



Hoveton Great Broad Restoration Project

Design Report for

Fish Barriers at Hoveton Marshes, The Dam & Foxborrow Dyke

Version 3



Client: Natural England

Date: 14th January 2021

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EXECUTIVE SUMMARY

As part of the wider bio-manipulation of the Great Hoveton Broad in Norfolk, Natural England has commissioned Breheny Civil Engineering Ltd to design, fabricate & install fish barriers to replace existing structures. Fishtek has been commissioned by Breheny to carry out the design of these structures.

This Report originally prepared to convey the design scope at conceptual stage has been updated to reflect the development of the design in detail following receipt of GI data and to accommodate eel fyke & trap requirements stipulated by the Environment Agency (EA).

This Report conveys:

- How the design achieves the technical requirements of the fish barriers.
- The design in the form of sketches.
- High level advice on installation & removal methodology, bank clearance works requirements & site restoration works required following removal of the barriers.

Fish barriers are to be installed at three designated locations to prevent fish moving into the Hoveton Great Broad: Hoveton Marshes, The Dam & Foxborrow Dyke.

Each of the fish barriers will be formed by housing removable screens in vertical frames, which are slotted into fixed guide rails off propped cantilevered piles. All will be accessed by boat across the Great Hoveton Broad. Gates provide emergency & operational boat access through the barriers.

The form & type of materials have been carefully selected to achieve compliance with the technical requirements and mitigate sustainability risks.

The EA has requested that provision is made for the upstream passage of eels, but this does not yet form part of the current scope of works. Upstream passage would entail the design of pumped eel passes, probably powered by solar panels at each of the barriers.

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1. INTRODUCTION

Natural England (NE) is seeking to deliver the restoration of Hoveton Great Broad and Hudson's Bay. The site forms part of the Bure Broads & Marshes Site of Special Scientific Interest (SSSI), the Broadland Special Protection Area (SPA), the Broads Special Area of Conservation (SAC), Broadland Ramsar Site and part of the Bure Marshes National Nature Reserve. Under the Water Framework Directive, they are currently classified as having poor ecological status and the SSSI status of the broads is unfavourable.

As part of the wider bio-manipulation of this site to address these issues, NE has commissioned Breheny Civil Engineering Ltd to design, fabricate & install fish barriers, *Figure 1*, under Phase 4 of the wider Hoveton Great Broad Restoration Project¹. The existing structures are to remain. Fishtek Consulting Ltd, a specialist fisheries & engineering consultancy, has been commissioned by Breheny to assist in delivery of this project.



Figure 1 – Existing Typical Fish Barrier

Fish barriers are to be installed at three designated locations, *Figure 2*, to prevent fish moving into the Hoveton Great Broad: Hoveton Marshes, The Dam & Foxborrow Dyke.

The original Conceptual Design Report was prepared following the inaugural project meeting of 13th June 2019 attended by:

Chris Terry	-	Project Manager, Natural England
Tim Sievers	-	Science, Natural England
Andy Fletcher	-	Project Manager & Contracts Manager Breheny Civil Engineering Ltd
Steve Holland	-	Framework Manager, Breheny Civil Engineering Ltd
Mike Lakin	-	Lead Engineer, Fishtek Consulting Ltd

The purpose of this revised Design Report, which is prepared in advance of the outline & detailed phases of Phase 4, is to:

- Describe how the design achieves the technical requirements of the fish barriers.
- Show the design in the form of sketches.
- Provide high level advice on installation & removal methodology, bank clearance works requirements & site restoration works required following removal of the barriers.

¹ Natural England Project Management Plan – Hoveton Great Broad Restoration Project, May 2019, version 3.

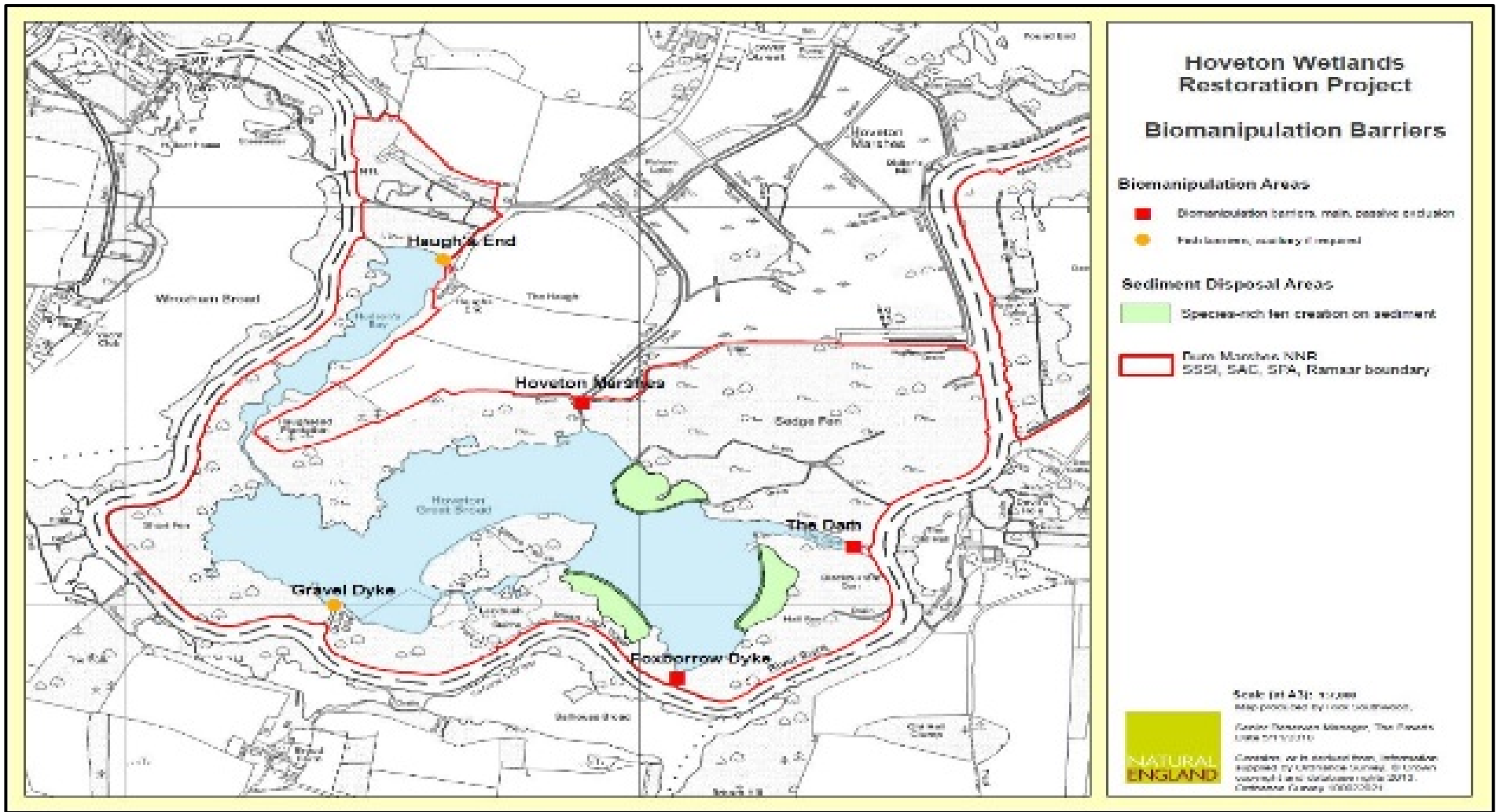


Figure 2 – Location of fish barriers

2. TECHNICAL REQUIREMENTS OF THE FISH BARRIERS

The key technical requirements, supplied with the Client's original brief, of the fish barriers form the basis of the general technical specification as far as is reasonably possible:

- Barriers should be between 0.7 & 0.75m AOD (the approx. mean height of the riverbanks).
- Barriers will use a 2mm screen to prevent fish movement but allow flow of water in & out of the broad.
- Fish barriers should be designed to be easily installed and removed minimising impact on the natural environment.
- Fish barriers should be designed to prevent undercutting & scour caused by river & tidal flows.
- The barriers should be low maintenance and easy to clean on site when the 2mm screen becomes clogged with detritus. The project has previously trialled stainless steel and CuNi screens; other options such as antifouling paint will be considered to manage cost.
- The barriers should be designed to have removable panels, to allow access in emergencies, and to allow removal of panels and replacement with spares where more extensive cleaning/repair is required.
- The barriers should be engineered to withstand flood surge events, bearing in mind the barriers will over top in significant flood events. Tidal range at the site can be as much as 0.5m during large tidal event, and 0.3m regularly.
- The barriers should be designed to be effective at excluding fish for a minimum of 10 years with minimal maintenance.
- The contractor should, where possible, maximise the use of recyclable & sustainable materials in the barrier design.

Further information to inform the design & installation was provided at the Project start-up meeting:

- The barriers must address emergency access and should thus have regard to ease of use.
- Installation works must commence after the planned dredging of the broad by Salix on behalf of Natural England. Dredging is currently planned for completion by Dec 2019.
- The dredging contractor's access route shall be made from Haugh's End to the Hoveton Marshes fish barrier, which is outside of the SSSI. Access arrangements will be left by Salix and made available for Breheny to access the site for installation of the fish barriers.
- Natural England's Tim Sievers science role in the project will be handed onto Natural England's Scott Hardy from 1st July 2019.

Further information was also supplied, post Project start-up meeting:

- The inclusion of gates will facilitate fish removal from Hoveton Broad in two stages. The first to exclude large fish after dusk, the second to exclude small fish after dawn. Actual times will depend upon the time of year. Each would require nets as part of the fish removal. The gates should be no greater than 300mm above the height of the screens.
- Natural England conveyed that siltation rates are conservatively 1cm per annum. This will be used to predict bed levels for the min. 10-year design life of the screens.
- The existing gate barrier structures are to remain under these works.

The Environment Agency (EA) has also since stipulated during the design phase that the screens must provide a facility for migration of eels to the sea. Fishtek was instructed by NE to include fyke and trap facilities within the screens. These were designed in outline and agreed with the Environment, and the detailed designs prepared.

3. DETAILED DESIGN

3.1. Background

In essence, the aim of the screens is to prevent fish entering Hoveton Great Broad at the proposed sites:

- Hoveton Marshes
- The Dam
- Foxborrow Dyke

Prior to installation of the screens, the EA also require provision to be made for the **downstream passage** of silver phase European eels, to enable those eels currently resident to migrate to the sea. Passage facilities to enable the **upstream passage of juvenile eels** have not been considered as the purpose of the exclusion screens is to prevent fish entering the Hoveton Great Broad. Note that the EA has also requested that provision is made for the upstream passage of eels, but this does not yet form part of the current scope of works. Upstream passage would entail the design of pumped eel passes, probably powered by solar panels at each of the barriers.

Water flows out of the Hoveton Great Broad at both The Dam and Foxborrow Dyke, but into the Broad at Hoveton Marshes. The proposed one-way system will therefore enable silver eels (and other fish) to migrate out of the Hoveton Great Broad towards the sea at both The Dam and Foxborrow Dyke.

A trap and transport system is required at the Hoveton Marshes screen to prevent other fish species entering Hoveton Great Broad (i.e., so as not to negate the purpose of the exclusion screens). Refer to Section 3.8.

3.2. Form

In essence, fish barriers are formed by housing removable screens in vertical frames, which are slotted into fixed guide rails off propped-cantilevered piles. The design is presented in *Figures 3 – 7*. A 4m wide opening, created by opening & closing of hinged gate(s), will be provided for boated access through the fish barrier. The gate(s) will similarly house removable screen sections.

The two flanking fish barriers are set a level commensurate with the adjoining riverbank level:

- The top of screen is set above bankside ground levels; so that they remain accessible even under higher tide levels.
- Solid toe boards are positioned within the frame to form a cill level, off which the screens will sit. The crest level is set at a level to mitigate the risk of siltation levels fouling the installation & removal of the screens (over the min. 10-year design life period).
- Navigation Markers may need to be provided off the piles forming the navigational channel (-the gated opening) but are not currently included.
- In accordance with Natural England's preference, warning signs (of submerged obstructions) will not be hung between the fixed screen pile shoulders. The navigational risks being mitigated by retention of the existing barrier structures.
- The top of piles in the barrier shoulders are set at a nominal height above the screens as per Natural England's preference.

3.3. Structural Design Considerations

3.3.1. Function Framing

The universal bearing piles will act as propped cantilevered structural members. These are braced by horizontal lattice girders which are supported off vertical and raking screw piles to achieve stability. The size, form & depth of penetration of the bearing piles has been assessed and analysed

by interpolation of GI data obtained from the site. The design reflects the significant depth of peat identified, up to 8m, which provides little or no structural support.

3.3.2. Effective Height of Barriers

The effective height of the fish barrier screens at each location is determined by the adjoining mean riverbank to bed height. The bed level allows for a nominal dredging of circa 300mm, commensurate with that planned for general dredging of the open eastern area of the Hoveton Great Broad. Thus, screen heights are typically 700mm to 750mm with a 300mm cill toe board (to allow for design life sedimentation).

The length of the fish barriers will be informed by a topographical survey, but typically will be 8m, 12m and 20m for Marshes, Foxborrow Dyke and The Dam fish barriers, respectively. The fish barrier representation in *Figures 3 – 7* is purely conceptual.

3.3.3. Loading

The fish barriers will be designed against structural failure of the cantilevered piles for the following environmental load conditions:

- A differential hydrostatic head of 0.5m assuming full screen blockage during a large tidal event & overtopping.
- Hydrodynamic loading associated with 0.5m head assuming screen unblocked during a tidal surge.
- Accidental loading from a small boat.
- Impact loading from a small tree log travelling at nominal current speed.

The screens & frames will be designed for the following environmental load conditions:

- A differential hydrostatic head of 0.5m assuming full screen blockage during a large tidal event & overtopping.
- Hydrodynamic loading associated with 0.5m head assuming screen unblocked during a tidal surge.

3.4. Geotechnical Design – Preventing Piping Failure

Based upon interpretation of available GI data and seepage flow analyses, a 3m deep cut-off into the underlying peat strata under the barriers is required, in conjunction with 8m long aprons placed upstream and downstream of the barriers. These aprons are formed from stone over a geogrid. These works are required to prevent piping failure and erosion of the peat bed.

3.5. Hydraulic Design of Barrier Screens

A 2mm aperture size screen is stipulated by Natural England, which is sufficient to prevent the ingress of fish (including juvenile fry stages) into the Hoveton Wetlands. In addition, 2 mm aperture mesh prevents the passage of the juvenile elver stage of European eel². The plan size of the screen is dictated by the overall screen depth and width commensurate with the topography of each site. To ensure juvenile fish are not impinged on the screens as water passes through a target maximum water velocity of 0.1 m/s through the screens will be aimed for², which will also reduce maintenance requirements by minimising debris build up.

Industry standard 'Wedge Wire' passive mesh screens are used, which are fixed screens commonly used for the exclusion of fish at abstractions. A 'Screen Systems (Wireworkers) Ltd' model '34SB' screen is used for a 2mm aperture and open area of 41.67%.

² Environment Agency, 2011. Screening at intakes and outfalls: measures to protect eel. The Eel Manual – GEHO0411BTQD-E-E (last accessed online October 2018: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/297342/geho0411btqd-e-e.pdf)

3.6. Design Life

Materials for the barriers have been selected to provide a minimum of 10 – 15 years of use with minimal maintenance, with due consideration of durability and structural robustness.

3.7. Operation & Maintenance Considerations

3.7.1. Operation

The screens are designed for in situ brushing / cleaning from an appropriate small, flat-bottomed river boat -Refer to Figure 8 for locations of the barriers. The maximum beam for access through the Marshes and Foxborrow barriers is less than 2m and for the Dam barrier, less than 3.6m all is less than 2m. Frequency of cleaning requirements may vary to suit hydraulic performance requirements.

The screens are designed for manual removal & lifting (if ever needed) into an appropriate small river boat, typically c.5m, taking due account of width, height, and weight of the screens. To assist in lifting operations, the panels are fitted with handles. Nevertheless a min. two-man team will be necessary to lift the screens, fykes and traps. A boardwalk is currently not included for manual handling of screens to avoid both capital & ongoing maintenance costs.

Moorings facilities (e.g., mooring rings have not be specified) but boats can tie off the piles to aid activities e.g., cleaning &/or removal of the screens. Moorings for bankside egress into and out of boats at each barrier location are not included.

3.7.2. Maintenance

Maintenance during the minimum 10-year design life is principally limited to cleaning of the screens and repair of accidental or extreme event damage.

3.7.3. Security

All screens and gates are designed for fitting padlocks and latches. Security will be subject to Natural England emergency access protocols. Eel traps are designed with lids secured using hasp & staple locks for padlocks.

3.8. Design of Eel Fykes and Traps

3.8.1. Trap at Hoveton Marshes

The trap has been designed on the principal of the Fyke net. The conical entrance to the trap has a 300 mm width entrance, narrowing to 75 mm (to protect water voles) after approximately 500 mm leads into a trap box that holds any fish passing through the cone. The trap entrance is located flush with the proposed exclusion screen to maximise the chance that eels will locate it, and at the riverbed as downstream migrating silver eels are channel floor oriented. The mesh size of the trap box is 2 mm (i.e., the same as the exclusions screens) apart from at the upstream side with the entrance, which is 8 mm to prevent silver eel escapement (based on the EA guidance for screening at intakes and outfalls for small silver eels) but enabling smaller fish to escape back upstream (but not to enter the Hoveton Great Broad).

An otter guard comprising of a rigid square grille with bars separated by 85 mm is located at the entrance to the cone to protect otters. Two holes are also provided towards the top of the trap box on the face with the 8 mm mesh to enable water voles to escape and return upstream if they enter the trap. The water vole holes are 75 mm diameter, leading water voles back upstream.

Only one trap is to be located at this site as the channel is relatively narrow (ca. 4 m) and thus downstream migrating eels are likely to find the trap entrance.

3.8.2. One way system out of The Dam & Foxborrow Dyke

The one-way system at these two locations is based on the same Fyke net principle as the trap at Hoveton Marshes but with the exception that there is no trap box and all mesh sizes being 2 mm (i.e., to prevent all fish returning upstream into the Hoveton Great Broad). A 'sock' is located at the narrow end of each of the cones to prevent fish moving back upstream via this route.

At both sites, a cone will be placed at both the left and right sides of the proposed screens to provide a greater chance of eels locating one of them. Otter guards are provided on each of the cones. Water voles will be able to pass through the cone and then move straight to the surface and therefore no additional mitigation measures are necessary for water voles. Refer to Figure 7.

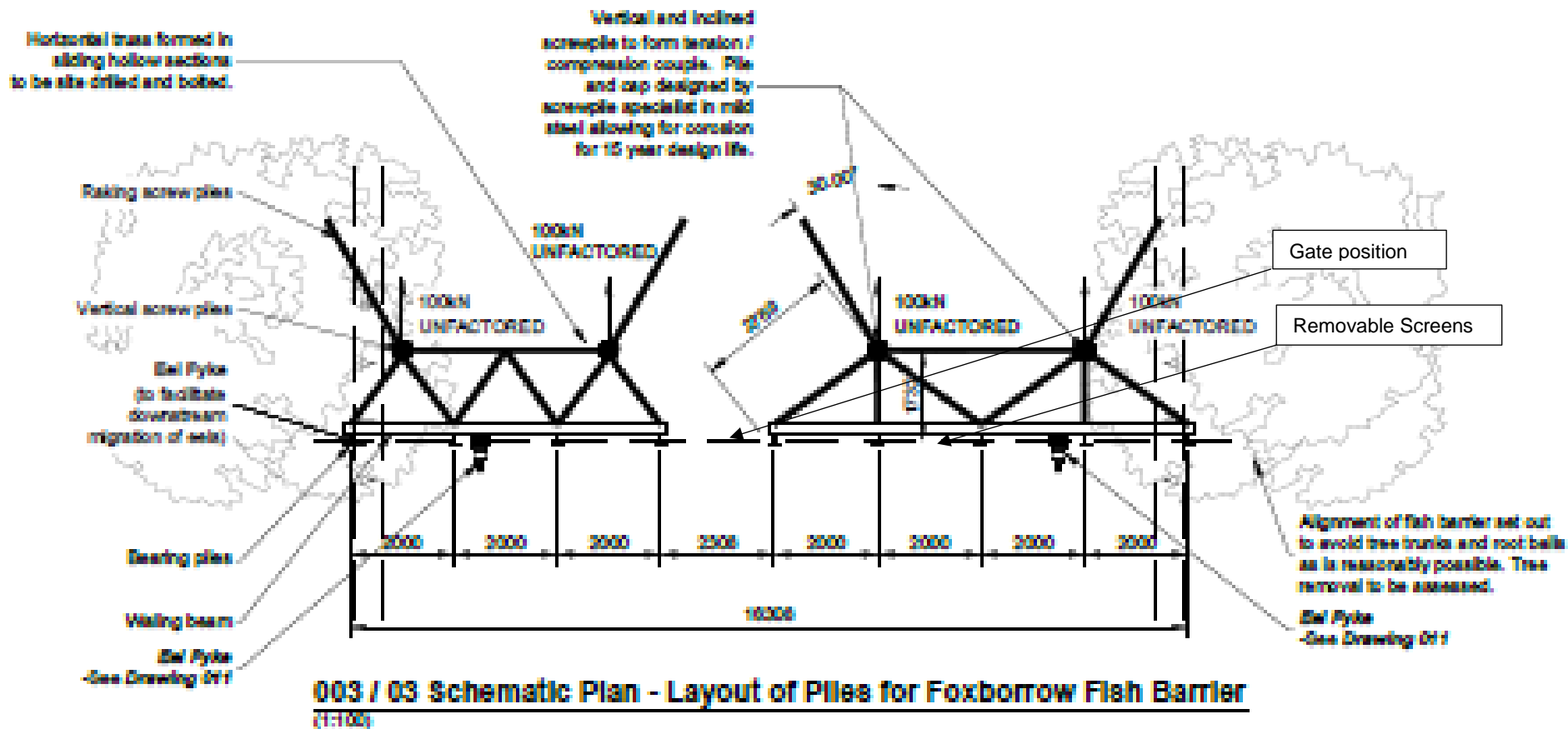


Figure 3 - Design of Fish Barrier – Plan Extract From Drawing 003

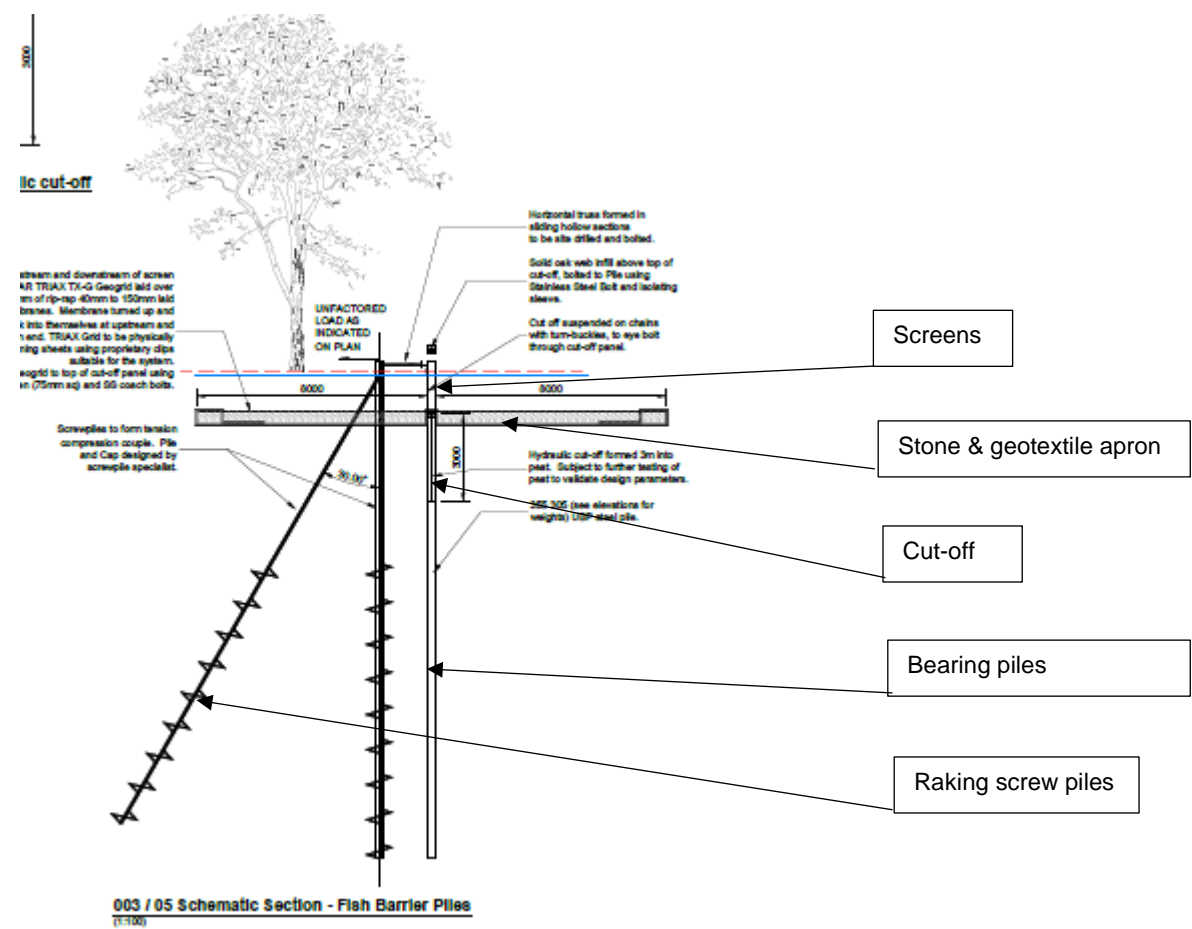
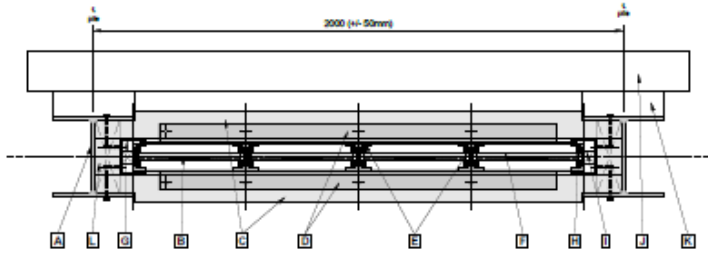
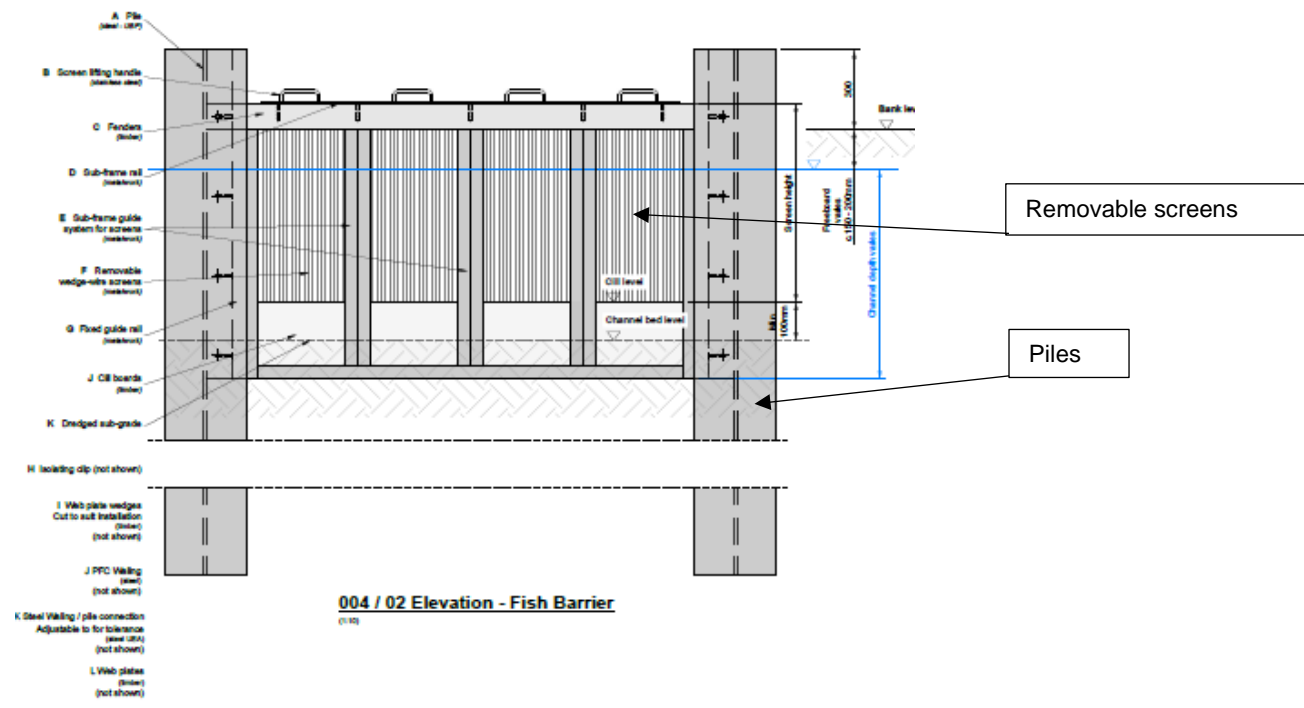


Figure 4 - Design of Fish Barrier – Section Extract from Drawing 003



004 / 01 Plan - Fish Barrier (1:10)



004 / 02 Elevation - Fish Barrier (1:10)

Figure 5 –Design of Barrier – Assembled Screens in Plan & Elevation – Extract From Drawing 004

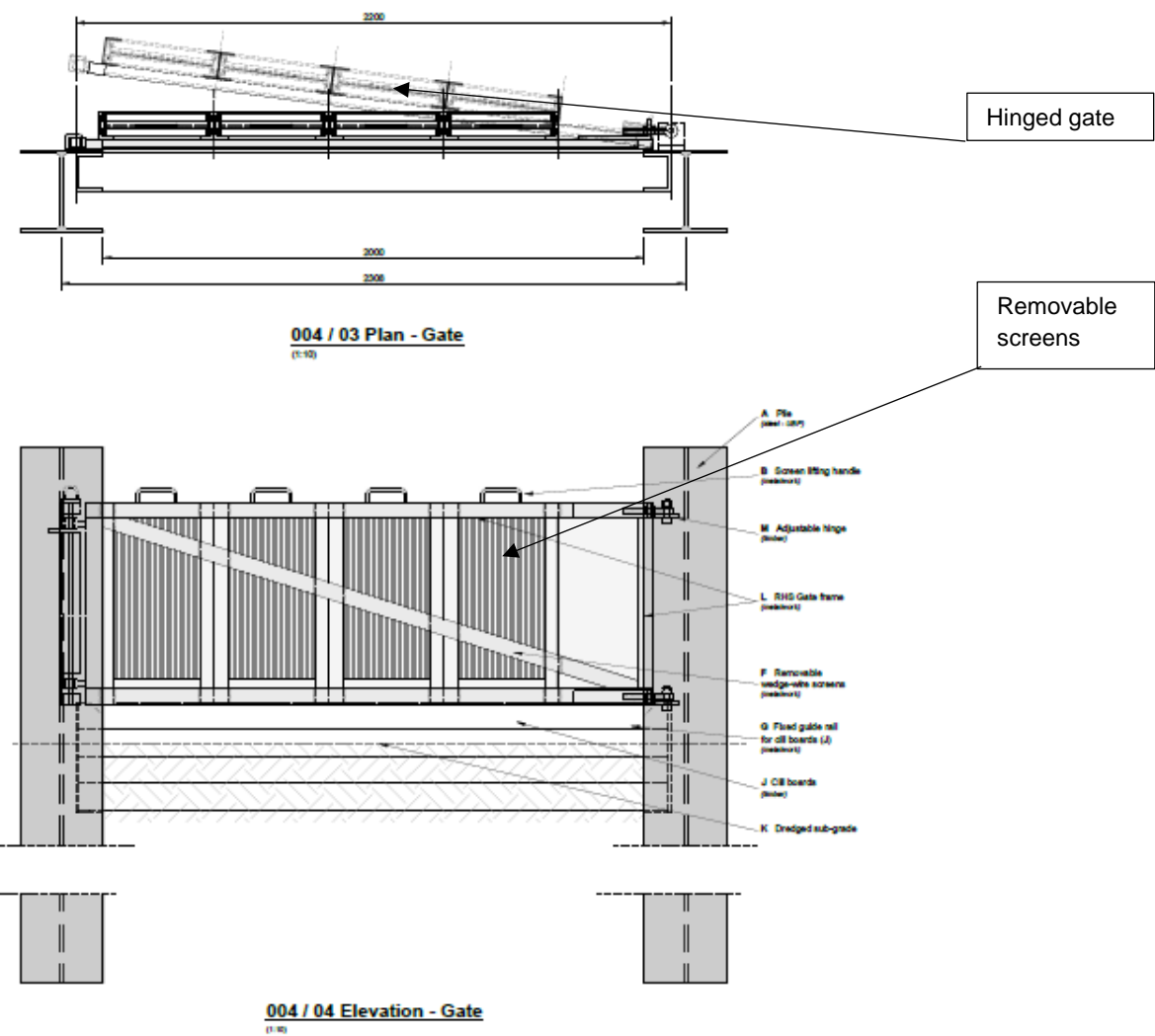


Figure 6 – Design of Barrier – Assembled Gate – In Plan & Elevation – Extract From Drawing 004

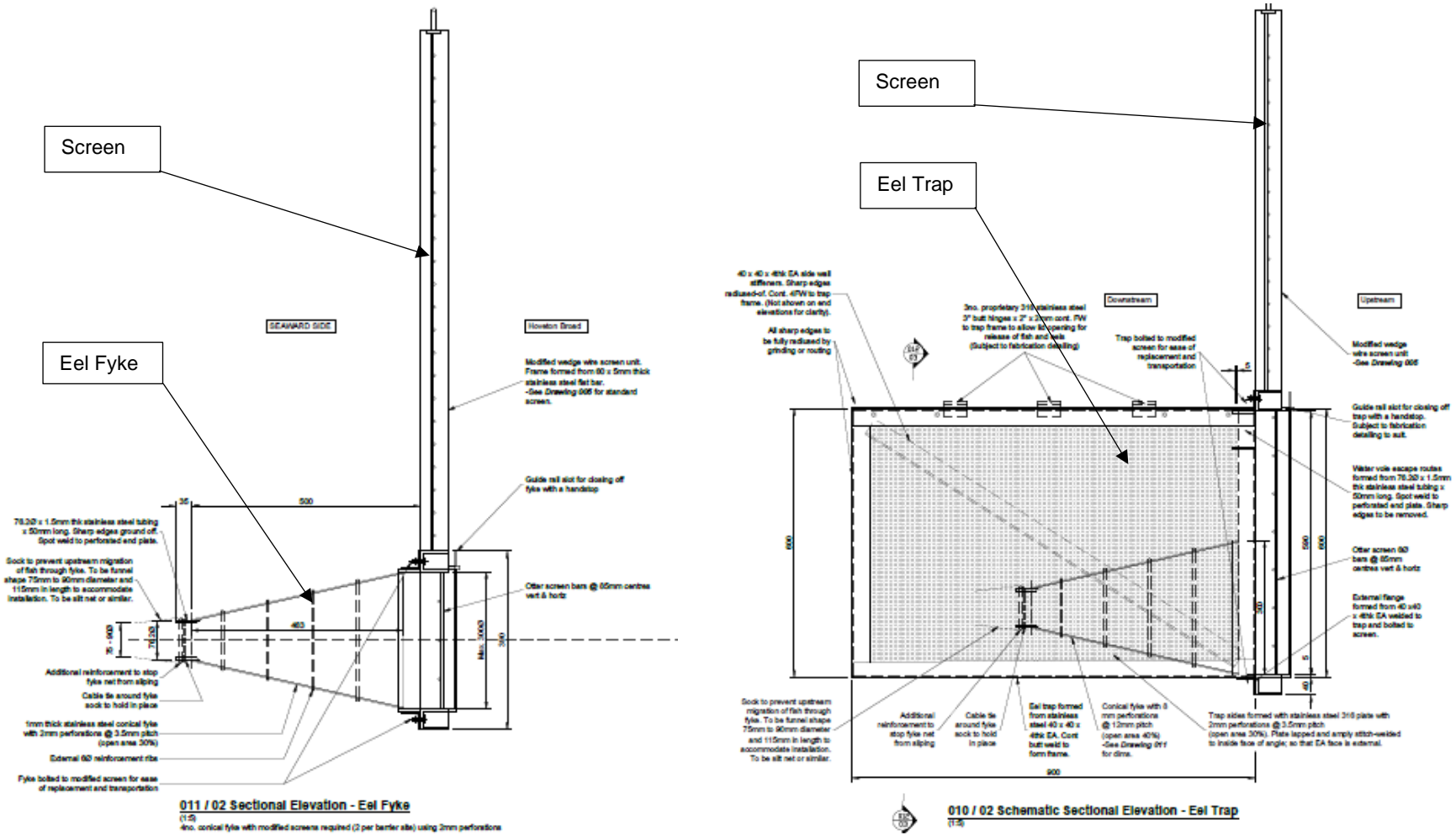


Figure 7 – Barrier Design – Detail of Eel Fykes and Traps – Extract From Drawings 010 & 011

3.9. Materials

All materials comply with the CESWI 7TH Edition³ as applicable. Appropriate certification will be supplied to authenticate all materials supplied & installed. Materials are essentially limited to mild steel (bearing piles, screw piles, cut-off plates, guide frames and gates), timber (fenders, cills and plates), stainless steel (removable screens), stone (apron) and plastic (nylon rubbing strips attached to the gates to mitigate electrolytic action between dissimilar metals, and the geogid in the apron). All materials can be removed from the site and recycled. Concrete is not used.

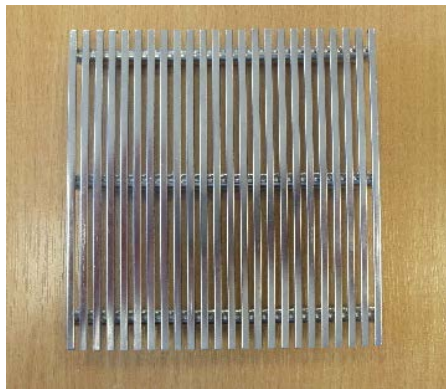
3.9.1. Piles

17m long piles are required in view of the embedment requirements associated with the significant depth of peat strata. These piles need to be formed using grade 355 steel universal bearing piles (H-shape in plan).

3.9.2. Screens

These are formed from:

- Proprietary wedge wire screens to achieve 2mm aperture size.
- Stainless steel, grade 316, to minimise maintenance requirements and fully recyclable as a standard system for other sites.



To limit weights, the span and size of these screens needs to be limited to 390mm wide for a maximum weight of 22kg for manhandling. Nevertheless, these removable screens are up to 1.6m long; so, may still require a two man-lifting team in a boat, in the absence of a board walk.

3.9.3. Screen frames & fixings:

These are formed in mild steel for the purposes of economy and in view of the short design life. These elements maybe hot-dipped galvanised or painted to provide a longer design life if required by the Client.

3.9.4. Ancillaries

Small, proprietary elements mooring rings, latches, hinges will be undertaken in galvanised mild steel. Coir ropes, or similar, would be used in preference to galvanised mild steel chain. Signs would be in aluminium.

3.10. Installation & Removal

³ Civil Engineering Specification for the Water Industry.

The installation of the fish barriers is subject to the development of a risk assessment & method statement RAMS, by Breheny, and would be in accordance with the CDM Regs 2015⁴:

- It is envisaged that construction traffic and deliveries will use Haughs End Road and that site access will be made around the northern and west perimeter of The Haugh, a green open space outside of the Bure Marshes SSSI.
- Access across Great Hoveton Broad will be made by pontoon, which will be delivered to site and assembled at Hoveton Marshes, *Figure 8*.
- Bank-side clearance at each fish barrier location will largely be limited to:
 - Local removal of the tree canopies, which may interfere with safe piling operations.
 - Local removal of scrub & roots, which may interfere with the positioning of the bankside piles.

These issues may be mitigated by careful selection of position & setting out, to be agreed with Natural England.

- The sites will be locally dredged using a sediment pump and back-actor excavator as required to achieve the design bed levels in advance of pile driving.
- The piles will be driven to depth & alignment. A temporary works steel frame will be required to facilitate the required alignment of the piles. Steel shoes / plates may need to be fitted to the 'tips', to prevent damage to the piles whilst driving. This will be subject to review of the G.I. findings.
- Subject to design, the piles may be pre-fitted with guide rails for installation of screen frames. The timber cills and screen will be fitted within the fixed screens.

The fish barriers will be removed in a similar sequence of operations as per installation. All fish barrier materials will be removed from site.

3.10.1. Further Surveys & Design

The following activities are recommended prior to any commencement of construction:

- Further GI is undertaken with laboratory testing of the peat, to validate the assumed soil parameters used in the current design.
- A service utility search of the three sites is required to confirm the locations of the barriers.

The design would also benefit from further topographical survey of the riverbanks and bed, to mitigate the risk of change in construction requirements, inform working areas and setting out.

⁴ CDM Regs 2015 – Construction & Design Management Regulations, which places statutory duties upon duty holders to ensure that projects are carried out in a way that secures health & safety.



Figure 8 – Access Routes for Installation

4. SUSTAINABILITY RISKS

The design & installation of the fish barriers addresses sustainability criteria in the following manner:

Natural England Sustainability Indicators	Mitigation
Climate change – Priority to reduce CO2 emissions	The use of concrete will be eliminated from the design unless otherwise agreed.
Acid Rain	<p>Vehicular transport movements will be minimised on site using prefabricated components off site. Thus, minimising the need for a protracted construction period on site.</p> <p>Vehicular transport movements from site will be minimised by placing locally dredged material (to accommodate the fish barrier installation) bankside. Alternatively, placed elsewhere on site under the instruction of Natural England.</p>
Emissions to water	<p>The use of concrete, grout and epoxys will be eliminated from construction to mitigate risks of pollution of the Broad.</p> <p>The works will be carried out in accordance with industry guidelines, PPG 5⁵ & PPG6⁶.</p>
Waste to Landfill	<p>Recycled materials will be sourced if reasonably practicable.</p> <p>Locally dredged material (to accommodate the fish barrier installation) will be placed bankside or alternatively, placed elsewhere on site under the instruction of Natural England to avoid waste to landfill.</p> <p>Waste off-cuts from piles will be recycled for use on other river engineering projects or sold on as is reasonably possible to avoid waste to landfill.</p>
Energy	<p>Steel is adopted within the design, which is recyclable and re-usable for other such screening projects. The stainless-steel screens are a valuable commodity, which can be reused within the river engineering industry.</p> <p>The extent of screening will be minimised as is reasonably possible, and timber used to form infill cills to predicted design-life sediment levels.</p>
Other Natural Resources	The risk of pollution and thus damage to the other natural resources e.g., fish stocks are mitigated by the choice of materials, method of working and adherence to pollution control guidelines.
Water Usage	Water usage in manufacturing is principally limited to the manufacture of the stainless-steel components. The use of textiles and fibrous materials, which require water to purge chemicals has been minimised. The use of anti-fouling paint on the screens is not necessary and is not proposed.
Local Environment	<p>The sites are in relatively isolated rural areas, only accessible by boat or pontoon.</p> <p>Distances to nearest properties:</p>

⁵ Pollution Prevention Guidelines – Works in or near watercourses.

⁶ Pollution Prevention Guidelines – Working at Construction & Demolition Sites

- The Dam is located c.190m from The Old Hall.
- Hoveton Marshes is located c.380m from Haughs End.
- Foxborrow Dyke is located c.680m from The Old Hall.

There are no significant activities required on site, which may lead to air-quality issues. Piling activities maybe involve percussion or vibratory driven techniques for a short period of time but are not likely to cause significant disturbance to local communities nor to local wildlife. Silent piling techniques may be employed subject to discussion with Natural England.

Health

The works are subject to the Health & Safety at Work Act 1974 and the CDM Regulations 2015.

Biodiversity,
Education,
Employment,
Community,
Developing World
Supply Chains,
Equality & Diversity,
Other Socio-
economic (social
inclusion and well-
being)

It is assumed that Natural England has and will continue to address these sustainability indicators as part of the wider project and procurement.