 44.198 | -0.021 | 42.309 | 1.889 |
| 100.0 | -0.708 | 43.482 | -0.200 | 42.130 | 1.352 |




## 2.7 G - As this is a novel design, it is recommended that the gaps in the dividing wall between the baffle and brush pass should be designed so that they can be shut off if shown to be detrimental to the operation of the pass.

The dividing wall support posts on either side of the gaps have been changed to an 'H' post design. Under normal conditions (left below) there are infill sections within the H section. If for any reason it is decided to separate the brush and baffle parts of the pass, the infill sections are removed and a full panel inserted (right).



# 3. Panel Recommendation: Form and dimensions of the fish pass will be consistent with Provisional Approved Status, subject to:

## 3.1 H - Correction of errors in the application form and drawings.

All known errors corrected on tender drawings and construction set. However, the application form has not been updated as all updates are detailed in this document. The application form can be updated if required.

## 3.2 I - Monitoring to demonstrate that the hydraulic conditions within the pass are suitable for fish passage.

Question continued: This could be achieved via an initial desk-based assessment of the ability of fish to ascend the pass based on pass length, the velocities provided in the application and a consideration of fish swimming ability and followed by field monitoring of hydraulic conditions post-construction to ensure that velocities are as predicted. If this monitoring demonstrates, to the satisfaction of the Area team, that the pass functions as described in the application and that conditions are suitable for fish passage, then the pass will be consistent with Approved Status.

A swim speed calculation (ENV0003198C-JAC-SF-00-CA-C-0004) has been carried out on the designed fish pass for various fish species.

Brush Pass

The average velocities in the brush pass are low, and within the brush layer there is negligible change in average velocity with increasing river flows. i.e. an average velocity of 0.44m/s at Q95 to 0.46m/s at Q5.

Using the swim speed check calculation (SWIMIT, Environment Agency) spreadsheet the brush pass has velocities which are below the burst speed of all assessed species; chub, roach, bream, brown trout and barbel. At every set of brush blocks there is a resting area plus areas of slack water so the burst distances are very short. It is therefore considered that all species should be able to successfully navigate the pass based on burst speed.

Looking at the sustainable speed (90th%) most length of chub can maintain the required speed, for roach approximately half the fish could pass based on sustained speed, for bream all but the shorter fish can pass, for brown trout most can pass and for barbel all but the smallest in cold water temperatures can pass.

To note that the Swim Speed check undertaken only considers the average velocity in the Brush section. As discussed in paragraph 2.4 there is in fact a range of velocities within the various parts of the brush unit, with many areas behind brush blocks providing velocities much lower than the average velocity.

Given the gravel substrate, the brush blocks and walls it is considered that eel and lamprey will be able to use the brush pass successfully.

Field measurement of flow velocities is planned for Walsham fish pass which is of a similar design. Flow velocity measurements can also be carried out at Benson upon completion of construction.

Baffle Pass

Higher velocities occur in the baffle section of the pass with the following velocities calculated:

| Flow condition | Velocity (m/s) |
|---|---|
| Q10 | 2.13 |
| Q50 | 1.83 |
| Q90 | 1.65 |
| Q95 | 1.56 |

From the swim speed check calculation spreadsheet the velocities in the baffle section exceed the limits for the burst speeds of chub, roach, bream and all but the largest brown trout. Barbel are able to achieve the required burst speed to make progress up the pass but may struggle to maintain the speed for the full length of the pass.

Studies of Atlantic Salmon (Booth, McKinley, Okland, Sisak,1996) reported sustained swim speeds of 2.1m/s which would allow them to make it up the pass under most conditions. It could be suggested that salmon could be used as a surrogate for large trout and barbel which are more likely to be found in the Benson reach.

Fish that are unable to complete the baffle pass in one effort can potentially rest in the brush pass, transiting from the baffle to the brush at one of the 600mm wide gaps in the dividing wall which are at 2500mm intervals (centre to centre) along the dividing wall between the baffle and brush passes. This design is however relatively unproven in this regard and how easily fish will be able to migrate from the baffle to the brush pass and vice versa is not fully understood. Below is an indicative image showing the route a fish in the baffle pass (on the right in this image), may rest in one of the brush pass resting pools before continuing up the baffle pass.

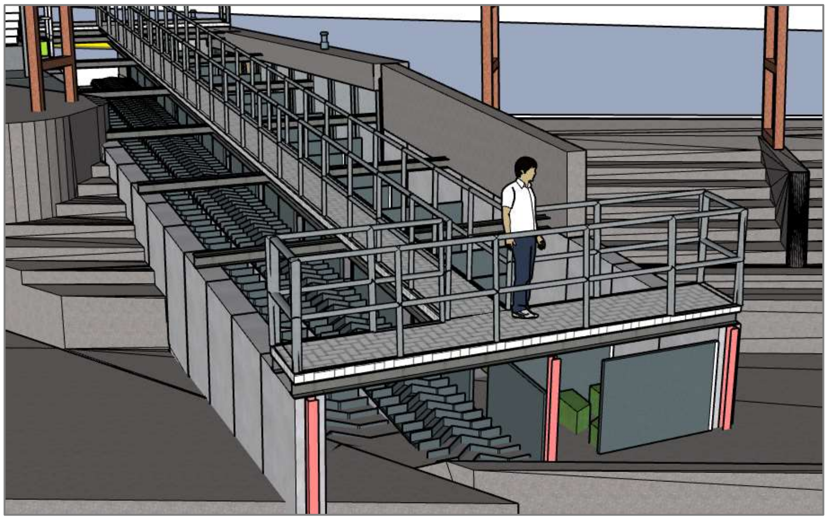
The brush pass should be usable by the majority of the target species identified in the fish pass application, however, the dual benefit of the baffle pass is that it can cater for passage of larger species <u>and provide the vast majority (~90%) of the required attraction flow</u>.

<u>Monitoring</u>

In order to monitor the effectiveness of the fish pass the following are suggested.

Use of a flow meter to determine the actual flow velocities at various locations within the pass, such as; above the baffles, in the openings between the baffle and brush passes, in the brush resting pools, between the brushes, etc.

Visual monitoring. This will be greatly aided by the central walkway (shown below) along with the cross walkways at the top and bottom of the pass. From these it should be possible to observe fish using the brush and baffle passes and congregating downstream of the weir, etc.

 Walkway used for monitoring.

At present no other measure have been put in place to aid the monitoring of fish passage.

A couple of possible options have been suggested by Darryl Clifton-Dey. These were as follows.

First: *On the flat section at the upstream end of the pass, could this be made from a white piece of plastic? It will inevitably get covered in algae, but if someone wanted to do some filming at a later date it would be much easier to clean off the algae and have a white background to see fish against rather than trying to spot them against an algae-covered concrete. (Darryl Clifton-Dey)*

Second: *I don't know where the control for the weir (and fish pass penstocks?) is going to be, but if there could be space in there for a laptop, and a couple of 240v three-pin sockets then that would make it much easier to house and run any recording equipment. (Darryl Clifton-Dey)*

On this second point the penstock at the top of the fish pass is currently manually operated so there is not power going to the fish pass. There is power along the walkway for the operation of the main gates so it may be possible to take a feed from that but ducting routes, etc. would need to be considered.

If either of the above, or any other facility is required to aid monitoring and ascertain the effectiveness of the fish pass please request these via the Environment Agency Project Manager (Paul Warrington) for an instruction to be given for their implementation.

A relatively simple measure which could be implemented post-construction is just to mount a Go-Pro camera on a pole under the water at various location within the pass. Some good footage has been seen from such devices, however, it is obviously a continuous recording without fish recognition and the battery life and storage capacity is limited, typically to a few hours.

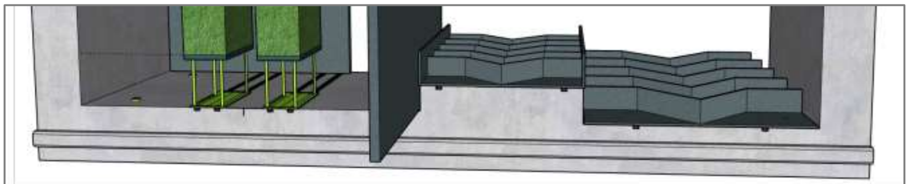
# 4. Design details which have changed since fish pass application

The following are design details which have changed from those shown on the application and drawings.

These changes should be reviewed by the Area. The designers do not consider that any of these are fundamental changes to the design ethos, however, Area should review and if considered significant enough to warrant so, be referred back up to the Fish Pass Panel for review.

## 4.1 Change in baffle size

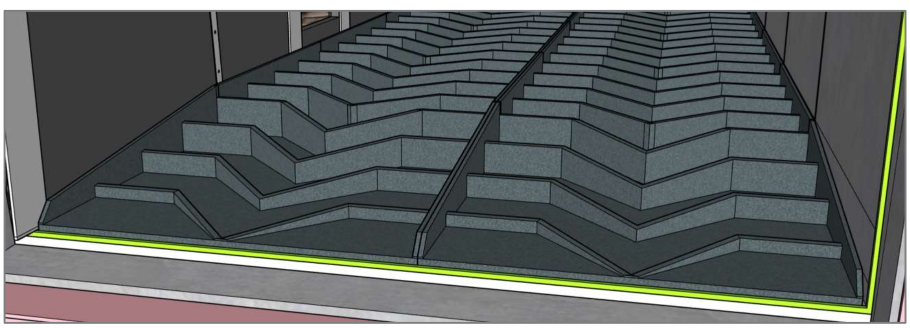
In the application there was a large baffle unit which was 150mm high and 1400mm wide and a medium baffle unit which was 125mm high and 1000mm wide. The medium baffle was set at a high level than the large baffle as indicated on the image below.



The dimensions (all in mm) of the baffle units is as follows.

| Dimenson | Medium baffle | Large baffle |
|---|---|---|
| Width | 1000 | 1400 |
| Length | 1250 | 1750 |
| Baffle height | 125 | 150 |
| Baffle spacing c/c | 250 | 350 |

The design has changed and now consists of two baffle units of equal size and set at the same level (as shown on the image below). The total baffle width is still 2400mm but made up of two 1200mm wide units each with 150mm high baffles.



The result of this change on flows is detailed on the following page.

Left (blue box) baffle rating for original 1400 & 1000 wide baffles. Right (green box) is baffle rating for each 1200mm wide baffles. Highlighted lines are depth a Q90 in the pass, so originally (orange) 700mm on the large baffles and 500mm on the medium baffles. Now 600mm on both sets of baffles (green).

Large baffles and medium baffles (highlighted rows show information for Q90 water level):

**Rating curve baffle section 2 (1400/700)**

| Nr. | h | h/hbfl | lambda | v | Q |
|---|---|---|---|---|---|
| | m | [-] | [-] | m/s | l/s |
| 1 | 0.250 | 1.667 | 5.605 | 0.529 | 185.2 |
| 2 | 0.275 | 1.833 | 4.814 | 0.599 | 230.5 |
| 3 | 0.300 | 2.000 | 4.190 | 0.670 | 281.6 |
| 4 | 0.325 | 2.167 | 3.687 | 0.744 | 338.4 |
| 5 | 0.350 | 2.333 | 3.276 | 0.819 | 401.2 |
| 6 | 0.375 | 2.500 | 2.934 | 0.896 | 470.2 |
| 7 | 0.400 | 2.667 | 2.647 | 0.974 | 545.3 |
| 8 | 0.425 | 2.833 | 2.403 | 1.054 | 626.9 |
| 9 | 0.450 | 3.000 | 2.194 | 1.135 | 714.9 |
| 10 | 0.475 | 3.167 | 2.012 | 1.217 | 809.4 |
| 11 | 0.500 | 3.333 | 1.854 | 1.301 | 910.7 |
| 12 | 0.525 | 3.500 | 1.715 | 1.386 | 1018.7 |
| 13 | 0.550 | 3.667 | 1.592 | 1.472 | 1133.7 |
| 14 | 0.575 | 3.833 | 1.483 | 1.560 | 1255.6 |
| 15 | 0.600 | 4.000 | 1.386 | 1.648 | 1384.6 |
| 16 | 0.625 | 4.167 | 1.299 | 1.738 | 1520.8 |
| 17 | 0.650 | 4.333 | 1.220 | 1.829 | 1664.2 |
| 18 | 0.675 | 4.500 | 1.148 | 1.921 | 1815.0 |
| 19 | 0.700 | 4.667 | 1.084 | 2.013 | 1973.2 |
| 20 | 0.725 | 4.833 | 1.025 | 2.107 | 2138.9 |
| 21 | 0.750 | 5.000 | 0.971 | 2.202 | 2312.2 |
| 22 | 0.775 | 5.167 | 0.921 | 2.298 | 2493.1 |
| 23 | 0.800 | 5.333 | 0.876 | 2.394 | 2681.8 |
| Calculation for Duration Curve points | | | | | |
| Invert offset | -0.2 | m | | | |
| 24 | 0.918 | 6.120 | 0.703 | 2.863 | 3679.0 |
| 25 | 0.832 | 5.547 | 0.823 | 2.520 | 2934.7 |
| 26 | 0.751 | 5.007 | 0.969 | 2.206 | 2319.2 |
| 27 | 0.700 | 4.667 | 1.084 | 2.013 | 1973.2 |
| 28 | 0.683 | 4.553 | 1.127 | 1.950 | 1864.8 |

**Rating curve baffle section 1 (1000/500)**

| Nr. | h | h/hbfl | lambda | v | Q | |
|---|---|---|---|---|---|---|
| | m | [-] | [-] | m/s | l/s | |
| 1 | 0.250 | 2.000 | 4.190 | 0.612 | 153.0 | |
| 2 | 0.275 | 2.200 | 3.598 | 0.693 | 190.5 | |
| 3 | 0.300 | 2.400 | 3.132 | 0.775 | 232.6 | |
| 4 | 0.325 | 2.600 | 2.756 | 0.860 | 279.6 | |
| 5 | 0.350 | 2.800 | 2.449 | 0.947 | 331.5 | |
| 6 | 0.375 | 3.000 | 2.194 | 1.036 | 388.4 | |
| 7 | 0.400 | 3.200 | 1.979 | 1.126 | 450.5 | |
| 8 | 0.425 | 3.400 | 1.796 | 1.219 | 517.9 | |
| 9 | 0.450 | 3.600 | 1.640 | 1.312 | 590.6 | |
| 10 | 0.460 | 3.680 | 1.583 | 1.350 | 621.2 | |
| 11 | 0.470 | 3.760 | 1.530 | 1.389 | 652.6 | |
| 12 | 0.480 | 3.840 | 1.479 | 1.427 | 685.0 | |
| 13 | 0.490 | 3.920 | 1.431 | 1.466 | 718.2 | |
| 14 | 0.500 | 4.000 | 1.386 | 1.505 | 752.4 | |
| 15 | 0.510 | 4.080 | 1.343 | 1.544 | 787.4 | |
| 16 | 0.520 | 4.160 | 1.302 | 1.583 | 823.3 | |
| 17 | 0.530 | 4.240 | 1.263 | 1.623 | 860.1 | |
| 18 | 0.540 | 4.320 | 1.226 | 1.663 | 897.9 | |
| 19 | 0.550 | 4.400 | 1.190 | 1.703 | 936.6 | |
| 20 | 0.560 | 4.480 | 1.157 | 1.743 | 976.2 | |
| 21 | 0.570 | 4.560 | 1.124 | 1.784 | 1016.7 | |
| 22 | 0.580 | 4.640 | 1.094 | 1.824 | 1058.1 | |
| 23 | 0.590 | 4.720 | 1.064 | 1.865 | 1100.5 | |
| Calculation for Duration Curve points | | | | | | |
| Invert offset | 0.000 | m | | | | |
| 24 | 0.718 | 5.744 | 0.778 | 2.407 | 1728.0 | Q5 |
| 25 | 0.632 | 5.056 | 0.954 | 2.039 | 1288.9 | Q10 |
| 26 | 0.551 | 4.408 | 1.187 | 1.707 | 940.5 | Q50 |
| 27 | 0.500 | 4.000 | 1.386 | 1.505 | 752.4 | Q90 |
| 28 | 0.483 | 3.864 | 1.465 | 1.439 | 694.9 | Q95 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Benson Weir and Lock | | | | | | |
| Baffle-Brush Fish Pas | | friction factor lambda = f(h/hbfl) | | | Coefficients | |
| | | lambda = a/(h/hbfl)^b | | | a | 12.6645 |
| Baffle Section 1 | | hbfl | 0.150 | m | b | 1.5959 |
| | | **b** | **1.200** | **m** | | |
| | | lo | 0.08 | [-] | | |

**Rating curve baffle sections (1200/600)**

| Nr. | h | h/hbfl | lambda | v | Q | |
|---|---|---|---|---|---|---|
| | m | [-] | [-] | m/s | l/s | |
| 1 | 0.250 | 1.667 | 5.605 | 0.529 | 158.7 | |
| 2 | 0.275 | 1.833 | 4.814 | 0.599 | 197.6 | |
| 3 | 0.300 | 2.000 | 4.190 | 0.670 | 241.3 | |
| 4 | 0.325 | 2.167 | 3.687 | 0.744 | 290.1 | |
| 5 | 0.350 | 2.333 | 3.276 | 0.819 | 343.9 | |
| 6 | 0.375 | 2.500 | 2.934 | 0.896 | 403.0 | |
| 7 | 0.400 | 2.667 | 2.647 | 0.974 | 467.4 | |
| 8 | 0.425 | 2.833 | 2.403 | 1.054 | 537.3 | |
| 9 | 0.450 | 3.000 | 2.194 | 1.135 | 612.7 | |
| 10 | 0.460 | 3.067 | 2.118 | 1.168 | 644.5 | |
| 11 | 0.470 | 3.133 | 2.046 | 1.201 | 677.1 | |
| 12 | 0.480 | 3.200 | 1.979 | 1.234 | 710.7 | |
| 13 | 0.490 | 3.267 | 1.915 | 1.267 | 745.2 | |
| 14 | 0.500 | 3.333 | 1.854 | 1.301 | 780.6 | |
| 15 | 0.510 | 3.400 | 1.796 | 1.335 | 816.9 | |
| 16 | 0.520 | 3.467 | 1.742 | 1.369 | 854.2 | |
| 17 | 0.530 | 3.533 | 1.689 | 1.403 | 892.4 | |
| 18 | 0.540 | 3.600 | 1.640 | 1.438 | 931.6 | |
| 19 | 0.550 | 3.667 | 1.592 | 1.472 | 971.7 | |
| 20 | 0.560 | 3.733 | 1.547 | 1.507 | 1012.8 | |
| 21 | 0.570 | 3.800 | 1.504 | 1.542 | 1054.8 | |
| 22 | 0.580 | 3.867 | 1.463 | 1.577 | 1097.8 | |
| 23 | 0.590 | 3.933 | 1.424 | 1.613 | 1141.8 | |
| 24 | 0.600 | 4.000 | 1.386 | 1.648 | 1186.8 | |
| 25 | 0.610 | 4.067 | 1.350 | 1.684 | 1232.7 | |
| 26 | 0.620 | 4.133 | 1.315 | 1.720 | 1279.7 | |
| Calculation for Duration Curve points | | | | | | |
| 24 | 0.818 | 5.453 | 0.845 | 2.465 | 2419.3 | Q5 |
| 25 | 0.732 | 4.880 | 1.009 | 2.134 | 1874.2 | Q10 |
| 26 | 0.651 | 4.340 | 1.217 | 1.832 | 1431.5 | Q50 |
| 27 | 0.600 | 4.000 | 1.386 | 1.648 | 1186.8 | Q90 |
| 28 | 0.574 | 3.827 | 1.488 | 1.556 | 1071.9 | Q95 |

Looking at the total flow (at Q90) through the baffle section, we have originally 1973+752 = 2725 litres per second. The current design has 1187 x 2 = 2374 litres per second. The flow through the brush pass remains unchanged between the application design and current design.

This change in flow is summarised below with the total flow through the fish pass for various Q-flows. This is then also expressed as a percentage of the flow in the river. i.e. at Q50 it is now 16.3% compared with 18.4% previously.

Benson Weir and Lock — BRUSH & BAFFLE

Fish Pass — Inflow inver 43.760 mAOD (design for Q90)

Summary of Discharges

| Percent. of Exceed. | Duration of Exceedance | River Discharge | Headpond level | Inflow head* | Discharges: Brush pass | Discharges: Baffle sec. 1 1000/500 | Discharges: Baffle. Sec. 2 1400/700 | Discharges: Discharge Fish Pass | Discharge fish pass | % of flow going down fish pass |
|---|---|---|---|---|---|---|---|---|---|---|
| % | days | m³/s | mAOD | m | l/s | l/s | l/s | l/s | m³/s | |
| 5 | 18 | 118.0 | 44.478 | 0.718 | 536 | 1,728 | 3,679 | 5,943 | 5.94 | 5.04% |
| 10 | 37 | 82.9 | 44.392 | 0.632 | 399 | 1,289 | 2,935 | 4,623 | 4.62 | 5.58% |
| 50 | 183 | 19.4 | 44.311 | 0.551 | 301 | 940 | 2,319 | 3,561 | 3.56 | 18.35% |
| 90 | 329 | 5.4 | 44.260 | 0.500 | 260 | 752 | 1,973 | 2,986 | 2.99 | 55.29% |
| 95 | 347 | 4.3 | 44.243 | 0.483 | 252 | 695 | 1,865 | 2,811 | 2.81 | 65.38% |

* over inflow invert (designed for Q90)

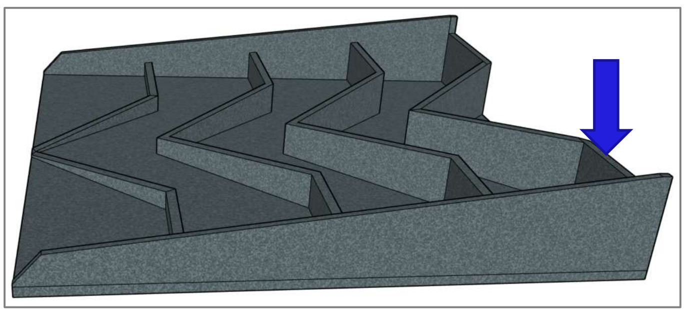
*Original Baffle design with submission in March 2023*

| Benson Weir and Lock | | | | | | BRUSH & BAFFLE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fish Pass | | | Inflow inver | 43.760 | mAOD | (design for Q90) | | | | | |
| | | | | | | | | | | | |
| Summary of Discharges | | | | | | | | | | | |
| | | | | | Discharges | | | | | | |
| Percent. of Exceed. % | Duration of Exceedance days | River Discharge $m^3/s$ | Headpond level mAOD | Inflow head* m | Brush pass l/s | Baffle sec. 1 1200/600 l/s | Baffle. Sec. 2 1200/600 l/s | Discharge Fish Pass l/s | | Discharge fish pass $m^3/s$ | % of flow going down fish pass |
| 5 | 18 | 118.0 | 44.478 | 0.718 | 536 | 2,419 | 2,419 | 5,374 | | 5.37 | 4.55% |
| 10 | 37 | 82.9 | 44.392 | 0.632 | 399 | 1,874 | 1,874 | 4,148 | | 4.15 | 5.00% |
| 50 | 183 | 19.4 | 44.311 | 0.551 | 301 | 1,431 | 1,431 | 3,164 | | 3.16 | 16.31% |
| 90 | 329 | 5.4 | 44.260 | 0.500 | 260 | 1,187 | 1,187 | 2,634 | | 2.63 | 48.77% |
| 95 | 347 | 4.3 | 44.243 | 0.483 | 252 | 1,072 | 1,072 | 2,396 | | 2.40 | 55.71% |
| | | | | | | | | | | | |
| * over inflow invert (designed for Q90) | | | | | | | | | | | |

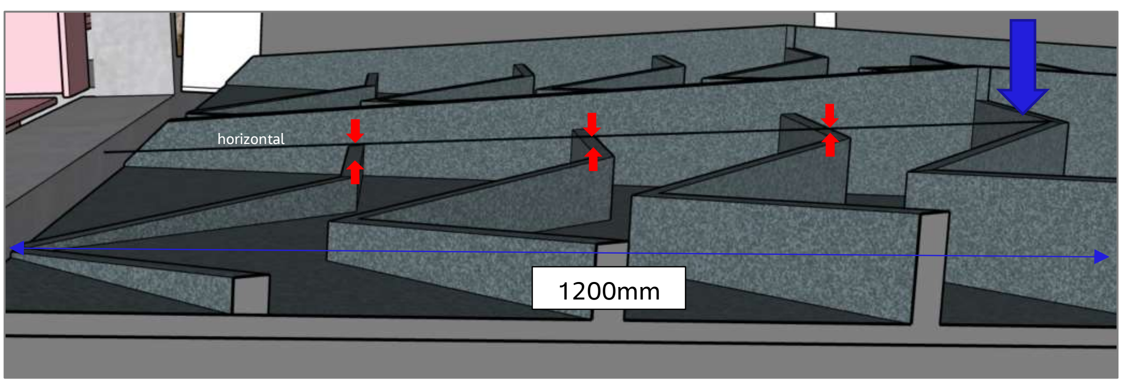
*New baffle design August 2023*

## 4.2 Change to profile of top baffles

In the design submitted to the fish pass panel the baffles were full height to the top of the fish pass. On the current design the first full height baffle is the fourth baffle down the pass as indicated by the arrow on the image below.



This baffle is 1200mm from the top of the fish pass. All the baffles upstream of this are at a slightly lower level (mAOD) than the fourth baffle. The top of the fourth baffle is the hydraulic invert of the baffle pass.

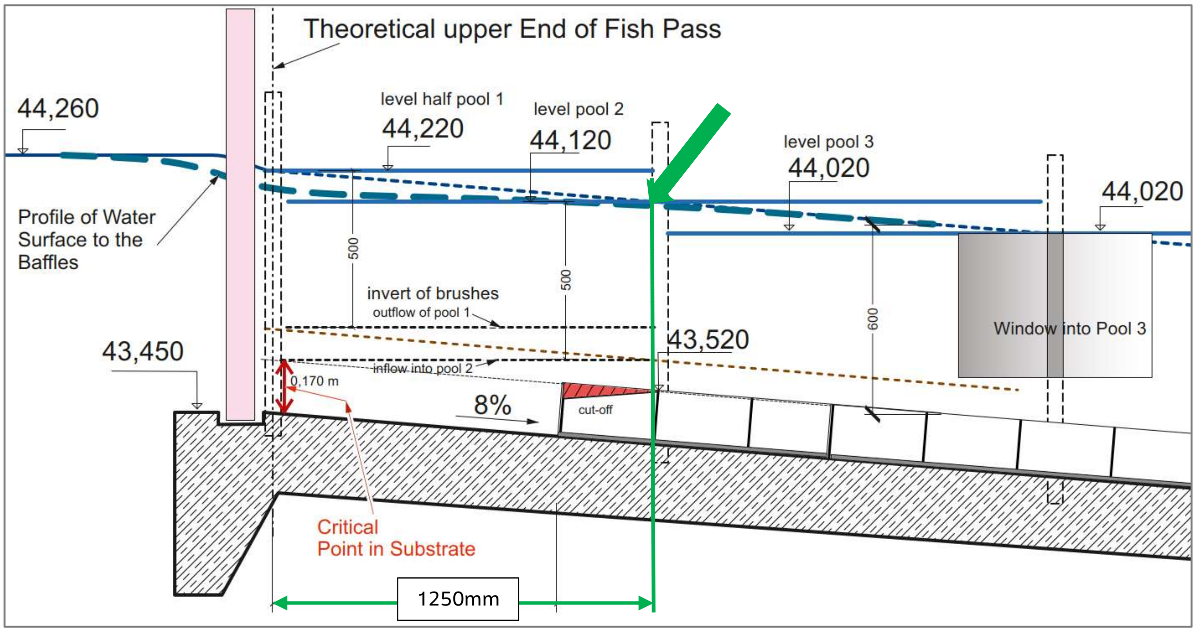



This arrangement is distinct from a Super Active Larinier design where the convention is to set the first full height baffle at a distance of 2.6 times the baffle height from the crest (pg.117 fish pass manual).

This distinction is explained by the way that the Hassinger baffle is designed to operate alongside the brush units, under a slacker gradient (1:12.5 compared with 1:6.667 for a standard Larinier) and with a higher head water condition compared with the Larinier design.

Because the brushes do not require any gain in velocity for the operating conditions, the brushes can be positioned close to the crest position. In order to maintain the continuity and lateral transition between brushes and baffles that is essential to the baffle brush design to have this feature which matches water levels in the baffle and brush sections.

Due to the relatively low head water conditions and shallow gradient at the head of the baffle section, water will need to be accelerated slightly to achieve optimal velocity/turbulence in the baffle section.




Above – image indicating point where water levels in the baffle and brush passes are equal.

In order to gain this velocity the first fully upright baffle is set at a distance calculated from the velocity head gain required.

From the brush pass it is determined that a water level drop of 140mm is required between the head pond level and the water surface at the hydraulic beginning of the baffles (44.260-44.120mAOD).

The function for the water profile in the brushes is:

h_brush =44.260 - 0,04 (the drop for acceleration into pool 1) - x * 0.08 = h_baffle

You get the equation: 44.12 = 44.22 - x * 0.08.

Solving for x: x = 0.1/0.08 = 1.25 m. This is the horizontal position from the crest to the first upright baffle.

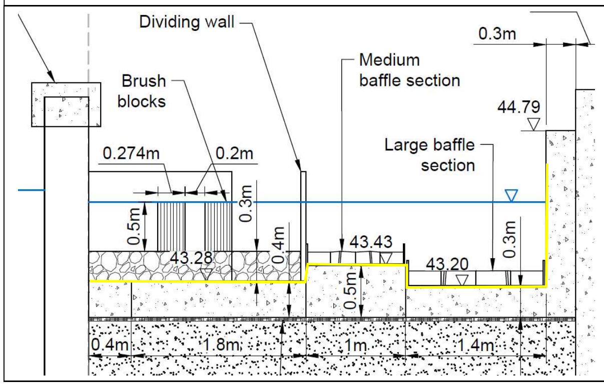
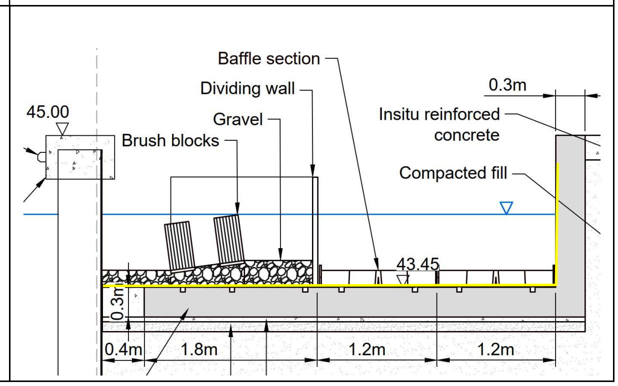
As the baffle units are 1200mm this has been reduced by 50mm.

The first full height baffle is therefore 1200mm from the crest.

Upstream of this there is a need for some bed roughness so the baffles are continued but all cut down so that they are lower than the first full height baffle.

The positioning of the hydraulic invert for this Hassinger Baffle design is consistent with the Millmead Fish Pass design on the River Wey

## 4.3 Stepped bed profile

| As application | Current design |
|---|---|
|  |  |

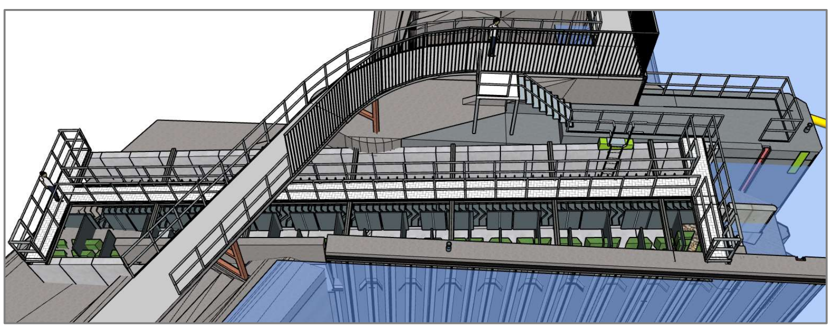




The design submitted for the fish pass application had a stepped cross section with different concrete levels for each of the baffle units and the brush blocks. As a result of changing the baffles this has been simplified so that the top surface of the concrete is flat the full width of the fish pass. As well as simplifying construction this also reduces materials usage and creates less constraints if the internal arrangement of the pass needs to be changed at any time in the future.

## 4.4 Central walkway and ladders

In order to provide access to the downstream stoplogs and for routine removal of light debris (i.e. using a boating hook), a central walkway has been provided down the pass.



To minimise shadowing, the greatest beam spacing and minimum walkway width (800mm) have been selected. The walkway sits on the left side of the baffles just clear of the dividing wall – to allow the insertion of infill boards if required and for clear site of all of the brush pass - as this is the side of the pass most likely to snag debris. Visual fish pass monitoring should also be possible from the walkway.

This walkway was not included on the fish pass application drawings. The requirement for it is a response to a health and safety review of maintenance of the fish pass by the Environment Agency's Senior User and Operational Manager and was considered by far the safest arrangement for clearing light debris, checking the pass and accessing the downstream stoplogs.

## 4.5 Slight change in crest levels

The following table compares the crest levels in the fish pass application (blue rows) vs current design (green rows).

| Pass | Concrete inverts at top of pass | Hydraulic invert | Notes |
|---|---|---|---|
| Baffle Application | 43.40 | 43.76 (medium baffles)<br>43.56 (large baffles) | Top of first baffle |
| Baffle Current Design | 43.45 | 43.52 | Top of first full height baffle ($4^{th}$ baffle) |
| Brush Application | 43.76 | 43.76 | Top of gravel in first bay |
| Brush Current Design | 43.72 | 43.72 | Top of gravel in first bay |

The changes are not considered significant.

If the Area Team can review these changes detailed in Section 4 and either confirm acceptance or the need for them to be referred back to the Fish Pass Panel.

End of Document