Physical and biological monitoring of STREAM restoration projects

Year Three Report

Natural England

April 2009

Final Report

LIFE05 UK/NAT/000143
9S0459

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Document title	Physical and biological monitoring of STREAM restoration projects Year Three Report
Status	Final Report
Version	01
Date	April 2009
Project name	River Avon STREAM Monitoring
Project number	9S0459
Client	Natural England
Client Reference	LIFE05 UK/NAT/000143
Reference	9S0459/R04/JLE/Hayw

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Date/initials approval	26/01/2009	JLE

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(*All appendices are contained in a ringbinder that accompanies this report and will be updated on an annual basis)

1 INTRODUCTION

1.1 The STREAM Restoration Project

Demonstrating Strategic Restoration and Management (STREAM) is funded jointly by the European Commission's LIFE-Nature programme, Natural England, Environment Agency, Wiltshire Wildlife Trust, Hampshire and Isle of Wight Wildlife Trust, and Wessex Water to improve river habitat conditions along a number of reaches of the River Avon Special Area of Conservation identified in **Table 1.1** and **Figure 1.1**.

Table 1.1 Location of river restoration sites within the Avon catchment

Site name	Watercourse	Upstream limit	Downstream limit
1.1 Upper Woodford	River Avon	SU 13183755	SU 12603723
1.2 Fovant	River Nadder	SU 00213059	SU 00663072
1.3 Seven hatches	River Wylye	SU 09243304	SU 09833178
1.4 Amesbury	River Avon	SU 15834257	SU 15624195
1.5 Hale	River Avon	SU 17401889	SU 16351791
1.6 Blashford	Dockens Water	SU 15410828	SU15300826

Further details about the project and outline design of the restoration works to be undertaken are contained within the original LIFE bid document (English Nature, 2005).

1.2 Physical and Biological Monitoring

As part of the STREAM project, Royal Haskoning has been commissioned by Natural England to undertake physical and biological monitoring at each of the six restoration sites.

Monitoring will involve one pre-restoration and one post-restoration survey at each site. These surveys will be used to document the restoration works and to identify the possible influence of the works on ecology within the reach. Reach-scale mapping and repeat photography techniques will be used to monitor change at all restoration sites. It is not possible to undertake detailed survey at all sites due to resource constraints and practical limitations. Therefore two of the sites will also be subject to more detailed survey and the use of control sites.

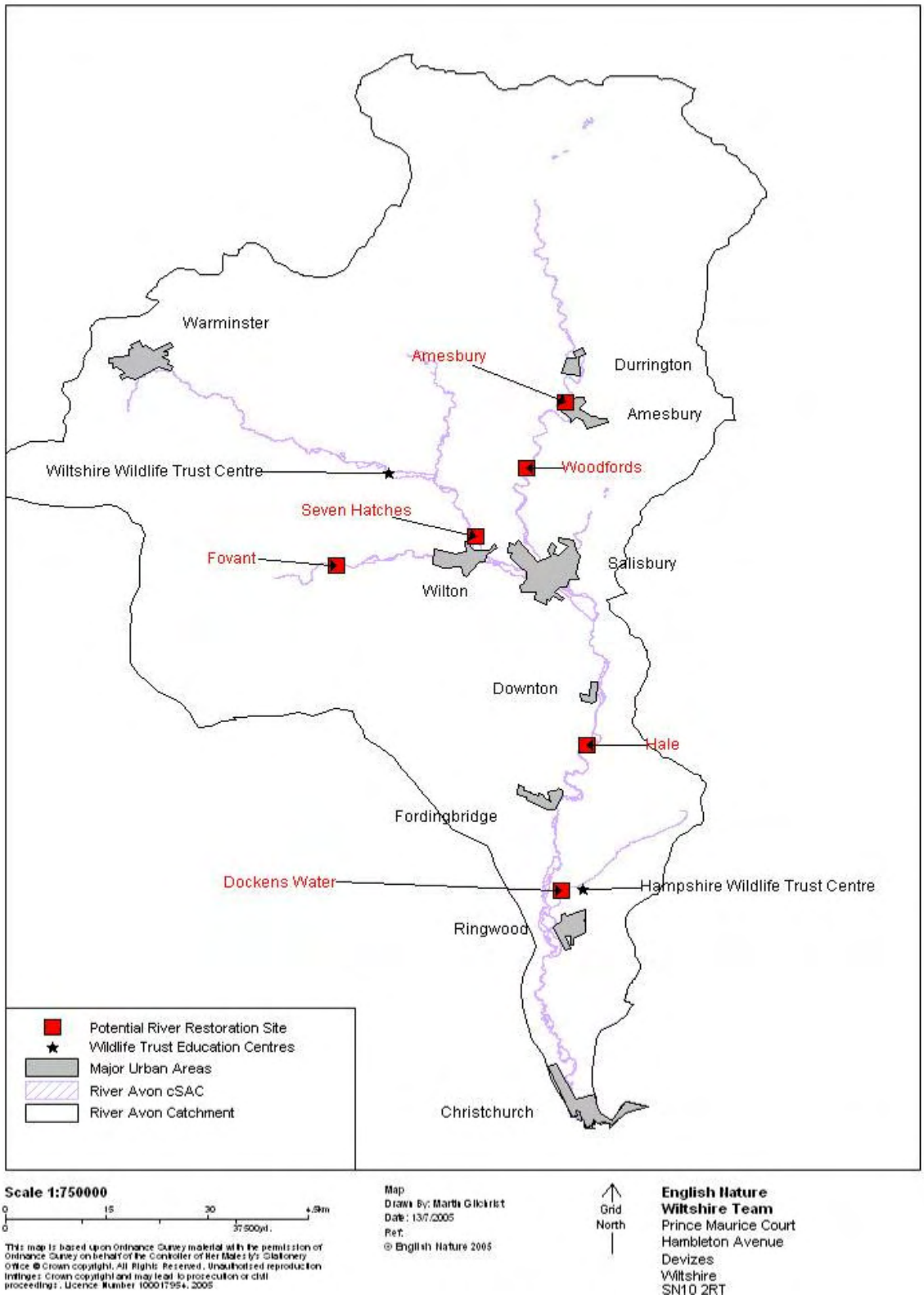
1.3 Reporting format

The findings of the monitoring project are to be reported at the end of each of the four years of the project. This document reports on the findings of the third year's baseline monitoring surveys undertaken in 2008 at the following sites:

Detailed survey
- Upper Woodford Control (UWC) and Restoration (UWR) sites
- Seven Hatches Control (SHC) and Restoration (SHR) sites

Rapid assessment
- Fovant Restoration Site (FOR)
- Hale Restoration Site (HAR)

Figure 1.1 Location of STREAM restoration sites within the Avon Catchment



The purpose of this report is to present the data that has been collected to date and summarise any initial findings in relation to the physical and biological characteristics of the sites surveyed.

The primary data is contained in the accompanying ringbinder of appendices. This ringbinder will be updated following subsequent annual reports in order to collate all of the data gathered over the four year period in one place.

2 METHOD

2.1 Monitoring Protocol

The methods used in gathering the physical and biological survey data presented in this report are based on those agreed with Natural England in developing the STREAM Monitoring Project – Monitoring Protocol (Royal Haskoning, 2006). The monitoring protocol describes how the monitoring sites were selected and the monitoring framework (**Figure 2.1**) together with the rationale underlying the project and should be read in conjunction with this report.

The following statements define the purpose and limitations of the monitoring framework.

- The pre-restoration survey will establish a record of biological and physical conditions at the site prior to restoration.

- The post-restoration survey will record modifications to physical conditions after restoration.

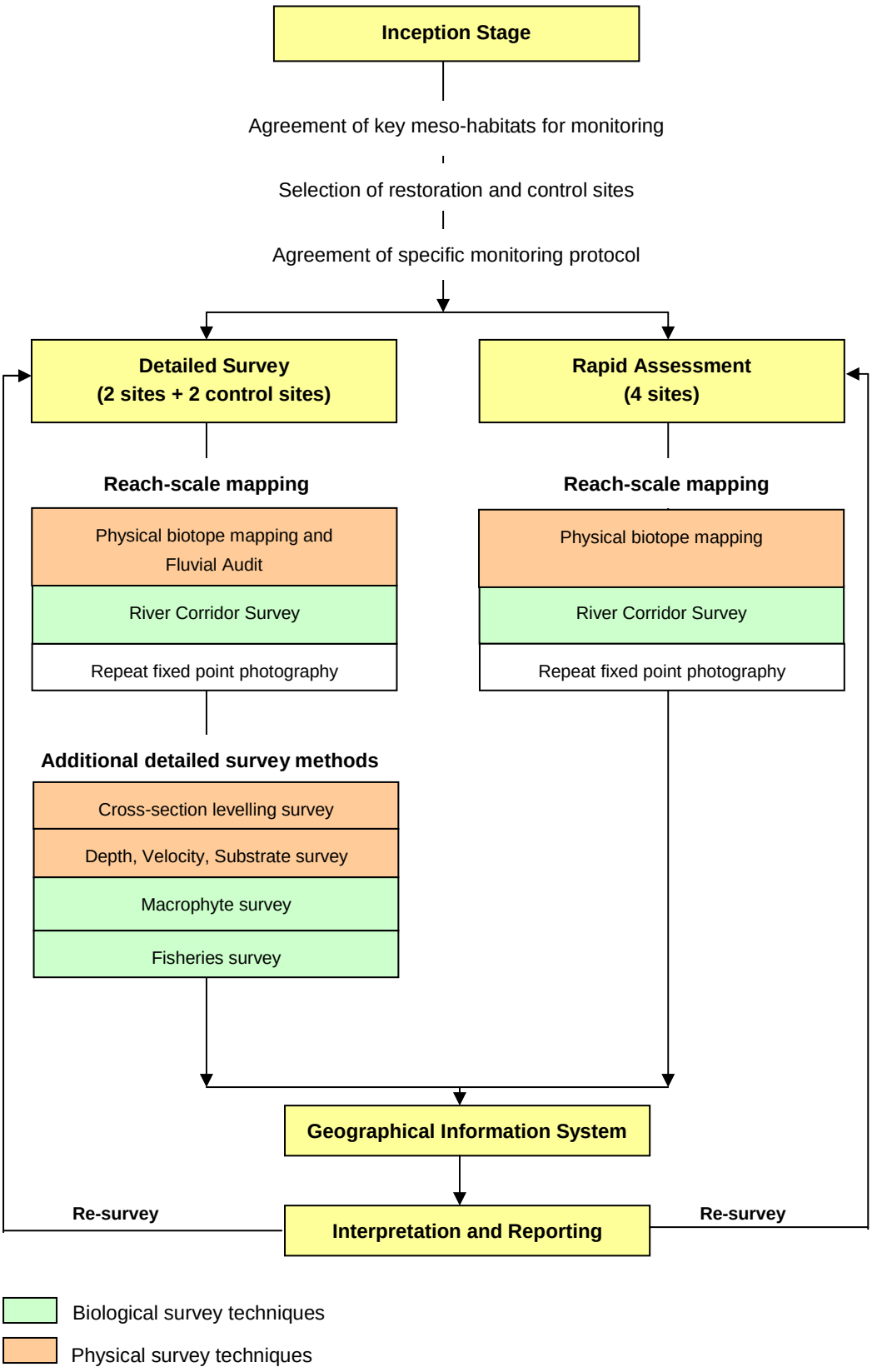
- The surveys will both provide snapshots pre- and post-restoration. It is important to recognise that there is a limitation to the comparisons that can be made over this short duration and it will not be possible to draw any conclusions regarding changes in conditions at a site pre / post-restoration.

- The relationship between physical and biological conditions will be analysed at each site. Comparisons will be made concerning the relationships identified at each site at the time of survey, taking into account other factors and processes that may influence relationships.

- The limitations of the control sites will prevent direct comparison of the restoration reaches with the control sites. The purpose of using the control site is to compare the relationship between physical and biological conditions as recorded at both sites on a given day rather than to compare the magnitude of change of either physical or biological parameters between sites. Comparisons will therefore be made between pre-restoration and post-restoration surveys at each individual site. Inference may be drawn about changes in each parameter and in the relationship between physical and biological character.

- This monitoring framework will establish a documented baseline in order that repeat surveys of both physical and biological conditions can be made over longer time periods.

Figure 2.1 **Monitoring framework for the STREAM Monitoring Project**



2.2 Changes since the pre-restoration surveys

2.2.1 Implemented river restoration works

A summary of the restoration works implemented as part of the STREAM project is provided below. More detailed information can be obtained in the bespoke design reports – please contact Natural England to obtain for further details.

Upper Woodford

The channel at Upper Woodford has been over-widened and over-deepened as a result of past river management. Subsequently, this reach exhibited uniform flow and morphological characteristics and the bed substrate was dominated by silt towards the downstream limit. The implemented restoration works aimed to demonstrate a range of bio-engineering techniques useful for the narrowing of river channels. This included the creation of a network of small island features constructed from faggots and woody debris. These 'island' features are subject to local erosion and deposition, which aims to increase habitat variation for a range of species. A 90m causeway has also been constructed in order to narrow the channel and behind it, an isolated area of stillwater fringed with emergent vegetation has been retained. There have also been large submerged 'v' profile log groynes installed to create scour and faggot bank protection in selected locations.

Seven Hatches

The channel at Seven Hatches was previously dredged which had a significant impact on physical habitat conditions. Past land drainage work had resulted in a reduction of bed level, loss of hard bed substrate, over-widening of the channel and the creation of raised flood banks, with an associated loss of hydrological connectivity with the floodplain. The implemented restoration works included the re-introduction of excavated gravel and stone bed material to reduce incision and improve hydrological connectivity. Other techniques were to narrow the channel using large poplar logs and hazel bundles to create a framework which was then filled with brush and chalk, creating a partially submerged ledge and the introduction of large woody debris to increase variable bed morphology. The erection of a fence has also stopped livestock from accessing the riverbank.

Fovant

The channel of the Nadder at Fovant was over-wide with a relatively homogenous bed and little channel vegetation. A sluice at the downstream limit of the reach was also operated in a semi-closed position during low flow periods causing impoundment of flows upstream. The implemented restoration works included selected felling of trees along the right hand bank and creation of "V" shaped groynes using these materials. In addition, it was agreed that the sluice at the downstream limit of the site would be operated in an open position to reduce upstream impoundment.

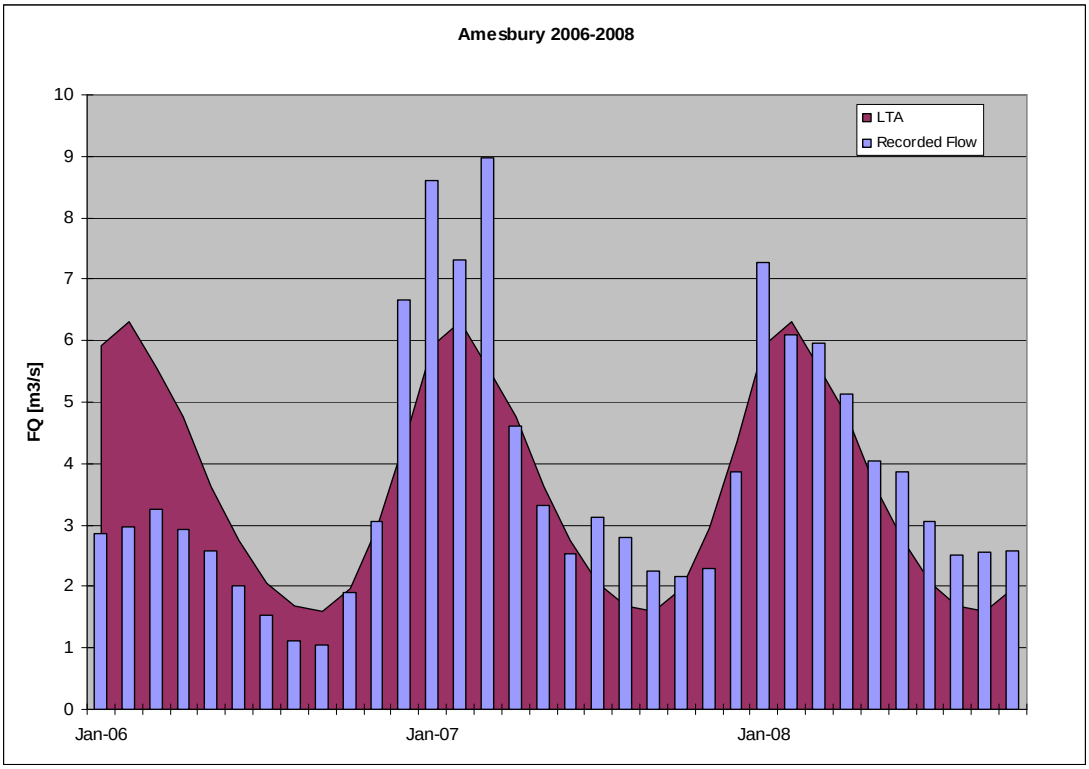
Hale

The main channel is generally over-sized at Hale due to past dredging, with deposited spoil creating a bund on right and left banks. Due to the lack of riparian shrubs and trees there is very little large woody debris present in the reach, which should be characteristic of the river at this location. The implemented restoration works included creation of a riffle feature using existing and imported gravels and construction of deflectors using large woody debris (felled trees).

2.2.2 Gauged flow data

In the period since baseline surveys were completed in 2006, flow in the upper River Avon has been high for extended periods compared to long term average. This is evidenced in gauged flow data from the Environment Agency flow gauging station at Amesbury, as summarised in **Figure 2.2.**

Figure 2.2 Recorded flow at Amesbury compared with long term average 2006-2008



The summer flow conditions in 2008 were particularly extreme and at the time of the monitoring surveys, discharge was approximately 40% greater than the long term average. The summers of 2000 and 2007 are the only other similar high flow summers since 1980. In 2008, the high summer flows coincided with a high level of weed growth, whereas in 2000 weed growth was significantly less. These differences in flow conditions between the 2006 and 2008 surveys are likely to have had a significant bearing on the monitoring findings, as discussed in subsequent sections of this report.

2.3 Realisation of the Monitoring Protocol

2.3.1 Reach-scale mapping

Reach-scale mapping of all sites was undertaken according to the monitoring protocol using Fluvial Audit, Physical Biotope Mapping, River Corridor Survey and repeat photography. Fluvial Audit sheets, Physical Biotope maps and River Corridor Survey maps have been prepared for each site and are presented in **Appendix A**. Definitions of the physical biotopes that were used during Physical Biotope Mapping are provided in Table 2.1. These definitions are consistent with those used during River Habitat Survey (RHS)

Table 2.1 Physical biotope definitions

Physical Biotope	Definition
Rapid	Boulder/cobble substrate with stepped profile. Associated with 'white water' from broken standing waves
Riffle	Shallow, fast flowing, discrete section of up to 5 channel widths in length. Unconsolidated gravel substrate with 'bubbling' unbroken standing waves.
Run	Shallow, fast flowing section, similar in character to a riffle but not a discrete feature.
Boil	Associated with upwelling flow, typically found on the outside of tight meander bends, behind structures, d/s of waterfalls
Glide	Section of smooth or rippled flow, deeper flow than a run.
Pool	Sections of deeper flow of up to 3 channel widths in length that are sustained by scour. Typically located on the outside of meander bends, downstream from bedrock outcrops (plunge pools) and weirs. Does not include impounded sections.
Ponded reach	Sections of no perceptible flow where water is impounded upstream of natural bedrock controls and weirs.
Marginal deadwater	Margins of the main channel where there is no perceptible flow.

For definitions of other terms used in the Fluvial Audit and River Corridor Survey please refer to the relevant reference sheets within **Appendix A**.

Photographic survey records are contained within **Appendix B.** In some locations, it was difficult to take photographs at exactly the same location due to significant changes that have taken place since the pre-restoration surveys and the margin of error in GPS readings. This was particularly true at Upper Woodford, where higher water levels made access along the original channel margin very difficult.

2.3.2 Macrophyte survey

Macrophyte survey was undertaken according to the monitoring protocol using the rapid assessment method identified in Monitoring ***Ranunculion fluitantis*** and ***Calitricho-Batrachion*** Vegetation Communities (**Life in Rivers, 2003**). The estimated coverage of macrophyte species within the transects surveyed is presented in **Appendix C**.

Reporting on the findings of this survey focuses on the coverage and absence of the species found during the survey. Key species are defined as species of water-crowfoot (***Ranunculus spp.***) and starwort (***Callitriche spp.***) present in the vegetation communities, for which the River Avon is designated as a Special Area of Conservation (SAC). Other key species are those identified to be of regional and local importance. Hemlock water dropwort (***Oenanthe crocata***) is defined within the River Avon SAC Conservation Strategy as of local importance (**English Nature, 2003**), while common meadow rue (***Thalictrum flavum***) is a regionally scarce species (**Pilkington, 2006 pers. comm.)**

The only negative indicator that was identified during the survey was fennel pondweed (***Potamogeton pectinatus***) and the only invasive species recorded was Himalayan Balsam (***Impatiens glandulifera***). The absence of other negative or invasive species known to be present in the Avon catchment, such as Canadian pondweed and water milfoil is therefore not commented on for each reach.

It was more difficult to undertake the macrophyte survey in 2008 in comparison with 2006 due to the higher water levels experienced. In particular, at Upper Woodford, it

was difficult for the surveyor to access the channel and wade across some transects where this was previously possible.

2.3.3 Cross-sectional levelling

Cross-sectional levelling survey was undertaken at eight cross-sections at each site according to the monitoring protocol, except at the Upper Woodford Restoration Site (UWR) where an additional ninth cross-section was surveyed. Cross-sectional levelling data is contained within **Appendix D**.

2.3.4 Depth, Velocity and Substrate (DVS) survey

Velocity readings were taken alongside the cross-sectional levelling survey of each cross-section. Due to the high flow conditions at the time of the survey and time constraints the full British Standard for measuring flow in open channels was not applied. Velocity was measured at regular 2m (sites UWC and UWR) or 1m (sites SHC and SHR) intervals across the channel (see **Appendix D**). However, since accurate measurements had already been taken to determine the cross-sectional profile, measurements of depth were not taken at the same time. Such measurements of depth would have been less accurate than those already taken of bed elevation and water depth during the cross-sectional levelling survey. The mean velocity was therefore calculated using the regularly spaced velocity readings and the cross-sectional area of flow calculated using the levelling survey data.

Measurement of bed substrate was undertaken at five locations along the cross-section according to the monitoring protocol, using the definitions provided in **Table 2.2**. The bed substrate data collected during survey is also presented in **Appendix D**.

Table 2.2 Bed substrate definitions

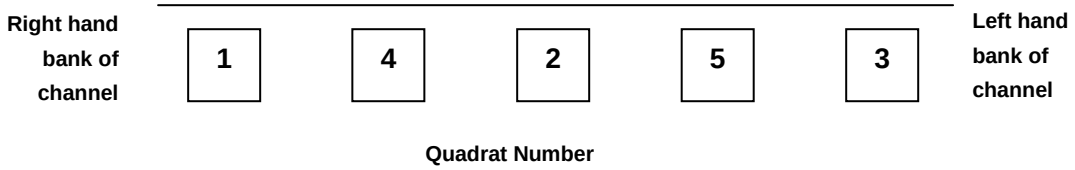
Bed Substrate	Defintion
Clay	Particle size < 0.002 mm
Silt	Particle size 0.002 – 0.063 mm
Sand	Particle size 0.063 – 2 mm
Gravel	Particle size 2 – 16mm
Pebble	Particle size 16 – 64 mm
Cobble	Particle size 64 – 256mm
Artificial	Non-natural bed material (e.g. concrete)

The term “bankfull” is referred to, in accordance with the River Habitat Survey (RHS) methodology, as the width, depth or area of the cross-sectional profile corresponding with the maximum flows that are contained within the channel itself, prior to spilling out onto the floodplain. The “cross-sectional area of flow” refers to the cross-sectional area covered by water at the time of survey.

2.3.5 Fisheries survey

The fisheries survey was undertaken based on the methods set out within the monitoring protocol. The quadrat survey of lamprey was undertaken at each site using the quadrat layout indicated in **Figure 2.2**.

Figure 2.3 Numbering scheme for quadrats used during the lamprey survey



Practical limitations encountered in the field made it necessary to make some alterations to the fisheries survey method on site. These alterations were standardised for all of the sites surveyed to maintain consistency. Some of the limitations encountered may also affect the quality of the data that could be collected. The key issues encountered are listed below and should be considered in using the data collected during the fisheries survey.

- The first run for each site was dominated by the capture of larger fish, notably trout, grayling and eels (>100g). They were captured and housed in oxygenated tanks for the remaining duration of the survey to avoid capture on subsequent runs.

- The electric field has a greater effect the larger the fish. During the first survey run, whilst large fish remained in the river, a current of 3 amps was used. Once the large fish had been removed the current was turned up to enable the capture of smaller fish. This was undertaken consistently at all sites and considered necessary as many smaller fish were otherwise not pulled in by the lower current due to the weak electric field.

- The large size and depth of the river constrained the capture of bullheads and optimum habitat was preferentially surveyed over sub-optimum habitat areas (within the same meso-habitat).

- The extensive weed cover on the river bed, particularly at Upper Woodford constrained the capture of some smaller fish species such as bullhead and salmon parr.

- As in 2006, presentation of fisheries survey data has focused on the minimum density of fish observed and the number of fish caught, including Annex II and other fish species.

- It was necessary to leave a considerable amount of time between each run to enable sediment that had been stirred up by walking in the channel to settle. This ensured that the visibility for each run remained constant.

3 DETAILED SURVEY RESULTS

3.1 Upper Woodford Control Site (UWC)

Upstream limit: 413238 137851
Downstream limit: 413181 137563
Length of site: 250m

Location:
The site is located downstream of Durnford Mill where there is a sluice and a large weir, which create rapid flow conditions immediately upstream of the study site (**Map 3.1**). The upstream boundary of the site is located where the mill leat from the mill re-enters the main channel. The downstream boundary of the site is located parallel with boundary fencing on the right hand bank.

Typical photographs:

a) 2006

b) 2008

Photo 3.1.1 - UWC MS01c: Towards the upstream end of site UWC, looking downstream.

a) 2006

a) 2008

Photo 3.1.2 - UWC MS03: Glide biotope towards middle of site UWR, looking upstream.

a) 2006

b) 2008

Photo 3.1.3 - UWC MS04c: Glide biotope towards downstream end of site UWC, looking downstream

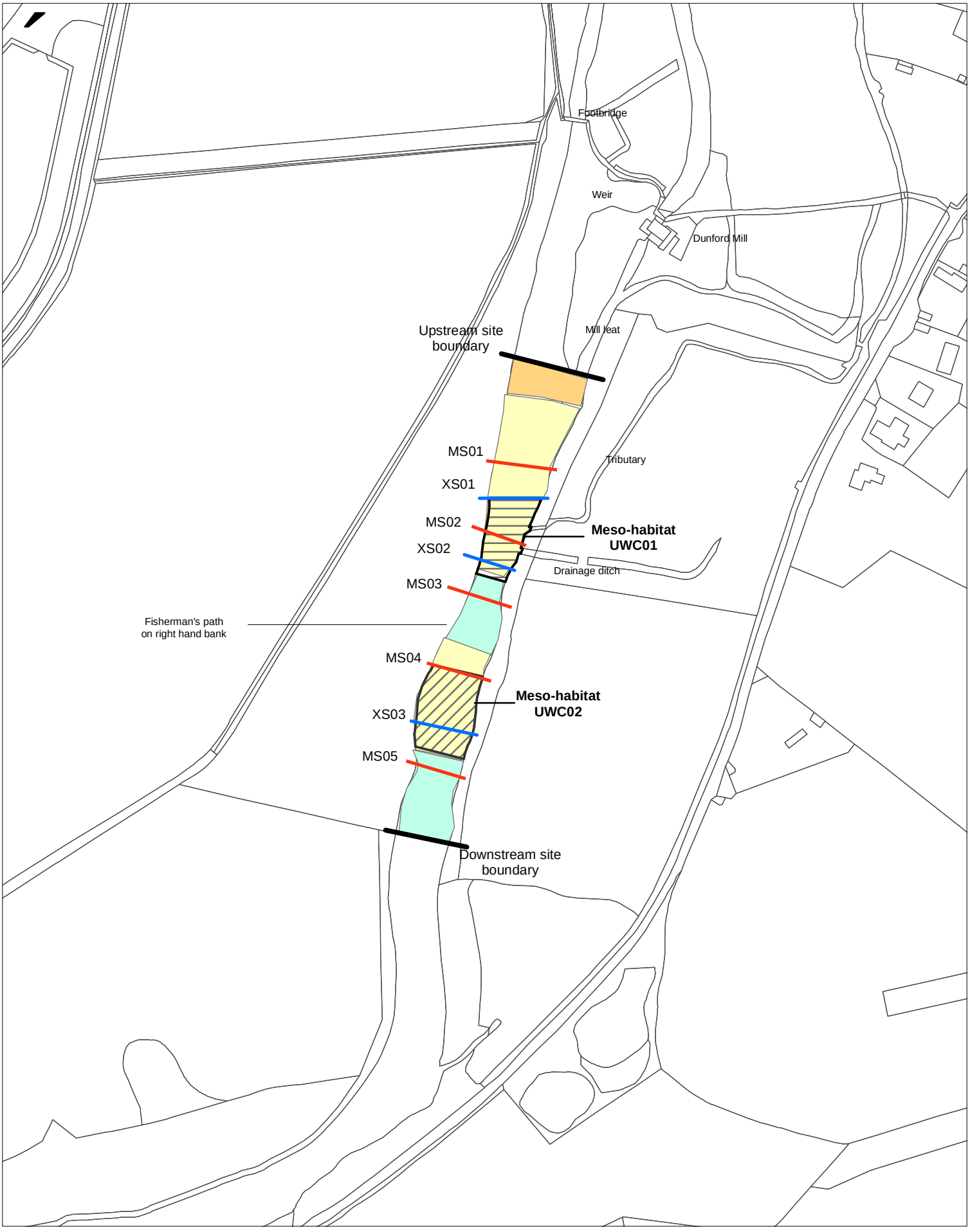
a) 2006

b) 2008

Photo 3.1.4 - UWC MS04e (2006): Run biotope towards downstream end of site UWC, looking across channel

Comparison with pre-restoration survey (2006)

Although no restoration works were undertaken within reach UWC, there are significant visual differences at the control site comparing post-restoration photographs and those taken during the pre-restoration survey. These differences largely relate to the increased discharge and higher water levels during the 2008 survey. The difference in water level is illustrated in **Photo 3.1.1a and 3.1.1b**. The fisherman's bench which was on the bank top in 2006 is in the river channel and partly submerged in 2008. Channel narrowing measures implemented prior to 2006 were also observed to be submerged and being undermined by higher flows. It was also more difficult to see gravel on the bed of the river due to the increased depth of water (**Photo 3.1.3a and 3.1.3b**).



Legend

Physical biotope

biotope

- Glide (rippled)
- Glide (slow)
- Run

Cross-section location

- Macrophyte transects (MS)
- Additional corss-sections (XS)

Fisheries meso-habitat

- UWC01
- UWC02

Title: Upper Woodford Control Site (UWC)
Physical biotopes and survey references

Project: Avon STREAM Monitoring Project

Client: Natural England

Date: 25/01/2009

Scale: 1:2,500

Map 3.1

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3.1.1 Physical Characteristics

Physical biotopes

One run and four glides were recorded within the site during the Physical Biotype Mapping survey as illustrated in **Map 3.1**. The run is a short section just downstream of the upstream site boundary and is characterised by shallow, fast flowing water. The remainder of the reach was observed as a glide, split into two slow and fast sections. These biotopes occur alternately as illustrated in **Map 3.1.** The fast flowing sections are shallower with rippled flow while the slower sections are deeper with smooth flow.

Comparison with pre-restoration survey (2006)

In 2006, a number of runs were observed within reach UWC with rippled flow and a visible gravel bed **(Photos 3.1.1a and 3.1.3a**). In 2008, at the same locations, glides were observed with rapid but smooth flow (**Photos 3.1.1b and 3.1.3b**). This difference in physical biotope is related to the increased depth of water, acting to "drown out" the run features. A similar difference was evident in runs throughout the reach.

Sediment regime

The Fluvial Audit recorded little evidence of channel adjustment through erosion or deposition (see **Appendix A**), as is often characteristic of a chalk stream. No diffuse sediment sources and no defined sediment sinks (e.g. channel deposits) were observed within the main channel. A drain enters the channel along the left hand bank at cross-section MS02 and is likely to act as a source of fine sediment. Out-flanked channel narrowing structures (spiling) were acting as a localised sediment sink by creating areas of still water. Due to higher water levels, fine sediment was also being trapped by vegetation along the channel margins.

Comparison with pre-restoration survey (2006)

The key differences noted in relation to the sediment regime are increased siltation along the channel margins due to the higher water levels and the deposition of silt behind out-flanked channel narrowing structures.

Physical channel form

Levelling survey was conducted at eight cross-sections, the locations of which are illustrated in **Map 3.1**. Cross-sections with the pre-fix "MS" are those that were also subject to macrophyte assessment (see 3.1.2). Cross-sections with the pre-fix "XS" are cross-sections located to ensure measurements were distributed throughout the site. Graphical presentation of the cross-sections is provided in **Appendix D** together with the original data. A summary of the data from 2006 and 2008 for each of the cross sections surveyed is provided in **Table 3.1**.

The channel is widest upstream of cross-section MS01, where there are two existing in-channel islands and the mill leat enters the channel (**Map 3.1**). Downstream of cross-section MS01, the channel had previously been narrowed through the use of willow spilling on both banks (see **Appendix A**).

The cross sections that were recorded as runs in 2006 were all observed as fast glides in the 2008 survey. Those cross sections situated within fast glide sections are generally wider and shallower at bankfull and therefore have a higher width:depth ratio than those situated within sections of slow glide physical biotope (**Table 3.1**). The width:depth ratio

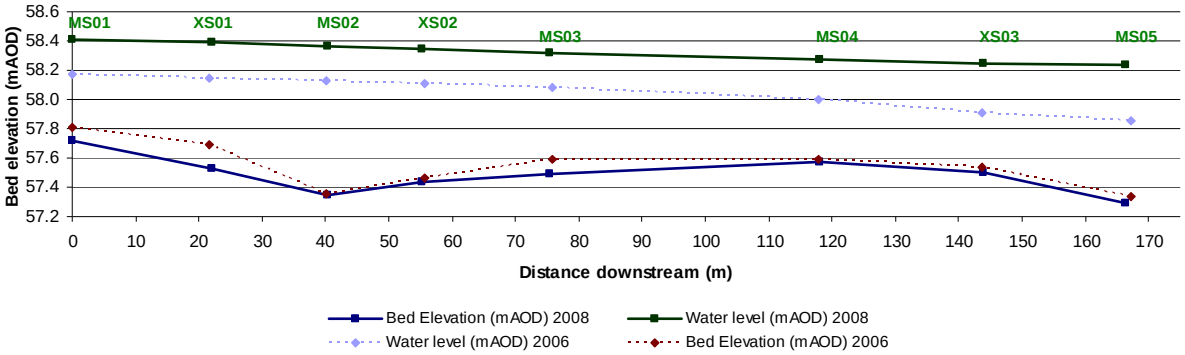
is greatest at cross sections MS01, XS01, MS04 and XS03 and these also display the lowest water depth and the greatest water width and bankfull width (**Table 3.1**).

Table 3.1 Comparison of cross-sectional summary data for 2006 and 2008

Tran-sect	Physical biotope		Bankfull width (m)		Bankfull depth (m)		Width:depth ratio		Water width (m)		Water depth (m)	
	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008
MS01	Run	Glide	38.56	38.28	0.70	0.68	55.3	56.3	33.28	36.49	0.36	0.69
Difference			**-0.30**		**-0.02**		**+1.00**		**+3.21**		**+0.33**	
XS01	Run	Glide	37.67	34.99	0.74	0.73	50.7	48.3	24.51	31.99	0.46	0.87
Difference			**-2.68**		**+0.01**		**-2.40**		**+7.48**		**+0.41**	
MS02	Glide	Glide	26.88	23.45	1.00	1.01	26.9	23.2	20.83	23.46	0.77	1.01
Difference			**-2.22**		**+0.12**		**-3.70**		**+2.63**		**+0.24**	
XS02	Glide	Glide	24.90	20.93	0.71	0.82	34.9	25.5	19.99	20.93	0.64	0.91
Difference			**-0.75**		**+0.51**		**-9.40**		**+0.94**		**+0.27**	
MS03	Glide	Glide	32.68	29.34	0.90	0.83	36.4	35.4	24.79	28.28	0.49	0.83
Difference			**-2.56**		**+0.12**		**-0.10**		**+3.49**		**+0.34**	
MS04	Run	Glide	35.10	33.45	0.65	0.69	53.8	48.3	30.44	33.45	0.41	0.70
Difference			**+0.97**		**+0.17**		**-5.50**		**+3.01**		**+0.29**	
XS03	Run	Glide	38.53	36.65	0.50	0.75	77.5	48.9	26.35	34.54	0.38	0.75
Difference			**-1.77**		**+0.32**		**+28.6**		**+8.19**		**+0.37**	
MS05	Glide	Glide	28.43	27.64	0.82	0.95	34.8	29.0	19.20	24.42	0.52	0.95
Difference			**-0.79**		**+0.13**		**-5.80**		**+5.22**		**+0.43**	
Mean			**33.91**	**30.59**	**0.75**	**0.81**	**47.8**	**39.4**	**26.83**	**29.19**	**0.50**	**0.84**
Difference			**-3.32**		**+0.06**		**-8.40**		**+2.36**		**+0.34**	

The long profile of the channel, derived using the deepest points at each of the cross-sections, is presented in **Figure 3.1**.

Figure 3.1 Long profiles derived from cross-sectional data from MS01 to MS05 in 2006 and 2008



Over a distance of 171m (between cross-section MS01 and MS05), there is a fall in bed elevation of 0.43m, corresponding to a gradient of 0.003 (**Figure 3.2**). The long profile illustrates that the channel is deepest at cross sections MS02 and MS05 which are located in the slow glide biotope sections.

Comparison with pre-restoration survey (2006)
The cross-sectional data collected in 2008 shows similar trends to those observed in 2006, with the same cross sections displaying the greatest width:depth ratio, water width and bankfull width. However, it is also possible to identify differences in the cross-sectional profiles recorded in 2006 and 2008.

There has been a decrease in bankfull width at the majority of cross-sections. This is related to increased growth and encroachment along the channel banks of marginal vegetation, as a result of wetter marginal conditions and limited access. Cross-sectional profiles have also changed in response to the undermining of previous channel narrowing measures at some locations (e.g. cross-sections XS03 and MS03) (**Appendix D**). Localised scour is evident at the base of the channel banks where higher velocities and water levels have led to flow behind the willow spiling.

There has also been an increase in bankfull depth at all cross-sections. This is in part related to increased vegetation growth at channel margins and subsequent trapping of silt, increasing the height of channel banks. Each cross section also displays slightly lower maximum bed elevation in 2008 in comparison to 2006. This may be attributable to bed scour during more frequent periods of high flow that have preceded the 2008 survey. The survey data also illustrates the effect of increased discharge within the channel, which includes an increase in both water width and water depth at every cross-section.

Boundary conditions
The channel banks are graded and are extensively obscured from view by vegetation on both banks. Where visible the banks were observed to be composed of sand/silt material. Bed substrate samples taken from the channel centre, both channel margins and intervening points (see **Table 3.3**) indicate that the dominant substrate is gravel / pebble material (2-64mm in diameter).

Gravel-sized sediment is dominant (2-16mm in diameter) in the majority of locations, although pebble-sized material (16-64mm in diameter) is dominant at XS02 (right of centre), MS03 (right of centre and centre), XS03 (centre and left of centre) and at MS02 (left margin). There is silt present in the centre of the channel within cross section XS01, at the left and right margins within cross sections MS03 and XS03 and in the left margin and centre of the channel at cross section MS05. Within cross section MS04 silt is present to the right of the channel centre. Silt occurring in the channel margins is likely to be as a result of deposition caused by the lower flow velocities found in these locations and silt towards the channel centre could be attributable to extensive weed growth which decreases the flow velocity at the river bed and causes deposition.

Comparison with pre-restoration survey (2006)
While gravel-sized sediment is dominant in both 2006 and 2008, there are less occurrences of pebble sized material and increased presence of silt substrate in 2008, particularly towards the downstream limit of the reach. The dominance of material of smaller diameter may be related to the increased depth of flow resulting in decreased shear stress and less pronounced armouring of the bed. The deposition of silt on the channel bed is likely to be encouraged by increased coverage of in-channel vegetation (see Section 3.1.2). Siltation at the channel margins was also noted behind the out-flanked channel narrowing measures (e.g. XS03, MS03).

Table 3.2 Bed substrate and flow velocities sampled at surveyed cross-sections in 2006*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Run	Silt	Gravel / **Pebble**	**Gravel** / Pebble	Gravel / **Pebble**	**Gravel** / Pebble
		0.00	0.07	0.00	0.03	0.01
XS01	Run	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble	Silt
		0.50	0.01	0.01	0.22	0.00
MS02	Glide	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Sand
		0.22	0.03	0.01	0.07	0.00
XS02	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Sand
		0.01	0.32	0.02	0.04	0.00
MS03	Glide	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble	**Gravel** / Pebble	Sand
		0.00	0.15	0.01	0.01	0.00
MS04	Run	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble
		0.00	0.05	0.03	0.23	0.07
XS03	Run	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble
		0.00	0.46	0.15	0.05	0.45
MS05	Glide	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble	**Gravel** / Pebble
		0.22	0.29	0.01	0.09	0.22

*Left and right channel margins are defined looking in a downstream direction

***Bold type** indicates whether pebble or gravel sized substrate was dominant.

Table 3.3 Bed substrate and flow velocities sampled at surveyed cross-sections in 2008*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Glide	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble
		0.214	0.276	0.298	0.291	0.397
XS01	Glide	**Gravel**/Pebble	**Gravel**/Pebble	Silt	**Gravel**/Pebble	**Gravel**/Pebble
		0.372	0.323	0.367	0.495	0.216
MS02	Glide	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Gravel/**Pebble**
		0.06	0.397	0.514	0.370	0.069
XS02	Glide	**Gravel**/Pebble	Gravel/**Pebble**	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble
		0.162	0.378	0.425	0.429	0.352
MS03	Glide	Silt	Gravel/**Pebble**	Gravel/**Pebble**	Silt	Silt
		0.015	0.108	0.443	0.352	0.300
MS04	Glide	**Gravel**/Pebble	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble
		0.130	0.216	0.469	0.429	0.032
XS03	Glide	Silt	**Gravel**/Pebble	Gravel/**Pebble**	Gravel/**Pebble**	Silt
		0.000	0.278	0.314	0.409	0.078
MS05	Glide	Silt	**Gravel**/Pebble	Silt	**Gravel**/Pebble	**Gravel**/Pebble
		0.000	0.191	0.343	0.280	0.056

*Left and right channel margins are defined looking in a downstream direction

***Bold type** indicates whether pebble or gravel sized substrate was dominant.

Velocity
Flow velocity measurement data is contained within **Appendix D** and summarised for each cross-section in **Table 3.4** which includes a comparison with the 2006 survey.

Table 3.4 Velocity summary data 2008 and comparison with 2006

Transect	Physical biotope	Cross-sectional area of flow (m^2)	Difference from 2006 (m^2)	Mean Velocity (ms^{-1})	Difference from 2006 (ms^{-1})
MS01	Glide	20.49	+9.77	0.31	+0.20
XS01	Glide	17.94	+9.10	0.39	+0.21
MS02	Glide	15.24	+5.37	0.28	+0.18
XS02	Glide	14.55	+5.07	0.36	+0.27
MS03	Glide	16.84	+6.62	0.33	+0.24
MS04	Glide	17.73	+8.49	0.24	+0.12
XS03	Glide	19.80	+11.53	0.26	+0.07
MS05	Glide	16.43	+8.46	0.20	+0.01
Mean		**17.38**	**+8.05**	**0.30**	**+0.16**

Comparison with pre-restoration survey (2006)
Higher discharge and water levels during the 2008 survey result in a greater cross-sectional area of flow at each cross section in comparison with 2006. The greatest increases in cross-sectional area of flow are at the wider cross-sections. The mean velocity at each cross section is also significantly greater with an average increase of 0.16ms^{-1}, which is related to the increase in discharge. The cross sectional area of flow is also influenced by changes in channel form. In some cross-sections (e.g. cross-sections XS03 and MS04) (**Appendix D**), undermining of previous channel narrowing measures has occurred, resulting in localised scour at the base of the channel banks and an increase in the cross sectional area of flow.

3.1.2 Biological characteristics

Vegetation structure
In-channel vegetation is present throughout the reach and consists of submerged aquatic plants, including dense, extensive areas of brook water-crowfoot (***Ranunuclus pencillatus*** spp. ***pseudofluitans***) and less dense areas of starwort (***Callitriche***).

The bank vegetation on the right hand bank consists predominantly of reed sweet grass (***Glyceria maxima***) but also present are stands of common reed (***Phragmites australis***), gipsywort (***Lycopus europaeus***), meadow sweet (***Filipendula ulmaria***), common fleabane (***Pulicaria dysenterica***), water mint (***mentha aquatica***) and great willow herb (***Epilobium hirsutum***). The left hand bank is dominated by common reed (***Phragmites australis***) with reed sweet grass (***Glyceria maxima***) at the upstream end of the site.

There is a continuous strip of riparian vegetation along both banks, which provides a buffer to surrounding landuse. The left hand bank is semi-continuously treelined, while there are isolated and set back trees on the right hand bank. The left hand bank is dominated by crack willow (***Salix fragilis)*** while the right hand bank has occurrences of ash (***Fraxinus excelsior***), grey willow (***Salix cinerea***), hybrid black poplar, sycamore, and red maple (***Acer rubrum***). Willow has been used in previous channel narrowing

measures, which were observed to be out-flanked by flows and silted, limiting vegetational growth.

Landuse consists of rough pasture and broadleaved woodland on the left hand bank and recreational use (fisherman's path, although not a public right of way) and scrub on the right hand bank.

Macrophyte coverage
A total of 56 taxa were recorded during the macrophyte assessment of the site in 2008. The locations of the five transects (MS01-MS05), selected to represent different physical biotopes, is illustrated in **Map 3.1**. Each of the transects was also subject to cross-section levelling survey (see Section 3.1.1). The species that were found to be most common at each site, with a coverage of <5 % or more (over the whole site), are listed in **Table 3.5.** A full species list is provided in **Appendix C.**

Growth of brook water-crowfoot (***Ranunuclus pencillatus*** spp. ***pseudofluitans***) is extensive along the whole reach with 75% coverage at MS04. Other key species of regional and local importance that were recorded across the site were various-leaved water-starwort (***Callitriche platycarpa***); common water-starwort (***Callitriche stagnalis***) and hemlock water dropwort (***Oenanthe crocata***).

The transition zone between the bank top of the channel and the channel bed was previously extended through channel narrowing using willow spilling. These features were submerged in many instances because of the high water levels at the time of survey and have been outflanked.

The site contains no negative indicator species or invasive species.

Comparison with pre-restoration survey (2006)
In-channel vegetation was more extensive in 2008 than in 2006. Coverage of brook water-crowfoot (***Ranunuclus pencillatus*** spp. ***pseudofluitans***) has increased from an estimated 40% coverage over the whole site to 55%. The most extensive coverage remains at cross section MS04, although increased coverage was observed at all cross-sections. Horned pondweed (***Zannichellia palustris***) was previously subject to grazing by swans and may be reduced in its coverage because of this.

The continuous riparian buffer strip remains on both banks with similar diversity of trees observed. There is a much wider marginal zone of wetland vegetation along the right hand bank, although this consists of larger stands of species that were already observed in 2006 (e.g. reed sweet grass and common reed). Overall, fewer taxa were observed in 2008 than in 2006 (56 compared with 66). This may be related to the wetter marginal conditions and undermining of the channel narrowing measures which have reduced the hydrological transition gradient and may have provided less suitable habitat for some species requiring drier conditions.

Table 3.5 Macrophyte species coverage (%) within site UWC

Latin Name	Common Name	Macrophyte coverage (%)											
		MS01		MS02		MS03		MS04		MS05		Whole site	
		2006	2008	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008
		Run	Glide	Glide	Glide	Glide	Glide	Run	Glide	Glide	Glide		
Key species													
Ranunculus penicillatus spp. Pseudofluitans	Brook water-crowfoot	40	**45**	30	**55**	40	**50**	70	**75**	40	**50**	40	**55**
Callitriche platycarpa	Various-leaved water-starwort	<1	**<5**	<1	**<5**	<1	**<1**	<1	**<1**	<1	**<1**	<1	**<5**
Callitriche stagnalis	Common water-starwort	<1	**<1**	<5	**<5**	<1	**<5**	<5	**<5**	<1	**<1**	<1	**<5**
Oenanthe crocata	Hemlock water dropwort	<1	**<1**	<1	**<5**	<1	**<1**	<5	**<5**	<5	**<1**	<5	**<5**
Species present in <5 % (in 2006 or 2008)													
Glyceria maxima	Reed sweet-grass	<5	**<5**	<1	**5**	10	**5**	10	**10**	20	**10**	10	**10**
Epilobium hirsutum	Great willowherb	<1		<5		<5	**<1**	<5	**<5**	<5	**<1**	<5	**<5**
Filipendula ulmaria	Meadowsweet	<1	**<1**	<5	**<5**	<1	**<1**		**<1**	<1		<5	**<5**
Lycopus europaeus	Gypsywort	<5	**<5**			<1	**<1**			<1		<5	**<5**
Phalaris arundinacea	Reed canary-grass	<5		<1					**5**	<1		<5	**<1**
Phragmites australis	Common reed			<5	**<5**	10	**<5**	<1	**<5**	10	**15**	<5	**<5**
Salix cineria	Grey willow	<5	**<5**	<5	**<1**	<5	**<5**	10		<5	**5**	<5	**<5**
Solanum dulcamara	Bittersweet	<5	**<1**	<5	**<5**	<1		<5	**<5**	<5	**<5**	<5	**<5**
Symphytum officinale	Common comfrey	<1	**<1**	<1	**<1**	<1	**<1**	<5				<5	**<1**
Urtica dioica	Common nettle	<1		<1		<5	**<1**	<5		<5		<5	**<1**
Calystegia sepium	Hedge bindweed						**<1**		**<5**		**<1**		**<5**
Veronica anagallis-aquatica	Blue water-speedwell	<1	**<5**	<1	**<1**	<5	**5**	10	**<5**			<5	**<5**
Zannichellia palustris	Horned pondweed	<5	**>1**	<1		10	**<1**	<5	**<1**	<5	**<1**	<5	**<1**
Negative indicators													
None													
Invasive species													
None													
No of Taxa Recorded		**36**	**33**	**29**	**23**	**31**	**32**	**25**	**21**	**24**	**26**	**66**	**56**

Fisheries survey

Electro-fishing was undertaken at two sites, the locations of which are indicated in **Map 3.1.** The total number of each fish species caught at each site during the electrofishing survey, including the Annex II species for which the Avon SAC is designated, are indicated in **Figure 3.2** (2006) and **Figure 3.3** (2008).

Figure 3.2 **Number of fish caught during electrofishing of sites UWC01 and UWC02 in 2006**

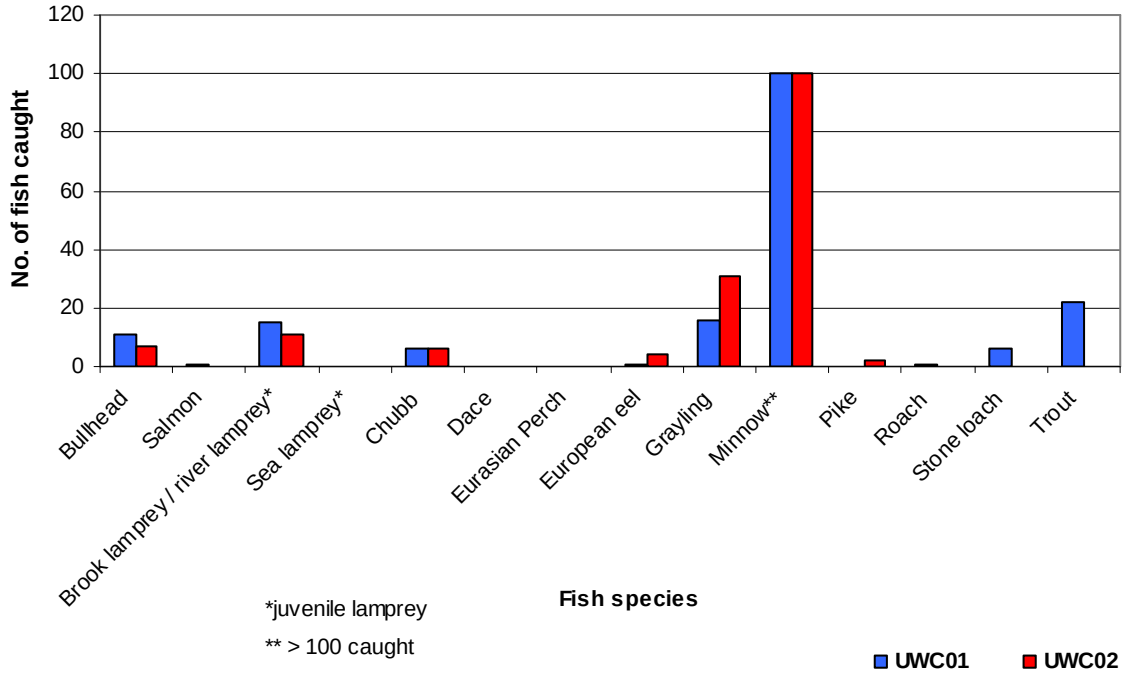
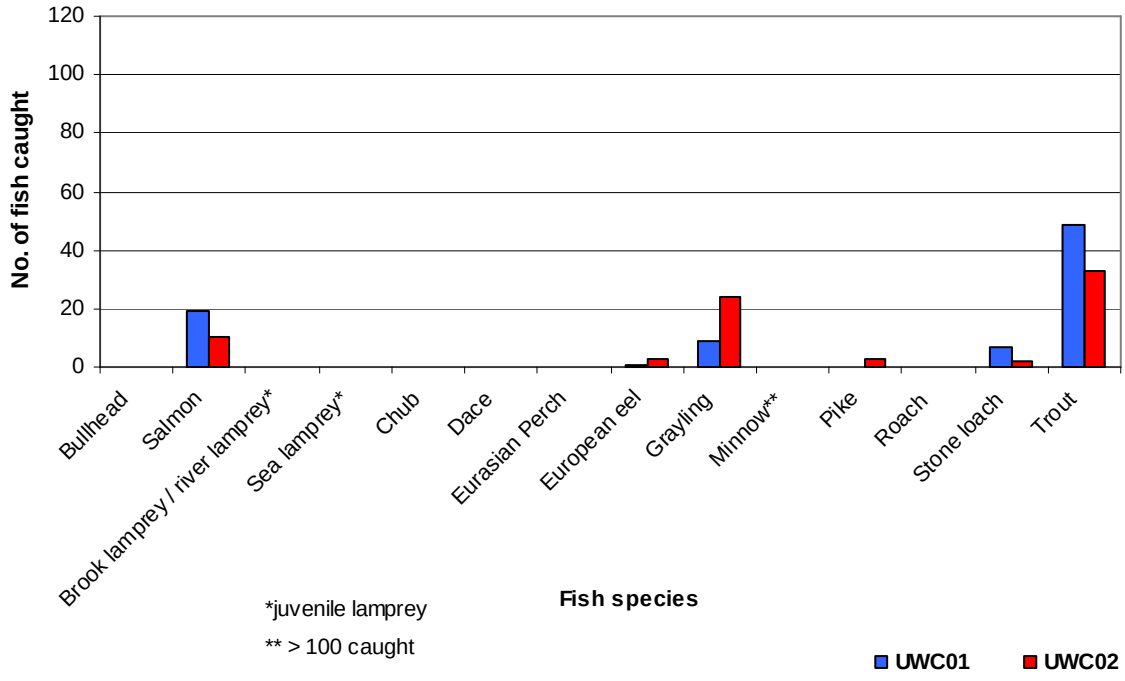


Figure 3.3 **Number of fish caught during electrofishing of sites UWC01 and UWC02 in 2008**



Within meso-habitat UWC01 19 salmon parr, one eel, nine grayling, seven stone loach and 49 trout were caught. Within UWC02, ten salmon parr, three eels and 24 grayling were caught. No bullhead or brook lamprey were caught in either meso-habitat in 2008.

Comparison with pre-restoration survey (2006)

The range and number of fish caught in 2008 varies significantly when compared with findings from 2006. Key differences include an increase in the number of salmonids and grayling, and a decrease in bullhead, lamprey and minnows.

In 2008, the total number of salmon caught at the two meso-habitats increased from one in 2006 to 29 in 2008; and the number of trout from 21 to 49. The increased number of salmonids and grayling may be related to greater flow velocities experienced in 2008, as these species require swift clear water. However, several other wider catchment conditions (such as water quality and prey availability) also influence fish populations, particularly of migratory fish.

In 2008, no bullhead, brook lamprey or minnows were caught compared to 13, 25 and >100 respectively in 2006. Bullhead thrive in swift to moderate clear flows, dominated by gravel and with macrophyte coverage of less than 40%. The reduction in the number of bullhead may be related to increased coverage of in-channel vegetation and associated silt deposits. Trout predation is also a key threat to bullhead, though other predators include pike and eel. Lamprey ammocoetes require shallow waters with low water velocity, and the presence of organic detritus and/or plant material. Minnows are also typically found in shallow waters with a sandy or gravelly bottom. The higher flow velocities and depth of flow experienced in 2008 together with the increase in silt may therefore have made habitat conditions less suitable for lamprey and minnows.

3.1.3 Summary of physical and biological relationships

- Despite there being no intervention within this reach between 2006 and 2008, key differences were observed between the two surveys undertaken. The majority of these differences are likely to be related to higher discharges and water levels experienced both during the survey and throughout 2007 and 2008.

- As a result of increased water levels, a glide physical biotope was observed throughout the reach in 2008, rather than the alternating run and glide sequence observed in 2006.

- Minor cross-sectional changes have occurred in association with increased marginal vegetation growth along the channel banks, and undermining of channel narrowing measures in the channel.

- Bed elevation has decreased at each cross section. This may be due to increased bed scour during high flows.

- The dominant substrate is now gravel rather than pebble sized material and there are more areas of silt. This may be due to reduced armouring resulting from increased flow depth and trapping of finer material by in-channel vegetation.

- Greater coverage of ***Ranunculus pencillatus*** spp. ***pseudofluitans*** was observed throughout the reach.

- Greater numbers of salmonids and grayling but no bullhead, brook lamprey or minnows were caught in 2008 compared with 2006. This is likely to reflect changes in flow velocities and water depth making physical habitat conditions more suitable for rheophilic fish species that prefer fast flowing water.

3.2 Upper Woodford Restoration Site (UWR)

Upstream limit: 413181 137563
Downstream limit: 413067 137896
Length of site: 734m

Location:
The site is located downstream of the boundary fencing on the right hand bank. A mown fisherman's path exists along the right hand bank. The downstream boundary of the site is at the boundary fencing on the right hand bank, upstream of The Bridge Inn public house.

Typical photographs:

a) 2006 **b) 2008**

Photo 3.2.1 - UWR01-MS01c: Glide biotope at upstream end of site UWR, looking downstream.

a) 2006 **b) 2008**

Photo 3.2.2 - UWR01-MS02c: Upstream end of site UWR, looking downstream.

a) 2006

b) 2008

Photo 3.2.3 - UWR01-MS04a: Glide biotope at downstream end of site UWR looking upstream.

a) 2006

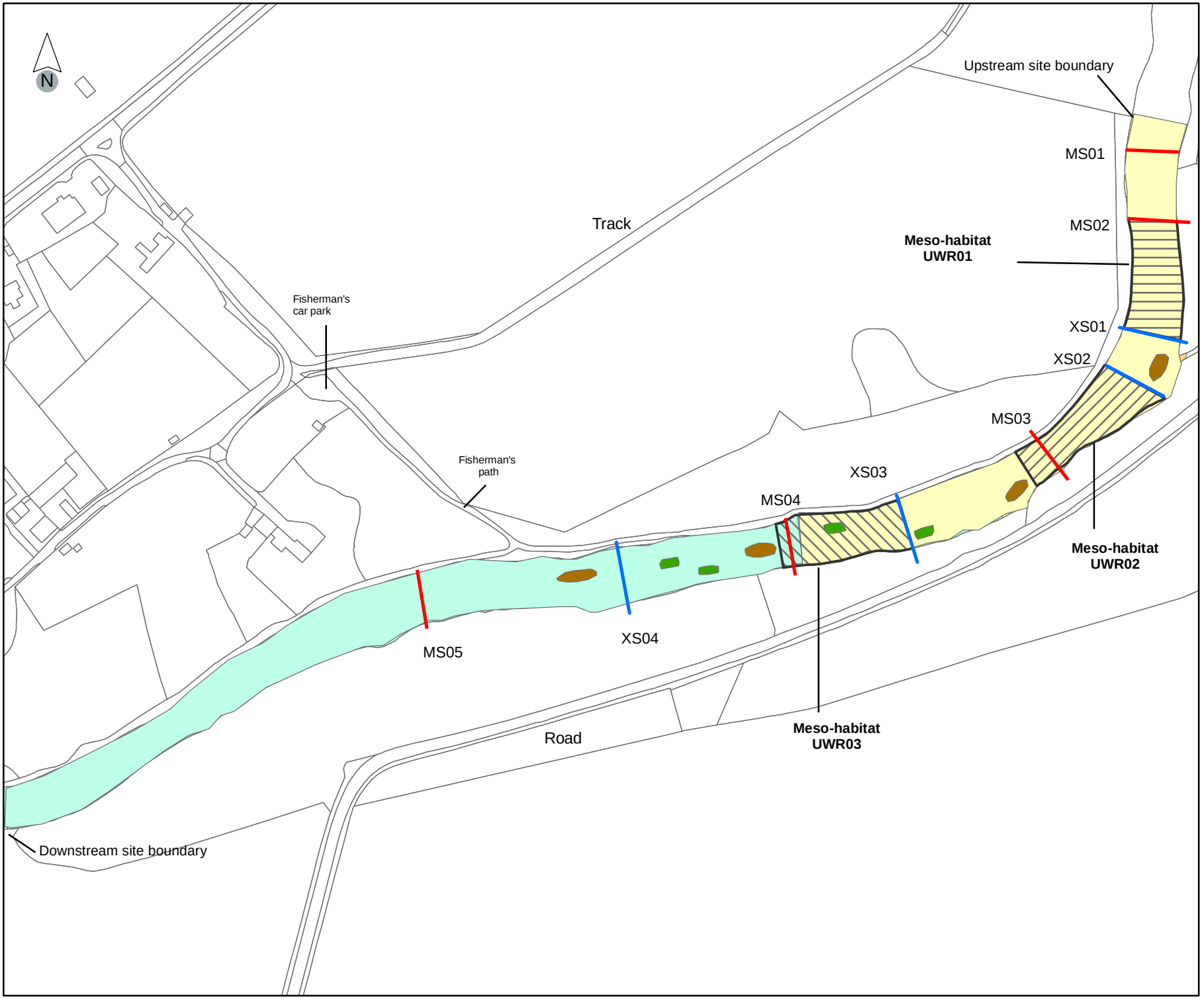
b) 2008

Photo 3.2.4 UWR01-MS05e: Glide biotope at downstream end of site UWR looking upstream.

Comparison with pre-restoration survey (2006)

There are significant differences at the restoration site comparing post-restoration photographs and those taken during the pre-restoration survey. Several in-channel islands and marginal 'D' shapes formed of brushwood have been installed downstream of cross-section XS01. Four islands were present at the time of the previous survey in 2006, and an additional five have been constructed (e.g. **Photo 3.2.3b).** Channel narrowing has also been undertaken downstream of the former fishing platform on the right hand bank, which is itself submerged and also vegetated and acting to narrow the channel.

Another notable visual difference is the increase in marginal wetland vegetation, as particularly evident in comparing **Photos 3.2.1a** and **3.2.1b.** These differences relate to increased discharge and water levels in the two year period preceding the 2008 survey. The difference in water level is illustrated particularly clearly in **Photos 3.2.2a** and **3.2.2b** where the bed of the river is less visible in 2008.



Legend

Physical biotope

- Glide (rippled)
- Glide (laminar)
- Existing Islands
- New islands

Cross-section locations

- Macrophyte transects (MS)
- Additional cross-sections (XS)

Fisheries meso-habitat

- UWR01
- UWR02
- UWR03

Title:
Upper Woodford Restoration Site (UWR)
Physical biotopes and survey references.

Project:
Avon STREAM Monitoring Project

Client:
Natural England

Date:
25/01/2009

Scale:
1:2,500

Map 3.2

3.2.1 Physical Characteristics

Physical biotopes

One glide was recorded within the site during the physical biotope mapping survey although the speed of flow varied within the reach. At the upstream end of the site the glide is fast flowing with areas of eddying current towards the left hand bank and a clean gravel bed substrate. Approximately half way along the reach, at the third original island, flow becomes uniformly laminar and increasingly slow as the channel becomes deeper and wider with evidence of impoundment (**Map 3.2**).

Comparison with pre-restoration survey (2006)

In 2006, the reach was divided into two rippled glides and a run at the upstream end of the site with a long stretch of laminar glide downstream of the second existing island. In 2008, although no run was observed, flow remained fast flowing and rippled for a greater extent downstream with a shorter section of uniformly laminar and impounded flow. These differences in observed physical biotopes are due to a combination of the restoration works, differences in flow conditions between the surveys and potentially differences in the level of impoundment from the structure downstream at Heale House. It is not possible to identify the influence of the restoration works themselves as the increased discharge and water levels have a strong influence on physical biotopes, as illustrated by the differences observed at the control site.

Sediment regime

The Fluvial Audit recorded no evidence of natural channel adjustment through erosion (see **Appendix A**). Localised fine sediment sourcing is occurring from the right hand bank as a result of access to the channel for fishing purposes. A drain entering the channel from the left hand bank at the meander bend also acts as a source of fine sediment. Deposition of silt was observed at the channel margins at the upstream end of the site and on the channel bed downstream of XS03. The depth of silt increases with distance downstream as the channel becomes deeper and more impounded.

Comparison with pre-restoration survey (2006)

The key difference noted in relation to the sediment regime is increased siltation along the channel margins, particularly along the right hand bank. This is due to higher water levels and subsequent increased growth of marginal vegetation, which is acting to trap fine sediment.

Physical channel form

Levelling survey was conducted at nine cross-sections, the location of which is illustrated in **Map 3.2**. Summary data for each of the cross-sections surveyed and a comparison with the 2006 survey is provided in **Table 3.6.** Graphical presentation of the cross-sections is provided in **Appendix D** together with the original data.

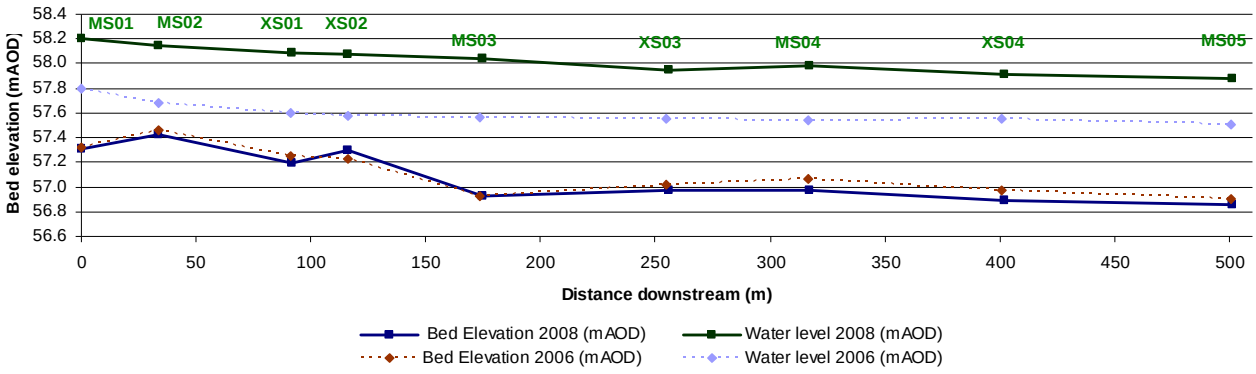
The channel is wide throughout the reach with sections of over 30m at both the upstream (XS01) and downstream (XS04) ends of the site. The bankfull depth is lowest at the upstream end of the reach (MS01, MS02, XS01 and XS02) and these sections consequently have a higher width:depth ratio (**Table 3.6**). Water depth is also generally lower and over a greater width within these sections of the site.

Table 3.6 Cross-sectional summary data

Transect	Physical biotope		Bankfull width (m)		Bankfull depth (m)		Width:depth ratio		Water width (m)		Water depth (m)	
	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008
MS01	Glide	Fast Glide	20.51	20.90	0.76	0.89	26.9	23.5	16.68	20.90	0.47	0.89
Difference			**0.39**		**0.13**		**-3.40**		**4.22**		**0.42**	
MS02	Run	Fast Glide	26.03	26.31	0.67	0.72	38.6	36.5	24.36	26.31	0.23	0.72
Difference			**0.28**		**0.05**		**-2.10**		**1.95**		**0.49**	
XS01	Run	Fast Glide	32.18	33.64	0.77	0.90	41.8	37.6	26.10	33.64	0.35	0.89
Difference			**1.46**		**0.13**		**-4.20**		**7.54**		**0.54**	
XS02	Run	Fast Glide	27.78	27.79	0.73	0.79	38.1	35.3	22.60	27.79	0.34	0.79
Difference			**0.01**		**0.06**		**-2.80**		**5.19**		**0.45**	
MS03	Glide	Fast Glide	21.15	22.60	1.01	1.11	20.9	20.4	16.82	22.60	0.63	1.11
Difference			**1.45**		**0.10**		**-0.50**		**5.78**		**0.48**	
XS03	Glide	Fast Glide	29.10	27.89	0.88	0.98	33.2	28.5	22.92	27.89	0.53	0.98
Difference			**-1.21**		**0.10**		**-4.70**		**4.97**		**0.45**	
MS04	Glide	Fast Glide	22.62	23.41	0.94	0.98	24.0	23.1	20.76	22.35	0.48	1.00
Difference			**0.79**		**0.04**		**-1.10**		**1.59**		**0.52**	
XS04	Glide	Slow Glide	30.24	30.39	1.03	1.01	29.9	30.2	22.87	30.39	0.58	1.02
Difference			**0.15**		**-0.02**		**0.30**		**7.52**		**0.56**	
MS05	Glide	Slow Glide	24.96	19.73	0.92	1.02	27.1	19.4	19.42	19.73	0.61	1.03
Difference			**-5.23**		**0.10**		**-7.70**		**0.31**		**0.42**	
Mean			**26.06**	**25.85**	**0.86**	**0.93**	**31.1**	**28.3**	**21.39**	**25.73**	**0.47**	**0.94**
Difference			**-0.21**		**0.07**		**-2.80**		**4.34**		**0.47**	

The long profile of the channel, derived using the deepest points at each of the cross-sections, is presented in **Figure 3.4**.

Figure 3.4 Long profiles derived from cross-sectional data from MS01 to MS05 in 2006 and 2008



Over a distance of 506m (between cross-section MS01 and MS05), there is a fall in bed elevation of 0.46m (a gradient of 0.001). The long profile illustrates that the channel is generally deeper towards the downstream end of the reach downstream of MS03.

Comparison with pre-restoration survey (2006)

The cross sectional data collected in 2008 shows similar trends to those observed in 2006 with the same cross sections (MS02, XS01 and XS02) displaying the greatest width:depth ratio, water width and bankfull width. There is also little difference in bankfull depths. However, it is also possible to identify differences in the cross-sectional profiles recorded in 2006 and 2008.

Some cross-sections show increased bankfull width (e.g. MS03). This may be related to localised alteration of the profile resulting from the installation of "D" shapes within the channel, and localised increase in weed growth. The profile of cross-section XS04 is significantly altered and likely to be related to the construction of mid-channel islands upstream. A raised margin is evident along the right hand bank in several of the 2008 cross-sections (but not in 2006) and is associated with increased marginal vegetation growth. Increased marginal vegetation growth is also evident at MS05 resulting in reduced bankfull width.

The water width and water depth is greater at every cross section in 2008, as a result of higher discharge and water levels at the time of survey. Although there is little difference in the bed long-profile, the gradient of the water surface is more constant throughout the reach. This reflects a reduced influence of impoundment during such high flow events (the hatches at Heale House are also likely to be opened further under such conditions).

Boundary conditions

The channel banks are shallow ending in a vertical face. The bank is also reinforced semi-continuously by wooden toe boarding along the left hand bank. Where visible the banks are composed of sand/silt material.

Bed substrate samples taken from the channel centre, both channel margins and intervening points (see **Table 3.8**) indicate that the dominant substrate is gravel / pebble material (2-64mm in diameter) although in several areas a silt substrate was evident.

Gravel-sized sediment is dominant (2-16mm in diameter) in the majority of locations, although pebble-sized material (16-64mm in diameter) is dominant towards the left of the channel in cross section MS01. Silt is found at the channel margins throughout the reach (**Table 3.8**). This is associated with trapping of silt by marginal vegetation, deposition in the lee of channel "D" shapes. The presence of silt within section MS01 is likely to be related to high cover of in-channel trapping fine sediment.

Comparison with pre-restoration survey (2006)

While gravel-sized sediment is dominant in both 2006 and 2008, there is greater presence of silt, particularly towards the channel margins in 2008. This is likely to be due to lower flow velocities, the presence of marginal structures and more extensive marginal vegetation. In 2008, increased gravel was observed in the centre of the channel. This is likely to be due to the higher flow velocities and reduced impact of impoundment during the 2008 survey, resulting in transport of fine material further downstream.

Table 3.7 Bed substrate and flow velocities sampled at surveyed cross-sections in 2006*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Glide	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble
		0.58	0.17	**0.06**	**0.02**	**0.01**
MS02	Run	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble
		0.13	0.34	0.35	0.32	0.00
XS01	Run	**Gravel** / Pebble	**Gravel** / Pebble	Sand	Sand	Sand
		0.16	0.21	0.15	0.10	0.00
XS02	Run	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Sand	**Gravel** / Pebble
		0.03	0.19	0.15	0.04	**0.00**
MS03	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble
		0.01	0.17	0.18	0.15	0.00
XS03	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.07	0.01	0.12	0.01
MS04	Glide	Silt	**Gravel** / Pebble	Silt	**Gravel** / Pebble	Silt
		0.01	0.05	0.04	0.06	0.00
MS05	Glide	Silt	Silt	Silt	Silt	Silt
		0.01	0.02	0.04	0.05	0.00

*Left and right channel margins are defined looking in a downstream direction

Bold type indicates whether pebble or gravel sized substrate was dominant.

Table 3.8 Bed substrate and flow velocities sampled at surveyed cross-sections in 2008*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Glide	**Gravel**/Pebble	Silt	Silt	Gravel/**Pebble**	Gravel/**Pebble**
		0.307	0.276	0.390	0.454	0.148
MS02	Glide	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble
		0.031	0.268	0.324	0.371	0.013
XS01	Glide	Silt	**Gravel**/Pebble	**Gravel**/Pebble	Silt	Silt
		0.365	0.312	0.177	0.250	0.022
XS02	Glide	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Silt	**Gravel**/Pebble
		0.066	0.378	0.347	0.212	0.074
MS03	Glide	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Silt
		0.426	0.431	0.399	0.176	0.015
XS03	Glide	Silt	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble
		0.000	0.015	0.319	0.290	0.144
MS04	Glide	Silt	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble
		0.000	0.268	0.324	0.371	0.013
MS05	Glide	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Silt
		0.000	0.201	0.235	0.212	0.183

*Left and right channel margins are defined looking in a downstream direction

Bold type indicates whether pebble or gravel sized substrate was dominant.

Velocity

Flow velocity measurement data is contained within **Appendix D** and summarised for each cross-section in **Table 3.9**.

Table 3.9 Velocity summary data 2008 and comparison with 2006 for site UWR

Transect	Physical biotope	Cross-sectional area of flow (m^2)	Difference from 2006 (m^2)	Mean Velocity (ms^{-1})	Difference from 2006 (ms^{-1})
MS01	Glide	13.73	7.49	0.30	0.14
MS02	Glide	15.47	10.76	0.24	-0.05
XS01	Glide	22.54	15.42	0.24	0.11
XS02	Glide	19.44	13.26	0.24	0.10
MS03	Glide	16.23	9.10	0.29	0.16
XS03	Glide	20.59	11.60	0.18	0.11
MS04	Glide	19.35	10.47	0.24	0.20
XS04	Glide	21.27	11.99	0.21	n/a (not measured 2006)
MS05	Glide	17.11	7.85	0.17	0.14
Mean		**18.41**	**10.88**	**0.21**	**0.10**

Comparison with pre-restoration survey (2006)

Higher discharge and water levels during the 2008 survey result in a greater cross-sectional area of flow at each cross section in comparison with 2006. The greatest increases in cross-sectional area of flow are at the wider cross-sections. The mean velocity at each cross section is also greater with the exception of MS04, and is more constant throughout the reach. This reflects the reduced influence of downstream impoundment and the higher discharge and water levels experienced in 2008.

3.2.2 Biological characteristics

Vegetation structure

In-channel vegetation is present throughout the site and is dominated by extensive coverage of brook water crowfoot (***Ranunculus penicillatus*** spp. ***pseudofluitans).*** Fennel pondweed (***Potamogeton pectinatus***) is also present at cross section MS05 although not to a great extent. In-channel vegetation is subject to limited grazing by swans.

Several marginal "D" shapes have been installed along both channel banks. The "D" shapes located upstream of cross-section MS03 were observed to be unvegetated, which may be due to high water levels and siltation of the structures since their installation.

The riparian zone on the right hand bank is dissected by a mown fisherman's path. The marginal fringes of both banks contain reed sweet grass (***Glyceria maxima***), greater pond sedge (***Carex riparia***) and common reed (***Phragmites australis***). Common reed was dominant on the left hand bank. Also present on the left hand bank is the common nettle (***Urtica dioica***) and reedmace (***Typha latipholia***). Whilst reed-canary grass (***Phalaris arundinacea***) and reed sweet grass (***Glyceria maxima***) was dominant on the right hand bank. The survey was undertaken from the right hand bank, and recorded

water mint (***Mentha aquatica***), purple loosestrife (***Lythrum salicaria***), branched bur-reed (***Sparganium emersum***) and great willow herb (***Epilobium hirsutum***).
There is a continuous riparian buffer strip along both banks. The left hand bank is semi-continuously treelined, while there are isolated and set back trees on the right hand bank. The dominant species on both banks is crack willow (***Salix fragilis)*** with occasional alders (***Alnus glutinosa***) and a poplar at the downstream end of the site on the left hand bank.

Landuse consists of broadleaved woodland on the left hand bank and recreational use (fisherman's path), unimproved grassland, wetland and scrub on the right hand bank.

Macrophyte coverage
A total of 55 taxa were recorded during the macrophyte assessment of the site. The locations of the 5 transects surveyed (MS01-MS05) were selected to represent different physical biotopes (see **Map 3.2**). Each transect was also subject to cross-section levelling survey (see Section 3.2.1).

Key species and those species that there were found to be most common within the site, with a coverage of <5 % or more, are listed in **Table 3.9.** The site contains one negative indicator species (***Potomageton pectinatus***), which is only present in the lower reaches. No invasive species were observed during the survey.

Growth of brook water-crowfoot (***Ranunculus penicillatus spp. pseudofluitans***) is extensive at the upstream end of the site (MS01 and MS02) and horned pondweed (***Zannichellia palustris***) is also present at MS02, MS03 and MS04. Observation of the presence and coverage of other macrophytes at MS05 was limited by the lack of visibility of the channel bed and depth of flow.

Comparison with pre-restoration survey (2006)
In-channel vegetation was more extensive in 2008 than in 2006, with an increase in the coverage of brook water-crowfoot (***Ranunuclus pencillatus*** spp. ***pseudofluitans***) at all transects. The greatest difference is at cross section MS02 where coverage has increased from less than 5% to 50%. The extent of this species has also spread downstream to MS05. Horned pondweed (***Zannichellia palustris***) was previously subject to grazing by swans and may be reduced in its local coverage at some transects because of this.

The continuous riparian buffer strip remains on both banks with similar diversity of trees observed, although selected trees have been removed as part of the restoration works. There is a much wider marginal zone of wetland vegetation along the right hand bank, although this consists of larger stands of species that were already observed in 2006 (e.g. reed sweet grass and common reed). Overall, fewer taxa were observed in 2008 than in 2006 (55 compared with 88). This may be related to the wetter marginal conditions which may have provided less suitable habitat for some species requiring drier conditions.

Table 3.10 Macrophyte species coverage (%) within site UWR

Latin Name	Common Name	Macrophyte coverage (%)											
		MS01		MS02		MS03		MS04		MS05		Whole site	
		2006	2008	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008
		Glide	Glide	Run	Run	Glide	Glide	Glide	Glide	Glide	Glide		
Key species													
Ranunculus penicillatus spp. Pseudofluitans	brook water-crowfoot	40	**65**	<5	**50**	10	**10**	<1	**15**		**5**	<5	**30**
Callitriche platycarpa	various-leaved water starwort		**<5**	<1	**<5**	<1	**<1**		**<5**			<1	**<5**
Callitriche stagnalis	common water starwort	<1		<1	**<1**			<1				<1	**<1**
Oenanthe crocata	hemlock water dropwort		**<1**							<1		<1	**<1**
Species present in <5 %													
Carex riparia	greater pond sedge				**<1**	10	**10**		**<5**	10	**<10**	20	**10**
Epilobium hirsutum	great willow herb	<5	**<1**	10	**<1**			<5	**<1**	<1		<5	**<1**
Filipendula ulmaria	meadow sweet	<1		<1	**<1**				**<1**	<1		<5	**<1**
Glyceria maxima	reed sweet grass				**5**				**<5**			<5	**<5**
Lythrum salicaria	purple loosestrife		**<1**	<5	**<1**				**<5**	<1	**<1**	<5	**<5**
Phalaris arundinacea	reed-canary grass	<5	**10**	10	**10**	10	**10**	<5	**<5**	<1	**<1**	<5	**<5**
Phragmites australis	common reed		**10**	10	**10**	<5	**<5**					<5	**<5**
Pulicaria dysenterica	common fleabane	<5	**<1**	<5	**<1**	<1	**<1**	<5	**5**	<1	**<1**	<5	**<5**
Salix cinerea	grey willow		**<5**		**<1**						**<1**	<5	**<5**
Sparganium erectum	branched bur-reed			<1		<5	**<5**	<1			**<5**	<5	**<5**
Symphytum officinale	common comfrey	<5						<1	**<1**	<1		<5	**<1**
Urtica dioica	common nettle	<5	**<1**	<5						<1	**<1**	<5	**<1**
Zannichellia palustris	horned pondweed	30	**<1**	10	**10**	10	**10**		**20**		**5**	<5	**10**
Negative indicators													
Potamogeton pectinatus	fennel pondweed									<1	**<5**	<1	**<1**
Invasive species													
No invasive species												<1	
No of Taxa Recorded		**27**	**22**	**33**	**30**	**18**	**18**	**23**	**23**	**27**	**18**	**88**	**55**

Fisheries survey

Electro-fishing was undertaken at three sites, the location of which is indicated in **Map 3.2.** The total number of each fish species caught at each site during the electrofishing survey, including the Annex II species for which the Avon SAC is designated, is indicated in **Figure 3.6**.

Figure 3.5 Number of fish caught during electofishing of sites UWR01, UWR02 and UWR03 in 2006

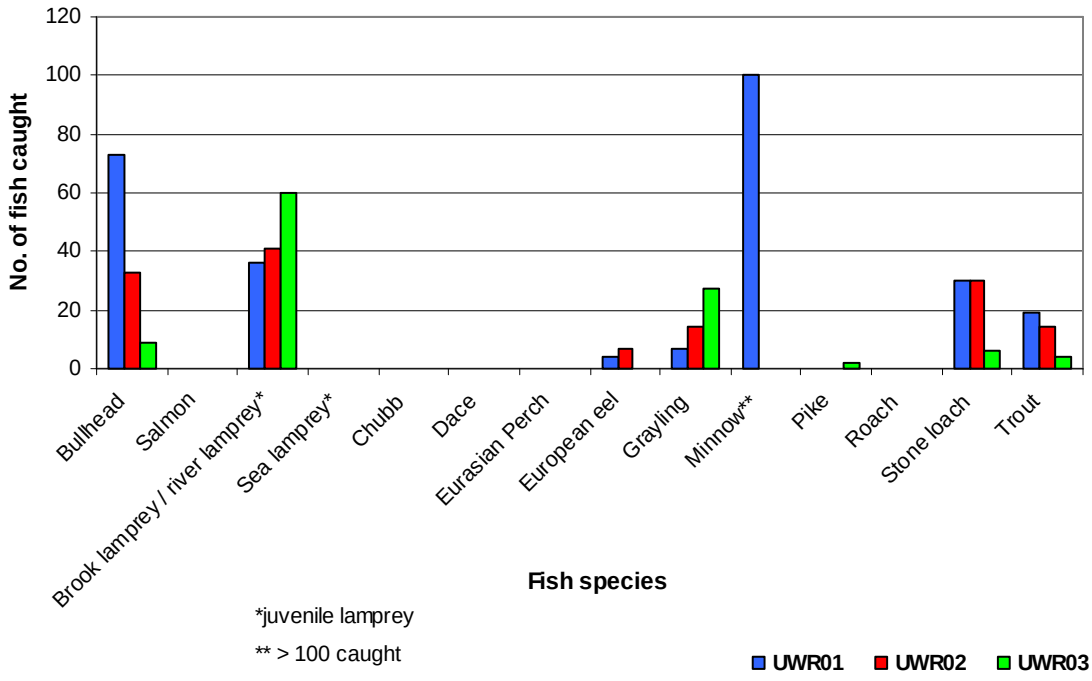


Figure 3.6 Number of fish caught during electofishing of sites UWR01, UWR02 and UWR03 in 2008

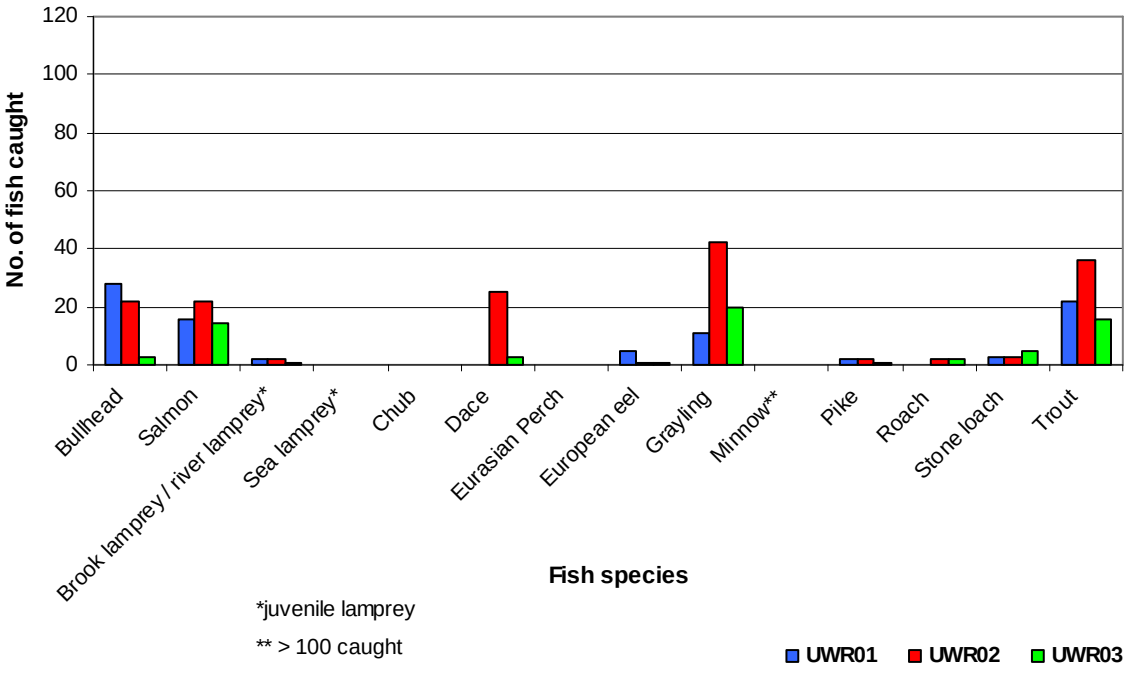


Table 3.11 Minimum density of brook lamprey and bullhead per m^2 in 2006

Fish species		Brook lamprey(quadrats only)			Brook lamprey (quadrat & sweep)			Bullhead		
Meso-habitat		UWR01 (Run)	UWR02 (Glide)	UWR03 (Glide)	UWR01 (Run)	UWR02 (Glide)	UWR03 (Glide)	UWR01 (Run)	UWR02 (Glide)	UWR03 (Glide)
Area		5	5	5	27	22	22	1377	1200	1100
No. fish caught	Shock 1	5	12	12	7	12	12	31	10	3
	Shock 2	4	3	13	4	3	13	18	23	6
	Shock 3	3	7	10	3	7	10			
	Total	12	22	35	14	22	35	49	33	9
Minimum density (observed no. per m^2)		2.40	4.40	7.00	0.52	1.00	1.59	0.036	0.028	0.008

Table 3.12 Minimum density of brook lamprey and bullhead per m^2 in 2008

Fish species		Brook lamprey (quadrats only)			Brook lamprey (quadrat & sweep)			Bullhead		
Meso-habitat		UWR01 (Glide)	UWR02 (Glide)	UWR03 (Glide)	UWR01 (Glide)	UWR02 (Glide)	UWR03 (Glide)	UWR01 (Glide)	UWR02 (Glide)	UWR03 (Glide)
Area		5	5	5	27	22	22	1377	1200	1100
No. fish caught	Shock 1	4	0	6	4	0	6	15	1	0
	Shock 2	0	0	6	0	0	6	9	16	3
	Shock 3	0	0	0	0	0	0	4	5	0
	Total	4	0	12	4	0	12	28	22	3
Minimum density (observed no. per m^2)		0.80	0	2.40	0.15	0.00	0.55	0.020	0.018	0.003

Table 3.12 indicates that the observed minimum density of brook lamprey is greatest within UWR03 meso-habitat while that of bullhead is greatest in UWR01.

Comparison with pre-restoration survey (2006)

The range and number of fish caught in 2008 varies significantly when compared with findings from 2006. Key differences include an increase in the number of salmonids, grayling and dace, and a decrease in bullhead, lamprey and minnows.

In 2008, the total number of salmon caught increased from none in 2006 to 52 in 2008. There were also increased catches of dace, grayling and trout. As at the control site, the increased number of these species may be related to greater flow velocities experienced in 2008, as these fish require swift clear water. However, several other wider catchment conditions (such as water quality and prey availability) also influence fish populations, particularly of migratory fish.

In 2008, the total number of bullhead caught was 53 compared with 115 in 2006, whilst the number of lamprey caught was 5 in comparison with 137 in 2006. The minimum density of both bullhead and lamprey is much lower in 2008 at all sites than in 2006 and no minnows were caught in 2008. As at the control site, these differences are likely to be due to the higher flow velocities and depth of flow experienced in 2008 making habitat conditions less suitable for these species. Trout predation is also a key threat to bullhead, though other predators include pike and eel.

3.2.3 Physical and biological relationships

- Restoration works have been undertaken within this reach between 2006 and 2008 and key differences were observed between the two surveys undertaken. However, the majority of these differences reflect similar differences observed at the control site upstream and are likely to be related to higher discharges and water levels experienced both during the survey and throughout 2007 and 2008. Due to the drastically different flow conditions, it is not possible to relate specific differences, other than the physical interventions themselves, to the restoration works.

- As a result of increased water levels, a glide physical biotope was observed throughout the reach in 2008, rather than the alternating run and glide sequence observed in 2006. The influence of impoundment was also less pronounced.

- Cross-sectional changes have occurred in association with both implementation of the restoration works and increased marginal vegetation growth along the channel banks.

- The dominant substrate in the centre of the channel in 2008 at the most downstream cross-section was gravel in 2008, rather than silt. This is likely to reflect increased flow velocities. Localised increases in silt were observed in the channel, particularly at the channel margins. This is likely to be attributable to the lower flow velocities at the margins, and trapping of sediment by vegetation and marginal structures.

- Cross sectional area of flow and flow velocities were significantly greater in 2008 as a result of higher discharges.

- Greater coverage of brook water-crowfoot was observed throughout this reach as well as at the control site. The increased cover of this key interest species is therefore unlikely to be directly related to the restoration works themselves.

- As in 2006, coverage of brook water-crowfoot generally declines with distance downstream. This trend is likely to be related to increasing flow depth, decreasing flow velocities and increasing siltation.

- Greater numbers of salmon, trout and grayling but fewer bullhead, brook lamprey and minnows were caught in 2008 compared with 2006. This is likely to reflect changes in flow velocities and water depth, making physical habitat conditions more suitable for rheophilic fish species and those not requiring shallow waters (minnows). Trout predation is also a key threat to bullhead, though other predators include pike and eel.

3.3 Seven Hatches Control Site (SHC)

Upstream limit: 408307 134584
Downstream limit: 408628 134264
Length of site: 512m

Location:
The site is located alongside the village of South Newton upstream of South Newton gauging weir. The upstream site boundary is a footbridge across the river. The downstream site boundary is upstream of the gauging weir itself (**Map 3.3)**. The control site is some distance upstream of the restoration site (see the Monitoring Protocol which describes site selection).

Typical photographs:

a) 2006

b) 2008

Photo 3.3.1 - SHC01a: Looking downstream from footbridge over "riffle" and glide physical biotopes.

a) 2006

a) 2008

Photo 3.3.2 - SHC02 - MS04a: Towards downstream end of site SHC looking upstream to undermined

a) 2006

b) 2008

Photo 3.3.3 - SHC02e: Looking across deep channel towards private gardens on left hand bank.

a) 2006

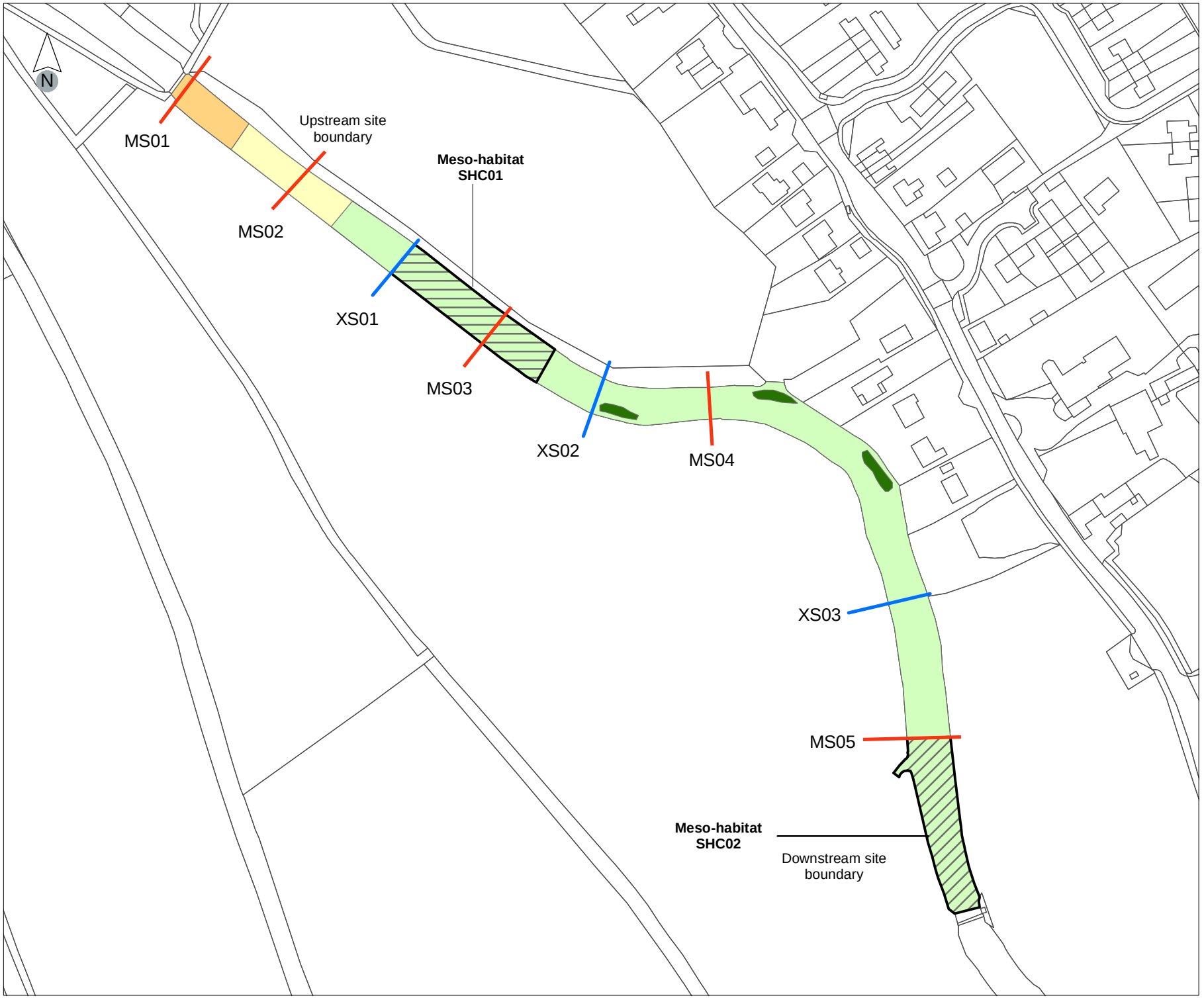
b) 2008

Photo 3.3.4 –SHC02f: Looking from the gauging weir at South Newton upstream.

Comparison with pre-restoration survey (2006)

Although no restoration works were undertaken within reach SHC, there are some visual differences at the control site comparing 2008 photographs and those taken during the 2006 survey. Due to increased discharge during the 2008 survey, flow velocities were higher than in 2006 (**Photos 3.3.2a and 3.3.2b**). Water levels were not significantly higher in 2008 (**Photo 3.3.3a and 3.3.3b**). This is likely to be due to the influence on water levels of control structures, including the South Newton gauging weir immediately downstream.

Willow trees used in previous restoration measures have also grown significantly since 2006 (**Photos 3.3.1a and 3.3.1b**).



Legend

Physical biotope

- Riffle
- Glide (rippled)
- Glide (laminar)
- Pool

Cross-section locations

- Macrophyte transects (MS)
- Additional cross-sections (XS)

Fisheries meso-habitat

- SHC01
- SHC02

Title:
Seven Hatches Control Site (SHC)
Physical biotopes and survey references

Project:
Avon STREAM Monitoring Project

Client:
Natural England

Date:
25/01/2009

Scale:
1:2,000

Map 3.3

3.3.1 Physical Characteristics

Physical biotopes

One riffle and two glides were recorded within the site during the physical biotype mapping survey. The riffle is present immediately downstream of the footbridge which marks the upstream boundary of the site (**Map 3.3**). Downstream of the riffle there is a short glide within which the water surface is rippled followed by a second glide where flow becomes laminar with deeper pools located along the outer edges of the meander bends.

Comparison with pre-restoration survey (2006)

The physical biotopes observed remain predominantly unchanged from those observed in 2006 with flow becoming more uniform and laminar with distance downstream. The main difference observed was that the glide was faster flowing throughout the reach in 2008 and included sections of rippled flow. This is related to the higher discharge during the 2008 survey.

Sediment regime

The Fluvial Audit recorded no evidence of natural channel adjustment through erosion (see **Appendix A**). Both banks are protected by willow spiling, which is continuous along the right hand bank upstream of the private gardens (**Map 3.3)** and prevents bank erosion. Eight small deflectors comprised of posts with wire netting in between, were previously installed and have encouraged deposition and marginal vegetation growth. A larger deflector made of paving slabs is located on the inside of the first meander bend. This has been displaced since the 2006 survey, probably in response to high flows. Downstream of the paved deflector (see **Map 3.3**), channel modification has contributed to a steep vertical bank on the inside of the meander bend. The channel is overdeep and deposition of silt is occurring on the channel bed. The depth of silt increases with distance downstream due to impoundment of flows upstream of South Newton gauging weir.

Comparison with pre-restoration survey (2006)

Increased silt deposition around the deflectors was observed; otherwise few differences were identified in the sediment regime between the 2006 and 2008 surveys.

Physical channel form

Levelling survey was conducted at eight cross-sections, the location of which is illustrated in **Map 3.3**. A summary of the data for each cross section and a comparison with the 2006 survey is provided in **Table 3.13.**

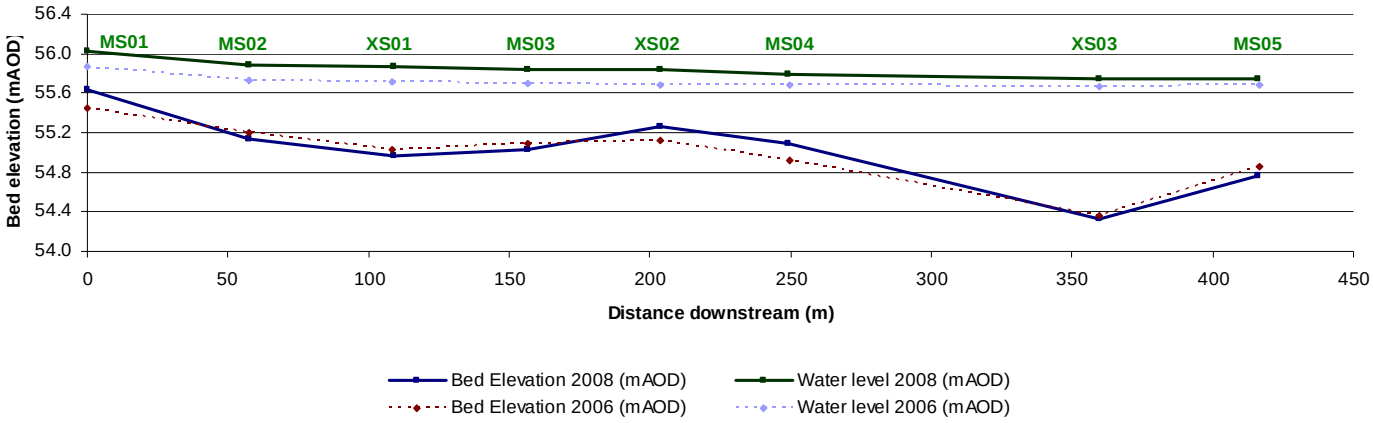
The channel is embanked on the right hand bank and of relatively uniform width throughout the site. The channel is shallowest at the most upstream cross-sections (MS01 and MS02) and particularly deep at cross-section XS03, which is located across a pool. The water depth is shallowest at XS02 where the water width is greatest.

Table 3.13 Cross-sectional summary data for site SHC

Transect	Physical biotope		Bankfull width (m)		Bankfull depth (m)		Width:depth ratio		Water width (m)		Water depth (m)	
	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008	2006	2006
MS01	Riffle	Riffle	20.69	20.97	1.05	0.88	19.7	23.8	16.39	16.20	0.42	0.39
Difference			**0.28**		**-0.17**		**4.1**		**-0.19**		**-0.03**	
MS02	Glide	Glide	20.72	20.11	0.95	1.00	21.8	20.1	10.42	11.46	0.52	0.74
Difference			**-0.61**		**0.05**		**-1.7**		**1.04**		**0.22**	
XS01	Glide	Glide	13.09	11.00	0.80	0.83	16.4	13.3	10.10	10.32	0.69	0.91
Difference			**-2.09**		**0.03**		**-3.1**		**0.22**		**0.22**	
MS03	Glide	Glide	15.81	15.50	1.02	1.13	15.5	13.7	10.77	11.29	0.61	0.81
Difference			**-0.31**		**0.11**		**-1.8**		**0.52**		**0.20**	
XS02	Glide	Glide	20.48	21.00	1.29	1.16	15.9	18.1	15.81	16.39	0.56	0.57
Difference			**0.52**		**-0.13**		**2.2**		**0.58**		**0.01**	
MS04	Glide	Glide	18.62	18.11	1.23	1.07	15.1	16.9	15.73	16.38	0.77	0.71
Difference			**-0.51**		**-0.16**		**1.8**		**0.65**		**-0.06**	
XS03	Glide	Glide	15.40	16.00	1.75	1.84	8.8	8.7	13.51	13.21	1.31	1.42
Difference			**0.60**		**0.09**		**0.1**		**-0.30**		**0.11**	
MS05	Glide	Glide	19.40	20.25	1.49	1.60	13.0	12.7	14.93	15.62	0.82	0.97
Difference			**0.85**		**0.11**		**0.3**		**0.69**		**0.15**	
Mean			**18.03**	**17.86**	**1.20**	**1.18**	**15.77**	**15.91**	**13.46**	**13.51**	**0.71**	**0.82**
Difference			**-0.17**		**-0.02**		**-0.14**		**0.05**		**0.11**	

The long profile of the channel, derived using the deepest points at each of the cross-sections, is presented in **Figure 3.7**.

Figure 3.7 Long profiles derived from cross-sectional data from MS01 to MS05 in 2006 and 2008



Over a distance of 416m (between cross-section MS01 and MS05), there is a fall in bed elevation of 0.86m (a gradient of 0.002). The long profile illustrates the relative uniformity of bed elevation and water depth upstream of cross-section MS04 and how the channel deepens downstream as it flows around the meander bend. The cross-sectional profile of the channel downstream of MS04 is overdeep in comparison with the channel upstream.

Comparison with pre-restoration survey (2006)

The cross sectional data collected in 2008 show minor differences in cross-sectional profile between the 2006 and 2008 surveys. Localised differences in the shape of the cross-section profile are also evident at cross-sections XS02 and MS04. These cross-sections are located upstream of the meander bend and downstream of the displaced deflector. The differences may relate to the movement of the deflector since the 2006 survey. There has been some localised natural scour along the left hand bank at XS03, which is likely to be related to increased flow velocities during 2007 and 2008 around the outside of the meander bend. The greater variability of maximum bed depth along the long profile may also relate to slightly greater scour and deposition processes associated with pool-riffle development during the higher velocity flows that have been experienced in 2007 and 2008.

Due to the high flows at the time of the 2008 survey, water width and depth has increased at most cross sections. Where the water width has decreased (MS01), this is due to the encroachment of marginal vegetation narrowing the channel. At other cross-sections, the bank profile has also been altered by changes in the density of marginal vegetation cover (XS01) and riparian vegetation on the embankment itself (MS03).

Boundary conditions

The channel banks are steeply graded and embanked along the right hand bank. Where visible the banks were observed to be composed of sand/silt material. Upstream of cross-section MS04 the toe of the bank is protected by willow spiling.

Bed substrate samples taken from the channel centre, both channel margins and intervening points (see **Table 3.12**) indicate that the dominant substrate is gravel / pebble material (2-64mm in diameter).

Pebble-sized material (16-64mm in diameter) is dominant within the riffle section at the upstream end of the site and within the rippled glide immediately downstream (2-16mm in diameter). The centre of the channel at cross sections XS02, MS04 and XS03 is also dominated by pebble-sized material. Silt is present along the left hand and right hand banks downstream of cross-section MS03 with the exception of the left margin of XS02. This is likely to be related to the overdeep nature of the cross-sectional profile in comparison with the channel upstream, low flow velocities observed at the channel margins and trapping of silt by marginal vegetation.

Comparison with pre-restoration survey (2006)

There is a greater dominance of pebble-sized material on the channel bed both upstream of the reach and further downstream within the central channel. This is consistent with more pronounced armouring and greater scour and deposition processes associated with pool-riffle development in response to increased flow velocities during 2007 and 2008.

As in 2006, silt is present along the channel margins, although it is more extensive along the right channel margin in 2008. This may be related to increased vegetation and trapping of silt by the deflectors present on the right hand bank at cross-sections MS03 and XS02.

Table 3.14 Bed substrate and flow velocities sampled at surveyed cross-sections 2006*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Riffle	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**
		0.00	0.31	0.41	0.18	0.00
MS02	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble
		0.01	0.16	0.32	0.13	0.00
XS01	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.12	0.16	0.13	0.00
MS03	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.01	0.13	0.13	0.13	0.00
XS02	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.20	0.22	0.10	0.00
MS04	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.11	0.23	0.01	0.00
XS03	Glide	Silt	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.06	0.01	0.00	0.00
MS05	Glide	Silt	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.04	0.04	0.02	0.00

*Left and right channel margins are defined looking in a downstream direction

Bold type indicates whether pebble or gravel sized substrate was dominant.

Table 3.15 Bed substrate and flow velocities sampled at surveyed cross-sections 2008*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Riffle	Gravel/**Pebble**	Gravel/**Pebble**	Gravel/**Pebble**	Gravel/**Pebble**	Gravel/**Pebble**
		0.484	0.577	0.674	0.559	0.000
MS02	Glide	Gravel/**Pebble**	Gravel/**Pebble**	Gravel/**Pebble**	Gravel/**Pebble**	Gravel/**Pebble**
		0.30	0.527	0.597	0.576	0.062
XS01	Glide	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble
		0.218	0.421	0.461	0.226	0.172
MS03	Glide	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Silt
		0.153	0.262	0.396	0.238	0.076
XS02	Glide	Silt	Gravel/**Pebble**	Gravel/**Pebble**	**Gravel**/Pebble	**Gravel**/Pebble
		0.272	0.392	0.553	0.137	0.08
MS04	Glide	Silt	Gravel/**Pebble**	Gravel/**Pebble**	Silt	Silt
		0.072	0.149	0.476	0.122	0.046
XS03	Glide	Silt	Gravel/**Pebble**	Gravel/**Pebble**	Gravel/**Pebble**	Silt
		0.107	0.345	0.216	0.06	0.009
MS05	Glide	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Silt
		0.167	0.332	0.330	0.27	0.036

*Left and right channel margins are defined looking in a downstream direction

Bold type indicates whether pebble or gravel sized substrate was dominant.

Velocity

Flow velocity measurement data is contained within **Appendix D** and summarised for each cross-section in **Table 3.16.**

Table 3.16 Velocity summary data 2008 and comparison with 2006 for site SHC

Transect	Physical biotope	Cross-sectional area of flow (m^2)	Difference from 2006 (m^2)	Mean Velocity (ms^{-1})	Difference from 2006 (ms^{-1})
MS01	Riffle	5.60	1.56	0.550	0.22
MS02	Rippled Glide	6.43	1.91	0.441	0.24
XS01	Glide	6.98	1.29	0.320	0.20
MS03	Glide	8.11	2.33	0.270	0.17
XS02	Glide	5.64	0.85	0.273	0.11
MS04	Glide	8.49	2.16	0.237	0.14
XS03	Glide	13.73	1.46	0.170	0.12
MS05	Glide	10.61	1.57	0.233	0.20
Mean		**8.20**	**1.64**	**0.312**	**0.18**

Flow velocity is highest within the upstream riffle section (**Table 3.16**). Along the downstream glide (XS01 - XS02) flow velocity is lower but remains relatively constant. From cross-section MS04 downstream there is a distinct decrease in flow velocity which reflects the greater water depth and cross-sectional area of flow, particularly at XS03, and influence of impoundment on this section.

Comparison with pre-restoration survey (2006)

Higher discharge and water levels during the 2008 survey result in a greater cross-sectional area of flow and higher velocities at each cross-section in comparison with 2006. There remains a significant difference between velocities at the upstream and downstream limits of the reach. This indicates that over-deepening of the channel and impoundment continues to influence flow velocities in the lower section.

3.3.2 Biological characteristics

Vegetation structure

In-channel vegetation is present but limited in its coverage within the site. Brook water crowfoot (***Ranunculus penicillatus)*** was observed at several locations along the reach but coverage was not extensive. Downstream of XS03 there was very limited in-channel vegetation.

The channel has a short marginal transition zone due to the steep bank gradient and embankment of the channel along the right hand bank. However, where willow spiling is present it has enabled emergent species to readily colonise the channel margins. Dredging has resulted in a steep vertical right bank face on the inside of the meander bend downstream of cross-section MS03.

The adjacent landuse is semi-improved grassland / private gardens on the left hand bank and arable on the right hand bank. The embankment on the right hand bank is colonised by ruderal species, in particular common nettle (***Utrica dioica***), which indicate high nutrient levels. This is likely to be due to the agricultural landuse and associated use of fertilisers on the right hand bank. There are isolated trees along the right bank

including elder (***Sambucus nigra***), crack willow (***Salix fragilis***) and black poplar (***Populus nigra)***. The left hand bank has occasional clumps of trees which include alder (***Alnus glutinosa***) and black poplar (***Populus nigra).*** Willows that have been used to narrow the channel have now grown. The left hand bank becomes treelined downstream of the private gardens.

Macrophyte coverage

A total of 65 taxa were recorded during the macrophyte assessment of the site. The locations of the five transects surveyed (MS01-MS05) were selected to represent different physical biotopes (see **Map 3.3**). Each of the transects was also subject to cross-section levelling survey (see Section 3.3.1).

The species found to be most common within the site, with a coverage of <5 % or more, are listed in **Table 3.17.** The site contains only one negative indicator species and no invasive species. The highest coverage of brook water-crowfoot (***Ranunuclus pencillatus*** spp. ***pseudofluitans***) was found within transect MS01, which crosses the "riffle" physical biotope. Further downstream the presence of fennel pondweed (***Potamogeton pectinatus***) in MS02 is a negative vegetation habitat indicator, although minimal coverage of brook water-crowfoot was found throughout the reach. The greatest number of macrophyte species were identified within transect MS04, where there is a steep bank on the right hand bank but silted margins.

Comparison with pre-restoration survey (2006)

Less in-channel vegetation was observed during the 2008 survey throughout the reach. In-channel vegetation, particularly horned pondweed (***Zannichellia palustris***) was previously subject to grazing by swans at transects MS01 and MS02 which may account for reduced coverage at MS01. The variety and coverage of willow species within the transects is greater in 2008 due to the growth of willow used in channel narrowing, particularly along the left hand bank. A similar number of overall taxa were observed in both surveys, although an increased number of taxa were observed within the survey transects in 2008.

Table 3.17 Macrophyte species coverage (%) within site SHC

Latin Name	Common Name	Macrophyte coverage (%)											
		MS01		MS02		MS03		MS04		MS05		Whole site	
		2006	2008	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008
		Riffle	Riffle	Glide	Glide	Glide	Glide	Glide	Glide	Glide	Glide		
Key species													
Ranunculus penicillatus spp. pseudofluitans	brook water crowfoot	20	**5**	<1	**<1**	<1	**<1**	10	**<1**	<1	**<1**	10	**<5**
Callitriche obtusangula	blunt-fruited water starwort			<1				<1	**<1**			<1	**<1**
Oenanthe crocata	hemlock water dropwort	<1	**<5**			<1	**<1**		**<1**			<5	**<1**
Species present in <5 %													
Epilobium hirsutum	great willow herb	<5	**<5**	<5	**<5**	10	**5**	<1	**<1**	<5	**<1**	10	**<5**
Potentilla anserina	silverweed											10	
Sparganium erectum	branched bur-reed		**<1**	10	**10**	<1	**5**		**<1**	<5	**5**	10	**10**
Alnus glutinosa	alder				**<1**							<5	**<1**
Arrhenatherum elatius	false oat-grass		**<1**		**<1**		**<1**		**<5**		**<1**	<5	**<1**
Fontinalis antipyretica	common water moss	<1	**<1**	<1	**<1**		**<1**	<1	**20**		**<1**	<1	**<5**
Calystegia sepium	hedge bindweed	10	**10**	<1			**<1**	<1	**<5**	<1	**5**	<5	**5**
Carex riparia	greater pond sedge		**<5**		**<5**					<5	**10**	<5	**<5**
Persicaria amphibia	amphibious bistort					<1	**<1**					<5	**<1**
Populus nigra	black poplar											<5	
Salix alba	white willow											<5	
Salix cinerea	grey willow	<1	**<5**	<1	**5**	<1	**5**		**10**			<1	**<5**
Salix fragilis	crack willow	<1	**5**	<5	**5**	<5	**5**	<5		<1	**<5**	<1	**<5**
Urtica dioica	common nettle	10	**10**	10	**10**	<1	**15**	<1	**<5**	5	**5**	<5	**10**
Scrophularia auriculata	water figwort	<1	**<1**	<1	**<1**	<1	**<1**	<5	**<5**		**<1**	<5	**<1**
Symphytum officinale	common comfrey		**<1**	<1	**<5**				**<1**	<1	**<1**	<5	**<1**
Negative indicators													
Potamogeton pectinatus	fennel pondweed			10	**10**		**5**	10	**<5**	<1	**<1**	10	**<5**
Invasive species													
None													
No of Taxa Recorded		**16**	**28**	**29**	**31**	**17**	**37**	**20**	**40**	**20**	**20**	**68**	**65**

Fisheries survey

Electro-fishing was undertaken at two sites, the location of which is indicated in **Map 3.3.** The total number of each fish species caught at each site during the electrofishing survey, including the Annex II species for which the Avon SAC is designated, is indicated in **Figure 3.9**.

Figure 3.8 Number of fish caught during electofishing of sites SHC01 and SHC02 in 2006

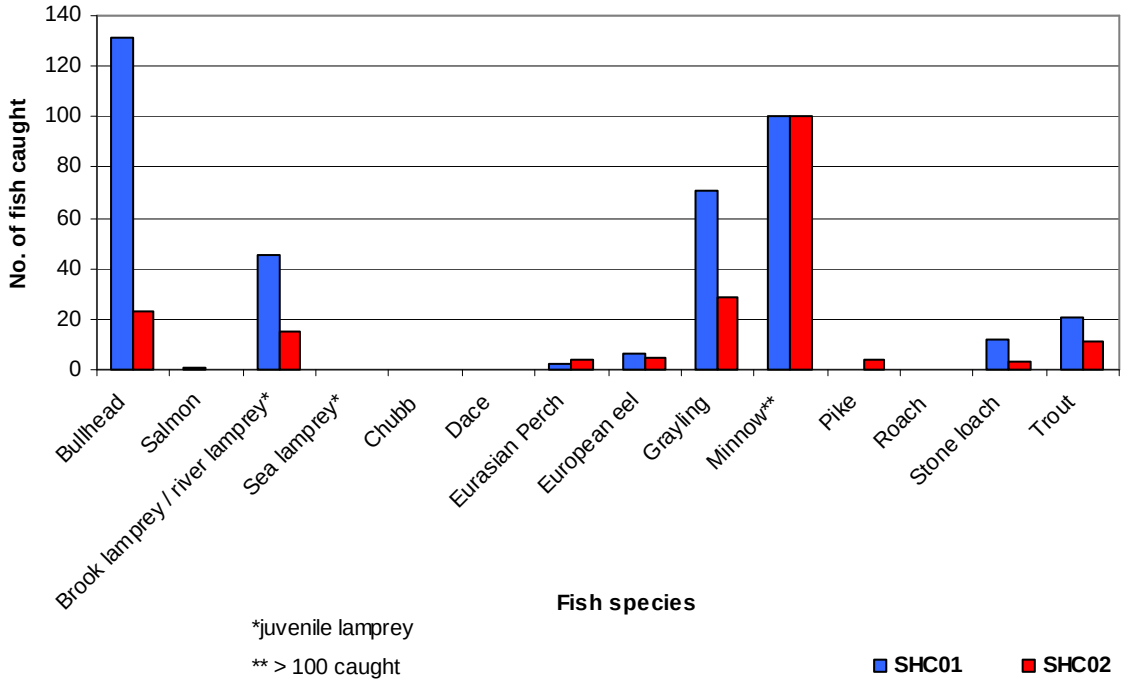
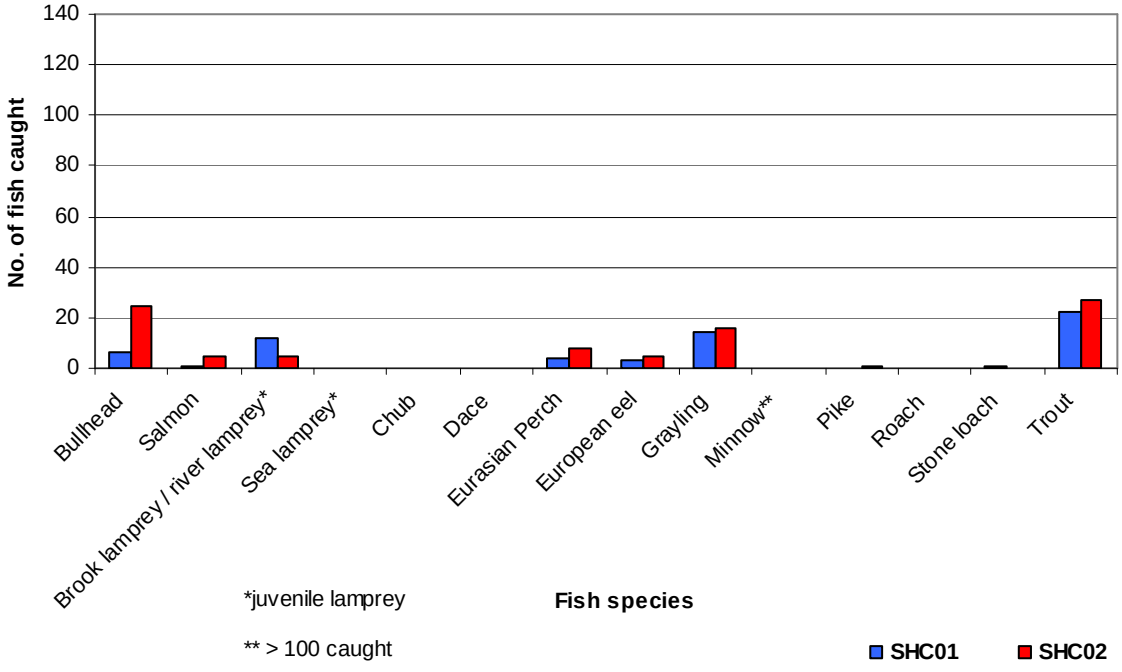


Figure 3.9 Number of fish caught during electofishing of sites SHC01 and SHC02 in 2008



One salmon parr was caught within meso-habitat SHC01 and five within meso-habitat SHC02. There were also significant numbers of bullhead, grayling and trout, with a greater overall number of fish caught within meso-habitat SHC02.

The calculated minimum density of brook lamprey and bullhead within both of the meso-habitats surveyed is shown in **Table 3.19**.

Table 3.18 Minimum density of brook lamprey and bullhead per m^2 in 2006

Fish species		Brook lamprey (quadrats only)		Brook lamprey (quadrat & sweep)		Bullhead	
Meso-habitat		SHC01 (Glide)	SHC02 (Glide)	SHC01 (Glide)	SHC02 (Glide)	SHC01 (Glide)	SHC02 (Glide)
Area		5	5	20	20	1740	1000
No. fish caught	Shock 1	0	5	0	5	74	15
	Shock 2	1	2	1	2	57	8
	Shock 3	2	8	2	8	0	0
	Total	3	15	3	15	131	23
Minimum density (observed no. per m^2)		0.60	3.00	0.15	0.75	0.075	0.023

Table 3.19 Minimum density of brook lamprey and bullhead per m^2 in 2008

Fish species		Brook lamprey (quadrats only)		Brook lamprey (quadrat & sweep)		Bullhead	
Meso-habitat		SHC01 (Glide)	SHC02 (Glide)	SHC01 (Glide)	SHC02 (Glide)	SHC01 (Glide)	SHC02 (Glide)
Area		5	5	20	20	1740	1000
No. fish caught	Shock 1	4	4	4	4	0	3
	Shock 2	4	0	4	0	7	18
	Shock 3	0	0	0	0	1	4
	Total	8	4	8	4	8	25
Minimum density (observed no. per m^2)		1.60	0.80	0.40	0.20	0.005	0.025

Table 3.19 indicates that the observed minimum density of bullhead is greatest within meso-habitat SHC02.

Comparison with pre-restoration survey (2006)

The range and number of fish caught in 2008 varies significantly when compared with findings from 2006. Key differences include an increase in the number of salmon and trout and a decrease in bullhead, lamprey and minnows. There is also a difference in the distribution of fish between the two meso-habitats sampled.

The increased number of salmon and trout may be related to greater flow velocities experienced within the reach in 2008, as these fish require swift clear water. However, several other wider catchment conditions (such as water quality and prey availability) also influence fish populations, particularly of migratory fish.

In 2008, the total number of bullhead caught was 31 compared with 154 in 2006, whilst the number of lamprey caught was 17 in comparison with 60 in 2006. The minimum density of both bullhead and lamprey is much lower in 2008, apart from for bullhead in SHC02, than in 2006. No minnows were caught in 2008. These differences are likely to be due to the higher flow velocities and depth of flow experienced in 2008 making habitat conditions less suitable for these species. The greater number of fish caught in SHC02 in comparison with SHC01 in 2008, in particular bullhead, may indicate that this shallow and fast flowing section provides less preferable habitat for the fish species observed during higher flows than SCH02. This could be due to a lack of deeper, resting areas and shelter. More lamprey are still found in SHC01, which may be due to the continued presence of silted marginal habitat in this location.

3.3.3 Physical and biological relationships

- There has been no intervention within this reach between 2006 and 2008, and channel morphology remains largely the same when comparing the two surveys. Localised differences are likely to be related to higher discharges and water levels experienced both during the survey and throughout 2007 and 2008.

- The site can be divided into three physical biotopes; a short riffle section, one rippled glide and one longer section of laminar flow.

- In the upper section (MS01-XS02) the channel remains shallower and flow velocities are greater than further downstream. Flow velocities decline and the cross-sectional area of flow and influence of impoundment increases upstream of South Newton gauging weir.

- The extent of channel vegetation has decreased since 2006, which may be a result of swan grazing. The presence of fennel pondweed (***Potamogeton pectinatus***) indicates poorer vegetation habitat conditions downstream of the riffle at MS01.

- Greater numbers of salmonids were recorded but fewer bullhead, brook lamprey or minnows were caught in 2008 compared with 2006. This is likely to reflect changes in flow velocities and water depth.

- The greater number of fish caught in SHC02 in comparison with SHC01 in 2008, in particular bullhead, may indicate that this shallow and fast flowing section provides less preferable habitat for the fish species observed during higher flows than SCH02. This could be due to a lack of deeper resting areas and shelter.

3.4 Seven Hatches Restoration Site (SHR)

Upstream limit: 409357 132978
Downstream limit: 409849 131814
Length of site: 1329m

Location:
The site is located downstream of Chilhampton Farm and includes the impounding structure known as Seven Hatches. The upstream site boundary is the fence downstream of the footbridge (**Map 3.4a and 3.4b**). The downstream site boundary is the tractor bridge located upstream of the second railway crossing. Due to the length of this site, detailed survey techniques have been focussed on the section downstream of the Seven Hatches and upstream of the first railway crossing (**Map 3.4a and 3.4b**).

Typical photographs:

a) 2006 **b) 2008**

Photo 3.4.1 - SHR02f: Looking downstream along uniform glide section downstream of the Seven Hatches structure.

a) 2006 **b) 2008**

Photo 3.4.2 - SHR02 MS03a: Looking upstream at new riffle

a) 2006 b) 2008

Photo 3.4.3 - SHR03e: Looking downstream along glide with eroding right hand bank

a) 2006 b) 2008

Photo 3.4.4 - SHR04g: Looking downstream along uniform glide downstream of the first railway crossing.

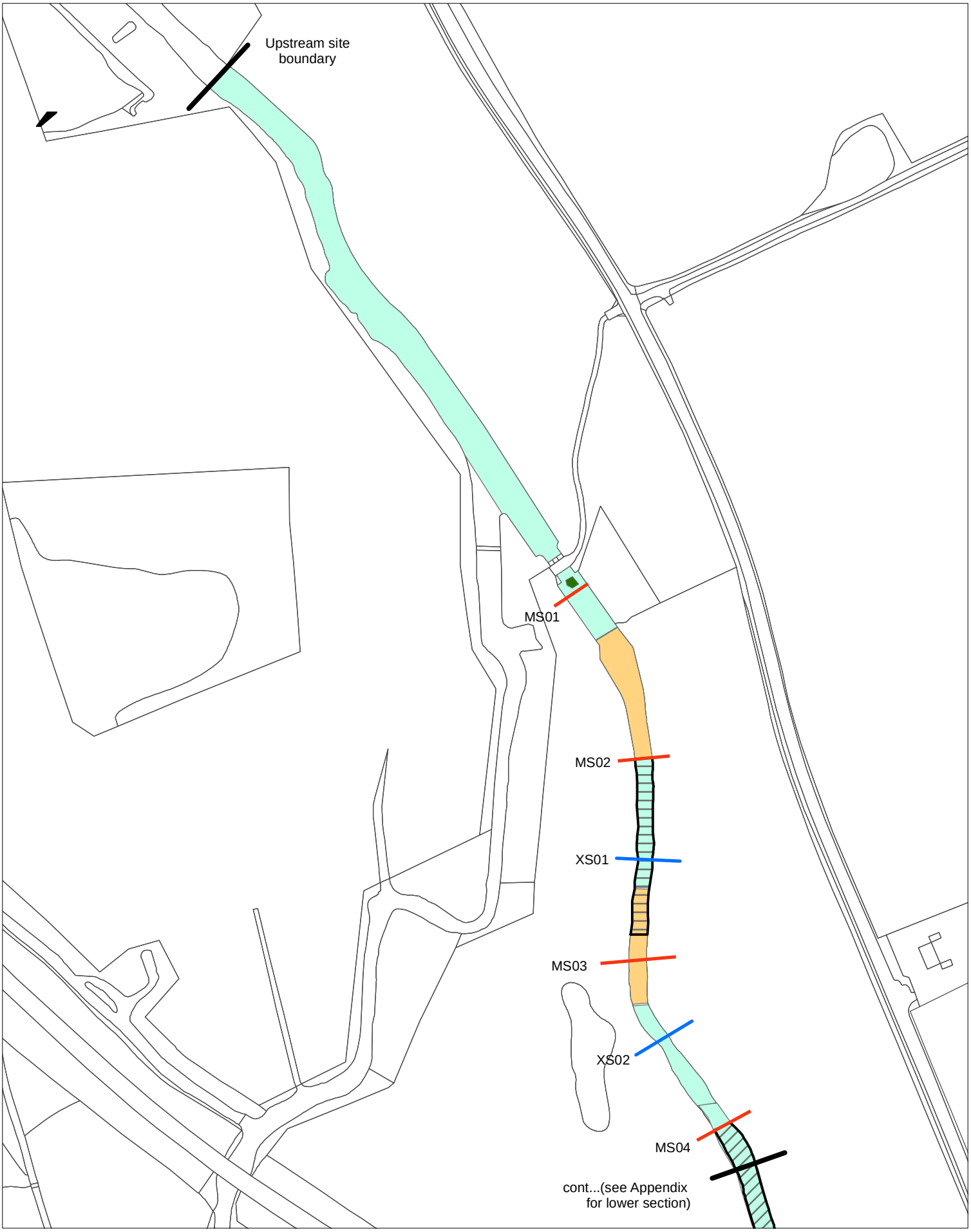
Comparison with pre-restoration survey (2006)

There are significant differences at the restoration site comparing post-restoration photographs and those taken during the pre-restoration survey. At the upstream end of the site, marginal vegetation has increased significantly on both banks. There is also a more established and wider riparian vegetation zone due to the prevention of livestock grazing (**Photo 3.4.1a and 3.4.1b**).

The reintroduction of excavated gravel and stone bed material and the introduction of large woody debris have increased variable bed morphology as illustrated in **Photo 3.4.2a and 3.4.2b**.

Felling of selected trees along the left hand bank has also had a visual impact on the reach and resulted in less shading of the channel (although the trees were already set back from the channel edge).

Evidence of erosion downstream of the railway crossing is illustrated in **Photo 3.4.3a and 3.4.3b** and further downstream flow becomes uniform as evident in **Photo 3.4.4a and 3.4.4b.**



Legend

Physical biotope
- Riffle
- Glide (laminar)
- Pool

Fisheries mesohabitats
- SHR01
- SHR02

Cross-section locations
- Macrophyte transect (MS)
- Additional cross-sections (XS)

Title: Seven Hatches Restoration Site (SHR)
Physical biotopes and survey references

Project: Avon STREAM Monitoring Project

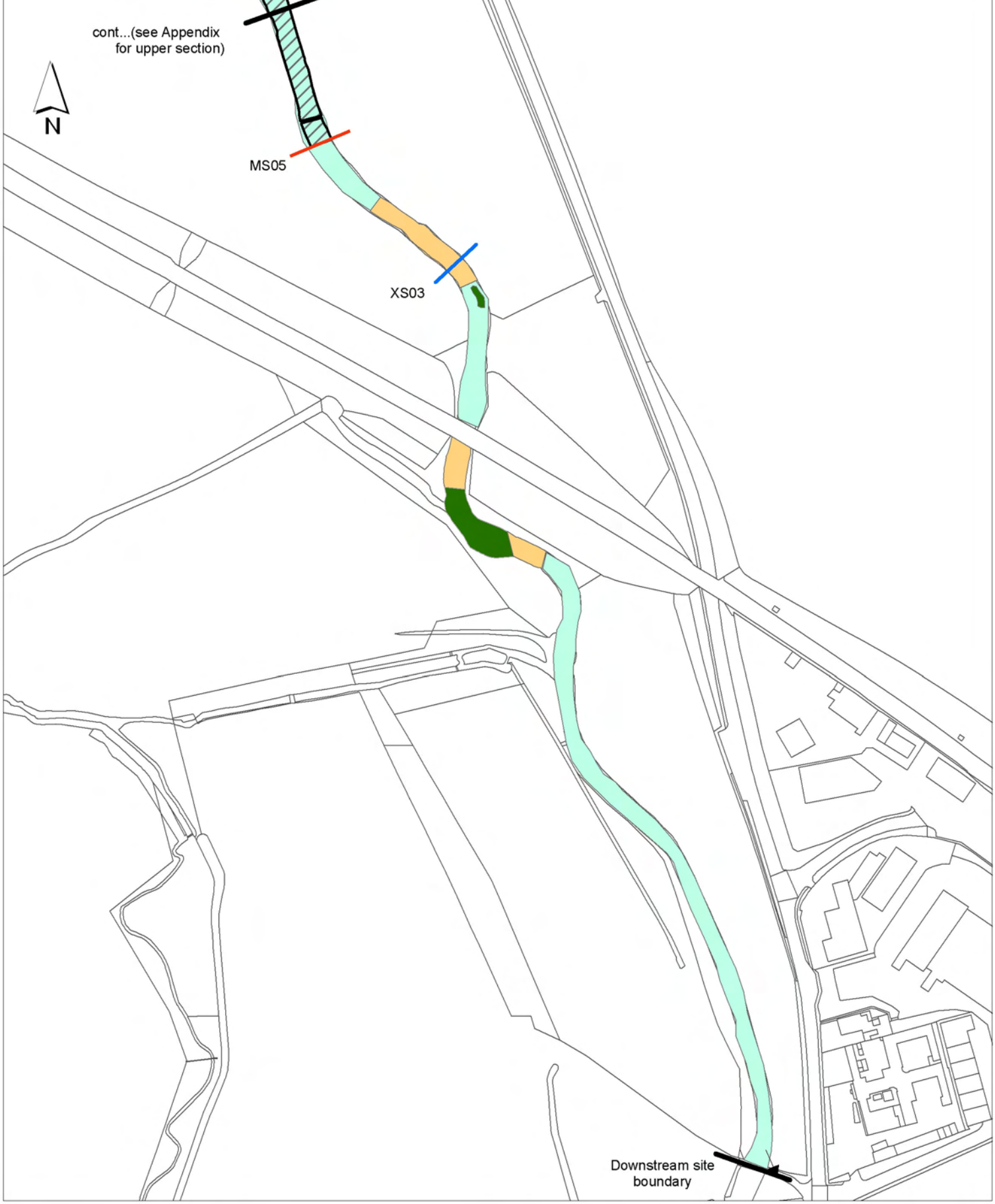
Client: Natural England

Date: 25/01/2009

Scale: 1:2,500

Map 3.4a

ROYAL HASKONING



Legend

Physical biotope
- Riffle
- Glide (laminar)
- Pool

Fisheries mesohabitats
- SHR01
- SHR02

Cross-section locations
- Macrophyte transect (MS)
- Additional cross-sections (XS)

Title: Seven Hatches Restoration Site (SHR)
Physical biotopes and survey references

Project: Avon STREAM Monitoring Project

Client: Natural England

Date: 25/01/2009

Scale: 1:2,500

Map 3.4b

ROYAL HASKONING

3.4.1 Physical Characteristics

Physical biotopes

Upstream of Seven Hatches, a glide physical biotope was observed with a short section continuing downstream of the hatches (**Map 3.4a**) caused by high flows. An alternating pattern of riffle and glide was observed downstream of this, which continues until just downstream of the railway bridge after which a uniform glide was present. A number of pools exist throughout the reach on the outside of meander bends, the largest of which is located downstream of the railway bridge (**Map 3.4a and 3.4b**).

Comparison with pre-restoration survey (2006)

Upstream of Seven Hatches and downstream of the railway bridge, the biotopes observed in 2008 are the same as in 2006. However, the implemented restoration works have included creation of a series of riffles downstream of Seven Hatches, over which flow is fast, shallow and rippled rather than the glide observed in 2006. The creation of the riffle features has therefore increased localised diversity of physical biotopes within the section subject to restoration.

Sediment regime

For the purposes of Fluvial Audit the site was divided into four reaches. The first reach, upstream of Seven Hatches, is impounded and deposition of silt was observed on the channel bed. Silt is being trapped at the channel margins by emergent vegetation forming semi-permanent deposits at the bank toe which have established into a berm on the left hand bank. A new fence erected since the previous survey in 2006 is preventing cattle poaching and reducing erosion of the bank within this section.

Downstream of Seven Hatches the dominant sediment process remains deposition of silt. However, this does not occur over the riffle structures and is typically observed at the channel margins where fine sediment is trapped by marginal vegetation. Marginal vegetation has also stabilised localised areas of toe undermining on the left hand bank. There was no evidence of cattle poaching and an area that was previously poached, just upstream of XS02, is now silting up.

The pool-riffle reach downstream of the railway crossing is geomorphologically active and exhibits cliff erosion, toe scour and deposition of gravels as discrete point bar deposits. This reach terminates at a widened, silted section where two field drains join the main channel sourcing fine sediment to the channel.

Further downstream the channel reverts to a uniform glide which is impounded by the tractor bridge at the downstream boundary of the site. Toe scour and undermining is occurring along the outside of a meander on the right hand bank. The dominant sediment process is deposition on the channel bed.

Comparison with pre-restoration survey (2006)

The restoration works have had a significant influence on the sediment regime. The glide-riffle sequence created results in contrasting, localised areas of sediment deposition and transport. Restriction of livestock access has removed the influence of poaching reducing fine sediment input to the channel. The lack of poaching has also allowed establishment of riparian and marginal vegetation, which is acting to trap fine sediment along the channel margins.

Physical channel form

Levelling survey was conducted at eight cross-sections, the location of which is illustrated in **Maps 3.4a and 3.4b**. **Table 3.20** provides summary data for each of the cross-sections surveyed.

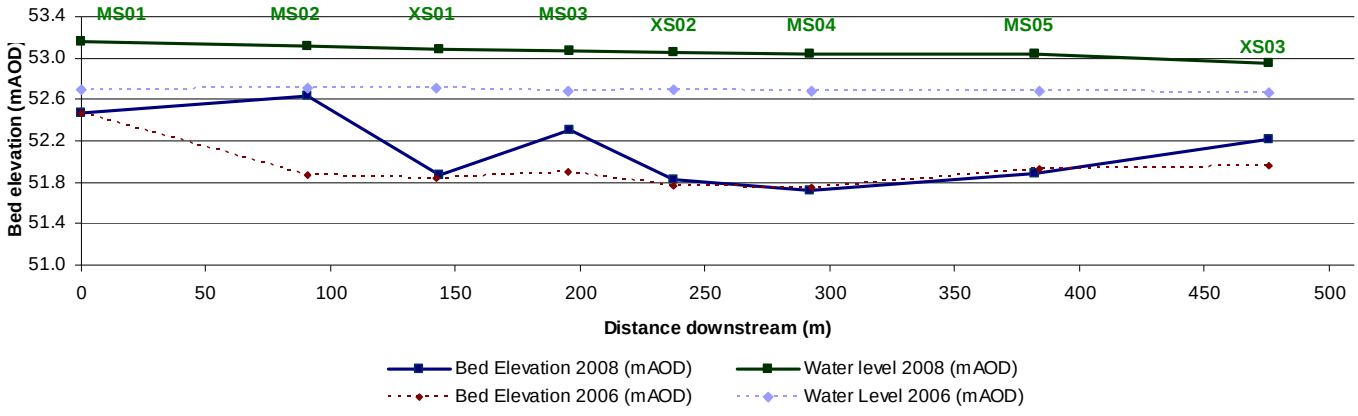
Table 3.20 Cross-sectional summary data

Transect	Physical biotope		Bankfull width (m)		Bankfull depth (m)		Width:depth ratio		Water width (m)		Water depth (m)	
	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008
MS01	Riffle	Riffle	17.06	17.68	1.88	1.93	9.1	9.2	10.08	13.32	0.23	0.69
Difference			**0.60**		**0.05**		**0.1**		**3.24**		**0.46**	
MS02	Glide	Riffle	14.75	15.83	1.76	1.13	8.4	14.0	8.47	10.95	0.84	0.49
Difference			**1.08**		**-0.63**		**5.6**		**2.48**		**0.35**	
XS01	Glide	Glide	12.36	12.65	1.64	1.83	7.5	6.9	8.64	10.65	0.87	1.21
Difference			**0.29**		**0.19**		**-0.60**		**2.01**		**0.34**	
MS03	Glide	Riffle	13.51	14.68	1.83	1.65	7.4	8.9	9.86	10.80	0.78	0.77
Difference			**1.17**		**-0.18**		**1.50**		**0.94**		**-0.01**	
XS02	Glide	Glide	16.46	16.97	1.98	2.04	8.3	8.3	8.35	10.22	0.93	1.22
Difference			**0.51**		**0.06**		**0.00**		**1.87**		**0.29**	
MS04	Glide	Glide	16.00	15.97	1.90	2.11	8.4	8.2	9.13	11.14	0.94	1.32
Difference			**-0.03**		**0.21**		**-0.20**		**2.01**		**0.38**	
MS05	Glide	Glide	16.51	16.59	1.81	1.48	9.1	11.2	10.22	10.62	0.74	1.16
Difference			**0.08**		**-0.33**		**2.10**		**0.40**		**0.42**	
XS03	Glide	Riffle	13.57	13.15	1.34	1.10	10.1	12.0	10.41	11.15	0.71	0.74
Difference			**-0.42**		**-0.24**		**1.90**		**0.74**		**0.03**	
Mean			**15.03**	**15.44**	**1.77**	**1.67**	**8.5**	**9.8**	**9.39**	**11.11**	**0.76**	**0.95**
Difference			**0.41**		**-0.10**		**1.30**		**1.72**		**0.19**	

The channel is widest at cross section MS03 where gravel has been added to create a riffle. Cross sections MS02, MS03 and XS03, all located at riffles, also display the shallowest bankfull depth, the highest width to depth ratio, and the shallowest water depth.

The long profile of the channel, derived using the deepest points at each of the cross-sections, is presented in **Figure 3.10**.

Figure 3.10 Long profiles derived from cross-sectional data from MS01 to MS05 in 2006 and 2008



Over a distance of 476m (between cross-section MS01 and XS03), there is a fall in bed elevation of 0.26m (a gradient of 0.001). The long profile also illustrates that the shallowest sections occur at the riffles (MS02, MS03 and XS03).

Comparison with pre-restoration survey (2006)
At cross-sections where no restoration works have been undertaken the cross-sectional profiles recorded in 2008 are very similar to 2006. The major differences in cross-sectional profile are at cross-sections MS02, MS03 and XS03. At these locations, the bed of the channel has been raised, decreasing the bankfull depth and resulting in shallower water depth in comparison with upstream and downstream cross-sections (although higher water levels mean that water depth is not less than recorded in 2006). The differences in bed elevation at the three riffles are also clearly evident in the long profile. The bankfull width of the channel, however, has only altered at MS03 and is likely to be due to modification of the bank profile during riffle construction.

Due to the high flows at the time of the 2008 survey, water width and depth has increased at most cross sections, even where riffles have been created.

Boundary conditions
The channel banks are graded and embanked with dredged material along the left hand bank. The bank has been previously subject to localised poaching but a new fence prevents this occurring. Toe scour and undermining has been stabilised by marginal vegetation and berms (see **Maps 3.4a and 3.4b**). The banks are composed of sand/silt material with gravel within the matrix. Immediately downstream of Seven Hatches both banks are protected by artificial walling.

Bed substrate samples taken from the channel centre, both channel margins and intervening points (see **Table 3.22**) indicate that the dominant substrate within the centre of the channel is gravel material (2-16mm in diameter) although pebble is dominant at MS01 and MS02. Silt is the dominant substrate at the channel margins at all cross sections with the exception of the riffles at MS03 and XS03. Cobble is dominant towards the centre of the channel at MS03 and XS03, but this is imported material used to create the riffles.

Comparison with pre-restoration survey (2006)
The creation of riffles has introduced coarser material at cross-sections MS02, MS03, and XS03. There is also no silt along at least one margin within each of these cross-sections, which is likely to reflect the faster flows and transport of fine sediment through these sections.

Less coverage of silt was also observed at cross-sections where riffles have not been created (XS01 and MS04). This may be related to increased transport of fine sediment as a result of higher discharge and flow velocities, as well as the restoration measures themselves. However, it is not possible to separate these influences.

Table 3.21 Bed substrate sampled at surveyed cross-sections in 2006*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Riffle	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**
		0.09	0.10	0.12	0.1	0.00
MS02	Glide	Silt	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.01	0.01	0.01	0.00
XS01	Glide	Silt	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.01	0.00	0.00	0.00
MS03	Glide	Silt	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.01	0.00	0.00	0.00
XS02	Glide	Silt	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.00	0.01	0.00	0.00
MS04	Glide	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt	Silt
		0.00	0.01	0.00	0.00	0.00
MS05	Glide	Silt	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.01	0.00	0.00	0.00
XS03	Glide	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt	Silt
		0.00	0.01	0.00	0.00	0.00

*Left and right channel margins are defined looking in a downstream direction

***Bold type** indicates whether pebble or gravel sized substrate was dominant.

Table 3.22 Bed substrate sampled at surveyed cross-sections in 2008*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Riffle	Silt	Gravel/**Pebble**	Gravel/**Pebble**	Gravel/**Pebble**	Silt
		0.054	0.064	0.176	0.226	0.075
MS02	Riffle	Silt	Gravel/**Pebble**	Gravel/**Pebble**	Gravel/**Pebble**	Gravel/**Pebble**
		0.030	0.148	0.560	0.322	0.060
XS01	Glide	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Silt
		0.068	0.145	0.125	0.108	0.108
MS03	Riffle	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Cobble	Gravel/**Pebble**
		0.002	0.026	0.354	0.397	0.186
XS02	Glide	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Silt
		0.050	0.100	0.138	0.130	0.074
MS04	Glide	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Silt
		0.096	0.113	0.116	0.064	0.061
MS05	Glide	Silt	**Gravel**/Pebble	**Gravel**/Pebble	**Gravel**/Pebble	Silt
		0.303	0.372	0.372	0.211	0.006
XS03	Riffle	Gravel/**Pebble**	Cobble	Cobble	Gravel/**Pebble**	Silt
		0.037	1.103	0.170	0.310	0.332

*Left and right channel margins are defined looking in a downstream direction

***Bold type** indicates whether pebble or gravel sized substrate was dominant.

Velocity

Flow velocity measurement data is contained within **Appendix D** and summarised for each cross-section in **Table 3.23**.

Table 3.23 Velocity summary data 2008 and comparison with 2006 for site SHC

Transect	Physical biotope	Cross-sectional area of flow (m^2)	Difference from 2006 (m^2)	Mean Velocity (ms^{-1})	Difference from 2006 (ms^{-1})
MS01	Riffle	7.57	5.85	0.124	0.021
MS02	Riffle	4.85	0.11	0.456	0.446
XS01	Glide	8.31	2.84	0.104	0.094
MS03	Riffle	6.29	0.65	0.207	0.197
XS02	Glide	8.24	3.58	0.109	0.099
MS04	Glide	11.12	5.24	0.091	0.081
MS05	Glide	11.16	5.34	0.290	0.280
XS03	Riffle	4.18	-1.18	0.290	0.280
Mean		**7.72**	**2.80**	**0.210**	**0.190**

The values presented in **Table 3.23** illustrate that mean flow velocity is greatest at the riffle sections (MS02, MS03 and XS03). These cross sections also have significantly lower cross sectional area of flow than the glide sections. Mean velocity at XS03, which is not as fast as at the other riffles, is likely to be reduced as a result of impoundment upstream of the railway bridge footings.

Comparison with pre-restoration survey (2006)

The influence of changes in the cross-sectional profile on flow velocities at riffles is not as clear due to higher discharge and water levels during the 2008 survey. Flow velocities are higher in 2008 at all cross-sections in comparison with 2006. However, it is notable that, despite higher water levels in 2008 the difference in cross-sectional area of flow is far less at the riffles than at the glides, and decreases at cross-section XS03.

3.4.2 Biological characteristics

Vegetation structure

Brook water-crowfoot (***Ranunuclus pencillatus*** spp. ***pseudofluitans***) is present at MS01, MS02, MS03 and MS04 and downstream of the railway bridge, although coverage is minimal at all locations. Fennel pondweed (***Potamogeton pectinatus***) is also present at MS04, indicating poorer in-channel vegetation conditions.

Emergent vegetation is extensive throughout the site forming a marginal fringe which acts to trap fine sediment. The dominant species are reed sweet grass (***Glyceria maxima***) and branched bur-reed (***Sparganium erectum***). Other species present include common nettle (***Urtica dioica***), creeping bent grass (***Agrostis stolonifera),*** fool's watercress (***Apium nodiflorum)*** and perennial ryegrass (***Lolium perenne).***

The riparian zone upstream of the railway crossing is protected by a fence on both banks. On the right hand bank a number of saplings have been planted. On the left hand bank there are regularly spaced non-native crop poplars (***Populus nigra***) set back approximately 5m from the channel. Some of these trees have been felled as part of the restoration works.

Downstream of the railway crossing, riparian vegetation is more varied, including trees, shrubs and tall herbs. Species present include water chickweed (***Myosoton aquaticum)*** and hemp agrimony (***Eupatorium cannabinum***) with occasional ash (***Fraxinus excelsior***) and grey willow (***Salix cinerea***).

Landuse within the site is predominantly semi-improved grassland on both banks. Downstream of the railway crossing landuse on the left hand bank is broadleaved woodland giving way to tall herb / ruderal vegetation in the final section.

Macrophyte coverage

A total of 58 taxa were recorded during the macrophyte assessment of the reach between Seven Hatches and the railway crossing. The locations of the 5 transects surveyed (MS01-MS05) were selected to represent different physical biotopes (see **Maps 3.4a and 3.4b**). Each of the transects was also subject to cross-section levelling survey (see Section 3.4.1).

The species that were found to be most common within the site, with a coverage of <5 % or more, are listed in **Table 3.19.** The site contains only one negative indicator species and no invasive species. The coverage of in-channel vegetation, including brook water-crowfoot (***Ranunuclus pencillatus*** spp. ***pseudofluitans***), is limited within the reach. ***Glyceria maxima*** and ***Sparganium erectum*** are the dominant emergent species and are present along both channel margins.

Comparison with pre-restoration survey (2006)

There are key differences between the macrophyte survey findings in 2006 and 2008. In 2008, less brook water-crowfoot was observed at some cross sections, although it was identified within all but one transect. Fennel pondweed, which was not present in 2006, is now present over 30% of the channel in cross-section MS04. This is the deepest section of the reach and this species is a negative indicator.

Installation of fencing to exclude livestock has increased marginal vegetation growth at some cross-sections. Riparian vegetation on the right hand bank is not grazed and grasses are growing with planted saplings.

Overall a fewer number of taxa were observed in 2008 than in 2006, and a reduced number of species were recorded as covering <5% of the channel. Several species observed in 2006 were not observed at all in the 2008 survey. This may be due to temporary disturbance caused by construction of the restoration works.

Table 3.24 Macrophyte species coverage (%) within site SHR

Latin Name	Common Name	Macrophyte coverage (%)											
		MS01		MS02		MS03		MS04		MS05		Whole site	
		2006	2008	2006	2008	2006	2008	2006	2008	2006	2008	2006	2008
			Riffle		Riffle		Riffle		Glide		Glide		
Key species													
Ranunculus penicillatus spp. pseudofluitans	brook water-crowfoot	<1	**<1**		**<1**		**<1**	<5	**<1**			<5	**<1**
Oenanthe crocata	hemlock water dropwort				**<5**				**<1**			<5	**<1**
Species present in <5 %													
Glyceria maxima	reed sweet grass			10	**10**	<5	**5**	<1	**10**	<5	**15**	10	**10**
Agrostis canina	velvet bent										**<1**	<5	**<1**
Agrostis stolonifera	creeping bent grass		**5**	<5	**<5**	<5	**5**		**<5**		**<5**	<1	**<5**
Apium nodiflorum	fool's watercress		**<1**	<1	**<5**	<1						<1	**<5**
Carex hirta	hairy sedge		**<1**	<1	**<1**	<1		<1		<1		<5	**<1**
Carex riparia	greater pond sedge			<1			**<1**					<5	**<1**
Juncus inflexus	hard rush				**<1**	<1				<1	**<1**	<5	**<1**
Lolium perenne	perennial ryegrass		**<1**				**5**		**<1**				**<5**
Mimulus guttatus	monkey flower											<5	
Myosotis scorpioides	water forget-me-not	<1	**<1**	<5	**<1**	<5	**<1**	<5	**<5**	<5	**<1**	<5	**<1**
Ranunuclus repens	creeping buttercup	<5	**<5**	<5	**<1**	10	**<1**	<1		<5	**<1**	<5	**<1**
Rumex sanguineus	wood dock			<1			**<1**	<1		<1		<5	**<1**
Sparganium erectum	branched bur-reed	<1	**<1**	10	**10**	<5	**<5**	<5	**<5**	<1	**5**	<5	**10**
Urtica dioica	common nettle	10	**10**	<1		<1			**<1**			<5	**<5**
Negative indicators													
Potamogeton pectinatus	fennel pondweed			10				10	**30**	<1	**5**	10	**<5**
Invasive species													
None													
No of Taxa Recorded		**14**	**29**	**20**	**20**	**19**	**24**	**22**	**25**	**13**	**17**	**70**	**58**

Fisheries survey

Electro-fishing was undertaken at two sites, the location of which is indicated in **Maps 3.4a and 3.4b.** The total number of each fish species caught at each site during the electrofishing survey, including the Annex II species for which the Avon SAC is designated, is indicated in **Figure 3.12**.

Figure 3.11 Number of fish caught during electrofishing of sites SHR01 and SHR02 in 2006

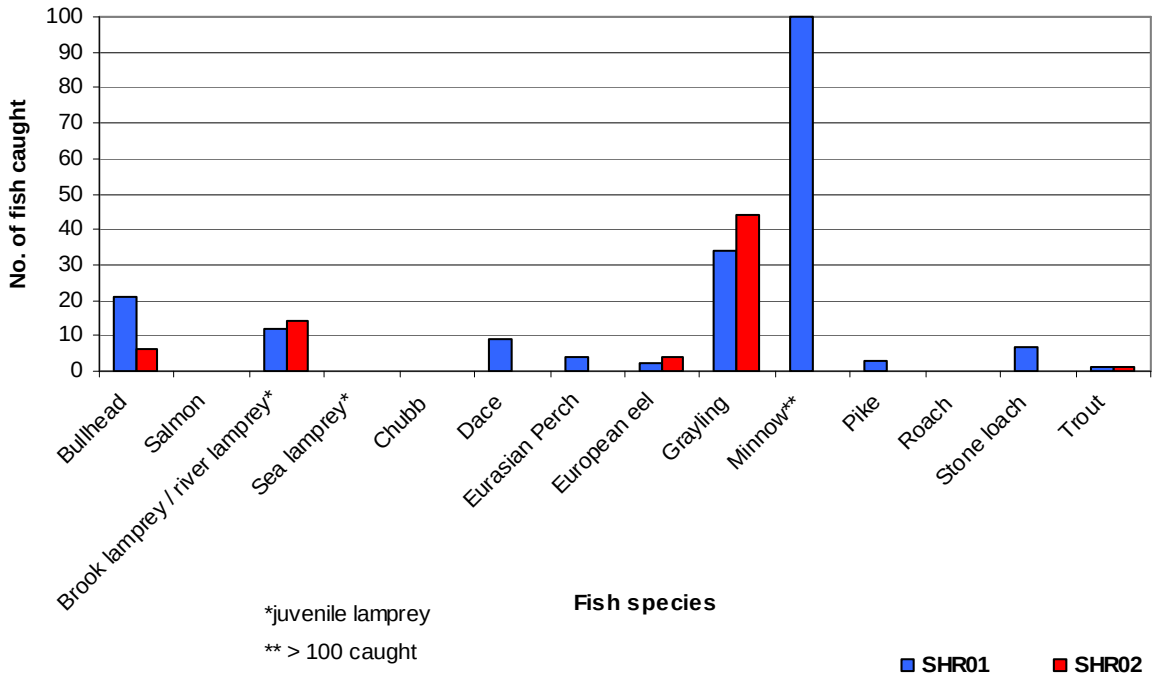
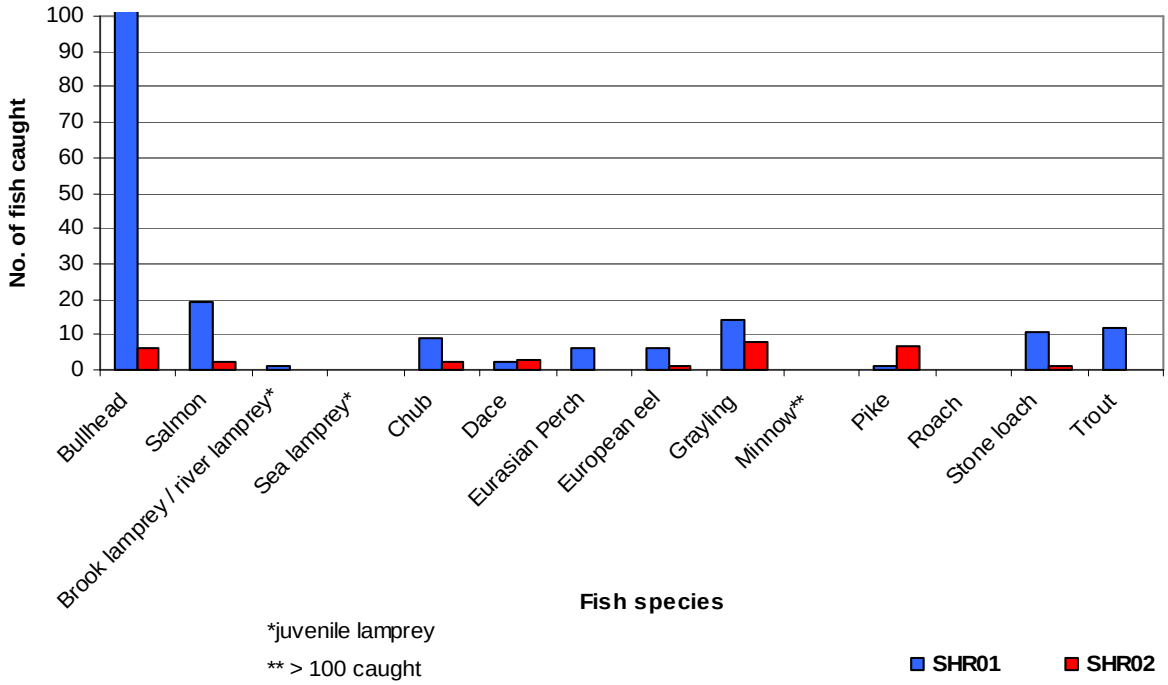


Figure 3.12 Number of fish caught during electrofishing of sites SHR01 and SHR02 in 2008



Within meso-habitat SHR01, 101 bullhead and 19 salmonids were caught. Other notable catches were 12 grayling and 11 trout. Lower numbers of these species were caught in meso-habitat SHR02.

The calculated minimum density of brook lamprey and bullhead within both of the meso-habitats surveyed is shown in **Table 3.26**.

Table 3.25 Minimum density of brook lamprey and bullhead per m^2 in 2006.

Fish species		Brook lamprey (quadrats only)		Brook lamprey (quadrat & sweep)		Bullhead	
Meso-habitat		**SHR01 (Glide)**	**SHR02 (Glide)**	**SHR01 (Glide)**	**SHR02 (Glide)**	**SHR01 (Glide)**	**SHR02 (Glide)**
Area		**5**	**5**	**24**	**24**	**1200**	**1200**
No. fish caught	**Shock 1**	2	1	2	1	9	3
	Shock 2	2	5	2	5	12	3
	Shock 3	2	2	2	2		
	Total	6	8	6	8	21	6
Minimum density (observed no. per m^2)		**1.20**	**1.60**	**0.25**	**0.33**	**0.018**	**0.005**

Table 3.26 Minimum density of brook lamprey and bullhead per m^2 in 2008.

Fish species		Brook lamprey (quadrats only)		Brook lamprey (quadrat & sweep)		Bullhead	
Meso-habitat		**SHR01 (Glide)**	**SHR02 (Glide)**	**SHR01 (Glide)**	**SHR02 (Glide)**	**SHR01 (Glide)**	**SHR02 (Glide)**
Area		**5**	**5**	**24**	**24**	**1200**	**1200**
No. fish caught	**Shock 1**	1	0	1	0	53	1
	Shock 2	0	0	0	0	81	3
	Shock 3	0	0	0	0	29	2
	Total	1	0	1	0	163	6
Minimum density (observed no. per m^2)		**0.20**	**0.00**	**0.04**	**0.00**	**0.136**	**0.005**

Table 3.26 indicates that the observed minimum density of bullhead is greatest within meso-habitat SHR01. This may indicate a strongly localised presence of this species in meso-habitat SHR01 between the created riffles that are immediately upstream and downstream. Very few brook lamprey were caught within either meso-habitat, possibly due to the high flows at the time of the survey limiting visibility of the channel bed.

Comparison with pre-restoration survey (2006)

The range and number of fish caught in 2008 varies significantly when compared with findings from 2006. Key differences include an increase in the number of salmon, trout and bullhead; and a decrease in lamprey and minnows.

The increased number of salmon and trout may be related to greater flow velocities experienced within the reach in 2008, as these fish require swift clear water. This may in part be due to the river restoration works, although it is not possible to separate this influence from the increase in flow velocity due to higher discharge within 2007 and

2008. Several other wider catchment conditions (such as water quality and prey availability) also influence fish populations, particularly of migratory fish

The increased number of bullhead caught in mesohabitat SHR01 (101 in 2008 compared with 21 in 2006) may indicate a localised preference or confinement of bullhead between the upstream and downstream riffles.

The minimum density of lamprey is much lower in 2008 in both meso-habitats than in 2006. No minnows were caught in 2008. Lamprey ammocoetes require shallow waters with low water velocity, and the presence of organic detritus and/or plant material. Minnows are also typically found in shallow waters with a sandy or gravelly bottom. The higher flow velocities and depth of flow experienced in 2008 may therefore have made habitat conditions less suitable for lamprey and minnows.

3.4.3 Physical and biological relationships

- Restoration works have been undertaken within this reach between 2006 and 2008 and key differences were observed between the two surveys where measures have been implemented.

- Cross-sections located on riffles and the channel long-profile illustrate how the bed has been raised in these sections. The riffles are associated with shallower, faster flows in comparison with the alternating glide sections. However, differences in flow velocity in comparison with 2006 are masked by differences due to the higher discharge during the 2008 survey.

- Due to historical dredging the cross-sectional profile of the channel remains overwide and overdeep where restoration measures have not been implemented. Inpoundment is also still occurring upstream of the railway crossing, resulting in lower flow velocities and siltation on the channel bed.

- In-channel vegetation coverage remains extremely limited even on riffle areas. Brook water-crowfoot is present in all transects apart from MS05 but is limited in coverage. However, fennel pondweed is also present at MS04 indicating adverse habitat conditions.

- Macrophyte growth is dominated by emergent species growing along the channel margins. These species are able to establish in silt on the channel bed under slow flow conditions. Coverage of marginal vegetation throughout the reach was higher in 2008 due to the exclusion of livestock poaching using fencing. This has also resulted in establishment of a riparian buffer zone and increased coverage of grasses.

- The observed minimum density of bullhead and number of other fish species caught is greatest within the upstream glide meso-habitat. This may reflect a preference for less impounded conditions within this meso-habitat.

- Greater numbers of salmon, trout and bullhead but fewer brook lamprey and minnows were caught in 2008 compared with 2006. This is likely to reflect changes in flow velocities and water depth resulting from both the restoration works themselves and higher discharge throughout in 2007 and 2008. In particular, the

high density of bullhead recorded in SHR01 appear to be related to the location of the river restoration works. However, it is not possible to separate the influences of the works and prevailing flow conditions.

4 RAPID ASSESSMENT RESULTS

4.1 Fovant

Upstream limit: 400215 139594
Downstream limit: 400672 130740
Length of site: 490m

Location:
This site is located on the River Nadder near Dinton, upstream of a sluice structure (**Map 4.1**). The upstream boundary of the site is located where a drain flowing from Mill Farm joins the main channel. The downstream boundary of the site is the Iron Hatches structure itself.

Typical photographs:

a) 2006

b) 2008

Photo 4.1.1 - FOR01b: Looking downstream from start of restoration reach

a) 2006

b) 2008

Photo 4.1.2 - FOR01h: Looking upstream along the glide physical biotope with broadleaved woodland along the right hand bank.

a) 2006

b) 2008

Photo 4.1.3 - FOR01k: Looking upstream along glide section.

a) 2006

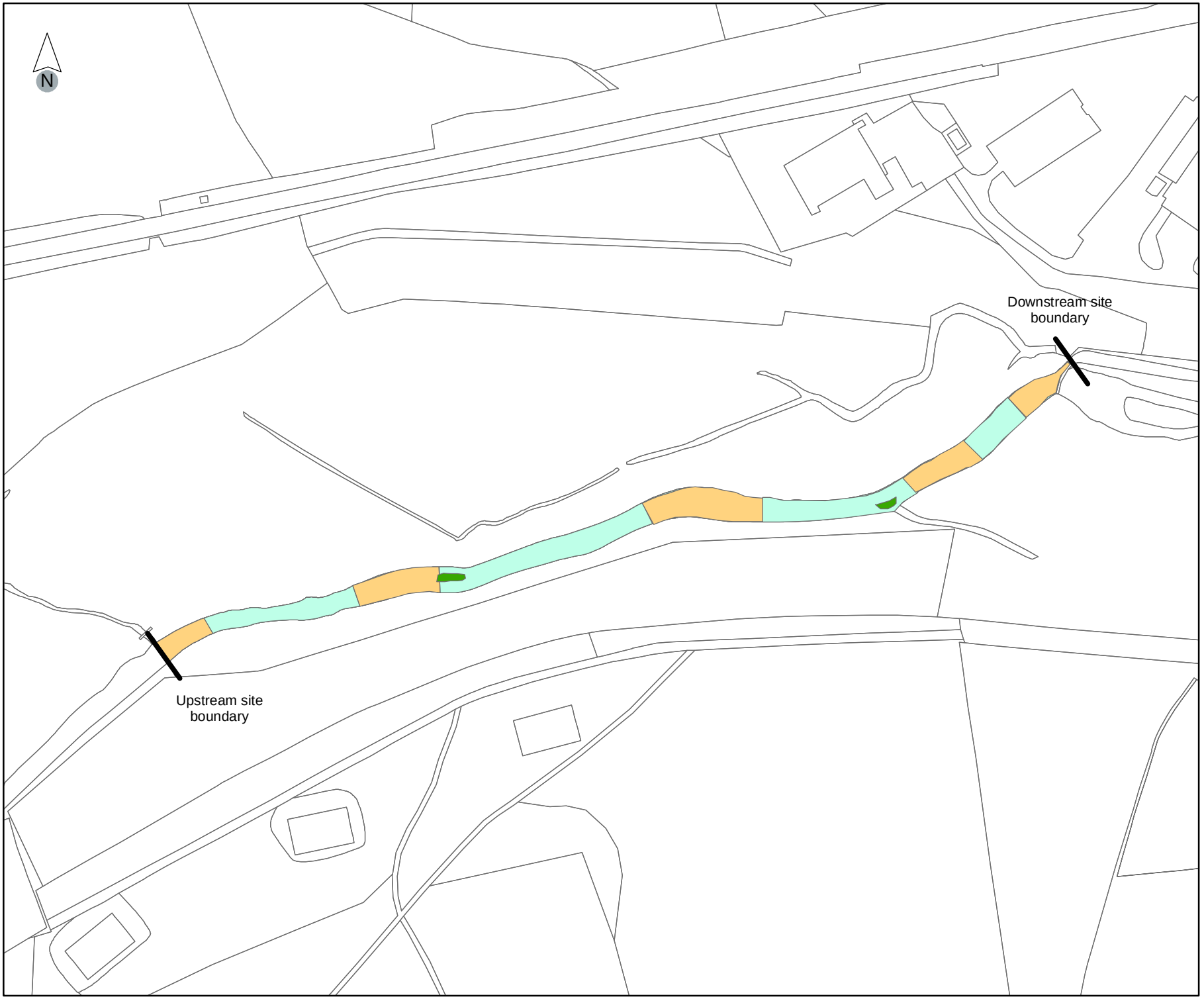
b) 2008

Photo 4.1.4 - FOR01s: Looking downstream towards Iron Hatches

Comparison with pre-restoration survey (2006)

The restoration works at Fovant focussed on reduction of impoundment and narrowing the river channel to provide more varied flow conditions. The impacts of this narrowing is clearly evident in Photos 4.1.1a, 4.1.1b, 4.1.2a and 4.1.2b where the river has greater flow velocity with a less uniform glide physical biotope.

In-channel vegetation has visibly increased in coverage within the reach, as illustrated in Photos 4.1.3a, 4.1.3b. Channel narrowing, as evident in Photos 4.1.4a and 4.1.4b where a 'V' shaped groyne has been introduced, has also helped to increase marginal vegetation coverage within the hydrological transition zone.



Legend

Physical biotope

- Glide
- Pool
- Run

Title:
Fovant Restoration Site (FOR)
Location and physical biotopes

Project:
Avon STREAM Monitoring Project

Client:
Natural England

Date:
25/01/2009

Scale:
1:2,500

Map 4.1

4.1.1 Physical Characteristics

Physical biotopes

At the upstream boundary of the site the main physical biotope is a run, where the channel has been narrowed using deflectors. Downstream of this there is an alternating run and glide pattern (**Map 4.1**). The location of the runs and glides does not directly reflect channel planform – e.g. there is a run at the outside of the meander bend which was previously a pool. However, the main glide sections do coincide with locations where the channel is straight and treelined on the right hand bank. There are now two pools within the reach, one upstream of the first treelined section and one where a field drain feeds into the main river.

Comparison with pre-restoration survey (2006)

The reduction of impoundment due to the opening of Iron Hatches has resulted in increased flow velocities and lower water levels throughout the reach. These improvements in flow conditions, together with in-channel restoration works, have helped create diverse physical biotopes in contrast to the uniform, ponded glide that was observed in 2006. The most significant restoration action has been the reduction of impoundment, as these physical biotopes would not have been able to develop without improved flow conditions. The groynes and associated vegetation are, however, contributing to narrowing of the channel and creation of further diversity.

Sediment regime

The series of groynes that have been placed in the channel since the 2006 survey where highlighted in the Fluvial Audit as fine sediment sinks (see **Appendix A**). They are encouraging marginal silt deposition and subsequent vegetation. Marginal vegetation that has become established has stabilised the toe scour that was previously observed along the left hand bank. The right hand bank remains consolidated by tree roots from treelining upstream of the confluence with the field drain on the right hand bank. The predominant sediment process within the reach is transport downstream, with deposition of fine sediment between the groynes at the channel margins. Gravel bed substrate was observed throughout the reach.

Comparison with pre-restoration survey (2006)

The reduction of impoundment has resulted in a fundamental difference in the sediment regime in this reach. In 2006, silt deposition was occurring on the channel bed in response to the impounded conditions. The majority of fine sediment is now likely to be transported through the reach. Localised deposition of fine sediment is occurring between the groynes and subsequent vegetation is effectively narrowing the channel. Localised bank erosion that was evident in 2006 has been stabilised as a result of lower water levels and increased marginal vegetation.

4.1.2 Biological characteristics

In-channel vegetation occurs throughout the reach and there is significant coverage of brook water-crowfoot (***Ranunuclus pencillatus*** spp. ***pseudofluitans***).

Emergent vegetation is present along both banks although it is still limited to some extent on the right bank by shading, which results from the adjacent broadleaved woodland. The dominant species is reed sweet grass (***Glyceria maxima***) with occasional butterbur (***Petasites hybridus***) and reed canary grass (***Phalaris arundinacea***).

The riparian zone along the right hand bank is better established than along the left hand bank and contains a variety of aquatic species. Along the left hand bank there is a mown grass fisherman's path which limits the width of the riparian zone. Species present include common nettle (***Urtica dioica***), yellow flag iris (***Iris pseudacorus***), bramble (***Rubus fruticosa***) and reed sweet grass (***Glyceria maxima***). Himalayan balsam (***Impatiens glanifer***), an invasive non-native species is also present on the right hand bank. Both banks have occasional trees which include crack willow (***Salix fragilis***), alder (***Alnus glutinosa***) and ash (***Fraxinus excelsior***).

Landuse along the left hand bank is a historic water meadow and is now unimproved grassland / extensive grazing. The ditch system within this field contains greater pond sedge (***Carex riparia***) and reed sweet grass (***Glyceria maxima***). Evidence of water voles was also observed along the left hand bank.

Comparison with pre-restoration survey (2006)
The extent of in-channel vegetation has increased significantly since 2006, with extensive coverage of brook-water crowfoot (***Ranunuclus pencillatus*** spp. ***pseudofluitans***) throughout the reach. This is likely to be a result of the increased flow velocities that have occurred since impoundment was reduced.

Reed sweet grass (***Glyceria maxima***) remains the dominant emergent species on the left hand bank and shading from trees is now less limiting on the right hand bank due to selected tree felling. The extent and variety of marginal vegetation coverage on both banks has also been increased as a result of the installation of marginal groynes, which have subsequently trapped silt and become vegetated, thus improving the hydrological transition zone.

4.1.3 Summary of physical and biological relationships

- Opening Iron Hatches has resulted in increased flow velocities, lower water levels and creation of varied physical biotopes in contrast to the uniformly laminar glide.
- Growth of brook-water crowfoot (***Ranunuclus pencillatus*** spp. ***pseudofluitans***) has significantly increased as a result of the improved flow conditions.
- The combination of lower water levels and installation of groynes has improved the hydrological transition zone between the channel and the banks. This has resulted in greater coverage of marginal fringe species, such as water mint (***Mentha aquatica***).
- Shading along the right hand bank has been reduced and is less of a limiting factor on the diversity of riparian and emergent macrophyte species along this bank. Groynes that are not within the treelined section are, however, better vegetated than those within it.

4.2 Hale

Upstream limit: 416352 117930
Downstream limit: 417703 118644
Length of site: 1940m

Location:
This site is located on the River Avon near Hale and Breamore. The upstream boundary of the site is located at the bridge between Church Copse and the adjacent water meadows. The downstream boundary of the site is near St Michael's Priory just upstream of the weir and near the Mill pond (**Maps 4.2a, 4.2b and 4.2c**)

Typical photographs:

a) 2006 **b) 2008**

Photo 4.2.1 - HAR01e: Looking downstream along the glide with broadleaved woodland along the left hand bank.

a) 2006 **b) 2008**

Photo 4.2.2 - HAR01s: Looking downstream along the glide

a) 2006

b) 2008

Photo 4.2.3 - HAR02c: Looking across channel at eroding bank

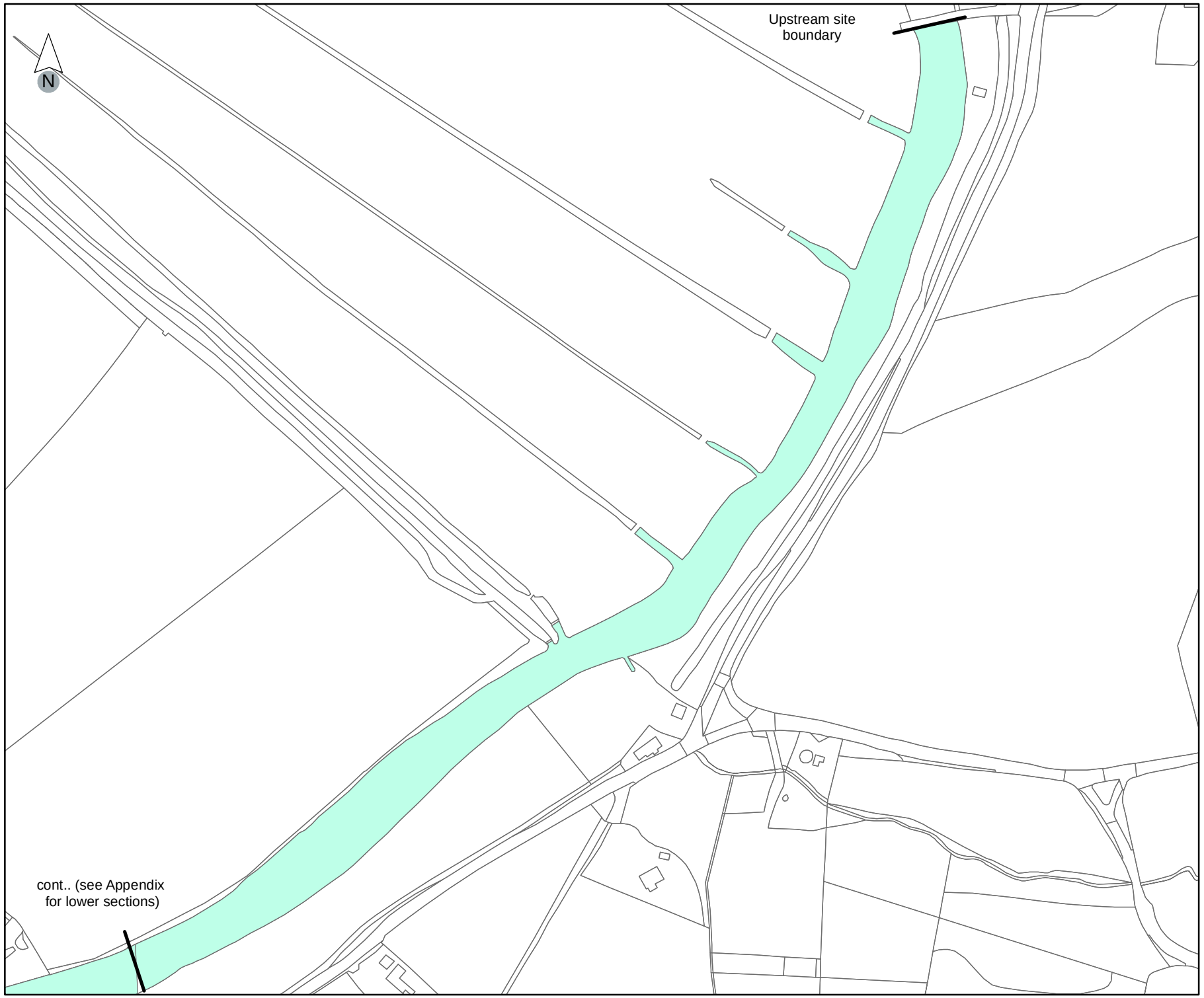
a) 2006

a) 2008

Photo 4.24 - HAR02f: Looking upstream along the glide from the downstream boundary.

Comparison with pre-restoration survey (2006)

Flow levels at the time of the 2008 survey were particularly high, as evident in all of the photographs. This prevented direct observation of the impacts of the implemented restoration works, which were consequently submerged. Water-logged conditions along the right hand bank also made access difficult. Visual differences included greater flow velocities, with fast, rippled glides at the upstream end of the site (**Photos 4.4.2a and 4.4.2b**). The eroding bank shown in **Photos 4.4.3a and 4.4.3b** appears to have been stabilised by increased vegetation.



Legend

Physical biotope

Glide

Title:
Hale Restoration Site (HAL)

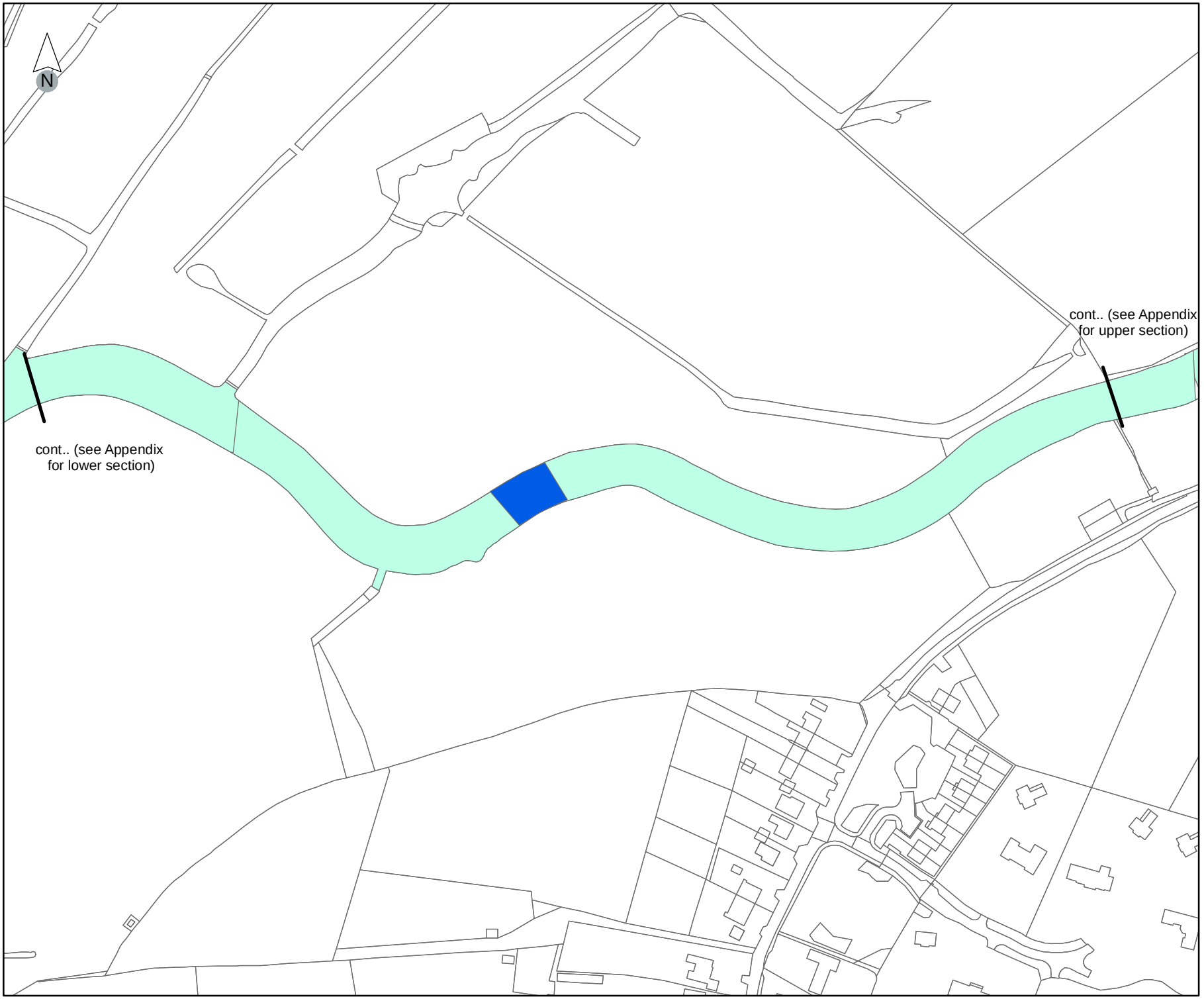
Project:
Avon STREAM Monitoring Project

Client:
Natural England

Date:
25/01/2009

Scale:
1:2,500

Map 4.2a



Legend

Physical biotope

- Glide
- Upwelling

Title:
Hale Restoration Site (HAL)

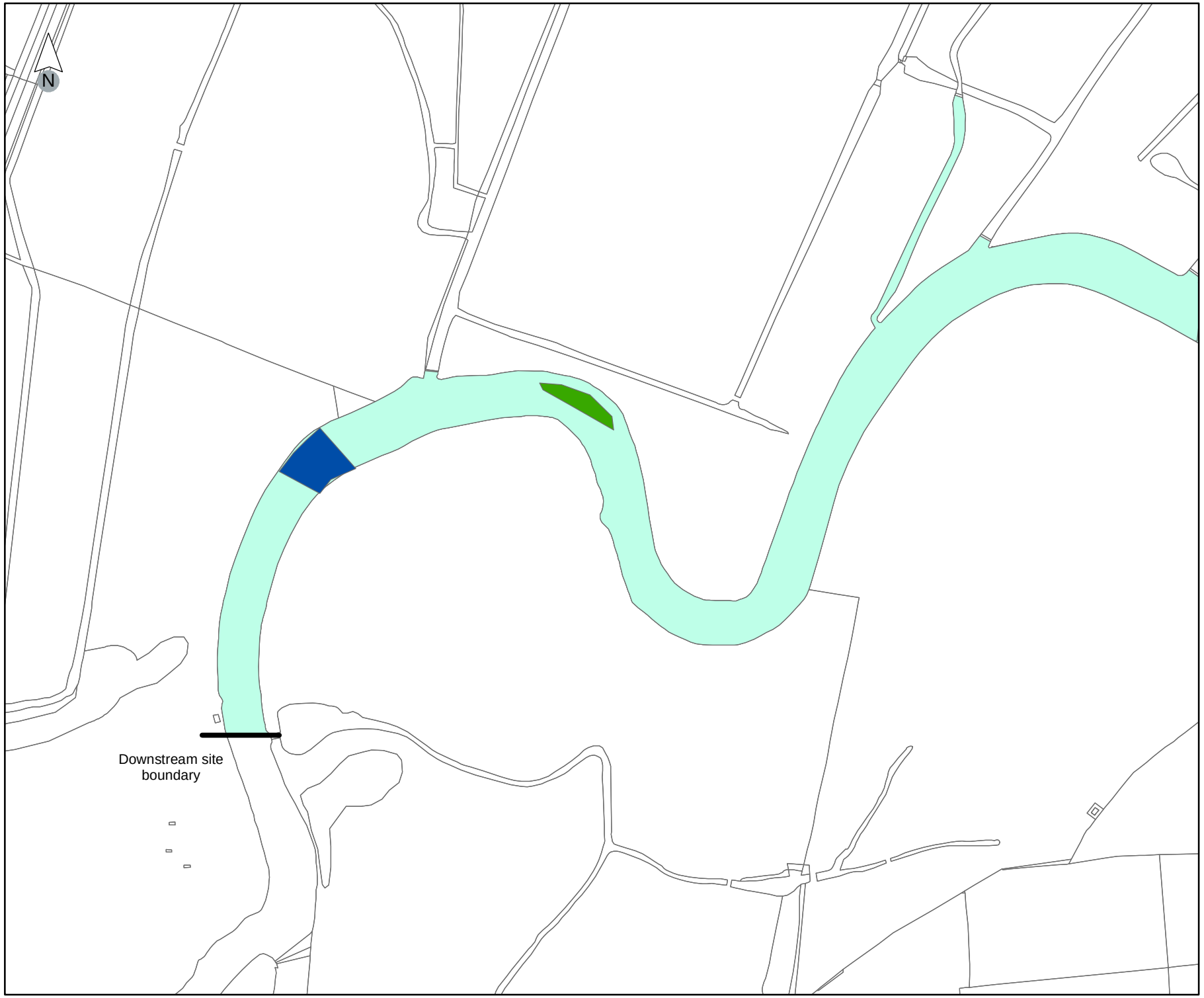
Project:
Avon STREAM Monitoring Project

Client:
Natural England

Date:
25/01/2009

Scale:
1:2,500

Map 4.2b



Legend

Physical biotope

- Glide
- Upwelling
- Pond

Title:
Hale Restoration Site (HAL)

Project:
Avon STREAM Monitoring Project

Client:
Natural England

Date:
25/01/2009

Scale:
1:2,500

Map 4.2c

4.2.1 Physical Characteristics

Physical biotopes

The main physical biotope present is glide, with a deeper and faster flowing section towards the downstream limit. Within this, on the outside of the start of the last meander bend of the section, a deep pool was observed (**Map 4.2c**). There is also an area of rippled flow at the upstream end of reach resulting from marginal vegetation. Further downstream at two locations, upwelling was observed.

Comparison with pre-restoration survey (2006)

The dominant physical biotope, as in 2006, is a glide that becomes deeper and faster flowing towards the downstream limit of the reach. At the time of the 2008 survey, discharge and water levels were particularly high and this is likely to have "drowned out" much of the localised diversity of physical biotopes that may have resulted from in-channel restoration structures. Areas of upwelling occur naturally within areas of high flow velocity as a result of three-dimensional flow dynamics. The two areas of upwelling observed may be related to creation of the large riffle upstream of the first area and the large woody debris deflectors installed within the second area downstream.

Sediment regime

The river has a low gradient[1], meandering planform and uniform flow velocities. Previous channel modification through dredging has made the channel over-wide and over-deep, and there remains generally a lack of hydrological transition zone at the channel margin. The dominant bed material is thought to be fine gravel but was not visible at the time of survey. Silt was evident at the channel margins, particularly along the right hand bank where the banks and associated vegetation were waterlogged. The bank material is predominantly cohesive and consists of silts and sand.

For the purposes of Fluvial Audit, the site was divided into two reaches (HAR01 and HAR02). The downstream reach (HAR02) exhibits deeper and faster flows in comparison with the upper reach (HAR01). At the downstream end of HAR01 three vegetated berms have established since 2006.

Localised sourcing of fine sediment to the channel is occurring throughout the reach from field ditches and minor poaching due to livestock and fishing access. Natural bank erosion, in the form of eroding cliffs on the outside of meander bends, is also a minor source of fine sediment to the channel. Fencing has been erected since 2006 to prevent exacerbation of natural erosion by poaching at one location in the middle of the reach. Fine sediment was also being transferred to water-logged channel margins at the time of survey.

Comparison with pre-restoration survey (2006)

Similar fine sediment sources were observed, although increased marginal vegetation, and in one location exclusion of livestock through fencing, have reduced bank erosion at meander bends. Several deflectors and a gravel riffle have been installed as part of the restoration works and it is likely that they are having a localised impact on the sediment regime through the trapping of fine sediment. Due to the high water levels however, it was not possible to ascertain whether the restoration measures have resulted in altered patterns of sediment deposition on the channel bed.

[1] As defined under the Fluvial Audit methodology – "Looking back over the reach there is no obvious flow or slope**"**

4.2.2 Biological characteristics

In-channel vegetation occurs intermittently along the channel and is limited to water-crowfoot (*Ranunculus penicillatus*). The greatest coverage occurs at the upstream end of the site.

At the upstream end of the site, the left hand bank is wooded and dominated by sycamore (*Acer pseudoplatanus*) and ash (*Fraxinus excelsior*), with occasional willow (*Salix* sp.*)* and English oak (*Quercus robur*). The right hand bank is predominantly reeds and the dominant species are reed sweet grass (*Glyceria maxima*) and common reed (*Phragmites australis*) with reed canary grass (*Phalaris arundinacea*). There are also occasional willow trees (*Salix* sp.), hawthorn (*Crataegus.monogyna*) and areas of bramble (*Rubus fruticosus* agg.).

Further downstream the vegetation is similar in nature on both banks. The dominant species are reed sweet grass (*Glyceria maxima*) and common nettle (*Urtica dioica*) and other species present include yellow flag iris (*Iris pseudacorus*), reed canary grass (*Phalaris arundinacea),* bramble (*Rubus fruticosa*), water mint (*mentha aquatica*), great willow herb (*Epilobium hirsutum*), branched bur-reed (*Sparganium erectum*) and occasional alders (*Alnus glutinosa).*

The riparian buffer zone is continuous but narrow on the left hand bank and land use varies between tall ruderal plants, broadleaved woodland, and semi improved grassland. Along the right hand bank the dominant landuse is semi improved grassland which supports sheep and cattle grazing. The riparian zone is consequently limited and in places non-existent. The ditch system within the fields on the right hand bank contains common reed (*Phragmites australis*) and reed sweet grass (*Glyceria maxima).*

Comparison with pre-restoration survey (2006)
Vegetation structure and species diversity appears generally similar to the 2006 survey. There was, however, no evidence of horned pondweed during the 2008 survey.

4.2.3 Summary of physical and biological relationships

- The cross-sectional profile of the channel remains over sized and flow conditions were deep and largely uniform in physical biotope. Localised diversity may be evident at lower flows as a result of the in-channel restoration works that have been undertaken, but were not observed at the time of survey.

- Livestock poaching, natural depositional features and installed vegetated berms are providing habitat diversity by modifying the profile of channel margins and water depths in places. These are associated with the establishment of marginal vegetation species.

- Increased growth of marginal vegetation is likely to be related to sustained higher water levels within 2007 and 2008.

- Landuse practices are still limiting the width of the riparian zone; and allowing livestock access to the channel is increasing localised fine sediment supply. At one location, however, fencing has been successfully used to reduce poaching.

- Landuse practices are still limiting the width of the riparian zone; and allowing livestock access to the channel is increasing localised fine sediment supply. At one location, however, fencing has been successfully used to reduce poaching.

- The fluvial bank erosion observed is localised and reflects lateral planform change through meander development.

5 CONCLUSIONS

Having analysed the pre-restoration and post-restoration survey data for the four sites, it is possible to draw some general conclusions:

- Through pre-and post-restoration monitoring it has been possible to document differences in physical and biological conditions between 2006 and 2008.

- Physical differences resulting from changing the operation of a structure to reduce impoundment were evident at Fovant. The increase in flow diversity upstream can be largely attributed to this change in operation (although in-channel measures are also likely to have contributed to the differences observed).

- Due to significant difference in flow conditions between the pre-restoration and post-restoration surveys, it is not possible to link the biological differences observed in plant and fish species at the detailed assessment sites, with the physical changes that have been made as part of the restoration works.

- Many of the biological differences that can be observed between the two datasets are likely to be related to higher discharge and water levels throughout 2007 and 2008 in comparison with 2006.