The Wye & Usk Foundation
ACTION FOR FISHERIES

# Strategic Evidence & Partnership Project

## *Demonstrating the use of Local Catchment Evidence to Meet Good Ecological Status in the River Lugg Catchment*

defra
Department for Environment Food and Rural Affairs

THE RIVERS TRUST
where there's water there's life
The new name for the Association of Rivers Trusts

**Contents**

## Summary

The Water Framework Directive is a very ambitious piece of legislation reflecting the pressing need to provide a framework for the protection of inland and coastal water in order to arrest deterioration in aquatic ecosystems, promote sustainable use, enhance protection, support efforts to make improvements and ensure the progressive reduction of water pollution. It provides the UK with the opportunity to adopt a holistic and inclusive approach to water management and deliver real improvements on a catchment scale.

In this study the Wye & Usk Foundation conducts a systematic review of Water Framework Directive classification for waterbodies in the River Lugg catchment, using local knowledge of the catchment to ground truthing in the current waterbody classifications. Following this desk based exercise, the Tippets brook and River Lodon catchment were selected for additional investigation to explore how, with the use of proven methodologies, Rivers Trusts may further inform the WFD assessment process and guide appropriate mitigation measures.

The desk based study identified limitations with the current biological monitoring network which is likely to be creating an unrealistically positive picture of the current state of the waterbodies in the catchment. In the absence of appropriate assessment data, increased emphasis needs to be placed on adjacent biological classification and less on Physico-chemical indicators.

The foundation is concerned by the distinct lack of ambition displayed in the plan,
80% of these are classified as moderately failing; these sites could represent 'quick wins', with the implementation of targeted remedial measures it would not be a massive leap to bring these sites up to GS for Phosphate by 2015. However lack of ambition is again of concern, all sites showing single elemental failures for phosphate are not predicted to reach GS by 2015.

The Foundation is concerned by inaccuracies in current fish classifications which could beand recommends the application of local knowledge and additional monitoring to further inform the classifications.

Tippets summary:
The current system of classification which provides an automatic downgrade to failing status on the accumulation of adverse biological data is potentially unhelpful. **Full use of all data sources at the incept should be used to beneficially inform the classification process or waterbodies**

## 1. Introduction

### 1.1 The River Lugg catchment description:

The River Lugg is the major tributary of the River Wye, rising at its upland source in Powys it flows in a south easterly direction, joining with the River Wye near to Mordiford, having drained a total area of 1,077km2. Once a major part of the Wye Salmon fishery, the River Lugg supported a healthy population of returning Atlantic salmon with annual redd counts in excess of 1,000 recorded. Over the last 20 years a wide range of issues and pressures have seen salmon populations undergo a sharp decline. In recognition of its wildlife and geomorphological importance main stem of the River Lugg is designated as a Site of Special Scientific Interest (SSSI), with the river below Hampton Court forming part of the River Wye Special Area of Conservation (SAC) designation. The weir at Hampton Court marks the upstream point of the SAC, as the distribution of salmon at the time of designation terminated at this point

**Figures 1: Left: Position of the River Lugg within the River Wye catchment.**

Land use within the catchment compromises mixed arable and livestock production. Grassland and woodland dominate the upper regions and the Bodenham massive with arable cropping increasing through the middle reaches to become the prevailing land use in the lower part of the Lugg. Livestock production is dominated with sheep in the headwaters and cattle in the middle and lower sections of the catchment. Pig and poultry units are also present, with a large number located within the River Arrow and Pinsely brook sub-catchments

### 1.2 Water quality pressures:

Major pollutants enter the River Lugg through point and diffuse sources. Discharges from agriculture, sewage treatment works, industry and residential sites combine in the watercourse with damaging effects. In 1994, water quality concerns lead to the Lugg being designated as a 'eutrophic sensitive area' under the Urban Wastewater Treatment Directive.

There are approximately 40 recognised inputs of STW effluent to the River Lugg and its tributaries, and at least an additional 50 inputs from private and trade effluents, notably Cadbury's large chocolate crumb factory in Marlbrook (figure 2). Environment Agency modelling has attributed 50% of the Lugg's Phosphate loadings to industrial point sources (including STW's), with phosphate loadings increasing along the length of the catchment.

**Figure 2&3: Left: Cadburys factory situated on the Lugg at Marlbrook. Right: Evidence of IDB channel modification in the Lugg catchment.**

Draining a predominantly rural catchment, many of the Lugg's water quality pressures can be attributed to agricultural land use pressures. In the lower catchment, the last 10 years has seen a shift from livestock production to highly profitable cash crops including, soft fruit, asparagus and potatoes. These land use changes have had a major impact on water quality through the associated pollution of sediments, nutrients, pesticides and herbicides and high levels of unlicensed abstraction. In an attempt to reduce agricultural pollution, the River Lugg has been a priority catchment for the Defra's Catchment Sensitive Farming Delivery Initiative since 2007.

Large sections of the river have been physically modified through the construction of weirs (>100 in the catchment) and a flood defence by-pass channel in Leominster. In addition, much of the lower catchment comes under the management of River Lugg Internal Drainage Board (IDB). Covering 11,130 ha of land and 176 km of scheduled watercourses, past IDB work has seen many of the catchments channelised and cleared with the intention of maximising agricultural productivity and to protect agricultural land from flooding. IDB modifications and clearance have transformed stretches of the Lugg waterbodies from meandering streams with riffles and pools, to straight, uniform depth channels and an artificially low bed height. These channels are over widened and prone to filling in with vegetation so are annually flailed or sprayed resulting in limited bankside vegetation (see figure 3).

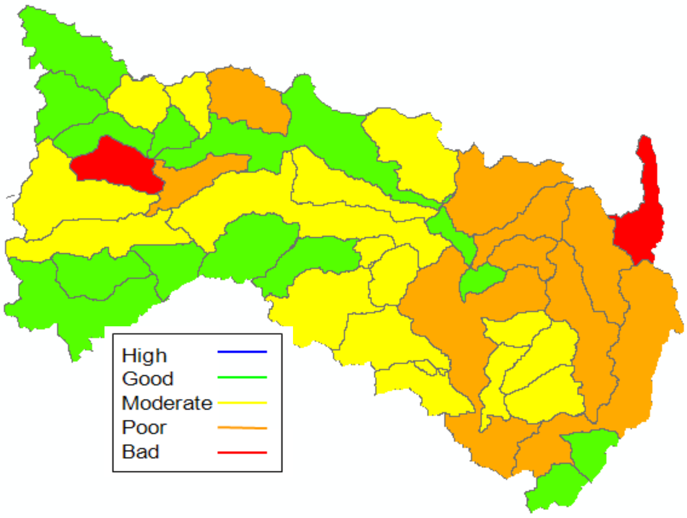



**Figure 4: Current WFD waterbody classification in the River Lugg.**

Classifications for the River Lugg catchment published in the Severn Basin Management Plan (2010) highlight that 71% of Water bodies (WB's) are currently failing to meet WFD water quality targets, with 27% of WB's currently rated as being in bad or poor condition (see figure 4). There is a concerning lack of ambition, with only one water body (Gilwern brook) that is currently failing being predicted to attain GES by 2015. This is one of the water bodies currently failing on fish due to barriers to migration that are in the process of being removed but WUF and EAW. It begs the question why some of the other water bodies potentially able to benefit from this work are not forecast to improve.

## 2.0 Assessment of current WFD classification for the River Lugg

### 2.1 WFD monitoring network:

The Lugg catchment is divided into 40 individual waterbodies, with a total of 150 WFD monitoring sites. Most WB's are considered as being at an appropriate scale to allow accurate assessment and the effective implementation of remedial measures. However, the delineation of WB 42030 (R Lugg: Conf Norton- conf R Arrow [42030]) shown in figure 5, is of concern as land use undergoes a significant change around this WB's mid-point. To ensure accuracy in the WFD classification it would be more appropriate to split this WB at the mid-point, into two distinct management units.


**Figure 5: WFD monitoring sites in the River Lugg catchment**

### 2.2 Chemical monitoring network:

In the Lugg, WFD Physico-chemical element monitoring is comprehensive with 97% of waterbodies sampled. The most common Physico-chemical failure is for phosphate, with 30% of WBs failing WFD Phosphate targets. 42% of these WB's are also failing targets for dissolved oxygen.

The number of WB's measured for the full suite of chemical pollutants is much more limited, with a full range of polluting substances only monitored in the lower reaches of River Frome, at its confluence with the River Lugg and lower main stem at Mordiford.

In-line with extensive published research, the Lugg waterbodies often show discrepancies between Physico-chemical and ecological elemental results. Only 25% of waterbodies displaying ecological parameter failures are also failing on chemical parameters. This is indicative of two factors. Firstly the fluctuations in water quality, are often not effectively identified through monthly monitoring and there is also a tendency to sample during dry weather flows, which often negates the true assessment of loadings from storm water and combined sewage outflows. Secondly, many parts of the catchment are suffering from elevated levels of fine sediment which impact severely on the salmonid fish stocks, causing multiple failures for fish

**2.3 Biological Monitoring network:**

The four principle biological element coverage across the 40 waterbodies in the Lugg Catchment is shown in Table 1.

| Element | No of WB's with data | % of WB's with data |
|---|---|---|
| Fish | 22 | 55 |
| Inverts | 22 | 55 |
| Phytoplankton/ benthos | 1 | 2.5 |
| Macrophytes | 0 | 0 |
| Any biological data | 32 | 80 |

**Table 1: Biological monitoring coverage**

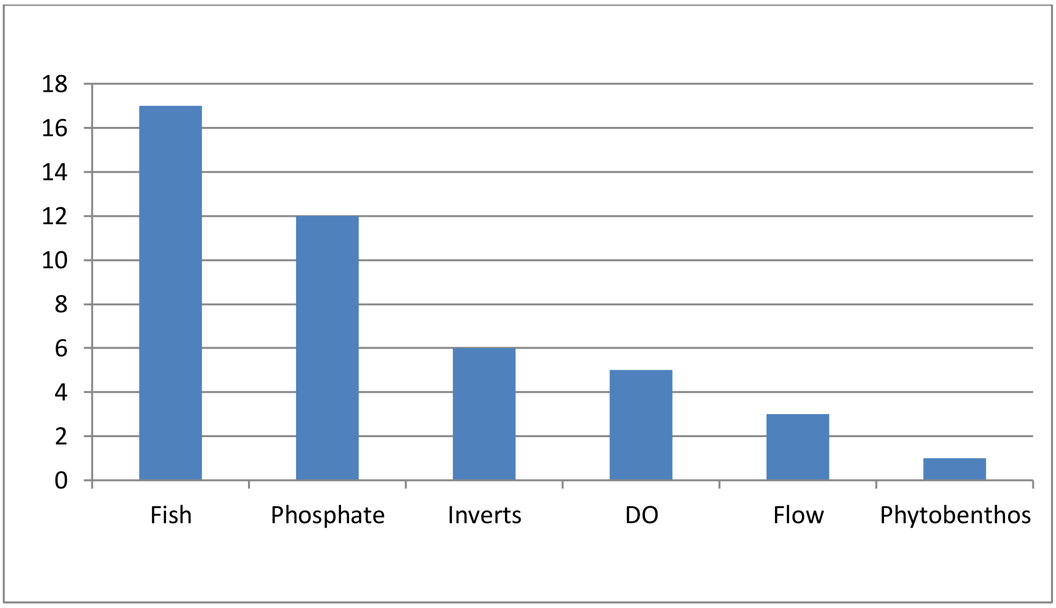



**Figure 6: Summary of failing elements in the River Lugg catchment.**

20% of waterbodies are currently lacking inclusion of biological monitoring in their assessments. In the Lugg Catchment 33% of WBs are currently classified in the absence of biological monitoring data. Where biological monitoring is absent, the WB status has been estimated based on the classification of adjacent waterbodies and Physico-chemical classifications (where available). This is of concern, as there is a notable difference in the rate of attainment of good status for Physico-chemical standards of ammonia, phosphate, pH with those for biological elements (see table 2). It is also noted that the two waterbodies rated as bad are currently passing all other Physico-chemical parameters.

| | |
|---|---|
| Biological data (lowest determinant) | 35% |
| Physico-chemical data (lowest determinant) | 69% |

**Table 2: % Attainment of good status for WB's in the River Lugg**

Of particular concern to WUF is the classification of the Tippets brook as at GES in the absence of biological monitoring data, WUF and EA surveys have identified the waterbody as being heavily impacted by agricultural diffuse pollution and channel modifications (see section 3.0).

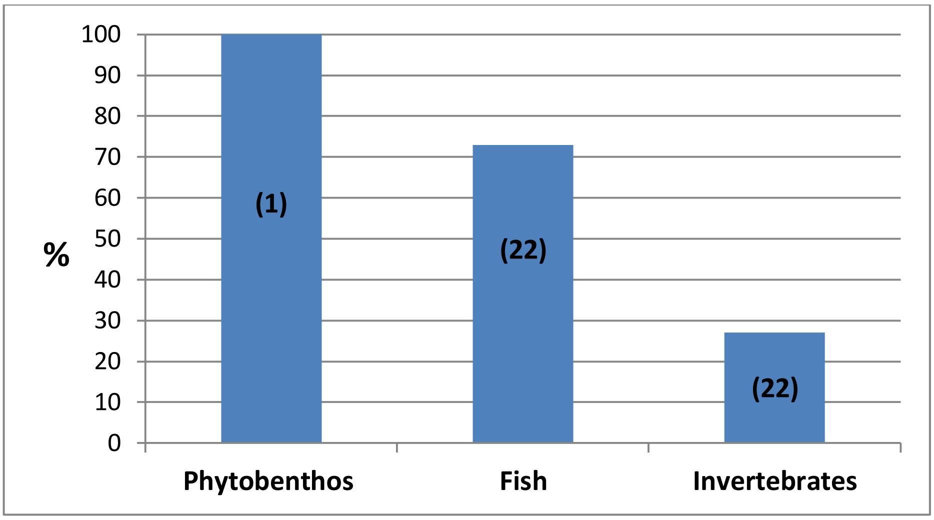



**Figure 7: % failures for biological elements, (including total sample size)**

**4.8 Fish classifications:**

Fish monitoring is an effective indictor of waterbody health, most sensitive to the effects of morphology, barriers to migration and sediment. In the Lugg catchment 55% of waterbody classifications contain fish monitoring results. Fish are responsible for the largest number of WB failures (figure 6) and in total accounting for 70% of all the biological element failures (figure 7) Note that this is in the absence of comprehensive phytobenthos monitoring which we anticipate to incur an even higher failure rate.

Figure 8 shows current fish classifications in the River Lugg catchment; the map highlights a trend between fish failures, and decreasing water quality along the length of the catchment. Other elements do not display a similar trend, which could further indicate the sensitivity of fish to subtle changes in water quality and habitat often missed with monthly chemical and invertebrate monitoring.

Several waterbodies draining the Western flank of the Leominster flood plain are not currently assessed for fish. Temporary cropping, including large amounts of winter cereals and contract potato production dominate this area, associated high risk soil management practises on the light, friable soils has lead to high levels of soil erosion. IDB modifications have also reduced the streams natural ability to buffer pollutants and as such, salmonid spawning and nursery habitats in these reaches are inundated by high levels of fine sediment. It is WUFs opinion that most of these waterbodies are also failing to meet WFD fish targets.

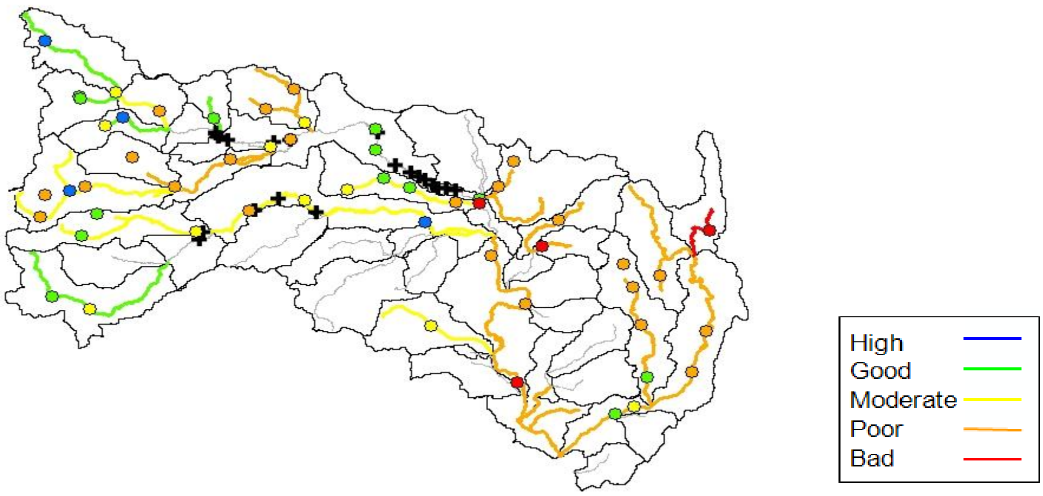



**Figure 8: Fish WFD classification in the River Lugg (Source EA, 2011)**

The EA's Fish Classification Scheme assesses the status of a waterbody by comparing the number of species found with what would be expected to have been found in a similar pristine location. A waterbody displaying an anomaly in its FCS classification is the R. Arrow (source to conf Gladestry brook). Situated in the upper catchment, with relatively pristine habitats we would expect to see very healthy populations of brown trout and salmon. However, this is not the case due to the presence of a series of sizeable weirs along the Arrow catchment, which were acting as a barrier to fish migration at the time of classification. The likely error in the FCS classification is as a result of the samples being used co-inciding with a period when salmon were artificially stocked in the catchment, and does not reflect the true natural populations of fish.

In contrast, there are cases where streams are known to be supporting healthy population of fish, but are currently classified as failing. One such example is the Pinsley Brook, a small tributary that joins the Lugg north of Leominster. The Pinsley displays many characteristics of a Southern chalk stream and contains a healthy population of brown trout and an increasing population of salmon following the removal of a barrier in its lowest reaches. WUF habitat work has further improved the stream, and as such we have confident that the waterbody is now meeting WFD targets for fish.
Another WB likely to be showing an overly negative classification is the Hindwell brook (conf Knobley Bk to conf R Lugg). The site is classified as poor for fish, and not predicted to reach GES until 2027 with justification detailed as 'disproportionately expensive- known physical barrier to fish migration'. Over the past 4 years WUF and EAW have been progressively working on the weirs downstream and this year completed the construction of two fish passes on the final impassable weirs located in the middle of this waterbody. As a result, the waterbody is now fully accessible to migratory fish. Salmon were first recorded in 2009 and populations are increasing. We expect this WB to be demonstrating GES for fish by 2015.

Justification for non-attainment of GS for fish is summarises in figure 9. 'Disproportionately expensive- known physical barrier to fish migration', is the most prevalent justification for non attainment of GES for fish. In the last 5 years WUF in partnership with EA has completed 33 fish passes on impassable weirs in the Lugg catchment, opening an additional 224 km of juvenile habitat. This highlights the important role Rivers Trust can play in directly influencing WFD classifications, especially where mitigation measures are deemed to be infeasible or too expensive.

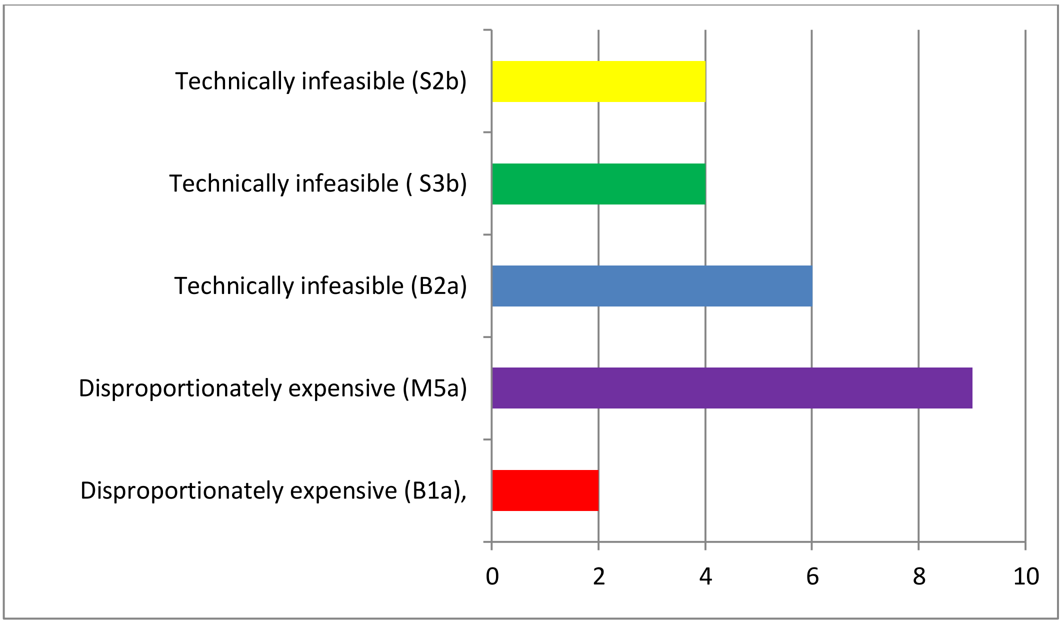



**Figure 9: Summary of WB fish failures**

### 4.9 Invertebrate classifications

Freshwater invertebrate families vary in their sensitivity to pollution; their relative abundance can be used as a good indicator of water quality, displaying greatest sensitivity to organic enrichment and pesticides.
43% of sites have been monitored for invertebrates. In total invertebrates are responsible for 25% of all biological elemental failures. 66% of WB'S meeting WFD targets for invertebrates are failing on fish, which reflects the fish access problems at point of classification (2002) and elevated sediment loadings.

WFD Invert classifications do not always conform to other elemental classifications, for example 4 WB's passing on invertebrates are failing to meet phosphate standards. This is likely to be a consequence of infrequent sampling, or the method of assessment which does not take into account the relative abundance of taxon species and is less likely to detect the effects of chronic, low level diffuse pollution.

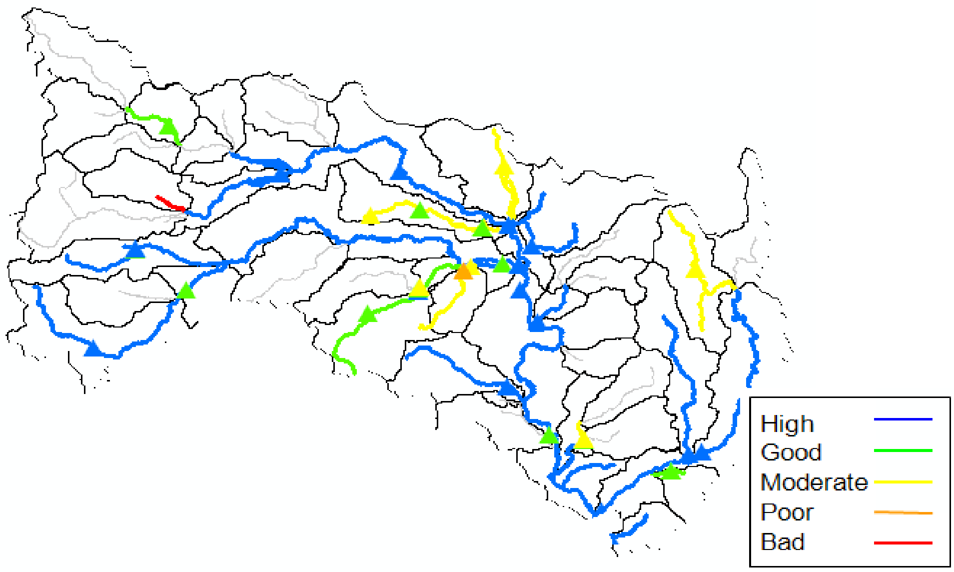



**Figure 10: Invertebrate WFD classification in the River Lugg (Source EA 2011)**

**2.8 Phosphate classifications**

Phosphate monitoring is comprehensive with all but one WB monitored. Of all the river waterbodies assessed as failing to meet good ecological status, the failure of the phosphate quality element accounted for 38%. 80% of these are classified as moderately failing; these sites could represent 'quick wins', with the implementation of targeted remedial measures it would not be a massive leap to bring these sites up to GS for Phosphate by 2015. However lack of ambition is again of concern, all sites showing single elemental failures for phosphate are not predicted to reach GS by 2015.

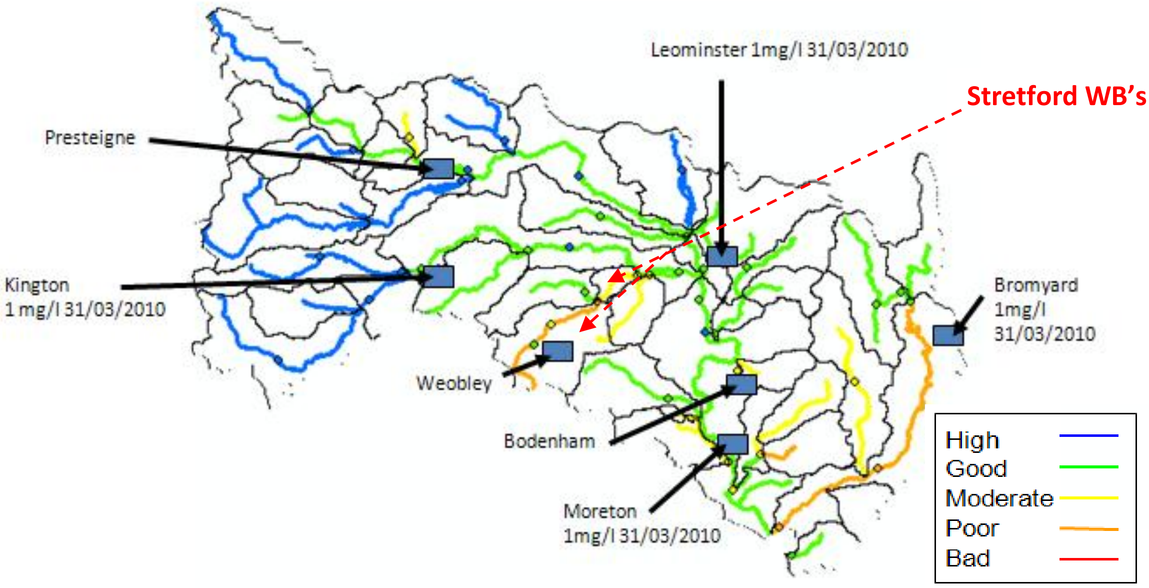



**Figure 11: WFD Phosphate classification in the River Lugg, and the location of major sewage treatment works and the Stretford Brook sub-catchment (Source EA 2011)**

Of notable concern to WUF are the phosphate classifications in the Stretford sub-catchments (shown in figure 11), both WBs are failing for phosphate with the upper WB rated as poor and the lower WB as moderate. The catchment contains the highest mean concentrations of total P in the whole of the Lugg catchment, with orthophosphate levels regularly exceeding 0.5mg/l in the upper catchment.

The P failure can be attributed to outflow from a STW situated in the town of Weobley, one of the 5 largest STWs in the Lugg catchment it is designed to serve a population of 2935. The outflow from the STW discharges into the upper Stretford catchment. The STW has no provision for phosphate stripping, which is concerning, considering the population size and the proportionate loading of P entering the catchment where it is less than a metre in width.

Action to install additional P treatment to the site could have a major impact on P levels in the Stretford WB's; however disappointingly, no remedial action is planned during this WFD planning cycle as action is deemed, 'disproportionately expensive- total phosphate unknown'.

**Figure 12: Weobley STW outflow into the upper Stretford waterbody**

## 3.0 Waterbodies selected for additional investigation:

When in the process of determining which WB's would be the focus of more detailed desk based study and additional investigation, WUF's main objective was to choose WB's where confidence in the current classification was low, or where additional investigations had the potential to identify appropriate mitigation measures to raise current WFD ambition. The process involved a systematic review of all WFD classifications in the River Lugg using the waterbody data sheets contained in Annex B of the Severn Basin Plan and knowledge of the catchment to produce a shortlist of suitable waterbodies for additional investigation. Shortlisted waterbodies and reasons for selection are provided in table 1 of the appendix.

To allow a desk based study to be completed full WFD chemical and biological datasets were requested from the Environment Agency on the 12th January 2011. Using established contacts in the local EA area office, our request was handled very timely. Physico-chemical datasets were supplied 26 days after the initial request and provided in a very user friendly format, with a separate worksheet for each waterbody and overall summary work sheet.

Our request for ecological data went through a more convoluted chain of people, but once with the right person, the request was dealt with efficiently. The team leader for the local biological monitoring department requested a meeting so she could fully understand our requirements and project objectives. The meeting took place on the 10th February and the data was submitted on the 14th February, 33 days after the initial request was submitted, again in a very helpful format.

After more detailed analysis of this data, the Tippets brook and River Lodon were the WB's selected for additional investigation. Occupying different areas of the catchment, both presented a different set of issues and opportunities for investigation. The location of the selected WB's is highlighted in figure 13, full waterbody descriptions, methodologies and results are provided in the following sections.

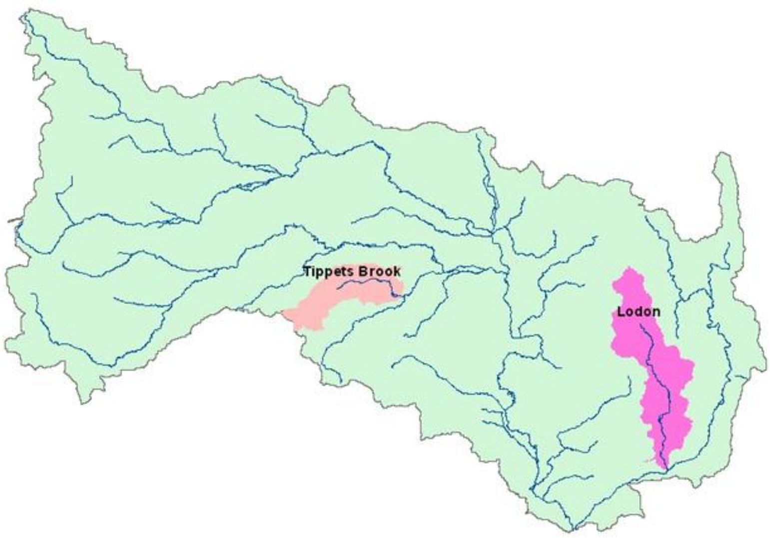



**Figure 13: Showing the location of the Tippets Brook and River Lodon WB's**

## 4. The Tippets Brook:

### 4.1 Introduction:

The assessment of WB classifications in the Lugg catchment has highlighted just how significant the biological monitoring parameters are in determining waterbody health, bringing into sharp focus waterbodies that are passing simply because ecological health has not been assessed. The WFD also makes it clear that Member States must apply the necessary measures to prevent deterioration in the condition of surface waterbodies. With public funding of remedial measures focused at failing WB's, it is imperative that classifications are accurate and based on a broad set of both chemical and biological indicators.

A waterbody classification of notable concern to the Foundation was the Tippets Brook, where known watercourse pressures have resulted in a serious lack of confidence in the current classification. The Foundation selected this watercourse for additional biological investigations to ground truth the current classification and highlight where additional remedial measures may be required to prevent 'deterioration' when WFD biological monitoring is extended. WUF also query the approach which necessitates a WFD 'downgrade', solely on the basis of additional monitoring information. This reflex response provides a skew in the real picture of water quality trends.

**Figure 14&15: Left: View of the Tippets brook, showing evidence of IDB modification. Right: Tippets brook in spate conditions.**

### 4.2 Catchment description:

The Tippets Brook is a tributary of the River Arrow, rising from a spring in Broxwood, crossing approximately 11km of agricultural land before joining the Stretford Brook. Synonymous with other WB's draining Leominster's highly fertile western flood plains; the catchment is dominated by a mixture of temporary pasture and arable cropping with large amounts of winter cereal and contract potato production.

The middle and lower reaches of the brook comes under the management of IDB - the resultant heavy modification to maintain land drainage has lead to significant habitat degradation, with large sections of the catchment displaying uniform channel morphology, artificially low bed height and limited bankside vegetation (figure 14).

Figure 15 was taken by the Foundation in 2006 and shows the Tippets brook during spate flows In spate flows the stream transports large volumes of sediment and associated nutrients, figure 15 was taken by the Foundation during spate flows, the odour of farm yard manures (see figure 15). Soil types along the catchment are predominately fertile clay loams prone to impeded drainage which increases the risk of water logging and compaction.

**4.3 Assessment of waterbody classification:**

The WFD assessment currently rates the Tippets Brook as good, in the absence of biological monitoring data (see table 3). The classification compromises water chemistry samples taken by the Environment Agency between 2006-2008, at a single monitoring point located at the confluence with the Stretford Brook. Table 4 shows frequency in WFD Physico-chemical monitoring. The majority of sampling is conducted on a monthly basis in dry conditions, although there are notable gaps. In total, the WFD classification compromises approximately 36 collected water samples, giving 499 individual chemical measurements.

**Table 3: Summarised WFD Classification for the Tippets Brook**

| Overall Status | Biological data | Phys-chemical elements | Current status |
|---|---|---|---|
| Good | Absent | Ammonia (phys-chemical)<br>Dissolved Oxygen<br>pH<br>Phosphate<br>Temperature<br>Copper<br>Zinc<br>Ammonia (Annex 8)<br>Quantity and dynamics of flow<br>Morphology | High<br>Good<br>High<br>Good<br>High<br>High<br>High<br>High<br>Supports good<br>Supports good |

**Table 4: Frequency of WFD water sampling of the Tippets Brook with weather conditions where available (right of grey column indicates data collected post WFD classification).**

| | 2006 | 2007 | 2008 | | 2009 | 2010 |
|---|---|---|---|---|---|---|
| **Jan** | • | • | • (OC) | | • (D) | |
| **Feb** | • (D) | • (D) | •• (OC/D) | | • (D) | • (D) |
| **Mar** | • (D) | | • (OC) | | | •• (D/D) |
| **Apr** | • | •• (D/*) | • (D) | | | • (D) |
| **May** | • | • | | | | |
| **Jun** | | •(D) | | | • (D) | |
| **Jul** | • | | • | | | |
| **Aug** | •• (*/D) | • | • | | | |
| **Sep** | • | •• | | | • (D) | |
| **Oct** | | • (D) | •• | | •• (D/D) | |
| **Nov** | •• (D/*) | • (OC) | •• (*/D) | | •• (R/D) | |
| **Dec** | • (HR) | • | | | • (F) | |

**Key:**
D= Dry
OC= Overcast
R= Rain
HR= Heavy rainfall
F= Frost

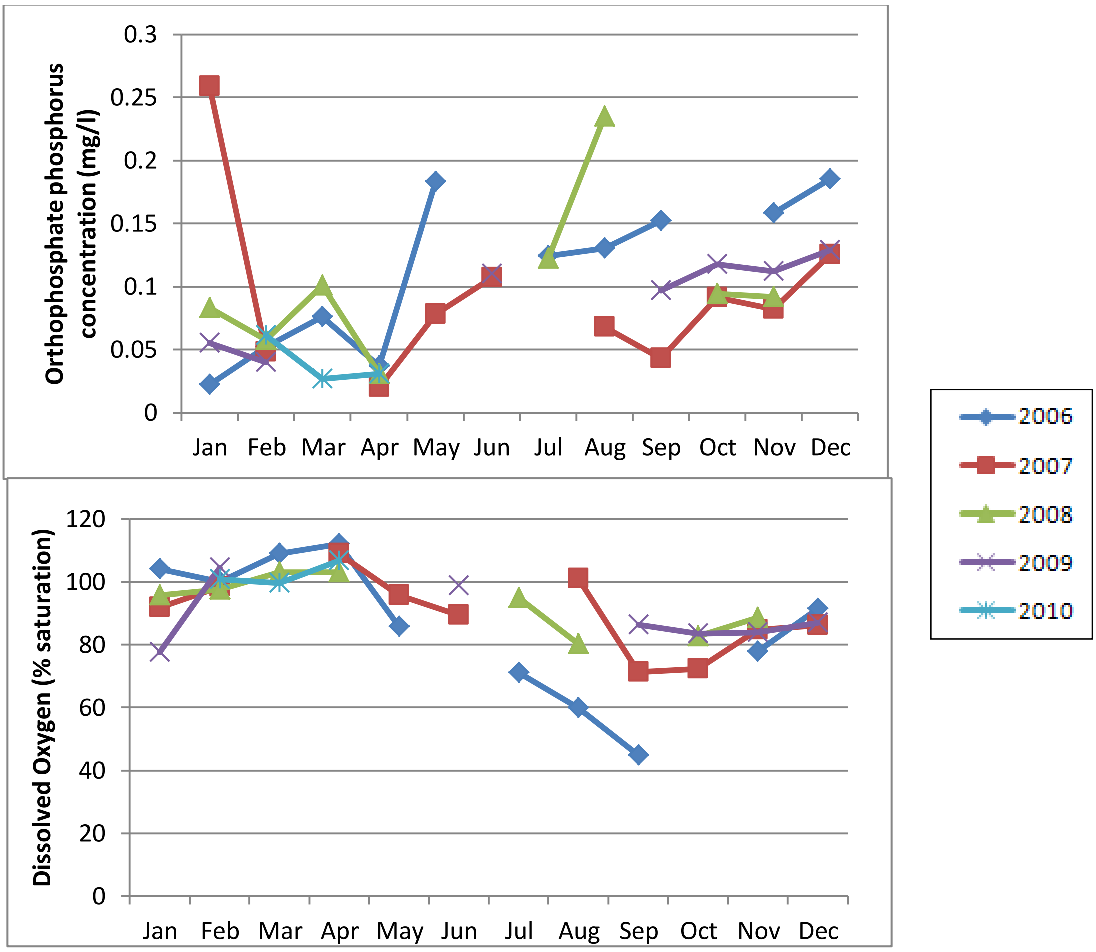
**4.3.1 Physico-chemical elements:**

The Tippets Brook is currently passing on all Physico-chemical elements. Summarised results for the period 2006-mid 2010 are provided in table 3, and show that all elements are rated as high, with the exception of phosphate and BOD which are both achieving good status. Nearly all samples were collected during dry conditions, as discussed earlier in the report this may negate the effects of fluctuations in P levels, likely to occur during storm flows. The validity of single-point measurements in describing the full catchment also gives some concern when the impact on loading may be temporally and spatially more transient.

**Table 5: Mean levels of Physico-chemical elements (including standard deviation and WFD classification boundary standards).**

| Element | Mean | Std Dev | WFD High Std | WFD Good std | WFD Mod std | WFD poor std |
|---|---|---|---|---|---|---|
| Ammonia (mg/l) | 0.04531 | 0.0505 | 0.3 | 0.6 | 1.1 | 2.5 |
| BOD (mg/l) | 1.79 | 1.07 | 4 | 5 | 6.5 | 9 |
| DO (% saturation) | 88.98 | 15.07 | 70 | 60 | 54 | 45 |
| pH lower | 7.909 | 0.209 | 6 | 6 | 4.7 | 4.2 |
| Phosphate (mg/l) | 0.097 | 0.0616 | 0.05 | 0.12 | 0.25 | 1 |
| pH upper | 7.909 | 0.209 | 9 | 9 | 100 | 100 |
| Temperature (°c) | 9.24 | 3.92 | 25 | 28 | 30 | 32 |

**Figure 16: Orthophosphate and dissolved oxygen levels in the Tippets brook**



**4.4 Catchment walk-over survey :**

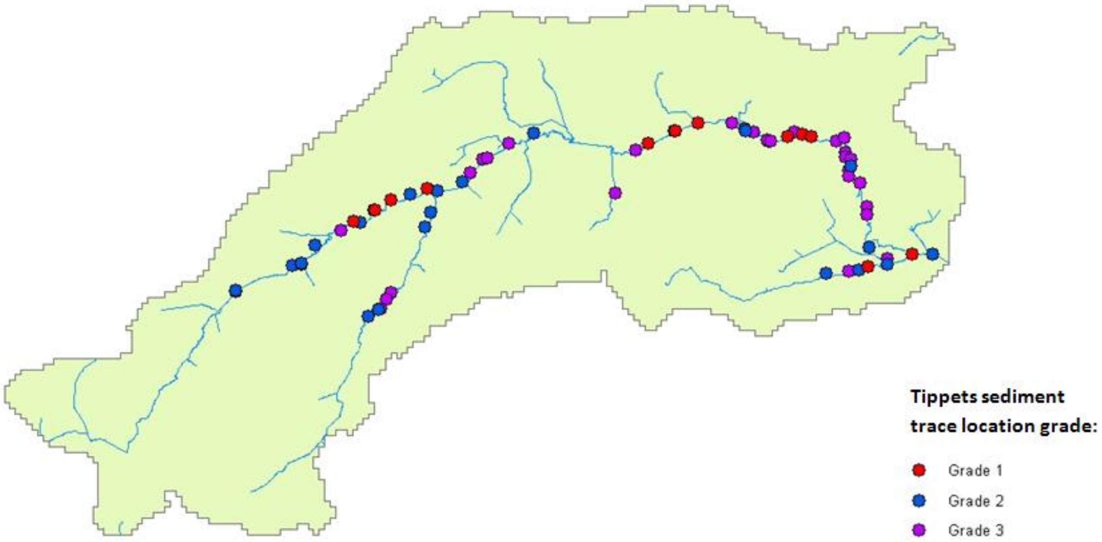
In 2006, a walk-over survey completed by the Foundation, highlighted the Tippets Brook as being in particularly poor condition with large areas of the catchment heavily modified and suffering from the impacts of sediment and nutrient run-off from arable cropping and uncontrolled livestock access. In addition, point source pollution from two farms, a cider and a crisp factory was also detected. The farm pollutions were corrected by WUF in 2009 and 2011 and both companies subsequently prosecuted by the Environment Agency (figure 21&22).

These findings were supported by an APEM sediment tracing survey, conducted in the River Lugg catchment in 2010. The survey highlights the Tippets Brook as being in particularly poor condition, with the largest number of Grade 1 Sediment Sources in the Lugg catchment, with the majority of substrate found to be covered by fine sediment and deleterious algal growth despite the correction of the identified point source pollutions (APEM, 2010).

**Figure 17&18: Pollution from a crisp and cider factory identified during WUF walk over survey of the Tippets Brook**

**Figure 19&20: Examples of agricultural diffuse pollution and habitat destruction in the Tippets Brook catchment**

**Figure 21: Map showing the location of fine sediment sources identified during an APEM river walkover surveys completed in 2010.**




**4.5 Waterbody investigations:**

**4.5.1 Study aim:**

The following investigations were selected to test the current WFD classification, through the assessment of biological health. Utilising the Foundation's understanding of known pressures affecting the catchment the study will identify targeted mitigation measures to ensure that the WB meets WFD biological targets.

In addition, following the 2006, walk-over survey, the Foundation has completed over 1.98km of watercourse fencing work in the middle catchment (at site shown in Fig. 20). The study also aims to quantify the effectiveness of these actions though an assessment of biological parameters and comparison with unimproved areas of the catchment.

**4.5.2 Chosen investigations:**

- Marco-invert sampling
- Semi quantitative electro-fishing surveys
- Diatom survey

**4.5.3 Sampling sites:**

Waterbody investigations were conducted on all, or at a selection of the following sites within the Tippets Brook. Located in upper, middle and lower regions of the catchment, the sites were chosen as representative of typical habitat characteristics in the locality.

**Site 1- Dovecote:** Representing the Upper catchment the stream here is around 1m in width, flows over gravel with a well established pool riffle sequence and large amounts of woody debris in the channel. It is outside the control of the Internal Drainage Board

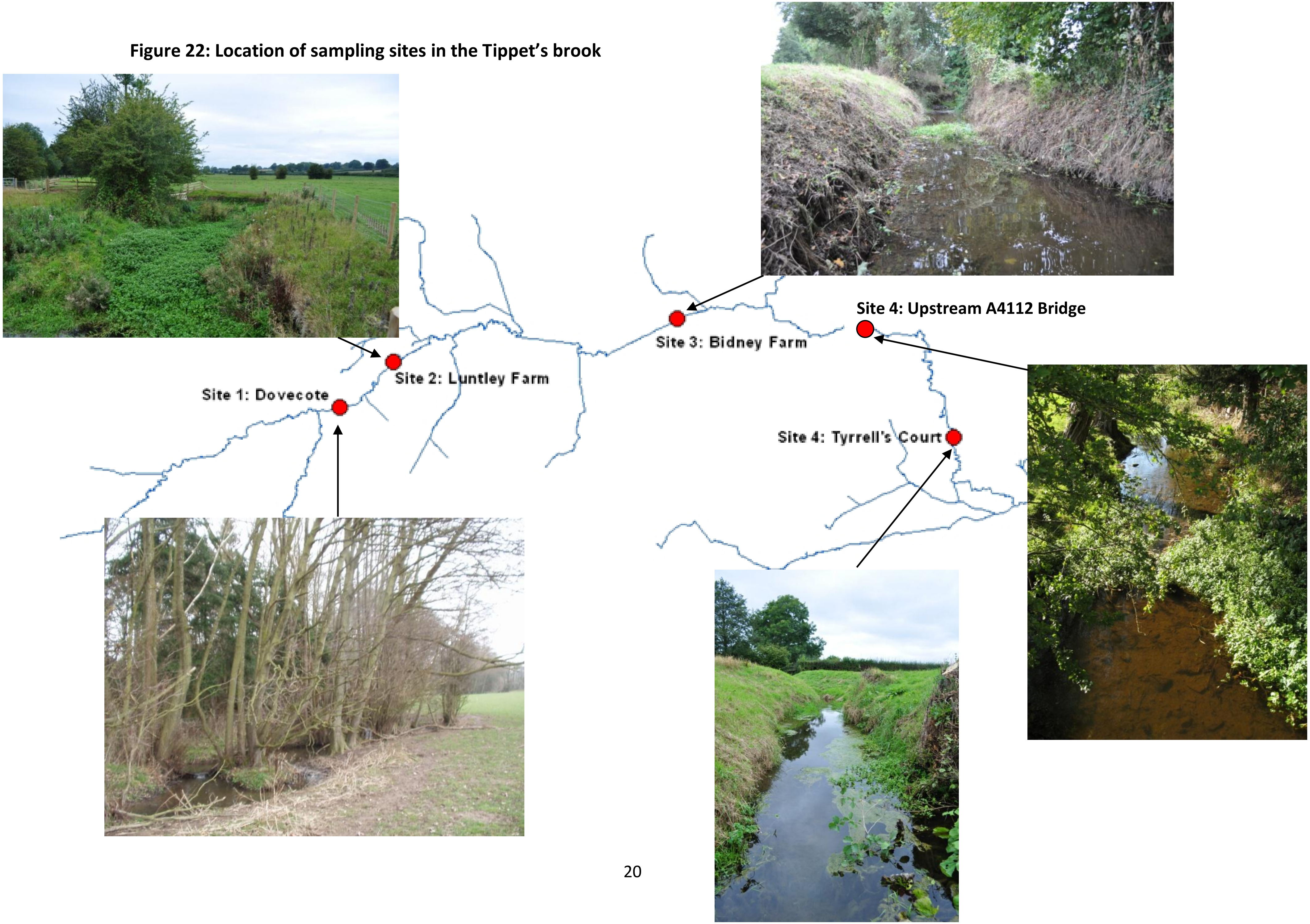
**Site 2- Downstream Bridge in Luntley:** This is the section where WUF has excluded livestock. Under the control of the IDB but as part of their BAP plan and agreed with WUF they have agreed to cease managing this section as an experiment. 3 of the pollutions that have been corrected are upstream of this site

**Site 3- Bidney Farm:** Representing the catchment in its mid-section, the sampling site is located downstream of Bidney farm and transects a large arable field. The channel displays the effects of extensive channel modifications, with an artificial bed depth and minimal bankside vegetation. Flow is uniform and slow, with sediment the dominant bed substrate.

**Site 4- Upstream A4112 Bridge:** A slow flowing section of the Tippets Brook situated upstream of the A4112 Bridge. Substrate is inundated with high levels of fine sediment. Surrounding land is in temporary grassland. This site represents the catchment in its mid-lower region.

**Site 5- Tyrrell's Court:** Situated in the lower reaches of the catchment, the sampling site is located downstream of the Tyrrell's crisp factory where the stream runs along the edge of an arable field. The channel is heavily modified and also displaying an artificial bed depth with minimal bankside vegetation. Flow regimes are more diverse with stretches of riffles and glides, gravels are present but with heavily embedded fine sediment).

**Figure 22: Location of sampling sites in the Tippet's brook**



### 4.6 Macro-invertebrate survey:

#### 4.6.1 Methodology:

Macro-invertebrate sampling was completed at all of the monitoring sites. The sampling procedure was compliant with the Environment Agency's operational instruction manual produced in 2008 (Technical reference material: freshwater macro-invertebrate sampling in rivers). A one minute manual search was initially carried out at each site, followed by kick sampling using the three minute, pond, net sampling method. The net used was a standard 1mm mesh sampling net. The kick sampling technique involves disturbing the substrate by foot and capturing any displaced invertebrates as they drift downstream with the flow into the sampling net. All available habitat types at each site were sampled proportionately and for a total time of three minutes.

Collected samples were placed into a container and then preserved using IMS (industrial methylated spirits). All samples were first examined on the bank side for dead invertebrates.

The physical characteristics of each site, including depth, substrate and flow type, a subjective assessment of turbidity and any other relevant observations were recorded. Estimates of algae and macrophyte cover were also recorded.

At a later date, the samples were sieved using a 500-micron sieve and placed into a sorting tray**.** Where possible, macro-invertebrates were identified to species level with the exception of Oligochaeta which were identified to class, and Simuliidae, Sphaeridae and Chironomidae which were identified to family level. Factors making it impossible to identify other macro-invertebrates to species level include size or crucial identification features missing.

The families present in a sample contribute to the derivation of a biological (BMWP) score for each site. This scoring system was developed as a way of assessing the biological quality of rivers and streams. The method assigns a score to each taxon ranging from 1 to 10 depending on their capacity to tolerate pollution. Those most tolerant to pollution have a low score, whilst those least tolerant have a high score. The sum of the taxa scores from a sample is the Biological Monitoring Working Party (BMWP) score. The BMWP score, and ASPT (average score per taxon) were calculated for each sample.

**Figure 23: Macro-invertebrate sampling at Bidney Farm (Site 3).**

#### 4.6.2 Results:

Table 2 of the appendix shows the number of each species of macro-invertebrate recorded in each sample. Where a species was very abundant, the total number was estimated. Table 6 shows summarised macro-invertebrate results for each site.

Populations of invertebrates sampled in the upstream sites are indicative of very good water quality. The sites display a good range of species, with high numbers of total individuals present.

Results for Tyrrell’s Court display good water quality, with a good range of invertebrates found to be present. But considering the diversity of habitat at the sampling site, a higher score was anticipated.

Macro-invertebrates sampled at Bidney Farm scored almost the same as the Tyrrell's site, but contained the least diverse range of species and overall total populations. Based on the BMWP scores of 157 and 160 at the upstream sampling sites, the Bidney and Tyrrell’s sites have the potential for higher macro-invertebrate diversity.

**Table 6: Summarised macro-invertebrate sampling results (full results are provided in Table 2 of the appendix).**

| | ***Site 1*** | ***Site 2*** | ***Site 3*** | ***Site 4*** |
|---|---|---|---|---|
| ***BMWP*** | *157* | *160* | *106* | *111* |
| ***TAXA*** | *26* | *28* | *21* | *22* |
| ***ASPT*** | *6.04* | *5.71* | *5.04* | *5.04* |

**Figure 24: Vaucheria algae at the Bidney site indicating enrichment at the site.**

**Figure 25: Silt and algae stream substrate at Bidney Farm providing poor fish habitat.**

**4.6.3 Discussion:**

Macro-invertebrate levels were indicative of good water quality, and support previous efforts by WUF and EA to correct the known point pollutions. A particularly diverse range of species was identified in the upper catchment. The site where habitat restoration work has been completed scored the highest in terms of BMWP and total number of TAXA, indicating the beneficial impact of the habitat work in providing improved conditions for macro-invertebrates.

The results obtained in the two sites in the upper catchment would suggest that the lower sites also have the capacity to support increased macro-invertebrate populations, which may currently be restricted as a result of reduced habitat diversity and water quality.

Vaucheria algal identified during the biological sampling at Bidney farm indicates that this section of the watercourse is suffering from nutrient enrichment. It would be of interest to know whether this would have resulted in WFD water chemistry failure, had sampling been conducted in this region.

**4.7 Electro-fishing survey:**

**4.7.1 Methodology:**

Electro-fishing surveys were conducted in September 2011, to obtain a representative sample of the fish assemblage at Site 1 and Site 4. The sites were sampled using a single pass, semi-quantitative method over a 50m length. Two trained operatives were required to complete the survey, one responsible for operating the battery powered back pack equipment and the second netting fish into a bucket. After the survey was completed the fish were recorded and returned along the length of the survey area. The survey assessments conformed to EA and WFD protocol and could potentially be used in the WFD classification of the Tippets brook.

**4.7.2 Results:**

Results from the survey are shown in table 1. In total six species were identified at Site 2 and two species identified at Site 4. With the absence of trout at either of the sampling sites, the waterbody would not be meeting WFD targets for fish.

**Table 7: Summary of electro-fishing surveys conducted in the Tippets brook.**

| ***Site 2: 68m2 fished*** | | ***Site 4: 130m2 fished*** | |
|---|---|---|---|
| **Species** | **Number** | **Species** | **Number** |
| Roach | 1 | Bull head | 10-50 |
| Eel | 2 | Minnow | 5 |
| Bull head | 10-100 | | |
| Minnow | 10-100 | | |
| Stoneloach | 10-100 | | |
| Stickleback | 10-100 | | |

**4.7.3 Discussion:**

In the absence of salmonids at either sampling sites, the Tippets Brook is highly unlikely to be meeting WFD targets for fish with the population in the lower reaches being particularly impoverished. Results for both sites were disappointing, but the greater diversity in species observed at Site 2 could be indicative of the more favourable habitat conditions as a result of WUF habitat restoration works. To substantiate these results, additional monitoring is recommended.

The failure of the Tippets Brook to support a healthy fish population is attributed to the limited availability of suitable in-stream habitats, as a result of extensive channel modifications and agricultural diffuse pollution, causing elevated levels of in-stream sediment and nutrients.

**Figure 26: Semi-quantative electro-fish survey at Tyrrell's Court, using battery powered back pack equipment.**

**4.8 Diatom survey:**

**4.8.1 Methodology:**

Diatoms samples were collected and analysed By Ingrid Jüttner, National Museum of Wales on the 16th September 2011 at Site 4. A sample of the thick biofilm (algae bloom) which covered the fine sediment and silted stones was removed using a thin wooden stick.

The sample was preserved in ethanol and processed using standard methods (hot hydrogen peroxide oxidation) and mounted in Naphrax (Krammer & Lange-Bertalot, 1986-1991). Diatoms were identified and a minimum of 500 valves counted at x1000 magnification using a Nikon Eclipse E600 microscope equipped with differential interference contrast (DIC). The relative abundances of species were calculated. Identifications were based on Krammer & Lange-Bertalot (1986-1991), Krammer (1997a, b, 2002), Reichardt (1999) and Lange-Bertalot (2001).

To assess the ecological status of the site a recently revised and new metrics for rivers were calculated. They included the Trophic Diatom Index (TDI) and Ecological Quality Ratios (EQR), methods developed to monitor trophic status and ecological status in U.K. rivers (Kelly et al., 2007, 2008; DARLEQ - Diatom Assessment of River and Lake Environmental Quality). EQRs were calculated to assess the deviation of diatom assemblages from reference conditions and to determine ecological status classes as defined by the WFD (Council of the European Communities, 2000; Kelly et al., 2007). Uncertainty analysis to assess the risk of misclassification was performed on DARLEQ following Ellis & Adriaenssens (2006).

**Figure 27: Showing bed substrate at the diatom sampling location**.

**4.8.2 Results:**

**4.7.3 Discussion:**

**4.9 Conclusion:**

- Accepting the limited nature of this study the Tippets Brook is not considered by WUF to be in a good ecological status and therefore should not be regarded as WFD target- compliant.

- The current system of classification which provides an automatic downgrade to failing status on the accumulation of adverse biological data is potentially unhelpful. Full use of all data sources at the incept should beneficially inform the classification process.

- The results suggest that fish and invertebrate health is greatest in the upper sites and declines markedly in the lower and middle reaches

- There is an indication that fencing at Luntley Farm may have a beneficial impact on macro-invertebrates and fish.

- It would be useful to revisit the sampling points in order to achieve greater confidence in these results.

**4.10 Achieve GES in the Tippets Brook- An Holistic Approach:**

**4.10.1 The problem:**

Although important, habitat restoration alone is insufficient to address all the issues identified in the Tippets Brook, the shift in farming in this area from pastoral to intensive arable cropping provides greater challenges.

Nutrient and sediment levels in the Tippets Brook are more frequently a consequence of soil and fertiliser management under intensive cropping in the vicinity of the brook. A secondary issue in this area is the presence of intensive livestock systems and organic nutrient loss from hard surfaces and waterlogged fields.

Pathways of transport and connectivity are not simple and require a level of investigation to establish risk. In addition, historic channel modification reduces the ability of the Tippets Brook to self remedy.

**4.10.2 The Holistic approach to land managers:**

Awareness in this farming community of the problems has been raised over recent years and we are now at the stage where actions need to be influenced. Risky soil management under increasingly unpredictable climatic scenarios needs to be addressed. Nutrient management and pesticide planning needs to be strategic and safe. Infrastructural provision for housed livestock needs to keep pace with intensification.

These aspirations can be best met through an integrated combination of measures ranging through advice, incentive, compliance and enforcement and WUF can make significant contribution to the first three of these at this local level:-

- **Advice provision:**

This can be provided directly or achieved through signposting to relevant sources of sound soil, nutrient, pesticide and buildings advice. Rivers Trust staff, with detailed local knowledge have a good track record in targeting this advice to maximum benefit, whether or not advice is supplied internally.

- **Incentivisation:**

Incentives and support for improved land management can provide major benefit as long as these measures are targeted to appropriate recipients. They provide maximum benefit where strategically applied to known problem areas. This need for local knowledge and familiarity with frequently complex pollution pathways and connectivity is best met from strong local knowledge. Again Rivers Trust Staff are well placed to ensure maximum environmental return for investment and can play a significant role in both administration of and signposting of existing and novel funding streams. The most severe pollution found in the walk over survey was corrected this way.

- **Compliance & Enforcement:**

Whilst working with the Tippetts Brook Land Managers, the maintenance of trust is vital. Farmers need to recognise the confidentiality and impartiality of advice given if they are to remain receptive to diffuse pollution ambitions. However the raft of compliance measures required from EU support mechanisms provide useful tools in reducing diffuse pollution. It is our belief that increased enforcement by the Environment Agency and RPA would significantly increase the uptake of advice, and build confidence with the great majority of compliant farmers.

WUF recommend full use of all the levers as identified above to bring about satisfactory reduction in diffuse pollution and achievement of WFD targets in the Tippets Brook.

**4.10.3 Case studies illustrating the holistic approach:**

The following case studies highlight work that has been completed by the Foundation under its successful Lugg and River Arrow (LARA) Project, which has restored biodiversity, species richness and variety in rivers within 10 miles of Leominster. Focussing on fish, the 3-year project is funded by the SITA Trust's Enriching Nature Programme and completed in September this year.

**Case Study 1: Large Livestock unit in the Tippets Brook catchment:**

During the 2006 walk-over survey, WUF identified a large section of the upper catchment as being seriously impacted by uncontrolled livestock access. The land manager was contacted and agreed to an advisory visit from the Foundation's catchment officer.

The farmer recognised that the current management was unsatisfactory, but regarded the required investment in watercourse fencing as being of little benefit to his business. Incentivised by the offer of WUF grant aid, 2km of watercourse fencing was erected, with the provision of designated livestock drinking bays.  Before and after photos are shown below, highlight the benefit of this targeted action. Bankside vegetation has re-established reducing erosion and providing additional in-stream cover for fish and invertebrates.

Livestock poaching was not the only source of watercourse pollution on the farm. During the visit the officer also identified a source of nutrient rich run-off, from a fouled yard.

The absence of roof guttering and down pipes was significantly increasing the volumes of nutrient-charged run-off across the yard.

With WUF grant aid, replacement guttering and downpipes were installed, significantly reducing leachate from this site.

**Case study 2: Catchment officer advice: Large arable farm in the Tippets Brook catchment**

In November 2010, WUF's Catchment officer visited a large arable farm in the Tippets catchment. In addition to the management over 500ha of intensive arable land, the farmer also operates as the catchments main contract sprayer.

During the catchment officer's visit, the farmer was offered practical and economically sound advice, covering all aspects of soil, nutrient and infrastructure management. Of particular concern to the officer was the location of the farms pesticide filling area. Wash- off from the hard surface area was at risk of reaching a drainage ditch located less than 10m away. The officer highlighted the risk of watercourse pollution and the risk of penalties if a pollution incident was identified.

The farmer agreed that this was unsatisfactory, and took up the offer of grant aid for the construction of a covered filling area with linked bio-bed treatment system.

Utilising links with the local CSF officer WUF were also able to provide the farmer with a free advisory visit from a bio-bed expert, who produced a detailed site specific report advising on the bio-bed construction.
The construction of the bed was then part funded by a wider WUF biodiversity project running in the area

**4.10.4 In-channel restoration measures:**
In addition to tackling sources of diffuse agricultural pollution, actions are also needed to ameliorate the effects of extensive channel modification of the Tippets Brook in its middle and lower reaches. The following cases studies highlight suitable remedial measures applied by WUF to other parts of the Lugg catchment:

**Case Study 3: Check weirs in the Wellington Brook**

The Wellington Brook, which flows into the river Lugg near the Herefordshire village of Marden, was once an important spawning stream for fish species such as salmon and trout. As with the Tippets Brook, years of heavy modification, including the dredging of gravels to improve land drainage has drastically reduced its ability to support fish species and other wildlife.

Following approval from the Lugg IDB, the Foundation created areas of riffles using check weirs, backfilled with alluvial gravel to increase flows and provide suitable spawning sites to maximise egg survival.

Tarmac supplied the machinery and gravel with WUF contributing other materials, staff and environmental expertise.

## 5. The River Lodon

### 5.1 Introduction:

WUF is concerned by the lack of ambition displayed in the current classification of failing WB's in the Lugg Catchment. Where causes of failure have been identified, often the sources or extent of the problem are unknown leading to the prescription of broad and extensive remedial measures, resulting in low ambition for WB improvement. This is often a consequence of WB assessments being remote from local knowledge or investigations.

A WB demonstrating distinct lack of ambition as a result of unidentified causes of elemental failure is the River Lodon which is currently failing on fish and phosphate and not predicted to meet WFD targets until 2027. The Foundation selected this watercourse for additional investigations to identify the causes of the elemental failures and using case studies, highlight how targeted remedial measures can be used to raise ambition in the current WB classification.

### 5.2 Catchment description:

The River Lodon is located in the eastern Lugg catchment, rising from woodland in Grendon Bishop it transects approximately 18km of agricultural land before joining the River Frome.

The character of the Lodon catchment varies considerable between the upper and lower reaches. The upper Lodon cuts through a sloping valley, the river is reasonably fast flowing with series of deep pool and riffles, and should provide an ideal habitat for brown trout and salmon. Uncoppiced alders line much of the banks, causing dark tunnelling of long sections of the river channel.

Higher grain prices have lead to an increase in temporary cropping on sloping land that would have historically been permanent pasture.

As the gradient declines below Stoke Lacy, and through the Lodon's lower reaches, the river slows and has a more uniform depth and flow rate with increased levels of silt accumulating in the bed substrate. Banks are steep and increasingly vulnerable to erosion. Land use is increasingly a mix of temporary grassland with intensive arable cropping. Below Stoke Lacy Bridge the catchment falls within the Lugg, IDB drainage district with large sections of the catchment displaying uniform channel morphology, artificial bed height and limited bankside vegetation.

**Figure 28: Representative views of the River Lodon in its upper (left) and lower reaches (right).**

### 5.3 Assessment of waterbody classification:

The River Lodon is currently rated as poor, with fish poor (very certain) and phosphate moderate (quite certain) the failing elements (see table 8). Macro-invertebrates and all other Physico-chemical elements are rated as high. The waterbody is predicted to fail to meet good status by 2015, with fish and phosphate the elements preventing target achievement. On inception of the WB investigation, EA classification of the Lodon WB attributed unknown causes to the elemental failures. Re-assessment of the WFD classification by the EA in the spring of 2011 resulted in the WB being afforded sediment as the suspected cause of fish failure. Full justification codes are provided in table 9.

**Table 8: Summarised WFD Classification for the River Lodon**

| Overall Status | Biological data | Current status | Physico-chemical elements | Current status |
|---|---|---|---|---|
| Poor | Fish<br>Invertebrates | Poor<br>High | Ammonia (phys-chemical)<br>Dissolved Oxygen<br>pH<br>Phosphate<br>Temperature<br>Copper<br>Zinc<br>Ammonia (Annex 8)<br>Quantity and dynamics of flow<br>Morphology | High<br>High<br>High<br>Moderate<br>High<br>High<br>High<br>High<br>Supports good<br>Supports good |

### 5.3.1 Physico-chemical classification:

Physico-chemical classification comprises water chemistry samples taken by the Environment Agency between 2006- 2008, at one monitoring at Stoke Lacy Bridge. Table 10 shows WFD sampling in the River Lodon, highlighting that the majority of sampling is conducted on a monthly basis in dry conditions, although there are notable gaps. In total, the WFD classification compromises approximately 37 collected water samples giving 512 individual chemical measurements. The validity of single-point measurements in describing the full catchment also gives some concern when the impact on loading may be temporally and spatially more transient.

**Table 9: Decision codes for non-attainment of GES by 2015 in the River Lodon**

| Decision code | Reason for failure | Justification for alternative objective | Reason | Sub-reason |
|---|---|---|---|---|
| S2b | Biological element Suspected – sediment from diffuse source | The source (sector or general activity) of the sediment impacting on biology is not yet confirmed | Technically infeasible | Cause of adverse impact unknown |
| P1b | Phosphate or Total Phosphorus Unknown - uncertain there is a failure / impact | There is not sufficient weight of evidence to confirm the need to control eutrophication risk | Disproportionately expensive | Significant risk of unfavourable balance of costs and benefits |

**Table 10: Showing frequency of Physico-chemical WFD water sampling of the Lodon with weather conditions where available (right of grey column indicates data collected post WFD classification).**

| | 2006 | 2007 | 2008 | | 2009 | 2010 |
|---|---|---|---|---|---|---|
| **Jan** | • | • (D) | • (D) | | • (D) | |
| **Feb** | • (D) | • | •(D) | | • (D) | •• (D) |
| **Mar** | • (D) | •(D) | • (D) | | | • (D) |
| **Apr** | • | • (D) | • | | •(D) | |
| **May** | •(D) | • (D) | • | | •(R) | • (D) |
| **Jun** | • | • | • | | • (D) | |
| **Jul** | •(D) | • | • | | | |
| **Aug** | • (D) | • | • | | | |
| **Sep** | • (R) | • | • | | | |
| **Oct** | • (HR) | •• (D) | • | | •• | |
| **Nov** | • | • | • | | | |
| **Dec** | • (D) | •(D) | • (D) | | •• | |

**Key:**
D= Dry
R= Rain
HR= Heavy rainfall

**5.3.2 Fish:**

The fish assessment comprise four sample locations, with 21 individual assessments made between the period 1992-2010, individual site classifications are shown in table 11. The main driver for the classification of poor is the low numbers of brown trout. FCS2 also predicts that Atlantic salmon should be present at W064M (Site FCS classifications are included in table 3 of the appendix).

The most dominant species within the waterbody is brown trout. Other species present include bullhead at all sites with the addition of minnow and stoneloach at W064L, W064M and W171K. Classification of site W171K as good is based on data from 2003 which appeared to be a satisfactory year for brown trout with all sites seeing higher than average sample numbers. The site has not been sampled since, so based on population trends at the other sites, this is potentially a skewed assessment. Additional monitoring is required at this site to increase confidence in the current classification.

**Table 11: WFD fish classifications for monitoring sites in the Lodon**

| Site name | NGR | Year used for classification | Site Classification |
|---|---|---|---|
| W064D | SO6060054400 | 2008 | Poor |
| W064L | SO6130052500 | 2008 | Poor |
| WO64M | SO6184449376 | 2008 | Poor |
| W171K | SO6130052500 | 2003 | Good |

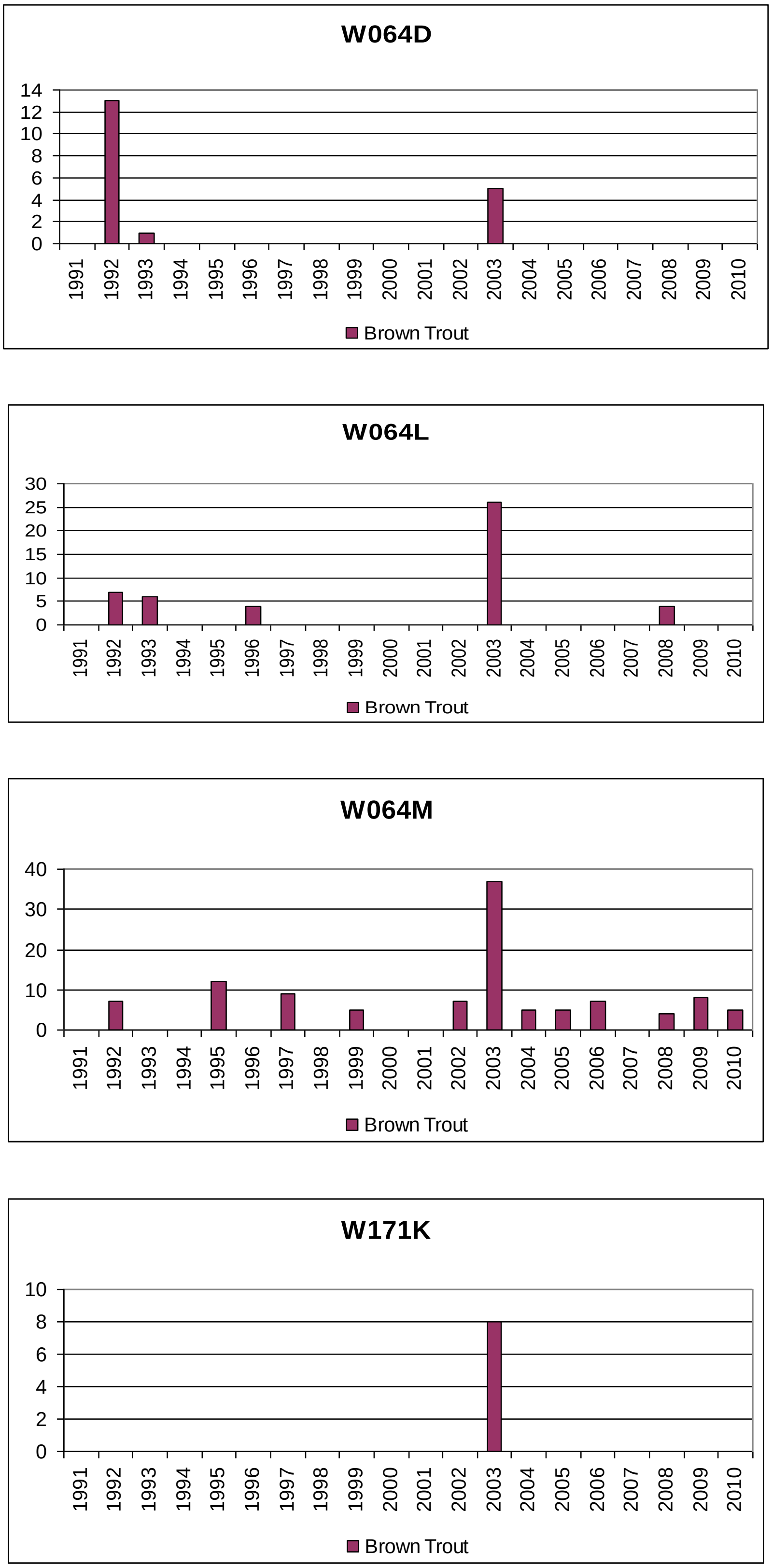



**Figure 29: Trout numbers in the River Lodon (Source EA, 2010)**

**5.3.3 Invertebrates:**

Invertebrates were monitored in 2000, 2003 and 2006, with all data taken at the same sampling site in the lower reaches of the tributary at Covender (SO624 432). BMWP and ASPT scores are indicative of high water quality, and up until 2006, when sampling ceased were displaying an upward trend (figure 28). Sites are displaying a good range of species with high numbers of total individuals found.

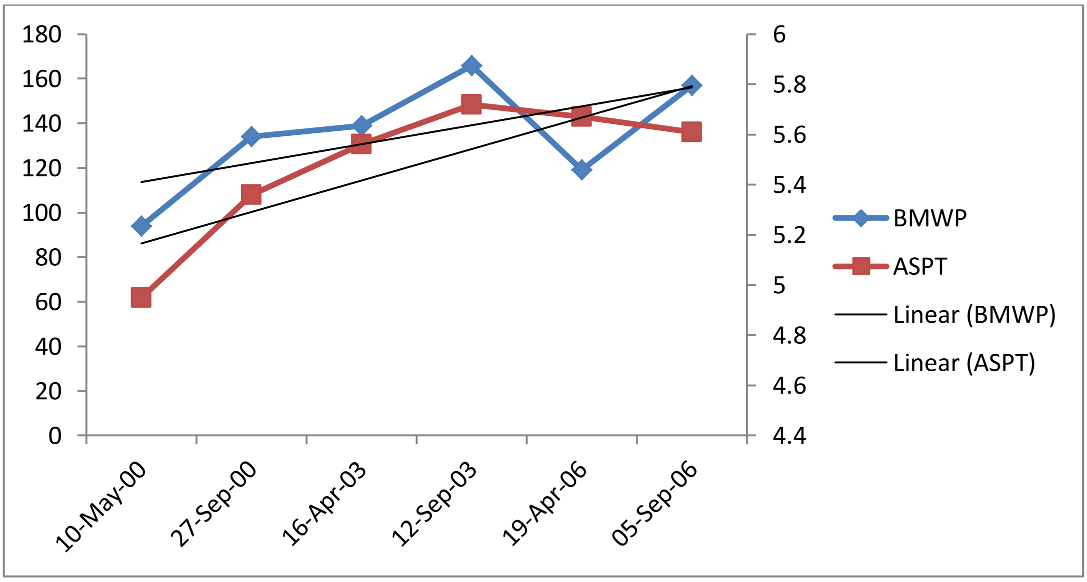



**Figure 30: BMWP and ASPT scores at Covender (with trend lines)**

**5.3.4 Phosphate:**

Physico-chemical monitoring has highlighted elevated phosphate levels within the River Lodon, resulting in a moderate classification for this element (figure 29). Monthly samples collected between 2006 and 2008 compromise the current WFD classification, sampling past 2008 has been less frequent, but TP levels still show a moderate status.

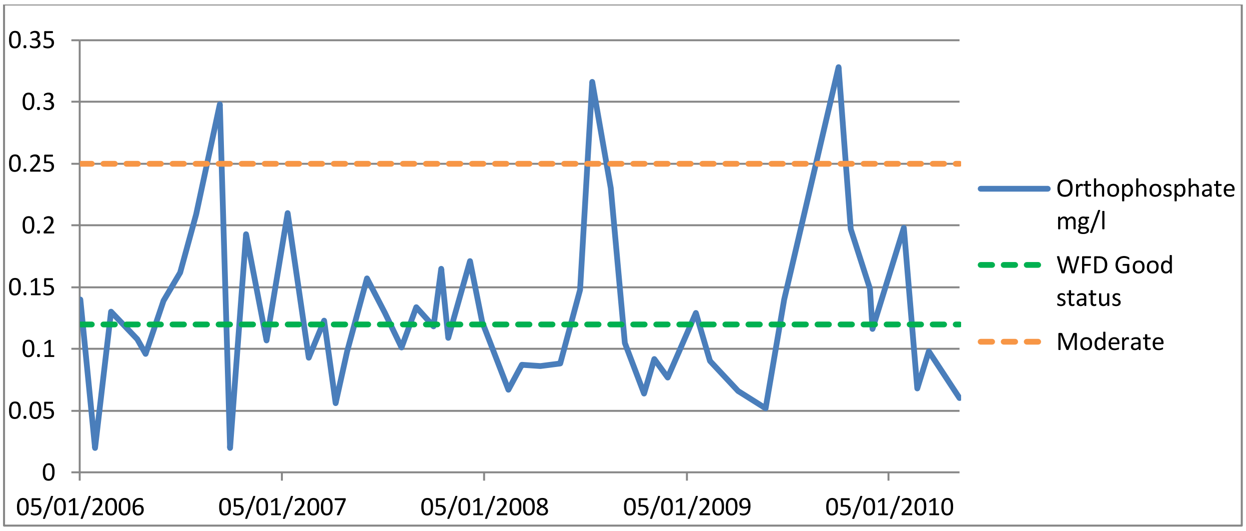



**Figure 31: Orthophosphate levels at Stoke Lacy bridge with WFD, showing good and moderate status standard levels, over period 2006-2010. (Source: Environment Agency, 2011).**

In-frequent sampling and lack of rainfall data makes it impossible to link the peaks in phosphate with non-point sources, however the overall trend shows that peak levels occur during summer months and are possibly a result of reduced dilution of point source discharges occurring during low flows. Currently, the apportionment of point and diffuse source P loading is uncertain, with more work underway. Known potential point source contributions occur at Pencombe STW, The Wye Valley Brewery and numerous private, septic tank systems within the catchment

Ecologically significant loads of phosphate and suspended sediment (SS) are also likely to be originating from surrounding agricultural land, with a combination of landscape morphology and land management practice, generating the highest pollution risk. Sediment has already been identified as the suspected cause of fish failure and is known to be impacting on the ecological health of the WB.

Agricultural diffuse P in rivers originates from residual P in soil or from manure or fertilisers applied to agricultural land. Phosphorus becomes mobilised, either in particulate form or soil solution by surface runoff, splash detachment, dissolution and desorption processes. Once mobilised, it is transported via several hydrological pathways where it will interact with the environment before being delivered to rivers.

**5.4 Waterbody investigations:**

**5.4.1 Study aim:**

At inception, WFD failure in the Lodon for fish and phosphate were attributed as 'unknown causes' On turning our attention to the Lugg system, WUF were concerned by this lack of attributable cause to what we perceived from our local knowledge as a known problem and decided to investigate the failure causes further. The following investigations were chosen to identify possible sources and allow assessment of the most appropriate remedial measures likely to raise ambition in the current WB classification.

It was apparent that unravelling the Phosphate issue would require significant scientific input, beyond the scope of our 'in-house' resources. Subsequently EA have extended chemical monitoring in the Lodon with the specific intention of increasing the understanding of phosphate sources and water quality impacts within the catchment. With EA's acknowledged expertise in this area, WUF were keen not to replicate this work, choosing rather to focus on methodologies to improve specific awareness of the catchment and its pressures, thus identifying cost effective and targeted mitigation measures.

**5.4.2 Chosen investigations:**

- Land use mapping and SCIMAP to identify fine sediment delivery risk from non-point sources
- Catchment walk-over survey

### 5.5 Land use mapping and modelling:

The aim of this investigation was to conduct a desk-based study using GIS mapping, and hydrological modelling to identify potential diffuse pollution sources, and delivery pathways, likely to be impacting on water quality in the Lodon catchment.

#### 5.5.1 Land use mapping:

Land use maps were created in ARCMAP using interpolated agricultural statistics from Defra 2010 ag-census. Data have been interpolated using Inverse Distance Weighted algorithm and a cell size of 1000m. Figure 30 shows that arable cropping is spread widely throughout the catchment; with a significant amount of winter cereals grown in the upper regions where cultivation land gradient increases the risk of diffuse run-off. Soil conservation advice would be best targeted in these upper regions.

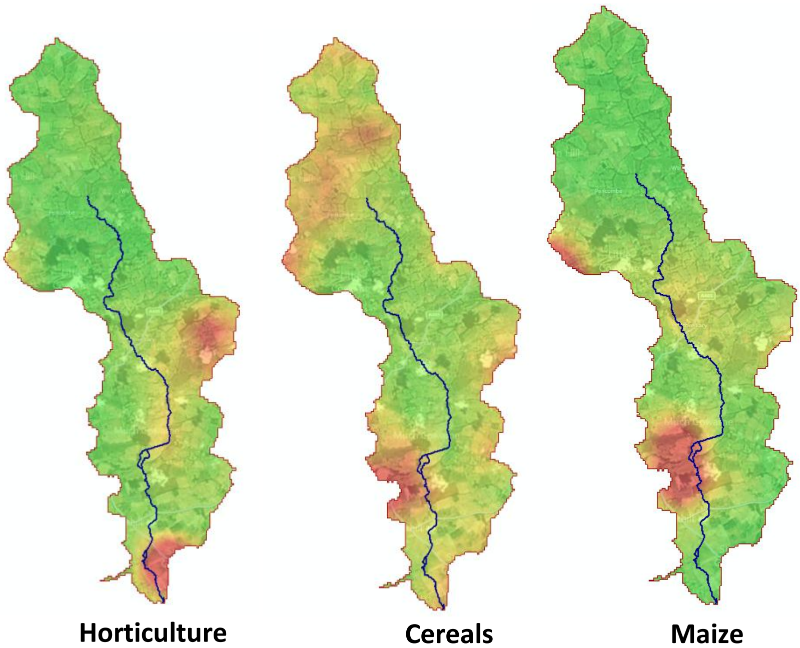



**Figure 32: Arable cropping in the Lodon catchment**

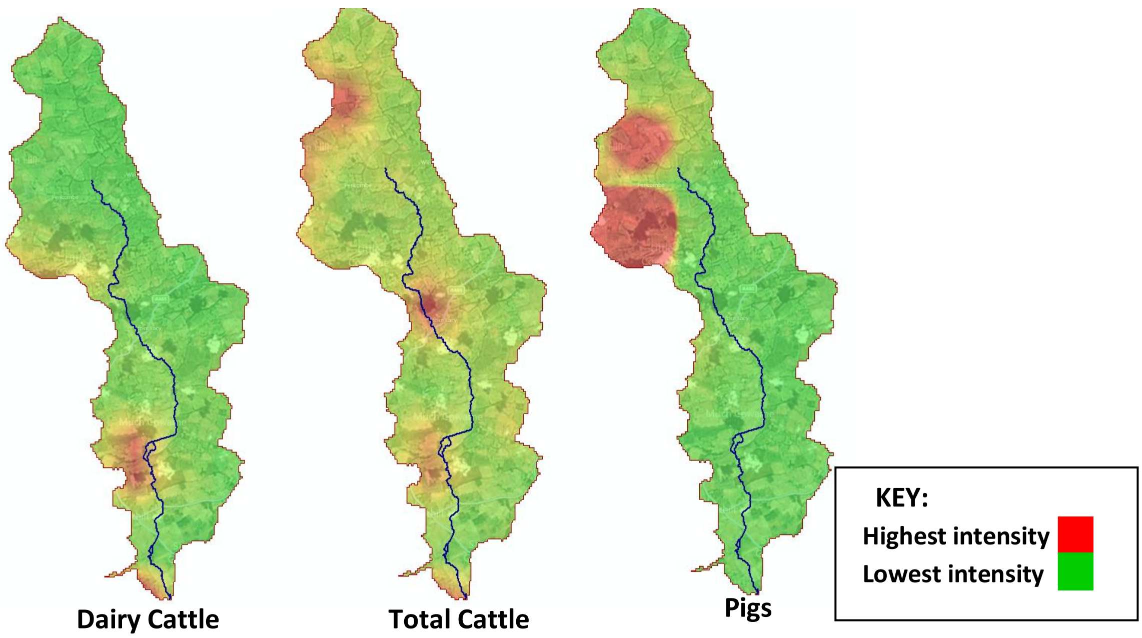



**Figure 33: Livestock number in the Lodon catchment**

Livestock numbers are shown in figure 31. Cattle are distributed throughout the catchment, with notable 'hot spots' in the mid section and in the upper catchment.  Indoor pig units are concentrated in the North West regions of the catchment will be generating large volumes of slurry. These farms would potentially be priorities for the delivery of nutrient management advice and assessments of slurry storage capacities.

**Figure 34 & 35: Left: Poor winter wheat establishment and impeded infiltration providing a run-off pathway for sediment and nutrient in the upper catchment. Right: Maize production in the upper catchment.**

**5.5.2 Scimap to identify diffuse pollution sources:**

A step on from simple catchment scale land use mapping, was the application of a more sophisticated hydrological model- Scimap, in the Lodon catchment.  Scimap is a particularly powerful tool combining land use risk, slope and rainfall data to produce a map showing areas of the catchment which generate diffuse pollution and which are hydrologically connected to a watercourse and thus present a high risk of diffuse pollution to water.

Scimap does not provide definitive answers but assists with targeting across broad spatial scales by assigning a risk probability framework to a landscape and can be powerful tool in directing mitigation measures most effectively. WUF are well placed to use Scimap data for a targeted campaign of contact with risky management practices within the Lodon.

**Scimap works by:**

(1) Assessing the risk of pollution generation at a location through the use of land cover data and the apportioned 'risk' of soil erosion.

(2)  Identification of sources most likely to deliver pollution to the channel based on connectivity to the channel network by surface flow pathways during storm events (the hydrological connectivity risk or surface flow index).

(3) Calculating in-stream risk by integrating risk from all sources contributing to that point.

It is important to remember that Scimap results will only be as accurate as the data incorporated into the model. WUF ran the model using 10m resolution DTM data and freely available CORINE land cover data from 2000.  Problems were encountered when modelling surface flow pathways and

hydrological connectivity risk in low-lying areas of the catchment, as the model was not able to resolve correct drainage at this resolution. After a large amount of time spent investigating these anomalies, it was resolved that the model would need to be re-run with finer resolution DEM data (probably 5m), and most likely the catchment would need to be modelled in smaller sections. Whilst the in-channel sediment concentration was found to be unreliable, the sediment source risk maps were still found to be reliable, as the risk is primarily located on steeper ground where the model resolves drainage more accurately.
WUF were able to use the data and Scimap model to produce maps showing the risk of fine sediment delivery on a catchment scale. These results, provided in figure 34 indicate the highest risk of fine sediment delivery in the North West region of the catchment, an area that has been of concern to the Foundation following catchment inspections, due to the large amounts of maize and winter cropping on steeply sloping fields. Severe erosion from a maize field was witnessed in this area of the catchment in October 2010 (Figure 32).

WUF are eager to start using the Scimap model across the entire catchment and are currently in the process of attaining quotes for Nextmap Britain 5m DTM data and Land Cover Map 2007 from the Centre of Ecology and Hydrology. Initial quotes suggest that this will cost in the region of £8,400 (£8,126 for Nextmap 5m DEM, and £277 for LCM 2007).

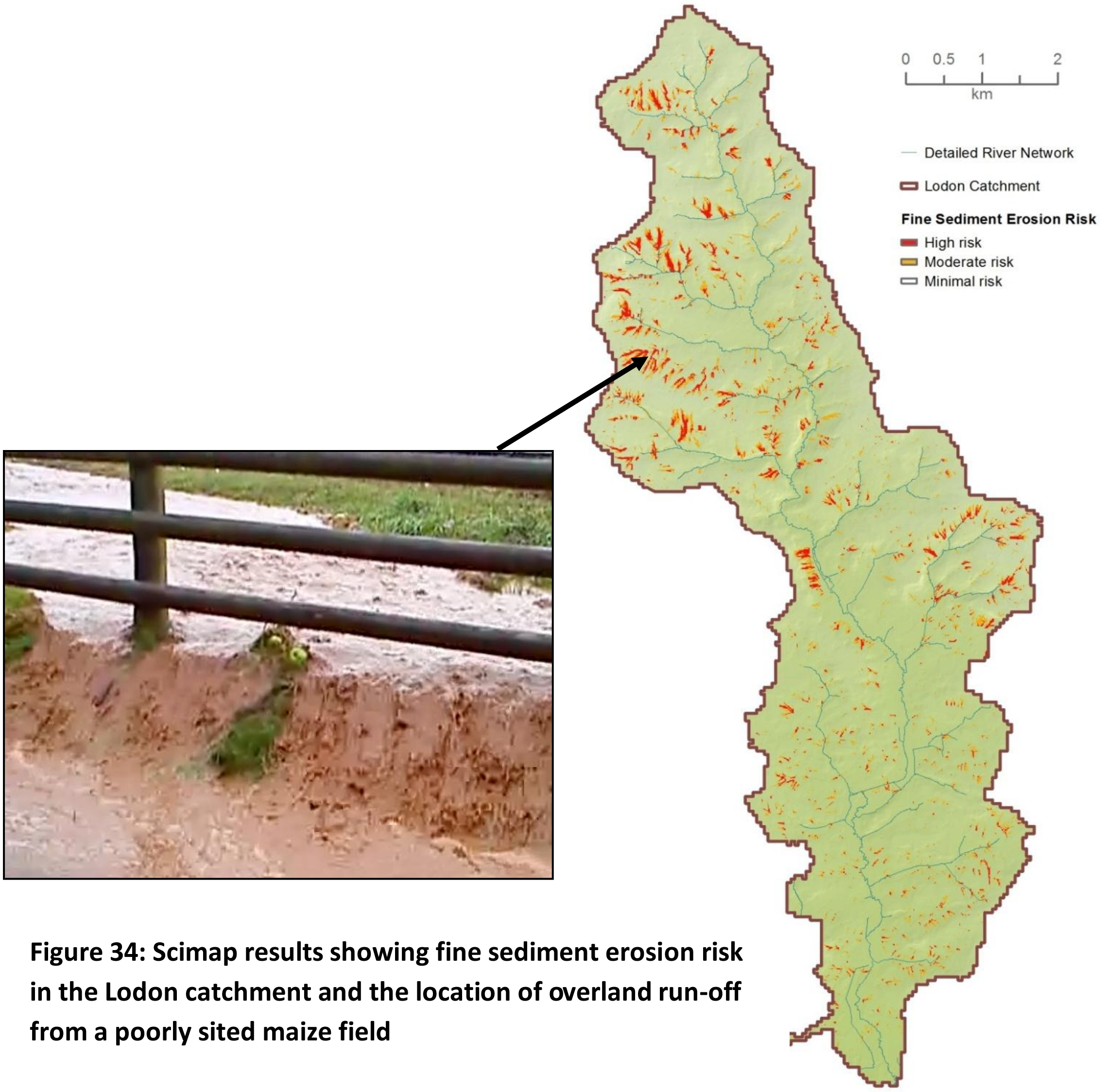



**Figure 34: Scimap results showing fine sediment erosion risk in the Lodon catchment and the location of overland run-off from a poorly sited maize field**

### 5.6 Catchment walk-over survey:

Catchment walk-over survey provides an additional and powerful tool for identifying more specific catchment pressures along the riparian corridor. The walk-over survey, conducted by an experienced surveyor, allows risky practices to be mapped and indications of sediment contribution investigated. The walk-over survey is at its most powerful when used in conjunction with previous desk-based risk assessments, allowing for ground truthing and subsequent targeting of remedial input.

#### 5.6.1 Methodology:

The walk-over survey in the Lodon catchment was completed in November 2010, and recorded features to include levels of in-stream sediment, channel shading by riparian trees, occurrence of riffles and pools, watercourse fencing, bank erosion, sources of fine sediment and potential barriers to fish migration. Photographs were taken at regular intervals to illustrate identified pressures and in-stream habitats.

In-stream sediment was measured using a visual assessment of gravel embeddedness, under the following categories:

Heavily embedded gravel (HEG): Sediment filling gravel matrix

Medium embedded gravel (MEG): Sediment visible between gravel. Some gravel still visible.

Low embedded gravel (LEG): No sediment in gravel.

The catchment walk-over survey results appear in the appendix, and the following observations are made:-

#### 5.6.2 Gravel embeddedness survey:

Waterbody substrate was found to be heavily embedded with sediment throughout, with additional high levels of deleterious algal growth, see figure 34&35. Limited availability of suitable spawning sites and juvenile areas is likely to be having a major impact on spawning success. A number of specific sites were identified where significant sediment and nutrient impact was recorded. One such site was an organic dairy unit, located in the mid-section of the catchment which was noted as a target for further WUF activity (see case study 3).

**Figure 37 & 38: Showing in-steam gravels heavily embedded with fine sediment and deleterious algal growth.**

### 5.6.3 Riparian bank erosion:

Much of the upper catchment is grazed by cattle and sheep, with approximately 70% of the river bank upstream of Stoke Lacy currently unfenced. Unrestricted livestock access and resultant over grazing and trampling of bankside vegetation has lead to extensive poaching and is contributing large quantities of silt into the river channel. High levels of sediment within in-stream gravels is likely to be seriously restricting juvenile habitats for salmonid species.


**Figure 39 &40: Poached banks and faecal contamination from uncontrolled stock access.**

### 5.6.4 Shading:

90% of the catchment was found to be heavily shaded, with un-coppiced alders causing dark tunnelling of long sections of the river channel. Where over shading is accompanied by uncontrolled livestock access this is likely to be having a detrimental impact on fish populations, through increased bank erosion, channel widening and the resultant loss of in-stream habitat diversity. In addition, resultant widening of the channel reduces the WB's natural ability to ameliorate the effects of increased sediment loadings.


**Figure 41 &42: Showing dark tunnelled section of the River Lodon.**

### 5.6.5 Barriers to fish migration:

The walk-over survey also highlighted the presence of significant barriers to fish migration, located within the lower and middle section of the catchment. These barriers were deemed to be an additional factor contributing to the WB, fish failure, preventing access for salmon and the in-stream movement of existing trout populations. In 14 locations, large woody debris has also collected in the channel and is also likely to be restricting fish movements in the channel.

**Figure 43&44: Barriers to fish migration identified during the walk-over survey**

**5.7 Conclusions:**

- Sources of agricultural P were identified during the walk-over survey and are likely to be contributing to the WFD target failure. The monitoring network needs to be extended to allow P apportionment to fully assess the loadings from Pencombe STW, domestic septic tanks and the Wye Valley Brewery.

- The walk-over survey has highlighted bankside erosion, as a result of uncontrolled livestock access as a significant source of fine sediment in the upper catchment. The impact of stock erosion is further intensified by increased shading from uncoppiced alders which are halting bank repair and the WB's natural ability to ameliorate the effects of increased sediment loading.

- Measures to control suspended solids and P loadings from diffuse agricultural sources should be targeted to those areas where combinations of landscape attributes and land management generate the highest pollution risk.

- Combining the SCIMAP data with the knowledge gained from the river walk-over survey allows us to recommend and target specific mitigation activity to the problems identified.

- SCIMAP is a useful for tool for highlighting diffuse sources of fine sediment delivery in the catchment; however when working on a sub-catchment basis, local knowledge must be used to ground truth and highlight possible inaccuracies, ensuring land management advice is targeted effectively.

- SCIMAP reveals the extent to which arable cropping on significant slope angles with connectivity risks sediment and phosphorous transfer, particularly in the upper reaches of the Lodon. This was reinforced by the walk-over survey.

- Barriers to migration are also impacting on fish populations within the catchment.

- Subsequent to the WUF walk-over survey, EA chose to conduct their own geomorphological assessment of the catchment. It is really important that all interested parties working in this area co-operate with and inform each other of existing areas of knowledge so that maximum gain can be made and all best synergies achieved.

**5.8 Achieving GES in the River Lodon:**

**WUFs WB investigations have identified the following key actions as essential in order to achieve GES in the River Lodon:**

**1. Reduce overland flow of sediment and phosphate**

Nutrient and sediment levels in the River Lodon are also a consequence of soil and fertiliser management under intensive cropping in the vicinity of the watercourse. A secondary issue in this area is the presence of intensive livestock systems and organic nutrient loss from hard surfaces and waterlogged fields.

Additional action is also needed to address these diffuse sources of agricultural pollution, particularly in the upper catchment, where the shift from pastoral to intensive arable cropping on high risk sites provides greater risk. It is WUFs opinion that this is most effectively addressed through the use of advise, incentivisation and enforcement tools discussed in Section 2.

**2. Maintain free access for fish passage**

In-stream barriers are placing additional pressure on trout populations, preventing access to more suitable habitats. WUF recommends action to open up the catchment, through removal of the barriers or the construction of suitable easements.

**3. Reduce bank erosion to improve the ability of the channel to ameliorate pollutants.**

The catchment investigations highlighted the need for targeted habitat restoration in the riparian corridor, through a concerted programme of stock exclusion and coppicing.

**5.8.1 Action undertaken by WUF following the WB investigations:**

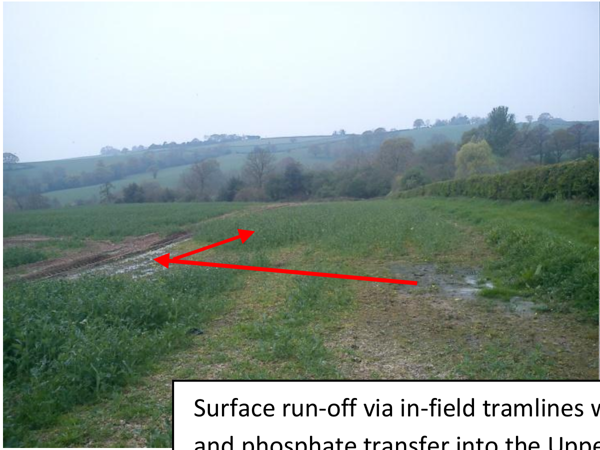
Under the Foundation's LARA project, land management advice has been targeted in the catchment. Under this programme farmers have been offered free and confidential advice on aspects of their management that impacts on water quality, highlighting opportunities for environmental and financial gain. The advisory service has also been supported by a capital grant programme, assisting with funding works that bring measurable benefits to water quality.

WUF's incisive approach to awarding grant aid has tackled identified sources of sediment and P in the Lodon catchment. There has also been effective partnership working with the catchments CSF officer, information has been shared to ensure grant aid is targeted in the right places. Case studies below highlight work completed by the Foundation in the Lodon catchment over the past 6 months:

**5.8.2 Case studies illustrating WUF's holistic approach to tackling agricultural phosphate and sediment sources in the River Lodon:**

**Case study 1: Sediment and nutrient treatment ponds in the upper Lodon**

Following an advisory visit to a large arable and indoor pig rearing unit in the Upper Lodon catchment, the Foundation identified a significant source of nutrient and sediment run-off from the farm buildings and hard surfaces. With a total hard surface area of over 7,000sq. M., run-off was draining below the farmyard, causing water logging and poaching of the adjacent arable field. With connectivity over the surface, via tramlines, this resulted in considerable nutrient loading to the Lodon. Advice from WUF's Catchment Officer, together with grant assistance allowed for the construction of a series of treatment ponds and a vegetative infiltration berm to slow the flow, providing a sink for sediment and nutrients, drastically reducing levels entering the river system. Total cost of the work was £11,000, grant aid was provided at 50% intervention rate.



Surface run-off via in-field tramlines was acting as a direct pathway for sediment and phosphate transfer into the Upper Lodon. Yard run-off is now treated through a series of treatment ponds and a vegetated in-filtration berm.

**Case study 2- Watercourse fencing in the River Lodon**

A major source of sediment is derived from bank erosion as a result of uncontrolled livestock access. To date, WUF grant funding has supported over 1.2km of watercourse fencing in severely impacted sections identified during the Foundations walk-over survey. Further stock exclusion works are planned in the near future.

**Case Study 3: Run-off from an organic dairy farm**

The Foundation had major concern over with the impact of an Organic Dairy Farm located next to a small tributary of the River Lodon in its middle reaches. The watercourse, which spans the length of the holding was found to be inundated with fine sediment and showed major signs of nutrient enrichment.

The farmer was contacted in April 2011 but was initially reluctant to engage with the Catchment Officer, fearing that undue attention would result in statutory intervention. However, confidence was gradually gained along with the realisation that existing practise was untenable. Once this hurdle was overcome strong and enthusiastic engagement was achieved and the measures, as described below instigated. The ability of the WUF, catchment officer to be 'the honest broker' in this case was a major factor in advice being accepted and the following measures implemented.

Arrow indicates where yard run-off was discharging directly into the watercourse

Poor yard buffering was leading to run-off into the watercourse which runs along the length of the yard

The source of the problem was soon identified- the holding yard was poorly buffered and slurry and manure leachate was draining across the hard surfaces and entering the watercourse at numerous locations. The officer explained the deleterious impact this was having on the waterbody, and highlighted the possible financial implications to his business if this was identified by the Environment Agency. The farmer admitted he had been living in fear of an EA visit, but financial constraints had prevented him from addressing the problem.

The officer advised urgent action be taken to increase yard buffering and divert the flow of yard run-off into a new cross drain and collection tank. The farmer agreed to take up the WUF grant assistance to cover 60% of the capital works and within a month the work had been completed. Total cost of this project was £4,690, 40% of the capital works costs were covered by the farmer and the remainder funded by the SITA Trust under the Foundation's LARA project.

In addition to this very focused intervention, the WUF catchment officer identified further improvements that could be made to the unsatisfactory yard surface. The farmer was introduced to the Natural England CSFO and assisted with a CSF grant application. As a result he now has funding secured to completely resurface the yard area, to the considerable betterment of water quality downstream from the holding.

**Cont....**

Subsequent to the infrastructure works being completed an EA environmental officer visited the farm. Following the visit the EA officer contacted WUF to discuss the works and expressed his satisfaction with the action that had been taken to protect water quality in the River Lodon.

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