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Removing or Passing Barriers

12.7 Bypassing fixed crest weir

RIVER CAM

LOCATION - BYRON'S POOL, GRANTCHESTER, CAMBRIDGESHIRE TL436546
DATE OF CONSTRUCTION - DECEMBER 2010 – MARCH 2011
LENGTH - 110m
COST - £150,000 (including footpath work and bridges)

Type	Low energy, chalk
Status	Failing for physical habitat modification and Phosphate. HMWB. Moderate (2016)
Waterbody ID	GB105033042750
Designation	Byron's Pool LNR, County Wildlife Site
Monitoring	Fish camera, electrofishing, water chemistry, velocity, macroinvertebrates

Description

The site is located within a semi-natural woodland owned and managed by Cambridge City Council as a Local Nature Reserve (LNR) and the bypass channel was one of a number of ecological enhancements carried out by the Council within the reserve prior to the construction of an adjacent housing development. The River Cam at Byrons Pool is within the Cam & Ely Ouse catchment. It was identified as a failing water body (2009 baseline) with a number of anthropogenic structures directly impacting fish populations classified as 'moderate status'. Historically a weir of some description has been at this location since recorded in the Doomsday Survey 1086.

The present day fixed crest weir and radial sluice was constructed in c.1949 and at the same time the weir pool was recut, partially in-filled and straightened with the aim of controlling discharge downstream and retaining water levels upstream for recreational use. With a head difference of c.960mm and a broad crest width of c.1500mm, it remains dry during normal flows and is a complete barrier to fish, eels and the development of natural river processes. The reach is impounded for approximately 1km upstream.

There is greater flow and morphological diversity immediately downstream of the weir with a predominant gravel substrate and some aquatic macrophytes in areas not shaded by the adjoining woodland.

Byrons Pool radial sluice gate and fixed crest weir. The structure is a complete barrier to fish passage upstream and the weir is completely dry in normal flows – May 2011

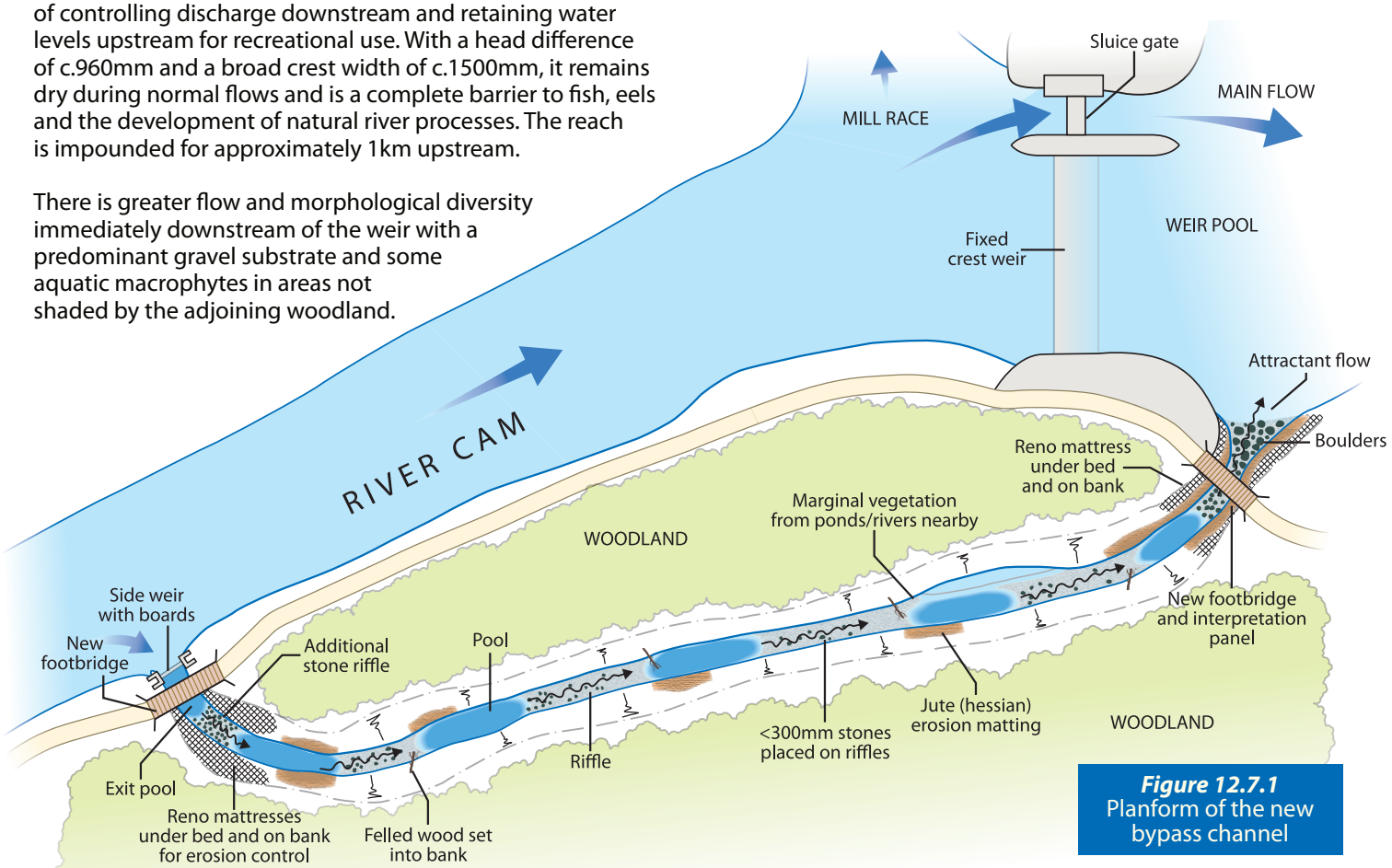

Figure 12.7.1 Planform of the new bypass channel

The aim of the project was to develop a suitable 'natural' fish pass to bypass the existing weir to allow free passage for all of the present fish species and eels whilst restoring and enhancing key features identified in the Byron's Pool LNR Management Plan. The concept of a 'nature-like fish pass' is that as well as allowing passage it also mimics a natural side channel, adding habitat (especially for juvenile fish) that is missing due to the impoundment of the river.

When designing a fish bypass channel it is essential to ensure that the downstream entry to the pass is located in the attractant current where the fish tend to congregate. At this site, this would ideally be where water exits the sluice gate on the far bank, however this was not possible due to engineering and land ownership constraints. As a result the fish pass entrance was located as close as possible to the main weir and designed with a sufficient gradient to generate a flow velocity that would create an obvious attractant flow to the fish (which actively seek onward passage by swimming along an obstruction).

Constructing the upper entry side weir to the bypass channel. – Nov 2010

Design

The bypass channel gradient was essential to the design in order to ensure its future use by fish and eels and to afford channel stability. The new channel has a gradient of 0.1% with a 2% gradient at the downstream connection to generate an attraction water velocity within the range of 0.8 to 2m/s, both suitable for all fish species to be able to negotiate and sufficient to generate attractant flow into the main weir pool.

A preliminary topographic survey indicated that there might be a hard bed of gravels. However this was not found during excavation with material consisting primarily of river silts. A mixture of coarse gravels was imported to form a variable-width channel with pools and riffles.

The works comprised:

1. A bypass channel measuring 110m in length with an average width of 2m was created by excavating a heavily silted drainage channel running round the existing weir. The excavated material was spread within the woodland, outside of the floodplain, in an area of low botanical interest.

2. A small concrete side-weir was installed at the upper entry to the pass. Based on flood modelling the weir crest height was set at 7.7mAOD, 300mm below mean water level. This would allow control at times of low flow using stop boards, and for any maintenance operations.

Before (**a**) during (**b**) and immediately after (**c**) construction. The absence of a suitable bed material was overcome by using imported gravels to create a series of pools and riffles along the channel. Jute (hessian) matting was installed to provide erosion protection along the newly created banks – November 2010

Photos © Ellis Selway

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3. To provide stability and erosion control, matresses were installed at the upper and lower entry points, on the banks and below the gravel bed.

4. Imported gravels were used to form a bed of pools and riffles. These were sourced locally and included a mixed fill of claybound rejects (ranging from 20-100mm) and graded gravel (10-20mm).
   a. The series of pools (c.10m long x 2m wide x <0.7m deep) were designed to offer areas of rest where water velocity is <0.5m/s.
   b. The riffles (c.10m x 2m wide x <0.4m deep) offered an attractant water velocity of <1.4m/s to a maximum of 2m/s.

5. Felled timber, sourced from the site, was set into the bank protruding into the channel with the aim of deflecting flow and retaining the gravels. Hessian erosion matting was fixed along the opposite bank where there might be initial scour until vegetation became established.

6. Extra woody material and individual angular rocks, up to 200mm in diameter, were placed randomly in the channel to provide suitable refuge for fish such as bullhead (*Cottus gobio*) and to create habitat heterogeneity.

7. Marginal plants were translocated from adjacent ponds and the river margin to speed up the process of colonisation and add bank stability.

8. Two footbridges were built across the new bypass channel to maintain the riverside path access.

This technique demonstrates the importance of understanding the channel flow velocity requirements of fish within a bypass channel and the location of the attractant flow leading to the channel.

An additional stop log installed on top of the side weir structure and turreted – April 2011

Electrofishing the new bypass – a brown trout already occupying the habitat created. – May 2011

Additional riffle built using granite to allow minnows to exit the pass – April 2011

Modifications

Once the bypass channel became operational a number of modifications were required to overcome unforeseen problems:

Bypass inflow and control structure

Initial discharge through the channel was excessive, swamping the riffles and producing a highly turbulent flow at the downstream entrance to the pass. An additional board was installed to the side-weir to reduce the flow entering the pass. However, this created a head difference of approximately 300mm between the 'exit pool' and the upstream water level such that minnows (Phoxinus phoxinus) were observed failing to swim over. To resolve this, three sections (450mm wide by 100mm deep) were cut out of this board reducing the head difference by 100mm. Even then, the flow through the 'turreted' board was still too high for minnows to negotiate so additional stone was added downstream of the exit pool using 200-300mm angular granite. This successfully raised the water level in the exit pool thereby eliminating the head difference.

Bypass outflow

The water level at the pass outflow was initially very shallow (<100mm) and the water velocity was identified as potentially exceeding the maximum swimming performance of some of the fish species found in the River Cam. So a combination of gabion rocks and larger 300-450mm perturbation boulders were placed between the lower entry to the pass and the first riffle to baffle the flow, producing areas of slack water for fish to rest in whilst ascending into the pass. Flow velocity was later measured and was well within the maximum velocity parameters of 2m/s for the species present in the Cam.

All necessary documents were produced for the EA consenting process and Local Authority planning permission, including detailed design drawings, Design and Access Statement, Flood modelling and Flood Risk Assessment, Environmental statement and archaeological brief.

The attractant flow exits as close to the weir as the structure would allow. – April 2011 © Ellis Selway

Gabion rocks and perturbation boulders installed at the downstream entrance to the pass, to baffle the flow – April 2011 © Ellis Selway

Subsequent performance – 2012 to 2019

2012 post works fish monitoring, through a combination of electrofishing, remote camera and visual observations, indicated that the bypass channel was being used by 11 fish species, 3 of which had been recorded on the remote cameras successfully exiting the pass. Spawning activity was observed and the 2012 survey showed an excellent population of brown trout (*Salmo trutta*). Water velocity, dissolved oxygen and temperature were also monitored following the works and all were within the physical and biological parameters required by most fish. However, it should be noted that the water velocity, as measured, in the upstream exit was at the limit for the passage of elvers (juvenile eels).

Invertebrate monitoring was also carried out in 2012 using kick sampling and demonstrated that the macro-invertebrate community in the bypass channel was well balanced. A number of oxygen demanding species were present, for example blue winged olive nymphs (*Serratella ignite*) and caddis fly (*Mystacides sp* and *Goera pilosa*), as well as more tolerant taxa such as river snails (*Notopala sublineata*). High BMWP and ASPT scores (140 and 5.38 respectively) reflected this.

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Entrance to the bypass channel, looking downstream towards the weir pool. The perturbation boulders have remained in position and marginal vegetation has colonised the banks – February 2013

Over the past eight years high flows and the accumulation of woody material has contributed to some vertical adjustment of the mattresses and movement of the perturbation boulders in the lower entrance to the pass. The stone mattresses should only have been used on the 'at risk' bed and lower banks, perhaps in-combination with green bank protection techniques.

There was an official launch of the pass by the Environment Agency Area Manager and the Mayor of Cambridge City Council in August 2011. Key stakeholders and volunteers were also invited. The pass was well received by users of the site and although not measured, use of the site increased after installation. After eight years, this increased visitor pressure has led to greater disturbance of the channel by people and dogs. There is evidence of a deterioration of rheophilic spawning opportunities due to fine sediment accumulation on the gravels.

There has been some addition of imported fine gravels but further action is needed to restrict access, reduce siltation and to enhance spawning. There is a follow up fisheries survey planned in 2020 to understand the impact from increased visitor pressure and to inform potential mitigation.

a) Lessons – for wider application

This case study highlights the need for a 'hands on' approach during the initial operation of the pass and awareness that on-site modifications may be required. Pre and post monitoring is a vital aid in the decision making process and, at this site, identified the need for adjustments. The pass has influenced the delivery of other natural bypasses in the Ouse Catchment.

Contacts

Ellis Selway, Cambridge City Council (Now Environment Agency, Geomorphology Technical Specialist) – Project design, supervision and monitoring (MSc project).
ellis.selway@environment-agency.gov.uk. Tel: 03708 506506