Department for Environment Food & Rural Affairs

Environment Agency

Healthy Catchments – Managing Water for Flood Risk and the Water Framework Directive

Introduction

The Water Framework Directive (WFD) is a European directive which aims to protect and improve the water environment. Flood and Coastal Risk Management (FCRM) activities can have a big impact (positive and negative) on the water environment.

The WFD defines a list of mitigation measures (referred her as **environmental improvements**) which need to be implemented by a set deadline to improve the water environment. This webpage provides you with a selection of case study examples, which will give you ideas of how to implement these environmental improvements when you undertake FCRM activities.

It will show you that implementing the WFD need not be complicated. Instead, we can deliver exciting integrated solutions to improve the environment for people and wildlife. Whilst this webpage focuses on FCRM it will also be of use to others involved in the management of rivers, estuaries and coasts.

To help those who are not office based we have summarised the content of the webpage below and appended the case studies in one PDF.

The webpage and associated case studies can be accessed by clicking here:

- Healthy Catchments – Flood Risk and the WFD
- Healthy Catchments – Case Studies

How does FCRM affect the WFD?

FCRM works can impact upon the shape of a watercourse and the natural processes that occur within it, such as:

- flow patterns;
- width and depth of river channels;
- river features such as pools and riffles;
- sediment availability/transport; and
- interaction between the river and its floodplain.

When FCRM works impact on these natural processes they can damage important habitats which support plants and animals. This can cause a water body's[1] ecology to deteriorate and prevent environmental improvements from being undertaken. FCRM works can also be beneficial, they can be designed to help achieve environmental improvements included in your RBMP, enhancing the water environment for plants and animals. When you undertake FCRM works you need to:

- ensure you do not make things worse and cause a water body's ecology to deteriorate;
- not prevent the environmental improvements identified in the River Basin Management Plans (RBMP) from being undertaken; and
- seek opportunities to undertake environmental improvements to achieve Good Ecological Potential.

So... how do I implement the WFD?

River basin management plans (RBMPs) describe how the WFD will be achieved in your region. They also tell you, at a local level, which environmental improvements you need to implement to achieve the objectives of the WFD.

RBMPs can be found on the Environment Agency webpage. Annex B ncludes one page summaries for each water body, explaining what environmental improvements need to be undertaken to achieve Good Ecological Potential (GEP). Your RBMP sets out:

- ecological objectives for each water body; and
- deadlines by when ecological objectives need to be met.

In FCRM your work mainly falls in artificial or heavily modified water bodies (AWB/HMWB). These are water bodies which have been altered through human activity (for example by FCRM, urbanisation and land drainage). AWB/HMWBs need to achieve GEP by a set deadline. GEP is the best ecology that can be achieved in a water

[1] The WFD divides the water environment into water bodies which include lakes, reservoirs, streams, rivers, canals, groundwaters, transitional waters (estuaries) and coastal waters.

body whilst still enabling FCRM works to be undertaken to protect people and property from flooding.

Implementing environmental improvements

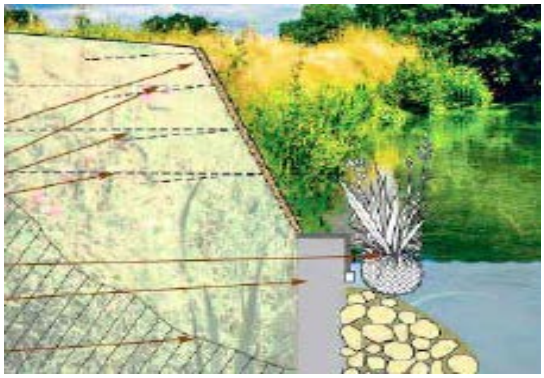
Prior to implementing an FCRM activity you can find out which environmental improvements are relevant to your site by going to the Environment Agency's 'What's in your backyard?' website. Find your site on the map and lick it to find the following key information:

- Name of the water body and its identification number.
- Which RBMP your site fall sin.
- Whether the water body is Artificial or Heavily Modified.
- Description of the condition of the water body, and the targets that have been set.

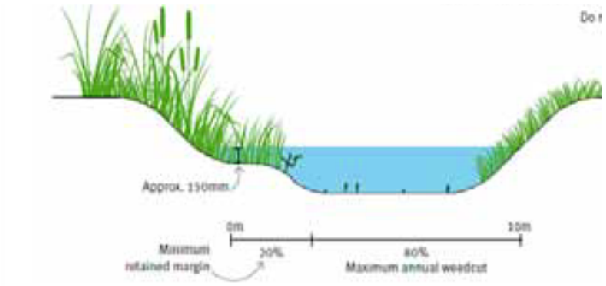
Once you have the water body identification number, go to the Annex B of the RBMP and look-up this number, you will find a list of the environmental improvements which need to be implemented and by when.

What do environmental improvements look like?
Once you know which environmental improvements relate to your site, refer to the case studies to get ideas of how you could implement your FCRM activity and meet the requirements of the WFD at the same time.

Environmental improvements can be achieved in many ways such as swapping sheet piling for green engineering:



Or altering the way you do channel maintenance:



5) Vary cutting regime along length watercourse so that aquatic and marginal vegetation is only managed in key locations and one bank is left uncut

WFD screening, assessments and flood defence consents

You may need to screen your activities to see if you need to undertake a WFD assessment. The Environment Agency can advise you on this for Main Rivers. On Ordinary Watercourses you will need to contact the relevant Lead Local Flood Authorities or Internal Drainage Boards for advice. WFD assessment guidance will be available on the Environment Agency webpages early in 2014.

When undertaking works which affect a water body you may be required to apply for flood defence consent from the Environment Agency on Main Rivers and either Lead Local Flood Authorities or Internal Drainage Boards on Ordinary Watercourses. For more information and guidance see:

- Environment Agency - How Do I Apply for a Flood Defence Consent
- Environment Agency - Riverside Property Owners: Know Your Rights and Responsibilities

The **Environment Agency's National Customer Contact Centre** will be able to advise you if other licenses are needed and will be able to put you in contact with relevant staff : **03708 506 506*** (Mon-Fri, 8am - 6pm).

This summary relates to information from project SC120019, reported in detail in the following output(s):

Webpage: Healthy Catchments – Managing for Flood Risk and the Water Framework Direction
Title: Healthy Catchments – Managing Water for Flood Risk and the WFD

August, 2013
Report Product Code:
Internal Status: Released to all regions
External Status: Publicly available

Project manager: Lydia Burgess-Gamble, Evidence Directorate.

Research Collaborator: Natural England, Association of Drainage Authorities, Internal Drainage Boards, Natural England, Association of Rivers Trusts, UK River Restoration Centre and EU RESTORE.

Research Contractor: Phil Williamson, Royal Haskoning DHV (philip.williamson@rhdhv.com)

This project was commissioned by the Environment Agency's Evidence Directorate, as part of the joint Environment Agency/Defra Flood and Coastal Erosion Risk Management Research and Development Programme.

Email: fcerm.evidence@environment-agency.gov.uk.

Further copies of this summary are available from our publications catalogue: http://publications.environment-agency.gov.uk or our National Customer Contact Centre: T: 08708 506506
E: enquiries@environment-agency.gov.uk.
© Environment Agency.

CASE STUDY

Create compensatory habitat to offset impacts

Project Summary

Title: Trimley and Shotley Intertidal Habitat Creation
Location: Trimley and Shotley, Suffolk, England
Technique: Create new intertidal habitat
Cost of technique: £££££
Overall scheme cost: £££££
Benefits: £££££
Dates: 1998-2010

Mitigation Measure(s)

Create compensatory habitat to offset impacts
Realign flood defences to increase coastal and intertidal habitat

How it was delivered

Delivered by: Harwich Harbour Authority
Partners: Department for Transport; Department for Environment, Food and Rural Affairs, Royal HaskoningDHV.


Habitat enhancement bunds on Shotley foreshore


Intertidal habitats created by the new bunds


Intertidal habitats created by the new bunds

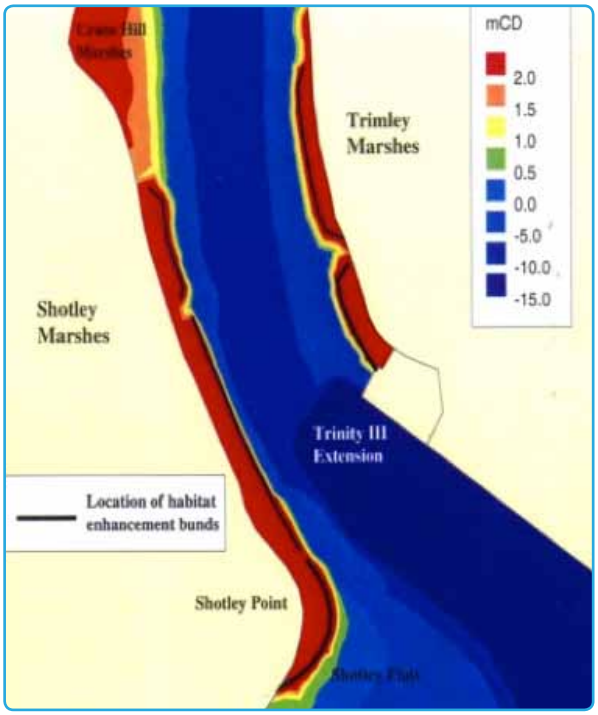
All images © Royal HaskoningDHV copyright and database rights 2013

Background and issues

Planning consent was given to Harwich Haven Authority (HHA) in 2002 for the Trinity III Terminal (Phase 2) Extension. The construction of the extension started in February 2003 and was completed in September 2004. As part of the scheme, HHA was granted a Food and Environment Protection Act 1985 (FEPA) licence to beneficially dispose of dredged material arising from the capital dredging that was undertaken as part of the scheme. This material was used for the construction of intertidal bunds on the foreshore at two sites along the River Orwell at Shotley and Trimley. Dredged material was subsequently placed behind the bunds to create new intertidal habitats.

The objectives of the habitat enhancement schemes are as follows:

1. To provide an enhanced level of protection to the seawalls along the Trimley and Shotley frontages by raising the level of the intertidal area.



Location of habitat enhancement bunds along the Orwell Estuary

2. To enhance the ecological value of 23 ha of intertidal habitat (of which approximately 20 ha will be intertidal mud and 3 ha saltmarsh), replacing the feeding habitat lost due to the immediate effect of the quay extension and dredging, over the short to medium term.

3. To raise the level of the intertidal mud, thereby increasing its exposure and providing a feeding habitat for waterfowl for a longer period in the tidal cycle (i.e. increasing the number of bird feeding hours), mitigating the effect of a reduced tidal range.

Step-by-step

Construction of the habitat enhancement schemes was completed in October 2003. The schemes involved the placement of clay and gravel bunds on the Shotley and Trimley foreshores which were then landscaped to create a variety of land heights and. The area behind the bunds was then backfilled with silt and sandy gravel and left to recover naturally. The scheme utilised approximately 107,000 dry tonnes of dredged material that would otherwise have been placed offshore at the Inner Gabbard disposal site.

On completion of the bunds and backfilling, the total area covered by the enhancements was approximately 18.3 ha. Of this area, it is estimated that approximately 3 ha was comprised of the bunds themselves, with the remainder being raised mudflat.

Dredged material being placed on the foreshore

Trimley

The Trimley enhancement scheme is situated on the east bank of the Orwell Estuary, approximately two nautical miles upstream from Felixstowe. The enhancement site was created on an existing mudflat which had eroded down to the underlying clay.

The scheme utilised both clay and gravel for the bund which was obtained from capital dredging undertaking as part of the Trinity III Extension. Following the removal of silt from the approach channel during the capital dredge, gravel was dredged from the new approaches and placed in the quay construction zone and onto the Trimley foreshore. Approximately 22,000 m^3 of gravel was placed on the Trimley foreshore to create the bund. The scheme at Trimley essentially comprises one bund, 1.4 km in length, which runs parallel to the seawall approximately 50 – 60 m seaward. The bund was initially deposited to serve as a buffer for wave action, thereby offering some protection to the base of the historic seawall which was showing signs of deterioration. The mudflat created behind the bund acts as a feeding area for wading birds replacing the area lost during the development of Felixstowe port.

Shotley

The Shotley enhancement scheme is situated on the west bank of the Orwell Estuary directly opposite the Trimley site. Sediment placement was first carried out here as part of a trial recharge in December 1997. At this location, a 2 km earth wall, protecting low lying grazing land, had undergone severe erosion following the near complete loss of fronting saltmarsh. The trial recharge involved the use of approximately 22,000 m^3 of maintenance dredgings from the estuary, mostly silt, which was pumped behind a retaining bund of coarse poorly sorted gravel.

In September 2003, in line with the CMMA, further enhancement at Shotley was completed. This involved the construction of clay bunds around Shotley Marina, backfilled with silt (the 'south bunds'). Further north, two areas of existing gravel were 'topped up' with silts (the 'middle bunds') and another scheme was constructed based on bunds created using in-situ material backfilled with silts (the 'northern bunds').

CASE STUDY

Benefits

Trimley

- Since the recharge, the number of species, individuals and diversity of benthic invertebrate at the Trimley recharge site has typically increased. The species richness, abundance and diversity at the recharge sites are now similar to intertidal habitat reference sites having been allowed to recover naturally.
- Since construction the area has be colonised by new marine invertebrates.
- In 2011/12 the peak number of birds at Trimley was the highest since the construction of the bund in 2003 and since the start of the surveys in 2000/01. In 2011/12 there were increases in a number of the key species, including dunlin, redshank, lapwing, shelduck and wigeon which were all recorded to have the highest peak numbers of the entire monitoring period.

Shotley

- Colonisation and community development of benthic invertebrates has increased at the recharge sites since construction, although has yet to reach the levels found at the intertidal habitat reference site.
- New saltmarsh has been created behind the bund, with species including common glasswort flourishing in some areas.
- The site continues to support a large number of birds and the benthic invertebrates in the mudflats appear to be providing sufficient feeding material to support over-wintering populations, including dunlin, lapwing and ringed plover.

(1) Clay bunds backfilled with silt around Shotley Marina;
(2) Common glasswort growing on Shotley;
(3) Wildfowl using the area as a feeding resource.

Lessons Learnt

- Recognition of the importance of monitoring in mitigation.
- For schemes with significant implications, the establishment of a participatory forum is vital.
- Ensuring delivery and establishing trust are key to large-scale beneficial use projects.
- Enabling shared decision-making.
- Delivery through existing management forums.

Project contact: Coastal and Marine Environment team, Royal HaskoningDHV.

CASE STUDY

Create compensatory habitat to offset impacts

Project Summary
Title: Greatham Managed Realignment Scheme
Location: Greatham Creek, Hartlepool, England
Technique: Managed realignment
Cost of technique: £££££
Overall cost of scheme: £££££
Benefits: £££
Dates: 2011 – 2014

Mitigation Measure(s)
Create compensatory habitat to offset impacts

How it was delivered
Delivered by: Environment Agency
Partners: Natural England, RSPB

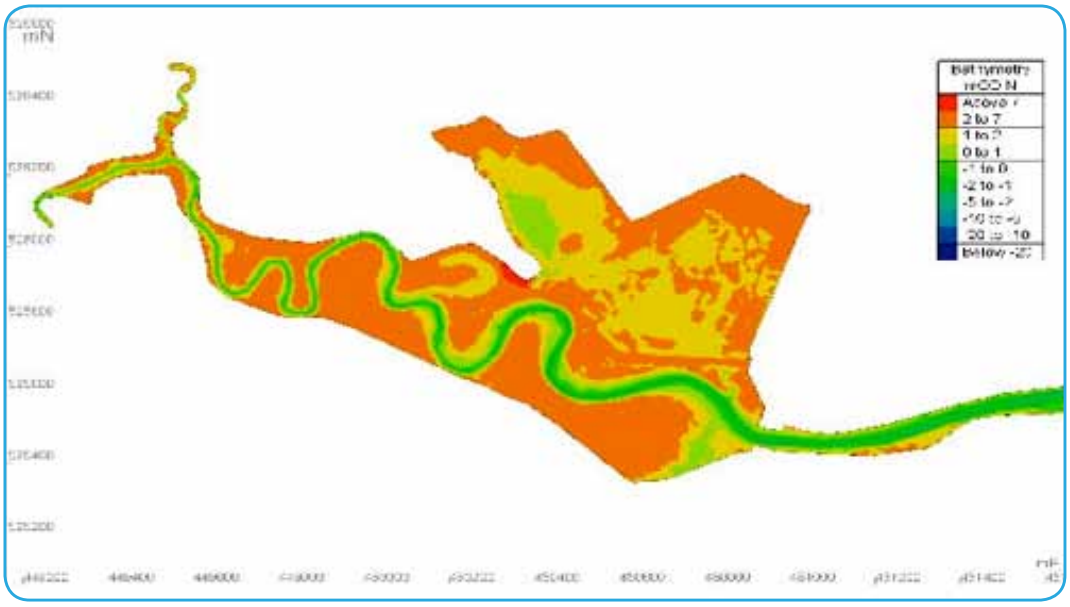

Greatham Creek All images © NEAS copyright and database rights 2013

Background / Issues

The Environment Agency identified that the implementation of the Tees Tidal Flood Risk Management strategy would result in in the loss of intertidal habitats which form part of the Teesmouth and Cleveland Coast Special Protection Area (SPA) and Ramsar site. In addition, the need for further coastal defence works necessary as part of the Redcar Flood Alleviation Scheme also has the potential to cause a loss of SPA habitats.

The Environment Agency therefore had a legal requirement to deliver at least 20 ha of intertidal habitat within the Tees Estuary as compensation for the impact predicted as part of its flood and coastal risk management projects. The Environment Agency purchased 77 ha of land alongside Greatham Creek (part of the Greatham North flood cell) in order to implement a managed realignment scheme and create the required habitats.

The Greatham Managed Realignment Scheme allows future work to the tidal flood defences of the Tees Estuary to continue whilst providing long-term environmental benefit through the conservation of the integrity of the Teesmouth and Cleveland Coast SPA and Ramsar site. The scheme aimed to create a range of complementary habitats of benefit to a variety of wildlife, and ensure better access to for the public was available.


Bathymetry in the vicinity of the managed realignment site

CASE STUDY

Step-by-step

The creation of compensatory intertidal habitats as part of the Greatham Managed Realignment Scheme was achieved through the:

- Construction of a new embankment alongside the inland limits of the managed realignment area. Embankments were constructed with a height of approximately 2.5 m and with 1 in 3.5 m to 1 in 4 m side slopes (dependent upon local ground conditions). The materials used to construct the embankments were partly obtained from a borrow site within the area of land that was purchased, although some materials were imported.
- Construction of two breaches along the original Greatham Creek flood embankment to allow for tidal flooding and creation of a new area of intertidal habitat.
- Restoration of borrow pits to freshwater and grassland habitats.

Benefits

- The scheme delivered 22 ha of intertidal habitat, comprising a mixture of saltmarsh and mudflats. In addition, other parts of the site delivered areas of saline and brackish water, rough grasslands and coastal and floodplain grassland.
- The borrow pits were restored to provide a minimum of 12 ha of freshwater habitat for species such as great crested newt, common frog and aquatic invertebrates and species rich and meadow grassland.
- No significant adverse impacts to the hydromorphology and sediment regime in the Tees Estuary are expected.
- Features of historic significance, such as salterns (sites historically used for salt making), will be returned to their pre-reclamation situation, reducing current pressures from erosion by burrowing and grazing animals. The regrading of the relic drainage system on site and the location of the breaches were designed, in part, to reduce erosion of the salterns.

Lessons Learnt

- Cumulative benefits can be achieved through undertaking managed realignment schemes for habitat improvements which also form part of the local areas flood defence strategy.

Project contact: Fisheries and Biodiversity Team, Yorkshire and North-East Region, Environment Agency

CASE STUDY

Create compensatory habitat to offset impacts

Project Summary

Title: Moselle Brook
Location: Tottenham, North London, England
Technique: Deculverting
Cost of technique: ~~£~~£~~£~~£
Overall cost of scheme: ~~£~~£~~£~~£
Benefits: ~~£~~£~~£~~£~~£~~
Dates: 2009 - 2011

Mitigation Measure(s)

Create compensatory habitat to offset impacts
Remove culverts
Improve channel geomorphology to create habitat

How it was delivered

Delivered by: London Borough of Haringey
Partners: Environment Agency; Heritage Lottery Fund; Greater London Authority; Thames Water; Haringey Heartlands Redevelopment.

All images © Environment Agency copyright and database rights 2013

Background / Issues

The Moselle Brook was previously culverted beneath a footpath in Lordship Recreation Ground Tottenham. The London Borough of Haringey had received funding to improve the park, but required additional money to deculvert the watercourse. The Olympic Delivery Authority had culverted a watercourse on the Olympic Park, with no mitigation available within that site. Funding to the equivalent cost of mitigation was therefore transferred via the Environment Agency to LB Haringey to enable a newly constructed open watercourse to flow through the improved park. The Moselle Brook was chosen due to it being part of the same water body (Lower Lea Valley) where the Olympic Park culverting had taken place.

Designs for new watercourse to be created in Tottenham as compensation for the culverting of a watercourse in the Olympic Park, Stratford.

CASE STUDY

Step-by-step

As the open watercourse on the Olympic Park was culverted over a length of 200m, an equivalent length of open channel was created on Moselle Brook to compensate. A new meandering channel was created to the west of the original course of the river. This incorporated shallow banks to encourage public access, and marginal planting and bankside planting to encourage ecological habitat improvements. The existing culvert was kept in-situ to provide additional flood risk benefits, whereby flow is apportioned predominantly down the new cut channel and the culvert utilised during higher flows.

(1) Culvert at the Moselle Brook during construction; (2) the newly-restored channel after construction.

Benefits

- The creation of newly restored watercourse at the Moselle Brook has resulted in no overall loss of open watercourse in the Lower Lea Valley.
- Improvements to in-channel, bankside and riparian habitats in the Moselle Brook.
- The scheme delivers multiple benefits as a central part of the creation of an improved multi-use landscape within the park. In particular, the deculverting improves public access to natural open water. This provides considerable recreational benefits in a deprived area with little access to exposed watercourses.

Newly exposed Moselle Brook. Reseeding is visible on banks.

Lessons Learnt

- In constrained sites, offsite enhancement can be a viable option for mitigating actions and delivering environmental enhancements within the same catchment.

Success

Project contact: Fisheries & Biodiversity team, London Environment Team, Environment Agency

CASE STUDY

Development of a strategy to manage sediment in an appropriate way

Project Summary

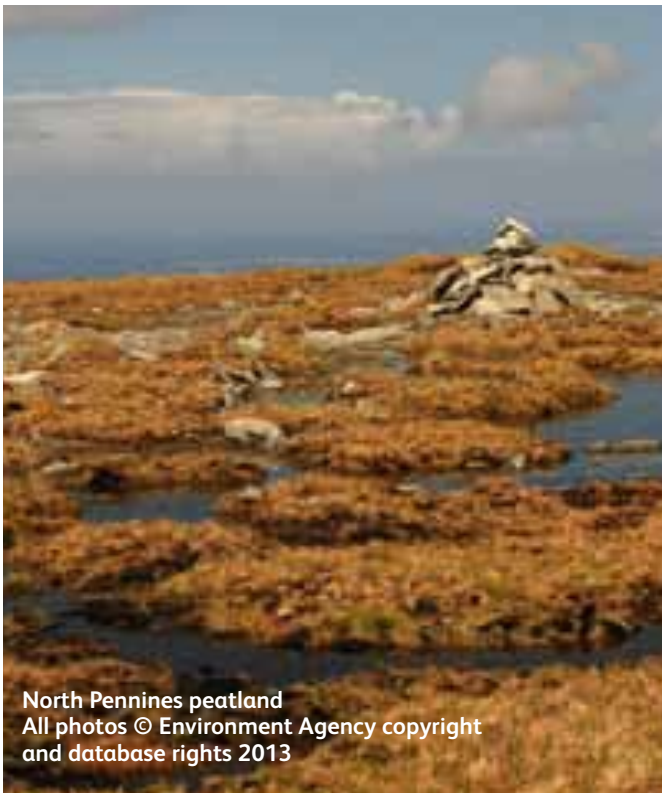
Title: Whitfield Moor (Peatscapes Project) Grip Blocking
Location: Whitfield Moor, North Pennines, England
Technique: Infilling drainage ditches to improve water retention of landscape
Cost of technique: ~~£~~£
Overall cost of scheme: ~~£~~£~~£~~£
Benefits: ~~£~~£~~£~~£
Dates: 2007-2008

Mitigation Measure(s)

Development of a strategy to manage sediment in an appropriate way

How it was delivered

Delivered by: Environment Agency
Partners: AONB Partnership; RSPB; Natural England; Moorland Association; English Heritage, Wildlife Trusts; Northumbrian Water; Durham University



North Pennines peatland
All photos © Environment Agency copyright and database rights 2013

Background / Issues

Attempts to make the North Pennines agriculturally productive between the 1950s and 1980s have led to the creation of approximately 9,400km of "grips" (ditches which drain the peatland) within the North Pennines Area of Natural Beauty (AONB). As a result of this practice, large areas of the moorlands have dried with some serious consequences for the peatland habitat. These include more rapid hydrological response to rainfall events, which causes increased erosion and leads to increased sediment loads in the rivers downstream. These changes to the drainage network cause negative effects on habitats and wildlife and a reduction in the capacity of peatlands to moderate flooding and store carbon.

A strategy to control erosion and sediment input into the local river network was established through the use of a technique aimed at increasing water storage within the peatland landscape.

1) Grip before blocking, 2) after blocking

CASE STUDY

Step-by-step

The Whitfield Moor project aimed to restore an area of 480 ha of peatland through the blocking of 120 km of grips and subsequent rewetting of the surrounding landscape.

The grip blocking method consisted of:

- Utilising an excavator with low pressure tracks to dig out dam material from an area adjacent to the grip.
- Placing excavated material in the grip to form dams of approximately 30-50 cm, blocking flows.
- Repeat grip infilling at 7 to 12 m intervals until the length of the ditch is blocked leading to water build up and vegetation colonisation of the dams.

Grip blocking using an excavator

Benefits

- Impoundment of water behind the dams promotes the raising of the water table in the areas surrounding the ditches, contributing towards the saturation of the soils and the recovery of the peat ecology.
- Improvements to hydrology of the peatland by increasing of storage capacity and flood amelioration.
- Changes to hydrology cause a reduction in stream energy, resulting in a decrease in erosion of peatland and a reduction in sediment supply to the river network downstream; Holden *et al.* (2007) have reported restored grips to reduce sediment production by 54 % when compared to unrestored grips.
- Improvements to local biodiversity;
- Improvements to potential for carbon storage and sequestration within peatland habitat.

Moorland research project sponsored through the AONB Partnership's Peatscapes

Lessons Learnt

- While changes in local hydrology and recovering ecology were quickly observable, the need for long-term monitoring of ecosystem recovery as well as hydromorphology has been stressed by the scientific community and is recommended for similar future projects.
- Communication across a multi-organisation project as well as landowners has proven a significant challenge for this project. The appointment of a "field officer" enabled effective communication through a single contact, successfully overcoming stakeholder engagement issues.

Project contact: Flood and Coastal Risk Management, North Yorkshire Area, Environment Agency

CASE STUDY

Development of a strategy to manage sediment in an appropriate way

Project Summary

Title: River Hull Headwaters WFD Wet Woodland Project
Location: Harpham, East Yorkshire, England
Technique: Installation of large woody debris; bankside tree clearance
Cost of technique: ££
Overall cost of scheme: £££
Benefits: ££
Dates: 2012-2013

Mitigation Measure(s)

Development of a strategy to manage sediment in an appropriate way
Manage natural obstructions in the channel
Retain and improve existing water's edge and bankside habitats in modified watercourses
Preserve and improve water's edge and bank side habitats
Improve channel geomorphology to create habitat

How it was delivered

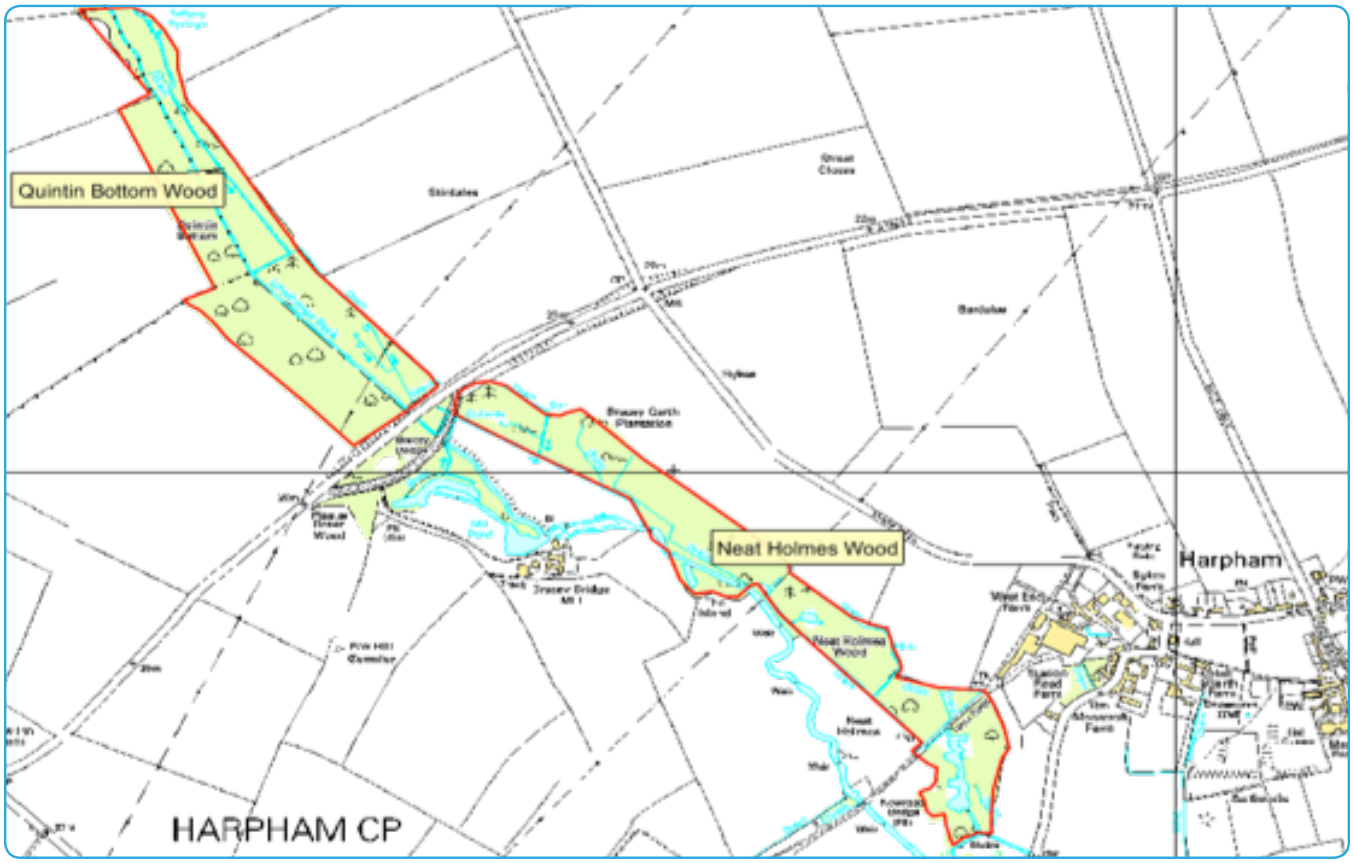
Lead Partner: Environment Agency
Partners: East Yorkshire Rivers Trust (EYRT), Yorkshire Wildlife Trust (YWT)

All images © Environment Agency copyright and database rights 2013. Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

Background and Issues

Kelk Beck (also called Lowthorpe or Harpham Beck) is located in the River Hull Headwaters SSSI, which is designated for its chalk stream communities. 33 ha of wet woodland in the upper reaches of the beck influences the state of the stream habitat by providing diverse pockets of shade and flow variation due to the influence of tree roots and branches. Walk over surveys identified that silt laden feeder streams had disconnected runoff from the wet woodland into the main channel and created high levels of siltation in the river itself. The origin of the silt was identified as agricultural input into the drains to the east of the woodland.

The high levels of siltation combined with dense tree cover as a result of lack of riperian tree management had created very poor conditions for fish species such as brown trout, aquatic macrophytes and various freshwater invertebrates. These conditions are atypical of the chalk stream habitats for which the SSSI is designated.



Step-by-step

1. Geomorphological assessment of the site by Royal HaskoningDHV (2010) as part of SSSI river restoration plan, in order to identify the geomorphological issues which prevent the SSSI reaching favourable condition.
2. Site walk over by EYRT project officer to identify all sources of fine sediment which contribute to siltation in the reach. EYRT took the findings to local board members to advise on environmentally sustainable drainage practices.
3. Design and construction of large woody debris features to act as silt traps, using large woody debris from trees felled to allow more light to get to the river. This was delivered by officers from EYRT and YWT (see also 'Manage Natural obstructions in channel case study: River Hull Headwaters WFD Wet Woodland Project').

Examples of siltation in Neat Holmes wood prior to implementation of strategy.

Benefits

- Restoration of more varied river processes through encouraging in siltation resulting in channel narrowing and reduced sediment load in the channel.
- Improvements to range of in-channel and riperial habitats.
- Benefits to fish, macrophyte and invertebrate populations.
- Contribution towards achievement of good ecological status at a water body level.
- Contribution towards river restoration plan for River Hull Headwaters SSSI.
- Excellent working relationship developed with landowner which may result in additional joint working and biodiversity benefits.

(1) Restored section of stream showing hinged trees and Coarse Wood debris (LWD); (2) LWD trapping silt in a feeder stream

Lessons Learnt

- Local partner knowledge and expertise of the site and how it functions helped to minimise costs by matching the shape of some felled trees to create in channel diversity in appropriate places, rather than designing the work in advance and sourcing the material to deliver the design.

Project contact: Richard Jennings, Biodiversity Technical Specialist, Environment Agency

CASE STUDY

Manage invasive species

Project Summary

Title: Pevensey Floating Pennywort Control Trials
Location: Pevensey, East Sussex, England
Technique: Herbicide spraying of invasive species
Cost of technique: ££
Overall cost of scheme: ££
Benefits: ££
Dates: 2010-2011

Mitigation Measure(s)

Manage invasive species
Sensitive techniques for managing vegetation (beds and banks)

How it was delivered

Delivered by: Environment Agency
Partners: Sussex Wildlife Trust; Natural England, Royal HaskoningDHV

Floating pennywort in Hurt Haven, 2010

All images © Environment Agency copyright and database rights 2013

Background and issues

Pevensey Levels consist of a large area of low-lying grazing meadows intersected by a complex system of ditches. The Levels are a designated a Site of Special Scientific interest (SSSI) and a Ramsar wetland of international importance due to the invertebrate and plant assemblages found on the site, which include one nationally rare and several nationally scarce aquatic plants, and many nationally rare invertebrates.

Floating pennywort is classified as a non-native invasive species in the UK and is listed under Part II of Schedule 9 to the Wildlife and Countryside Act 1981 with respect to England, Wales and Scotland. Surveys in 2008 confirmed the presence of the perennial and stoloniferous (i.e. spreads via horizontal stems) floating pennywort extending to approximately 10 % of the watercourses on the Levels.

The plant grows very rapidly and forms large rafts of vegetation that can block water control structures, thus increasing flood risk and also reducing the amenity value of infested areas. By choking the watercourse the plant may also cause damage to species of interest in the Levels.

In order to develop a practicable method for the control of floating pennywort, Natural England and the Environment Agency established experimental trials at the Pevensey Levels to address the above issues, as a pilot study on options for the management of this invasive aquatic plant within a Site of Special Scientific Interest.

Floating pennywort in drainage ditch 2010

CASE STUDY

Step-by-step guidance

Pre-study works

A number of studies were undertaken to inform the development of the trials, including a desk-based hydroecological study, floating pennywort growth monitoring, protected species survey and aquatic invertebrate and macrophyte surveys.

Ditches of different sizes for selected as experimental sites to represent the influence of ditch size on control effectiveness. Control ditches (to which no clearance would be attempted) were also used.

Works to the SSSI

- Mobilisation of equipment and start of experimental methods (August 2010);
- Initial mechanical clearance of floating pennywort (August 2010). A tracked excavator with a long 45' boom was used for the mechanical clearance of pennywort biomass, both floating and rooted into bottom sediment or bank sides;
- Herbicide main treatment (September 2010). Two chemical control treatments, the herbicides glyphosate and 2,4D amine, were applied to experiment ditches based on Environment Agency operations staff recommendations. Herbicides were applied using a portable backpack sprayer with a variable telescopic boom and a pressure / volume control nozzle.

Post-works assessment

- Post-treatment aquatic invertebrate survey (October 2010) to assess treatment impacts
- Post-treatment aquatic macrophyte survey (November 2010) to assess treatment impacts

(1) 2,4-D amine after 11 days; (2) 2,4-D amine after 36 days

(1) Glyphosate after 11 days; (2) Glyphosate after 36 days

Benefits

- Depitox (2,4-D amine) herbicide displayed significant reduction in the distribution and abundance of floating pennywort, with some reaches nearly devoid of significant infestation. The glyphosate, whilst successful, was less effective.

Lessons Learnt

- Declines in macrophyte species in treated ditches were similar to declines in macrophyte species in untreated ditches, suggesting that mechanical / chemical treatments do not impact on macrophytes.
- There was a significant decline of macroinvertebrates in treated watercourse, which is anticipated to be due to physical destruction of habitats. Such impacts have not been acknowledged through herbicide manufactures own ecotoxicological trials.
- Depitox (2,4-D amine) appeared to have a faster action than glyphosate, resulting in a significant reduction in the distribution and abundance of floating pennywort after 30 days.

Project contact: Fisheries & Biodiversity team, Kent & East Sussex Area, Environment Agency

CASE STUDY

Manage invasive species

Project Summary

Title: Tweed Invasives Project
Location: Tweed River Catchment, England / Scotland border
Technique: Herbicide control of invasive species
Cost of technique: £££££
Overall cost of scheme: £££££
Benefits: £££
Dates: 2002 – 2013 (ongoing)

Mitigation Measure(s)

Manage invasive species

How it was delivered

Delivered by: Tweed Forum, with funding coming from Natural England, Environment Agency, DEFRA, Tubney Trust, Esmee Fairbairn Foundation, Scottish Government, Landfill Tax Credits, Scottish Natural Heritage, Scottish Environment Protection Agency, Northumbrian Water, Interreg, Monsanto, SITA Trust, Countdown 2010, Northumberland County Council, Berwick Borough Council, Heritage Lottery Fund, Forestry Commission.
Partners: The main active partners are landowners, farmers, local communities, and angling associations.

Invasive Non-Native Species (INNS) on the north bank of the River Tweed at Coldstream, Scottish Borders

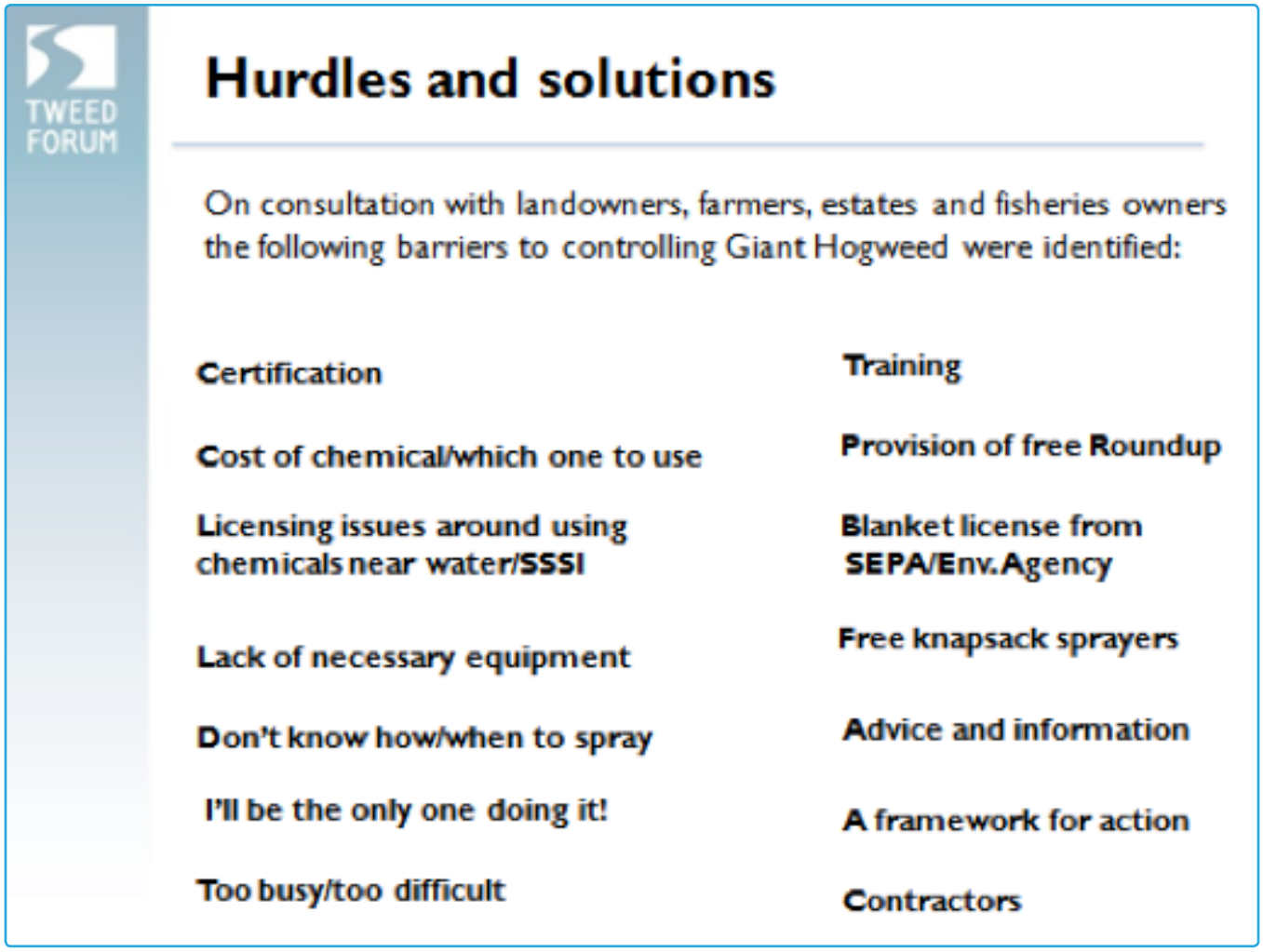
All images © Environment Agency copyright and database rights 2013

(1) Giant hogweed infestation (and asscoiated bank erosion); (2) Infestation of the river bank near Hawick, Scottish Borders, by Japanese knotweed

Background and issues

Non-native invasive plant species such as giant hogweed (Heracleum mantegazzianum) , Japanese knotweed (Fallopia japonica) and Himalayan balsam (Impatiens glandulifera) have been present in the River Tweed catchment since the 19th century, when they were introduced through botanical garden collections or by accidental importation with other goods. In recent decades these have spread all over the catchment and in the lower reaches form dense stands that out-compete all native species.

The main target for this project was the control of giant hogweed and Japanese knotweed. These two species are particularly difficult to eradicate and cause a variety of problems: biodiversity issues, river erosion due to out-competing native vegetation, leaving banks exposed during winter die back, and the potential to impact on the human environment through H&S risks and damage to property. Giant hogweed is capable of producing a seed head that contains over 10,000 seeds which can remain dormant in the soil for a number of years. Japanese knotweed reproduces through rhizomes and is capable of regenerating from small sections of root, often thought to have been killed by the treatment.



Deliverables produced through consultation with local stakeholders were aimed at education and creating a greater understanding of the problems of dealing with the situation

Step-by-step

Giant hogweed
Control of giant hogweed was managed through application of glyphosphate weed killer ('Round-Up') to plants that have grown to about 60cm high. Giant hogweed seeds germinate at different times, so it was essential that the site was revisited a few weeks after the initial application to determine whether a second application was required.

Japanese knotweed
Control of Japanese knotweed was managed through the cutting of the stem and injection of glyphosphate weed killer directly into the stem. Japanese knotweed is exceedingly resilient to both cutting and chemical treatment. Once a stand of Japanese knotweed has become established it is very difficult to kill, therefore a strategy of continued management and treatment involving repeated visits on a rolling programme was required.

Himalayan balsam
Control of Himalayan balsam has been carried out on one major tributary, the River Till, by spraying plants with glyphosphate. However, concentrations of the weed killer can be reduced as the species is more receptive to treatment than the other plants. Hand pulling of balsam was initially trialled as an alternative to spraying but was found to be time consuming and not cost effective in comparison.

The size of the Tweed catchment, which includes more than 300 miles of river, produces considerable logistical problems. There is an optimum window of a few weeks for the effective treatment of each target species; rendering it impossible for a single group of contractors to carry-out all necessary work. Tweed Forum therefore put much of the onus on the landowners and farmers, acting as coordinator to ensure that every area was treated effectively. All riparian landowners were contacted, told about the project and asked to undertake control measures on their land. They were also provided with appropriate chemicals, training and technical guidance. Contractors were brought in for sections that posed particular difficulties because there was no clear ownership or the terrain was hazardous to access.

Norham Bank, Northumberland, before treatment. The white flowers of giant hogweed can be clearly identified.

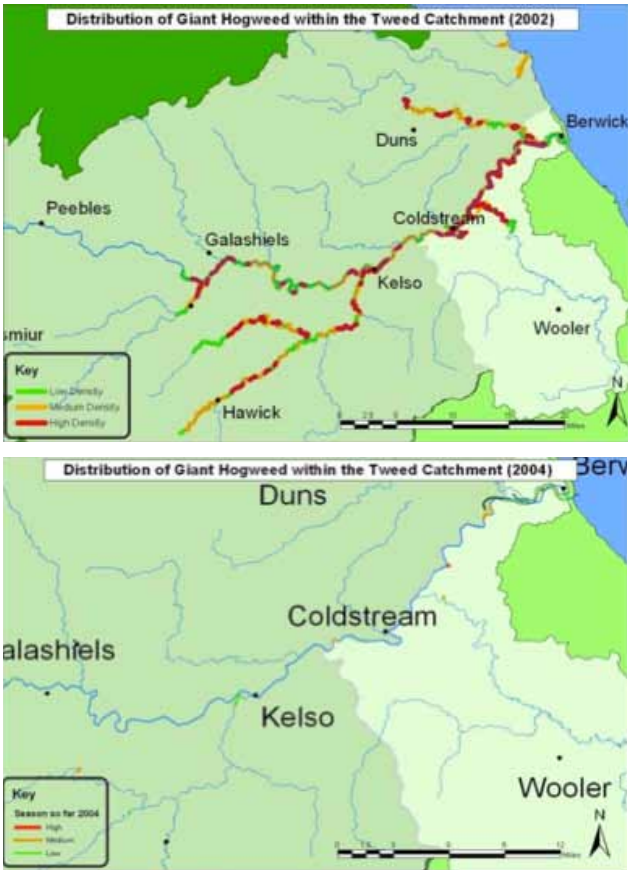
Norham Bank, Northumberland, showing treated giant hogweed plants

Benefits

- Large areas that were virtual monocultures of INNS have been restored to native vegetation:
  - o Japanese knotweed: There are signs that stands of knotweed have been eradicated altogether, although this success is not even throughout the catchment due to varying skills in the application of the glysophate.
  - o Giant hogweed: Hogweed has reduced massively although the viability of the existing seed bank should not be overestimated and work should continue on reducing hogweed.
  - o Himalayan balsam: The balsam has responded much quicker to treatment that the other species in recognition of the shorter viability of the seeds.

The successful control of these species has led to the following benefits within the catchment:

- Improved access to the riparian zone.
- Reduced riverbank erosion.
- Reduced siltation.
- Improved habitat for native species.
- Reduced risk to human health.
- Reduced damage to property.



Distribution of flowering giant hogweed (1) before and (2) 2 years after the project started. Flowering hogweed is now present at very few sites although the same areas still have to be controlled due to the seed bank.

Lessons Learnt

- Control is possible but it does take dedicated coordination and leadership to keep momentum going.
- Costs have not reduced as envisaged and have 'plateaued' out in recognition that the same amount of ground needs to be walked and treated.
- Large floods can expose and redistribute seeds and thus all reaches need to be covered each year.
- Public interest/participation can drop off rapidly once invasive species are no longer perceived as a priority issue. Many members of the public forget the scale of the problem once an area has been treated.
- Himalayan balsam's ability to colonise is still an issue even in treated areas.
- Hand pulling of balsam was time consuming and not cost effective compared to spraying.
- Use of existing stakeholder engagement networks and delivery mechanisms is crucial for stakeholder buy-in and support.
- Encouraging the development of a network of 'champions' to engage and educate stakeholders. These 'champions' were local community representatives that enabled good consultation and acceptance of the treatment teams so that there was no significant disturbance to local residents and stakeholders..
- INNS can present a long term problem and it is therefore important to be persistent when undertaking control and eradication programmes. The project demonstrated a clear need for a long term strategy of 25 years or more.

Project contact: Tweed Forum, info@tweedforum.org

CASE STUDY

Manage invasive species

Project Summary

Title: Bourn Brook Giant Hogweed Control Pilot Project
Location: Cambridgeshire, England
Technique: Herbicide treatment of invasive species
Cost of technique: ££ (per annum)
Overall cost of scheme: ££
Benefits: ££
Dates: 2010 – on going

Mitigation Measure(s)

Manage invasive species

How it was delivered

Delivered by: Environment Agency
Partners: Wildlife Trust for Bedfordshire, Cambridgeshire and Northamptonshire (WTBCN)

Environment Agency team spraying giant hogweed in one of the most affected areas.

All images © Environment Agency copyright and database rights 2013

Background / Issues

An invasive species survey undertaken by the Wildlife Trust for Bedfordshire, Cambridgeshire and Northamptonshire in 2011 identified that this water body contained giant hogweed (Heracleum mantegazzianum) and Himalayan balsam (Impatiens glandulifera). These invasive species were shading out native species, and during winter months when they died back left bare banks which increased sediment input to the brook at times of high flow. This survey was a repeat of a 2002 survey and showed a massive increase in the extent of giant hogweed during this time.

Mapping: Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

Step-by-step

Pilot scheme

A pilot scheme was devised to establish if it is possible to eliminate giant hogweed from a water body, and how long this will take. In addition the pilot examined how well native species re-establish once invasive species have been removed. Giant hogweed seeds remain viable for up to 10 years in the soil so this is a long term undertaking. Bourn Brook was chosen as a pilot site to control giant hogweed for the following reasons:

- It is a relatively small water body.
- Control can be undertaken throughout the affected area.
- The site is at the upstream end of the catchment so there is no chance of re-colonisation from upstream.
- Detailed information was available on the extent of giant hogweed (WTBCN survey).
- Landowners were willing for the control to take place on their land.
- In-house resources using experienced operations staff were available to undertake the work.
- The Environment Agency was able to work in partnership with the Wildlife Trust, who were the main contact with landowners and undertook surveys.
- There are downstream water bodies that could become colonised if the giant hogweed was not treated.

Method

The most appropriate control method was glyphosate treatment. Spraying occurred early in the year (during April and May. once plants are easily identifiable) to prevent plants maturing and producing seed. A second treatment was applied in late summer to catch any plants which germinated later in the year. Another crucial part of the project was the control of the other Invasive Non-Native Species (INNS). WTBCN raised awareness of the issues caused by all the species and recruited local volunteers to control the Himalayan balsam. Land owners were also advised on the best management of giant hogweed

Extensive giant hogweed cover, 2011

Benefits

- From the first year's spraying the number of plants was greatly reduced from spring to September, indicating the treatment was successful.
- The partnership approach has established a strong relationship between the Environment Agency and the local Wildlife Trust. This is mutually beneficial as there would be much larger resource implications for both organisations if they attempted to address the INNS problem alone.
- Local community and landowners are engaged with the watercourse, and are working to reduce the problems caused by other INNS.
- Access to the brook has become safer as the number of giant hogweed plants is greatly reduced.
- Native species will re-establish, increasing the biodiversity value of the brook and preventing soil erosion during winter high flows – this represents a contribution towards overall improvement in water body status.

CASE STUDY

Lessons Learnt

- A whole catchment approach with an excellent partners and volunteers means that it is possible to tackle a number of INNS successfully at the same time, in a cost effective manner.
- The exceptionally wet year in 2012 meant it was not possible to spray the giant hogweed twice. This may reduce native plant species and increase time required to manage non-natives.

Project contact: Fisheries and Biodiversity team, Anglian Region, Environment Agency

CASE STUDY

Preserve and improve water's edge and bank side habitats

Project Summary

Title: Martins River Island Enhancement
Location: Ilsington, Tincleton, Dorset, England
Technique: Placement of large woody debris, removal of embankments, bed and bank reprofiling
Cost of technique: £
Overall cost of scheme: £££
Benefits: £££
Dates: 2012-2013

Mitigation Measure(s)

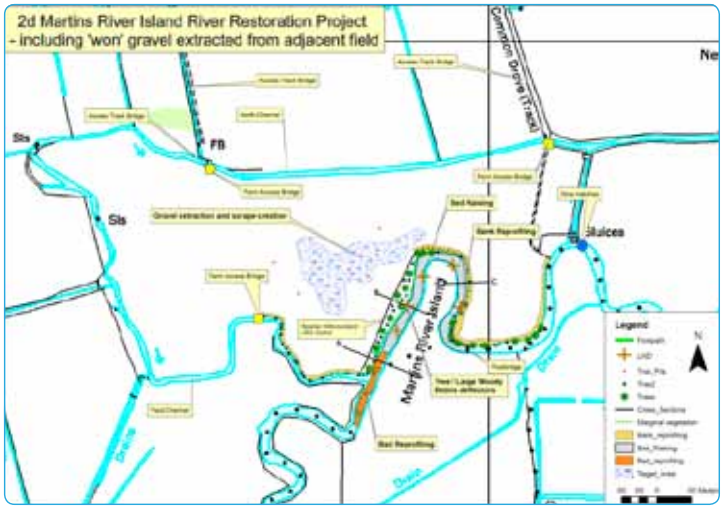
Preserve and improve water's edge and bank side habitats
Manage natural obstructions in the channel
Allow the river to flood its floodplain
Restore aquatic habitats in modified watercourses

How it was delivered

Delivered by: Environment Agency as part of River Frome Rehabilitation Plan
Partners: Environment Agency; Natural England

The key aims of the project were to remove artificial raised embankments and return gravels to the dredged reach creating a range of in channel features and a varied bed profile. *All images © Environment Agency copyright and database rights 2013*

Background / Issues



Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

The reach of the River Frome at Martins River Island had been significantly degraded by land drainage activities in the 1970s, including extensive river dredging. These works removed significant quantities of river gravels, creating an over deep slow flowing canalised channel and adversely affecting the salmonid spawning potential of the river. The dredged material was predominantly placed on the north bank, creating a raised embankment along the edge of the river. This reduced flooding of the adjacent fields and improved land drainage, allowing agricultural intensification through arable production. As part of the River Frome Site of Special Scientific Interest (SSSI) this reach was classified as being in unfavourable condition (i.e. Natural England have assessed the SSSI as not being properly conserved) due to morphological condition and flow changes. Furthermore, the river is failing to reach the required quality status for fish under the Water Framework Directive due to its degraded morphology.

CASE STUDY

Step-by-step

The embankments were removed and reprofiled to a natural bank level. The material was piled up and consisted of river gravels and finer sediments excavated from the river during the historic dredging.

It was originally planned to use the material from the embankments to raise the bed. However, it was found that the natural floodplain material in the adjacent field contained a much higher proportion of suitable gravels than the embankment material. This meant that it was more efficient to use newly won material from the floodplain than to reuse the embankment material.

A borrow pit was therefore dug in the floodplain to win gravels for riffle creation and bed raising. The hole created was in-filled with the embankment material, and any sands and silts that were screened out of the floodplain gravels. This left a shallow open water wetland area with water levels that fluctuate depending on rainfall and river levels.

The won gravels were added to the river at key locations for riffle creation and bed raising to create a range of bed profiles. Gravel was placed in areas where it would naturally be expected to occur in the river channel, such as shallower channel margins on the inside of meander bends, and in particularly deep sections of the channel.

Large woody debris in various sizes (taken from root ball, crown, cut trunk and branches) sourced from local trees was also added to the reach at key locations to provide refuge habitat and also to increase flow variations throughout the reach.

The works were not totally finished in 2012 as severe weather in October led to out of bank flows and wet fields forcing the contractors off site until early summer 2013.

Embankment removal

Gravel extraction

Riffle creation

Bed raising

CASE STUDY

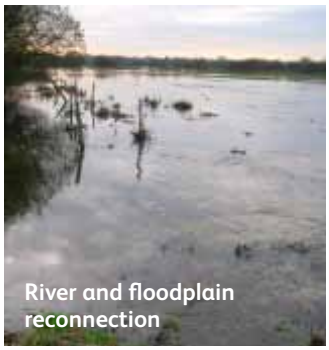
Benefits

- Removed 400 m raised embankments, which improved the connectivity between the river and floodplain.
- Reintroduced 2500-3000 tonnes of river gravels, creating a more natural river bed and increasing spawning habitat for fish.
- Created four new riffles and pools, and raised 250 m of river bed by varying depths between 0.5 m and 1.5 m. This has improved flow variation and increase the morphological diversity of the river bed.
- Increase flow and morphological diversity through the installation of large woody debris.
- Create new and improve existing wetland habitats, including a pond and wetland scrape with a combined area of 2500 m^2.
- There was no waste from the site, which minimised local construction impacts (approximately 150 lorry loads of material avoided) and reduces the overall cost and carbon impact of the scheme.
- An improvement in the available habitat and biology; and therefore the WFD status of the water body.


Wetland creation


Spawning habitat


Wide margins


River and floodplain reconnection

Lessons Learnt

The Martins River Island Project was nearly completed before extensive and prolonged flooding affected the Frome during the winter of 2012. There was widespread out of bank flooding in the fields adjacent to the project area. The landowner and Natural England welcomed this, especially with huge numbers of wetland and migratory birds making use of the flooded fields. The flooding did cause some bank erosion on subsidiary channels in the area. Post flooding discussions were held with the landowner to mitigate some low points in the banks and repair the bank erosion.

Despite the conditions the landowner has been very supportive and still agrees with the project objectives. Winter flooding of the fields, partly as a result of the project, has benefited numerous species of wintering wildfowl and other wetland birds, with thousands of individuals observed.

The project has demonstrated that it is important to:

- Have clear discussions and agreements with land owners with regards to consequences of out of bank flows and flooding.
- Ensure all parties are clear as to the objectives and what to expect during and post project completion, especially in the event of extreme conditions.
- Think about what will happen to flood water when flows return to the channel bank erosion and scour is likely.
- Have confidence to stop work when conditions deteriorate and return when suitable, even if it is during the next construction window.

Success

Project contact: WFD Planning & Delivery Team, Wessex Area, South West Region, Environment Agency

CASE STUDY

Manage natural obstructions in the channel

Project Summary

Title: River Hull Headwaters WFD Wet Woodland Project
Location: Harpham, East Yorkshire, England
Technique: Installation of large woody debris; bankside tree clearance
Cost of technique: ££
Overall cost of scheme: £££
Benefits: ££
Dates: 2012-2013

Mitigation Measure(s)

Manage natural obstructions in the channel
Development of a strategy to manage sediment in an appropriate way
Retain and improve existing water's edge and bankside habitats in modified watercourses
Preserve and improve water's edge and bank side habitats
Improve channel geomorphology to create habitat

How it was delivered

Delivered by: Environment Agency
Partners: East Yorkshire Rivers Trust (EYRT), Yorkshire Wildlife Trust (YWT)

All images © Environment Agency copyright and database rights 2013. Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency,

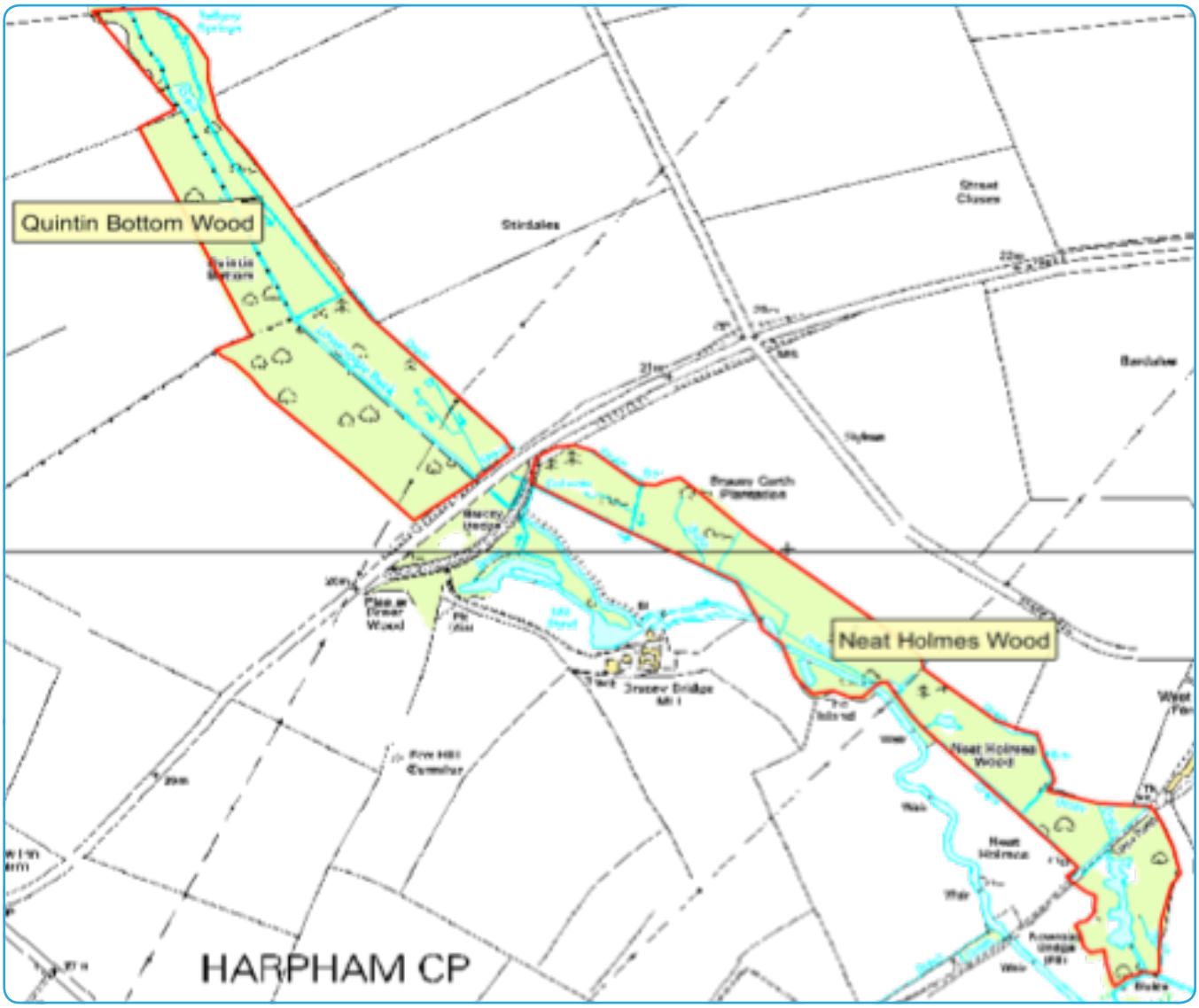
Background and Issues

Kelk Beck (also called Lowthorpe or Harpham Beck) is located in the River Hull Headwaters SSSI, which is designated for its chalk stream communities. 33 hectares of wet woodland in the upper reaches of the beck habitat influences the state of the stream habitat by providing diverse pockets of shade and flow variation due to the influence of tree roots and branches. There are two blocks of woodland, with the northern area known as Quintin Bottom Wood and the area to the south known as Neat Holmes Wood. The beck which flows through the woodland was identified as having high levels of siltation, for which a sedimentation strategy was devised to alleviate the issue (see also Sediment management strategies: River Hull Headwaters WFD Wet Woodland Project).

Silt was arriving in the system from agricultural inputs outside of the woodland, and had disconnected feeder channels from the main river due to sediment build-up which, combined with dense tree cover, had created very poor conditions for fish species such as brown trout, aquatic macrophytes and various freshwater invertebrates. This project has carried out habitat improvement works both in-channel and in the adjacent wet woodland for the benefit of fish and also leading to reduced sedimentation.

Work was undertaken to redirect water within the feeder channels, which are currently disconnected from the adjacent wet woodland habitat, using woody debris and other forest material. The effect of this was to locally raise water levels and encourage out of bank flows, reconnecting the woodland habitat and causing a reduction in sedimentation in the main carriers, by trapping silt within the wet woodland habitat.

CASE STUDY



Step-by-step

The WFD Wet Woodland project seeks to re-connect the woodland habitat with the watercourses leading to a reduction in sedimentation in the main carriers, by trapping silt within the wet woodland habitat.

Several stretches of watercourse removed sections of over-shading through pollarding or felling of the some larger trees. Other trees growing by the side streams had branches cut on the topside of the branch to enable a hinging effect so that they either over-hung the banks or were lying in the channel. These will grow and in future years provide shade and shelter for fish and other wildlife.

The large woody debris (LWD) from the tree work was used to narrow the river channel and speed up flows. The LWD also increases the range of habitat available for fish and aquatic invertebrates. In addition an old sluice structure within the wood, which was in a state of disrepair, has been restored. This structure allows improved control of water levels within the wet woodland. This restored sluice also allows a level of control of water levels mitigating the increased flood risk caused by the restoration.

Benefits

- Restoration of natural river processes by increasing flow and morphological diversity.
- Improvements to range of in-channel and riparian habitats.
- Reduction in fine sediment loads.
- Benefits to fish, macrophyte and invertebrate populations.
- Contribution towards achievement of good ecological status at a water body level.
- Contribution towards river restoration plan for River Hull Headwaters SSSI.
- Excellent working relationship developed with landowner which may result in additional joint working and biodiversity benefits.

(1) Large woody debris (LWD); in feeder stream; (2) Restored section of stream showing hinged trees and LWD

(3) LWD creating silt trap, in channel growth and channel diversity and flow; (4) Fallen tree, pinned in situ to create shallow pool for macrophyte and invertebrate habitat

Lessons Learnt

- Local partner knowledge and expertise of the site and how it functions helped to minimise costs by matching the shape of some felled trees to create in channel diversity in appropriate places, rather than designing the work in advance and sourcing the material to deliver the design.

Project contact: Richard Jennings, Biodiversity Technical Specialist, Environment Agency

CASE STUDY

Improve channel geomorphology to create habitat

Project Summary

Title: Moreton Channel Restoration Project
Location: Moreton, Dorset, England
Technique: Placement of large woody debris and bed and bank re-profiling
Cost of technique: £
Overall cost of scheme: £
Benefits: £££
Dates: 2010

Mitigation Measure(s)

Manage natural obstructions in the channel
Improve channel geomorphology to create habitat
Restore aquatic habitats in modified watercourses
Preserve and improve water's edge and bank side habitats

How it was delivered

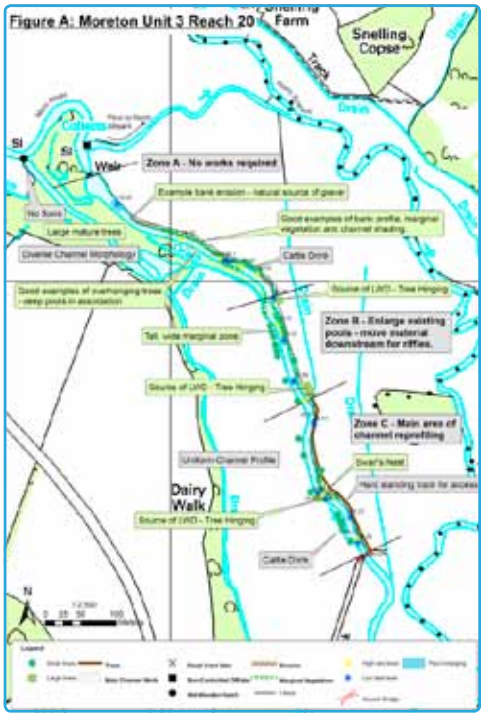
Delivered by: Environment Agency as part of River Frome Rehabilitation Plan
Partners: Frome, Piddle and West Dorset Fisheries Association, Moreton Fishery Syndicate, Natural England

The key aims of the project were to increase the amount of large woody debris within the channel and to improve the river bed morphology to enable the reach to support all fish life stages. *All images © Environment Agency copyright and database rights 2013*

Background / Issues

The reach of the River Frome at Moreton was identified in the River Frome Rehabilitation Plan as requiring morphological enhancement as the existing bed and bank profiles were uniform, showing little variety in terms of habitat and geomorphological features. Extensive dredging is not thought to have happened here in the previous decades, unlike other reaches of the river, but the condition has noted as poor. The regular bed profiles had few deep pools and supported few adult fish. There was also little woody debris within the channel to provide refuge for invertebrates and juvenile fish or to increase flow diversity which could create natural bed scouring and sediment deposition.

Under the Water Framework Directive, the River Frome is failing its target of Good Ecological Status for fish and macrophytes, and is in unfavourable condition as part of the Site of Special Scientific Interest, both of which were addressed through this project.



Moreton Channel project scheme design. *Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380*

Step-by-step

The Moreton Channel project aimed to reprofile morphologically uniform sections of the river bed. A variety of bed features were created by using a long reach excavator to reprofile existing river gravels within the channel. The features created included a more defined low flow channel, deep pools, shallow riffles and exposed gravel bars.

The introduction of large woody debris (LWD) sourced from varying parts (crown, root ball, trunk, whole trees, half trees or branches) of local trees in combination with the new bed features has created a greater range of habitats designed to support the assemblage of macrophytes and fish that is expected in this reach of the River Frome SSSI. The varied bed profile also provides a wide range of habitats for fish throughout all their life stages, and allows the reach to be more resilient during low flows.

(1) Bed reprofiling; (2) Bank reprofiling; (3) Riffle creation; (4) Bed raising

Benefits

The scheme has delivered the following benefits:

- Reprofiling 100 m of bank and 350 m of river bed has considerably improved the geomorphology of the river channel, creating deep pools, shallow riffles and emergent gravel bars. In particular, these works have improved flow variation and increased river bed morphological diversity. Therefore, this technique is also a cost effective method of improving channel morphology.
- Development of wider margins to enable establishment of marginal aquatic vegetation.
- The introduction of LWD throughout the reach has increased the variety of habitats available for aquatic ecology.


LWD installation


Wide margins


Varied channel morphology


Varied channel morphology

Lessons Learnt

LWD installation is a relatively cheap and simple method to improve a reach. It provides fish refuge, flow variation and bed scouring which in turn can increase spawning success and adult fish habitat. Using the partnership approach with the Frome, Piddle and West Dorset Fisheries Association meant that more could be achieved with small funds available.

The fishing syndicate recognised the value of the habitat improvements and fully embraced the concept of LWD use. They actively encouraged more to be hinged into the channel by the end of the project. This level of stakeholder support could be the most beneficial aspect of the project in the context of the wider River Frome, as it will help to promote the benefits of LWD use as a cost effective means to improve river habitats to a much wider group of stakeholders.

Part of the aims of the project was to climate proof the river enchantment to allow the reach to be more resilient to low flows. There were some fears initially that some of the bed reprofiling was too bold. However in the 18 months post-works near-drought conditions have been experienced and the reach now supports many more fish and other aquatic life than it had done in previous low flow events.

Project contact: WFD Planning and Delivery Team, South-West Region, Environment Agency

CASE STUDY

Use green engineering techniques instead of hard bank protection

Project Summary

Title: Riverbank Repairs at Thames Side, Laleham
Location: Penton Hook Reach, Thames Side, Laleham, England
Technique: Installation of coir rolls
Cost of technique: ££
Overall cost of scheme: ££
Benefits: £££
Dates: Completed May 2009

Mitigation Measure(s)

Use green engineering techniques instead of hard bank protection
Manage vegetation appropriately
Sensitive techniques for managing vegetation (beds and banks)

How it was delivered

Delivered by: Environment Agency

Overview of site at Laleham

All images © Environment Agency copyright and database rights 2013

Background / Issues

The river banks at Laleham were being eroded by a combination of natural river action and boatwash rolling over the shallow channel margins and up the bank toe.

In addition, waterfowl grazing of riparian vegetation had resulted in the creation of a sizeable area of mudflat. Before the project, bank destabilisation, particularly during high flows, had been further augmented by the lack of rooted foliage on and adjacent to the banks.

A method for reducing the energy of the wash from the boats and stabilise sediment was, therefore, required to halt the erosive processes which were impacting upon the banks. Given the relatively low levels of energy present in the system in this area and the need to preserve and, where possible, enhance bankside habitats, a "soft engineering" solution focusing on bankside vegetation planting was advanced.

Bare, eroding banks

CASE STUDY

Step-by-step

A combination of soft engineering techniques and the appropriate management of the bankside vegetation were deemed best suited to the local bankside and flow conditions. These included

- Installation of soft bank protection in the form of pre-planted coir fibre rolls, which were held in place by stakes through their entire length and dug into the bed level.
- Anti-scour protection was installed to safeguard the coir rolls where water levels deepened.
- Creation of irrigation trenches joined to a rear trench planted with further marginal vegetation.
- Temporary fencing of the area to prevent access and promote establishment of vegetation (some gaps were put in place to allow access to the waters' edge).
- No vegetation management at the edge of the channel – the edge of the bank was left to establish.

(1) Access point along riverside
(2) Planting along the bankside

Benefits

- The coir rolls provide a valuable habitat for fish, mammals and aquatic insects.
- Root systems provide consolidation of sediments and maintain a stable bank through prevention of scour.
- The marginal vegetation absorbs wave energy and boat-wash – boat wave dissipation varies according to species and width of reed bed (typically 2 m of common reed will absorb about 60 % of boat wave energy). In central sections of the project area the marginal vegetation was growing to a width of up to 3 m two years after the project conclusion.
- The natural bank has regenerated and maintained its own stability.
- No further maintenance investment is required due to appropriate selection of vegetation.

Lessons Learnt

- Incorporating specific access points along the bank is important to control trampling of newly established vegetation.
- Fencing off the site during the establishment phase protects the young plants from trampling and animal erosion, promoting the successful establishment of marginal aquatic vegetation.
- Allow some contingency against the failure of one or more species due to external factors, such as the grazing of waterfowl.
- Coir fibre rolls should be installed such that they are partly (2/3rds) submerged below normal summer water level.

Project contact: Fisheries and Biodiversity team, Thames Region, Environment Agency

CASE STUDY

Use of green engineering techniques instead of hard bank protection

Project Summary

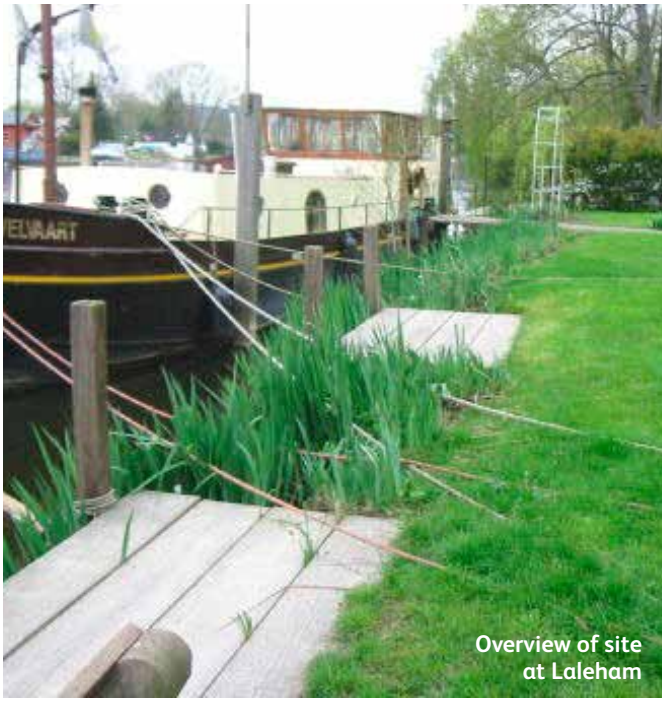
Title: Wargrave Road, Henley-On-Thames Bank Protection
Location: River Thames at Marsh Reach, England
Technique: Use of green engineering techniques
Cost of technique: £
Overall cost of scheme: £
Dates: completed late 1999

Mitigation Measure(s)

Use of green engineering techniques instead of hard bank protection
Manage vegetation appropriately
Sensitive techniques for managing vegetation (beds and banks)

How it was delivered

Delivered by: Environment Agency
Partners: No partners involved



Overview of site at Laleham

All photos © Environment Agency copyright and database rights 2013

Background / Issues

The Environment Agency identified a proposed over-engineered solution as part of an application for a boat mooring on the River Thames. The application involved the proposed installation of steel sheet piling along the riverbanks. The Environment Agency suggested a 'soft' solution as an alternative design to a traditional engineering design for boat moorings.

The site is characterised by a very shallow section of river adjacent to the bank. The structure and substrate of the river bed in this section is dominated by low energy character of the watercourse and associated silting conditions. This has led to regular cutting of the vegetation at the channel banks to ensure access and navigation.

An alternative solution involving the establishment of a selective vegetation control regime and the prevention of the destruction of aquatic habitat was proposed and installed at the site.

Bare, eroding banks

CASE STUDY

Step-by-step

The adopted solution aimed at managing vegetation appropriately while protecting the toe of the bank against undercutting and stabilising it This included:

- The installation of 300 mm diameter by 3 m long planted fibre rolls to retain the shallows along the bank in order to retain the shallows.
- The use of non-contaminated material (silts or gravels) to backfill between the bank and the rolls (no dredging was permitted to minimise disturbance).
- No vegetation management plan or control of the bankside vegetation – the edge of the bank was left to establish.

(1) Access point along riverside
(2) Planting along the bankside

Benefits

In this particular project the toe protection through a selective vegetation control regime presented a wide array of benefits to local ecology and hydromorphology. These included:

- The promotion of a marginal habitat for birds and invertebrates.
- Vegetation component will potentially be self-sustaining and once established, provide permanent bank stabilisation (vegetation was well established on an assessment visit at the site two years after the conclusion of the project).
- Vegetation is providing anchorage as well as absorbing boat and wave wash.
- Pre-planted coir fibre rolls increase the resistance of the banks to erosion.
- No further maintenance investment is required due to appropriate selection of vegetation.

Lessons Learnt

- Toe geotextiles such as coir fibre rolls perform well in low energy shallow water environments.
- A vegetated bank provides a natural and aesthetically pleasing means of protecting a bank from boatwash whilst maintaining a natural bank and habitats.
- Banks supported by geotextile matting reinforcement should be re-seeded with a grass mixture at the time of installation to help bind the soils.
- Existing natural habitats in the channel or on the bank should always be maintained and enhanced where possible when installing a bank protection structure.
- An applicant must provide sufficient justification for the need of hard bank protection in a low energy natural environment.
- Marginal aquatic vegetation planted at the toe of the bank requires minimal maintenance once established and provide long-term protection to the bank toe.

Project contact: Flood & Coastal Risk Management, Thames Region, Environment Agency

CASE STUDY

Manage vegetation appropriately

Project Summary

Title: Bankside grass cutting
Location: Applied throughout England by the Environment Agency via the Operations Maintenance Standards
Technique: Bankside grass cutting
Cost of technique: £
Overall cost of scheme: N/A
Benefits: £££
Dates: Timed to minimise environmental impact (e.g. avoid bird nesting season)

Mitigation Measure(s)

Manage vegetation appropriately

How it was delivered

Delivered through: Riparian owners
Partners: Partners relevant to watercourse in question

Natural river channel cross-section without management

All images © Environment Agency copyright and database rights 2013

Background / Issues & Step-by-step

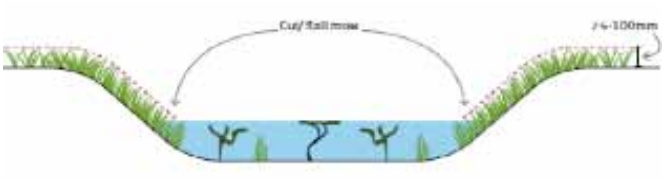
Routine maintenance activities create many opportunities for environmental enhancement, but they can also have a significant impact on the environment. Maintenance needs to be undertaken sensitively to ensure that the plants and animals that are dependent on the water environment are not negatively impacted. Management options must achieve a balance between providing flood protection and protecting the conservation value of a watercourse.

In general, the more diverse the physical structure of a river, estuary or coastal water, the more diverse the plant and animal communities. These features and habitats must be retained to preserve the plants and animals they support throughout their life cycle. Their retention/ restoration is a key requirement of the Water Framework Directive.

The key is to select the most appropriate environmental option for the site. Figures 1 - 5 show a range of maintenance options with a gradual decrease in environmental impact. Where possible the option with the least environmental impact should be selected. Vegetation management should be timed to avoid bird nesting seasons and to avoid impacting on habitats and species which are protected by law.

Where operational activities are to be carried out within or adjacent to statutory designated conservation sites, permission is required from Natural England or Natural Resources Wales.

CASE STUDY



1) Cut both banks completely

2) Cut 1m zone on water's edge of both bank

3) Cut vegetation on both banks leaving 1m margin along water's edge

4) Cut all vegetation on one bank only

Benefits & Lessons Learnt

- Altering bankside grass-cutting regimes to be less frequent and intensive can reduce costs.
- More sensitive grass-cutting improves habitat for plants and animals, including fisheries.
- Provides amenity value.
- Helps manage sediment by trapping runoff and reducing its input to a watercourse.
- Can improve water quality by intercepting point source pollution.

Project contact: Asset Performance Teams, Environment Agency

CASE STUDY

Manage vegetation appropriately

Project Summary

Title: Environment Agency in-channel vegetation management
Location: Applied throughout England by the EA via the Operations Maintenance Standards
Technique: In-channel vegetation management
Cost of technique: £
Overall cost of scheme: N/A
Benefits: £££
Dates: Timed to minimise environmental impact (e.g. bird nesting season)

Mitigation Measure(s)

Manage Vegetation Appropriately
Sensitive Timing of Vegetation Management

How it was delivered

Delivered by: Environment Agency
Partners: Partners relevant to watercourse in question

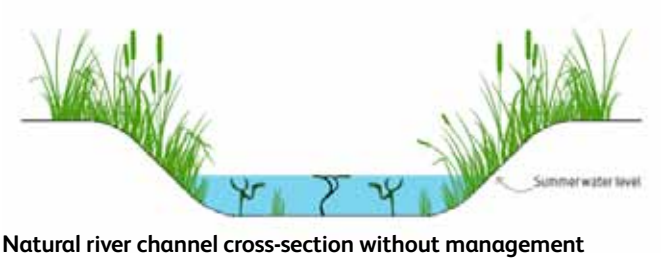
Background / Issues & Step-by-step

Routine maintenance can have a significant impact on the environment. Maintenance needs to be undertaken sensitively to ensure that the plants and animals that are dependent on the water environment are not negatively impacted.

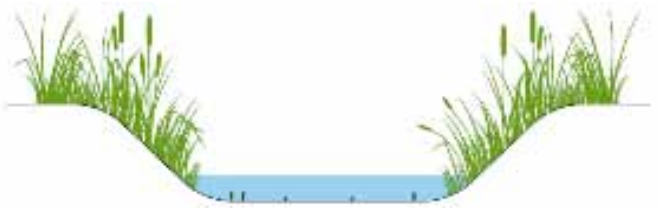
The features and habitats in rivers must be retained to preserve the plants and animals they support throughout their life cycle. Their retention or restoration is a key requirement of the WFD.

Figures 1-5 show a range of maintenance options with a gradual decrease in environmental impact. Where possible the option with the least environmental impact should be selected. Vegetation management should be timed to avoid bird nesting seasons and to avoid impacting on habitats and species which are protected by law.

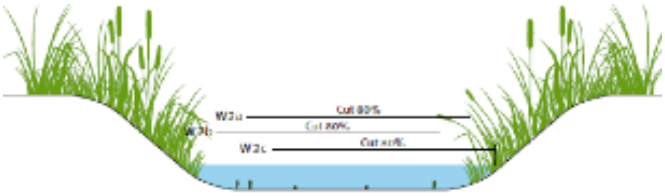
Where operational activities are to be carried out within or adjacent to statutory designated conservation sites (this includes SSSIs, SACs and SPAs), permission is required from Natural England or Natural Resources Wales.



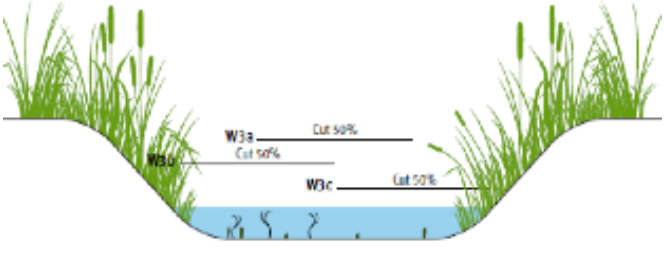
Natural river channel cross-section without management
All images © Environment Agency copyright and database rights 2013



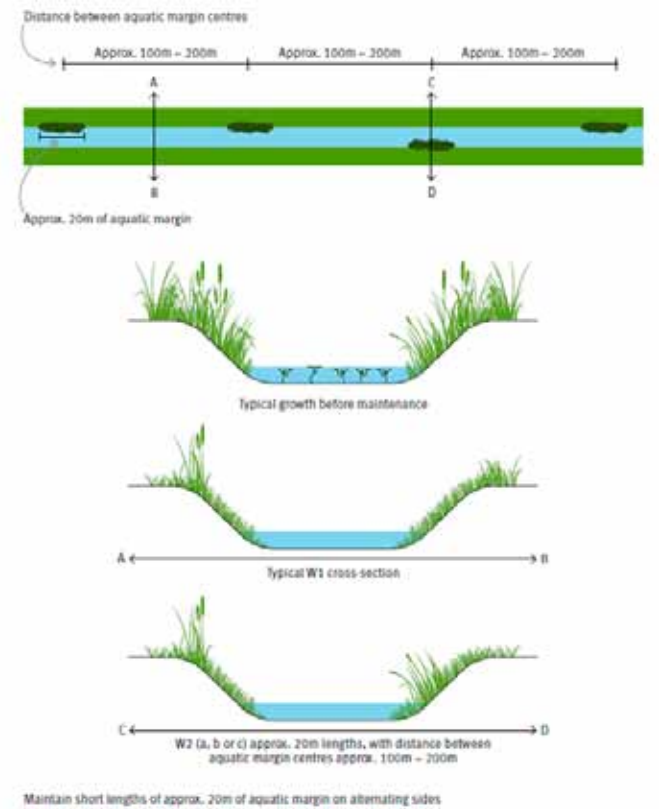
1) Cut in-channel vegetation completely



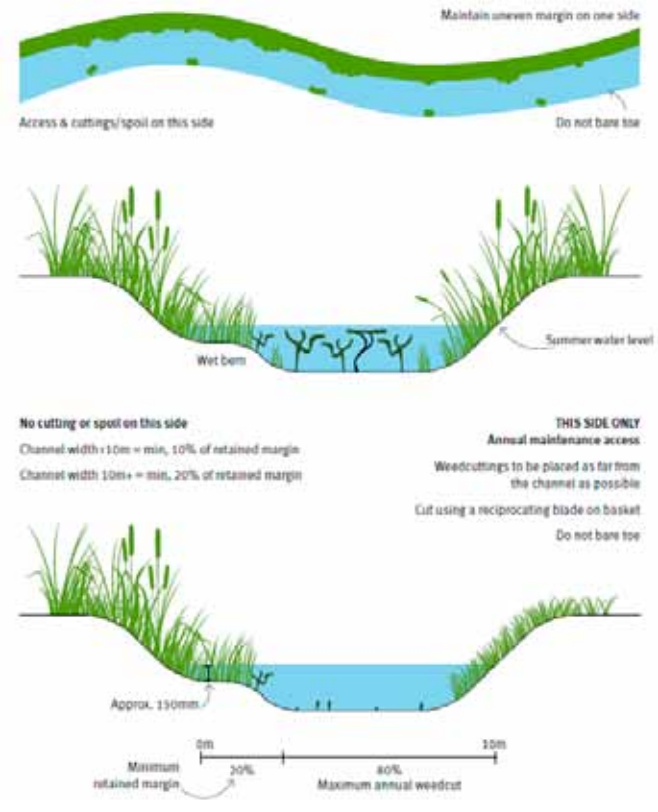
2) Cut 80% of in-channel vegetation



3) Cut 50% of in-channel vegetation



4) Vary cutting regime along length watercourse so that aquatic and marginal vegetation is only managed in key locations



5) Vary cutting regime along length watercourse so that aquatic and marginal vegetation is only managed in key locations and one bank is left uncut

Benefits & Lessons Learnt

- Altering bankside grass-cutting regimes to be less frequent and intensive can reduce costs.
- More sensitive grass-cutting improves habitat for plants and animals.
- Provides amenity value by creating clearer visuals of the channel.
- Helps manage sediment by trapping runoff and resucing its input to a watercourse.
- Can improve water quality by intercepting point source pollution.

Project contact: Environment Agency, Asset Performance Teams

CASE STUDY

Manage water levels appropriately

Project Summary

Title: Sustainable Wetland Restoration in the New Forest
Location: New Forest, Hampshire, England
Technique(s): Installation of debris dams; reconnecting disused meanders; raising river bed levels.
Cost of technique: £££££
Overall cost of scheme: £££££
Benefits: £££££
Dates: 2002-2006

Mitigation Measure(s)

Manage water levels appropriately
Improve channel geomorphology to create habitat
Allow the river to flood its floodplain

How it was delivered

Delivered by: Environment Agency (LIFE3 funding stream)
Partners: New Forest National Park Authority, Hampshire County Council, Forestry Commission, Natural England, National Trust, RSPB

All images © Environment Agency copyright and database rights 2013

Background / Issues

The New Forest is located in the county of Hampshire in southern England. Past water level management strategies in the New Forest have proved detrimental to the local hydrological regimes and associated wet woodland habitats, resulting in threats to the New Forest SAC priority habitats. Straightening and deepening of river channels and the creation of drainage ditches has disrupted the natural hydromorphology of the forest streams, leading to a decrease in quality of habitats and capacity for self-regeneration. A survey conducted by the Environment Agency in 1996 found that over 100 km of New Forest river channels showed signs of degradation.

This project aimed at changing the regional water management strategy to improve priority interest features of the New Forest SAC and their supporting adjacent habitats. The project has also promoted the establishment of long-term sustainability and the regeneration of areas of priority habitat by reinstating natural processes.

LIFE-3 project catchments showing the locations of channel/ floodplain restoration and the main monitoring reaches.
1 = Semi-natural Control,
2 = Channelised Remeandered Reach,
3 = Channelised LWD Reach,
4 = Rhinefield Re-meandered reach.

CASE STUDY

Step-by-step

The project has restored 10 km of river channel by implementing a number of techniques. These include constructing and installing debris dams. These occur naturally in the forest, e.g. by a tree falling over and forming a partial blockage which then impedes transport of further woody debris, thus forming a woody dam. They play an important role in maintaining water levels in the adjacent wetland areas and slowing down water flows. Additional techniques include re-installing and connecting disconnected meanders using evidence of previous meanders from the modified river systems, and raising river bed-levels using spoil originally removed from the channels.

The results of these works are more natural, slower flowing river systems that now have the ability to overflow onto their floodplains as part of the 10 year integrated catchment management plan for management of water levels.

(1) Before restoration – Deep, straightened channel;
(2) U-channel once completed

Benefits

- Improved water level management strategies, including more natural hydromorphology with slower moving river systems and increased reconnection with floodplains.
- Restoration of 261 ha of riverine woodland, 18 ha of bog woodland, 184 ha of valley mire and 141 ha of wet grassland.
- The moving of 1330 ha of SSSI units into recovering condition.

Restored Wet Grassland Habitats

Lessons Learnt

- The introduction of large woody debris together with channel re-meandering has increased flood attenuation and is reported as having a net positive impact on downstream flood risk.

Project contact: New Forest National Park Authority, Forestry Commission, Hampshire

CASE STUDY

Manage water levels appropriately

Project Summary

Title: Beckingham Marshes Washland Creation
Location: Gainsborough, Nottinghamshire, England
Technique: Changes to a water level management strategy
Cost of technique: £
Overall cost of scheme: £££££
Benefits: ££££
Dates: 2010-Present

Mitigation Measure(s)

Manage water levels appropriately
Allow the river to flood its floodplain

How it was delivered

Delivered through: Environment Agency
Partners: RSPB

Beckingham Marshes
All images © Environment Agency copyright and database rights 2013

Background / Issues

The towns of Gainsborough and Beckingham have a long history of flooding from the tidal River Trent. A flood protection program aimed at decreasing flood risk was undertaken in the 1960s, resulting in the embankment of 1000 ha of agricultural land. While this water level management strategy has been effective in reducing flood risk, it has also resulted in the loss of a large area of wetland habitat and associated range of wildlife.

The project aimed to create approximately 94 ha of floodplain grassland and improving habitats for breeding wildfowl, wading birds (such as lapwings and curlews), water voles, dragonflies and damselflies, amphibians and a variety of aquatic plant life. This has involved a restructuring of the water management strategy in the area, promoting a water storage function.

Overview of area to be wetted through project and the River Trent

CASE STUDY

Step-by-step

The "retro-fitting" of wetland habitat into an existing drained flood washland has involved:

- The creation of 4 km of new ditches;
- The digging of 100 large wet ponds;
- The design and installation of a gravity and wind pump assisted drainage system;
- The removal of approximately 30,000 tons of soil related to "ground lowering" and creation of wetland storage.

When the floodplain is inundated, water levels are controlled via a fixed level inflow into the marsh drainage system. Floodwater leaves the floodplain via a flapped outfall. Water that remains in the marshes is controlled with via a combination of a natural system where water levels are controlled by the levels of the ditches and in the river, and pump-assisted drainage. This has resulted in a substantial increase of the water storage capacity in the area of Beckingham Marshes, creating conditions capable of supporting floodplain grassland habitats through changes to the water level management strategy.


Digging of wet ponds

Benefits

- The project will make a significant contribution towards Defra's Outcome Measure 5 target for freshwater habitat creation. Beckingham Marshes will be responsible for approximately 50 % of the regional BAP target in the Nottinghamshire BAP.
- The project will provide supporting habitat for breeding waders, wildfowl, water voles, brown hares, dragonflies and barn owls.
- Increased amenity value and educational opportunities neighbouring population.
- The project will provide added opportunities for off-setting the potential loss of storage associated with raising water levels associated with climate change.
- In addition, the project will offer storage for 1:10 year floods.


Floodplain grassland habitat

Lessons Learnt

Constraints related to the project's location, utilities present in and archaeological value of the landscape are providing valuable lessons related to:

- The need to ensure buried infrastructure (in this case oil pipelines) in not compromised
- Identification and mitigation of the potential impact of landscaping and re-wetting on buried archaeology.

Project contact: Beckingham Marshes Team, Langford Lowfields, RSPB

CASE STUDY

Manage water levels appropriately

Project Summary

Title: River Frome Water Level Management Plan
Location: River Frome Site of Special Scientific Interest (SSSI), Dorset
Technique: Develop water level management strategy
Cost of technique: £££
Overall cost of scheme: £££
Benefits: ££££
Dates: 2006-2010

Mitigation Measure(s)

Manage water levels appropriately
Change the way structures are operated to reduce barriers to flow, sediment transport and fish/eel migration
Reduce erosion caused by land drainage
Improve channel geomorphology to create habitat

How it was delivered

Delivered by: Environment Agency
Partners: Natural England, Royal HaskoningDHV (to appraise and design projects); Dyer and Butler and Kingcombe (construction).

Hyford Hatches: restored allowing more effective and safe water level management through operation control.
All images © Environment Agency copyright and database rights 2013

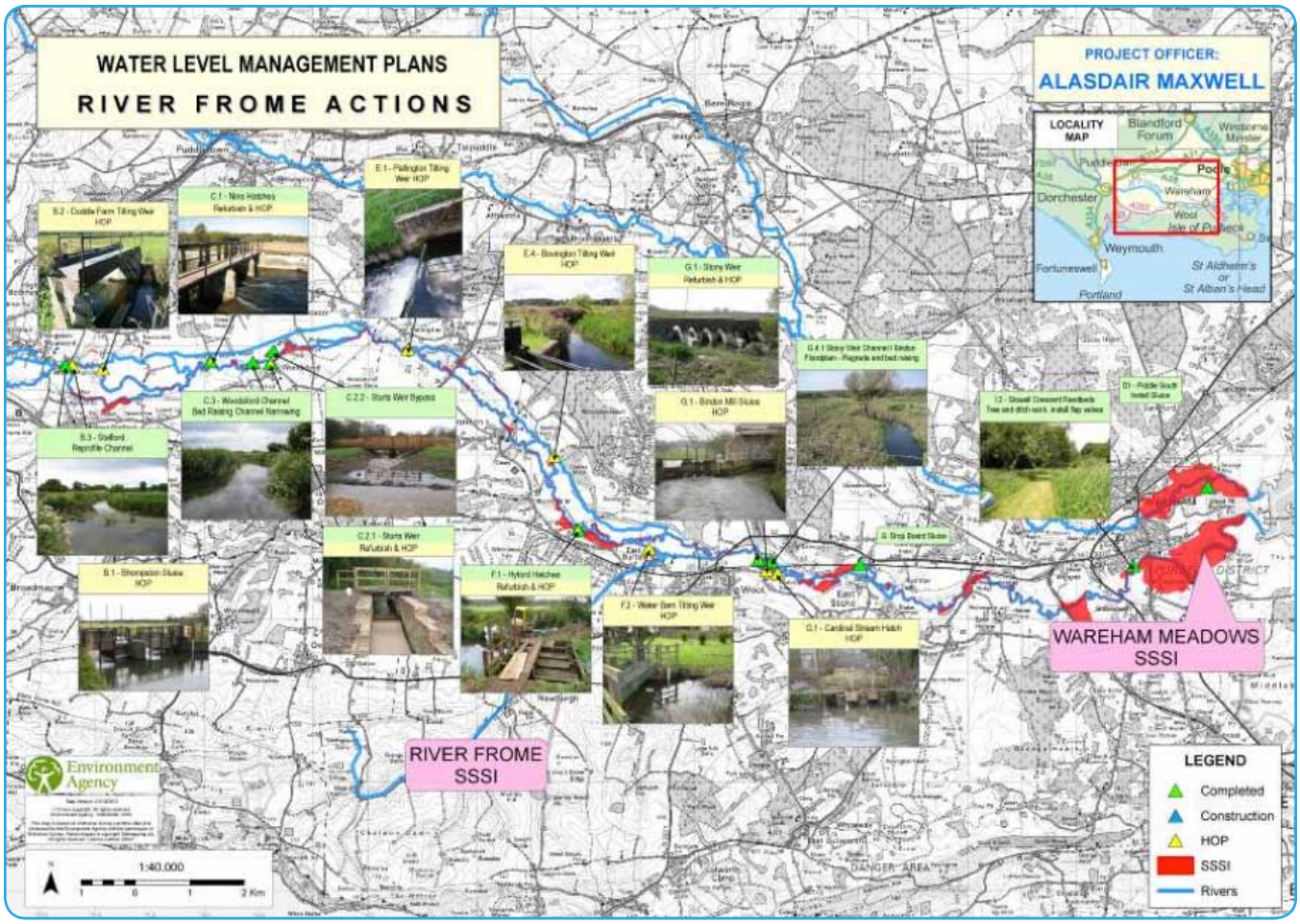
CASE STUDY

Background / Issues

The environment Public Service Agreement (PSA) aimed to achieve a target of 95 % of Sites of Special Scientific Interest (SSSI) in favourable or recovering condition by the end of 2010. Under the PSA target, 'water level management' is where water levels are directly controlled to meet the ecological requirements of specific interest features (the species for which the SSSI has been designated). Water level management involves setting specific target water levels related to these requirements. These targets are delivered through Water Level Management Plans (WLMPs).

WLMPs aim to remedy adverse conditions of inappropriate ditch management or inappropriate drainage. A WLMP comprises a written statement that outlines the water level management objectives for a SSSI and provides details of how they might be achieved, considering other activities such as agriculture or flood defence. The Environment Agency, as the operating authority, has the primary responsibility for formulating these plans in agreement with Natural England.

The WLMP for the River Frome was completed in 2006, and contained a number of measures including changing the operation protocol of water level structures, refurbishment of structures, river restoration, channel modification and vegetation management.



Summary of all actions comprising WLMP.
Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

Step-by-step

Once the WLMP for the River Frome was completed in 2006, all the actions within the strategic WLMP were appraised to identify the most appropriate solution and a programme of works was developed. This ran over four years from 2007.

Design and construction of a variety of schemes progressed until 2009. Outline and detailed design were progressed where appropriate involving extensive consultation with land owners, farmers and fishing clubs.

Construction was completed at Woodsford Channel (restoration pilot), Stinsford Channel, Nine Hatches, Sturts Weir (mill leat and bypass), Hyford Hatches, East Stoke drop board, Bindon Abbey and Stowell Crescent Reedbeds.

The works at Woodsford Channel were considered a pilot project for the River Frome Rehabilitation Plan. Techniques and features such as installing large woody debris, bed and bank reprofiling were undertaken to see how effective they were leading into delivery in future restoration projects.

The Moreton Channel project aimed to reprofile morphologically uniform sections of the river bed (using a long reach excavator). Through moving existing gravels a variety features were created including; deep pools, gullies, riffles and exposed gravel berms.

River restoration pilot

Engagement

Water level control structures

Side channel off take

Monitoring (gauge board)

Side channel management

Structure Operation Protocols (SOPs) were developed and agreed for all existing and installed structures, and were delivered in 2010/2011. These aim to gain agreement as to their future operation to maintain or improve SSSI condition. The River Frome Flow and Structure Project was initiated in 2010/11 to help formulate the SOPs, and also inform river restoration action appraisal.

Benefits

Improvements implemented through the WLMP:

- 9 Structure Operation Protocols.
- 6 structures refurbished or installed.
- Pilot river restoration project completed (Woodsford Channel and the Moreton Channel).
- Gauge boards installed at structures to allow water levels to be monitored and adjusted as necessary

Outcomes:

- Improved water level management at numerous structures throughout the SSSI leading to an improvement in the SSSI condition.
- New partners and relationships formed with landowner owners, farmers and fishing clubs.
- Improved and agreed future flow apportionment between multiple channels.
- Established Project Groups on the Frome, with farming and fishery interests and statutory partners. Six newsletters produced, articles for external and internal publications, presentations at conferences, poster exhibition, workshops (national and local), radio interview and public briefings given and a number of commendations for this programme (including the Avon WLMP).

Sturts Weir bypass channel

Stowell Crescent reedbed

Lessons Learnt

The River Frome WLMP was a large multi-year programme of works. The approach taken to employ a single consultant to appraise the original WLMP, developing projects to detailed design and undertake site supervision during construction had many benefits. It allowed relationships to develop between the Environment Agency team and the consultant staff and allowed for more innovation during design and construction.

Consultation played a large role in the success of the River Frome WLMP. It is important for other similar projects to involve the key stakeholders early and use their input to help inform the designs. This allows a greater degree of buy-in, understanding and general acceptance of the projects.

Some aspects of the Frome WLMP were more complex and harder to achieve in a defined period. The SOPs for example are dynamic, live documents that will need to be revised year on year depending on how effective the originally agreed levels and operations are in achieving the stated objectives.

The SOPs were considered draft documents and consultation has continued as part of the River Frome Rehabilitation Plan, which aims to improve the physical condition of the River Frome SSSI.

Project contact: WFD Planning and Delivery Team, Wessex Area, South-West Region, Environment Agency

CASE STUDY

Minimise disturbance to channel bed and banks

Project Summary

Title: River Nar rehabilitation strategy
Location: Lexham, Castle Acre and Narborough, North Norfolk, England
Technique: Bank reprofiling
Cost of technique: ££££
Overall cost of scheme: ££££
Benefits: ££
Dates: February – March 2011

Mitigation Measure(s)

Minimise disturbance to channel beds and banks
Improve channel geomorphology to create habitat

How it was delivered

Delivered by: Norfolk Rivers Trust
Partners: Norfolk County Council; Alconbury Environmental Consultants

Water vole on the banks of the River Nar
All images: © Alconbury Environmental Consultants copyright and database rights 2013

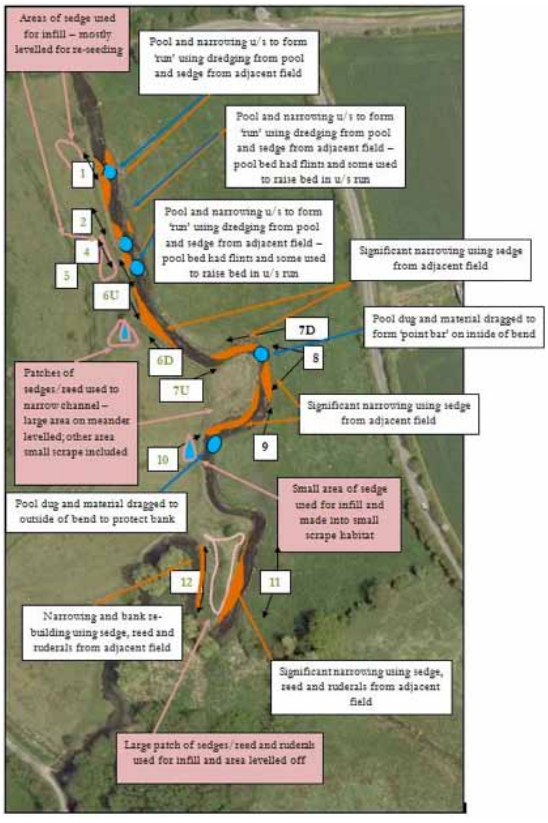
Background / Issues

The River Nar has been the subject of prolonged management which included substantial impoundment and straightening of river sections, resulting in the loss of in-channel habitat quality and diversity.

Restoration efforts undertaken in 2011 aimed to:

- Restore a natural flow and sediment regime through the removal of in-channel barriers.
- Increase morphological diversity through the installation of deflectors, vegetated berms and selective narrowing of the channel.

Water voles are a Protected Species under the Wildlife & Countryside Act and it is an offence to damage or destroy their habitat. The River Nar has been extensively surveyed and is known for a high water vole population. Given the high likelihood of the presence of water voles at the restoration site, a working protocol was established to ensure works could be progressed without impacting these animals and their habitats. This strategy aimed to minimise disturbance to the banks without compromising the delivery of ecological benefits through river restoration initiatives.



Details of proposed works at Castle Acre, River Nar
Source: Alconbury Environmental Consultants

Step-by-step

The delivery of the River Nar rehabilitation strategy and water vole protection working protocol has included the implementation of a number of mitigation measures aimed at minimising disturbance to the river bed and banks, including:

- Restriction of machine movement. Machines were never allowed to encroach within 1m of the top of the bank.
- No reprofiling of earth banks. Exceptions were only considered following on-site confirmation from Natural England that no water voles are present.
- Placing of dredged materials along the channel margin, leaving a gap of approximately 10 cm between the inside edges of the existing bank and material deposited in the river, in order to avoid damaging existing bank habitats.
- Where narrowing of the channel with dredged material was undertaken to create deflector "shoulders" or ledges and there is no gap between the dredged material and the bank (this is prime water vole habitat) spades or the back of the excavator bucket were used to reinstate it.
- Ensure that no compression of the bank toe occurred by not compressing deflector posts into the bed if within 30 cm of the bank.

Construction of deflectors using dredged material

Benefits

- The scheme delivered significant improvements to the quality and range of in-channel habitats. These included improvements to local hydrology and morphology, contributing towards re-naturalisation of the flow and sediment regimes.
- Existing marginal habitats were protected during the construction works, safeguarding water voles and their habitat.

Creation of gap between banks and newly deposited dredged material

Lessons Learnt

- Water vole populations are present in many fluvial and transitional watercourses. This project demonstrates that it is possible to undertake restoration works which deliver geomorphological and ecological benefits without compromising the quality of water vole habitat.

Project contact: River Nar Restoration Team, Norfolk Rivers Trust

CASE STUDY

Preserve and improve water's edge and bank side habitats

Project Summary

Title: Cottenham Lode bank repairs
Location: Rampton, Cambridgeshire, England
Technique: Bank reprofiling
Cost of technique: £££
Overall cost of scheme: £££
Benefits: ££££
Dates: April 2013

Mitigation Measure(s)

Preserve and improve water's edge and bank side habitats
Use green engineering techniques instead of hard bank protection

How it was delivered

Delivered by: Environment Agency

Bank reprofiling at Cottenham Lode

All images © Environment Agency copyright and database rigths 2013

Background / Issues

The left bank in the Cottenham Lode was failing the required asset condition. The The Environment Agency's Asset Performance and Operations team were therefore tasked with identifying suitable measures to reinstate the bank (approximately 60 m in length) to its correct asset condition to provide adequate flood protection.

While hard revetment techniques were initially considered, these were subsequently dismissed given the ecologically sensitive nature of the site. A solution was required that could meet the vital engineering criteria but also enhance the marginal habitats for the water voles and contribute towards achieving Water Framework Directive (WFD) objectives. The Environment Agency opted to implement a solution that included bank reprofiling and soft engineering techniques as to not compromise the quality of bankside habitats.

Overview of straightened and impounded project site

CASE STUDY

Step-by-step

The implementation of the Cottenham Lode bank repairs was achieved through:

- Reprofiling of river banks.
- Creation of a new berm along the left bank.
- Use of soft engineering techniques, namely a combination of pre-established coir rolls and matting.
- Installation of piping to allow water voles to gain access to burrow entrance.

1) Failing bank at Cottenham, before scheme implementation
2) Installation of "soft" bank protection

Benefits

- Return of the bank to good condition, in compliance with WFD-defined measures for this water body.
- Reinstatement of flood defence protection level.
- Decrease in bank erosion potential, given the vegetation capacity to slow down flows in proximity to the bank.
- Creation of water vole suitable habitat.

Overview of reprofiled bank and coir roll staking

Lessons Learnt

- Soft banks may require some vegetation management in the future – this needs to be considered at design stage.

Project contact: Fisheries and Biodiversity team, Anglian Region, Environment Agency

CASE STUDY

Retain and improve existing water's edge and bankside habitats in modified watercourses

Project Summary

Title: River Pinn Blue Ribbon Network Enhancements
Location: River Pinn, London Borough of Hillingdon, England
Technique: Restore historic watercourse; bankside scrub clearance
Cost of technique: ~~£~~£
Overall cost of scheme: ~~£~~£
Benefits: ~~£~~£~~£~~
Dates: 2008 - 2013

Mitigation Measure(s)

Retain and improve existing water's edge and bankside habitats in modified watercourses
Sensitive techniques for managing vegetation (beds and banks)

How it was delivered

Delivered by: London Borough of Hillingdon, Big Green Fund, Section 106 Agreement, Heritage Lottery Fund
Partners: Groundwork Thames Valley, Friends of Eastcote House Gardens, Blue Sky Social Enterprise

Tree clearance works daylighting the channel of the River Pinn at Long Meadow

All images © London Borough of Hillingdon copyright and database rights 2013

Background / Issues

The Long Meadow reach of the River Pinn is part of a Site of Importance for Nature Conservation and consists of both semi-improved neutral grassland (managed by London Borough of Hillingdon as a hay meadow), and a strip of amenity grassland with a mosaic of copses, scattered trees and scrub alongside the River Pinn and High Road Eastcote. London Borough of Hillingdon in partnership with Groundwork Thames Valley and community groups / volunteers aimed to enhance the River Pinn corridor as a strategic river corridor and key part of London Borough of Hillingdon's Blue Ribbon Network. This entails river restoration as well as regular vegetation clearance, with the aim of achieving a number of biodiversity and environmental benefits. In particular, the project was intended to benefit spawning fish and freshwater invertebrates as well as enhance and create new riparian habitats. The project also aimed to increase community involvement with the river by encouraging access and views of the channel and enabling environment education sessions.

Long Meadow Reach prior to works. Proposed habitat enhancements (relic backwater and river channel) indicated. Mapping: © Ordnance Survey Crown copyright. All rights reserved. London Borough of Hillingdon

CASE STUDY

Step-by-step

A number of activities were undertaken as part of the scheme. Key to the management of beds and banks were:

Restoration works

- Excavate part of the former channel of the River Pinn, before it was straightened in the 1930s, as a high level overflow.
- To excavate an old backwater to create a wetland habitat.

Vegetation works

- Appropriate planting for wetland stabilisation, undertaken by volunteers.
- Selected tree works and scrub clearance along shaded river banks to allow more light into the area, undertaken by volunteers.

(1) River Pinn Volunteers pulling Himalayan balsam; (2) Scrub clearance around Old River Pinn relic channel; (3) Volunteers planting resistant elm trees (4) Tree clearance in Long Meadow

Benefits

- The backwaters provide a new and important wetland area for amphibians, aquatic invertebrates and a refuge for spawning fish. In addition, the restored channel now provides a range of new habitats.
- Reprofiling the section of the river bank by the footbridge allows easy access for children to enjoy environmental education sessions organised by London Borough of Hillingdon officers and volunteers. This provides opportunities for local children to experience river habitat.
- By involving existing volunteer groups in the river restoration projects and monitoring they will learn both useful skills and an appreciation of the environment that will ensure the long term sustainability of the river to continue the success of the enhancement scheme.

Lessons Learnt

- Bringing the community to the watercourse through restoration and community events can maximise the amount of benefits the local and wider community can gain from minimal works undertaken to the watercourse.
- Use of volunteers and using existent remnant channel can deliver environmental benefits at a low cost.

Project contact: Flood and Water Management, Planning Specialists Team, London Borough of Hillingdon

CASE STUDY

Manage water levels appropriately

Retain and improve existing water's edge and bankside habitats in modified watercourses

Project Summary

Title: Amble Marshes Water Level Management Plan
Location: Wadebridge, Cornwall, England
Technique: Water level management
Cost of technique: ~~££££~~
Overall cost of scheme: ~~££££~~
Benefits: ~~££££~~
Dates: 2010-2012

Mitigation Measure(s)

Manage water levels appropriately
Retain and improve existing water's edge and bankside habitats in modified watercourses
Manage water levels appropriately
Improve channel geomorphology to create habitat
Remove or modify structures to increase access for fish and eel

How it was delivered

Delivered by: Environment Agency FCRM (Public Service Agreement relating to SSSIs)
Partners: Natural England, local landowners, Cornwall Bird Watching and Preservation Society

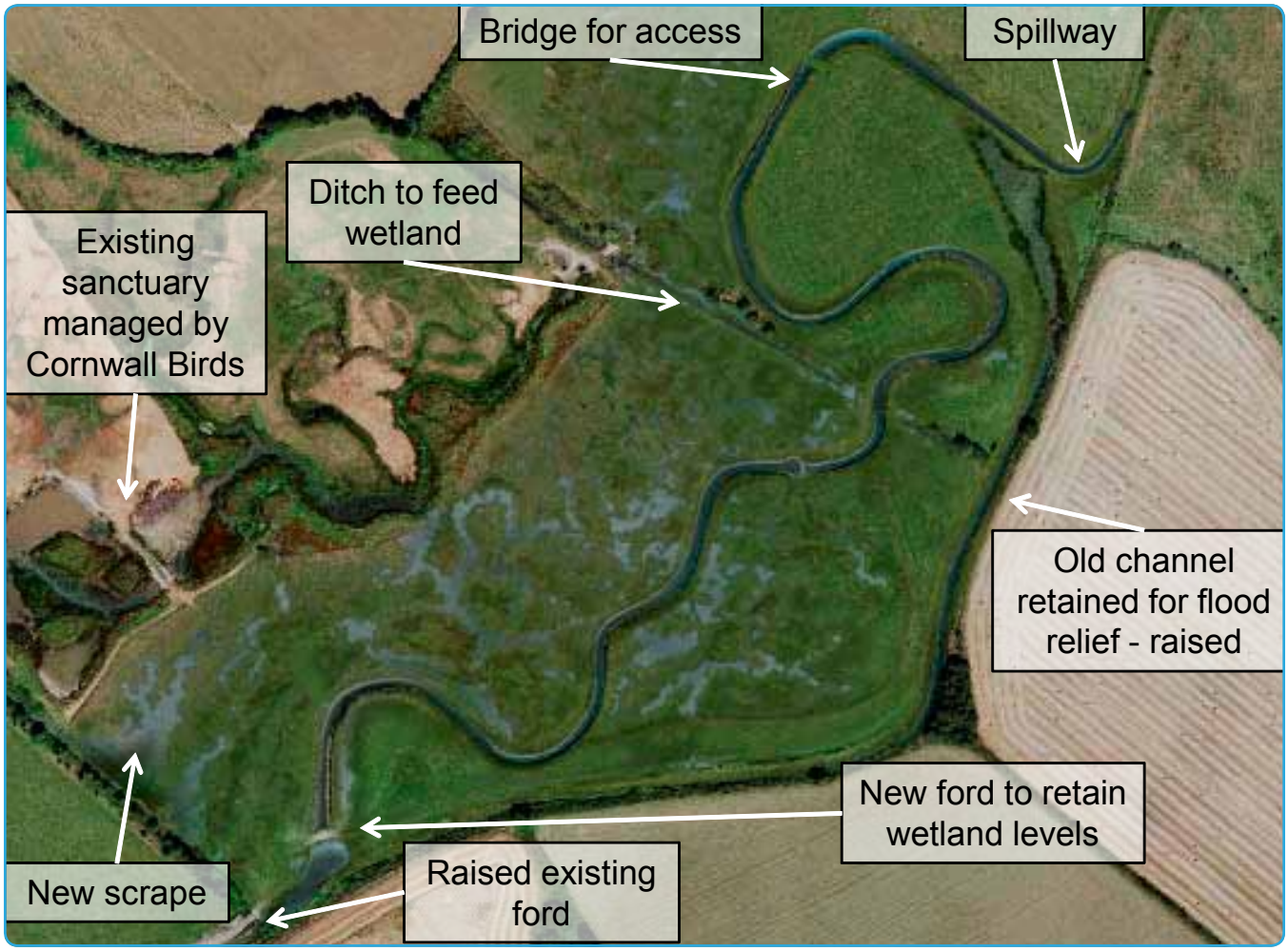
Aerial view of relic salt marsh channels that now hold water during dry periods © Oliver Bampton copyright and database rights 2013

Background / Issues

Amble Marshes is located 2.3 km north of Wadebridge, and covers the floodplain around the River Amble, between Chapel Amble and its outlet into the Camel Estuary. Amble Marshes SSSI was notified in 1951 for over wintering waders and wildfowl and its value as a bird breeding site.

The River Amble has a history of modifications to improve flood defence, including installation of a tidal barrage and river straightening / deepening in the 1960s. This has led to lowered water levels in the Marshes, and a severely reduced frequency of flooding. The quality of wetland wildfowl habitat was consequently degraded.

The aims of the project were to increase floodplain grazing marsh were possible; restore approximately 50 ha marshy grassland and 5 ha of open standing water. These target areas are maintained to support non breeding birds, specifically curlew and lapwing. A secondary target is for improved fish passage at the tidal barrier. The key elements of this scheme can be seen in the annotated plan.



Plan indicating the location of the works. New wetland habitat in relic channels shown using LiDAR imagery
© Nicholas Pearson Associates copyright and database rights 2013

Step-by-step

Phase 1 (2011)

- The water table was raised through the valley by a series of fish passable structures in the river channel and a flood relief spillway which diverted the River Amble through a new channel in the floodplain.
- To increase standing open water a new scrape within the Walmsley Sanctuary was created using a tilting weir that manages water supply to the existing pools.

Phase 2 (2012)

- Modifications made to the tidal barrier to improve fish and eel passage, including installation of a tidal flap valve.

(1) Low water table prior to scheme, resulting in drained marshes and degraded habitat;
(2) Raised water levels post-scheme have led to restoration of grazing marsh
© Environment Agency copyright and database rights 2013

CASE STUDY

Benefits

- The Amble Marshes SSSI has been returned to favourable condition.
- Valuable freshwater coastal and floodplain grazing marsh has been created in the SSSI.
- The new works will enhance fish passage through the SSSI.
- There has been no increase in flood risk at the nearby village of Chapel Amble.
- The wetland has been enhanced as a recreational resource, with an improved public footpath network and two new bird hides planned.

Aerial view of new habitats created
© Oliver Bampton copyright and database rights 2013

Lessons Learnt

- Landowner inclusion and consultation has been key to the success of this scheme, with two landowners now entering into Educational Access agreement with Natural England for guided walks in and around this SSSI.

Project contact: Fisheries and Biodiversity team, South West Region, Environment Agency

CASE STUDY

Preserve and improve water's edge and bank side habitats

Project Summary

Title: Shaldon Intertidal Habitat Enhancement
Location: Shaldon, Devon, England
Technique: Design modifications to ecologically enhance a flood wall
Cost of technique: ££
Overall cost of scheme: £££££
Benefits: ££
Dates: 2010-2012

Mitigation Measure(s)

Preserve and improve water's edge and bank side habitats

How it was delivered

Delivered by: Environment Agency
Partners: Interserve; Atkins Global; University of Exeter; Plymouth University; Treweek Environmental Consultants

(1) Construction of two walls of the Shaldon and Ringmore tidal defence scheme, into which ecological enhancements were incorporated. May 2010

All photos © Larissa Naylor copyright and database rights 2013

(2) Niche habitat colonisation after 18 months

CASE STUDY

Background / Issues

Shaldon and Ringmore on the River Teign in Southwest Devon suffered two near-miss flooding events in October 2004 and March 2008. In response to these events the Environment Agency (EA) secured funding and together with its contractors, Interserve and Atkins Global, designed an £8.3 million tidal flood risk management scheme (Figure 1). The scheme was designed to provide a 1 in 300 year standard of protection for 453 homes and businesses in Shaldon and Ringmore and was the first example of the EA's "Building Trust with Communities" approach to public engagement.

As several of the existing concrete walls were beyond repair, new walls were required in places. These were built from local stone with mortar pointing (Figures 3 and 4). This necessitated a modest 'advancement' of the line of protection (approximately 1 m). The new walls encroached onto the mixed sand and gravel foreshore, which was not designated for its ecology and was of modest ecological value due to degradation caused by compaction by human activity (e.g. walking and boating) on the foreshore. For these reasons, it was decided that restoration of the foreshore would yield limited ecological gains. However, the scheme required planning approval and the Environmental Impact Assessment required some form of ecological compensation to offset impacts.

(3) Old flood wall with low numbers of species and individuals

(4) New flood wall with ecological enhancements. Note low visual intrusion

Step-by-step

Proposal of ecological enhancements

The decision not to offset the foreshore habitat directly, led to identifying alternative forms of mitigation to meet planning requirements. The scientific need for ecological enhancement of hard coastal structures is clear; hard coastal structures typically lack physical complexity and are poor surrogates for natural rocky habitats, often with fewer species. At Shaldon, ecological enhancements were initially proposed by the EA's NEAS team during the design phase, based on existing examples from Sydney and Seattle, which demonstrate the ecological and planning benefits of including niche habitats in the design of new flood walls and sheltered habitats under slipways.

Scheme development

During the development of the scheme at Shaldon, the NEAS team consulted ecologists and geomorphologists from two UK universities (Exeter and Plymouth) involved in complementary research on the influence of engineering design on the ecology of hard coastal structures. An initial meeting with these partners was held to discuss opportunities for enhancement based on existing scientific evidence from the UK and around the world, followed by a feasibility walkover survey on site. Three key recommendations were made: 1) that niche habitats could be incorporated into the scheme to meet local planning requirements and to provide much-need, scientific evidence to support further implementation of this type of enhancement in the UK; 2) that different niche habitat types should be tested (ranging from surface texturing to artificial rock pools made in the mortar pointing between stone blocks (Figures 5 – 8), and 3) that the niche habitats should be replicated within the walls (as discrete units) in order to achieve a scientifically robust experimental design. Following an iterative design process, a test wall was built to illustrate the different habitat niches, and the final designs were ultimately signed off by the lead engineer.

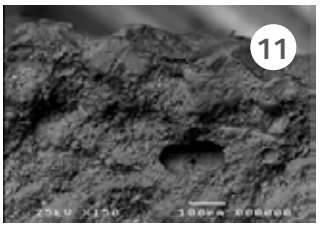
Post-installation monitoring

Post-installation monitoring (which is critical to evaluate the success of enhancement schemes) was completed for the statutory monitoring period (i.e. 18-months after colonisation). It was subsequently lengthened by an EU research grant. Macrobiota results showed a particularly clear response.

(5) Normal mortar finish (= control)
(6) Brushed
(7) Holes
(8) Pool

Benefits

- Nineteen months after they were built, 9 species of macrobiota had colonised the walls. Species abundance and diversity was significantly greater in hole and pool niches compared with the control and grooved niches (Firth et al. in press; Figures 9 and 10).
- Microbiotic (i.e. less than 1 mm) communities were well-developed after 18 months for all niche types, which provide an important food source for macrobiota.
- Evidence of weathering of the construction materials associated with the intertidal setting was found (e.g. biochemical crusting, micro-cracking, salt crystallisation and granular disintegration), but there was no evidence that inclusion of the niche habitat enhancements exacerbated these processes in any way (Figure 11).
- Simple and inexpensive (< 0.3 % of the total project budget) manipulations to the design of hard coastal structures can have a significant effect on ecology, particularly macrobiota with no adverse effects on material properties, 18 months after installation. These types of enhancements can therefore provide cost effective offset and mitigation tools, particularly for mitigating hydromorphological impacts under the WFD.
- Inclusion of niche habitat enhancements helped the scheme win the 'Heath, Safety and Environmental Management' category in the 2012 Environment Agency Project Excellence Awards.
- This is the first known application of ecological enhancement in new hard structures in the UK. It thus serves as a full scale 'proof of concept' for this type of enhancement.
- This momentum of this work led to the creation of the first guidance on including ecological enhancements in the planning, design and construction of hard coastal structures.



(9) Hole treatment pre-colonisation
(10) The same treatment 18 months after colonisation
(11) Scanning electron photograph of brushed mortar showing no deterioration after 18 months

Lessons Learnt

- Ecological enhancement of hard coastal structures can be inexpensive to implement and post-construction monitoring has demonstrated its effectiveness for increasing the numbers and species present.
- Knowledge brokers are critical to ensure that habitat enhancements are progressed from the idea phase to installation. They are especially helpful for working through concerns by members of the project team.
- Input from Universities is critical to delivery as existing operational evidence is limited but quickly building momentum.
- Environmental Impact Assessment was the driver for this enhancement; it also helps maximise ecological potential
- Monitoring for longer than the required 18 months produced stronger evidence of the successful ecological and geomorphological outcomes of the enhancement.
- Only some parts of schemes may be suitable for intertidal ecological enhancement; enhancements on part of a structure or scheme can still have considerable benefits. The environmental and ecological context has to be considered on a case by case basis in order to maximise the ecological and geomorphological potential of enhancements.
- Unforeseen engineering (i.e. needing to install weep vents) and/or build phase changes may happen – we recommend designing in a few extra enhancements to accommodate these changes and still obtain robust evidence.

Project contact: Dr. Deborah Dunsford, NEAS team, Environment Agency and Dr. Martin Coombes (University of Oxford), Dr. Larissa Naylor (University of Glasgow), Prof. Richard Thompson and Juliette Jackson (Plymouth University)

CASE STUDY

Sensitive techniques for managing vegetation (beds and banks)

Project Summary

Title: River Cam weed control (downstream of Whittlesford Bridge)
Location: Whittlesford, Cambridgeshire, England
Technique: Weed control with the use of herbicide
Cost of technique: £
Overall cost of scheme: £
Benefits: £
Dates: 2011 - present

Mitigation Measure(s)

Sensitive techniques for managing vegetation (beds and banks)

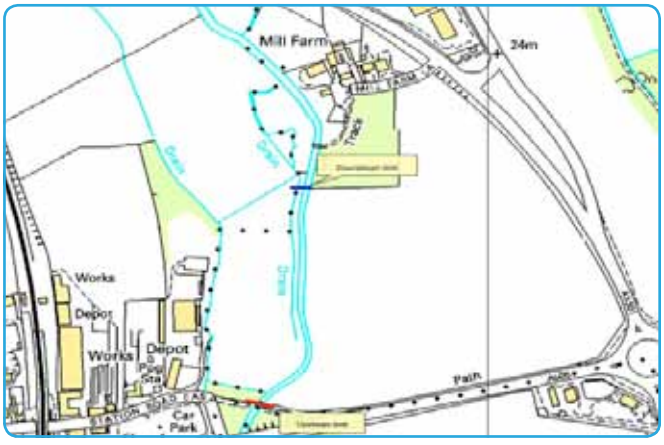
How it was delivered

Delivered by: Environment Agency

Uniform channel before herbicide application.
All images © Environment Agency copyright and database rights 2013

Background / Issues

The control of aquatic weed through the targeted application targeted application of the Defra approved herbicide Roundup Pro Biactive by trained and experienced staff to reduce flood risk has been considered beneficial in comparison to the less discriminate mechanical removal using weed cutting boats or land-based plant machinery. In this method, herbicide application is targeted at emergent vegetation which reduce the ability of the channel to convey floodwater. Treatment early in the growing season is still an effective control method and can be beneficial in situations where channels become choked with vegetation later in the season and are then at risk from reduced dissolved oxygen levels when the plant material breaks down as well as presenting an increased flood risk.

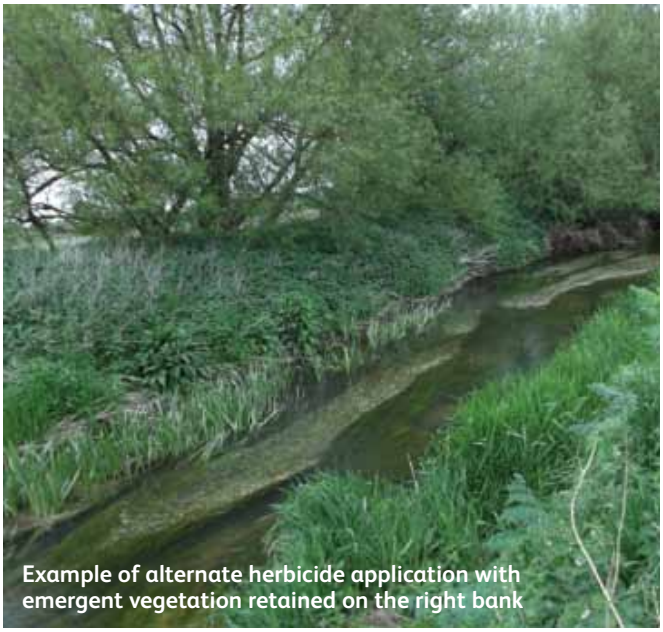


Location map for herbicide application works at Whittlesford.
Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

CASE STUDY

Step-by-step

- The herbicide was applied using boat-mounted apparatus
- Subject to the specific flood risk of particular stretches, herbicide was applied to the central parts of the channel only. Vegetated margins of at least 0.5 m width were retained on either side of the channel.
- Where possible, application was undertaken on alternate banks to provide refugia and promote the creation of a sinuous channel.
- Herbicide application was undertaken early in the growing season and targeted species like the Norfolk reed, reed canary grass and reed sweet grass, which are indicative of eutrophication and less than good ecological status.



Example of alternate herbicide application with emergent vegetation retained on the right bank

Benefits

- 55 to 60 % in cost savings compared to less discriminate mechanical removal;
- The die back of plants in the channel occurs over time, allowing the invertebrate and fish communities to re-distribute as the die-back takes place, thus preventing in-channel ecology from degrading.
- By allowing the chemical to take effect and the plants to die back, the root systems are also killed (unlike a weed cut where root systems remain). Once the root system has died, the next significant flow event will wash away the entire plant. This in turn removes the silts, which congregate around the roots of the emergent vegetation, helping to reduce recolonisation in subsequent years.

Resulting sinuous channel requiring less vegetation management

Lessons Learnt

- Flood defence teams are finding evidence that the creation of sinuous channels using this technique is contributing to more self-sustaining systems and diminished need for subsequent weed control. This indicates that this technique is more effective at controlling plants than traditional cutting, with fewer impacts on ecology and geomorphology.

Success

Project contact: National Environmental Assessment Service, Anglian Region, Environment Agency

CASE STUDY

Sensitive techniques for managing vegetation (beds and banks)

Project Summary

Title: River Pinn Blue Ribbon Network Enhancements
Location: River Pinn, London Borough of Hillingdon, England
Technique: Hand-picking and manual clearance
Cost of technique: ££
Overall cost of scheme: ££
Benefits: £££
Dates: 2008 - 2013

Mitigation Measure(s)

Retain and improve existing water's edge and bankside habitats in modified watercourses
Sensitive techniques for managing vegetation (beds and banks)

How it was delivered

Delivered by: London Borough of Hillingdon, with funding from the Big Green Fund, Section 106 Agreement, and Heritage Lottery Fund
Partners: Groundwork Thames Valley, Friends of Eastcote House Gardens, Blue Sky Social Enterprise

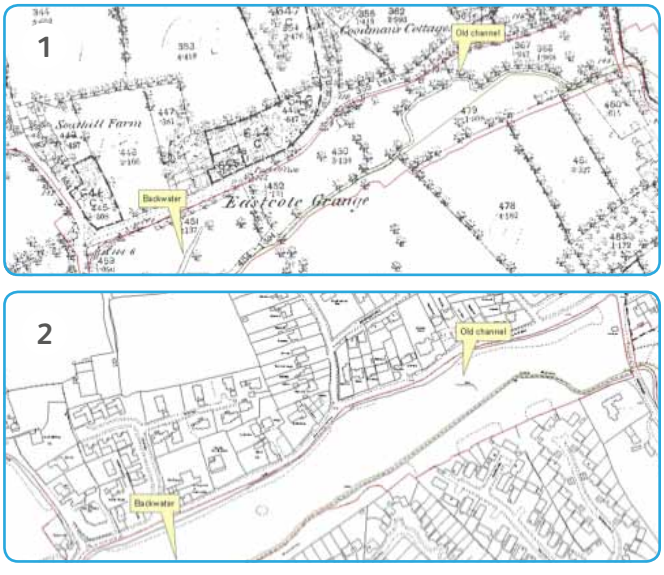
Friends of Eastcote House Gardens planting resistant Elm trees

All images © London Borough of Hillingdon copyright and database rights 2013

Background / Issues

Long Meadow is part of a Site of Importance for Nature Conservation and consists of semi-improved neutral grassland which is managed as a hay meadow, a strip of amenity grassland with a mosaic of copses, scattered trees and scrub alongside the River Pinn and High Road Eastcote.

The London Borough of Hillingdon in partnership with Groundwork Thames Valley and community groups / volunteers aimed to enhance the River Pinn as a strategic river corridor and a key part of the local Blue Ribbon Network. This entails river restoration as well as regular vegetation clearance, with the aim of achieving a number of biodiversity and environmental benefits.



(1) The River Pinn 1846-1901; (2) The River Pinn prior to scheme Mapping: © Ordnance Survey Crown copyright. All rights reserved. London Borough of Hillingdon

CASE STUDY

Step-by-step

The River Pinn Volunteers have been involved in managing the River Pinn on a monthly basis since 2008. This work includes:

- Scrub management via hand picking adjacent to pathways.
- Removal of Himalayan balsam from river banks through supervised manual clearance.

The current project involves the work of a range of volunteers groups including River Pinn Volunteers, Countryside Conservation Volunteers, Friends of Eastcote House Gardens and local charity Groundwork Thames Valley. Blue Sky, a social enterprise organisation which employs ex-offenders also works alongside the volunteers. Community groups participate in delivery of the project through:

- Wetland planting along the stretches of restored river.
- Monitoring surveys.
- Scrub management, including bramble clearance.

A 5 year management plan for Long Meadow, including long-term involvement from volunteer groups, has been completed. Hands-on training days for local residents are run by the Wild Trout Trust and supported by the Environment Agency, and have resulted in the development of skills useful in achieving the long term management of the site.

River Pinn Volunteers pulling Himalayan balsam

Old River Pinn ditch (1) prior to and (2) after clearance

Benefits

- By involving existing groups in the river restoration projects and monitoring, a connection is created between the community and the aquatic environment creating environmental responsibility and a culture of environmental stewardship.
- Integrating the community with the aquatic environment converts the aquatic environment into a community resource providing education, recreation opportunities.
- Vegetation management reduces flood risk in the area, and prevents the spread of invasive species.

Lessons Learnt

- The future of a maintenance programme can be secured through including the local community within the construction of a scheme, thereby creating an interest in the river and a desire to provide volunteer workforce to maintain the river for future generations.

Project contact: Flood and Water Management, Planning Specialists Team, London Borough of Hillingdon

CASE STUDY

Change structures or the way they are operated to reduce barriers to flow, sediment transport and fish/eel migration

Project Summary

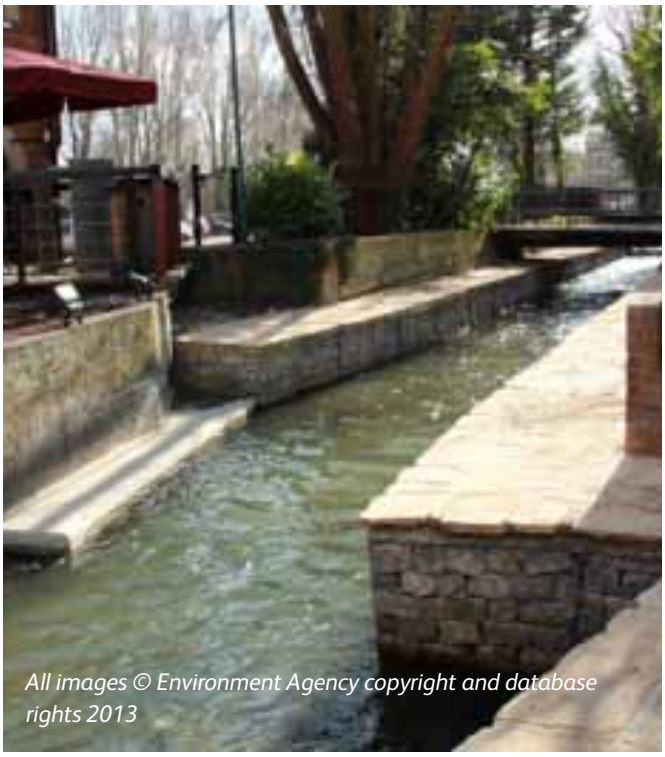
Title: Pledge's Mill Weir Improvements
Location: Ashford, Kent, England
Technique: Structural modification to fish pass
Cost of technique: ~~£~~£~~£~~£
Overall cost of scheme: ~~£~~£~~£~~£
Benefits: ~~£~~£
Dates: 2012-2013

Mitigation Measure(s)

Change the way structures are operated to reduce barriers to flow, sediment transport and fish/eel migration

How it was delivered

Delivered by: Environment Agency
Partners: Ashford Water Group, Ashford Borough Council, Ashford School, Mott Macdonald, Jackson Frameworks.



All images © Environment Agency copyright and database rights 2013

Background / Issues

Pledge's Mill is located at the confluence of two rivers in Ashford: the Great Stour and East Stour, at the centre of the Ashford Green Corridor and conservation area.

The mill channel on the Great Stour was constructed approximately 500 years ago to provide a head of water to Pledge's Mill. By design, the mill channel gradient was very low and the channel was made over-wide. A fixed crest weir and three sluices impounded the river at the mill, resulting in deeper and more tranquil flow than the natural river channel. The sluices at the mill were operated during high flows to reduce localised flood risk.

The channel gradient had reduced further due to sedimentation upstream of the mill structures; and the mill structures also presented a barrier to fish passage, including eels, coarse fish and brown trout.

The Great Stour upstream of the mill was categorised at "bad ecological status" due to the obstruction to fish passage and a reduction of water quality (due, in part, to poor flow conditions). The removal of the physical barrier along this reach was identified in the South East River Basin Management Plan Programme of Measures and in the Ashford Integrated Water Management Strategy. The river was effectively canalised and provided little aesthetic or social benefit to local residents or visitors to the town. As such, it was disregarded and badly affected by littering.

CASE STUDY

Design solution:

- Lower the existing weir and upstream channel, rather than remove it completely or bypass the structure. This option was selected to remove the risks associated with altering the unknown foundations of the historic mill structure.
- A new Larnier fish pass and eel brush pass would overcome the obstruction to fish passage.
- Existing bypass sluices that run under the mill should be left open, meaning that the upstream conditions are regulated for a wide range of flows and the fish pass therefore is functional for more of the year.
- A faced gabion and reno mattress solution was chosen to shore-up the existing mill walls to allow the channel to be lowered

Step-by-step

Pre-works

- Ashford School (the landowner) undertook structural repairs to the mill before commencement of the channel works to reduce the risk of walls collapsing.

Works

- The construction works took place on a 70 m-long section of river.
- Clay bunds were set up upstream of the works to divert flow and allow works to be undertaken. This created the dry environment required to install the reno mattresses / gabion baskets, and reduced the risk of dry-area collapse during high flows, leading to an safe working area.
- The new weir was constructed and a high density polyethylene (HDPE) Larinier fish pass and covered eel pass were installed in the channel downstream of the new weir.

(1) Lowering of the existing weir; (2) Installing gabion baskets in dry-working area behind clay-bunds

CASE STUDY

Benefits

- The improvements at Pledge's Mill will help fish and eels move upstream to their spawning grounds.
- The river is flowing more naturally and water quality is showing signs of improvement, leading to a wider variety of habitats and wildlife.
- This has helped create a more natural environment for local residents, school children and visitors to enjoy and value.
- The valuable industrial heritage and context of the mill building has been maintained whilst achieving these other objectives.
- Localised flood risk has been reduced and the need to operate sluice gates during flood events has been removed.


New fish and eel brush pass

Lessons Learnt

- Moving the timing of the works can have significant construction implications, in this case moving the works from summer to autumn / winter lead to a full redesign of the methods used to create a dry-working area due to the increased river flows anticipated during the winter season.

Success

Project contact: Fisheries and Biodiversity Team, South East Region, Environment Agency

CASE STUDY

Change structures or the way they are operated to reduce barriers to flow, sediment transport and fish/eel migration

Project Summary

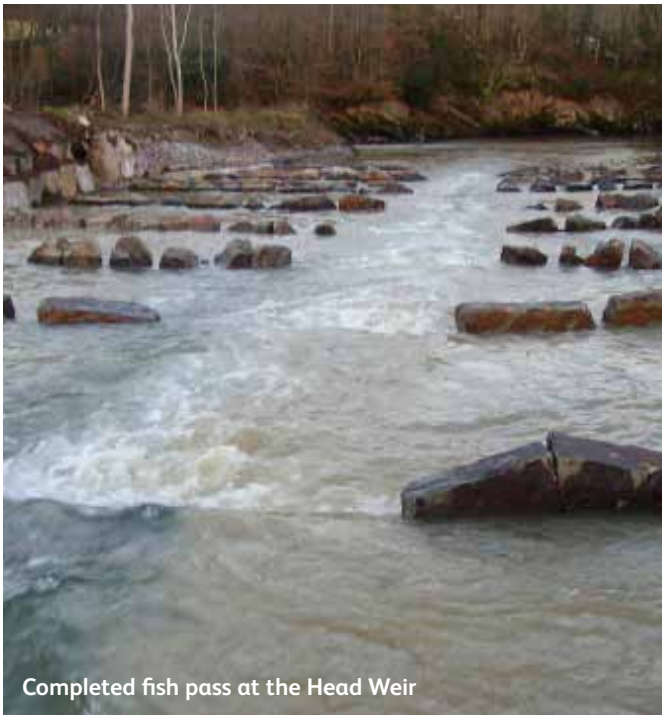
Title: River Mole Head Weir Natural Fish Pass
Location: King's Nympton, Devon, England
Technique: Weir modification to improve fish passage
Cost of technique: £££££
Overall cost of scheme: £££££
Benefits: ££££
Dates: 2009-2011

Mitigation Measure(s)

Change structures or the way they are operated to reduce barriers to flow, sediment transport and fish/eel migration
Remove or modify structures to increase access for fish and eel

How it was delivered

Delivered by: Westcountry Rivers Trust (WRT) via the Catchment Restoration Fund
Partners: Environment Agency; River Taw Fisheries Association; Halcrow.



Completed fish pass at the Head Weir

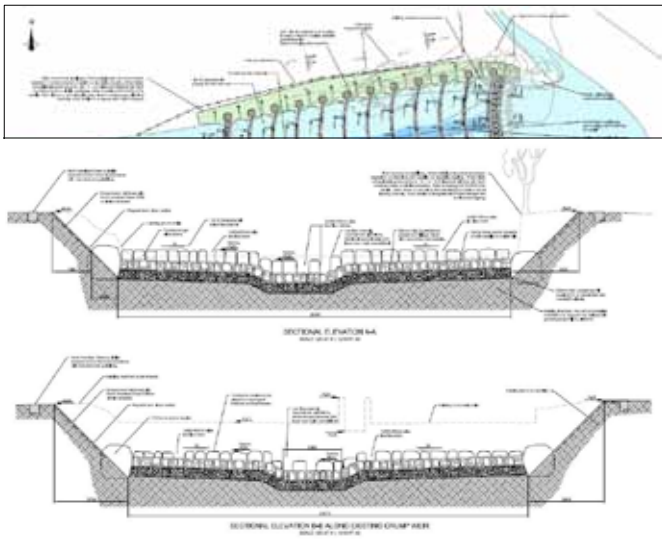
All images © Environment Agency copyright and database rights 2013

Background / Issues

The River Mole is an important sub-catchment of the River Taw in North Devon and provides the primary spawning and nursery area for Atlantic salmon and sea trout in the Taw catchment. There are no obstructions on the Taw prior to its confluence with the Mole so fish have free access to Head Weir, which prior to its removal, formed the most downstream obstruction on the Mole. The weir was constructed c.1840 to feed an abstraction to the Grade II Listed Head Mill, with the leat diverging from the right bank immediately upstream.

A denil fish pass was constructed in 1991/2 when the weir crest level was raised by the then owners. This fish pass was ineffective due its location in the middle of the weir and the short submerged length at its downstream end. There were a number of unsatisfactory features that reduced the performance of the fish pass, including poor attraction to fish, poor access for maintenance, frequent sedimentation of the exit and blockage of the baffles.

This was identified as an issue in the River Taw Salmon Action Plan (2003) and was contributing towards the water body failing to reach Good Ecological Status.



CASE STUDY

Step-by-step

The agreed solution was the modification of the weir and fish pass and its replacement with 11 low stone weirs with a new off-take to supply water to the Head Mill leat.

The design comprised the break-up of the weir and fish pass and the re-grading of the river bed to create a shallower 1 in 30 gradient. New weirs of embedded tombstone shaped boulders were placed in rows perpendicular to flow, with the crest of each boulder bar dropping progressively to create a stepped system. A low flow channel concentrates low flows in the centre of the river.

Prior to construction

- The River Mole was diverted around the site by the creation of a by-pass channel to link in with an existing ditch adjacent to the weir which discharged back into the river downstream of the site.
- An upstream cofferdam was formed from river bed material and sandbags to divert water down the by-pass channel to enable work to be undertaken in relatively dry conditions.

Construction

- Excavators with rock-grabs were used to install the tombstones and blockstones. Larger, 2 and 4 tonne boulders were placed beside and above / below the boulder bars to provide long-term stability. Existing river bed material was used to form the pools between bars.
- A reinforced concrete off-take fitted with a penstock, stop-logs and smolt screen upstream of a 450m diameter pipe conveys water to the leat and mill.

(1) View downstream during construction;
(2) Installing tombstones to low stone weirs

Benefits

- Over 40km of spawning habitat has become accessible with the operation of the new fish pass - this could result in production of up to 2,000 additional salmon smolts each year.
- Naturally-abundant levels of salmon, sea trout and other species will be restored to the River Mole, and improve habitat upstream to Good Ecological Status under the Water Framework Directive.
- Angling opportunities improved above the weir boosting potential economic growth of local communities.
- The scheme, coupled with the closure of a local fish farm, has significantly improved water quality downstream and there will no longer be a deprived reach as a result of unsustainable abstraction.

Lessons Learnt

- Flexible delivery team meant that when issues arose during construction, including flooding of the site during periods of heavy rainfall, work could be suspended during this period for very little cost.
- A policy of local material reuse saved approximately £18K in landfill costs. Material from the demolished weir, excess bed material, and cofferdams was reused after construction to infill the tanks of a nearby defunct fish farm, whilst felled timber was used by landowners for fuel.
- The project has shown that working in partnership is important to achieve desired outcomes and ensure that the environment is managed sustainably for the benefit of wildlife and people.

Project contact: Fisheries and Biodiversity Team, South West Region, Environment Agency

CASE STUDY

Change structures or the way they are operated to reduce barriers to flow, sediment transport and fish/eel migration

Project Summary

Title: Ashlone Wharf
Location: Beverly Brook from Motspur Park to the Thames (GB106039022850) in Barnes, London, England
Technique: Modifying structures to improve fish passage
Cost of technique: £££
Overall cost of scheme: £££
Benefits: ££
Dates: May 2011 – Dec 2011

Mitigation Measure(s)

Change structures or the way they are operated to reduce barriers to flow, sediment transport and fish/eel migration

How it was delivered

Delivered by: Environment Agency
Partners: London Borough of Hammersmith & Fulham

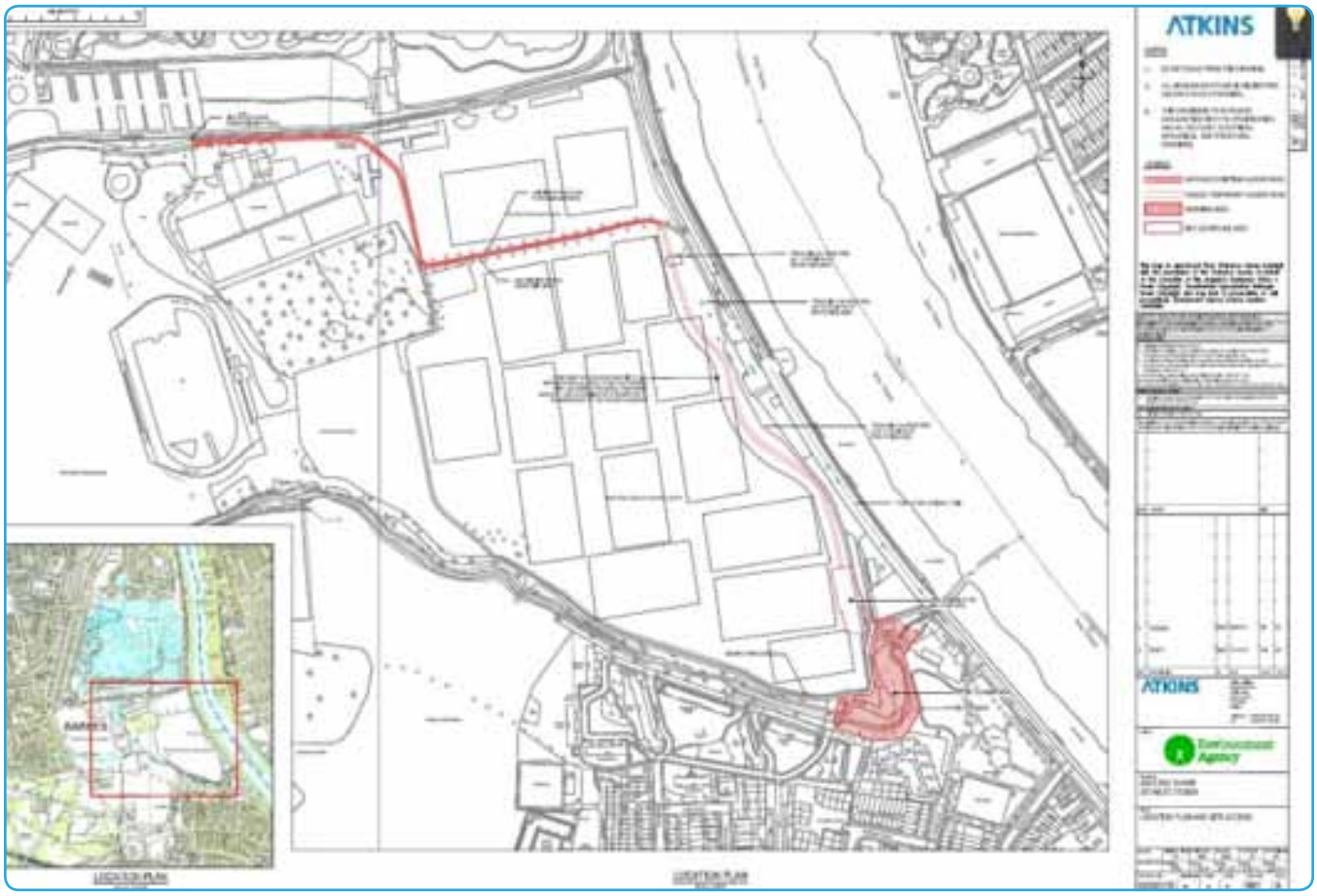
Location of Ashlone Wharf
© Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

Background and issues

The Beverley Brook is currently failing to achieve Good Ecological Potential (GEP), mainly due to pressures resulting from flood protection and urbanisation. The site at Ashlone Wharf included a complex of flood relief culverts, channels and penstocks estimated to convey approximately 50-80 % of the flows in the Beverley Brook. These barriers represented an impoundment that restricted free flows and fish movement through the Beverley Brook and promoted the build-up of silt in the lower reaches of the brook.

The constraints identified at the site and its overall state of disrepair led to the implementation of a strategy for operational and structural changes aimed at mitigating the impact of the barriers and contributing towards the restoration of a naturalised flow and sediment regime in the Beverley Brook.

Given the presence of accumulated silt exceeding the two Port of London Authority dredging acceptance criteria regarding volume of accreted silt and the presence of invasive species like Japanese knotweed and Himalayan balsam, the scheme left the silt as undisturbed as possible.



Site overview at Ashlone Wharf © Atkins copyright and database rights 2013.
Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

Step-by-step

Work on the project included changes to the structures currently in place to achieve the goals set out in the previous section. This involved:

- The replacement of two of the existing cast iron flap gates with motorised winch lifting mechanisms and access platforms for safe operation and maintenance.
- Replacement of one of the remaining existing flap valves with a new side hinged self-regulating flap gate to facilitate fish passage.
- The closing in semi-permanent fashion of a fourth, obsolete culvert and installation of three motorised penstocks, with non-rising spindles for the three functioning culvert barrels to focus flows, increase sediment transport and allow more accurate control of water levels.
- Installation of a Larinier fish pass in the sluice channel upstream of the current gate.
- Replacement of the current sluice gate and screen.
- Installation of a new stop log controlled arrangement directing normal flow through the fish pass.
- Planting and stabilisation landscape scheme in order to minimise the chance of silt erosion.

(1) Gate at Ashlone Wharf;
(2) One of the culverts and associated flap gate to be modified
© Environment Agency copyright and database rights 2013

CASE STUDY

Benefits

- Potential for increased flexibility in the operation of the structures at the site.
- Decrease in number and extent of barriers to the natural flow and sediment regimes.
- Significant improvements to fish passage through the site.
- Creation of fish refugia and reed habitat in the lagoon upstream of the structures.

Open gate during operation
© Environment Agency copyright and database rights 2013

Lessons Learnt

- Improvement of structural operability enables review of operation regimes to minimise the requirement for further improvement works. Whilst replacement of existing structures is not a sustainable measure, the operating regime that follows increases the long term condition of the river and structure.

Project contact: Fisheries and Biodiversity team, South Thames Region, Environment Agency

CASE STUDY

Manage the risk of fish and eels being trapped in pumps & turbines

Project Summary

Title: Gold Corner Pumping Station Eel Passage
Location: East Huntspill, Somerset, England
Technique: Installation of eel passage system
Cost of implementation: £££
Overall cost of scheme: ££££
Benefits: ££
Dates: 2013

Mitigation Measure(s)

Manage the risk of fish and eels being trapped in pumps and turbines
Remove or modify structures to increase access for fish and eel

How it was delivered

Delivered by: Environment Agency
Partners: KLAWA, Fisktek, Royal HaskoningDHV

KLAWA silver eel bypass system
© KLAWA copyright and database rights 2013

Background / Issues

Gold Corner Pumping Station, located approximately 8 km north east of Bridgwater (ST 36802 43049), is the largest and most complicated land drainage pumping station in Southwest England. The station was a major barrier to fish and eel migration, and site visits confirmed fish mortality associated with the pumping operations.

The Environment Agency required an effective, low cost solution that would increase silver eel escapement at Gold Corner into the downstream Huntspill River to enable eels to continue their journey to the Sargasso Sea to spawn.

The KLAWA silver eel passage system was recommended by Royal HaskoningDHV for use at this location due to positive indicative test results. It is the first of its kind to be used in the UK. This system has been tested effectively at hydropower stations, and provides a low-cost solution to eel entrainment.

(1) Eel mortality due to pumping station;
(2) Fish injury due to pumping station;
(3) Fish mortality due to pumping station;
(4) Fish mortality due to pumping station.

CASE STUDY

Step-by-step

Pre-construction monitoring
Eel and fish mortality monitoring is undertaken prior to installation of the new system to inform design.

Eel passage construction (August/September 2013)
The silver eel bypass system consists of a special perforated zig-zag collection-pipe, the main element of this system, and a bypass-pipe which flushes out collected migratory silver eels which have entered the zig-zag-pipe into the backwater of hydropower stations unharmed. Construction also includes the installation of bristles upstream of the pipe (see picture) to create optimum flow conditions to allow eel ingress into the pipe.

Post-construction monitoring
Post-hoc monitoring is undertaken to determine the success of the scheme in terms of reducing eel entrainment.


KLAWA silver eel bypass systemas

Benefits

- It is anticipated that the KLAWA eel bypass system will significantly increase eel (and potentially fish) passage at Gold Corner Pumping Station thus allowing adult eels to spawn in the Sargasso Sea and complete their life cycle.


Eel entering pipe

Lessons Learnt

- The applicability of the KLAWA system in this case indicates the success to be gained through investigating innovative low cost solutions for fish entrainment.

Project contact: Flood and Coastal Risk Management, Wessex Area, Environment Agency

CASE STUDY

Manage the risk of fish and eels being trapped in pumps & turbines

Project Summary

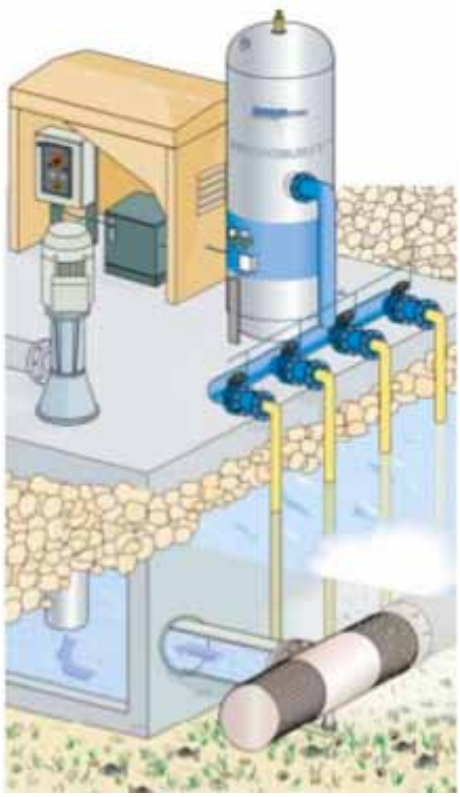
Title: Intake design for a desalination facility at the Riverside Resource Recovery Energy from Waste Plant
Technique: construct water intake with fish and eel screens
Location: River Thames, Belvedere, Kent, England
Technique: Construct water intake with fish and eel screens
Cost of technique: £££
Overall cost of scheme: £££
Benefits: £££
Dates: 2012

Mitigation Measure(s)

Manage the risk of fish and eels being trapped in pumps and turbines
Technique
Construct water intake fish and eel screens

How it was delivered

Delivered by: Riverside Resource Recovery Limited
Partners: Environment Agency; Royal HaskoningDHV; Cory Environmental; Fichtner; Johnson Screens



Protecting eels and other fish species from entrainment by installation of a suitable screen on water intakes
© Johnson Screens copyright and database rights 2013

Background / Issues

In order to provide a sustainable source of water for cooling and other operations at both the existing Energy from Waste plant and a nearby food manufacturer, a desalinisation facility was developed at Belvedere. The facility abstracts 59,000m3 of water a day. Given the large populations of juvenile eels and other estuarine fish in this part of the Thames, the intakes of the facility present a risk to fish populations.

In order to reduce this risk, screens which prevent entrainment (i.e. entering the intake) and / or impingement (i.e. trapping against the intake) of juvenile eels and other fish species, whilst maintaining flow into the intakes, were designed and installed at the plant.

Energy from Waste Facility at Belvedere, with water intakes highlighted
© Royal HaskoningDHV copyright and database rights 2013

CASE STUDY

Step-by-step

1. Options appraisal, looking at a number of possible intake designs that might prevent the entrainment of fish and eels.
2. Identification of a 2mm wedge wire screen with a less than 15 cms-1 through-slot velocity as the best available technology with the best outcome for ecology. This is fitted over the intakes and acts as a cylindrical cover over it. Parameters for the selected screen are detailed below.
3. Detailed design to ensure that the screening arrangements are optimal.

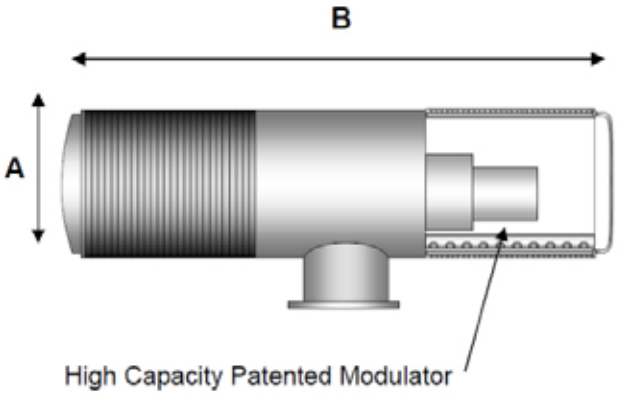
Type of screen	PWWC (T30E manufactured by Johnson Screens)
No of screens	2
Slot width	2mm
Screen diameter	0.770m
Screen length	2.375m
Maximum through slot velocity	10cms^{-1} (9cms^{-1} average)
Depth of water above screen at lowest recorded water level[1]	1.635m at mean low water spring (0.425m at lowest recorded water level)
Distance from screen to water's edge at lowest recorded water level[3]	50m
Depth of water between screen and river bed[3]	1.115m (1.5m to centre of screen)
Angle of screen relative to flow direction[1]	10° to tidal flow direction
Air backwash facility	Yes

Diagram of PWWC Screen

Dimensions

A = Outside diameter (mm)

B = Length (mm)



© Johnson Screens copyright and database rights 2013

Benefits

- State of the art protection for fish populations in the Thames Estuary preventing all fish entrainment and impingement.
- Demonstration of how best practice can be achievable and affordable.

Lessons Learnt

- It is important to engage with developers early, and make it clear what they need to do and how it can be achieved. If they are given all of the facts, they are more likely to be able to achieve the required solution.

Project contact: Fisheries and Biodiversity Team, South East Thames Area, South East Region, Environment Agency

CASE STUDY

Manage the risk of fish and eels being trapped in pumps and turbines

Project Summary

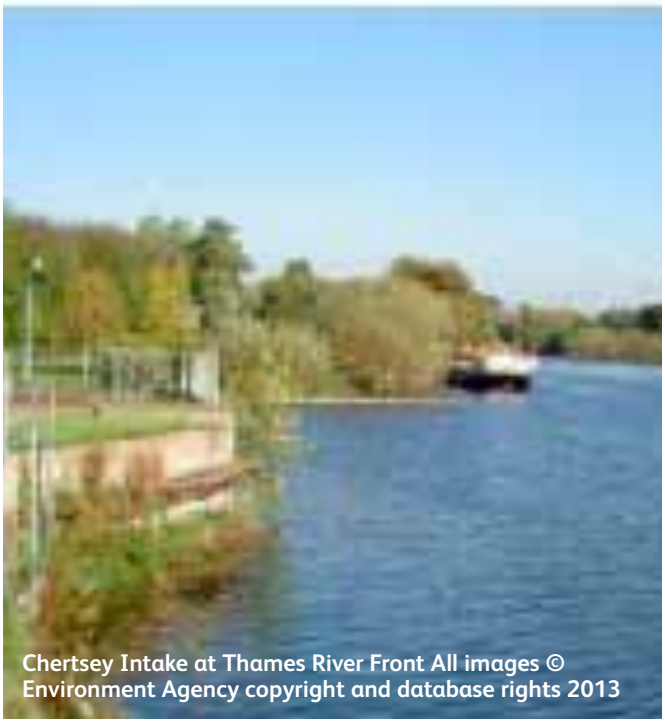
Title: Fish Screening on Lower Thames Potable Water Intakes
Location: Chertsey, England
Technique: Fish screens on abstraction intakes
Cost of technique: ~~£££££~~
Overall cost of scheme: ~~£££££~~
Benefits: ~~£~~£
Dates: 2013 - 2014

Mitigation Measure(s)

Manage the risk of fish and eels being trapped in pumps and turbines

How it was delivered

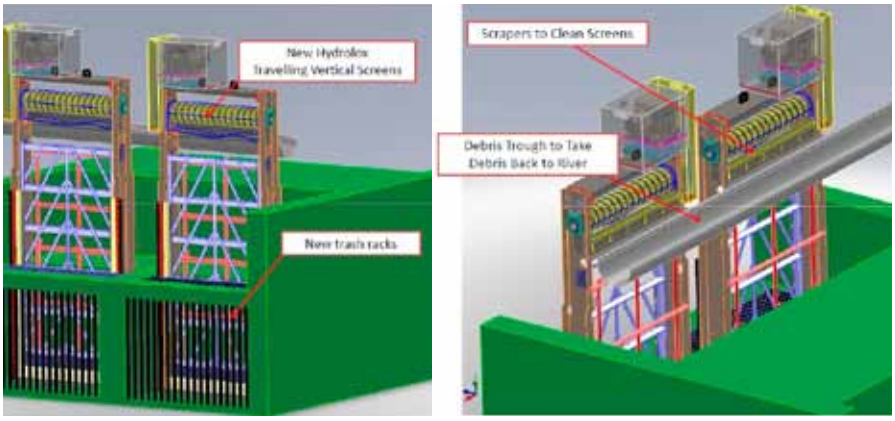
Delivered by: Veolia Water (now Affinity Water); Thames Water
Partners: Environment Agency



Chertsey Intake at Thames River Front All images © Environment Agency copyright and database rights 2013

Background / Issues

A comprehensive study was carried out to look at the scale of entrainment of fish into the major potable water intakes on the River Thames. The study revealed that very few intakes on the river currently have any positive exclusion screening for fish, and that there is a significant level of entrainment. This has a potentially detrimental impact on fish populations in the river.



Scematic view of proposed structural changes at the Chertsey intake

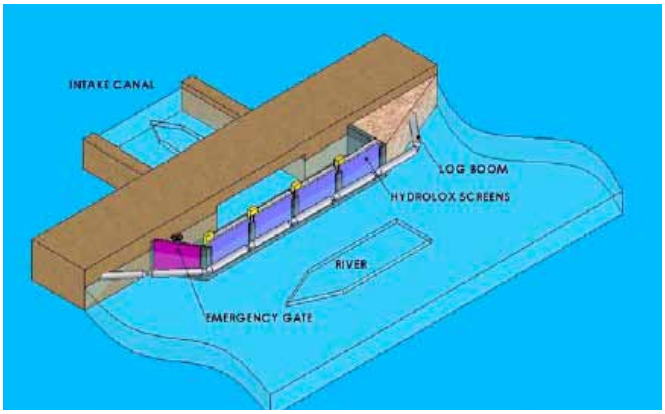
CASE STUDY

Step-by-step

Following recommendations included in the investigation report the preferred solution was to:

- Install Hydrolox self cleaning belt screens to one group of Veolia Water intakes on the Thames at a single location. These were tested, (along with other technologies) as part of the study and proved to be effective and suitable for use at a number of the intakes. The narrow slot width of 1.75 mm effectively excludes all but the very smallest of juvenile fish.
- Install screens at the river's edge, providing sufficient surface area to maintain low levels intake in and around the abstraction pumps which preventing fish from being sucked onto the outside of the screen. In addition, because these are self-cleaning, there is no significant blinding or reduced abstraction head loss

Best practice 3 mm passive wedge wire cylinder screens were installed over the 1.75 mm slots on the first intakes in 2013. Installation will continue until the end of 2014.



Overview of Hydrolox self-cleaning belt screens

Benefits

- Improved fish stocks (in terms of both productivity and diversity) with a wider range of species recorded and greater numbers of each species.
- Protection for downstream migrating adult eel and salmonid smolts.
- Protection for upstream migrating elvers.
- Improved angling opportunities.
- Improved water treatment efficiency as the water pumps do not need to be regularly cleaned out of entrained fish.

Lessons Learnt

- The first screen installed as part of this project included a screen set slightly recessed into the inlet behind the trash racks. Where possible this needs to be avoided and the travelling screen positioned at the river front so that a sweeping flow is maintained across the face of the screen to guide fish safely downstream.
- Subsequent intakes are being designed with the travelling screens positioned flush with the river bank. This can make installation more expensive (in some situations) but can be a very important consideration in reducing the risk of fish entrainment (and for debris handling).

Project contact: Fisheries & Biodiversity Team, South East Thames Area, South East Region, Environment Agency

CASE STUDY

Use green engineering techniques instead of hard bank protection

Project Summary

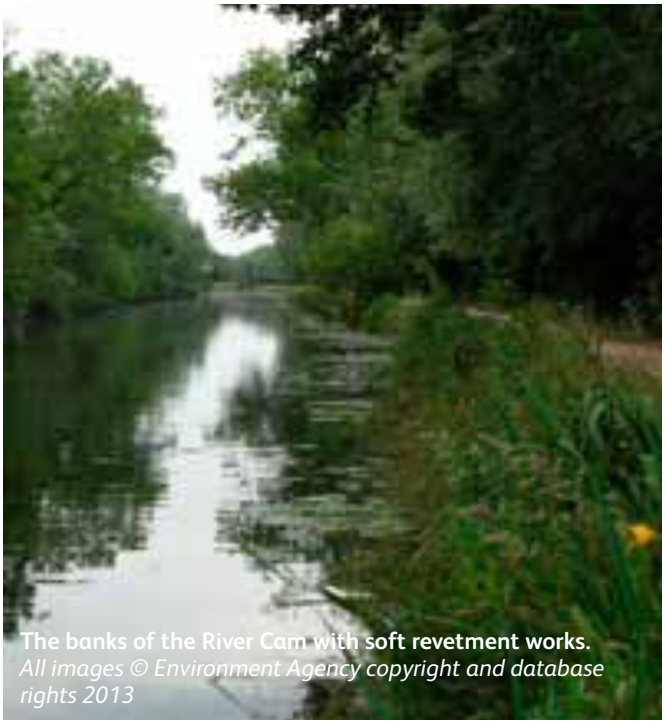
Title: River Cam soft revetment project
Location: Cambridge, Cambridgeshire, England
Technique: Installation of coir roll bank protection
Cost of technique: £££
Overall cost of scheme: £££
Benefits: ££££
Dates: 2009-2011 (initial project)

Mitigation Measure(s)

Use green engineering techniques instead of hard bank protection
Preserve and where possible enhance ecological value of marginal aquatic habitat, banks and riparian zone

How it was delivered

Delivered by: Cam Conservators
Partners: Environment Agency



The banks of the River Cam with soft revetment works.
All images © Environment Agency copyright and database rights 2013

Background / Issues

The River Cam has been managed by the Cam Conservators since 1702. Navigation by rowers, punts and other craft is extremely popular in and around Cambridge leading to high volumes of river traffic, which coupled with high river flows in times of flood has led to erosion of the riverbank. On top of the river bank is a heavily used footpath and cycle route, which also provides angling access.

A lack of marginal habitat in this heavily used water body is contributing to the current moderate ecological potential.

Eroding riverbank with no marginal vegetation, prior to soft revetment works

CASE STUDY

Step-by-step

Feasibility/planning
The Cam Conservators trialled a soft engineering solution to the erosion issue in 2009, which was very successful. They then identified the priority areas that would benefit from this method of protection. A water vole survey was undertaken prior to implementation to ensure there would be no adverse impacts on this protected species. Land Drainage Consent was obtained.

Implementation
The project used coir rolls pre-planted with native species to provide a soft engineering solution to the erosion issue, with the area behind the rolls seeded with native grass mix.

The original line of the bank was identified and marked with survey posts. Geotextile matting was attached to the wooden stakes and coir rolls placed behind. The remaining gap was infilled with soil to re-establish the bank. Native species grass seed was used to further enhance the biodiversity value whilst still preventing erosion of the bank during high flows.

Once established the coir rolls will lead to the development of a marginal vegetation fringe which will provide habitat for fish and invertebrates as well as protecting the toe of the bank from erosion.

(1) Survey line for position of retaining posts for coir rolls. Shows extent of erosion and lack of marginal vegetation; (2) Pile driving posts

Benefits

- Increase in marginal habitat for fish and macro-invertebrates.
- Reduction in diffuse pollution as less silt input from erosion.
- Protection and enhancement of well used public access.
- Aesthetic improvement for all users with native macrophytes.
- Improved habitat for water voles.

Infill behind pre-planted coir rolls

Lessons Learnt

- Trialling the method first meant that there was confidence that the soft engineering option would provide the necessary standard of bank protection in this area.

Project contact: Fisheries and Biodiversity team, Anglian Region, Environment Agency

CASE STUDY

Preserve and improve water's edge and bank side habitats

Project Summary

Title: Good and bad back gardens
Location: Applied throughout England by the Environment Agency via the Operations Maintenance Standards
Technique: Consideration of the river for residential developments
Cost of technique: £
Cost of overall scheme: N/A
Benefits: £££
Dates: works should be timed to minimise environmental impact (e.g. bird nesting season)

Mitigation Measure(s)

Preserve and improve water's edge and bank side habitats

How it was delivered

Delivered by: Riparian owners
Partners: Partners relevant to watercourse in question

(1) Poorly laid out gardens
All images © Environment Agency copyright and database rights 2013

(2) Well laid out gardens

CASE STUDY

Background / Issues & Step-by-step

Riparian land owners can design their gardens to reduce the impacts of flooding to their gardens and communities whilst improving the river corridor for wildlife.

Poorly laid out gardens (See 1) can have the following effects:

- In heavy rainfall, fences across streams can block the rising water causing levels to increase upstream. They also trap any debris and if the fence breaks, a lot of water can suddenly be released.
- A smooth channel bed and banks will increase the speed of the flowing water. This fast moving water can be deceptively dangerous but may also increase the flooding downstream.
- Decking should not be in the stream. Supporting posts near the stream can easily trap debris and block the stream, flooding your garden.
- Fencing built alongside the stream stops excess water spreading and causes the water level to rise. Fences can be pulled down by flood water and block the stream.
- Drains flowing straight into the stream add to the flood waters.
- Waste stored near the stream can be washed away during a flood. This can end up in neighbouring gardens or get blocked on bridges causing flooding and will frequently cause flooding when trapped on bridges or bends.

Well laid out gardens (See 2) can have the following outcomes:

- Provides habitat for plants and animals.
- Placing a fence at the top of a bank allows the stream to rise and fall without causing damage.
- A bridge that allows a larger volume of flood water underneath it will reduce the risk of blockages.
- Removing fences that cross the stream means the water level can rise and fall without causing blockages. Security can be achieved by fencing gardens or building fences at the main bridges.
- Moving decking further back from the channel means that people can enjoy the views of their stream and will not trap debris.

Benefits & Lessons Learnt

- Preserves riparian habitat.
- Reduces bed and bank erosion.
- Helps manage sediment by trapping runoff and resucing its input to a watercourse.
- Can improve water quality by intercepting point source pollution.

Project contact: Environment Agency, Partnerships & Strategic Overview Teams.

CASE STUDY

Preserve and improve water's edge and bankside habitats

Project Summary

Title: Wandsworth Riverside Quarter – Intertidal terraces
Location: London Borough of Wandsworth, England
Technique: Construction of intertidal terraces
Cost of technique: £££
Overall cost of scheme: ££££
Benefits: ££
Dates: 2009

Mitigation Measure(s)

Preserve and improve water's edge and bank side habitats
Retain and improve existing water's edge and bankside habitats in modified watercourses
Realign flood defences to increase coastal and intertidal habitat
Restore aquatic habitats in modified watercourses
Use green engineering techniques instead of hard bank protection

How it was delivered

Delivered by: Frasers Property
Partners: London Borough of Wandsworth, Environment Agency, J.T Mackley & Co Ltd, Salix Wetland, Beckett Rankine, Capita Lovejoy, Biodiversity By Design.

Tidal terraces after completion of works
© Capita Lovejoy copyright and database rights 2013

Artist's impression of the completed intertidal terraces © Capita Lovejoy copyright and database rights 2013

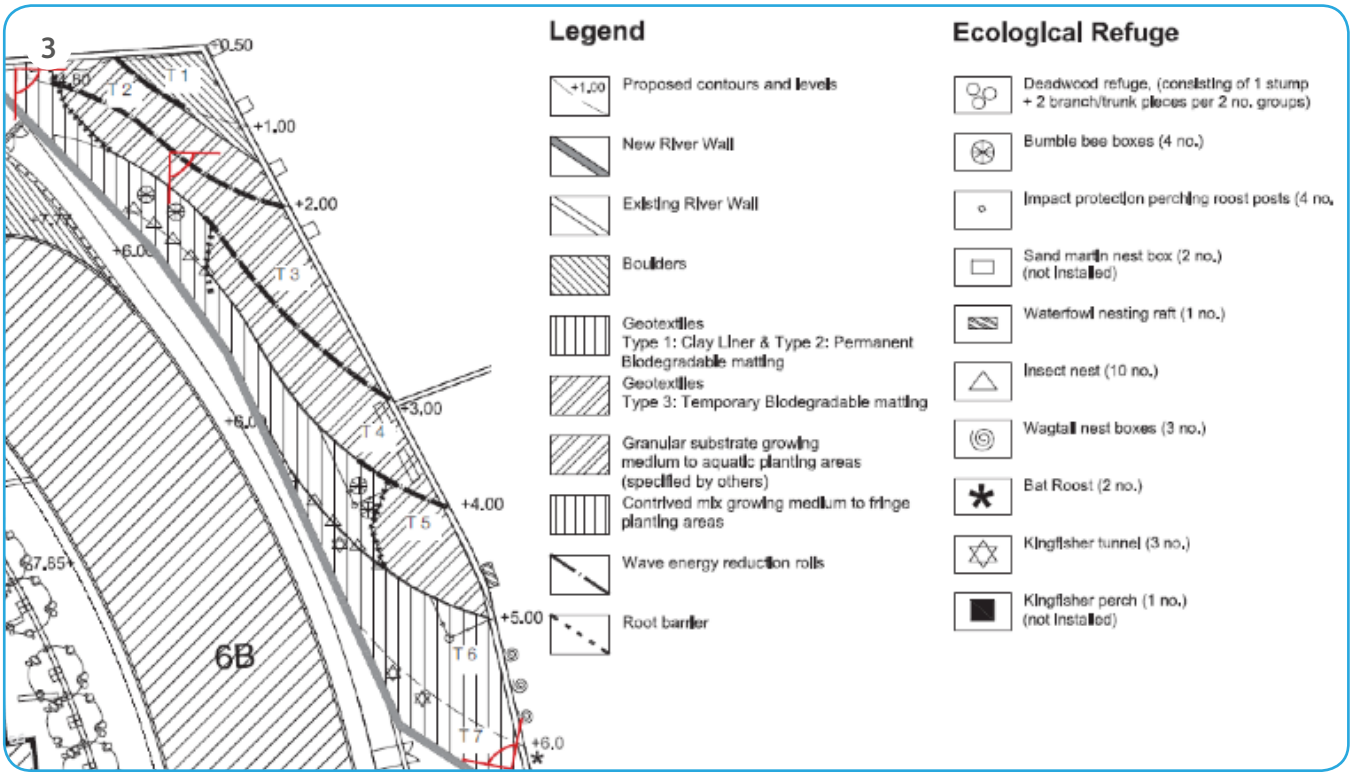
Background / Issues

The area of the London Borough Wandsworth on the west bank of the confluence of the River Wandle and the tidal River Thames was previously a 4 hectare Shell Oil terminal, and subsequently a brownfield industrial site. The area had been protected over time from tidal flooding through a combination of concrete quays and timber and metal tidal defences. The history of the site led to issues of contaminated land and a disconnection of the area from the rivers it borders.

The former industrial site was redeveloped through a number of phased developments, which together comprised a complex of residential and commercial properties on the Thames waterfront under the name 'Wandsworth Riverside Quarter'.

The redevelopment was identified by the Environment Agency as having the potential to provide an improved riverside environment, and an opportunity to reconnect the rivers with the people now using the previously-derelict site. The suggested solution was to replace the existing tidal defences with a series of tidal terraces, creating a new intertidal zone and facilitating a range of associated transitional habitats.

(1) Tidal defences prior to works © Unicomarine copyright and database rights 2013;
(2) Tidal defences prior to works © Unicomarine copyright and database rights 2013;
(3) Artists impression of the completed tidal terraces © Capita Lovejoy copyright and database rights 2013



CASE STUDY

Step-by-step

Formation works (January 2009)

- Preparation of site (coffer dams, excavation and soil removal, bank re-profiling, and set up site compound).

Hard landscape works (February 2009):

- Laying contamination textile to reduce risk of contaminated soils entering the Thames during the works.
- Constructing timber terraces.
- Placing backfill materials.
- Laying root barrier.
- Laying silt accretion geotextiles to encourage silt to accumulate between the terraces.
- Fixing coir rolls at channel margins.
- Installing dead wood habitat staked at the margins between the slope and the channel to encourage more diverse plant establishment and flow conditions.

Monitoring period (March-May 2009)

- After installation silt was allowed to naturally accrete in the lower terraces to allow for the growth of tidal flora. Silt accumulation was monitored during this period and a significant increase in sediment accretion between the terraces was recorded.

Rock roll installation (May 2009)

- Rock rolls (wave energy reduction structures installed by long reach plant) installed along with coir matting to encourage plant growth.

Planting (June 2009)

- Intertidal vegetation was planted and dead wood installed along the terraces.

(1) Construction of timber terraces;
(2) Backfilling behind upper terraces;
(3) Installation of rock rolls and coir matting;
(4) Placement of gravels and planting
© Capita Lovejoy copyright and database rights 2013

CASE STUDY

Benefits

- Creation of a range of intertidal habitats in an otherwise biodiversity-poor area of the constrained Rivers Wandle and Thames.
- Improved access to the River Thames and River Wandle, bringing residents and members of the public closer the watercourse.
- Provides access to the watercourse for local wildlife.
- The site links in within green roofs and other green infrastructure designed as part of the redevelopment master plan creating an extended green network.
- The site acts as a showcase to demonstrate what can be achieved on tidal rivers.

Tidal terraces after completion of works
© Capita Lovejoy copyright and database rights 2013

Lessons Learnt

- Proactive discussion between the Environment Agency and the developers led to beneficial outcomes for both parties, and the creation of a multifunctional, more natural riverside environment.
- Use of coir rolls to stabilise the sediment accretion and bank reprofiling was insufficient and required rock roll installation.
- Success of sediment accretion between the terraces demonstrates good geomorphological understanding of processes and modelling.

Project contact: Fisheries and Biodiversity team, South Thames Area, Environment Agency

CASE STUDY

Restoring river banks using green engineering

Project Summary

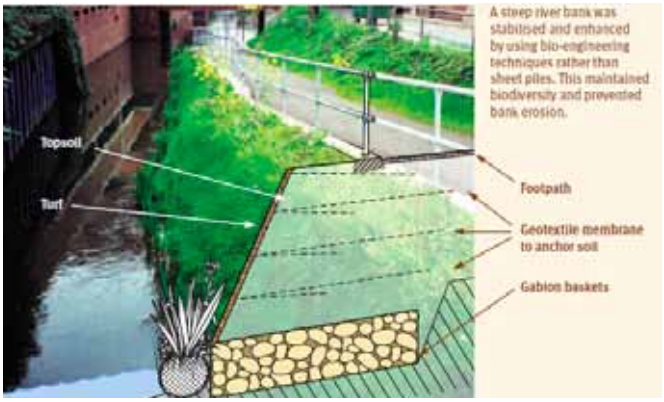
Title: Maidenhead Ditch river bank restoration
Location: Green Lane footpath, Maidenhead Ditch, Maidenhead, Berkshire, England
Technique: Installation of coir rolls
Cost of technique: £
Overall cost: ££
Benefits: ££
Dates: circa 2004

Mitigation Measure(s)

Use green engineering techniques instead of hard bank protection

How it was delivered

Delivered by: Maidenhead Council (land owner)
Partners: Maidenhead Council, MMG Engineering (contractor) and Environment Agency



Cross-section showing techniques used to restore bank profile and protect from erosion at Maidenhead ditch.
All images © Environment Agency copyright and database rights 2013

Background / Issues & Step-by-step

The local council wanted to extend a footpath alongside the Maidenhead Ditch. As part of their application for Flood Defence Consent a green engineering solution was agreed to be a better alternative to sheet piling or gabion baskets. The contractor (MMG) developed an engineering solution which withstands the high flows in the watercourse whilst providing amenity and biodiversity value.

Benefits & Lessons Learnt

- Greater wildlife benefit.
- Natural river bank restored.
- Re-graded banks designed to withstand erosion and under-cutting.
- A higher quality environment created along the footpath for people.
- A good example of how green engineering can achieve the objectives set out in RBMPs whilst providing flood and erosion protection.

Project contact: Asset Performance Team, South East Region, Environment Agency

CASE STUDY

Remove or modify structures to increase access for fish and eel

Project Summary

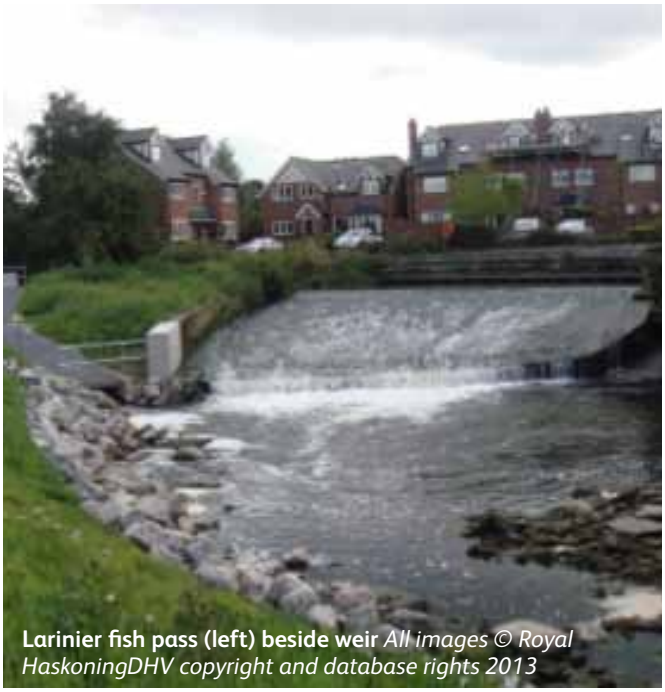
Title: Heatley Fish Weir Fish Pass
Technique: Larinier fish pass in bypass channel
Location: River Bollin, Cheshire, England
Cost of technique: ~~£££~~
Overall cost of scheme: ~~£££~~
Benefits: ~~£££~~
Dates: 2008-2009

Mitigation Measure(s)

Remove or modify structures to increase access for fish and eel.

How it was delivered

Delivered by: Environment Agency
Partners: Royal HaskoningDHV



Larinier fish pass (left) beside weir *All images © Royal HaskoningDHV copyright and database rights 2013*

Background / Issues

The River Mersey, downstream of the River Bollin tributary, was once a prolific fishery. However, as a consequence of the Industrial Revolution and increased urbanisation, water quality declined and by the early 1980s fish stocks were virtually extinct. Since the mid-1990s, improvements in water quality management have resulted in an improving fishery. Migratory fish such as salmonids are now returning to the lower reaches of the Mersey catchment and trying to migrate to the headwaters to spawn, and are believed to be migrating up into the Bollin.

In 2003, an Environment Agency study identified 12 weirs that caused a significant barrier to fish movement under all but the most extreme flow conditions, including the Heatley weir. As such, it was proposed that a fish pass should be constructed on this structure.

A 1.8 m wide Larinier Superactive baffle fish pass was constructed to enable fish passage over Heatley Weir, requiring two flights with an intermediate resting pool. The fish pass was located immediately below the weir on the right bank, and the fish pass routed across the flood plain, as shown above. The length of each flight is approximately 8.8 m at a gradient of 15 %, with retaining walls high enough to prevent the ingress of flood waters.
Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

CASE STUDY

Step-by-step

The Larinier Superactive baffle fish pass consists of a reinforced concrete U-channel with resting pools between and Glass Reinforced Plastic (GRP) covers to allow access by foot across the channels. An earth embankment will runs parallel to the new fish pass between the pre-existing embankment sections.

Construction took place in 2009 and involved the following steps:

Site preparation

- Temporary works were put in place to protect the work area from inundation from the River Bollin during construction.

Construction works

- Construction involved excavation of the pass route.
- Installation of piles, steel reinforcement and poured concrete to create fish pass channel.
- Fixing of baffles within the fish pass channel.
- Installation of penstock and safety grating to finish pass.
- Landscape area to integrate the pass with the floodplain.

Site de-mobilisation

- Removal of temporary works.

(1) Concrete U-channel of the fish pass during construction; (2) U-channel once completed

Benefits

- An Environment Agency study (Salmon behaviour in the Mersey Catchment) indicated that salmon are able to successfully locate and use the Heatley fish pass. Salmon are now successfully spawning upstream in the River Bollin.

Looking downstream from the completed fish pass

Lessons Learnt

- The ground conditions were particularly challenging for the construction team. As such the piling required for the project needed to be modified for this individual scheme to complete the structure.
- 'Off the shelf' designs for fish passes are not necessarily best applicable where further investigation (in this instance into ground conditions) requiring the need for bespoke design solutions.

Project contact: Fisheries & Biodiversity, Midlands Region, Environment Agency

CASE STUDY

Remove or modify structures to increase access for fish and eel

Project Summary

Title: Sharpsbridge Fish Passage Easement Project, Middle Ouse Restoration of Physical Habitats (MORPH)
Location: Uckfield, East Sussex, England
Technique: Weir modification to rock ramp
Cost of technique: ~~£~~~~£~~~~£~~~~£~~
Overall cost of scheme: ~~£~~~~£~~~~£~~~~£~~
Benefits: ~~£~~~~£~~~~£~~
Dates: 2009-2012

Mitigation Measure(s)

Remove or modify structures to increase access for fish and eel
Remove structures that are no longer needed

How it was delivered

Delivered by: Environment Agency
Partners: Ouse and Adur Rivers Trust, Royal HaskoningDHV, C A Blackwell

© Royal HaskoningDHV copyright and database rights 2013

Background / Issues

Sharpsbridge is a road bridge, with two culverts that carry flow under the road and an island in the channel downstream. The footings of the road bridge are formed of a solid concrete slab which acts as a weir, backing up flow. The height of the drop between the concrete slab and the water level was causing a barrier to fish passage. Previous work was undertaken to place rubble rock at the downstream extent of the concrete slab to enable fish migration; however, this began to function as an additional barrier. The aim of this project was to improve fish passage in one of the culverts, to allow free movement of fish upstream. In order to eliminate the barrier to fish passage, the water levels in the downstream weir pool were raised by the addition of a rock ramp structure.

River prior to scheme. Yellow arrow indicates weir in the western channel.
OART © copyright and database rights 2013

CASE STUDY

Step-by-step

Preparation

- The western channel was blocked using temporary dams and pumps to move water through the eastern side of the bridge. During high water flows, the dams were periodically removed to prevent flooding.

Works

- The existing rubble rock weir was removed.
- A 4.5 m wide rock ramp was constructed in-situ, using granular fill and geotextile at the base, concrete at the upstream end, and rock armour forming the surface of the ramp.
- Kentish ragstone (a hard limestone) was used for the main perturbation boulders because of its durability.
- Rocks were positioned approximately equidistant, with increasing height of rocks upstream, to ensure a smooth gradient of flow over the former head drop.

Post-construction works

- Works to rectify the site compound were undertaken. Signs were erected to divert canoeists around the eastern channel.

Rock ramp during construction
© Royal HaskoningDHV copyright and database rights 2013

Benefits

- During low flows, the flow velocities between the perturbation boulders and the water depth are expected to be good for fish migration. At high flows, the flow will be much slower flowing over the high-flow channel, and sufficiently deep to allow fish passage.

Rock ramp after completion of works
© Royal HaskoningDHV copyright and database rights 2013

Lessons Learnt

- The project team was able to draw upon experience from Belgium and The Netherlands to help determine the best layout of the large boulders on the ramp.
- Carbon calculators were used, and were able to highlight the transport of materials as a high carbon cost, leading to the successful sourcing of local materials to construct the ramp.

Project contact: Fisheries & Biodiversity team, Worthing, Environment Agency

CASE STUDY

Remove or modify structures to increase access for fish and eel

Project Summary

Title: Stoke-on-Trent Fish Passage Improvements
Location: Stoke-on-Trent, England
Technique: Low-cost baffles on weir apron
Cost of technique: ££
Overall cost of scheme: ££
Benefits: ££
Dates: 2011-2013

Mitigation Measure(s)

Remove or modify structures to increase access for fish and eels
Change the way structures are operated to reduce barriers to flow, sediment transport and fish/eel migration

How it was delivered

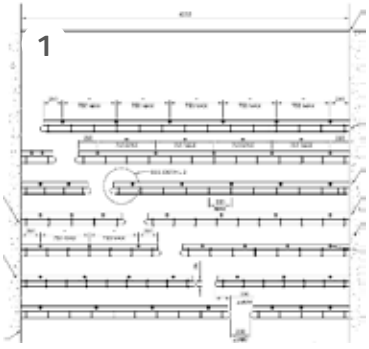
Delivered by: Environment Agency
Partners: Royal HaskoningDHV; Fishtek

All images © Environment Agency copyright and database rights 2013

Background / Issues

Stoke Weir is a 4 m wide crump weir used to historically gauge river flows for flood warning purposes. The structure was a major barrier to fish passage during most flow conditions, with a drop in water levels of approximately 1.5 m over the structure. Because of the on-going gauging function of the weir, any improvements to fish passage had to avoid adversely affecting the accuracy of the gauging equipment.

In order to improve fish passage over the rump weir without affecting its flow gauging function, a series of low cost plastic baffles were bolted onto the downstream face of the existing weir, creating a minor impoundment over the apron of the weir that retard the flow of water, increasing the water depth and reducing the velocity, therefore, improving fish passage.



(1) Plan of baffles on downstream weir face (crest of weir at top of diagram);
(2) Baffles prior to construction

CASE STUDY

Step-by-step

Site preparation

- Fish strainers installed upstream of weir to prevent fish from accessing the structure during construction; silt boom placed downstream of weir to minimise the risk of concrete waste being entrained in the river.
- Consultation between Environment Agency hydrometry staff and fisheries staff to agree what compromise could be met regarding water levels for differing functions (fish & gauging).

Installation

- Weir brushed to remove vegetation.
- Hole drilled into weir and individual 200 mm tall, 75 mm thick baffles affixed to the weir face, placed approximately 100 mm downstream from one another. Process repeated for all baffles, working up the weir face.

Post construction

- Pumping equipment and flow barrier removed.
- Monitoring of water levels over the weir. Migratory fish observed passing upstream and impacts on gauging accuracy were minimal following conversion rate calculations (to allow comparison between historical data and new data).

Clockwise from top left:
(1) Weir prior to baffle installation;
(2) Site during construction;
(3) Low cost baffles prior to installation;
(4) Upstream debris collectors

Benefits

- The weir allows passage for migratory fish (but not for all coarse fish during some flows).
- Approximately 1 km of river open upstream of the structure for additional fish passage and spawning.
- Alone, this scheme has limited effect on water body status, but is part of a catchment-scale fish passage project that has improved the water body for migratory fish.


New flow regime across crump weir after baffles installation

Lessons Learnt

- The design of the baffle fish pass was a trade-off between improving fish passage for as wide a range of species during as wide a range of flows as possible, and minimising the reduction in gauging accuracy. In the case of the low cost baffles used here, the closer the top baffle is to the weir crest the greater the improvements in fish passage and the greater the impact on flow gauging. A compromise solution was therefore developed that satisfied the structure's hydrometry requirements and those of migratory fish, accompanied with a monitoring programme to determine the success of this approach in improving fish passage whilst not eroding gauging accuracy.

Project contact: Flood and Coastal Risk Management, Wessex Area, Environment Agency

CASE STUDY

Use green engineering techniques instead of hard bank protection

Project Summary

Title: Coir roll revetment at Bedlam Bridge
Location: Bedlam Bridge, March, Cambridgeshire, England
Technique: Coir roll revetment installation; bank re-profiling
Cost of technique: ££
Overall cost of scheme: ££
Benefits: £££
Dates: January 2009

Mitigation Measure(s)

Use green engineering techniques instead of hard bank protection
Retain and improve existing water's edge and bankside habitats in modified watercourses
Preserve and improve water's edge and bank side habitats

How it was delivered

Delivered by: Middle Level Commissioners
Partners: Biffaward, funding organisation for the Middle Level Water Vole Support Project.

An eroded and undercut bank exposing bare earth at the water margin was restored using coir rolls pre-established with native water plants to create a naturally regenerating revetment and to restore water vole habitat.

© Environment Agency copyright and database rights 2013

Undercutting erosion caused by wave erosion and discharge from adjacent pumping station outfall

September 2009, seven months after installation, lesser pond sedge and purple loosestrife have developed strongly.

© Environment Agency copyright and database rights 2013

CASE STUDY

Background / Issues

The Sixrteen Foot Drain is a low energy system with a small underwater marginal shelf (0.5 to 1 m deep, 0.5 to 1.5 m wide) quickly shelving to deeper water (circa 2 to 3 m). The substrate is predominately comprised of clay or clay/silt, although there are riverine gravels locally. The banks are predominately local topsoil and excavated clay silt with a clay core.

The main issues at the site include erosion from an adjacent pumping station outfall created undercutting of the bank at the waterline and additional wave erosion from boat wash, in places up to 1m back from the original margin. The erosion also prevented water voles from establishing their burrows and entry points to the channel due to the undercut and the absence of any marginal shelves. In addition, the undercutting erosion led to bank slippages.

The traditional repair method would have used hard revetment materials such as steel piles or wooden posts and toe boards reinforced with stone. Instead, as part of the Middle Levels Water Vole Support Project, a method more sympathetic to the overall ecology of the channel and the habitat requirements of water voles was proposed at the site.

Aerial view of approximate area of works
© Mid Level IDB copyright and database rights 2013

Step-by-step

The coir roll revetment project at Bedlam Bridge involved the following key elements:

- The undercut bank toe was pulled back approximately 1.5 m to create a ledge for the coir rolls to be laid on just above winter water level, which is about 0.25 m below summer water level (1 and 2). The rolls are half submerged during the summer growing period;
- The coir rolls were initially positioned on the ledge and secured with timber stakes approximately 1.5 m in length pushed in on either side with an excavator bucket. (3) The second inner row of posts were not required at future sites as it was found that they could be pinned against the bank with a single row of posts on the drain side. Future work was adapted to follow this second methodology;
- The coir rolls were held in a wide mesh and pre-established with a mix of native emergent plants (4).

1

2

3

4

© Environment Agency copyright and database rights 2013

Benefits

- Bank erosion eliminated.
- Natural protective revetment established.
- Water vole habitat re-created.
- Pollen-rich plants attractive to insects established, especially purple loosestrife.
- Aesthetically attractive riparian margin created.
- Emergent vegetation contributes to improvement in water quality via nutrient stripping.

Lessons Learnt

- Pre-planted coir rolls are a viable alternative to hard revetment methods if erosion areas are addressed early. A total of 1,267 m of coir rolls have been installed at 21 locations in the Middle Level system between 2009 and 2013 and the method has become an established 'stitch in time' method for Operations Engineers.
- Costs are less than hard revetment materials, especially when longer sections of bank protection are required.
- Pre-established coir rolls provide an instant 'beachhead' that allows a naturally regenerating vegetation revetment to become established.
- Fresh willow faggots should not be used as a base for the coir rolls, a method trialled at another site. If they get their tips above water the willows set root and have to be controlled to prevent trees becoming established and presenting future management problems.
- Public appreciation of the varied bank edge vegetation is very positive, especially when established in villages and amenity areas.

April 2009, three months after installation, yellow flag is the first plant to develop. Summer water level is now nearly covering the coir rolls.

August 2011, new vegetation, branched bur-reed, has become established in front of the coir rolls ensuring the revetment process are naturally regenerating.

© Environment Agency copyright and database rights 2013

Project contact: Mid-Level Commissioners IDB

CASE STUDY

Reduce erosion caused by land drainage

Project Summary

Title: Outfalls to Brook Dyke Wath
Location: Wath Manvers, South Yorkshire, England
Technique: Structural modifications to outfall
Cost of technique: £££
Overall cost of scheme: £££
Benefits: ££
Dates: 2007

Mitigation Measure(s)

Reduce erosion caused by land drainage

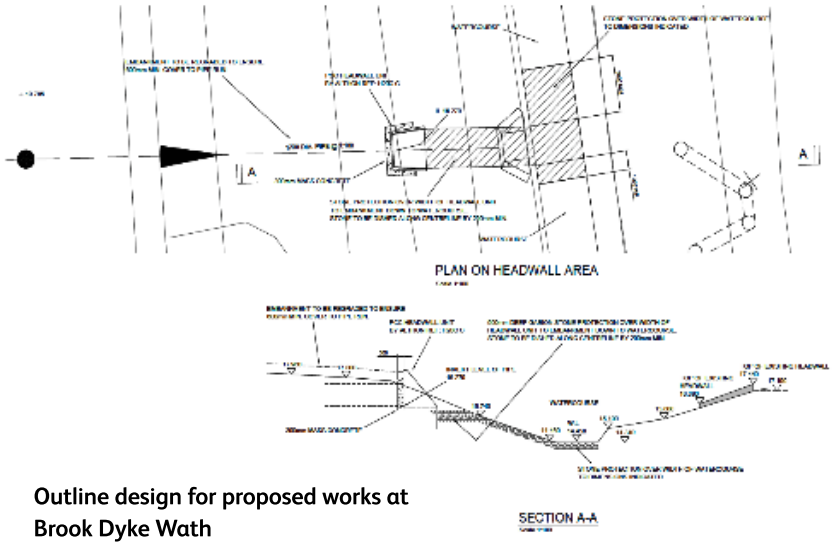
How it was delivered

Delivered by: Next
Partners: Danvm Drainage Commissioners (DDC) as Land Drainage Authority

All images © Environment Agency copyright and database rights 2013

Background / Issues

Brook Dyke is a heavily altered watercourse serving a rural catchment upstream of Wath, South Yorkshire, and a significant part of the town. The watercourse also drains surface water from the Manvers development. This development, which was promoted by Rotherham Metropolitan Borough Council, included the regeneration of a former colliery, gas ovens and railway sidings. Runoff is drained out of the Manvers development and goes into Brook Dyke through an outfall. The watercourse is particularly deep in this area and any erosion of the bed and banks would result in instability and increase the probability of bank slips. DDC was required to reduce the risk of erosion at the outfall exit point to a minimum while not reducing the conveyance capacity of the Manvers watercourse and ensuring access would be retained for maintenance.



Outline design for proposed works at Brook Dyke Wath

CASE STUDY

Step-by-step

To achieve the desired standard of erosion protection at the outfall, works have included:

- Regrading of the bank where the outfall is located.
- Installation of a new headwall unit at the outfall.
- The level of outfall pipe has been decreased to reduce the drop between the outfall and apron.
- Over-pumping of flows to facilitate construction.
- Installation of stone gabions to increase bank protection between outfall and water body.
- Reinforcement of river bed for an extent of approximately 7 m downstream using stone gabions.

1) View of outfall before works

2) Reinforcement with stone gabions

Benefits

- Removal of the risk of scour of the bed and banks of the watercourse due to high velocity flow from the outfall.
- Removal of the risk of bed material resulting from scour being deposited downstream, reducing conveyance capacity and disturbing ecology of the watercourse bed.
- Minimal environmental impacts for engineering constraint works.

Lessons Learnt

- Ensure that proposals for scour protection are included in the initial design of a new development and drainage scheme.
- Ensure that adequate measures are taken to allow flood flows to pass during construction.

Project contact: Shire Group Internal Drainage Board

CASE STUDY

Reduce erosion caused by land drainage

Project Summary

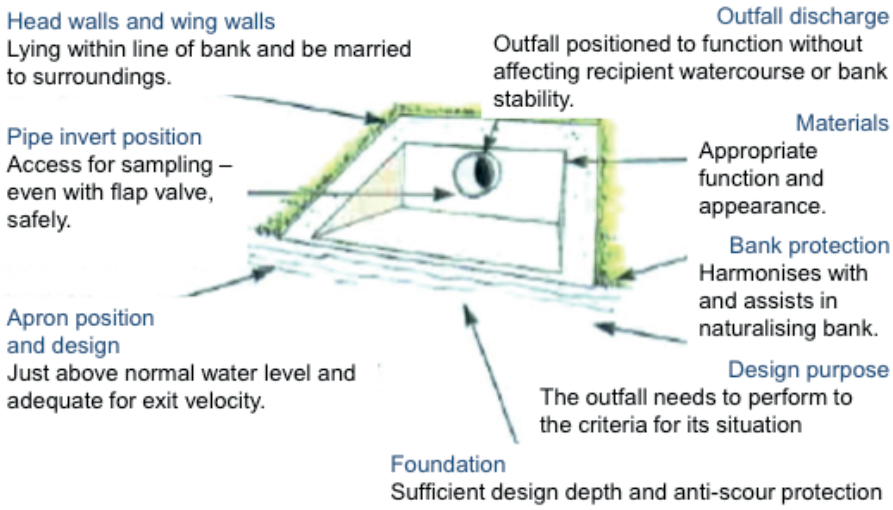
Title: Greener surface water outfalls
Location: Anywhere
Technique: Greener surface water outfalls
Cost of technique: £
Overall cost of scheme: £
Benefits: ££
Dates: Any

Mitigation Measure(s)

Reduce erosion caused by land drainage

How it was delivered

Delivered by: Riparian owners
Partners: Partners relevant to watercourse in question



Outline of principles for outfall design to minimise environmental and aesthetic impact All images © Environment Agency copyright and database rights 2013

Background / Issues & Step-by-step

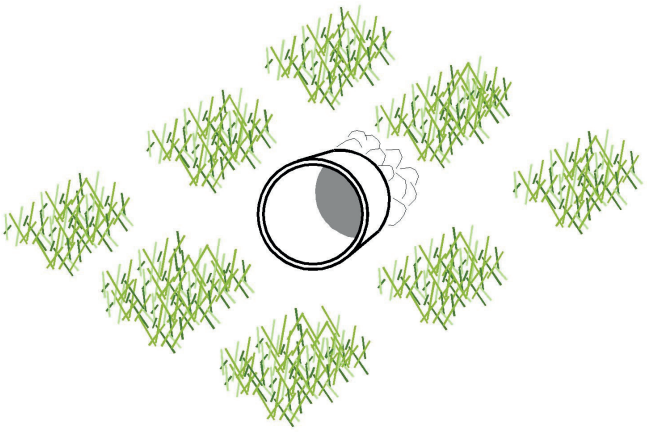
When not designed sensitively, surface water outfall pipes which discharge into watercourses can:

- Cause bed and bank erosion.
- Disrupt the connectivity of a river corridor.
- Destroy river bank habitat.
- Discharge pollutants.

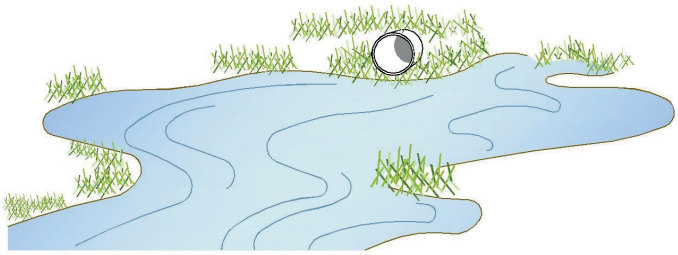
It is possible to design outfalls so that they blend-in with the local environment and minimise their impact on the water environment. Outfall design should follow the principles set out (see image 1). However, the materials used in outfall design can be altered to suit the site and provide greater amenity and habitat benefit. Images 2 and 3 are examples where an outfall has been encapsulated within a river bank using geotextiles and minimising its environmental and aesthetic impact.

Where flow control structures are causing bed or bank erosion, erosion control mechanisms can be retrofitted. Outfalls can include a geotextile mattress to dissipate flow and prevent erosion and scour. However, any erosion control methods should start with the principle of using natural materials if possible. Reed beds can be planted next to outfalls to control erosion, create habitat and improve water quality. The rate of flow from the outfall should as far as is possible be controlled to the rate of drainage from an undeveloped greenfield site in order to minimise erosion locally and reduce flood risk.

CASE STUDY



2) Encapsulating an outfall within watercourse bank using geotextiles



3) A naturally designed outfall with minimal impact on the watercourse

Benefits & Lessons Learnt

- Preserves riparian habitat.
- Reduces bed and bank erosion.
- Helps manage sediment by trapping runoff and resucing its input to a watercourse.
- Can improve water quality by intercepting point source pollution.

Project contact: Partnerships & Strategic Overview Teams, Environment Agency,

CASE STUDY

Allow the river to flood its floodplain

Project Summary

Title: Long Eau (Great Eau) Floodplain Reconnection
Technique: Bank reprofiling and flood bank set back
Location: Manby and Little Carlton (Long Eau) and Withern (Great Eau), Linconshire, England
Cost of technique: £££
Overall cost of scheme: £££
Benefits: ££££
Dates: May – June 1995

Mitigation Measure(s)

Allow the river to flood its floodplain
Increase of in-channel morphological diversity

How it was delivered

Delivered through: Environment Agency
Partners: Gainsborough Internal Drainage Board

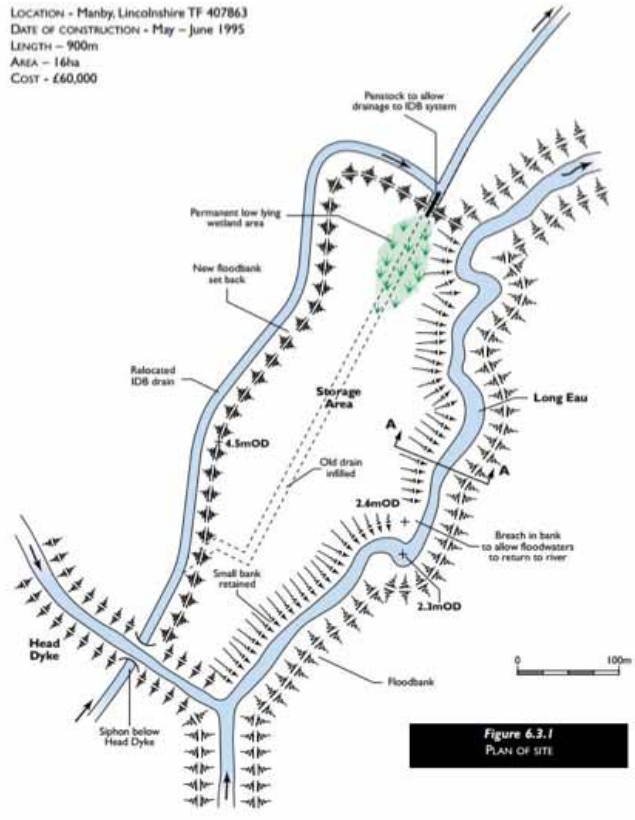
Bog Woodland within project area. *All images © Environment Agency copyright and database rights 2013*

Background / Issues

The Long Eau, a tributary of the Great Eau, and the Great Eau (total catchment area of 112km^2) have both become largely disconnected from their floodplains due to embanking and channelisation of the water courses to protect adjacent agricultural land from flooding.

The steeply sloped flood banks along with dredging and removal of bankside vegetation as part of the maintenance regime further contributed to the diminishing quality of in-channel habitats, the structure and substrate of the river bed and the overall morphological condition of these water bodies.

A restoration scheme was implemented at three sites (Manby and Little Carlton on the Long Eau, and Withern on the Great Eau) with the aim of restoring floodplain connectivity while improving flood protection standards through a process of relocating flood banks. In addition, the scheme aimed to combine floodplain restoration with river channel enhancement and marginal habitat creation.



Plan of scheme at Manby

CASE STUDY

Step-by-step

The restoration of connectivity to 16ha of floodplain included:

1) At each site the flood bank was removed and reprofiled to encourage overtopping of the banks, and a flood storage area was created on adjacent land.
2) Marginal berms were constructed at the base of each reprofiled bank (approximately 1m in width) to aid marginal vegetation establishment.
3) In the Long Eau at Manby, the left flood bank was lowered to just above ground level. The floodplain in the adjacent field was widened and flattened to act as an overspill area (1 in 10 slope). Material generated from embankment removal was used to infill the Internal Drainage Board drain which ran through the flood storage area at Manby.
4) Relocation of the drain behind the new embankment at Manby to maintain land drainage.
5) Creation of new embankments to a height of 2.5-2.7m (slopes were 3:1 at all sites). In addition, ledges and berms were created along the channel to increased habitat potential.

(1) Relocation of IDB drain and flood bank set-back;
(2) Removal of flood bank and marginal berm creation.

Benefits

- Creation of valuable wetland habitat. Waterfowl and waders numbers have increased on the floodplain. Also, lapwing and redshank have bred on the Manby site. Flocks of over 60 redshank and snipe, curlew, ruff, common and green sandpiper are amongst the birds that use the washlands in the winter. Also, lapwing and redshank have bred on the Manby site.
- Increase in flood protection as water spills onto the reconnected floodplain when water levels in the channel reach 2.6m or above. Below this level, 75 % of the floodplain will retain water up to 0.5m for up to 4 months.
- Increase of 30 years to the standard of protection over a 3km stretch of the Long Eau at Little Carlton and at Manby.

Floodplain with permanent wetland area

Lessons Learnt

- Financial mitigation was instrumental in securing landowner support and ensuring project success. This was achieved through the successful entry of landowners into the Countryside Stewardship scheme.
- Consultation with the local Internal Drainage Board enabled local stakeholders to gain a greater understanding of the need for the works, and the potential ecological benefits associated with the works.
- Monitoring of the site has detected increased numbers of wildfowl using the catchment area.

Project contact: Flood & Coastal Risk Management, Anglian Region, Environment Agency

CASE STUDY

Allow the river to flood its floodplain

Project Summary

Title: River Lea – Olympic Park
Location: Stratford, East London, England
Technique: Bank reprofiling and flood storage area
Cost of technique: ~~£~~£~~£~~£
Overall cost of scheme: ~~£~~£~~£~~£~~£~~
Benefits: ~~£~~£~~£~~£~~£~~
Dates: 2009 - 2011

Mitigation Measure(s)

Allow the river to flood its floodplain
Retain and improve existing water's edge and bankside habitats in modified watercourses

How it was delivered

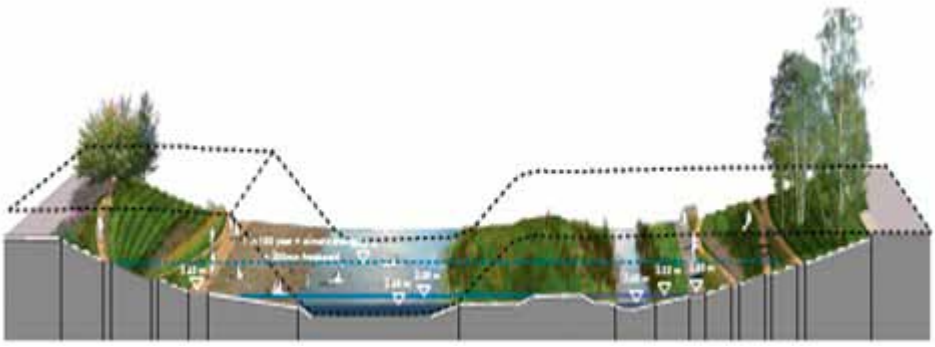
Delivered by: Olympic Delivery Authority
Partners: Environment Agency; Natural England; Canals & Rivers Trust

The River Lea with reprofiled banks, through the Olympic Park

All images © Environment Agency copyright and database rights 2013

Background / Issues

This reach of River Lea was largely inaccessible to the public, had steep sided banks with low value habitat and a lack of geomorphological diversity due to navigational resectioning. The river also caused flood risk issues locally and effected neighbourhoods downstream, as the channel morphology encouraged flow conveyance and pushed issues downstream to areas where water could get out of bank. By addressing issues at this location, it was hoped that the catchment, and particularly areas at risk downstream, would benefit.



Left: The River Lea prior to reprofiling. Below: Reprofiled bank plan. The diagram shows the existing bank profile in dotted lines with the scheme design of a wider graded back channel profile with backwaters, reed beds, public access routes.

CASE STUDY

Step-by-step

As part of the Olympic Park development, a reach of the River Lea at North Park was allocated for restoration. Through early engagement with the Olympic Delivery Authority, the Environment Agency were able to ensure that the designs to improve the North Park river system incorporated improved river profiles and a variety of marginal and riparian habitats.

A phased approach to construction was adopted. Contaminated land was treated, new river bank profiles were excavated, and an agreed landscape and planting strategy implemented.

Significant bank reprofiling works were undertaken to lower the bank and reconnect the channel with its floodplain. Areas of land previously dominated by low-value riparian vegetation were lowered to create a floodplain that could also be used for flood storage purposes. Vegetation clearance works were aimed at allowing landscape and amenity benefits to be recognised by opening up the river for the public.

(1) Anticipated scheme layout;
(2) New river profiles during construction

Benefits

- New bank profiles have created a new flood storage facility on the River Lea for 1 in 50 year flood events.
- Water conveyance has also been improved by reducing how quickly flow passes through the system. This has benefits for flood risk and aids marginal vegetation establishment.
- New bankside habitat creation.
- Improved public access to the water course.


River Lea after construction

Lessons Learnt

- Early engagement with developer to agree scope of works and improve flood risk in other locations through work upstream.
- Ask for improvements to be delivered by third parties, whilst the opportunity exists.

Project contact: London Environment Team, Environment Agency

CASE STUDY

Allow the river to flood its floodplain

Project summary

Title: Knepp Castle Floodplain Restoration
Location: Knepp Castle, Horsham, West Sussex, England
Technique: River restoration scheme (floodplain reconnection, bed and bank reprofiling, backwater creation, structure removal)
Cost of technique: ~~£££~~
Overall cost of scheme: ~~£££~~
Benefits: ~~£££~~
Dates: 2009-2013

Mitigation Measure(s)

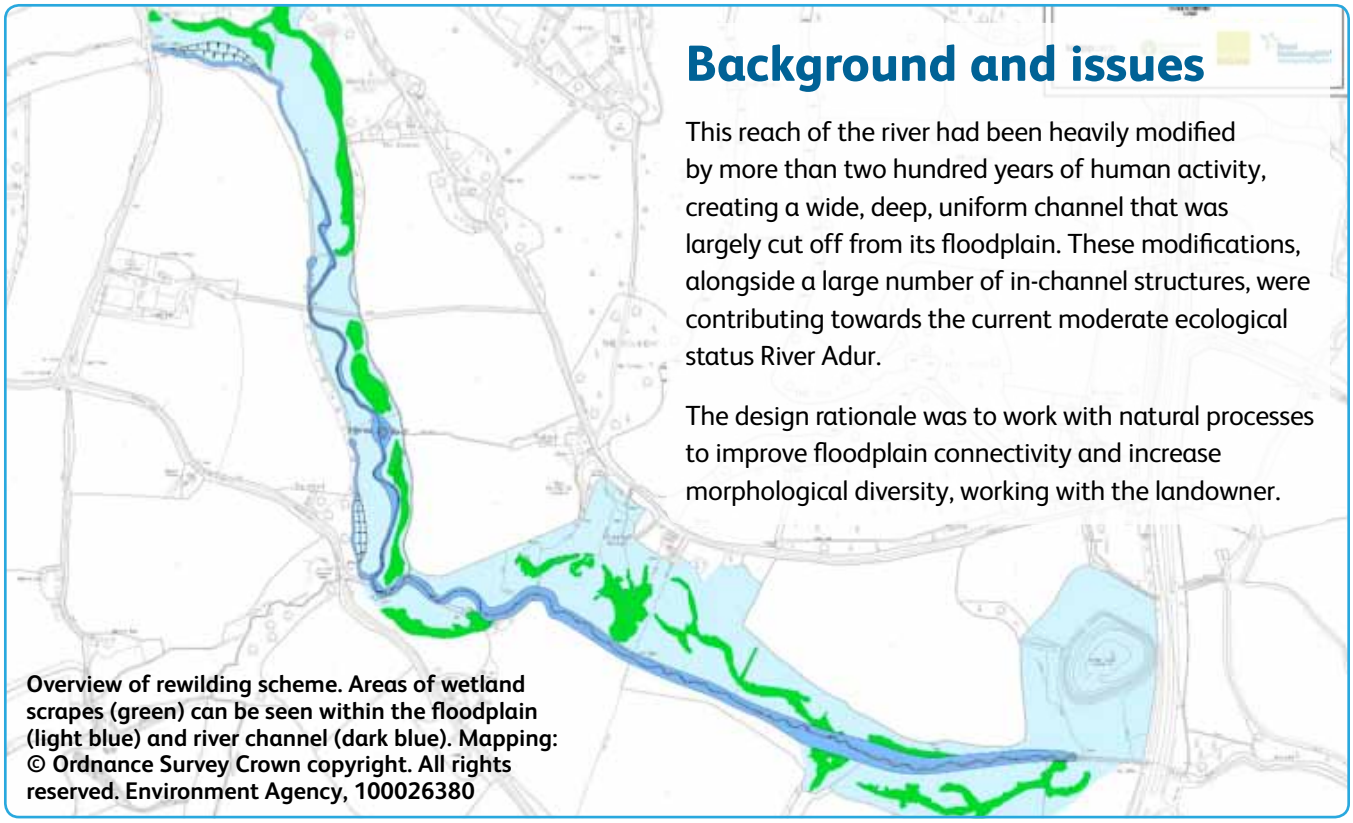
Allow the river to flood its floodplain
Improve channel geomorphology to create habitat
Preserve and improve water's edge and bank side habitats
Remove structures that are no longer needed

How it was delivered

Delivered by: Environment Agency
Partners: Knepp Castle Estate; Natural England, Royal HaskoningDHV

The project has renaturalised a long reach of the River Adur and reconnected it to its floodplain.

All images © Royal HaskoningDHV copyright and database rights 2013



Overview of rewilding scheme. Areas of wetland scrapes (green) can be seen within the floodplain (light blue) and river channel (dark blue). Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

Background and issues

This reach of the river had been heavily modified by more than two hundred years of human activity, creating a wide, deep, uniform channel that was largely cut off from its floodplain. These modifications, alongside a large number of in-channel structures, were contributing towards the current moderate ecological status River Adur.

The design rationale was to work with natural processes to improve floodplain connectivity and increase morphological diversity, working with the landowner.

Step-by-step guidance

The renaturalisation of this 2.5 km reach of the Adur can be divided into 3 main stages:

Feasibility studies: Studies undertaken included a geomorphological walkover survey, analysis of historical maping and LiDAR and ISIS-Tuflow modelling. These resulted in the outline of a preferred option that included a smaller channel with shallower banks and a more natural planform, the incorporation of large woody debris (LWD) and the creation of backwaters, ponds and floodplain scrapes.

The project identified a strategy to significantly increase river connectivity and improve the range and quality of in-channel and riparian habitats present in this reach of the Adur.

Detailed Design: Using outline options, hydrological modelling outputs and detailed topographical data, a team of engineers produced detailed designs that ensured the achievement of the opportunities outlined in the feasibility stage of the project without compromising flood risk at neighbouring properties. This included detailed channel designs, bank profiles, location of floodplain scrapes and LWD, materials to be used and location of plants and access routes for construction.

Construction: The construction stage (Sept 2011 – Sept 2013) resulted in:

- Creation of a new meandering channel with reduced capacity to increase floodplain connectivity
- Enhancement of remaining channel to increase morphological diversity without increasing flood risk to assets
- Removal of a sluice and stepped weir
- Improvements to fish passage at third structure
- Creation of floodplain scrapes


Over-widened channel


Barrier to fish passage


New meandering channel (during construction)

Benefits

- Restoration of natural river processes.
- Floodplain reconnection.
- Improvements to river continuity and range of in-channel and riparian habitats.
- Benefits to fish, macrophyte and invertebrate populations.
- Contribution towards achievement of Good Ecological Status at a water body level.
- Increase in amenity value for the public using the Knepp Castle Estate.

Lessons Learnt

- It is important to maintain site supervision to ensure that the outcomes are as expected. However, focus should be put in adherence to project objectives and not “cosmetic” finishing.
- The use of appropriately detailed modelling was essential in order to ensure that the central aim of increasing floodplain connectivity could be delivered without increasing flood risk to nearby assets and infrastructure.

Project contact: Fisheries & Biodiversity, Solent and South Downs Area, South East Region, Environment Agency

CASE STUDY

Improve channel geomorphology to create habitat

Project Summary

Title: Knettishall Heath River Restoration
Technique: Bed and bank re-profiling
Location: Little Ouse, Knettishall Heath, Suffolk, England
Cost of technique: ££
Overall cost of scheme: ££
Benefits: £££
Dates: September 2012

Mitigation Measure(s)

Improve channel geomorphology to create habitat

How it was delivered

Delivered by: Environment Agency
Partners: Suffolk Wildlife Trust

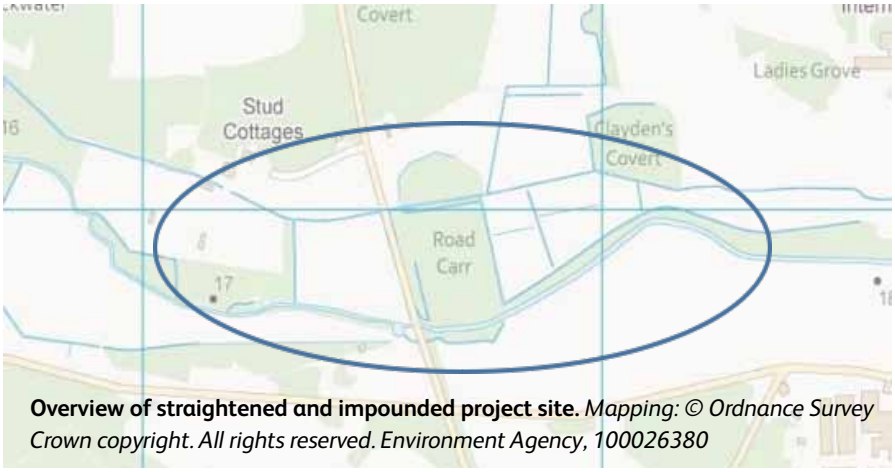
Straightened and impounded section of the Little Ouse
All images © Environment Agency copyright and database rights 2013.

Background / Issues

The Little Ouse has been subject to continuous management for the last century, which has included the installation of a series of stop-board weir water level management structures throughout the length of the reach at Knettishall Heath, resulting in extensive impoundment and lack of in-channel habitat diversity.

In addition to improvements to local hydromorphology, the amenity value of the river landscape was also considered in project design, given the visibility of the project site as it is located within Knettishall Heath Country Park and is therefore well used by the public.

The in-channel structures have a considerable impact on the river and prevent it reaching Good Ecological Status under the Water Framework Directive. While removal of in-channel structures was not a viable option at the site due to funding constraints, restoration options involving bed and bank re-profiling aimed at improving the local hydromorphology by increasing the range and quality of in-channel habitats were implemented.



Overview of straightened and impounded project site. *Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380*

CASE STUDY

Step-by-step

The implementation of the Knettishall Heath River Restoration Plan was achieved through the:

- Creating of pools and runs from existing flat river bed through re-profiling of the material that currently existed.
- Creation of a two-stage channel by installing dense reed stands to prevent the complete 'closure' of the channel and avoid ponding of water upstream.
- Narrowing of sections of the channel by pushing the banks in.
- Installation of single (pushing flow toward a particular bank) and double deflector shoulders (that focus flow into the centre of the channel) created from local large woody debris, encouraging hydromorphological diversity and zones of erosion and deposition.

Cutting of two-stage channel

Narrowing of channel

Benefits

- All works and alterations were achieved without importing any materials into the site. Similarly no disposal of spoil was necessary during the implementation of the scheme.
- The scheme delivered significant improvements to the quality and range of in-channel habitats through the introduction of numerous in-channel features.
- Improvements to local hydrology and morphology contributed towards renaturalisation of flow and sediment regimes and achievement of Good Ecological Status for the Little Ouse water body.

Restored section after project completion

Lessons Learnt

- It is possible to deliver significant hydromorphological and ecological improvements in a heavily impounded river without the necessity to removal structures. This represents a significant cost saving.

Project contact: Fisheries & Biodiversity, Anglian Region, Environment Agency

CASE STUDY

Improve channel geomorphology to create habitat

Project Summary

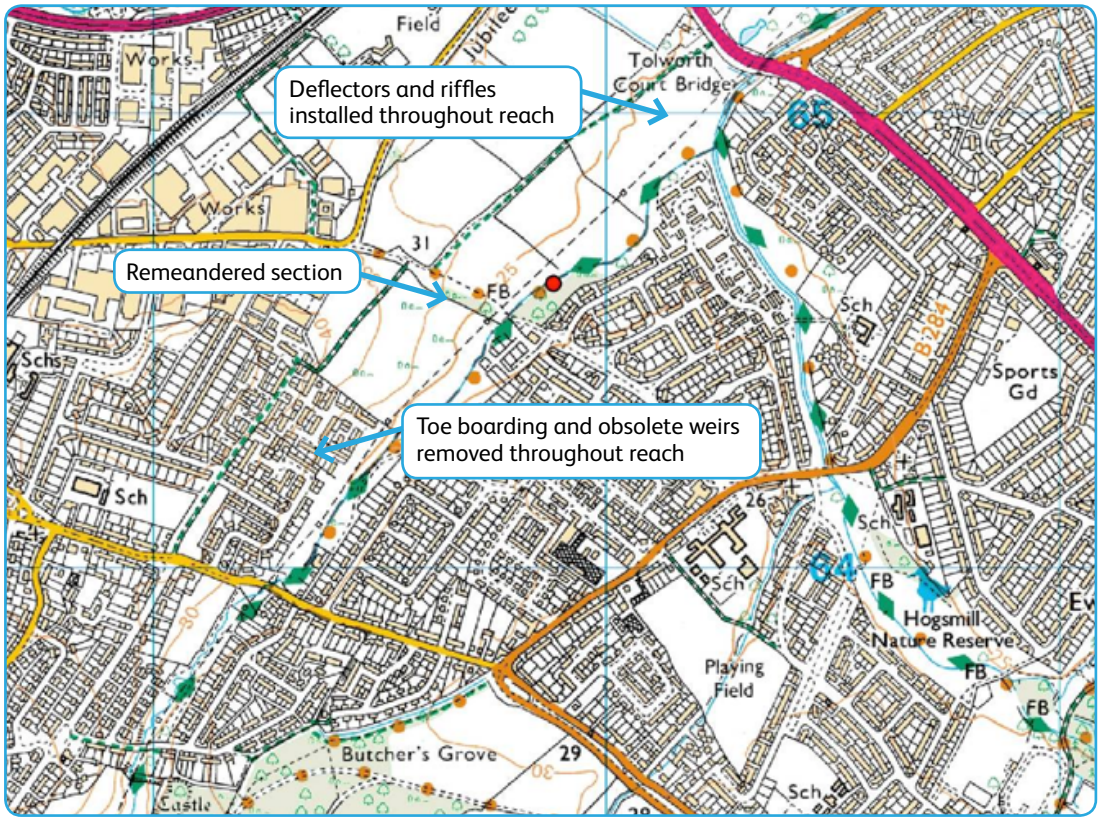
Title: Bonesgate Stream Restoration Sscheme
Location: Bonesgate Stream, West Ewell, Surrey, England
Cost of technique: ££
Overall scheme cost: ££££
Dates: 2008

Mitigation Measure(s)

Improve channel geomorphology to create habitat
Use green engineering techniques instead of hard bank protection

How it was delivered

Delivered by: Environment Agency
Partners: Cascade Consulting, Martin Wright Associates



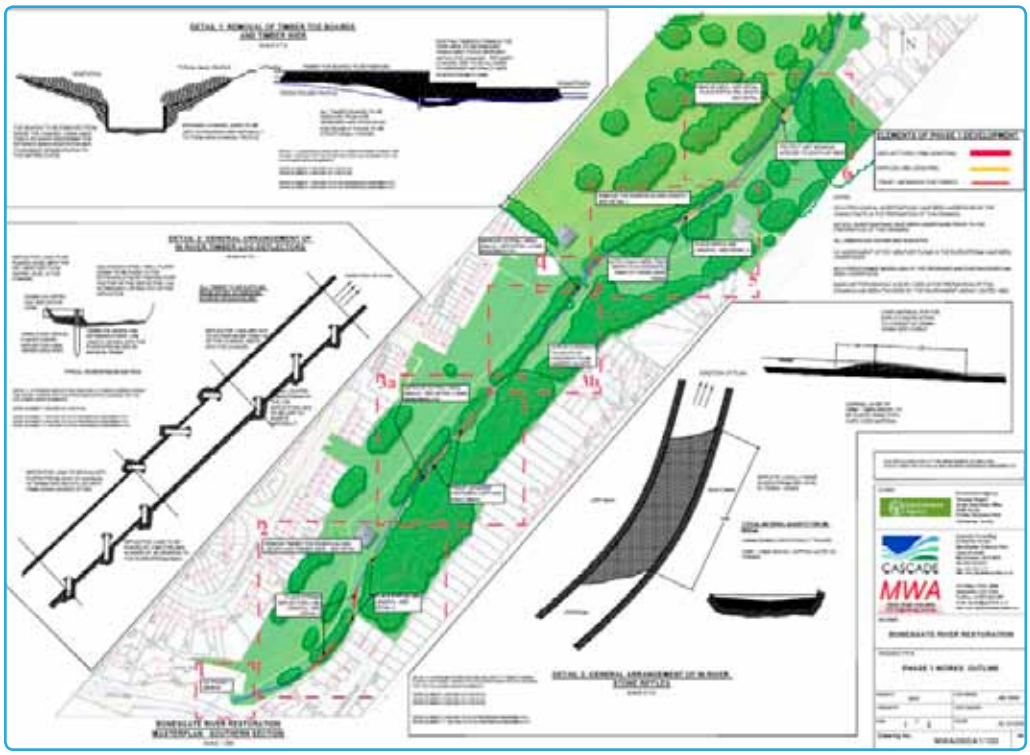
All images © Environment Agency copyright and database rights 2013

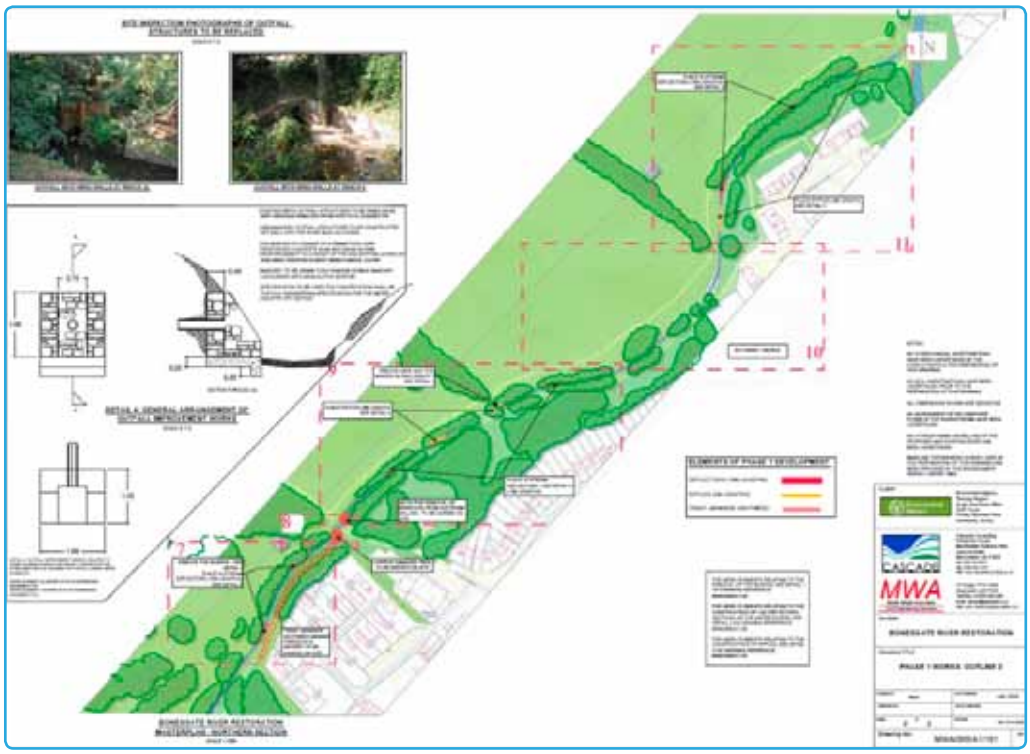
Overview of Bonesgate Stream restoration

Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

Background and issues

The Bonesgate Stream was historically modified to improve drainage in the neighbouring urban areas. The stream was designated as a main river in 2005, and responsibility for its maintenance was passed to the Environment Agency. The Environment Agency instigated a river restoration scheme in 2008 to improve the ecological value of the watercourse and return its geomorphology to its pre-modification (1859) character. The pre-restoration channel consisted of a narrow, steep sided ditch that had been historically straightened to increase the conveyance of flood flows. In order to reduce the gradient, the pre-restoration channel contained six concrete step weirs at intervals of approximately 200 m.





Details of restoration plan for Bonesgate Stream

CASE STUDY

Step-by-step

Approximately 0.8 km of the Bonesgate Stream at the downstream end was restored by the Environment Agency in 2008. The aim of the project was to recreate some of the historical course of the river, identified from the 1859 historical mapping. The following construction took place:

- The weirs were removed. This involved either in situ crushing, leaving some parts in the stream, or complete removal from the stream.
- Meanders were reinstated along one section of the stream – two stage channel for these sections.
- The toe-boards were removed (entirely in some sections, but in others, sections remain in situ).
- Two different designs for log flow deflectors were installed in four locations in sets of threes, made from the conifer trees removed from part of the bank – small deflectors and large 'box' deflectors.
- Gravel riffles were constructed.

(1) Reach where toe-boarding has been removed; (2) pine-box deflectors backfilled with gravel; (3) small flow deflectors; (4) artificial riffle in a straightened section of the channel; (5) remeandering of previously straightened channel; (6) former location of weir with concrete base and banks retained.

CASE STUDY

Benefits

- Toe board removal has increased flow and geomorphological variability at the channel margins, resulting in undercutting a short distance up and downstream.
- Deflectors have locally increased flow diversity and resulted in localised erosion and bank retreat (the small deflectors have achieved this to a greater extent than the larger ones, which are above normal low flow levels).
- The new riffles locally increase flow diversity, changing slow, uniform glide flows into swift, shallow riffle flows, although they remain as static features and have not yet dynamically joined up with the wider river system.
- Remeandering has locally increased sinuosity and flow diversity.
- The removal of weirs has increased upstream flow diversity, and also bed scour and bank adjustment where hard bank protection has also been removed

Improved channel conditions resulting from mitigation measures outlined above.

Lessons Learnt

- The large deflectors and riffles used in this scheme are not appropriately scaled to the channel, resulting in a degree of ineffectiveness and a failure to become properly incorporated into the channel system. Deflectors need to be appropriate scaled to a scheme to be successful.
- The effectiveness of the toe boarding removal could be enhanced if the protection was removed from the entire reach, rather than in a more sporadic fashion.
- The effectiveness of the measures is likely to be limited by the continued presence of the flow control structures upstream of the restoration reach, which constrain the conveyance of coarse sediment downstream.

Project contact: Fisheries and Biodiversity team, South Thames Region, Environment Agency

CASE STUDY

Improve channel geomorphology to create habitat

Project Summary

Title: River Quaggy enhancement scheme at Chinbrook Meadows
Location: River Quaggy, London Borough of Lewisham, England
Technique: Structure removal, channel realignment and natural enhancement
Cost of technique: ££££
Overall cost of scheme: ££££
Benefits: ££
Dates: 2002

Mitigation Measure(s)

Use of green engineering techniques instead of hard bank protection
Improve channel geomorphology to create habitat

How it was delivered

Delivered by: Environment Agency
Partners: Quaggy Waterways Action Group; Lewisham Council

All images © Royal HaskoningDHV copyright and database rights 2013

New, restored channel

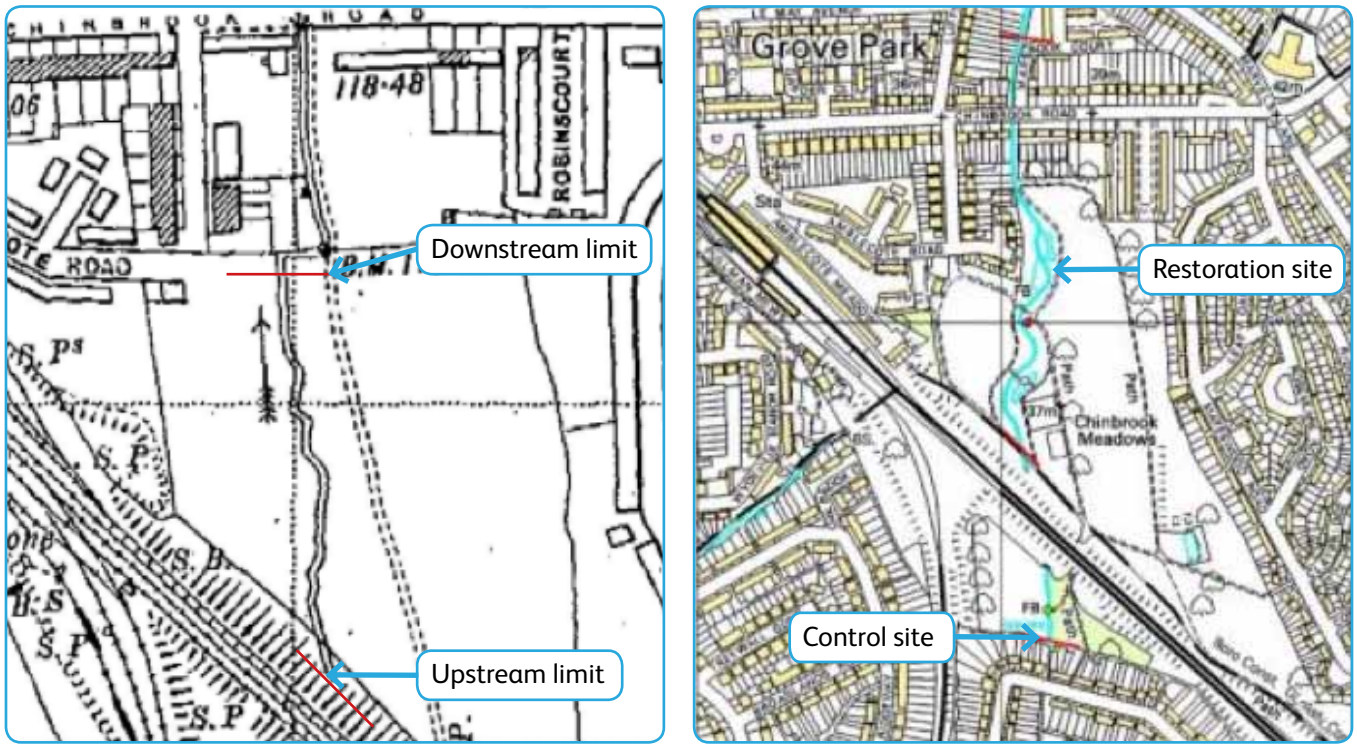
CASE STUDY

Background and issues

The River Quaggy is a tributary of the River Ravensbourne, and is located in Bromley and Lewisham in south east London. The river rises in Sundridge Park, from where it flows in a northerly direction. When the river reaches Sutcliffe Park, it flows in a westerly direction until it enters the River Ravensbourne to the north of Lewisham town centre. The Chinbrook Meadows restoration site is located in Grove Park, in the south of the London Borough of Lewisham.

The river has been extensively modified in the past, with large sections straightened, channelised or culverted as part of flood defence schemes during the 1950s and 1960s. After the 1960s the river flowed for 300 m through Chinbrook Meadows in a straight, uniform concrete-lined channel. The upstream (southern) end of Chinbrook Meadows is bounded by a railway embankment carrying the railway between Grove Park and Elmstead. The river passed beneath the railway embankment in a culvert and then through the meadows in a concrete channel. Downstream of Chinbrook Meadows the channel passes through a gauging station and down a concrete flume.

In 2002, river enhancement works including removal of the concrete-lining and re-meandering of the river in the park to create a more natural planform were undertaken in the Chinbrook Meadows reach.



Overview of the River Quaggy restoration site in Chinbook Meadows

CASE STUDY

Step-by-step

The river enhancement scheme in Chinbrook Meadows involved the following key elements:

- Breaking out the majority of the original concrete channel.
- Realignment of approximately 300 m of the river by the excavation of a meandering, naturalistic channel with increased morphological diversity.
- Creation of offline flood storage ponds.
- Removal of hedges and fencing adjacent to the concrete channel.
- Diversion of storm water drains that previously discharged into the original channel.
- Boardwalk, pond dipping and educational area constructed at the upstream end.
- Construction of a gauging station and measuring facilities in part of the concrete channel, which was retained at the downstream end of the site.

The constraints of the site (e.g. upstream and downstream levels and the invert levels of existing concrete bridges) meant that the top half of the scheme required a very shallow gradient of approximately 1:1000. To align the channel back into the downstream connection, the gradient of the second part of the channel was far steeper at around 1:150. The top half was designed as a meandering channel and the bottom half provided a gravel riffle and pool system.

(1) Previous toe-boarding of straight channel and (2) concrete bridge from 1950 / 1960s channelisation;

(3) Current soft-engineered channel, with new sinuosity resulting in (4) increased morphological diversity and natural erosion and deposition patterns

CASE STUDY

Benefits

- Removal of the concrete bed and banks and the creation of a sinuous planform with unprotected banks have increased flow and geomorphological diversity, and allowed natural processes to operate. This has resulted in bank toe scour and the formation of depositional features, particularly in the lee of meanders.
- Increased flow diversity resulting from structure removal has resulted in the formation of erosional and depositional features throughout the reach, with several gravel bars forming within the channel. These depositional features are creating a naturally occurring sinuous low flow course within the main channel and pool and riffle sequences have or are starting to form.
- The naturalised channel cross section that has been created has increased channel-floodplain connectivity. In high flows the park is regularly inundated, supplying water to the scrapes and ephemeral ponds that were created as part of the scheme, and helping to maintain wetland habitats.
- The enhanced, meandering channel provides landscape and amenity benefits and provides an area that is used by local residents for walking, exercising their dogs and by children playing. The trees planted as part of the scheme provide additional landscape features within the park.

(1) Typical section of restored channel; (2) meandering channel

Lessons Learnt

- Minimising the use of artificial bank protection has allowed natural processes to operate in the restored channel. This means that the river has been able to adapt to the prevailing flow and sediment regime, creating a diverse range of in-channel morphological features which support varied habitats for plants and aquatic organisms.
- Channel incision created by increased sinuosity has lowered the bed level of the channel below the level of the offtake for the flood storage ponds and therefore natural flow to the ponds is limited during periods of moderate flows (although the features fill up during periods of higher flow). This connectivity could be improved through deepening the existing offtake or creating a new offtake. The lesson learnt is that although geomorphological change was considered in the scheme design, not all changes are easily predictable and that it may be necessary to undertake minor works to rectify this.
- The scheme may require some vegetation management in the long term, but is otherwise viewed as being sustainable.

Project contact: Fisheries and Biodiversity Team, South East Thames Area, South East Region

CASE STUDY

Improving the channel bed within a culvert

Project Summary

Title: Lodge Burn Flood Alleviation Scheme
Location: Coleraine, Northern Ireland
Technique: Artificial bed construction
Cost of technique: £££
Overall cost of scheme: £££££
Benefits: ££
Dates: May 2008 – Dec 2012

Mitigation Measure(s)

Improving the channel bed within a culvert

How it was delivered

Delivered through: The Rivers Agency

Poundstretcher culvert in Coleraine. *All images © Rivers Agency copyright and database rights, 2013*

Background / Issues

Regular localised flooding of the tidal section of Lodge Burn, particularly in the area of Coleraine, led to the design and implementation of an extensive programme of flood alleviation works. While Lodge Burn largely flows in an open channel through its lower reaches, there were two culverts in Coleraine which were identified as potential factors for increased local flood risk, given their poor state of repair. The scheme included the refurbishment of the old masonry culvert under the Poundstretcher store in Coleraine, given the presence of numerous barriers to flow and fish passage within the culvert.

The Lodge Burn Flood Alleviation Scheme (FAS) proposed works to improve conveyance and provide 1 in 100 year standard of protection through Coleraine by refurbishing the two existing culverts (including the Poundstretcher culvert), the construction of flood walls and the diversion of services that currently increase flood risk. Concomitantly, the scheme also included the provision of environmental enhancements in Lodge Burn through river restoration measures in Anderson Park as well as the implementation of mitigation measures in the culverts aimed at promoting Good Ecological Status (GES).

Overview of Lodge Burn Flood Alleviation Scheme

CASE STUDY

Step-by-step

The Poundstrecher culvert was in poor structural condition and contained obstructions to river flows. This culvert was, therefore, renovated in-situ to improve flow conditions and fish passage. Refurbishment works included:

1st Phase (autumn 2008 to spring 2009)

- Consultation and design development phase, including a detailed flood feasibility and economic appraisal study

2nd Phase (summer 2009 to summer 2010)

- Detailed design and procurement

3rd Phase (autumn/winter 2010)

- Procurement and mobilisation

4th Phase (January 2011 to January 2012)

- Installation of gravel bed in culvert channel – gravels were secured by drilled baffles (approximately 0.4m high) placed across the culvert
- Installation of baffles along the length of culvert to raise water levels for fish passage and provide stability for gravels
- Creation of low flow channel using a two-stage cross-section secured by baffles to allow flow and fish passage during dry periods.
- Gravel and rock material was sourced from break-up of former flood walls and local quarry material.

Poundstrecther culvert during refurbishment works still showing services within culvert

Benefits

- In addition to wider benefits related to increased flood protection, restoration of in-channel habitats and improved Water Framework Directive compliance associated with the larger Lodge Burn FAS, the proposed works also delivered a good example of improvements to fish passage – enabling migratory fish to pass into and through the culvert (coarse fish are unable to pass) – where deculverting is not considered a viable option due to urbanisation and land use constraints.

Artist impression of restored Lodge Burn at Anderson Park (Downstream of Poundstrecher culvert)

Lessons Learnt

- In projects where culvert refurbishment is involved ground conditions may present added challenges to construction. In the Lodge Burn scheme ground conditions in some areas of the works have been more challenging than expected. The project team also encountered some further instability in the steep slope adjacent to the river prior to commencement of works which necessitated more extensive temporary works / enabling works than were expected, resulting in delays to project completion.

Project contact: Conservation Team, Western Region, Northern Ireland Rivers Agency

CASE STUDY

Realign flood defences to increase coastal and intertidal habitat

Project Summary

Title: North Trimley Marsh Habitat Creation
Location: Trimley, Suffolk, England
Technique: Managed realignment
Cost of technique: £££££
Overall cost of scheme: £££££
Benefits: £££££
Dates: 1998-2010

Mitigation Measure(s)

Realign flood defences to increase coastal and intertidal habitat
Create compensatory habitat to offset impacts

How it was delivered

Delivered by: Harwich Harbour Authority
Partners: Department for Transport, Department for Environment, Food and Rural Affairs; Centre for Environment, Fisheries and Agriculture Science; The Royal Society for the Protection of Birds; Natural England; Suffolk County Council; Environment Agency; Eastern Sea Fisheries Joint Commission (now Eastern Inshore Fisheries and Conservation Authority).

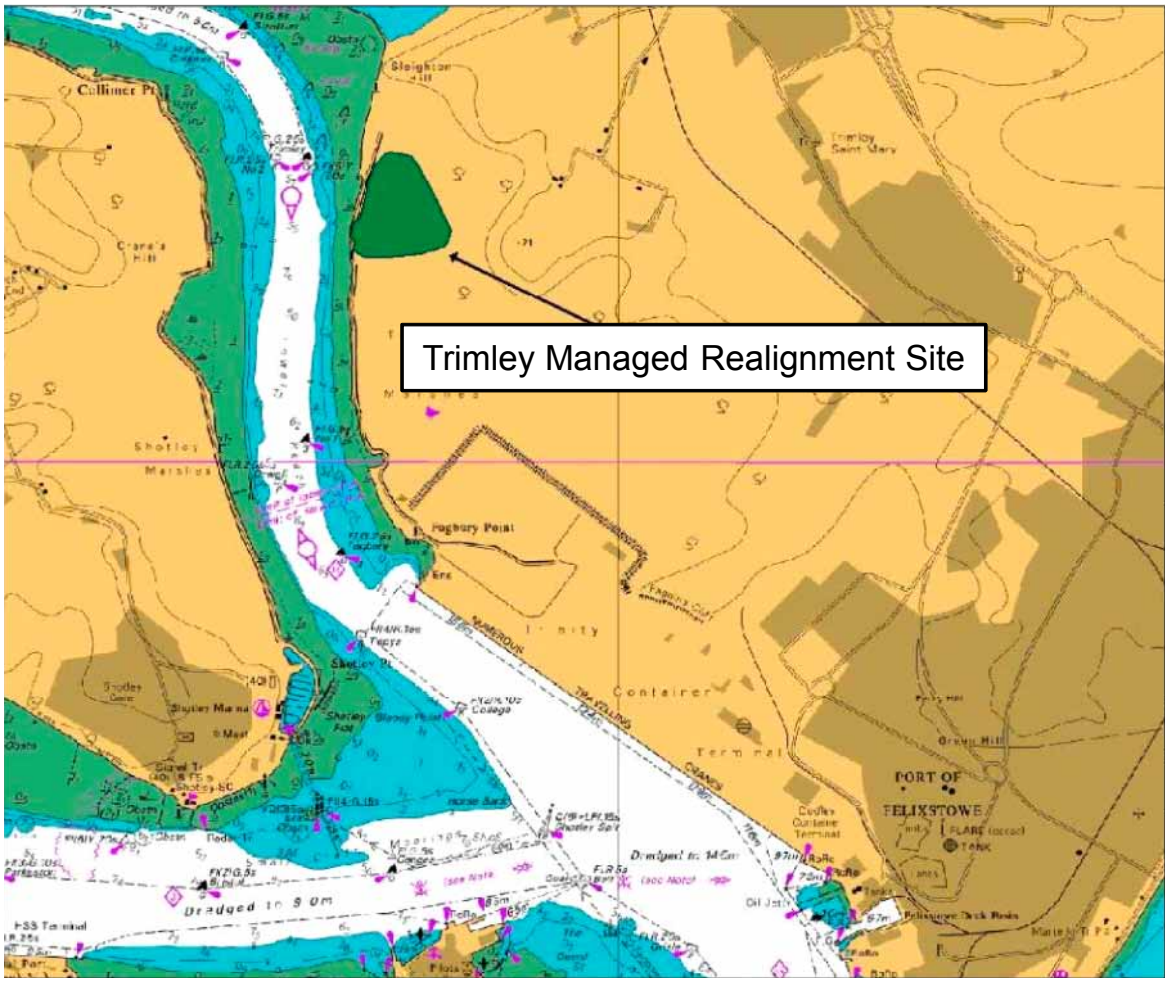
16.5ha of new habitat created through managed realignment scheme at North Trimley Marsh

Restored saltmarsh habitat at Trimley managed realignment

All images © Royal HaskoningDHV copyright and database rights 2013

Background and issues

In October 1998, the Harwich Haven Authority (HHA) commenced works to deepen the approach channel to the Haven Ports. As a condition of obtaining the various permissions to carry out the deepening, a Mitigation and Monitoring Package (MMP) was agreed with the Department of the Environment, Food and Rural Affairs (Defra) and the Department for Transport (DfT) to minimise the potential environmental impacts of the scheme. Part of the package was to develop a habitat creation scheme to compensate for potential impacts on the Stour and Orwell Estuaries Special Protection Area (SPA). To this end, 16.5 ha of intertidal habitat was created through managed realignment at North Trimley Marsh. This habitat represents 0.5 % of the total SPA designated area.



Location of the Trimley managed realignment site on the Orwell Estuary

Step-by-step

The Trimley managed realignment site is situated on the east bank of the Orwell Estuary, approximately two nautical miles upstream from Felixstowe. The site now consists of approximately 16.5 ha of intertidal mudflat fringed with developing pioneer saltmarsh.

The site was created on arable land. The western perimeter is made up of the seawall which previously separated the Orwell Estuary from the farm land. A new counter-wall was created around the northern, eastern and southern perimeters of the land.

One of the required criteria for the site was that no more than 30 % of its area should develop into saltmarsh. At least 70 % of the realignment area was, therefore, designed to be below the level of +3.5m Chart Datum (CD), as saltmarsh is estimated to develop at levels higher than +3.5 m CD. The entrance (i.e. the breach in the sea wall) was designed at +1.5 m CD to enable the site to completely drain at low tide.

Maintenance dredged material (fine mud) from the channel in the lower Orwell Estuary was pumped into the site to provide a suitable substratum for colonisation of estuarine flora and fauna. Approximately 35,000 m^3 of dredged material was pumped from a trailing suction hopper dredger, through a floating pipeline (which entered the site through the breach) to a floating pontoon. At high water, the material on the pontoon was deposited in four locations, from where it was spread out over the site. The dredged material formed a layer approximately 30 to 50 cm deep above the underlying soil and a series of mini-bunds were created throughout the site, to retain the dredged material and to allow access for surveying.

As part of the original agreement, a 10-year monitoring programme was conducting following scheme implementation to monitor a number of physical, chemical and biological factors to determine the long-term success of the scheme.

Progression of the Trimley managed realignment scheme during the 10-year monitoring programme (2001-2010)

Benefits

- Since construction, the benthic community has increased in species richness, abundance and diversity as the site has developed.
- The diversity and density of saltmarsh plants on the Trimley managed realignment site has increased significantly since construction. The distribution of saltmarsh over the site is uneven and some areas support much larger areas of vegetation than others, particularly the northern extent of the site. The saltmarsh area is expanding slightly.
- Of the species which qualify for international status as part of the Stour and Orwell SPA, there were increases in numbers of five species in 2009/10 including black-tailed godwit, dunlin, grey plover, knot and redshank. The site is functioning well as a SPA habitat.

Habitat creation around the opening in the flood defence

CASE STUDY

Lessons Learnt

- Recognition of the importance of monitoring in mitigation
- For schemes with significant implications, the establishment of a participatory forum
- Ensuring delivery and establishing trust are key to the success of such as scheme
- Enabling shared decision-making amongst partner organisations
- Delivery through existing management forums improves participatory engagement.

Project contact: Coastal and Marine Environment team, Royal HaskoningDHV.

CASE STUDY

Realign flood defences to increase coastal and intertidal habitat

Project Summary

Title: Hesketh Out Marsh
Location: Southport, Merseyside, England
Technique: Managed realignment
Cost of technique: £££££
Overall cost of scheme: £££££
Benefits: £££££
Dates: 2006-2009

Mitigation Measure(s)

Realign flood defences to increase coastal and intertidal habitat

How it was delivered

Delivered by: Environment Agency
Partners: RSPB; Lancaster City Council, Natural England, Lancashire Rural Recovery Action Plan, Biffa Award

View of Hesketh Out Marsh after re-establishment of saltmarsh habitat *All images © Environment Agency copyright and database rights 2013*

Background / Issues

The site at Hesketh Out Marsh forms part of the Ribble estuary, the most important single estuary for birds in the U.K.

While the estuary supports significant bird, shellfish, shrimp and mussel populations, extensive construction of flood embankments and drainage ditches has resulted in Hesketh Out Marsh being disconnected from the rest of the estuary. Following modifications, this area was converted to agricultural land and used for grazing by sheep.

A scheme aimed at creating additional intertidal habitat resulted in the purchase of approximately 236 ha of land in Hesketh Out Marsh, allowing for the implementation of a flood defence realignment scheme which included the creation ofnew saltmarsh habitat in the Ribble estuary as well as a new RSPB reserve on the site.

Aerial view of Hesketh Out Marsh project

CASE STUDY

Step-by-step

Works on the site have resulted in the implementation of the country's largest flood defence managed realignment. The scheme included:

- Repairing the secondary flood defence embankment to act as the primary line of defence upon conclusion of the project.
- Raising embankments with material won on site.
- Creation of four 100 m wide breaches in the existing embankment.
- Excavation of creeks and drainage ditches to a typical maximum of 2.75 m OD to act as extensions of existing creeks located in the intertidal area prior to scheme.
- Excavation of 8 saline lagoons to a typical maximum of 2.75 m OD (approximately 1 ha each).
- Construction of associated facilities for the RSPB reserve.

Creation of breaches in existing embankment

Benefits

- Creation of intertidal habitat to be used by wintering and breeding waterfowl.
- Improved adaptation to threat of sea level rise associated with climate change.
- Provided an offset for intertidal habitat lost elsewhere in the estuary.
- Contributed to the EA's high level target of creation of 150ha of BAP habitat.

Saltmarsh adjacent to Hesketh Out Marsh West

Lessons Learnt

- Responses to climate change and sea level rising has created a multi-beneficial approach to plan for the future in creating stronger sea defences and creation of saltmarsh habitat lost elsewhere.
- The scheme is one of the largest of its kind in the UK and represents a successful collaborative working arrangement that can be imitated across a large number of alternative sites.
- Due to its success, further funding has been attracted through the Biffa Award.

Project contact: The Royal Society for the Protection of Birds, Lancashire, North West Region

CASE STUDY

Realign flood defences to increase coastal and intertidal habitat

Project Summary

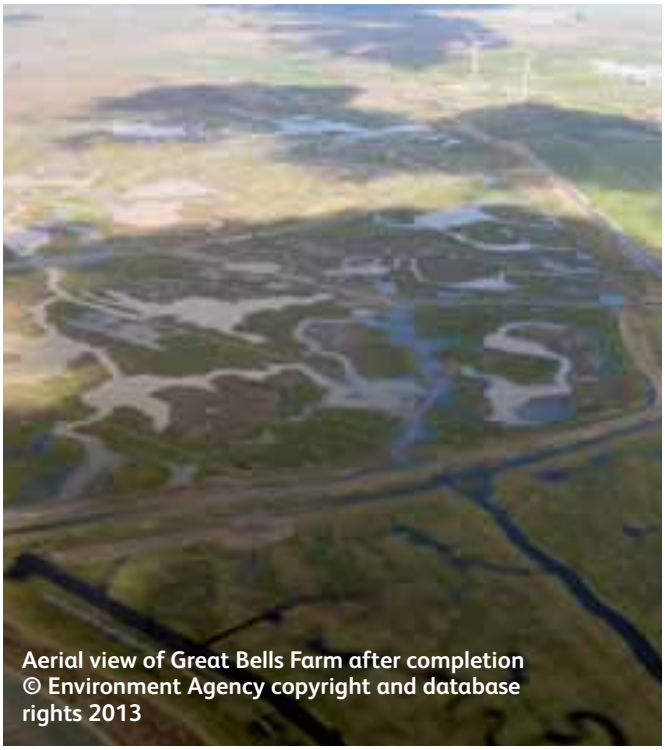
Title: Great Bells Farm Habitat Creation project
Location: Isle of Sheppey, Kent, England
Technique: Managed realignment
Cost of technique: £££££
Overall cost of scheme: £££££
Benefits: £££££
Dates: 2012 - 2013

Mitigation Measure(s)

Realign flood defences to increase coastal and intertidal habitat
Improve channel geomorphology to create habitat
Reposition or alter river embankments to create a natural floodplain

How it was delivered

Delivered by: Environment Agency
Partners: RSPB

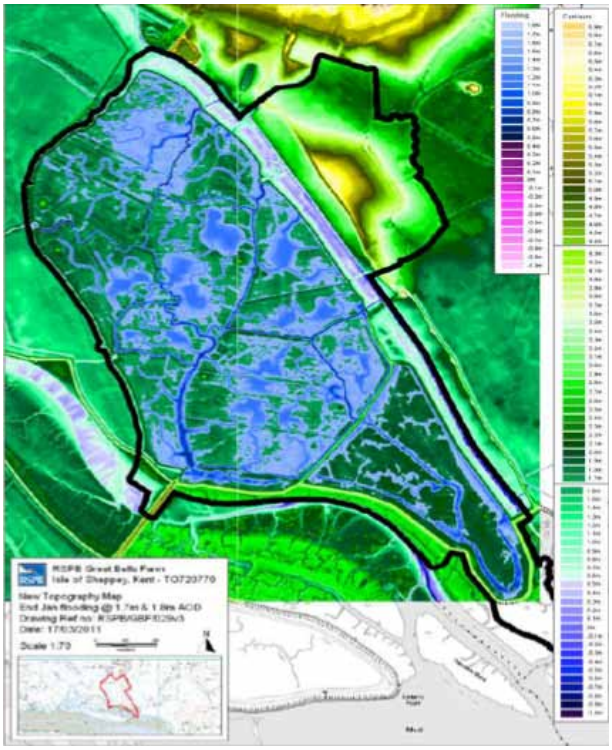


Aerial view of Great Bells Farm after completion
© Environment Agency copyright and database rights 2013

Background / Issues

The Great Bells Farm site lies to the north of Windmill Creek, which is the northern boundary of the Elmley Marshes Nature reserve on the Isle of Sheppey. The site was purchased by the Environment Agency to allow the managed realignment of flood defences by removing embankments adjacent to the river channel. This would mitigate for coastal habitat losses identified in the Medway and Swale Shoreline Management Plan (SMP), through the restoration of remnant creek and fresh water features reclaimed from the sea during the last 500 years.

The Environment Agency commissioned the RSPB to design and build the new wetland habitat and grazing marsh, due to their experience in creating similar habitats in their reserves.



Detailed topographical survey of the area
© RSPB copyright and database rights 2013

CASE STUDY

Where historic hydromorphological features such as former creeks and drainage channels were still present in the drained landscape, these were used as a guide to restore a fresh or brackish wetland and coastal grazing marsh habitats, in order to offset coastal grazing marsh losses. The total area of new habitat created was 145 ha. Additional issues at the site included its proximity to a World War II air base and the presence unexploded ordnance (UXO) was discovered prior to excavation.

Step-by-step

The implementation of the Great Bells Farm Habitat Creation project was achieved through the:

- Use of LIDAR data for detailed topographical mapping of historic hydromorphological features in the landscape.
- The use of GPS equipped excavators loaded with maps detailing what levels the embankments were required to be excavated to.
- Installation of a pump to assist in raising water levels from the surrounding ditches in dry months.
- Creation of a long term storage area to maintain area wet throughout the year.
- Reuse of all excavated material on site.
- Use of magnetometer surveys, specialist site investigation and army specialists for controlled UXO detonation.

Project area shortly after project completion (2 months after)
© Environment Agency copyright and database rights 2013

Benefits

- Restoration of the hydrological connectivity between the river channel and the floodplain.
- Contribution to SMP habitat creation targets.
- Restoration of historic hydromorphological features. By allowing floodplain inundation and restoration of relic water pathways.
- Creation of new habitat for the nationally rare Maid of Kent beetle.
- Increased habitat availability for water voles, local bird species and nationally scarce flora.
- Improvement of the visual enjoyment of the landscape, transforming a marginal poor quality grazed area of land into a biodiverse new wetland reserve, which is expected to support thousands of key Special Protected Area wetland bird species.

Example of water storage on site
© Environment Agency copyright and database rights 2013

Lessons Learnt

- Properly costed risk registers and a healthy risk budget are key to success, especially if there is a risk of UXO and archaeology.
- Good project design and procurement of a contractor that understand the schemes objectives are vital.
- Careful site selection is key, to limit expensive unnecessary earth work costs.
- A good working relationship and close project team who trust and understand each other's goals is essential.

Project contact: National Environmental Assessment Service, Kent & East Sussex Area, South East Region, Environment Agency

CASE STUDY

Reopening existing culverts

Project Summary

Title: Wandle Park River Restoration
Location: London Borough of Croydon, England
Technique: Providing ecological and landscape enhancements through daylighting a culverted urban watercourse
Cost of technique: ~~£~~~~£~~~~£~~~~£~~
Overall cost of scheme: ~~£~~~~£~~~~£~~~~£~~~~£~~
Benefits: ~~£~~~~£~~~~£~~~~£~~~~£~~
Dates:2009- 2013

Mitigation Measure(s)

Remove culverts
Increase in-channel morphological diversity

How it was delivered

Delivered by: Croydon Council
Partners: Environment Agency, Heritage Lottery Fund, The Mayor's Help a London Park scheme, Friends of Wandle Park, Royal HaskoningDHV, LDA Design

New ornamental bridge over the deculverted River Wandle through Wandle Park All images © Royal HaskoningDHV copyright and database rights 2013

Background / Issues

Wandle Park is a seven hectare urban park near the centre of Croydon in south London. The park is popular with dog walkers, joggers, skate boarders, cyclists and families with children. The River Wandle, a tributary of the River Thames, runs through the park but it was culverted in the 1960s and the original channel in-filled predominantly with building waste. Croydon Council sought to improve the amenity and environmental nature of the park as part of wider regeneration plans for the local area, and deal with the contaminated land issues typically associated with a green space located centrally in a town space.

Wandle Park was one of ten parks in London that were improved under the 'Help a London Park' scheme. This project was a key opportunity to create river and wetland habitat in an urban context and re-establish the park as an area of high quality green space for public enjoyment, whilst contributing to reduction of flood risk.

Layout of the park during the early stages of scheme construction

CASE STUDY

Step-by-step

Works consisted of:

- Diversion of the River Wandle.
- Removal of the previous culvert.
- Placement of a 300 mm capping layer of topsoil on the banks to prevent contaminated material from entering the watercourse.
- Diversion of a 900 mm Thames Water pipe.
- Excavation of 28,000 m^3 of soil as well as dealing with the high quantities of contaminated ground.
- Construction of flint walls to complement the existing Victorian flint walls.
- Building of two river control structures at the culvert inlet and outlet to the Park with trash screens, erosion control measures and landscaping.
- Landscaping of 50,000 m^2 of park.
- Play area works and recreating, through different types of paving, the abandoned River Wandle route.
- Construction of new ponds, footpaths and a pedestrian bridge over the river.
- Resurfacing existing footpaths and car park.
- Refurbishment of an existing Victorian fountain.

Clockwise:
(1) Looking downstream from culvert at eastern end of park;
(2) earthworks adjacent to the watercourse;
(3) construction of amenity access routes;
(4) excavation and landscaping of banks around downstream culvert

Benefits

- 300 m of the River Wandle have been deculverted and a semi-natural watercourse created, improving the environment for aquatic invertebrates – a post-construction river survey found improvements in aquatic invertebrates.
- Landscaping elements of the scheme have been designed to draw people to the watercourse, creating a new community resource.
- Community allotments created on the site.
- The River is now used as an educational resource, with attendance from school groups.
- Historic features from the 19th century park, including the bandstand, have been restored.


New footpaths created in the east of the park

Lessons Learnt

- The aim of the project changed as the original aim (flood alleviation) was found to only achieve limited benefits. The scheme was successfully re-envisaged as a river restoration scheme to realise both water body ecological status and wider community benefits.

Project contact: Parks & Open Spaces, London Borough of Croydon

CASE STUDY

Remove culverts

Project Summary

Title: River Ravensbourne at Norman Park
Location: Norman Park, Bromley, England
Technique: Restore previously culverted river
Cost of technique: ~~££££~~
Overall cost of scheme: ~~££££~~
Benefits: ~~£££££~~
Dates: March – June 2000

Mitigation Measure(s)

Remove culverts
Increase of in-channel morphological diversity
Improve floodplain connectivity

How it was delivered

Delivered by: Environment Agency
Partners: London Borough of Bromley

Aerial view of the Ravensbourne at Norman Park
© Environment Agency copyright and database rights 2013

Background / Issues

As part of an historic flood defence scheme for Hayes and Bromley Common, the River Ravensbourne was diverted into a concrete culvert, 1 m wide and 330 m long. This buried culvert ran the entire length of Norman Park before finally re-emerging at ground level in a field downstream of the park. This turned the park into one large, uniform recreational area with little visual or habitat diversity. The park was consequently deprived of all the social and environmental benefits that a river can provide for a local area and its people.

A project to deculvert the Ravensbourne was proposed with the aim of reducing the high costs associated with culvert maintenance, removing a trash screen and associated health and safety risk, and increasing flood storage. In addition, this project also aimed to restore the river corridor by recreating an open channel (in replacement of the culverted section) with diverse in-channel and bankside habitats linking to Scrogginhall Woods upstream of the park.

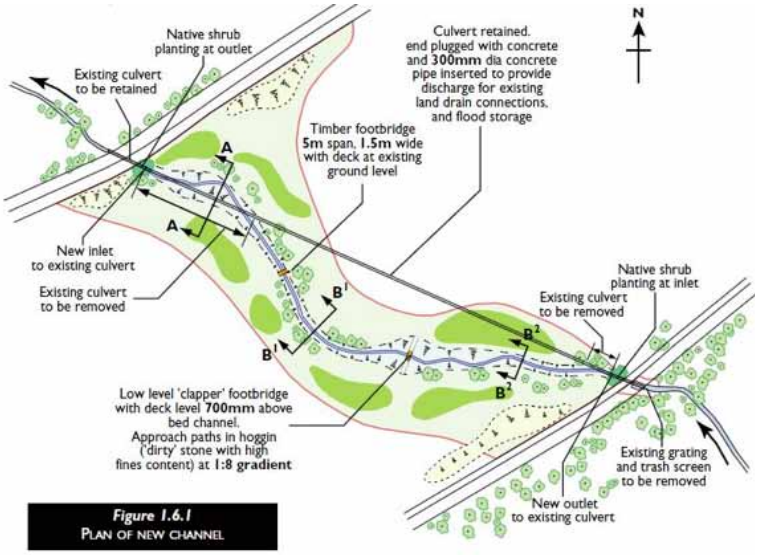


Figure 1.6.1
PLAN OF NEW CHANNEL

Scheme overview at Norman Park
© RRC copyright and database rights 2013

CASE STUDY

Step-by-step

The design of the project was based on the historic alignment of the channel, the geomorphology of less modified sections of the river, flooding considerations and present day use of the park. Works involved:

- The removal of 70 m of the 300 m culvert.
- The closing off of the remaining sections of the culvert (removal of culvert, backfilling and reshaping of a straight culvert is more expensive and, if other options are available, a less desirable option).
- The design and excavation of a new meandering, two-stage channel. The new channel is sinuous, 12.5 % longer than the culvert and possesses varying top-of-bank widths.
- Promotion of access to channel through the creation of a shallow (1:8 slope) 'berm, and new meanders (1:5 slope).
- Creation of a sediment trap at the end of the downstream limit of the new channel through the widening of the channel to lower flow velocities so that sediment will drop out of the flow and accrete.
- Seeding the new channel with gravel, thus allowing the stream to naturally shape its new bed, rather than attempting to construct pools, riffles, and other bedforms.
- On-site use of spoil from excavation to create mounds as part of the park landscaping.
- Planting of native vegetation along the riparian zone.

Excavation of new sinuous channel © Environment Agency copyright and database rights 2013

Benefits

- Improvements to in-channel, marginal, wetland and floodplain habitats.
- An improved physical habitat with has the potential to support improved ecology.
- Naturalised geomorphology.
- Increased flood storage capacity.
- Creation of a more attractive, diverse and accessible public open space.
- Educational opportunities for local schools and the community.

Marginal planting © Environment Agency copyright and database rights 2013

Lessons Learnt

- Post-project ecological monitoring has revealed low biologic score and reduced biological quality at Norman Park. This has been attributed to a "washing out" element, lack of in-channel refuge and community disturbance. Fencing to create buffer areas and in-stream planting have been identified as potential solutions.
- Marginal planting may suffer disturbance from early use and may take longer than expected to establish.
- Allowing the river to find a natural equilibrium with respect to the gravel placement has meant that significant cost savings have been made that could have been allocated to bed and bank re-profiling.

Project contact: Flood & Coastal Risk Management, South Thames Area, South East Region, Environment Agency

CASE STUDY

Remove culverts

Project Summary

Title: Tanner's Brook Restoration
Location: Southampton, England
Cost of technique: £££££
Overall cost of scheme: £££££
Benefits: £££££
Dates: 2012 - 2013

Mitigation Measure(s)

Remove Culverts

How it was delivered

Delivered by: Environment Agency
Partners: Southampton Council, Arup, Southampton Golf Club

All images © Environment Agency copyright and database rights 2013

Background / Issues

Holly Brook is a tributary of Tanner's Brook, a heavily urbanised watercourse which flows through Millbrook and into Southampton Water. Both watercourses are heavily modified in their lower reaches due to urban development and are subject to fluvial flooding at various locations. The Holly Brook channel has been straightened and culverted in some sections. Flow in the Holly Brook is predominantly uniform glides with a meandering planform and localised riffles and pools – overall it has limited geomorphological diversity. Further downstream it is constrained by urban development.

In Southampton Golf Club the channel had been culverted, resulting in poor drainage. The 27 hole golf course is characterised by a highly managed undulating landscape with frequent copses of mature trees throughout the course.

Holly Brook is currently culverted through the middle of the course, with the exception of a short stretch through a large woodland copse in the very centre of the course (designated as a Site of Importance for Nature Conservation). To the north of the golf course, the brook flows naturally through a mature woodland copse. To the south, the brook is culverted underneath Southampton Sports Centre.

Holly Brook deculverting design

CASE STUDY

Step-by-step

The main constraints at the site (the requirements of the golf course and wet woodland habitat) played an important role in determining how deculverting works on the Holly Brook were undertaken.

The culvert was excavated and a two-stage channel was profiled to maximise the potential for marginal aquatic habitat to establish. Online ponds and backwaters were also excavated for the same reason. The channel was left to naturally develop, which has resulted in natural riffle formation, immediately increasing the in-channel morphological diversity.

To reduce the impact on wet woodland habitat the channel alignment was optimised through the production of an arboricultural method statement and increased involvement of an arboriculturalist onsite to refine channel alignment. To reduce the impact of the construction works on the landscape character of the area and users of the golf course and sports centre, the works were undertaken in winter.

(1) Seasonally waterlogged location of subsequent naturalised channel; (2) Seasonally waterlogged location of subsequent naturalised channel; (3) Vertical edged pond; (4) Raised timber boardwalk over waterlogged ground.

Benefits

- Creation of wet woodland, lowland fen, river channel and pond habitats.
- Creation of new habitat areas including log piles and deadwood, of value to reptiles and invertebrates.
- Creation of a new naturalised brook, of particular value for fish.
- Improved drainage and aesthetics of the golf course.
- Increased standard of flood protection at the Dale Valley Road area due to increased flood storage as a result of the open channel and ponds.
- Improved water quality and hydromorphology of Holly Brook in accordance with WFD requirements.

(1) Weirs creates acoustic feature along channel. Increasing in-channel morphological diversity; (2) Natural riffles forming. Increasing in-channel morphological diversity; (3) Online pond/ Backwater. Ecological value of marginal aquatic habitat, banks and riparian zone improved; (4) Two stage channel enhances ecological value of marginal aquatic habitat, banks and riparian zone.

Lessons Learnt

- Winter working and preceding saturated ground conditions resulted in soil not being reusable, and increased expenditure from its export and import of suitable material for the flood embankment. It is therefore important to consider soil storage arrangements and working schedules when planning river restoration work.

Project contact: National Environmental Assessment Service, Solent and South Downs Area, South East Region, Environment Agency

CASE STUDY

Remove structures that are no longer needed

Project Summary

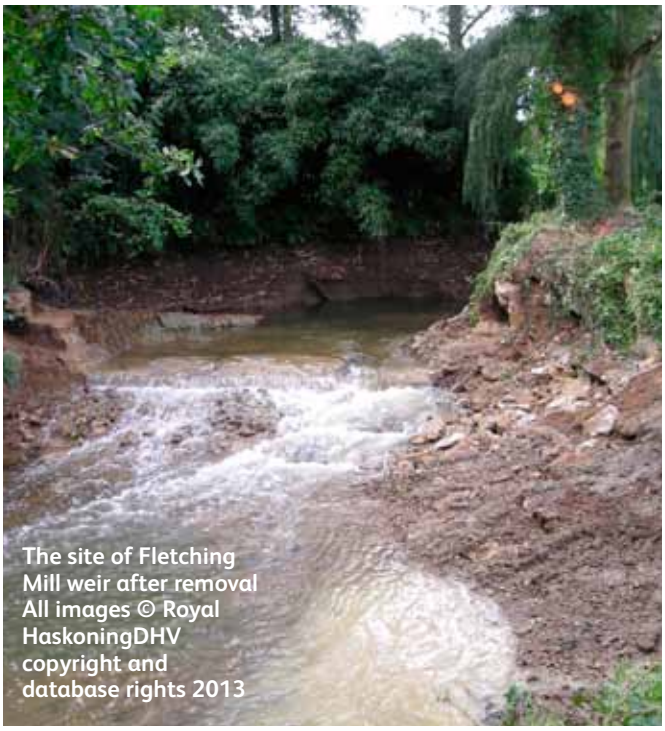
Title: Fletching Mill Weir Removal, Middle Ouse Restoration of Physical Habitats (MORPH) project
Location: River Ouse, East Sussex, England
Technique: Weir removal
Cost of technique: ~~£~~£
Overall cost of scheme: ~~£~~£
Benefits: ~~£~~£~~£~~
Dates: 2010

Mitigation Measure(s)

Remove structures that are no longer needed

How it was delivered

Delivered by: Environment Agency (Defra Catchment Restoration Fund)
Partners: Ouse and Adur Rivers Trust, Royal HaskoningDHV



The site of Fletching Mill weir after removal
All images © Royal HaskoningDHV copyright and database rights 2013

Background / Issues

At Fletching in East Sussex, the River Ouse was impounded by a fixed crest weir on the main channel and a fixed gate on the adjacent lock channel. This weir complex restricted fish passage along the River Ouse. Despite the installation of a fish pass, fish were only able to migrate over the weir during periods of high flow. As such, removal of the weir and restoration of the channel were planned by the Environment Agency as part of the MORPH project. An options appraisal for the site was undertaken and a rock ramp scheme recommended in order to achieve optimal flow apportionment between the main channel and the lock channel.

However in August 2010, before the restoration plan was implemented, the weir partially failed and markedly reduced the height of the impoundment, creating a similar environment to one which would have been achieved through restoration. As a consequence emergency removal works were planned for the weir instead.

Step-by-step

Weir collapse
In August 2010 the weir failed, markedly reducing the height of the crest (see image overleaf).

Weir removal
In September 2010 the remainder of the weir was removed with a long reach excavator. No further remedial works were undertaken.

As a result, the large impounded section upstream of the weir complex was naturally transformed. Silt deposits upstream of the weir were regraded by fluvial scour without adversely affecting channel morphology or habitats downstream. Increased flow velocities upstream of the former weir markedly increased in-channel morphological diversity, creating a more natural series of riffles and pools which support a greater range of in-channel habitats.

CASE STUDY

Benefits

- The density and diversity of fish species, including brown trout and eel, were greatly increased upstream of the weir.
- Improvement in all aspects of aquatic ecology, including habitat quality for invertebrates, macrophytes and fish upstream of the weir. Consequently, the upstream stretch now passes the WFD classification.
- The removal of the structure has led to a reduction in Environment Agency maintenance costs.

Lessons Learnt

- Significant results can be achieved from structure removal, and this scheme is an example of how quick and wider ranging the positive outcomes for aquatic ecology can be.
- Minimal intervention was required to restore morphology and habitats at the site. This reflects the low suspended sediment volume of the clay-dominated river and the availability of a riparian corridor upstream of the structure in which adaptation can occur without adversely affecting existing land use.

Project contact: Fisheries and Biodiversity Team, Solent and South Downs Area, South East Region, Environment Agency

CASE STUDY

Remove structures that are no longer needed

Project Summary

Title: Kentchurch Weir Removal
Technique: Weir removal
Location: River Monnow, Kentchurch, Monmouthshire, England / Wales
Cost of technique: ~~£~~~~£~~~~£~~~~£~~
Overall cost of scheme: ~~£~~~~£~~~~£~~~~£~~
Benefits: ~~£~~~~£~~~~£~~
Dates: 2011

Mitigation Measure(s)

Remove structures that are no longer needed
Improve channel geomorphology to create habitat

How it was delivered

Delivered by: Environment Agency Wales (now Natural Resources Wales)
Partners: UK European Fisheries Fund Operational Programme; Atkins; Cardiff University; local landowners.

River Monnow at the site of Kentchurch weir, after removal. *All images © Natural Resources Wales copyright and database rights 2013*

Removal of Kentchurch weir

CASE STUDY

Background / Issues

Kentchurch Weir was situated on the River Monnow within the Kentchurch Estate near Hereford, where the river marks the border between England and Wales (the counties of Herefordshire and Monmouthshire respectively).

In 2008, EA Wales supported by Atkins constructed a fish pass at Osbaston Weir, which is also located on the River Monnow, approximately 3 km upstream of the confluence with the River Wye. This scheme had restored habitat connectivity in the lower River Monnow catchment, after fragmentation that had lasted for centuries.

With the weir at Osbaston now being passed by hundreds of brown trout, plus salmon and other species of fish, the last remaining major barrier on the Monnow was the weir at Kentchurch, a further 20 km upstream.

There is excellent river habitat in the upper reaches of the Monnow, but the full potential of this habitat was not being realised, as it was effectively inaccessible due to the two metre high weir. The removal of the weir was preferable to creating a fish pass at the site as removing the barrier would completely reinstate full habitat connectivity and therefore generate major biodiversity improvement, and allow the uninterrupted transportation and supply of river gravels to downstream reaches.

(1) Kentchurch weir during high flows;
(2) Kenthcurch weir during low flows, just prior to removal

Step-by-step

Preparation

- The weir was inspected in 2008 as part of strategic study conducted to identify opportunities for removing barriers to fish passage within the catchment of the River Wye. This study was followed by a feasibility study regarding weir removal.
- Bathymetric (level) survey and sediment sampling and analysis were conducted to ascertain the risks of pollutant release and the increased risk of bankside failure from water level change from weir removal.

Demolition

- Weir demolition took two weeks.
- Straw bales were installed downstream to create a sediment trap during removal.
- Work commenced by slowly removing a section of the weir through demolition to bed level adjacent to the abutment on the east side of the river. The river was diverted to flow through the lowered section and the level progressively lowered to the downstream level.
- Much of the material that was excavated was recycled on site in order to reinstate access routes between the farmer's fields.
- Upstream regarding of the bed and banks to increase stability and reduce risk of significant erosional impacts.

Monitoring

- Active monitoring programme, in collaboration with Cardiff University.
- Intervention to ensure re-naturalisation of the river happens in a way that does not have unacceptable adverse consequences for other stakeholders.

(1) Straw bales in place as a downstream sediment trap; (2) Excavator lowering the first section of weir to create a flow channel; (3) Demolition of the main weir; (4) Earthworks to previous site of weir after

Benefits

- The removal of Kentchurch Weir has allowed a further 160 km of the River Monnow catchment to return to its natural condition of connectivity and flow.
- The largest weir removal project in Wales, and one of the biggest in the UK.
- The project has resulted in improved access for fish to the river's upper reaches and in the immediate vicinity of the weir.
- It also reduces the risks of poaching and predation by removing a bottleneck where fish may be held up.
- A natural environment and habitats for macrophytes and invertebrates have been restored.
- Hydromorphological conditions have been restored through natural recovery, allowing natural processes to shape the watercourse.
- Farmers received new roads adjacent to the river.

(1) River Monnow upstream of the weir prior to removal, (2) River Monnow upstream on the weir, six months after removal

Lessons Learnt

- Engagement with local research organisations can provide multiple benefits when it comes to post-construction monitoring.
- The channel has adjusted naturally with very little intervention, suggesting that future weir removal projects do not need to include for significant bed and bank re-profiling (i.e. restoration works) post demolition.

Project contact: Fisheries and Biodiversity Team, South East Area, Natural Resources Wales

CASE STUDY

Remove structures that are no longer needed

Project Summary

Title: River Uck, Buxted Park: Middle Ouse Restoration of Physical Habitats (MORPH)
Location: Buxted, East Sussex, England
Cost of technique: ££
Overall cost of scheme: £££
Dates: 2012-2013

Mitigation Measure(s)

Remove structures that are no longer needed
Improve channel geomorphology to create habitat
Preserve and improve water's edge and bank side habitats
Development of a strategy to manage sediment in an appropriate way

How it was delivered

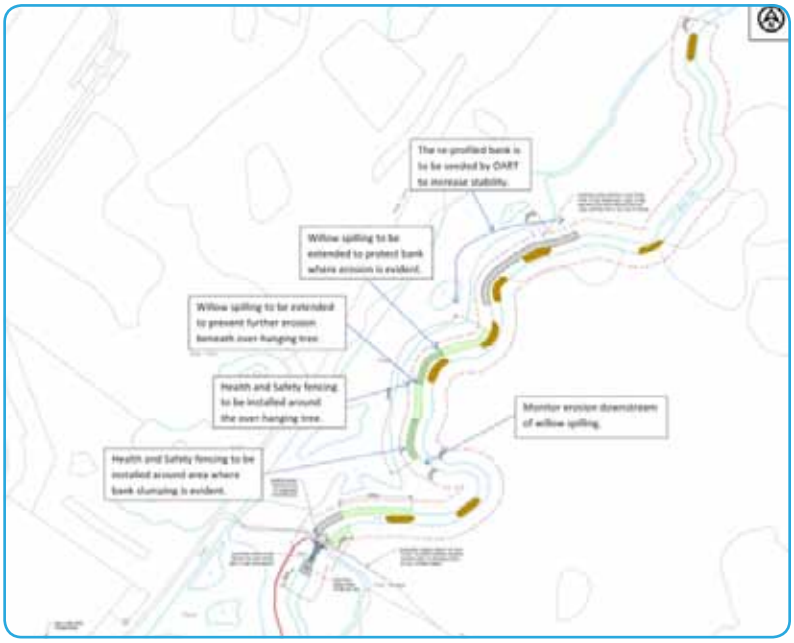
Delivered through: DEFRA / Environment Agency
Partners: Ouse and Adur Rivers Trust (OART); Royal HaskoningDHV

River Uck downstream of the weir after removal

All images © Royal HaskoningDHV copyright and database rights 2013

Background and issues

Historic modification to the watercourse for industrial and land drainage purposes included the construction of a concrete and wooden weir on the River Uck in in Buxted Park. The structure had a major influence on the river, and impoundment behind it extended for approximately 2km upstream. Prior to the MORPH project, OART in 2011 removed the wooden boards reducing the upstream impoundment and allowing the channel to begin to adapt naturally to the reduction in water levels. The MORPH project was responsible for removing the remaining parts of the structure, installing bank protection to prevent erosion capturing nearby fishing lakes, and enhancing fish habitats upstream of the structure.



Overview of the Buxted Park restoration scheme, including the weir at the southern end of the reach.
Mapping: © Odrnance Survey Crown copyright. All rights reserved. Envrionemt Agency, 100026380

CASE STUDY

Step-by-step

Summer 2012 – Spring 2013:

- The concrete weir was removed, including the wing walls and metal components, leaving the concrete apron. The banks were reprofiled and the weir pool was infilled using rock and gravel material;
- Kentish Ragstone gravel (sized between 20-40mm), selected to encourage barbel, chub and dace, was used for gravel seeding of key locations on the inside of meander bends throughout the reach;
- Willow spilling was installed to protect footpaths and ornamental fishing lakes where essential;
- Bank reprofiling was undertaken in high-risk areas at the downstream end of the reach.

Clockwise: (1) Weir prior to works; (2) weir after wingwall / metal removal; (3) construction of gravel beds; (4) willow spilling protecting reprofiled right hand bank.

Benefits

- The reduction in water levels has allowed the banks to collapse naturally, markedly increasing morphological diversity in this formerly uniform reach;
- Seeded gravels have successfully supplemented the naturally occurring gravels in the reach to create areas of increased flow diversity and depositional features. The features have been reworked during large floods but remain in place;
- The new natural bank profiles, in-channel features and gravel deposits provide valuable habitat for coarse fish species, aquatic invertebrates and plants.
- Targeted bank reprofiling and installation of willow spilling is effectively preventing erosion of the bank toe, and has stabilised vulnerable banks adjacent to the footpath and fishing lakes. This has been used sparingly to maximise the operation of natural processes.

Lessons Learnt

- The phased approach to structure removal allowed the river to begin responding to a reduction in water levels before bank protection measures were installed at vulnerable locations. This minimises the impact on natural processes and demonstrates that extensive bank reprofiling is not necessary at a relatively unconstrained rural site.

Project contact: Fisheries and Biodiversity Team, Worthing, Environment Agency

CASE STUDY

Replace flood walls with earth banks

Project Summary

Title: River Brent – Tokyngton Park Project
Location: Wembley, North West London, England
Technique: Removal of concrete banks; creation of new natural banks
Cost of technique: ~~£~~£~~£~~£
Overall cost of scheme: ~~£~~£~~£~~£~~£~~
Benefits: ~~£~~£~~£~~£~~£~~
Dates: 1999 – 2003

Mitigation Measure(s)

Replace flood walls with earth banks
Appropriate vegetation control technique
Improve channel geomorphology to create habitat

How it was delivered

Delivered by: Environment Agency
Partners: London Borough of Brent; London Waterways Partnership; London Development Agency; European Regional Development Fund; local community.

Earth banks after removal of concrete reinforcement.
All images © Environment Agency copyright and database rights 2013

Background / Issues

A long history of flooding in the River Brent fuelled a programme of flood alleviation between the 1940s and 1970s, which straightened the channel and protected significant sections of its bed and banks with concrete reinforcement in order to maximise channel capacity and flow conveyance.

This channelisation of the River Brent was accompanied by the loss of in-channel features and disconnection of the river from its natural floodplain. In addition to providing poor habitats for wildlife, the amenity value was very low as the River Brent provided little or no recreational value for park users.

As part of a project to improve the diversity and quality of in-channel habitats in the River Brent while providing amenity improvements for Tokyngton Park, a total of 2 km of the river were restored. This included the renaturalisation of the river banks by replacing the concrete flood walls and reinforced banks with earth banks.

Outline of the River Brent Park Project (only Phase 1 sections have been completed so far – Phase 2 is awaiting additional funding)

CASE STUDY

Step-by-step

The scheme aimed to restore the river and change the hydromorphological regime of the River Brent as it flows through the park, including:

- Removal of concrete banks and creation of a new meandering course of the channel following the same alignment as a historic course of the river. The former alignment was in-filled.
- Maintenance of the same level of flood protection through the use increase connectivity with the floodplain – the park now acts as a temporary flood storage area.
- Stabilisation of the new earth banks by using the crushed concrete removed from the former channel and the use of live willow poles to stake these in. This ensures the banks to not erode heavily and stay in place.
- Where flood risk did not represent a significant risk to nearby properties, banks were left to renaturalise and naturally adjust to the new flow conditions in the channel.

1) Brent park during construction (2003)
2) restored reach (2005)

Benefits

This project offered a significant contribution to biodiversity, ecology and amenity at a local-scale, including:

- The restoration of the original channel planform and natural development of in-channel features such as pools and riffles has improved the quality of local habitats.
- Local diversity of plants and animals has been increased through restoration of the channel and riparian zone.
- The project contributed to creating a more attractive, diverse and attractive open space for the local community while maintaining the previous level of flood protection.

Lessons Learnt

- Inclusion of river restoration projects in wide urban regeneration initiatives can significantly increase benefits to local population.
- Involvement of universities as partners in the project can significantly boost potential for long-term monitoring.

Project contact: Fisheries & Biodiversity, Thames Area, South East Region, Environment Agency

CASE STUDY

Replace flood walls with earth banks

Project Summary

Title: Yeading Brook
Location: Yeading Brook, Ruislip, NW London, England
Technique: River bank restoration as part of a redevelopment
Cost of technique: £
Overall cost of scheme: £
Benefits: ££
Dates: 2004 - 2005

Mitigation Measure(s)

Replace flood walls with earth banks

How it was delivered

Delivered by: Funded as part of site re-development
Partners: Private developer, London Borough of Hillingdon and Environment Agency

Pre-development 2004 - an unappealing drain All photos © Environment Agency copyright and database rights 2013

Background / Issues & Step-by-step

A site on the left bank of Yeading Brook came up for redevelopment prior to the production of the first round of RBMPs. As part of the redevelopment, the developer was asked to remove the concrete river wall and re-grade the river banks in order to increase flood storage and restore more natural riparian habitat. The developer undertook a flood risk assessment as part of the consenting process and agreed to include a previously shelved EA bank restoration design as part of a Flood Defence Consent application. 40m of river banks were first regraded behind the concrete wall and excess spoil was reused across the site. The concrete walls were then broken out and removed off site. Low level wooden boarding was installed along the toe of the re-graded bank to protect it from erosion and avoid any potential impacts on the adjacent development. The banks were then planted with a native wildflower mix. The opposite bank could not be restored as it supports a major road and limited space was available.

CASE STUDY

Benefits & Lessons Learnt

- The reprofiling has created a naturally functioning marginal and riparian zone that is closely connected to the river.
- Greater wildlife benefit.
- Natural river bank restored.
- Vegetated buffer strip created that acts as a runoff interceptor.
- A higher quality environment created on the development site for people.
- A cheap and easy example of how to implement mitigation measures on the back of development to meet requirements of the WFD whilst improving the overall development.

Post-development 2005 – an emerging river

Project contact: Flood and Coastal Risk Management, North West Thames Area, South East Region, Environment Agency

CASE STUDY

Reposition or alter river embankments to create a natural floodplain

Project Summary

Title: Long Preston Deeps Restoration
Location: Long Preston, North Yorkshire, England
Technique: Construction of set-back embankments
Cost of technique: ~~£~~£~~£~~£
Overall cost of scheme: ~~£~~£~~£~~£
Benefits: ~~£~~£~~£~~£~~£~~
Dates: 2011 – 2012

Mitigation Measure(s)

Reposition or alter river embankments to create a natural floodplain

How it was delivered

Delivered by: Environment Agency
Partners: Natural England, Jacobs

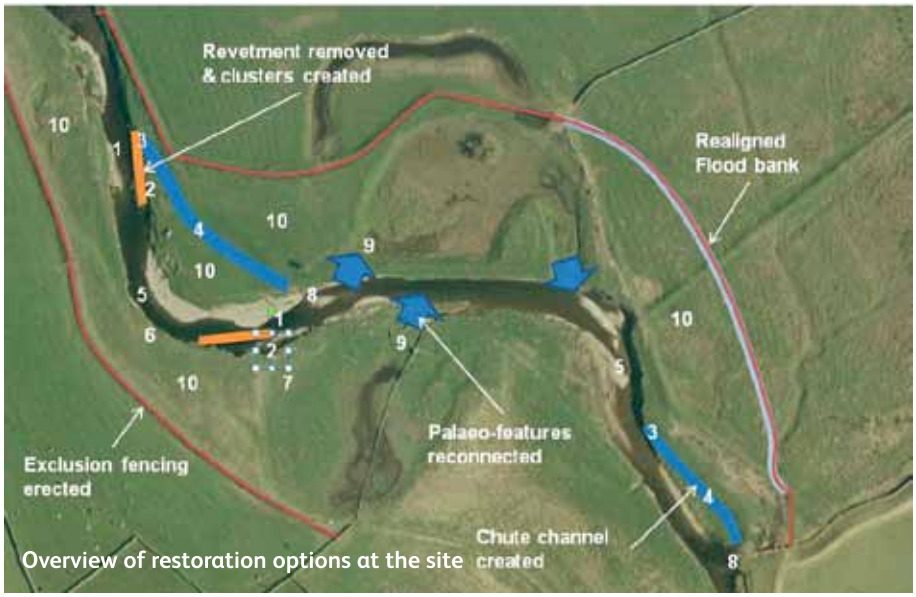
New set back embankment at Long Preston. *All images © Environment Agency copyright and database rights 2013*

Background / Issues

A 7 km long reach of the River Ribble near Settle in North Yorkshire is designated as the River Ribble (Long Preston Deeps) SSSI, which covers the river and localised areas of the floodplain.

As part of the North West River Basin Management Plan (RBMP), the Long Preston Deeps Restoration Plan was developed aiming to promote the restoration of the floodplain, attenuating flows in the upper Ribble catchment and reducing flood risk downstream. The plan included a significant degree of alteration of river embankments.

The river and floodplain at Long Preston Deeps have undergone considerable modification over time and are subject to land management pressures including flood embankments to protect agricultural land. Significant alterations to the physical form and function of the river have occurred historically, which in turn have affected the flora and fauna across the entire site. As a result the system was degraded and displayed few of the geomorphological and ecological features expected under more natural conditions.



Overview of restoration options at the site

CASE STUDY

Step-by-step

The implementation of the Long Preston Deeps restoration plan in regards to the alteration of embankments was achieved through the:

- Removal of the embankment adjacent to river channel to a level of 125.5 m AOD to reduce the height of structure
- Construction of a new embankment, set bank from river margins varying between 1 m and 10 m at a level of 126.5 m AOD (higher to increase flood protection). This created approximately 7,500 m^2 of additional floodplain.
- Materials used for construction of the embankments were partly obtained from excess spoil. Scrapes were created on the floodplain to source the material.
- Seeding of new embankment during construction.
- Grass, wet woodland and wildflower meadow seeding of the new floodplain area that was previously occupied by the original embankment.

View of new floodplain during construction

Newly created floodplain

Benefits

The scheme has resulted in:

- A reduction in stream power at flows above bankfull, influencing local sediment transport by encouraging sedimentation during out of bank flows, and reducing erosive pressure that previously eroded the banks.
- Fine sediment deposition on the floodplain, providing nutrients to floodplain habitats and reducing deposition on gravel features in the main channel.
- The floodplain has been planted with wet woodland species, therefore increasing the ecological diversity and flow diversity locally as a source of large woody debris to the river channel.
- An improvement in the status of the SSSI, which has been moved from 'unfavourable' condition to 'favourable recovering'. This will make favourable condition achievable once further natural recovery has occurred.

Flooding across Long Preston Deeps

Lessons Learnt

- Landowner support was instrumental in ensuring project success. This was achieved through the appointment of a Higher Level Stewardship (HLS), project officer in partnership with the RSPB who supported the successful entry of landowners into the Higher Level Stewardship scheme HLS.

Project contact: Restoration & Creation Team, North West Region, Environment Agency

CASE STUDY

Reposition or alter river embankments to create a natural floodplain

Project Summary

Title: Elgin Flood Alleviation Scheme
Location: Elgin, Moray, Scotland
Technique: Construction of set back embankments; flood plain lowering
Cost of technique: ~~£~~£~~£~~£
Overall cost of scheme: ~~£~~£~~£~~£~~£~~
Benefits: ~~£~~£~~£~~£~~£~~
Dates: 2012 - 2014

Mitigation Measure(s)

Reposition or alter river embankments to create a natural floodplain
Replace flood walls with earth banks
Allow the river to flood its floodplain
Preserve and improve water's edge and bank side habitats
Retain and improve existing water's edge and bankside habitats in modified watercourses
Use green engineering techniques instead of hard bank protection

How it was delivered

Delivered by: Scottish Government (Flood Prevention) and Moray Council
Partners: Moray Council, Royal HaskoningDHV, Morrison Construction and EC Harris

All images © Royal HaskoningDHV copyright and database rights 2013

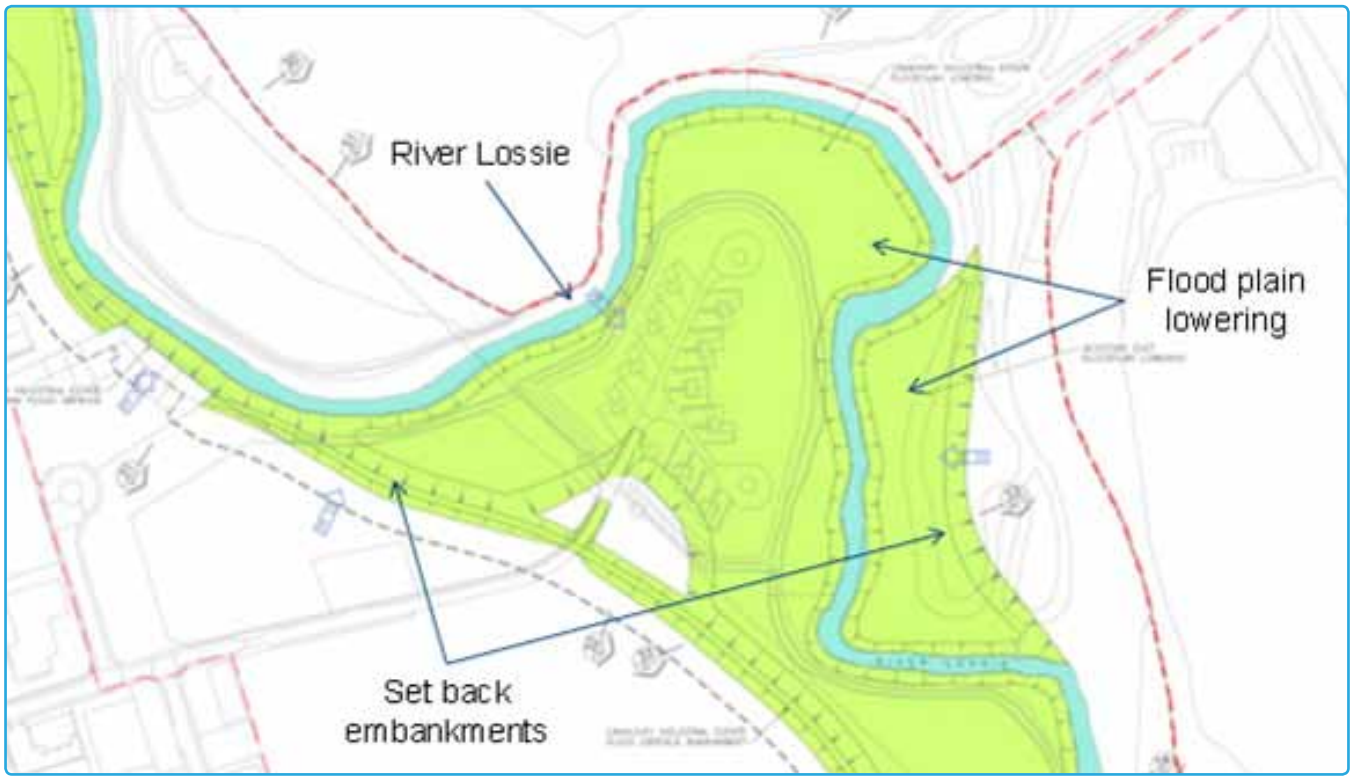
The project has provided protection to Elgin from a 1 in 200 year flood event through the recreation of flood plains through the city, removing numerous constrictions to flow, setting back embankments from the river channel, creating a flood relief channel and diverting two burns

CASE STUDY

Background and issues

The historic city of Elgin is subject to flooding from both the River Lossie and the Tyock Burn, which has affected approximately 600 residential properties and 120 commercial properties. Development on the floodplain and the construction of embankments adjacent to the river has resulted in a number of constraints to natural flooding in the area, disconnecting the river from the floodplain and reducing its ability to cope with flood events.

The flood alleviation scheme aimed to provide 1 in 200 year flood protection for the City of Elgin, considerably reducing the flood risk to people and properties. This was achieved by creating more space for the online storage of flood waters, by reconnecting the river with the natural floodplain, ground lowering and setting back embankments as far as possible within the urban setting of Elgin. This means that water can be safely stored without affecting nearby assets and infrastructure.



Example design of the Elgin Flood Alleviation Scheme. This section indicates the floodplain lowering and set back embankments used around the Moycroft and Chanonry section of the River Lossie. The full scheme involved modification to 1.5km of the River Lossie, Tyock Burn and Linkwood Burn.

Step-by-step

The development of the scheme can be divided into 4 main stages:

Identification and Assessment of Options: 25 options were assessed and three viable options were identified. A range of studies were undertaken including geomorphological walk over surveys to characterise the functionality of the river, hydraulic modelling, geotechnical investigations; ecological surveys and contaminated land investigations. These studies provided the information required to make a detailed assessment of the three options and identify the preferred option.

Outline Design: Using the information obtained in the assessment stage, additional hydraulic modelling, and more detailed geomorphological assessments and ecological surveys, the design team (comprising of environmental scientists and engineers) identified the optimum locations for the set back of embankments and floodplain lowering, and determined the necessary dimensions to achieve the required standard of protection. Details of a flood relief channel and flood walls in areas where embankments could not be set back from development were also included at this stage. The outputs were then used to produce drawings to support a planning application.

Detailed design: During the detailed design stage of the project, the outline design was developed to produce drawings which were suitable for construction. Details about the types of embankment cores and toe drainage were included in the final design and drawings as were details of wall reinforcement. In addition, details relating to site compound layout and finalised access routes were detailed.

Construction: The construction stage of this project (April 2012 – March 2015) will involve:

- The creation of over 5 km of set back embankments (completed 2012).
- The creation of 21 hectares of lowered floodplain.
- The creation of 1.5 km of new watercourse, the creation of a 300 m flood relief channel and the realignment of a 180 m stretch of the River Lossie.
- The construction of three new clear span bridges.
- The demolition of a small number of residential properties, commercial properties and four bridges. These obstacles provided significant constraints to the operation of the flood alleviation scheme, and in the case of the residential properties had been constructed without planning permission.

(1) Existing flood embankment to be breached, with set back embankment constructed behind; (2) Flood plain to be lowered behind embankment shown here, with set back embankments constructed and buildings removed; (3) Bridge to be removed.

CASE STUDY

Benefits

- Alleviation of flooding in Elgin.
- Recreation of a naturally functioning floodplain which is connected to the river.
- Creation of wet meadow habitats.
- Creation of riparian wet woodland.
- Waste minimisation – material from flood plain lowering used for construction of embankment.
- Increased amenity value of the water's edge for the public.
- Contribution towards maintenance of the water body's good ecological status.

New flood alleviation measures at Elgin after construction

Lessons Learnt

When creating set back embankments, a key requirement is to balance the construction programme with the seeding programme so that seeds are sown as soon as the embankments are completed and in a time that is right for the seed to germinate. Failing to factor this into the initial planning can lead to a failure of the seeding programme, requiring reseeding at a later date, and delaying the date at which the embankments regain their amenity / landscape value.

Site selection is important when identifying which areas can set back embankments. Negative press was generated when an illegal traveller's site (constructed without planning permission) was demolished to make space for the new floodplain.

Project contact: Environment and Planning Department, The Moray Council

CASE STUDY

Preserve and improve water's edge and bank side habitats

Project Summary

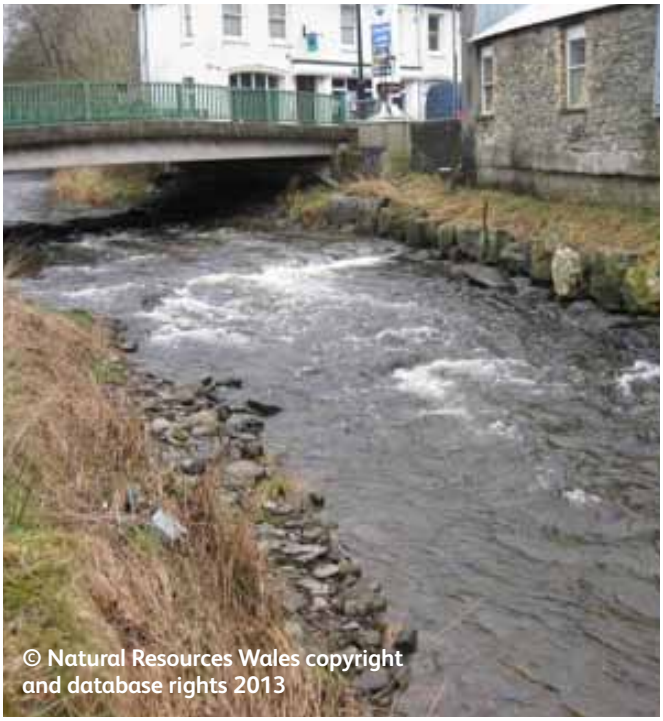
Title: Afon Brennig Flood Alleviation Scheme
Location: Afon Brennig, Tregaron, Wales.
Technique: Installation of rock revetments
Cost of technique: £££
Overall cost of scheme: £££££
Benefits: £££
Dates: 2008

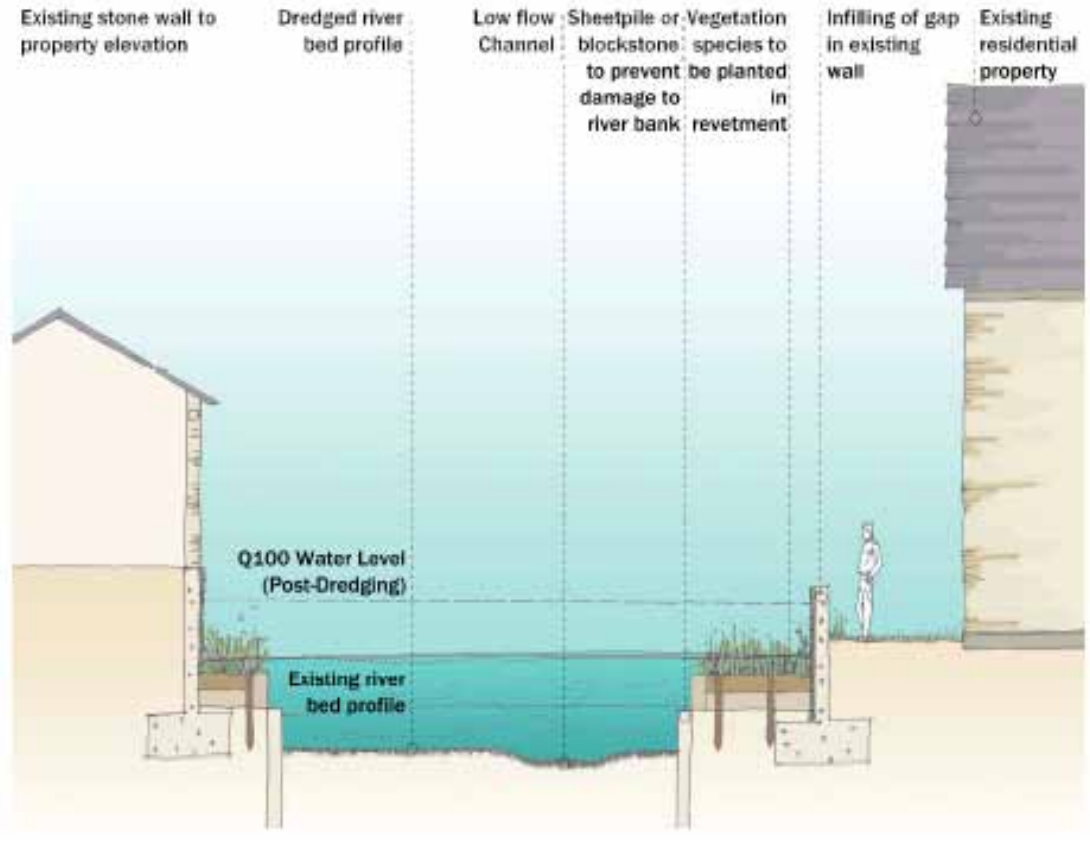
Mitigation Measure(s)

Preserve and improve water's edge and bank side habitats
Improve channel geomorphology to create habitat

How it was delivered

Delivered by: Environment Agency Wales (now Natural Resources Wales)
Partners: Arup


© Natural Resources Wales copyright and database rights 2013



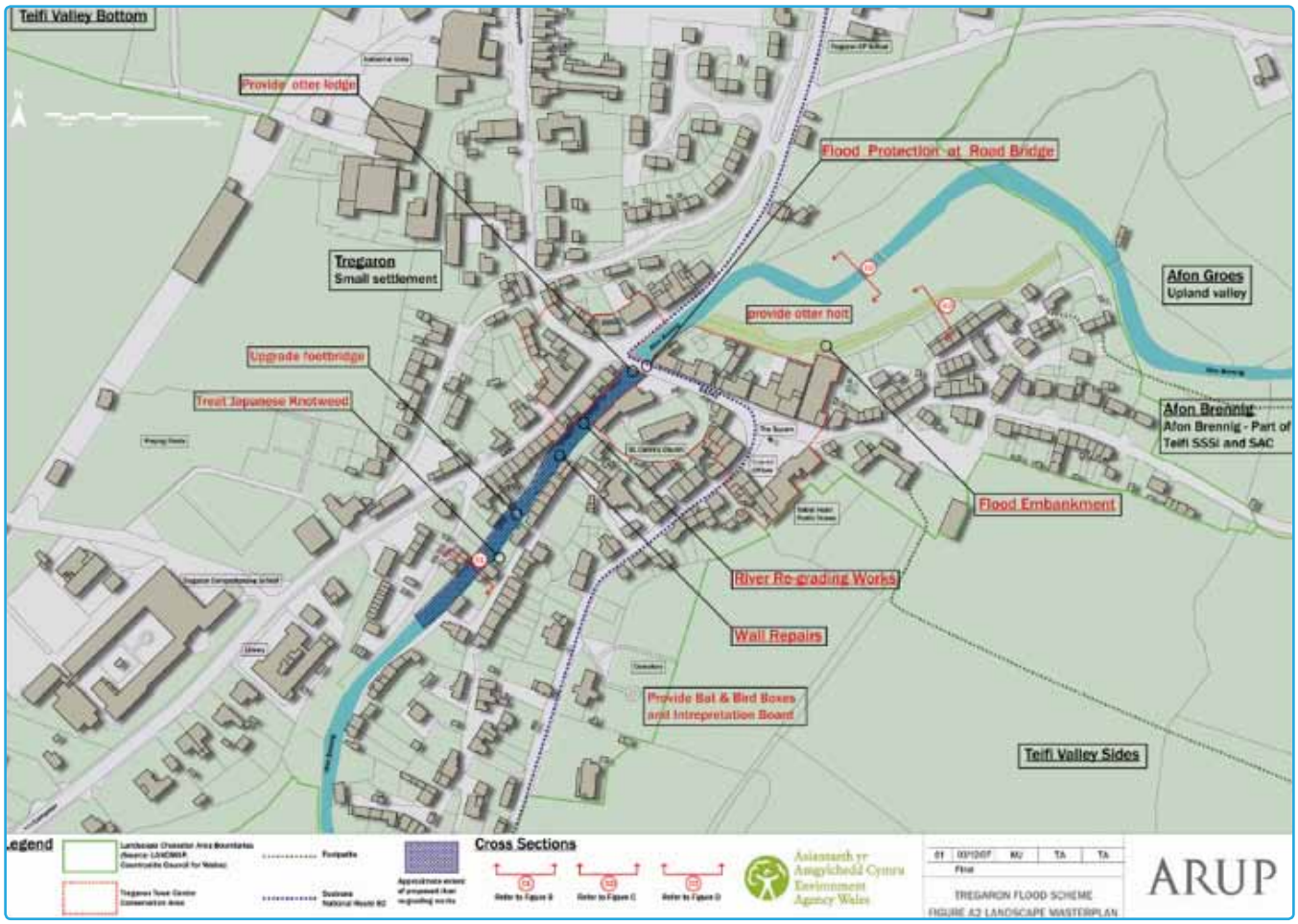
Channel cross section: schematic design © ARUP copyright and database rights 2013

Background and issues

The Afon Brennig is situated in Tregaron in Ceredigion, mid Wales. The river is an upland tributary of the Afon Teifi, which flows into Cardigan Bay at Cardigan. The Afon Brennig and its tributaries, the Groes and the Berwyn, rise on the edge of the Cambrian Mountains (specifically Bylchau'r Llyn, Garn Gron and Esgair Fawr). The Afon Brennig is located within the Afon Teifi SAC and SSSI, which is designated due to the vegetation, fish and mammal communities that it supports.

The river has a moderately sinuous, meandering planform, which appears to be predominantly natural. However, the channel has been heavily engineered for a length of approximately 200m as it flows through Tregaron, where it is encroached on by residential development. This urban development pre-dates the first edition Ordnance Survey mapping of the area, which was published in 1889. The channel has not changed significantly since this time, although two small offtakes associated with historical milling are no longer present. A weir at the downstream of St. Caron's church that was associated with one of these offtakes was removed at some point between 1905 and 1964.

Tregaron previously had a long history of flooding, with up to 133 residential and commercial properties at risk. Those flood defences that were in place prior to 2008 generally formed part of buildings or property boundaries, and were not specifically intended to be flood defence assets. A flood alleviation scheme was constructed on the Afon Brennig in 2008 in order to alleviate flooding in Tregaron. As part of the flood alleviation scheme, the defences through the town were formalised, with new concrete walls, additional protection to the main road bridge, and the installation of new revetments to narrow the channel. In addition, a redundant sewer which previously impounded flows was removed and the bed regraded accordingly.



Flood alleviation scheme design overview © ARUP copyright and database rights 2013.

Step-by-step

Several mitigation measures were implemented as part of the flood alleviation scheme, alongside the installation of concrete flood walls and structural modifications to the road bridge to prevent overtopping. These measures consist of the following:

- A redundant surface water sewer that was located in the middle of the reach influenced by the flood alleviation scheme was removed. This structure formerly acted as a weir.
- A 215 m-long reach of the Afon Brennig as it flows through Tregaron was regraded, with the depth of the channel increased to an average of 600 mm below the original bed level. The regraded bed incorporated a series of pools and riffles at a spacing of approximately 35 m. A blockstone check structure was installed at bed level at the upstream end of the regraded section to prevent erosion propagating upstream. The regraded bed replaced the drop in bed levels originally formed by the sewer.
- A blockstone and planted earth revetment was constructed along both banks of the regraded reach to prevent increased scour of the existing channel boundary walls.

(1) Blockstone check structure preventing upstream erosion, (2) Bar forming on right-hand bank.

(3) Rock and geotextile revetments and a blockstone check structure at the upstream end of the regraded reach; (4) Rock and geotextile revetments on both sides of the channel.

© Royal HaskoningDHV copyright and database rights 2013

CASE STUDY

Benefits

- Improved flood protection for 133 residential and commercial properties in Tregaron.
- The regrading of the bed and deepening of the bed level in the reach through the centre of Tregaron has created a series of riffles and pools, with lateral gravel bars at the channel margins. This has created a range of physical conditions that can support a variety of ecological niches.
- The installation of rock revetments on either side of the river has successfully narrowed the channel and created riparian habitats in a reach that previously had entirely artificial banks.

Example colonised vegetation

Increased channel sinuosity

© Royal HaskoningDHV copyright and database rights 2013

Lessons Learnt

- Whilst good morphological diversity has been achieved through the scheme, it may be possible to improve the range of habitats supported by creating higher gravel deposits in places (potentially graded onto the permanent banks) to ensure that a greater quantity of sediment is exposed during flows that are above base levels.
- Where possible, the use of "softer" alternatives to large boulders should be explored when revetments are used to narrow a river channel. The rocks used here produce a very abrupt and immobile transition between the banks and river channel, and as such limit the potential for the development of riparian habitats.
- The range of plants found on revetments could potentially be increased with planting of suitable native species rather than grasses.

Project contact: Flood & Coastal Risk Management, Mid-Wales Team, Natural Resources Wales

CASE STUDY

Restore aquatic habitats in modified watercourses

Project Summary

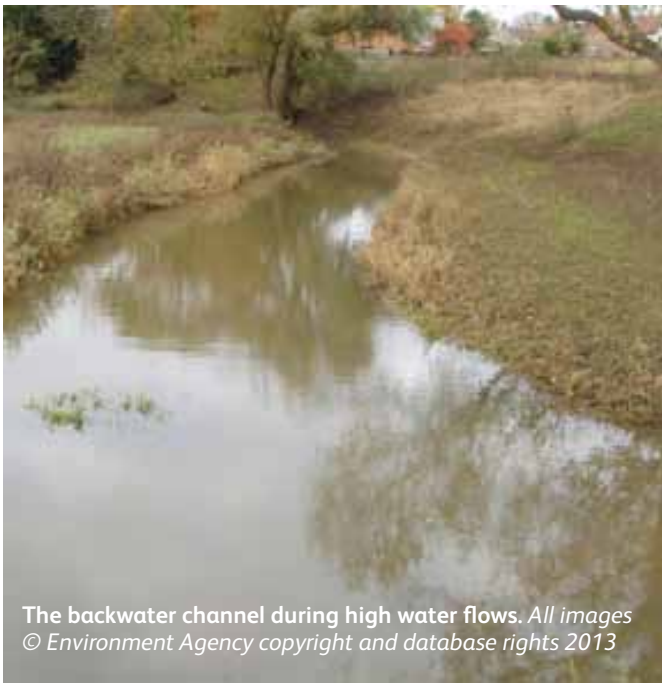
Title: Radwell Backwater Restoration Project
Location: Radwall, Bedfordshire, England
Technique: Vegetation clearance and bank re-profiling of backwater channel
Cost of technique: ££
Overall cost of scheme: ££
Benefits: ££
Dates: 2012

Mitigation Measure(s)

Restore aquatic habitats in modified watercourses

How it was delivered

Delivered by: Environment Agency
Partners: Water Framework Directive funding via the Great Ouse Wetland Vision

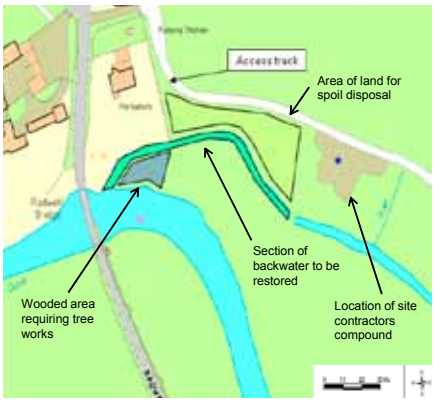


The backwater channel during high water flows. *All images © Environment Agency copyright and database rights 2013*

Background / Issues

Environment Agency fish population surveys and angling catches show that there has been a decline in fish populations in some sections of the upper Great Ouse since 2009. Barbel, chub and roach populations appear to be most affected. A combination of predation of spawning areas by signal crayfish and otters, poor spawning habitat and in particular a lack of suitable refuge areas for juvenile fish that enable fish to shelter from predators and unsuitable weather conditions.

Upstream of Radwell Bridge on the River Great Ouse there is a 500 m section of unmaintained backwater channel that has been allowed to overgrow and over time became cut off from the main channel. Although the Radwell backchannel is classed as "Main River" in terms of flood defence it has received no maintenance for over twenty years. This has resulted in the watercourse becoming heavily silted and densely vegetated with reed sweet grass. The channel is virtually dry in low flow spring / summer conditions but contains water during the autumn / winter months due to runoff and overland flow.



(1) Upstream section of unrestored backwater near to an old farm bridge; (2) Design layouts for restoration works. *Mapping © Environment Agency copyright and database rights 2013. © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380*

CASE STUDY

Step-by-step

During February and March 2012 the Environment Agency restored 130 m of the backwater feature through vegetation clearance as part of the Great Ouse Wetland Vision project.

Approximately 650 m^3 of silt and dense vegetation were removed, opening up the back channel as an off-river refuge. Vegetation was removed to expose the soft sediments that had filled in the channel, and this was then removed to restore the previous bed and bank profile. Sediment arising from the excavation was used to create a slight levee (embankment) leading from the backwater channel on to the floodplain.

This created a suitable refuge area for fish to use during high flow conditions in the main river. The project also created a ford, a sheep drinking area and included reseeding of a small woodland area with native woodland plant species.

(1) Backwater channel prior to restoration works
(2) Backwater channel post restoration works

Benefits

- A fish population survey on 13th November 2012 in the restored backwater found 12 coarse fish species where previously there was no opportunity for fish populations to survive. The survey provided evidence the restoration project was a success and future opportunities to create similar off-river refuge areas that are able to support fish spawning and areas of shelter will be investigated.
- The restored river channel created additional off-stream flood storage potential.

(1) Restored channel during high flows

Lessons Learnt

- A small restoration project such as this can yield significant returns in terms of juvenile fish species supported. Only 130 m of channel (of a possible 500) were restored, but an increase in juvenile fish (from zero) was found within the channel in the first year.

Project contact: Fisheries and Biodiversity Team, Central Area Office, Anglian Region, Environment Agency

CASE STUDY

Use green engineering techniques instead of hard bank protection

Project Summary

Title: River Cole river restoration
Location: River Cole, Shard End, Birmingham, England
Technique: Removal of sheet piling and concrete bank protection
Cost of technique: £~~£~~£
Overall cost of scheme: £~~£~~£
Benefits: £~~£~~
Dates: 1992-1997

Mitigation Measure(s)

Use green engineering techniques instead of hard bank protection
Improve channel geomorphology to create habitat

How it was delivered

Delivered by: Birmingham City Council, Metropolitan Borough of Solihull
Partners: English Nature, Environment Agency, Wildlife Trust for Birmingham and the Black Country

All images © Environment Agency copyright and database rights 2013

(1) Area of sheet piling prior to works (1994); (2) The same section of bank after removal of the piling and a period of natural development (2011).

CASE STUDY

Background and issues

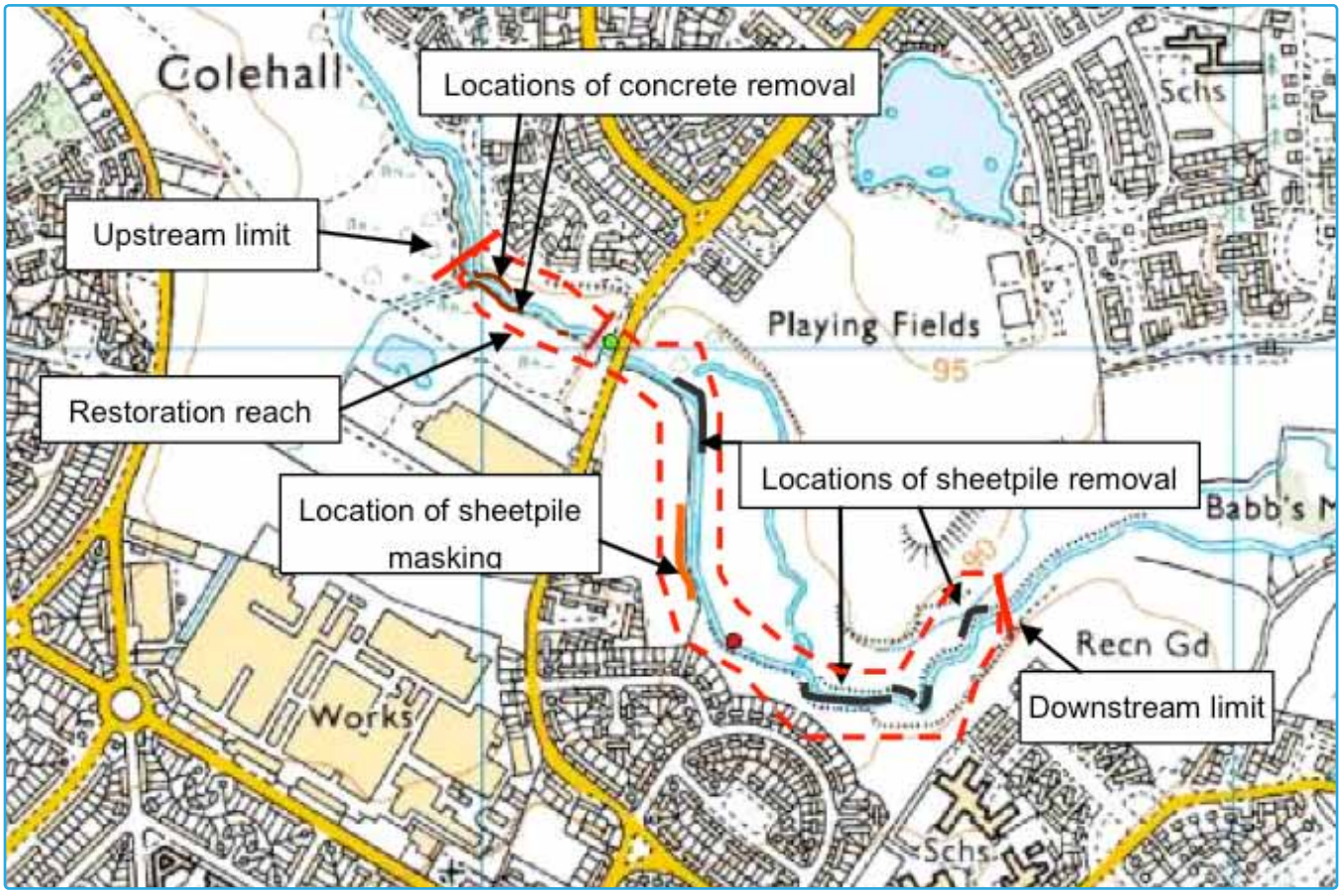
The River Cole rises in Red Hill to the south of Birmingham. The river flows through arable fields in the upper reaches and urbanised areas in the mid to lower reaches, before discharging into the River Tame at Blyth End. Prior to restoration, this reach was heavily modified with concrete banks upstream of Lea Ford Road bridge and sheet piled reinforced banks downstream of the bridge.

Project Kingfisher was established in 1985 with the overall aim of caring for the valley of the River Cole, improving it both for people and wildlife. The project created Kingfisher Country Park in July 2004, which consists of an 11 km stretch of the River Cole running from the Coventry Road (A45) at Small Heath as far downstream as the M6 at Chelmsley Wood.

As part of Project Kingfisher, the Shard End reach of the River Cole was restored in two phases:

- Phase 1: In 1994, the sheet piling upstream of Lea Ford Road was removed. A stretch of sheet piling close to residential properties on Fordfield Road had to remain in place so it was instead masked to reduce the visual impact and allow natural habitats to develop in front of it.
- Phase 2: In 1997, the concrete channel downstream of Lea Ford Road was removed. Some banks were re-profiled as part of the bank protection removal process to provide more of a natural "tick-shape" channel cross section, allowing natural erosion and deposition processes to operate in the rehabilitated channel.

The improvements were designed to function naturally without the need for maintenance, resulting in sustainable rehabilitation of the channel for the majority of this reach.



Schematic of the restoration works along the River Cole through Shard End
Mapping: © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380

Step-by-step

Phase 1: Sheet pile removal (1994)

- Approximately 405 m of sheet piling was removed in discrete lengths from seven different locations (generally on the right bank). The longest continuous length removed was 50 m long and in some cases the banks were reprofiled following removal of the sheet piling.
- A 50 m length of sheet pile was retained and masked with spoil and rocks to form new berms at the bank toe. Willow branches were also planted in the new toe material, and the berms were subsequently colonised by vegetation.

Phase 2: Concrete bank removal (1997)

- Approximately 54 m of concrete bank protection on the left bank and 75 m on the right bank were removed and reprofiled as part of the deculverting project at Yardley Brook which joins the River Cole approximately 200 m upstream of Lea Ford Road bridge.
- In some places, concrete was simply broken up and retained in situ to allow established trees to continue to inhabit the banks.
- A failing outfall was removed from the left bank upstream of the road bridge.

Sheet pile removal works

Concrete bank removal works

CASE STUDY

Benefits

- The removal of sheet piling and concrete bank protection on the River Cole has allowed the channel to adjust in a natural fashion, changing the flow conditions and resulting in increased morphological diversity and the reinstatement of natural processes. The channel has widened and meanders have migrated by more than a metre (similar changes have occurred in unprotected reaches downstream of the site).
- The removal of hard bank protection has resulted in the creation of new habitat niches due to the more natural banks forms and the creation of an active channel with a plentiful supply of coarse sediment. The renaturalised sediment regime has created a range of depositional features in the channel, including coarse sediments and fine sediments which support a range of different habitats.
- The masked sheet piling is now completely overgrown with willows, providing valuable organic matter and shading to the reach.
- This stretch of the watercourse is now followed in part by the Cole Valley Way Long Distance Path, bringing people in contact with the restored watercourse.

(1) Banks prior to removal of sheet piling; (2) The same banks post-removal

Lessons Learnt

- By allowing the river to adjust naturally, the channel has increased in overall geomorphological diversity with features such as eroding bank cliffs, gravel riffles and shoals, point bars creating a range of different flow types and riparian habitats.
- In active alluvial rivers such as the River Cole, designers should consider allowing natural processes to operate rather than artificially regrading the banks. Ungraded sections have stabilised more effectively as they have been undercut, failed and naturally regraded with a vegetated toe.
- The masking of the sheet piling one location (where it could not be removed has been effective and this is largely due to the planting of willows in front of the structure. This technique could be considered in the future for other locations, although factors such as velocity, bed gradients and channel type need to be taken into account.

Project contact: Environment and Regeneration Team, Birmingham City Council

CASE STUDY

Use green engineering techniques instead of hard bank protection

Project Summary

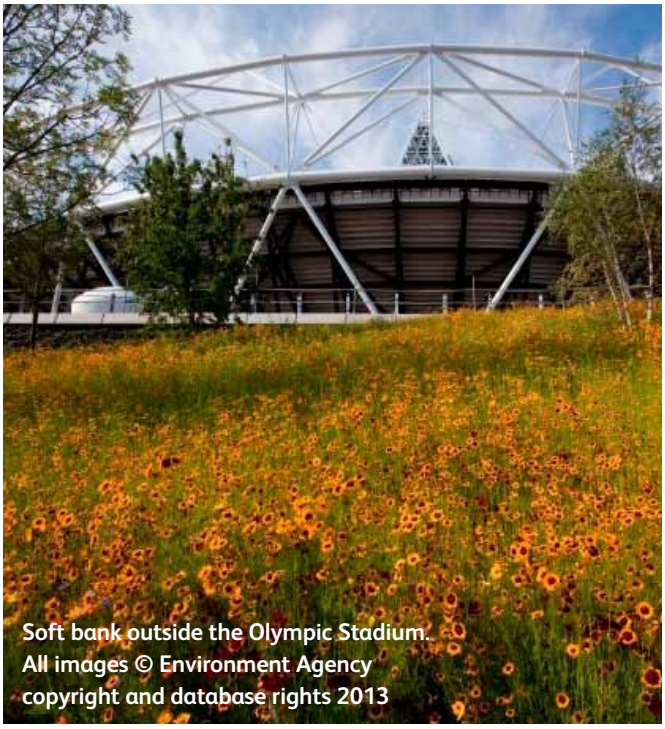
Title: City Mill River, Olympic Park
Location: Stratford, East London, England
Technique: replacing hard banks with soft revetment
Cost of technique: ££££
Overall cost of scheme: ££££
Benefits: £££
Dates: 2009 - 2011

Mitigation Measure(s)

Use green engineering techniques instead of hard bank protection
Restore aquatic habitats in modified watercourses
Replace flood walls with earth banks

How it was delivered

Delivered by: Olympic Delivery Authority
Partners: Environment Agency; Canals and River Trust



Soft bank outside the Olympic Stadium.
All images © Environment Agency copyright and database rights 2013

Background / Issues

The reach of City Mill River running through the Olympic Park had banks comprised of concrete wall revetments, and was bounded by industrial land. Prior to restoration, the reach had low ecological value, poor aesthetic condition and was failing to reach required water quality standards.

It was decided to restore the river as part of the developments at the Olympic Park due to its proximity to the site and the significant investment in the area. Improvement works downstream of City Mill River meant that catchment benefits could be realised, rather than localised improvements, and the Environment Agency had the opportunity to work with local stakeholders and developers that were enthused to be associated with the Olympic project works. The aim of the scheme was to create a better landscape setting for park venues with improved habitat, water quality and flood risk management. This involved the removal of the walls and development of natural banks with sensitive planting.

General negiect of the waterways in East London, leading to poor water quality, poor flood defences, low value ecology, poor public access to waterways

CASE STUDY

Step-by-step

A structural survey of all river walls within the reach was undertaken to determine the integrity of structures for future "fit for purpose". A variety of different works were then undertaken depending on the condition / situation of each stretch:

- Where hard protection was required and the assets were in a reasonable condition, they were repaired.
- Where hard protection was required but the assets were failing, they were demolished and rebuilt.
- In locations where a green engineering solution was deemed to provide sufficient protection, the concrete structures were removed and replaced with a soft revetment that delivered environmental improvements.
- Sheet piling was set further into the channel (to narrow it and increase flow diversity) and earth placed behind to enable planting and re-profiling.

Contaminated land was an issue, but was dealt with on a site wide basis using a global remediation strategy, enabled by delivery partner contractors, prior to construction.


Original river bank


River frontage under construction


Complete revetment

Benefits

- Restoration of natural river bank where hard defences were not required or were failing along the reach.
- Improved water's edge and bankside habitat creation at these locations.
- Improved public access to watercourse.

Lessons Learnt

- Early engagement with developer via a partnership approach to take advantage of enthusiastic stakeholder engagement and to agree scope of works yields project efficiency savings further down the line.
- Sediment washing of contaminated land is an effective method for dealing with constructions and restorations in heavily industrial areas.

Project contact: London Environment Team, Environment Agency

CASE STUDY

Use green engineering techniques instead of hard bank protection

Project Summary

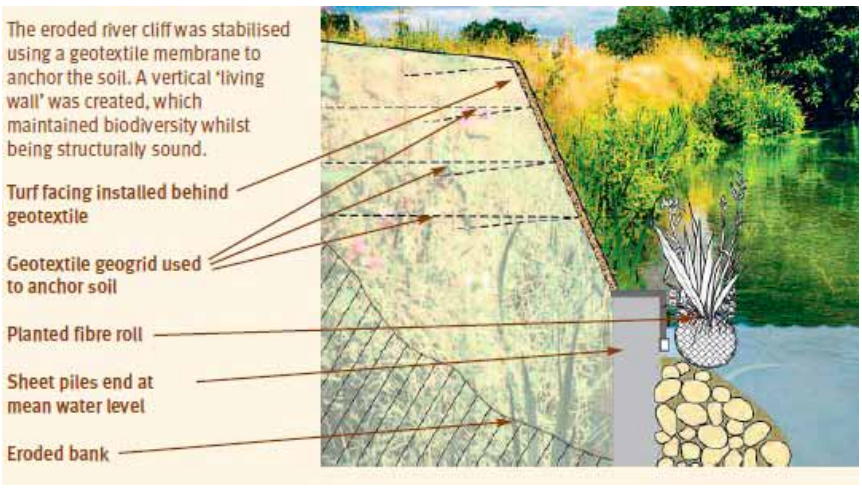
Title: River Wey bank restoration
Location: River Wey, Elstead, Surrey, England
Technique: Restoring river banks using a 'living wall'
Cost of technique: ££
Overall cost of scheme: ££
Benefits: £
Dates: 1992

Mitigation Measure(s)

Use green engineering techniques instead of hard bank protection

How it was delivered

Delivered through: Surrey County Council
Partners: Environment Agency and MMG engineering



Engineering cross-section showing teqchniques used to restore bank profile and protect from erosion
All images © Environment Agency copyright and database rights 2013

Background / Issues & Step-by-step

A bank of the River Wey in Elstead had been badly affected by erosion during high flows. This resulted in considerable bank retreat and the loss of the public footpath which followed the top of the bank. The landowner, Surrey County Council, wanted to restore the bank to its original profile and protect the land adjacent to the river from further erosion. A green engineering solution was developed to withstand the erosive pressures caused by high flows in the watercourse whilst improving the amenity and biodiversity value of the river. This solution included:

- The installation of sheet piles to protect the bank toe from further erosion. The height of the piling was limited to the mean water level, reducing the impact on natural bank habitats whilst providing a high degree of protection from further bank toe scour.
- The installation of fibre rolls to mask the piling and provide marginal habitats.
- The creation of a "living wall" behind the piling to create a new stable bank profile. The area behind the piling was infilled, and the new bank face was secured using a geogrid. This was covered by turn, held in place by geotextile.

CASE STUDY

Benefits & Lessons Learnt

- Greater wildlife benefit.
- Natural river bank restored.
- Re-graded banks designed to withstand erosion and under-cutting.
- A higher quality environment created along the footpath for people.
- A good example of how green engineering can achieve the objectives set out in River Basin Management Plans whilst providing flood and erosion protection.

Project contact: Flood and Coastal Risk Management, South East Region, Environment Agency,

CASE STUDY

Use green engineering techniques instead of hard bank protection

Project Summary

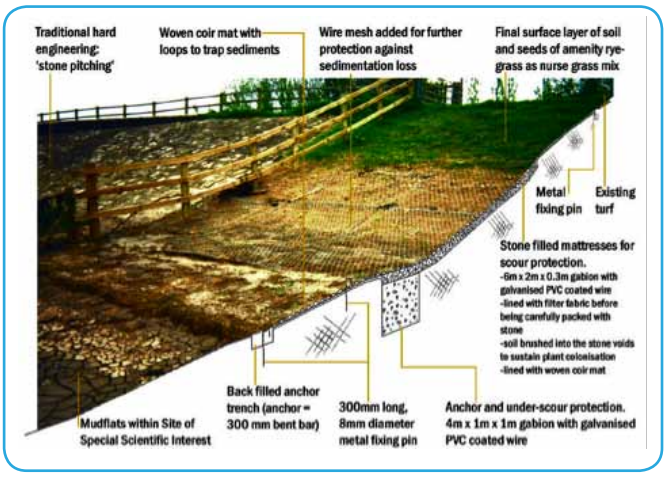
Title: Biotechnically engineered designs
Location: River Severn, Purton, Gloucestershire, England
Technique: Regrading, planting of bank slope and installation of stone gabions
Cost of technique: £££
Overall cost of scheme: £££
Benefits: ££
Dates: Completed 1998

Mitigation Measure(s)

Use green engineering techniques instead of hard bank protection

How it was delivered

Delivered through: Environment Agency
Partners: Local landowners



Schematic for installation of gabion baskets in SSSI bank

All images © Envrionemt Agency copyright and database rights 2013

Background / Issues & Step-by-step

Around 80 m of the bank of the River Severn (also designated as a SSSI) at Purton had been affected by significant erosion at the high tide line. The river at this site is approximately 3 km wide, with a maximum tidal range of approximately 10 m. Given local conditions, conventional green engineering techniques were considered insufficient to withstand the peak forces anticipated at the site. Planting was therefore reinforced with structurally engineered components to maintain bank integrity during extreme events when the bank vegetation may be washed out. The scheme consisted of the following elements:

- The scoured area was excavated to accommodate structural reinforcement, which would be below the final bank line.
- Installation of 30cm deep gabion mattresses. These were composed of woven wire, which was galvanised and PVC-coated for increased durability. The gabions were also lined with a filter fabric before being carefully packed with stone.
- Seeded soil was brushed into the voids, which made up 30 % of the gabions by volume. A loop-piled woven coir matting was laid over the surface and extended beyond the mattress both up and down the slope.
- At the river-wards edge, the matting was laid over the mudflat and anchored in a trench.

CASE STUDY

Successful restoration with well-established bankside vegetation

Benefits & Lessons Learnt

- Some coir loop matting was incorrectly attached, resulting in loss of soil infil and stone movement. It is therefore important that the reinforcement is finished correctly, particularly in high energy environments. This resulted in a requirement to undertake remedial works to put the construction issues right.
- Once repaired, local vegetation quickly colonised mattresses, halting erosion processes.
- Design was considered appropriate to the SSSI.

Project contact: Flood and Coastal Risk Management, South West Region, Environment Agency

CASE STUDY

Use green engineering techniques instead of hard bank protection

Project Summary

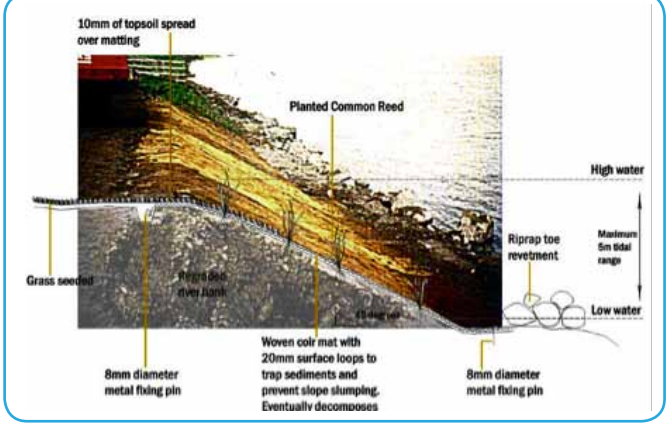
Title: Bioengineered bank protection
Technique: Regrading and planting of bank slope
Location: River Severn, Longney, Gloucestershire, England
Technique: Regrading of bank slope and planting
Cost of technique: £££
Overall cost of scheme: £££
Benefits: ££
Dates: 1997

Mitigation Measure(s)

Use green engineering techniques instead of hard bank protection

How it was delivered

Delivered by: Environment Agency
Partners: Local riparian landowners



Schematic for installation of loop mat planted with pre-grown common reed

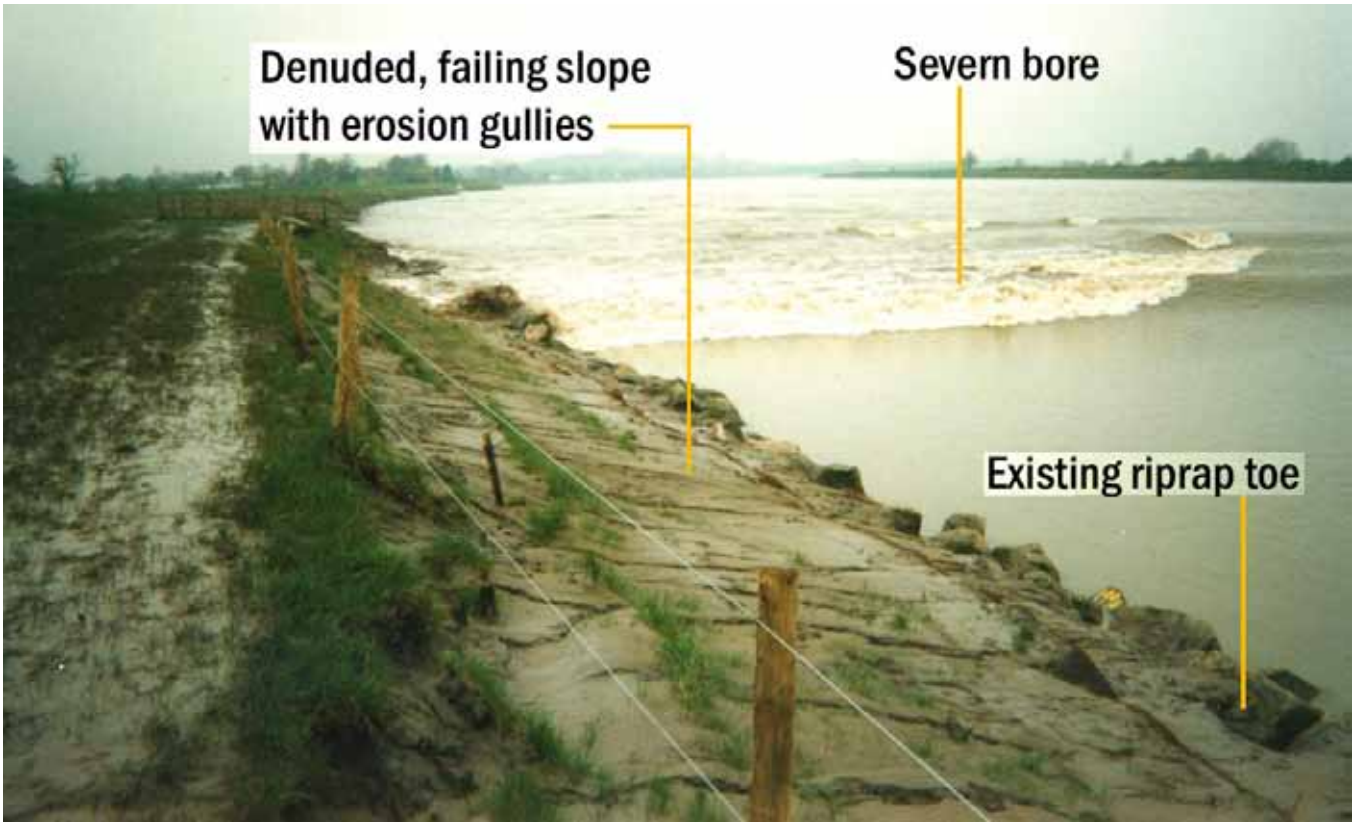
All images © Environment Agency copyright and database rights 2013

Background / Issues & Step-by-step

The bank of the River Severn at Longney was experiencing considerable erosion due to the erosive forces of the Severn Bore. The banks were characterised by a localised lack of vegetation (unlike adjacent areas), making them particularly vulnerable to erosion. While subject to fast tidal currents, the site presents good conditions for vegetation establishment (if initially assisted to take root). Therefore, an approach aimed at stabilising substrate for long enough to allow strong estuarine species such as common reed or sea aster to become established was adopted. The solution included:

- The installation of anchored biodegradable erosion control matting in the form of three-dimensional woven coir mats with an initial 9 kN tensile strength, This was applied to the re-profiled slope and anchored top and bottom.
- The original riprap toe revetment was retained to provide underlying stability, but the main slope was completely bioengineered.
- Localy collected cCommon reed rhizomes were planted through the matting.

CASE STUDY



Eroding banks at Longney

Benefits & Lessons Learnt

- The common reed established well, continuing to provide stability to the substrate after the decomposition of the coir matting.
- Localised erosion caused by fast flows was greatly diminished, due to substantial decrease in near bank flow speed.
- The design was considered to be highly successful, cost-effective and appropriate to the location.

Project contact: Flood and Coastal Risk Management, Severn Team, South West Region, Environment Agency