

Restoring the River Hull Headwaters

River Restoration Plan

Final Report
June 2010



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Document title Restoring the River Hull Headwaters
River Restoration Plan
Document short title River Hull Headwaters Restoration Plan
Status Final Report
Version 04
Date June 2010
Project name River Hull Restoration Plan
Project number 9T5336
Client Environment Agency
Reference 9T5336/Hull02/303330/Lond

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Checked by Helen Dangerfield
Date/initials check 01/06/10 HRD
Approved by Helen Dangerfield
Date/initials approval 01/06/10 HRD

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Royal Haskoning would like to thank the Environment Agency, Natural England, East Yorkshire Chalk Rivers Trust and riparian landowners for their assistance in the production of this report.

VISION FOR THE RIVER HULL HEADWATERS SSSI

The River Hull Headwaters is a northerly chalk stream designated as a Site of Special Scientific Interest (SSSI) but is currently in poor condition as a result of historic management. The river has been widened and deepened and when combined with low flows resulting from abstraction and flow diversion this results in poor habitat quality. Our vision is to see the river return to ecological health with high water levels in the winter when the springs rise, and a clean gravel bed supporting a rich variety and abundance of aquatic plants for invertebrates, fish, mammals and birds to thrive.

The character of the restored River Hull Headwaters

Our vision for the River Hull Headwaters is to work towards a river system which has:



High quality chalk stream habitats on Lowthorpe Beck at Harpham, with swift flows, a clean gravel bed and in-channel *Ranunculus* communities. Photo courtesy of A. Mullinger, EYCRT.

- Clear flowing water, with clean gravels and smaller areas of silt on the channel bed.
- Variable river depths and flow speeds, although predominantly slow flowing as characteristic of chalk streams.
- Shallow river banks along which marginal vegetation can colonise, and grow out into the channel, naturally narrowing the river.
- Varied bankside plant structure, including areas of shading and more open stretches in the lower reaches
- Diverse plant, invertebrate and breeding bird communities that are able to use the river corridor with minimal disturbance.
- Low levels of artificial impoundment, such as weirs, and sluices, so that impacts on river function are minimised and there is free passage for fish.
- Increased connection with the floodplain where wet grassland and meadows, fen, carr and wooded areas will develop.



West Beck chalk stream habitat at Wansford Bridge with in-channel *Ranunculus* communities. Photo courtesy of J. Traill, YWT.



Swift, clear flows and a clean gravel bed in Gypsey Race. Photo courtesy of A. Mullinger, EYCRT.

How can we deliver restoration?

- Continue positive management of reaches already in good ecological health.
- Support and allow the river to recover where natural processes are already working well.
- Assist natural recovery by changing management or undertaking selective river restoration works.
- Remove manmade features where they damage the function of the river, whilst recognising the need to protect people and property from flooding and also the cultural, historic and landscape aspects.
- Actively restore the river channel where the characteristic features of the river can only be achieved by habitat re-creation.
- Ensure the river is adaptable into the future to new pressures such as climate change.



High quality chalk stream habitat on Driffield Beck near the showground with well developed in-channel and marginal vegetation communities. Photo courtesy of J. Traill, YWT.

Keys to success

- Maintaining the vision of restoring a site of national importance.
- Learn from early actions and those already implemented in this and other rivers under threat.
- Working together with the support of the community across the Hull Headwaters.
- Accepting that sustainable recovery will be over longer timescales.
- Being adaptable to new challenges and opportunities.
- Building solutions through consensus which can benefit all.
- Securing funding to implement solutions.

1. INTRODUCTION

The River Hull Headwaters Site of Special Scientific Interest

The River Hull Headwaters is located to the east of the Yorkshire Wolds, close to the town of Driffield, approximately 30km north of Kingston-upon-Hull. The site comprises two main tributaries, although different names are used along the length of the watercourse as it flows through the different parishes. The River Hull itself flows southward from the River Hull Headwaters to the Humber Estuary.

The river has been designated as a Site of Special Scientific Interest (SSSI), from Harpham, Elmswell and Kirkburn, to the confluence between the West Beck and Frodingham Beck at Emmotland (**Figure 1.1**). SSSIs are areas that have been notified as being of special interest under the Wildlife and Countryside Act 1981 and cover the country's very best wildlife and geological sites. Natural England works with land owners and managers, to monitor and conserve these important sites.

The River Hull Headwaters are nationally important as the most northerly chalk stream system in Britain. Also of interest within the site are areas of riverside grassland, woodland and fen; remnants of habitats formerly more widespread but now limited in distribution due to agricultural and urban development. The SSSI designation is based on the following characteristics:

- **Aquatic vegetation community characteristic of chalk streams**, including stream water crowfoot, lesser water-parsnip, mare's tail, spiked water-milfoil, pondweed, water cress, common reed and reed sweet grass.
- Areas of **species rich wet grassland** and fen, most notably between Driffield and Wansford.
- **Extensive areas of alder and willow carr** among several areas of wet woodland.
- **Rich invertebrate fauna** including locally uncommon species mayfly and snail.
- Diverse **breeding bird community**, including waders such as lapwing, snipe, wildfowl, yellow wagtail, sedge warbler, reed warbler, reed bunting and many more widely occurring species.



The SSSI is divided into 22 SSSI units, however only five of these units are classified as "Rivers and Streams" habitat, which form the study area. The condition of all five riverine units is currently assessed to be "unfavourable no change". The five river-based units are detailed in **Table 1.1** and their location illustrated in **Figure 1.1**.

Table 1.1: Location of SSSI Units within the River Hull Headwaters SSSI

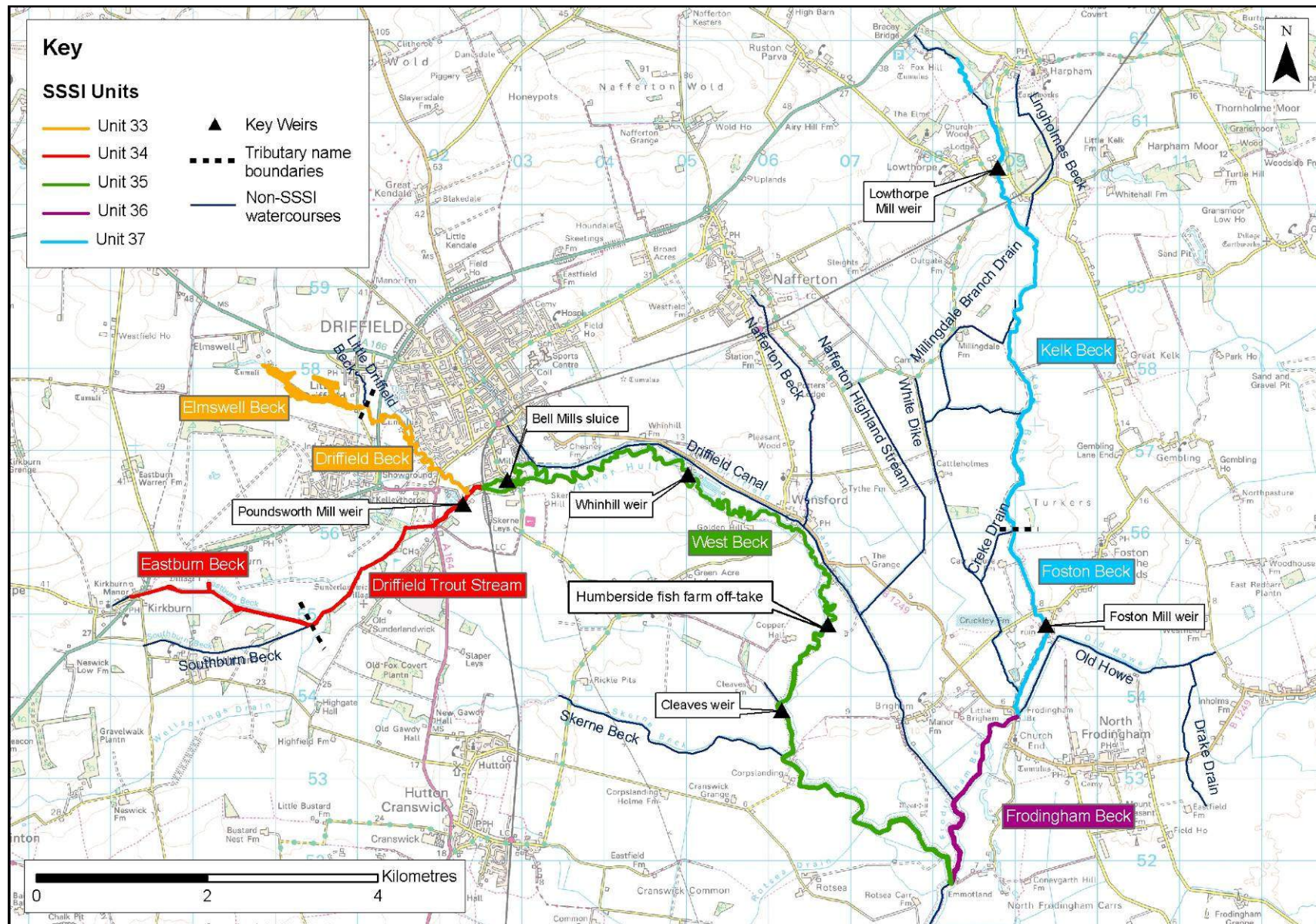
SSSI Unit	Watercourse Name	Upstream and downstream SSSI unit boundaries	Length of River (km)
33	Elmswell Beck and Driffield Beck	Elmswell to confluence with Driffield Trout Stream.	0.95
34	Eastburn Beck and Driffield Trout Stream	Kirkburn to Driffield Railway Bridge.	2.80
35	West Beck	Driffield Railway Bridge to confluence point at Emmotland.	12.75
36	Frodingham Beck	Confluence point of the Old Howe drain and Foston Beck to Emmotland.	1.45
37	Kelk Beck and Foston Beck	Harpham to confluence with Old Howe drain.	9.30
Total			27.25

Find out more

River Hull Headwaters SSSI citation

http://www.sssi.naturalengland.org.uk/citation/citation_photo/1003424.pdf

Figure 1.1: Map of the River Hull Headwaters SSSI



Favourable condition and the need for restoration

The Government's target for the condition of SSSIs

The condition of all SSSIs in England, including the River Hull Headwaters, is assessed by Natural England against site-specific Conservation Objectives. These objectives are shown in **Table 1.2**. A SSSI unit is assessed to be in "favourable condition" if the SSSI is being adequately conserved and is meeting its Conservation Objectives. The Government has set a Public Service Agreement (PSA) target to bring into favourable or recovering condition 95% of the area of Sites of Special Scientific Interest (SSSIs) in England by 2010. This is an ambitious target, which Defra is working closely with Natural England and a wide range of other stakeholders to achieve. The Environment Agency is responsible for a number of solutions agreed with Natural England to help meet the PSA target.

Table 1.2: Conservation objectives of the SSSI

Type	Interest Feature
a) General conservation objectives	
Flow	Flow regime should be characteristic of the river. There should be no obvious shortage of water availability within the unit. Ecological flow criteria (e.g. for passage of migrating fish) should also be complied with.
Channel form	Channel form should be generally characteristic of river type, with predominantly unmodified planform and profile. Less than 10% of each SSSI unit should be artificial, straightened, widened or deepened. Bank and riparian zone vegetation structure should be near-natural.
Suspended solids	No unnaturally high loads. Targets should be set locally according to river type, catchment characteristics, and an analysis of available data. The highest value that may be appropriate is 25 mgL ⁻¹ (annual mean), based on the EC Freshwater Fish Directive. Considering prevailing concentrations in most SSSI rivers, a more precautionary target of no more than 10 mgL ⁻¹ is likely to be suitable for most river reaches.
Substrate	No excessive siltation. Channels should contain characteristic levels of fine sediment for the river type.
Plant reproduction	A sufficient proportion of aquatic macrophytes should be allowed to reproduce in suitable habitat unaffected by river management practices.
Functionality of terrestrial compartments	The terrestrial compartment is in hydrological continuity with the river. The terrestrial unit supports semi-natural vegetation. Management of terrestrial units does not contribute to the unfavourable condition of the river units.
Functionality of terrestrial compartments and adjacent bankside habitats	Management of the adjacent bankside and floodplain habitat, where not included within a terrestrial unit of the SSSI does not contribute to the unfavourable condition of the river units.
Negative indicators – in-stream barriers	No artificial barriers significantly impairing characteristic migratory species from essential life cycle movements.

Type	Interest Feature	Physical habitat attribute
b) SSSI species population objectives		
Vegetation	Flora characteristic of chalk stream rivers including <i>Ranunculus penicillatus</i> spp. <i>pseudofluitans</i>	Swift to moderate, clear flows
		Channel dominated by clean, stable, un-compacted gravel
		Adequate in-channel light
	Flora characteristic of lowland rivers including <i>Potamogeton</i> spp.	Moderate to slow flowing water
		Suitable water quality
		Lack of algal growth
Invertebrates	Rich assemblage of invertebrates	Presence of variously structured vegetation on banks, margins and in channel
Birds	Excellent breeding bird community	Adjacent wetland floodplain habitats
		Open grassland (limited tree cover)
c) Other species of interest *		
Mammals	Otter	Bankside shelter for day cover
		Undisturbed areas for holts
		Adjacent wetland floodplain habitat
		Suitable fish habitat for feeding purposes
Fish	Brown Trout & Grayling	Channel dominated by clean, stable gravel for spawning.
		Clean well oxygenated water for spawning
		Swift to moderate clear flows for nursery and migration
		Appropriate cover for nursery and migration
		Deeper pool features

* Although these species are not included in the SSSI citation, they are important indicators of the quality of the SSSI.

Current condition of the River Hull Headwaters

Although the River Hull Headwaters have been recognised for its ecological value, it has been heavily modified over time for a variety of different reasons, including land drainage, flood defence, water supply, fish farming and navigation. All of these changes have impacted to some extent upon the ecological value of the river. All SSSI units were found to be in unfavourable condition within the 2006 assessment.

Reasons for unfavourable condition

According to the condition assessment undertaken by Natural England in 2006, the River Hull Headwaters SSSI is in unfavourable condition for the following reasons:

- Abstraction
- Loss of natural channel structure
- Diffuse pollution
- Siltation
- Barriers to migratory fish passage
- Water level management
- Fishery management
- Agricultural management
- The spread of invasive species

Restoration of the River Hull Headwaters

The Environment Agency and Natural England are therefore working together with their partners to restore the river towards a more favourable condition. In order to produce a plan for the physical restoration of the River Hull headwaters, a catchment wide fluvial geomorphological study has been undertaken to assess the physical functioning of the river, and how it impacts on the river ecology. The findings from this study can be found in the Technical Report accompanying this River Restoration Plan (Royal Haskoning, 2010).

Fluvial geomorphology is the study of landforms associated with river channels and the processes that form them. It considers the process of sediment transfer (erosion, transport and deposition) in river channels and also the relationship between channel forms and processes. Geomorphological processes help to create a variety of habitats within a river with different physical characteristics relating to flow depths, flow speeds, bed and bank material and channel and marginal vegetation. These habitats are critical to supporting the ecological interest features of the River Hull Headwaters SSSI.

The importance of geomorphology is reflected in the Conservation Objectives for the River Hull Headwaters SSSI, which relates to appropriate flow, sediment and channel form within the river habitat as well as the presence of designated species. Specific physical attributes required by the ecological interest features of the SSSI are detailed in **Table 1.2**.

Further Information Sources

Government PSA Target:

<http://www.defra.gov.uk/wildlife-countryside/protected-areas/sssi/psa.htm>

Current Condition Assessment for the River Hull Headwaters SSSI

http://www.sssi.naturalengland.org.uk/special/sssi/sssi_details.cfm?sssi_id=1003424

Aims and objectives of the River Restoration Plan

Actions to restore the physical structure of the river to a better condition for ecology have been set out in this River Hull Headwaters River Restoration Plan. The Plan uses the findings of the accompanying Technical Report (Royal Haskoning, 2010) to identify opportunities and constraints for managing, conserving and enhancing the river and returning the SSSI to favourable or recovering condition. It suggests a range of catchment-scale and reach-based solutions that could potentially be implemented. The ultimate goal is to move towards a more naturally functioning and un-constrained system that is able to adjust and respond to changes without constant management.

However, it is recognised that the River Hull Headwaters supports a wide range of other interests in addition to ecology (e.g. fish farming, agricultural farming, mills, drinking water abstractions) and that all of these will need to be taken into account when planning actions.

Structure of this report

This report is divided into five sections as outlined in **Table 1.3**.

Table 1.3: Contents of the River Restoration Plan

Section		Content	Recommendation for use
1	Introduction	Explains the purpose of the plan.	Use this section to understand why and how the restoration plan has been developed for the River Hull Headwaters SSSI.
2	Key issues	Outlines the key issues which affect the River Hull Headwaters SSSI.	Use this section to obtain a catchment-scale overview of the key issues underlying the current unfavourable condition of the River Hull Headwaters SSSI. This includes a description of the cause of the issues and how they are affecting ecology within the SSSI. Potential solutions relevant to each issue are highlighted.
3	Potential solutions	Outlines potential solutions for restoring the SSSI to favourable condition.	Use this section to find out what solutions are proposed in the River Restoration Plan in order to tackle the key issues identified and bring the SSSI into favourable or recovering condition.
4	Reach-based restoration solutions	Outlines how and where the solutions could potentially be implemented.	Use this section to identify, at a reach-scale, where it is proposed that the solutions identified are applied. It should be noted that catchment-scale solutions are not included in this section.
5	Action plan	Sets out the actions needed to deliver the solutions identified at the reach scale.	Use this section to find out what actions have been proposed, timescales for implementation and indicative costs.

Intended audience

This report is primarily intended for use by river managers planning improvements to the River Hull Headwaters SSSI or other capital works that are likely to have an impact on physical habitat conditions within the SSSI. A list of further information sources is provided for those who require more detailed information about the issues raised, and can be found at the back of this report (page 103).

2. KEY ISSUES IN THE RIVER HULL HEADWATERS SSSI

Key issues

A detailed investigation of the geomorphological and ecological behaviour of the River Hull Headwaters has been undertaken, the results of which are presented in the accompanying Technical Report. As a result of this investigation, which combined a detailed walkover survey of the entire catchment and a comprehensive review of existing data and reports, four key issues that are currently having an adverse impact on the condition of the SSSI have been identified.

- Fine sediment supply and deposition.
- Channelisation and low flows.
- Lack of bankside shelter and over-shading.
- In-channel structures.

For each of these issues this section provides the information identified in **Table 2.1**.

Table 2.1: Information provided for each of the four key issues

Section	Contents
What the issue is	The underlying causes of the issue are described together with the resulting physical conditions and why they are an issue.
Where it occurs	This section describes the location of the issue and whether it is catchment-wide or more localised. Particular spatial trends and any locations where the issue is most significant are highlighted.
How it affects the SSSI	The impacts on the SSSI are identified, in terms of both condition of the overall river habitat and specific requirements of SSSI designated species.
What the potential solutions are	Potential solutions that may contribute to meeting the conservation objectives (refer to Table 1.2), tackling the issue and achievement of favourable or recovering condition are identified. In most cases, more than one solution is identified. Further details of these solutions are provided in Section 3.

FINE SEDIMENT SUPPLY AND DEPOSITION

What is the issue?

Sedimentation describes the settling out of fine sediment (muds, silts and sands) on the river bed. Rivers only transport sediment when the rate of flow is sufficient to pick up and transport particles. Sediment is deposited and stored when the rate of flow slows or when there is too much sediment to be transported. If the sediment is not transported it is deposited on the river bed (a process known as sedimentation). Although supply of sediment to the river system is an important element of natural river functioning, when there is a prolonged and or excessive build up of sediment, this can be a problem for a range of species that depend on the conditions of the river bed for habitat, shelter or food sources.

Where does it occur?

Fine sediment supply is a persistent issue throughout the River Hull Headwaters, which is largely attributable to management of the surrounding land. This catchment is particularly vulnerable to soil erosion and large quantities of fine sediment are supplied to the River Hull Headwaters as a result of inwash directly from the land (diffuse supply) and via field drains and tributaries (point supply). Cultivation and trampling of the river banks by livestock act to increase erosion rates at some locations, and the absence of bankside vegetation in places means there is little or no buffer zone to prevent fine sediment entering the watercourses. Discharges from two fish farms also act as localised sources of fine sediment.



Tilled land adjacent to Kelk Beck upstream of Lynesykes Road

As a consequence, many of the streams in the upper River Hull Headwaters are subject to fine sedimentation and silt can be observed on the river bed (**Figure 2.1**). This shows that fine sediment is present in the majority of the river system, with the exception of the relatively unmodified headwaters of Eastburn Beck and Elmswell Beck. Where the channel has been more modified along Kelk Beck and Foston Beck sediment accumulates immediately upstream of weirs due to impoundment of flow, with significant deposits present upstream of Lowthorpe Mill weir and Foston Mill. Sediment deposition also occurs on Driffeld Beck upstream of Poundsworth weir and on West Beck upstream of Bell Mills sluice and Cleaves weir. A significant build up of sediment is also present on the channel bed, downstream of the discharge points from both the Wansford and Driffeld Trout hatcheries.

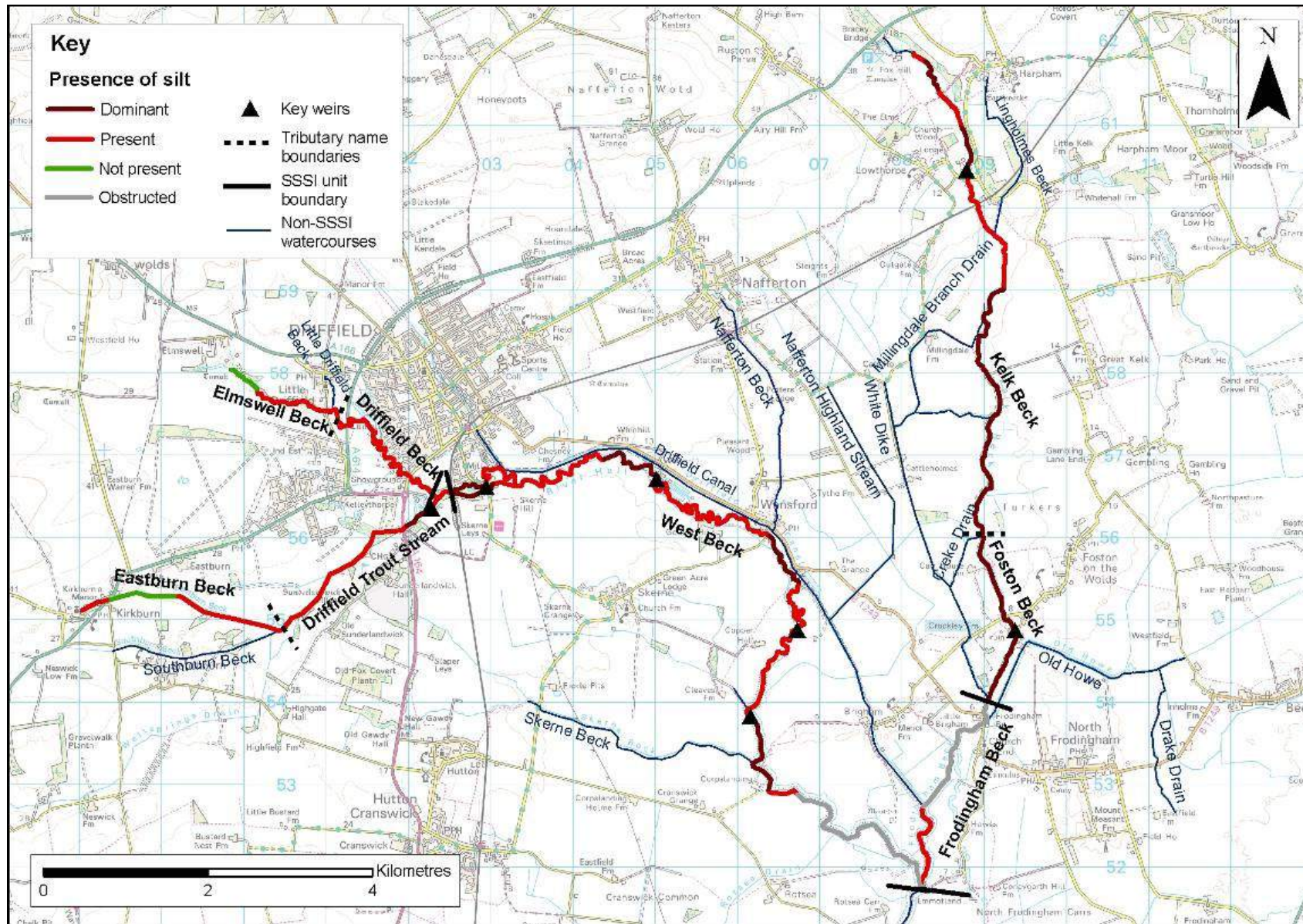
Superficial geological deposits have a strong influence on the character of the River Hull Headwaters with gravel, sand and silt sediments deposited on the riverbed in varying proportions. The variation in the riverbed sediments is reflected in the species composition of the aquatic vegetation which grows within the headwaters during the summer months.

How does it affect the SSSI?

Fine sedimentation has a detrimental effect on the main habitat requirements of the key SSSI interest species including aquatic plants such as *Ranunculus spp.*, *Potamogeton spp.* and associated aquatic plant communities. Deposition of fine sediment is a key issue for aquatic vegetation due to reduced light availability for attached aquatic plants effecting photosynthesis and can also reduce biomass of algae communities and aquatic plants (macrophytes) through direct smothering of existing plants. Fine sedimentation is one of the main reasons for the SSSI units being in unfavourable condition.

Excessive fine sedimentation can lead to a lack of diversity in the structure of the bed. Fine sedimentation can also lead to smothering of important gravel substrate, which reduces the diversity of invertebrate fauna, restricting presence to only those species that can tolerate a soft, muddy substrate. Generally, low diversity in habitat structure can lead to low diversity in invertebrates and aquatic plants. This in turn can have a negative impact on the fish and birds that depend on them for shelter and feeding. Fine sedimentation also limits the potential for fish spawning.

Figure 2.1: Bed material observed during 2008 field survey



Dredging has historically been used, together with more recent de-silting, to reduce sedimentation by physically removing fine sediment that has accumulated on the river bed, for example upstream of Lowthorpe Mill weir and Foston Mill. However, this solution is only short-term as it treats the symptoms of sedimentation rather than the underlying causes. Dredging out of fine sediment, which is reducing the capacity of the channel, results in continuation of the process of sedimentation and can adversely impact on river habitat. It also physically damages features that form the basis of the SSSI designation of the Hull Headwaters. Dredging is therefore not identified as a solution to the issue of sedimentation.

The impacts of fine sedimentation in the Hull Headwaters are exacerbated by the combination of low flows and over-deepening and widening (legacy of dredging) of the channel resulting in increased rates of deposition in certain areas. This can lead to sediment deposition within gravel beds and the development of channel side bars or berms as the river adjusts to reduce the channel cross section area in response to low flows and supply of fine sediment. The development of side bars (e.g. in the lower Foston Beck system and downstream of Wansford in the West Beck System) should be viewed as a positive feature of the Hull Headwaters as it indicates the channel is undergoing some natural recovery from legacy maintenance practices and they provide appropriate areas for aquatic plants to colonise.

The major weir and sluice structures within the River Hull Headwaters result in localised impoundment of water upstream. This reduces the flow rate within the channel, and leads to localised heavy fine sediment deposition on the bed. The cumulative effect of these weirs on the sediment transport system is significant as they limit the opportunity to transfer sediment downstream and consequently alter natural river processes.

What are the potential solutions?

The main solutions that could potentially be implemented to help address the issues relating to fine sedimentation are:

- Review of the maintenance regime and weed cutting techniques
- Establish buffer strips adjacent to tributaries and field drains
- Selectively restrict livestock access to banks to prevent trampling

The main aim of these solutions is to reduce the supply of sediment from the land into the river channel, through reducing the production of sediment, preventing it entering the drainage network, and, if it does become entrained, retaining it within the drains rather than the main channel without compromising drainage requirements. These solutions can be applied locally, but need to be considered on a wider catchment-scale in order to be most effective. The last solution is a mechanism by which the benefits of the other solutions may be realised.

In addition, actions to narrow the channel and increase flows could also help to reduce in-channel sedimentation, including:

- River rehabilitation (channel narrowing, bed raising)

More details about each of these solutions are provided in the **Potential Solutions** section.

CHANNELISATION AND LOW FLOWS

What is the issue?

As a base-flow dominated chalk stream, the River Hull Headwaters would naturally be characterised by a wide, shallow cross-section. These characteristics are still evident in some parts of the catchment, such as the relatively unmodified upper reaches of West Beck and Driffield Beck. However, a large proportion of the river channels in the River Hull Headwaters SSSI have been historically modified (or channelised which includes widening and deepening) for navigation, land drainage and flood defence, and to support historical milling activities. The end result of these modifications is the creation of an over-wide and over-deep channel that has a considerably larger capacity than a comparable natural channel.

Periods of low flow are a cause for concern in parts of the Hull Headwaters SSSI, as a result of low rainfall and insufficient groundwater recharge but also abstraction and water use within the catchment. The issues caused by a lack of incoming water to the system are exacerbated by the increased capacity of the river channel, which is too large for the amount of water it transports.



In-channel sedimentation in Driffield Beck

The increased channel capacity means that, under most conditions, flow velocities are considerably lower than they previously were. As a result, the transport capacity of the water column is reduced, and sedimentation on the bed of the channel increases. In addition, a reduction in winter flow levels means that sediment deposited during lower flow conditions is not transported out of the system as effectively as it once was. The net effect of these processes is a sustained accumulation of sediments in the river channel.

In addition to changing the channel cross-section, dredgings from channel maintenance have been stored on the banks and now act as informal embankments, in some cases, disconnecting the river from the floodplain. Under less modified conditions, a range of flow types would be present, including shallower and faster sections as well as longer sections of slow flowing water.

The uniformity of the channel and banks within sections of the River Hull Headwaters mean that the types of habitat that the river is able to support are limited. In addition, flood embankments have been constructed adjacent to the river channel along the lower reaches, many of which were originally constructed in the late 1200s. These structures limit the diversity of the bank habitat and can cut the river off from the floodplain by acting as a physical barrier to the free passage of water, sediment and wildlife.



Overwidening and deepening of West Beck

Where does it occur?

A significant proportion of the River Hull Headwaters have been subject to channelisation. Eastburn Beck, Driffield Trout Stream, Kelk Beck, Foston Beck, Frodingham Beck and the lower reaches of West Beck have all been highly modified in cross-section and planform with resultant river profile change and informal embankments from channel dredgings.

Meanders have been cut-off at various locations including around Bell Mills, south of Wansford Bridge and at Wansford Trout Farm. Dredging of the lower reaches of West Beck and Frodingham Beck was undertaken in association with the commercial navigation that existing on these watercourses until 1944.

Flood embankments have been constructed along a considerable proportion of the lower reaches of the River Hull Headwaters. The lower Kelk Beck, Foston Beck, Frodingham Beck and lower West Beck are constrained by raised flood defences, protecting areas of arable and grazing land (**Figure 2.2**).

How does it affect the SSSI?

Channelisation and disconnection from the floodplain impact on the River Hull Headwaters SSSI in several ways. Deepening of the channel and steepening of the banks restricts the occurrence of shallower in-channel and marginal habitat. These habitats are important in providing the diversity required to support the full range of aquatic plants and invertebrates that characterise the SSSI, as well as mammals and fish that prey on them.

The deepening and over-widening of the channel has also increased its capacity, exacerbating the impact of low flows which can be detrimental to in-channel habitats. Low flows are an issue in the Hull Headwaters and the channelisation of the river has meant that when low flows do occur, the river does not have the natural form to help keep gravels clean, flows fast or retain sufficient flow depth for a range of flora and fauna. Natural chalk streams often have a two stage channel which includes a smaller, narrower (low flow) channel set within the wider, larger (high flow) channel. The low flow channel is demarked by the presence of low vegetated berms or aquatic ledges and is often only evident during drier months (spring to summer) when the supply of groundwater to the river is reduced and marginal vegetation encroaches into the channel. Over the winter this vegetation is scoured out and the process begins again in the spring. The low flow channel is an important feature of the chalk stream as it provides a means by which a river can naturally regulate its form and function by still enabling downstream transport of sediment. Channelisation has removed this low flow channel and consequently, when flows are reduced, water in the channel is spread thinly across a wide channel bed area resulting in low velocities, increased siltation and shallow depths. This results in the river only supporting limited quality and quantity of SSSI aquatic vegetation species and associated invertebrate assemblages as the habitat niches during different flow conditions have been removed.

The steep, high banks and raised flood embankments disconnect the river from its natural floodplain. This restricts the potential for transfer and storage of water, sediment and nutrients on the floodplain in periods of high flow, and limits the development of the floodplain wetland habitats that are important for breeding birds. The embankments not only limit drainage back to the river, but also restrict the development of good quality habitats on the bank top. This means that parts of the bank are lacking in shelter for mammals and birds (see **Lack of shelter and over-shading** for more information).

What are the potential solutions?

The main solutions that could potentially be implemented to help address channelisation and disconnection from the floodplain are:

- River rehabilitation (channel narrowing, bed raising)
- Alter flood embankments

In addition, measures intended to address the lack of shelter and shading could also be considered, including:

- Enhance floodplain wetland habitats

More details about each of these solutions are provided in the **Potential Solutions** section.

LACK OF BANKSIDE SHELTER / OVER-SHADING

What is the issue?

Bankside shelter includes trees and vegetation that are found along the top of the river banks. Bankside vegetation, often referred to as a riparian buffer zone, can contribute to favourable conditions by:

- Providing bankside shading and shelter in exposed tree roots.
- Growing roots that bind and stabilise channel banks, limiting bank erosion.
- Trapping fine sediment in surface runoff, preventing it entering the channel.

The shelter and shading provided by bankside vegetation is important for designated SSSI species, both in the channel (e.g. aquatic plants and invertebrates) and along the channel banks (marginal vegetation). When large areas of the river bank are exposed and lacking in bankside vegetation, the range of potential habitats for these designated species is limited.

However, excessive or over-shading can also be detrimental to the quality of the river habitats by limiting the amount of light available for plants to photosynthesise. It is therefore important to obtain a balance between providing enough shelter for invertebrates and other aquatic species, and excessive shading for aquatic plants to survive. A mosaic of bankside vegetation would be ideal for the range of species present in the River Hull Headwaters, with some open areas where aquatic plants could take hold (given a suitable bank profile) and other tree-lined areas to provide cover.



Lack of shelter and shading on the right hand bank of West Beck due to lack of vegetation



Over-shading on the left hand bank of Driffield Beck due to un-managed vegetation

Where does it occur?

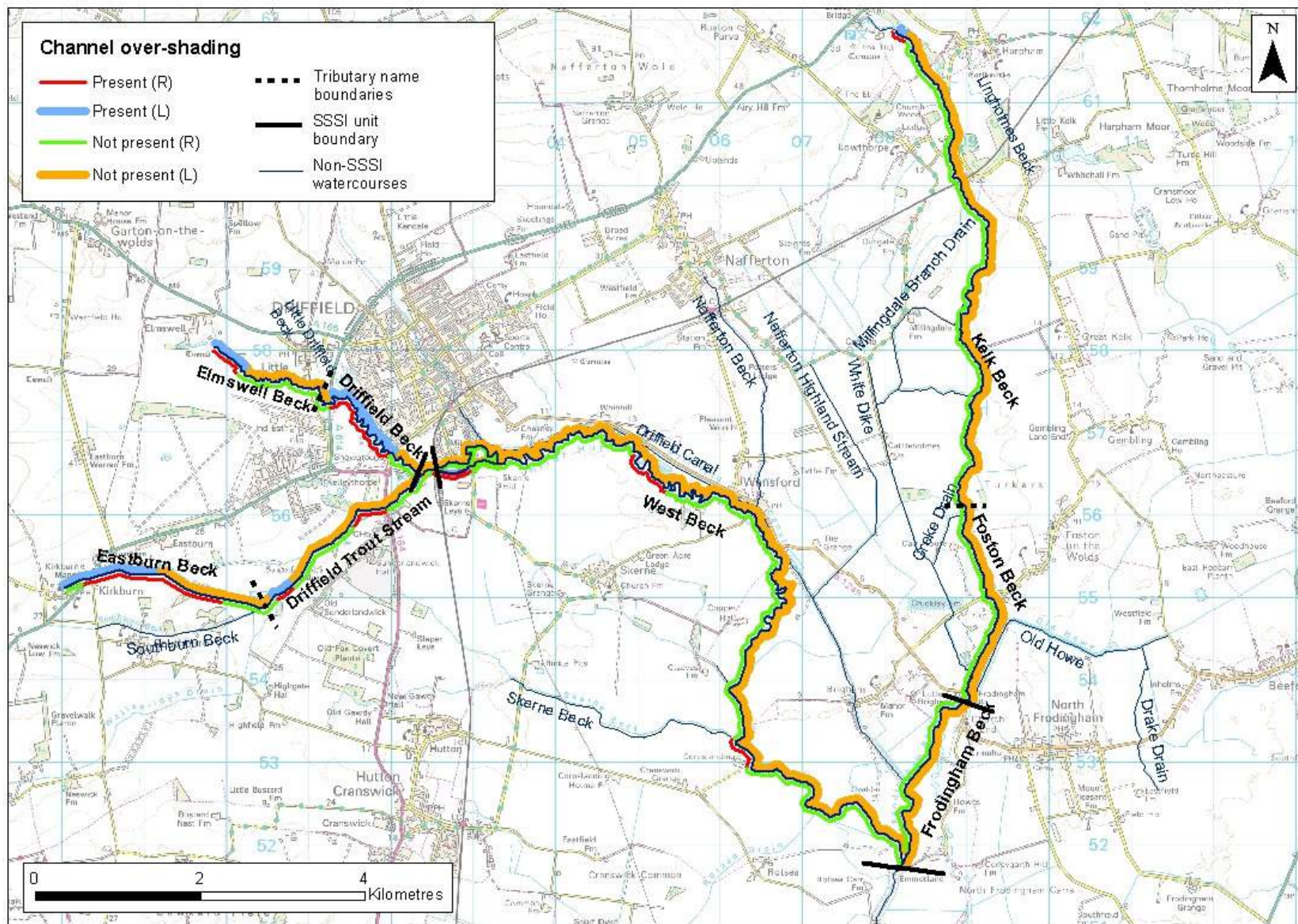
Considerable reaches of the river channel are lacking in shelter and shading, including the majority of Elmswell Beck, and large parts of West Beck and Kelk/Foston/Frodingham Beck.

Over-shading tends to be present in localised pockets rather than continuous stretches. Over-shading was most prevalent in the upper reaches of Eastburn Beck, Elmswell Beck and the middle reach of Driffield Beck (**Figure 2.3**).

How does it affect the SSSI?

Lack of bankside vegetation contributes to uniform conditions along the river and a lack of habitat diversity. It can have an adverse impact on a number of the designated SSSI species that occur in the River Hull Headwaters. Above the waterline, lack of bankside trees and shrubs can mean that the shelter required to support breeding birds and mammals, such as otters, is not available. Roots of bankside trees are particularly important for otters, which use holes in the bank supported by the roots as holts and breeding dens. These are often well hidden and very difficult for potential predators to access.

Figure 2.3: Reaches exhibiting over-shading



Below the waterline, a lack of plant roots and woody debris that falls off the trees can mean there is insufficient shelter for aquatic invertebrates and fish which use this shelter as they migrate upstream to spawn. Fish may also be adversely affected by a lack of shading from bankside trees, which helps to protect them from predation.

Overshading as a result of poor management of bankside vegetation can also have an adverse effect on designated SSSI species (**Figure 2.3**). Many aquatic plants are sensitive to overshading, which limits their ability to photosynthesise. As a result, reaches with very dense bankside vegetation can lack healthy aquatic vegetation in the channel. This can therefore have knock-on impacts on the invertebrates and fish that live in the water, and the mammals and birds that prey on them. In managing overshaded areas, however, the function of shading in reducing water temperature also needs to be considered.

What are the potential solutions?

The main solutions that could potentially be implemented to help address the lack of shelter and shading and overshading along parts of the river are:

- Establish and enhance bankside vegetation
- River rehabilitation
- Enhance floodplain wetland habitats

The main aim of these solutions is to enhance the quality of the river banks and the habitats they support, and where possible improve habitats in the adjacent floodplain areas. These solutions could be implemented locally to deliver real improvements at the reach scale. This could lead to major improvements on a much larger scale, when actions in neighbouring reaches are considered together.

In addition, measures to preserve favourable conditions, where suitable shading and shelter exist should be preserved. Such solutions could include:

- Preserve existing quality habitats
- Preserve existing in-channel woody debris

More details about each of these solutions are provided in the **Potential Solutions** section.

IN-CHANNEL STRUCTURES

What is the issue?

In-channel structures, such as weirs and sluices, that are built across a river channel alter flow patterns and disrupt downstream transport of sediment. An in-channel structure such as a weir or sluice alters the natural flow patterns of a river by impounding water upstream. This increases water levels and slows the rate of flow, leading to the deposition of sediment upstream of the structure. Depending on the size of the in-channel structure, its influence can propagate for a considerable distance upstream and downstream. These effects can be detrimental to river habitats by encouraging sedimentation on the river bed and creating uniform flow conditions. This can smother the coarse substrate required by SSSI interest features such as *Ranunculus* and *Potamogeton* communities, and reduce light availability by increasing turbidity. Flow over the obstruction can also become very rapid leading to erosion of the bed and banks associated with the weir pool downstream.

In addition, in-channel structures can act as a physical barrier to the free movement of fish in the river channel if they are not able to swim past or jump over them. The presence of in-channel barriers within the SSSI may limit the upstream migration and therefore breeding of these species. Strong-swimming fish species may be able to pass barriers when flows are high enough, but weaker swimmers, including many coarse fish and lamprey may not be able to do this. A fish pass may allow fish to pass upstream of a structure, but require careful design in order to make them suitable for all fish species. The presence of structures within the channel can therefore limit the movement of fish within the river, and have a detrimental effect on fish populations and those of the species that prey on them. Alternatively, in-channel structures can also be viewed as providing important barriers to keep different fish species separate such as pike and trout and provide delineation between specific habitat types for different communities.

Where does it occur?

There are six major in-channel structures within the River Hull Headwaters SSSI; Poundsworth Weir on Driffield Trout Stream, Bell Mills sluice, Whinhill weir and Cleaves Weir on West Beck and Lowthorpe Mill weir and Foston Mill weir on Kelk Beck / Foston Beck. There are also 18 smaller structures as shown on **Figure 2.4**.

Each of these structures results in impoundment upstream and localised fine sedimentation (see Fine Sediment Supply and Deposition). A brief description of each of the structures within the River Hull Headwaters is provided below and further information about the weirs is available in the **Technical Report** that accompanies this Restoration Plan:

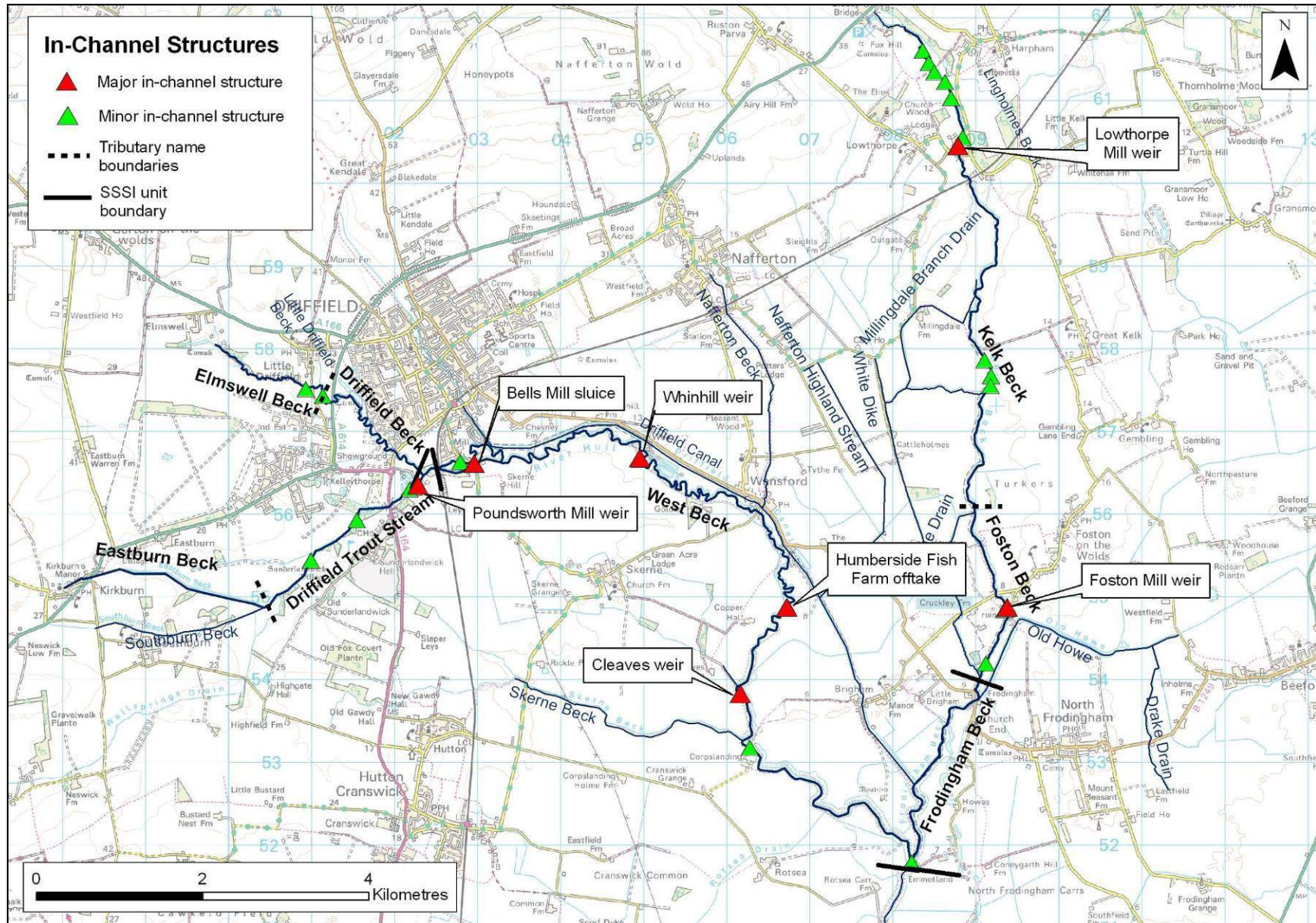
Poundsworth Weir



Poundsworth Weir is located on Driffield Trout Stream, upstream of the confluence with Driffield Beck. The weir was primarily used for the Poundsworth Fish Farm, which ceased to operate in 2005. It is contained within an artificial channel, approximately 1.5m wide and some 2.4m deep, which is formed from a brick retaining structure with concrete cladding. Up to six stop logs can retain upstream water levels approximately 1m above a concrete sill, which is itself some 1.4m above the bed level of the downstream channel.

The impoundment effect of the structure is considerable and impacts on the natural form and function of the stream and does not provide suitable conditions for SSSI designated vegetation communities within the zone of impact. The structure does not include a fish pass, so is therefore also considered to represent a significant barrier to upstream fish passage.

Figure 2.4: In-channel structures



Bell Mills Sluice

There are several structures that control water levels within the river at Bell Mills. These are:

- Main sluice structure immediately upstream of Skerne Road bridge
- Three further sluices located downstream of Skerne Road (on a separate arm of the watercourse) which together control the balance of flows between the natural watercourse that runs to the north of the Mill, the mill race through the Mill building and an assumed artificial channel drain that runs to the south of the Mill.

Any of the four sluice structures could be used to control upstream water levels.

The sluice has been vandalised over the last 10 years, and was fenced off to prevent public access (during September 2008). At Bell Mills, the river is split into two channels, where historically, water was required for milling purposes. The sluice remains in place. The structure does not include a fish pass, so is therefore also considered to represent a significant barrier to upstream fish passage.



The impounded area behind Bells Mill Sluice is large, and probably runs at least 400m upstream, under the Driffield / Beverley railway bridge. Between the Railway Bridge and Skerne Road, the impounded watercourse encloses an island; it is not known whether this area would still be an island if the river was not impounded.

Whinhill Weir



Whinhill weir comprises a set of 5 vertical rising sluices, acting as weirs, each 1.7m wide. The sluices are wooden, with steel supporting frames, separated by concrete supports set in the river channel. The sluices are used to impound water within the River Hull, which is then used to supply the adjacent fish farm (Wansford Trout Farm). The water that flows through the fish farm is returned to the main river approximately 500m downstream of Whinhill weir.

The impoundment effect of this structure extends up to 1km upstream under certain flow conditions. The structure does not include a fish pass, so is therefore also considered to represent a

significant barrier to upstream fish passage.

Humberside Fish Farm Off-take

The Humberside Fish Farm off-take is operated in association with the Humberside Fish Farm, located adjacent to the West Beck. The weir is a small concrete structure across an off-take channel and does not include a fish pass. The weir is not considered to be a barrier to upstream fish migration as it is located on an off-take channel feeding into the Humberside Fish Farm. However, the weir does cause a small amount of impoundment and silt deposition on the channel bed.





Cleaves Weir

Cleaves weir is located adjacent to the Humberside Fish Farm on the upstream face of an access track bridge over West Beck. Cleaves weir is in three main sections, each 3.75m wide, with a further two 2.5m sections tying in to either bank of the river. The main weir at Cleaves is of simple stoplog operation. Insertion of additional stoplogs will impound more water and increase the upstream water level. It is understood that the owner of the weir is permitted to maintain a 0.4m difference in levels between the river upstream and downstream of the weir. This allows water to be abstracted at the Humberside Fish Farm offtake and for this water to flow through the fish farm. The weir is resulting in impoundment of water (500m) upstream but is not considered to present a significant barrier to fish passage.

Lowthorpe Weir

Lowthorpe Weir is a concrete structure that is associated with a former mill at Mill Farm. The structure comprises two undershot sluices, which are set into a brick and concrete channel structure adjacent to Mill Farm. A brick arch over the channel upstream of the sluices possibly acts as bracing. The sluice mechanism is of cast iron, and consists of rack and pinion operation. The 1.4m wide sluice has two racks and the 0.75m wide sluice only one. The pinions are handle wound from a position on the right bank of the watercourse. The sluices are in poor condition. Reportedly only one of the sluices can currently be operated. Upstream water levels, and the balance of flows down the mill race, are controlled by the operation of the mill sluices (if possible) and the level of the stoplogs on the bypass weir. The structure does not include a fish pass and impacts of the natural river form and function as a consequence of the impounding effect which extends upstream. The structure does not include a fish pass, so is therefore also considered to represent a significant barrier to upstream fish passage.



Foston Mill Weir



Foston Mill Weir is a concrete structure that is associated with a former mill. The weir is a gauging weir which has been operating since the 1950s. The structure is a rectangular thin plate 2.80m in width, which can be raised and lowered to alter the extent of impoundment. The weir is currently set at 0.15m above gauge zero, and cannot be lowered any further. It is thought that the weir is capable of being raised and lowered over a range of approximately 1.00m. The structure does not include an operational fish pass, although an eel pass comprising two pieces of piping is present. However, although the pipe work is in place along the right hand bank, a collection chamber and a pump have not been fitted so the eel pass is not currently operable. The impact on river form and function is significant with the impoundment extending several kilometres upstream. The structure does not include a fish pass, so is therefore also considered to represent a significant barrier to upstream fish passage.

How does it affect the SSSI?

The structures identified impound water upstream, which creates uniform ponded flow conditions upstream for long distances in some cases and encourages sediment deposition on the channel bed. This smothers bed habitats for aquatic plants which require a coarse bed substrate to thrive, including *Ranunculus* spp., and adversely affects spawning habitats for fish such as brown trout and grayling.

During low flows, the weirs are likely to create impounded conditions for a considerable distance upstream (up to the crest level of each structure). There is currently insufficient data (including information on water levels during low flows) to identify the full impoundment effects of the structures at this stage. It is clear, however, that the crest levels of the structures are considerably higher than the water levels which occur during relatively small flood events (with a return period of once in every two years), and are generally higher than a much larger flood (with a return period of 1 in 200 years) (**Figures 2.5 and 2.6**). This suggests that the weirs are likely to have a considerable impact on the river system, creating impounded conditions even during periods of flooding.

Another effect of in-channel structures on the River Hull Headwaters SSSI is the physical obstruction of free fish passage along the river. There is currently inadequate provision for fish passage at Bell Mills sluice, Lowthorpe Mill, Poundsworth Mill, Foston Mill and Whinhill weirs. This may have a detrimental impact on fish by preventing access to suitable spawning habitats upstream of these features.

What are the potential solutions?

The main solutions that could potentially be implemented to help address the problems created by in-channel structures are:

- Remove the structure
- Modify the structure
- Alter the operation of the structure
- Provide a suitable fish pass
- Other (specific to certain weirs)

The main aim of removal/alteration of structures is to restore river function / form and remove their impounding effects. Free fish passage is another requirement in addition. The main aim of these solutions is to alter the existing structures to reduce impoundment, increase flows and improve fish passage. These solutions could potentially lead to wide improvements in the River Hull Headwaters SSSI. All in-channel structures solutions need to be sustainable at low flows.

Figure 2.5: Bed levels and water levels along West Beck. Note Poundworth weir has been omitted due to no elevation information.

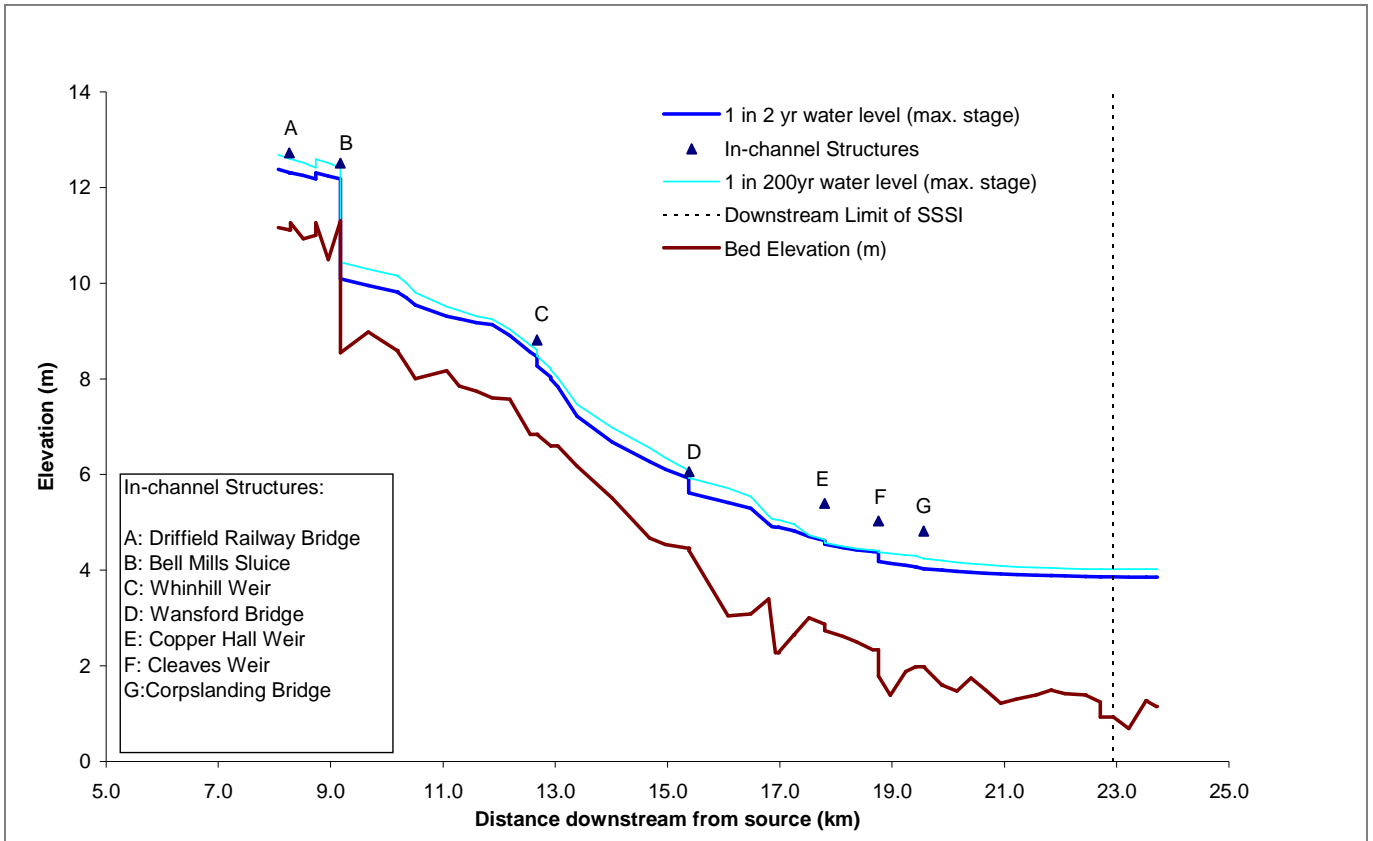
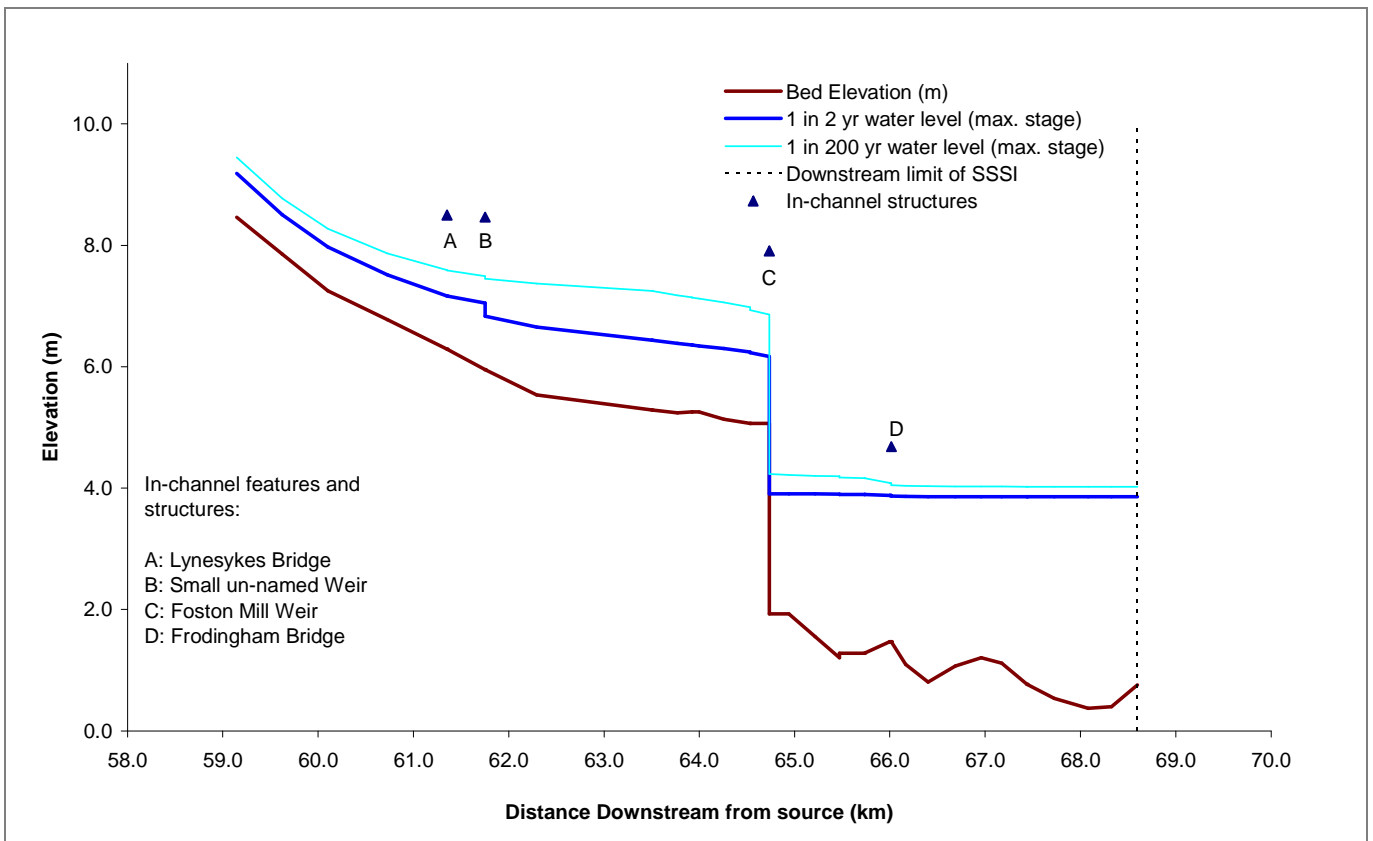


Figure 2.6: Bed levels and water levels along Foston Beck



3. POTENTIAL SOLUTIONS

Potential solutions to the key issues

Several solutions need to be implemented within the River Hull Headwaters catchment in order to help address the key issues and contribute to achievement of favourable condition of the SSSI. This section of the River Restoration Plan outlines these solutions, focussing on the aim of each solution, and how it could potentially be implemented. These solutions are intended to address the key conservation objectives which have been set by Natural England habitats within the SSSI. The conservation objectives are shown in **Table 1.2** and information on how each solution addresses the objectives can be found in **Appendix B**.

Fourteen solutions have been identified within five broad categories (**Table 3.1**). The majority of solutions are intended to address one or more of the key issues described in the previous section. However, it should also be recognised that good habitat conditions and features already exist within the River Hull Headwaters SSSI. The solutions identified therefore include those that involve preservation of current favourable conditions.

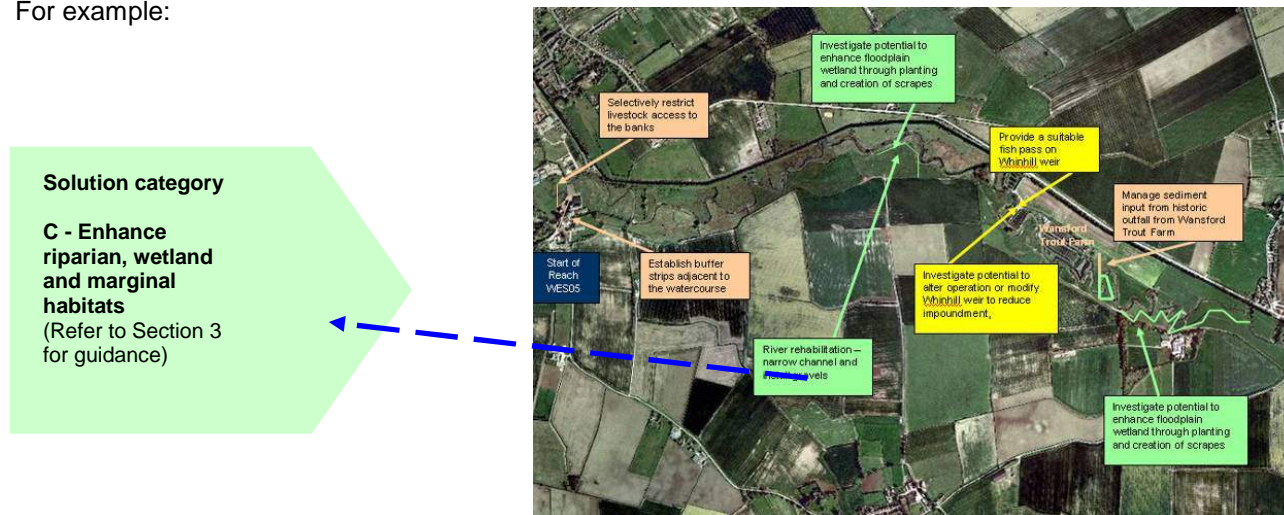
Table 3.1: Potential solutions to tackle the key issues in the River Hull Headwaters SSSI

Category	Solution	Key Issues Addressed			
		Fine sedimentation	Channelisation and low flows	Lack of bankside shelter / over shading	In-channel structures
A – Changing agricultural and land drainage management practices	Review the maintenance regime of watercourses	✓			
	Establish buffer strips adjacent to watercourses	✓		✓	
	Selectively restrict livestock access to banks	✓		✓	
B – Alter flood and informal embankments	Investigate the future management of flood embankments	✓	✓	✓	
	Remove or re-grade informal (dredging arisings) embankments	✓	✓	✓	
C – Enhance aquatic, marginal, bankside and wetland habitats	Establish and enhance aquatic, marginal and bankside habitats	✓		✓	
	River rehabilitation	✓	✓	✓	
	Enhance floodplain wetland habitats		✓	✓	
D – Modify in-channel structures	Remove structures	✓			✓
	Modify structures	✓			✓
	Alter operation of structures	✓			✓
	Provide a suitable fish pass				✓
E – Preserve existing habitats	Preserve existing quality habitats	n/a	n/a	n/a	n/a
	Preserve existing woody debris in the river channel	n/a	n/a	n/a	n/a

Finding out more about the solutions

Section 3 provides information on each category of solution, referencing key guidance which can be referred to for more information. The categories of solution are colour coded using the colours shown in **Table 3.1**. This colour coding is repeated in **Section 4** when the solutions for each reach are also colour coded, making it easy to cross-reference to the information contained **Section 3**.

For example:



Implementing solutions on the ground

To take forward the solutions in practise there will be some important considerations that will need to be taken into account. **Section 5** shows an action plan which can be used to take forward the solutions for delivery on the ground over the short, medium and long term. In many cases the first action to be taken towards implementing the solution will be to investigate the feasibility of whether the solution is sustainable (taking into account the function of the river for both wildlife and those who use the river now and into the future). A key part of this must also be to take into account climate change and how the plan takes account of the need for solutions to be adaptable to climate change.

Climate change implications for the River Hull Headwaters

The latest climate projections (UKCP09) produced by the UK Climate Impacts Programme (UKCIP) suggest that, over the next 20-50 years, temperatures and precipitation levels in the River Hull catchment could be considerably different to current conditions. The main changes that are likely to occur are:

- Increased annual average daily temperatures: Temperatures are predicted to increase by up to 2°C by the 2020s, and 3°C by the 2050s.
- Decreased summer precipitation: Summer precipitation levels are predicted to decrease by up to 10% by the 2020s and up to 30% by the 2050s. This is likely to reduce river flows in the summer, and reduce the amount of water available to wetland habitats and grazing livestock.
- Increased winter precipitation: Winter precipitation levels are predicted to increase by up to 10% by the 2020s and up to 20% by the 2050s. This is likely to increase flows during the winter, leading to increased flood frequency and more sediment runoff.
- This means that, over the next 50 years, summers are likely to become warmer and drier and winters are likely to become warmer and wetter.

The plan must take into account the changing climate to ensure that the river is resilient and adaptive to change and where possible works towards mitigating climate change.

A. Changing agricultural and land drainage management practices

A.1 Review the maintenance regime of watercourses

*This solution would help to address the issue of **Fine Sedimentation**.*

Aim

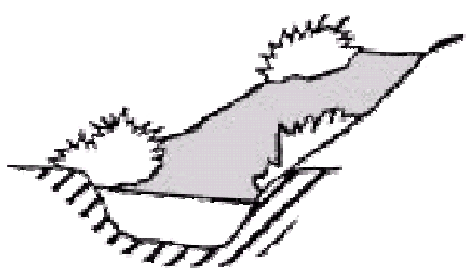
The aim of this solution is to change the way drainage ditches and land drains are managed, in order to help retain sediment within them and prevent sediment from reaching the main channel. There are a number of drains and tributaries which flow into the main channel, and transport a significant amount of sediment from the adjacent arable and grazing land (**Figure 3.1**). By working with landowners, farmers and Beverley and North Holderness Internal Drainage Boards (IDB) to improve current drain and tributary management practices, it should be possible to reduce sediment supply from these sources. Although this solution can be targeted at individual watercourses, it will be most effective if it is applied at a catchment scale to address sediment supply from cultivated land, field drains and tributaries to the main river.

Description

The Environment Agency and Beverley and North Holderness IDB are currently responsible for the maintenance of the majority of the drainage network. They undertake a range of activities including grass cutting, tree and bush maintenance, weed cutting and sludging, debris removal, pumping station and structures maintenance. Grass cutting works are commenced from mid July, while tree and bush maintenance is undertaken in autumn and winter; other works are undertaken all year round and when access permits. De-silting works are carried out on a rolling programme or when a specific need is identified. The current maintenance regime could potentially be modified in order to reduce the amount of sediment that enters the main river from wider catchment sources. Changes to the drain maintenance regime could offer cost savings to the land owner. Three potential measures that could be introduced as part of a revised maintenance regime are described below.

Reduce the frequency and extent of drain clearance

At present, many field drains are cleared of debris and sediment on a regular basis. A reduction in the frequency and extent of drain clearance could help to reduce the supply of sediment to the River Hull Headwaters SSSI by retaining it in the field drains. The maintenance of the drains could be undertaken on a rotational basis leaving part of the drainage network untouched. Ideally, an individual section of drain should only be cleared every three to four years. When a drain has been cleared, the resulting sediment should be spread on the adjacent fields and not allowed to enter the drainage network (Association of Drainage Authorities and Natural England, 2008).



Vegetation left uncleared on alternate banks

Encourage the growth of vegetation in the channel

Vegetation and small blockages can be used to slow flows and encourage sediment to settle within drains rather than being readily transported into the main channel. This option should only be considered as long as the primary function of land drainage is not significantly impeded. The drains can be maintained on a rotational basis so that they do not become too heavily overgrown. Up to half of the vegetation within a drain should remain un-cleared to enable re-colonisation.

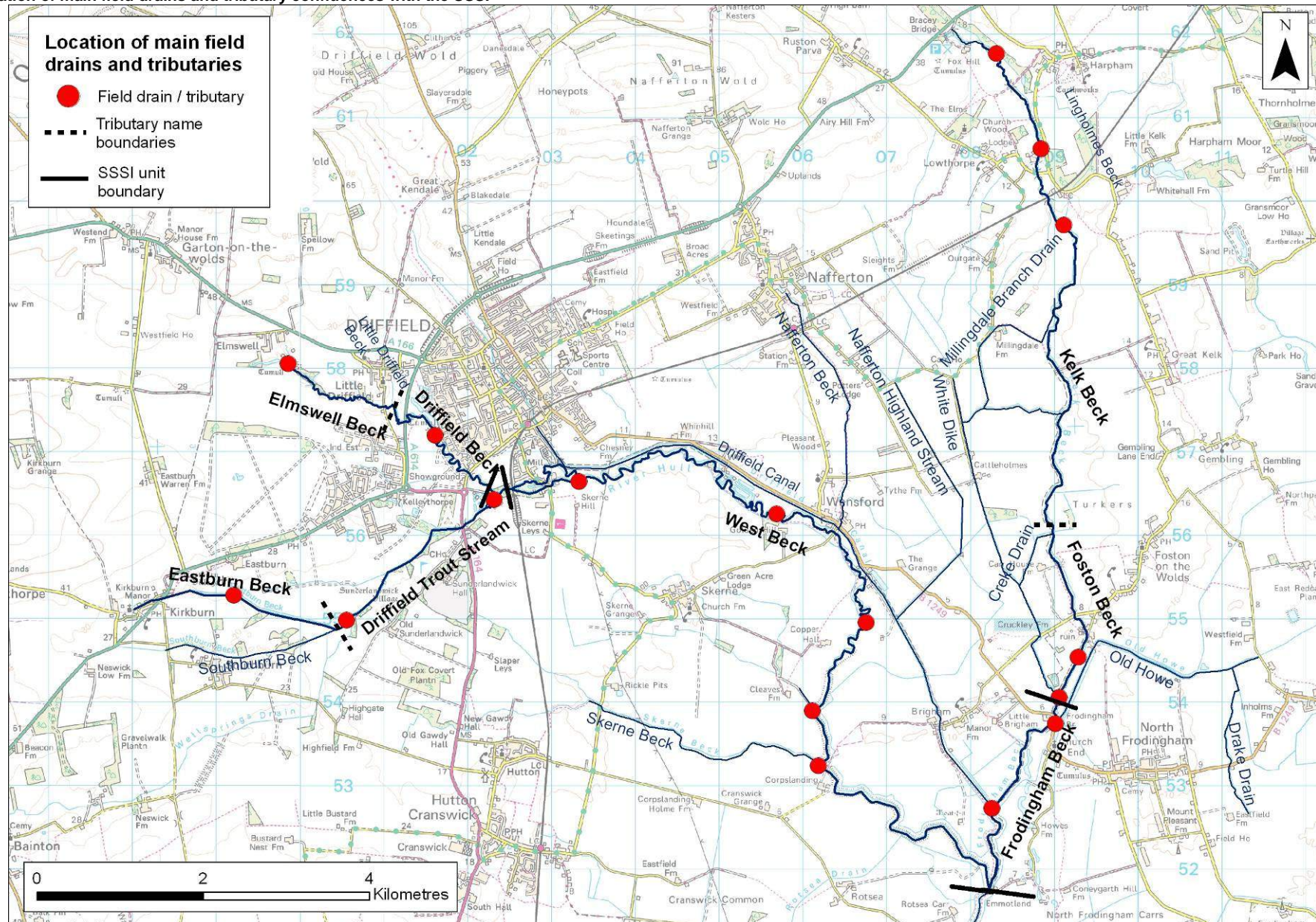
Install sediment traps within the drainage channel

In addition to encouraging the growth of vegetation to slow flows and trap sediment within the drainage channels, small sediment traps or dams could also be used to reduce sediment supply into the main channel. Dead natural materials could be used to construct traps or dams, and impound small amounts of water within ditches. This would encourage any sediment within the drainage channel to settle behind the structure. Such structures could be cleared on a rotational basis as part of the ditch maintenance regime.

These measures could be implemented by landowners, potentially as part of an Environmental Stewardship Agreement, and by Internal Drainage Boards as part of their Biodiversity Action Plans.

See identified Further Information Sources for more detailed guidance.

Figure 3.1: Location of main field drains and tributary confluences with the SSSI



A.2. Establish buffer strips adjacent to watercourses

This solution would help to address the issues of **Fine Sedimentation** and **Lack of bankside shelter**.

Aim

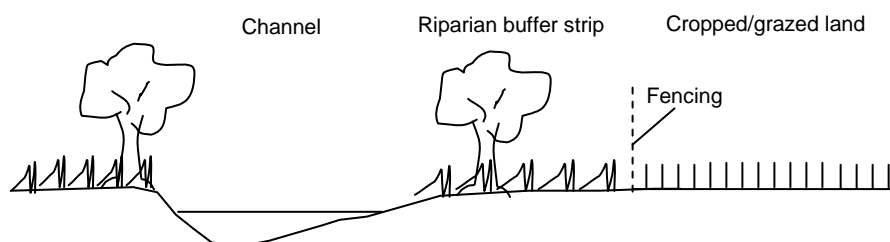
The aim of this solution is to reduce the transfer of eroded sediment from fields and floodplain land into the drainage network as well as the main channel itself. By working with land owners and land managers, it should be possible to reduce sediment supply from the land into the tributaries and drains which subsequently feed into the River Hull Headwaters. This solution could be applied catchment wide for maximum benefit, but could also be targeted to specific areas where sediment supply is particularly high due to factors such as soil erodibility, topography and land management practices.



Good buffer strip along the West Beck

Description

A buffer strip is an area of land adjacent to a watercourse that is left un-cropped in order to intercept surface drainage and to minimise soil erosion. Buffer strips can effectively reduce the amount of sediment and pollutants carried by runoff to tributaries, drainage networks and the main channel by slowing down overland surface flows and encouraging sediment to settle out. Buffer strips can be comprised of a mixture of natural plants, including grasses, shrubs and trees, and therefore can also provide valuable habitats for invertebrates, mammals and birds.



Schematic diagram of a buffer strip adjacent to a watercourse

Buffer strips are typically between 1 and 50m wide. They should be at least 5m wide to be effective, and their optimum width is approximately 20m. Wider strips with thicker vegetation are typically more effective at trapping sediment than narrower strips with less dense vegetation cover. In practice, the exact width of the features is largely dependent on the space available for their creation, the erodibility of the underlying soils and the nature of surrounding land use.

Buffer strips could potentially be established in a number of areas in the river catchment. To be most effective, they could be established next to the tributaries and field drains that drain easily erodible soils, particularly where they are cropped right up to the water's edge or grazed heavily. In this case, it may be necessary to fence off the strips to prevent them being trampled by livestock. In addition, this measure could also be introduced adjacent to the main river in areas where sediment supplied through direct runoff is a concern.

This measure should ideally be implemented alongside other measures to limit sediment supply. For example, it is likely to have maximum benefit if used in conjunction with changes to the ditch maintenance regime (**Solution A.1**) to limit the amount of sediment that is supplied from catchment sources.

This measure could be implemented by landowners potentially as part of an Environmental Stewardship Agreement (see **Solution A.3** and **Appendix A**).

See identified Further Information Sources for more detailed guidance.

A.3. Selectively restrict livestock access to banks

This solution would help address the issues of **Fine sedimentation** and **Lack of bankside shelter**.

Aim

The aim of this solution is to help control cattle trampling along the banks of the main river, in order to limit bank erosion and the input of sediment to the river channel. In addition, this solution can also be used to capitalise on the effects of trampling in areas where it has already occurred, for by allowing trampled banks to re-vegetate and provide new habitats. This solution could be applied locally in areas where trampling of banks is a particular problem.

Description

Trampling can be defined as alterations to the bank profile caused by livestock as they seek drinking water from the river channel. Trampling changes the bank structure by decreasing its steepness and creating a more gradual, often stepped profile with little vegetation and exposed sediments. Where livestock trampling is not controlled, large sections of bank can collapse and become devoid of vegetation cover, and as such become sources of sediment into the river channel. However, if a formerly trampled bank is allowed to re-vegetate, it can provide good quality habitats for marginal and bankside flora and fauna. There are two main techniques that could potentially be employed to restrict livestock access to banks: i) Fencing off trampled areas; and ii) Introducing a rotational grazing system.



Fencing of riparian buffer zone with defined cattle access point

Fencing off trampled areas

An effective method to prevent trampling is to fence off grazed river banks to prevent access to badly affected areas so that they can re-vegetate. It will be important to allow some management of bank habitats to continue to ensure that the botanical interest of the river banks are maintained and that they continue to provide high quality habitats for invertebrates and other interest features. Allowing grazing to continue in a targeted and controlled manner, for example by periodically relocating fences once banks have recovered, is likely to be an effective way of achieving this aim. In fenced off areas, drinking water supply for livestock can be maintained through the provision of galvanised troughs, the installation of a piped water supply, or creating defined access points to the river. These access points can simply consist of areas of bank that are left unfenced for a period, which are later fenced off when trampling

becomes heavy. The fence can then be reinstated and removed from another part of the bank to maintain access. Alternatively, fixed access points with wooden reinforcement (e.g. railway sleepers) could be installed, although these ultimately offer less flexibility.

Rotational grazing

In a rotational grazing strategy, livestock are only allowed in the riparian zone for short periods of time to drink and graze (typically less than a week) and only when conditions are dry and bank erosion is minimised. Livestock can be restricted from having direct access to the stream (see above), and drinking points can be rotated throughout the year to allow adequate time for the river banks to recover before grazing is resumed.

Climate change adaptation: Changing agricultural and land drainage management practices

Solutions aimed at changing agricultural and land drainage management practices can contribute towards climate change adaptation in several ways.

- **Increased annual average daily temperatures:** Improved conditions for vegetation growth in the channel and riparian zone could improve shading and regulate temperatures if management practices are altered.
- **Decreased summer precipitation:** Reduced summer flows could increase livestock trampling pressures, so improved watercourse management could prevent further increases in sediment supply.
- **Increased winter precipitation:** An altered land management regime could help to mitigate potential increases in sediment runoff from agricultural land, which are likely to occur in response to increased rainfall.

See identified Further Information Sources for more detailed guidance.

B. Alter flood and informal embankments

B.1. Investigate the future management of flood embankments

*This solution would mainly help to address the issue of **Channelisation and low flows**. It could also help to address the issues of **Fine sedimentation** and **Lack of bankside shelter**.*

Aim

The aim of this solution is to investigate the future management of the flood embankments to identify an adaptive management strategy and assess the potential benefits flood embankment alteration may provide to the SSSI.

Description

Due to the low lying nature of the catchment, the River Hull has a long history of channel modification for flood defence, predominantly in the form of flood embankments. Records show that by the late 1200s, the entire lower reaches of the River Hull and adjacent drains were embanked, and have been continuously maintained since that time. The presence of the flood embankments reduces inundation frequency, particularly during small floods, and therefore limits the potential for floodplain storage of fine sediments. In addition, many of the flood embankments that fringe the river currently prevent the development of riparian habitats, due to their close proximity to the channel edge.

Identifying the best solution

Currently embankments within the River Hull Headwaters are maintained by the Environment Agency with works including vermin control and protection from bank breaching as well as repair and assessment of the condition of the banks themselves. The condition of the embankments is assessed on a five point scale as below:

Grade	Rating
1	Very Good
2	Good
3	Fair
4	Poor
5	Very Poor

Some sections of the embankments are currently in a fair or poor condition, as illustrated in **Figure 3.2**.

Future management of the embankments for flood risk management purposes is being consulted upon as part of the River Hull Flood Risk Management Strategy.

There is a potential for the Environment Agency to work with Natural England and landowners in the Headwaters area to work out which floodbanks are critical to both the SSSI and agriculture in the area.

There may also be opportunities within the River Hull Headwaters to alter the flood embankments along the river in a way that creates additional adjacent floodplain habitats, or enhances existing habitats. The location of observed floodplain habitats along the river corridor is shown in **Figure 3.3**. Comparison of this map with the condition of embankments within the River Hull Headwaters indicates the potential to enhance floodplain habitats at locations where the embankments are in fair or poor condition, along the lower reaches of West Beck, Foston and Frodingham Beck. The option would be subject to consultation and the support of local landowners and farmers and is in accordance with current Defra policy, and reduces the likelihood of bank failure during flood events by decreasing flow velocities and erosion potential of flows.

One of the key impacts of altering the flood embankments would be on land use and land management practices on the adjacent land. It is envisaged that this option could be implemented with support from the Environment Agency and Natural England in conjunction with the Higher Level Stewardship or Catchment Sensitive Farming initiatives (see **Appendix A** and **Appendix C** for further details)

Figure 3.2: Condition of flood defences

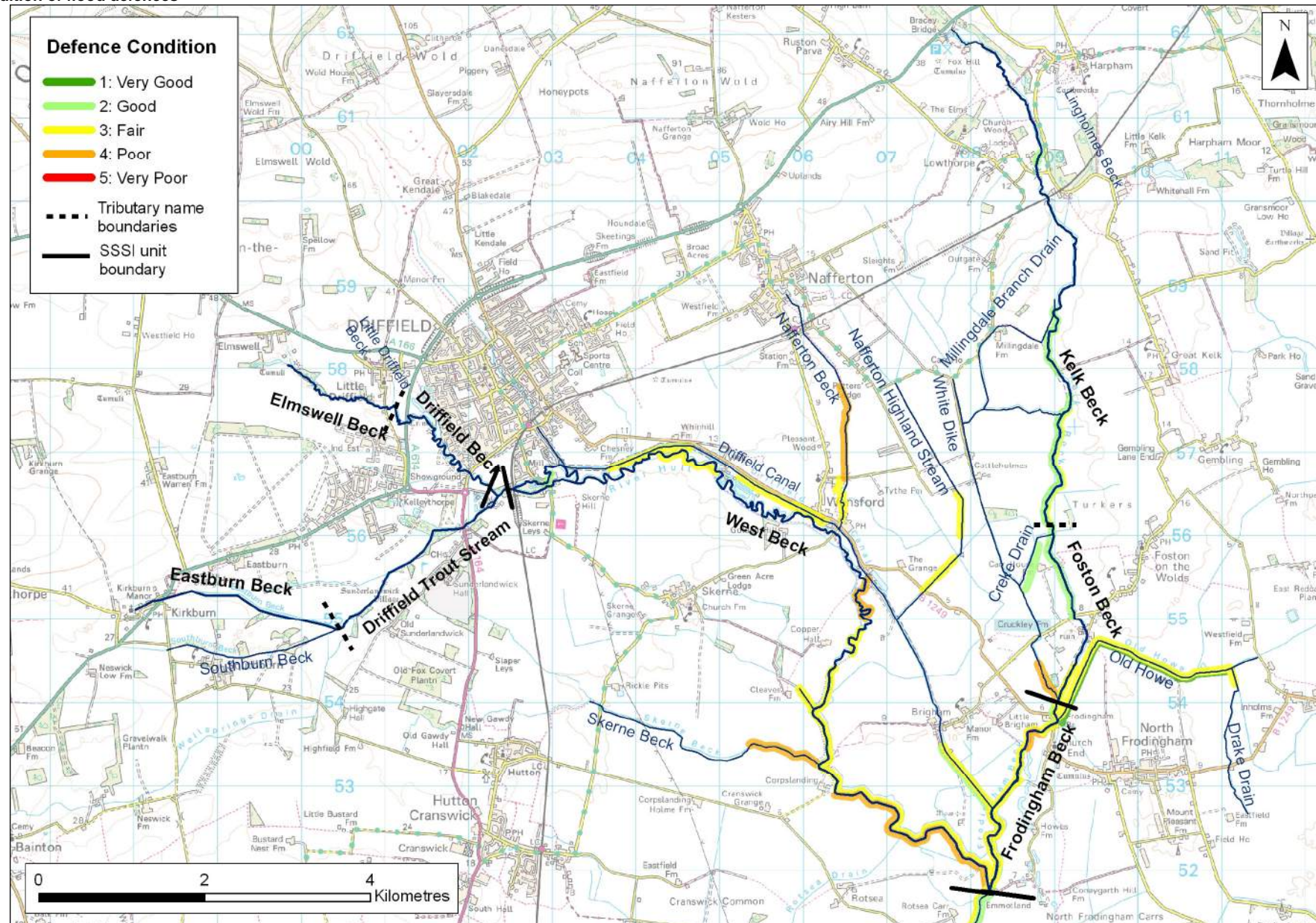
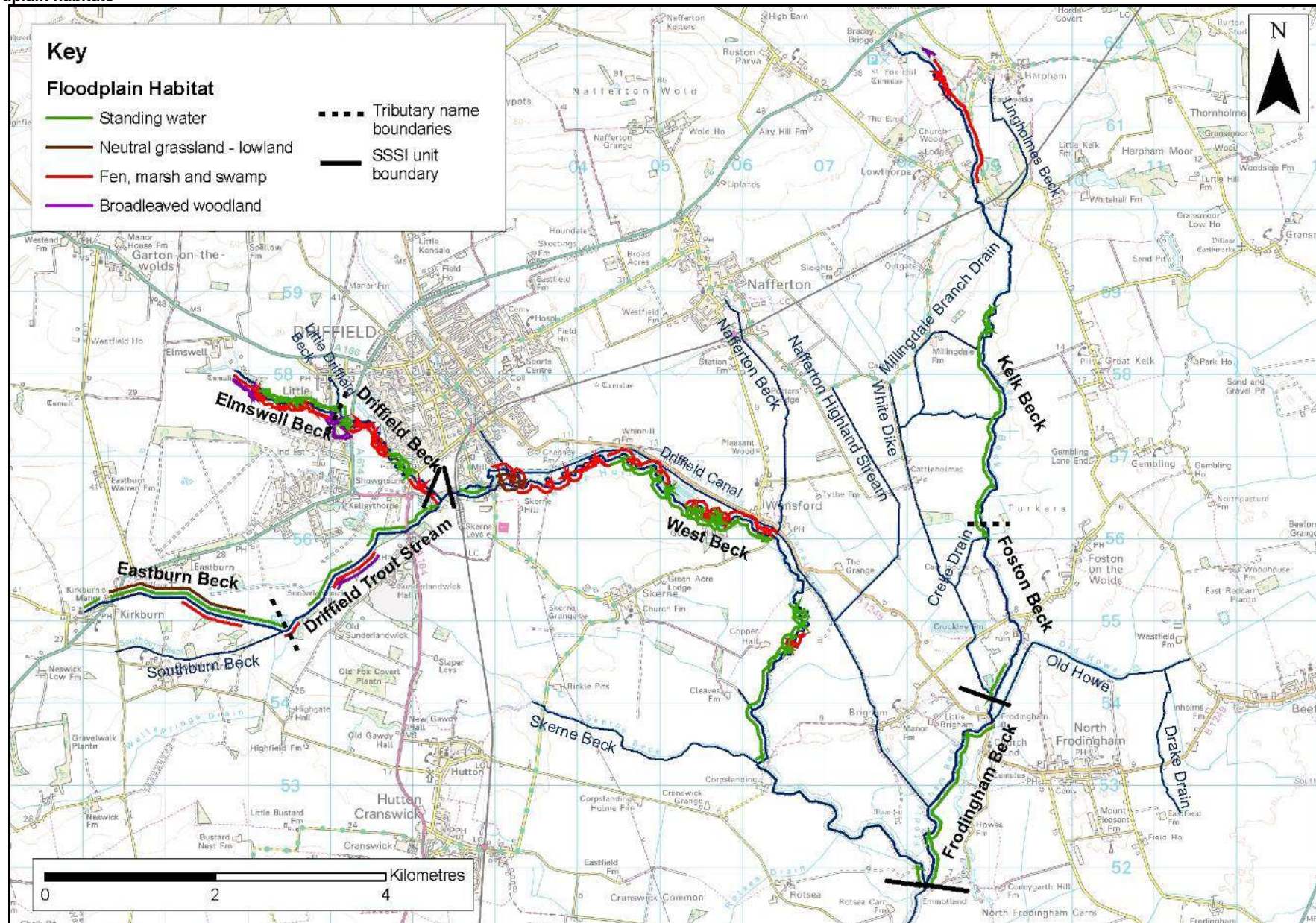


Figure 3.3: Floodplain habitats



B.2. Remove or re-grade informal embankments

*This solution would mainly help to address the issue of **Channelisation and low flows**. It could also help to address the issues of **Fine sedimentation** and **Lack of bankside shelter**.*

Aim

The aim of this solution is to modify informal embankments to improve the connectivity between the channel and the floodplain, increase the potential for overbank storage of fine sediments, and improve the quality of wetland floodplain habitats. This measure could be applied locally to address the issues posed by individual structures, but is likely to be more effective if applied on a wider scale.

Description

Informal embankments are defined as those that have not been intentionally built to provide a flood defence function. Informal embankments in the Hull Headwaters predominately occur as a result of dredging arisings from past channel maintenance practices being placed in piles or low bunds on top of the river bank. The informal embankments often consist of gravel and silt that has been removed from the channel bed. Although these informal embankments do not provide a flood defence role in high flows, they do reduce the frequency of floodplain inundation and hence provide some disconnection of the floodplain thereby keeping more flow and sediment in the channel than would naturally occur. Informal embankments can also impact on the drainage of floodplains as once they are overtopped, floodwaters can remain trapped behind these embankments resulting in fields remaining waterlogged and inundated for long periods of time.

The two options that could be employed to improve floodplain connectivity and drainage include:

- Removal of informal embankments
- Re-grade informal embankments

Removal of informal embankments

In some reaches, there could be potential to remove the informal embankments entirely using an excavator or equivalent construction equipment. Depending on the amount of material and the ease of access, this can be a time-consuming process, and produce large quantities of material that may need to be transported off site which could have significant cost implications. In some cases, it may be possible to spread the material across the ground surface.

A more sustainable and cost effective option would include the reclamation of the informal bank material on site to locally raise the river bed in stretches to create riffles. This option of bed raising is dependent on a number of factors such as amount of gravel material in the informal embankment, percentage of fine silt material and location suitability. However, where it is suitable, this option can provide considerable benefits to the SSSI both in terms of increased floodplain connectivity and improved channel form.

Removal of the informal embankments will increase the frequency of overbank flooding, and the land behind the former embankments will become wet more often. However, it will also drain more naturally, and as a result may not necessarily be inundated for longer periods. This solution will deliver the most potential benefits to the river and floodplain by fully restoring channel-floodplain connectivity, removing sediment from the river channel, and allowing natural riparian and floodplain wetland habitats to develop.

Re-grade informal embankments

Re-grading of informal embankments involves using an excavator to push the embankment material down the river bank to create a new bank profile with a shallower slope and an aquatic ledge to encourage the development of marginal vegetation. This solution also provides multiple benefits in terms of floodplain connectivity and channel enhancement and is particularly relevant for over-widened channels.

Climate change adaptation: Alter flood embankments

Solutions aimed at altering flood embankments in the catchment can contribute towards climate change adaptation in several ways:

- **Decreased summer precipitation:** Decreased summer precipitation will reduce flow levels, so removal or lowering of embankments will help to maximise inundation frequency and maintain wetland habitats.
- **Increased winter precipitation:** Increased winter precipitation will increase flow levels, so removal or modification of selected embankments will allow more frequent floodplain attenuation of high flow events.

C. Enhance aquatic, marginal, bankside and wetland habitats

C.1. Establish and enhance aquatic, marginal and bankside habitats

This solution would help to address the issue of **Lack of bankside shelter/over-shading, Channelisation and low flows, and Fine sedimentation.**

Aim

The aim of this solution is to establish natural bank habitats adjacent and within the river channel, particularly in areas that are open and exposed, as well as manage areas that are over-shaded due to overhanging vegetation. An increase in bankside, aquatic and marginal vegetation will increase the availability of shelter and shading for mammals and birds that live in and around the river, and improve in-channel habitat for fish. A reduction in bankside vegetation is likely to increase light penetration into the channel and subsequently improve the habitat for marginal and aquatic vegetation. This reach-scale solution could bring real benefits in the reaches where it is implemented, and will help to provide good habitats along the entire river corridor if implemented in a targeted manner.

Description

Long reaches of the lower reaches of the River Hull Headwaters are relatively exposed, with steep banks and little cover from bankside trees and shrubs. This means that fish are vulnerable to predation and there is insufficient cover for mammals and birds. The main solution to this issue is to plant suitable vegetation cover of appropriate water tolerant species along the bank top. Smaller plants could also be planted in particularly exposed areas. This will provide shelter on the bank top as well as root systems and woody debris for in-channel shelter. A complementary physical solution to this issue is described in Solution C.2.

When trees and shrubs are established on the bank top, care should be taken to ensure that cover does not become dense enough to cause over-shading in the channel. Rather than planting trees to provide thick cover along extended stretches of bankline, it will be more appropriate to target planting more carefully in order to create a more diverse mixture of light and shade in the river channel whilst still improving cover on the bank itself. Planting could therefore take the form of small linear clumps interspersed with more open areas of bank. For example, one half to two thirds of the banks identified for planting could be left open to allow light to reach the banks and channel. Clumps should contain between 5 and 20 trees, utilising a mixture of trees and shrubs to produce maximum structural diversity. The ratio of trees to shrubs should be approximately 1:2. Clump locations should be chosen to complement the natural features of the channel, such as on the inside of bends, in locations that already have some vegetation present, and near pools and spawning gravels for the benefit of salmonids. Young trees with a maximum of 1 or 2 years growth should be planted where possible, as they generally have the highest survival and growth rates. Where possible, plants should be sourced from native populations. A list of some species that may be suitable is provided in **Table 3.3**.

Table 3.3 Species potentially suitable for establishment of bankside vegetation along the River Hull Headwaters SSSI

Trees	Shrubs
Alder (<i>Alnus glutinosa</i>)	Blackthorn (<i>Prunus spinosa</i>)
Ash (<i>Fraxinus excelsior</i>)	Hazel (<i>Corylus avellana</i>)
Aspen (<i>Populus tremula</i>)	Holly (<i>Ilex aquifolium</i>)
Crab apple (<i>Malus sylvestris</i> ssp. <i>Sylvestris</i>)	Dog rose (<i>Rosa canina</i>)
Wych elm (<i>Ulmus glabra</i>)	Elder (<i>Sambucus nigra</i>)
Goat willow (<i>Salix caprea</i>)	Privet (<i>Ligustrum vulgare</i>)
Grey Willow (<i>Salix cineria</i>)	Common hawthorn (<i>Crataegus monogyna</i>)
Osier willow (<i>Salix viminalis</i>)	Gean (<i>Prunus avium</i>)
Crack willow (<i>Salix fragilis</i>)	Oak (<i>Quercus robur</i>)
White willow (<i>Salix alba</i>)	

In contrast to reaches lacking shelter and shading, other reaches are over-shaded. This is most prevalent within Eastburn Beck, Elmswell Beck and Driffild Beck. Over-shading reduces light penetration into the channel and restricts the potential for in-channel vegetation growth. It is therefore important that this issue is addressed alongside lack of shelter, to ensure that the banks along the whole system offer optimal habitat. Potential solutions to over-shading include tree pollarding and coppicing, which can allow sufficient light penetration into the channel.

See identified Further Information Sources for more detailed guidance (p103).

C.2 River rehabilitation

This solution would help to address the issues of **Lack of bankside shelter/over-shading**, **Fine sedimentation** and **Channelisation and low flows**.

Aim

The aim of this solution is to physically improve the river banks and the in-channel habitats they offer by altering the structure of the banks and modifying river cross section and long profile in order to reinstate physical habitat that will support the characteristic ecology of the river. This includes measures such as bank re-profiling, channel narrowing, aquatic ledge development, gravel importation and re-meandering of the channel. This will improve the quality of habitats for a range of species that live on and around the river banks, including aquatic and marginal plants, invertebrates, fish and mammals and birds. This solution will be most effective if it is targeted in individual reaches, although it may also help to improve longer sections of the river. This solution will typically go hand in hand with modification of any in-channel structures and to mitigate against the issues of low flows.

Description

Historical modifications to the river channel and changes to the flow regime have also restricted morphological diversity, resulting in steep river banks and uniform cross section predominantly along the Kelk Beck, Foston Beck and Frodingham Beck and upstream of structures on West Beck. The lack of shallow areas adjacent to the bank restricts the occurrence of water tolerant and aquatic plants such as river water crowfoot and shining pondweed, as well as fish fry, invertebrates, birds and mammals. The more diverse an ecosystem is, the higher the species diversity is likely to be. The many types of niche habitat that exist in diverse ecosystems allow different life stages of invertebrates to be more successful.

The main solution to the lack of varied bank habitats in some reaches is to undertake river rehabilitation. This consists of several techniques that aim to reduce the uniformity of the bank and bed to provide a range of niches for different habitats:

- Bank re-profiling.
- Creation of aquatic ledges.
- Channel narrowing.
- Reinstatement of gravel bed.
- Re-meandering of the channel.
- Introduction of large woody debris.



Steep uniform banks along the lower Kelk Beck

Bank re-profiling

River banks can be artificially re-profiled to reduce their gradient and create shallow areas next to the channel edge. For example, a bank with a steep, uniform slope right down to the edge of the channel can be re-profiled to incorporate shallow ledges just under the water line, areas of vertical river cliff, and intermediate ledges that lead to a more stepped profile. This process is generally undertaken using an excavator. If the bank material is particularly easy to erode, it may be necessary to prevent erosion and stabilise the bank surface using vegetation or geotextile matting. This can be pre-planted, and will allow natural vegetation to colonise.



Lowering of the informal embankments and reprofiling the bank at West Beck, downstream of Bells Mills in 2006. Photo courtesy of A. Mullinger EYCRT.



Regenerated banks at the same reach, two years after reprofiling. Photo courtesy of A. Mullinger EYCRT.

Creation of aquatic ledges

In addition to re-profiling the banks, new aquatic ledges could be created along the edge of the river. This can be achieved by building up the river bank from its base to the low water mark, using material from the bed where possible or from the top down by re-profiling the banks and reshaping some of the material into a shallow ledge that gently dips in the channel. Both of these techniques have been used successfully by the East Yorkshire Chalk Rivers Trust (EYTRC) in the past in the catchment with excellent results (refer to the Technical Report for more details). The aquatic ledges can be protected with planted geotextile matting and/or aquatic vegetation to prevent it eroding although cheaper methods have been employed by the EYCRT by placing vegetated turfs on the water edge side of the ledge to provide short term protection of the edge from erosion allowing plants to establish behind the turf. Experience by the EYCRT in the Hull Headwaters has found that planting of the ledges is rarely required as adequate seed stock is available in the banks and from vegetation upstream to allow quick colonisation of a variety of marginal plants. The end result is a series of narrow ledges in and around the water line that provide good habitats for emergent and marginal plants.

Channel narrowing

Channel narrowing is an effective river rehabilitation technique that is used to significantly reduce the cross sectional area of an over-widened channel, while at the same time providing new habitats for aquatic and marginal communities. Narrowing the channel also ensures that sedimentation of gravel beds is reduced by locally increasing flow velocity and encouraging scouring. Channel narrowing can be in the form of aquatic ledges as described above or using a combination of soft engineering techniques and backfilled material from the river bed if necessary. Narrowing the channel using faggots and allowing the river to naturally infill behind the faggots is a technique that has been used successfully on Driffild Beck and Kelk Beck by EYCRT. Allowing the river to naturally infill behind narrowing techniques is a sustainable and cost effective way of kick starting the river to naturally adjust to a more suitable form and function. Narrowing also provides the opportunity to create a meandering low flow channel that provides increased habitat niches for aquatic vegetation and invertebrates. Narrowing also improves habitat provision at low flows and improves hydrological connectivity with banks and floodplain, allowing the recreation of fen, carr and wet grassland communities.



Hazel faggots installed to narrow an overwide reach of Lowthorpe Beck. Photo courtesy of A. Mullinger, EYCRT.



Sedimentation is occurring naturally behind the faggots, creating a faster-flowing low flow channel with cleaner gravel. Photo courtesy of A. Mullinger, EYCRT.



Hazel faggots installed to narrow an overwide reach of West Beck. Photo courtesy of A. Mullinger, EYCRT.



The faggots were backfilled with silt from the river and several years later the bank is stabilised and supporting marginal communities. Photo courtesy of A. Mullinger, EYCRT.

Reinstatement of channel bed

Past dredging and channel maintenance practices has resulted in the loss or reduction of gravel bed substrate from the channel in the Hull Headwaters. As with all chalk streams, the removal of gravel from the system is permanent as the presence of gravel is a consequence of past geological processes and the river is not able to naturally deliver sufficient gravel to the system to replenish the lost gravel. Consequently, the reinstatement of the channel bed using gravel is often required and this can be achieved by either using imported gravel or more appropriately, reusing dredged coarse material left on top of the bank. This latter option is a sustainable and cost effective option as it increases floodplain connection by removing informal embankments and it returns the natural gravel to the system. Reinstatement of the coarse bed material provides substrate for aquatic vegetation to colonise, habitat niches for different species of invertebrates and riffle dwelling fish and improves hydrological connectivity with banks and floodplain by raising the bed in over-deepened channels.

Re-meandering of the channel

Certain reaches of the West Beck System and Foston and Frodingham Beck have historically been straightened as a consequence of dredging and drainage works. Re-meandering of the channel helps to restore habitat length/area and improve flow, substrate and depth diversity, thereby providing improved habitat conditions to a wider range of fauna and flora. Re-meandering can be undertaken at two scales, the full channel cross section or in-channel as part of the creation of a low flow channel using channel narrowing or aquatic ledge techniques.

Introduction of large woody debris

Large woody debris (LWD) can be introduced to the river channel as part of bank re-profiling/channel-narrowing or as discrete features keyed in the river bank or pinned to the channel bed. LWD can also be used to protect the bank toe by either absorbing or deflecting erosive forces from high flow events protecting the stream bank from erosion. Guidelines (see Further Information Sources) are available for the placement of reintroduced LWD as discrete structures and if placed appropriately, these structures can provide an important function in initiating and maintaining scour pools downstream and raising water levels locally upstream providing important refuges during low flow periods. They also increase flow diversity and aid in the development of a natural sediment regime by trapping sediment behind whilst also narrowing the channel in some circumstances thereby encouraging the transference of sediment downstream.



Large woody debris placed in the channel to increase flow diversity in Foston Beck. Photo courtesy of A. Mullinger, EYCRT.

See identified Further Information Sources for more detailed guidance (p103).

C.3. Enhance floodplain wetland habitats

This solution would help to address the issues of **Lack of bankside shelter/over-shading** and **Channelisation and low flows**.

Aim

The aim of this solution is to enhance existing floodplain wetlands so that they provide more diverse habitats. This solution is generally focussed on a reach-scale, but could help to deliver habitat improvements in the wider catchment.

Description

Floodplain wetlands are currently restricted in the catchment as a result of current land use practices and the disconnection caused by the flood embankments. Floodplain habitats develop in areas where water collects on the floodplain surface before slowly draining back into the river. Diverse and sometimes rare species of plants can become established, providing good habitats for invertebrates, amphibians, and the mammals and birds that prey on them. Waterlogged wetland habitat is often drained so that the land it occupies can be used for agriculture. This has historically occurred within the River Hull Headwaters catchment, so that only relatively small areas of unaltered habitat remain. It is therefore important to enhance the remaining areas so they can support as wide a range of species as possible. Once in place, wetlands are largely self-sustaining, and require little post-construction maintenance. There are several solutions that could be implemented to help enhance floodplain wetland habitats:

- Re-grading of informal embankments to increase connectivity of the floodplain with the channel;
- Creation of scrapes to enhance habitat diversity; and
- Introduction of improved management techniques.

Re-grading informal embankments

Re-grading informal embankments can increase the connectivity between the channel and floodplain which leads to increased deposition of silts on the floodplain, more frequent wetting of the floodplain and also importantly, free drainage of the floodplain – all important features for a sustainable and diverse floodplain wetland habitat.

Creation of scrapes

Scrapes, or low points, in the floodplain surface can be created to extend and enhance wetlands. Natural topographic low points can be extended so that they contain a small amount of standing water, up to a maximum depth of 30 cm. They can potentially cover a large area, and should have gently sloping sides so that there is no threat to livestock. Scrapes are very simple to construct using an excavator and may colonise naturally. It is considered that an archaeologist would be required to screen such developments, in order to reduce the potential for archaeological disturbance. Environment Agency guidance also states that such scrapes would have to be designed to prevent fish stranding. There are a number of locations in the Hull where the creation of scrapes can be undertaken alongside the re-grading of informal embankments on the inside bend of meanders to enhance wetland 'pockets'. These wetland 'pockets' encourage sediment deposition, provide niche habitats and improve the quality of SSSI habitat by providing a habitat continuum between the water's edge and the top of the bank.

Introduction of improved maintenance techniques to encourage suitable wetland plants

Some of the existing wetland areas do not currently support a diverse range of plants, as a result of the current grazing regime and the availability of water. Appropriate management techniques should be identified such as the introduction of an improved grazing regime or cutting and removal of vegetation. This should help improve the conditions for a range of wetland plants.

Climate change adaptation: Enhance riparian, wetland and marginal habitats

Solutions aimed at enhancing riparian, wetland and marginal habitats can contribute towards climate change adaptation in several ways:

- **Increased annual average daily temperatures:** Improved riparian habitats will provide additional shading, helping to regulate water temperatures.
- **Decreased summer precipitation:** Reduced summer precipitation could lead to stresses in important habitats, making the presence of high quality in-channel and riparian habitats more important for SSSI interest features.
- **Increased winter precipitation:** Increased winter precipitation could increase the frequency of overbank flooding, providing suitable conditions for wetland habitat development in more locations.

See identified Further Information Sources for more detailed guidance (p103).

D. Modify in-channel structures

This solution would be intended to address the issue of **In-channel structures and Fine Sedimentation**.

Aim

The aim of this set of solutions is to improve the natural river form and function and ecological habitats in the Hull Headwaters SSSI to achieve favourable condition. This solution has a number of alternatives depending on the type, use, condition and operation of the structure: These include:

- Do nothing.
- Remove structures.
- Modify structures.
- Alter operation of structures.
- Provide fish pass.
- Other (options relevant to specific structures).

A description of each of these options is provided in the subsequent sections. An engineering assessment of the six main in-channel structures has been carried out alongside a qualitative assessment of the options to modify the structures. The details are presented in the accompanying Technical Report with a summary presented in the Restoration Plan. A Do Nothing option was included in the weir assessment exercise and it was concluded that this option is not viable going forward as it does not address the impacts on the SSSI and has not been recommended for any of the six options. As such it is not detailed here although further information can be found in the Technical Report.



A small weir in Elswell Beck causing impoundment and siltation upstream (Photo courtesy of A. Mullinger, EYCRT).



The same reach after removal of the weir in 2007, with increased flow velocities and clean gravel bed habitats (Photo courtesy of A. Mullinger, EYCRT).

Climate change adaptation: Modify in-channel structures

The solutions aimed at modifying in-channel structures can contribute towards climate change adaptation in the following way:

- **Decreased summer precipitation:** Decreased summer precipitation will reduce flows in the channel resulting in more deposition of fine sediment and increased length of storage times. This could have negative implications on the robustness and diversity of aquatic plant communities of *Ranunculus penicillatus* subsp. *pseudofluitans*. The removal of structures will help to increase flow velocities in the channel and keep sediment moving through the system. However, river rehabilitation in the form of channel narrowing and bed raising will need to go hand in hand with structure removal to mitigate the lower flows anticipated in summer as a part of climate change. Decreased summer precipitation will also reduce flows over in-channel structures, potentially making them more of a barrier to fish passage. The modification or removal of these structures will therefore help to ensure that they remain passable to fish populations during predicted lower flows.

D.1 Remove structures

This solution would be intended to address the issue of **In-channel structures and Fine Sedimentation**. However, implementation of this solution is constrained by several factors within the River Hull Headwaters SSSI.

Aim

The aim of this solution is to remove in-channel structures to return natural form and function to the river by creating more natural patterns of flow and sediment movement in keeping with the chalk stream character. This measure would remove flow impoundment and reduce the deposition of fine sedimentation in the reach upstream of the structure. This measure is specifically targeted in individual reaches, but is likely to help improve much larger reaches of the river.

Description

If a structure is no longer required for water level control or flood risk management, it could be possible to remove it. For example, structures originally built to raise water levels for a mill offtake may no longer be required if the mill no longer exists. The removal of a structure can provide significant benefits to the river channel in terms of reinstating chalk river habitat by restoring characteristic water depths and flow velocities, reducing siltation of gravel substrates and allow free movement of fauna. The removal of the impoundment effect of the structure also provides benefits by increasing flow diversity thereby re-establishing riffle habitat and allowing plants such as *Ranunculus penicillatus* subsp. *pseudofluitans* to thrive.

Invasive works within the river channel are required in order to remove an in-channel structure. The nature of the works is dependent on the type of structure, but will typically involve breaking up the main elements above the river bed using heavy construction equipment. Removal of the foundations of the structure will require greater excavation. Construction of temporary dams in the river is likely to be required to create dry areas in which to work. Measures to prevent the escape of sediments and potential contaminants from construction equipment into the river would be required, and materials would need to be transported off site for disposal.

Complete removal of an in-channel structure will result in the improvement to the river character and its ecology. Ultimately, the cause of impounded flow conditions and the barrier to sediment transport and migration of aquatic species within the SSSI would be removed. The river channel itself would also adjust to new flow conditions resulting from the removal of the structure and these conditions would be more in keeping with chalk stream characteristics. In the short term, sediment that has accumulated upstream of the former structure would be available to be transported downstream, and deposition is likely to occur in the former weir pool, adversely impacting on spawning gravels where they exist if mitigation in the form of sediment removal or trapping is not implemented. Removal of in-channel structures need careful consideration and although this option will require mitigation, the benefits to the channel form and function, marginal vegetation, aquatic fauna and flow are significant particularly in terms of returning the SSSI to favourable condition. River rehabilitation needs to go hand in hand with weir removal to reinstate a more natural channel form and to mitigate issues of low flows and potential bed and bank instabilities.

The removal of structures within the River Hull Headwaters SSSI requires careful consideration taking into account the function and cultural heritage and socio-economic aspects of each structure, together with the potential impacts on existing channel stability, ecological value and flow constraints. Several of the structures are still required for water level control and flood risk management purposes. A brief summary of the potential for removal of each of the structures is provided in **Table 3.4** and based on the engineering survey and weir option assessment detailed in the accompanying Technical Report. Further investigation into the feasibility of removing weirs needs to be undertaken alongside consultation with parties likely to be affected by the option.

Table 3.4: Potential for removal of structures within the River Hull Headwaters SSSI

In-channel structure	Potential for removal of the structure
Lowthorpe Mill weir	There is no abstraction licence associated with this weir, therefore there is potential to remove the weir as it is causing significant impoundment and sedimentation upstream. Engineering works may also be required to ensure that the Lowthorpe Mill buildings are not impacted by reduced water levels and it may be necessary to undertake some bank stabilisation works upstream of the site. River rehabilitation would need to be implemented as part of weir removal to reinstate a more natural channel form.
Foston Mill weir	The Foston Mill weir is a gauging weir; therefore its removal would compromise this existing use. However, complete removal of the structure is feasible in engineering terms, although the works themselves would need to be undertaken manually due to lack of vehicular access. Removal of the weir would cause a significant drop in upstream water levels (c. 1.5m estimated), which is likely to have a significant effect on a number of structures, and for a large distance upstream. The most significant impacts would be on those structures closest to the weir, including the adjacent retaining walls (and hence possibly buildings), and the Sheepdike Bridge upstream. It may be possible to mitigate the structural impact of this by reinforcing the banks in these locations (e.g. through installation of sheet piles to below new bed level). However, this would be difficult to achieve given the accessibility problems.
Poundsworth weir	Poundsworth weir is used to increase water levels in the Driffield Trout Stream so that water could be abstracted for use by the Poundsworth Fish Farm. The Poundsworth Fish Farm is no longer operable and closed in 2005. It is therefore considered that the weir could potentially be removed as it is causing significant sediment deposition upstream. There is no current abstraction license at Poundsworth, so the weir is no longer required for abstraction purposes. River rehabilitation would need to be implemented as part of weir removal to reinstate a more natural channel form.
Bell Mills sluice	If the structures are not required for milling purposes, there may be potential to remove the sluices as they are causing significant impoundment and sedimentation. Complete removal of the sluice structure is simple in engineering terms and could be easily achieved. However, engineering works may be required to ensure that other structures (e.g. railway bridge, nearby properties) are not impacted by reduced water levels. Additional works may be required to remove the sluice seating structure. River rehabilitation would need to be implemented as part of weir removal to reinstate a more natural channel form.
Whinhill weir	The structure is currently used to impound water to allow abstraction for Wansford Fish Farm. Its removal would therefore compromise this existing use. If the fish farm was to cease operating, the removal of the weir would be a fairly straightforward exercise in engineering terms however, would require mitigation in the form of channel bed re-grading and river rehabilitation. Depending on the upstream effect of water level reductions, it may also be necessary to undertake some bank stabilisation works to ensure, for example, the integrity of the Driffield Canal channel.
Cleaves weir	<p>The structure is currently used to increase water levels in the West Beck so that water can be abstracted for use by the Humberside Fish Farm. If the fish farm was to cease operating, removal of the weir structure would be straightforward, as it is only constructed from simple stop logs retained within I-section columns. It would be simple, therefore, to remove the stop logs that currently impound water.</p> <p>Should a more complete removal be required, the I-section columns could be removed by cutting them off the main bridge structure. This would prevent stop logs being replaced in the future.</p> <p>The only upstream impact of structure removal would be in terms of lowered water levels impacting on the operation of the Humberside Fish Farm offtake. It may be necessary to amend this offtake in order to address these issues. However, as the offtake is a simple concrete structure with stop log operation, it is unlikely that significant construction works would be required to change its operation.</p>

There are a number of small un-named weirs throughout the River Hull Headwaters which are considered to have been installed to retain water levels upstream during periods of low flows. It may be possible to remove these weirs as they do not appear to be required and some of the weirs are in a poor state of repair with only the wooden struts remaining. There are nine small weirs on the Kelk Beck, one on the Elmswell Beck, one on Driffield Beck, one upstream of the Frodingham Bridge on the Frodingham Beck and three on the Driffield Trout Stream adjacent to Driffield Golf Course. The Copper Hall weir is located on the West Beck which also has the potential for removal as it is in a very poor state of repair. A small weir on Elmswell Beck has already been removed by the EYCRT in January 2008. The weir was becoming unsafe and was causing erosion to the river banks. The weir was also considered to be a barrier to fish migration. The EYCRT re-instated the bank and created important habitat from much of the woody debris found on-site.

D.2. Modify structures

This solution is intended to address the issue of **In-channel structures and Fine Sedimentation**.

Aim

The aim of this solution is to modify in-channel structures to reduce impoundment and fine sedimentation upstream of the structure and increase the extent of chalk stream habitat as well as improve the passage of fish and other aquatic species. This measure is specifically targeted in individual reaches, but could potentially help improve much larger reaches of the river.

Description

Although it may not be possible to remove all of the major structures that are present within the River Hull Headwaters catchment due to their current water level control function, it could be possible to physically modify some of the structures so that they continue to control water levels whilst making them more easily passable to fish, water and sediment.

There are several ways in which existing structures can be modified, including:

- Reduce the crest height of a weir to allow fish to pass upstream during lower flows and decrease impoundment levels.
- Cut a v-notch channel into a weir to allow fish to swim up the structure.
- Replace overshot sluice gates with an undershot system to improve the passage of sediment downstream and fish upstream.
- Remove a number of stop logs.

The physical alteration of a weir can be technically difficult, depending on the nature of the original structure. For example, it can be difficult and therefore time consuming and expensive to cut a channel in an existing reinforced structure, and older structures may not be stable enough to be modified easily. It can, therefore, be more cost effective to remove a structure and replace it with one of a more suitable design than to modify an existing and potentially unstable structure. A brief summary of the potential to modify each of the in-channel structures is provided in **Table 3.5**.

Table 3.5: Potential for modification of structures within the River Hull Headwaters SSSI

In-channel structure	Potential for modification of the structure
Lowthorpe Mill weir	Modification of the main sluice structure (alone) is simple in engineering terms and could be easily achieved. However, it is also noted that on the day of survey (27 November 2009) the brick low flow weir within the channel was controlling upstream water levels (rather than the sluice). This could be removed to reduce the extent of the impoundment. Engineering works may be required to ensure that the Lowthorpe Mill buildings are not impacted by reduced water levels. Depending on the upstream effect of water level reductions, it may be necessary to undertake some bank stabilisation works upstream of the site.
Foston Mill weir	Modifications to Foston Mill Weir have been identified as technically feasible and potentially beneficial. Minor modifications could be achieved relatively easily by removing the existing thin plate weir. This would drop water levels on to the concrete weir sill and reduce upstream water levels by 75 to 100mm. However, the benefit of this would have to be offset against the potentially reduced effectiveness of the Environment Agency's gauging station. Minor works could be easily achieved in the short term, but it is recommended that further investigations into the impact of modifications to the structure on water levels and the Environment Agency gauging station are undertaken prior to any site works.
Poundsworth weir	Given the structure's age and condition, it is unlikely that modifications could be easily undertaken. The options are further limited by the proximity of the Driffild Anglers access bridge immediately upstream of the weir. Modifications to the weir structure are also likely to impact on the access bridge, potentially even requiring a replacement of that bridge. Modification also has the potential to impact on the new flow gauge upstream of the A164 bridge, although this impact can be mitigated. Modifications are unlikely to be viable in the short to medium term, and alternative options are likely to be more feasible, cost effective and beneficial for the SSSI in the long term.
Bell Mills sluices	The sluices could potentially be replaced with an undershot system that allows downstream transport of sediment, although implications for the mill functionality and heritage would need to be investigated. Engineering works may be required to ensure that other structures (e.g. railway bridge, nearby properties) are not impacted by reduced water levels.
Whinhill weir	Modification of the sluice structure is simple in engineering terms and could be easily achieved to lower the height of the weir crest. However this would have to be agreed with the fish farmer who uses the weir to impound water for fish farm usage. Engineering works would be required to ensure that other structures (e.g. Wansford Fish Farm house and barns) are not impacted by reduced water levels. Depending on the upstream effect of water level reductions, it may also be necessary to undertake some bank stabilisation works to ensure, for example, the integrity of the Driffild Canal channel.
Cleaves weir	Modification of the structure is feasible from an engineering perspective and would involve removing one or more stop logs.

D.3. Alter operation of structures

*This solution would help to address the issue of **In-channel structures and Fine Sedimentation**. It is only applicable to structures that can be operated (i.e. Bell Mills sluice), and does not apply to fixed weirs.*

Aim

The aim of this solution is to alter the operation of in-channel structures to help reduce impoundment in the main river channel and increase the extent of chalk stream habitat as well as improve the passage of fish and other aquatic organisms. This measure is specifically targeted in individual reaches, but could potentially help improve much larger reaches of the river.

Description

As an alternative to removing or modifying in-channel structures to reduce the effects of impoundment and improve fish passage, it may be possible to alter the way structures are operated. Some structures are operated manually in response to a pre-defined timetable or to prevailing conditions in the river channel, whilst others are operated automatically to maintain conditions in the river within a fixed set of parameters. In addition, many of the structures are operated to mitigate low flows or provide suitable conditions for recreational activities. These operation protocols could potentially be altered to be more sympathetic to the natural functioning of the river system. For example, a set of sluices that are used to impound water to reduce flood risk could be opened more frequently during low flows to improve patterns of flow and sediment movement and the passage of aquatic plant propagules. This would also provide more favourable conditions for SSSI vegetation communities to develop and this has knock on effects for supporting a more diverse population of invertebrates and amphibians. However, any changes to the operating protocol of a structure would need to ensure that the primary function is not adversely affected. For example, it is likely to be easier to alter the protocol of a flood defence structure than it is to alter the operation of a structure that is designed to maintain water levels within tight constraints for purposes of water abstraction (fish farms or drinking water supply).

The impounding effects of the sluices will be reduced, and more natural patterns of flow and sediment movement will be adopted for a larger extent of the reach. In addition, fish and other aquatic organisms may be able to move freely past the structures in some circumstances. A brief summary of the potential for altering the operation of in-channel structures is provided in **Table 3.6**.

Table 3.6: Potential for modification of the operation of structures within the River Hull Headwaters SSSI

In-channel structure	Potential for altering the operation of the structure
Lowthorpe Mill weir	The main weir sluices do not appear to be operated regularly, and are reported to be difficult to operate, if not inoperable. However, under certain flow conditions this structure does not actually control upstream water levels. It is therefore also necessary to consider alterations to the operation of the bypass weir structure. This could easily be achieved, as it is a simple stop log operation. It would be possible, for example, to undertake a test by removing one (or more) stop logs from this structure to determine impact on water levels.
Foston Mill weir	The structure operates only as a gauging station weir, and significant changes to the weir height rarely occur. There is little scope in the short term, therefore, for changing the operation of the weir. There may be an opportunity in the future as part of upgrading or maintenance requirements to replace the existing gauging station with an acoustic gauge.
Poundsworth weir	Changes to the operation of Poundsworth Mill Weir were identified as one of the preferred options for this structure. In this case, the stop logs which make up the structure could be removed. This would reduce water levels upstream by approximately 1m, leaving the weir sill as a lower control to water levels. This could initially be undertaken as an easily reversible short term measure to determine potential impacts, prior to longer term implementation if proven to be effective. The impact of lowering water levels would have to be considered in line with the issues identified above, and notably the potential impact on the Driffeld Anglers access bridge and the A164 Beverley Road bridge.
Bell Mills sluice	Changes to the operation of Bell Mills Weir have been identified as one of the preferred options for this structure. The sluice gates are rarely operated, and could be opened (or potentially removed) to reduce impoundment upstream of the structure. This could initially be undertaken as an easily reversible short term measure to determine effectiveness, prior to longer term implementation or potential modification of the sluices if necessary. Changes to the water level upstream would need to consider the impacts on upstream structures such as the railway bridge and some river rehabilitation works is likely to be required.
Whinhill weir	The current operating regime is linked to the operation of the fish farm and the need to maintain water levels within the river to supply the fish farm. Clearly some reduction in water level could be achieved by lowering the weir sluices. However, this could have an adverse effect on the fish farm operation. Further investigation would be required to determine the feasibility of altering the operation of the weir whilst the fish farm is still operating. Any change in water levels upstream would need to be assessed in terms of impacts on the integrity of upstream structures and embankments for Driffeld Canal.
Cleaves Weir	As the structure controls water levels through use of stop logs, it would be straightforward to alter the operation to lower upstream water levels by adjusting the number and height of stop logs.

D.4. Provide a suitable fish pass

*This solution is intended to address the issue of **In-channel structures**.*

Aim

The aim of this solution is to provide fish passes on structures that are currently impassable, in order to allow free movement of fish (particularly coarse fish) in the River Hull Headwaters. This measure is specifically targeted in individual reaches, but if all impassable structures are addressed this will help to improve the whole river. This option does not directly improve SSSI features and should only be considered if all other options for the structures are not feasible.

Description

In-channel structures can often act as a physical barrier to the free movement of fish in a river channel. In order to help solve this problem and allow fish to move upstream of the obstruction, a fish pass can be installed. A variety of different types of fish pass are commonly used in England and Wales, and they generally fall into three main categories:

- Stepped fish passes: In this approach, the height that must be passed is divided into a series of smaller steps that fish can jump up. Small traverses (essentially small weirs) on each level are used to create pools for fish to rest in between jumps.
- Sloped fish passes: In this approach, a slope is provided for water to spill down. This can be relatively steep, and baffles are provided to slow down the flow sufficiently for fish to swim up the slope.
- Bypass channels: in this approach, a new channel is cut into the river bank adjacent to the obstruction to allow fish to swim past it.

When considering which fish pass to use, it is important to consider the needs of the species that will use the structure. For example, trout are strong swimmers and can therefore use most types of pass. However, coarse fish are weaker swimmers and need gentler flow. Streaming pool and weirs (stepped) fish passes, v-notch weirs and bypass channels are all likely to be suitable for these species.

All of the in-channel structures in the River Hull Headwaters currently lack any provision for fish passage. There is therefore opportunity to improve fish pass provision to allow free movement of fish throughout the river system. It should be noted that this option is only considered if options to modify, alter the operation or remove the structure are not viable as the provision of a fish pass will only benefit fish and does not improve the chalk stream habitats. An overview of potential improvements at each in-channel structure is provided in **Table 3.7**.

Table 3.7: Potential improvements to fish passage at in-channel structures

In-channel structure	Consideration of the potential to improve fish passage
Lowthorpe Mill weir	<p>It would be feasible to provide a fish pass at this site, although it may require the importation of a certain volume of fill to support the fish pass channel. A pass could be provided either to the east of the main mill weir, or either side of the bypass weir. If it was to be provided on the bypass weir channel, it may also be necessary to amend the operation of the weirs to provide a greater flow down the bypass channel than currently occurs.</p> <p>It could also be achieved by constructing an embankment across the mill race and using the natural bypass channel as the principal flow route.</p> <p>Although the installation of a fish pass may be feasible for this structure, this option should only be considered if no other options can be implemented in this location due to the limited benefits it would provide for the SSSI conservation objectives.</p>
Foston Mill weir	<p>The structure contains an incomplete eel pass. It would be necessary to complete the installation in order to allow passage of eels however the scope to provide a fish pass is limited due to access and space constraints.</p>
Poundsworth weir	<p>It would be feasible to provide a fish pass at this site, although it may require the importation of a certain volume of fill to support the fish pass channel. A pass could be provided either to the east of the main mill weir, or either side of the bypass weir. If it was to be provided on the bypass weir channel, it may also be necessary to amend the operation of the weirs to provide a greater flow down the bypass channel than currently occurs.</p> <p>Although the installation of a fish pass may be feasible for this structure, this option should only be considered if no other options can be implemented in this location due to the limited benefits it would provide for the SSSI conservation objectives.</p>
Bell Mills sluices	<p>There is plenty of space alongside the structure where a fish pass could be provided if appropriate. However, impacts on adjacent vegetation (e.g. trees) would need to be considered. Depending on the location and type of fish pass an additional structure under Skerne Road may also be required. A fish pass could be implemented in the short term but it will not improve the chalk stream habitat upstream and as such should be considered only if the other options are found to be unfeasible.</p>
Whinhill weir	<p>This structure has several constraints associated with the other options and currently does not allow fish to pass upstream during normal flows. There is ample space to the north of the sluice structure to provide a fish pass that could connect the upstream and downstream sections of the river and as such, this option should be considered further if other options to modify the weir are not found to be feasible.</p>
Cleaves Weir	<p>Fish can move pass this structure in medium and high flows so the cost benefit ratio of this option is low. It is also not considered an applicable option in this case as other options are more feasible for this structure.</p>

E. Preserve existing habitats

E.1. Preserve existing quality habitats

Aim

The aim of this solution is to ensure that the high-quality habitats that currently exist in the river catchment are preserved and protected from degradation. This measure should be implemented at a catchment scale for maximum benefit.

Description

The River Hull Headwaters has been extensively modified by human activities, however the river still provides good quality habitats for a wide range of plants, invertebrates, fish, birds and mammals (**Figure 3.4**). These habitats have been identified throughout the catchment and along the river corridor, and include a diverse range of features such as:

- Reaches with suitable gravel substrate for in-channel vegetation growth.
- Existing in-channel and marginal vegetation communities.
- Reaches with gravel substrate for fish spawning.
- Stretches of the channel with good flow and morphological diversity.
- Stretches of the channel with shelter for aquatic organisms but sufficient light for plants to thrive.
- River banks with a suitable profile to provide habitats for emergent and marginal vegetation.
- River banks with suitable vegetation cover for mammals and birds.
- Floodplain wetland.
- Wet woodland.

Existing examples of these habitats should be preserved in order to maintain the integrity of the river SSSI and prevent it from degrading further. Changes to current management practices or development that could potentially damage these habitats should be avoided where possible, and measures to minimise the potential impacts of any changes should be adopted on a site-specific basis.



Existing riparian habitat on Elmswell Beck.

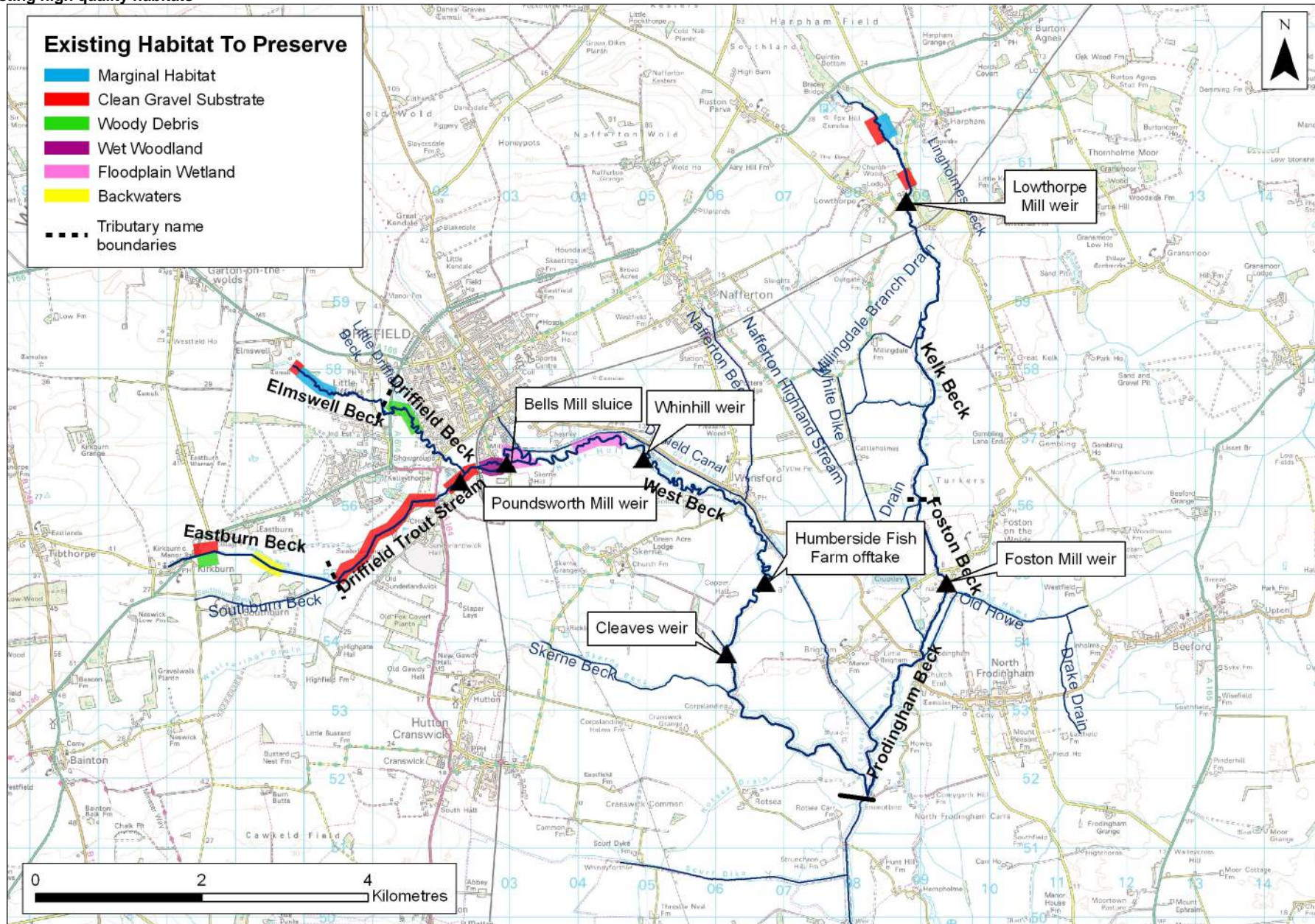


Existing clean gravel substrate downstream of Poundsworth Weir.

Areas of high quality habitat to be preserved should be clearly flagged in Environment Agency/Natural England GIS systems so that they can be fully taken into account in the consenting process.

See identified Further Information Sources for more detailed guidance (p103).

Figure 3.4: Existing high quality habitats



E.2. Preserve existing woody debris in the river channel

Aim

The aim of this solution is to preserve woody debris in the river channel, in order to provide a substrate for colonisation of aquatic vegetation and provide cover for fish and aquatic invertebrates. This measure should be targeted on a catchment scale for maximum benefit.

Description

Woody debris is formed from trees and branches that fall into the river. Depending on the size of the debris and the strength of flow in the river, this debris can remain in situ or become transported further downstream. Woody debris is therefore rarely static, and is often moved downstream during periods of high flow. Woody debris is generally sourced from areas of banks with thick tree lining, but any bankside vegetation could potentially be a source of woody debris.

Coarse woody debris is an essential natural process and driver for providing in-channel morphological diversity. In an un-managed river system, trees would naturally fall into the river and become lodged in jams. These log jams are a major driver for significant channel re-alignment and the formation of new channels. The difficulties in allowing natural processes to have free reign within a heavily managed system are well known, however a co-ordinated package of managed coarse woody debris could be used to drive morphological diversity.

This woody debris provides an important refuge for fish, which is particularly important in uniform reaches of the River Hull. In some reaches, species such as trout and grayling are reliant on the cover provided by woody debris to protect them from predators. In addition, some fish species use woody debris to spawn on when in-channel vegetation and coarse bed material are unavailable. Accumulations of woody debris can also provide a substrate for invertebrates and aquatic plants, which helps to increase the biodiversity of an otherwise uniform river channel.

It is therefore important to ensure that woody debris in the river channel is preserved, so that it can continue to provide valuable habitats for a range of aquatic life. The practise of routinely removing all woody debris from the river channel should be discouraged where possible, in order to allow more natural levels of wood to remain in the channel. This could be helped through the provision of information on the beneficial qualities of in-channel debris to landowners and other parties who clear debris from the river.

This solution does not intend that all removal of woody debris in the catchment should cease. A large debris accumulation could potentially cause structural damage or block flow through bridges, causing an increase in flood risk. In cases such as these where any potential benefits are outweighed by increased risk, it is recommended that sensitive management of woody debris is undertaken in the form of realignment, securing in place or selected removal.



Existing Large Woody Debris within the Elmswell Beck tributary of the River Hull

Natural England/Environment Agency should produce guidelines on woody debris in the River Hull Headwaters SSSI and ensure that trees are not removed by default.

Climate change adaptation: Preserve existing habitats

The solutions aimed at preserving existing habitats are unlikely to contribute directly towards climate change adaptation in the River Hull. However, measures to preserve existing high quality habitats in the catchment should help to ensure that these are not lost as a result of changing temperatures and precipitation patterns.

4. REACH-BASED RESTORATION SOLUTIONS

The subsequent sections provide details of how the specific solutions could be implemented on a reach-by-reach basis. An annotated aerial photograph is provided for each reach, alongside details of the type of solution that could potentially be implemented.

The Reaches

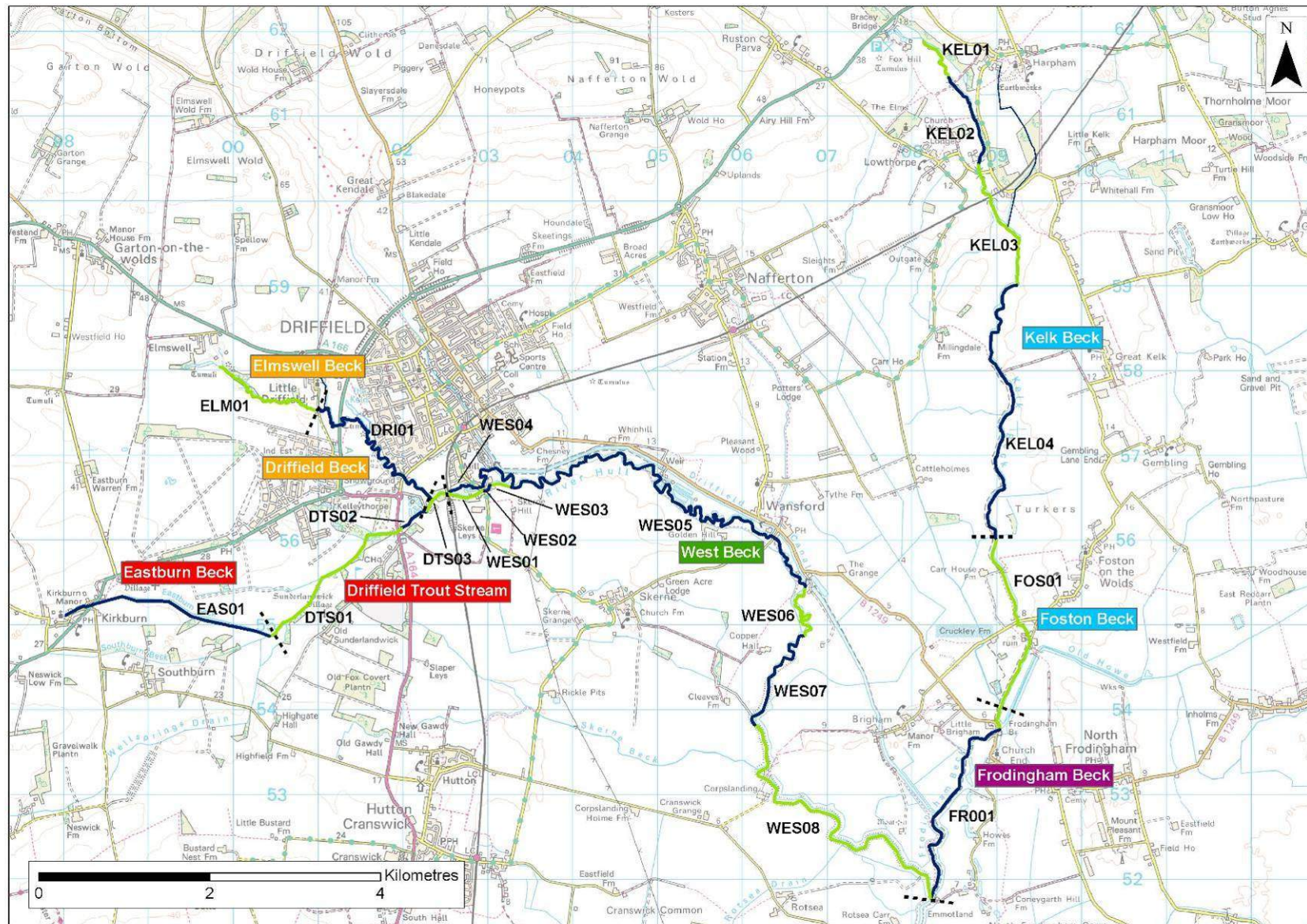
The river channel has been sub-divided into 20 individual reaches, based on the prevailing geomorphological and ecological characteristics of each reach (**Figure 4.1**). A brief breakdown of the boundaries of each reach is provided in the table below. Further information on how the river was subdivided, and on the geomorphological and ecological characteristics of each reach, is provided in the accompanying Technical Report.

SSSI Unit	Reach	Upstream Limit	Downstream Limit
Unit 33	ELM01	Upstream limit of Elmswell Beck	Downstream limit of Elmswell Beck
	DRI01	Upstream limit of Driffield Beck	Downstream limit of Driffield Beck
Unit 34	EAS01	Upstream limit of Eastburn Beck	Downstream limit of Eastburn Beck
	DTS01	Upstream limit of Driffield Trout Stream	Upstream limit of impoundment by Poundsworth weir
	DTS02	Upstream limit of impoundment by Poundsworth weir	Poundsworth weir
	DTS03	Poundsworth weir	Downstream limit of Driffield Trout Stream
Unit 35	WES01	Upstream limit of West Beck (southern section of river downstream of Driffield Railway)	End of southern section of river downstream of Driffield Railway
	WES02	End of southern section of river downstream of the junction	Removal of bank protection downstream of Bell Mills
	WES03	Removal of bank protection downstream of Bell Mills	Confluence Point
	WES04	Upstream limit of West Beck (northern section of river downstream of the junction)	Bell Mills Sluice
	WES05	Bell Mills Sluice	Wansford Bridge
	WES06	Wansford Bridge	Downstream limit of Nafferton Drain
	WES07	Downstream limit of Nafferton Drain	Cleaves Weir
	WES08	Cleaves Weir	Downstream limit of West Beck at Emmotland
Unit 36	FRO01	Upstream limit of Frodingham Beck	Downstream limit of Frodingham Beck
Unit 37	KEL01	Upstream limit of Kelk Beck	Weir south of Neat Holmes
	KEL02	Weir south of Neat Holmes	Southern end of Mill Farm
	KEL03	Southern end of Mill Farm	Downstream limit of drain from Little Kelk
	KEL04	Downstream limit of drain from Little Kelk	Downstream limit of Kelk Beck (aqueduct)
	FOS01	Upstream limit of Foston Beck	Downstream limit of Foston Beck

Reach Summary Sheets

The following pages contain summary sheets for each reach which identify the solutions recommended for each reach. The solutions are colour coded to reflect the solution category so that it is easy to cross-reference back to the colour coded **Section 3** which contains an explanation and more guidance on the solutions.

Figure 4.1: Location of River Restoration Plan reaches



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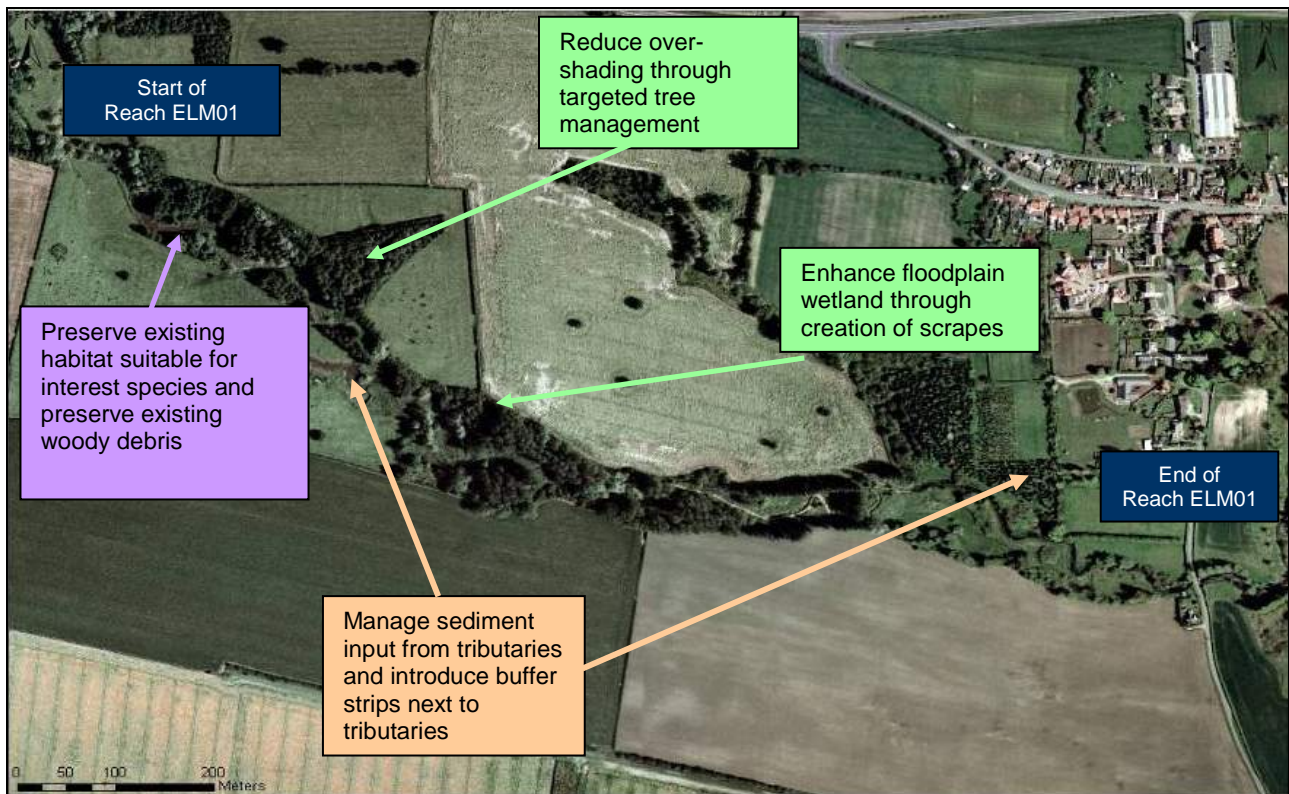
Reach ELM01 – Upstream limit of Elmswell Beck to downstream limit of Elmswell Beck

Opportunities for enhancement

The Elmswell Beck follows a sinuous course upstream, becoming a natural meandering course further downstream. Both banks display graded vegetated profiles, with a predominantly gravelly substrate with localised sediment. The largely un-modified nature of the reach has retained natural flow and morphological diversity, which needs to be preserved. The river could be enhanced through targeted tree thinning in the upstream sections to increase light penetration into the channel. The channel already has good connection with the floodplain, given the marshy ground bordering the channel. Fencing along the tributary flowing into the beck at Bramble Hill could be used to prevent cattle access to the banks. This could reduce the sediment supply to the channel, and prevent any further sediment deposition on the channel bed. This is also likely to reduce the turbidity of water at the confluence point.

Potential restoration measures

Measure		Issues addressed	Description
A.2 A.3	Manage sediment input from tributary at Bramble Hill and selectively restrict livestock access to banks	Fine sedimentation	The channel is spring fed throughout the reach with water entering the main channel from both sides. The main tributary at Bramble Hill is bordered by grazed boggy floodplain. Cattle access to the tributary is likely to be contributing sediment into the channel, causing the turbidity at a pool immediately downstream of the confluence point. Riparian buffer strips could be established along the banks of the main tributary that feeds into this reach, particularly where sediment supply due to cattle trampling is at its highest.
C.1	Enhance riparian vegetation through tree management.	Over-shading	The upper sections of this reach are bordered by mature deciduous trees, causing localised over-shading and limiting light penetration to the channel. This could be a factor for the lack of aquatic vegetation in the upstream section of the reach. Targeted tree management could be used to reduce over-shading.
C.3	Enhance floodplain wetland habitats	Lack of bankside shelter	There is potential to enhance the floodplain wetland habitat that is located on both banks on the inside of meanders through the creation of scrapes on the floodplain surface.
E.1 E.2	Preserve existing habitat suitable for interest species. Preserve existing woody debris in the river channel	Preserve existing habitat	The river survey identified that there is suitable habitat for <i>Ranunculus</i> , breeding birds, otter and fish species. Although there was a lack of aquatic vegetation in the upstream section, habitats in the reach should benefit if this area was managed. Gravel habitats and existing woody debris should also be preserved.



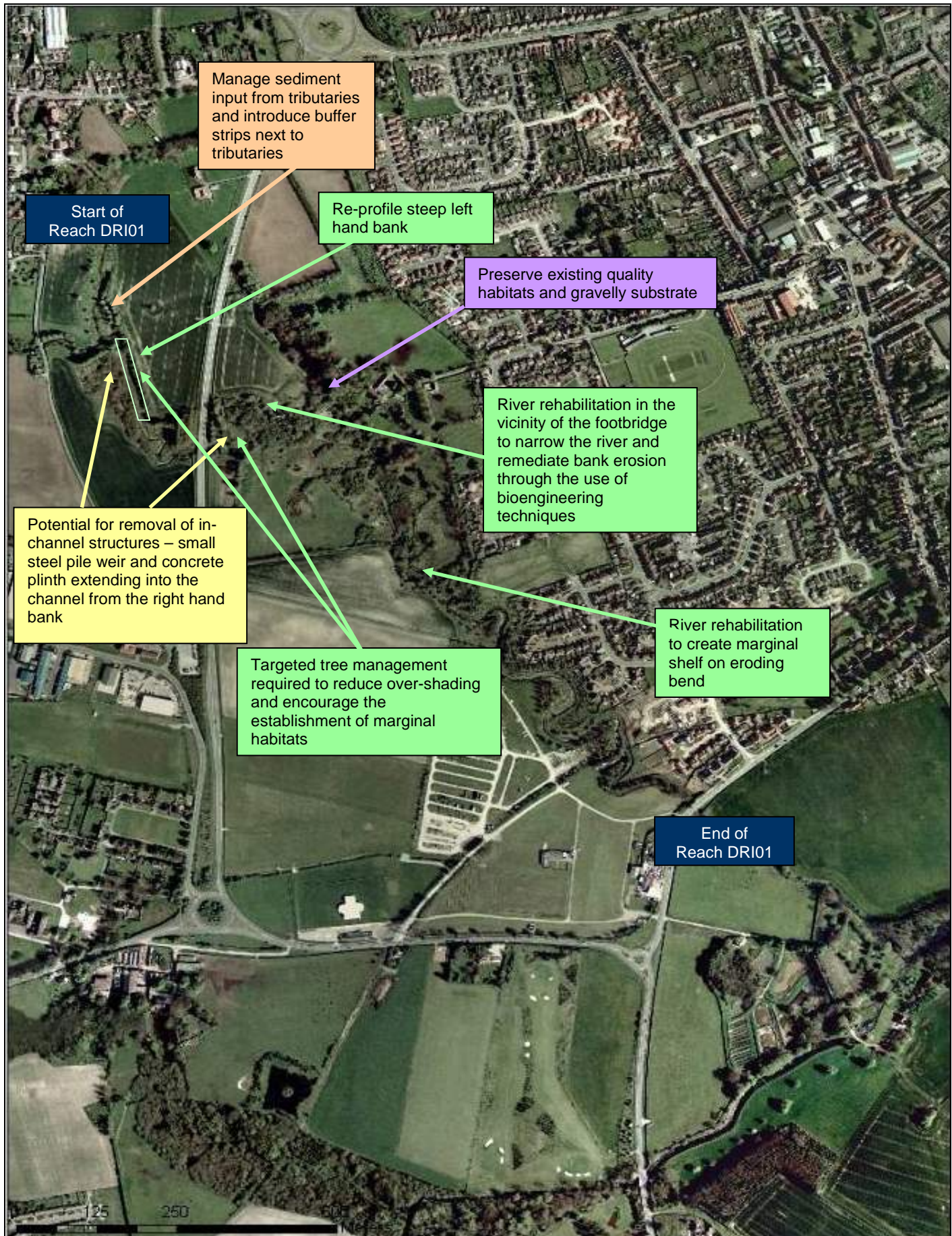
Reach DRI01 – Upstream limit of Driffield Beck to Downstream limit of Driffield Beck

Opportunities for enhancement

The river follows a gently meandering course in this reach, with locally straight and deep sections of channel. There are a number of in-channel structures which are resulting in a system which is not functioning naturally. The in-channel structures and locally straightened sections are causing increased fluvial erosion of the banks. The river could be enhanced by reducing over-shading in the central section of the reach, increasing the light penetration into the channel and encouraging in-channel vegetation growth. The in-channel structures could be removed / modified to reduce the erosion of banks immediately downstream and reduce sediment deposition upstream. The reach was lacking in marginal vegetation, a likely result of over-shading by mature deciduous trees. The river is lacking adjacent wetland floodplain habitat, limiting the potential for breeding birds. The river was bordered by wet woodland in the central section which needs to be preserved. Finally, attempts to limit the input of sediment from tributaries and field drains will contribute to a reduction in fine sedimentation both locally and throughout the whole reach.

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	Manage sediment input from Little Driffield Beck and field drains and introduce buffer strips next to the main watercourses	Fine sedimentation	The Little Driffield Beck flows into the channel and supplies sediment from the adjacent agricultural land. Small sediment traps could be installed within the tributary to impound small amounts of water which will encourage sediment to settle behind the structure. The sediment trap could be cleared on a rotational basis. In addition, riparian buffer strips could be created along both banks of the tributary.
C.1	Establish bank habitats through tree management	Over-shading	The overhanging trees throughout the reach (particularly the section downstream of the A614 road bridge) could be managed to prevent over-shading, and subsequently increase the light penetration into the channel and increase both marginal and in-channel vegetation growth.
C.2	River rehabilitation in the vicinity of the footbridge to narrow the river and remediate bank erosion through the use of bioengineering techniques	Lack of bankside shelter	There is potential to re-profile the locally steep banks, particularly the left hand bank upstream of the A614 road bridge. The steep sections of bank could be re-profiled to give a gentle gradient, particularly in areas where there is no tree cover, and additional aquatic plants could be planted. This will improve habitats for marginal plants and invertebrates, and the birds and fish that prey on them. Marginal vegetation could be used to prevent further erosion of banks and to create increased flow diversity within the significantly over-wide section adjacent to Kelk Pond.
C.2	River rehabilitation – create shelf adjacent to eroding bank and encourage deposited seedlings to grow to protect the bank behind in long term and retain cliff bank for kingfishers	Lack of bankside shelter	There is potential to undertake river rehabilitation works to address bank erosion issues and create new habitats. A new marginal shelf could be created in front of the eroding vertical bank, in order to create new habitats for deposited seedlings, and, in the long term, minimise potential for direct fluvial erosion. This method would retain the existing vertical bank, which currently provides valuable nesting habitat for kingfishers.
D.1	Remove the small steel pile weir that is currently in disrepair	In-channel structures	The small weir downstream of Little Driffield Beck on the straightened section of river acts as a barrier to the free movement of fish, flow and sediment on the river bed. The complete removal of the weir could be investigated.
D.1	Remove the brick wall and concrete plinth extending into the channel	In-channel structures	The brick wall and concrete plinth that extend in to the channel adjacent to Kelk Pond do not appear to have a current function within the system, and could potentially be removed.
E.1 E.2	Preserve existing habitat suitable for interest species. Preserve existing woody debris in the river channel	Preserve existing habitat	The river survey identified that there is suitable habitat for <i>Ranunculus</i> , breeding birds, otter and fish species. Although there was a lack of aquatic vegetation in the upstream section, habitats in the reach should benefit if this area was managed. Gravel habitats and existing woody debris should also be preserved.



Reach EAS01 – Upstream limit of Eastburn Beck to downstream limit of Eastburn Beck

Opportunities for enhancement

The river in this reach is predominantly straight with slight sinuosity. The river has been artificially straightened as a result of historical navigation and / or flood prevention. The banks are predominantly graded / vertical depending on marginal vegetation. The river could be enhanced by reducing over-shading in the upper section of the reach, increasing the light penetration into the channel and encouraging in-channel vegetation growth. The reach was lacking in marginal vegetation at the downstream limit, a likely result of over-shading by mature deciduous trees which were recently felled. The river is lacking adjacent wetland floodplain habitat, limiting the potential for breeding birds. The river did have marginal backwaters in the central section of the reach, which need to be preserved as they provide important habitat for a number of species. Finally, attempts to limit the input of sediment from tributaries and field drains will contribute to a reduction in fine sedimentation both locally and throughout the whole reach.



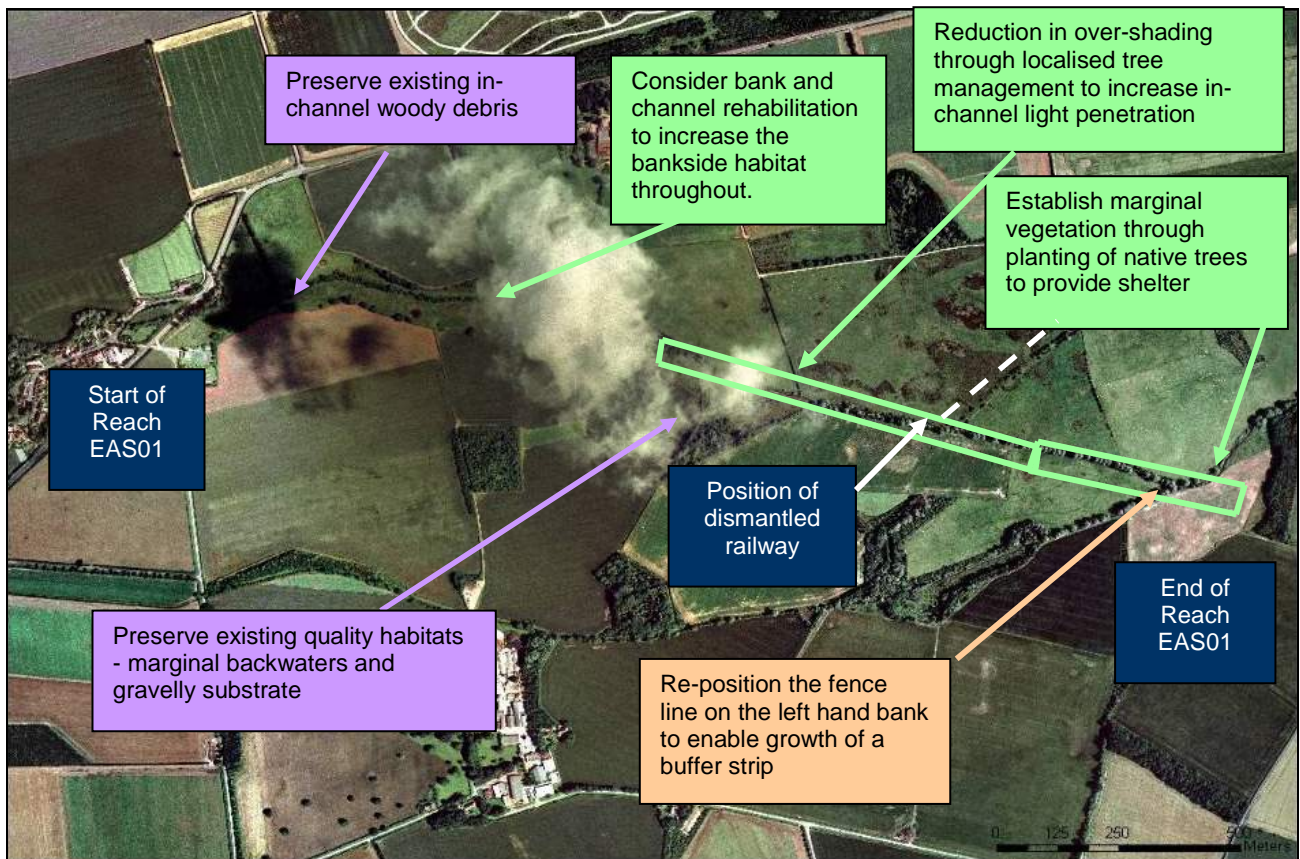
Exposed channel downstream of the dismantled railway bridge



Marginal backwater

Potential restoration measures

Measure		Issues addressed	Description
A.2	Establish buffer strips adjacent to watercourses	Fine sedimentation	The left hand bank is bordered by a fence line at the downstream extent of the reach. The fence line is very close to the top of the bank, with the adjacent land grazed. Re-positioning the fence could encourage the development of a buffer strip, to reduce overland flow from grazing land.
C.1	Enhance riparian vegetation by establishing bank habitat	Lack of bankside shelter /over-shading	The majority of the reach is bordered by deciduous trees at the base of the channel banks, causing localised over-shading reducing light penetration into the channel. Downstream of the dismantled railway, there is a lack of marginal vegetation with the majority of the reach exposed. Native trees could be planted on the both banks of the river. This would provide tree root cover for trout and provide shelter and rest sites for otters and shading for bullhead and other fish species.
C.2	River rehabilitation to narrow the channel and create low level berms	Lack of bankside shelter	The banks are locally steep, which have limited potential for the establishment of marginal habitats. Low benches and shallow areas could be created at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach. More trees could be planted to provide shelter and shading in exposed areas, particularly on the downstream of the dismantled railway. There is potential to reconnect the old river channel.
E1	Preserve existing quality habitats	Preserve existing habitat	Sections of river backwaters are present on the right hand bank, providing areas of slow flowing water with shelter for aquatic organisms but sufficient light for plants to thrive. These important habitats should be preserved. The coarse bed substrate should also be preserved.
E.2	Preserve existing woody debris in the river channel.	Preserve existing habitat	The woody debris identified in the channel should be retained as it provides refuge for fish interest species, and provides some diversity in flow.



Reach DTS01 – Upstream limit of Driffield Trout Stream to upstream limit of impoundment by Poundsworth weir

Opportunities for enhancement

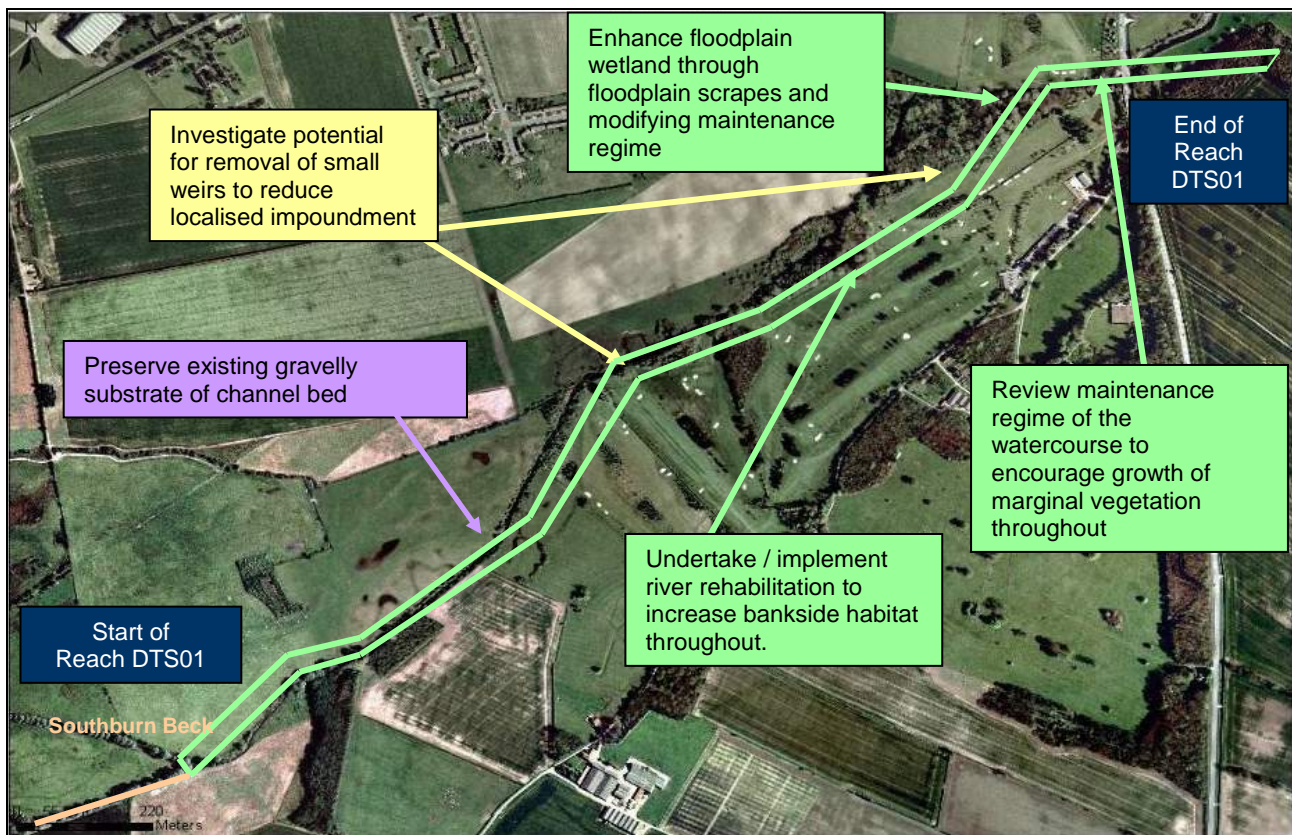
Downstream of the confluence with Southburn Beck, the river continues to flow as a straightened watercourse. It is likely that the watercourse was straightened for flood defence or historic navigation. The banks are generally steep, with little marginal vegetation, possibly a result of river management. There are a number of in-channel structures within the reach which are causing localised impoundment and silt deposition. The reach could be enhanced through the management of bankside vegetation to prevent localised over-shading, with native plant species used to increase shelter and shading in exposed areas. The adjacent floodplain habitat needs to be protected and enhanced to ensure that it does not deteriorate. The in-channel structures could be removed / modified to reduce the erosion of the bed and banks immediately downstream and reduce sediment deposition upstream. Finally, attempts to limit the input of sediment from tributaries and field drains will contribute to a reduction in fine sedimentation both locally and throughout the whole reach.



Upper section of Driffield Trout Stream - steep banks and uniform flow rate with little morphological diversity.

Potential restoration measures

Measure		Issues addressed	Description
C.1	Establish bank habitats	Lack of bankside shelter	The maintenance regime of the watercourse could be reviewed to allow marginal vegetation to develop and encourage flow and morphological diversity. Marginal vegetation could be used to reduce the width of the channel, as it appears to have been historically over-widened. The fence line at the top of the left hand bank could be re-positioned to allow increased marginal vegetation to establish and act as a buffer strip to any overland runoff.
C.2	River rehabilitation	Lack of bankside shelter	The banks are generally steep, which limit the potential for establishment of marginal habitats. Low benches and shallow areas could be created at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach. More trees could be planted to provide shelter and shading in exposed areas.
C.3	Enhance floodplain wetland habitats	Lack of bankside shelter	The river has good connection with the floodplain on the left hand side of the channel, adjacent to Driffield golf course as a result of the low bank height. The area could be enhanced through modification of the current maintenance regime and creation of floodplain scrapes.
D.1	Investigate potential to remove two small sheet pile weirs	In-channel structures	Two weirs are present within the downstream section of the reach which are causing sediment deposition upstream and erosion of the bed and banks downstream. The potential for removal of the weirs should be investigated.
E.1	Preserve existing quality habitats	Preserve existing habitat	Although there is localised silt on the river bed, the majority of the substrate is gravelly, providing good spawning habitat for fish.



Reach DTS02 – Upstream limit of impoundment by Poundsworth weir to Poundsworth weir

Opportunities for enhancement

The Driffield Trout Stream follows a relatively straight course in this reach, with uniform channel and flow conditions and a deep bed. The river is significantly impounded by the Poundsworth weir which is resulting in significant sediment deposition on the channel bed. The banks are generally steep with little marginal vegetation, a possible result of management of the river banks. The channel is perched above the surrounding land on the left hand side. The river could be enhanced through the alteration of the Poundsworth weir to prevent as much deposition of sediment on the river bed. The channel was also exposed with very little marginal vegetation on the right hand bank. Planting of native species on the bank is likely to improve the habitat for fish and otter by providing increased shelter.



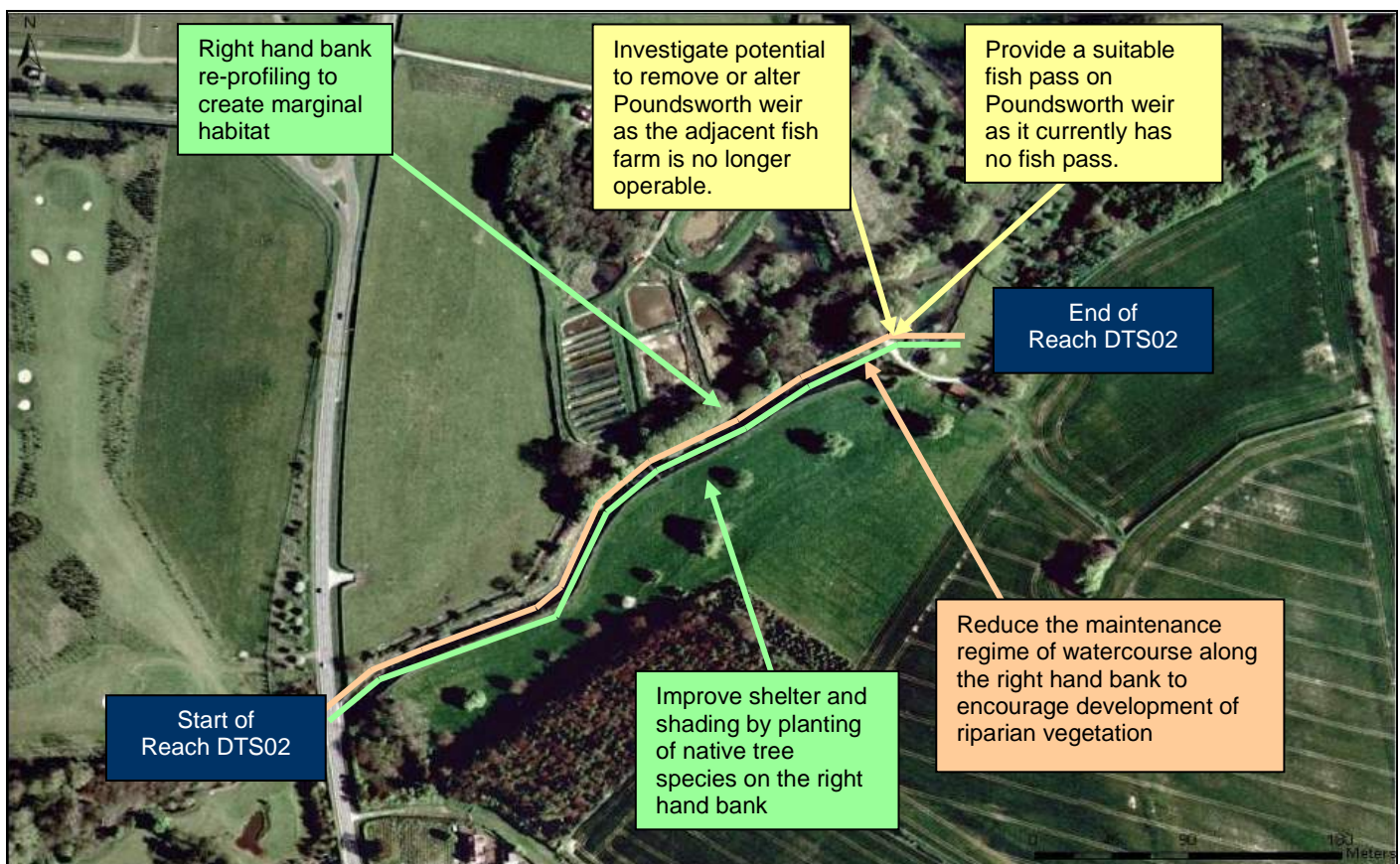
View downstream towards Poundsworth weir



View upstream towards Poundsworth weir

Potential restoration measures

Measure		Issues addressed	Description
A.2	Establish buffer strips adjacent to watercourses	Lack of bankside shelter	The land on the right hand side of the channel (looking downstream) was grazed grassland which is fenced off to prevent cattle access to the banks. The management regime of the watercourse could be reviewed in order to allow establishment of a riparian buffer strip along the right hand bank.
C.1	Improve riparian vegetation by establishing bank habitats	Lack of bankside shelter	Native trees could be planted along exposed parts of the right bank. This would provide tree root cover in the channel for fish species and bankside shelter for otters and other mammals and birds. Planting could be used to create areas of shelter along the channel, whilst preventing the river becoming over-shaded.
C.2	River rehabilitation to create low berms	Channelisation and low flows	Low benches and shallow areas could be created at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach.
D.1	Investigate potential to remove or alter Poundsworth Weir	In-channel structures	Poundsworth weir is used to increase water levels in the Driffield Trout Stream so that water could be abstracted for use by the Poundsworth Fish Farm. The Poundsworth Fish Farm is no longer operable and closed in 2005. It is therefore considered that the weir could potentially be removed or altered as it is causing significant sediment deposition upstream.
D.4	Provide a fish pass	In-channel structures	The Poundsworth weir could be upgraded with the addition of a suitable fish pass to allow free movement of fish. There is also potential to develop a weed trap at the sluice off-take on the left bank



Reach DTS03 – Downstream limit of impounded section to downstream limit of Driffield Railway Bridge

Opportunities for enhancement

The Driffield Trout Stream follows a predominantly straight course, with slight sinuosity. The river within this reach is managed by a river keeper for angling purposes, which limits the marginal vegetation. The banks are predominantly low and lack marginal vegetation as the banks are over-managed. The channel has an overly wide, shallow cross section, and evidence of attempted river restoration (meandering) is evident. The river could be enhanced by creating new marginal habitats to reduce the width of the channel. The river is fed by field drains and tributaries from the left hand side, supplying sediment into the reach. A significant source of sediment the discharge channel from the historic trout farm.



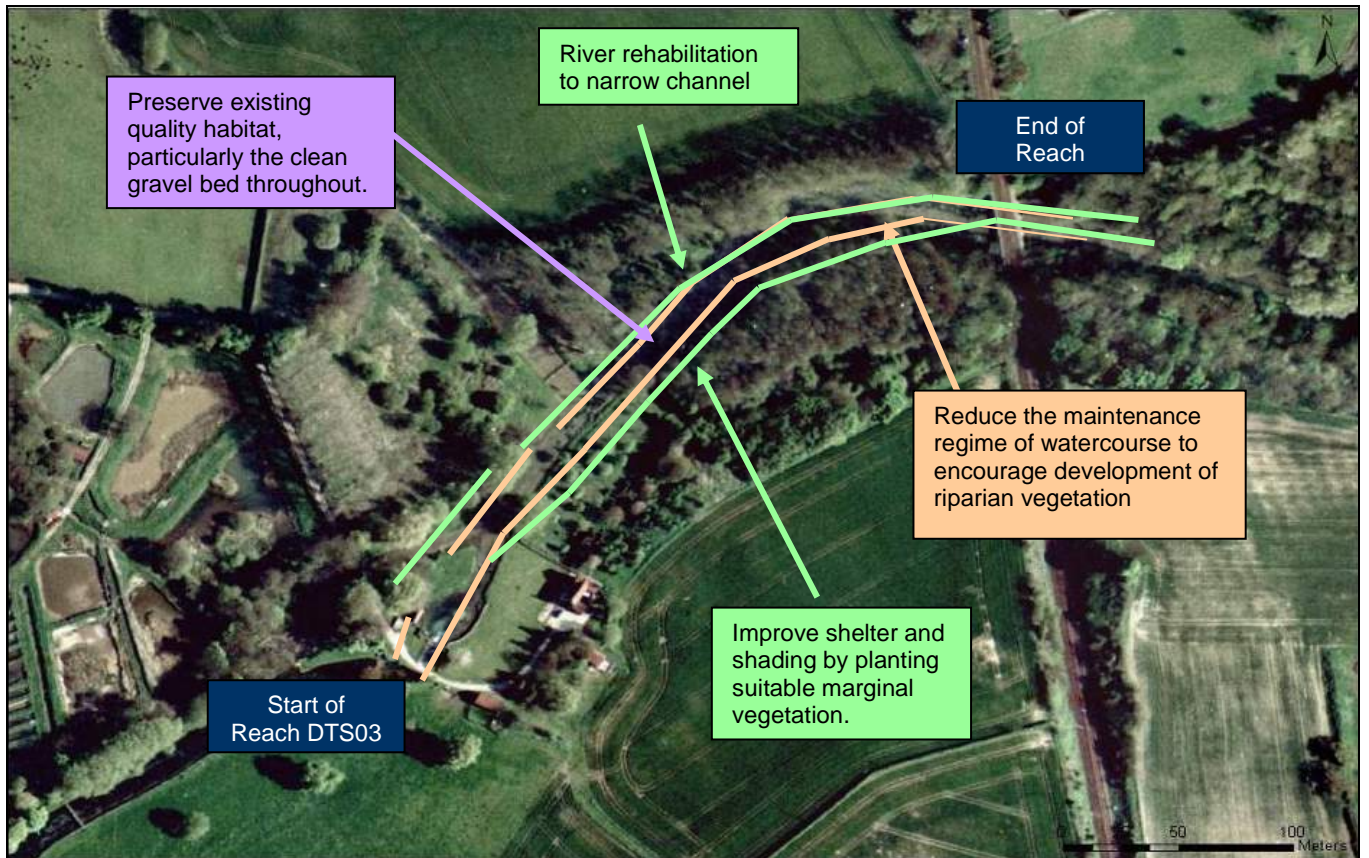
Lack of marginal vegetation downstream of Poundsworth weir



View upstream from Driffield Railway crossing

Potential restoration measures

Measure		Issues addressed	Description
A.2	Establish buffer strips adjacent to the watercourse	Lack of bankside shelter	The managed nature of the river limits the marginal habitat available for otter and fish. A reduction in maintenance would increase the shelter for these interest species, improving the habitat.
C.1	Improve riparian vegetation by establishing bank habitats	Channelisation and low flows and lack of bankside shelter	Planting of suitable marginal vegetation could be used to narrow the channel and create some diversity in the flow. This would provide cover in the channel for fish species and bankside shelter for otters and other mammals and birds.
C.2	River rehabilitation to narrow the channel and create low level berms	Channelisation and low flows	A number of attempts have been made over the years to narrow and re-meander the over-widened channel. Channel narrowing at this location must be undertaken using materials such as faggots that are in-filled behind and then seeded. Allowing the channel to silt up naturally behind the faggot is unlikely to be sustainable due to the location on a sweeping meander. Narrowing works need to be undertaken in tandem with reducing the current management regime of the bank with some selective tree thinning on the right bank.
E.1	Preserve existing quality habitats	Preserve existing habitat	The clean gravelly bed substrate needs to be preserved. The gravelly substrate provides suitable spawning habitat for brown trout and grayling.



Reach WES01 – Driffield Railway crossing to Bell Mills sluice

Opportunities for enhancement

The West Beck has been split into two channels downstream of Driffield Railway bridge as a result of Bell Mills, with this reach being the southern channel. An un-disturbed vegetated island is present along the left hand bank providing good habitat for otter which needs to be retained. Bell Mills sluice is present at the southern extent of the reach, causing significant impoundment of the river and sediment deposition. The sluice is in a poor condition due to vandalism and is only operable with the use of machinery. The reach would also benefit from improved fish passage, either through upgrading the sluice to allow fish passage or changing the way the sluices are operated.

Potential restoration measures

Measure		Issues addressed	Description
D.1	Remove Structure	In-channel structures	Removal or changes to the operation of Bell Mills Weir have been identified as the preferred options for this structure. The sluice gates are rarely operated, and could be opened (or potentially removed) to reduce impoundment upstream of the structure. This could initially be undertaken as an easily reversible short term measure to determine effectiveness, prior to longer term implementation or potential modification of the sluices if necessary. In addition, there may be potential to install a fish pass to improve fish passage in the reach.
D.2	Modify Structure		
D.3	Alter operation of structures		
D.4	Provide a suitable fish pass		
			The undisturbed vegetated island on the left hand bank provides good habitat for otter. Alternative habitats should be provided if options to alter the management of the sluices and improve the river cause a degradation in the quality of these habitats.



Reach WES02 – End of southern section of river downstream of bifurcation to bridge crossing

Opportunities for enhancement

The West Beck flows out from Bell Mills in a heavily constrained channel. The channel banks are predominantly vertical, high and concrete covered. Land use adjacent to the channel is sub-urban, limiting the potential for floodplain enhancement without significantly affecting the processes at Bell Mills. The velocity within the reach is fast, resulting in gravelly bed substrate which is suitable for in-channel vegetation growth. There is also adequate in-channel light due to the lack of bankside shelter.

Potential restoration measures

Measure		Issues addressed	Description
C.1	Establish bank habitats	Lack of bankside shelter	Native trees could be planted on the right bank of the river, as this would have fewer effects on the processes at Bell Mills. This would provide tree root cover for trout and provide shelter and rest sites for otters and shading for bullhead and other fish species. Sections of the left bank are well vegetated, so planting on the right bank should only occur in areas where there is no cover on the opposite bank.
C.2	River rehabilitation to create low berms	Lack of bankside shelter ; Channelisation and low flows.	The concrete banks could be removed to create a more natural system with bankside habitat. It is considered that this would create significant disruption to Bell Mills however. Low benches and shallow areas could be created at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach.
E.1	Preserve existing quality habitats	Preserve existing habitat	The clean gravel substrate within the reach needs to be preserved as it is suitable habitat for <i>Ranunculus</i> growth.



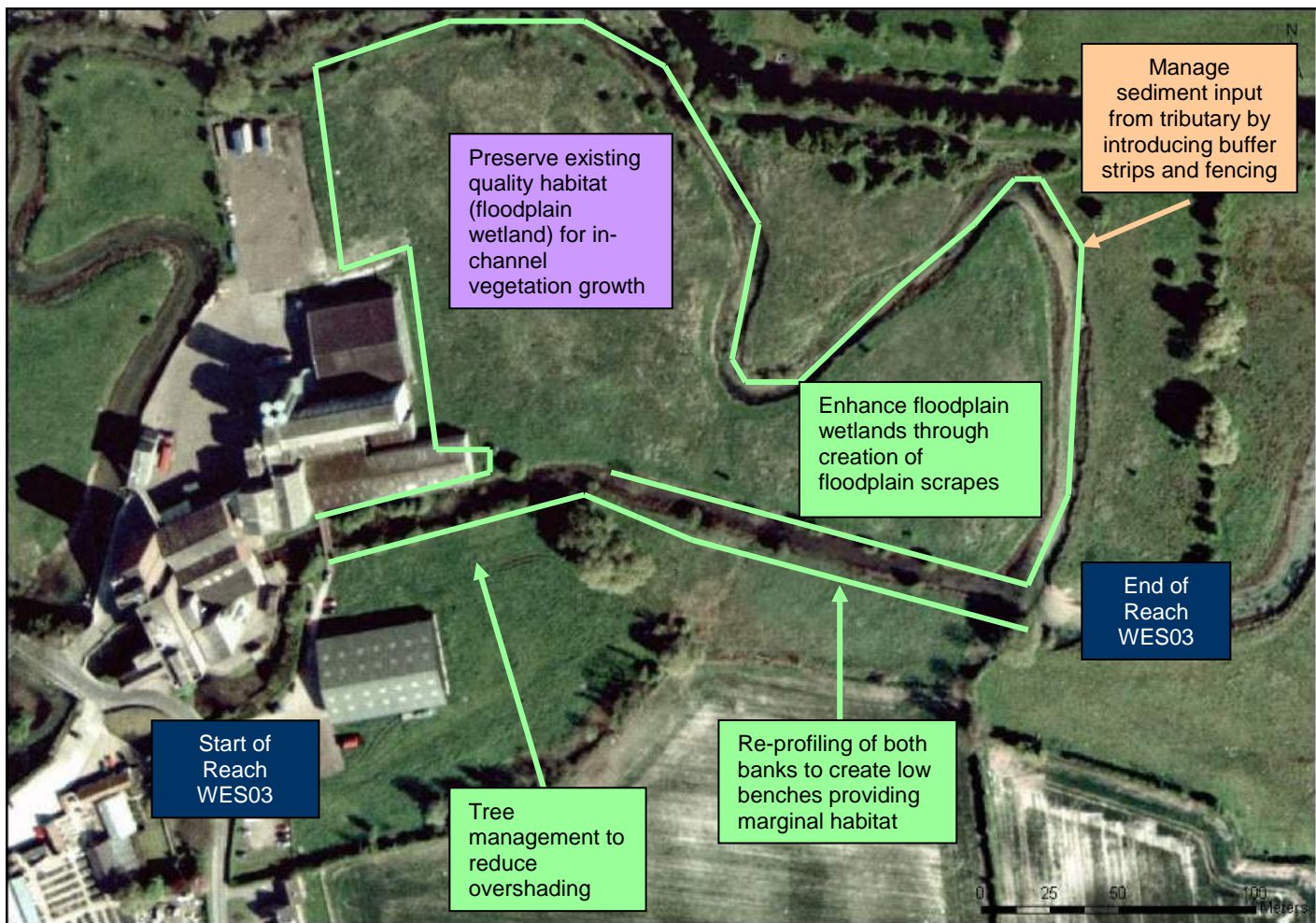
Reach WES03 – Bell Mills bridge crossing to confluence point

Opportunities for enhancement

The river follows a straight course in this reach, lacking in flow and morphological diversity. The channel is deep with steep, high banks, and has been straightened in the past. Flow within the reach is relatively swift, and there is suitable cover provided for otter and fish given the discrete sections of overhanging vegetation. The bed substrate material is predominantly gravelly upstream, becoming silty downstream at the confluence point. The channel is bordered by wetland floodplain habitat which needs to be preserved. A mown path is present at the top of the left hand bank, which could be managed more sympathetically to enhance the available habitat. Evidence of introduced species (mink) was noted during the field survey, given the presence of a mink raft at the base of the right hand bank. It is considered that management of this species should be encouraged to reduce the predation risk to water vole. The reach could be enhanced by managing the sediment supply from the West Beck, which is bordered by grazed grassland.

Potential restoration measures

Measure		Issues addressed	Description
A.2	Manage sediment input from West Beck by establishing buffer strips adjacent to watercourse.	Fine sedimentation Lack of bankside shelter	The West Beck flows around Bell Mills to the north of this reach, flowing back into the West Beck at the downstream extent of the reach. The upstream 0.35km of the West Beck to the north of Bell Mills is grazed grassland with no buffer zone. Marginal vegetation could be allowed to grow, as well as use of a fence line to prevent further cattle access to the banks. This is likely to reduce the sediment supply to the West Beck. The maintenance regime adjacent to the beck could be reviewed to manage the public walkway more sympathetically. This is likely to increase the bankside shelter and reduce the disruption to habitat on the wetland floodplain.
C.1 C.2 C.3	Establish bank habitats River rehabilitation Enhance floodplain wetland habitats	Lack of bankside shelter. Channelisation and low flows Fine sedimentation	The banks along the reach are steep with overhanging vegetation causing localised over-shading. The bankside trees could be managed more effectively to increase light penetration to the channel, and encourage growth of both marginal and in-channel vegetation. The steep uniform river banks could be re-profiled to create low benches and shallow areas at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach. There is potential to enhance the floodplain wetland habitat that is located on both sides of the channel, through the creation of scrapes on the floodplain surface.
E.1	Preserve existing quality habitats	Preserve existing habitat	The wetland habitat adjacent to the river channel should be protected to ensure the continued presence of breeding bird and otter habitat, and maintain greater habitat diversity to benefit SSSI invertebrate and bird populations.



Reach WES04 – Driffield railway bridge to Bell Mills Sluice

Opportunities for enhancement

The West Beck has been split into two channels downstream of Driffield Railway bridge as a result of Bell Mills, with this reach being the northern channel. An un-disturbed vegetated island is present along the right hand bank providing good habitat for otter which needs to be retained. Bell Mills sluice is present at the southern extent of the reach, causing significant impoundment of the river and sediment deposition. The sluice is in a poor condition due to vandalism and is only operable with the use of machinery. The land on the left hand side of the channel is grazed grassland, with no barriers preventing cattle access to the banks. The reach could be enhanced by the addition of riparian and marginal vegetation to act as a buffer to any overland runoff. A fence could also be used to prevent cattle accessing the banks and supplying sediment into the reach. The reach would also benefit from improved fish passage at Bell Mills sluice, either through upgrading the sluice to allow fish passage or changing the way the sluices are operated.

Potential restoration measures

Measure		Issues addressed	Description
A.3	Selectively restrict livestock access to banks.	Fine sedimentation	<p>Trampling occurs on a large proportion of the left bank of the river, and is most heavy in the 0.30km reach downstream of the Driffield Railway bridge. These areas could be fenced off to allow the banks to re-vegetate, and new marginal habitats would develop.</p> <p>Where necessary, grazing livestock could be provided with access to drinking water using reinforced access points. Alternatively, poached areas could be fenced off on a rotational basis. This would ensure that the banks do not become too degraded, whilst maintaining access to the river at points along the reach.</p>
C.1	Establish bank habitats	Lack of bankside shelter	Native trees could be planted on the left hand bank of the river. This would provide tree root cover for trout and provide shelter and rest sites for otters and shading for bullhead and other fish species. Sections of the right bank are well vegetated, so planting on the left bank should only occur in areas where there is no cover on the opposite bank.
C.3	Investigate the potential of creating wetland habitats adjacent to the river	Channelisation and low flows	A raised embankment is present along the left hand bank to prevent flooding of the grazing land. This embankment could be altered to encourage more regular inundation of the floodplain on the left hand side. This will remove sediment from the main channel, reducing sedimentation further downstream at Bell Mills and could encourage the development of improved habitats on the bank top and floodplain.
D.1 D.2 D.3 D.4	Remove Structure Modify Structure Alter operation of structures Provide a suitable fish pass	In-channel structures	<p>Removal or changes to the operation of Bell Mills Weir have been identified as the preferred options for this structure. The sluice gates are rarely operated, and could be opened (or potentially removed) to reduce impoundment upstream of the structure. This could initially be undertaken as an easily reversible short term measure to determine effectiveness, prior to longer term implementation or potential modification of the sluices if necessary. In addition, there may be potential to install a fish pass to improve fish passage in the reach.</p> <p>The undisturbed vegetated island on the left hand bank provides good habitat for otter. Alternative habitats should be provided if options to alter the management of the sluices and improve the river cause a degradation in the quality of these habitats.</p>



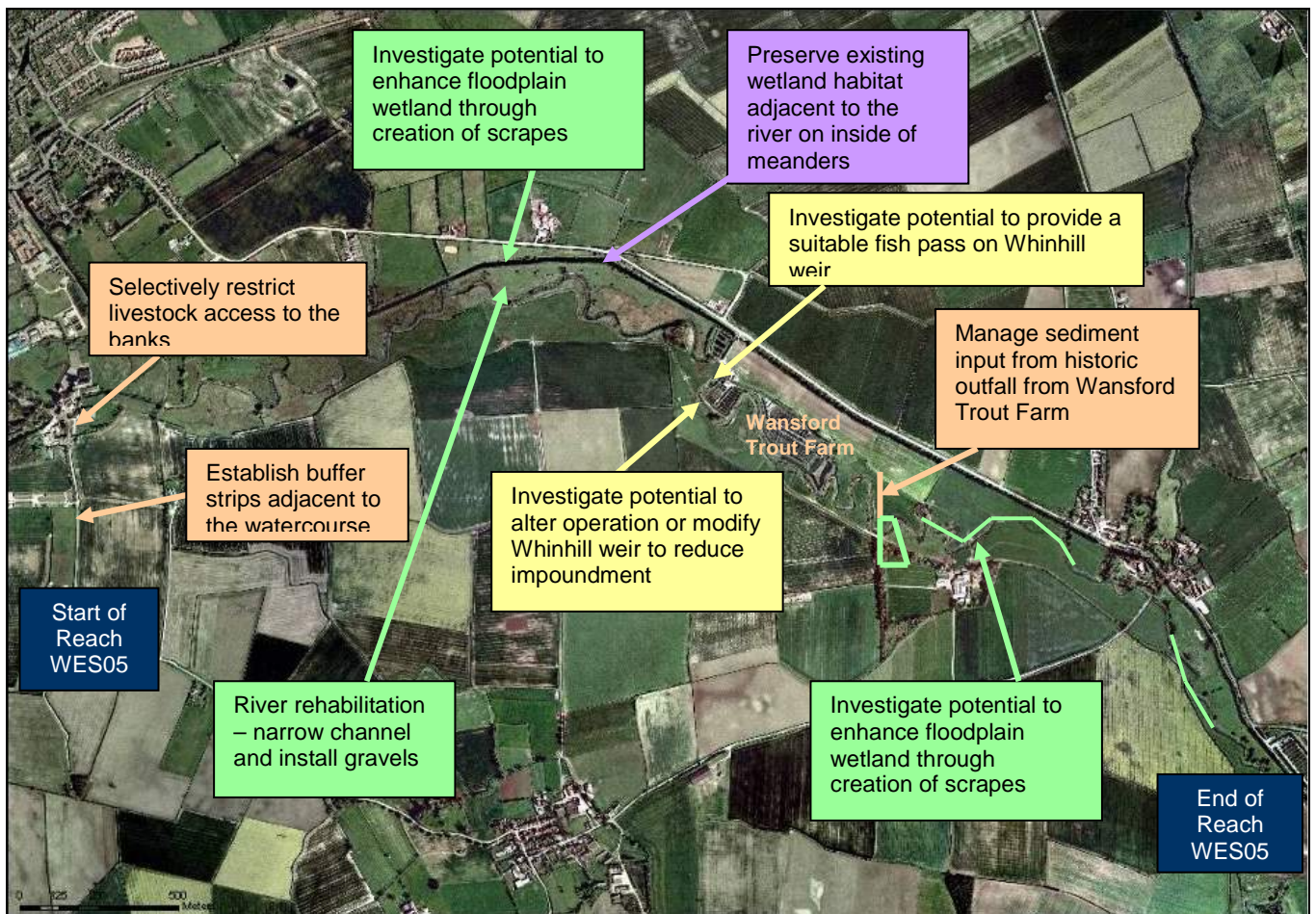
Reach WES05 – Bell Mills sluice to Wansford Bridge

Opportunities for enhancement

The West Beck follows a meandering course within the reach. The channel appears to have been historically over-widened and over-deepened in the downstream sections. Banks are predominantly graded throughout the reach, with no barriers to cattle access in the upstream section adjacent to Bell Mills. The channel has good connection with the floodplain throughout the majority of the reach given the low bank height, with floodplain deposits identified on the left hand bank during the field survey. The Wansford Fish Farm is present within the reach abstracting water from the main channel, as well as the Whinhill weir which is causing significant impoundment. The reach could be enhanced by restricting cattle access to the banks in the upstream section, and modifying the operation of the weir at Wansford Fish Farm. The weir has no fish pass therefore presents a significant barrier to upstream migration of fish. The reach would benefit from improved fish passage over the weir, either through upgrading the weir to allow fish passage or changing the way the weir is operated.

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	Review maintenance regime of watercourse	Lack of bankside shelter Fine sedimentation	Small sediment traps could be installed within the old outfall from Wansford Trout Farm to impound small amounts of water which will encourage sediment to settle behind the structure. The sediment trap could be cleared on a rotational basis.
	Establish buffer strips adjacent to watercourses		Riparian buffer strips could be established along the left hand bank of the beck, particularly in areas where grazing is most intensive. This would act as a buffer to any overland runoff from the grazing land. Riparian vegetation has been encouraged to develop within the central and lower sections of the reach which should be preserved as it provides significant shelter for otter and fish species.
A.3	Selectively restrict livestock access to banks	Lack of bankside shelter Fine sedimentation	Trampling occurs locally within the upper 0.35km of the reach on the left hand bank. These areas could be fenced off to allow the banks to re-vegetate, and new marginal habitats would develop. Where necessary, grazing livestock could be provided with access to drinking water using reinforced access points. Alternatively, trampled areas could be fenced off on a rotational basis. This would ensure that the banks do not become too degraded, whilst maintaining access to the river at points along the reach.
C.2	River rehabilitation – channel narrowing and gravel rehabilitation	Channelisation and low flows	The channel is currently over-wide. River rehabilitation works to narrow the channel, for example by creating low berms at the bank toe, would improve flows and enhance habitat diversity.
C.3	Enhance floodplain wetland habitats	Lack of bankside shelter. Channelisation and low flows	The majority of the reach has good connection with the floodplain given the low bank height. There is potential to enhance the floodplain wetland habitat that is located on both sides of the channel, through the creation of scrapes on the floodplain surface.
D.3 D.4	Investigate options to modify or alter operation of Whinhill Weir. Investigate potential to provide a suitable fish pass on Whinhill weir	In-channel structures	The Whinhill weir is located at Wansford Trout Farm and is causing significant impoundment and sediment deposition upstream. There is a significant head drop downstream of the weir. Whinhill Weir does not currently have a fish pass, and is too high for many fish species to pass upstream in most flow conditions. There may be potential to install a fish pass on the structure to improve fish passage. A new pass could be constructed across the main structure, or could be cut into the bank adjacent to the weir. As an alternative to modifying the structure, the operating protocol could be reviewed to reduce the impoundment of water, as long as the primary function of the structure is not affected.
E.1	Preserve existing quality habitats	Preserve existing habitat	The wetland habitat adjacent to the river channel should be protected to ensure the continued presence of breeding bird and otter habitat, and maintain greater habitat diversity to benefit SSSI invertebrate and bird populations.



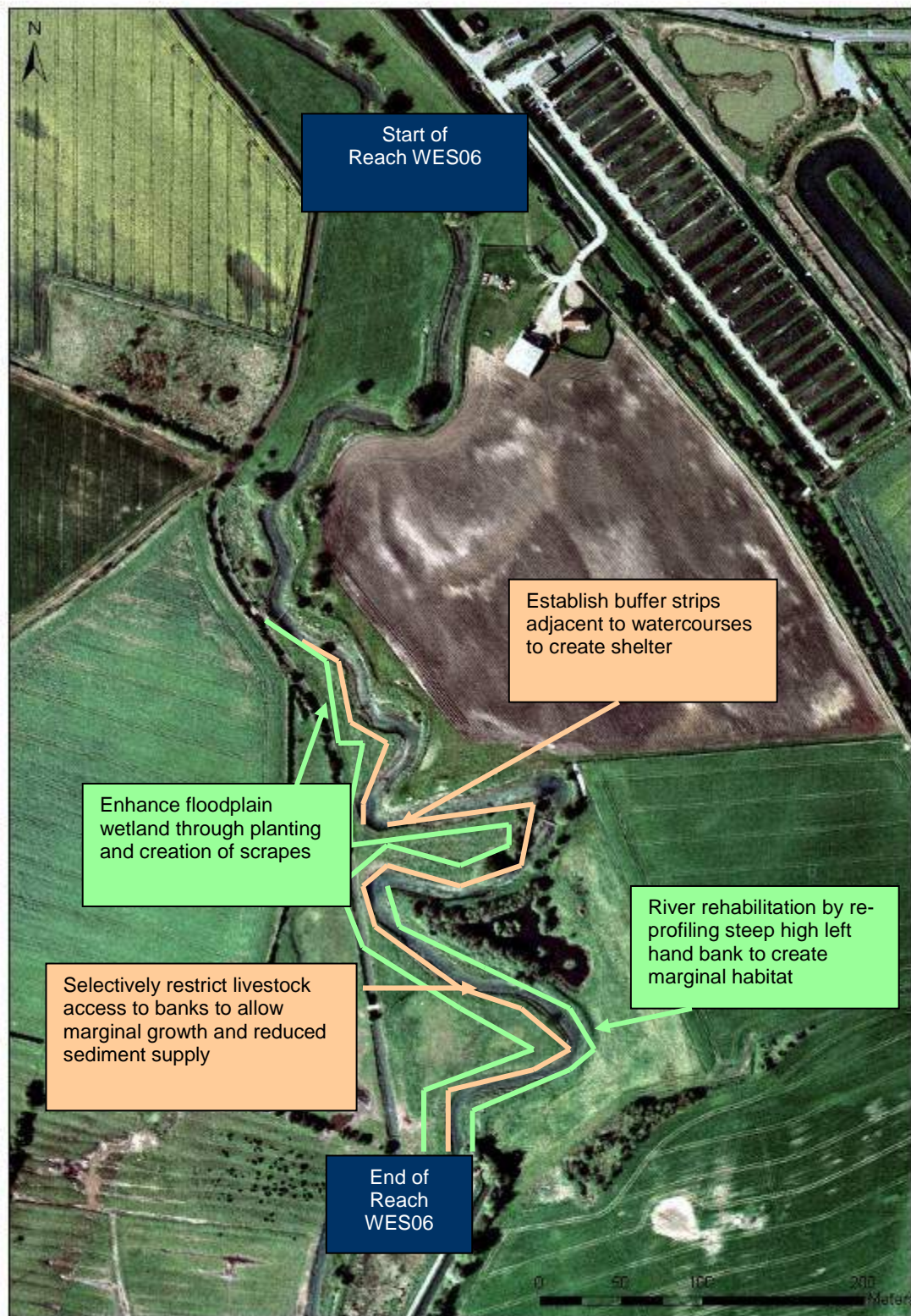
Reach WES06 – Wansford Bridge to downstream limit of Nafferton drain

Opportunities for enhancement

The West Beck follows a meandering course within this reach. Large sections of the right hand bank within the lower have been subject to historic cattle trampling, which has created a shallower bank profile in comparison with the left hand bank. The lower bank height within the downstream section improves the connection with the adjacent floodplain. The channel has varied width and depth profiles creating varied flow and morphological diversity. This reach could be improved if sediment input from the adjacent grazing land was reduced, and the adjacent floodplain habitat was enhanced.

Potential restoration measures

Measure		Issues addressed	Description
A.2	Establish buffer strips adjacent to watercourse	Lack of bankside shelter Fine sedimentation	Riparian buffer strips could be established along the right hand bank of the beck, particularly in areas where grazing is most intensive. This would act as a buffer to any overland runoff from the grazing land. Riparian vegetation has been encouraged to develop within the upper sections of the reach which should be preserved as it provides significant shelter for otter and fish species.
A.3	Selectively restrict livestock access to banks	Lack of bankside shelter Fine sedimentation	Trampling occurs locally within the upper 0.35km of the reach on the left hand bank. These areas could be fenced off to allow the banks to re-vegetate, and new marginal habitats would develop. Where necessary, grazing livestock could be provided with access to drinking water using reinforced access points. Alternatively, trampled areas could be fenced off on a rotational basis. This would ensure that the banks do not become too degraded, whilst maintaining access to the river at points along the reach. Fencing can also be set back from the river so that reduced numbers of livestock can graze the site. This would allow some grazing of riparian vegetation which will benefit some species and provide structural diversity.
C.2	River rehabilitation	Channelisation and low flows	The steep left hand bank could be re-profiled to create low benches and shallow areas at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach.
C.3	Enhance floodplain habitat	Lack of bankside shelter	The lower section of the reach has good connection with the floodplain given the low bank height. There is potential to enhance the floodplain wetland habitat on the right hand side of the channel, through the creation of scrapes on the floodplain surface.



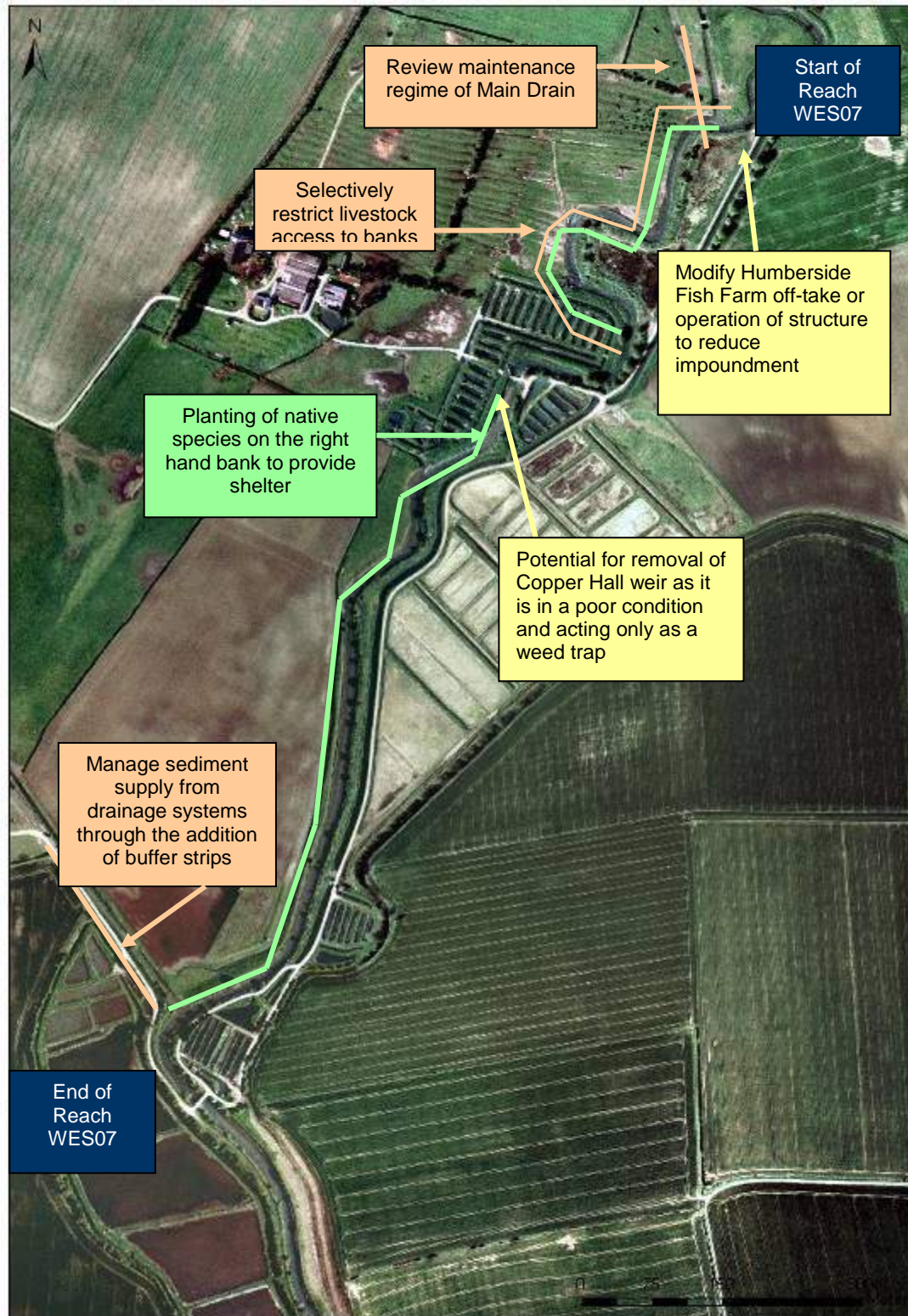
Reach WES07 – Downstream limit of Nafferton Drain to Cleaves Weir

Opportunities for enhancement

This reach follows a meandering course upstream becoming sinuous further downstream. The off-take for Humberside Fish Farm is present at the upstream extent, as well as the Main Drain which drains agricultural land. The Copper Hall weir is present adjacent to Copper Hall farm however is in a very poor condition with only the wooden struts remaining. The reach could be enhanced through the removal of the weir as it is not considered to serve any particular function with the exception of a weed trap. A number of fish farms are present very close to the left hand bank, which have been protected with flood embankments. In this reach, the river could potentially be enhanced through selective planting to increase shelter and shading on the right bank. The abstracted volume of water for the fish farm could also be reduced to increase the flow of water through the reach and prevent problems during times of low flow. In addition, actions to reduce sediment supply as part of a catchment-wide initiative to reduce sediment supply could be taken in this reach.

Potential restoration measures

Measure		Issues addressed	Description
A.1	Review the maintenance regime of watercourse	Fine sedimentation	The Main Drain flows into the West Beck and supplies it with sediment from adjacent agricultural land. The maintenance regime of the field drains could be reviewed to reduce this supply. This could include measures to retain sediment within the drains, for example by reducing the frequency of drain clearance, encouraging vegetation growth adjacent to the drain and installing willow sediment traps to intercept sediment prior to reaching the drain.
A.2	Establish buffer strips adjacent to watercourses	Lack of bankside shelter	Riparian buffer strips and marginal vegetation could be established along the right hand bank of the beck, to provide increased shelter to otter and fish species.
A.4	Selectively restrict livestock access to banks	Fine sedimentation and lack of bankside shelter	Trampling occurs on a large proportion of the right bank of the river, and is most heavy in the upstream 0.3km of the reach. This area could be fenced off to allow the banks to re-vegetate, and new marginal habitats would develop. Where necessary, grazing livestock could be provided with access to drinking water using reinforced access points. Alternatively, trampled areas could be fenced off on a rotational basis. This would ensure that the banks do not become too degraded, whilst maintaining access to the river at points along the reach. Fencing can also be set back from the river so that reduced numbers of livestock can graze the site. This would allow some grazing of riparian vegetation which will benefit some species and provide structural diversity.
C.1	Establish bank habitats	Lack of bankside shelter	Native trees could be planted on the right hand bank of the river. This would provide tree root cover for trout and provide shelter and rest sites for otters and shading for bullhead and other fish species. Sections of the left bank are well vegetated, so planting on the right bank should only occur in areas where there is no cover on the opposite bank.
D.2 D.3	Investigate potential to modify the Humberside Fish Farm offtake or alter operation to reduce abstraction	In-channel structures	The Humberside Fish Farm off-take structure could be modified or alter the operation to reduce the abstraction of water from the channel. This would reduce the impoundment immediately upstream of the structure and associated sediment deposition.
D.1	Investigate potential to remove Copper Hall Weir	In-channel structures	There is also potential for removal of the Copper Hall weir as it is currently in a very poor state of repair.



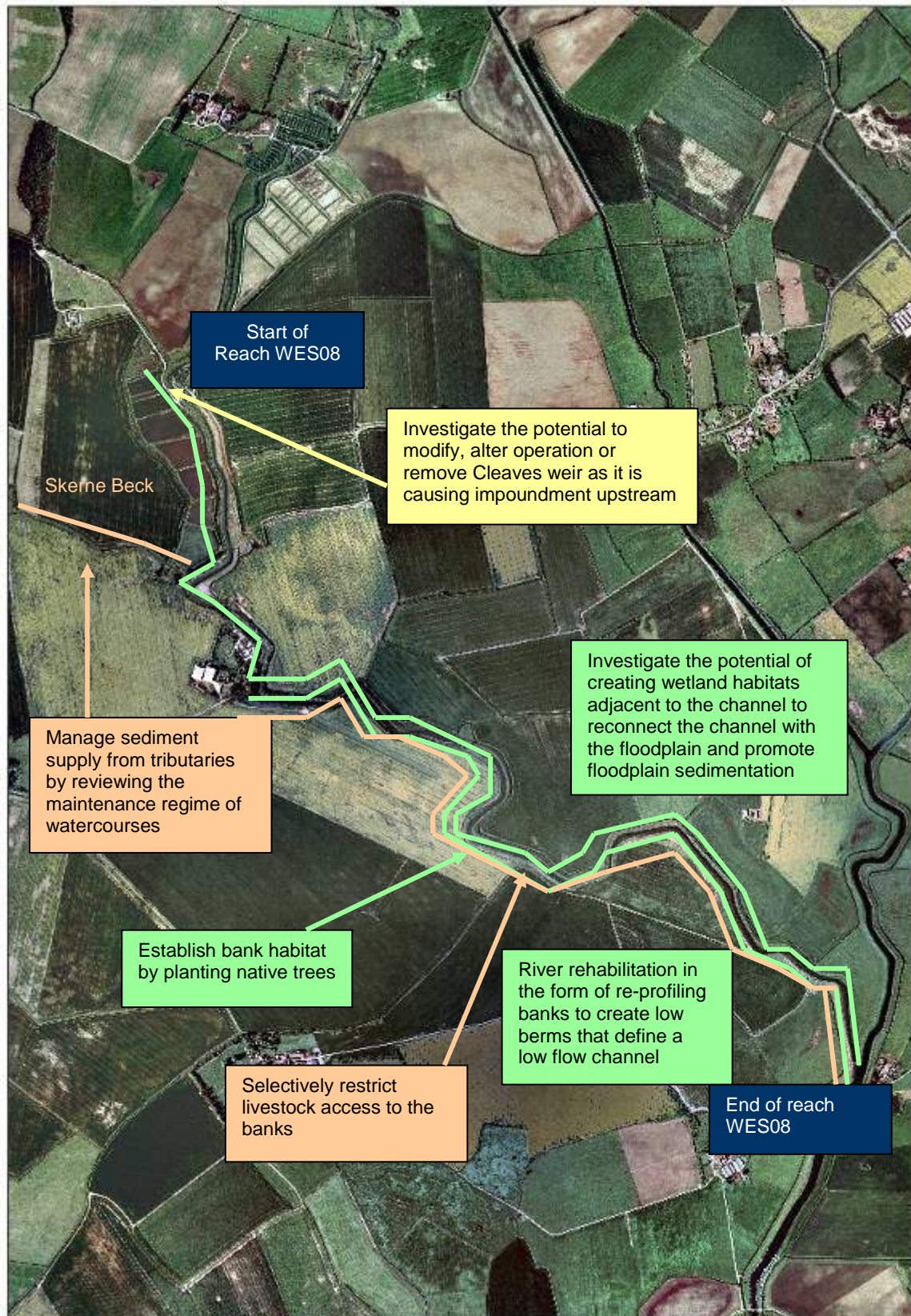
Reach WES08 – Cleaves Weir to downstream limit of West Beck at Emmotland

Opportunities for enhancement

This reach is predominantly meandering, and has been historically over-deepened and over-widened for navigation purposes. As a result, the river is very deep, with steep banks and uniform flow conditions. The channel is largely bordered by flood embankments. Large parts of the banks are exposed, although there is localised tree cover downstream of Cleaves weir. This reach could be improved through the re-profiling of the steep banks, which would allow marginal and riparian habitats to develop.

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.3	Review the maintenance regime of watercourses Encourage uptake of Environmental Stewardship	Fine sedimentation	The Skerne Beck flows into the West Beck, which contains a high concentration of suspended sediment. The maintenance regime of the beck could be reviewed to reduce this supply. Input from these sources should be managed in order to help reduce the amount of fine sediment that is currently transported by the river. This could potentially be achieved through changes to land use (e.g. the promotion of Catchment Sensitive Farming (CSF), Entry Level and Higher Level Stewardship), changes to the maintenance regime of each watercourse, and the establishment of buffer strips in areas where sediment supply is at its greatest.
A.3	Selectively restrict livestock access to river banks	Fine sedimentation and lack of bankside shelter	Historical trampling of banks is present along the majority of the reach downstream of Corpslanding, which has altered the bank profile. The banks have been left to re-vegetate and new riparian and marginal habitats have developed. If cattle are to be grazed on the banks in the future, access to water for grazing livestock could potentially be managed through the provision of reinforced access points. Alternatively, areas of the bank could be left unfenced to allow continued access for the cattle. These areas could be rotated periodically, to ensure that the banks do not become too degraded and the positive benefits are realised.
C.1	Establish bank habitats	Lack of bankside shelter and fine sedimentation	Native trees could be planted on both banks of the river downstream of Corpslanding. This would provide tree root cover for trout and provide shelter and rest sites for otters and shading for bullhead and other fish species. Sections of the left bank are well vegetated, so planting on the right bank should only occur in areas where there is no cover on the opposite bank.
C.2	River rehabilitation	Lack of bankside shelter. Channelisation and low flows	River could be re-profiled to create low benches and shallow areas at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach.
C.3	Investigate the potential of creating wetland habitats adjacent to the channel to reconnect the channel with the floodplain and promote floodplain sedimentation	Channelisation	The potential for reconnecting the channel to the floodplain needs to be investigated as part of an assessment of the benefits to the SSSI Floodplain reconnection is likely to remove sediment from the main channel, reducing sedimentation further downstream and could encourage the development of improved habitats on the bank top and floodplain
D.1 D.2 D.3	Investigate potential to modify, alter operation or remove Cleaves Weir	In-channel structures	Cleaves Weir causes considerable impoundment upstream. Removal or modification of this structure would remove the impoundment upstream of the structure, considerably reducing sedimentation in this reach, and improve fish passage. It is recommended that more detailed assessments (including geomorphological and ecological investigations and hydraulic modelling) are undertaken for those structures that are identified as being potentially suitable for removal.



Reach KEL01 – Upstream limit of Kelk Beck to weir south of Neat Holmes

Opportunities for enhancement

The Kelk Beck flows in a predominantly sinuous course upstream, becoming a meandering course downstream. There has been previous environmental enhancement (hazel bundles) undertaken by the fishing club and the banks have been fenced to prevent cattle access in the upstream section. There are a number of small weirs present throughout the reach which do not appear to be necessary and are causing localised impoundment. The reach could be enhanced by removing these weirs. The lower section of the reach is significantly deeper than the upstream section as a result of historic dredging. The reach is bordered by dense vegetation upstream, which is causing localised over-shading. A reduction in over-shading would increase light penetration to the channel bed and encourage in-channel vegetation growth. This would encourage photosynthesis and increase the oxygen content of the water.



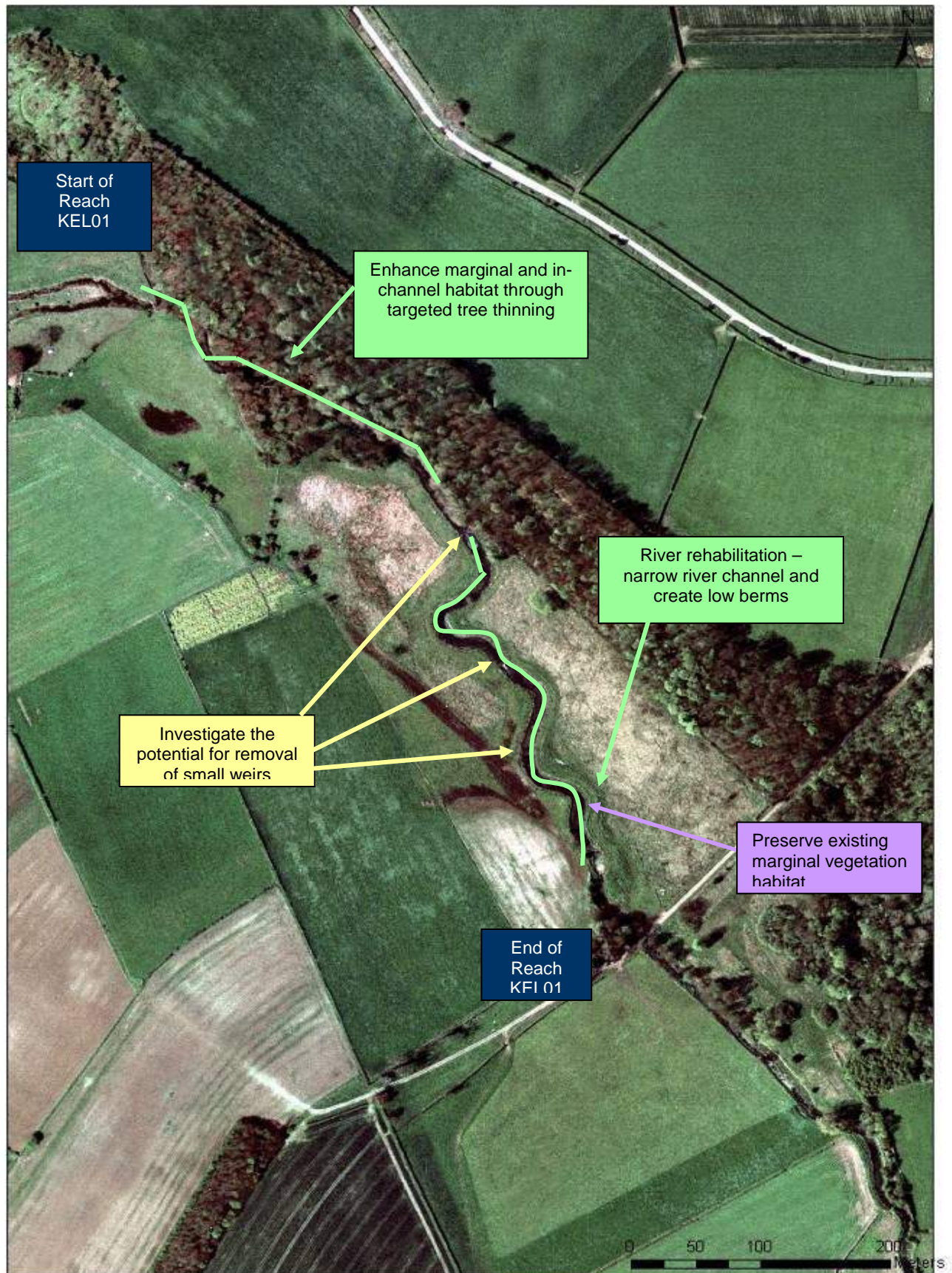
Local over-shading in the upper section



Marginal vegetation within the downstream section

Potential restoration measures

Measure		Issues addressed	Description
C.1	Enhance riparian habitat through tree thinning	Overshading	Targeted tree thinning could be adopted to improve the light penetration into the channel and encourage further in-channel vegetation growth.
C.2	River rehabilitation – narrow river channel and create low berms	Channelisation and low flows	The over-wide channel could be narrowed to improve flow and habitat diversity in the reach. However, this should only be undertaken once the weirs have been removed, so that the effects and full scope of works can be identified.
D.1	Investigate potential to remove small weirs	In-channel structures	<p>A number of small weirs are present within the reach, which do not appear to have any impact of water levels and are causing localised impoundment. It is therefore considered that these weirs could be removed to revert back to a more natural system. .</p> <p>There is concern that removal of the weirs could lead to very low flows within the Kelk Beck. The weirs were originally installed to retain water levels at low flows, Removal of these structures would remove their current function and river rehabilitation would be required to mitigate this (see above).</p>
E.1	Preserve existing habitat	Preserve existing habitat	The marginal vegetation on both banks should be protected to ensure the continued presence of otter and fish habitat, and maintain greater habitat diversity to benefit SSSI invertebrates.



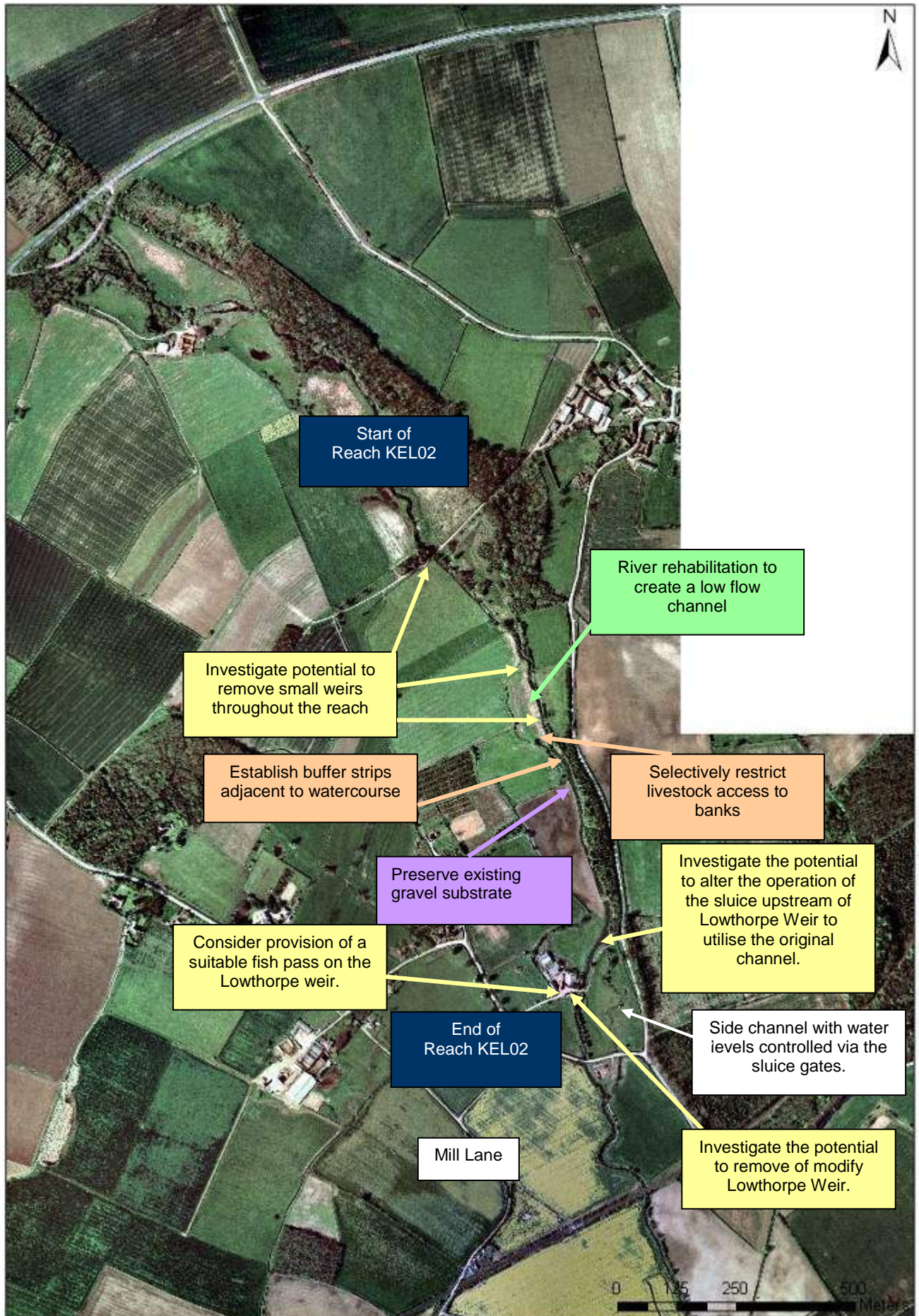
Reach KEL02 – Weir south of Neat Holmes to southern end of Mill Farm

Opportunities for enhancement

Kelk Beck flows in a straight course in this reach. The banks are predominantly low and graded, with the exception of the middle section where the left hand bank is significant steeper and higher. Lowthorpe weir is present at the downstream extent of the reach which is causing significant impoundment and sediment deposition extending approximately 100m upstream. Lowthorpe weir could be modified to allow the upstream migration of fish, and to reduce the impoundment. The reach could be enhanced by an increase in the wetland floodplain habitat to improve the habitat for breeding birds and otter. The operation of the sluice upstream of Lowthorpe Mill on the right hand bank could be modified to divert additional water through the meandering side channel which flows back into the main channel downstream of Mill Lane.

Potential restoration measures

Measure		Issues addressed	Description
A.2	Establish buffer strips adjacent to watercourses	Fine sedimentation	Riparian buffer strips and marginal vegetation could be established along the right hand bank of the beck, to provide increased shelter to otter and fish species.
A.3	Selectively restrict livestock access to banks	Fine sedimentation	Localised trampling of the right hand bank is present, contributing sediment to the reach. The post and wire fence is in a poor condition and could be upgraded to prevent cattle access to the banks. Access to water for grazing livestock could be maintained through the provision of reinforced access points. Alternatively, areas of the bank could be left unfenced to allow continued access for the cattle. These areas could be rotated periodically, to ensure that the banks do not become too degraded and the positive benefits are realised.
C.2	River rehabilitation to create a low flow channel	Channelisation and low flows	The steep banks could be re-profiled to create low benches and shallow areas at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach.
D.1 D.2 D.3 D.4	Investigate potential to remove or modify Lowthorpe Mill Weir and provide fish passage. Also consider altering the operation of the smaller sluice upstream of Lowthorpe Mill weir.	In-channel structures	Lowthorpe weir provides a significant impoundment impact upstream and options to reduce this impact should be investigated. The potential to remove the weir should be considered in the long term however in the short term, the operating protocol of the weir should be investigated in more detail to reduce the impoundment and sediment deposition. The operation of the sluice upstream of Lowthorpe weir on the left hand bank should also be considered.
D.1	Remove small structures	In-channel structures	The small weirs throughout the reach could potentially be removed to revert back to a more natural channel. However, there is concern that removal of the weirs could lead to very low flows within the Kelk Beck. The weirs were originally installed to retain water levels at low flows and removal of these structures would remove their current function.
E.1	Preserve existing habitat	Preserve existing habitat	The clean gravel substrate should be protected to ensure the continued presence of in-channel vegetation growth and suitable substrate for fish spawning.



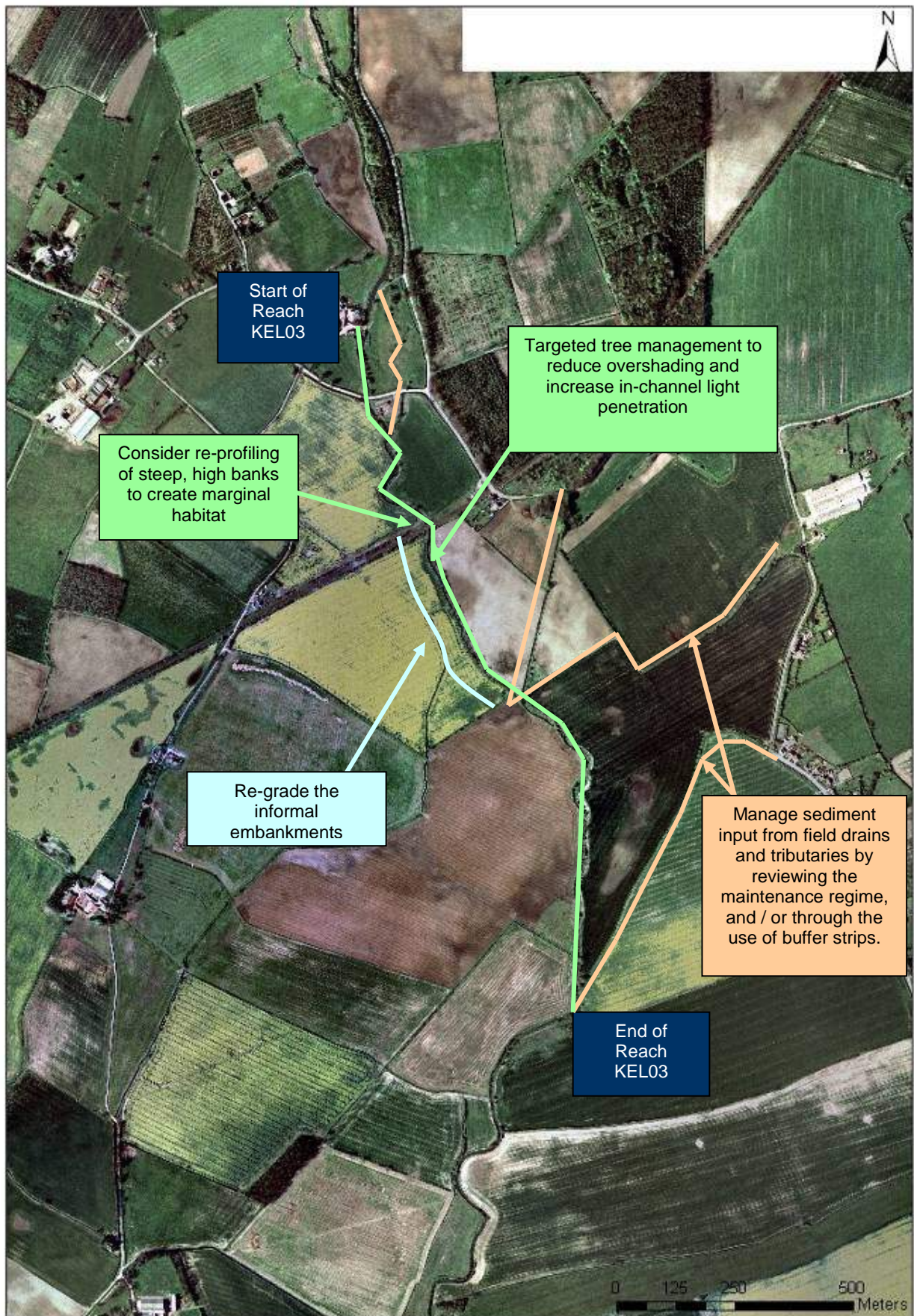
Reach KEL03 – Southern end of Mill Farm to downstream limit of drain from Little Kelk

Opportunities for enhancement

This section of Kelk Beck flows in a predominantly straight course. Both banks display steep, high graded profiles. There is a lack of marginal vegetation as a result of the managed nature of the banks. Arable land is located immediately adjacent to the channel, with only a very narrow buffer strip of grass. The arable land also slopes down towards the channel within the downstream section, which is likely to supply sediment to the channel as a result of overland runoff. This is likely to be exacerbated by the ploughing of fields directly towards the channel. The reach could be enhanced by the addition of a riparian buffer strip and a reduction in localised over-shading.

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	Establish buffer strips and review the maintenance regime of watercourses	Fine sedimentation	The beck is fed by a number of tributaries supplying significant sediment into the reach. The maintenance regime of the tributaries could be reviewed to reduce this supply. Input from these sources should be managed in order to help reduce the amount of fine sediment that is currently transported by the river. This could potentially be achieved through changes to land use (e.g. the promotion of Entry Level and Higher Level Stewardship), changes to the maintenance regime of each watercourse, and the establishment of buffer strips in areas where sediment supply is at its greatest.
B.1	Re-grade informal embankments downstream of Lowthorpe Bridge	Channelisation and low flows	The informal embankments which fringe the river from the footbridge downstream could be removed to improve floodplain connectivity.
C.1	Enhance riparian vegetation through tree thinning	Over-shading	Targeted tree thinning could be adopted to improve the light penetration into the channel and encourage further in-channel and marginal vegetation growth.
C.2	Enhance marginal and riparian vegetation by river rehabilitation	Channelisation and low flows	The steep banks could be re-profiled to create low benches and shallow areas at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach.



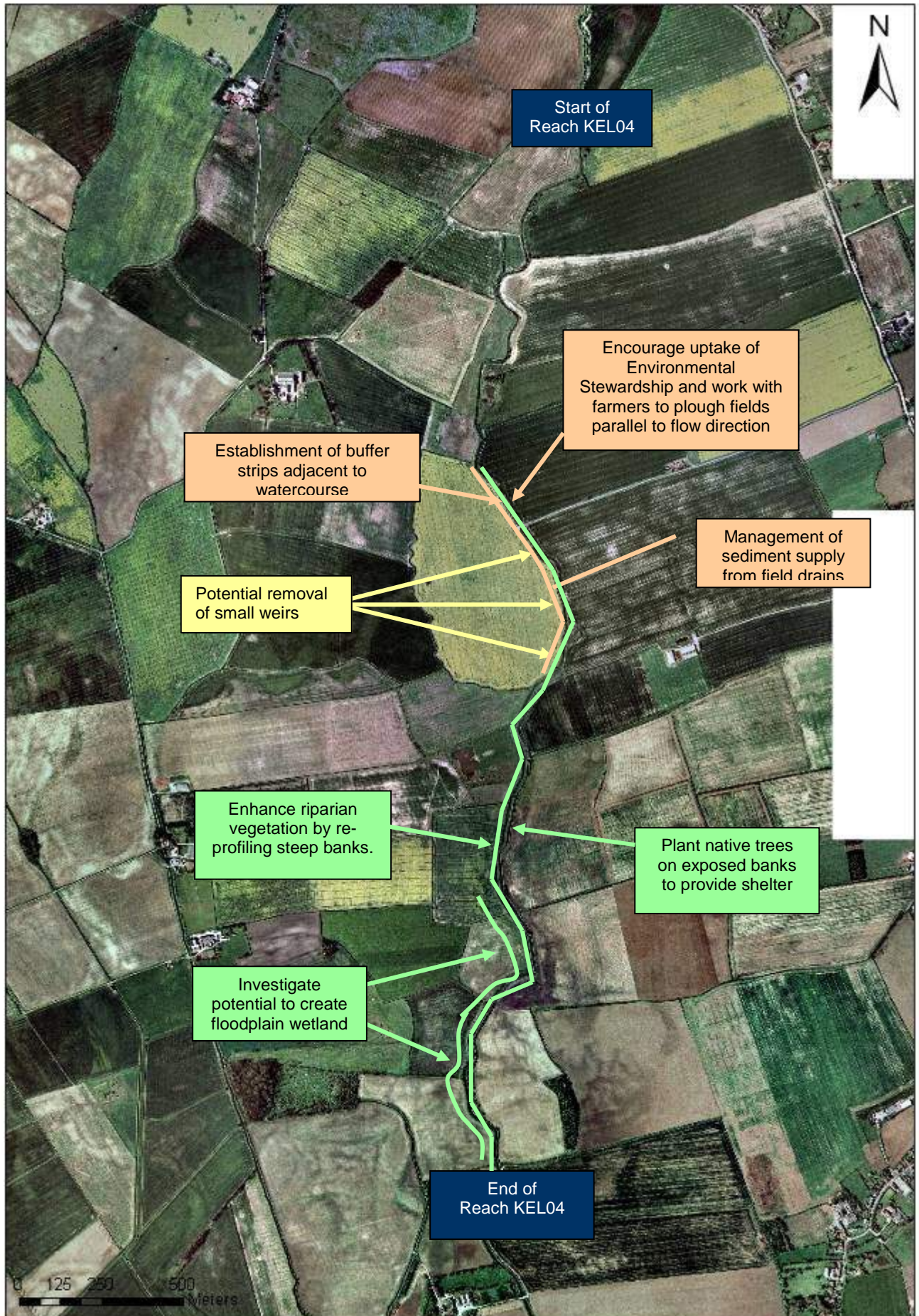
Reach KEL04 – Downstream limit of drain from Little Kelk to Downstream limit of Kelk Beck at the aqueduct

Opportunities for enhancement

The Kelk Beck flows in a predominantly sinuous course. Both banks display steep, high graded profiles. There is a lack of marginal vegetation as a result of the managed nature of the banks. Arable land is located immediately adjacent to the channel with only a very narrow buffer strip of grass. The arable land also slopes down towards the channel within the downstream section, which is likely to supply sediment to the channel as a result of overland runoff. This is likely to be exacerbated by the ploughing of fields directly towards the channel. The reach could be enhanced by the addition of a riparian buffer strip and a reduction in localised over-shading. A number of small weirs are present throughout the reach and are acting as weed traps due to the poor condition of the weirs. It is considered that the reach could be enhanced by the removal of these structures. Downstream of Lynesykes bridge, the channel is bordered by continuous raised embankments which disconnect the river from the floodplain.

Potential restoration measures

Measure		Description	
A.1 A.2	Review the maintenance regime of watercourses. Establish buffer strips adjacent to watercourses.	Fine sedimentation Lack of bankside shelter	Input of sediment from adjacent agricultural land should be managed in order to help reduce the amount of fine sediment that is currently transported by the river. This could potentially be achieved through changes to land use (e.g. the promotion of Entry Level and Higher Level Stewardship), changes to the maintenance regime of each watercourse, and the establishment of buffer strips in areas where sediment supply is at its greatest.
C.1	Enhance riparian habitat through tree planting	Lack of bankside shelter	Native trees could be planted on both banks of the river downstream of Lynesykes bridge. This would provide tree root cover for brown trout and grayling and provide shelter and rest sites for otters.
C.2	Enhance riparian vegetation by river rehabilitation	Lack of bankside shelter	The steep banks throughout the reach could be re-profiled to create low benches and shallow areas at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach.
C.3	Investigate potential to create floodplain wetland habitats	Channelisation	Investigate potential to create a reedbed or area of wet woodland in the meander pocket, and if combined with additional re-profiling, the creation of a reedbed further downstream.
D.1	Investigate potential to remove three weir structures	In-channel structures	The numerous small weirs throughout the reach could potentially be removed in order to prevent build up of weed on the wooden struts, which could lead to further sediment accumulation.



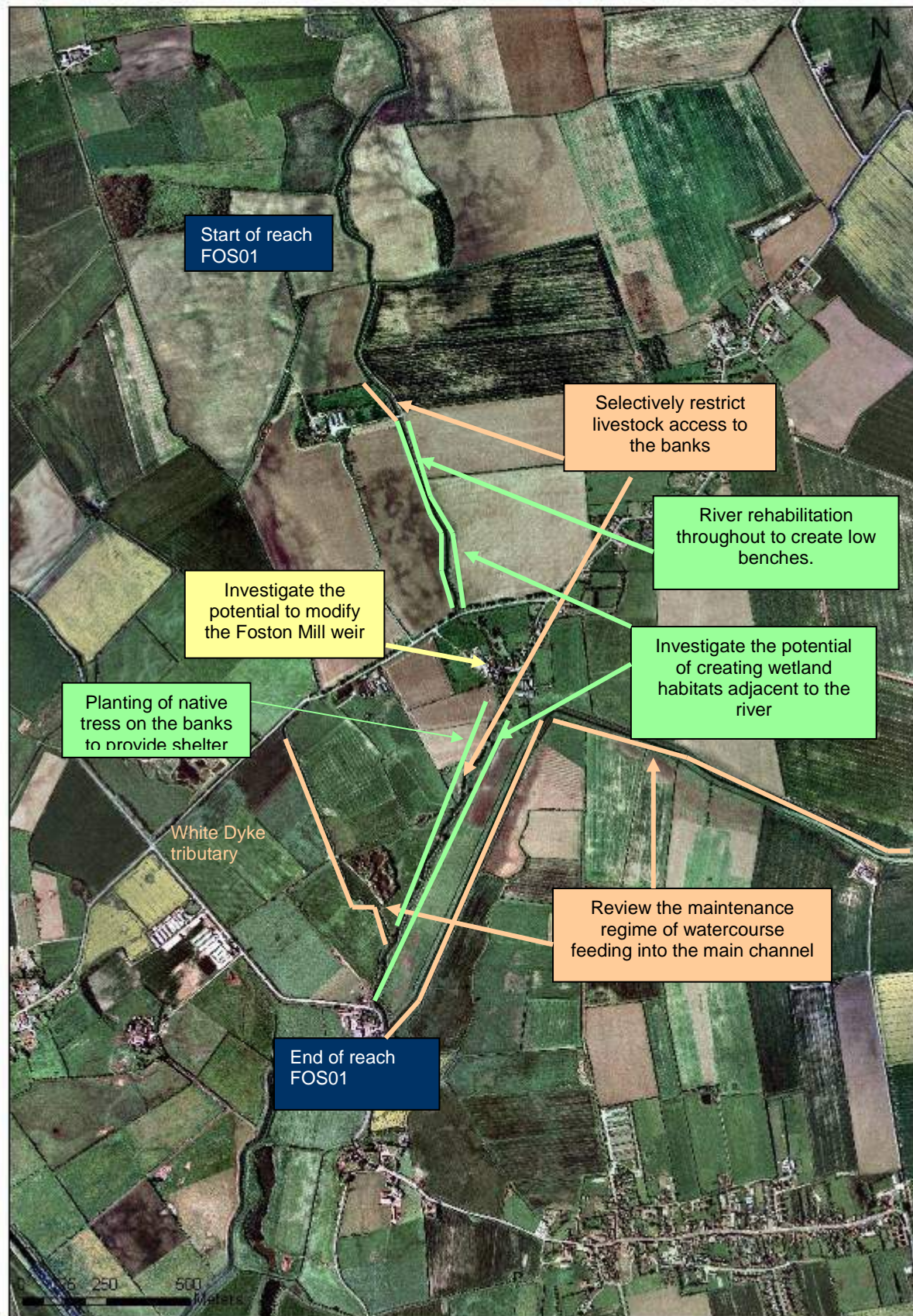
Reach FOS01 – Upstream limit of Foston Beck to downstream limit of Foston Beck

Opportunities for enhancement

The Foston Beck flows as a predominantly straight course as a result of historic navigation or flood defence. This has resulted in a deep, uniform channel with steep banks and little flow diversity. A large proportion of the reach has been embanked, and as a result there is little tree cover). The Foston Mill weir controls the water levels within the upstream section of the reach, resulting in sedimentation upstream. Field drains and tributaries from a large area enter the channel in this reach, supplying large quantities of sediment. This reach could be enhanced if riparian tree cover was increased, providing improved bank habitat for mammals and birds and in-channel shelter for fish. In addition, actions to reduce the input of sediment from the field drains could be implemented as part of a catchment-wide management scheme.

Potential restoration measures

Measure		Issues addressed	Description
A.1	Review the maintenance regime of watercourses	Fine sedimentation	The beck is fed by a number of tributaries supplying significant sediment into the reach. The maintenance regime of the tributaries could be reviewed to reduce this supply. Input from these sources should be managed in order to help reduce the amount of fine sediment that is currently transported by the river.
A.3	Selectively restrict livestock access to banks	Fine sedimentation	Localised trampling of the right hand bank is present, contributing sediment to the reach. Access to water for grazing livestock could be maintained through the provision of reinforced access points. Alternatively, areas of the bank could be left unfenced to allow continued access for the cattle. These areas could be rotated periodically, to ensure that the banks do not become too degraded and the positive benefits are realised.
C.1	Enhance riparian vegetation by establishing bank habitats	Lack of bankside shelter	Native trees could be planted on both banks of the river. This would provide tree root cover for brown trout and grayling and provide shelter and rest sites for otters.
C.2	River rehabilitation – re-profile banks to create low benches	Channelisation and low flows	The steep banks throughout the reach could be re-profiled to create low benches and shallow areas at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach.
C.3	Investigate the potential of creating wetland habitats adjacent to the river	Channelisation and low flows	A raised flood embankment is present immediately adjacent to the channel on both banks throughout the majority of the reach downstream of Carr House Farm. Low lying land may provide opportunities to create wetland habitats adjacent to the river.
D.2	Investigate feasibility of modifying Foston Mill Weir	In-channel structures	The Foston Mill weir is causing significant impoundment of water upstream and deposition of sediment on the bed. The potential for modifying the operation of the weir could be investigated to reduce impoundment.



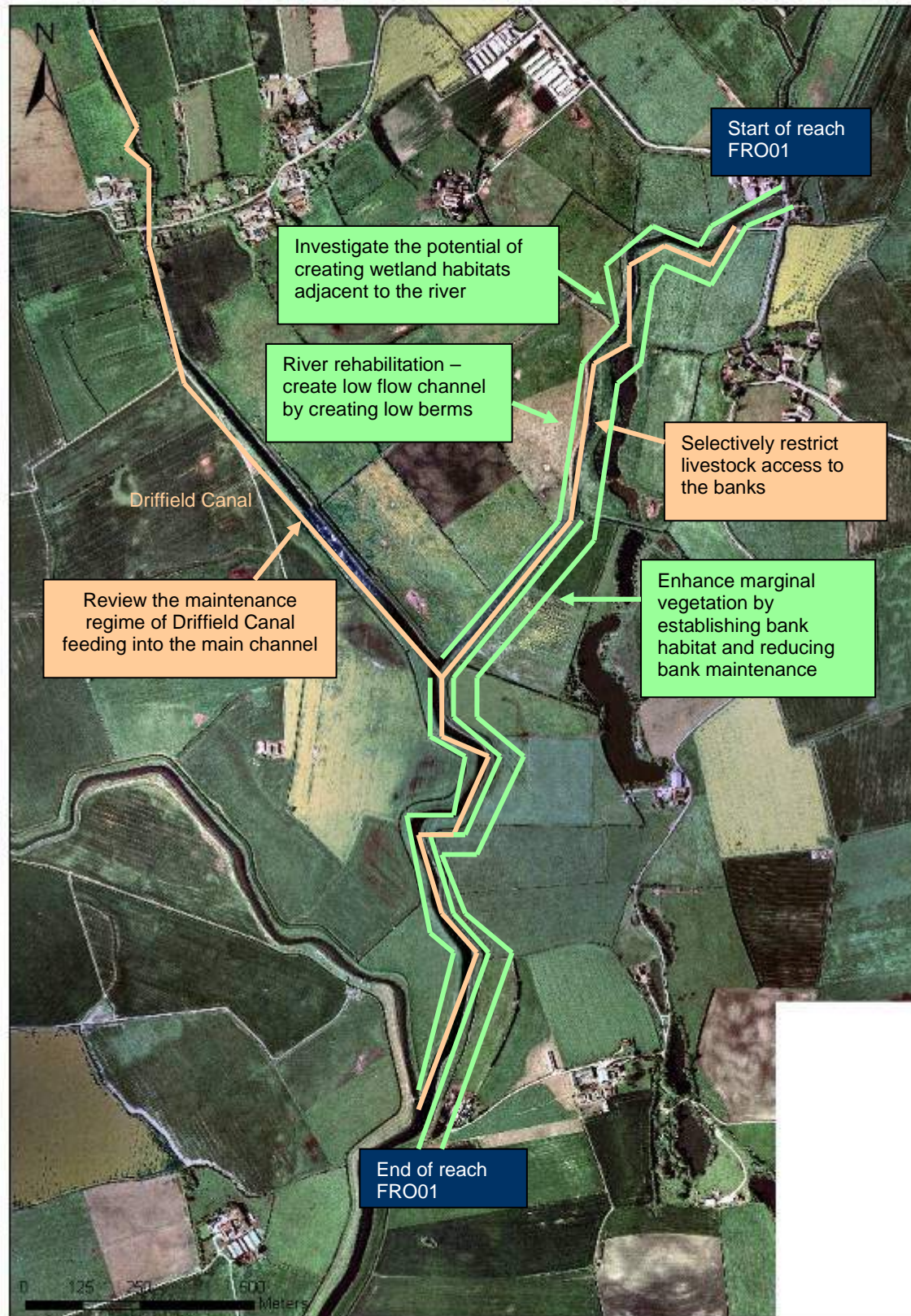
Reach FRO01 – Upstream limit of Frodingham Beck to downstream limit of Frodingham Beck

Opportunities for enhancement

The Frodingham Beck flows in a sinuous course, bordered by steep high banks. The channel is perched above the surrounding land, with managed banks to prevent excess vegetation growth. The channel is wide, and deep with little flow diversity. The Driffield canal flows into the channel, likely to be supplying a significant amount of sediment into the reach. The channel appears to be used by small boats which were identified during the field survey. The banks have been trampled by cattle, leading to bank instability and sediment supply to the channel. The reach could be enhanced by planting of native trees to provide shade and increase bank stability. The maintenance regime of bankside vegetation could also be reviewed to increase shelter.

Potential restoration measures

Measure		Issues addressed	Description
A.1	Review the maintenance regime of watercourses	Fine sedimentation	The beck is fed by the Driffield Canal which is likely to be supplying significant sediment into the reach. The maintenance regime of the canal could be reviewed to reduce this supply. Input from this source should be managed in order to help reduce the amount of fine sediment that is currently transported by the river.
A.3	Selectively restrict livestock access to banks	Fine sedimentation	Localised trampling of the right hand bank is present, contributing sediment to the reach. Access to water for grazing livestock could be maintained through the provision of reinforced access points. Alternatively, areas of the bank could be left unfenced to allow continued access for the cattle. These areas could be rotated periodically, to ensure that the banks do not become too degraded and the positive benefits are realised.
C.1	Enhance marginal vegetation by establishing bank habitat and reducing bank maintenance	Lack of bankside shelter	Native trees could be planted on both banks of the river. This would provide tree root cover for brown trout and grayling and provide shelter and rest sites for otters.
C.2	River rehabilitation – create low flow channel by creating low berms	Lack of bankside shelter	The steep banks throughout the reach could be re-profiled to create low benches and shallow areas at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along this reach.
C.3	Investigate potential to create floodplain wetland habitats adjacent to the river	Channelisation	The potential to explore opportunities to create wetland habitats adjacent to the river should be assessed.



5. ACTION PLAN

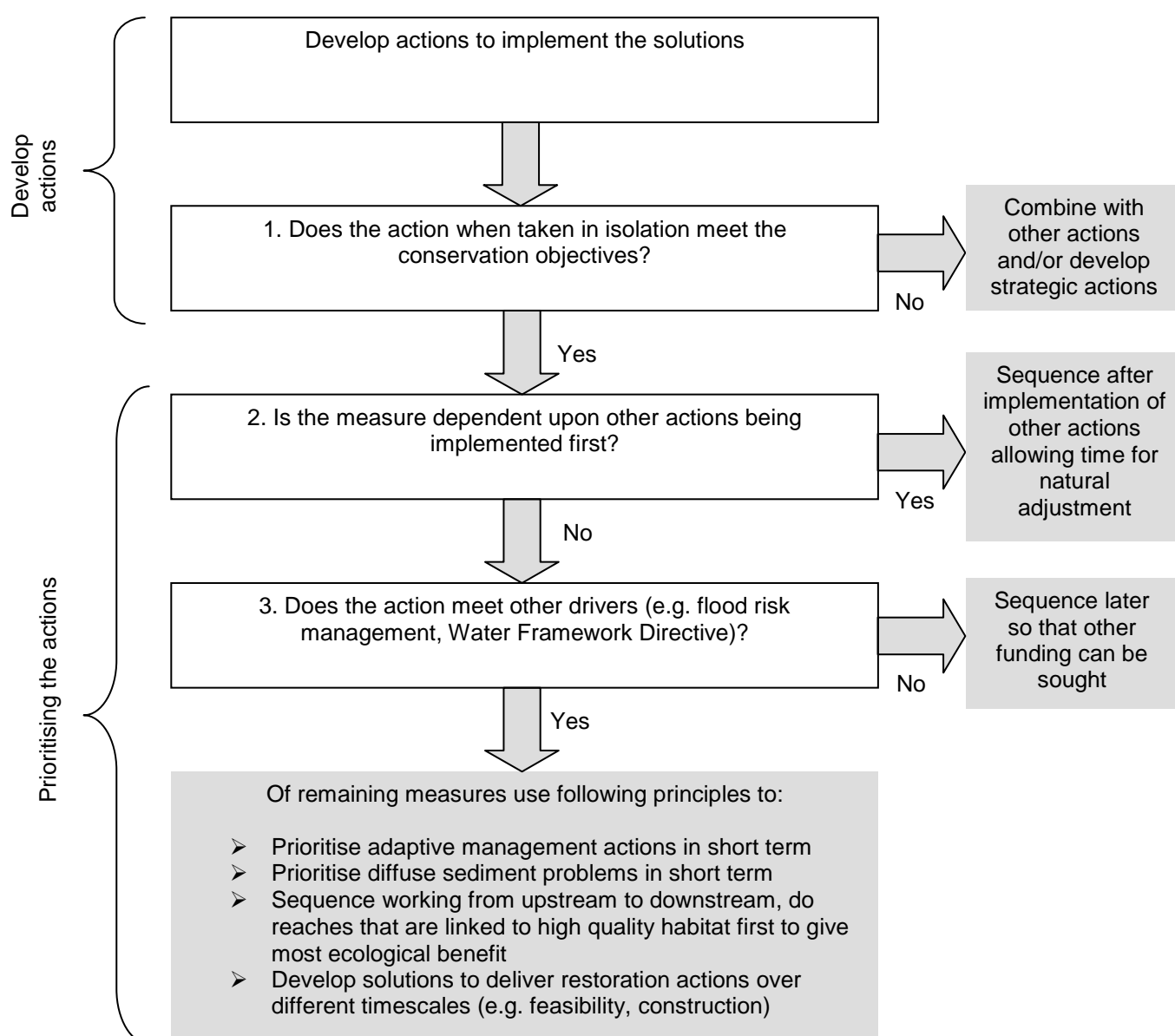
Purpose of this section

The purpose of this section is to set out a plan of action for the implementation of the reach-based solutions outlined in **Section 4**. These solutions are proposed to restore the ecological health of the River Hull Headwaters SSSI and deliver the conservation objectives for the catchment. In order to implement the solutions, it is important to develop a plan of actions to:

- Develop the list of actions needed to implement the solution.
- Identify which actions need to be taken in combination in order to be most effective.
- Prioritise which actions need to be taken forward first (for example, some require planning and pre-feasibility).
- Review key drivers and mechanisms that could be used to fund or co-delivery actions.
- Estimate indicative costs to allow forward planning for funding.

Figure 5.1 summarises how the reach based actions have been taken forward into an action plan based on short, medium and long term phases. The subsequent sections provide more detail on each element of the flow chart.

Figure 5.1 Flow chart explaining steps to prioritisation of actions to deliver solutions



Develop actions to implement the solutions

The initial stage of the process is to identify the actions which can be taken to implement the solutions within the catchment. In many cases the solutions have been identified on a reach by reach basis, and are individually tailored to meet the specific requirements of each part of the river and are therefore actions that can be taken forward for prioritisation.

In some circumstances it will be important to investigate the feasibility of a solution prior to implementation and the first action is therefore to undertake a feasibility study. Feasibility studies, which may include detailed design and planning applications, could be potentially time consuming, and it is therefore important that they are undertaken at a suitably early stage in the process. Any actions arising from these studies can then be incorporated into the prioritisation system at a later date (e.g. a feasibility study can be prioritised in the short term, and delivery of the outcomes of the study can be prioritised over the medium to long term). Feasibility studies would address three key questions:

1. Will the solution successfully deliver the required objectives?
2. What are the potential constraints and benefits for:
 - water quality and morphology (these are key constraints on the current condition of the SSSI)
 - biodiversity
 - fisheries
 - flood risk
 - landscape
 - recreation
 - cultural heritage and archaeological value
3. Is the solution sustainable? (this takes into account the function of the river for both wildlife and those who use the river now and into the future)

Does the action when taken in isolation meet the conservation objectives?

Conservation objectives are set for all SSSIs, and are the main driver for improving the physical, biological and chemical status of the habitats they contain. For river SSSIs morphological objectives are set to help support and deliver ecological health. A copy of the conservation objectives for the River Hull can be found in **Appendix B** of the plan. It is important that all actions undertaken in the catchment are aimed at delivering these objectives, setting challenging targets to achieve the overall vision for the River Hull Headwaters SSSI (as described at the beginning of this report). These targets will need active support from key stakeholders and funding bodies if they are to be delivered successfully.

Some actions may be capable of delivering the conservation objectives without the need to combine them with other actions. Others may need to be taken in combination with others and a strategic action may be required to combine these together.

Prioritisation of Actions

Not all actions can be taken immediately and it is important to prioritise actions in order to make the plan more achievable. The actions are split into short, medium and long term after the prioritisation shown in **Figure 5.1**:

Short term actions:	by 2015
Medium term actions:	by 2021
Long term actions:	by 2050

Is the measure dependent on other actions being implemented first?

Some options may only be effective once other options have been implemented. It is therefore important to sequence the implementation of all actions to take these inter-dependencies into account. Actions on which other actions are dependent should be given a higher priority than actions which are dependent on others.

Does the action meet other drivers?

There are other initiatives which are targeting morphological improvements to meet other legislation; to assist in sensitive catchment management for ecology or to manage flood risk working with natural processes. **Appendices A, C and D** provide details on different drivers.

Appendix A Environmental Stewardship is an environmental scheme for landowner participation which aims, among other objectives, to help conserve wildlife through changing land management. Appendix A gives more information on the scheme.

Appendix C The England Catchment Sensitive Farming Delivery Initiative is a joint venture between the Environment Agency and Natural England funded by Defra working in 50 priority catchments of which the River Hull is one. Delivering strategic objectives aimed at tackling diffuse pollution could work in partnership with this existing initiative.

Appendix D The Water Framework Directive is European Legislation aimed at improving the management of rivers, coasts and estuaries to improve their ecological health. Geomorphological changes from river management are recognised as contributing to degradation of habitat and all rivers (waterbodies) have had objectives set for improvement. The measures identified for improvement in the Hull Headwaters are included in Appendix D. These measures may have funding associated with them.

Flood risk management is progressed strategically through Catchment Flood Management Planning and implementation of the strategy should identify ways of working with flood risk management to ensure policies set down in the strategic planning documents are adhered to and local works do not impact upon the river SSSI.

Any actions which could potentially meet other drivers, and therefore delivered using other funding streams, should be sequenced later in the prioritisation to give sufficient time for funding applications to be prepared and submitted.

Estimate costs to allow forward planning for funding

Approximate cost estimates (including a lower and upper boundary) have been provided for each action. These costs are aggregated to provide total costs for each unit, and summed to provide an estimate of likely total expenditure over short, medium and long timescales.

In addition, an estimate of the likely proportion of funding which can be apportioned to different funding streams has also been made, using the upper and lower estimates described above. These are presented as a potential lower and upper limit for each funding stream. Where funding could potentially be derived from more than one source, the lower limit is assumed to be zero and the upper limit is assumed to be the maximum cost of the measure.

What will happen to the plan?

The plan will be freely available to all and can be accessed from either the Environment Agency or Natural England. Progress on the plan will be reported on through delivery processes against funding and where possible more widely. The plan shows the options that have been identified as desirable to meet the conservation objectives for each reach. These options will need to be developed in the future through detailed consultation with key stakeholders (including landowners, land managers, riparian users, conservation bodies and recreational groups). The plan will be updated and revised to take account of this consultation process.

SHORT TERM ACTIONS

Unit	Action –reach shown in brackets	Other drivers & delivery mechanisms in addition to SSSI conservation objectives	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
Strategic	Develop an adaptive management strategy for the future management of the flood embankments with respect to the SSSI and flood risk, working with River Hull Flood Risk Management Strategy.	WFD Measures: Modify embankments, Improve floodplain connectivity, Remove obsolete structures	£50,000	£100,000	£51,000	£110,000
Strategic	Ensure areas to preserve/maintain habitat are clearly flagged in Environment Agency/Natural England GIS systems so that consenting take them fully into account. Develop guidelines to preserve/maintain woody debris in channel and ensure these are adopted by Natural England and Environment Agency operational staff.	Flood risk maintenance reduction; HLS & CSF	£1,000	£10,000		
Unit 33 Elmswell & Driffield Beck	Enhance floodplain wetland habitats (ELM01)	HLS; WFD Measures: Appropriate timing (vegetation control), Appropriate vegetation control technique,	£1,000	£10,000	£24,000	£190,000
	Establish riparian buffer strips on tributary to limit sediment delivery to channel (ELM01)	HLS/Countryside Stewardship Scheme	£1,000	10,000		
	Establish bank habitats through tree management (DRI01)	HLS; WFD Measures: Appropriate timing (vegetation control), Appropriate vegetation control technique, Selective vegetation control regime	£1,000	£10,000		
	Establish riparian buffer strips on tributary to limit sediment delivery to channel (DRI01)	HLS/Countryside Stewardship Scheme	£1,000	£10,000		
	River rehabilitation to narrow the river, create low berms and remediate bank erosion through the use of bioengineering techniques (downstream of weir structure) (DRI01)	WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£100,000		
	Investigate potential to remove small steel pile weir that is currently in disrepair, and the brick wall and concrete plinth that extend into the channel (DRI01)	WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£10,000	£50,000		
Unit 34 Eastburn Beck Driffield Trout Stream	Enhance bankside vegetation by establishing marginal habitat (EAS01)	HLS/Countryside Stewardship Scheme	£1,000	£10,000	£34,000	£240,000
	Establish buffer strips adjacent to watercourse by repositioning fenceline (EAS01)	HLS/Countryside Stewardship Scheme	£1,000	£10,000		
	River rehabilitation to narrow the channel and create low level berms (downstream of weirs) (EAS01)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£100,000		
	Investigate potential to remove 2 small sheet pile weirs (DTS01)	HLS; WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures,	£10,000	£50,000		
	Investigate potential to remove or alter Poundworth Weir (DTS02)	HLS; WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£10,000	£50,000		

Unit	Action –reach shown in brackets	Other drivers & delivery mechanisms in addition to SSSI conservation objectives	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
	Improve riparian vegetation by establishing bank habitats and narrowing the channel (DTS03)	HLS	£1,000	£10,000		
	Establish buffer strips adjacent to watercourse (DTS03)	HLS & Catchment Sensitive Farming	£1,000	£10,000		
Unit 35 West Beck	Investigate potential to modify the Bell Mills structures, change their operation, and improve fish passage and creation of a weed trap (WES01)	HLS (in part); WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£10,000	£50,000	£76,000	£510,000
	Establish buffer strips adjacent to watercourse (WES01)	HLS & Catchment Sensitive Farming	£1,000	£10,000		
	Establish bank habitats on right bank (WES02)	HLS	£1,000	£10,000		
	Manage sediment input from West Beck by establishing buffer strips (WES03)	HLS	£1,000	£10,000		
	Selectively restrict livestock access to banks (WES04)	HLS & Catchment Sensitive Farming; WFD Measure: Sediment management strategies (develop and revise)	£1,000	£10,000		
	Establish bank habitats on left bank (WES04)	HLS	£1,000	£10,000		
	Selectively restrict livestock access to banks (WES05)	HLS & Catchment Sensitive Farming; WFD Measure: Sediment management strategies (develop and revise)	£1,000	£10,000		
	Establish buffer strips adjacent to watercourse (WE05)	HLS & Catchment Sensitive Farming	£1,000	£10,000		
	River rehabilitation - channel narrowing and gravel reintroduction (WES05)	WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£100,000		
	Enhance floodplain wetland habitats (WES05)	HLS	£1,000	£10,000		
	Investigation option to alter operation of Whinhill Weir and improve fish passage (WES05)	WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£10,000	£50,000		
	Selectively restrict livestock access to banks (WES06)	HLS & Catchment Sensitive Farming; WFD Measure: Sediment management strategies (develop and revise)	£1,000	£10,000		
	Establish buffer strips adjacent to watercourse (WES06)	HLS & Catchment Sensitive Farming; WFD Measure: Sediment management strategies (develop and revise)	£1,000	£10,000		
	Enhance floodplain habitat through the creation of scrapes on floodplain (WES06)	HLS	£1,000	£10,000		
	Establish bank habitats to provide refuge and shelter for fish and fauna (WES07)	HLS & Catchment Sensitive Farming	£1,000	£10,000		
	Manage sediment supply from drainage systems through addition of buffer strips (WES07)	HLS & Catchment Sensitive Farming;	£1,000	£10,000		
	Selectively restrict livestock access to banks (WES07)	HLS & Catchment Sensitive Farming; WFD Measure: Sediment management strategies (develop and revise)	£1,000	£10,000		
	Investigate potential to remove Copper Hall Weir (WES07)	WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to	£10,000	£50,000		

Unit	Action –reach shown in brackets	Other drivers & delivery mechanisms in addition to SSSI conservation objectives	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
		enable fish to access waters upstream and downstream				
	Investigate potential to modify or alter operation of the Humberside Fish Farm offtake to reduce abstraction (WES07)	WFD Measures: Operational changes to locks, weirs, sluices etc., and Remove obsolete structures	£10,000	£50,000		
	Selectively restrict livestock access to banks (WES08)	HLS & Catchment Sensitive Farming; WFD Measure: Sediment management strategies (develop and revise)	£1,000	£10,000		
	Manage sediment delivery to Skerne Beck (WES08)	HLS & Catchment Sensitive Farming; WFD Measure: Sediment management strategies (develop and revise)	£1,000	£10,000		
	Investigate potential to modify, alter operation or remove Cleaves Weir (WES08)	WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£10,000	£50,000		
Unit 36 Frodingham Beck	Selectively restrict livestock access to banks (FRO01)	HLS & Catchment Sensitive Farming; WFD Measure: Sediment management strategies (develop and revise)	£1,000	£10,000	£1,000	£10,000
Unit 37 Kelk & Foston Beck	Investigate potential to remove small weirs (KEL01)	HLS; WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£10,000	£50,000	£82,000	£470,000
	Enhance riparian habitat through tree thinning on banks (KEL01)	HLS & Catchment Sensitive Farming	£1,000	£10,000		
	Establish buffer strips adjacent to watercourse (KEL02)	HLS & Catchment Sensitive Farming	£1,000	£10,000		
	Selectively restrict livestock access to banks (KEL02)	HLS & Catchment Sensitive Farming; WFD Measure: Sediment management strategies (develop and revise)	£1,000	£10,000		
	Investigate potential to remove or modify Lowthorpe Mill Weir and smaller structures in the reach, alter the operation of the sluices, and improve fish passage (KEL02)	HLS (in part); WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£10,000	£50,000		
	Re-grade informal embankments downstream of Lowthorpe Bridge (KEL03)	HLS; WFD Measures: Modify embankments, Improve floodplain connectivity, Remove obsolete structures	£10,000	£100,000		
	Enhance riparian habitat through tree thinning (KEL03)	HLS; WFD Measures: Appropriate timing (vegetation control), Appropriate vegetation control technique, Selective vegetation control regime	£1,000	£10,000		
	Enhance marginal and riparian vegetation by river rehabilitation (KEL03)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£1,000	£10,000		

Unit	Action –reach shown in brackets	Other drivers & delivery mechanisms in addition to SSSI conservation objectives	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
	Enhance riparian habitat through tree planting (KEL04)	HLS & Catchment Sensitive Farming	£1,000	£10,000		
	Investigate potential to remove 3 small weir structures (KEL04)	HLS; WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£10,000	£50,000		
	Investigate potential to create reedbed/ wet woodland habitat within meander pocket (KEL04)	HLS; WFD Measures: Improve floodplain connectivity,	£10,000	£50,000		
	Selectively restrict livestock access to banks (FOS01)	HLS; Catchment Sensitive Farming; WFD Measure: Sediment management strategies (develop and revise)	£1,000	£10,000		
	Investigate potential to modify Foston Mill weir (FOS01)	HLS; WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£25,000	£100,000		
TOTAL					£268,000	£1,530,000
<i>Potential costs split: Higher Level Stewardship</i>					<i>£51,000</i>	<i>£460,000</i>
<i>Potential costs split: WFD implementation</i>					<i>£135,000</i>	<i>£650,000</i>
<i>Potential costs split: other funding sources</i>					<i>£82,000</i>	<i>£420,000</i>

MEDIUM TERM ACTIONS

Unit	Action	Other drivers & delivery mechanisms in addition to SSSI conservation objectives	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
Strategic	Undertake feasibility studies for modification of the flood embankments in line with the adaptive management strategy	WFD Measures: Modify embankments, Improve floodplain connectivity, Remove obsolete structures	£100,000	£1,000,000	£100,000	£1,000,000
Unit 33 Elmswell & Driffield Beck	Removal of small steel pile weir and the brick wall and concrete plinth that extend into the channel (DRI01)	HLS (in part); WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£0	£100,000	£0	£100,000
Unit 34 Eastburn & Driffield Trout Stream	Removal of 2 small sheet pile weirs (DTS01)	HLS (in part); WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£0	£250,000	£24,000	£1,790,000
	Remove or alter Poundsworth Weir and improve fish passage (DTS02)	HLS (in part); WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£0	£1,000,000		
	River rehabilitation to narrow channel by creating berms following the removal of small weirs (DTS01)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£250,000		
	Enhance wetland habitats by modifying maintenance regime (DTS01)	HLS	£1,000	£10,000		
	Establish bank habitats by reviewing in channel maintenance regime and repositioning fence (DTS01)	HLS, operational maintenance	£1,000	£10,000		
	Improve riparian vegetation by establishing bank habitats (DTS02)	HLS	£1,000	£10,000		
	River rehabilitation to narrow channel by creating berms following the removal/modification of Poundsworth weir (DTS02)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	10,000	£250,000		
	Review maintenance regime of watercourse and banks to allow the establishment of a buffer strip (DTS02)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£1,000	£10,000		
Unit 35 West Beck	Remove or modify the Bell Mills Structures (WES01)	HLS (in part); WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£0	£1,000,000	£61,000	£4,710,000
	River rehabilitation to create low berms and establish bank habitats (WES02)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£250,000		
	Implement river rehabilitation (channel narrowing) and habitat creation scheme in channel and on floodplain (WES03)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£250,000		
	Investigate potential of creating wetland habitats (WES04)	HLS; WFD Measures: Modify embankments, Improve floodplain connectivity, Remove obsolete structures	£10,000	£50,000		
	Alter operation or provide fish pass for Whinhill Weir (WES05)	WFD Measures: Operational changes to locks,	£0	£100,000		

Unit	Action	Other drivers & delivery mechanisms in addition to SSSI conservation objectives	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
		weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream				
	River rehabilitation to narrow the river (WES06)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow t	£10,000	£250,000		
	Remove Copper Hall Weir (WES07)	WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£0	£1,000,000		
	Modify or alter the operation of the Humberside Fish Farm offtake (WES07)	WFD Measures: Operational changes to locks, weirs, sluices etc., and Remove obsolete structures	£0	£500,000		
	Establish bank habitats once structures have been modified (WES07)	HLS	£1,000	£10,000		
	Modify, alter operation or remove Cleaves Weir (WES08)	WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£0	£1,000,000		
	River rehabilitation - narrow channel, create low berms, and establish bank habitats (WES08)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£250,000		
	Investigate potential to create wetland habitats (WES08)	WFD Measures Flood risk management: Maintenance, Modify embankments, Improve floodplain connectivity	£10,000	£50,000		
Unit 36 Frodingham Beck	No actions					
Unit 37 Kelk & Foston Beck	Removal/ alteration of small weirs (KEL01)	HLS(in part); WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£0	£100,000	£31,000	£2,960,000
	River rehabilitation - narrow channel and create low berms following weir work (KEL01)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£250,000		
	Remove or modify Lowthorpe Mill Weir and smaller weir structures, and alter the operation of the sluices (KEL02)	HLS(in part); WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£0	£1,000,000		
	River rehabilitation to create a low flow channel (KEL02)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£250,000		
	Review maintenance regime of watercourse and banks to allow the establishment of a buffer strip (KEL03)	HLS; WFD Measure: Appropriate techniques to align and attenuate flow to limit detrimental effects of these features	£1,000	£10,000		

Unit	Action	Other drivers & delivery mechanisms in addition to SSSI conservation objectives	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
	Remove 3 small weirs (KEL04)	HLS; WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream	£0	£250,000		
	Enhance marginal and riparian vegetation by river rehabilitation (KEL04)	HLS and Catchment Sensitive Farming; WFD Measures: Appropriate timing (vegetation control), Appropriate vegetation control technique, Selective vegetation control regime	£10,000	£100,000		
	Modify Foston Mill Weir (FOS01)	HLS (in part); WFD Measures: Operational changes to locks, weirs, sluices etc., Remove obsolete structures, Structures or other mechanisms in place to enable fish to access waters upstream and downstream;	£0	£1,000,000		
TOTAL					£216,000	£10,560,000
<i>Potential costs split: Higher Level Stewardship</i>					<i>£26,000</i>	<i>£160,000</i>
<i>Potential costs split: WFD implementation</i>					<i>£90,000</i>	<i>£9,400,000</i>
<i>Potential costs split: other funding sources</i>					<i>£100,000</i>	<i>£1,000,000</i>

LONG TERM ACTIONS

Unit	Action	Other drivers & delivery mechanisms in addition to SSSI conservation objectives	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
Strategic	Implement actions to modify embankments in line with the adaptive management strategy	WFD Measures Flood risk management Maintenance: Modify embankments, Improve floodplain connectivity, Remove obsolete structures	£0	£1,000,000	£0	£1,000,000
Unit 34 Eastburn & Driffield Trout Stream	River rehabilitation to create low berms (DTS02)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£250,000	£10,000	£250,000
Unit 35 West Beck	Detailed design and implementation of habitat creation scheme (WES04)	WFD Measures Flood risk management, Maintenance: Modify embankments, Improve floodplain connectivity, Remove obsolete structures	£0	£1,000,000	£0	£2,000,000
	Detailed design and implementation habitat creation scheme (WES08)	WFD Measures Flood risk management: Maintenance, Modify embankments, Improve floodplain connectivity, Remove obsolete structures	£0	£1,000,000		
Unit 36 Frodingham Beck	Detailed design and implementation of habitat creation scheme (FRO01)	WFD Measures: Flood risk management, Maintenance, Modify embankments, Improve floodplain connectivity, Remove obsolete structures	£0	£1,000,000	£20,000	£1,300,000
	Enhance marginal vegetation by establishing bank habitat and reducing bank maintenance (FRO01)	HLS ; WFD Measures, Maintenance: Appropriate timing (vegetation control), Appropriate vegetation control technique, Selective vegetation control regime	£10,000	£50,000		
	River rehabilitation - create low flow channel by creating low berms (FRO01)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£250,000		
Unit 37 Kelk & Foston Beck	Detailed design and implementation of habitat creation scheme (FOS01)	WFD Measures Flood risk management, Maintenance,: Modify embankments, Improve floodplain connectivity, Remove obsolete structures	£0	£1,000,000	£20,000	£1,300,000
	Enhance riparian vegetation by establishing bank habitats (FOS01)	HLS ; WFD Measures: Appropriate timing (vegetation control), Appropriate vegetation control technique, Selective vegetation control regime	£10,000	£50,000		
	River rehabilitation - re-profile banks to create low benches (FOS01)	HLS; WFD Measure: Appropriate techniques to align, diversify and attenuate flow	£10,000	£250,000		
Total					£50,000	£5,850,000
<i>Potential costs split: Higher Level Stewardship</i>					£20,000	£100,000
<i>Potential costs split: WFD implementation</i>					£30,000	£750,000
<i>Potential costs split: other funding sources</i>					£0	£5,000,000

6 FURTHER INFORMATION SOURCES

SSSIs, SACs and their management

Introduction to Sites of Special Scientific Interest

<http://www.naturalengland.org.uk/ourwork/conservation/designatedareas/sssi/default.aspx>

Information relating to the Government's Public Service Agreement Target for SSSIs

<http://www.defra.gov.uk/wildlife-countryside/protected-areas/sssi/psa.htm>

The River Hull Headwaters

River Hull SSSI citation

http://www.sssi.naturalengland.org.uk/citation/citation_photo/1003424.pdf

Current Condition Assessment for the River Hull Headwaters SSSI

http://www.sssi.naturalengland.org.uk/special/sssi/sssi_details.cfm?sssi_id=1003424

River restoration and management

River Restoration Centre (2000) Manual of River Restoration Techniques, RRC, Silsoe

http://www.therrc.co.uk/rrc_manual_pdf.php

The Chalkstream Habitat Manual

http://www.wildtrout.org/index.php?option=com_content&task=view&id=324&Itemid=315

RSPB, NRA and RSNC (1994) The New Rivers and Wildlife Handbook. RSPB, Sandy, Bedfordshire.

Environment Agency (1999) Waterway Bank Protection Guide, R&D Project W5-635, Cranfield.

C Soulsby (2002) Managing River Habitats for Fisheries, Scottish Environment Protection Agency

http://www.sepa.org.uk/water/habitat_enhancement/best_practice_guidance.aspx

Mott, N (2006) 'Managing Woody Debris in Rivers, Streams & Floodplains'. Staffordshire Wildlife Trust, UK

<http://www.staffordshirewildlife.org.uk/download.asp?fileid=193&detailsid=30>

Changing agricultural and land drainage management practices

Defra (2005) Controlling soil erosion: A manual for the assessment and management of agricultural land at risk of water erosion in lowland England

<http://www.defra.gov.uk/erdp/pdfs/es/guidance/soilerosion-lowlandmanual.pdf>

Environment Agency (1997) Understanding Buffer Strips, Environment Agency, Bristol.

Association of Drainage Authorities and Natural England (2008) The Drainage Channel Biodiversity Manual: Integrating Wildlife and Flood Risk Management

<http://naturalengland.etraderstores.com/NaturalEnglandShop/product.aspx?ProductID=e2dae3b7-f789-40e8-b0f6-8cf8a1637032>

WWF (Scotland) (2000) Farming and Watercourse Management Handbook.

http://www.sepa.org.uk/water/habitat_enhancement/best_practice_guidance.aspx

Environment Agency/BDB Associates (2001) Best Farming Practices: Profiting from a good environment.

<http://www.environment-agency.gov.uk/business/sectors/bestfarmingpractices.aspx>

Appendix A: Environmental Stewardship

Environmental Stewardship

Description

Natural England currently works with landowners through **Environmental Stewardship**, an agri-environmental scheme which aims, among other objectives, to help conserve wildlife. Environmental Stewardship has three elements:

- Entry Level Stewardship (ELS) provides a straightforward approach to supporting the good stewardship of the countryside through simple and effective land management that goes beyond the Single Payment Scheme requirement to maintain land in good agricultural and environmental condition. It is open to all farmers and landowners.
- Organic Entry Level Stewardship (OELS) is the organic strand of ELS. It is geared to organic and organic/conventional mixed farming systems and is open to all farmers not receiving Organic Farming Scheme aid.
- Higher Level Stewardship (HLS) concentrates on the more complex types of management where land managers need advice and support and where agreements will be tailored to local circumstances. HLS applications will be assessed against specific local targets and agreements will be offered where they meet these targets and represent good value for money.

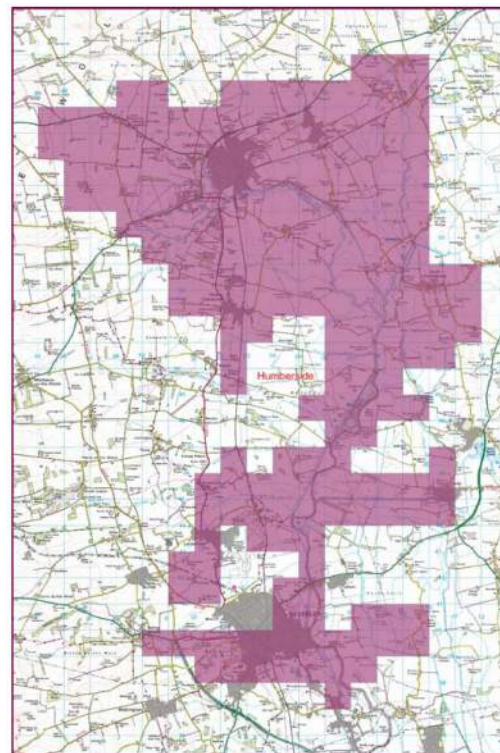
The River Hull Headwaters is one of Natural England's Target Areas for Higher Level Stewardship. The Target Area covers the length of the river and extends southwards to Beverley, and aims to help protect the SSSI. In order to qualify for HLS in the River Hull Headwaters Target Area, land managers must perform one or more specific land management activities, which include:

- Maintaining, restoring or creating important areas of fens, reed beds, wet grasslands and wet woodlands.
- Providing habitat for wet grassland birds, including nesting habitats and summer food sources, where three or more of the following species breed (lapwing, snipe, redshank, curlew, yellow wagtail). The scheme may also be applicable if there is strong supporting evidence for a regionally important breeding colony of one of the species.
- Implementing land management practices and capital works to minimise soil erosion from land at risk of generating diffuse pollution within the catchment of the River Hull.

The requirements of HLS area likely to be particularly useful in the implementation of actions to reduce sediment input from agricultural land (e.g. Solutions A.1 and A.3). In addition, HLS could also be used as a mechanism to implement solutions that aim to improve floodplain and riparian habitats (e.g. Solutions C.1, C.3 and E.1).

Currently, although there has been extensive uptake of Entry Level Stewardship throughout the catchment, Higher Level Stewardship is very limited in extent. By working closely together, landowners and Natural England could increase the extent of land under HLS agreement, leading to decreased soil erosion and fine sediment input to the river.

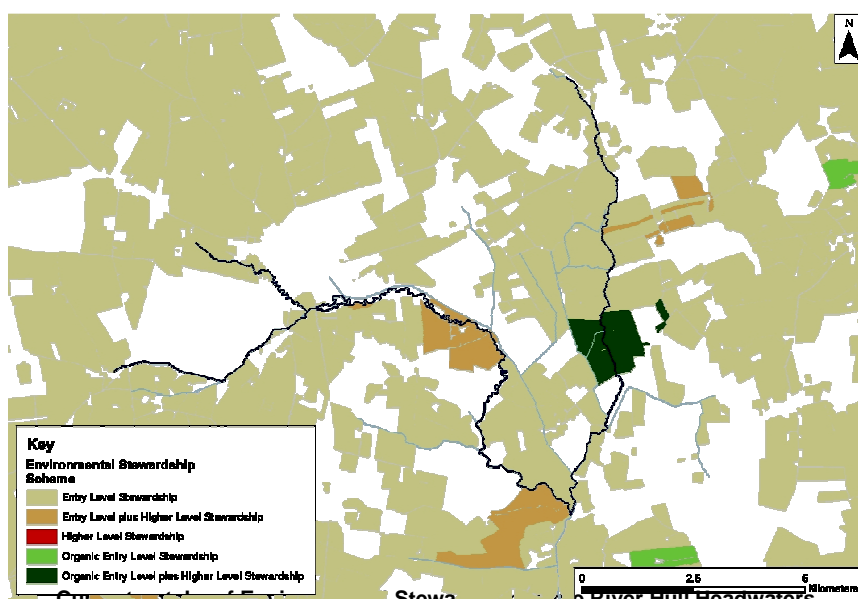
It is also emerging that HLS special projects can be used to deliver some aspects of river restoration capital projects.



The River Hull HLS Target Area

Entry Level Stewardship could potentially be used as a mechanism to encourage landowners to establish riparian buffer strips, since the scheme includes payments for the creation of 2 m, 4 m and 6 m-wide strips. In addition to these solutions, Higher Level Stewardship also offers payments for the following practices that are all intended to reduce the production of sediment from agricultural land:

- Reversion from arable land to unfertilised grassland or grassland with low fertiliser use;
- In-field grass areas to reduce erosion and runoff;
- Preventing erosion or runoff from intensively managed, improved grassland; and
- Seasonal livestock removal on grassland.



(NB. this map does not include older Countryside Stewardship Scheme agreements)

Steps to encourage the uptake of Environmental Stewardship within the River Hull Headwaters catchment are therefore likely to be important in reducing sediment supply at a catchment scale.

Another way in which the Environment Agency, Natural England and Defra are working together to improve land management practices is through **Catchment Sensitive Farming (CSF)**. This is a partnership which aims to reduce the pollution of watercourses caused by farming operations. Discussion with the Environment Agency CSF Officer has highlighted the area to the north of Harpham (upstream of the SSSI boundary of the Kelk Beck) as a particular target area for CSF.

Further Information Sources

- **Environmental Stewardship**

Information regarding Environmental Stewardship (ELS, OELS and HLS) (Natural England).

<http://www.naturalengland.org.uk/ourwork/farming/funding/es/default.aspx>

The River Hull Headwaters HLS Target Area - HLS Target Area Statement YH05

http://www.naturalengland.org.uk/Images/hlstargeting/River_Hull_Headwaters.pdf

- **Catchment Sensitive Farming**

England Catchment Sensitive Farming Delivery Initiative (ECSFDI) (Natural England)

<http://www.naturalengland.org.uk/ourwork/farming/csf/default.aspx>

Catchment Sensitive Farming: Catchment 6 - East Riding of Yorkshire & North Lincolnshire

<http://www.defra.gov.uk/farm/environment/water/csf/pdf/fps0910/CSF5-6.pdf>

Catchment Sensitive Farming Officer:

Mr Richard Wilson, Tel: 01904 825806 / Mobile: 07554 458956

richard.wilson@environment-agency.gov.uk

Appendix B: Conservation objectives

Category	Conservation objectives addressed
A - Changing agricultural and land drainage management practices	<p>Habitat structure – substrate</p> <ul style="list-style-type: none"> No excessive siltation. Channels should contain characteristic levels of fine sediment for the river type <p>Functionality of terrestrial compartments</p> <ul style="list-style-type: none"> The terrestrial compartment is in continuity with the river The terrestrial compartment supports semi-natural vegetation Management of terrestrial units does not contribute to the unfavourable condition of the river units <p>Functionality of terrestrial compartments and adjacent bankside habitats</p> <ul style="list-style-type: none"> Management of the adjacent bankside habitat, where not included within a terrestrial unit of the SSSI, does not contribute to the unfavourable condition of the river units
B - Alter informal and flood embankments	<p>Habitat structure - channel and banks</p> <ul style="list-style-type: none"> Less than 10% of each SSSI unit should be artificial, straightened, widened or deepened Bank and riparian zone vegetation structure should be near-natural <p>Functionality of terrestrial compartments</p> <ul style="list-style-type: none"> The terrestrial compartment is in hydrological continuity with the river
C - Enhance riparian, wetland and marginal habitats	<p>Habitat structure - channel and banks</p> <ul style="list-style-type: none"> Bank and riparian zone vegetation structure should be near-natural <p>Functionality of terrestrial compartments</p> <ul style="list-style-type: none"> The terrestrial compartment is in continuity with the river The terrestrial compartment supports semi-natural vegetation Management of terrestrial units does not contribute to the unfavourable condition of the river units <p>Functionality of terrestrial compartments and adjacent bankside habitats</p> <ul style="list-style-type: none"> Management of the adjacent bankside habitat, where not included within a terrestrial unit of the SSSI, does not contribute to the unfavourable condition of the river units
D - Modify in-channel structures	<p>Open water - flowing chalk stream</p> <ul style="list-style-type: none"> Flow regime should be characteristic of the river. There should be no obvious shortage of water availability in the unit <p>Habitat functioning: water flow</p> <ul style="list-style-type: none"> Ecological flow criteria (e.g. for passage of migrating fish) should also be complied with <p>Negative indicators - in-stream barriers</p> <ul style="list-style-type: none"> No artificial barriers significantly impairing characteristic migratory species from essential life cycle movements
E - Preserve existing habitats	<p>Plant community – reproduction</p> <ul style="list-style-type: none"> A sufficient proportion of aquatic macrophytes should be allowed to reproduce in suitable habitat unaffected by river management practices <p>Functionality of terrestrial compartments</p> <ul style="list-style-type: none"> The terrestrial compartment is in continuity with the river The terrestrial compartment supports semi-natural vegetation Management of terrestrial units does not contribute to the unfavourable condition of the river units <p>Functionality of terrestrial compartments and adjacent bankside habitats</p> <ul style="list-style-type: none"> Management of the adjacent bankside habitat, where not included within a terrestrial unit of the SSSI, does not contribute to the unfavourable condition of the river units

Appendix C: Catchment Sensitive Farming

Catchment Sensitive Farming (CSF)

CSF Programme

Catchment Sensitive Farming is land management that keeps diffuse emissions of pollutants to levels consistent with the ecological sensitivity and uses of rivers, groundwaters and other aquatic habitats, both in the immediate catchment and further downstream. It includes managing appropriately the use of fertilisers, manures and pesticides; promoting good soil structure and rain infiltration to avoid run-off and erosion; protecting watercourses from faecal contamination, sedimentation and pesticides; reducing stocking density; managing stock on farms to avoid compaction and poaching of land; and separating clean and dirty water on farms.

The England Catchment Sensitive Farming Delivery Initiative

The England Catchment Sensitive Farming Delivery Initiative is a joint venture between the Environment Agency and Natural England funded by Defra working in 50 priority catchments. It delivers practical solutions and targeted advice to enable farmers and land managers to take action to protect water bodies and the wider environment. The initiative was initially rolled out in April 2006 in forty priority catchments in England, and will continue to at least 2010-11. In October 2008 an additional 10 priority catchments were added to the existing 40, and extensions were made to 7 of the existing catchments.

Engagement with farmers will remain the main objective of the Initiative and there will continue to be an extensive programme of farmer events and farm visits. In its first two years of operation the ECSFDI delivered advice to over 6000 farmers representing 15% of farm holdings (23% by area) within the original forty priority catchments.

Source: <http://www.defra.gov.uk/foodfarm/landmanage/water/csf/index.htm>

Appendix D: Measures to be undertaken to reach Environmental Objectives under WFD

Map code	Waterbody ID	Waterbody name	SSSI Units	Status	Measures to be applied to improve ecological status
R10	GB104026067100	Kelk Beck from Harpham to Frodingham Beck	37	Poor	
R5	GB104026067020	Frodingham Beck - Kelk Bk/Old Howe Conf to R	36/37	Moderate	<p>Appropriate timing (vegetation control)</p> <p>Appropriate vegetation control technique</p> <p>Selective vegetation control regime</p> <p>Sediment management strategies (develop and revise)</p> <p>Operational and structural changes to locks, sluices, weirs, beach control, etc</p> <p>Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works</p> <p>Improve floodplain connectivity</p> <p>Modify embankments</p> <p>Remove obsolete structure</p>
R60	GB104026067050	Eastburn Beck	34	Moderate	
R61	GB104026067060	Driffield Trout Stream	34	Poor	
R62	GB104026067080	West Beck Upper	35	Moderate	<p>Appropriate techniques to align and attenuate flow to limit detrimental effects of these features (drainage)</p> <p>Appropriate timing (vegetation control)</p> <p>Appropriate vegetation control technique</p> <p>Selective vegetation control regime</p> <p>Educate landowners on sensitive management practices (urbanisation)</p> <p>Operational and structural changes to locks, sluices, weirs, beach control, etc</p> <p>Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works</p> <p>Remove obsolete structure</p>
R7	GB104026067040	West Beck Lower to River Hull	35	Moderate	<p>Appropriate techniques to align and attenuate flow to limit detrimental effects of these features (drainage)</p> <p>Appropriate timing (vegetation control)</p> <p>Appropriate vegetation control technique</p> <p>Selective vegetation control regime</p> <p>Sediment management strategies (develop and revise)</p> <p>Improve floodplain connectivity</p> <p>Modify embankments</p>