Heavily Modified Waters in Europe

Case Study on the Sankey Catchment

(Case Study submitted by the Environment Agency of England & Wales and the UK Government Department for Food, Environment and Rural Affairs)

Edited by Michael Dunbar (CEH Wallingford)

Authors:
Douglas Booker, Michael Dunbar, Charlie Stratford (CEH Wallingford)
Peter Latimer, Helen Rogerson (JBA Consulting Engineers and Scientists)
Jonathon Bass, Hugh Dawson, Rodolphe Gozlan, Stewart Welton (CEH Dorset)
John Ash, Teresa Fenn, Meg Postle (Risk & Policy Analysts)

Centre for Ecology and Hydrology
Wallingford
Oxon
OX10 8BB
Tel: +44 1491 838800
Fax: +44 1491 692424

JBA Consulting – Engineers & Scientists
South Barn
Broughton Hall
Skipton
North Yorkshire
BD23 3AE
Tel: +44 1756 799919

Centre for Ecology and Hydrology
Winfrith Technology Centre
Dorchester
Dorset
DT2 8ZD
Tel: +44 1305 213500

Risk & Policy Analysts
Farthing Green House
Beccles Road
Loddon
Norfolk
NR14 6LT
Tel: +44 1508 528465

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PART I

1 Preface

On 22nd December 2000, the Water Framework Directive (WFD) came into force. The WFD is a major legislative initiative, which is intended to resolve the piecemeal approach to European water legislation, which has developed since 1975. The overriding goal of the Directive is that Member States should aim to achieve at least "Good Ecological Status" (GES) in all bodies of surface water and groundwater, and also to prevent deterioration in the status of those water bodies.

There will be limited exceptions to achieving good status. In particular, certain bodies of water will be required to achieve an alternate objective of at least "Good Ecological Potential" (GEP). This objective takes account of the constraints imposed by the use-value of modifications to the physical structure of the water body and is equivalent to achieving good ecological status in unmodified water bodies. Such designation will either be as “Artificial” or “Heavily Modified” as appropriate, and will depend on whether it satisfies the designation tests outlined in section 4.3 of the WFD.

Under the agreed common strategy for implementation of the Directive, several working groups have been established to “develop informal guiding and supporting documents on key aspects of the WFD”. There will be at least 10 working groups, Project 2.2. is the working group to develop guidance on the designation of Heavily Modified Water Bodies (HMWBs).

The EU Project 2.2 will co-ordinate *Case Studies* in a number of member states for the identification and designation of Heavily Modified Waters and the identification of good ecological potential under the proposed requirements of the Water Framework Directive (Article 4(3)). The EU project will produce a synthesis of experience from member state case studies and will identify best practice, consensus or differences in approach taken by member states in the case studies. The case studies chosen from all member states include riverine and estuarine/coastal areas and represent a range of modifications (navigation, flood defence, coastal defence, hydropower, agriculture/forestry, water supply, urbanisation etc) and size of catchment area (small-large).

The output from the EU project (with special reference to the UK case-studies) will be used to help develop technical guidance for the identification and designation of heavily modified water bodies in the UK.

This project represents the England & Wales contribution to the EU HMWB project. The project is sponsored by the Environment Agency of England and Wales (Water Framework Directive Group based in Wallingford, Oxfordshire) and the UK Department of the Environment, Food and Rural Affairs (DEFRA). DEFRA is responsible for transposing the Directive in England, while the Environment Agency is the likely competent authority for implementing the Directive in England and Wales.

Existing available information is being compiled and interpreted in order to produce case-study documents for each chosen case study catchment according to a pre-defined format. When this stage is complete, an England & Wales synthesis report will be produced.

2 Summary Table

	Item	Unit	Information
1.	Country	text	England & Wales
2.	Name of the case study (name of water body)	text	Sankey Brook – Rainford and Main Sankey Brooks.
3.	Steering Committee member(s) responsible for the case study	text	David Forrow, Environment Agency of England & Wales
4.	Institution funding the case study	text	Environment Agency for England & Wales Department for Environment, Food and Rural Affairs (DEFRA)
5.	Case-studies project manager	text	Marc Naura, Environment Agency of England & Wales
6.	Institution carrying out the case study	text	Centre for Ecology & Hydrology, Wallingford; CEH (with CEH, Dorset; Risk & Policy Analysts RPA; Jeremy Benn Associates JBA; Mike Dunbar (CEH, Wallingford)
7.	Start of the work on the case study	Date	June 2001
8.	Description of pressures & impacts expected by	Date	September 2001
9.	Estimated date for final results	Date	February 2002
10.	Type of Water (river, lake, AWB, freshwater)	text	River
11.	Catchment area	km^2	179
12.	Length/Size	km/ km^2	126 km of main river
13.	Mean discharge / runoff	m^3/s - mm	2.6 m^3/s – 540 mm at Causey Bridge
14.	Population in catchment	number	260,000
15.	Population density	Inh./km^2	633
16.	Modifications: Physical Pressures / Agricultural influences	text	**Pressures** Urbanisation Flood defence Land drainage Agriculture Navigation – St Helens canal (not currently used) **Modifications:** Historical channelisation (re-alignment, re-grading, resectioning) of river Urban development leading to loss of floodplain Culverting in urban and rural areas Agriculture to banktop Illegal waste tipping
17.	Impacts?	text	**Physical:** - Over-wide channel, shallow at low flows - loss of habitat diversity - Unstable banks - Siltation - Loss of amenity value - Disconnection of river from floodplain - Loss of riparian system **Chemical:** - Contaminated land - CSO (combined sewer overflow) discharges - STW (sewage treatment works) discharges - runoff from urban areas, especially trading estates - runoff from roads - rising groundwater levels - nutrient pollution
18.	Problems?	text	
19.	Environmental Pressures?	text	
20.	What actions/alterations are planned?	text	**Physical** Opportunities for removal of culverts being identified

			Other river rehabilitation opportunities being identified and pursued Bank profiles being returned to more natural states (lower slopes) **Chemical** Considerable efforts going into improvements to sewerage system Likewise, efforts to remediate contaminated land Fish stocking as appropriate as water quality improves
21.	Additional Information	text	
22.	What information / data is available?	text	Wide range of data available, across all Environment Agency functions, + Local Environment aAgency Plans (local environmental planning strategy) and R&D River flow, river water chemistry, groundwater chemistry, macroinvertebrate surveys, river corridor surveys, mean trophic rank (macrophyte) surveys and trophic diatom index surveys at selected sites. Occasional fisheries surveys. River Habitat surveys at many sites.
23.	What type of sub-group would you find helpful?	text	Mixed flood defence/ agriculture/ urbanisation
24.	Additional Comments	text	

3 Introduction

3.1 Choice of Case Study

The Sankey catchment has been selected as a case study for several reasons. It is subject to a mixture of pressures arising from urbanisation and agricultural development, including land drainage, flood defence, poor water quality and general degradation of instream and riparian habitats.

A considerable amount of data exist for the catchment, not least of which is a set of 125 River Habitat Survey (see Annex C) sites (each 500m long) throughout the catchment. The Sankey has been used as a test case in the development of the River Habitat Survey Methodology. A recent project, the Sankey Natural Assets Register[1], has interpreted these data, in addition to macro-scale habitat information, while the Sankey Integrated River Basin Management (IRBM) study[2] has collated further data on water quality, flood defences and geomorphology, which have been used in a GIS catchment model.

The history of the Sankey Brook is representative of many rivers located in the industrial regions of the UK. Principal impacts have been on water quality, but extensive physical modifications have been made to the river and its tributaries. The Environment Agency recognises that a range of issues affects the management of the catchment and that there is considerable potential for improving the ecological status of the river.

3.2 General Remarks

The Sankey Catchment (Figure 1), in north west England, is a tributary of the River Mersey. The main Brook originates at the confluence of Hardshaw and Sutton Brooks, in the centre of the town of St. Helens, 10 miles east of Liverpool. The overall catchment extends south-east from the headwaters of the river, north of Rainford in Cheshire, to its confluence with the Mersey near Penketh. It includes the tributaries of the Rainford, Black and Newton Brooks (Figure 1). The catchment area is 179 km^2 and the Main River[3] length is 126km. The catchment is a mixture of agricultural and urban land use, with some woodland areas.

Historically, impacts to the river have arisen from urbanisation, industry (notably the chemical industry) and mining. In recent years there has been a change in the nature of the industry in the catchment. Mining has largely ceased but, the legacy of these past activities remains. Ongoing water quality impacts have arisen from contaminated land and Combined Sewer Overflows (CSOs), while in-channel and floodplain habitats have been degraded by urbanisation and land drainage.

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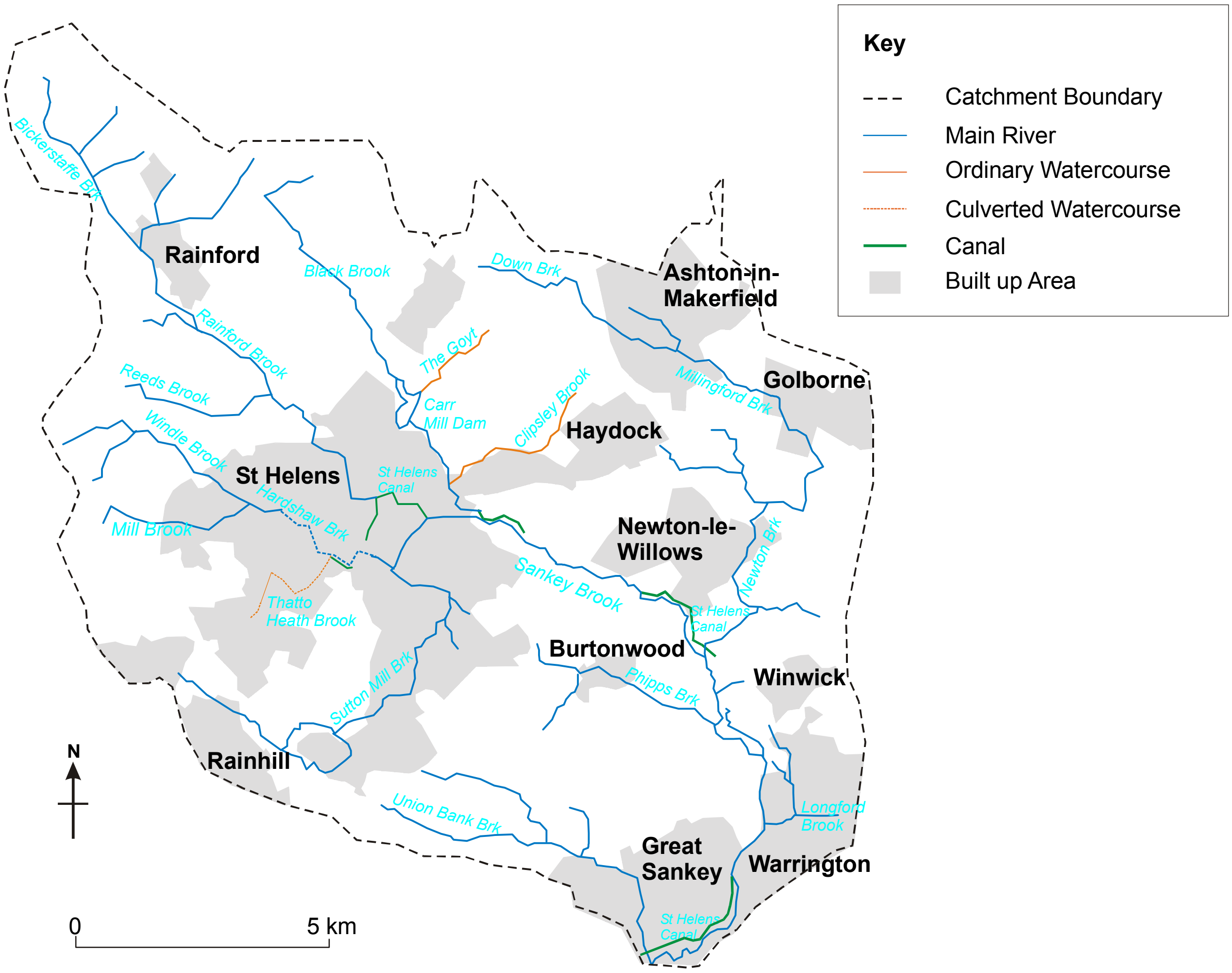
[1] The Environment Practice (1998). A Natural Assets Register for the Sankey Catchment. Report to the Sankey NOW River Valley Initiative Steering Group.

[2] Jeremy Benn Associates (1998). Sankey Integrated River Basin Management Study. Report to the Environment Agency, North West Region.

[3] "Main River" indicates river channel that the Environment Agency has permissive powers for undertaking flood defence works. The Environment Agency has fewer powers on "Ordinary Watercourses".

Figure 1. Map of the Sankey Catchment.



4 Description of Case Study Area

4.1 Geology, Topography and Hydrology

Geographically the catchment is contained within a boundary of 2°45'W/53°20'N and 2°35'W/53°35'N. The elevation of land within the catchment varies from 120 metres above sea level (masl) to sea level at the confluence with the River Mersey.

The northern and north-western part of the catchment is underlain by rocks of the Carboniferous Age (Coal Measures), comprising alternating sandstones, shales or mudstones, and coal seams. The dominant control on the hydrogeology of the Coal Measures is the extensive and often interconnected mine workings within the area. These have resulted in complex drainage networks that were subject to dewatering while the mines were active. Mine closures and cessation of de-watering activity has recently led to rising groundwater.

To the south east of a line from Ashton-in-Makerfield to Rainhill, and to the south of a line from Abram in the west to Boothstown in the east, younger permo-triassic rocks are present. These are predominantly Sherwood Sandstones, which are heavily exploited for public water supply. Finer grained Mercia Mudstones occur in the extreme south east of the area, around Hollins Green. The Mercia Mudstones are generally of low permeability and are classed as “non aquifer” although they may be capable of yielding very limited quantities of groundwater.

Except for a few areas of rock outcrop the solid geology of the entire Sankey catchment is overlain by drift deposits. Glacial till (boulder clay) is present throughout the area, overlain by a widespread, thin belt of windblown sand to the northwest of St Helens. The glacial clay has been incised by alluvial deposits associated with the Mersey and its tributaries. Peat bodies have also developed in this area, for example at Holiday Moss and Reeds Moss. In areas north-east of Rainford, the peats have been drained to form intensively managed mossland farmland.

Long term average rainfall (1961-1990) varies from 850-900 mm per annum in the north of the catchment to 800-850 mm in the south. The mean discharge at the Causey Bridge gauging station (catchment area 154 km^2) is 2.64 m^3s^{-1}, giving a mean annual runoff of 540mm. At this gauging station, the highest recorded peak flow is 40.6 m^3s^{-1} (28/12/78) and the minimum recorded daily flow is 0.26 m^3s^{-1} (17/08/77). Measured flows are affected by public water abstraction, industrial/agricultural abstraction and effluent returns. The base flow index (BFI) for the catchment is 0.54 (i.e. 54% of the total flow is baseflow), which is indicative of a catchment with a reasonably permeable underlying geology. The low gradient means that the watercourses are generally slow flowing.

Many smaller tributaries feed the main Sankey, the most notable being Newton Brook draining Ashton-in-Makerfield, Golborne and Newton-Le-Willows; Hardshaw and Sutton Brooks draining Windle, Eccleston and Rainhill; Rainford Brook draining Rainford and Black Brook which drains the north of St. Helens and Billinge areas. Many water courses, particularly within urban areas, have been piped underground in culverts beneath roads, tips, fields and buildings. A high percentage of watercourses in the area have been artificially channelised, straightened, deepened and shortened. Banks have been reinforced or reprofiled to prevent natural erosion and meandering. Rural watercourses have been modified to create more land for agriculture and to drain the land more effectively.

There is one dam in the catchment (Carr Mill Dam) constructed at the confluence of the Black Brook and the Goyt. The impoundment has a surface area of 22ha and was built to supply / store water for the St Helens Canal. It is now a popular wildlife site and is used for recreation.

4.2 Socio-Economic Geography and Human Activities in the Catchment

The population of the catchment is 260,000, concentrated primarily in the towns of St Helens (pop 178,000), Newton-le-Willows, Ashton-in-Makerfield and those parts of Warrington that lie within the catchment. Degree of urbanisation in the various sub-catchments is shown in Box 2. Public water supply is obtained from groundwater. There are eleven licensed public groundwater sources within the Sankey catchment. There are also a small number of private domestic groundwater abstractors.

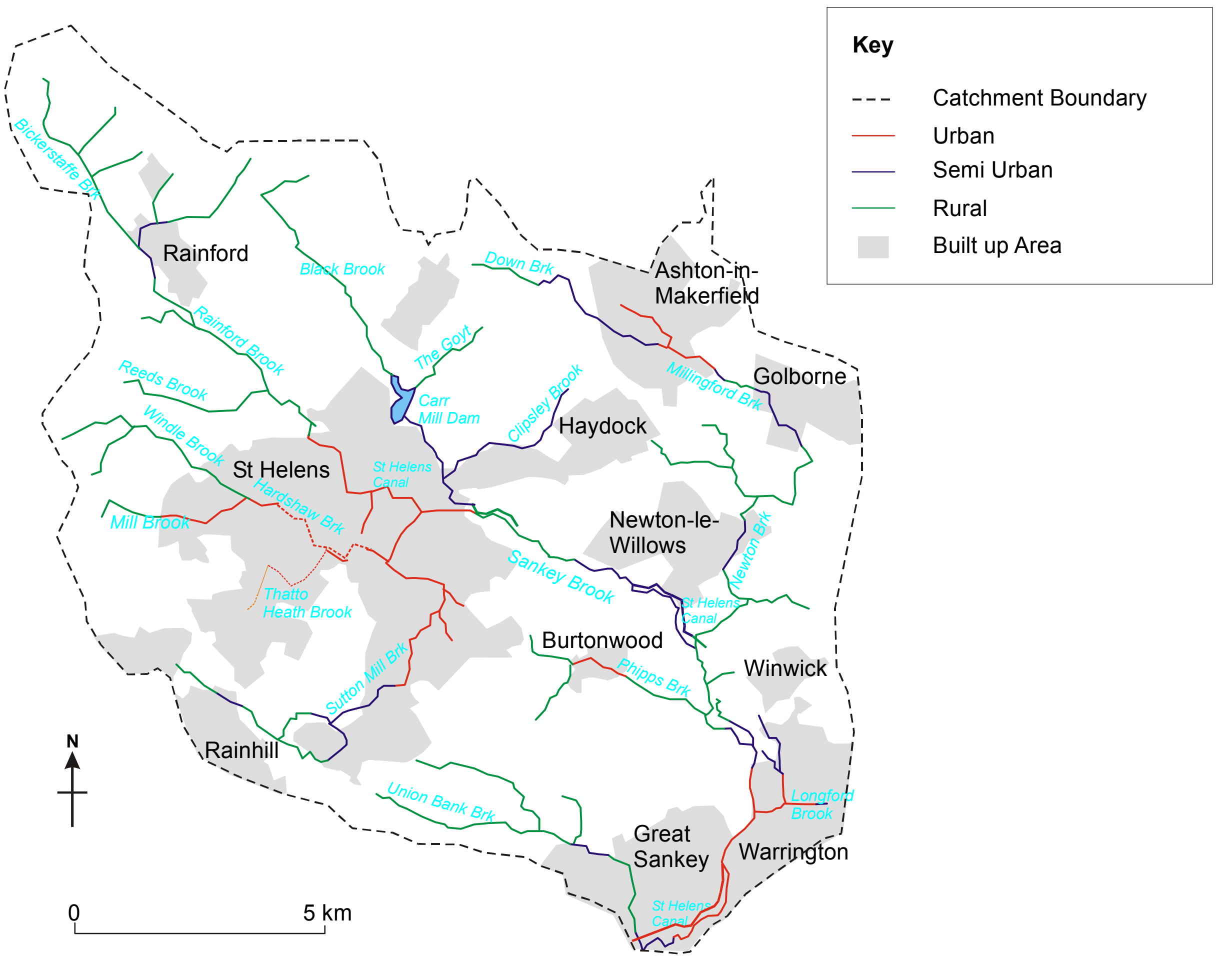
Historically the area was important for the extraction of coal and various industrial processes, including the production of chemicals. This development had a major shaping influence on the area. Large volumes of water were abstracted for manufacturing and cooling purposes. These industrial abstractions, in conjunction with mine dewatering, resulted in lowered water tables. Historical pollution has resulted in a legacy of contaminated land and contamination of aquifers. The decline in large-scale industrial abstraction and mine dewatering over the last two decades has resulted in a general increase in groundwater levels and water quality problems associated with the flooding of old mine workings (e.g. acid mine drainage). In recent years there has been a change to smaller industrial units, established on industrial and trading parks. These sites continue to impact the water environment (particularly water quality) of the catchment. Presently, within the Sankey catchment there are 12 licensed abstractions for a variety of industrial uses.

Intensive farming within the catchment, both upstream and downstream of St Helens, impacts water resources and quality. Agricultural landuse comprises arable (cereals and horticulture) and grassland (lowland sheep farming and cattle). There are 17 licenses authorising abstractions for spray irrigation within the Sankey area, mainly from surface water sources. Five of these are for golf course irrigation and the remainder are for crop irrigation.

The Sankey is used for effluent disposal. This comprises treated domestic and industrial effluent from water company sewage treatment works (the St Helens plant is by far the largest), on-site treated effluent from industrial plants, and combined sewer overflows. Downstream of St. Helen’s the water quality of most of the length of Sankey Brook is classified as chemically “bad” under the Environment Agency’s General Quality Assessment (Annex C). Pollution arises as a consequence of urban runoff, poorly treated industrial discharges, flow from the combined sewer outfalls during storms, runoff from historically contaminated land and spoil tips and agricultural runoff. Due to the poor water quality and access there are few established parks or recreational areas within the catchment.

The Sankey (St Helens) Canal is an important heritage feature of the catchment. Opened in 1757, it was the first canal of the industrial revolution. It was abandoned by Act of Parliament in 1963. Since then it has been partly filled in, however there are still water transfers between remaining sections of the canal and the Brook. The potential for restoration of navigation on the canal is being investigated, and a pressure group has been formed to promote this. British Waterways are the navigation authority for this canal.

Figure 2. Sankey Land Use adjacent to river.



4.3 Identification of Water Bodies

An *a-priori* (prior) approach to defining water bodies specific to this project has been rejected. This is because the Water Body should be defined by management considerations, and it is only possible to understand all the management considerations once the HMWB assessment has been completed. Two approaches have been considered – use of existing stretches and a new bottom-up approach. Their advantages and disadvantages are outlined below.

The six draft criteria for identification of reaches with homogenous morphology (as defined by the Environment Agency RHS team) are as follows:

1. Significant change in underlying geology based on erodable characteristics of rocks grouped as:
   - a) Peat, Alluvium, Clay,
   - b)'No drift – soft rocks (shale, sandstone, chalk, limestone)',
   - c) No drift – hard rocks.

2a. Significant change in discharge OR

2b. Change in stream order.
3. Significant changes in landuse. - ITE landuse classification[4] grouped as urban/ woodland/ agricultural/ semi-rural,semi-natural).
4. Major structures in the channel (major weirs and dams).
5. Significant breaks in slope. Resolution 500m vs available spot heights and test for levels of change > 2%, 5%, 10% or 20%).
6. Presence of 'Indicative flood plain'

As a result of problems in implementing the bottom-up approach, we have proceeded with the pragmatic use of the stretches defined for existing Water Quality Assessment purposes, the following stretches of river are defined in Table 2. These designations are referred to as GQA (General Quality Assessment) stretches.

For the Sankey Brook, the boundaries for these river lengths are set at all major tributary junctions, plus there are some boundaries between major changes in land use such as on the Rainford and Sutton Mill Brooks (Table 1 and Figure 3).

Table 1. Water Bodies in the Sankey catchment

Name of group	Main pressures on group	Main physical alterations of group	Water bodies
Heavily Urbanised sections	Urbanisation	Bank reinforced Channel dredged Channel straightened Channel culverted Floodplain diversity lost	D/s Rainford Brook (urban area) # D/s Hardshaw Brook Sutton Mill Brook U/s Sankey Brook Lower Sankey Brook D/s Whittle Brook
Semi-urban	Urbanisation, Agriculture (land drainage and flood defence)	Bank reinforced Channel dredged Channel straightened Channel culverted Floodplain diversity lost	Clipsley Brook Millingford Brook* Newton Brook Middle Sankey Brook *
Rural	Agriculture (land drainage and flood defence)	Channel dredged Channel straightened Channel culverted Floodplain diversity lost	U/s Rainford Brook (rural area) # Black Brook Ellams Brook U/s Hardshaw Brook Phipps Brook * U/s Whittle Brook Union Bank Brook

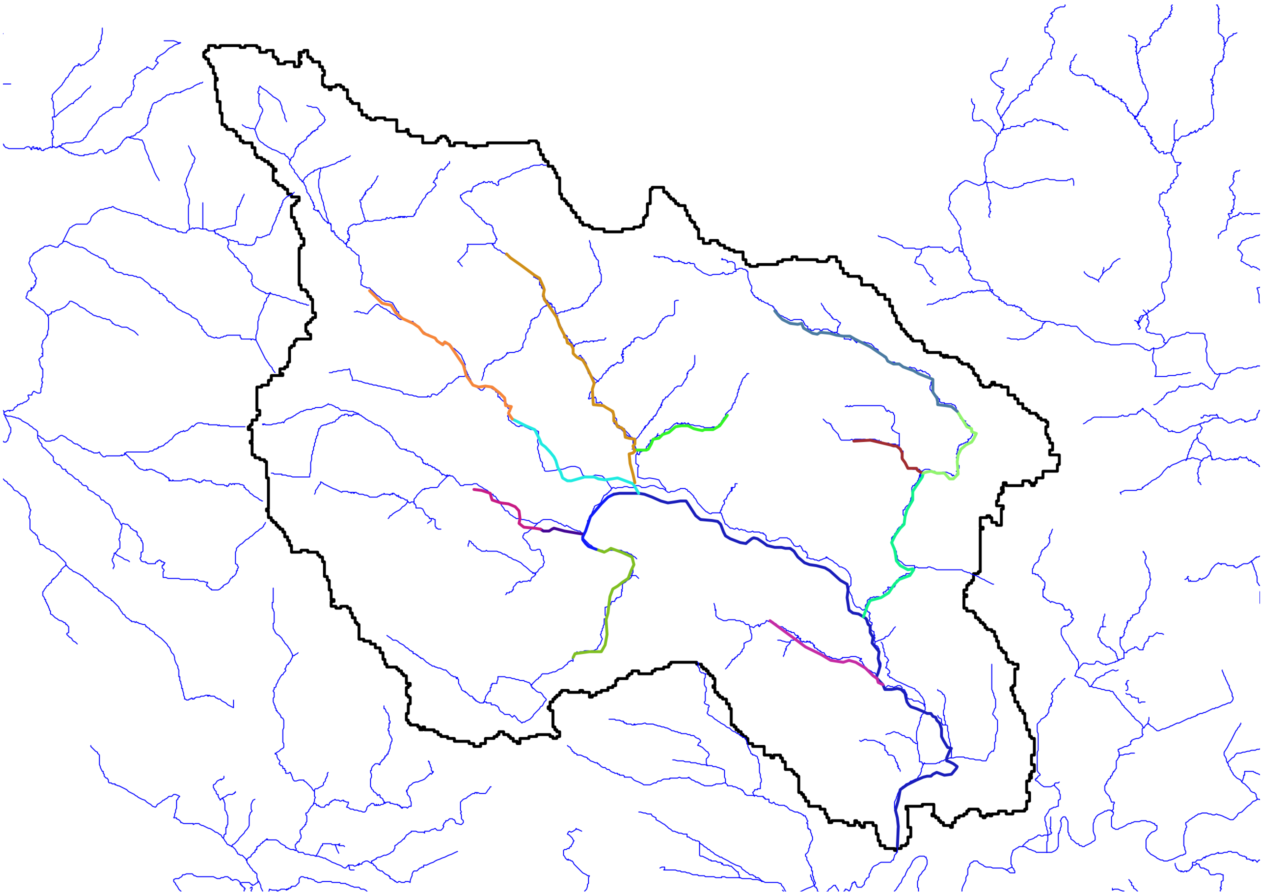
* mixture of levels of urbanisation within a short length of river
# water bodies considered in further detail in this report.

[4] Institute of Terrestrial Ecology (now CEH Monks Wood).
The Land Cover Map of Great Britain (1990) is a digital dataset, providing classification of land cover types into 25 classes, at a 25m (or greater) resolution. Data from the map provide:

- the first complete map of the land cover of Great Britain since the 1960s
- the first time the land cover of Great Britain has been comprehensively mapped from satellite information
- the first digital map of national land cover
- accuracy to the field scale, checked against ground survey

Fuller, R.M., Groom, G.B. & Jones, A.R. 1994a. The Land Cover Map of Great Britain: an automated classification of Landsat Thematic Mapper data. *Photogrammetric Engineering & Remote Sensing* **60** 553-562.

Figure 3. Coloured GQA stretches on the Sankey Brook



(The GQA stretches are distinguished by colours selected at random).

4.4 Discussion and Conclusions

The provisional methodology for identifying water bodies classifies a break in a reach as a change in three of the six reach definition criteria within a 500m stretch of river. However, there have been problems in actually using this system to define workable reaches, particularly in how to define a "significant" change in land-use or slope.

Advantages and disadvantages of the two approaches are listed in Table 2.

Table 2. Options for Water Body identification

	Advantages	Disadvantages
Use existing stretches of river used for water quality management, undertake assessment, then revise stretches based on appropriateness for HMWB designation	Maintains compatibility across Agency (important for RBMP process) Rapid to implement Existing macro-invertebrate monitoring data is based around these stretches. They do take into account major flow changes (i.e. confluences), and in some cases urbanisation	Based on river network digitised at 1:250,000, not 1:50,000. Stretches chosen for water quality purposes (some boundaries occur because of a major point source water quality input such as a sewage treatment works) Some river lengths have upstream limits which are downstream of the upstream limit considered under the Water Framework Directive ($10km^2$). [5]
Define homogenous reaches using available map-based physical coverages, undertake assessment on these stretches, then aggregate the stretches based on the management options	Ultimately more scientifically defensible (physically based). Being developed for national application by the Environment Agency RHS team.	Potentially not compatible with other Agency functions Difficulties in producing workable protocol. Needs to be tested and implemented.

[5] Criteria under Annex 2, Section 1.2.1 – Small catchments have an area of between 10 and 100 km^2

PART II

5 Physical Alterations

5.1 Pressures and Uses

Navigation

The only navigation pressures in the upper catchment relate to the St Helens Canal. Whilst this was abandoned by Act of Parliament in 1963, there are still water transfers between remaining sections of the canal and the Sankey Brook. A pressure group has been formed which is seeking to restore the canal to full navigation (http://www.scars.org.uk/) and, if this is successful, it would result in new navigation pressures on the river.

There is a marina at the confluence between the Sankey and Mersey and locks enable navigation on the lowest part of the canal, which runs between Warrington and Widnes, parallel to the River Mersey.

Flood protection
There are several stretches of the river which have been modified to protect property and agriculture from flooding.

Hydro-power generation
There are no hydro-power generation pressures in the catchment.

Agriculture
The non-urban areas of the catchment are primarily used for agriculture with land use split between arable and grassland. This includes intensive cultivation of land to the edge of watercourses in rural parts of catchment

Water Supply
There are several groundwater abstractions in the catchment for public water supply purposes together with a small number of private abstractions. There are also several licensed surface water abstractions for agricultural spray irrigation purposes.

Urbanisation
There are significant urban areas, notably the towns of St Helens, Newton-le-Willows, Ashton in Makerfield and those parts of Warrington which lie within the catchment.

Invasive Species
Himalayan Balsam is present in some parts of the catchment (present in 30% of RHS sites on the Sankey / Glaze), it can cause bank collapse when it dies down in winter. It also competes with native species. Japanese Knotweed is also present at 27% of the sites on the Sankey / Glaze.

5.2 Physical Alterations

Navigation
Physical alterations as a result of the St Helens Canal in its abandoned state are limited with some disruption to the river continuum associated with water transfers to and from the canal. If the canal is restored to full navigation, there will inevitably be additional physical alterations.

Flood protection
Channels in both urban and agricultural areas have, in many places, been re-sectioned or reinforced for flood defence purposes. Some of these modifications are continuous for long lengths of the river. The bank profile is typically uniformly angled and frequently mown. In some instances, the watercourses have been straightened causing a loss of many stream and bank features. Many stretches have toe reinforcement in place, but reinforcement of the entire bank profile is relatively rare. Some urban sections have armoured bank faces, often of concrete.

Agriculture
Rivers and watercourses in the agricultural parts of the catchment have often been re-sectioned, dredged, straightened and channelised. Peatlands in the north of the catchment have been extensively drained and field boundaries are formed by linear and deeply channelled drainage ditches.

Urbanization
Stretches of watercourse in urban areas have been culverted. Others have been straightened and channelised.

5.3 Changes in the Hydromorphological Characteristics of the Water Bodies and Assessment of Resulting Impacts

5.3.1 Introduction

In order to develop and test methodologies for the designation of HMWBs, it was decided to concentrate on two sub-areas for detailed data collection and analysis. Each sub-area contains at least two water bodies. The selection of sub-areas is subjective but is guided by the existence of physical alterations together with the availability of data. It was hoped that each sub-area would contain a clearly-defined example of an HMWB and a borderline example, although in advance, it was impossible to be certain. Following a review of the preliminary data, the ranking of the potential sub-areas was as follows:

Table 3. Sub-areas considered for further study

Rank	Sub-area	
1	E	Rainford Brook
2	B	Sankey Brook – Black Brook confluence to Alder Lane bridge
3	D	Sutton Mill Brook
4	F	Black Brook
5	A	Sankey Brook – Alder Lane Bridge to confluence with River Mersey
6	C	Sankey Brook/Hardshaw Brook through St Helens

In general, available geomorphological data from River Habitat Surveys indicate that all the above sub-areas have low feature and process diversity.

Visits were made to Environment Agency offices to discuss data availability with staff and to obtain local knowledge about the degree and nature of modifications. These discussions confirmed that clear examples of HMWBs and borderline cases should both be contained within Sub-areas E (Rainford Brook) and B (Sankey Brook from Alder Lane bridge to the Mersey confluence). Consequently, the following data were collected for the two Sub-areas:

- River Habitat Survey (RHS) data (details of survey methods and scoring are outlined in Annex C).
- Asset data from the Environment Agency Flood Defence Management System (FDMS) (briefly describe in Annex) database
- Details of Abstraction Licences
- Details of Discharge Consents
- Updated chemical quality data
- Details of United Utilities Asset Management Plans (AMP3) schemes for improvements in discharges from Sewage Treatment Works and the Sewerage Network.[6]

For the physical elements, the following impacts are evident:

- Flow regime will be influenced by the land drainage in the upper parts of the catchment, plus loss of floodplain to agriculture throughout the catchment. Land drainage is often thought to increase speed of runoff and thus peak flows, however the mechanisms for this

[6] Asset management plans are agreed plans between water companies and government to enable environmental improvements to be scheduled and costs recouped from water customers. They work on a six year cycle.

are complex, and the reverse is sometimes true. The consequences in the Sankey will depend on the catchment context and topography and for any particular event, the antecedent rainfall regime. For the Rainford Brook, quantification of any impact to the flow regime must be by association with the pressures as there are no gauging stations on the Brook and there is also no simple way of producing a naturalised flow for the Brook.

- Flow regime will further be influenced by urbanisation. Regimes will be flashier due to reduced infiltration and the presence of urban drainage.
- River continuity is affected by the structures present in the channel (culverts and weirs).
- River depth and width can be affected by a variety of river engineering practices (see above), depth is also affected by in-channel structures.
- Similarly, substrate conditions will be affected by the channel engineering and land-management.
- The structure of the riparian zone is affected by historical land drainage and flood-defence activities, and ongoing flood-defence maintenance activities.

5.3.2 Rainford Brook

RHS Data and Habitat Modification Scores

The Rainford Brook is approximately 13km long. It is divided into two General Quality Assessment stretches (of length 4.7 and 3.2 km), with the upper part not routinely assessed for water quality purposes. It contains nine 0.5km long River Habitat Survey (RHS) sites (Table 4). RHS provides Habitat Modification Scores, which indicate the level of modification from natural. No modification would be scored as zero, there is no theoretical upper limit. It can be used to classify the level of modification of a river (see Annex C for further details). The Habitat Modification Scores (HMS) obtained from the RHS data vary in value from 17 to 56, with a median of 34. Thus on the basic HMS scale, one of the sites is classified as 'Obviously Modified', five are classified as 'Significantly Modified', and one as 'Severely Modified'. The RHS data support the differentiation of the Rainford Brook into two water bodies.

The RHS surveys show that the bank material is entirely earth with very few 'bank features' although there are considerable lengths of concreted banks and laid stone or brickwork typical of the extensively re-sectioned and often reinforced banks; culverts were quite common features and small dams were present. Despite this there are a surprising number of RHS bank features particularly stable earth cliff and deposition bars. Water flows are often smooth or rippled reaches although both higher and lower energies types occur and often flow over particularly sand, although silts, gravels and even cobble substrates are present when the bed is visible. Channel features are absent as would be expected and much human rubbish (e.g. dumped non-toxic materials) is present; channel vegetation is very limited but the bank structure can be varied. Adjacent land-use is varied but predominantly tilled upstream often with scrub, tall herbs or woodland when not suburban downstream.

The effect of this general modification is reflected in a wide range of Habitat Quality Assessment (HQA) scores (see Annex C) of 0-59 with a mean of 28 and with upper and lower quartiles ranging from 21-33; values of 65-70 would be expected for benchmark sites of this low energy lowland rivers on soft geologies. The extent of navigation was not recorded but urban improvements probably account for much of the modification of this channel; channel and bank features are variable but bank vegetation structure (on average an HQA sub score of 8) or channel vegetation could be substantially improved to raise the general RHS quality of the river.

Summaries of the RHS data are given in Tables 4 and 5.

Table 4. Basic data on RHS surveys on the Rainford Brook

Site no	Slope	Height of source	Distance from source (km)	Altitude	Grid Ref: Easting	Grid Ref: Northing	HMI
14852	5	55	1.5	45	346100	402800	30
14854	5	55	3.5	38	347100	401100	17
14859	1.5	55	5.5	37	348200	399700	42
14858	10	55	6	37	348400	399600	56
3349	0.5	52	8	35	350400	398100	35
14860	1.5	55	8	35	349800	398400	34
14863	2.9	55	10	35	350900	397300	50
14864	1.5	55	11.5	25	352000	396300	36
14865	1.5	55	13.5	19	353800	395900	31

Table 5. Basic data on habitat quality on the Rainford Brook

Site no	Aggregate HQA	HQA flow type	HQA channel substrate	HQA channel features	HQA bank features	HQA bank veg. structure	HQA point bars	HQA channel veg.	HQA land use	HQA trees	HQA spec feat
14852	31	6	3	0	0	12	0	2	3	5	0
14854	39	6	4	0	2	9	0	2	2	9	5
14859	23	3	4	0	1	9	0	4	1	1	0
14858	34	6	6	1	2	7	0	5	1	6	0
3349	44	7	5	0	5	11	1	4	2	9	0
14860	16	5	3	0	1	0	0	5	0	2	0
14863	47	6	4	1	1	9	0	4	14	8	0
14864	17	7	4	0	0	0	0	5	0	1	0
14865	24	7	4	0	1	5	0	2	2	3	0

Identification of potential HMWBs

Details of the pre-screening methodology for this identification are contained in the accompanying report "Guidelines on identification, assessment and designation of rivers". Briefly it uses available information, primarily RHS and local knowledge, to complete a proforma. This is then used as a basis for preliminary classification into "Non-candidate", "Borderline" and "Potential HMWB".

When redefined into the three proposed categories for HMWBs, the RHS sites in Rainford Brook consist of one Borderline case, and six Candidates for being a HMWB. On this basis, approximately 4% of the reach would be a Borderline case and approximately 23% a Candidate. The remaining length outside the RHS sites is undefined and totals 73% of the reach. By using the FDMS data to extend the Habitat Modification Scores (as described in 2.1.3), the reach can be divided into 4% Borderline sites, 58% Candidate sites, and 38% undefined.

FDMS data
Asset data held in FDMS potentially provides a method of checking and backing up the RHS data.

FDMS data for Rainford Brook is in general agreement with the Habitat Modification Scores, indicate that the majority of the river is highly modified. There are some discrepancies between the data, as some assets shown in the FDMS data are not repeated in the RHS data, and vice-versa. These discrepancies tend to be for point structures, for example FDMS data shows five weirs on Rainford Brook are not shown on RHS data. This is possibly because the RHS sites are not continuous.

5.3.3 Sankey Brook

RHS Data and Habitat Modification Scores
The case study stretch of Sankey Brook is approximately 8km long and contains seven 0.5km long River Habitat Survey (RHS) sites. The Habitat Modification Scores (HMS) obtained from the RHS data vary in value from 0 to 36, with a median of 30. According to the HMI classification system, two RHS sites are classified as ‘Semi-natural’, one site as ‘Obviously Modified’, and four are classified as ‘Significantly Modified’.

When redefined into the three proposed categories for HMWBs, the RHS sites in Sankey Brook consist of two that are Non-candidates for being a HMWB, one Borderline case, and four Candidate sites requiring further study. This results in approximately 25% of the reach being an HMWB Candidate, 6% a Borderline case, and 13% of the reach a Non-candidate leaving 56% undefined. Linear interpolation between the RHS sites results in approximately 87% of the reach being an HMWB Candidate, 4% Borderline and 9% Non-candidate.

FDMS data
Use of the FDMS data to back up the RHS data and Habitat Modification Scores would be limited to the upstream end of the reach as the data does not extend downstream. There is little overlap between the two data sets and therefore this method cannot be used.

5.4 Discussion and Conclusions

Four modifications have been identified (Annex D, Proforma 1). These are summarised in Table 6, below.

Table 6. Summary of Modifications and Intended Uses for Rainford Brook.

Modification	Intended Use
Channel has been dredged to connect with field underdrainage	Rapid evacuation of floodwaters
Channel has been straightened and embanked	Flood protection
Culverts have been installed	Access to fields for agricultural vehicles
Road bridge	Shortened road connection (e.g. from Rainford to Liverpool)

6 Ecological Status

6.1 Biological Quality Elements

6.1.1 Fish status

The fish population of the Sankey Brook is relatively poor. This assessment has been made based on recent fish survey data (2000), plus references to previous surveys. Table 7 summarises these data. There are a total of 14 species in the Sankey catchment, however the distribution of most of these is very localised. Using existing methods for deriving reference conditions has not been satisfactory for three reasons:

- Firstly there is a lack of comparable reference sites in the River Invertebrate Prediction and Classification System (RIVPACS; see annex B) database;
- Secondly there is no national biological database for fish which could be consulted; and
- Thirdly the concept of reference conditions for fish is of questionable use as fish populations are affected not just by site typology but also by palaeohistory and connectivity.

Status has thus been derived by expert opinion.

Table 7. Fish species present in the Sankey catchment.

Category	Main Sankey	Rainford Brook
Dominant species	Three spine stickleback (66%)	Three spine stickleback (94%)
Abundant species	dace (9%), chub (8%), roach (7%), eels (5%)	None
Common species:	gudgeon (2%), perch (2%), rudd (1%)	tench (2%), eel (2%), bullhead (2%)
Rare (each <1%)	None	None
Used to occur		bitterling (up to 1994)
Biomass class[7]	D	D

Overall the Main Sankey Brook is considered to be of poor status with regard to fish species. Possible reasons for this are the poor water quality, the loss of marginal habitat for spawning & fry, general lack of longitudinal habitat diversity, and impoundment. Similarly the Rainford Brook is considered to be of poor status. Possible reasons for this are the poor water quality, the loss of marginal habitat for spawning and fry, and impoundment. Table 8 summarises the likely significance of major modifications for fish of differing habitat requirements and reproductive strategies.

[7] Environment Agency classification (A 20 ± 2g/m^2, B 10 ± 2g/m^2 to 20± 2g/m^2, C 5± 1g/m^2 to 10± 2g/m^2, D 0 to 5± 1g/m^2)

Table 8. Sankey sites: overall assessment of how physical alterations are likely to affect biology independently from the water quality.

Modification	Classification	Reproductive style	Sign	Mod	Small
Straightening & embankment of river for flood protection purposes	rheophil	phytophil			□
		lithophil			□
	limnophil	phytophil	□		
		lithophil		□	
	generalist	phytophil			□
		lithophil			□
	anadromous				□
	larvae & 0+		□		
culverting	no significant impact on fish population				

6.1.2. Macro-invertebrate status

Data from two sources were collated:

- Data from the 1995 General Quality Assessment (GQA) (hereafter referred to as the GQA sites), consisting of samples for spring and autumn
- Additional, mostly ad-hoc monitoring data collected between 1992 and 2000.

The GQA dataset were found to be the only consistent, verified UK macro-invertebrate data readily available for comparison. Unfortunately there are only three monitoring sites within the stretches considered. Further species lists were thus examined, taken from ad-hoc monitoring samples.

The RIVPACS system (see Annex B), plus further, more detailed investigation was used to investigate the invertebrate fauna of the Sankey stretches. Table 9 shows basic RIVPACS outputs for these sites, indicating moderately high expected scores.

Our analysis consisted of the following elements:

- Observed / expected ratios for standard indices (ASPT, BMWP, number of taxa)
- Unexpected absences of taxa
- Provisional scoring system to assess biological impacts of habitat modification

Table 9. GQA sites on the selected Sankey catchment stretches

River	Agency site no.	Expected taxa	BMWP score	ASPT	Site suitability code
Rainford Brook	100008229	29	167	5.58	5
Rainford Brook	100008230	33	185	5.57	1
Sankey Brook	100007157	34	194	5.66	3

Comparisons with RIVPACS predicted reference conditions

RIVPACS can be used to define reference conditions based on a suite of physico-chemical variables. However, two of the three GQA sites on the selected sub-areas (Rainford Brook and the main Sankey Brook) show a poor fit to RIVPACS site groupings. Suitability codes were 5 and 3, respectively corresponding to probabilities of <0.1% and <2% of the sites belonging to any discrete RIVPACS group (RIVPACS III+ User Manual, p49). Therefore the predictions of reference condition community composition and RIVPACS scores are less robust for these two sites than for UK sites in general.

The ratio of Observed over Expected (O/E) RIVPACS scores provides a site-specific measure of site performance, based on macro-invertebrate community structure (Table 10). The results are influenced by pressures, such as water quality and the degree and type(s) of habitat degradation at individual sites and at upstream reaches.

Table 10. RIVPACS GQA sites: 1995 Observed divided by Expected results for RIVPACS scores on the candidate HMWB sub-catchments (upstream sites first).

River	Site	Year	O/E BMWP	O/E #TAXA	O/E ASPT
Rainford Brook	D/S PARK ROAD WEIR	1995	0.22	0.36	0.61
Rainford Brook	DAGNALS BRIDGE	1995	0.23	0.37	0.64
Sankey Brook	U/S A57	1995	0.1	0.2	0.48

A further 46 sites within the main Sankey catchment were sampled for macro-invertebrates in the period 1992-2000. Single visits are recorded for many of these sites and some sites lack location data (National Grid References). For all sites comparatively poor conditions are indicated by low macro-invertebrate scores. The macro-invertebrate fauna was generally richer at the two Rainford Brook sites than in the main Sankey Brook. The balance between 'high' and 'low' scoring BMWP taxa was more equitable on the Rainford Brook than noted in the main Sankey Brook. This may be associated with either less severe pollution or less severe habitat degradation and may be partially resolved by the assessment of corresponding water quality (chemistry) performance of the sites.

No analysis has yet been undertaken to compare the Sankey/Rainford Brook GQA sites with the catchment-wide sites, in general the catchment–wide sites have been visited on so few occasions that the “noise” in signal arising from single samples will outweigh any true response to habitat degradation.

Indicators of habitat degradation

Absence of Simuliidae (a velocity-dependent taxon) is one simple method that could be used to assess habitat degradation (Table 11). However, the over-arching effect of poor water quality within the Sankey Catchment mean that little can be obtained from such an assessment.

Table 11. Presence of Simuliidade at Sankey / Rainford sites

Site	Spring 1995	Autumn 1995
D/S Park Road Weir	0	0
Dagnals Bridge	0	1
U/S A57	0	0

Table 12 presents a provisional attempt at a more sophisticated scoring system involving known tolerances of a range of taxa to three habitat features known to be affected by river engineering (marginal vegetation, free flowing (i.e. not impounded) water and clean riffles). This procedure shows promise but needs further development.

Table 12. Sankey sub-areas: results of the scoring system (draft) for sensitivity to habitat modification at the Sankey Brook and Rainford Brook GQA sites.

Macro-invertebrate BMWP family [1,2]	Affinity for vegetated margin [3]	Affinity for non-impounded [3]	Affinity for clean riffles [3]	Sum of affinities for unmodified/ modified conditions [4]
total possible score	446	438	410	1294
mean	5.44	5.34	5	15.78
SANKEY - U/S A57				
total possible score	91	73	76	240
mean	5.68	4.56	4.75	15
RAINFORD BR D/S PARK RD				
total possible score	120	97	98	315
mean	5.71	4.62	4.67	15.47
RAINFORD BROOK DAGNALS BRIDGE				
total possible score	125	104	101	330
Mean	5.68	4.73	4.59	15

[1] 82 possible scoring families
[2] Sankey / Rainford scores based on 1992-2000 routine macro-invertebrate monitoring
[3] High-10, Low-1
[4] sum of three mean scores (15=neutral response to modification examples)

6.1.3 Macrophyte status

Currently, there are no direct links between the standard macrophyte assessment methodologies and the degree and type of modification impacting water bodies. Such links with the distribution of aquatic plants, their interactions and habitat requirements especially substrate, water flow and water chemistry, have been made in progressively greater detail over the last century (Arber 1922, Butcher 1933, Whitton 1975, Westlake 1976, Dawson 1988). Recent attempts have concentrated on pollution and trophic status of the stream water (Haslam 1978, Newbold & Palmer 1979, Holmes & Newbold 1984, Holmes *et al.* 1999), culminating in assessment of the national Mean Trophic Rank (MTR) methodology of Holmes *et al* (1999) and assessed by Dawson, *et al.* (1999) for assessing sites in response to the Urban Waste Water Treatment Directive. A Phase 1 study for the Environment Agency of a Plant prediction, Classification and Assessment system (PLANTPACS), similar to the RIVPACs system for invertebrates, has been undertaken but no further work has yet been started. CEH –Dorset has undertaken preliminary studies to separate the effects of the physical habitat, especially water flow in modified channels and other changes in basic water chemistry from water transfer or discharges from nutrient or trophic status.

<u>Rainford Brook</u>

The combined data from the Environment Agency, Conservation Agencies and CEH plants databases were queried to investigate the macrophyte flora (further details of the survey methods can be found in Annex C). However no plant survey sites were identified for the main course and only one site on a tributary near the lower junction of the section. The RHS surveys indicate that only a few of the in-channel plant morpho-types occur in this section

The only plant species survey in the sub catchment is of two 10m sections on the bank and margin of the stream on one of the downstream tributaries, Sutton Brook. This may be indicative of the type of flora of this area and of the main stream course. There is some degree of reduced trophic status i.e. pollution, indicated by a MTR score of 35 but the nearest site in the adjacent catchment is less than this at the critical level for action of 25. The species list for the Sutton Brook site is:

Plant species	plant cover - 3 point scale
Berula erecta	1
Carex acutiformis	1
Carex riparia	2
Filipendula ulmaria	3
Mentha aquatica	1
Potamogeton perfoliatus	1
Pulicaria dysenterica	3
Ranunculus fluitans	3
Salix sp.	3
Schoenoplectus lacustris	3
Scrophularia auriculata	1
Zannichellia palustris	3

In addition historical data from Haslam (1982) indicate that the Sankey did not have several plant genera that might be expected when comparing with rivers of a similar type. This was ascribed to the effects of disturbance and turbid water. Haslam also noted that the system had improved from Harding's survey of 1979 when filamentous algae were found throughout the length.

Overall it appears that emergent marginal species predominate. This is indicative of high water velocities which in turn are likely due to the engineered nature of the channel and ongoing river maintenance. Two submerged species are present. Further assessment is difficult with so little data available, however on the basis of expert opinion, upwards of 60 species could be expected for this type of site in excellent physical and trophic condition. Thus 11 species could be considered poor but not bad, given the presence of the two submerged species. The over-riding poor water quality within the Sankey catchment may mean that little can be obtained from such an assessment.

6.2 Physico-Chemical Elements

In general, the chemical status elements (such as dissolved oxygen, nutrient status) are most influenced by water quality, not by the physical attributes.

6.3 Definition of Current Ecological Status

From the limited biological data available, it does not appear that either the Rainford or main Sankey Brook achieves good status either for fish or macro-invertebrates. Overall, poor water quality, combined with modifications of the river are responsible for the low biological status, and thus low ecological status.

For the physical elements, the flow regime is likely to be affected by the aforementioned elements, but it is not possible to judge the extent. However, it is clear from the data on the channel structure that, the river does not reach good status on that basis alone.

The macro-invertebrate community composition may change in response to a wide variety of physico-chemical modifications (e.g. reduced water velocity and dissolved oxygen, increase water turbidity, or changes in substrate composition and channel shading, etc). The physiological constraints and responses of macro-invertebrates are probably mediated by the prevailing water quality. The Sankey macro-invertebrate data indicate a restricted range of taxa, including none that are very sensitive to poor water quality. There is, therefore, very limited scope at present for detecting differences in macro-invertebrate communities between sites with a gradation of physical modifications in the Sankey.

Using the standard UK-wide interpretation of macro-invertebrate data from running waters, it is not possible to quantify the extent to which physical modification of the waterbody influences ecological status. This probably arises from the over-riding impacts of poor water quality on the macro-invertebrates in the Sankey catchment.

For fish, all the in-channel physical modifications are likely have an impact on the status. Low habitat diversity is the ultimate result of all of the modifications, severely restricting the species present.

In particular:

- The bank and in-channel engineering leads to a lack of plant diversity, in turn reducing habitats for invertebrates and fish.
- Lack of natural channel features such as meanders and pool-riffle sequences restrict habitats.
- Culverts and weirs inhibit connectivity.
- Lack of floodplain channels reduces habitat diversity and refuge areas, particularly for spawning and young fish.

For the Rainford Brook, poor water quality has a considerable impact on ecological status, equalling or exceeding that of the physical modifications. For fish, this could explain the disappearance of bitterling *Rhodeus sericeus* in 1994, which use a freshwater mussel to spawn. If water quality were responsible for the disappearance of the mussel, it would have a knock on effect on the survival of bitterling. Other species such as bullhead (2% of total density) are known to be water quality sensitive.

Thus, overall, the poor water quality has two implications:
1. Difficulty in assessing the impacts of the physical modifications on the biology and thus uncertainty as to whether HMWB designation is appropriate.
2. The timing of future physical improvement works (to be scheduled in the RBMP) will need to be scheduled along with water quality improvements to ensure cost-effectiveness

Further details are contained in Proforma 1 in Annex D, and in Section 6.1.

6.4 Discussion and Conclusions

The greatest handicaps to an effective assessment of macro-invertebrate community responses to physical modification in the Sankey/Rainford Brook sub-areas have been:

1. The low number of sites with data of adequate quality (3 in the defined sub-areas);
2. The poor fit of two of these sites to any discrete RIVPACS site group, indicating a lack of suitable reference conditions in the RIVPACS database; and
3. The overriding influence of poor water quality, which leads to low diversity and masks the possible influences of physical modifications on macro-invertebrate community structure.

These factors have severely restricted the scope for interpreting the influences of physical modifications on macro-invertebrate community structure. The water quality issue (3) in particular will likely be a problem for assessing many HMWB reaches. Issue 1 may be a problem in some areas, it would be desirable to have at least two monitoring sites in each candidate water body. A particular problem arises when Issue 1 is compounded with Issue 2.

In situations such as this (i.e. lack of data AND poor water quality), we recommend that in the short-term, direct measures of habitat structure are used to make an assessment of the status of the water bodies. For fish the situation is slightly better because although it is not possible to objectively define reference conditions, we can clearly state that the water bodies are far from at good status.

In the longer-term, we recommend the development of a new macro-invertebrate scoring system which responses to physical modification stresses and can utilise the current and past macro-invertebrate monitoring data.

7 Identification and Designation of Water Bodies as Heavily Modified

The following example for the Rainford Brook is based on habitat features required to achieve good ecological status, provided the water body is not suffering from major water quality problems. In practice the Rainford Brook does have poor water quality which clearly affects ecological status. This raises several issues discussed below.

The Rainford Brook has been assessed to determine if it should be recommended for designation as a HMWB (the full set of proformas is given in Annex D). The modifications considered are listed in Section 5, and in further detail in Annex D.

7.1 Necessary Hydromorphological Changes to Achieve Good Ecological Status

Potential restoration measures have been identified that would mitigate the impacts of the modifications on ecological status (Annex D, Proforma 1). These restoration measures are:

- raise the river bed level and recreate longitudinal diversity in channel form;
- channel narrowing and creation of lateral channel diversity;
- removal of embanked sections and channelised sections of river bed;
- re-engineering of channel;
- removal of culverts with access from other sites; and
- removal of bridge and re-routing of traffic.

Of these measures, two (removal of culverts and removal of road bridge) have been discounted as having significant adverse effects on uses. It is unclear whether the remaining four restoration measures would have significant adverse effect on uses, hence, these are carried forward for more detailed assessment.

7.2 Assessment of Other Environmental Options

Where the restoration measures are considered to have significant adverse effects (or where this is unclear), technically feasible alternative measures are identified (Annex D, Proforma 2). For example, where culverts have been installed, the technically feasible alternative to removing the culverts is to construct new bridges over Rainford Brook. A total of six alternative measures have been identified.

The next step is to determine whether the technically feasible alternative measures are disproportionately costly (or not) (Annex D, Proforma 3). Two of the technically feasible alternatives are screened out at this stage either because they provide fewer benefits than measures of equal cost or because they provide the same level of benefits but are more expensive to implement (Annex D, Proforma 4). The remaining four technically feasible alternatives are carried forward for more detailed assessment (Annex D, Proforma 5).

7.3 Designation of Heavily Modified Water Bodies

For each measure carried forward (whether a restoration measure or technically feasible alternative), the capital and operating costs are estimated (Annex D, Proformas 6 to 9). All costs are given in Present Value terms (i.e. discounted back to year 0 using a discount rate of 6%). This means they can then be compared with benefits accrued as a result of restoration or a technically feasible alternative.

Only one of the measures considered would result in full Good Ecological Status (GES) being achieved (Annex D, Proforma 10). The other measures (which would achieve partial GES) need to be packaged together so that full GES is achieved. The results of the benefit assessment (Annex D, Proforma 11) show that re-engineering for diversity in the channel has sufficient benefits to be considered ‘not disproportionately costly’. As it achieves only partial GES, it could be packaged with other measures considered ‘not disproportionately costly’ to increase the chance that GES is achieved throughout the whole reach. Such measures include putting in parallel drainage channels (to allow rapid evacuation of floodwaters) and/or construction of new span bridges (to replace culverts).

7.4 Discussion and Conclusions

For a river that suffers from both water quality problems and physical habitat degradation, there are two key issues at this stage.

Firstly, poor water quality makes it difficult to make an assessment of the ecological impacts of the modifications. Thus more expert opinion is required, and also there is greater uncertainty over whether given water quality improvement and habitat improvement will lead to achievement of GES. This highlights the need for a risk-based assessment approach that includes some level of uncertainty.

Secondly, it will be necessary to phase the recommended habitat improvement works so that best use is made of limited resources in the short term. This work is best carried out within the overall RBMP process, however there is a danger that if the HMWB and RBMP procedures work in parallel, that there will not be adequate time for this to occur. Two-way linkages are thus required between HMWB and RBMP at various stages to ensure both that effort is not duplicated and that issues relating to modification impacts are highlighted to the RBMP at the earliest possible stage.

8 Definition of Ecological Potential

Overall, given sufficient water quality improvements, the Rainford Brook has not been designated as Heavily Modified. There is considerable uncertainty arising from lack of data and the effects of poor water quality. However the overall decision is that it is possible to engineer improvements to the channel that will allow the habitat for future achievement of good ecological status. If the Brook had been designated heavily modified, then individual options would still need to be adopted within the constraints imposed by the use of the river for drainage and flood protection. Some options would not be possible or would not be effective. For example the installation of parallel drainage channels and removal of embankments would not be possible. However, to achieve good ecological potential, some channel narrowing and creation of in-channel diversity will be possible. Raising of the bed level may be possible in some areas. Hydraulic modelling studies would be required to ensure that such measures did not adversely effect the flood carrying capacity of the channel, this may need to be extended to evaluate any increased soil moisture in nearby fields.

PART III

10 Conclusions, Options and Recommendations

10.1 Conclusions

The following problems are highlighted:

- The difficulty in selecting water bodies *a priori*, before data on a river are obtained and analysed;
- Uncertainty about the representativeness of RHS sites present on a potentially heavily modified river;
- The difference between degree of modification which can be scored relatively easily and feasible restorability which is what the WFD HMWB text refers to;
- Problems with determining a "signal" from the modifications in the presence of water quality impacts;
- The general lack of good time-series of macro-invertebrate biomonitoring data in this type of river;
- The lack of any means to create a reference condition-based approach for fish because of
    - Lack of data;
    - A multitude of technical factors (connectivity, palaeo-history);
- The lack of representation of some categories of reference sites in the RIVPACS database.

Overall, the results obtained and methods used are highly applicable to other similar rivers in the UK. The many river habitat survey sites present in the Sankey catchment has been put to good use in this case study, however this does highlight the likely problems in lowland catchments with a less dense survey network.

10.2 Options and Recommendations

Further harmonised work is required to link morphological impacts both with pressures and with ecological response.

Annex E. Draft screening methodology and description of candidate sub-areas of the Sankey Catchment

A key requirement of the project is to develop a procedure for the initial selection of Potential HMWBs for more detailed analysis. This section describes the proposed procedure. The data available for this study consists of River Habitat Survey (RHS) data, and Environment Agency Flood Defence Management System (FDMS) data. The FDMS data contains details of assets associated with the Environment Agency Flood Defence function.

By applying a simple set of rules to the RHS data, the extent of the modification can be expressed as a Habitat Modification Score (HMS). The structure of this Habitat Modification Score (HMS) system provides a suitable scoring mechanism necessary for the identification of Potential HMWBs and has therefore been adopted for this part of the project. The FDMS data will be used to back up the RHS data, and check for conflicts and additional information.

Data Availability and methodology

The River Habitat Survey data have been chosen as the basis for selecting Potential HMWBs. The reasons for this are:

- The data are reasonably consistent across the country
- It incorporates all aspects of habitat modification
- There is a numerical scoring mechanism in place
- Photographic data are available as a 'sense-check'
- The dataset can be expanded (at a price).

In contrast, the Environment Agency FDMS, or other asset data, are:

- Incomplete
- Inconsistent
- Use more than one database
- Out of date
- There is no scoring system
- Non-Agency assets (including informal defences) are excluded.

Methods of Investigation

Three trial methods have been used to determine the extent of the modification in the four study areas chosen for this pilot study.

RHS data alone

The Habitat Modification Scores obtained from the RHS data are divided into categories each with a Habitat Modification Index (HMI) as shown in the following table:

Habitat Modification Score categories for describing the physical state of the river channel at RHS sites.

Habitat Modification Score (HMS)	Habitat Modification Index (HMI)	Description
0 – 2	1	Semi-natural
3 – 8	2	Predominantly unmodified
9 – 20	3	Obviously modified
21 – 44	4	Significantly modified
45 +	5	Severely modified

The scores can be divided into categories that suggest whether the site is a Potential HMWB, a Borderline case, or a Non-candidate and can be disregarded immediately. The following table shows the suggested thresholds for these categories.

Categories for determining whether a reach is a Potential HMWB

Habitat Modification Score (HMS)	Potential HMWB?
0 – 8	Non-candidate
9 – 20	Borderline
21+	Potential HMWB

The 500m long sections of the reaches with associated Habitat Modification Scores can be categorised using these boundary values. No RHS survey data are available for the remainder of the reaches and these are therefore undefined.

Interpolated RHS data
Large proportions of some of the study reaches do not contain RHS sites and therefore cannot be classified by the available HMS scores alone. However, the HMS scores available at each end of these undefined reaches can be used to interpolate HMS scores along the reach.

Simple linear interpolation enables the whole stretch to be designated into the three categories. It is assumed that each HMS value is valid for the centre of the 0.5km site, and that the values are interpolated between points to find the position of the boundary between categories. The whole stretch can then be defined either as a Potential HMWB, a Borderline case, or a Non-candidate.

It is important to remember that this method is crude and is not a viable method where there are very few RHS sites on a long reach. It must be used with extreme caution.

RHS data extended with FDMS
The Habitat Modification Scores associated with RHS data sites can be extended to cover other parts of the reach by examining the FDMS data. The scores can be extended to areas that have similar features shown in the FDMS data. This has been done by looking at the nature of the assets at the RHS data sites on FDMS and then applying the same RHS scores to sites with similar assets.

This method does not guarantee to give defined categories for 100% of the stretch. Some reaches can remain undefined if the FDMS data do not contain suitable features, or if the FDMS data do not cover the extent of the RHS data.

This method assumes that the FDMS data give a good indication of the similarity of different parts of the river, with respect to the extent of modification.

The features of the six sub-areas identified as candidates for further study, are as follows:

Area A - Sankey Brook – Alder Lane bridge to confluence with River Mersey
This includes agricultural land upstream of the Warrington conurbation together with urbanised sections through Warrington. Chemical quality of this stretch is Poor and biological quality is Bad.

There are stretches of river which are heavily modified. Others may not be physically heavily modified but may be influenced by upstream effects. Most of this stretch of the river is at risk of flooding. There are long lengths of flood defences. Flood defence maintenance activities include grass-cutting.

Area B - Sankey Brook – Black Brook confluence to Alder Lane bridge
This is principally a rural, agricultural part of the river, although the upstream end is in the St Helens urban area. The RHS data indicates a range of HMI scores. Chemical quality is Poor and biological quality is Bad. Some stretches are physically modified, whilst others appear not to be, although they are heavily influenced by upstream effects. Much of this stretch of river is at risk of flooding and flood defences are present in some reaches.

Area C - Sankey Brook/Hardshaw Brook through St Helens
This stretch of river lies within the St Helens urban area. The RHS data indicates some variability in habitat. Most of this area appears to be heavily modified. Biological quality is Fair to Bad and chemical quality is Fairly Good.

Area D - Sutton Mill Brook
This stretch of river lies within the St Helens urban area. Biological quality and chemical quality are both Fair. There is a limited range of habitat modification according to the RHS map. The upper stretch of this area appears to be unaltered but the lower stretch has been physically modified. A section of the river has been culverted. This stretch appears to have the most promising fisheries quality. Maintenance activities include grass cutting and aquatic weed cutting.

Area E - Rainford Brook
This is largely an agricultural part of the catchment, apart from the stretch running through Rainford itself. HMI scores range from 29 to 63 (i.e. significantly or heavily modified), so the main brook has been fairly extensively modified. These modifications are principally re-sectioning and straightening. Parts of the upper tributaries have much lower HMI and higher HQI scores and some are described as semi-natural and wooded. The small size of the brook and the presence of agricultural land may mean that opportunities for restoration are good (e.g. the presence of under-field culverts may contribute considerably to the HMI scores). Maintenance activities include grass cutting, de-silting and bed maintenance. Surveyed parts of the channel indicate that it is "recovering" from historical works. Biological quality is Poor and chemical quality is Fairly Good in the upstream reaches and Fair in the lower reaches.

The River Ecosystem target for the Rainford Brook is RE3 – i.e. high quality coarse fish population.

Area F - Black Brook
This is a mainly rural and agricultural part of the river with Fair biological quality and Good chemical quality. There has been some physical modification in the lower stretches. Availability of habitat data is unknown. Maintenance activities include grass cutting and de-silting.

Proforma 1: Assessment for Test 4.3(a) - would restoration have a significant adverse effect on uses?

Rainford Brook – from source upstream of Rainford to confluence with Sankey Brook

Modification and Intended Uses	Potential Restoration Measures	Impacts of Restoration on Intended uses	Significance of Impacts and Direction			Impacts of Restoration on Wider Environment	Significance of Wider Impacts			Significant Adverse Effect?
			Small	**Mod**	**Large**		**Small**	**Mod**	**Large**	
Channel dredged to connect with field underdrainage to allow rapid evacuation of flood waters	Raise river bed level, recreate longitudinal diversity in channel form	Loss of agricultural land, reduced yields of arable crops and/or effects on cropping patterns; potential increase in flood damages on adjacent land areas		-ve		Partial achievement of GES; greater opportunities for marginal plants and increased diversity of invertebrates (although floods could wash out plants affecting invertebrates); land will go to grazing or wetland with potential conservation, possible flood attenuation and landscape benefits	+ve			Unsure
	Channel narrowing and creation of lateral channel diversity	Some loss of agricultural land and possible increase in flood related damages	-ve			Partial achievement of GES; greater opportunities for marginal plants and increased diversity of invertebrates (although floods could wash out plants affecting invertebrates) ; potential creation of wetland areas with potential conservation, flood attenuation, and landscape benefits	+ve			Unsure
Straightening and embanking of river for flood protection purposes	Removal of embanked sections and channelised sections of river bed	Likely increase in flood damages on adjacent agricultural land and residential areas		-ve		Partial achievement of GES; greater opportunities for marginal plants and increased diversity of invertebrates; potential loss of some agricultural land; landscape benefits		+ve		Unsure

Proforma 1: Assessment for Test 4.3(a) - would restoration have a significant adverse effect on uses?

Rainford Brook – from source upstream of Rainford to confluence with Sankey Brook

Modification and Intended Uses	**Potential Restoration Measures**	**Impacts of Restoration on Intended uses**	**Significance of Impacts and Direction**			**Impacts of Restoration on Wider Environment**	**Significance of Wider Impacts**			
			Small	**Mod**	**Large**		**Small**	**Mod**	**Large**	
	Re-engineering of channel - meanders, etc.	Likely increase in flood damages on adjacent agricultural land and residential areas; loss of agricultural land areas		-ve		Achievement of GES in relevant stretches. Increase in marginal plant communities and increased diversity of invertebrates; fishery improvements; wetland creation with potential conservation, flood attenuation and landscape and recreation benefits		+ve		**Significant Adverse Effect?** Unsure
Culverting for access to fields	Removal of culverts with access from other sites	Loss of easy access to field areas		-ve		Some contribution to GES. Increase in distances on road by tractors with associated disruption; limited and localised effects on invertebrates (+ve and -ve)	-ve			Yes
Road bridge	Removal of bridge and re-routing of traffic	Increase in mileage across all road users			-ve	Some contribution to GES. Increase in air emissions, disruption, congestion on other roads; possible impacts on economic development; limited and localised effects on invertebrates (+ve and -ve)			-ve	Yes

Proforma 2: Assessment for Test 4.3(b) - are there technically feasible alternatives? ***Rainford Brook - from source upstream of Rainford to confluence with Sankey Brook***				
Modification	**Possible Alternatives for Providing Intended Uses**	**Technically Feasible? (✔)**		**Factors Affecting Implementation**
		Yes	**No**	
Channel dredging to connect with field underdrainage	Put in parallel drainage channels	✓		Loss of land
	Pumped wellpoints (dig channel/pipe around field and pump out)	✓		Loss of land (smaller than drainage channels); power requirements for pumping
Straightening and embanking for flood protection	Re-engineering of river channel with meanders, etc.	✓		Requires purchase of agricultural land and can only be implemented on certain stretches
	Off-channel embankments	✓		Not always feasible because of proximity of housing to river
	Residential protection works (e.g. flood gates, barriers at doors)	✓		Relies on householders being home and responding to flood warnings; high risk of failure on demand
Culverting of river for access to agricultural land	Construction of new bridges over river	✓		Although technically feasible would lead to potentially significant losses of agricultural land; unlikely to be acceptable to land owners and some technical problems concerning alignment of bridges likely to arise
Road bridge	Construction of new road bridge that does not obstruct channel		✓	Not feasible within constraints of road system

Proforma 3: Assessment for Test 4.3(b) - are there alternatives that would not be disproportionately costly?

Rainford Brook - from source upstream of Rainford to confluence with Sankey Brook

Modification	**Cost of Operating/ Maintenance for Existing Modification (✔)**			**Alternatives**	**Costs of Alternatives: Capital and Operating/Maintenance (✔)**				**Potential Environmental Benefits**	**Disproportionately Costly? (✔)**		
	<£100k <€160k	**<£1m <€1.6m**	**>£1m >€1.6m**		**<£100k <€160k**	**<£1m <€1.6m**	**<=£10m <=€16m**	**>>£10m >>€16m**		**Yes**	**No**	**Unsure**
Channel drainage and field under-drainage	✓			put in parallel drainage channels		✓			Returns to more natural flow regime; potential improvement in water quality; more natural river profile; benefits of additional ditch habitat			✓ (need more data)
				pumped wellpoints (dig channel/pipe around field and pump out)		✓			Returns to more natural flow regime; potential improvement in water quality	✓	Same cost as putting in parallel drainage channels with fewer benefits, and is less cost-effective	
Straightening and embanking for flood protection	✓			Re-engineering of river channel with meanders, etc.		✓			Create a natural river channel with improved flow regime and more natural river profile; conservation, recreation, fisheries and landscape benefits			✓
				Off-channel embankments		✓			Must be combined with other works to generate any environmental gains			✓

Proforma 3: Assessment for Test 4.3(b) - are there alternatives that would not be disproportionately costly?

Rainford Brook - from source upstream of Rainford to confluence with Sankey Brook

Modification	**Cost of Operating/ Maintenance for Existing Modification (✔)**			**Alternatives**	**Costs of Alternatives: Capital and Operating/Maintenance (✔)**				**Potential Environmental Benefits**	**Disproportionately Costly? (✔)**		
	<£100k <€160k	**<£1m <€1.6m**	**>£1m >€1.6m**		**<£100k <€160k**	**<£1m <€1.6m**	**<=£10m <=€16m**	**>>£10m >>€16m**		**Yes**	**No**	**Unsure**
				Residential protection works			✓		Must be combined with other works to generate any environmental gains	✓	Most expensive and would not (on its own) generate significant environmental benefits	
Culverting of river for access to fields	✓			Construction of new span bridges over river		✓			Improve river flow regime creating more natural channel			✓

Proforma 4: Measures Carried Forward for More Detailed Assessment

Rainford Brook - from source upstream of Rainford to confluence with Sankey Brook

Modification	**Restoration Measure or Alternative Means of Providing Intended Use**	**Effect on Ecological Status? (Achieve Full or Partial GES?)**	**Reason More Detailed Assessment Required**
Channel dredged to connect with field underdrainage, to allow rapid evacuation of flood waters	Raise river bed level, recreate longitudinal diversity in channel form	Full	More data needed to determine whether ecological status gains together with other benefits are significant enough to justify capital works, losses in agricultural land and increases in flood risk
	Channel narrowing and creation of lateral channel diversity	Full (but only across part of the whole reach)	Although impacts on intended uses are likely to be smaller, so are wider gains in comparison to costs of works
	Put in parallel drainage channels	Full (but only across part of the whole reach)	More data needed to determine whether ecological status gains and other benefits are significant enough to justify capital works, losses in agricultural land and increases in flood risk
Straightening and embanking of river for flood protection purposes	Removal of embanked sections and channelised sections of river bed	Full (but only across part of the whole reach)	Considerable uncertainty over the potential increase in flood risk to residential properties
	Re-engineering for diversity in channel - meanders, etc	Full (but only across part of the whole reach)	Greater loss of land, more costly works than other options and considerable uncertainty over the potential increase in flood risk to residential properties. However environmental and wider benefits may be considerable
	Off-channel embankments	Partial (needs to be combined with other options)	May be good option in certain locations but feasibility is uncertain; costs will depend on location specific factors
Culverting for access to fields	Construction of new span bridges for access	Partial (affects only river flow, not channel morphology or bank habitats)	Queries over associated land take, acceptability and some technical issues

Proforma 5: Measures Dropped from the Further Analysis (Fail Test 4.3(a) or 4.3(b))

Rainford Brook - from source upstream of Rainford to confluence with Sankey Brook

Modification	Restoration Measure or Alternative	Test Failed	Reason
Channel dredging	Pumped wellpoints	Test 4.3(b)	Estimated to cost the same as other options but generate fewer benefits
Straightening and embanking of river for flood protection	Residential protection works	Test 4.3(b)	Most expensive alternative and is not expected to generate significant environmental benefits
Culverting for access to fields	Removal of culverts	Test 4.3(a)	Expected to have overall negative impact due to effect on road traffic, disruption and air quality, therefore, assessed as having significant adverse effect
Road bridge	Removal of bridge	Test 4.3(a)	Expected to have overall large negative impact due to effect on road traffic, disruption and air quality, therefore, assessed as having significant adverse effect
	Construction of new bridge	Test 4.3(b)	Not possible within constraints of current road system

Proforma 6: Detailed Description of Restoration and Alternative Measures			
Measure	**Capital Works Required**	**Operating Works Required**	**Number, Length or Area Affected**
Current modifications: channel drainage and field underdrainage; flood embankments; culverts	None	Channel dredging every 5 to 10 years (assumed every 7 years); maintenance of flood embankments; maintenance of culverts	5 km (whole reach)
Raise river bed level, recreate longitudinal diversity in channel form	Raise bed by importing material	Ongoing maintenance over first 5 years until stabilised; annual clearance works may be required	5 km (stretch of river basis) – no work associated with current modifications required
Channel narrowing and creation of lateral channel diversity	Reduce width by placing material on banks; replanting to stabilise	Ongoing maintenance over first 5 years until stabilised; annual clearance works may be required	2 km (stretch of river basis) – no work associated with current modifications required
Put in parallel drainage channels	Ditch either side of river to act as field drainage	Annual clearance	3 km (6km in total to account for both sides) – no work associated with current modifications required
Removal of embanked sections and channelised sections of river bed	Remove flood banks and re-engineer river over section downstream of reach	Maintenance ongoing for first five years and then annual clearance	1.5 km (stretch of river basis) – no work associated with current modifications required
Re-engineering for diversity in channel - meanders, etc	Remove flood banks and construct natural channel to appropriate gradient, including meanders. Footpath access and planting of banks to be undertaken	Ongoing maintenance for first five years with annual clearance as required	3 km (stretch of river basis) – no work associated with current modifications required
Off-channel embankments	Construction of flood embankments on a retired line	Annual mowing and inspection	1.25 km (2.5 when considering both banks) – no work associated with current modifications required
Construction of new span bridges for access	Construct 3 x 5 metre wide and 1x 10 metre wide span bridges	None	Maintenance of flood banks and culverts required (as for current modifications)

Proforma 7: Estimated Capital Costs of Restoration Measures and Alternative Means ***Rainford Brook - from source upstream of Rainford to confluence with Sankey Brook***		
Measure	**Cost Component**	**Capital Costs Estimate**
Current modifications: channel drainage and field underdrainage; flood embankments; culverts	Design and planning costs	£0

	Land costs	£0
	Site works	£0
	Other	£0
	Total capital(to nearest £10,000)	**£0**
Raise river bed level, recreate longitudinal diversity in channel form	Design and planning costs	£24,000 (€39,000)
	Land costs	-
	Site works	£315,000 (€520,000)
	Other	-
	Total capital(to nearest £10,000)	**£340,000 (€560,000)**
Channel narrowing and creation of lateral channel diversity	Design and planning costs	£16,000 (€26,000)
	Land costs	-
	Site works	£201,000 (€330,000)
	Other	-
	Total capital(to nearest £10,000)	**£220,000 (€360,000)**
Put in parallel drainage channels	Design and planning costs	£2,700 (€4,400)
	Land costs	£8,100 (€13,000)
	Site works	£33,700 (€55,000)
	Other	-
	Total capital(to nearest £10,000)	**£40,000 (€73,000)**
Removal of embanked sections and channelised sections of river bed	Design and planning costs	£3,000 (€4,900)
	Land costs	-
	Site works	£37,500 (€61,000)
	Other	-
	Total capital(to nearest £10,000)	**£40,000 (€66,000)**
Re-engineering for diversity in channel - meanders, etc	Design and planning costs	£10,000 (€16,000)
	Land costs	£8,000 (€13,000)
	Site works	£98,000 (€160,000)
	Other (planting along banks)	£120,000 (€200,000)
	Total capital(to nearest £10,000)	**£240,000 (€390,000)**
Off-channel embankments	Design and planning costs	£7,000 (€11,000)
	Land costs	£10,500 (€17,000)
	Site works	£87,500 (€140,000)
	Other	-
	Total capital(to nearest £10,000)	**£110,000 (€170,000)**
Construction of new span bridges for access	Design and planning costs	£6,800 (€11,000)
	Land costs	£1,500 (€2,500)
	Site works	£85,000 (€140,000)
	Other	-
	Total capital(to nearest £10,000)	**£90,000 (€150,000)**
Note: [1] €1 is taken as £0.61 (all cost estimates are given to a maximum of two significant figures)		

Proforma 8: Estimated Operating Costs of Restoration Measures and Alternative Means ***Rainford Brook - from source upstream of Rainford to confluence with Sankey Brook*** ***Assumes time period of 30 years over which present value costs are incurred***		
Measure	**Cost Component**	**Cost Estimate**
Current modifications: channel drainage and field underdrainage; flood embankments; culverts	Annual maintenance of flood embankments and culverts	£3,000 per annum (€4,900)
	Dredging costs (every 7 years)	£5,000 (€8,200)
	Total present value costs (to nearest £10,000)	**£50,000 (€90,000)**
Raise river bed level, recreate longitudinal diversity in channel form	Each year for first 5 years	£10,000 per annum (€16,000)
	Annual	£4,000 per annum (€6,600)
	Total present value costs (to nearest £10,000)	**£90,000 (€150,000)**
Channel narrowing and creation of lateral channel diversity	Each year for first 5 years	£4,000 per annum (€6,600)
	Annual	£2,000 per annum (€3,300)
	Total present value costs (to nearest £10,000)	**£40,000 (€66,000)**
Put in parallel drainage channels	Annual	£3,000 per annum (€4,900)
	Total present value costs (to nearest £10,000)	**£40,000 (€66,000)**
Removal of embanked sections and channelised sections of river bed	Each year for first 5 years	£3,000 per annum (€4,900)
	Annual	£1,200 per annum (€2,000)
	Total present value costs (to nearest £10,000)	**£30,000 (€49,000)**
Re-engineering for diversity in channel - meanders, etc	Each year for first 5 years	£6,000 per annum (€9,800)
	Annual	£2,000 per annum (€3,300)
	Total present value costs (to nearest £10,000)	**£50,000 (€82,000)**
Off-channel embankments	Annual mowing	£7,500 per annum (€12,000)
	Total present value costs (to nearest £10,000)	**£80,000 (€130,000)**
Construction of new span bridges for access	Additional works (as for current modifications)	£3,000 per annum (€4,900)
	Total present value costs (to nearest £10,000)	**£40,000 (€70,000)**
Note: [1] €1 is taken as £0.61 (all cost estimates are given to a maximum of two significant figures)		

Proforma 9: Total Estimated Costs - Present Value Costs and Equivalent Annual Cost ***Rainford Brook - from source upstream of Rainford to confluence with Sankey Brook***				**Discount Rate: 6%** **Time Period: 30 years**
Measure	**Present Value Costs**		**Economic life of asset[2]**	**Net Costs (in PV)**
Current modifications: channel drainage and field underdrainage; flood embankments; culverts	Capital	£0	> 50 years	£0
	Operating	£50,000 (€90,000)		£50,000 (€90,000)
	Total[1]	**£50,000 (€90,000)**		**£50,000 (€90,000)**
Raise river bed level, recreate longitudinal diversity in channel form	Capital	£340,000 (€560,000)	> 50 years	£340,000 (€560,000)
	Operating	£90,000 (€150,000)		£40,000 (€70,000)
	Total[1]	**£430,000 (€700,000)**		**£380,000 (€630,000)**
Channel narrowing and creation of lateral channel diversity	Capital	£220,000 (€360,000)	> 50 years	£220,000 (€360,000)
	Operating	£40,000 (€66,000)		-£10,000 (-€16,000)
	Total[1]	**£260,000 (€430,000)**		**£210,000 (€340,000)**
Put in parallel drainage channels	Capital	£40,000 (€73,000)	> 50 years	£40,000 (€73,000)
	Operating	£40,000 (€66,000)		-£10,000 (-€16,000)
	Total[1]	**£90,000 (€150,000)**		**£30,000 (€50,000)**
Removal of embanked sections and channelised sections of river bed	Capital	£40,000 (€66,000)	> 50 years	£40,000 (€66,000)
	Operating	£30,000 (€49,000)		-£20,000 (-€33,000)
	Total[1]	**£70,000 (€110,000)**		**£20,000 (€30,000)**
Re-engineering for diversity in channel - meanders, etc	Capital	£240,000 (€390,000)	> 50 years	£240,000 (€390,000)
	Operating	£50,000 (€82,000)		£0 (€0)
	Total[1]	**£280,000 (€460,000)**		**£240,000 (€390,000)**
Off-channel embankments	Capital	£110,000 (€170,000)	> 50 years	£110,000 (€170,000)
	Operating	£80,000 (€130,000)		£30,000 (€50,000)
	Total[1]	**£190,000 (€310,000)**		**£140,000 (€230,000)**

Proforma 9: Total Estimated Costs - Present Value Costs and Equivalent Annual Cost				**Discount Rate: 6%**
Rainford Brook - from source upstream of Rainford to confluence with Sankey Brook				**Time Period: 30 years**
Measure	**Present Value Costs**		**Economic life of asset[2]**	**Net Costs (in PV)**
Construction of new span bridges for access	Capital	£90,000 (€150,000)	> 50 years	£90,000 (€150,000)
	Operating	£40,0000 (€70,000)		-£10,000 -(€16,000)
	Total[1]	**£90,000 (€150,000)**		**£80,000 (€130,000)**

Notes: [1] all **Total** values are given to the nearest £/€10,000 (or to a maximum of two significant figures)
[2] if the asset is considered to have significant residual value this can be subtracted from the present value costs. Any residual values should be described in full with details given as to why the asset is considered to have residual value

Proforma 10: Cost Effectiveness of Restoration Measures and Alternative Means

Rainford Brook - from source upstream of Rainford to confluence with Sankey Brook

Measure	**Achievement of Good Ecological Status - Length Affected (km)**	**Net Cost (Present Value)**	**Cost per km Delivered FULL - WHOLE REACH**	**Lower cost-effectiveness than other measures?**	**Cost per km Delivered FULL (PART REACH)**	**Lower cost-effectiveness than other measures?**
Raise river bed level, recreate longitudinal diversity in channel form	5 km - full	£380,000 (€630,000)	£80,000 (€120,000)	Unsure - but may not deliver bankside improvements desired		
Channel narrowing and creation of lateral channel diversity	2 km - full (part reach)	£210,000 (€340,000)			£105,000 (€170,000)	Unsure, would need to be packaged with another measure
Put in parallel drainage channels	3 km - full (part reach)	£30,000 (€50,000)			£10,000 (€16,000)	No, but would need to be packaged with another measure
Removal of embanked sections and channelised sections of river bed	1.5 km - full (part reach)	£20,000 (€30,000)			£10,000 (€16,000)	No, but would need to be packaged with another measure
Re-engineering for diversity in channel - meanders, etc	3 km - full (part reach)	£240,000 (€390,000)			£80,000 (€130,000)	Unsure, would need to be packaged with another measure
Off-channel embankments	1.25 km - partial (needs to be combined with other options)	£140,000 (€230,000)			Not available – relative level of benefits is unknown	Yes – more expensive than measures which are likely to achieve full GES over a longer reach
Construction of new span bridges for access	3km - partial (affects only river flow, not channel morphology or bank habitats)	£80,000 (€130,000)			Not available – relative level of benefits is unknown	No, but would need to be packaged with another measure

Notes: All Present Value costs are given to the nearest £10,000 (or to a maximum of two significant figures)
Measures which would achieve only partial GES (or would deliver full GES for only part of the whole reach) are compared to provide an indication as to which measures could be packaged together to achieve full GES across the whole reach

Proforma 11: Assessment Summary Table for Determining Disproportionate Costs
Rainford Brook – from source upstream of Rainford to confluence with Sankey Brook
Measure: Re-engineering for diversity of river bed

Discount Rate : 6% *Time Period: 30 years*
Length achieving good ecological status: 3 km
Net Present Value Costs: £240,000/€390,000

Impact Category	Current Situation (Baseline)	Qualitative Description	Quantitative Data	Benefit/Cost Transfer Assessment	
				Benefits	**Costs**
Water-Related Environment					
Water quality	Diffuse pollution identified as an issue by EA. RE3 target has been set for River Ecosystem quality with current compliance good	Some reduction in diffuse pollutant concentrations (N, P, sediments), with creation of buffer strips or less intensive management as measures for improving quality.	GES achieved for 3km (full GES for part reach)	**Impact Rating**: *intermediate positive –* affects 3km of the reach, mainly diversity of river bed, although bank habitat may also be improved **Nature Conservation Evaluation**: Category *C* – Sankey Valley Park is SINC **Impact Assessment**: intermediate positive and C – *moderate benefit*	
Physical habitat		Increase in diversity of in-channel habitats for 3km, also improved diversity of bank habitats	GES achieved for 3km stretch due to increase in diversity of physical habitats		
Conservation Importance:		Increase in habitat diversity along both banks of 3 km stretch	N/a		
Designated sites	Sankey Valley Park is a site of Importance for Nature Conservation	May be impacted positively as a result of improvements in upstream river ecology/morphology	N/a		
Non-designated sites	Sites of Community Wildlife Interest	Not likely to be affected by works	N/a		
Plants		Increased opportunities for colonisation of bank habitats; planting will be undertaken to reduce time required to achieve benefits and also to stabilise banks	Increased opportunities for plants along 3km stretch (6km of banks) - increases chance of achieving GES		

Proforma 11: Assessment Summary Table for Determining Disproportionate Costs
Rainford Brook – from source upstream of Rainford to confluence with Sankey Brook
Measure: Re-engineering for diversity of river bed

Discount Rate : 6% *Time Period: 30 years*
Length achieving good ecological status: 3 km
Net Present Value Costs: £240,000/€390,000

Impact Category	Current Situation (Baseline)	Qualitative Description	Quantitative Data	Benefit/Cost Transfer Assessment	
				Benefits	Costs
Macro invertebrates		Increased diversity of habitats should encourage more diverse invertebrate fauna	Increased number/type of habitats and refuges along 3km stretch - increases chance of achieving GES		
Fish		Increase in fish biomass and species richness, particularly in populations of coarse fish. Potential increase in spawning areas for fish using marginal vegetation	Increased opportunities for fish (both habitats and spawning) across 3km stretch		
Recreation and Amenity					
Angling	Land owners have expressed interest in supporting recreational fisheries	Improvements could lead to the creation of a high quality coarse fishery, with access enabling new angling opportunities to be created.	On average 9% of households contain at least one coarse angler, who will travel up 20 miles for a day's fishing. Value to riparian owner of a high class fishery estimated at about £7,500/km/annum (€12,000), with economic rent estimated as being rough equal to this amount	£30,000 per annum (€49,000) (based on high quality coarse fishery being created). However, the Rainford Brook is small with limited scope for developing a worthwhile (valuable) coarse fishery, hence, may overestimate potential benefits	
In-stream recreation		None currently undertaken and no development likely	N/a	No in-stream recreation	

Proforma 11: Assessment Summary Table for Determining Disproportionate Costs *Rainford Brook – from source upstream of Rainford to confluence with Sankey Brook* *Measure: Re-engineering for diversity of river bed*				*Discount Rate : 6%* *Time Period: 30 years* *Length achieving good ecological status: 3 km* *Net Present Value Costs: £240,000/€390,000*	
Impact Category	**Current Situation (Baseline)**	**Qualitative Description**	**Quantitative Data**	**Benefit/Cost Transfer Assessment**	
				Benefits	**Costs**
Informal recreation	Quality of informal recreation areas is of low quality	Creation of new footpath access along river as part of re-engineering works; continuation of Sankey Valley Park. Re-engineering to include tree planning marginal reed planting, etc would be of high added value	Full population of Rainford within 3km of river (8,500 people, 85% over 16); assume roughly 25,000 people in St Helens live within 3km (out of 178,000 in wider area). Larger % of St Helens population may visit area if joined to Sankey Valley Park, with area then acting as a honeypot site	£24,000 (€39,000) based on assumption that access is provided along full 3 km stretch and area becomes a 'honeypot' through linkages with Sankey Valley Park; alternative approach suggests that 60,000 to 150,000 visits to a honeypot site, which when valued at £0.50 per visit suggests benefits of £30,000 to £75,000 (€49,000 to €120,000). Note figures used are lower than those found for Skerne restoration study	
Residential amenity	small number of properties located in the 1:100 flood plain area	Regeneration works may lead to increase in amenity value; potential gains captured by informal recreation benefits as no properties adjoining affected length)	Approximately 12 properties affected	Not possible to value (due to lack of empirical data)	
Commercial amenity	No visual or physical link with the river	None likely as there is no visual or physical link with the river	N/a	No impact on commercial amenity	

Proforma 11: Assessment Summary Table for Determining Disproportionate Costs
Rainford Brook – from source upstream of Rainford to confluence with Sankey Brook
Measure: Re-engineering for diversity of river bed

Discount Rate : 6% *Time Period: 30 years*
Length achieving good ecological status: 3 km
Net Present Value Costs: £240,000/€390,000

Impact Category	Current Situation (Baseline)	Qualitative Description	Quantitative Data	Benefit/Cost Transfer Assessment	
				Benefits	**Costs**
Priced Uses of Waterbody					
Public water supply		N/a	N/a	No impact on public water supply	
Industrial water use		N/a	N/a	No impact on industrial water use	
Agricultural water use and productivity		Loss of 5 ha of Grade 2 agricultural land included in costs of measure; increase in flood risk from 1:100 to 1:50 year flood frequency on a further 10 ha	N/a		Costs included in costs of measure (see Proforma 7)
Commercial fisheries/shellfisheries		No commercial fisheries/shellfisheries	N/a	No commercial fisheries/shellfisheries	
Wider Environment					
Archaeology		No known archaeology sites	N/a	No impact (*neutral*)	
Heritage		No known heritage sites	N/a		
Landscape and geomorphology		Improvement in landscape through creation of more natural river valley; river now plays virtually no role in landscape quality	Landscape along a 3km stretch of river to be improved	*Slight beneficial impact*	
Townscape		N/a	N/a	No impact on townscape	
Air quality:					
Local		No impacts expected – measure does not affect local air quality	N/a	No impact on local air quality	
Regional		No impacts expected – measure does not affect regional air quality	N/a	No impact on regional air quality	

Proforma 11: Assessment Summary Table for Determining Disproportionate Costs *Rainford Brook – from source upstream of Rainford to confluence with Sankey Brook* *Measure: Re-engineering for diversity of river bed*			*Discount Rate : 6%* *Time Period: 30 years* *Length achieving good ecological status: 3 km* *Net Present Value Costs: £240,000/€390,000*		
Impact Category	**Current Situation (Baseline)**	**Qualitative Description**	**Quantitative Data**	**Benefit/Cost Transfer Assessment**	
				Benefits	**Costs**
Global		No impacts expected – measure does not affect global air quality	N/a	No impact on global air quality	
Waste		No impacts expected – measure result in additional waste being generated	N/a	No impact on waste	
Energy		No impact expected – measure does not result in a change in the amount of energy being consumed	N/a	No impact on energy (consumption or generation)	
Wider Economic Impacts					
Employment		No impacts expected – measure does not affect businesses	N/a	No impact on employment	
Regeneration/development		No impacts likely – regeneration/development areas not affected	N/a	No impact on regeneration/development	
Tourism		Potential increase in visitors to the area through extension of footpath to join Sankey Valley Park which is an important asset to the area	Increase in visitor numbers from outside the Rainford/St Helens area not quantifiable	Not possible to value – may be moderate	
Competitiveness		No impacts expected – measure does not affect businesses	N/a	No impact on competitiveness	
Property (i.e. flood damages)		Level of flood protection to downstream and upstream residential areas remains unaffected (1:100 years)	No change in numbers of properties affected or in level of risk	No change in flooding risk	

Proforma 11: Assessment Summary Table for Determining Disproportionate Costs
Rainford Brook – from source upstream of Rainford to confluence with Sankey Brook
Measure: Re-engineering for diversity of river bed

Discount Rate : 6% *Time Period: 30 years*
Length achieving good ecological status: 3 km
Net Present Value Costs: £240,000/€390,000

Impact Category	**Current Situation (Baseline)**	**Qualitative Description**	**Quantitative Data**	**Benefit/Cost Transfer Assessment**	
				Benefits	**Costs**
Infrastructure (transport)		Impacts on vehicle access to fields but no impacts on major/local transport routes	8 fields likely to be affected		Not possible to value
Social Considerations					
Social inclusion/cohesion	DLTR's *Indices of Deprivation* give Rainford a rating of 4,242	May add to social cohesion by extending existing footpath network, providing further opportunities to residents in Rainford and St Helens	N/a	No impact on social inclusion/cohesion 'neutral' area	
Equity	N/a	Some losses to farmers that are not offset by gains to them	Losses equal to increase in flood damages to agricultural land	Environment, local residents and visitors (recreation)	Farmers (extent and duration of flooding unknown)
Policy Integration		No relevant policies identified	N/a	No impact on policy integration (*neutral*)	

Proforma 11: Assessment Summary Table for Determining Disproportionate Costs
Rainford Brook – from source upstream of Rainford to confluence with Sankey Brook
Measure: Re-engineering for diversity of river bed

Discount Rate : 6% *Time Period: 30 years*
Length achieving good ecological status: 3 km
Net Present Value Costs: £240,000/€390,000

Impact Category	**Current Situation (Baseline)**	**Qualitative Description**	**Quantitative Data**	**Benefit/Cost Transfer Assessment**	
				Benefits	**Costs**
Summary of Results and Sensitivity	**Net Present Value Costs of Measure**				£240,000 (€390,000)
	Additional Present Value Costs				None quantified
	Total Quantified Present Value Costs				£240,000 (€390,000)
	Total Annual Benefits			£54,000 (€89,000)	
	Present Value Benefits (Benefit Transfer) - discounted at 6% over 30 years			£800,000 (€1.3 million)	
	Notes on benefit estimate and sensitivity analysis - *Value of riparian fishery may be order of magnitude too high (due to small size of fishery and alternative sites that may be available) - taking £750 (€1,200) per km per annum (instead of £7,500 (€12,000) per km per annum) reduces total annual benefits to £27,000 (€44,000). The lower value takes into consideration the small size of the fishery and, hence, the lower participation rates that can be expected.* - *This reduces Present Value Benefits to £400,000 (€660,000) which is still a benefit-cost ratio of 1.7 (NPV of £160,000/€270,000)* - *The £24,000 (€39,000) for recreation benefits is the low estimate (with alternative estimates of £30,000 to £75,000 (€49,000 to €120,000) per annum), therefore, benefits are assumed to outweigh costs even when lower estimate is taken for value of angling. Further more, there are qualitative benefits that are not included within this (quantitative) estimate and benefits may be under-estimated. Costs to farmers due to flooding of farmland are not included but with an increase in likelihood of flooding from 1:100 to 1:50 are not expected to be significant*				
	Designation Decision and reasons: *Benefit-cost ratio greater than one with NPV also positive (including where low benefit estimates are taken); qualitative benefits may be significant, hence, overall benefits may be under-estimated; qualitative costs (to farmers) are unlikely to be significant*			*Not HMWB (but measure would need to be packaged with another measure to achieve full GES across whole reach)*	

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Annex B. Acronyms used

AOD	Above Ordanance Datum
AMP	Asset Management Plan
ASPT	Average Score per Taxon. See RIVPACS below.
BFI	Base Flow Index
BHS	British Hydrological Society
BMWP	Biological Monitoring Working Party. See RIVPACS below.
BOD	Biochemical Oxygen Demand
CEH	Centre for Ecology and Hydrology
CS	Combined Sewer. System where stormwater runoff from impermeable land surface areas is routed through the same sewage system as waste sewage
CSO	Combined Sewer Overflow. Point at which CS system discharges to river, operates during high rainfall events to prevent overloading of sewage treatment works.
DEFRA	UK Department of the Environment, Food and Rural Affairs
DO	Disolved Oxygen
EA	Environment Agency of England and Wales
EU	European Union
ITE	Institute of Terrestrial Ecology (now CEH Monks Wood)
FDMS	Flood Defence Management System
GEP	Good Ecological Potential
GES	Good Ecological Status
GQA	General Quality Assessment. See GQA below.
HES	High Ecological Status
HMI	Habitat Modification Index. Classification of HMS into 5 categories
HMS	Habitat modification Score. See RHS below.
HMWB	Heavily Modified Water Body
HQA	Habitat Quality Assessment score. See RHS below.
JBA	JBA Consulting Engineers and Scientists
LEAP	Local Environment Action Plan
MEP	Maximum Ecological Potential
NDC	Not Disproportionately Costly
NGR	National Grid Refrence
MTR	Mean Trophic Rank
NFCDD	National Flood and Coastal Defence Database
O/E	Observed / expected
OS	Ordnance Survey
RBMP	River Basin Management Plan
RIVPACS	River InVertebrate Prediction And Classification System
SBEO	Significantly Better Environmental Option
SPA	Special Protection Areas
SSSI	Site of Special Scientific Interest
STW	Sewage Treatment Works
QA	Quality Assurance
UK	United Kingdom
UPM	Urban Pollution Manual
URBEXT1990	Urban Extent in 1990

SPRHOST	Standard percentage runoff for a natural catchment.
STW	Sewage Treatment Works
WFD	Water Framework Directive

Annex C. Description of survey and analysis methods used.

Plant Surveys

During River Habitat Surveys on the physical structure of the watercourses in the UK, channel vegetation types were recorded as present or extensive in 10m wide belt transects at 50m intervals over 500m reaches for the several thousand UK reference sites. Vegetation data on attached, submerged, emergent and free-floating aquatic vegetation (which were grouped into nine broad morphological groups such as submerged broad-, linear- and fine-leaved, free-floating, emergent, etc) were also recorded and these data are supported by assessments of physical parameters at each site including dimension, flow types, channel substrate and the slope of the channel. The general habitat requirements for each group are shown to agree with assumed requirements but with a broader distribution of habitats (Dawson, Raven and Gravelle 2000).

Additional historical data are available from the surveys of Haslam (1982) and Holmes (1983). The former, records common aquatic taxa but is geographically comprehensive. The latter is restricted to potential sites for conservation status, it classifies the aquatic flora to ten main groups with several sub-types; it is thus not indicative of trophic status or other impacts but only relates typical associations.

RHS (River Habitat Survey)

Physical habitat of British watercourses are assessed using the River Habitat Survey. Results of surveys are incorporated in a series of scores which summarise and categorise the data into indices which assess the extent of modification, the contextual assessment of the variety of natural features (i.e. quality) and a proposed overall contextual assessment of quality status. Modifications to river banks, bed and other features such as bridges, groynes, and the alignment of the river, are assessed by a simple ‘transparent’ scoring system to give the Habitat Modification Score (HMS). Any site can be designated into one of the five categories of the Habitat Modification Index. The variety of riverine habitats are scored for the variety of flow, bank and bed substrates, features and vegetation plus special features, to form the Habitat Quality Assessment score (HQA). This score may then be compared to the range of scores for similar sites and form overall assessment river quality. The proposed overall contextual assessment of quality status (River Quality Assessment) for a site relates the extent of modification, HMS, to the assessment of habitat quality, HQA, in the context of similar rivers and thus defines the current management status, such as, high quality - protect, average - maintain and improve, bad – rehabilitate.

The River Habitat Survey methodology has been well tested and data are readily available. QA tests have been performed during development and periodically since 1994. A reference data set of data of mainly three RHS surveys from each 10km by 10km square of the UK sampled using a random stratified method, is available and includes semi-natural and all levels of modification. Similarly, RHQ scores are available for comparison. These assessment systems are subjectively derived but are transparent in use and although they have not been exhaustively tested in a range of conditions in relation to geomorphological drivers and relationships for all conditions, they show the underlying trends. Thus, there may be non-linearity or dis-junctures in these relationships but they reflect the well known and well-understood conditions. The RHS system is continuously under development and review, particularly in order to expand its use within Europe in particular

The following section summarises the derivation of the Habitat Modification Score. It is a total of all the component scores in the categories listed below:

A. Modifications at spot checks (abbreviations in brackets)

Score per spot check	
Reinforcement to banks (RI)	2
Reinforcement to bed (AR)	2
Resectioned bank or bed (RS)	2
Two stage bank modification (BM)	1
Embankment (EM)	1
Culvert (CV)	8
Dam, weir or ford (DA, FO)	2
Bank poached by livestock	0 (<3 spot checks)
	1 (2-5 spot checks)
	2 (>5 spot checks)

B. Modification present but not recorded at spot-checks

	One bank or channel	both banks
Artificial bed material	1	
Reinforced whole bank	2	3
Reinforced top or bottom of bank	1	2
Resectioned bank	1	2
Embankment	1	1
Set-back embankment	1	1
Two stage channel	1	3
Weed-cutting	1	
Bank mowing	1	1
Culvert	8 each	
Dam, weir, ford	2 each	

C. Scores for features in site as a whole

	One	Two or more	Site
Footbridge	0	0	
Roadbridge	1	2	
Enhancements, such as groynes	1	2	
Site partly affected by flow control			1
Site extensively affected by flow control			2
Partly re-aligned channel			5
Extensively or wholly realigned channel			10

Summary of descriptions of total HMS score:

HMS	Descriptive category of channel (HMI)
0	Pristine
0-2	Semi-natural
3-8	Predominantly unmodified
9-20	Obviously modified
21-44	Significantly modified
45 or more	Severely modified

The Habitat Quality Assessment (HQA) score is similarly open-ended but categories are not defined, the score must be interpreted by comparison with sites of similar character. HQA values generally range between 10 and 90, with a median of around 40. In practice, it is difficult to obtain anything other than the broadest picture from the aggregate HQA scores, and the sub-scores for each category must be examined in more detail. The sub-HQA scores quantify:

- Surface flow type diversity
- Channel substrate diversity
- Channel features (e.g. mid-channel bars)
- Bank features (e.g. side bars)
- Bank vegetation structure
- Point bars
- In-stream channel vegetation
- Land use within 50m of bank
- Trees and associated features
- Special features (e.g. waterfalls, braided channels)

RIVPACS (River InVertebrate Prediction And Classification System)

BMWP

For many years, biological quality in UK rivers and streams has classified using macro-invertebrate families. In the 1970's, the UK BMWP (Biological Monitoring Working Party) produced a system of scoring macro-invertebrate families in terms of their sensitivity to organic pollution. Scores between 1 and 10 are allocated to 82 macro-invertebrate families. For each family the score reflects its sensitivity to organic pollution (10=very sensitive). The combined BMWP scores for each taxon and the average score per taxon (ASPT) reflect both community richness and the balance between pollution tolerant and pollution sensitive taxa present. This scoring system was based on expert judgment and has remained stable for over two decades. The BMWP scoring system was subsequently adopted for use in RIVPACS (River InVertebrate Prediction And Classification System).

RIVPACS

The RIVPACS approach generates seasonal (spring, summer, autumn) site performance predictions from a small number of standard map-based and physico-chemical site descriptors. Site performance, in terms of macro-invertebrate community structure, is quantified by comparison with results from reference sites of the same type. The reference sites have been chosen to be free of chemical pollution and *where possible*, other stresses. Within RIVPACS a series of 'Expected' BMWP scores are generated, based on the standard site physico-chemical descriptors/variables. Observed / Expected ratios may be calculated for BWMP, ASPT and number of taxa present.

Links to habitat

If data extent and quality are good, rises or falls in Expected/Observed values may be matched to recorded differences in habitat modifications between sites. This is because overall, the underlying taxa will reflect physical habitat quality as well as chemical water quality. However, as the current system was primarily designed to score organic pollution, it cannot be expected to give good sensitivity to the multitude of different types of habitat degradation that can be observed.

The dataset behind RIVPACS is extremely extensive and has the potential for new interpretations, such as exploring community responses to types and severity of habitat modification particularly in conjunction with RHS data on adjacent river reaches. Alternative scoring methods will need to be developed and applied utilising this data, reflecting macro-invertebrate community response and performance under varying degrees of habitat modification.

GQA (biology)

In England and Wales, water quality is reported on a rolling five year programme, called the General Quality Assessment (GQA). The 1995 GQA results were available in consistent format (spring and autumn) for this project, therefore broad assessments are based on this dataset. Nationally, the dataset consists of observations from around 7000 sites. As site conditions, with respect to physical modifications, are unlikely to change over short time-scales it was felt appropriate to confine the majority of the analysis to this dataset. Supplementary macro-invertebrate data, as supplied by the Environment Agency Regions, were incomplete and contained variable information, both in terms of coverage and accuracy. Many sites had just been sampled once. Some limited interpretation of the supplementary data has been undertaken.

GQA (chemistry)

The Agency's method for classifying the water quality of rivers and canals is known as the General Quality Assessment scheme (GQA). It is designed to provide an accurate and consistent assessment of the state of water quality and changes in this state over time. The scheme consists of separate windows on water quality. The Chemical GQA describes quality in terms of chemical measurements which detect the most common types of pollution. It allocates one of six grades (A to F) to each stretch of river, using the same, strictly defined procedures, throughout England and Wales. The process is set out below.

- Each sampling site is assigned the stretch of river that the site will characterise. In the main, these sites, and the monitoring, are the same as those used to take decisions on developments that may affect water quality - discharges, abstractions and changes in land use.
- Results from the routine pre-planned sampling programmes with samples analysed by accredited laboratories are used. To avoid bias all extra data collected for special surveys or in response to incidents or accidents are ignored. The routine programme involves monthly sampling at some 8,000 monitoring points on over 40,000 kilometres of rivers and canals.
- Sites are sampled a minimum of 12 times a year. The data collected over three years is used because this produces 36 samples per site, giving the required precision in making judgements about particular rivers, bearing in mind the

cost of monitoring. All the results collected over the three years are included. No extreme data values are excluded.

- The percentiles are calculated from the samples using the method of moments, assuming a normal distribution for dissolved oxygen and lognormal for biochemical oxygen demand (BOD) and ammonia. The estimates of the percentiles are compared with the standards. A grade is assigned to each river length according to the worst determinand. This is the 'face-value' grade.
- All data and results for all rivers are made available to the public.

The "Stresses" dataset

For the 1995 GQA survey, Environment Agency personnel were asked to score each site against a range of stresses. These include, but go far beyond, different types and extent of physical modifications. These have been documented for c.5000 of the c.7000 GQA sites throughout England and Wales. Future research on the influences of different stresses on macro-invertebrate community structure may enable a prioritised removal of stresses to delivery 'good ecological status' or 'good ecological potential', as appropriate.