River Clun SAC
Nutrient Management Plan - FINAL
Part 1 Evidence Base and Part 2 Options Appraisal

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Executive Summary

Background

The River Clun is a tributary of the River Teme in southern Shropshire. The lower 4.7 km of the River Clun is a Special Area of Conservation (SAC) designated for freshwater pearl mussel (*Margaretifera margaretifera*). Surveys since 1995 have shown that the freshwater pearl mussel population is non-functioning and may only survive for up to another 20 years if nothing is done to improve conditions. Although the population is considered to be "non-functional" this does not mean that it is not recoverable. If water quality and habitat conditions are restored a slow recovery in the population should be possible.

Natural England and the Environment Agency have produced a Nutrient Management Plan (NMP) to provide a long term, whole-catchment strategic view of the types and combinations of measures that are needed to achieve the favourable condition of the River Clun SAC by 2027.

The NMP is not a fixed report, but will be regularly reviewed, updated and amended. This first iteration of the NMP identifies the sources of nutrients and sediment and the likely reductions that could be achieved. The input of catchment stakeholders during the development of the plan is gratefully acknowledged. Further iterations, refinements, discussions and agreements will be required before any measures are formally identified and implemented.

Objectives of the Nutrient Management Plan

The Nutrient Management Plan provides the evidence in relation to Phosphate, Nitrogen and Sediment to inform Local Authority Habitat Regulations Assessments (Reg 61) for proposed developments and their strategic development plans within the Clun SAC catchment. In addition it also provides a long term, whole-catchment strategic view of the types and combinations of measures that may be needed to achieve the favourable condition of the River Clun SAC by 2027.

The main objectives are to:

1. Assess the impacts of predicted population growth in the Clun catchment on water quality in the River Clun SAC;
2. Identify the sources of nutrients and sediment and collate evidence on their impact;
3. Provide an indication of the likely reductions achieved by different combinations of measures to address any nutrient or sediment issues identified;
4. Assess whether favourable condition targets (FCTs) for the freshwater pearl mussels can be met;
5. Help define monitoring to assess knowledge gaps and progress in the recovery of the River Clun SAC.

Current status of the River Clun SAC

Conservation Objectives set by Natural England for the River Clun SAC include Favourable Condition Targets (FCTs) for in-river phosphorus (P), nitrogen (N) and sediment (suspended solids) concentrations to protect freshwater pearl mussel from the adverse effects of nutrient enrichment and siltation. FCTs are based on current best-available evidence and the consensus of scientific opinion.

Analysis of water quality data for the River Clun SAC has identified that there are significant compliance gaps between the FCTs for freshwater pearl mussel and measured concentrations of phosphate, nitrogen and sediment in the River Clun SAC.

- Reductions of 43% and 71% are likely to be required to meet the short and long term phosphate FCTs respectively.
- Reductions in mean annual suspended solids concentrations of between 19 and 74% may also be required to meet the sediment FCT.
- Nitrogen concentrations in the River Clun SAC are high for a freshwater pearl mussel river and are in the order of 4 mg/l. Reductions in the order of 68% will be required to meet the nitrogen FCT.

Source apportionment

Phosphate

Use of industry-standard models to estimate phosphate apportionment in the Clun catchment has shown that point sources account for in the order of one third of the catchment phosphate loads on an annual basis with diffuse sources accounting for two thirds. Livestock are estimated to be the single largest source of phosphate and account for over half the catchment phosphate loads on an annual basis. Information provided by Defra indicates that there are close to 14,000 cattle, 120,000 sheep, 410,000 poultry and 150 pigs in the Clun catchment.

The second largest source is STW effluent in the catchment that contributes 35% of the catchment phosphate load on an annual basis. The current population of the Clun catchment is between 7,000 and 7,500 persons. 55-60% of the catchment population is on mains sewerage with the remainder on On site Waste Water Treatment Works (OsWwTWs) although the contributions of OsWwTWs are estimated to be small at the catchment scale (2%). Arable land is the third largest source of phosphate on an annual basis (5%).

Nitrogen

Modelling undertaken by the Environment Agency coupled with mass balance calculations estimate that between 92% and 99% of catchment nitrogen loads are from diffuse sources. However, best available current information does not provide a breakdown of the precise components (eg. arable and livestock farming) of the overall diffuse nitrogen contribution. The Environment Agency and UKWIR are currently updating a national modeling approach that will enable this assessment during 2014. STWs and other industries are responsible for only a small (1%) components of the catchment nitrogen load. Atmospheric deposition is estimated to account for approximately 6% of the annual nitrogen budget of the Clun catchment according to nationally-agreed methdologies.

Sediment

A number of studies have considered the sources of sediment in the Clun catchment. However, there is still some uncertainty regarding the precise proportions from diferent sources. However, the dominant soils in the Clun catchment are naturally susceptible to erosion and diffuse sources account for the majority of sediment loads in the river. Sediment derived from point sources are very small and account for 1-2% of the total annual loading. A current best estimate indicates that in the order of 15% of the annual sediment load in the Clun catchment may be sourced from bank erosion with 85% from erosion of catchment soils.

Fields cropped to cereals, and other land practices where the soil is bare during winter, are likley to have the highest soil erosion risk in the catchment. It has been estimated that 60% of the total sediment generated in the Clun catchment is sourced from the Kemp and Lower Clun sub-catchments where the largest proportions of tilled land are found.

Uncertainties regarding the precise contributions of different sediment sources are currently being investigated by Natural England as part of a study due for completion in 2015.

Impacts of population growth

The impats of population growth will be mainly on phsophate concentrations in the river. The effects of growth on nitrogen and sediment concentrations in the river are expected to be negligible; point sources are small components of the nitrogen and sediment budget of the catchment (see above).

Shropshire Council estimate that additional population growth in settlements until 2027 will increase the catchment population by in the order of 575 persons. This may result in an 8% increase in phosphate concentrations under fully-licensed (actual flow and consented P) conditions although external processes such as the 2015 limits on the phosphate content of some kitchen detergents are likely to offset some or all of the effects of growth in the catchment.

Potential measures to support restoration of the Clun SAC

The Clun NMP has assessed a range of potential options available to reduce the current compliance gap and deliver favourable condition in the River Clun SAC by 2027.

Point sources

Six potential measures to reduce phosphate concentrations in the River Clun SAC were identified by stakeholders during workshops to support the development of the NMP. The maximum potential reduction is delivered by a 75% reduction in STW-derived phosphate loads in the catchment suggested by Severn Trent Water as potentially achievable dring the next Asset Management Planning (AMP) period. The effects of point souce measures on nitrogen and sediment concentrations in the river are predicted to be small because point sources contribute only small proportions of the catchment nitrogen and sediment budget.

Diffuse sources

Measures to reduce diffuse sources of phosphate, nitrogen and sediment in the Clun catchment have been considered using FARMSCOPER, a Defra-funded farm-scale scoping tool. Agricultural practices in the Clun catchment were generalised to estimate the effectiveness of various land management measures applied to arable and upland grazing farms in the catchment.

Phosphate

Best practice (COGAP/Farm Assurance) or measures associated with NVZ were estimated to have relatively small (5-10%) effects on overall phosphate loads in the Clun catchment. The maximum potential reduction in phosphate loads were in the region of 60% although a large number of measures would be required to achieve this reduction. However, a ‘Top 5’ was found to deliver the majority of this benefit in the case of both arable and livestock farms in the Clun catchment and could reduce phosphate loads in the catchment by up to 50% although 100% uptake would be required.

Sediment

Implementation of Top 5 Farmscoper measures for sediment would also reduce sediment loss within the catchment by a large amount (75%). In addition, the ‘Top 5’ options for phosphorus and sediment reduction on the typical arable farm are the same, highlighting ancillary benefits to phosphate reduction if measures to control sediment loss were implemented.

Nitrogen

In contrast, whilst large reductions in phosphate and suspended solids are potentially possible using a 'Top 5' approach, even the maximum reduction possible for nitrogen is modest (<20%) and would require implementation of a very large number of measures.

Meeting the Favourable Condition Targets

Phosphate

Consideration of point and diffuse source measures have shown that neither on their own will reduce phosphate concentrations in the River Clun SAC to levels approaching the short- or long-term phosphate FCT.

Water companies and the farming community would both need to contribute to deliver the phosphate FCTs for the River Clun SAC. Modelling work has shown that the short term phosphate target of 0.02mg/l would be potentially achievable with management changes that exclude reversion. A combined implementation of ‘Top 5’ FARMSCOPER measures and a 75% reduction of catchment phosphate loads from STW effluent would be required to meet the short-term phosphate target for freshwater pearl mussel.

Meeting the long term phosphate target of 0.01mg/l is likley to require reversion to semi natural vegetaion e.g. woodland or heathland, in the order of half of the Clun catchment.

Sediment

Implementation of ‘Top 5’ measures may, on average, reduce sediment concentrations in the River Clun SAC to within the sediment favourable condition target for freshwater pearl mussel (10mg/l). However, the sediment FCT would still be exceeded in certain years and there is remaining uncertainty regarding whether it is the dominant regime (recorded by mean annual suspended soilds concentrations) or peak turbidities associated with short duration, high flow storms that are most likley to affect freshwater pearl mussel populations in the Clun catchment.

Nitrogen

Compared to phsophate and sediment, potential reductions in diffuse nitrogen are expected to be small, even at a large scale of implementation; a large compliance gap is therefore likely to remain even if maximum implementation of measures was achieved.

Further monitoring and investigations

A number of assumptions have necessarily been made during the production of the first NMP for the River Clun. An assessment of the knowledge gaps has enabled the identification of a series of data collection priorities that should be built into an integrated monitoring plan for the catchment. Additional data and assessments are currently required regarding:

- The current flow and phosphate concentrations at some of the minor STWs in the catchment;
- The flow regime of different tributaries of the Clun catchment;
- Chlorophyll concentrations (as a measure of algal activity) in the River Clun SAC and their relation to phosphate and nitriogen concentrations;
- A greater understanding of the factors driving sediment deposition (rather than suspended sediment) in the River Clun;
- The local applicability of Favourable Condition targets for phosphate, sediment and especially nitrogen;
- The seasonality of different sources relative to freshwater pearl mussel lifecycle and impact pathways to help determine the measures that are most likley to deliver restoration of the River Clun SAC.

To this regard, due consideration should be given to contiunuing turbidity and nutrient monitoring in the clun catchment and in the River Clun SAC as a minimum if funding allows. The sediment assessment should also be updated once the results of the detiled sediment apportionment work recently commissioned by Natural England is completed.

The collection of detailed farm information, including the timing of stock movements and the management of manure, will be important. Curently there are limited tools to help catchment managers target and prioritise areas for the implementation of measures. A formal way of capturing the large amount of potential data yielded by the activities of local catchment officers should therefore be developed as a priority. This would include the identification of high risk areas by, for example, mapping field underdrainage in the catchment.

Way forward

This first iteration of the River Clun SAC NMP has shown that restoration of the River Clun SAC will require a collaborative approach involving all catchment stakeholders. To this regard a steering group will be established to oversee implementation and review of the NMP. The steering group will lead future iterations of the NMP and will draw together actions needed. This will include a Clun freshwater pearl mussel conservation strategy to ensure populations are maintained whilst measures are implemented.

An iterative approach to restoration will be pursued, firstly aiming for the short-term target of 0.02mg/l of phosphate in the river by 2019 and then 0.01mg/l, reviewing ecological improvements along the way to amend the targets if evidence indicate that step-wise improvements deliver the required ecological improvements. Ongoing discussions with Defra will be required to discuss progress and funding requirements.

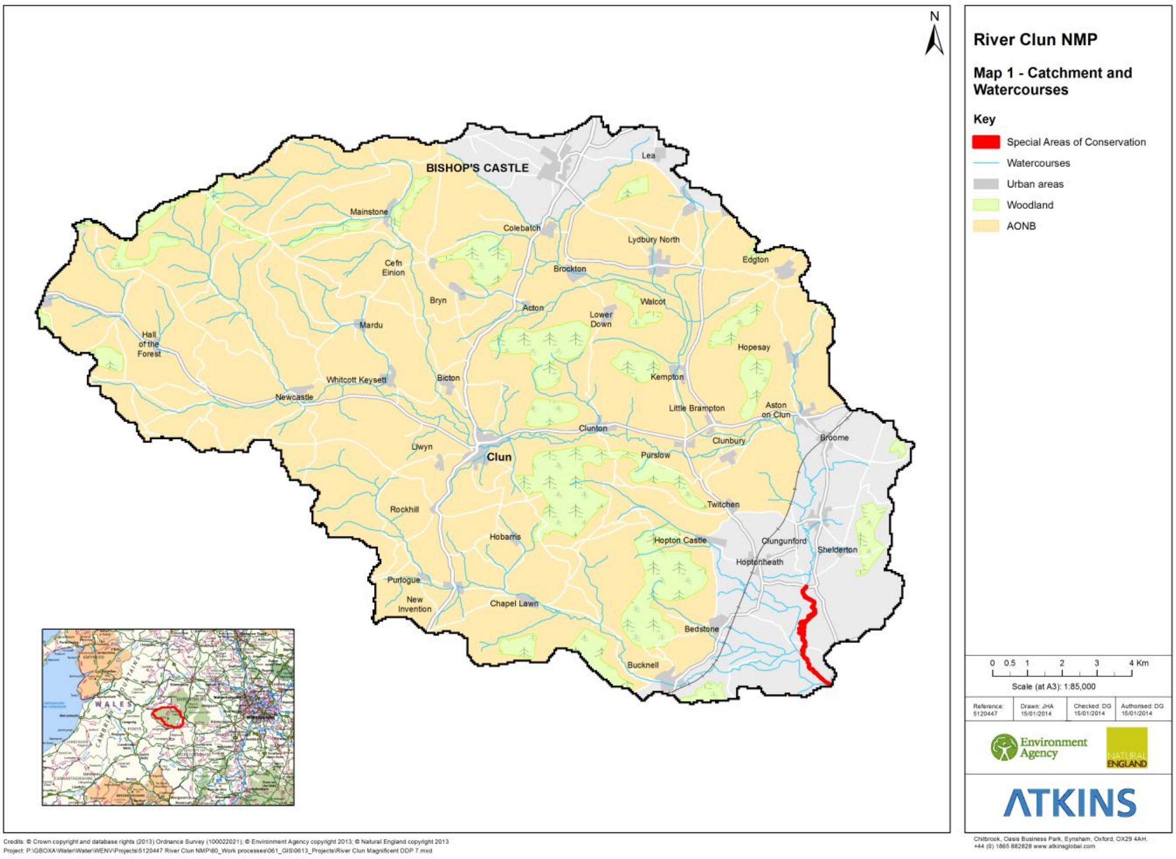
Implementation of measures to restore the River Clun SAC are likely to deliver a wide range of ancillary benefits that will make considerable contributions towards other economic and environmental targets. For example, benefits to the farming community are likely to result from reduced soil loss and at a broader scale, there will be benefits to flood risk and channel management, fisheries and tourism in the catchment.

1. Purpose of the Plan

1.1. Background

The River Clun is a tributary of the River Teme and drains 27,226ha of farmland and woods in southern Shropshire. The River rises in the Clun forest and flows eastwards through the villages of Newcastle-on-Clun, Clun and Purslow. At Aston-on-Clun the river turns southwards and continues through agricultural land to its confluence with the River Teme (Map 1).

The lower 4.7 km of the River Clun is a Special Area of Conservation (SAC) (Map 1) designated for freshwater pearl mussel (*Margaretifera margaretifera*). The latest condition assessment of the River Clun SAC has recorded its condition as ‘unfavourable declining’. Surveys since 1995 have shown that the freshwater pearl mussel population is functionally extinct, meaning that the population is declining with little evidence of recruitment (Natural England, 2010). It has been estimated that the mussels will only survive for another 20 years if nothing is done to improve conditions in the SAC (Killeen, 2008).



1.2. Aims and Objectives

This document provides the evidence base for a Nutrient Management Plan (NMP) for the River Clun SAC.

The Nutrient Management Plan provides the evidence in relation to Phosphate, Nitrogen and Sediment to inform Local Authority Habitat Regulations Assessments (Reg 61) for proposed developments and their strategic development plans within the Clun SAC catchment.

In addition it also provides a long term, whole-catchment strategic view of the types and combinations of measures that may be needed to achieve the favourable condition of the River Clun SAC by 2027

There is concern that population growth may increase nutrient loadings to the River Clun SAC and it is important to understand potential impacts and any required mitigation. Changes to agricultural activities in the catchment may also result in additional pressures on the River and their effects need to be assessed.

The NMP builds on previous studies to:

1. **Assess the impacts of predicted population growth in the Clun catchment on water quality in the River Clun SAC;**

2. **Identify the sources of nutrients and sediment and collate evidence on their impact;**

3. **Provide an indication of the likely reductions achieved by different combinations of measures which could be carried out within the wider catchment to address any nutrient or sediment issues identified;**

4. **Assess whether favourable condition targets (FCTs) can be met;**

5. **Help define monitoring to assess knowledge gaps and progress in the recovery of the habitats and species for which the River Clun is valued.**

The NMP is one of a number of initiatives that are working towards improving river habitat in the Clun catchment (Figure 1.1). The NMP has the potential to complement many of these plans and programmes and as such its implementation should proceed with the objectives in mind to secure mutual and multiple benefits where possible. Key points to emphasise are:

- The need for the integrated delivery of solutions coming out of various initiatives;
- The importance of local initiatives in delivering change in the catchment. For example, an AONB SITA funded project has undertaken practical work to reduce sediment and nutrient levels within the river over the last three years and the Upper Clun Management Initiative, aimed at integrating environmental management with sustaining rural livelihoods;
- The logistical challenges associated with coordinating delivery where a number of organisations with overlapping interest and responsibilities operate in a catchment; and.
- The need for leadership to coordinate all catchment activities and ensure available resources are best utilised.

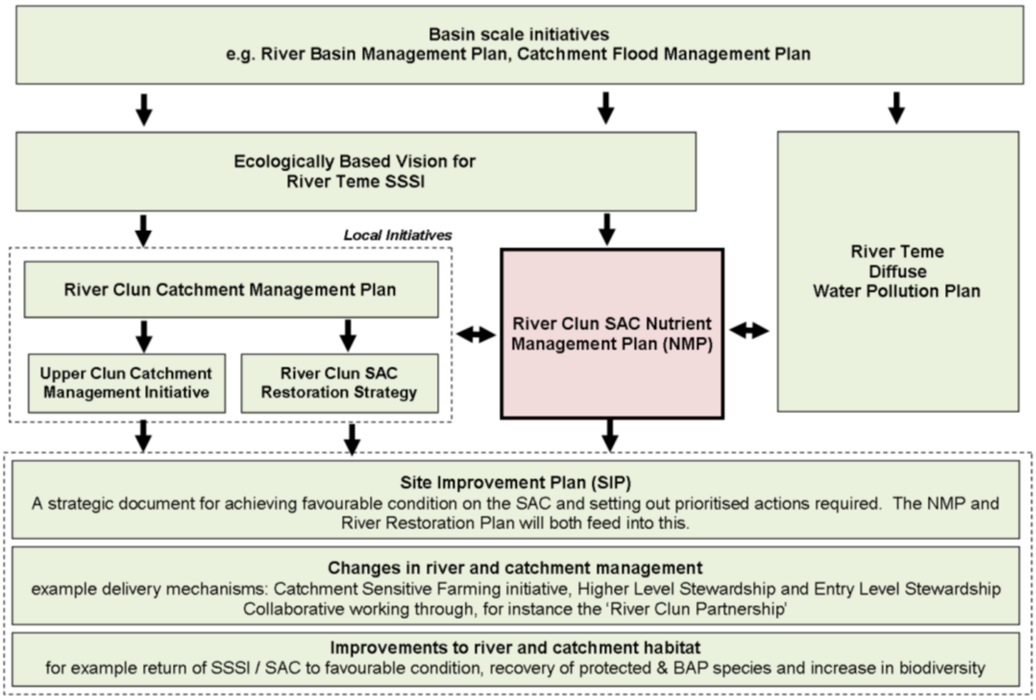


Figure 1-1 Clun catchment initiatives and linkages to the Nutrient Management Plan

1.3. Iterative approach

The NMP will not be a fixed report, rather it is anticipated to be a working document, regularly reviewed, updated and amended as decisions and progress is made, changes occur or new relevant data sets are collected within the Clun catchment.

The adopted approach for the production of this initial NMP evidence base is also iterative and summarised in Figure 1.2 below. It is based on a starting point of identifying the best available data, developing sensible assumptions and consultation with and review by local stakeholders to develop the NMP evidence-base report (this document). This approach can also be followed whenever a future update of the NMP evidence base is undertaken.

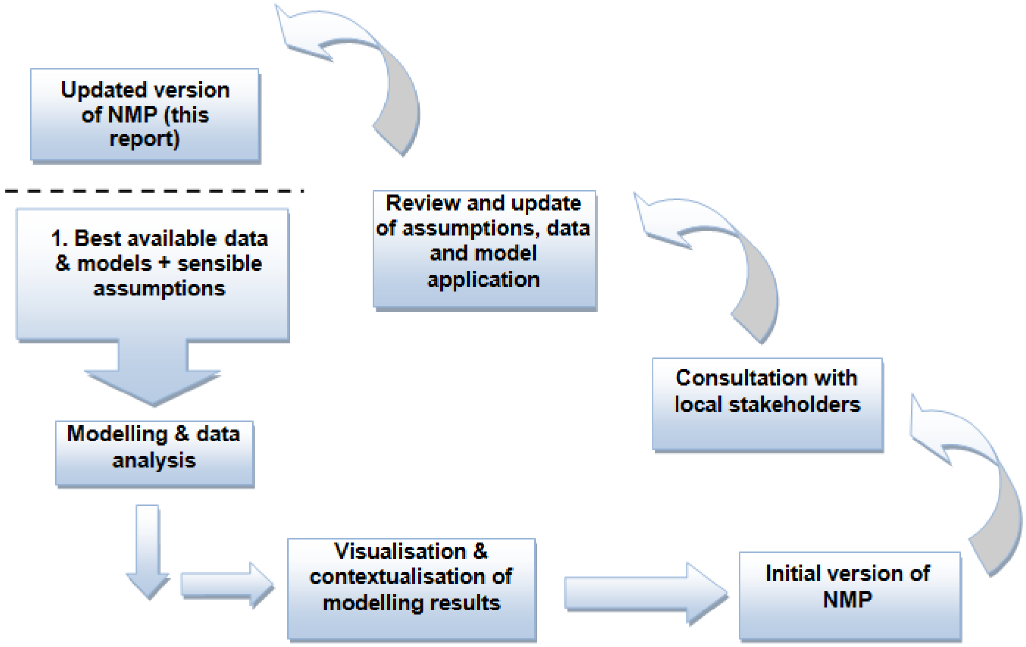


Figure 1-2 Iterative process adopted

It is envisaged that there will be further iterations and refinements of the NMP evidence base and further discussion and agreement on the strategy and measures to take forward before any significant changes to the measures already being implemented in the Clun catchment are formally identified. <u>This first iteration of the NMP evidence base is focused on identifying the sources of nutrients and sediment and the likely reductions that could be achieved by different combinations of measures which could be implemented to mitigate the risk of rising phosphorus, nitrogen and sediment levels in the River Clun SAC.</u>

Future iterations will look to refine the modelling assumptions, the measures lists produced and the tools that may become available through time as ongoing discussions between catchment stakeholders progress.

This current iteration of the NMP evidence base has used the best available information at the time of publication. Table 1-1 reviews the main tools and sources of information that have been made available to support the development of the NMP evidence base. Most of the tools used have been funded by Defra, the Environment Agency, Natural England and water companies and are industry standard methodologies to support catchment based planning and management. The NMP evidence base has also relied on the large number of previous investigations undertaken in the Clun catchment reviewed in Table 1-2.

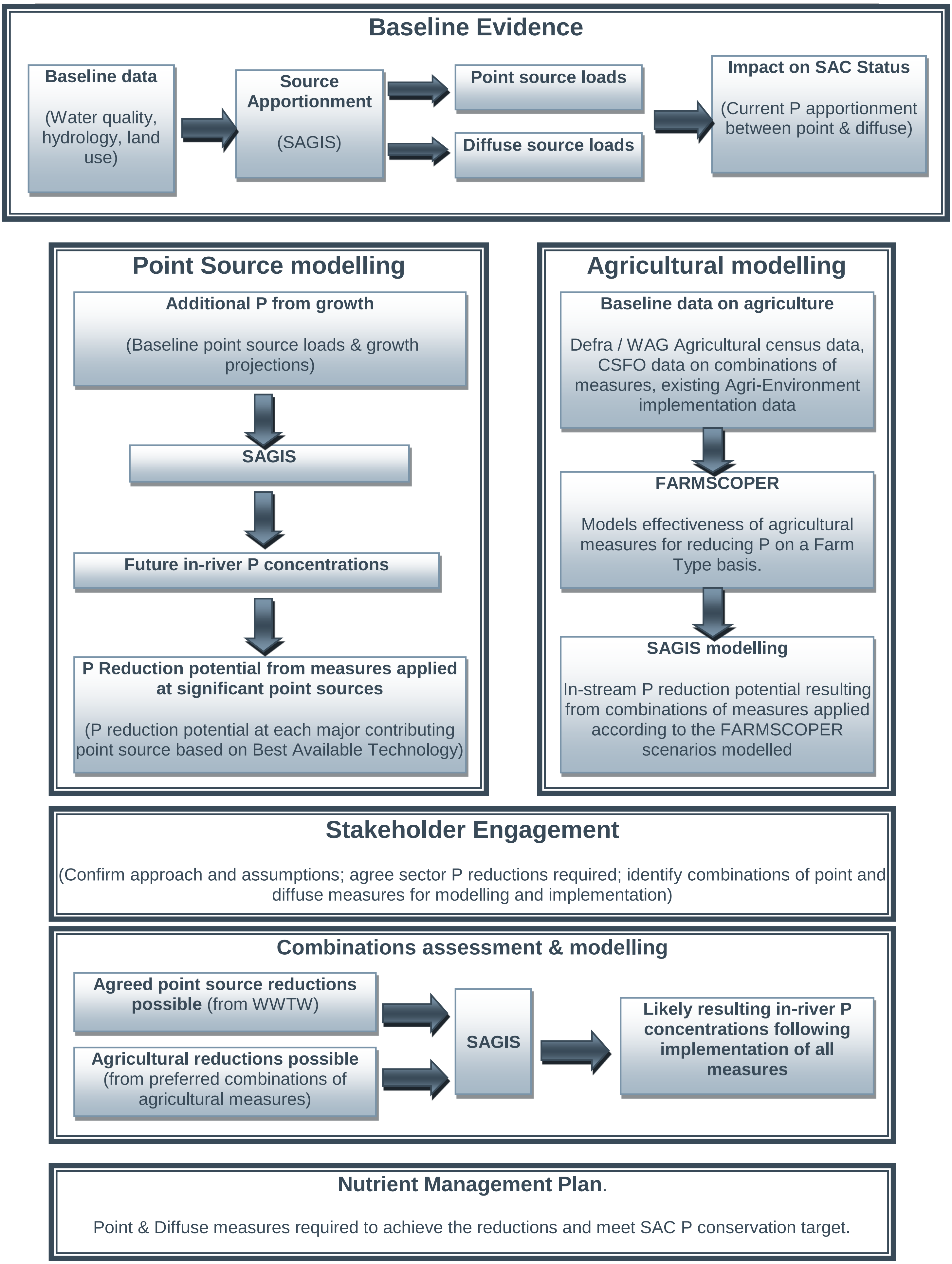


Figure 1-3 Overview of the approach taken on the Clun NMP

Table 1-1 Summary of the tools and data sources used to develop the Clun NMP.

Type	Name	Originator	Description	Further information
Modelling tools	SAGIS	UKWIR - Environment Agency	UKWIR, SEPA and the Environment Agency have funded the development of a source apportionment GIS model (SAGIS) to quantify the loads of pollutants to surface waters in the UK from 12 point and diffuse sources including wastewater treatment works discharges, intermittent discharges from sewerage and runoff, agriculture, soil erosion, mine water drainage, septic tanks and industrial inputs. Loads are converted to concentrations using the SIMCAT water quality model which is incorporated within SAGIS so that the contribution to in-stream concentrations from individual sources can be quantified enabling a proportioning of responsibility for improving water quality.	Details of the approach, assumptions and data used in PSYCHIC can be found in Comber *et al.* (2013).
	PSYCHIC	Defra	A Defra-funded, process-based model of phosphorus (P) and sediment (SS) mobilisation and delivery to watercourses. Transfer pathways include dissolution of soil P, detachment and mobilisation of SS and associated particulate P, incidental losses from manure and fertiliser applications, losses from hard standings, and transport to watercourses in under-drainage (where present) and via surface pathways..	Details of the approach, assumptions and data used in PSYCHIC can be found in Davison *et al.* (2008) and Stromqvist *et al.* (2008).
	FARMSCOPER		Defra-funded tool that collates more than a decade of UK scientific research on farm scale pollutant loads and the effects of different mitigation methods on losses of phosphorus, nitrogen and sediment. Estimates of the costs and effectiveness of different measures area also provided for each of the Defra Robust Farm Types. Over 100 mitigation methods, including those listed in the latest Defra Mitigation Method User Guide (Defra Project ES0203), are included within the tool.	Details of the approach, assumptions and data used in FARMSCOPER can be found in Gooday and Anthony (2010). Zhang *et al.* (2012), Gooday *et al* (2013) provide examples of how the tool has been applied elsewhere.
	SCIMAP	Rivers Trusts	A risk-based tool that predicts area at risk of soil erosion in catchments and the pathways between field and rivers	-
Water quality monitoring data	STW effluent water quality spot samples	Severn Trent Water	Concentrations of phosphate in the effluent of the Bishops Castle STW and Bucknell (STW) are monitored on a monthly basis. Historic data to 2008 is available for Clun STW, Newcastle-on-Clun STW, Lydbury North STW and Aston-on-Clun STW.	No recent phosphate concentration monitoring in effluent from STWs other than Bucknell and Bishops Castle.
	River water quality spot samples	Environment Agency	Water quality samples are taken on a monthly basis from a network of sites across the Clun catchment. This information is held on the Environment Agency water quality database called WIMS. In the River Clun, regular sampling includes orthophosphate, suspended solids and total oxidised nitrogen (TON).	Mainly 'fair weather' samples that may not reflect some of the larger events that typically occur at shorter timescales than recorded by a monthly sample.
	Sondes		The Environment Agency has provided data for turbidity sondes (auto-loggers) located in the River Clun at Clungunford and Leintwardine, and in the Folly Brook close to Newcastle-on-Clun. The loggers record temperature, pH, conductivity, dissolved oxygen, and turbidity on a 15 minute basis.	Sonde data are available for the period May 2012 to April 2013. This includes one of the wettest periods on record. The unusual weather conditions may have had an influence on the results and this should be taken into account when interpreting data currently available.
Hydrometric data	STW flows	Severn Trent Water	Flows are measured on a daily basis at the larger STWs in the Clun catchment	Daily flow data available only for the period between 2010 and 2012 for STWs at Bucknell, Bishops Castle, Lydbury North and Clun. At other locations, flows are estimated based on the population served by each works.
	Rainfall data	Environment Agency	Data for most of the Clun catchment has been compiled	-
	Water level data and spot flows	Environment Agency	Continuous water level data are available for the River Teme at Leintwardine A4113 Bridge. Monthly spot flows are also measured at this location	Monitoring location downstream of confluence of Teme and Clun. Spot flow data are limited across the rest of the catchment (see Atkins [2013] for a more detailed review.
Ecological monitoring data	Freshwater pearl mussel surveys	Natural England-Environment Agency	A number of surveys of FWPM have been undertaken in the catchment. Data have been used to develop the Plan.	Table 1.3 provides a review of available reports that discuss the constraints and assumptions of surveys in greater detail.

Table 1-2 Previous investigations commissioned on the River Clun SAC

Description	Year	Commissioned by	Author(s)
Report on the 1995 survey of the freshwater pearl mussel. Rivers Torridge, Clun, Esk, Irt, Ehen, Rede and N. Tyne.	1996	English Nature	Malacological Services
Freshwater pearl mussels survey report	2005	Environment Agency	Malacological Services
River Clun Geomorphology Baseline Assessment	2006	Natural England	Jacobs Babtie
River Clun SAC Habitats Directive Reports	2006	Natural England and Environment Agency	Natural England and Environment Agency
Freshwater pearl mussel survey report	2007	Environment Agency	Malacological Services
Assessment of the potential for the restoration of the freshwater pearl mussel population in the River Clun	2009	AONB	Malacological Services
Defining priorities: a conservation plan for freshwater pearl mussel populations in England and Wales	2010	Natural England, Environment Agency and Countryside Council for Wales	Natural England, Environment Agency and Countryside Council for Wales
River Teme SSSI Diffuse Water Pollution Plan	2010	Natural England and Environment Agency	Natural England and Environment Agency
Wastewater Infrastructure in the River Clun Catchment, An Assessment of Impact	2011	AONB	Keele University
Ecologically-based vision for the Teme SSSI	2011	Natural England	N Grieve
Land Life and Livelihoods Scoping Study: Clun Community Led Catchment Management Initiative	2011	AONB	Resources for Change
Shropshire Hills AONB Management Plan 2009–14	2011	AONB	AONB
River Clun SSSI/SAC Restoration Strategy and supporting Technical report	2012	Natural England	Atkins
Hydrological investigations of potential relocation sites for freshwater pearl mussels	2013	Natural England	Atkins
Freshwater pearl mussels survey report	2013	Environment Agency	Malacological Services
Highways Sediment Scoping Study	2013	Natural England	AONB

1.4. Drivers & alignment with other programmes & objectives

1.4.1. Habitats Directive

The River Clun is designated as Special Area of Conservation (SAC) under the European Community (EC) Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna, adopted May 21st 1992). This means that there is a legal requirement to maintain or restore protected habitats and species at “Favourable Conservation Status” and therefore to **avoid deterioration** or disturbance of the qualifying natural habitats and species for which the site is designated.

Furthermore, there is a **requirement to ensure that the integrity of the site is maintained** and to ensure that the site makes a full contribution to achieving Favourable Conservation Status of each of the qualifying features.

Natural England, as the Nature Conservation body for Habitats Directive sites, has set targets for phosphorus, nitrogen and sediment to support favourable condition/favourable conservation status.

There is a requirement under the Conservation of Habitats and Species Regulations (2010) hereby referred to as the Habitat Regulations, under Regulation 61 that ‘a competent authority, before deciding to undertake, or give any consent, permission or other authorisation for, a plan or project which—

a. is likely to have a significant effect on a European site or a European offshore marine site (either alone or in combination with other plans or projects), and
b. is not directly connected with or necessary to the management of that site,

c. must make an appropriate assessment of the implications for that site in view of that site’s conservation objectives’

This applies to all competent authorities and in relation to development planning, this means that the Local planning authority (LPA) have to undertake a Habitat Regulations Assessment for all planning applications and strategic planning documents which have the potential to impact the Clun SAC and this includes (but not necessarily limited to) those that have the potential to increase nutrients or sediment.

Providing the evidence specifically in relation to nutrients and sediment for the LPA to use and rely on when undertaking Habitat Regulations Assessments of planning applications and strategic development plans was the key driver for producing this NMP.

1.4.2. Water Framework Directive

All water dependent sites designated under the Habitats Directive are also classed as ‘Protected Areas’ under the EC Water Framework Directive (WFD). The Clun SAC is a Water Dependent SAC and therefore is designated as a **WFD Natura 2000 Protected Area. I**t is also designated as a **WFD Protected area for its Economically Significant Species** as it is an important salmonid fishery. The WFD also identifies water bodies and the requirement for all water bodies is to meet Good Ecological Status (GES) by 2015, subject to the application of extensions.

As part of the WFD, a River Basin Management Plan (RBMP) is produced which combines groups of water bodies into sub-catchments within each River Basin District (RBD). The Clun is within the Severn RBMP and is part of the Teme catchment, alongside the Onny, Corve and Rea as the Teme’s main tributaries. The Clun sub catchment is split into seven water bodies.

The requirement for protected areas under WFD is to meet the most stringent targets/objectives by 2015. For the Clun Natura 2000 Protected Area it is the SAC targets/objectives that WFD is looking to achieve not GES as these targets are less stringent. Therefore WFD reinforces the need to achieve the Habitat Directive requirements but in addition it provides a specific date for achieving the targets which the Habitats Directive does not do.

There are three 6 yearly river basin planning cycles, RMBP cycle 1 – 2010 - 2015, RBMP cycle 2 – 2016 - 2021 and RBMP cycle 3 – 2022 - 2027.

The 2015 deadline for meeting protected area requirements can be extended where actions needed to meet objectives in the first RBMP cycle are not technically feasible or are disproportionately expensive.

Therefore a secondary driver for this NMP is to provide the evidence to inform a long term strategy to achieve the requirements of both the Habitats Directive and WFD. The deadline adopted within this NMP is the final WFD deadline of 2027, based on considerations of technical feasibility.

Therefore, although the primary driver for the NMP is to provide evidence for the LPA to use for their Reg 61 Habitat Regulations Assessment for development, there is also a secondary driver for the NMP, which is to provide the evidence to underpin a strategy to achieve the wider Habitats Directive and WFD targets.

1.4.3. Growth and economic development

In order to meet the requirements of the Habitats Directive and the WFD whilst supporting growth and economic development within Shropshire, the Environment Agency, Natural England and Shropshire Council are committed to the development and implementation of a NMP to manage phosphorus, nitrogen and sediment levels within the SAC such that growth can proceed whilst restoring favourable conservation status between 2013 and 2027. In this context, growth and economic development refers to both potential increases in population and associated housing, as well as agricultural activity in the catchment.

1.5. Who is this plan for?

1.5.1. National regulatory stakeholders

The Environment Agency and Natural England are joint partners in the development and delivery of the NMP. The Environment Agency is the environmental regulator and Natural England is the Nature Conservation body responsible for the conservation and enhancement of the SAC and includes those delivering Catchment Sensitive Farming (CSF). Shropshire Council is the component authority responsible for the County growth strategy. Severn Trent Water is the local water company.

1.5.2. Local stakeholders and delivery partners

The Clun catchment is within the Shropshire Hills Area of Outstanding Natural Beauty (AONB). The National Farmers Union (NFU) has local representatives across the country, including water pollution specialists, to communicate messages between the farming industry, the regulators and Defra. Similarly, the Country Land and Business Association (CLA) is a large membership organisation representing key land owners and land managers across the country. The Severn Rivers Trust has a number of ongoing projects in the local area. A high level stakeholder map outlining the key national, regional and local stakeholders involved in both the delivery and implementation of the NMP is outlined in Figure 1.4 below.

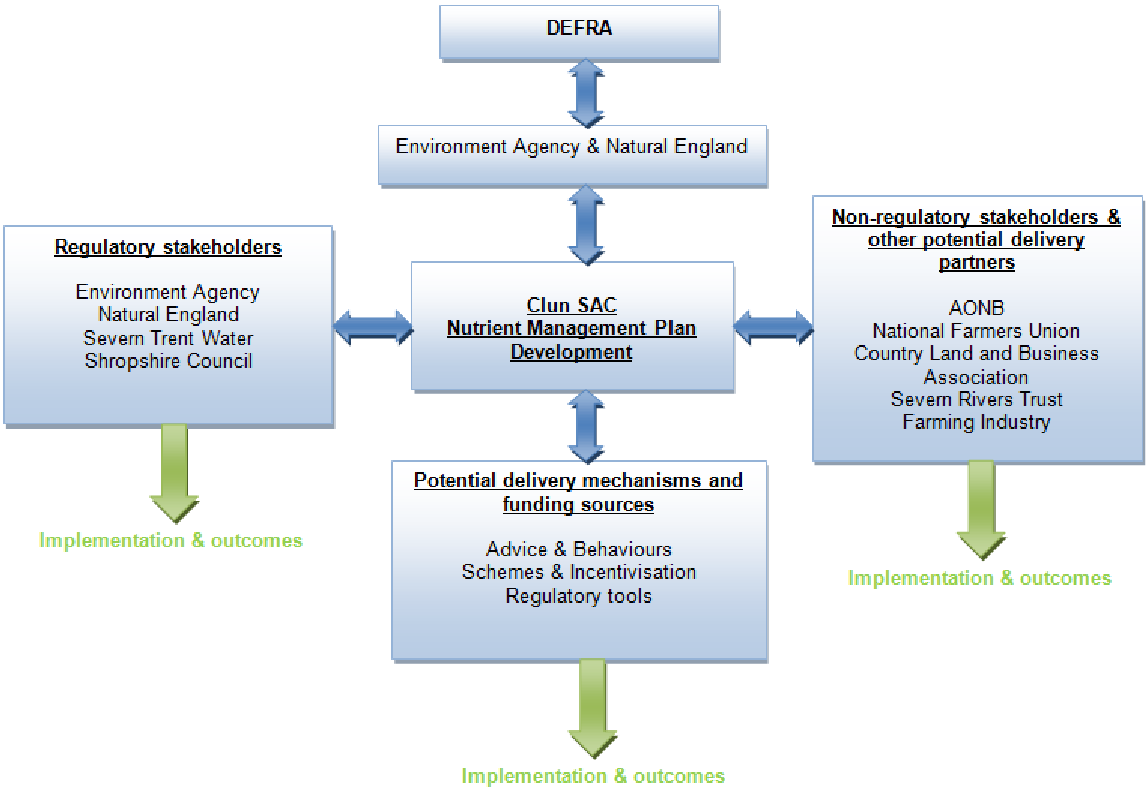


Figure 1-4 Key stakeholders and delivery partners for the Clun NMP

1.5.3. Approach to consultation

The Environment Agency and Natural England recognise the need for effective and positive engagement with all catchment stakeholders. As such, this initial iteration of the NMP evidence base has involved a broad consultation with catchment stakeholders. Three phases of consultation have been undertaken:

1. **Identifying issues** – during the initial stages of the development of the NMP evidence base, workshop sessions were held to identify data and other sources of information that could be incorporated within the NMP evidence base and to identify the main concerns;
2. **Understanding growth –** prior to the modelling and assessment workshop, two stakeholder workshops were held to identify the specifics of the scenarios to be considered;
3. **Discussing implications** – following a first-pass assessment of the data and model outputs, results were presented in a stakeholder meeting in October 2013. Main stakeholder comments are shown in Appendix A. These responses were then used to further focus technical work and to develop a first draft Nutrient Management Plan for the River Clun SAC.

The input of all stakeholders to the consultation process is gratefully acknowledged.

1.6. What next?

This NMP evidence base is the starting point in a long- term process. The Plan takes a long term strategic view of the actions required to achieve Favourable Condition of the River Clun SAC by 2027. In addition, there are short to medium term objectives to reduce phosphate levels towards the restoration target, and to see downward trends in the levels of nitrogen and suspended solids.

The next step is for Natural England, the Environment Agency, Shropshire County Council, Severn Trent Water, land managers and land owners to work collaboratively to agree how best to integrate the findings of this study within local catchment management initiatives.

To this regard, a catchment working group will be established. The catchment working group will be the custodians of the NMP evidence base and will lead the review and update of it at regular intervals as new information or data become available, or progress on actions are made within the catchment. They will also lead on ensuring implementation and progress with actions happens.

1.7. Structure of the evidence base and options appraisal

The structure of the plan reflects the main technical tasks undertaken as part of the investigation and is summarised in the table below. All maps, figures and tables are included in the main body text. Appendix B also contains the maps within the plan at a larger scale for reference.

	Section	Content	Recommendations for use
1	Purpose of the Plan	Project objectives and drivers	Context to the Plan
2	Freshwater Pearl Mussel	Summary of SAC features	Current and historic status
3	Catchment character	Defines hydrological catchment and identifies main features	How catchment character might influence water quality status
4	Water quality baseline	Reviews water quality data collected by the Environment Agency relative to favourable condition targets	Considers compliance with targets
5	Pressures	Reviews population and agricultural pressures	Identification of catchment issues to be considered in the Plan
6	Source apportionment	Use of modelling and monitoring data to assess the most important sources of phosphate, nitrogen and sediment	To help target mitigation actions in the Clun catchment
7	Options appraisal	Considers how different scenarios help deliver compliance	Basis for future catchment planning
8	Additional monitoring and investigation	Identifies and proposes ways of addressing data gaps	Basis for future programme of work

Part one – Evidence and Supporting Information

2. Freshwater Pearl Mussel

The European Union Directive on the Conservation of Natural and Semi-Natural Habitats and of Wild Fauna and Flora (Habitats Directive) lists the freshwater pearl mussel *Margaretifera* under Annex II (species whose conservation requires the designation of special conservation areas).

The UK is estimated to be holding approximately 40% of the entire complement of EU individuals. In England, most populations are 'functionally extinct' in that they consist of a relatively small number of old specimens with no substantial evidence of recent recruitment. At present only a single English river (the River Ehen in Cumbria) is considered to support a viable freshwater pearl mussel population and in a further 10 rivers the species is considered to be in danger of extinction without significant intervention; one of these is the River Clun where the mussel is a named feature in its SAC designation (Natural England, 2010).

Under the Habitats Directive, the designation and conservation of Natura 2000 sites is the responsibility of Member State governments. If sites continue to deteriorate due to inappropriate management, governments can be challenged for failing to take action according to Article 6. This can result in possible infraction proceedings. The European Union has considered infraction proceedings against Ireland where SACs designated for freshwater Pearl Mussel are in decline and where it is considered the Member State is neglecting its obligations under the Habitats Directive (Natural England, 2010).

2.1. Lifecycle

The freshwater pearl mussel begins its life as a tiny larva known as glochidia. These larvae are ejected into the water from an adult mussel in a mass of one to four million other larvae over a period of one or two days sometime between July and September. The glochidia resemble tiny mussels but their shells are held open until they snap shut on a suitable host – juvenile fish from the salmonid family. A small proportion will be inhaled by salmonids and snap shut onto the fish's gills. There they live and grow in the oxygen rich environment until the following May or June, when they drop off. They then need a clean gravel or sandy substrate into which they will burrow. The young will generally bury themselves completely, rising closer to the surface as they mature.

The freshwater pearl mussel grows extremely slowly, inhaling water through exposed siphons, and filtering out tiny organic particles on which it feeds. Maturity is reached at 10-15 years of age followed by a reproductive period of over 75 years during which about 200 million larvae can be produced. In early summer each year, around June or July the males release sperm into the water, where they are inhaled by female mussels. Inside the female, the fertilised eggs develop in a pouch on the gills for several weeks, until temperature or some other environmental cue triggers the female to release the larvae into the surrounding water.

2.2. Clun population

The first systematic survey of freshwater pearl mussel populations in the River Clun was undertaken in 1995. Surveys have subsequently been undertaken in 2000–01, 2005, 2007–08 and 2013 and are reviewed in Appendix C.

Figure 2.1 overleaf compares the results of different surveys from 1995 to the present. Overall, there has been a 60% decline in the catchment population of freshwater pearl mussel, from an estimated 4,000–5,000 individuals in 1995 to 1,000-1,500 individuals in 2013. Most of the mussels are in extremely poor condition, very few are well buried (indicative of stress), and most are covered in mud and diatom growths (Figure 2.2) (Killeen, 2013). Recent surveys also indicate a potential increase in the rate of decline (Figure 2.2).

The integrity of the River Clun SAC is not being maintained. The youngest mussels are estimated to be 50 years old suggesting that the last mussels that recruited to the Clun population were glochidia in the 1960s. Population decline has been variously linked to the drive to increase land production after the Second World War (Natural England, Pers. Comm.), changes to silt management in the river or historic pearl fishing (NFU, Pers. Comm.).

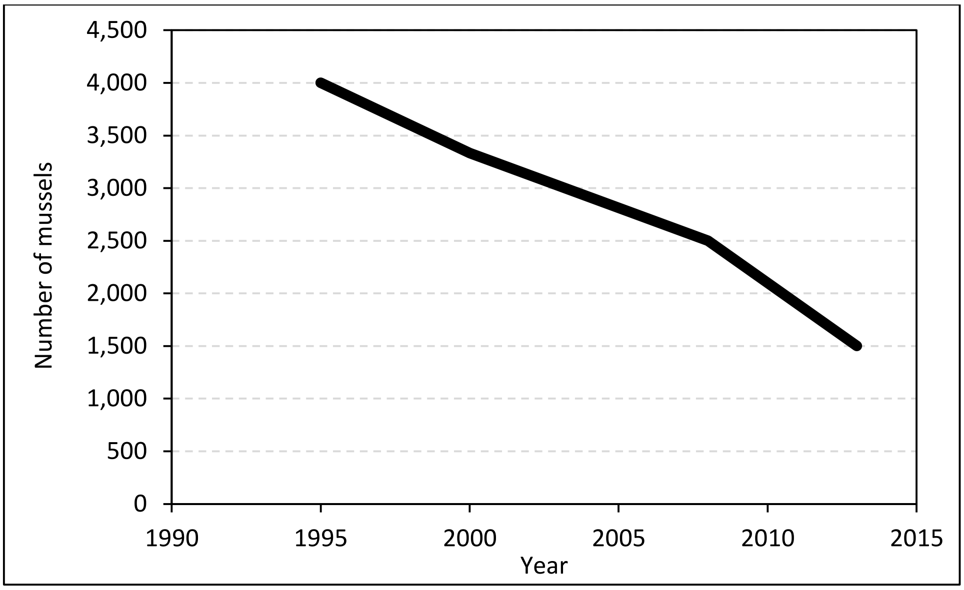


Figure 2-1 Estimated population of freshwater pearl mussel in the River Clun SAC 1995 to 2013.

NB a survey was undertaken in 2005 but did not provide a whole SAC population figure

Figure 2-2 Freshwater pearl mussel photographed in 2013

2.3. Reasons for unfavourable condition

Natural England's most recent condition assessment for the River Clun SAC has determined the designated area is currently in "unfavourable declining" condition due to:

- The continuing decline in the pearl mussel population;
- Poor condition of remaining mussels and evidence of continued stress;
- Lack of juvenile recruitment and failure to produce new generations of mussels;
- Continuing decline in the physical habitat structure; and
- Poor water quality from point and diffuse sources (high nutrient levels, suspended solids).

All of the above information provided by Natural England (Pers.Comm.).

River Restoration Strategies (Atkins, 2012 and Jacobs, 2013) provide a comprehensive overview of the reasons for unfavourable condition and identify the following main issues:

- Excessive silt loads, fine sediments and siltation of riverbed;
- Impacts of alder disease (*Phytophthora*) and accelerated bank erosion;
- Lack of / loss of riparian habitat and tree cover;
- Intensification and diversification of land management practices;
- Point and diffuse sources of pollution leading to declines in water quality and nutrient enrichment;
- Spread of non-native species (e.g. Himalayan balsam); and
- Limited connectivity with the floodplain and reduced longitudinal connectivity.

2.4. Potential impact pathways

The main impact pathways between nutrients, sediment and freshwater pearl mussel are thought to be as follows:

1 Excess siltation of riverbeds within the gaps between gravel stones leads to a **reduction in the oxygen available to juvenile mussels**. All sites measured in the Clun have a loss of over 50% of redox potential at a depth of 5cm within the gravels indicating that the substrate was severely silted.
2 **Direct ingestion** of silt and algae by adult mussels can lead to rapid death.
3 In addition, if mussels clam-up as a response to a siltation episode they may die from **oxygen starvation** if the sedimentation event extends over a period of days.
4 Changes in nutrients can lead to **increased algal growth**, leading to production of organic silt.
5 Washout during high flows has been previously identified as an issue, with shell remains being found downstream of habitat in the Clun catchment after large floods. This risk may be exacerbated if mussels are under stress as they will typically not burrow so deeply.

2.5. Favourable Condition Targets

The Conservation Objectives set by Natural England for the River Clun SAC include Favourable Condition Targets (FCTs) for in-river phosphorus (P), nitrogen (N) and sediment (suspended solids) concentrations. The targets have been set to protect freshwater pearl mussel from the adverse effects of nutrient enrichment and siltation. Above these targets there is a significant risk that undesirable changes will occur with associated negative effects on the interest features of the SAC.

The targets have been developed based on international, peer-reviewed studies of the habitat and water quality requirements of freshwater pearl mussel and observations and measurements by national experts. For the River Clun SAC, the targets are as follows:

- In the **short term, a target of <0.02 mg/l soluble reactive phosphorus (SRP)**. This corresponds to the concentration considered adequate for maintaining adult freshwater pearl mussels;
- In the **long term, a target of <0.01 mg/l** SRP corresponding to the concentration required for juvenile freshwater pearl mussel recruitment.
- **Suspended solids concentrations <10 mg/l.**
- A target of <**1.5mg/l for Total Oxidised Nitrogen (TON)** is also currently being appended to existing favourable condition targets for freshwater pearl mussels in the River Clun SAC.

Favourable condition targets for freshwater pearl mussel are currently draft and are awaiting update based on the latest Commons Standards Guidance for Rivers. All targets are annual averages. Where possible, compliance to the targets should be assessed using 12 monthly samples taken over a period of 3 consecutive years. It is important to note that specific monitoring to these standards needs to be requested and funded. Statutory monitoring is only four times a year. The targets are very low, and in the case of phosphate are beyond the historic detection levels used in operational practice. Any monitoring to assess compliance to these targets therefore needs to be separate from WFD monitoring in the long term.

In addition, the targets do not take account of extreme weather related incidents, event-based impacts or the seasonal aspects of some of the impact pathways. For example, a single peak in suspended solids may smother a freshwater pearl mussel population. Phosphorus and nitrogen are not thought to be toxic to freshwater pearl mussels but drive algal productivity, a primarily spring-summer process.

3. Catchment Character

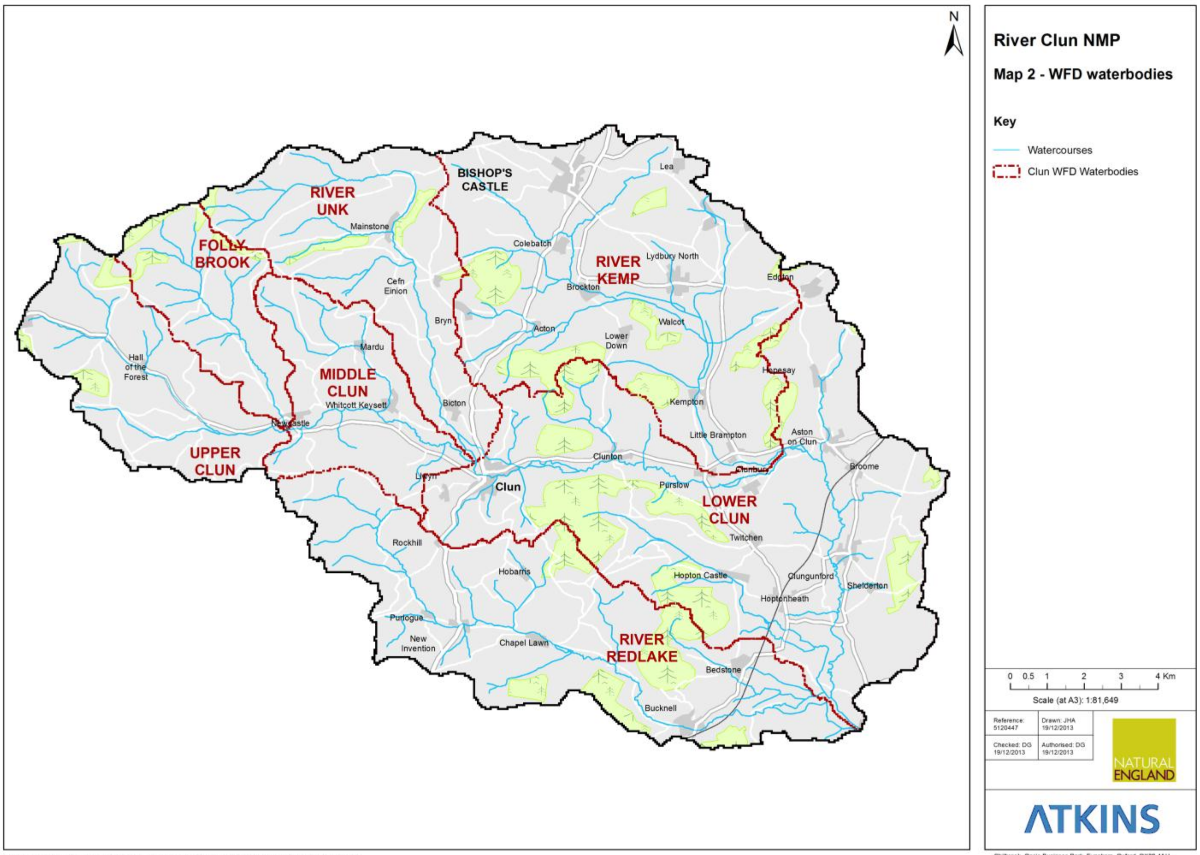
The characteristics of the catchment can play an important role in determining the water quality status of a river. In this section, an overview of the catchment of the River Clun is provided as a context for understanding some of the observed water quality variations described in Section 4 of this document.

3.1. Catchment, Landscape and topography

The catchment of the River Clun is 27.226km^2 in extent. For the purposes of WFD planning purposes, the Environment Agency has further subdivided the catchment into the seven water bodies listed in Table 3.1 below. The extent of each water body is shown in Map 2 below.

Table 3-1 Environment Agency WFD water bodies of the Clun catchment

Name	WFD ID		Area (ha)
Upper Clun	GB109054044000	R Clun - source to conf Folly Brook	2,333
Folly Brook	GB109054044020	Folly Bk - source to conf R Clun	1,451
River Unk	GB109054044040	R Unk - source to conf R Clun	2,945
Middle Clun	GB109054043980	R Clun - conf Folly Brook to conf R Unk	1,907
River Kemp	GB109054044060	R Kemp - source to conf R Clun	6,051
River Redlake	GB109054043950	R Redlake - source to conf R Clun	4,938
Lower Clun	GB109054043990	R Clun - conf R Unk to conf R Teme	7,601
		TOTAL	**27,226**



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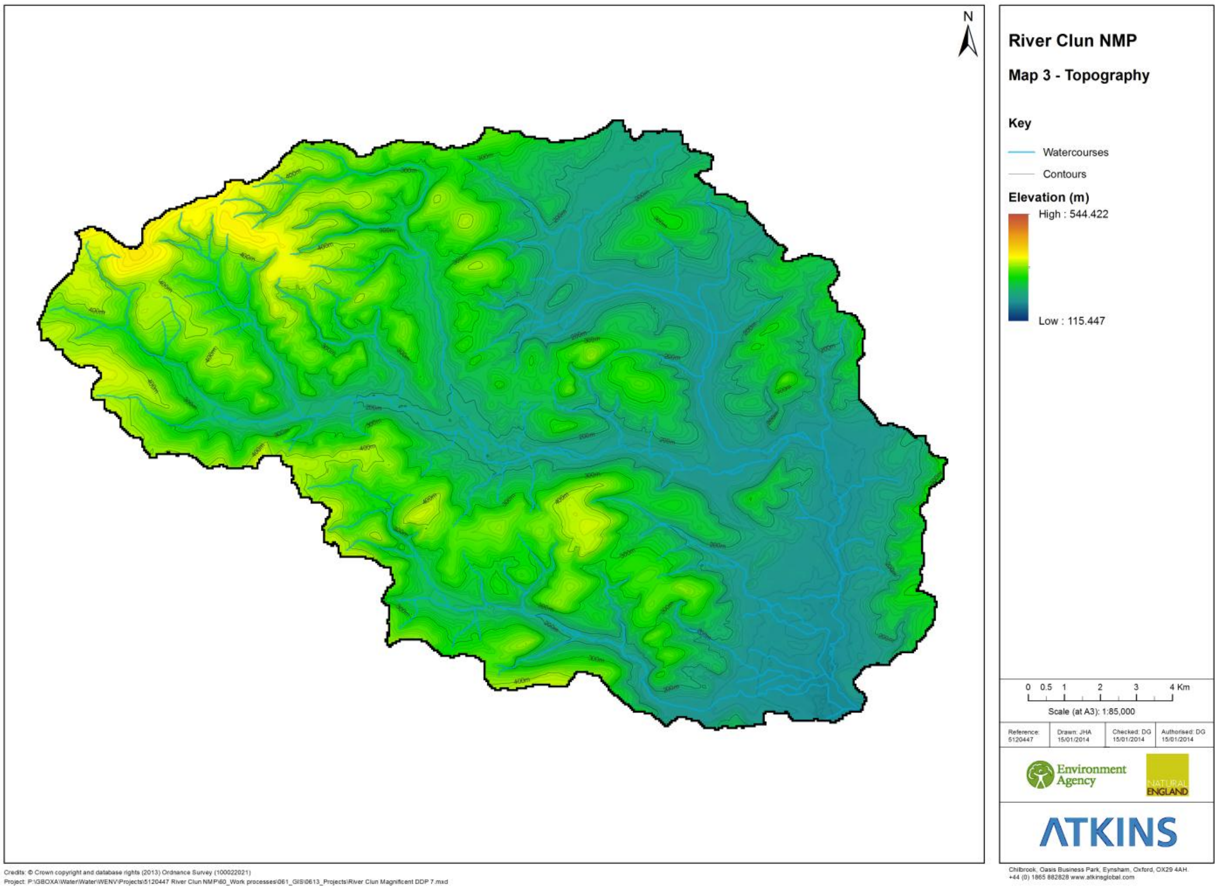
The landscape of the Clun catchment changes as the river flows from the hills in the west and north to lower areas in the south and east. The Upper Clun supports an open upland moorland landscape, with shallow-V valley forms that occasionally incise and fall steeply where bedrock outcrops are close to the ground surface. Most of the land to the west can be considered upland with areas of very steep slopes with gradients greater than 7 degrees, the slope of land most at risk in terms of runoff generation and erosion risk (Defra, 2005; Boardman *et al.*, 2008). The Lower Clun lies within a much wider, lowland valley floor. Map 3 overleaf shows the topography of the Clun catchment. Map 4 shows how slope varies across the catchment.



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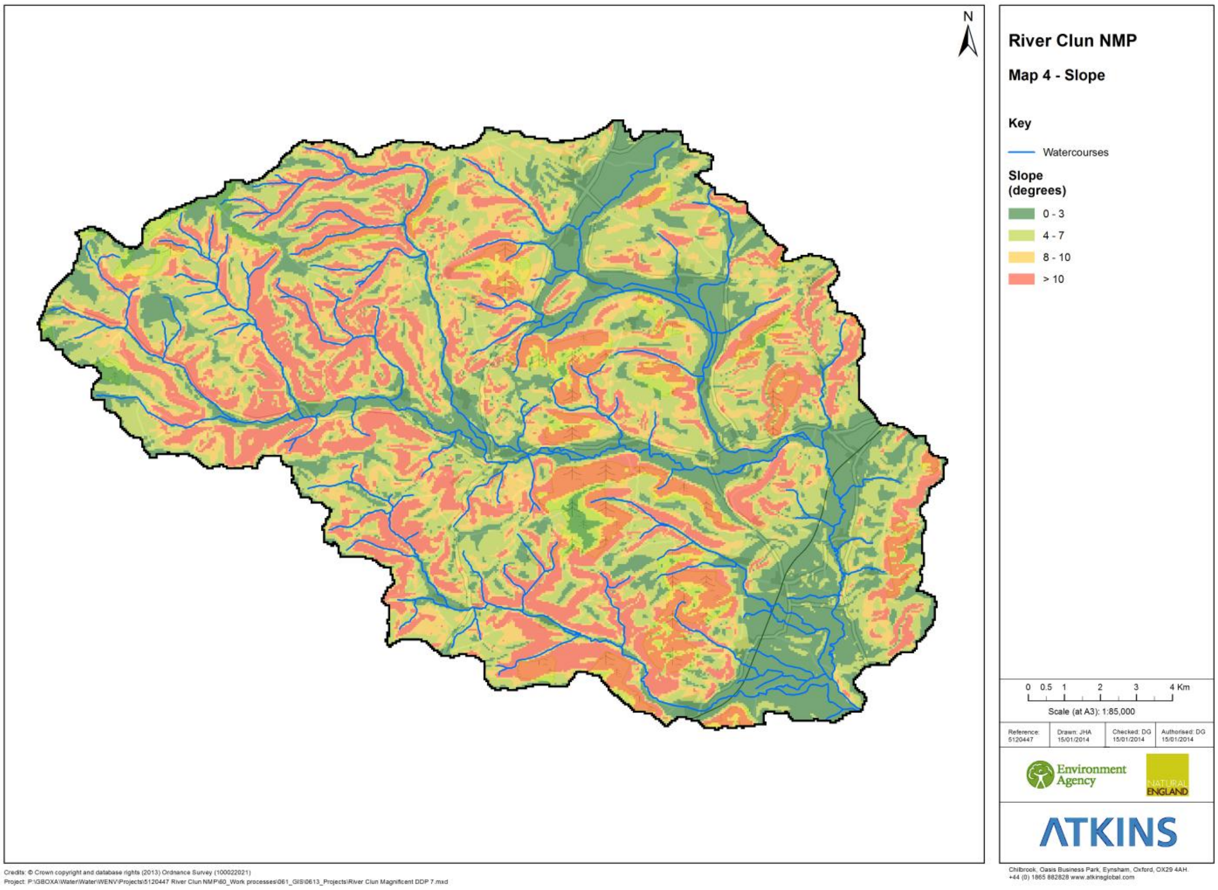

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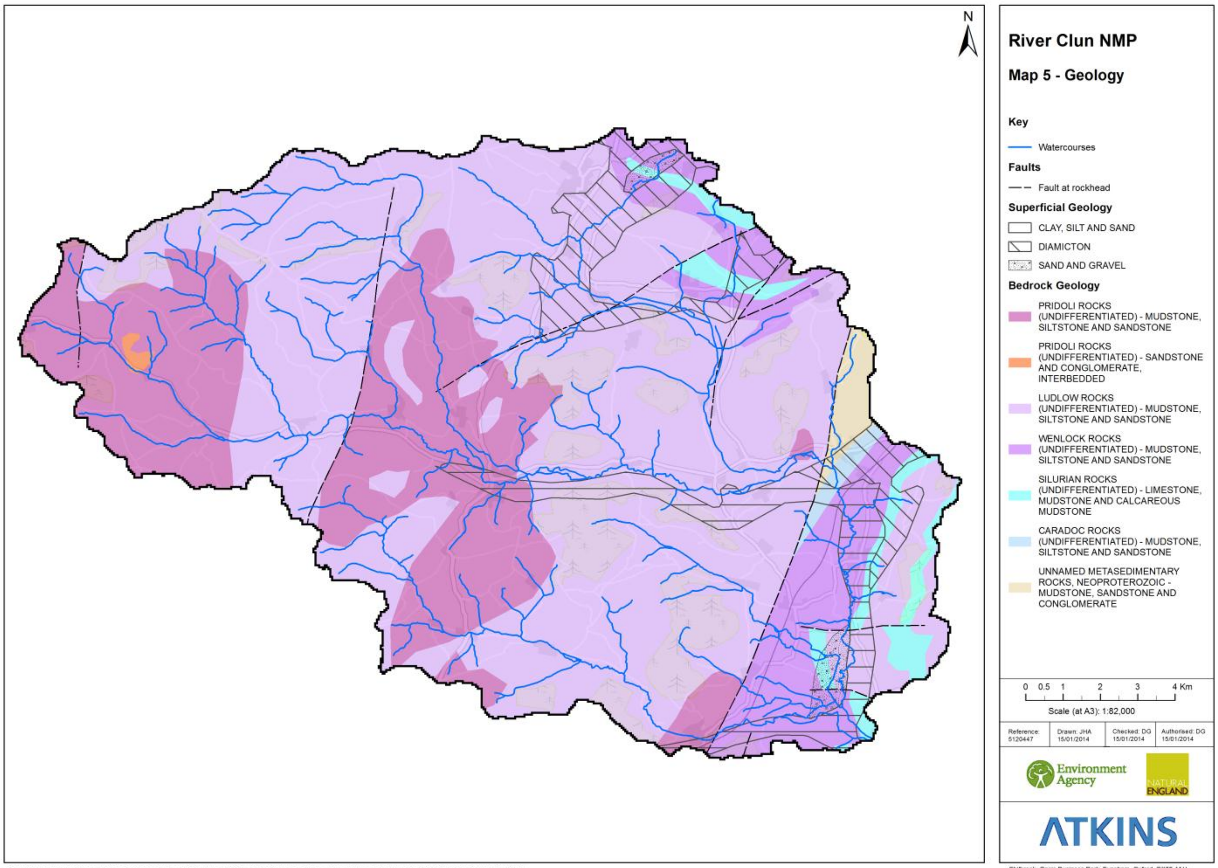
Project: P:\GBOXA\Water\Water\WENV\Projects\5120447 River Clun NMP\60_Work processes\061_GIS\0613_Projects\River Clun Magnificent DDP 7.mxd

3.2. Geology

Map 5 below shows the geology of Clun catchment based on open source 625k solid geology mapping data available from the British Geological Survey (BGS). The Clun catchment is underlain with Silurian mudstones, siltstones and sandstones. These relatively easily erodible rock formations tend to break down into small (cobble, gravel, fines) components.

Filling the valley floor within the catchment are sediments that are glacial in origin. These include unsorted drift, as well as partially sorted gravel and sand deposits (Map 5). Terraces associated with sequential cutting and reworking of these deposits through the Holocene are common and often pronounced valley floor features, particularly in the middle and lower catchment.



3.3. Soils

Soil types across the Clun catchment are shown in Map 6 below. Table 3-2 overleaf provides a detailed review of the main characteristics of Clun catchment soils according to the Soil Survey of England and Wales (Ragg *et al.*, 1984). The dominant soils are mostly free draining silt or loam soils. The only clay soils are those of the Conway Association that are found in the floodplain of the rivers and streams. Wet acid and peat soils are also present in the catchment headwaters.

The dominant soils in the Clun catchment are naturally susceptible to erosion. The large silt and fine sand content leads to capping during heavy rain and runoff then causes erosion on slopes (Ragg *et al,* 1984). Indeed, soils covering close to 60% of the Clun catchment are at risk from erosion (see Table 3-2).

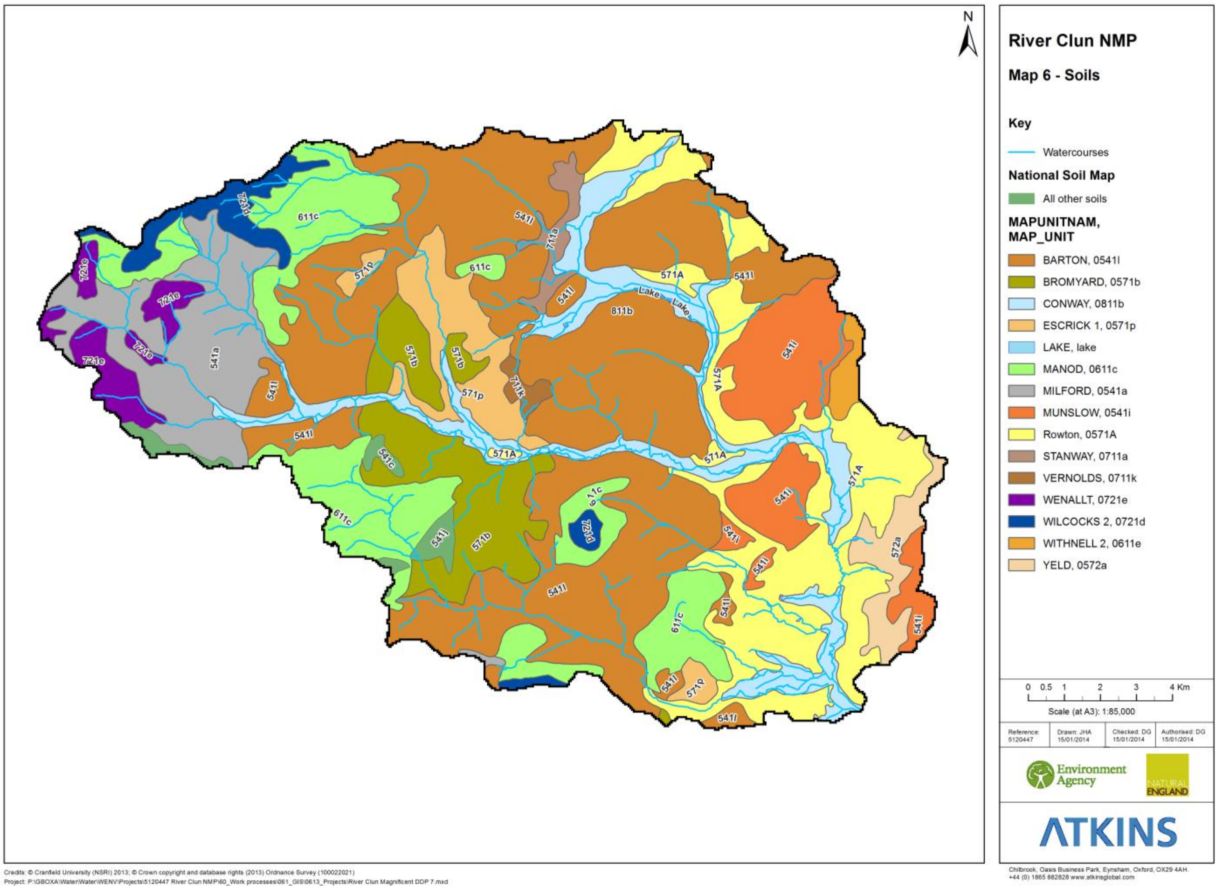


Table 3-2 Soil types in the Clun catchment. Summarised from Ragg *et al.* (1984).

Soil type		Catchment %	Location	Description	Land use	Erosion risk
541l	Barton series	35	Throughout the catchment.	Brown well-drained, silty soils. Surplus winter rainfall passes downwards through these permeable soils.	The soil is suited to livestock rearing but can also be cultivated in areas where the soil is deep or soils are gentle.	Large silt and fine sand content leads to capping during heavy rain and runoff then causes erosion on slopes. Risks greatest in spring before the crop cover is established and during summer storms which follow dry spells.
571A	Rowton Association	13	Valley sides in the Lower Clun between Clungunford and Leintwardine.	Well drained, silty soils usually overlying till at less than 1m in depth	Particularly suited to cereal farming.	Large silt content makes these soils susceptible to capping on recently ploughed or sparsely vegetated fields with the risk of subsequent erosion on sloping land.
611c	Manod	12	Southwest of Clun.	Fine clay loam soils	Free draining soils, permeable and well-drained.	Not applicable
811b	Conway Association	8	Floodplains of rivers and streams and valley bottoms	Silty alluvial gley soils that are seasonally waterlogged. May be under-drained.	Soil is seasonally wet so mainly permanent or rough grazing	Not applicable
571b	Bromyard Association	7	Core of the catchment extending from Clun to Whitcott Keysett, Bicton, New Invention and Cefn Linion.	Well-drained fine silty soils	Suitable for wheat and cattle/sheep rearing. Can be worked up until November.	Large silt and fine sand content means these soils are particularly susceptible to capping and subsequent erosion when recently ploughed. Risks are greatest in autumn or winter when ground is saturated.
0541i	Munslow series	7	Mainly in the highest areas to the east of the river in the Lower Clun and Kemp sub-catchments	Coarse, silty brown earths	Soil is well drained and suitable for arable with permanent grass on the steeper slopes	High silt and fine sand content makes them susceptible to capping and subsequent erosion. Risks are greatest during heavy summer storms after a dry spell by both sheet and gully erosion
541a	Milford	7	Mainly in the catchments of Folly Brook and the Upper Clun.	Well-drained, fine loamy brown earths.	Mainly under permanent or improved grassland. Where arable crops are grown, these are almost entirely for forage.	Not applicable
571p	Escrick 1	4		Deep, agriculturally valuable soils.	Mixed farming with cereals the most important crop.	Recently ploughed or sparsely vegetated fields are susceptible to rill/gully erosion.
572a	Yeld Association	2	Thin band to the east of the B4367 between Craven Arms and Leintwardine. Confined to slopes < 8 degrees	Fine silty soils	Cereals can be grown locally on gentle slopes.	Smearing and compaction may result from mistimed operations; the soil surface caps readily and on moderate slopes erosion often occurs during heavy rain.
721e	Wennalt Association	2	In the highest parts of the catchment, on the interfluves of the upper Clun and Folly Brook.	Acid, wet peaty soils ,	Lying over thick till with impermeable subsoils that hold up surface water, these soils are wet for most of the year and winter runoff is very rapid.	Not applicable
0721d	Wilcocks 2	2	Limited extent on the top of hills	Wet loamy peaty soils	Mainly under permanent or improved grassland. *Molinia* bog where natural	Not applicable
Other		1	-	-	-	-

3.4. Climate

There are a number of rain gauges in and around the Clun catchment (Map 7). Average annual rainfall increases along an east to west axis from 775 mm in the lower catchment to 1125 mm in the upper catchment (Atkins, 2013). Annual evapotranspiration is in the order of 450mm.

3.5. River flow

3.5.1. Headwaters

Previous studies commissioned by Natural England (Atkins, 2013) have identified that groundwater may be a source of water in headwaters of the River Clun. A number of springs are mapped on the OS maps along the river valley of the upper Clun, mainly on steep slopes and linked to patches of drift deposits or thick sandstones within the Clun Forest Formation. As these more permeable layers are generally of limited extent and often hydraulically isolated, it is likely that they are fed by a relatively small recharge area and the springs are likely to be of local significance and ephemeral in nature although this cannot currently be fully verified. Indeed, anecdotal information indicates that the channel at Upper Dyffryn dries up occasionally during the summer months and that during extreme drought period (e.g. 1976), the Clun as far downstream as Newcastle-on-Clun dries out.

3.5.2. Catchment

Although there is no formal gauging station on the River Clun, the Environment Agency has maintained a continuous water level logger at Leintwardine since the end of 2003. This monitoring location is downstream of the confluence between the Clun and the Upper Teme and is part of the Environment Agency flood risk management network (see http://apps.environment-agency.gov.uk/river-and-sea-levels/120747.aspx?stationId=2057). Regular spot flow measurements have also been taken at this location. As part of the NMP evidence base development, these data have been used to derive a synthetic flow time series for the Clun catchment. The data used are set out in Appendix D.

Figure 3-1 overleaf provides a summary of the flow data for the Clun catchment. Flow maxima are typically between November and February when the mean daily flow exceeds 5 cumecs compared to monthly flow minima in August and September when mean daily flows are on average less than 2 cumecs. The catchment is relatively flashy and may be susceptible to dry conditions. Figure 3-1a shows that summer flows can decline to very low levels during dry summers such as 2011. Comparison between total annual flows 2004-2012 (Figure 3-1c) show that total annual flows in the River Clun at Leintwardine vary from year to year. In years such as 2011, flows are half those in wetter years. Other dry years were 2005 and 2010. High flow years were 2007, 2008 and 2012 (Figure 3-1c).

Table 3.3 below provides a summary of mean monthly flows and annual flow statistics. Annual flow statistics based on measured spot flows and levels and the approach set out in Appendix D approximate those estimated by LowFlows Enterprise system (an industry-standard approach for estimating flows in ungauged catchments) especially at low flows.

Table 3-3 (a) Mean daily flow by month (cumecs) and (b) annual flow statistics in the River Clun SAC at Leintwardine. Table (b) compares local estimates from measured levels and spot flows (see Appendix D) and data provided by LowFlows Enterprise.

(a) Mean daily flow by month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7.89	5.07	4.27	3.41	2.55	2.07	3.01	1.81	1.90	3.56	6.35	6.10

(b) Annual flow statistics

Method	Mean daily flow (cumecs)	Q95 flow (cumecs)
Measured	3.94	0.44
Low Flows Enterprise	3.44	0.41

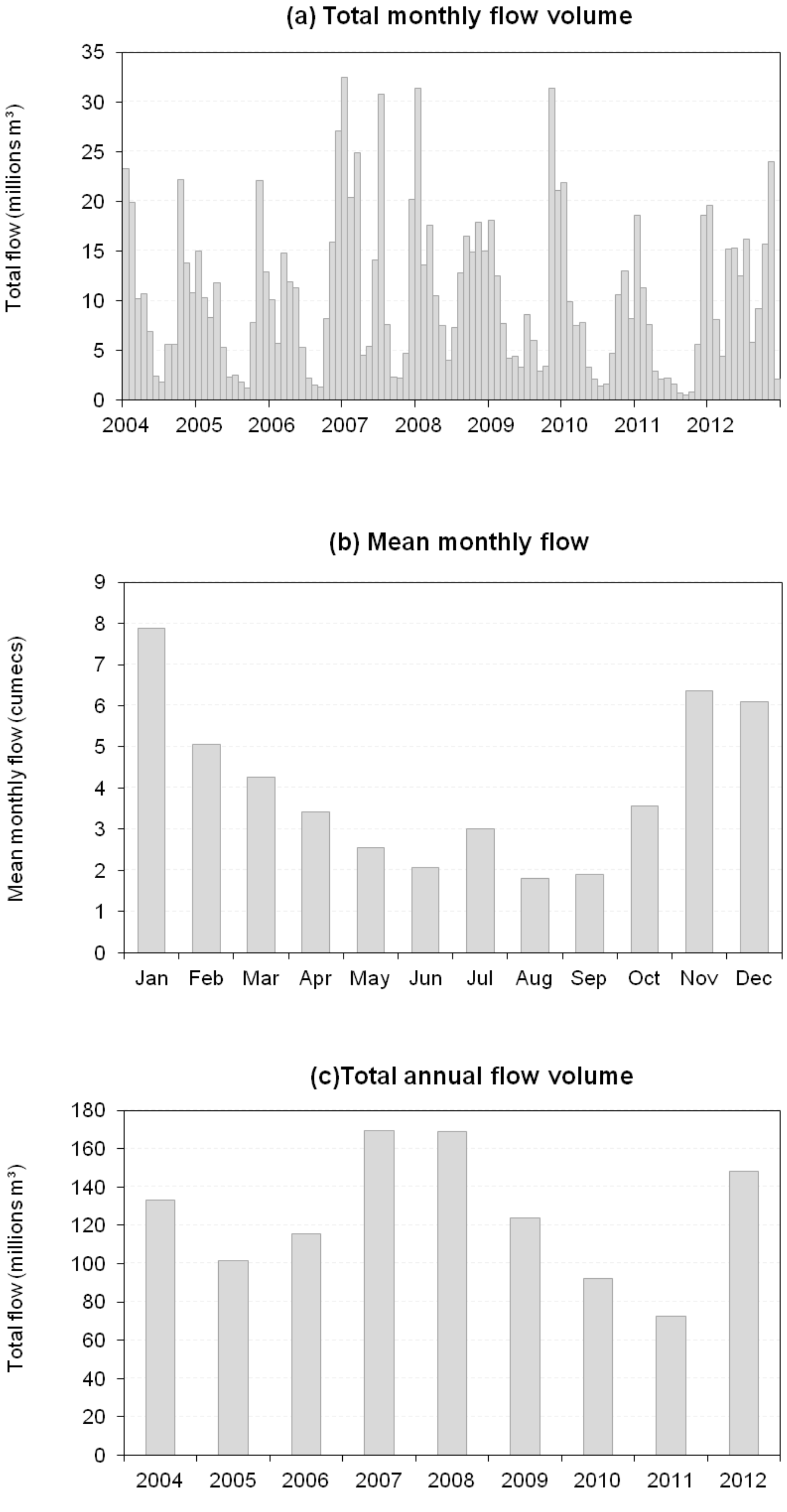
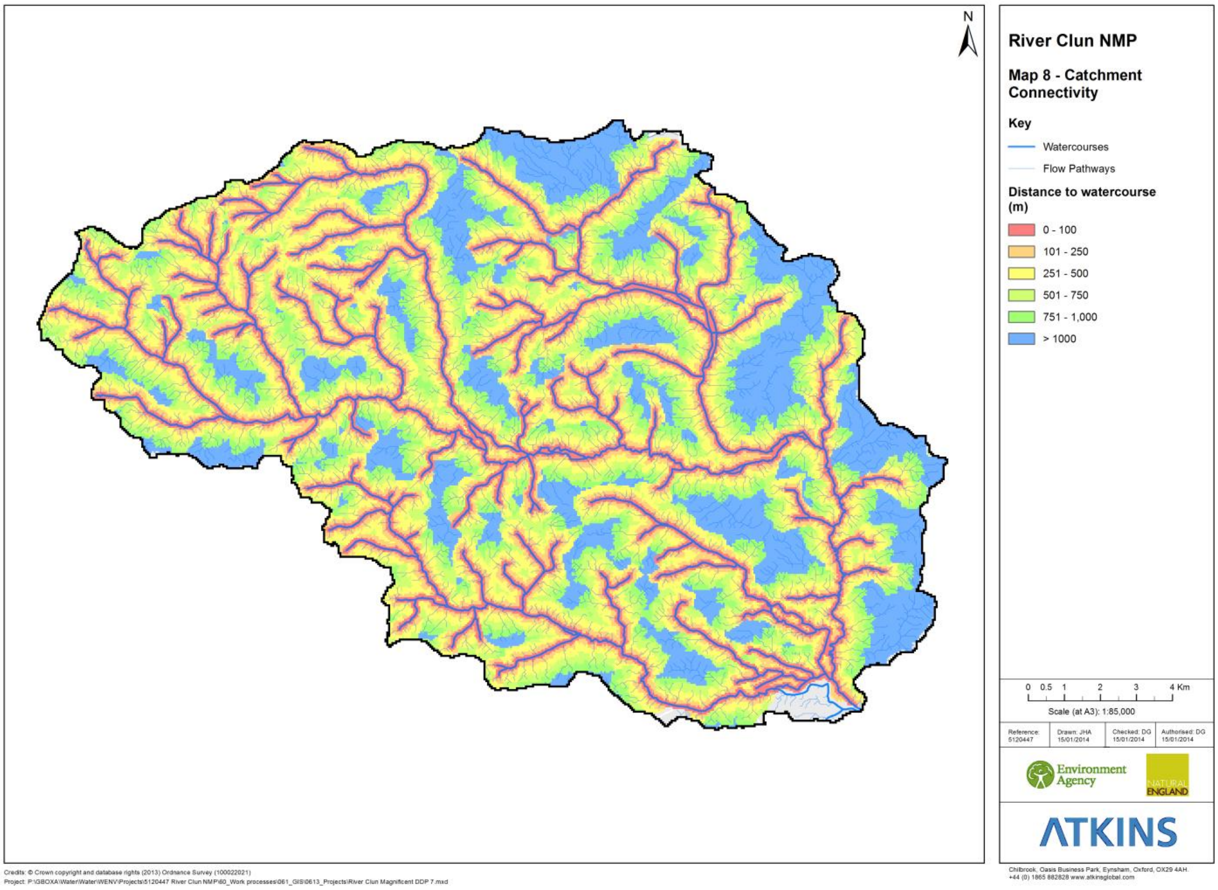


Figure 3-1 Summary of flow data for the River Clun catchment. The data have been synthetically derived through the development of a stage-discharge relationship described in Appendix D.

3.5.3. Connectivity

The Clun catchment is highly connected and a limited amount of land in the catchment is more than 1km from running water (Howells, 2011). In addition, the nature of the landscape, with its steep slopes, incised valleys, freely draining and transmissive soils provide a number of flow pathways into which the river system can expand during wet periods. Map 8 below shows a catchment connectivity map for the Clun. The map shows the distances between the main watercourses and different parts of the Clun catchment. Additional flow pathways in the Clun catchment mapped from topographic data are also shown and represent the areas into which the catchment watercourses are likely to expand during wet periods (termed the catchment contributory area).



3.6. Land cover

Local land management officers (e.g. AONB, Environment Agency) recognise a general intensification in land use and extension of the field and ditch drainage networks across the catchment in the post war period and associate these changes with an increase in the frequency of extreme (high and low) flow events. Although it is not currently possible to consider land cover in the pre-war period, a number of data sets do allow an assessment of current and recent historic land cover in the Clun catchment. Four main data sources are available and are reviewed in Table 3.4 below.

Table 3-4 Description of data sets describing land use and land cover in the Clun catchment

Data type	Description	Data availability	Limitations
Defra	Catchment and in some cases sub-catchment scale land use information	Summaries of the 2000 and 2010 agricultural census can be requested direct from Defra. Information includes the extent different crop and grasslands types and livestock numbers	2000 and 2010 statistics data are not comparable. The way the census data are reported has changed in the intervening period. There have been large reductions in the numbers of holdings reporting data (Defra only report on commercial holdings and exclude non-commercial holdings that are now excluded) and a much smaller reduction in the values themselves (e.g. the total area of crop items or the total number of certain types of livestock). The reduction they show when compared is not reflective of all changes in agricultural activity.
National land cover maps	Broadly decadal survey of land cover across England and Wales using satellite imagery.	GIS data layers for 1990, 2000 and 2006 can be downloaded from www.data.gov.uk	The way in which arable land is described as part of the different national land cover maps varies. All data generated by LANDSAT satellites but there have been changes in the sensors used since 1990 and specific descriptions of different land use types vary.
CLAD	Data set listing CPH numbers (unique ID for each land parcel) and land use description	Rural Payments Agency CLAD dataset is available for 2010 only.	Broad definitions of land use only. License constrained: only available for use by Environment Agency and Natural England staff without a special licence
Aerial photographs	Recent coverage for the whole of the UK	Recent aerial photographs can be viewed on Google Earth (with a suitable license), or requested via Natural England and the Environment Agency.	Environment Agency and Natural England aerial photography - License constrained and only available for use by Environment Agency and Natural England staff without a special licence. Google Earth imagery – special licence required to use data in reports and data cannot be digitised or manipulated.

3.6.1. Defra data

3.6.1.1. Catchment-scale

Table 3.5 shows the extent of different land cover types in the Clun catchment according to Defra agricultural census data for the years 2000 and 2010. Figure 3-2a summarises these data graphically. The catchment is primarily pasture over 5 years old with smaller areas of temporary grass and rough grazing. Approximately 20% of the farmed area within the catchment is under arable cropping (Figure 3-2a). Over two thirds of arable land in the catchment is under wheat and barley with the remainder cropped to oats and oil seed rape (Figure 3-2b).

Table 3-5 Defra land use data 2010

Crop type (ha)	Area (hectares)
Wheat	1,366
Barley	1,396
Oats & rye	617
Maize	80
Field bean and peas for harvesting dry	#
Potatoes	52
Oilseed rape	456
Sugar beet	0
Crops for stock feeding	129
Land use (ha)	**Area (hectares)**
Temporary grass (sown in last 5 years)	1,795
Permanent pasture (over 5 years old)	13,461
Sole right rough grazing	250
Woodland	557
Livestock type	**Number of livestock**
Cattle	13,914
Pigs	159
Sheep	119,282
Fowl(b)	287,784

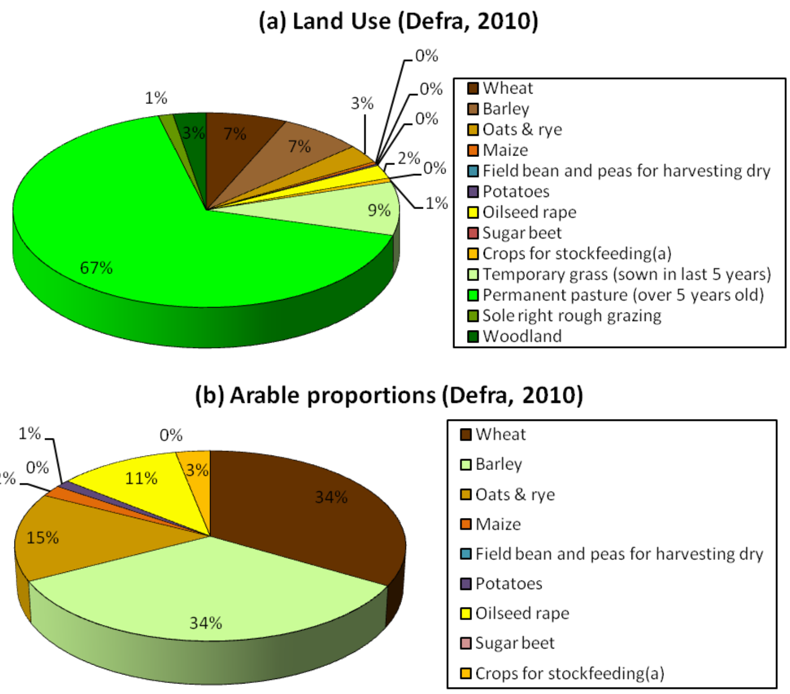


Figure 3-2 Defra land use 2010

3.6.1.2. Sub-catchment scale

Table 3.6 shows agricultural census data for the Clun sub-catchments according to the Defra agricultural census data for 2010. Figure 3-3 plot the data graphically to show how different agricultural activities vary across the catchment. In summary:

- Of all the Clun sub-catchments, the Kemp has the highest proportion of arable land cover; close to 25% of the total sub-catchment area is arable land. Approximately 15% of the Lower Clun sub-catchment is arable land and 10% of the Unk sub-catchment. Arable land is limited in remaining sub-catchments.
- The highest density of cattle is in the Middle Clun sub-catchment, with densities close to twice that anywhere else in the catchment.
- The highest density of sheep is in the Folly Brook and Middle Clun sub-catchments followed by the Upper Clun and Unk. In general, sheep density in the Lower Clun, Redlake and Kemp sub-catchments is half that in the upper sub-catchments.
- Fowl and poultry in the catchment are concentrated in the River Kemp and Lower Clun sub-catchments. There is also a large unit currently being constructed in the River Unk that will not be reflected in the figures below.

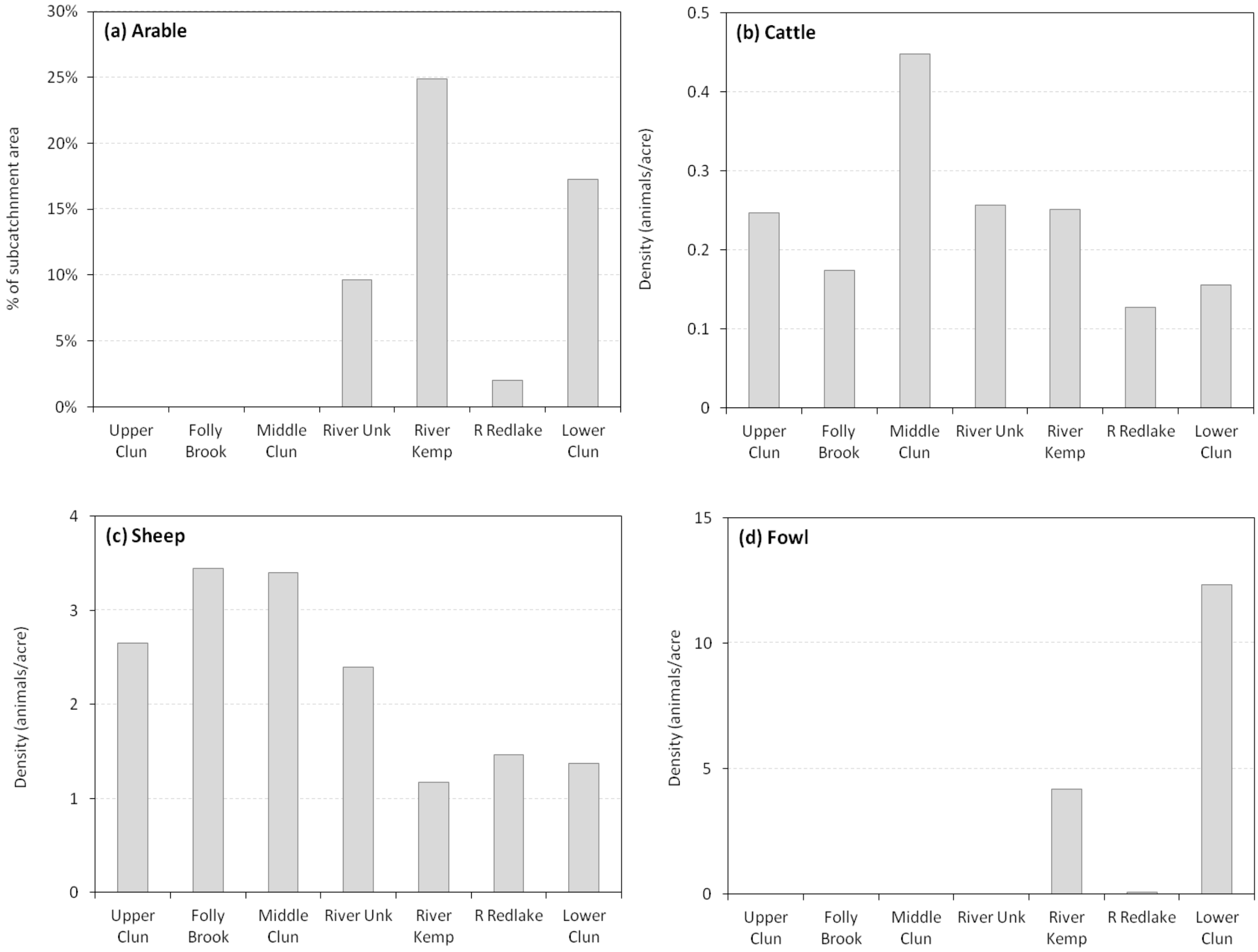


Figure 3-3 Sub-catchment data

Table 3-6 Defra 2010 agricultural census summaries for sub-catchments of the River Clun. Source of data: Defra.

WFD Water body ID		R Clun - source to conf Folly Bk GB109054044000	Folly Bk - source to conf R Clun GB109054044020	R Clun - conf Folly Bk to conf R Unk GB109054043980	R Unk - source to conf R Clun GB109054044040	R Kemp - source to conf R Clun GB109054044060	R Redlake - source to conf R Clun GB109054043950	R Clun - conf R Unk to conf R Teme GB109054043990	TOTALS
Name		**Upper Clun**	**Folly Brook**	**Middle Clun**	**River Unk**	**River Kemp**	**R Redlake**	**Lower Clun**	
Extent (ha)		**2,333**	**1,451**	**1,907**	**2,945**	**6,051**	**4,938**	**7,601**	**27,226**
Crop type	Wheat	0	0	#	98	636	#	445	**1,366**
	Barley	#	#	#	185	537	98	457	**1,396**
	Oats & rye	#	#	#	#	280	#	202	**617**
	Maize	0	0	0	0	#	0	#	**80**
	Field bean and peas	0	0	0	#	0	#	#	**#**
	Potatoes	#	0	0	0	#	0	#	**52**
	Oilseed rape	0	0	0	#	#	#	187	**456**
	Sugar beet	0	0	0	0	0	0	0	**0**
	Crops for stockfeeding	#	#	#	#	53	#	23	**129**
Land Use	Temporary grass (< 5 years old)	190	#	229	236	596	#	384	**1795**
	Permanent pasture (> 5 years old)	1 584	1 016	1 806	2 022	2 143	1 958	2 933	**13,461**
	Rough grazing	#	0	#	#	#	82	53	**250**
	Woodland	68	8	19	83	106	49	224	**557**
Livestock type	Cattle	1 390	610	2 058	1 823	3 668	1 517	2 847	**13,914**
	Pigs	#	0	#	#	#	#	#	**159**
	Sheep	14 901	12 053	15 615	17 030	17 115	17 387	25 181	**119,282**
	Fowl[(b)]	#	#	#	#	60 862	997	225 815	**287,784**

 # indicates data are available but have been suppressed to preserve the anonymity of the landholding. A value of 0 indicates that no crops of livestock are present in the sub-catchment

3.6.2. National land cover maps

Map 9 shows land cover in the Clun catchment based on the most recent national land cover map (in 2006). Agriculture is the main land use in the catchment and only a small proportion of the catchment is urban.

The catchment is dominated by grassland to the west, especially in the west. Moving east and southwards, there is a shift in agriculture towards arable or mixed farming. Arable farming currently accounts for 20% of the total catchment area. Land within the Clun catchment is predominantly classified as Grade 3, 4 and 5 (Map 10), with some valley areas classified as Grade 2.

3.6.3. Aerial photographs

Comparison between national land cover maps for 2006 and aerial photographs for 2012 (Map 9) show that the area of arable land increased by 1,232 ha between 2006 and 2012 and that the total area of arable land is currently in the order of 7,000ha.

3.7. Farm types

The favourable climate and land quality mean that the Clun catchment is suited to a wide range of farming activities.

Table 3-7 shows the breakdown of different farm types in the catchment as provided by Defra. There are approximately 200 farm holdings within the River Clun catchment. Cattle and sheep within the Less Favoured Area (LFA) represent the largest section of the agricultural industry within the River Clun catchment, accounting for close to two thirds of all agricultural holdings in the catchment. Many of these units tend to be small in size and rely heavily on Common Agricultural Payments and agri-environment payments to support their income.

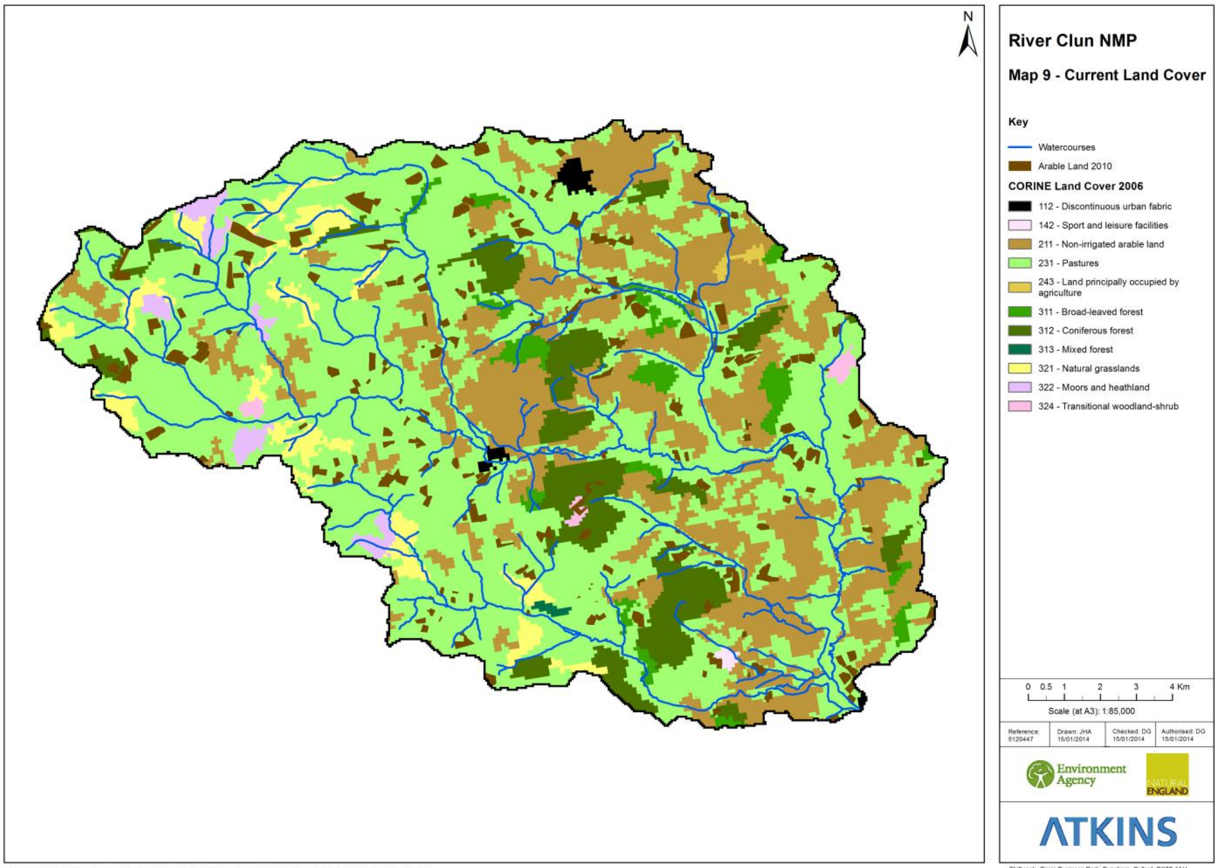
Table 3-7 Estimated numbers of farm holdings by robust farm type. Source of data: Defra.

Robust Farm type	No. of holdings	% of total
Cereals	6	3%
General cropping	8	4%
Mixed	19	9%
LFA Grazing livestock	126	62%
Lowland grazing Livestock	44	22%
Poultry*	3	1%
TOTAL	**203**	**100%**

3.8. Land management

Many initiatives focused on water quality improvement and agricultural advice is on-going within the Clun catchment. Local farmers have a long history of engagement with ESA, other agri-environment schemes, CSF and the AONB projects. Current mechanisms available to address water pollution in England are reviewed in Appendix F. The information has been compiled from information set out in the Best Farming Practices Guide (Environment Agency 2009) and the Defra, Natural England and Environment Agency websites.

Parts of the Clun catchment falls within the severely disadvantaged and disadvantaged Less Favourable area (LFA) designation (Map 10).



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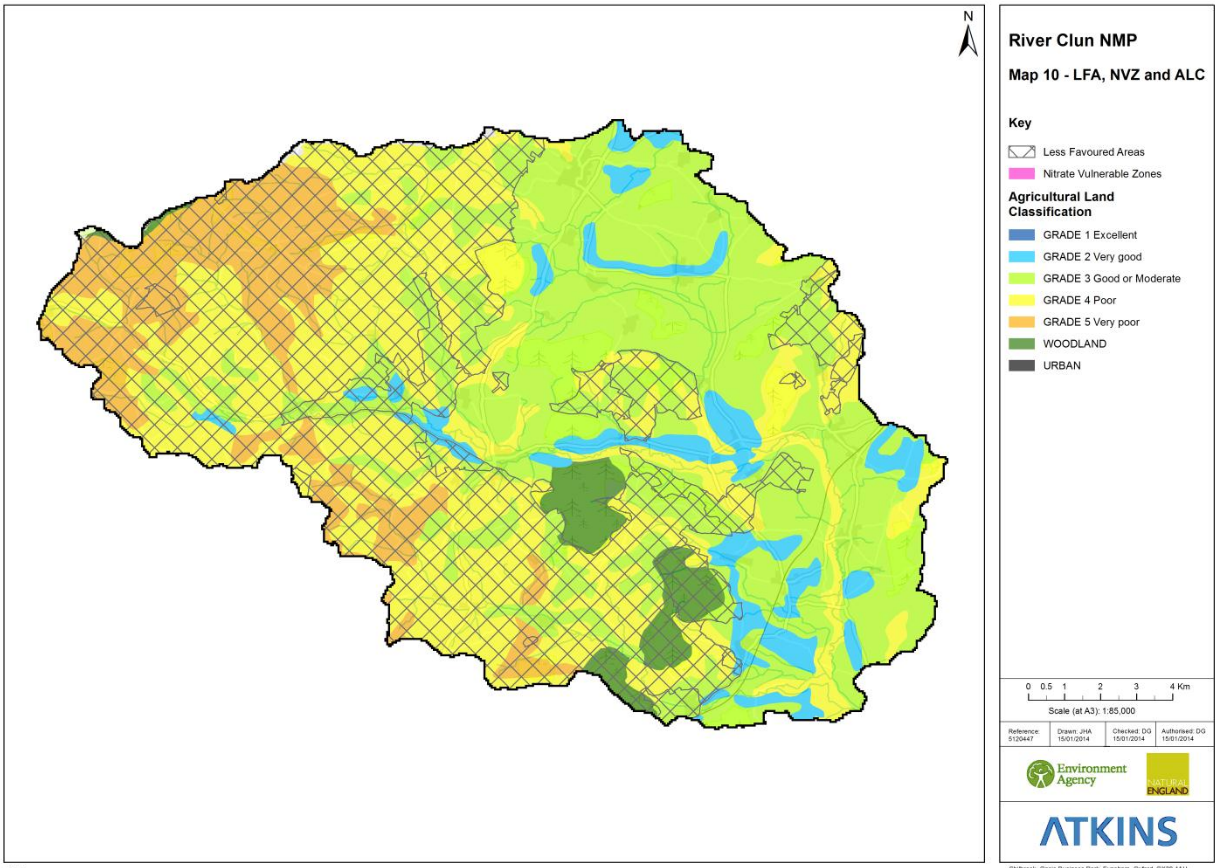

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3.8.1. ESA

The Clun catchment has been in an Environmentally Sensitive Area scheme for over 20 years. At the time of ESA designation 53% of the ESA was grassland, 23% was arable and 18% was dense scrub & woodland. By the end of 1995 grassland covered 59% of the ESA and less than 17% was arable land. The area of arable land has been reduced by 1,217 ha (a 25% reduction), while the area of permanent grassland has increased by 1,230 ha (an 11% increase). Most of the change from arable land to grassland has been brought about through the ESA scheme.

Map 11 shows the coverage of ESA in the Clun catchment.

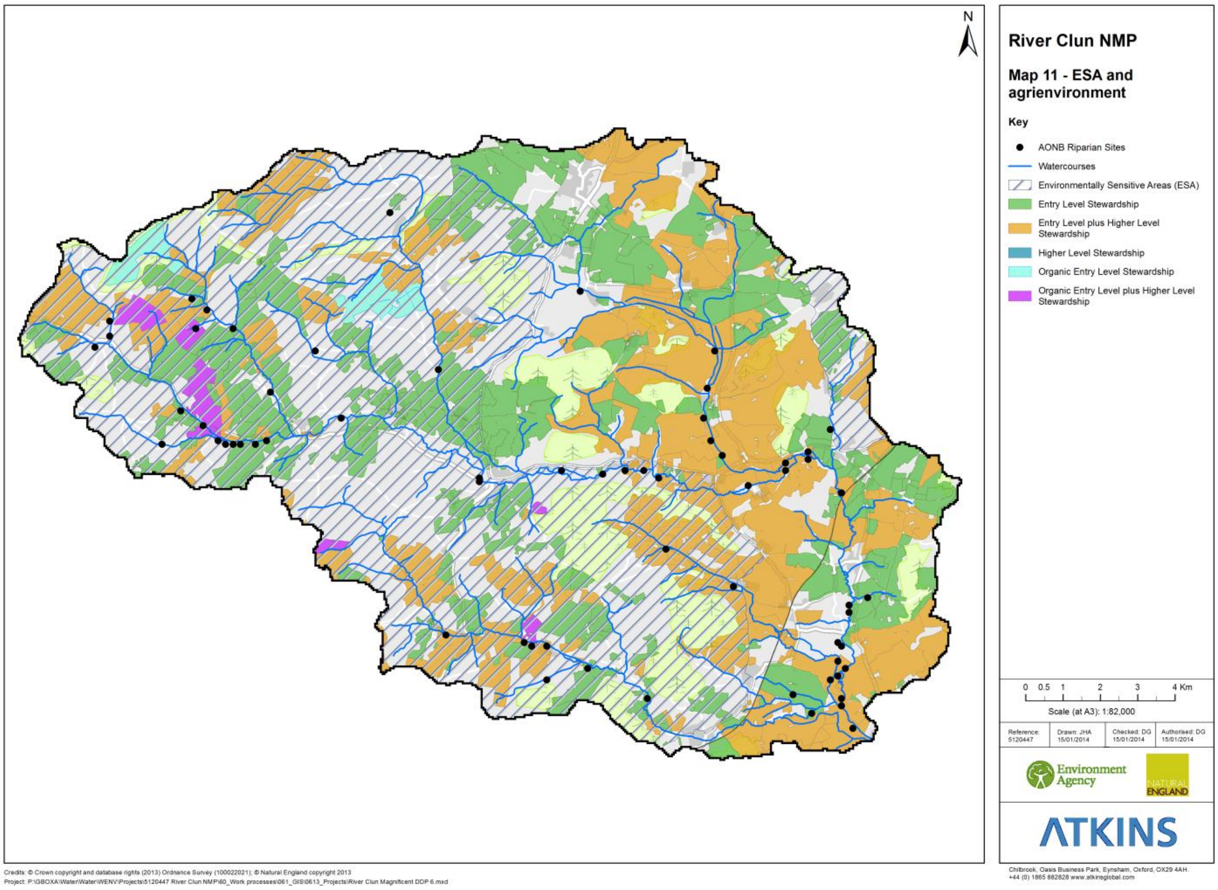
3.8.2. Agri-Environment

Agri-environment has been adopted by many land managers within the Clun catchment for a number of years. Map 11 shows the coverage of agri-environment schemes in the Clun catchment. Agreements that are currently live across the catchment equate to an investment of £10 million throughout the duration of all agreements (see Table 3-8).

Table 3-8 Investment in agri-environment in the Clun catchment

Scheme Type	Quoted investment
Entry Level plus Higher Level Stewardship	£7,978,412
Entry Level Stewardship	£1,125,905
Organic Entry Level plus Higher Level Stewardship	£880,776
Organic Entry Level Stewardship	£166,732
TOTAL	**£10,151,826**

Source of data: Natural England). Data presented cover the lifetime of current live agreements.



Entry Level Stewardship (ELS), which is available to all landowners in England, has traditionally not included many measures specific to resource protection (water), (although this is changing now with more resource protection options being incorporated into ELS from January 2013). It is also important to note that some of the ELS measures result in more considerate land management behaviours that have incidental water protection benefits. ELS is available to all land managers within the catchment, however traditionally is not thought to deliver significant benefits for water quality. Higher Level Stewardship (HLS) options are considered to deliver more benefits for water quality. A subset of these has been identified in a recent review by Natural England as providing resource protection. Uptake of resource protection options in the Clun catchment is shown in Map 12. Table 3-9 describes he coverage of different resource protection options in the catchment. The current implementation rates of resource protection options within ELS and HLS is summarised in Table 3-10.

Resource protection options currently cover approximately 10% of the catchment, with 5% as low input grassland and 5% with buffer strips (see **Error! Reference source not found.**).

Table 3-9 Summary of the extent of different Environmental Stewardship options in the Clun catchment

Option Description		Folly Brook	Middle Clun	Lower Clun	Upper Clun	River Kemp	River Redlake	River Unk	CATCHMENT TOTAL(ha)	CATCHMENT TOTAL (%)
Other		794	45	1,773	783	1,356	521	343	5,616	20.63%
Resource protection options	**Creation of woodland**	0	0	22	0	16	0	0	38	0.14%
	Grassland restoration	0	0	0	0	28	0	0	28	0.10%
	Large buffer strip	0	0	300	0	500	0	44	843	3.10%
	Livestock removal	0	0	37	9	20	0	0	67	0.24%
	Low input grassland	56	150	601	77	288	230	93	1,496	5.50%
	Pond creation/rSUDS	0	0	15	0	0	0	0	15	0.05%
	Small buffer strip	3	0	105	6	347	12	4	477	1.75%
	Unspecified buffer strip	0	0	23	0	0	0	0	23	0.09%
	Vegetation management	0	0	14	0	0	0	0	14	0.05%
TOTAL		**854**	**196**	**2,889**	**875**	**2,554**	**763**	**484**	**8,616**	**31.65%**

Table 3-10 Summary of the extent of different ESA tiers and prescriptions in the Clun catchment

Option	Option Description	Folly Brook	Middle Clun	Lower Clun	Upper Clun	River Kemp	River Redlake	River Unk	CATCHMENT TOTAL(ha)	CATCHMENT TOTAL (%)
1AA	All arable land	348	257	228	74	200	520	492	2,118	7.78%
1AG	Ley Grasses under 5 years old	189	572	522	860	242	1,765	1,090	5,240	19.25%
1AW	Woodland (within all land)	390	0	4	5	0	18	11	428	1.57%
HRS	Hedgerow restoration supplement	2	5	5	1	0	18	0	32	0.12%
O1B	Permanent Grassland	324	187	301	366	33	1,674	695	3,581	13.15%
O1C	Extensive permanent grassland	0	0	108	0	0	0	0	108	0.40%
O2A	Reversion of improved grassland to extensive permanent grassland	31	193	36	51	100	218	308	936	3.44%
O2B	Reversion of improved grassland to rough grazing	19	0	3	7	13	11	59	113	0.41%
O3A	Reversion of arable land to permanent grassland	0	0	1	11	0	70	40	122	0.45%
O3B	Conservation headlands	0	0	5	0	0	0	0	5	0.02%
OOW	Woodland Enhancement	0	8	2	9	2	7	5	34	0.12%
WLS	Wet area supplement	0	0	0	0	0	0	10	10	0.04%
TOTAL		1,303	1,222	1,213	1,383	590	4,301	2,711	12,725	46.74%

3.8.3. Catchment Sensitive Farming (CSF)

The CSF delivers advice to farmers on reducing diffuse water pollution from agricultural practices within the Clun catchment. The wider programme also offers capital grants for large items of farm infrastructure.

The Clun catchment was a pilot catchment for the Catchment Sensitive Farming initiative which started in 2005. More recent priority catchment targeting of CSF within the Clun catchment has identified phosphate and sediment run off in the catchment as a particular issue and has set objectives for implementation between 2011 and 2014. During 2013 within the Clun catchment particular attention has been paid to nutrient management planning.

Although CSF can provide a good route for delivery of advice to farmers on general diffuse pollution and capital grants to help with implementation, it is important to note that the CSF programme was not set up to specifically deliver reductions in agricultural phosphorus pollution in water bodies and as such is only so far estimated to have resulted in a small percentage reduction in in-river nutrient concentrations (Natural England, Pers. Comm.). The Environment Agency (2011) has estimated in-river reductions of 1-2% in orthophosphate and 1 - 7% of total oxidised nitrogen associated with current levels of activity of CSF

CSF is regularly reviewed and the future focus of the Programme is uncertain after 2014, but there may be future scope for including more targeted work within CSF for local level issues such as those in the Clun.

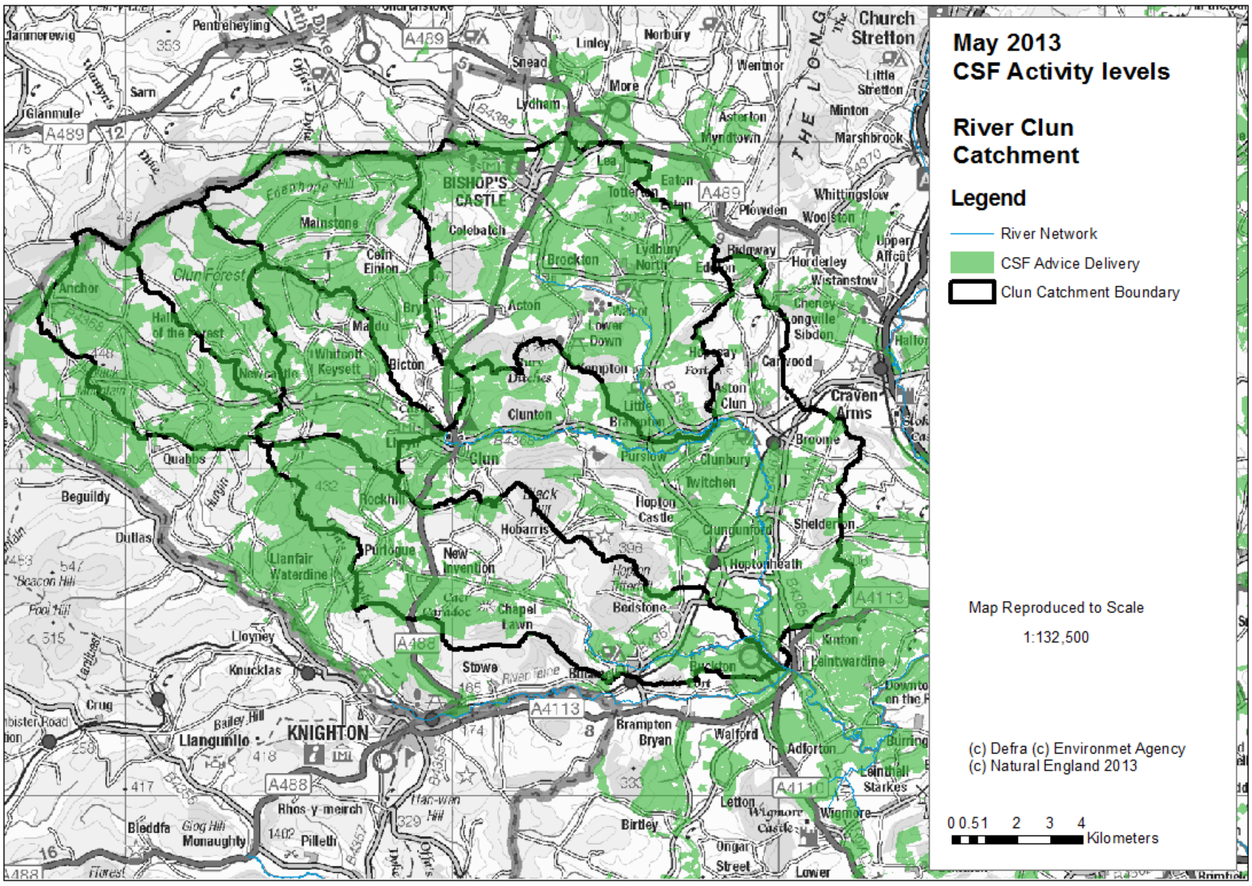


Figure 3-4 May 2013 Catchment Sensitive Farming activity levels in the River Clun catchment

3.8.4. Local scale initiatives

Over the past 2 years, Natural England has contributed £165,000 to an AONB-SITA funded project much of which has gone on practical work to reduce sediment and nutrient levels within the river (Natural England, Pers. Comm.).

Map 11 has identified some of these other measures.

4. Water quality baseline

This section reviews available phosphate, nitrogen and sediment data for the River Clun SAC to assess the compliance gap between current and historic river concentrations and the favourable condition targets for freshwater pearl mussel.

The Environment Agency maintains a detailed water quality monitoring network in the Clun catchment. A complete list of water quality monitoring locations in the catchment is given in Appendix G.

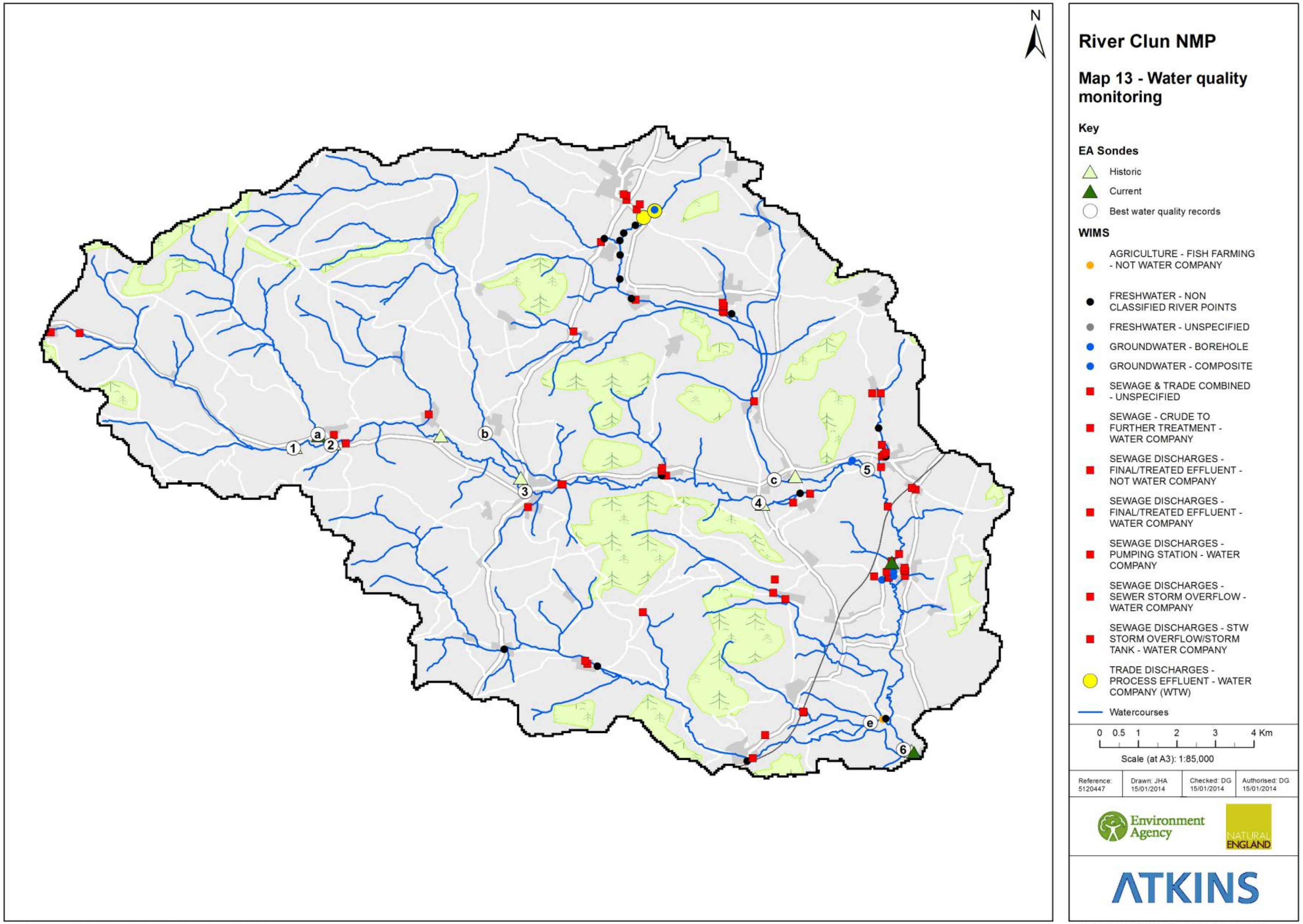
The longest and most complete water quality record in the catchment is in the River Clun SAC at Leintwardine where phosphate, nitrogen and suspended solids levels have been measured monthly since 1995. In addition, high frequency turbidity monitoring data are available for this location (see Map 13). There are also a number of long-term water quality records in the tributaries of the River Clun that enable a catchment-scale assessment of water quality variations. The best records in the catchment are reviewed in Table 4.1 below.

Where possible, water quality variations in the Clun sub-catchments have also been assessed to help to understand the potential main sources of nutrients and sediment, complementing modelling work presented in later parts of this report. There has also been historic interest in the potential for areas upstream of the SAC to act as freshwater pearl mussel habitat and this analysis contributes to this ongoing work although it is important to note that this is not one of the primary objectives of the NMP.

Table 4-1 Summary of the longest and most complete water quality records in the River Clun catchment.

ID	WFD Water body	Sampling location	NGR	Year			No. of samples
				Start	End	Missing	
1	Upper Clun	The Garn	SO2392081916	2008	2012	2009-2011	15
a	Folly Brook	Newcastle	SO3245628228	2007	2012	2008, 2010, 2011	49
2	Mid-Clun	Newcastle B4368 Bridge	SO3249028200	2007	2012	2008, 2010, 2011	56
b	Unk	Bicton	SO3289028230	2007	2012	2010, 2011	55
3	Mid Clun	A488 Bridge	SO2993880791	2003	2008	-	72
c	Kemp	Purslow New Bridge	SO3270085800	1995	2012	2010, 2011	217
4	Lower Clun	Purslow	SO3600080500	2006	2012	-	82
5	Lower Clun	Beambridge	SO3881981355	2003	2008	-	72
e	Redlake	Jay	SO3890074800	1995	2012	-	69
6	Lower Clun	Conf. with Teme (SAC)	SO3998474050	1995	2012	2010, 2011	183

The location of each monitoring point is shown on Map 13 overleaf. Numbers denote monitoring locations on the course of the Clun itself. Letters denote monitoring location on tributaries of the Clun. Source of data: Environment Agency.



Project: P:\GBOXA\Water\Water\WENV\Projects\5120447 River Clun NMP\60_Work processes\061_GIS\0613_Projects\River Clun Magnificent DDP 7.mxd

Chilbrook, Oasis Business Park, Eynsham, Oxford, OX29 4AH.
+44 (0) 1865 882828 www.atkinsglobal.com

4.1. Phosphate

4.1.1. Data availability, assumptions and limitations

The phosphate favourable condition target for freshwater pearl mussel is expressed as mean annual Soluble Reactive Phosphorus (See Section 2.5), hereafter termed SRP. However, no SRP measurements have historically been undertaken in the River Clun catchment. The Environment Agency uses orthophosphate to estimate dissolved and soluble phosphate levels in rivers. An assumption that orthophosphate and SRP are equivalent has therefore been made as part of the assessment.

Orthophosphate data for the River Clun SAC at Leintwardine are available monthly for the period between 1995 and 2012. Limited orthophosphate monitoring was undertaken in 2010 and 2011 and annual means for these years cannot therefore be calculated.

It is important to note that the orthophosphate detection limits used by the Environment Agency changed in 2011. Samples prior to this date have not been analysed to the lower detection level and comparing historic to post 2011 data has to be carried out with caution (Environment Agency, Pers. Comm.) where concentrations approach a concentration of around 0.01 mg/l.

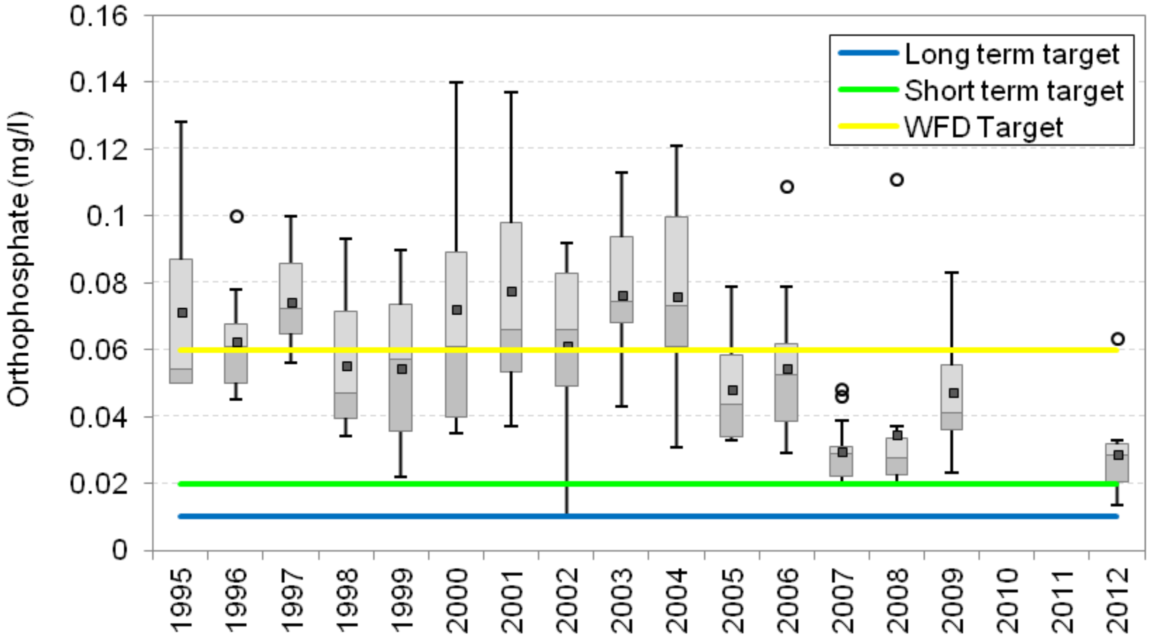
4.1.2. Results

4.1.2.1. Annual averages

Figure 4.1 overleaf compares mean annual phosphate levels in the River Clun SAC at Leintwardine 1995 - 2012 to the phosphate favourable condition targets for freshwater pearl mussel. The short term target (0.02 mg/l) is shown in green and the long term target (0.01 mg/l) is shown in blue. The historic Habitats Directive target of 0.06mg/l (yellow) is also shown for context.

Until 2004, measured phosphate levels were consistently above the Habitats Directive target of 0.06 mg/l. Since 2007, phosphate levels have declined as a result of AMP5 funded phosphate-stripping of the Bishops Castle STW (in 2007) and Bucknell STW (in 2010). There has also been a more general reduction in phosphate levels in STW effluent in the catchment (see Figure 4.2 overleaf). Since 1990, application of fertiliser are reported to have declined by 67% on grassland and 51% on tillage land, while phosphate from manures is reported to have reduced by 20% between 1990 and 2012 (National Farmers Union, Pers. Comm.).

Although the favourable condition targets are still exceeded, the current levels of phosphate in the river are very low. In three of the last four years for which data are available mean annual concentrations in the River Clun at Leintwardine have been in the order of 0.03mg/l (Figure 4.1), approaching the short-term phosphate favourable condition target for freshwater pearl mussel.



*The boxes represent the inter-quartile range and the midline of the box the median. The black circles represent outliers. Whiskers represent the maximum and minimum values falling within the range Q1-IQR*1.5 to Q3+IQR*1.5. The pale blue line is the long term favourable condition target. The green line is the short term favourable condition target. The yellow line is the boundary between WFD Good and Moderate classes that the Environment Agency is working towards as part of the WFD (Source of data: Environment Agency).*

Figure 4-1 Average annual orthophosphate concentrations in the River Clun SAC at Leintwardine between 1995 and 2012.

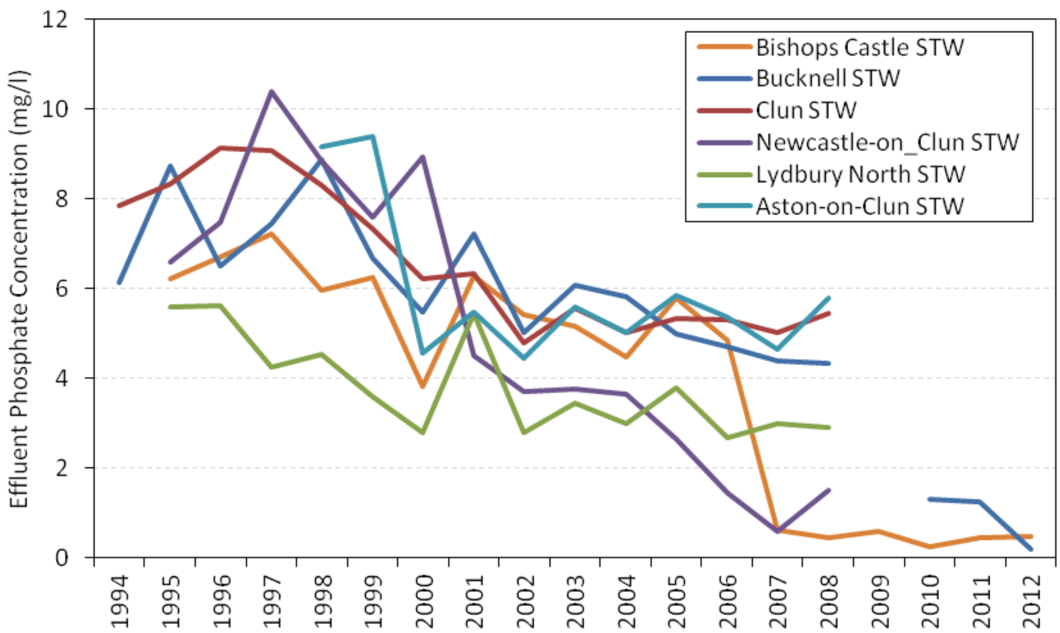


Figure 4-2 Changes in STW effluent phosphate concentrations between 1994 and 2012. There are no data for any works without a phosphate consent post-2008. Source of data: Environment Agency and Severn Trent Water.

4.1.2.2. Seasonal variations

Figure 4.3 overleaf shows seasonal variations in phosphate concentrations in the River Clun at Leintwardine between 2007 and 2012. This corresponds to the period following the introduction of phosphorus removal at Bishops Castle STW in 2007.

On average, the highest concentrations of phosphate in the River Clun at Leintwardine are recorded in the summer months when flows are lowest. The lowest concentrations are recorded in late winter and spring (February, March and April) when phosphate concentrations are close to the short term phosphate target. This is followed by a gradual increase during the summer months peaking in September when average phosphate levels exceed the Habitats Directive target. Phosphate levels in autumn and early winter (October to January) are generally between 0.03 and 0.045mg/l, above the phosphate favourable condition target.

A flow independent trend where phosphate levels increase in response to reduced flows is typically associated with catchments where point sources are important (Bowes, 2008). However, in the Clun catchment, this trend can also be observed (although suppressed) in the Folly Brook and Unk sub-catchments (see Figure 4.4 overleaf) where there are no known significant point sources, resident populations are small and upland agriculture dominates land usage. Potential hypotheses for this pattern include the impacts of private sewage treatment systems or seasonal agricultural management in the sub-catchments although at this stage insufficient evidence is available to confirm the seasonal variations sources in the Clun catchment. Flow dependent peaks where concentrations increase at times of high flows (for example in November and January) are typically associated with diffuse agricultural sources.

4.1.2.3. Spatial variations

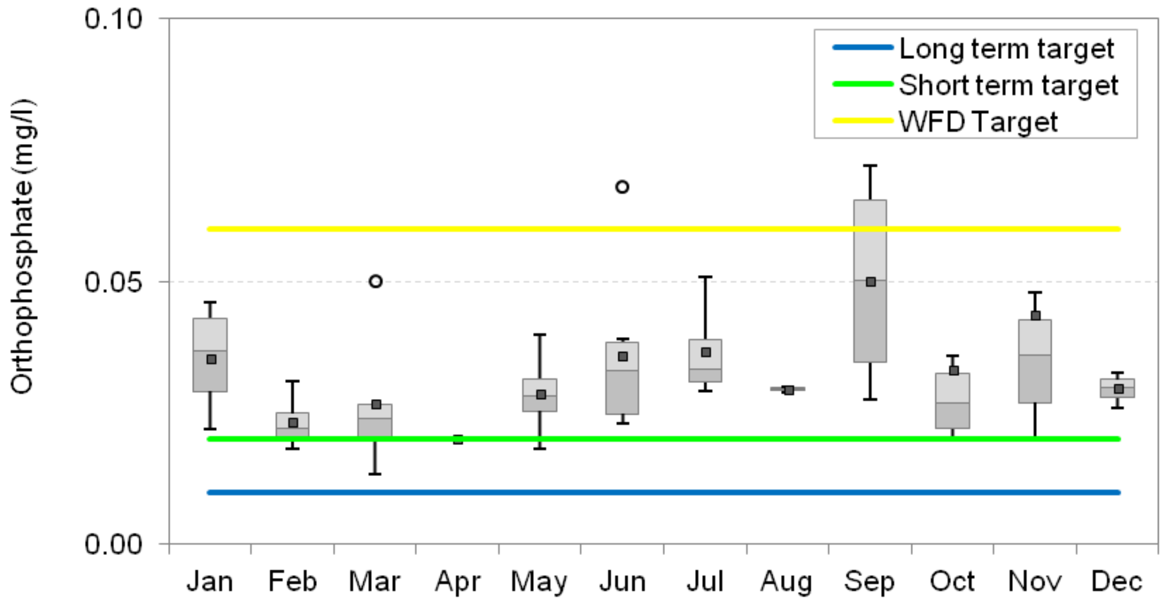
Table 4.2 below shows how phosphate levels vary down the Clun catchment. There is a general downstream increase in mean annual phosphate levels. At locations upstream of Newcastle-on-Clun, phosphate levels in 2012 were within the short term conservation objective target. Measured levels in the River Redlake were also within the short term conservation objective target.

At locations downstream of Clun phosphate levels were higher than those required for a functioning pearl mussel population. The highest concentrations were recorded in the River Kemp and in the Clun at Purslow.

Table 4-2 Mean annual phosphate levels in different sub-catchments of the River Clun.

ID	WFD Water body	Sampling location	Year	No. of samples	Mean annual measured orthophosphate (mg/l)	
					Mean	Max
1	Upper Clun	The Garn	2012	7	0.017	0.042
a	Folly Brook	Newcastle	2012	12	0.016	0.050
2	Mid-Clun	Newcastle	2012	12	0.019	0.032
b	Unk	Bicton	2012	11	0.014	0.025
3	Mid Clun	A488 Bridge (Clun)	2008	12	0.027*	0.044
c	Kemp	Purslow New Bridge	2012	14	0.037	0.088
4	Lower Clun	Purslow	2012	13	0.039	0.110
5	Lower Clun	Beambridge	2008	12	0.027	0.045
e	Redlake	Jay	2012	12	0.020	0.040
6	Lower Clun	Confluence with Teme	2012	12	0.029	0.064

Available data are presented from the top of the catchment to the bottom. NB data for different locations may cover different time periods and may be based on differing numbers of samples. This information is also provided in the table.



*The boxes represent the inter-quartile range and the midline of the box the median. The black circles represent outliers. Whiskers represent the maximum and minimum values falling within the range Q1-IQR*1.5 to Q3+IQR*1.5. The pale blue line is the long term favourable condition target. The green line is the short term favourable condition target. The yellow line is the boundary between WFD Good and Moderate classes that the Environment Agency is working towards as part of the WFD. (Source of data: Environment Agency).*

Figure 4-3 Seasonal phosphate variations in the River Clun SAC at Leintwardine between 2007 and 2012. Source of data: Environment Agency.

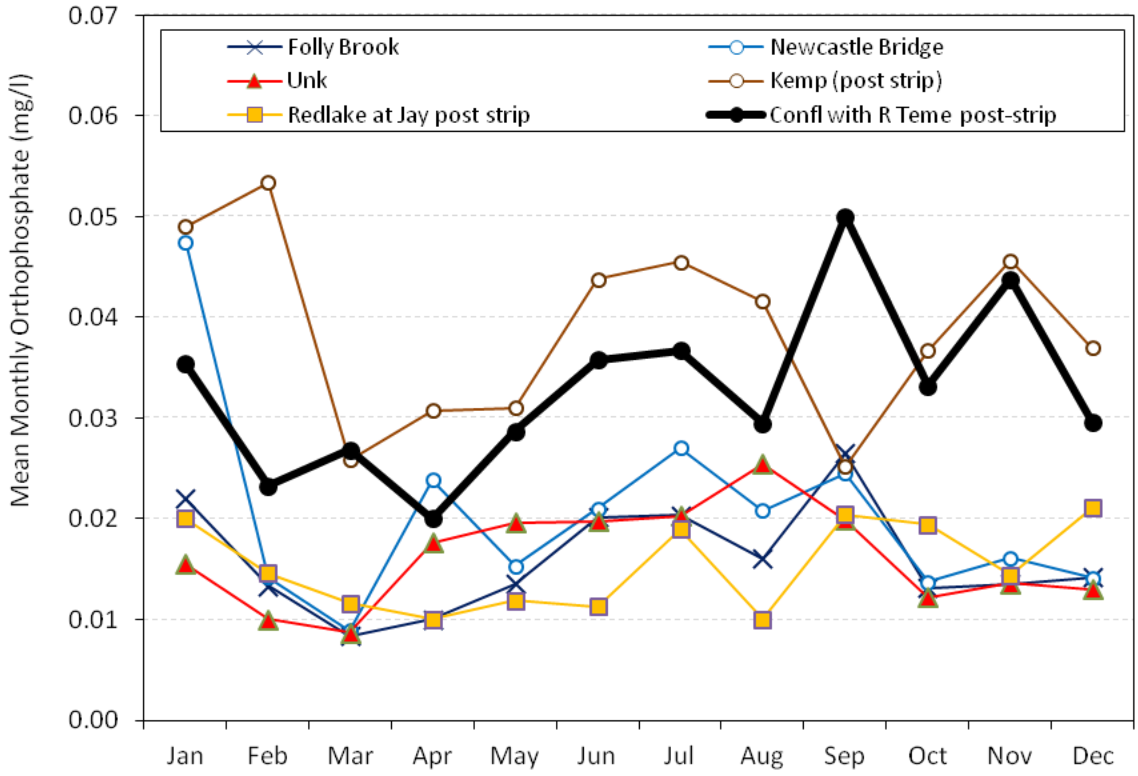


Figure 4-4 Seasonal phosphate variations in the tributaries of the River Clun. Source of data: Environment Agency.

4.1.3. Phosphate compliance gap

Table 4-3 shows the difference between phosphate concentrations in the River Clun at Leintwardine and both the short and long term phosphate favourable condition targets for freshwater pearl mussel.

Mean annual phosphate levels are currently above both the short and long term targets and the compliance gap is large, particularly for the long term target. Average annual phosphate levels are 1-2 times greater than the short term target and 3-4 times greater than the long term phosphate target.

Table 4-3 Phosphate compliance gap

<table>
<tr><th colspan="2" rowspan="3">Mean annual measured phosphate concentration (mg/l)</th><th colspan="2">Short term (2015)</th><th colspan="2">Long term (2027)</th></tr>
<tr><th rowspan="2">Favourable condition target</th><th>Difference</th><th rowspan="2">Favourable condition target</th><th>Difference</th></tr>
<tr><th>mg/l</th><th>mg/l</th></tr>
<tr><td>Average</td><td>0.035</td><td rowspan="7">0.02</td><td>0.015</td><td rowspan="7">0.01</td><td>0.025</td></tr>
<tr><td>2007</td><td>0.030</td><td>0.010</td><td>0.020</td></tr>
<tr><td>2008</td><td>0.035</td><td>0.015</td><td>0.025</td></tr>
<tr><td>2009</td><td>0.047</td><td>0.027</td><td>0.037</td></tr>
<tr><td>2010</td><td>No data</td><td>-</td><td>-</td></tr>
<tr><td>2011</td><td>No data</td><td>-</td><td>-</td></tr>
<tr><td>2012</td><td>0.029</td><td>0.009</td><td>0.019</td></tr>
</table>

4.2. Nitrogen

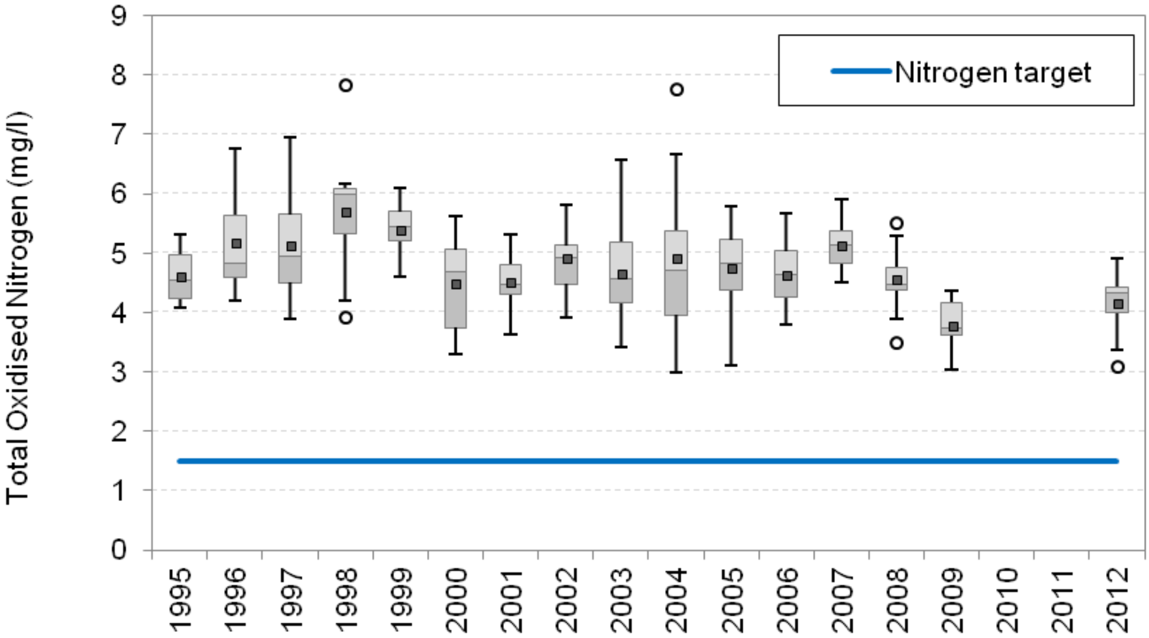
4.2.1. Data availability, assumptions and limitations

The nitrogen favourable condition target for freshwater pearl mussel is expressed as mean annual Total Oxidised Nitrogen (See Section 2.5), hereafter termed TON. TON data for the River Clun SAC at Leintwardine are available monthly for the period between 1995 and 2012. Limited TON was undertaken in 2010 and 2011 and annual means for these years cannot therefore be calculated.

4.2.2. Results

4.2.2.1. Annual averages

Figure 4.5 compares mean annual TON levels in the River Clun SAC between 1995 and 2012 and the TON favourable condition target of 1.5 mg/l (shown in blue). In the last five years, nitrogen levels have declined slightly from a mean level in the order of 5mg/l before 2007 to around 4mg/l thereafter. There also appears to have been a reduction in the annual variability of TON levels during this period although concentrations are still 2 – 3 times greater than the favourable condition target for freshwater pearl mussel.

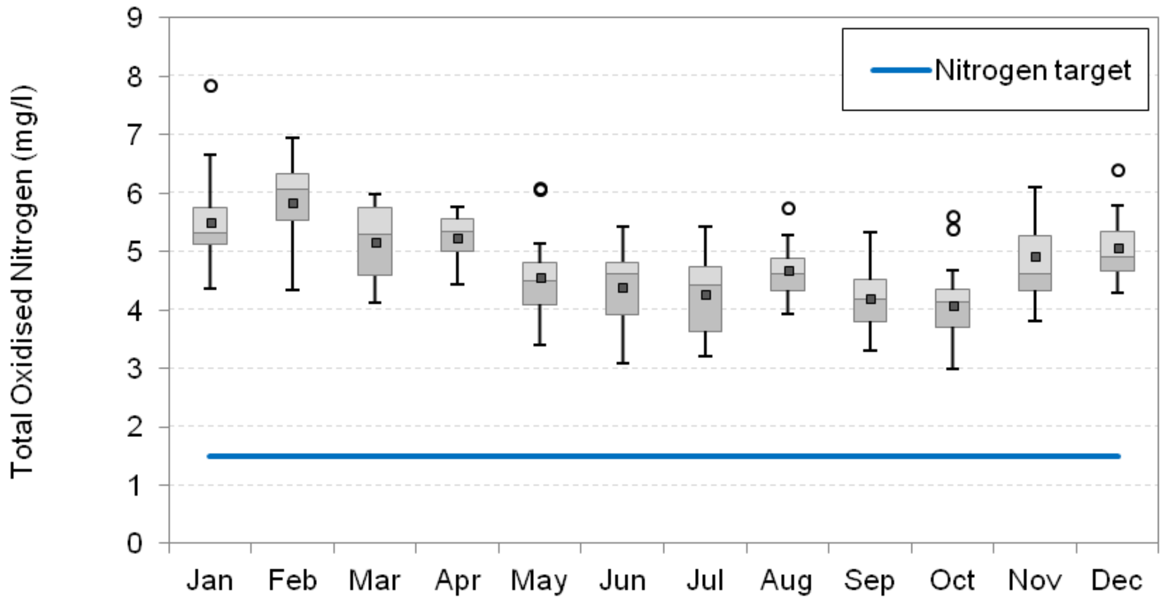


*The boxes represent the inter-quartile range and the midline of the box the median. The black circles represent outliers. Whiskers represent the maximum and minimum values falling within the range Q1-IQR*1.5 to Q3+IQR*1.5. The blue line is the long term favourable condition target (Source of data: Environment Agency).*

Figure 4-5 Average annual nitrogen levels (TON) in the River Clun SAC at Leintwardine from 1995 to 2012

4.2.2.2. Seasonal variations

The highest concentrations of TON in the River Clun SAC at Leintwardine are recorded in the winter months (Figure 4.6) when flows are highest. The lowest concentrations are recorded in spring and summer when nitrogen levels fall as it is taken up by biological activity in the river. Regardless of seasonal patterns, nitrogen levels throughout the whole year are significantly above the favourable condition water quality target.



*The boxes represent the inter-quartile range and the midline of the box the median. The black circles represent outliers. Whiskers represent the maximum and minimum values falling within the range Q1-IQR*1.5 to Q3+IQR*1.5. The blue line is the long term favourable condition target (Source of data: Environment Agency).*

Figure 4-6 Seasonal nitrogen (TON) variations in the River Clun SAC at Leintwardine

4.2.2.3. Spatial variations

Table 4.4 shows how TON levels vary down the Clun catchment. TON levels are above the favourable condition target throughout the Clun catchment. Levels upstream of Newcastle-on-Clun (in the Folly Brook and mid-Clun sub-catchments) are closest to the target. Elsewhere, annual average TON levels are at least two times the favourable condition target. The highest levels are recorded in the Kemp sub-catchment where TON levels are more than 5 times the favourable condition target.

Table 4-4 Variations in mean annual TON levels in the catchment of the River Clun.

Available data are presented from the top of the catchment to the bottom. NB data for different locations may cover different time periods and may be based on differing numbers of samples.

ID	WFD Water body	Sampling location	Year	No. of samples	Nitrogen (mg/l)	
					Mean	Max
1	Upper Clun	The Garn	2012	7	No data	No data
a	Folly Brook	Newcastle	2012	12	1.82	2.24
2	Mid-Clun	Newcastle	2012	12	1.65	1.84
b	Unk	Bicton	2012	11	3.45	3.9
3	Mid Clun	A488 Bridge (Clun)	2008	12	2.99	3.73
c	Kemp	Purslow New Bridge	2012	14	8.3	9.65
4	Lower Clun	Purslow	2012	13	2.81	3.3
5	Lower Clun	Beambridge	2008	12	4.61	5.55
e	Redlake	Jay	2012	12	3.12	3.6
6	Lower Clun	Confluence with Teme	2012	12	4.15	4.9

4.2.3. Nitrogen compliance gap

Table 4.5 shows the compliance gap between current TON levels in the River Clun SAC at Leintwardine and the nitrogen favourable condition target for freshwater Pearl mussel. There is no short term target for Nitrogen and only compliance with the long term target of 1.5 mg/l has been considered

Currently, the compliance gap is large and average TON levels in the River Clun SAC are approximately 3 times greater than the favourable condition target.

Table 4-5. Nitrogen compliance gap. Source of data: Environment Agency.

Mean annual measured TON concentration (mg/l)		Favourable condition target	Difference (mg/l)
Average	**4.4**	**1.5**	**2.9**
2007	5.1	1.5	3.6
2008	4.6	1.5	3.1
2009	3.8	1.5	2.3
2010	No data	-	-
2011	No data	-	-
2012	4.1	1.5	2.6

4.3. Sediment

4.3.1. Data availability

The sediment favourable condition target for freshwater pearl mussel is expressed as mean annual Suspended solids concentrations (See Section 2.5), hereafter termed SS. There are two data sets that allow the quantification of SS in the River Clun SAC as follows:

- **Monthly spot samples** - SS data for the River Clun SAC at Leintwardine are available monthly for the period between mid-1998 and early 2010; and
- **Continuous turbidity monitoring** - The Environment Agency is undertaking detailed turbidity monitoring both upstream of (at Clungunford) and within the SAC (at Leintwardine) using some water quality monitoring sondes (see Appendix H1). Data provided by the Environment Agency covered the period between May 2012 and April 2013 for both locations. In addition, data for the Folly Brook at Newcastle-on-Clun were provided for the period December 2012 to April 2013. Map 13 shows the location of the sondes described.

Following suggestions by local stakeholders, both data sets have been used to assess the compliance gap between current conditions in the River Clun SAC and the sediment favourable condition targets for freshwater pearl mussel.

4.3.2. Assumptions and limitations

4.3.2.1. Continuous turbidity monitoring

Due to the highly variable nature of SS transport, high frequency sampling is needed to capture the importance of flood events (WRC, 2010) that typically occur over considerably shorter timescales than monthly spot measurements. The main advantage of using continuous turbidity data to estimate suspended solids estimates is that it allows the measurement of flood peaks that typically drive sediment dynamics in rivers and are the types of events that may impact upon freshwater pearl mussels in the River Clun SAC based on the impact pathway identified in Section 2.4.

However, turbidity is measured in Nephelometric Turbidity Units (NTUs) whereas suspended solids are measured in mg/l. The conversion of turbidity to suspended solids has been used in a range of studies including the River Frome in Dorset (Collins, 2008) (Appendix H2) and as part of investigations in the River Teme (WRC, 2010) that has included monitoring locations in the Clun catchment (River Kemp at Little Bampton and River Clun at Mill Lane Leintwardine). These studies found a close, almost 1:1 relationship between SS and turbidity at a range of monitoring stations (see Appendix H3).

It has therefore been possible to make the assumption that turbidity and suspended solids levels are equivalent in the Clun catchment. This assumption has been further tested by pairing the sonde record at Clungunford to the nearest location for which monthly spot suspended solids data are available (Clun at Purslow). The relationship is shown in Appendix H4 and is close to 1:1 at this location although it is important to note that this check is only currently possible at the lower turbidity range as there are no SS samples coinciding with flood peaks.

It is important to note that the continuous turbidity monitoring data record used in the assessment is short and includes an unusually wet year (2012). These weather conditions may have had an influence on the results and this should be taken into account when interpreting results.

4.3.2.2. Monthly spot sampling

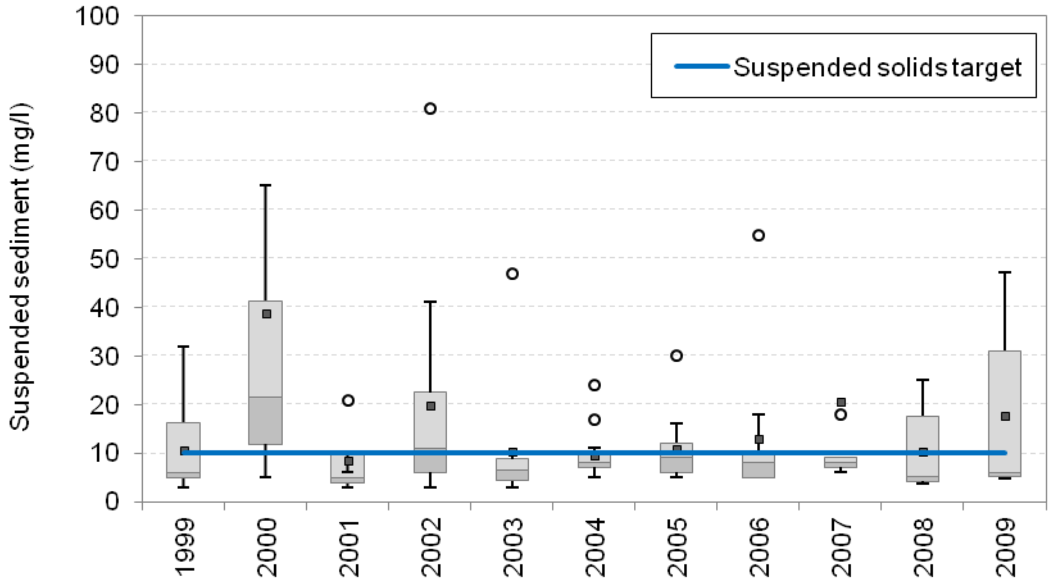
Monthly spot SS samples are typically ‘fair weather’ samples that may miss the main flood events that may drive the sediment dynamics of the Clun. The precise importance of high flow vs low flow events in terms of driving deposition is not currently understood for the River Clun. Appendix H5 compares the results of turbidity sampling at Clungunford and SS spot sampling at Purslow and shows how most monthly spot SS measurements are taken between the main flood peak events that are likely to drive potential impact on freshwater pearl mussels in the Clun catchment.

4.3.3. Results

4.3.3.1. Annual averages

Monthly spot samples

Figure 4.7 shows mean annual SS levels based on monthly spot samples in the River Clun SAC at Leintwardine between 1999 and 2009. Annual mean SS values are summarised in Table 4.6. Annual averages based on spot measurements varied significantly between years, from a maximum of 39 mg/l in 2000 to a minimum of 9 mg/l in 2001. In about half the years in the record, monthly spot sampling indicated that SS levels in the River Clun SAC was below or close to the favourable condition target for sediment. The mean of all the years was 16 mg/l.



*The boxes represent the inter-quartile range and the midline of the box the median. The black circles represent outliers. Whiskers represent the maximum and minimum values falling within the range Q1-IQR*1.5 to Q3+IQR*1.5. The blue line is the long term favourable condition target. (Source of data: Environment Agency)*

Figure 4-7 Suspended solids variations in the River Clun SAC at Leintwardine.

Table 4-6 Summary of suspended solids monitoring in the River Clun at Leintwardine 1999-2009.

Year	Suspended solids concentration (mg/l)											
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	***Mean***
Monthly spot sampling	11	39	9	20	10	10	11	13	21	10	18	*16*

Source of data: Environment Agency and * WRC (2010)

Continuous turbidity monitoring

Figure 4.8 shows the SS estimates calculated from the turbidity sonde in the River Clun SAC at Leintwardine. For the period between May 2012 and April 2013, the mean annual SS level in the SAC was 19 mg/l, nearly two times the favourable condition target. For long periods of time, SS levels were within the favourable condition target of 10 mg/l. On a smaller number of occasions turbidity levels were much higher than the favourable condition target.

WRC (2010) have also provided a range of mean annual SS estimates for the River Clun at Mill Lane Leintwardine based on historic sampling in the River Clun SAC. These data are reviewed in Table 4.7. As in the case of the monthly spot sampling, mean annual SS levels estimated using data from the turbidity sondes varied from year to year, from a maximum of 20mg/l in 2007 to a minimum of 5mg/l in 2009. In 2 out of the 5 years for which data were available, SS levels were within the sediment favourable condition target for freshwater pearl mussel. In remaining years, SS levels were close to two times the favourable condition targets.

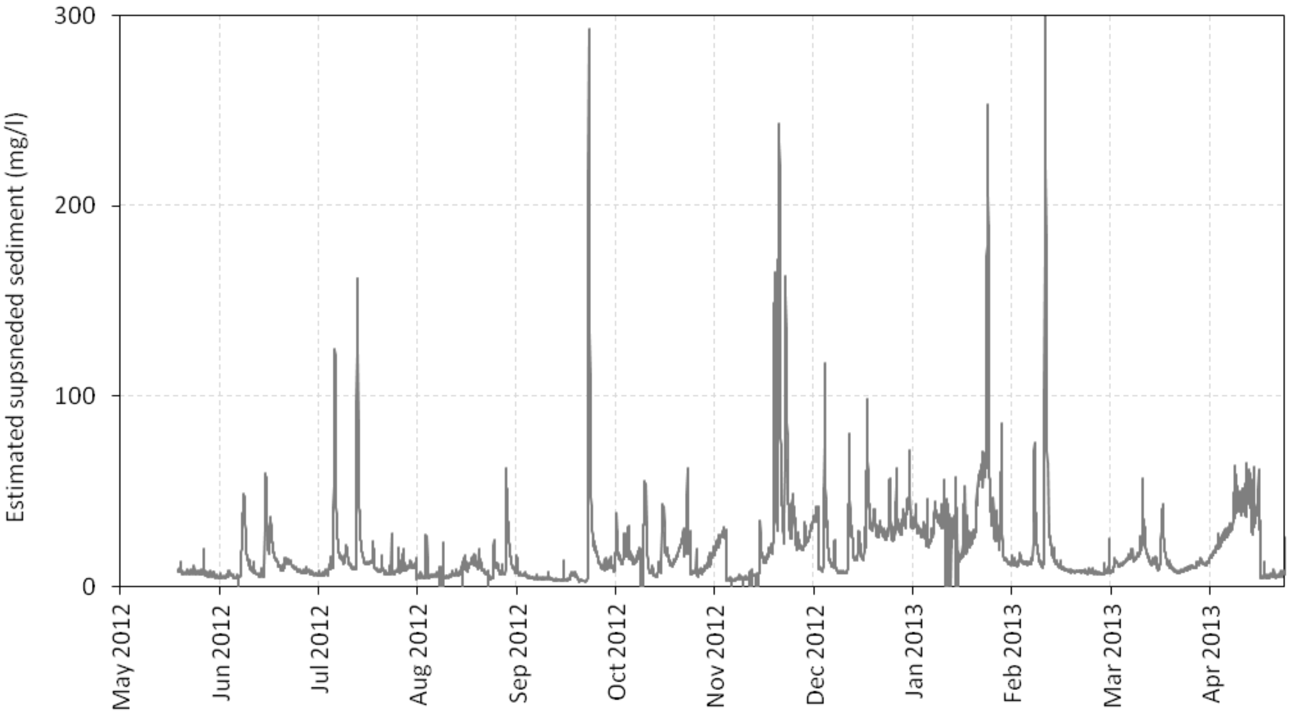


Figure 4-8 Estimated SS levels in the River Clun SAC at Leintwardine based on Environment Agency sondes.

Table 4-7 Mean annual suspended solids levels (in mg/l) in the River Clun SAC estimated using continuous turbidity sondes.

Year	Suspended solids concentration (mg/l)					
	2006*	**2007***	**2008***	**2009***	**2012-13**	***Mean***
Sondes	16	20	9	5	19	*14*

Source of data: * WRC (2010) and Environment Agency.

4.3.3.2. Individual events

During the consultation period, concerns were raised regarding the suitability of annual average suspended solids concentrations to protect freshwater pearl mussel. Given some of the impact pathways described in Section 2.4, a single siltation event may serve to impact upon freshwater pearl mussels or their habitat (Natural England, Pers. Comm.). Indeed, the River Clun suffers from extremely high siltation levels following rainfall (Atkins, 2012). Between May 2012 and April 2013, a total of 19 individual events were recorded where turbidity levels were at least 5 times the SS favourable condition target. The largest events had turbidity measurements of more than 100 units, an order of magnitude greater than the SS target. Although the monitoring covered an unusually wet year, these results were similar to those reported by Killeen (2009) and WRC (2010) who reported events of an equivalent magnitude occurring in both average and dry years.

Appendix I shows each of the main turbidity events recorded in the Clun at Leintwardine between May 2012 and April 2013. Table 4.8 summarises the characteristics of each event. The duration of the events varied between 1 and 4 days although most events (ca. 70%) lasted 2 days. The total duration of all events combined amounted to 40 days or 11% of the year. On average, the events were triggered by rainfall intensities in the order of 4mm/hr, equivalent to the land erosion rainfall intensity trigger identified by Chambers and Garwood (2000) or were part of multiple events covering extended periods of rainfall (Appendix I).

Table 4-8 Summary of the characteristics of individual suspended solids peaks in the Clun catchment May 2012 to April 2013.

Event		Peak Suspended solids (mg/l)		Approximate duration (days)	Peak rainfall intensity (mm/hr)
ID	Date	Leintwardine	Clungunford		
1	08/06/2012	49	**61**	3	2.8
2	15/06/2012	58	**80**	4	5.4
3	07/07/2013	124	**171**	2	3.6
4	14/07/2012	161	**234**	2	10.4
5	29/08/2012	**62**	61	2	7.4
6	24/09/2012	**293**	231	4	5.4
7	21/11/2012	**164**	121	1	3.2
8	23/11/2012	**240**	138	2	5.0
9	25/11/2012	**163**	93	2	4.2
10	07/12/2012	117	**151**	2	2.0
11	14/12/2012	80	**89**	2	2.0
12	20/12/2012	98	**121**	2	3.0
13	27/12/2012	62	**78**	4	5.0
14	27/01/2013	247	**324**	2	5.6
15	31/01/2013	86	**104**	1	4.0
16	10/02/2013	76	**88**	2	1.5
17	14/02/2013	**307**	163	2	3.6
18	17/03/2013	**57**	52	2	5.4
19	23/03/2013	43	**53**	2	1.2
	Averages	*131*	*127*	*2*	*4.2*

4.3.3.3. Seasonal variations

Monthly spot samples

Figure 4.9 presents mean monthly SS levels in the River Clun SAC at Leintwardine based on monthly spot sampling. The highest SS levels were recorded in the autumn and winter months between September and January (Figure 4-10). In these months, SS levels were, on average, 2-3 times the favourable condition target. At other times of year, mean monthly SS levels were typically lower, and close to or below target SS levels.

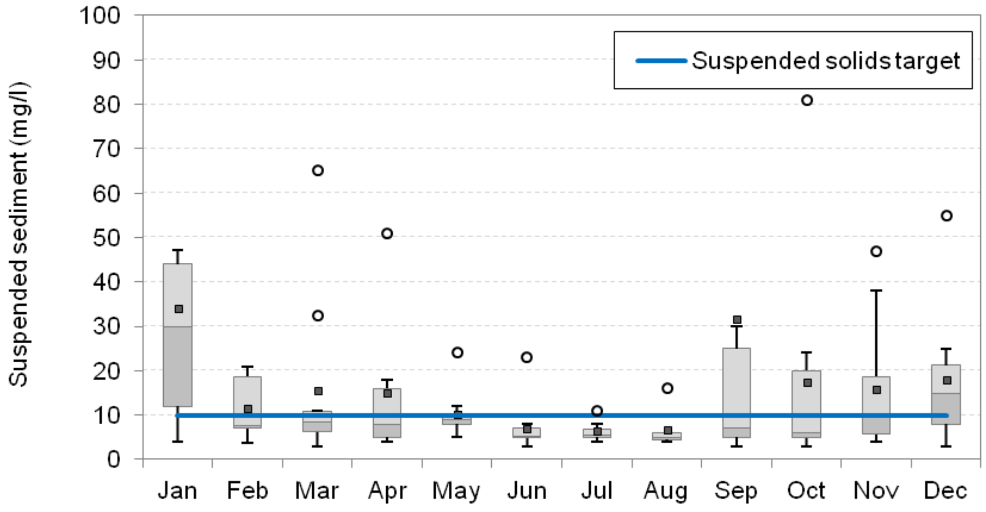


Figure 4-9 Seasonal variations in suspended solids in the River Clun SAC at Leintwardine 1999-2009. The blue line is the favourable condition target. Source of data: Environment Agency.

Continuous turbidity monitoring

Figure 4.10 shows how mean monthly SS levels varied at Leintwardine between May 2012 and April 2013. Mean SS levels were consistently higher at Leintwardine (within the SAC) than upstream at Clungunford. SS levels for Folly Brook were typically smaller than those estimated for downstream locations in the catchment. The monthly pattern was similar to the averages provided using monthly spot sampling, with peaks in the autumn and winter months. This illustrates that although 2012 was an unusually wet year, the sediment dynamics were not dissimilar to average conditions.

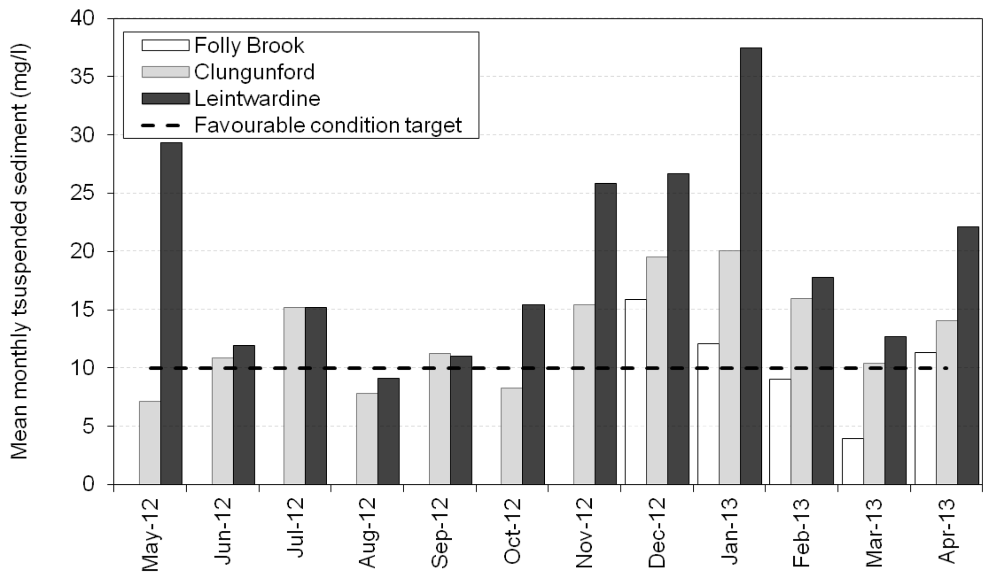


Figure 4-10 Mean monthly turbidity in the Clun catchment. Based on turbidity data measured at Environment Agency sondes between May 2012 and April 2013.

4.3.3.4. Spatial variations

Table 4.9 shows how SS levels vary down the Clun catchment. There are few SS data for the upstream reaches of the River Clun. However, where data are available these indicate that SS levels are within the favourable condition targets set for freshwater pearl mussel. However, at the downstream locations at Purslow and Leintwardine, SS levels exceeded the favourable condition target by 60-70%, although this is for a single year and there may have been high variability.

Table 4-9 Variations in mean annual suspended solids levels in the catchment of the River Clun. Available data are presented from the top of the catchment to the bottom.

ID	WFD Water body	Sampling location	Year	No. of samples	Suspended solids (mg/l)	
					Mean	Max
1	Upper Clun	The Garn	2012	7	3	4
a	Folly Brook	Newcastle	2012	12	No data	6¥
2	Mid-Clun	Newcastle	2012	12	No data	No data
b	Unk	Bicton	2012	11	No data	No data
3	Mid Clun	A488 Bridge (Clun)	2008	12	8	16
c	Kemp	Purslow New Bridge	2012	14	9	60
4	Lower Clun	Purslow	2012	13	17	141
5	Lower Clun	Beambridge	2008	12	7	14
e	Redlake	Jay	2012	12	10	36
6	Lower Clun	Confluence with Teme	2012	12	16	47¥

NB data for different locations may cover different time periods and may be based on differing numbers of samples. This information is also provided in the table.

4.3.4. Sediment compliance gap

Table 4.10 summarises the compliance gap between recent suspended solids levels in the River Clun SAC at Leintwardine and those required to meet the favourable condition target for freshwater pearl mussel.

Recent mean annual suspended solids levels in the River Clun are between 1 and 2 times the favourable condition target. The precise relationship between measured SS levels and the favourable condition target varies between years and the method used to estimate mean annual SS concentrations (see Table 4.10) although on average, different methods gave similar results (average of monthly spot samples = 12.3 mg/l; average of continuous turbidity monitoring = 13.8 mg/l). In addition, it is important to note that pressures associated with sediment may come from individual events rather than the ‘average’ conditions (Natural England, Pers. Comm.) described in Table 4.10. The River Clun suffers from extremely high siltation levels following rainfall and the largest events have SS levels more than 10 times the requirements of freshwater pearl mussel.

Table 4-10 Recent mean annual suspended solids levels in the River Clun SAC. Source of data: Environment Agency, except * from WRC, 2010.

Mean annual measured SS concentration (mg/l)			Favourable condition target	Difference (mg/l)
Monthly spot sampling	**Average**	**12.3**	**10**	**2.3**
	2007	8.9		-1.1
	2008	10.4		0.4
	2009	17.8		7.8
Continuous turbidity monitoring	**Average**	**13.8**		**3.8**
	2006*	16.0		6.0
	2007*	20.0		10.0
	2008*	9.0		-1.0
	2009*	5.0		-5.0
	2012-13	19.0		9.0

5. Pressures

Formulation of the evidence base to support this Plan, coupled with discussions with local land managers, the review of previous reports and catchment walkovers has enabled the identification of a number of current and future pressures on the River Clun SAC and its catchment that are reviewed in this section.

5.1. Current pressures

5.1.1. Wastewater Capacity and Quality

This pressure is tied in with the effluent arising from the existing built environment in the catchment. Point source pressures are easily identified and managed as they occur at a clearly identified point within the river system. Point source discharges thought to be of "significance", either in terms of their volume or polluting loads are controlled by a system of permits issued to the discharger by the Environment Agency, thereby requiring the discharger to meet certain standards.

Discharge permit data obtained from the Environment Agency has shown that there are 37 live permitted discharges in the Clun catchment (see Map 14). Some of these permits represent significant wastewater discharges and others represent small industrial or wastewater discharges. Appendix J1 provides details of each permitted discharge in the catchment.

The main permitted discharges are the sewage treatment works (STWs) owned or controlled by Severn Trent Water shown in Table 5.1 and Map 14. In 2006, the Environment Agency and Natural England undertook a review of all the permitted consents influencing the River Clun SAC. Through this process, existing consents were identified for review and modification depending on their licence conditions, thus enabling a legislative framework for controlling point source pressures on the SAC.

When the Environment Agencies Habitats Regulations Review of Consents (RoC) process was undertaken there were no specific freshwater pearl mussel phosphorus standards so the Environment Agency used a river based threshold for phosphorus of 0.06mg/l when reviewing the existing discharge permits. The licence modifications recommended from this process were therefore based on reaching a 0.06mg/l standard and therefore not the targets that have subsequently been set specifically to ensure that the freshwater pearl mussel achieve favourable condition.

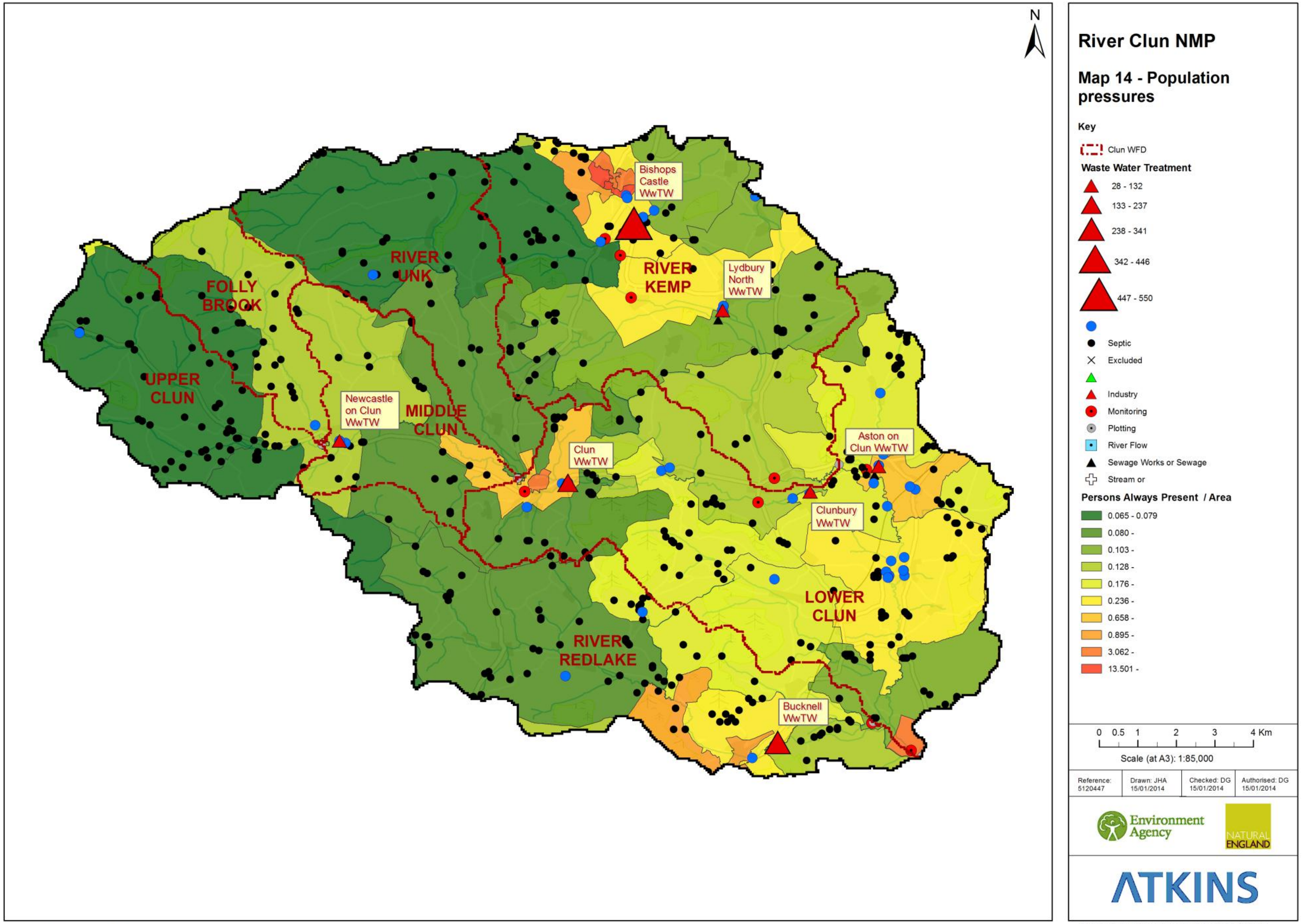
To this regard STWs at Bishops Castle and Bucknell were subject to phosphate removal in 2007 and 2010 in response to their observed impacts on the River Clun. This has resulted in significant improvements in effluent and river water quality (see Section 4). There have also been visible reductions in effluent phosphate concentrations more generally since 1995 as shown in Figure 4.2.

Table 5-1 River Clun Catchment STWs. Treatment works are listed in a downstream direction.

STW		Permit No.	Flow (m3/d) (DWF_Q90 limit)	Population served	P limit
1	Newcastle-on-Clun	S/09/56002/R	36	152	None
2	Clun	S/09/55923/R	119	690	None
3	Clunbury	S/09/5504/R	28	100*	None
4	Bishops Castle	S/09/55342/R	546	1,943	1mg/l
5	Lydbury North	S/09/50131/R	126	285	None
6	Aston-on-Clun	S/09/56005/R	37	187	None
7	Bucknell	S/09/55737/R	280	834	1.5 mg/l

**Treatment works constructed to serve about 100 people, however only 10 are actually connected.*

Remaining permitted discharges in the catchment are small and have a combined permitted volume of only 41 m^3/day (Environment Agency, Pers. Comm.) or 3.5% of the DWF_Q90 limit of the STWs above.



Chilbrook, Oasis Business Park, Eynsham, Oxford, OX29 4AH.
+44 (0) 1865 882828 www.atkinsglobal.com

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5.1.2. Septic tanks and small package treatment plants

In rural areas, a higher number of properties are not connected to the mains sewerage system and are instead reliant upon septic tanks or small package treatment plants to manage their wastewater. Volumes of septic tank discharges to soakaways are generally very small, invariably below 5m^3/day. Such discharges are not formally controlled by the Environment Agency. Due to the rural nature of the catchment, up to 50% of the catchment population is served private treatment plants or by soakaways.

Septic tanks are a chamber system that retains sewage for settling, allowing the solids to separate from the liquid portion. The liquid is then drained off to a soakaway and allowed to soak through the ground where pollutants are removed prior to the water infiltrating to a water course or groundwater. In order to minimise the risk associated with septic tanks, there are several good management practices that need to be followed such as regular emptying and maintaining a minimum distance from a well or a waterway. Where these management practices are not adhered to, risk to water quality from septic tanks and soakaways increases.

Small package treatment plants are slightly different to septic tanks in that they are essentially smaller versions of municipal sewage treatment works, treating the sewage on-site through techniques such as air filtration prior to discharge, rather than relying on a soakaway system.

These have been collectively termed “on-site wastewater treatment systems” (OSWwTSs) within this study. Although the risk from these two sources is not likely to be significant at the catchment scale compared with wastewater discharges and agricultural diffuse pollution, the potential local risk from these sources has been recognised for example in the Upper Clun by Fildes (2011).

There is uncertainty regarding the precise impact of OSWwTS on water quality, primarily as a consequence of a lack of information about the location, number and condition of OSWwTS and the limited monitoring data to support the effects of OSWwTS discharges to surface water and groundwater. The following assumptions are therefore typically made in modelling studies of this kind:

- Locations of OsWwTWs can be determined using information from an Environment Agency project aimed at characterising septic tank locations and their discharge of phosphorus across England and Wales (Environment Agency, 2010).
- Measured influent concentrations at STWs assumed not to be influenced significantly from industrial discharges which are assumed to be representative of inputs into OSWwTWs.
- The treatment effectiveness of OSWwTWs can be assumed to be low (<30%).
- Losses occur as the chemical load is transported toward the surface water (transmissivity).
- This input type is diffuse and input loads have therefore calculated on a 1km^2 basis.

The Environment Agency estimate that there are in the order of 450 private treatment plants or soakaways in the Clun catchment distributed according to Table 5.2 below (see also Map 14).

Table 5-2 OSWwTWs in the Clun catchment. Source of data: Environment Agency (2010)

WFD Water body			Number	% catchment total
Upper Clun	GB109054044000	R Clun - source to conf Folly Bk	55	12
Folly Brook	GB109054044020	Folly Bk - source to conf R Clun	23	5
Middle Clun	GB109054043980	R Clun - conf Folly Bk to conf R Unk	27	6
River Unk	GB109054044040	R Unk - source to conf R Clun	27	6
Lower Clun	GB109054043990	R Clun - conf R Unk to conf R Teme	147	32
River Kemp	GB109054044060	R Kemp - source to conf R Clun	91	20
River Redlake	GB109054043950	R Redlake - source to conf R Clun	86	19

5.1.3. Urban pressures

Diffuse pollution from urban areas is not likely to contribute significantly to nutrients and sediment within the Clun catchment but have been considered within the study.

Rain falling on impermeable areas in urban environments, such as roads, roofs, car parks etc., will runoff into the surface water drainage system. Depending on the surface water system within the urban environment, the runoff may be either be routed directly to the nearest watercourse, possibly via a balancing pond or wetland, or may alternatively flow into a combined sewer system carrying foul and surface water to the local STW (or a combination of these two fates).

Combined sewers have a finite capacity designed into them of typically 6 times the dry weather flow (DWF). Any rain events producing a flow greater than this results in the mixture of surface and foul water being discharged to the nearest watercourse via a combined sewer overflow (CSO) in order to prevent flooding of the sewer system. Similarly, at STWs receiving combined sewer discharges, storm tanks are provided to collect excess foul and surface water during rainfall events until it can be treated. If the maximum capacity of the storm tanks is exceeded (typically 3 times DWF) the overflow of mixed surface and foul water may be routed to the nearest watercourse to prevent flooding of the works.

5.1.4. Agricultural pressures

Agriculture and changes in agricultural practices lead to change in the characteristics of land and can lead to diffuse pollution. Disturbing the soil to plant crops significantly increases sediment losses to watercourses as the result of soil erosion. Use of fertilisers (both chemical and organic manures) and livestock within a catchment can increase the delivery of nutrients to surface and groundwater.

Awareness of pollution and the rapid rise in the cost of fertilisers have encouraged land managers to be more cautious in their use of nutrients through nutrient planning, such as precision farming techniques and using the Tried and Tested approach (see www.nutrientmanagement.org for further details). These approaches leave much lower nutrient residues that can be potentially leached or eroded, and they save money. Farmers and land managers only apply the nutrients that the crop require as this makes financial sense, but it is important that farmers receive the latest advice and information on this issue.

Consultation undertaken as part of the plan has highlighted three distinct agricultural pressures in the Clun catchment, those posed by livestock, poultry and arable farms. Each of these farm types is associated with different types of pressures.

5.1.4.1. Livestock

Livestock are responsible for much nutrient loss to water, especially in the wetter west of England where animal numbers, run off and slope angles are often high (Johnes *et al.*, 1996). The main pressures associated with livestock relate to production of manure, over grazing of fields and scrub removal with subsequent soil exposure and erosion, in-river poaching releasing sediments and direct voiding into rivers. Where grain is used to feed livestock this will represent a nutrient import to the catchment.

5.1.4.2. Poultry

The main catchment pressure associated with poultry farming relates to the production and spreading of poultry manure to arable land in the catchment. The use of poultry manure as organic fertiliser is part of certain arable agricultural systems. This may be associated with leaching of nitrogen and phosphate into watercourses.

The poultry industry has shown some significant changes over the last decades. Statistics for the Teme District indicate that there was a 150% increase in breeding flock and almost 50% increase in table chickens between 1987 and 1997 (Environment Agency, 1999).

A number of new poultry farms have been consented in the catchment for construction during 2013. These new poultry units are expected to double the licensable catchment population of poultry from in the order of 400,000 birds to close to 900,000. The figure shows data only for units housing over 40,000 birds that require a licence from the Environment Agency. There are other smaller units below this threshold that may be cumulatively significant. In addition, some poultry manure is imported into the Clun from neighbouring catchments (see Appendix J5).

5.1.4.3. Arable land

Agriculture and changes in agricultural practices may lead to changes in the characteristics of land. Disturbing the soil to plant crops significantly increases sediment losses to watercourses as the result of soil erosion. This can cause effects on river-dwelling species such as freshwater pearl mussel by siltation of the gravels within which they live. Catchment pressures associated with tilled land may also include the leaching of organic and inorganic fertilisers into watercourses.

National land cover maps (see Section 3) indicate that the area of arable land has increased over the last decades. Aerial photographs show that this trend has continued between 2006 and 2012 when an additional 1,232ha has been ploughed.

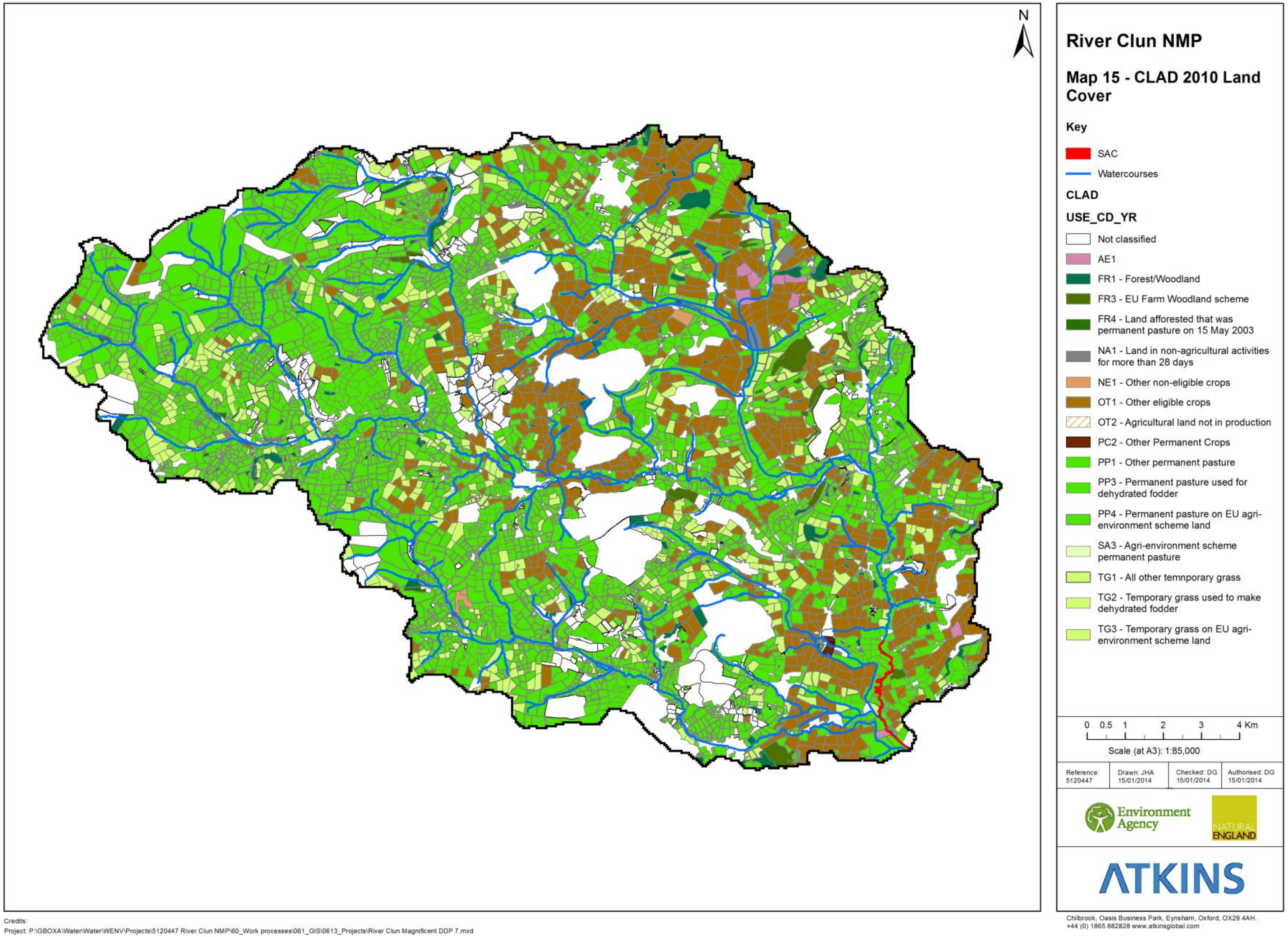
Map 15 shows the current extent of tilled land in the Clun catchment. Defra Agricultural Census data for 2010 indicate that close to 70% of arable land is under cereal (wheat and barley) with the remainder under oats and rye (15%), oil seed rape (11%), crops for stock feeding (3%), maize (2%) and potatoes (1%) (Section 3.8). It is not known whether wheat and barley grown in the Clun catchment is winter or spring sown. This distinction is likely to be important to sediment pressures. Increases in the incidence of soil water erosion on arable land have been associated with the expanded area of winter cereals in England and Wales (Chambers and Garwood, 2000). Cereals, especially winter varieties expose the soils during the wettest times of year. This is shown in Table 5.3 that presents an annual diary of crop cover information for the main crop types in the Clun catchment. The information is presented as percentage cover in each month of the year by crop and is shown colour coded. For example, brown tones showing months when soils are typically bare and at risk from erosion. Green tones show months when the crop is covering the soil and the soil is protected.

The dominant soils of the Clun catchment are susceptible to capping and subsequent erosion (see Section 3) and a number of arable fields in the Clun catchment are on steeply sloping land with visual evidence of significant sediment runoff during autumn and winter storm events (Figure 5.2); previous studies have indicated that arable land is the most important source of sediment to the River Clun during high rainfall periods (Atkins, 2012a) and that roads are an important pathway (Shropshire Hills AONB Partnership, 2013).

Table 5-3 % of field crop cover associated with the main crop types in the Clun catchment.

Crop type	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Winter cereal	88%	95%	95%	88%	0%	18%	18%	27%	27%	27%	32%	68%
Spring cereal	81%	95%	95%	95%	0%	0%	0%	0%	0%	0%	7%	48%
Oilseed rape	95%	95%	78%	0%	48%	72%	81%	86%	86%	86%	92%	95%
Grass <5 years	93%	95%	95%	93%	63%	67%	67%	71%	70%	70%	73%	88%

The colours reflect cover as follows: dark brown = bare (<25% cover), pale brown = partial cover (25-50% cover), pale green = mostly covered (50-75% cover) and green = complete cover (>75% cover). Source of data: ADAS.



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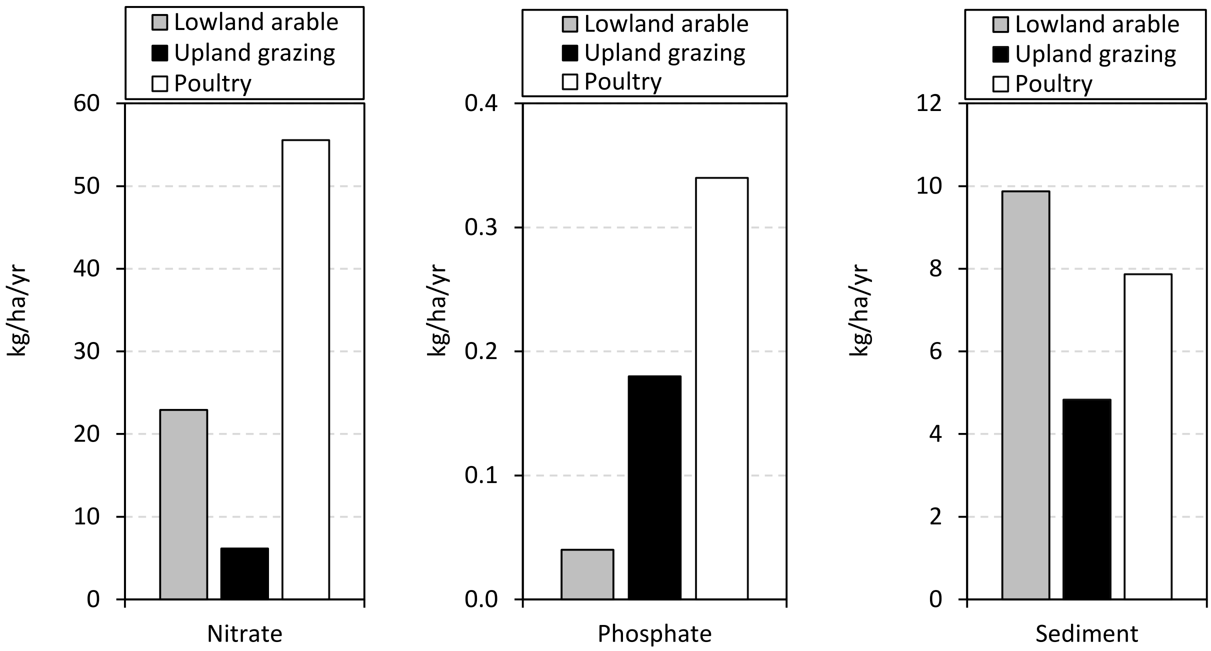


Figure 5-1 Comparison between loads of nitrate, phosphate and sediment generated by a 'typical' arable, livestock and poultry farm according to FARMSCOPER

- Field runoff from an arable field onto road

(b) Road acting as a pathway during flood

(c) Input of sediment to watercourse

(d) General view of silted Mussel habitat

Figure 5-2 Photographs illustrating one of the main pathways of sediment movement from arable fields to the River Clun.

5.1.5. Riparian management and alder disease (*Phytophthora)*

Trees form an intricate part of river form and function. Their roots stabilise banks and reduce erosion. Their living canopy and roots provide habitat in the form of shelter, shade, food and supply of natural organic matter to many species. Dead trees also provide habitat both as standing dead wood and in-stream woody debris and play role in nutrient exchange between riparian and aquatic habitats.

They may shade out algae and reduce water temperature, both of which are likely to be very important to freshwater pearl mussels and their hosts.

A number of factors have contributed to a reduction of tree cover in the riparian margin along the River Clun. Concerns have been raised regarding how more exposed banks may lead to increased erosion and suspended solids in the river. Factors controlling exposure of river banks to erosion in the Clun catchment are as follows:

- **The need to extend productive farm land** has reduced the majority of the Clun's riparian tree habitat to a single line of trees perched along the bank edge. This single line is prone to falling into the river because there is no inland support from other trees through canopy or inter-linked root systems. This has also resulted in a lack of buffer zones and fencing in some areas.
- Natural regeneration of trees in **a heavily grazed environment** such as the Clun floodplain is often curtailed because stock will eat young shoots. Stock will eat seedlings and saplings. Natural regeneration may be difficult in some places due to lack of trees in area providing seed material. Trampling of bank areas may further reduce the chance of new trees establishing and is itself a source of bank erosion and introduction of excessive sediment.
- **Phytophthora** (alder disease) has severely affected the Clun's alder population and, despite an active coppicing programme on the river, very few trees are likely to survive in the long term. This fungal species has been present in the River Clun since the 1990s (thought to be a hybrid of chestnut and strawberry pathogens) has devastated alders across Europe, spreading via water and human movements. At present there is no known cure for the disease; coppicing extends the life of a tree but does not eliminate the disease.

Table 5-4 Photographs showing erosion of river banks in the Lower Clun. From a survey on 22nd July 2013.

(a) Silty clay bank exposure on the Clun SAC	(b) Grazing to river edge
	
(c) Imminent tree collapse and bank loss	(d) Himalayan balsam
	

5.1.6. Non-native species

Non-native species such as Himalayan Balsam, Giant Hogweed and Japanese Knotweed form monocultures which shade out native species. It has been estimated that 41km of watercourses in the Clun catchment have Himalayan Balsam (Table 5.4.d) to an average width of 3m either side of the watercourse (AONB, Pers. Comm., AONB). This equates to a total catchment extent of 24.6ha. Whilst this vegetation can provide bank protection during the growing season, it also exposes un-vegetated areas to erosion when it dies back.

5.1.7. River management

The bed of River Clun has historically been dredged to remove sediment build up. Gravel removal and dredging mobilises fine material that has settled. Dredging causes over-deepening, straightening and modification of the natural river morphology. This is linked to an increase in erosion, a decoupling of the river-floodplain relationship, a decrease in heterogeneity of the river and loss of habitat (also important for hosts). Draining land by dredging drainage ditches causes extremes of flow in the river, rather than letting the land act as a sponge – sucking up excess water during heavy rain and releasing water during drought supplementing flows. Freshwater pearl mussel can be physically damaged by in-stream works. Gravel is important in the egg, alevin and juvenile life stages of salmonids. A decrease in salmonid habitat can therefore adversely impact freshwater pearl mussel which use them as hosts. In theory the natural flows of the river should mobilise and remove naturally eroded fine material from the system in a way local freshwater pearl mussels are adapted to.

5.2. Future pressures and trends

5.2.1. Development, population growth and housing

The Clun SAC flows through the Shropshire Council (SC) Local Planning Authority boundary. SC are currently consulting on the development of their Site Allocation and Management of Development (SAMDev) Plan which will identify the locations and amounts of development expected to take place in the catchment until 2027 whilst fulfilling their obligations under the Habitats Regulations.

Additional population growth in settlements is estimated to increase the current catchment population by 574 persons or 8% (Appendix J3). Additional growth in employment land is estimated to increase the current catchment flows by 22,000m^3 (Appendix J4).

Ordinarily, the preferred disposal route for foul effluent from any development is via a public sewer (where one exists) and treated at a public sewage treatment works (STW). However in the case of the Clun it has been suggested that there should be no increase in the wastewater entering the public sewer as this would increase the level of phosphate entering the Clun SAC from the STWs until such time as additional capacity has been made available by Severn Trent Water. Since the current level of phosphate in the Clun SAC is considerably higher than the favourable condition targets, there is little or no environmental capacity within the river to accept additional phosphate without other actions for phosphate management being in place (Natural England, Pers. Comm.).

5.2.2. Agricultural change

Agricultural practices within the Clun catchment have changed over the past decades. An example of this are increases in poultry numbers. Although it is not possible to predict the future when it comes to agriculture in the catchment, it is assumed that as market forces change the agricultural practices within the catchment could change similarly in the future. For example, there is a biomass plant in the Lower Clun that is growing maize as biofuel and local stakeholders indicate this practice may become more significant in the future.

5.2.3. Planned improvements in wastewater treatment

The future landscape for technology to reduce P at point sources is uncertain and not possible to specify at this stage, but it is likely that technological advances will enable more thorough removal of P prior to release into the environment. Some examples of the treatment options both currently and in the future are given in Table 5.5 below.

Table 5-5 Examples of current and future treatment options for point sources

Technology	Type	Limit	Note
Current	Chemical precipitation - dosing with iron or aluminium salts	Between 1.0mgTP/L to <0.1mgTP/L	Ultra-low discharge concentration reported in studies undertaken in the USA. Potential implications from new WQ standard for iron.
	Biological phosphorus removal	1.0mgTP/L	<1.0mg/L in combination with other technology options.
	Tertiary filtration	Between 1.0mgTP/L and 0.05mgTP/L	Final effluent polishing step - no examples of use within UK.
Future	Membrane bioreactors	<0.05mgTP/L	Membrane technology
	Reverse osmosis	<0.01mgTP/L	Membrane technology
	Blue-PROTM	<0.1mgTP/L	Moving bed sand filter with upstream ferric salt conditioning
	Fuzzy filters	<0.2mgTP/L	Compressible Medium Filters (porous synthetic media)

5.2.4. Legislation on detergents

Modern laundry detergents no longer contain phosphates due to a ban came into effect in June 2013. The law, however, did not apply to dishwasher detergents. EU member states recently agreed to proposals aimed at reducing the use of phosphorus compounds in dishwasher detergents; by 2015 there will be limits on the phosphate content of these and other cleaning products. It has been estimated that this will take 1mg/l off the effluent concentrations on works that do not have P stripping already in place (Severn Trent Water, Pers. Comm.). Indeed, Figure 4.2 shows a generally declining trend in the phosphate concentrations of STW effluent in the Clun catchment that illustrates the important role such external factors may play in offsetting population growth.

5.2.5. Climate change

It is recognised that climate change in the long run may result in changing patterns of rainfall and water availability and this may dictate agricultural practices through soil conditions and availability of irrigation water, however at this stage it is not possible to quantify the exact effects of climate change and therefore this has been included in the uncertainty factor within the modelling.

6. Source apportionment

This section quantifies the sources of phosphate, suspended solids and Total Oxidised Nitrogen in the Clun catchment. Understanding the sources of nutrients and sediments is the first step for targeting the causes of observed environmental issues and the mitigation measures that are most likely to lead to an improvement in the environmental condition of the River Clun SAC.

6.1. Phosphate

6.1.1. What information is available?

The relative importance of different phosphate sources in the River Clun catchment has been investigated as follows:

1. Using a **Source Apportionment GIS (SAGIS) model** for the River Clun catchment. SAGIS is a joint water industry/Environment Agency tool. Model performance was checked against observed flow and phosphate concentration data. Where necessary, flow calibration was carried out to improve model performance. Predicted phosphate concentrations were calibrated to measured values at different locations along the river. Appendix K provides further details regarding the modelling methodology, calibration and set up, as well as a guide to interpreting the model output results.
2. In line with stakeholder suggestions during the consultation period, **measured data** for the Clun catchment have been used to develop a phosphate mass balance for the River Clun at Leintwardine that compares the measured mean annual loads of phosphate in the River Clun at Leintwardine to the volumes generated by STW effluents in the catchment as a means of complementing the SAGIS modelling data.

The use of model outputs complemented by a mass balance assessment using monitoring data responds to suggestions by local stakeholders during consultation undertaken as part of the investigation and provides a more robust and complete evidence base to support the NMP, testing the outcomes of modelling results.

6.1.2. How are the data presented?

The results of the phosphate source apportionment are presented as follows:

- Figure 6.1 overleaf shows how phosphate levels and their sources vary along the main channel of the River Clun under current conditions (i.e. excluding growth) according to outputs from the SAGIS model of the Clun catchment.
- Figure 6.2 provides a summary of the current apportionment of phosphate in the River Clun SAC at Leintwardine according to the SAGIS model of the Clun catchment.
- Table 6.1 presents the results of the average annual mass balance assessment for the Clun catchment comparing the total loads of phosphate in the River Clun SAC at Leintwardine to estimates of loads from STWs in the catchment.

6.1.3. What are the most important sources?

The SAGIS model shows that throughout most of the river, diffuse pollution sources account for about two thirds of the annual phosphate loads with point sources accounting for the remainder (Figure 6.1). In the River Clun SAC at Leintwardine, livestock accounts for in the order of 55% of phosphate loads followed by STWs (35%), arable land (5%), OsWwTWs (2%) and urban inputs (1%) (Figure 6.2). The phosphate mass balance approach using monitoring data indicates a smaller contribution from STWs in the order of 18% under average conditions (see Table 6.2).

6.1.3.1. Livestock

Livestock provide the single largest source of phosphate in the Clun catchment. Table 6.2 provides an estimate of the potential breakdown of different livestock types in the catchment based on export coefficient rates proposed by Defra (White and Hammond, 2006) for use in areas of upland and moorland areas designated as Less Favoured Areas such as much of the River Clun catchment (see Section 3.6). Information provided by Defra indicates that there are close to 14,000 cattle, 120,000 sheep, 410,000 poultry and 150 pigs in the catchment (see Table 3-6). The breakdown of catchment-scale livestock sources according to this methodology is as follows: Sheep (46%), poultry (28%) and cattle (25%).

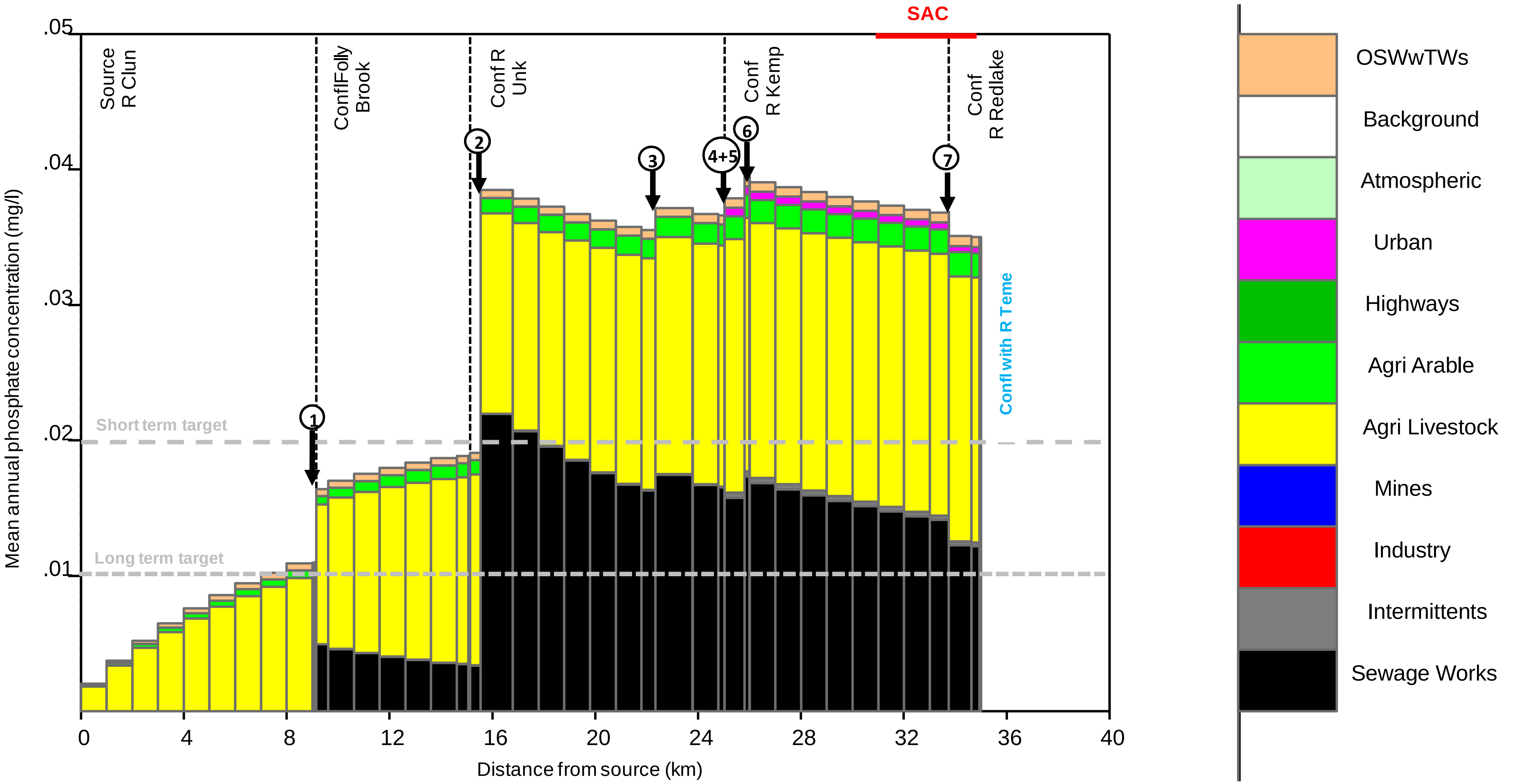


Figure 6-1 SAGIS predicted in-river phosphate concentration for the River Clun from its source to its confluence with the River Teme at Leintwardine.

This is under current conditions with no growth and based on measured (not fully licensed) STW effluent phosphate concentrations. Confluences with different WFD water bodies are labelled as are STWs according to where they inflow to the main channel of the River Clun as follows (1) Newcastle-on-Clun STW; (2) Clun STW; (3) Clunbury STW; (4 and 5) Bishops Castle STW and Lydbury North STW; (6) Aston-on-Clun STW and (7) Bucknell STW.

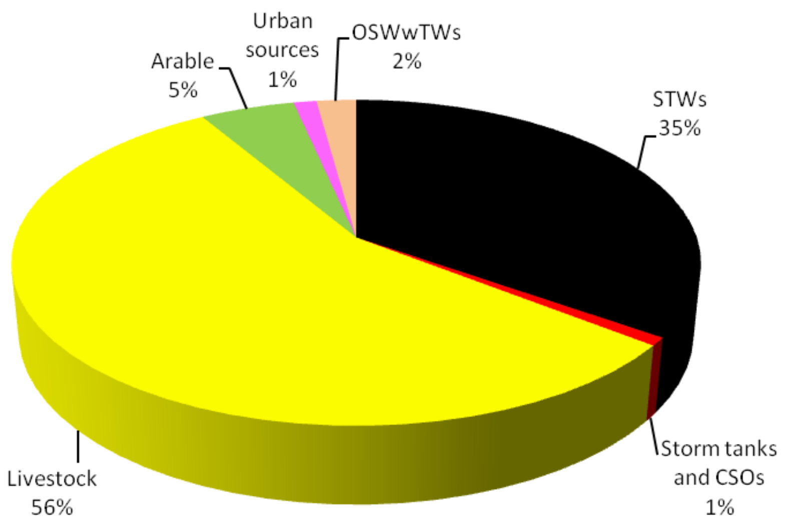


Figure 6-2 Summary source apportionment for the River Clun SAC at Leintwardine under current conditions (excluding growth)

Table 6-1 Estimated importance of different livestock types based on a standard export coefficient approach applied to Defra livestock data for the Clun catchment for the year 2010. Export coefficients used are applicable to 'upland Less Favoured Areas' given by White and Hammond (2006). Poultry numbers include predicted increases in population to end of 2013 according to the Environment Agency (see Appendix J5).

Livestock type	Numbers of livestock (Defra, 2010)	TP Export coefficient (kg/head/year)	Phosphate/TP ratio	Phosphate load (kg)	% of total
Sheep	119,282	0.023	0.50	1,372	46%
Cattle	13,914	0.096	0.56	748	25%
Poultry	800,000	0.003	0.35	840	28%
Pigs	159	0.072	0.55	6	0.2%
			TOTAL	**2,966**	**100.0%**

Table 6-2 Comparison between mean annual estimated phosphate loads in the River Clun SAC at Leintwardine and the contribution from Sewage Treatment Works

Monitoring location	Mean Flow (m^3 day)	Total annual flow (m^3)	Mean phosphate concentration (mg/l)*	P load (kg/day)	P load (kg/yr)	% of total river load
Bishops Castle STW	608	221,863	0.46	0.28	102	2%
Clun STW	160	58,414	5.23	0.84	306	7%
Lydbury North STW	143	52,199	2.84	0.41	148	4%
Bucknell STW	273	99,813	0.61	0.17	61	1%
Newcastle-on-Clun STW	34	12,376	4.63	0.16	57	1%
Aston-on-Clun STW	42	15,226	5.22	0.22	79	2%
Clunbury STW	9	3,257	5.22	0.05	17	0%
Clun at Leintwardine[α]	340,416	124,251,840	0.035[¥]	11.57	4,225	100%

**Mean annual effluent discharge concentrations for STWs from UKWIR (2013) ¥Based on data presented in Table 4.2 . αMean annual flow in the River Clun at Leintwardine is 3.94 cumecs*

6.1.3.2. Sewage Treatment Works

There are seven Severn Trent Water STWs in the catchment. Two of these wastewater treatment works (Bucknell and Bishops Castle STWs) have phosphate removal. Table 6.2 investigates current contributions of STWs and shows which ones currently provide the largest loads of phosphate to the river. The results are shown graphically in Figure 6-3. Flow and phosphate concentration data used in this assessment have been confirmed with Severn Trent Water who is responsible for the works.

Following phosphate removal at Bishops Castle STW and Bucknell STW these works now provide smaller proportion of phosphate loads to the river, in combination contributing approximately 20% of total STW-derived phosphate in the River Clun catchment. The most significant STWs in the Clun catchment are currently those at Clun and Lydbury North. In combination, these two STWS currently contribute close to 60% of the total STW-derived phosphate load in the catchment (Figure 6-3). It is important to note that no recent effluent phosphate concentration data are available for either of these two STWs and this assessment is based on the averages of data for the period 2006 and 2008. In the case of Newcastle-on-Clun STW this assessment is based on effluent concentration data for the period 1998-2006 (see Table 6.3).

Table 6-3 Relative importance of different STWs in the Clun catchment. Source of data: Environment Agency and Severn Trent Water.

Sewage Treatment Works	Population served	Mean daily flow (m^3)	Mean annual phosphate concentration (mg/l)	Phosphate concentration data used to derive mean	Total phosphate load (kg/yr)	%
Bishops Castle	1943	608	0.46	2007-2012	102	13%
Clun	690	160	5.23	2006-2008	306	40%
Lydbury North	285	143	2.84	2006-2008	148	19%
Bucknell	834	273	0.61	2010-2012	61	8%
Newcastle-on-Clun	152	34*	4.63	1995-2008	57	7%
Aston-on-Clun	187	42*	5.22	2006-2008	79	10%
Clunbury¥	30	7*	5.22	Estimated‡	13	2%
			TOTAL		**766**	**100%**

*Flow estimates from measured data 2010-2012 provided by Severn Trent Water except *estimated from PG+I, where G= 136l/h/d and I is assumed to be 30% of PG. G x 1.3 then gives mean flow. ¥Clunbury STW population served includes 4 houses and a primary school (with 3 classes + staff). Estimated at 30PE. ‡ in the absence of any phosphate concentration estimates for effluent from Clunbury STW, concentrations assumed to be equivalent to Aston-on-Clun.*

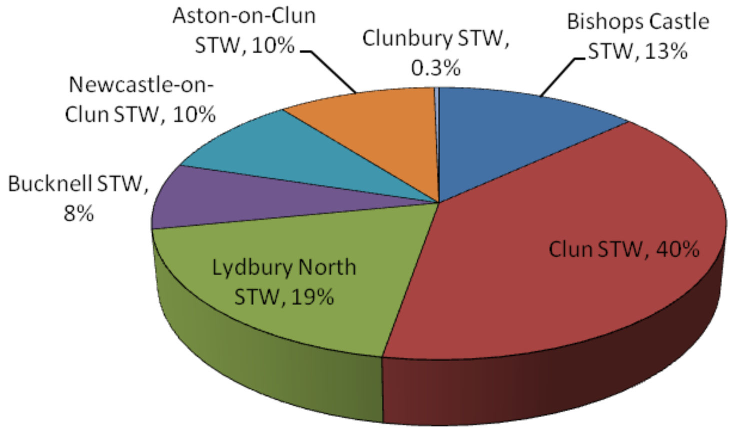


Figure 6-3 Graphical representation of the STW source apportionment for the Clun catchment (based on data shown in Table 6.3).

6.1.3.3. Arable

Arable farming provides a smaller source of phosphate to the River Clun (5%). Table 6.4 provides an estimate of the annual contributions of different types of arable cropping in the Clun catchment based on export coefficient rates proposed by Defra (White and Hammond, 2006).

Phosphate sources for the arable farming sector in the Clun catchment are dominated by wheat and barley that in total account for 65% of the total phosphate load associated with arable farming. This reflects the large proportion of arable land in the catchment devoted to cereal farming (70% of tilled land in the Clun catchment is cultivated for cereals according to Defra data - see Section 3.6.1).

Table 6-4 Relative importance of different arable crops based on catchment data provided by Defra (2010) and export coefficients proposed by White and Hammond (2006). Although export coefficients are expressed on an annual basis, in reality the application of fertiliser is typically focussed on the spring and autumn months (BSFP, 2008).

Crop type	Catchment extent (Defra, 2010)	TP Export coefficient (kg/ha/year)	Phosphate/TP ratio	Phosphate load (kg)	% of total
Wheat	1,366	0.6	0.35	287	33%
Barley	1,396	0.6	0.35	293	34%
Oats & rye	617	0.6	0.35	130	15%
Maize	80	0.6	0.35	17	2%
Potatoes	52	0.6	0.45	14	2%
Oilseed rape	456	0.6	0.35	96	11%
Stockfeeding crops	129	0.6	0.45	35	4%
TOTAL	4,096	-	-	871	100%

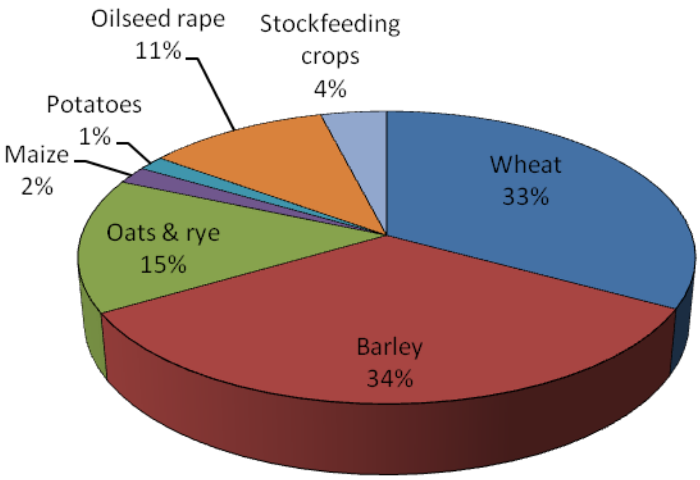


Figure 6-4 Graphical representation of the Relative importance of different arable crops in the STW source apportionment for the Clun catchment (based on data shown in Table 6.4).

6.1.3.4. On-site Wastewater Treatment Works (OsWwTWs)

OsWwTWs provide an overall small contribution at the catchment scale, in the order of 2%.

6.1.3.5. Urban and road sources

Urban sources provide an equally small contribution at the catchment scale, in the order of 1% of the annual phosphate balance. Roads themselves are not a source of phosphorus, nitrogen or sediment although they provide an important role as a flow pathway (see Figure 6-2).

6.1.4. Seasonal variations

Figure 6-5 shows the results of the mean monthly mass balance assessment for the River Clun SAC. The assessment is based on the mean monthly flows for STWs between 2010 and 2012, the mean monthly phosphate concentrations in the River Clun SAC and flows.

This shows that whilst the model provides a mean annual estimate of the apportionment of phosphate this will vary throughout the year. Seasonal variations in the apportionment may be important for targeting measures to control for example algal development as this is primarily a spring and summer process.

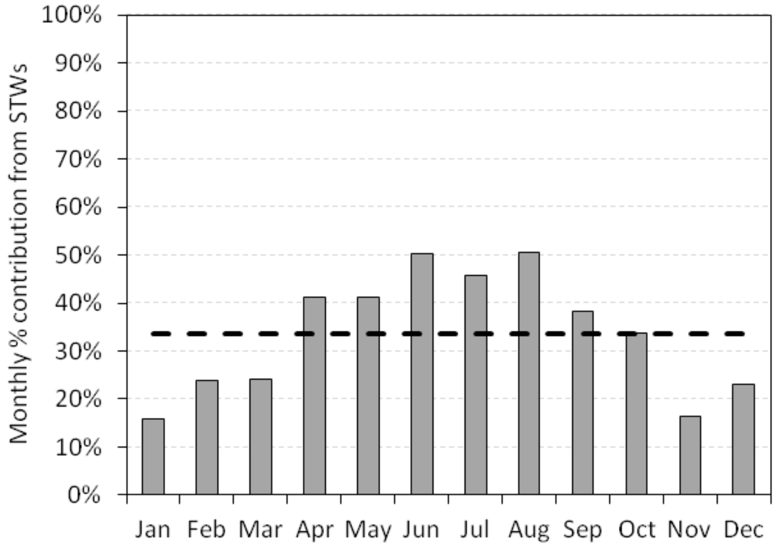


Figure 6-5 Seasonal variations in the contributions of STWs to the phosphate balance of the River Clun SAC.

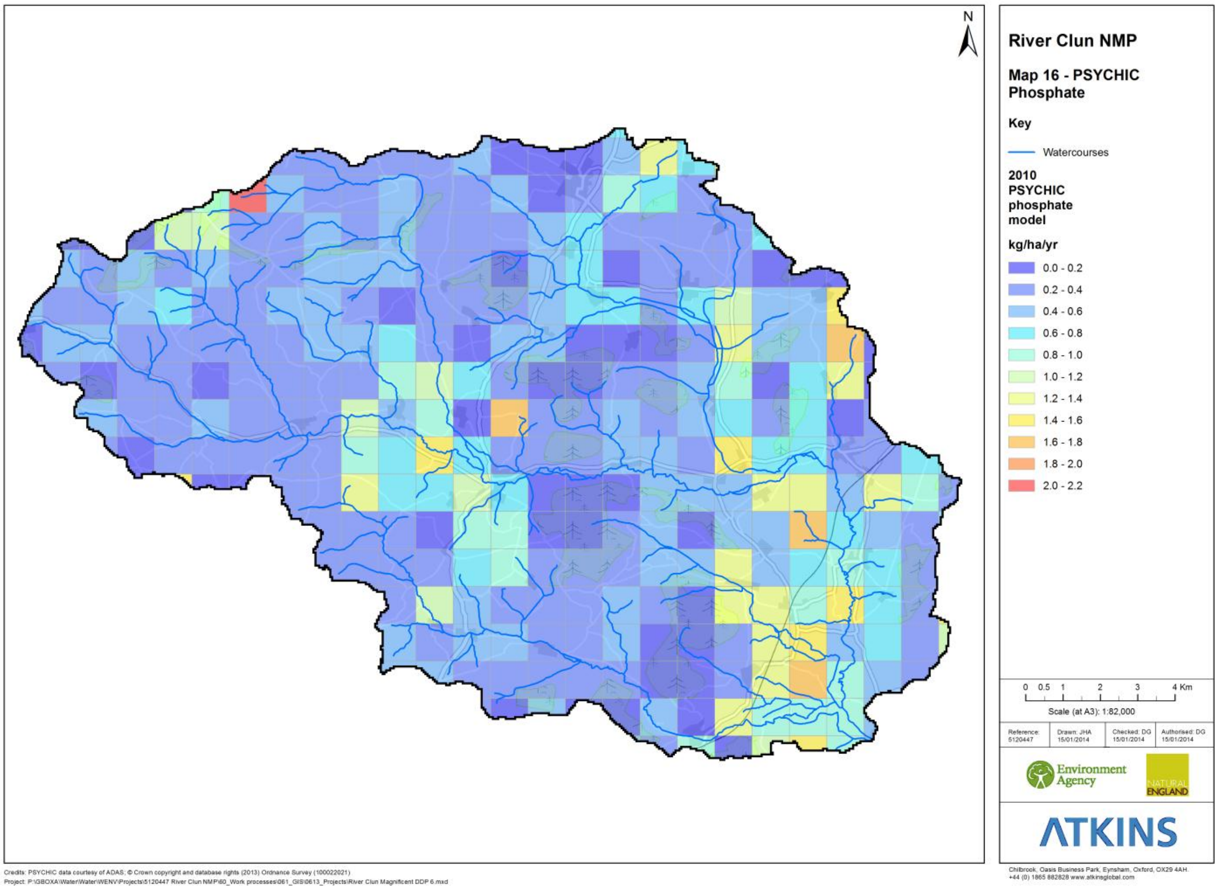
6.1.5. Spatial distribution

Map 16 shows a map of phosphate hotspots in the Clun catchment based on PSYCHIC data. PSYCHIC data are the input data used by the SAGIS model and is a Defra-funded data set developed over the last decade by the Agricultural Development Advisory Service (ADAS) to help manage phosphorus inputs to rivers. To protect the anonymity of individual land-holdings, the information is provided as a 1x1km (100ha) grid of the whole of England. This currently represents the best-available information describing how phosphate pressures vary across the Clun catchment.

Table 6.5 summarises the PSYCHIC data according to WFD water bodies in the Clun catchment.

Table 6-5 WFD water body assessment of PSYCHIC phosphate data

EA Water body Name		Area (km^2)	P export	% of total catchment load
Upper Clun	R Clun - source to conf Folly Bk	23.33	7.3	5%
Folly Brook	Folly Bk - source to conf R Clun	14.51	6.3	5%
River Unk	R Unk - source to conf R Clun	29.45	13.8	10%
Middle Clun	R Clun - conf Folly Bk to conf R Unk	19.06	10.9	8%
River Kemp	R Kemp - source to conf R Clun	60.51	26.4	19%
River Redlake	R Redlake - source to conf R Clun	49.38	23.4	17%
Lower Clun	R Clun - conf R Unk to conf R Teme	76.01	48.3	36%
	Grand Total	**272.25**	**136.4**	**100%**



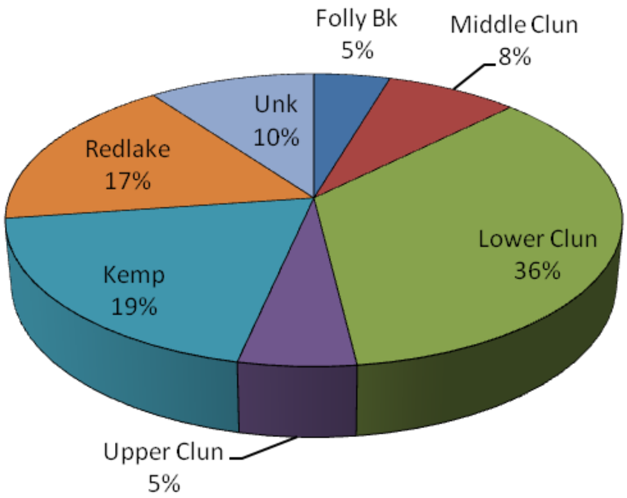


Figure 6-6 Contributions of different WFD water bodies to total diffuse phosphate loads in the Clun catchment. Based on PSYCHIC output.

6.1.6. Data gaps, assumptions and limitations

The phosphate source apportionment presented in this section has been undertaken using the best available information currently available for the Clun catchment. This review and subsequent discussions during the stakeholder review process have identified the main data gaps summarised below. Later sections of this plan set out a potential monitoring programme to address some of the data gaps that influence the phosphate source apportionment.

Data gap		Comment
1	**STW flow data**	There are currently no measured flow data for the smaller STWs in the catchment. At this stage, phosphate source apportionment modelling has used mean annual flows derived from quoted populations served and industry-standard approaches for flow estimation in the absence of measured flow data
2	**STW effluent concentrations**	There is currently no monitoring of the effluent phosphate concentrations in some of the smaller STWs in the Clun catchment. This reflects the fact that the smaller works do not currently have phosphate discharge limits. Although the current assessment shows that these two works in combination provide the greatest STW effluent-derived phosphate load in the catchment the only STW phosphate effluent concentration data available for the Clun and Lydbury North STWs are for the period between 2006 and 2008. To this regard, Severn Trent Water will be undertaking a programme of monitoring at these works as part of an early start project during Asset Management and Planning 6 (AMP6).
3	**River flow data**	There is no formal gauging station on the River Clun and flow estimation as part of the assessment is based on a rating relationship derived using spot flow and water level data collected at Leintwardine. This location includes the flow in the Upper Teme and assumptions regarding the similarity of both catchments are necessary. Elsewhere within the Clun catchment, the understanding of flows in the minor tributaries is limited by the limited historic spot monitoring in the catchment. However, it is acknowledged that the similarity of the geology and soils both within the Clun itself and between the Clun and the Upper Teme does indicate that the current flow estimation approach is likely to provide a reliable estimate of flow under most conditions.
4	**Phosphate detection limits**	The orthophosphate detection limit used nationally by the Environment Agency changed in 2011. Orthophosphate data prior to this period will not have been analysed to a lower detection level and comparing historic data to post 2011 data has to be carried out with caution (Environment Agency, Pers. Comm.) where levels close to the 0.01 mg/l detection limit are apparent.
5	**Phosphate controls on algal growth**	Phosphate itself is not thought to be toxic to freshwater pearl mussel but is likely to control algal growth in the river. Consequently, it will be important going forward to include chlorophyll-*a* in the suite of determinands monitored in the River Clun SAC (and at other catchment locations if deemed necessary) to help understand the interplay between phosphate concentrations, algal growth and the impact pathways between water quality and freshwater pearl mussel.
6	**Annual targets vs seasonal controls on impact pathways**	Freshwater pearl mussel favourable condition targets use mean annual phosphate concentrations as a means of protecting the species. It is likely that seasonal variations in phosphate source apportionment may drive the identification of the most suitable measures to pursue for the delivery of favourable condition in the River Clun by 2027.
7	**SAGIS calibration methodology and model update**	The Environment Agency is currently in the process of agreeing a national approach for the calibration of SAGIS. As part of this initial iteration of the Nutrient Management Plan, the most current calibration approach as applied on other NMPs has been used. This is an extension of the Simcat auto-calibration approach. The current calibration approach assumes that the typical overestimation of phosphate concentrations is related to diffuse sources. Consequently, the calibration methodology involves the step-wise reduction of diffuse sources until a model match is achieved. Due consideration should be given to revisiting the SAGIS calibration once the national approach has been tested and agreed. This model update would be timed to coincide with the availability of new STW flow and effluent concentration data that will be collected early during AMP6 to ensure the most up to date representation of pressures at the time of the review.

As part of this initial iteration of the Nutrient Management Plan, data gaps have been dealt with by calibrating and setting up models using the best available data at the time of production, making industry-standard assumptions where required (e.g. STW flow and concentration data), and comparing the results of different types of assessments (e.g. using modelling and monitoring data). In combination, these provide a way of testing uncertainties in the data and the assumptions made, identifying likely ranges and establishing whether and how they affect the overall outcome of findings.

In line with the ethos of the Habitats Directive that drives protection of Natura 2000 sites, where multiple data have been available the precautionary worst case outcome has been adopted and taken forward to an options appraisal where the measures to deliver favourable condition have been assessed.

6.2. Nitrogen

6.2.1. What information is available?

The relative importance of different nitrogen sources in the River Clun catchment has been investigated as follows:

1. The Environment Agency (2010) considered the apportionment of Nitrogen in the Clun catchment during the **Habitats Directive Stage 3 assessment. A SIMCAT water quality model** was used to consider the relative balance of diffuse and point sources in the catchment. SIMCAT is the normal Agency mathematical river water quality modelling tool that is used to represent river quality impacts resulting from both point source and diffuse sources.
2. Comparison between diffuse and point sources of nitrogen using the National Environment and Agricultural Pollution Nitrate (NEAP-N) dataset (Lord and Anthony, 2000) and estimated STW effluent loads. **NEAP-N** is a national scale tool for predicting concentration of nitrate in leachate from agricultural land for every 1km² in England and Wales and underpins Defra nitrate policy and is a key component of the Environment Agency method for defining NVZs. It also includes the component of leachate that is derived from atmospheric deposition.
3. In line with stakeholder suggestions during the consultation, **monitoring data** for the Clun catchment have been used to develop a nitrogen mass balance for the River Clun at Leintwardine that compares the mean annual loads of nitrogen in the river to the volumes generated by STW effluents in the catchment as a means of complementing the SIMCAT modelling data.

Combining these different methods provides a more robust and complete evidence base to support the NMP, testing the outcomes of modelling results.

6.2.2. How are the data presented?

The results of the different nitrogen source apportionment approaches are presented as follows:

- Figure 6.7 provides a summary of the apportionment of nitrogen in the River Clun SAC at Leintwardine according to the Environment Agency (2010) Habitats Directive Stage 3 SIMCAT water quality model.
- Table 6.6 compares the outputs from the NEAP-N model of the Clun catchment to calculated loads from STWs in the catchment.
- Table 6.7 presents the results of the mean annual nitrogen mass balance assessment for the Clun catchment comparing the total loads of nitrogen in the River Clun SAC at Leintwardine to loads from STWs in the catchment.

6.2.3. What are the most important sources?

The SIMCAT modelling shows that the Sewage Treatment Works and other industries discharging at their consented maximum load are responsible for only 1% of the catchment Total Nitrogen load (Figure 6.7). Results obtained from the application of other methods provide similar conclusions regarding the limited contribution of STWs to the catchment nitrogen balance, highlighting that most of the catchment nitrogen load is sourced from diffuse (agricultural) and natural background sources. Atmospheric sources account for in the order of 6% of the annual nitrogen budget of the catchment (see Table 6.7).

NEAP-N data available does not currently provide a means of identifying the precise diffuse sources that make up the nitrogen contribution.

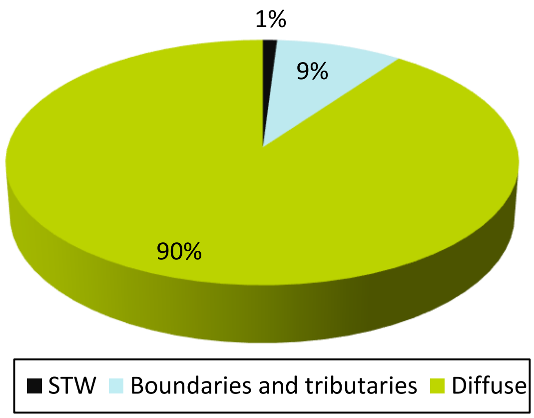


Figure 6-7 Nitrogen source apportionment for the Clun catchment. Source of data: Environment Agency (2010) Stage 3 Habitats Directive Investigation.

Table 6-6 Nitrogen source apportionment for the Clun catchment using NEAP-N

Source	Load (kg)	% of total	Assumptions
Diffuse agricultural	656,401	92%	NEAP-N data currently available is for 2004 and includes atmospheric deposition at the rate below
Atmospheric	43,562	6%	Calculated at the rate of 1.6kg/ha/yr (UKWIR, 2013) and a catchment area of 27, 226ha
STWs	7,975	1%	Based on measured flow data and a precautionary mean effluent concentration of 17.22 mg/l (UKWIR, 2013)
OsWwTWs	6,582	1%	Population-weighted from STW loads where 4,131 persons on mains sewerage and 3,041 on OSWwTWs
TOTAL	714,520	100%	

Based on the total flow in the year of 2004 the estimated total catchment nitrogen load gives an estimated concentration of 5.1mg/l compared to a measured concentration of TON in 2004 of 4.9 mg/l.

Table 6-7 Comparison between mean annual estimated loads of Total Oxidised Nitrogen in the River Clun SAC at Leintwardine and the contribution from Sewage Treatment Works from mass balance assessment

Monitoring location	Mean Flow (m^3 day)	Total annual flow (m^3)	Mean TON concentration (mg/l)	TON load (kg/day)	TON load (kg/yr)	% of total river load
Bishops Castle STW	608	221,863		10.47	3,820	0.70%
Clun STW	160	58,414		2.76	1,006	0.18%
Lydbury North STW	143	52,199		2.46	899	0.16%
Bucknell STW	273	99,813	17.22*	4.71	1,719	0.31%
Newcastle-on-Clun STW	34	12,376		0.58	213	0.04%
Aston-on-Clun STW	42	15,226		0.72	262	0.05%
Clungunford STW	9	3,257		0.15	56	0.01%
STW Total	1269	463,148		21.85	7,975	-
River Clun at Leintwardine[α]	*340,416*	*124,251,840*	*4.4[¥]*	*1,498*	*546,708*	-
Total STW TON loads as a function of total river flow						**1.5%**

**Mean annual effluent discharge concentrations for STWs from UKWIR (2013) ¥Based on data presented in Table 4.4 . αMean annual flow in the River Clun at Leintwardine is 3.94 cumecs (see Section 3.6)*

6.2.4. Spatial variations

Map 17 overleaf shows a map of the nitrate hotspots in the Clun catchment based on NEAP-N data. Table 6.8 considers how diffuse nitrogen sources vary across the Clun catchment. In combination the Lower Clun and Kemp catchments account for close to 60% of the total Clun catchment diffuse nitrogen load and have the highest rate of export per unit area.

Table 6-8 WFD water body assessment of NEAP-N data

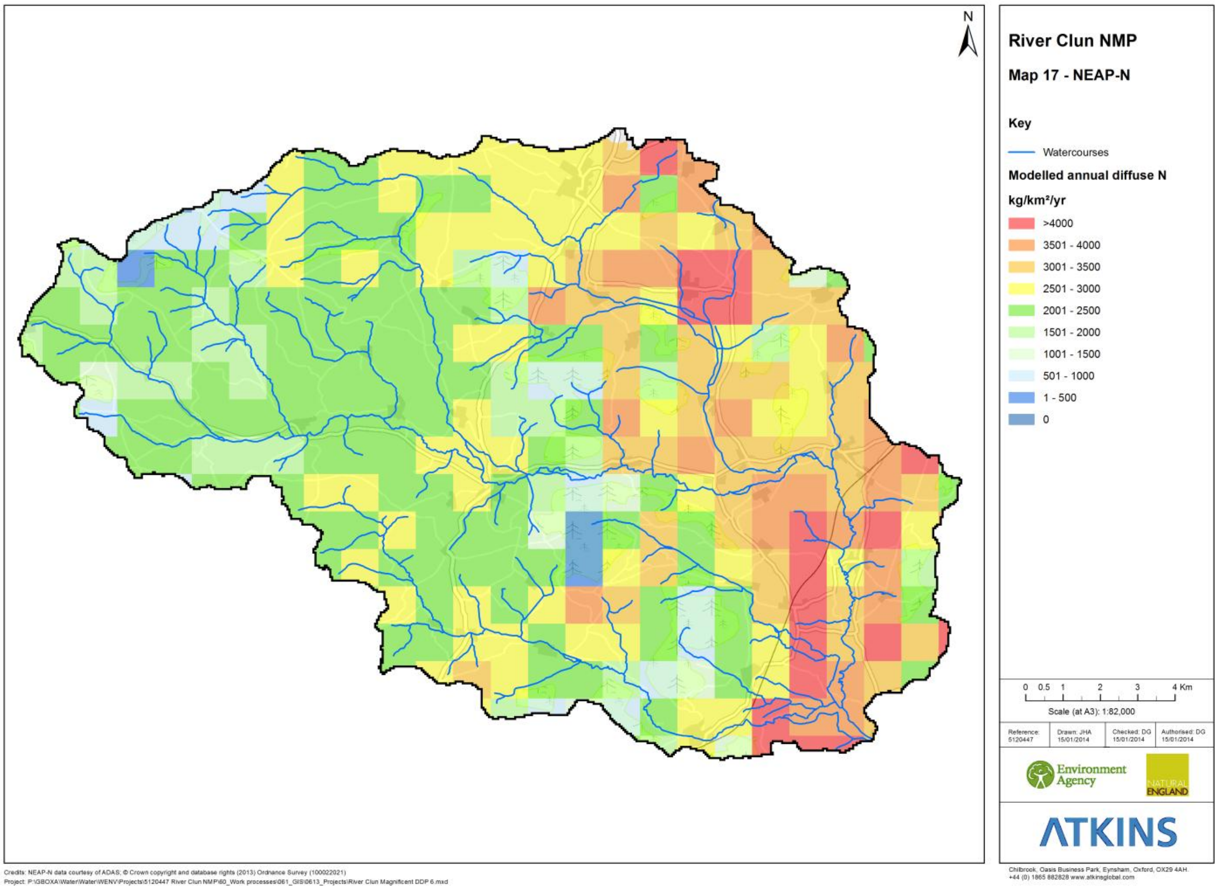
EA Water body name		Area (km^2)	N (kg/yr)	% of total catchment load	N (kg/ha)
Upper Clun	R Clun - source to conf Folly Bk	23.32	44,795	6%	19
Folly Brook	Folly Bk - source to conf R Clun	14.51	24,901	4%	17
River Unk	R Unk - source to conf R Clun	29.43	68,443	10%	23
Middle Clun	R Clun - conf Folly Bk to conf R Unk	19.07	43,278	6%	23
River Kemp	R Kemp - source to conf R Clun	60.25	178,371	26%	30
River Redlake	R Redlake - source to conf R Clun	49.37	120,132	17%	24
Lower Clun	R Clun - conf R Unk to conf R Teme	76	220,044	31%	29
	Grand Total	**271.95**	**699,963**	**100%**	**-**

6.2.5. Data gaps, assumptions and limitations

The nitrogen source apportionment presented in this section has been undertaken using the best available information currently available for the Clun catchment. This review and subsequent discussions during the stakeholder review process have identified the main data gaps summarised below.

Data gap		Comment
1	STW effluent concentrations	There is currently no monitoring of the effluent TON concentrations in the STWs in the Clun catchment. This reflects the fact that none of the STWs have nitrogen discharge limits. To this regard, industry-standard assumptions regarding the concentration of TON in STW effluent have been made as part of the assessment. Natural England and the Environment Agency should consider whether nitrogen monitoring should be built into the Severn Trent Water monitoring programme during the Asset Management and Planning 6 (AMP6).
2	Nitrogen controls on algal growth	Nitrogen itself is not thought to be toxic to freshwater pearl mussel but is likely to control algal growth in the river. Due regard should be given to establishing the interplay between phosphate, TON, algal growth and the impact pathways between water quality and freshwater pearl mussel. A particular focus should be an assessment of the conditions at which nitrogen might become limiting to algal growth in the River Clun.
3	NEAP-N update	The current assessment is based on NEAP-N for the year 2004. This is currently being updated as part of an Environment Agency project. Due regard should be given to updating the assessment once a new NEAP-N dataset for 2010 becomes publicly available.
4	NEAP-N apportionment	Currently, NEAP-N data available does not distinguish between different diffuse agricultural sources (e.g. arable and livestock). As part of update described above, the datasets required to distinguish between these sources are being developed as part of a formal incorporation of NEAP-N to the SAGIS source apportionment model.

As part of this initial iteration of the Nutrient Management Plan, data gaps have been dealt with by calibrating and setting up models using the best available data at the time of production, making industry-standard where required (e.g. STW flow and concentration data), and comparing the results of different types of assessments (e.g. using modelling and monitoring data). In combination, these approaches provide a way of testing uncertainties in the data and the assumptions made, identifying likely ranges and establishing whether and how they affect the overall outcome of findings.



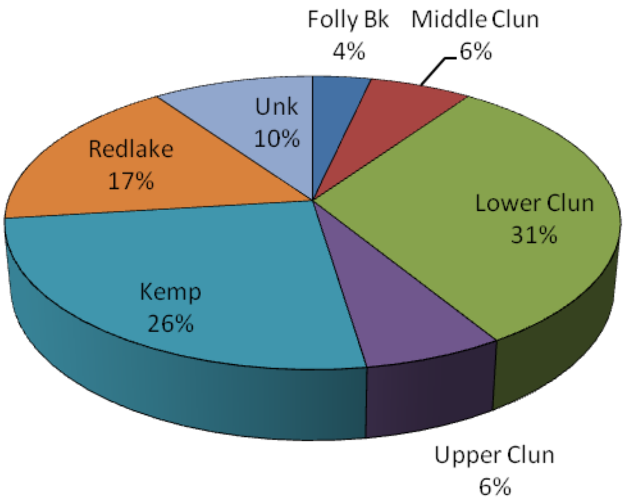


Figure 6-8 Contributions of different WFD water bodies to total diffuse nitrogen loads in the Clun catchment. Based on NEAP-N output.

6.3. Sediment

6.3.1. What information is available?

A number of recent studies have considered the sources of sediment in the Clun catchment as follows:

- The effects of sediment erosion in the Clun catchment extend beyond the catchment boundary. A 2005 report (WRc 2005a and 2005b) confirmed that the Rivers Clun and Corve are the major contributors to the levels of suspended solids in the River Teme system and that 99% of suspended solids in these tributaries originate from diffuse sources.
- Jacobs Babtie (2006) undertook a walkover survey of the channel of the River Clun identified bank erosion through natural fluvial processes as an important source of sediment to the river, occurring along 13% of the river length. Poaching by cattle was seen along 4% of the river. Surface runoff was also seen to be a sediment source. 70% of the river is lined by trees, which help to stabilise the banks. 29% of the river was lined with appropriate fencing and riparian buffer strips were only present on around 5% of the river.
- Atkins (2012) undertook a fluvial audit and a wet weather survey commissioned by Natural England and the Environment Agency in 2012. The survey strongly suggests that the principal source of fine sediments in the Clun is from agricultural land. Most of the pathways observed were roads and track ways.
- Shropshire Hills AONB Partnership (2013) undertook a field survey and highlighted some specific examples of pathways transferring runoff from agricultural land into the River Clun and confirmed the importance of the road network in acting as a pathway for the delivery of sediment into the river network.
- One walkover survey identified that 5% of the SAC length was affected by bank erosion (Environment Agency, Pers. Comm.).

As part of this investigation, suspended solids monitoring data from the River Clun turbidity sondes (Section 4.3.1) and flow data for the River Clun have been combined to estimate the total suspended solids loads in the river between May 2012 and April 2013. There are also a series of 'hotspot' maps that describe soil erosion risk across the catchment.

6.3.2. How are the data presented?

The results of the sediment source apportionment are summarised as follows:

- Section 6.3.3 reviews describes a method to develop an estimate of catchment and river bank estimates of sediment.
- Figure 6.9 considers the seasonality of sediment loads measured upstream and downstream of the Clun catchment between May 2012 and April 2013.
- Figures 6.10 and 6.11 provide a summary of the land at risk from erosion within each WFD water body in the Clun catchment based on standard, peer-reviewed scientific methods.
- Figure 6.12 uses the available monitoring data to provide a first pass assessment of sediment sources upstream and downstream of the River Clun SAC.

6.3.3. What are the most important sources?

There is still some uncertainty over the proportions in the Clun catchment and different studies undertaken to date reflect a conflict of opinion. Whilst there are multiple sources of silt and other pollutants (agriculture, forestry, urban development, vehicles, road surfaces, dry and wet deposition), the scientific consensus and local stakeholder consensus is that agriculture is responsible for the majority of silt transported to the River Clun. For other catchments source apportionment work indicates that 75% of the silt load in rivers is as a result of land use. Suspended solids derived from STWs in catchment are very small and in the Clun catchment account for 1.4% of the total loading (Environment Agency, 2010).

At this stage, only an outline estimate of the sediment source apportionment has been provided. The particular focus is on an assessment of the likely proportions of sediment being derived from bank erosion relative to catchment diffuse sources that has been a common theme of discussions during the project lifetime.

In the absence of the detailed field data required to adequately measure river bank erosion, loads have been estimated based on a series of simple assumptions and information collected as part of previous investigations in the catchment. The methodology is set out in Appendix L. The current best estimate indicates that in the order of 15% of the total annual sediment load may be sourced from bank erosion with the remainder (85%) from catchment diffuse sources. A more definitive conclusion is still not available. This will need be obtained based on a formal sediment budgeting or sediment fingerprinting approach, or targeted monitoring to address this data gap.

6.3.4. Seasonal variations

Figure 6.9 below shows how the monthly suspended solids load upstream (Clungunford) and downstream (Leintwardine) of the River Clun SAC varies throughout the year. The monthly loads are for the period between May 2012 and April 2013 and have been derived from 15 minute data combining SS estimates from the sondes (see Section 4.3) and area-weighted flow data based on the estimate at Leintwardine (Section 3.5.2).

The largest loads at both sites were seen in autumn and winter especially the months between November and February (Figure 6.9). This coincides with the time of year when flows are highest and fields cropped to cereals are most likely to lack significant crop cover (Figure 6.9).

Crop type	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Winter cereal	88%	95%	95%	88%	0%	18%	18%	27%	27%	27%	32%	68%
Spring cereal	81%	95%	95%	95%	0%	0%	0%	0%	0%	0%	7%	48%
Oilseed rape	95%	95%	78%	0%	48%	72%	81%	86%	86%	86%	92%	95%
Grass <5 years	93%	95%	95%	93%	63%	67%	67%	71%	70%	70%	73%	88%

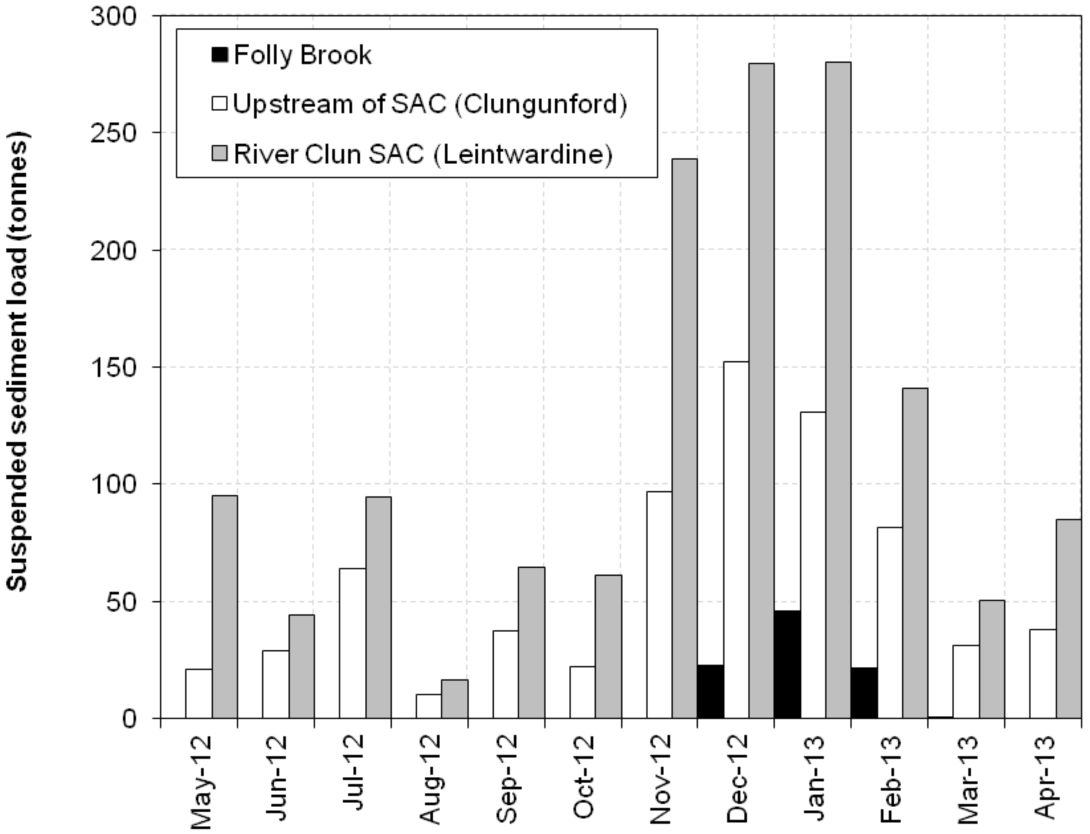


Figure 6-9 Estimated monthly sediment loads in the River Clun SAC at Leintwardine, upstream of the SAC at Clungunford and Folly Brook May 2012-April 2013. Source of data: Environment Agency.

6.3.5. Spatial variations

Data available for the River Clun has allowed an assessment of where the main sediment loads in the catchment come from.

PSYCHIC data

Map 18 shows a map of sediment hotspots in the Clun catchment based on PSYCHIC data. **Table 6-9** summarises the PSYCHIC data according to WFD water bodies in the Clun catchment. Figure 6.10 shows these data graphically. The PSYCHIC data suggest that close to 60% of the total sediment generated in the Clun catchment is sourced from the Kemp and Lower Clun sub-catchments (Figure 6.10).

Table 6-9 WFD water body assessment of PSYCHIC sediment data

EA Water body Name	Area (km^2)	N (kg/yr)	% of total catchment load
Folly Bk - source to conf R Clun	14.51	2,849	3%
R Clun - conf Folly Bk to conf R Unk	19.06	6,688	8%
R Clun - conf R Unk to conf R Teme	76.01	35,069	40%
R Clun - source to conf Folly Bk	23.33	2,990	3%
R Kemp - source to conf R Clun	60.51	17,648	20%
R Redlake - source to conf R Clun	49.38	14,605	17%
R Unk - source to conf R Clun	29.45	7,109	8%
Grand Total	**272.25**	**86,959**	**100%**

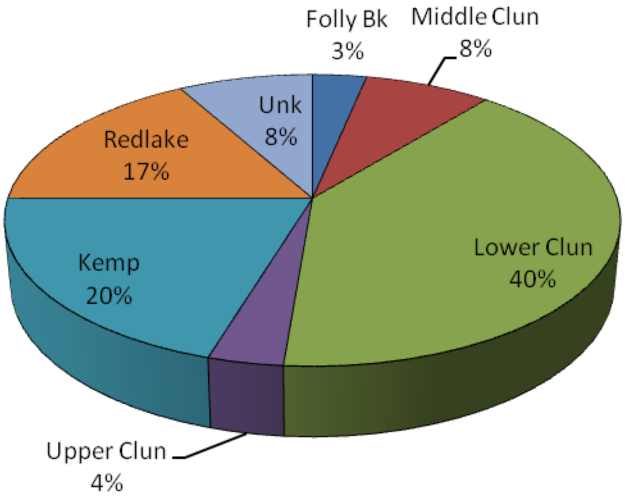
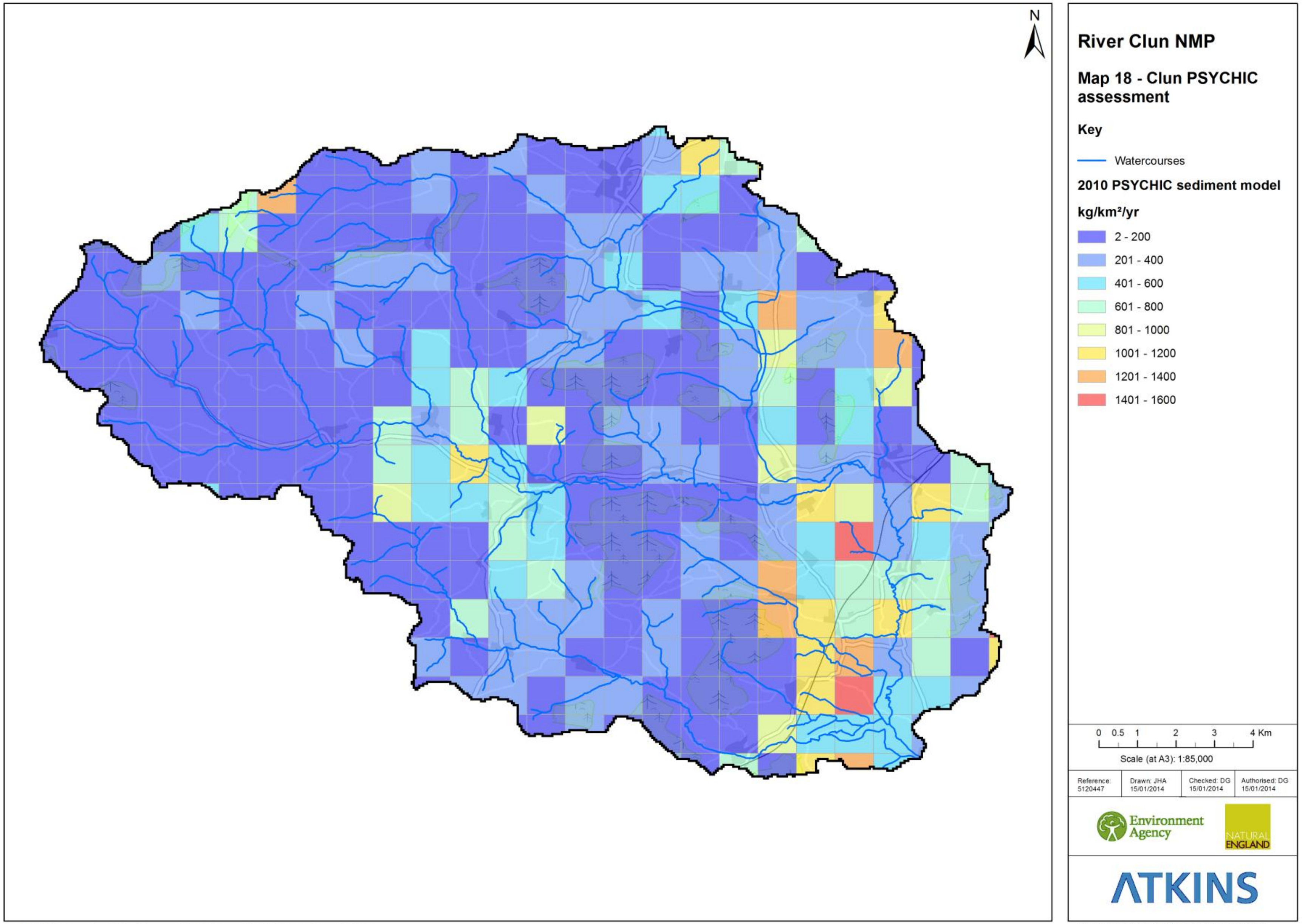


Figure 6-10 Contributions of different WFD water bodies to total sediment loads in the Clun catchment. Based on PSYCHIC output.



Credits: PSYCHIC data courtesy of ADAS; © Crown copyright and database rights (2013) Ordnance Survey (100022021)
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Defra risk maps and SCIMAP

A number of sediment source hotspot maps are available for the catchment of the River Clun as described below. Defra (2005) have proposed a risk mapping approach based on land cover, soil type and slope. SCIMAP uses digital elevation data to conceptualise catchments as a collection of flow pathways that accumulate spatially distributed diffuse pollution sources (Milledge *et al.*, 2012) and uses this information to map the risk to land and watercourses within a catchment. Both methods allow a more detailed view of specific areas at risk from soil erosion in the Clun catchment and could be used to help target measures.

- Map 19 shows a soil erosion risk map based on a methodology suggested by Defra (2005).
- Map 20 shows field scale sediment hotspots in the Clun catchment provided by SCIMAP.
- Map 21 shows sediment delivery in watercourses provided by SCIMAP.

Table 6-10 WFD water body assessment of Defra Soil Erosion risk mapping

EA Water body Name	Soil erosion risk (ha)			Total Area (km^2)	% in high or moderate categories
	Low	Moderate	High		
Folly Bk - source to conf R Clun	13.20	0.42	0.85	14.47	9%
R Clun - conf Folly Bk to conf R Unk	17.87	0.55	0.65	19.06	6%
R Clun - conf R Unk to conf R Teme	54.49	11.78	9.49	75.78	28%
R Clun - source to conf Folly Bk	21.83	0.72	0.60	23.14	6%
R Kemp - source to conf R Clun	41.90	9.92	8.49	60.32	31%
R Redlake - source to conf R Clun	45.68	1.94	1.45	49.08	7%
R Unk - source to conf R Clun	25.43	1.78	2.13	29.34	13%
Grand Total	**220.40**	**27.10**	**23.67**	**271.20**	**19%**

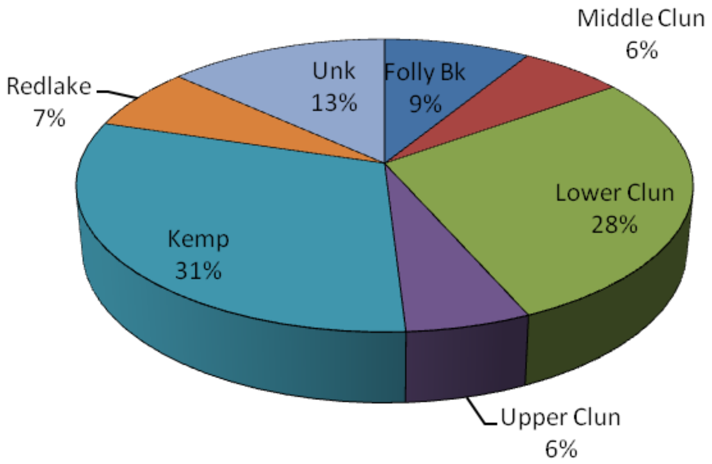
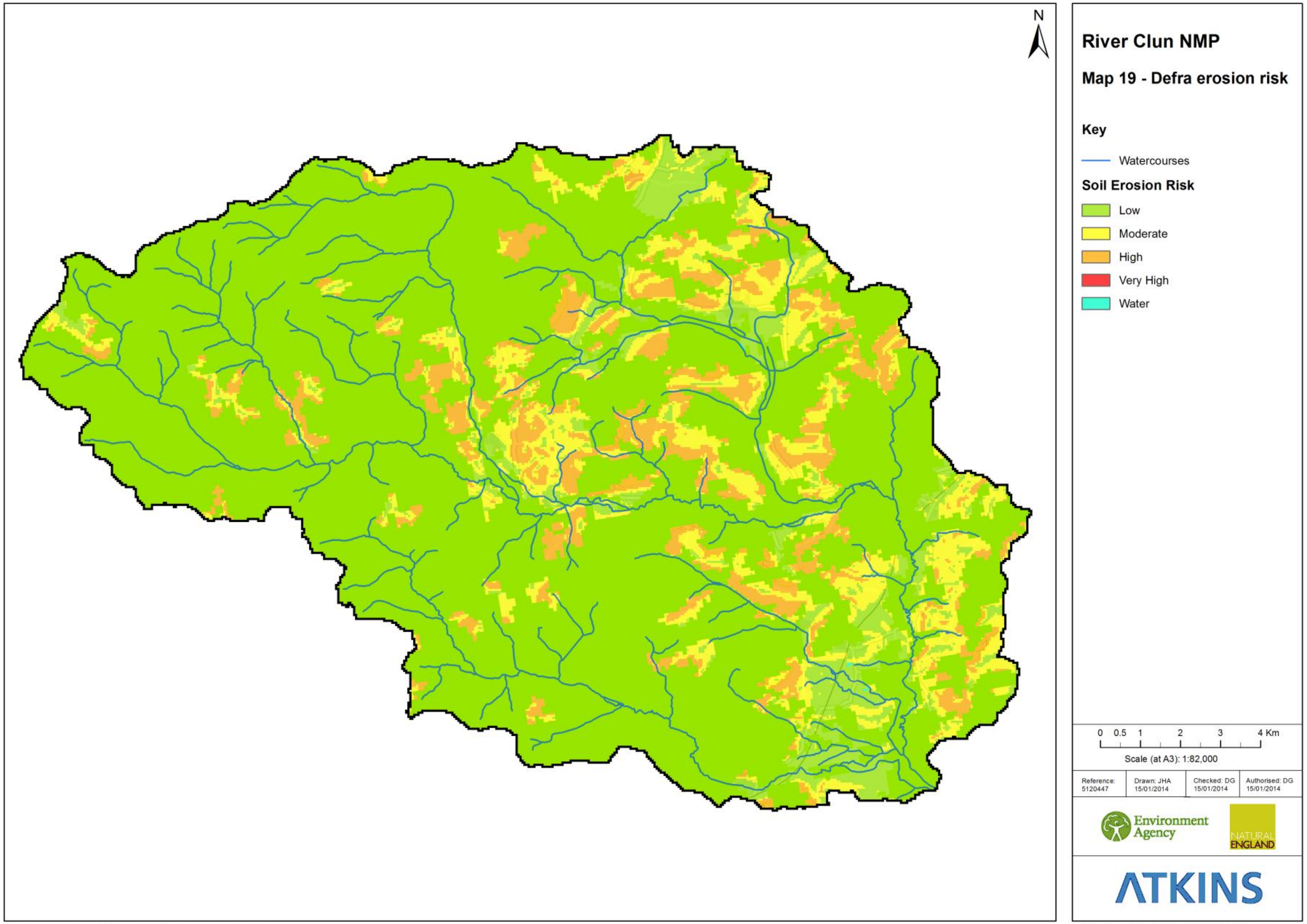


Figure 6-11 Distribution of land at high and moderate risk of erosion in the Clun catchment based on Defra Soil Erosion Risk Mapping.



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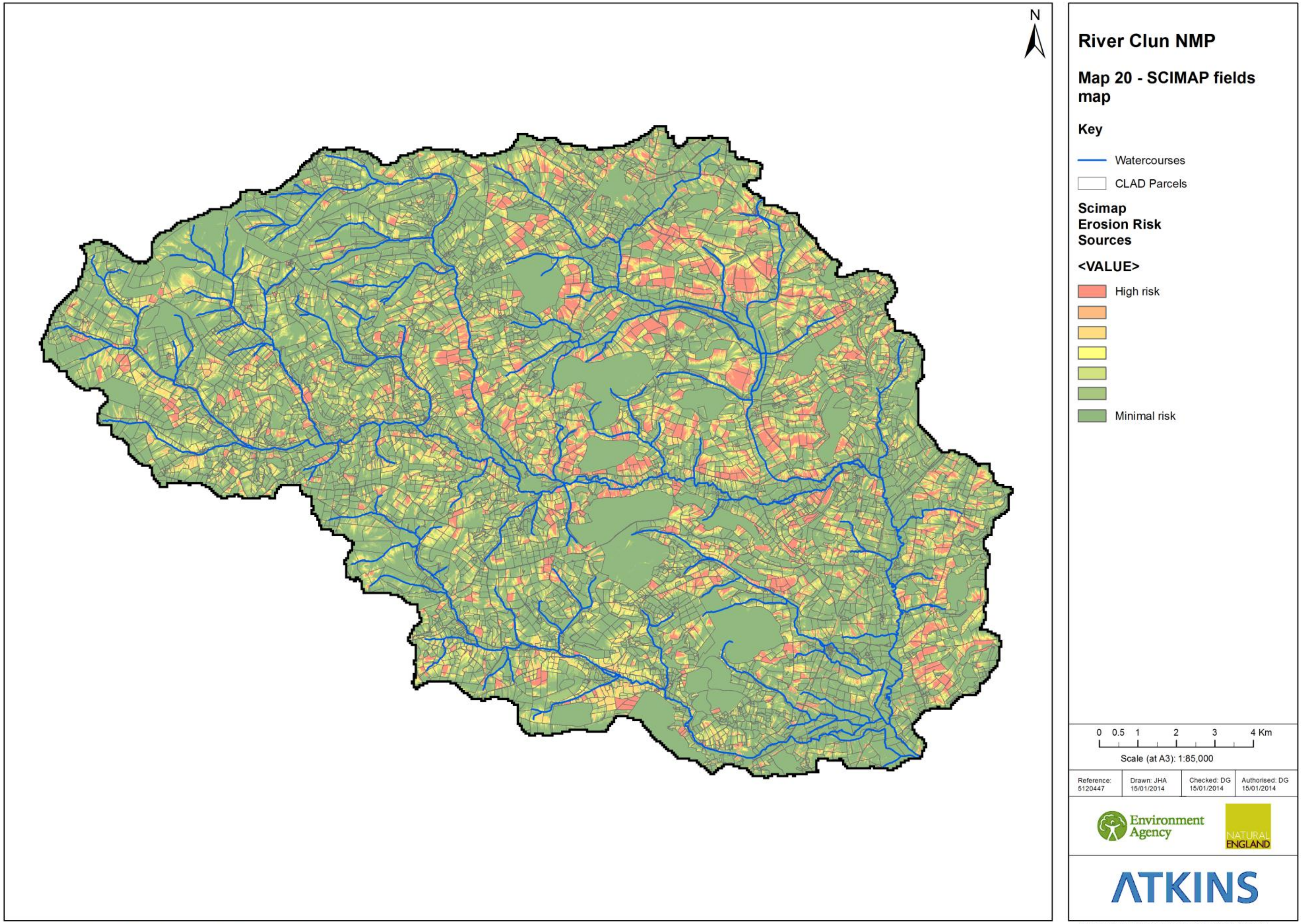

Credits: SCIMAP data courtesy of The Rivers Trust; © Crown copyright and database rights (2013) Ordnance Survey (100022021)
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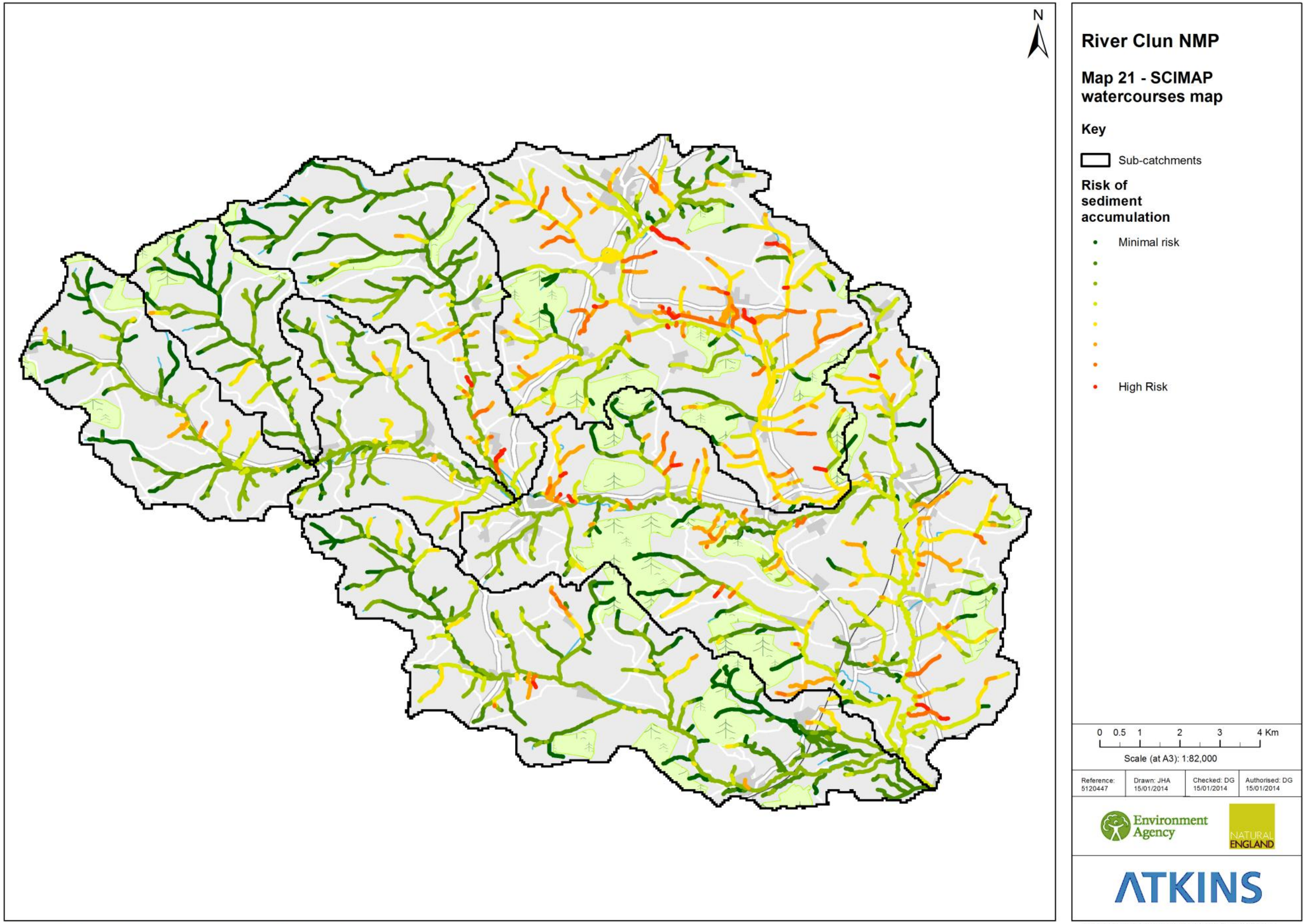

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Monitoring data

An additional assessment of sediment sources to the River Clun SAC is possible by comparing estimated loads measured upstream (at Clungunford) and downstream of the SAC (at Leintwardine) (see Figure 6.9). Monitoring data indicates that a large proportion of the total sediment recorded in the River Clun SAC at Leintwardine is sourced downstream of Clungunford and that only a small proportion of the total sediment load is likely to be generated in upstream tributaries such as the Folly Brook. Monitoring data would appear to suggest that, on an annual basis, more than two thirds of the overall sediment load passing through the River Clun SAC is generated downstream of Clungunford .

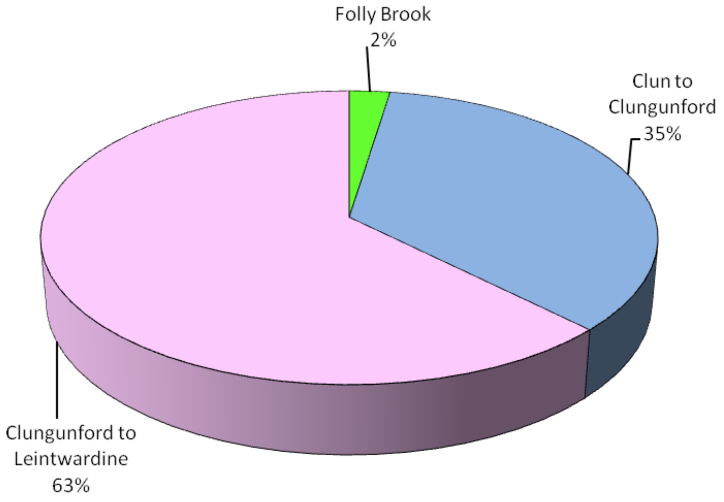

Figure 6-12 Sediment source apportionment calculated from variations in sediment concentrations down the River Clun

6.3.6. Data gaps, assumptions and limitations

The sediment source apportionment presented in this section has been undertaken using the best available information currently available for the Clun catchment. This review and subsequent discussions during the stakeholder review process have identified the main data gaps summarised below.

Data gap		Comment
1	Formal sediment source apportionment assessment	The majority of the loads of suspended solids measured in the River Clun SAC at Leintwardine are currently estimated to arise in areas downstream of Clungunford. Sediment source apportionment perhaps could attempt to assess this.
2	Ongoing monitoring	The current data period incorporates the wettest year on record. The unusual weather conditions may have had an influence on the results and this should be taken into account when interpreting data currently available. Due consideration should be given to maintaining monitoring for a further 12 months to assess whether conditions in a more typical year vary significantly from those observed during the existing data period. A better understanding of the contributions of each tributary is also required for targeted mitigation measures.
3	Flow monitoring	An enhanced programme of spot flow monitoring in some of the Clun tributaries could also be considered to develop ratings between flow and level at a broader variety of locations and to understand the flow-sediment relationship within some of the highest risk areas identified from field surveys and modelling. This could be tied in with other flow monitoring proposed by previous work commissioned by Environment Agency and Natural England.

As part of this initial iteration of the Nutrient Management Plan, data gaps have been dealt with by using the best available information and making assumptions that can be tried and tested as part of later iterations of the NMP. Additional investigations are suggested to address data gaps.

Part two – Options appraisal

7. Options appraisal

This section explores potential options available to reduce the compliance gaps and deliver favourable condition in the River Clun SAC by 2027 in line with the requirements of the Water Framework Directive. Options for point and diffuse sources are considered separately. The table below summarises the current compliance gap in the River Clun SAC between the favourable condition targets for freshwater pearl mussel and the measured values for phosphate, TON and SS in the River Clun SAC at Leintwardine. In summary:

- Phosphate reductions in the order of 43% and 71% will be required to meet the favourable condition targets set for the short and long term respectively.
- Reductions in the order of 68% will be required to meet the favourable condition target for TON; and
- Suspended solids reductions in the order of between 19 and 74% will be required depending on the data used to assess compliance and the year considered. There is currently concern that individual events may lead to impacts upon the species and it therefore, on a precautionary basis, the highest value of 74% has been taken forward as part of the assessment.

Further sections consider potential options available to reduce phosphate, TON and suspended solids concentration in the River Clun SAC and compare estimated reductions to those required to deliver favourable condition in the Clun SAC.

Table 7-1 Summary of the estimated compliance gap between phosphate, nitrogen and suspended solids favourable condition targets and concentrations in the River Clun SAC. Based on Environment Agency monitoring data.

Determinand		Mean annual concentration (mg/l)	Data period	Favourable condition target (mg/l)	Difference (mg/l)	Average reduction required (%)
Phosphate	Short term	0.035	2006-09 and, 2012	0.02	0.015	43%
	Long term			0.01	0.025	71%
TON	-	4.4	2007-2009 and 2012	1.5	2.9	66%
Suspended solids	Spot recent	12.3	2007-2009	10	2.3	19%
	Spot historic	15.6	1999-2009		5.6	36%
	Sonde recent	12.5	2006-2009		2.5	20%
	Sonde recent	39	2012-2013		29	74%

7.1. Point sources

Source apportionment for phosphate, TON and SS in Section 6 has shown that the proportions of sediment and nitrogen from point sources are negligible. Consequently, the assessment of options to reduce contributions from point sources focuses solely on phosphate.

7.1.1. Approach to modelling point source measures

Identifying a realistic and sensible combination of discharge quality consent conditions to control phosphorus inputs from point sources in the Clun catchment is potentially complex due to the limited recent data for the Clun or Lydbury North STWs that are currently thought to provide the main STW-derived phosphate contributions to the River Clun (Figure 6.3).

In addition, since this project is investigating potential impacts on water quality that might occur into the future (up until 2027), it is also reasonable to take into account how technological development and innovation aimed at enhancing phosphorus removal at sewage treatment works might influence decision making in the present. There are also likely to be other important influences such as the ban on phosphates in cleaning products (due in 2015) that are likely to produce further reductions in effluent concentrations in the Clun catchment and across England more generally. Indeed, it has been estimated that this will reduce effluent phosphate concentrations by up to 1mg/l at STWs that do not currently have P stripping in place (Severn Trent Water, Pers. Comm.).

The approach used to assess how changes to discharge consent conditions might offset any increase in phosphate loads to the River Clun due to population growth has been to use the SAGIS model to simulate a range of decision-making strategies and to evaluate the extent to which these are able to achieve compliance with favourable condition targets.

7.1.2. Simulating population growth

The approach to assess the effects of population growth on the River Clun was discussed and agreed during a project stakeholder workshop on the 10th June 2013. Population growth estimates for the Clun catchment were provided by Shropshire Council for the period 2011 up until 2026. The growth figures agreed at the workshop are given in Table 7.2 overleaf.

Overall population growth in the Clun catchment by 2027 is expected to be in the order of 575 persons. Compared to a total catchment population of between 7,000 and 7,500 persons according to the 2010 census (see Section 5), this represents a population increase of approximately 8%. The majority of growth will be accommodated on the existing mains sewerage network around Clun, Bucknell and Bishops Castle (Table 7.2). This is estimated to increase total catchment STW effluent volumes by 82m^3/day or 29,920m^3/year (Table 7.2). In addition, predicted increases in employment land have been estimated to increase effluent flows by 58m^3/day or 21,118m^3/year (Table 7.3). The majority of employment land growth is expected to be in Bishops Castle (Table 7.3).

The effects of population growth have been simulated using the SAGIS model by matching growth estimates across the catchment to the STWs that are most likely to treat the additional effluent (see Table 7.2) and increasing STW discharge flows in accordance with the Shropshire Council population growth estimate. Discharge quality was assumed to be unchanged since it is anticipated that any additional influent volume would be treated to same degree of quality as at present.

7.1.3. Point source scenarios considered

The point sources to be considered as part of the assessment were also agreed during the June 2013 workshop. Five main scenarios were agreed and are shown in the table below. A further sixth potential point source scenario was identified by Severn Trent Water during the final workshop whereby total catchment STW-derived phosphate loads are reduced by 75%. Severn Trent Water considers this option to be a realistic target for the next Asset Management Planning (AMP) period. The precise details of how this will be achieved will be determined as part of an early start Severn Trent Water investigation during AMP6 that will establish a new monitoring network across the catchment and evaluate each of the works in detail to consider the most cost-effective means of delivering this reduction.

As part of the assessment, the effects of all of the scenarios below on phosphate concentrations have been assessed using the SAGIS model for the River Clun. All of the point source scenarios have been considered against a baseline model run representing fully licensed STW discharges plus predicted growth (given as scenario 0 below and in subsequent summary charts).

Scenario		Modelling approach summary
0	Baseline	Fully-licensed STW discharges at Bucknell and Bishops Castle STWs. Additional effluent due to growth as in Tables 7.2 and 7.3.
1	Bishops Castle STW transferred out of catchment	All flow removed from Bishops Castle STW removed from the SAGIS model.
2	Bucknell STW transferred out of catchment	All flow from Bucknell STW removed from the SAGIS model.
3	Additional P stripping at Clun and Lydbury North (likley to be iron dosing and tertiary sand filter)	Consented limits of 1 mg/l applied at Clun and Lydbury North STWs in the SAGIS model
4	P stripping at all works except Bishops Castle and Bucknell (possible polishing using wetland treatment)	Consented limits of 0.3 mg/l were applied at all STWs in the SAGIS model. Bishops Castle and Bucknell STWs maintained as current.
5	Further P stripping at Bishops Castle (High technology solution), Bucknell and Clun STW	Consented limits of 0.1 mg/l at Bucknell, Bishops Castle and Clun STWs applied within the SAGIS model.
6	75% reduction in STW loads across the catchment	Effluent phosphate concentrations at each STW in the catchment reduced by 75%

Table 7-2 Predicted growth in the catchment of the River Clun to 2027. Source of data: Clun NMP growth workshop (June 2013).

Settlement	Overall growth target 2011-2027	Completions 2011- 2013	Commitments 2011-2013	Net growth figure	Population equivalent?	Additional flow		Assumed connection
						(m3/day)	(m3/year)	
Bucknell	75	4	2	69	151.8	21.7	7,915	Mains Sewerage
Clun	100	7	1	92	202.4	28.9	10,554	Mains Sewerage
Aston-on-Clun, Hopesay	15	1	2	12	26.4	3.8	1,377	A third on mains, two thirds non mains
Broome								
Horderley, Beambridge								
Long Meadow End, Rowton								
Round Oak cluster								
Clungunford	25	2	0	23	50.6	7.2	2,638	Non mains
SUB-TOTAL	**215**	**14**	**5**	**196**	**431.2**	**61.6**	**22,484**	**-**

Settlement	Overall growth target 2006-2027	Completions and commitments 2006-2013	-	Net growth figure	Population equivalent?	(m3/day)	(m3/year)	Assumed connection
Bishop's Castle	150	88	-	62	142.6	20.4	7,436	Mains Sewerage
SUB-TOTAL	**150**	**88**	**-**	**62**	**142.6**	**20.4**	**7,436**	**-**

Final net growth for settlements in the Clun catchment	**258**	**574**	**82**	**29,920**	**-**

Table 7-3 Employment land growth

Settlement	Site	Site Area (ha)	Anticipated Development Footprint (35%) (ha)	Square Metres per Employee	Estimated Numbers to be Employed to 2027 (persons)	Additional flow (m3/day)	Additional flow (m3/year)	Assumed connection
Bishops Castle	Bishops Castle Business Park	2.75	0.96	35	275	39	14,339	Mains sewerage
Bucknell	Timber Yard / Station Yard	1.08	0.38	35	110	16	5,736	Mains sewerage
Lydbury North	Former Garage Site	0.24	0.08	35	20	3	1,043	Mains sewerage
Final employment growth in the River Clun catchment		**4.07**	**1.42**	**105**	**405**	**58**	**21,118**	**-**

7.1.4. Results

7.1.4.1. Influence of growth

Overall population growth in the Clun catchment by 2027 is expected to be small, in the order of 574 persons, equivalent to 8% of the current catchment population. Figure 7.1 below shows how predicted growth will affect phosphate concentrations in the River Clun SAC at the fully-licenced rate. The SAGIS model estimates that predicted population growth in the catchment could result in an 8% increase in phosphate concentrations in the river, from 0.038 mg/l under the current fully-licensed scenarioo to 0.041mg/l under fully-licensed conditions with growth. This phosphate concentration is similar to the actual phosphate concentrations predicted before P-stripping at the Bucknell STW (Figure 7.1).

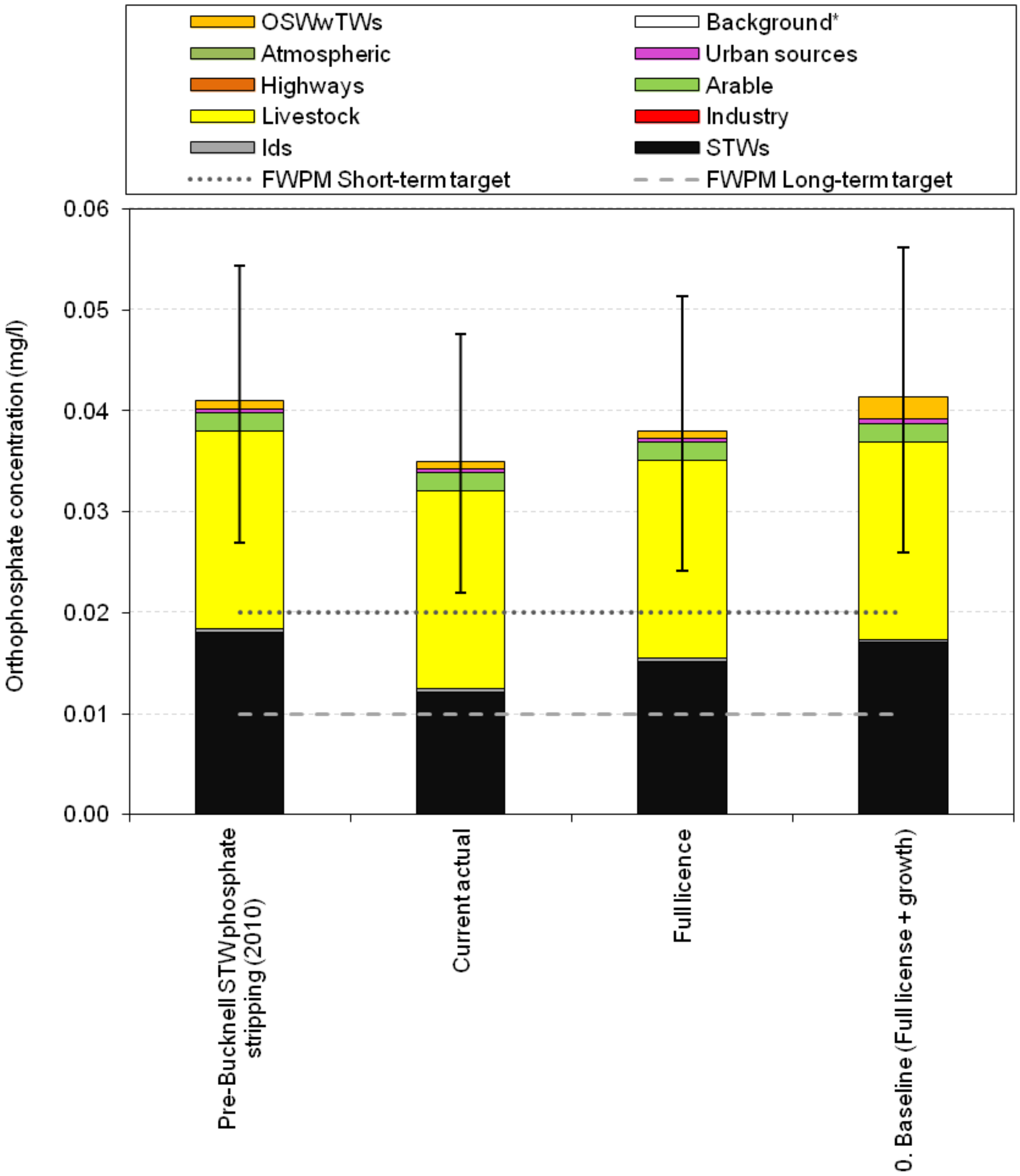

Figure 7-1 Predicted effects of growth in the Clun catchment on phosphate concentrations and apportionment. The full license + growth scenario is the baseline scenario for subsequent model runs.

7.1.4.2. Effectiveness of point source measures

Table 7.4 overleaf summarises how each of the point source measures might influence phosphate concentrations in the River Clun SAC at Leintwardine. In line with the objectives of the investigation, a fully-licensed scenario including growth has been used as the baseline against which to assess all the other scenarios. This baseline scenario is shown in bold in Table 7.4. Where available, Table 7.4 also identifies outline costs and provides some initial commentray on the feasibility of different options based on information provided by Severn Trent Water during the project workshops. Figure 7.2 below summarises the results of the point source options assessment graphically, showing how phosphate concentrations and the annual phosphate source apportionment change under different point source scenarios.

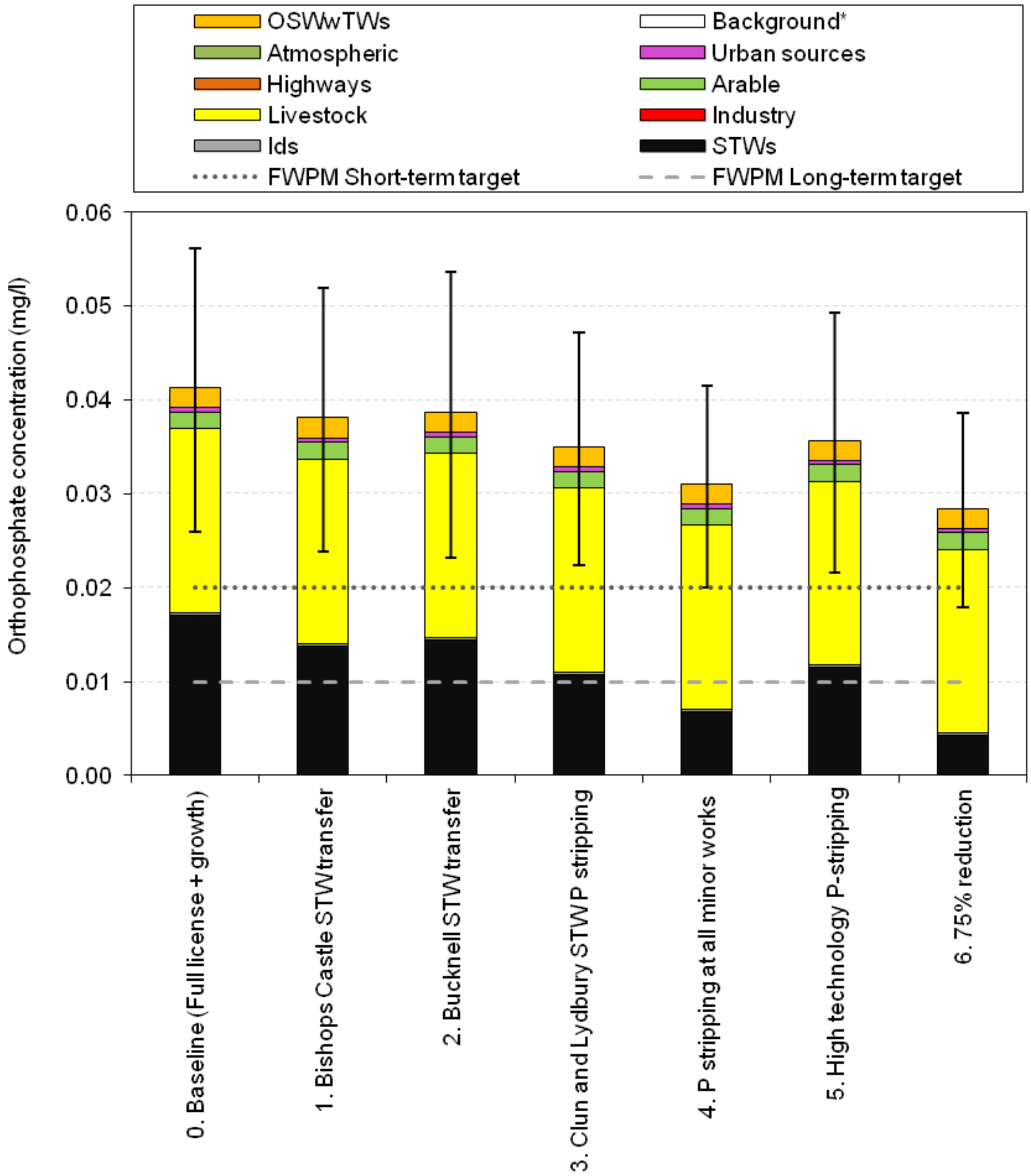

Figure 7-2 Predicted contribution of point source scenarios to compliance with phosphate favourable condition targets in the River Clun SAC. Bars are shown colour coded and denote the phosphate source apportionment. Section 7.1.3 provides further detail regarding each of the scenarios.

Table 7-4 Current best estimate of the potential changes in phosphate concentrations due to growth and different point source scenarios applied in the Clun catchment. * Data provided by Severn Trent Water.

Scenario		Implementation within SAGIS model	Phosphate concentration (mg/l)	Change from baseline phosphate concentration	Reduction in catchment STW loads	Estimated capital costs (million £)*	Comments on feasibility*	Value for money (% reduction/£million)
-	Calibration (2010)	Updated PSYCHIC2010 data. P-stripping at Bishops Castle STW. Effluent from all other STWs at historic P concentrations.	0.041	-1%	6%	-	-	-
-	Actual current (P stripping at Bucknell)	As the baseline but with P stripping from Bucknell STW that has been implemented since 2010.	0.035	-15%	-29%	-	-	-
-	Full licence	Bucknell and Bishops Castle STW effluent at 1.5 and 1.0mg/l P respectively. Other STW licences do not have P limits so effluent maintained at current P concentrations.	0.038	-8%	-11%	-	-	-
0	**Full license + Growth (Habitats Directive Baseline)**	**Growth scenario implemented as agreed at the project workshop.**	**0.041**	0%	**0%**	**-**	**-**	**-**
1	Full license + Growth with Bishops Castle STW transfer	Bishops Castle STW effluent removed from the catchment. All other STW effluent at current concentrations.	0.038	-8%	-19%	1.8 >10	Lower cost assumes no significant changes to permit conditions. Higher cost applies if a condition of this transfer was meeting an ammonia permit limit of 0.6mg/l (River Onny)	0.20 1.09
2	Full license + Growth with Bucknell STW transfer	Bucknell STW effluent removed from the catchment. All other STW effluent at current concentrations.	0.039	-6%	-15%	0.8	-	-
3	Full license + Growth with remaining P-stripping	Consented limits of 1 mg/l applied at Clun and Lydbury North STWs (likely to be iron dosing and tertiary sand filter). All other STW effluent concentrations as in the current scenario.	0.035	-15%	-37%	1.5 (£0.75mn/STW)	Costs of treatment to 0.5 mg/l.	4.78
4	Full license + Growth with wetland treatment	Consented limits of 0.3 mg/l at all STWs except Bishops Castle and Bucknell (maintained at current). Treatment to include wetland treatment.	0.031	-25%	-60%	Unknown	Trial work on P stripping reed beds carried out by other water companies is not yet getting down to the very low target levels. There is also an issue with elevated pH (above 9) which could be a problem.	-
5	Full license + Growth with high technology P-stripping	Consented limits of 0.1 mg/l effluent P at Bucknell and Bishops Castle STWs (High technology solution). All other STW effluent concentrations as in the current scenario.	0.036	-14%	-33%	>20	Complete rebuild of two STWs as Membrane Bio Reactors. Very expensive and huge carbon footprint (unsustainable).	0.25
6	Total catchment STW-derived effluent loads reduced by 75%	STW effluent contributions at all works in the catchment reduced by 75% in line with suggestions by Severn Trent Water	0.028	-31%	-75%	Not specified	Proposed by Severn Trent Water as possible during AMP6	Unknown

The following points summarise the point source scenarios assessment:

- Transferring effluent from Bucknell STW or Bishops Castle STW outside the catchment is expected to have a small effect on phosphate concentrations in the River Clun SAC. This is because phosphate stripping at both works has already been implemented and they currently provide a reduced contribution to the total STW-derived phosphate load in the river (Figure 6-3).
- For the same reason, the implementation of high technology P-stripping solutions at the Bucknell and Bishops Castle STWs are not likley to result in large changes in river phosphate concentrations.
- Aditional P stripping at the minor works would appear to be a more effective option for reducing in-river phosphate concentrations, especially with regards to Lydbury North STW and Clun STW that currently provide the largest contributions to the total catchment STW-derived phosphate load in the river (Figure 6.3). Aditional P stripping at these two works are estimated to reduce phosphate concetrations in the River Clun SAC by around 15%
- Larger reductions in the river phosphate concentration in the order of 25% are potentially possible if P-stripping was introduced at all minor STWs, and appending consented phosphate limits of 0.3mg/l.
- The maximum reduction using point source measures would deliver a phosphate concentration of 0.028mg/l. This is based on reducing all STW-derived phosphate loads in the catchment by 75% as suggested by Severn Trent Water. Implementation of this option would result in a predicted reduction of 31% of the mean annual phosphate concentration in the River Clun SAC at Leintwardine.

7.1.4.3. Contribution to compliance with favourable condition targets

Figure 7.2 shows that none of the point source scenarios will deliver the short or long-term favourable conditon targets on their own. Measures to control diffuse pollution in the catchment will also be required.

Figure 7.3 below shows the shows the long section of phosphate concentrations down the River Clun based on the most effective point source measure currently identified. This is Scenario 9 (Total catchment STW-derived effluent loads reduced by 75%) in Table 7.4 and Figure 7.2 that Severn Trent Water have suggested may be possible during AMP6. The precise details of how this will be achieved will be determined as part of an early start Severn Trent Water investigation during AMP6 that will establish a new monitoring network across the catchment and evaluate each of the works in detail to consider the most cost-effective means of delivering this reduction.

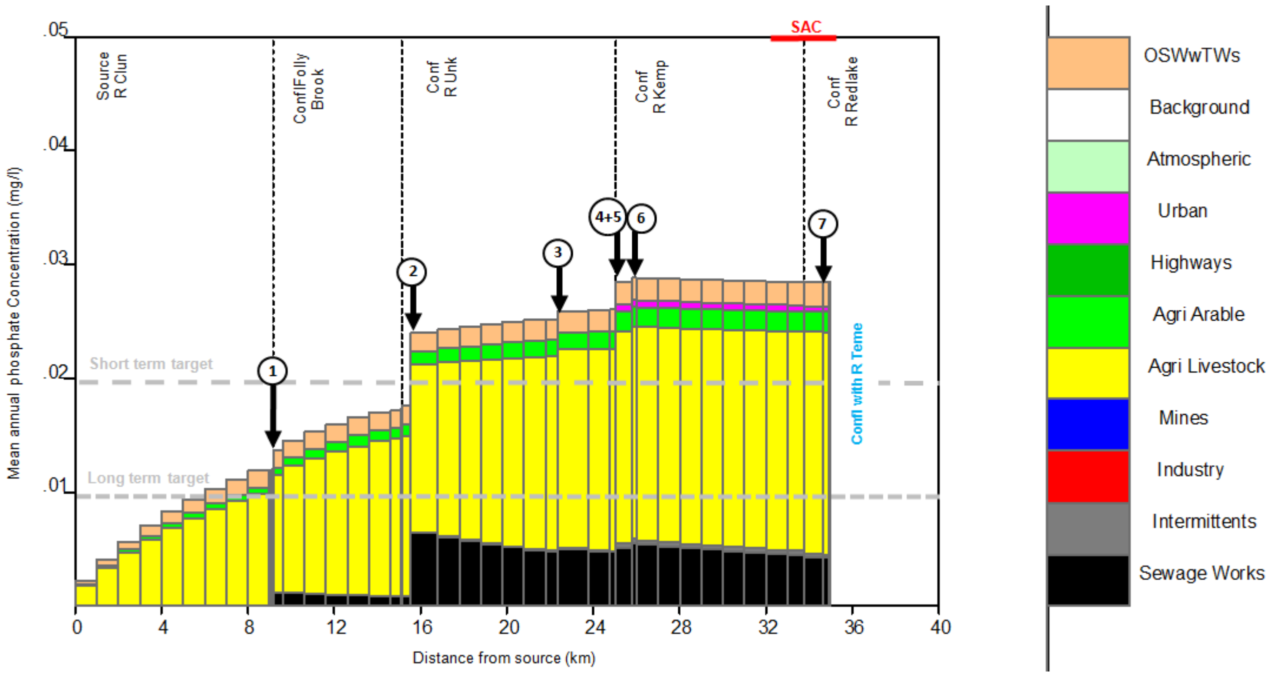

Figure 7-3 Best case point source reduction in phosphate concentrations in the River Clun

7.2. Diffuse sources

Source apportionment has shown that diffuse sources in the River Clun may contribute important proportions of sediment, nitrogen and phosphate to the River Clun catchment. Following the assessment of point source scenarios and their effectiveness, this section considers the range of options that might be available to reduce diffuse phosphate sources across the catchment using FARMSCOPER – FARM SCale Optimisation of Pollutant Emission Reductions (Goodhay and Antony, 2010). FARMSCOPER is a Defra-funded tool that collates more than a decade of UK scientific research on farm scale pollutant loads and the effects of different mitigation methods on losses of phosphorus, nitrogen and sediment that is quickly becoming the industry preferred model for understanding effectiveness of diffuse mitigation measures applied within the rural sector.

7.2.1. Approach to modelling diffuse sources and mitigation measures

7.2.1.1. FARMSCOPER

A wide range of agricultural measures are available for reducing the loss of phosphorus, nitrogen and sediment to surface water. Over 100 measures are listed in the latest Defra Mitigation Method User Guide (Defra Project ES0203) (Newell-Price *et al.*, 2011) and all of the methods are included in FARMSCOPER. FARMSCOPER is an Excel based model with the following functions:

1. Allows the calculation of phosphorus, nitrogen and sediment loss from an individual farm, for different farm types, drainage situations and climatic conditions.
2. Estimates the effectiveness of measures both individually and in-combination and how they might vary across different farm types.
3. Provides likely costs associated with the implementation of different mitigation measures.

As a farm systems model, FARMSCOPER produces outputs at the farm scale. Outputs can subsequently be scaled up to provide estimate of agricultural diffuse pollution and the effectiveness of potential mitigation methods at the water body and catchment scale.

In addition, the following assumptions are important:

- The baseline FARMSCOPER farm data are assumed to be broadly equivalent to PSYCHIC data and used in the SAGIS model. Therefore output, and thus SAGIS estimates of phosphorus loads from agriculture livesock and arable sectors. Both models are underpinned by the same scientific understanding and data.
- The FARMSCOPER model is designed to calculate the effectiveness of measures for an individual farm, with the outputs being a % reduction in phosphorus, nitrogen and sediment loss as a result of applying certain measure(s).
- Estimates of effectiveness of measures which underpin FARMSCOPER draw together the best available evidence, although it is important to note that there is a large variation in the reported effectiveness of different mitigation methods, derived from plot and field scale experiments and expert opinion. To address these limitations, the values incorporated within FARMSCOPER are lower than the centroid of the range to represent a cautious assessment of the average estimate of effectiveness (Goodhay and Antony, 2010).
- In calculating the net effectiveness of a suite of measures acting on the same pollutant source, FARMSCOPER rapidly decreases the gain provided by additional measures. Although this approach is not ideal or under-pinned by scientific observation it is considered to be a more realistic approach than treating effectiveness scores as additive that would quickly exhaust the pollutant source.
- The data that underpins the FARMSCOPER only represents commercial holdings; small holdings are not included.
- FARMSCOPER is based on a simple hydrological model. Local topography is not included, soil bands are generalised and it does not account for the location of specific farms within a water body or the proximity of specific farm infrastructures to the water course that may represent a pollutant source or risk.

7.2.2. Applying FARMSCOPER in the river Clun catchment

As part of the development of the River Clun NMP, FARMSCOPER has been used in a scoping sense only to describe the generalities of farming in the catchment, including assumptions on existing measures.

During the second NMP workshop, local stakeholders suggested generalising agricultural practices in the Clun catchment according to the LFA boundary as follows:

1. Farms within the Less Favoured Area (LFA) are mainly improved and semi-improved grassland grazed by sheep and beef. This farm is hereafter termed the '**Clun upland livestock farm'**. It is equivalent to the 'LFA Grazing' Defra Robust Farm Type and is described in FARMSCOPER as 'Upland Grazing'.

2. Farms outside the LFA are mainly arable consisting mainly of winter and spring-sown cereal, with some root crops and potatoes. This farm is hereafter termed the '**Clun lowland arable farm**' and is equivalent to the 'Cereals' Defra Robust Farm Type described in FARMSCOPER as 'Mixed combinable with manure'.

FARMSCOPER has been run for these two farm types. The following additional assumptions are relevant to application to the Clun catchment:

- Only a small proportion of the Clun catchment is likely to be under-drained. Consequently the tool has been run assuming no under-drainage.
- Temporal and seasonal variations in stocking densities are not included.
- Within each farm type, the specifics of different activities such as indoor wintered/outdoor wintered beef are not differentiated.
- The generic catchment farm types are an adequate reflection of the typical size, stocking densities and land-use across all the case study catchments.
- Soils in the catchment of the River Clun are described generally as free draining and have been modelled as such in FARMSCOPER.

It is recognised however that this is a simplification of actual farming practices in the catchment. For example, it doesn't include crop rotation and movement of animals between land parcels. It is however assumed that this data provides a useful scoping assessment of where the risks lie with regards to farm activities within the catchment, in line with the overall purpose of FARMSCOPER.

7.2.3. Using the results

7.2.3.1. Phosphate – interfacing with SAGIS

In order to understand how these measures then could affect in-river phosphorus concentrations, the FARMSCOPER outputs have been applied within the SAGIS model for the River Clun.

Within FARMSCOPER the effectiveness of measures is calculated at an individual farm level and the outputs are expressed as % reductions in phosphorus losses from that individual representative farm. In SAGIS the effectiveness of measures has to be calculated for the entire catchment. Data, resource and time constraints do not permit the application of FARMSCOPER for each individual farm within the catchment, and nor is it appropriate to do so at this level of assessment; some scaling up has therefore been undertaken to take the outputs of FARMSCOPER and model them within SAGIS. A high level overview of how this has been done is shown in Figure 7.4 overleaf.

7.2.3.2. Nitrogen and sediment

In the absence of detailed models for sediment and nitrogen FARMSCOPER outputs have been used to revise the mean annual measured concentrations of nitrogen and suspended solids in the River Clun SAC at Leintwardine to assess how measures might affect concentrations and compliance with favourable condition targets. This assessment has been undertaken for different years and methods for which data are available. Whilst this is a simplistic approach it reflects current data availability and reflects the scoping nature of the FARMSCOPER tool. A high level overview of how this has been done is shown in Figure 7.4 overleaf.

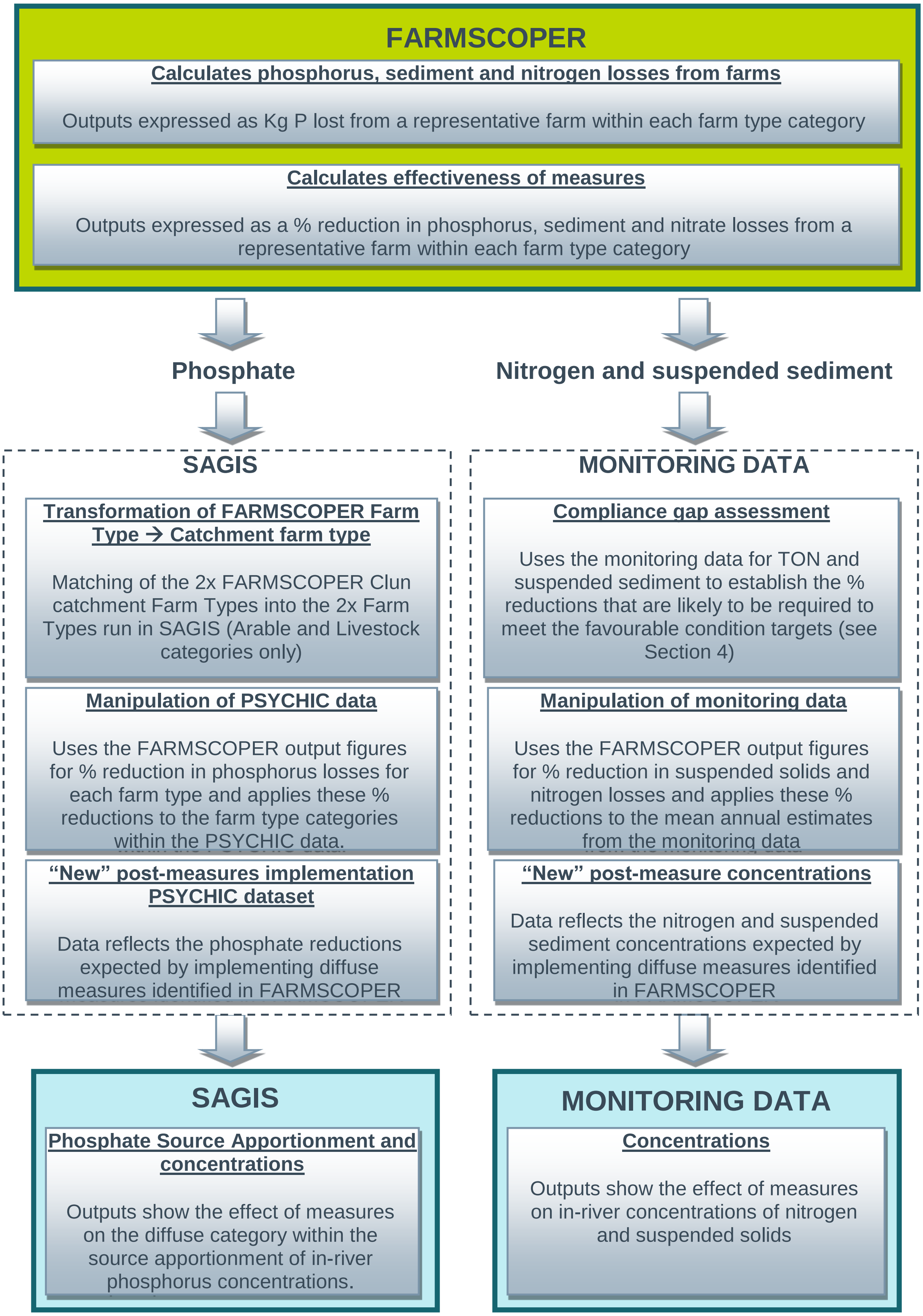

Figure 7-4 Interaction between FARMSCOPER, SAGIS and monitoring data as part of the assessment of the Clun NMP

7.2.4. Diffuse scenarios assessed

FARMSCOPER has been used to estimate the overall effectiveness of combinations of land management measures in reducing phosphorus, nitrogen and sediment loss from the two main farm types in Clun catchment. The diffuse source scenarios considered as part of the NMP were identified by Natural England as follows:

- **Farm assurance and Code of Good Agricultural Practice (COGAP)** - CoGAP is a code of practice for farmers, growers, contractors and others involved in agricultural activities to help avoid polluting water, air and soil. It sets out good management practices that can be used on farms and contributes towards Single Farm Payment (SFP) and other direct payments to meet what are called Cross-Compliance conditions.
- **Nitrate Vulnerable Zone (NVZ)** - A Nitrate Vulnerable Zone (NVZ) is designated on all land draining to and contributing to the nitrate pollution in “polluted” waters. Within NVZs, farmers must also comply with NVZ rules to be entitled to a full subsidy payment under the Single Payment Scheme (SPS). Measures associated with NVZ relate to the control, management and recording of organic manures.
- **FARMSCOPER top 5** where the tool is used in an automated sense to identify the 5 measures that would deliver the greatest combined reductions when applied in combination; and
- **Maximum FARMSCOPER reductions** where the tool is used in an automated sense to identify the maximum potential reductions that are possible for a given farm type.

All of the above are considered based on a catchment wide application relative to a baseline of no prior implementation in line with the PSYCHIC data that underlie SAGIS and a precautionary worst-case scenario required as part of the Habitats Directive and applied as part of the point source scenarios.

Table 7.5 overleaf sets out further detail of how FARMSCOPER has been used to feed into the SAGIS model. In Table 7.5, diffuse pollution scenarios are numbered sequentially following on from point source scenarios (see Table 7.4). The diffuse scenarios have also been run sequentially building on the previous scenario (see Table 7.5) to assess how increasing the suite of measures used contributes to compliance.

The diffuse scenarios assessed reflect the full range of potential tools and measures currently available to Natural England and its partners. It is important to note that, at this stage, the scenarios are hypothetical to investigate the likely range of reductions that may be possible within the catchment rather than providing an indication of the actual measures that are likely to be pursued. This assessment is likely to be needed at the farm scale lead by the local farm advisers. In addition, changes in the make-up of agri-environment schemes are expected in the lead up to 2016. It is currently unclear what measures will be available as part of a new environmental land management scheme (NELMS) that will be targeted to deliver WFD compliance and will be more strongly focussed on resource protection measures.

Scenario		Description	Scenario Rationale	Model set up
7	**No prior implementation**	Baseline	In line with PSYCHIC, a precautionary worst-case scenario in line with the HD and as used for point sources	All prior implementation options off Prior Implementation Options ☐ Minimum Farm Assurance Requirements ☐ Typical Practice ☐ Typical Practice (Nitrate Vulnerable Zones)
8	No prior implementation + **Farm assurance and COGAP**	All catchment landowners are meeting minimum farm assurance requirements	Shows how changes in behaviour might influence nutrient levels in the catchment	FARMSCOPER includes an option to assess the effectiveness of typical practices – Top 2 options on Prior Implementation Options ☑ Minimum Farm Assurance Requirements ☑ Typical Practice ☐ Typical Practice (Nitrate Vulnerable Zones)
9	No prior implementation + Farm assurance + **Nitrate Vulnerable Zone**	Entire catchment is included under an NVZ designation	Shows how a policy driver might influence nutrient levels in the River Clun. Although it is primarily targeted at reducing nitrate levels, there are additional potential benefits to phosphorus and sediment	FARMSCOPER includes an option to assess the effectiveness of these measures – All 3 options on Prior Implementation Options ☑ Minimum Farm Assurance Requirements ☑ Typical Practice ☑ Typical Practice (Nitrate Vulnerable Zones)
10	No prior implementation + **Top 5 FARMSCOPER**	Top 5 measures applied throughout the catchment	Scenario identifies the measures that might be promoted locally as part of land management advice and that provide a realistic number of measures for landowners to adopt, CSFOs to promote whilst delivering the maximum benefits possible across the catchment.	FARMSCOPER optimiser runs to assess the effectiveness of the full range of measures. FARMSCOPER predicted measures ranked to enable the identification of the top 5 most effective measures. These 5 measures are then re-run through FRAMSCOPER in combination to assess the in-combination reductions, taking account of the incremental effects of combining measures.
11	No prior implementation + **FARMSCOPER maximum estimated reductions** (automatically include all the farm assurance, NVZ and top elements)	All measures applied across the catchment	Maximum possible reductions according to FARMSCOPER	The maximum possible reductions estimated by the FARMSCOPER optimiser for each farm type is applied within the model (see Tables). Incremental to option 4

Table 7-5 Diffuse source scenarios considered using the Clun catchment SAGIS model

7.2.5. FARMSCOPER Outputs for the Clun catchment

The outputs from FARMSCOPER are summarised as percentage reductions in phosphorus, nitrogen and sediment losses from individual farms and lists of measures that might be implemented. Sections below set out the outputs for each of the diffuse scenarios, as provided by FARMSCOPER.

7.2.5.1. Scenario 8 - COGAP and Farm Assurance

The tables below show the estimated reductions in phosphorus, nitrogen and sediment that will result from the implementation of COGAP and Farm Assurance measures to the Clun Upland Grazing Farm and the Clun Lowland Arable Farm. Remaining tables show the list of measures for each farm type that are associated with COGAP and Farm Assurance in FARMSCOPER. Not all methods outlined will reduce N, P or sediment, this is just a list of the measures that FARMSCOPER switches on to assess COGAP/Farm assurance. Method IDs refer to measures listed in the 'Inventory of Methods to Control Diffuse Water Pollution from Agriculture (DWPA)' (Newell-Price *et al.*, 2011).

Estimated reductions (%) in phosphorus, nitrate and sediment

Farm type	% reduction		
	Nitrate	Phosphorus	Sediment
Clun Upland Grazing Farm	2.7	3.2	5.1
Clun Lowland Arable Farm	5.2	0.2	0.0

List of measures (Clun Upland Grazing Farm) applied within FARMSCOPER to assess the effectiveness of COGAP and Farm Assurance application throughout the catchment

Method IDs: Set 1	Description
21	Fertiliser spreader calibration
22	Use a fertiliser recommendation system
25	Do not apply manufactured fertiliser to high-risk areas
26	Avoid spreading manufactured fertiliser to fields at high-risk times
38	Move feeders at regular intervals
42	Increase scraping frequency in dairy cow cubicle housing
73	Incorporate manure into the soil
90	Calibration of sprayer
91	Fill/Mix/Clean sprayer in field
92	Avoid PPP application at high risk timings
94	Drift reduction methods

List of measures (Clun Lowland Arable Farm) applied within FARMSCOPER to assess the effectiveness of COGAP and Farm Assurance application throughout the catchment

Method IDs: Set 1	Description
21	Fertiliser spreader calibration
22	Use a fertiliser recommendation system
23	Integrate fertiliser and manure nutrient supply
25	Do not apply manufactured fertiliser to high-risk areas
26	Avoid spreading manufactured fertiliser to fields at high-risk times
38	Move feeders at regular intervals
42	Increase scraping frequency in dairy cow cubicle housing
43	Additional targeted bedding for straw-bedded cattle housing
60	Site solid manure heaps away from watercourses/field drains
67	Manure Spreader Calibration
68	Do not apply manure to high-risk areas
72	Do not spread FYM to fields at high-risk times
73	Incorporate manure into the soil
90	Calibration of sprayer
91	Fill/Mix/Clean sprayer in field
92	Avoid PPP application at high risk timings
94	Drift reduction methods
118	Locate out-wintered stock away from watercourses

7.2.5.2. Scenario 9 - Nitrate Vulnerable Zone

Tables below show the estimated reductions in phosphorus, nitrogen and sediment that will result from the implementation of Nitrate Vulnerable Zone measures to the Clun Upland Grazing Farm and the Clun Lowland Arable Farm. Remaining tables show the list of measures for each farm type that are associated with Nitrate Vulnerable Zones in FARMSCOPER. Not all methods outlined will reduce N, P or sediment, this is just a list of the measures that FARMSCOPER switches on to assess NVZs. Method IDs refer to measures listed in the 'Inventory of Methods to Control Diffuse Water Pollution from Agriculture (DWPA)' (Newell-Price *et al*., 2011).

Estimated catchment scale reductions (%) in phosphorus, nitrate and sediment due to implementation of NVZ throughout the catchment

Farm type	% reduction		
	Nitrate	Phosphorus	Sediment
Clun Upland Grazing Farm	5.0	10.8	5.5
Clun Lowland Arable Farm	10.3	0.8	0.0

List of measures (Clun Upland Grazing Farm) applied within FARMSCOPER to assess the effectiveness of NVZ measures applied throughout the catchment

Method IDs: Set 1	Description
21	Fertiliser spreader calibration
22	Use a fertiliser recommendation system
25	Do not apply manufactured fertiliser to high-risk areas
26	Avoid spreading manufactured fertiliser to fields at high-risk times
38	Move feeders at regular intervals
42	Increase scraping frequency in dairy cow cubicle housing
73	Incorporate manure into the soil
90	Calibration of sprayer
91	Fill/Mix/Clean sprayer in field
92	Avoid PPP application at high risk timings
94	Drift reduction methods

List of measures (Clun Lowland Arable Farm) applied within FARMSCOPER to assess the effectiveness of NVZ measures applied throughout the catchment

Method IDs: Set 1	Description
21	Fertiliser spreader calibration
22	Use a fertiliser recommendation system
23	Integrate fertiliser and manure nutrient supply
25	Do not apply manufactured fertiliser to high-risk areas
26	Avoid spreading manufactured fertiliser to fields at high-risk times
38	Move feeders at regular intervals
42	Increase scraping frequency in dairy cow cubicle housing
43	Additional targeted bedding for straw-bedded cattle housing
60	Site solid manure heaps away from watercourses/field drains
61	Store solid manure heaps on an impermeable base and collect effluent
67	Manure Spreader Calibration
68	Do not apply manure to high-risk areas
72	Do not spread FYM to fields at high-risk times
73	Incorporate manure into the soil
90	Calibration of sprayer
91	Fill/Mix/Clean sprayer in field
92	Avoid PPP application at high risk timings
94	Drift reduction methods
118	Locate out-wintered stock away from watercourses

7.2.5.3. Scenario 10 - FARMSCOPER Top 5

The tables included in this section show the estimated reductions in phosphorus, nitrogen and sediment that will result from the implementation of the Top 5 FARMSCOPER measures predicted for each farm type in the Clun catchment. Method IDs refer to measures listed in the 'Inventory of Methods to Control Diffuse Water Pollution from Agriculture (DWPA)' (Newell-Price *et al*., 2011).

7.2.5.3.1. Phosphorus

List of top 5 FARMSCOPER measures for phosphorus reduction on the Clun Upland Grazing Farm

ID	Description	Estimated % P reduction if applied individually	Estimated % P reduction in-combination
120	Capture of dirty water in a dirty water store	20	47
119	Use dry-cleaning techniques to remove solid waste from yards prior to cleaning	14	
81	Establish and maintain artificial wetlands - steading runoff	12	
76	Fence off rivers and streams from livestock	9	
61	Store solid manure heaps on an impermeable base and collect effluent (NVZ measure)	6	

List of top 5 FARMSCOPER measures for phosphorus reduction on the Clun Lowland Arable Farm

ID	Description	Estimated % P reduction if applied individually	Estimated % P reduction in-combination
8	Cultivate compacted tillage soils	25	50
13	Establish in-field grass buffer strips	25	
15	Loosen compacted soil layers in grassland fields	25	
106	Plant areas of farm with wild bird seed/nectar flower mixtures	25	
9	Cultivate and drill across the slope	18	

7.2.5.3.2. Sediment

List of top 5 FARMSCOPER measures for sediment reduction on the Clun Upland Grazing Farm

ID	Description	Estimated % S reduction if applied individually	Estimated % S reduction in-combination
106	Plant areas of farm with wild bird seed/nectar flower mixtures	10	21.2
78	Re-site gateways away from high-risk areas	4	
38	Move feeders at regular intervals	4	
35	Reduce the length of the grazing day/season	4	
39	Construct troughs with concrete base	4	

List of top 5 FARMSCOPER measures for sediment reduction on the Clun Lowland Arable Farm

ID	Description	Estimated % S reduction if applied individually	Estimated % S reduction in-combination
8	Cultivate compacted tillage soils	19	73.5
15	Loosen compacted soil layers in grassland fields	19	
13	Establish in-field grass buffer strips	18	
106	Plant areas of farm with wild bird seed/nectar flower mixtures	18	
9	Cultivate and drill across the slope	13	

7.2.5.3.3. Nitrate

List of top 5 FARMSCOPER measures for nitrate reduction on the Clun Upland Grazing Farm

ID	Description	Estimated % N reduction if applied individually	Estimated % N reduction in-combination
120	Capture of dirty water in a dirty water store	4	8.1
119	Use dry-cleaning techniques to remove solid waste from yards prior to cleaning	3	
76	Fence off rivers and streams from livestock	2	
25	Do not apply manufactured fertiliser to high-risk areas	2	
110	Uncropped cultivated areas	1	

List of top 5 FARMSCOPER measures for nitrate reduction on the Clun Lowland Arable Farm

ID	Description	Estimated % N reduction if applied individually	Estimated % N reduction in-combination
8	Cultivate compacted tillage soils	2	3.3
11	Manage over-winter tramlines	1	
15	Loosen compacted soil layers in grassland fields	2	
117	Use correctly-inflated low ground pressure tyres on machinery	1	
9	Cultivate and drill across the slope	1	

7.2.5.4. Scenario 11 - FARMSCOPER maximum estimated reductions

Tables below show the maximum estimated reductions in phosphorus, nitrogen and sediment predicted by FARMSCOPER for each farm type in the Clun catchment. Remaining tables show a ranked list of measures identified by FARMSCOPER that present, in order of significance, the reductions associated with individual methods. Method IDs refer to measures listed in the 'Inventory of Methods to Control Diffuse Water Pollution from Agriculture (DWPA)' (Newell-Price *et al.*, 2011).

Summary of the estimated catchment scale reductions (%) in phosphorus, nitrate and sediment due to maximum implementation of measures throughout the catchment

Farm type	% reduction		
	Nitrate	Phosphorus	Sediment
Clun Upland Grazing Farm	14.2	57.8	23.0
Clun Lowland Arable Farm	17.3	60.8	88.4

Ranked list of all FARMSCOPER measures for the Clun Lowland Arable Farm (P = phosphorus, N = nitrate and S = Sediment). The ranking has been done based on phosphorus to assess the benefits of an integrated approach whereby a single pollutant is targeted for mitigation and we assess the benefits to others also requiring reduction. This comparison shows that for the lowland arable farm both the top 5 measures and the general maximum to minimum reductions associated with ranking measures for phosphorus will also deliver close to the maximum benefits to sediment and nitrate reduction.

FARMSCOPER MEASURE ID	Estimated farm reduction if applied individually (%)		
	N	S	P
8 - Cultivate compacted tillage soils	2	19	25
13 - Establish in-field grass buffer strips	0	18	25
15 - Loosen compacted soil layers in grassland fields	2	19	25
106 - Plant areas of farm with wild bird seed / nectar flower mixtures	0	18	25
9 - Cultivate and drill across the slope	1	13	18
14 - Establish riparian buffer strips	0	7	10
78 - Re-site gateways away from high-risk areas	0	8	10
105 - Management of field corners	0	7	10
107 - Beetle banks	0	7	10
108 - Uncropped cultivated margins	0	7	10
114 - Take field corners out of management	0	7	10
117 - Use correctly-inflated low ground pressure tyres on machinery	1	7	10
11 - Manage over-winter tramlines	1	7	10
111 - Unfertilised cereal headlands	0	6	8
112 - Unharvested cereal headlands	0	6	8
103 - Management of in-field ponds	0	2	2
110 - Uncropped cultivated areas	0	1	2
10 - Leave autumn seedbeds rough	1	1	1
80 - Establish new hedges	0	0	0
101 - Protection of in-field trees	0	0	0
	8	160	219

Ranked list of all FARMSCOPER measures for the Clun Upland Grazing Farm (P = phosphorus, N = nitrate and S = Sediment). The ranking has been done based on phosphorus to assess the benefits of an integrated approach whereby a single pollutant is targeted for mitigation and we assess the benefits to others also requiring reduction. This comparison shows that for the lowland arable farm both the top 5 measures and the general maximum to minimum reductions associated with ranking measures for phosphorus will also deliver close to the maximum benefits to sediment and nitrate reduction.

FARMSCOPER MEASURE ID	**Estimated farm reduction if applied individually (%)**		
	N	**S**	**P**
120 - Capture of dirty water in a dirty water store	4	0	20
119 - Use dry-cleaning techniques to remove solid waste from yards prior to cleaning	3	0	14
81 - Establish and maintain artificial wetlands - steading runoff	1	0	12
76 - Fence off rivers and streams from livestock	2	0	9
61 - Store solid manure heaps on an impermeable base and collect effluent	1	0	6
106 - Plant areas of farm with wild bird seed / nectar flower mixtures	0	10	3
78 - Re-site gateways away from high-risk areas	0	4	2
38 - Move feeders at regular intervals	0	4	2
39 - Construct troughs with concrete base	0	4	2
68 - Do not apply manure to high-risk areas	0	0	1
72 - Do not spread FYM to fields at high-risk times	0	0	1
19 - Make use of improved genetic resources in livestock	1	0	1
60 - Site solid manure heaps away from watercourses/field drains	0	0	1
62 - Cover solid manure stores with sheeting	0	0	1
118 - Locate out-wintered stock away from watercourses	0	1	0
32 - Do not apply P fertilisers to high P index soils	0	0	0
103 - Management of in-field ponds	0	1	0
36 - Extend the grazing season for cattle	0	-4	0
25 - Do not apply manufactured fertiliser to high-risk areas	2	0	0
26 - Avoid spreading manufactured fertiliser to fields at high-risk times	0	0	0
110 - Uncropped cultivated areas	1	0	0
23 - Integrate fertiliser and manure nutrient supply	1	0	0
80 - Establish new hedges	0	0	0
101 - Protection of in-field trees	0	0	0
22 - Use a fertiliser recommendation system	1	0	0
570 - Minimise the volume of dirty water produced (sent to dirty water store)	0	0	0
37 - Reduce field stocking rates when soils are wet	0	1	0
35 - Reduce the length of the grazing day/grazing season	0	4	0

7.2.6. Effectiveness of diffuse scenarios

Table 7.6 below summarises how each of the diffuse source scenarios might influence nitrogen, phosphorus and sediment concentrations in the River Clun SAC at Leintwardine. In line with the objectives of the investigation and in common with the assessment of the point source scenarios, a fully-licensed scenario including growth has been used as the baseline against which to assess all the other scenarios.

Table 7-6 Summary of FARMSCOPER-predicted reductions for diffuse source scenarios

Diffuse scenario		Estimated farm reductions (%)					
		Clun Upland Grazing Farm			Clun Lowland Arable Farm		
		N	P	S	N	P	S
8	COGAP and Farm assurance	2.7	3.2	5.1	5.2	0.2	0.0
9	Nitrate Vulnerable Zone (NVZ)	5.0	10.8	5.5	10.3	0.8	0.0
10	FARMSCOPER Top 5	8.1	47.0	21.2	3.3	50.0	73.5
11	FARMSCOPER Maximum	14.2	57.8	23.0	17.3	60.8	88.4

7.2.6.1. Phosphate

7.2.6.1.1. Results

Figure 7.5 below summarises the results of the phosphate diffuse source options assessment graphically, showing how phosphate concentrations and the annual phosphate source apportionment change under different diffuse source scenarios.

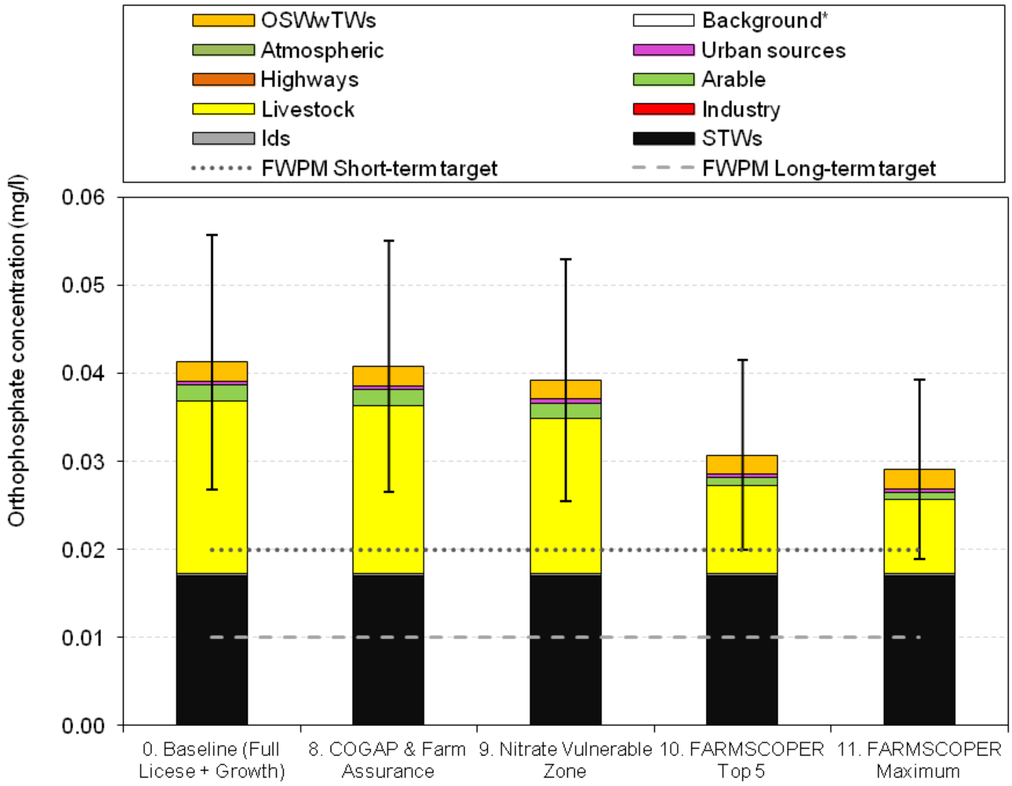

Figure 7-5 Contribution of diffuse source scenarios to compliance with phosphate favourable condition targets in the River Clun SAC. The colour coding provides information on how the different scenarios change the apportionment of phosphate.

The following points summarise the phosphate diffuse source scenarios assessment:

- COGAP and Farm Assurance measures (Scenario 8) are estimated to have relatively small (<5%) estimated effects on overall phosphate loads in the Clun catchment (Table 7-6). The predicted reductions are largest for the Clun upland livestock farm and smallest for the Clun lowland arable farm.
- Implementation of NVZ measures (Scenario 9) are predicted to provide ancilliary benefits to catchment phosphorus and sediment reductions in the Clun catchment. Although they are targetted primarily at nitrate reductions, FARMSCOPER suggests that implementation of NVZ measures would reduce phosphorus loads from livestock farms by approximately 10% (Table 7-6). NVZ measures have limited effects on phosphorus contributions from the Clun arable farm. This is in line with the focus of NVZ prescriptions on the management of animal waste.
- Top 5 FARMSCOPER measures (Scenario 10) and maximum predicted reductions according to FARMSCOPER (Scenario 11) are estimated to provide significant reductions of a similar scale (in the order of 50-60%) of phosphorus reductions from both the Clun upland grazing and lowland arable farms. This indicates that a more limited subset of targetted measures deliver the large majority of the maximum reductions in phosphate loads from both farm types and raises the possibility that a catchment strategy associated with promotion of the right measures implemented through say CSF, environmental stewardship or the new environmental land management scheme (NELMS) could work towards dleivery of these reductions. However, it is recognised that 100% uptake through voluntary measures is unlikely.

7.2.6.1.2. Contribution to compliance with favourable condition targets

Figure 7.5 shows that regardless of the scenario implemented, none of the diffuse source scenarios on their own are predicted to deliver phosphate concentrations in the river that are close to either the short-term or long-term favourable conditon targets (Figure 7.5). Combination of measures to control both diffuse and point source phosphate contributions in the catchment would also be required.

7.2.6.1.3. In-combination measures

Consideration of point and diffuse source measures alone has shown that based on precautionary, fully licensed plus growth baseline assumptions, neither of the point source or diffuse source measures identified are predicted to reduce mean annual phosphate concentrations in the River Clun SAC at Leintwardine to levels close to the short-term or long-term phosphate favourable condition targets. In-combination point source and diffuse source measures are likely to be required to deliver either of the favourable condition targets for phosphate.

To investigate the effects of in-combinations measures, predicted diffuse source reductions have been combined with the point source reductions that Severn Trent Water have suggested may be realistic during the AMP6 programme (Scenario 9). This approach is not an indication of the precise measures that are likely to be pursued but considers what, at the end of the current iteration of the NMP, may be the most likely outcome.

Table 7-7 describes the in-combination scenarios assessed and the predicted phosphate concentrations in the river resulting from each scenario. Figure 7.6 overleaf shows how the apportionment and phosphate concentrations in the River Clun SAC at Leintwardine might vary in response to different diffuse source scenarios using a 75% reduction in point source contributions (Scenario 9) as a starting point.

In combination implementation of maximum point source measures with FARMSCOPER Top 5 (Scenario 15) and maximum measures (Scenario 16) are both predicted to reduce phosphate concentrations in the River Clun SAC at Leintwardine to very low phosphate concentrations of 0.016 and 0.018 mg/l (Table 7-7), both of which are below the short-term phosphate favourable condition target (Figure 7.6). However, in both cases remaining phosphate concentrations in the river are significantly greater than the long-term phosphate target of 0.01 mg/l (Figure 7.6). In the case of the FARMSCOPER top 5 scenario, phosphate concenrations are predicted to remain at levels close to 2 times the long term phosphate favourable condition target for the River Clun SAC at Leintwardine. Figure 7.7 shows predicted reduction in phosphate concentrations across the length of the River Clun under Scenario 16.

Table 7-7 Details of in-combination scenarios

Scenario ID	Point source scenario	Diffuse source scenario	Phosphate concentration (mg/l)
12	7. STW-derived effluent reduced by 75% catchment-wide	Baseline	0.029
13		8. COGAP and Farm assurance	0.028
14		9. Nitrate Vulnerable Zone (NVZ)	0.026
15		10. FARMSCOPER Top 5	0.018
16		11. FARMSCOPER Maximum	0.016

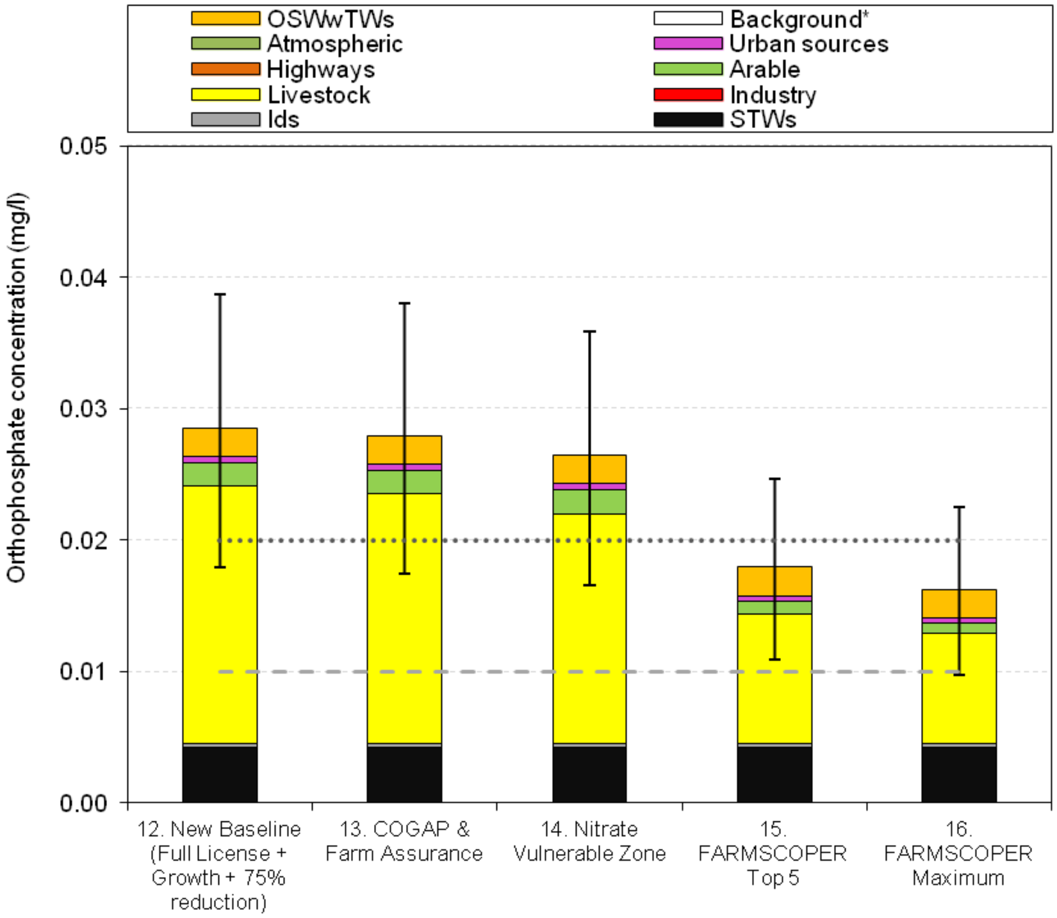

Figure 7-6 Contribution of in-combination point and diffuse source scenarios to compliance with phosphate favourable condition targets in the River Clun SAC. Bars are shown colour coded and denote the phosphate source apportionment.

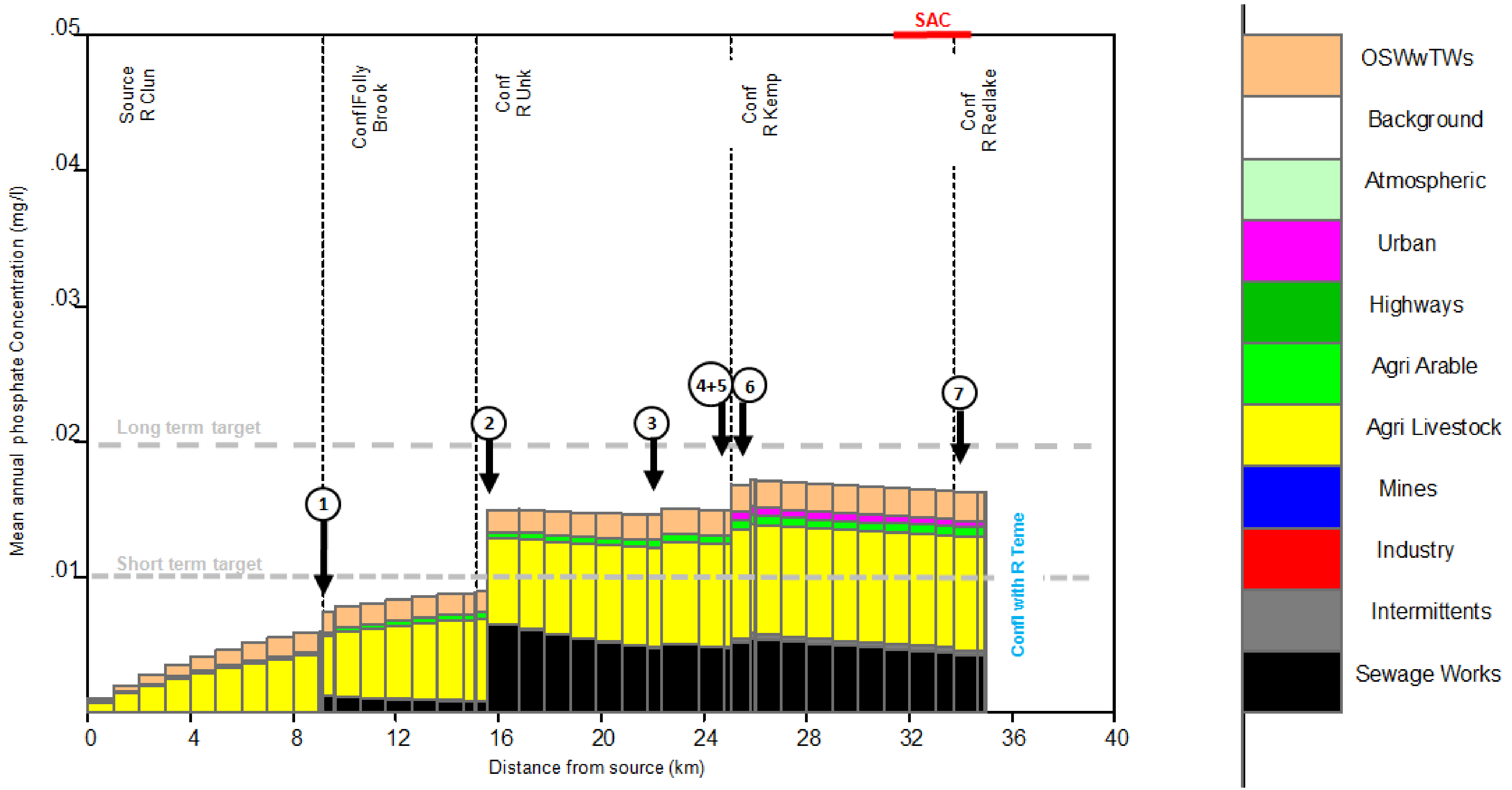

Figure 7-7 Downstream apportionment in the Clun catchment under a combined scenario where the maximum point and difffuse source reductions are implemented. The colour-coding relects the phosphate source apportionment. The long and short term freshwater pearl mussel favourable condition targets are also shown.

7.2.6.1.4. Other diffuse source measures

Figures 7.6 show that none of the in-combination scenarios will deliver phosphate concentrations in the river that reach the long-term favourable conditon target for freshwater pearl mussel.

An additional action that could be required to meet this long term target in the long term is to revert parts of the Clun catchment to deciduous woodland (Natural England, Pers. Comm.). The extent of deciduous woodland that would be required to meet the long term objective has been assessed as the final element of this iteration of the NMP. It is important to note that this is not currently a realistic scenario as the approach may have significant high-level socio-economic impacts, and the legislative tools to enable the scale of land use change likely to be required are not currently available.

FARMSCOPER does not select measures that require major land use change (such as reversion) so these have not been modelled using FARMSCOPER. The approach has used SAGIS directly. Phosphate concentrations in the River Clun SAC at Leintwardine have been estimated under scenarios where individual WFD water bodies in the Clun catchment are sequentially reverted to deciduous woodland until the long term phosphate favourable condition target of 0.01mg/l was reached. This approach reflects more the way in which SAGIS models phosphate generation processes rather than how reversion might be implemented although it is acknowledged that upstream areas are where most of the pilot catchment restoration measures are being implemented and where the quality of agricultural land is lowest.

To do this in SAGIS, loads associated with livestock and arable farming are switched off within the water body and replaced with a value for the 'natural' background phosphate generation in the catchment. It is important to note that there is a high uncertainty regarding 'natural' background phosphate generation in catchments in England as this will vary based on geology, land cover and factors such as temperature that affect the rate of natural vegetation decay. In addition, there are few truly natural catchments in England, and the resulting concentrations have until recently been below the level of phosphate detection utilised in operational practice. As such this assessment should be considered as a theoretical exercise to assess the likely scale of change required rather than providing a specific area of deciduous reversion that is likely to be required to achieve the long-term favourable condition target for phosphate.

The approach for estimating the 'natural' background phosphate load in the catchment has been to use an export coefficient of 0.02kg/ha/yr total phosphorus (applicable for deciduous woodland and areas of open moorland according to Johnes *et al.*, 1996; Bennion *et al.*, 2002; White and Hammond, 2006) adjusted to phosphate using the quotient of 0.5 proposed by White and Hammond (2006). Combining these two values gives an export coefficient of 0.01kg/ha/yr as an estimate of the natural background orthophosphate load from deciduous woodland. This rate has then been scaled up to provide a 'natural' phosphate load in each WFD water body that can be implemented within SAGIS whilst turning other diffuse sources off.

The starting point for the assessment is Scenario 15 with point sources reduced by 75% catchment-wide and FARMSCOPER Top 5 measures implemented across the catchment as a starting point. A number of sequential model runs have been undertaken where diffuse sources from WFD water bodies are progressively switched off until the target of 0.01mg/l is reached. This assessment has been undertaken to two decimal places in line with how the targets are expressed (see Section 2.5).

Table 7.8 below summarises the results of the assessment. The current best estimate is that over half of the catchment would need to be reverted to deciduous woodland to approximate the long term phosphate favourable condition target for freshwater pearl mussel. This would be additional to a catchment wide 75% reduction in STW-derived phosphate loads and Top 5 FARMSCOPER measures being applied across the catchment as a whole.

Table 7-8 Details of deciduous reversion scenarios

Point source scenario	Diffuse source scenario	Extent of deciduous forest in ha (% of catchment)	Phosphate concentration in Clun SAC (mg/l)
7 - STW-derived effluent reduced by 75% catchment-wide	15 - FARMSCOPER Top 5	0	0.02
		2,333 (9%)	0.02
		4,240 (16%)	0.02
		9,178 (34%)	0.02
		15,229 (56%)	0.01

7.2.6.2. Nitrogen

Source apportionment work in Section 6 has shown that in the order of 92-99% of nitrogen measured in the River Clun SAC at Leintwardine is from diffuse sources depending on the methdology used to estimate the load (Section 6.2.3).

The assessment of the effectiveness of measures in reducing nitrogen concentrations in the River Clun SAC has followed the same approach as for sediment whereby FARMSCOPER outputs are used to adjust mean annual concentrations from monitoring data to assess how implementation of measures might narrow the current compliance gap.

The compliance gap for TON is summarised in Table 7.9. Of the three substances considered as part of the NMP (phosphate, suspended solids and nitrogen), nitrogen exhibited the largest compliance gap between measured concentrations and the favourable condition target for freshwater pearl mussel. Mean concentrations of TON were 2-3 times the favourable condition target. In addition, FARMSCOPER runs show that whilst large reductions in phosphate and suspended solids are possible using a 'top 5' approach, even the maximum reduction possible for nitrogen is modest (in the order of 14-17% according to results presented inTable 7-9) and would require implementation of a very large number of measures

At the end of the first iteration of the NMP, the precise breakdown of diffuse sources of nitrogen is not fully understood with regards to the relative proportions sourced from arable or livestock sources. Consequently, monitoring data have been adjusted directly using FARMSCOPER outputs for both the Clun Upland Grazing Farm and Clun Lowland Arable Farm to provide the range of outcomes that would results from the changing assumption that either the clun upland or lowland farms dominate the nitrogen load in the catchment, although this is obviously will be somewhere between the two values.

The results of the assessment are shown in Table 7.9 below that compares current TON concentrations in the Clun SAC at Leintwardine to predcted concentrations following the implementation of FARMSCOPER Top 5 measures. Both current and predicted concentrations are shown colour-coded to reflect whether they would (green) or would not (orange) meet the TON favourable condition target for freshwater pearl mussel.

The small predicted reductions result in small predicted changes in TON concentrations. Even following these reductions, there would still be a large gap between the TON concentrations in the River Clun SAC at Leintwardine and the favourable condition target for nitrogen.

Table 7-9 Estimation of TON concentrations in the River Clun SAC at Leintwardine resulting from implementation of Top 5 FARMSCOPER measures

Mean annual measured concentration (mg/l)			Favourable condition target	FARMSCOPER Top 5 estimated reduction (%)	Reduction following adjustment for apportionment (%)*	Estimated mean annual TON concentration (mg/l)	Remaining reduction required to meet target
TON	**Mean**	**4.4**	1.5	3.3 – 8.1	3.0 – 7.5	**4.0 - 4.3**	63 – 65%
	2007	5.1				4.7 – 4.9	68 – 69%
	2008	4.6				4.1 – 4.5	63 – 67%
	2009	3.8				3.5 – 3.7	57 – 59%
	2012	4.1				3.8 – 4.0	61 – 63%

7.2.6.3. Sediment

The assessment of how predicted FARMSCOPER reductions on sediment might affect suspended solids concentrations in the River Clun SAC has been undertaken based on the assumption that 85% of the load is derived from agricultural sources (Section 6.3.3); predicted FARMSCOPER reductions are only applied to 85% of the recorded sediment concentration. Table 7.10 sets out the results of the assessment asuming a catchment reduction in sediment of 73.5% in line with Top 5 FARMSCOPER predictions.

The assessment shows that on average, application of Top 5 sediment measures across the catchment would reduce mean annual suspended solids concentrations to within the favourable condition target. However, in certain years suspended solids concentrations would still exceed the favourable condition target.

This assessment will need to be updated once the outcome of future, more detailed sediment apportionment work becomes available and when the dynamics of suspended solids impacts on freshwater pearl mussel is further understood, especially with regards to whether it is average conditions or individual events that drive impacts on freshwater pearl mussel and the river bed habitat.

Table 7-10 Estimation of suspended solids concentrations in the River Clun SAC at Leintwardine resulting from implementation of Top 5 FARMSCOPER measures

Mean annual measured suspended solids concentration (mg/l)			**Favourable condition target**	**FARMSCOPER top 5 estimated reduction (%)**	**Reduction following adjustment for apportionment (%) ***	**Estimated mean annual suspended solids concentration (mg/l)**
Monthly spot sampling	**Average**	**12.3**	10	73.5	62.5	**7.7**
	2007	8.9				5.6
	2008	10.4				6.5
	2009	17.8				11.1
Continuous turbidity monitoring	**Average**	**13.8**				**8.6**
	2006*	16.0				10
	2007*	20.0				12.5
	2008*	9.0				5.6
	2009*	5.0				3.1
	2012-13	19.0				11.9

**Assumes 85% of sediment load is sourced from diffuse sources (15% from river banks) (Section 6.3.2) and that sediment sources are predominantly from arable / tilled land according to the Defra (2005) soil erosion risk methodology (see Section 6.3.4)*

Part three – Conclusions and recommendations

8. Conclusions and recommendations

The conclusions of the River Clun SAC Nutrient Management Plan are summarised below. Conclusions are presented in relation to the main project objectives set out in Section 1.2.

8.1. Objective 1 - Assess the impacts of predicted population growth in the Clun catchment on water quality in the River Clun SAC.

1. The current population of the Clun catchment is between 7,000 and 7,500 persons according to the most recent decadal population census (2010). 55-60% of the catchment population is on mains sewerage with the remainder on OsWwTWs. **Shropshire Council estimate that additional population growth in settlements until 2027 will increase the catchment population by in the order of 575 persons, or 8%**.

2. The majority of growth is expected to be accommodated on the existing mains sewerage network around the towns of Clun, Bucknell and Bishops Castle. Predicted growth is estimated to increase total catchment STW effluent volumes by 82m^3/day or 29,920m^3/year. A small proportion in the order of 12% will be served by new OsWwTWs.

3. Additional growth in employment land is estimated to increase the current catchment flows by 21,118m^3. The majority of employment land growth will be new office space in Bishops Castle. **All of the growth in employment land is expected to be accomodated at the existing mains sewerage network around Bishops Castle, Bucknell and Lydbury North.**

4. An approach to assess the effects of population growth on the River Clun was developed during a project stakeholder workshop in June 2013. Growth estimates across the catchment were matched to the STWs most likely to treat the additional effluent. At these STWs, discharge flows were increased in accordance with growth estimates to assess the likely changes in phosphate concentrations in the River Clun SAC. Discharge quality was assumed to be unchanged since it is anticipated that any additional influent volume would be treated to the same degree of quality as at present.

5. The SAGIS model estimates that **predicted population growth in the catchment could result in an 8% increase in phosphate concentrations in the River Clun SAC**, from 0.038 mg/l under the current fully-licensed scenario to 0.041mg/l under fully-licensed conditions with growth.

6. Source apportionment investigations have shown that the contributions of sediment and nitrogen from point sources are small and **the effects of growth on nitrogen and sediment concentrations in the river are expected to be negligible**.

A number of external processes are likely to offset some of the effects of growth in the Clun catchment. For example, it has been estimated that limits on the phosphate content of some kitchen detergents in 2015 will reduce effluent phosphate concentrations by 1 mg/l on works that do not have P stripping already. Whilst this has not been formally assessed, this would be equivalent to a reduction of more than 20% in the effluent concentration of the STWs that currently provide the majority of point-source phosphate loads to the Clun catchment.

8.2. Objective 2 - Identify the sources of nutrients and sediment and collate evidence on their impact.

The assessment of the relative importance of different sources of phosphate, nitrogen and sediment has been a core component of the development of the River Clun NMP. The Plan has been developed based on the best information and data currently available to Natural England, the Environment Agency and its partners. A combination of previous targeted investigations, industry-standard modelling techniques and monitoring data collected by the Environment Agency have been used for this purpose.

Phosphate

A SAGIS model used to estimate phosphate apportionment in the Clun catchment has shown that:

7. Point sources account for in the order of one third of the catchment phosphate loads on an annual basis with diffuse sources accounting for two thirds

8. **Livestock are estimated to be the single largest source of phosphate in the Clun catchment** and account for over half the catchment phosphate loads on an annual basis. Information provided by Defra indicates that there are close to 14,000 cattle, 120,000 sheep, 410,000 poultry and 150 pigs in the Clun catchment. Applying an export coefficient approach provides a breakdown of catchment-scale livestock sources as follows: Sheep (46%), poultry (28%) and cattle (25%).

9. **The second largest source is STW effluent in the catchment** that contributes 35% of the catchment phosphate load on an annual basis. A phosphate mass balance approach using monitoring data indicates a smaller contribution from STWs in the order of 18% under average conditions. As phosphate removal is already in place at largest STWs in the catchment (Bishops Castle STW and Bucknell STW), the most significant point source contributions are from STWs serving Clun and Lydbury North that in combination contribute close to 60% of the total STW-derived phosphate load in the catchment. However, it is important to note that no post 2008 effluent phosphate concentration data are available for any of the smaller STWs in the catchment including Clun and Lydbury North.

10. **Arable land is the third largest source of phosphate in the Clun catchment** and is estimated to contribute 5% of the phosphate load on an annual basis. 70% of tilled land in the Clun catchment is cultivated for cereals according to Defra data and the majority of the catchment arable phosphate load is associated with this land use type.

11. OsWwTWs (2%) and urban inputs (1%) are expected to contribute smaller amounts of phosphate at the catchment scale. Roads themselves are not a catchment-scale source of phosphorus, nitrogen or sediment although they provide a critical role as a flow pathway.

Analysis of monitoring data indicates that the apportionment of phosphate will vary throughout the year. Further consideration of seasonal variations in the apportionment of phosphate using models and monitoring data are required to help target measures to control, for example, algal development that is primarily a spring and summer process not currently captured by annual phosphate targets.

Nitrogen

12. The Environment Agency has considered the apportionment of Nitrogen in the Clun catchment during the Habitats Directive Stage 3 assessment. Modelling work to support this assessment, coupled with mass balance calculations undertaken as part of the NMP show that **the majority of nitrogen in the catchment is derived from diffuse agricultural sources**. In the order of 92-99% of the nitrogen measured in the River Clun SAC at Leintwardine is from diffuse sources depending on the approach used to estimate the load.

13. **STWs and other industries discharging at their consented maximum load were responsible for only small (1%) components of the catchment nitrogen load.** Results obtained from a mass balance assessment using monitoring data have provided similar conclusions.

14. **Atmospheric sources account for in the order of 6% of the annual nitrogen budget of the Clun catchment** according to the National Environment and Agricultural Pollution Nitrate (NEAP-N) dataset (Lord and Anthony, 2000) that underpins Defra nitrate policy and is a key component of the Environment Agency method for defining NVZs.

15. However, **best available current information does not provide a breakdown of the precise components (eg. arable and livestock farming) that make up the overall diffuse nitrogen contribution**. However, NEAP-N mapping indicates that the Lower Clun and Kemp catchments have the highest rate of export per unit area and account for close to 60% of total annual nitrate loads in the Clun catchment.

The current update of the SAGIS national model (due April 2014) will provide a formal means of assessing nitrogen source apportioment including the breakdown of diffuse components using updates of NEAP-N. Due consideration should be given to obtaining this information when it becomes available to complement the assessment in the NMP.

Sediment

16. A number of recent studies have considered the sources of sediment in the Clun catchment. However, **there is still some uncertainty regarding the proportions in the Clun catchment and different studies reflect a conflict of opinion.** The current scientific and local stakeholder consensus is that agriculture is responsible for the majority of silt transported to the River Clun. For other catchments, source apportionment work indicates that 75% of the silt load in rivers is as a result of catchment land use practices. Suspended solids derived from STWs in catchment are very small and in the Clun catchment account for 1.4% of the total loading.

17. **The dominant soils in the Clun catchment are naturally susceptible to erosion**. Where soils are tilled, the large silt and fine sand content leads to capping during heavy rain and runoff then causes erosion on slopes Soils covering close to 60% of the Clun catchment are at risk from erosion. The soils with the highest erosion risk cover parts of the catchment with the highest density of arable land.

18. As part of the NMP, the sediment source apportionment has been estimated based on a series of simple assumptions, information collected as part of previous investigations and area-weighted flow data. **A current best estimate is that in the order of 15% of the total annual sediment load in the Clun catchment may be sourced from bank erosion with the remaining 85% from diffuse sources.**

19. The largest loads at both sites were seen in autumn and winter especially the months between November and February. This coincides with the time of year when flows are highest and when fields cropped to cereals are most likely to lack significant crop cover. **Fields cropped to cereals, and other land practices where the soil is bare during winter, are therefore likley to have the highest soil erosion risk in the catchment.**

20. PSYCHIC data suggest that **close to 60% of the total sediment generated in the Clun catchment is sourced from the Kemp and Lower Clun sub-catchments** where the largest proportions of arable land are found.

21. More specifically, an additional assessment quantifying sediment loads in the River Clun suggest that **up to two thirds of the overall sediment load passing through the River Clun SAC is generated downstream of Clungunford and only a small proportion of the total catchment sediment load is likely to be generated in upstream tributaries** such as the Folly Brook.

Uncertainties regarding the precise contributions of different sediment sources are currently being investigated by a sediment fingerprinting and source study commissioned by Natural England, due for completion in 2015. This study will serve to confirm the findings of this and previous investigations and help target catchment measures.

Evidence of impact

Evidence of impact represents one of the main knowledge gaps identified during the production of the NMP. For example:

22. To date, the focus of investigations and monitoring on the Clun has been on the effects of suspended solids on freshwater pearl mussel. However, **a greater understanding of the factors driving sediment deposition in the River Clun is required, especially with regards to the importance of high flow and low flows, and organic (algal) and inorganic (soil) sediment sources**.

23. **Phosphate is not thought to be toxic to freshwater pearl mussel but is likely to have indirect effects by controlling algal growth in the river**; algae have been previously identified as an important influence on the health of freshwater pearl mussel habitat as well as having potential effects on their physiological functions. There are no historic chlorophyll-a data (a surrogate for algal activity in rivers) to assess how algal growth in the River Clun is related to phosphate concentrations.

24. **Similarly, nitrogen is not thought to be toxic to freshwater pearl mussel themselves but is also likely to influence algal growth in the river**. There is increasing interest in nitrogen and its role in limiting algal growth. However, at the concentrations currently recorded in the river it is considered unlikely that nitrogen would act to limit algae although this would need to be formally considered using water quality data.

Objective 5 identifies potential areas of investigation to help identify the precise sources of impact on freshwater pearl mussels in the River Clun. This will help to identify the precise measures that have the greatest chance for the restoration of the SAC.

8.3. Objective 3 - Provide an indication of the likely reductions achieved by different combinations of measures which could be carried out within the wider catchment to address any nutrient or sediment issues identified.

The Clun Nutrient Management Plan has assessed a range of potential options available to reduce the current compliance gap and deliver favourable condition in the River Clun SAC by 2027. Options for point and diffuse sources have been considered separately.

Point sources

25. Five potential point source measures were identified during a workshop in June 2013. A sixth point source scenario has been recently identified by Severn Trent Water whereby total catchment STW-derived phosphate loads are reduced by 75%.

26. Source apportionment showed that the proportions of sediment and nitrogen from point sources were negligible. Consequently, the assessment of point source measures used the SAGIS model to estimate the phosphate concentrations in the River Clun SAC under each measure. In all cases, a baseline of fully-licensed STW discharges with predicted growth was used.

The point source assessment showed that:

27. **Transferring effluent or the implementation of high technology P-stripping solutions at Bucknell or Bishops Castle STWs would provide limited benefits to phosphate concentrations in the River Clun** SAC. This is because phosphate stripping at both works has already been implemented.

28. Aditional phosphate stripping at Lydbury North STW and Clun STW are estimated to reduce phosphate concetrations in the River Clun SAC by around 15%. Larger reductions in the river phosphate concentration in the order of 25% are potentially possible if P-stripping was introduced at all minor STWs.

29. **The maximum reduction in river phosphate concentrations was delivered by reducing all STW-derived phosphate loads in the catchment by 75% as recently suggested by Severn Trent Water.** This measure would deliver a phosphate concentration of 0.028mg/l in the River Clun SAC. This concentration still significantly above both the long and short term Favourable Condition Targets for freshwater pearl mussel.

Point source measures will not deliver the short or long-term favourable condition targets on their own. Measures to control diffuse pollution in the catchment will also be required.

Diffuse sources

30. The range of **measures available for the reduction of diffuse sources options has been identified using FARMSCOPER**, a Defra-funded farm-scale tool to scope the effectiveness of diffuse mitigation measures applied within the rural sector.

31. For application within FARMSCOPER, and in line with the scoping nature of the assessment, **agricultural practices in the Clun catchment were generalised according to the Less Favourable Area (LFA) boundary**. Upland grazing farms ('LFA Grazing' farm type in FARMSCOPER) were assumed to be dominant within the LFA boundary with lowland arable farms ('Mixed combinable with manure' farm type in FARMSCOPER) elsewhere.

32. **FARMSCOPER has been used to estimate the overall effectiveness of various land management measures and how they might reduce phosphorus, nitrogen and sediment loss** including agricultural best practice (COGAP and Farm Assurance) and catchment-wide application of

Nitrate Vulnerable Zone (NVZ). FARMSCOPER was also used to identify the top 5 measures to deliver reductions in phosphorus, nitrogen and sediment loss, as well as the maximum reductions that might be possible for each substance for each farm type.

33. **All scenarios were considered relative to a baseline of no prior implementation** in line with the PSYCHIC data that underlie SAGIS and a precautionary worst-case scenario required as part of the Habitats Directive and applied as part of the point source scenarios.

The diffuse source assessment has showed that:

34. **COGAP/Farm Assurance and NVZ measures would have relatively small (5-10%) estimated effects on overall phosphate loads** in the Clun catchment.

35. **The maximum potential reduction in catchment diffuse phosphate loads is in the region of 60%.** However, **a top 5 of measures delivers the majority of this benefit and could reduce phosphate loads in the catchment by up to 50%** although 100% uptake would be required.

36. Overall, **none of the diffuse source scenarios on their own are predicted to deliver phosphate concentrations in the river that are close to either the short-term or long-term favourable conditon targets for freshwater pearl mussel. Measures to control point sources in the catchment would also be required.**

37. Implementation of **Top 5 Farmscoper measures for sediment would reduce sediment loss from a typical winter combinable (arable) farm by 75%.** The Top 5 options for phosphorus and sediment reduction on the typical arable farm are the same, highlighting that there are ancillary benefits to phosphate reduction if sediment loss measures are implemented.

38. Whilst large reductions in phosphate and suspended solids are possible using a 'top 5' approach, **even the maximum reduction possible for nitrogen is modest (<20%) and would require implementation of a very large number of measures**.

8.4. Objective 4 - Assess whether favourable condition targets can be met.

39. The Conservation Objectives set by Natural England for the River Clun SAC include Favourable Condition Targets (FCTs) for in-river phosphorus (P), nitrogen (N) and sediment (suspended solids) concentrations. **The targets have been set to protect freshwater pearl mussel from the adverse effects of nutrient enrichment and siltation and are based on current best-available evidence and the consensus of scientific opinion.**

Analysis of measured water quality data for the River Clun SAC has identified that there are significant compliance gaps between the FCTs for freshwater pearl mussel and the measured concentrations of phosphate, nitrogen and sediment in the river as follows:

40. Measured phosphate concentrations in the River Clun SAC are low, and have been mostly in the order of 0.03 mg/l since 2007. **Nevertheless, phosphate reductions of 43% and 71% are likely to be required to meet the short and long term phosphate FCTs** respectively.

41. Reductions in mean annual suspended solids concentrations of between 19 and 74% may be required to meet the sediment FCT. The reductions required depend on the dataset used, and the years included in the assessment. Currently, there is concern that individual events may lead to impacts upon the species. On a precautionary basis therefore, the highest value of 74% has been used in the FCT compliance assessment.

42. Nitrogen concentrations in the River Clun SAC are high for a freshwater pearl mussel river and are in the order of 4 mg/l. **Of the three substances considered by the NMP, nitrogen exhibited the largest compliance gap between measured concentrations and the FCT.** Mean concentrations of TON were 2-3 times the favourable condition target. It is estimated that reductions in the order of 68% will be required to meet the nitrogen FCT.

Comparison between SAGIS and FARMSCOPER outputs has enabled an assessment of how and whether different measures contribute to reducing the observed compliance gap as described below.

Phosphate

Consideration of point and diffuse source measures alone has shown that neither will reduce phosphate concentrations in the River Clun SAC to levels approaching the short- or long-term phosphate FCT. Water companies and the farming community will both need to contribute to deliver the phosphate FCTs.

43. **The short term phosphate target of 0.02mg/l target is achievable with management changes so doesn't involve reversion but** will require the combined application of Top 5 FARMSCOPER measures with a 75% reduction of phosphate loads from STW effluent.

44. **Meeting the long term phosphate target of 0.01mg/l will require extensive reversion to semi natural vegetaion e.g. woodland or heathland.** An initial scoping assessment has estimated that in the order of half of the Clun catchment would need to be reverted to approach the long term phosphate FCT for freshwater pearl mussel. It is acknowledged that this is not currently a realistic scenario as the approach may have significant high-level socio-economic impacts, and the legislative tools to enable the scale of land use change likely to be required are not currently available.

Sediment

45. Based on an assumption that land use sources represent 85% of the sediment concentrations in the river, FARMSCOPER suggests that **implementation of the Top 5 measures may, on an average basis, reduce sediment concentrations in the River Clun SAC to within the sediment favourable condition target for freshwater pearl mussel of 10mg/l.**

46. However, in certain years suspended solids concentrations would still exceed the sediment FCT. There is also uncertainty regarding the effects of short duration, large turbidity events regularly recorded in the River Clun.

47. This assessment will need to be updated once the outcome of detailed sediment apportionment work becomes available and when the dynamics of suspended solids impacts on freshwater pearl mussel is further understood, especially with regards to whether it is average conditions or peak flow events that determine the health of frehswater pearl mussel and its habitat. Both elements are core components of a project commissioned by Natural England that will be completed during 2014.

Nitrogen

48. FARMSCOPER predictions indicate that potential reductions in diffuse nitrogen are likely to be small, even at a large scale of implementation. Based on current best-available information, it is estimated that **a large compliance gap between nitrogen concentrations in the River Clun SAC and the FCT is likely to remain even if maximum implementation of measures is achieved**.

49. A number of activities are being considered and planned by Natural England and the Environment Agency to address some of the main data gaps, assumptions and limitations and are set out under Objective 5 overleaf.

8.5. Objective 5 - Help define monitoring to assess knowledge gaps assess progress in the recovery of the habitats and species for which the River Clun is valued.

A number of knowledge gaps have been identified during production of the NMP. Proposals for additional data collection and investigations are summarised in the following tables. These items will inform some of the assumptions made and reduce limitations and uncertainties. Elements below should be considered for inclusion within an integrated catchment monitoring strategy that sets out the location and frequency of sampling, the costs associated with staff, equipment and sampling and the synergies between different drivers for data collection such as SAC restoration, WFD and flood risk management.

Monitoring

Monitoring action		Rationale
A	Collect flow data for minor STWs	There are currently no measured flow data for the minor STWs in the catchment. To this regard, phosphate source apportionment modelling has used mean annual flows derived from quoted populations served and industry-standard approaches for flow estimation.
B	Monitor phosphate concentrations in STW effluent at minor STWs, especially Clun and Lydbury North	Smaller STWs in the Clun catchment do not have phosphate discharge limits. There is currently no monitoring of the effluent phosphate concentrations at most of these smaller works. The current assessment shows that these two works in combination provide the greatest STW effluent-derived phosphate load in the catchment. It is understood that Severn Trent Water will be undertaking a programme of monitoring at these works as part of an early start project during Asset Management and Planning 6 (AMP6).
C	Consider the need for river flow monitoring for the River Clun	There is currently no formal gauging station on the River Clun although the Environment Agency does maintain a location downstream of the confluence with the River Teme. Elsewhere within the catchment, the understanding of flows in the minor tributaries is potentially limited by historic spot monitoring. An enhanced programme of spot flow monitoring in some of the Clun tributaries could also be considered to develop ratings between flow and level at a broader variety of locations. However, it is acknowledged that the similarity of the geology and soils both within the Clun itself and between the Clun and the Upper Teme does indicate that the current flow estimation approach is likely to provide a reliable estimate of flow under most conditions.
D	Review phosphate detection limits (if required)	The orthophosphate detection limit used nationally by the Environment Agency changed in 2011. Orthophosphate data prior to this period will not have been analysed to a lower detection level and comparing historic data to post 2011 data has to be carried out with caution.
E	Include chlorophyll-a within the current sampling suite in the Clun SAC at Leintwardine	Phosphate itself is not thought to be toxic to freshwater pearl mussel but is likely to control algal growth in the river. Chlorophyll-*a* should be included in the suite of determinands monitored in the River Clun SAC (and at other catchment locations if deemed necessary) to help understand the interplay between phosphate, algal growth and impact pathways between water quality and freshwater pearl mussel.
F	Consider sampling nitrogen concentrations in STW effluent	None of the STWs in the Clun catchment have nitrogen discharge limits and there is no monitoring of effluent TON concentrations. Natural England and the Environment Agency may consider collecting a small sub-sample of data to confirm the findings presented in this investigation.
G	Continued monitoring using turbidity probes	The data period included within the NMP incorporates one of the wettest years on record. The unusual weather conditions may have had an influence on the results. Due consideration should be given to maintaining monitoring across a range of years. Understanding of the contributions of tributaries may also benefit the targeting of measures.
H	Watching brief on population growth	Regular updates on growth and development in the Clun catchment should be sought to include in NMP revisions.
I	Collect catchment specific farm data to distinguish between	One of the key data sets that will be required to support spatial targeting of measures will be descriptions of catchment specific farm practices. For example, the ability to distinguish between cereal and other arable farms is likely to be of significant help in reducing sediment loads into the river. A large number of field

Monitoring action		Rationale
	different arable and livestock practices	officers operate across the catchment and could coordinate collation of this information.

Investigations

Investigation action		Rationale
J	Undertake a formal sediment source apportionment assessment	At this stage, there is insufficient evidence to quantitatively describe the sources of sediment in the SAC. Natural England is currently commissioning a project to address this knowledge gap.
K	Understand the dynamics of sediment deposition	To date, the focus of investigations and monitoring on the Clun has been on the effects of suspended solids on freshwater pearl mussel. A greater understanding of the factors driving sediment deposition in the River Clun is required, especially with regards to the importance of high flow and low flows, and organic (algal) and inorganic (soil) sediment sources on a seasonal basis.
L	Assess nitrogen limitation and controls on algal growth	Nitrogen itself is not thought to be toxic to freshwater pearl mussel but is likely to control algal growth in the river. Due regard should be given to establishing the interplay between phosphate, TON, algal growth and the impact pathways between water quality and freshwater pearl mussel. A particular focus should be an assessment of the conditions at which nitrogen might become limiting to algal growth in the River Clun. The outcome of this investigation will be critical to determine whether nutrient management activities in the catchment do need to focus on nitrogen reduction (if nitrogen is a limiting factor in algal growth).
M	Review favourable condition targets	There is a need for a general review of the favourable condition targets that apply to the River Clun SAC. For example, freshwater pearl mussel favourable condition targets currently use mean annual phosphate concentrations as a means of protecting the species. It is likely that seasonal targets reflecting the developing understanding of the impact pathways between nutrients, sediment and freshwater pearl mussel will be the most effective way of ensuring that the most cost-effective measures to deliver favourable condition in the River Clun are targeted.
N	Undertake a formal assessment of farm practices in the Clun catchment	Currently there are few data describing the specific management of farms within the Clun catchment. Due regard should be given to recording the main aspects of their management, for example the timing of livestock movements, livestock housing arrangements and the timing of ploughing on tilled land across the catchment all of which will help target measures.
O	Assess the effects of the 2015 phosphate ban	The effects of the ban on phosphate in dishwasher detergents and other kitchen products due in 2015 should be considered. It has been estimated that this may reduce phosphate loads flowing to STWs by a 20% and this process may help to offset future population growth.
P	Develop approaches for spatial targeting of measures	One of the key elements for meeting the favourable condition targets will be the availability of information that will help Natural England and the Environment Agency catchment officers target diffuse sources that provide the best value for public money. There are currently few data for the catchment that help target mitigation measures.
Q	Understand the management of poultry manure	There is a need to get a better understanding of when and where poultry manure is being spread in the catchment, whether poultry farms in the catchment currently spread manure within or outside the Clun catchment, and whether any poultry manure is imported.
R	Better understand extent and effect of under drainage	Field mapping of the extent of under-drainage in the catchment may help to identify high risk areas close to watercourses.
S	SAGIS calibration methodology and model update	The Environment Agency is currently in the process of updating the SAGIS model to include data for the period 2010-2012. A national approach for calibration is also being agreed. Due consideration should be given to revisiting the SAGIS modelling once the national model has been agreed. This model update would be best timed to coincide with the availability of new STW flow and effluent concentration data that will be collected early during AMP6 to ensure the most up to date representation of pressures.

Investigation action		Rationale
T	SAGIS Nitrogen	As part of the update of SAGIS, the ability to formally distingusih between diffuse sources of nitrogen is being built in based on updated NEAP-N data. The tool is currently being run nationally and due regard should be given to obtaining this data for future inclusion in the NMP.
U	Formal assessment of land use change	Due consideration should be given to a formal assessment of land use change in the catchment covering the pre-war period to the present day

Way forward and goverenance

Further development of this Nutrient Management Plan and any actions arising from it will be based on a series of core principles that will guide future work in the catchment.

Action	Rationale
Collaborative approach	In line with the production of this first NMP for the Clun catchment, further reviews and implementation of any actions will need to be done collaboratively with stakeholders within the catchment.
Governed by an active steering group	To this regard, a steering group will be established to oversee implementation and review of the NMP going forward. A technical group, field officers group and a partnership group will sit under this. The steering group as well as looking to take forward the NMP will look to draw together actions needed for the other plans within the Clun catchment, including a Clun freshwater pearl mussel conservation strategy to ensure populations are maintained whilst catchment actions are implemented.
An Iterative approach to restoration	An iterative approach to restoration will be pursued, firstly aiming for the short-term target of 0.02mg/l of phosphate in the river by 2019 and then 0.01mg/l, reviewing ecological improvements along the way to amend the targets if evidence indicates that step-wise improvements deliver the required ecological improvements.
Incorporating flexibility	Although it will be necessary to aim for 100% uptake of any measures identified. A measure of flexibility will need to be built into catchment management measures to enable these to be taken forward.
Use tools such as FARMSCOPER to help plan farm-scale actions	A central approach might be to build FARMSCOPER into operational practice and use it to engage land managers and as a platform to help all partners manage diffuse pollution in the catchment going forward. As a starting point, Farmscoper could be run at farm level for high risk areas/farms or for the Clun demonstration farm.
Maintain a watching brief on catchment management developments, regularly reveiwing and updating the plan to capture changes	Given increasing interest in the field of diffuse pollution, a large amount of time and effort is being invested by a large number of organisations in the collection and the develpment of tools to help catchment practitioners. Regular updates of the plan should seek to capture evidence provided by new data sets or methodologies to always ensure that measures being implemented are based on the most up to date science and methdologies.
Providing the full range of ecosystem services and economic benefits	The delivery of catchment management measures identified may produce a variety of ancillary benefits that make considerable contributions to improving the ecological condition and towards other economic and environmental targets. In the Clun catchment, benefits to the farming community are likely to result from reduced soil loss. At a broader scale, there will be benefits to flood risk and channel management, fisheries and tourism.
In consultation with Defra	Ongoing discussions with Defra will be required to provide regular updates on progress and funding requirements and the implications of any catchment changes to NMP objectives.

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Appendix A. Comments

A.1. Summary

This appendix provides a record of the comments received on the initial version of the River Clun SAC NMP. The main changes and additional technical work undertaken in response to stakeholder comments can be summarised as follows:

1. Alignment of Clun NMP with other NMPs;
2. Update of Sewage Treatment Works data and re-evaluation of the importance of different works;
3. Clarification regarding the main drivers of the NMP and linkages to other activities in the catchment;
4. Updated section on sediment, providing the results of a formal assessment of links between turbidity and suspended solids in the Clun catchment;
5. Includes clarifications provided by Natural England regarding Favourable Condition Targets;
6. Maps incorporated to text;
7. Soil erosion risk by soil type and distribution considered in greater;
8. Description of hydrology work undertaken incorporated as specific Appendix;
9. Additional detail on land cover data assumptions and limitations provided;
10. Removal of comparison of Defra 2000 and 2010 data – data showed artificial declines in agricultural practice due to way in which data have been recorded during each census. Defra have advised that 2000 data includes both commercial and non-commercial holdings whereas the 2010 data is for commercial holdings only;
11. The water quality baseline has been extended to look at trends elsewhere in upstream parts of the catchment to provide input to discussions on potential translocation raised in comments;
12. Additional analysis of suspended solids data has been undertaken to (a) establish the validity of assumptions that turbidity and suspended solids can be considered equivalent in the Clun catchment, (b) compares spot sampling and continuous data and (c) assess variations during individual events;
13. Identification of future pressures and trends (eg. agricultural change) to highlight importance of changes in subsidies or legislation and impacts on in-stream phosphate concentrations;
14. Update of the SAGIS model to incorporate revised STW concentrations, local flows and updated calibration procedure. The SAGIS model is currently being updated nationally to include 2010-2012 data, changes to the SIMCAT procedure and revision of specific approaches to calibration;
15. Source apportionment assessments extended using monitoring data to complement model outputs;
16. WFD waterbody assessment (spatial distribution) of model outputs eg. using PSYCHIC to assess which catchments have the biggest loads of phosphate, sediment and nitrogen;
17. New sections included detailing the data gaps, assumptions and limitations sections associated with phosphate, nitrogen and sediment apportionment included in the plan;
18. Identification of actions to reduce uncertainties included in recommendations;
19. Restructuring of NMP into three main parts: Part 1 - Evidence base (models and data), Part 2 - Options appraisal (scenario testing) and Part 3 – Conclusions and Recommendations;
20. Interfacing of FARMSCOPER and SAGIS to provide formal assessment of impacts of all measures identified by stakeholders on in-stream phosphate concentrations;
21. Assessment of different (current) policy outcomes (eg. NVZ, COGAP) on phosphate, sediment and nitrogen concentrations in the River Clun SAC;
22. FARMSCOPER and compliance assessments for N and SS (as well as P)
23. Identification of the specific combinations of measures most likely to deliver the range of short and long term Favourable Condition Targets for phosphate, sediment and nitrogen in the River Clun;
24. Assessment of additional monitoring and likely further investigations that could be undertaken to address current uncertainties.

A complete log of changes made to the NMP is provided in the tables that follow. The response to the comments has been colour coded describing how each has been addressed within the update of the NMP.

(green)	Changes made to the report
(blue)	Clarification or comment provided. No change made to report
(yellow)	No change to report currently made (eg. further external clarification, outside scope of NMP)

A.2. Severn Trent Water

Comments		Type of comment	Response
1	Table 5.1 on Page 26 The third column title should read "DWF_Q90 limit" (not Q80) There is a seventh public sewage treatment works that should be included in the table (Clunbury). DWF permit is 28m3/d. With regards to population served, it was built to serve 40 properties (about 100 people), but I think that only about 10 houses are actually connected.	Text edit	Changed
2	Section 5.2, fourth paragraph:- 'Ordinarily, the preferred disposal route for foul effluent from any development is via a public sewer (where one exists) and treated at a public sewage treatment works (STW). However in the case of the Clun it has been suggested that there should be no increase in the wastewater entering the public sewer as this would increase the level of phosphate entering the Clun SAC from the STWs.' This needs to be expanded to include the statement 'until such time as additional capacity has been made available by Severn Trent Water'.	Text edit	Changed
3	Figure 6.5 Relative importance of STWs This looks wrong to me. For sites without P removal, the total amount of Phosphate discharged will be directly proportional to the population served, which doesn't seem to be the case in this pie chart.	Figure change	Changed
4	Appendix H - SAGIS There is nothing in my draft copy under appendix H. On the assumption that Atkins are intending to include a description of the various modelled scenarios, could I ask that this be prefaced with a statement to the effect that 'there are a range of other options open to Severn Trent Water to reduce phosphate discharges to the river Clun SAC and that we will be working collaboratively to develop the optimum combination of improvement measures.' Or something similar.	Text edit	Included

A.3. AONB

Comments		Type of comment	Response
5	1.1 - Substitute villages for towns	Text edit	Changed -RD
6	1.2 - 15 years - should this be reconsidered, considering Ian Killeen's recent report?	Comment.	Changed to - It has been estimated that the mussels will only survive for another 15 years if nothing is done to improve these conditions *although recent surveys may indicate an increase in the rate of decline*.
7	1.3 - Is the target of Good Ecological Status appropriate for recruiting pearl mussel rivers? It is accepted that 'high status' is necessary for recruiting pearl mussel rivers.	Comment	Emphasised in report that it is the FC targets, not WFD targets that are the focus of the NMP
8	1.3, 1.8, 2.2 etc. - The plan frequently refers to a target date of 2027 to achieve favourable condition - is this appropriate given recent pearl mussel population survey – highly likely to be totally extinct by or before 2027 – Is there an ecological basis for this date? (recall the 2027 date in the Severn RBMP to achieve GES)? The plan must reconcile this target with the text in para B.4.6 and B.4.7 (imminent extinction)	Comment	This is a national regulatory deadline. No ecological basis is implicit. Statement included in plan and highlighted to identify likely earlier target date
9	1.8 - Clun Catchment Plan is currently an aspiration – on hold due to resource issues	Comment	Statement removed
10	Fig 2-3 - The cumulative downstream impact of STW without P stripping is problematic – will lower FCTs be met without addressing these levels? Assume this addressed in the action plan?	Comment	No change. One of the options assessed has been to P-strip some of the remaining STWs
11	3.3 - Validity of the turbidity data being questioned at recent NMP meeting due to the sampling period being within one of the wettest summers on record - Previous Killeen reports look at pre 2011 rainfall vs turbidity events throughout the catchment and comes to a similar conclusion even in 'normal' years		Included
12	5.3.2 - Table 5-2 records 3 poultry units, this is only for those units housing over 50,000 birds. There are other units below this threshold which cumulatively may be significant	Text edit	Included
13	5.3.3 - Observation Maize? — biomass plant near to SAC growing maize as biofuel. May become significant in the future – I assume the action plan will look at what cropping is sustainable near a pearl mussel river	Text edit	Included
14	Fig 5.5 - Photo - Remove ref to AONB	Text edit	Reference removed
15	5.1 - Clarification - Refers to 13 consented discharges Appendix G1 – Appendix C lists 77 discharges	Comment	Appendix C lists water quality monitoring locations rather than discharge consents
16	5.4 - Typo - Phytophthora	Text edit	Typo fixed
17	5.4 - Not potato (which is *P infestans*), but same family - *P. alni* is thought to be a hybrid of *P. cambivora* and species related to *P. fragariae*	Text edit	Potato changed to chestnut
18	Table 5-4 - Image (a) is on the Clun SAC not middle Clun	Text edit	Changed
19	6.3.1 - A few field drains present? – Only a small % of Shropshire is considered to be perfectly drained. High levels of post war grant support ensures the Clun has significant under-drainage and is a major conduit for sediment laden runoff to the River. It is also a factor influencing hydrology of the catchment and increasing the erosive force of the River. NB Land drains are still being installed in the catchment	Comment	No change. Underdrainage likely to be small in catchment context and confined to Conway association clay soils on valley floors
20	6.3.2 - Agree that tilled land is a key source, but accelerated erosion at the riverbank is a fundamental issue due to high mortality of alder and suppressed regeneration. Every time a tree falls into the river it is probably equivalent to a skip load of soil being deposited and then there is the on-going erosion as a result. The highest incidence of which is broadly coincident with the elevated silt load between Clungunford and Leintwardine. Sediment source apportionment perhaps could attempt to assess this.	Comment	Statements added to relevant sections

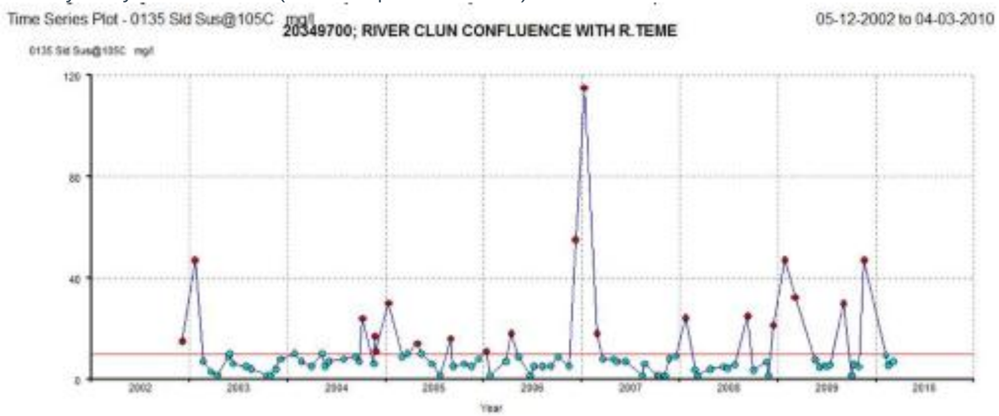
21	B1 - IUCN Red list - FWPM are "Critically Endangered" not Vulnerable see www.iucnredlist.org/details/12799/1	Text edit	Changed
22	B2 - The 2027 target for N is 1.5mg/l, this is higher than all the threshold figures detailed in table 7-1 and more than 10 times that recommended by WWF. Is this the figure that is thought to be achievable - if so what is the evidence that it is valid for a recruiting pearl mussel river given that it is accepted that FWPM demand the highest levels of water quality? Or is the Clun population thought to be adapted for higher N levels, if so what is the evidence for this? You might be already aware of this, but it might worth looking at the genetic study undertaken by Aberdeen University – Summary here: http://www.scotland.gov.uk/Resource/Doc/295194/0112370.pdf	Comment	Nitrogen target currently in draft
23	B4.7 - Given the highly stressed state of the population and critically low numbers, FWPM are now vulnerable to one-off extinction events - the 2028 date assumes a linear decline - Should this eventually be stated. FWPM are known to be lying on the substrate rather than embedded within. Flooding on the scale of 2007 and 2008 would see wash out into the Teme or onto riverbanks.	Comment	Statements added to relevant sections
24	Appendix F Pg74 - A three year project	Clarification	Changed
25	Appendix F Pg74 - Sita/NE Freshwater pearl mussel project	Clarification	Changed
26	Farmscoper - Assume this can be adapted to include Clun/Marches specific issues. Eg mass mortality of riparian alder	Clarification	FARMSCOPER is a tool that considers activities within farms rather than riparian issues

A.4. Natural England

Comments		Type of comment	Response
27	The whole document does need to be proof checked as there are a number of formatting and spelling etc changes required. Also a number of odd sentences that simple don't finish e.g. on p17 "This section compares ...." ?	Text edit	Removed
28	Use of Freshwater Pearl Mussel throughout the document. It is not necessary to capitalise each word.	Text edit	All instances changed in document changed
29	Charts – box whisker plots These need explanation – add the following note below each chart: Note: box represents the inter-quartile range, midline of the box the median, black circle the mean, and whiskers the maximum and minimum values.	Clarification and text edit	Changed. Text added to figs. 3-1, 3-3, 3-5, 3-6, and Appendix C.
30	What does open circles show? Outliers?	Clarification	They show outliers, reflected in text added addressed by comment 29. - RD
31	1.2 current status The River Clun is now recorded as "Unfavourable declining".	Text edit	Changed
32	Section 1.5 Structure of NMP Table - use of FWPM. Can you spell out freshwater pearl mussel in full and add FWPM in brackets in the column headed section.	Text edit	Changed
33	1.6 – What tools have we used? The Plan has been developed using the best and most detailed publically-available information describing point and diffuse sources of pollutants. Table 1.2 reviews the main sources of information that have been made available to the project. Most have been funded by Defra and water companies to help catchment based planning and the management. The Plan has also relied on the large number of previous investigations undertaken in the Clun catchment (see Table 1.3).	Text edit	Table references updated in paragraph
34	1.8 - What next? The Plan takes a long term strategic view of the actions required to achieve Good Ecological Status by 2027. This document is therefore the starting point in a longer process. As such, the Plan is a living document that will be regularly reviewed, updated and amended as progress is made within the catchment.	Text edit	Changed
35	The Plan is only one of a series of initiatives targeted at improving the condition of the River Clun catchment. The next step is for Natural England, the Environment Agency, Shropshire County Council, Severn Trent Water, land managers and land owners to work collaboratively to agree how best to integrate the findings of this study within local catchment management initiatives. An important vehicle for this collaborative working will be the existing collaborative catchment groups such as the Clun Catchment Partnership. Comment: It should be made clear that although the plan is long term there is a short to medium term objectives to get phosphates down to the restoration target and see downward trends for of the levels of nitrates and suspended solids. Refer to Jeff Edwards comments also.	Text edit	Comments added to text
36	Figure 1.1 describes the linkages between these initiatives. It works from policy level at the top of the diagram through plans and strategies to delivery mechanisms at the bottom. Key points to emphasise are: • The need for the integrated delivery of solutions coming out of the various initiatives on the Clun catchment COMMENT The key points to emphasise are: 1. need for integrated delivery across the various initiatives, 2. importance of local initiatiatives and solutions, 3. logistical challenge in aligning and coodinating change on the ground (not least lack of resources and leadership). • The importance of local initiatives in delivering change in the catchment. For example, the AONB SITA funded project with additional support from Natural England has undertaken practical work to reduce sediment and nutrient levels within the river over the last 3 years and the Upper Clun	Text edit	Changed

	Management Initiative (aimed at integrating environmental management with sustaining rural livelihoods) • The number of initiatives currently under way in the Clun is a vivid indication of the real interest in addressing the issues that the catchment faces. However it also presents a logistical challenge in aligning and co-ordinating the implementation of change.		
37	P12 Table 1-3 – need to check who commissioned which reports. Currently a number of incorrect entries: 2007 FWPM survey – should be EA not NE 2010 Conservation Plan – should be NE, EA and CCW (for both commissioned and authors) 2013 hydrological investigations – should be NE not EA 2013 FWPM survey – should be EA not NE	Text edit	Changed, assuming CCW means Countryside Council for Wales
38	Could you not use FWPM in table 1-3 – spell out in full.	Text edit	Changed
39	Add 2005 freshwater pearl mussel survey to table 1-3 – commissioned by EA and undertaken by Malacological Services	Text edit	Added
40	P13 Figure 1-1 Clun catchment initiatives and linkages to the Nutrient Management Plan This will need to be updated with the inclusion of the Site Improvement Plan (SIP) being drafted for the River Clun SAC as part of the IPENS (EU Life + project). The SIP will be a strategic document for achieving favourable condition on the SAC and setting out prioritised actions required. The NMP and River Restoration Plan will both sit under this. In relation to the River Clun Catchment Management Plan, this has never really got off the ground in the time I've worked on the Clun. It is rather redundant now given that we now have a NMP and RRP for the Clun and will also have the strategic SIP in place. You will need to check with Lucy and Roger about the Clun Management Plan and how this is progress if out all now	Comment	Diagram updated to include SIP
41	P14 – Part one – Evidence and supporting information Not sure if this title page adds anything. It is not referred to in the text. Unless you are adding further information under this sub section?	Comment	Section separator. There will be others later in the document as it develops
42	Section 2. Freshwater pearl mussel P 15 - text states surveys were undertaken in 2000-01, 2005, 2007-08 and 2013. However the chart (figure 2-1) does not show the results for the survey in 2005. Can you confirm that you have the data from EA for this year? I haven't see the report myself and will try and get EA to send a copy over.	Comment	No robust quantification of catchment population in 2005 so excluded. Note to this regard included on chart
43	2.2. Favourable Condition Targets P16 - The targets should be based on annual averages from 12 monthly samples taken over a period of 3 continuous years. Orthophosphate measurements taken by the Environment Agency are used to assess compliance with the phosphate targets. Suspended solids or turbidity data collected by the Environment Agency are taken as a surrogate of to asses compliance with the sediment target. Nitrogen data are Total Nitrogen estimates.	Text edit	Paragraph edited. EA measure of Nitrogen at Leintwardine is Total Oxidised Nitrogen
44	Section 3 Water quality (P17) Until 2004, phosphate levels were consistently above the WFD target of 0.05 mg/l. In the last five years, phosphate levels have declined further as a result of AMP5 funded phosphate-stripping of the Bishops Castle STW (in 2007) and Bucknell STW (in 2010). There has also been a more general reduction in effluent concentrations more generally (Figure 3.2). Although the Conservation Objective for phosphate is still exceeded, it can be seen that there has been a significant reduction in phosphate with levels now approaching the short term target of 0.02 mg/l. The annual mean concentration of phosphate in 2012 was 0.029mg/l (Figure 3.1).	Text edit	Changed
45	P18	Text edit	Changed

	3.1.2. Seasonal variations Figure 3.3 below shows seasonal variations in phosphate concentrations in the River Clun at Leintwardine. There is a distinct seasonal pattern. Phosphate concentrations are very close to the short term phosphate target of 0.02mg/l in February, March and April. This is followed an steady increase during the summer months peaking in September when phosphate levels are, on average, greater than the WFD phosphate target of 0.05mg/l for Good Ecological Status. Phosphate levels between October and January are consistently in the range of between 0.03mg/l and ????.		
46	3.2 Nitrogen P19 3.2.1. Annual averages A favourable condition target of 1.4 mg/l N for the freshwater pearl mussel in the River Clun is currently being incorporated to the River Teme SSSI Favourable condition table. The annual average of sampling results from 1995 – 2012 measured at the River Clun at Leintwardine (within the SAC) is shown in Figure 3.5 below. Nitrogen levels are typically 2 – 3 times the favourable condition target. In the last five years, nitrogen levels have declined slightly with a mean value of 4.04 mg/l over this period.	Text edit	Changed
47	Move figure 3-7 on variations of average nitrogen on p21 to end of section 3.2. Currently sits with section 3.3. on sediment.	Figure edit	Changed
48	Section 3.3. Sediment I would like this section to be re-written. I'm not particularly happy with the way the data is presented and analysed.	Text edit	Section re-written
49	Section 6.3 I would like this section to be re-written. I'm not particularly happy with the way the data is presented and analysed.	Text edit	Section re-written
50	First paragraph – map 4 shows the location of the sondes but we also need to show the location where SS and other water quality samples are taken. Or is this shown in map 3?	Figure edit	Changed
51	Figure 3-9 Mean monthly turbidity – For what year does this chart show? Also not referred to in text.	Figure edit	Changed
52	Section 4. Catchment character . The characteristics of the catchment can play an important role in determining the water quality status of a river. In this section, an overview of the catchment of the River Clun is provided as a context for understanding some of the observed water quality variations described in Section 3 of this Plan. *I am not sure about this statement – it is not particularly true to say that's it only the bottom end of the river that is suited for pearl mussels. Habitat and conditions for mussels exists elsewhere in the catchment. This paragraph looks odd under this section anyway and I suggest it is removed.*	Text edit	Removed
53	Use of turbidity data as a proxy for suspended solids It is often assumed that turbidity provides a direct measure of suspended sediment and that there is a formula or set of conversion factors with which SSC can be calculated from NTUs*. This is not the case and no such formulas exist. Each situation is different and a site would have to be calibrated to find the relationship. * The degree of turbidity is not equal to the suspended solids concentration because turbidity is an expression of only one effect that the suspended solids have on the characteristics of water, i.e. the ability of light to penetrate through the water column. Thus, because the particle size and nature, e.g. organic v. inorganic, of the suspended solids affect the light scattering, different turbidity values can be measured for waters having the same suspended solids concentration (McKee and Wolf, 1963). Can you remove from all charts showing turbidity data the line for the FWPM sediment target, in particular on p 22. Suspended solids measurements are essential to the estimation of particulate loads within the river network (in combination with gauged flow data), to provide an indication of the risk of siltation *. However, siltation is poorly measured by existing WFD tools.	Text and figure edit	Additional analysis undertaken. Report changed and addressed through section rewrite as suggested

	* There is general agreement that siltation is one of the most widespread pressures on rivers in farmed landscapes. Siltation within and on top of coarse beds is a major threat to interest features and in particular to species such as salmon and freshwater pearl mussel. The Life in UK Rivers report on the Ecology of the Freshwater Pearl Mussel notes a level of 30mg/l of suspended solids as the limit of tolerance by adult mussels. This level may not be critical if it occurs for a short time during floods. However, long-term levels of suspended solids should be much less. Levels consistently above 10mg/l should give cause for concern as elevated levels of suspended solids can clog the respiratory structures of fish and adversely affect mussel filter-feeding. In the absence of specific data the precautionary target of 10 mg L-1 (as used for salmon spawning areas) has been adopted. Issues with SS targets: It is difficult to define thresholds for suspended solids. Routine monitoring data on suspended solids and SS thresholds themselves have no simple relationship with siltation problems - a site with low average SS levels can have big siltation problems due to one or occasional big solids events that are not detected by routine water quality monitoring. The generic river habitat FCT suggests a site-specific evaluation of SS and biological trends/relationships etc to try and set something locally relevant. There is a separate siltation attribute in recognition of the fact that SS data doesn't tell the whole story. Also that average SS concentrations are not suited to characterising episodic problems, and so shouldn't be used (at least not on their own) to determine if there's a fine sediment delivery problem. I don't know if you've seen the attached technical information note on establishing fine sediment/siltation targets. It's more for catchment-based sediment delivery problems rather than point source problems, but the thrust of the advice is on local setting of sediment targets and reflects where we are with generic sediment targets. Also attached some case studies on monitoring siltation through the River Life Project. EA undertake monthly samples of SS on the Clun so I am unclear why there is no presentation of this data and any analysis undertaken (see example chart below). 		
54	Appendix B. FWPMChange FWPM to full “Freshwater pearl mussel”	Text edit	Changed
55	B1. Species details“The freshwater pearl mussel (Margaritifera margaritifera) is considered the most endangered species in the European Union, with 90% of individuals being lost in the 20th Century. The EC Habitats Directive lists the freshwater pearl mussel under Annex II (species whose conservation requires the designation of special conservation areas) and Annex V (species whose taking in the wild and exploitation may be subject to management measures). The most recent European IUCN red list classifies Margaritifera	Text edit	Changed

	margaritifera as "critically endangered" (Cuttelod et al., 2011). Large populations are now restricted to Ireland, Scotland and Scandinavia. The UK is estimated to be holding approximately 40% of the entire complement of EU individuals. In England, most populations are 'functionally extinct' in that they consist of a relatively small number of old specimens with no substantial evidence of recent recruitment. The River Clun falls into this category. At present only the River Ehen in Cumbria is considered to support a viable freshwater pearl mussel population in England."		
56	B3. Conservation objectives "The latest condition assessment for the River Clun was compiled in 2013 when its condition was recorded as 'unfavourable, declining. The main reasons for unfavourable condition in the River Clun SSSI/SAC are: 1. excessive silt loading from upstream sources; 2. impacts of alder disease and accelerated bank erosion, and 3. intensification and diversification of land management practices and nutrient enrichment.	Text edit	Changed
57	All of these factors impact on the typical habitats and species of the river and contribute to the continued decline of the pearl mussel population.	Text edit	Changed
58	On the basis of habitat requirement studies and expert opinion, Natural England have set the following conservation objectives for the freshwater pearl mussel in the River Clun SAC:	Text edit	Changed
59	4. Short term phosphate target – mean annual concentrations of <0.02 mg/l corresponding to the concentration considered adequate for adult pearl mussels. 5. Long term phosphate target – mean annual concentrations of <0.01 mg/l corresponding to the concentration required for juvenile recruitment. 6. Turbidity target mean annual concentrations of <10 mg/l suspended solids	Text edit	Changed
60	A target of 1.4 mg/l of Nitrogen is currently being appended to existing conservation objectives.	Text edit	Changed
61	All targets are based on at least three years of monthly samples. Phosphate data are orthophosphate as reactive P measurements routinely collected by the Environment Agency. Nitrogen data are ****TON, NO3??"	Text edit	Changed, Routine monitoring is TON
62	B.4.6 2013 A repeat survey in 2013 concluded that there has been at least a 50% loss of mussels since 2007/2008.	Text edit	Changed
63	B.4.7 Summary "Figure 7.2 plots the catchment population of freshwater pearl mussel over the last 15-20 years. At the current rate of decline, it is estimated that the species will become extinct in the catchment by 2028 (Figure 7.3)."	Text edit	Changed
64	Figure 7.2/7.3 – change axis title to "Number of mussels"	Text edit	Changed
65	Figure 7.3 – remove area of tilled land. Does not add anything in this context. Conservation objective review – also remove this line. FCTs will be kept under review throughout this period. The 2027 date is set by WFD to achieve good ecological status.	Text edit	Changed
66	B.5 Potential impact pathways "In general, freshwater pearl mussel sites are characterised by a small proportion of arable land in the catchment (<10%) (Figure 7.4). Within the lower Clun area, close to 50% of the area is under arable production."	Text edit	Changed
67	Can you provide an explanatory note below Figure 7.4 to explain the chart? Most readers won't understand this chart. Refer back to hydrological study that was undertaken by Atkins for Natural England.	Text edit	Changed
68	Objective 'whole-catchment view of the options that will be required to restore the River Clun SAC to favourable condition' – use of the word options implies AES (i.e. HLS/ELS options) – I suggest the use of measures which can include AES and others	Text edit	Changed

69	'Provide specific guidance on the measures that need to be carried out within the wider catchment and where they should be applied' This implies advice relating to meeting the conservation objectives elsewhere within the catchment outside the SAC – if this is the case then it would be good if this made explicit.	Text edit	Changed...to deliver the FCTs within the River Clun SAC.
70	'Plan when and how action will be taken and by whom' – I really do not think this is possible except for high level strategic actions – unfortunately apart from the water company it will be extremely difficult to identify which land owner will take action and which will not.	Comment	No change. Refers to statutory responses rather than landowners.
71	'Part 2 – 12 Other Issues - To identify other areas of concern that may require consideration' – need to refer to the River Restoration Strategies and not repeat actions identified in these.	Comment	Agreed. No change
72	1.7 - Delivering this Plan will require partnership working over the long term – we do not have the time for this and whilst accepting we need to take a longer term view we need to set this in the context of the decline of the FWPM an d ensure that action is prioritised to maximise the opportunities for retaining the FWPM within the catchment ('ark sites').	Comment	Comment inserted up front identifying that the 2027 target may not be appropriate with action required early on
73	1.8 – The DWPP has effectively been shelved. Any reference to it is farcical – I spent time trying to find who within NE or EA knew about it, referred to or indeed led on it and the resounding answer to this was NO-ONE. There is no reference to the River Restoration Strategy here – this document has at least been used and the dust is much lighter than that on the DWPP.	Comment	There is no DWPP for the River Clun. The River Teme DWP excludes the River Clun. No change
74	I think the report should also refer to the following The area has been in an ESA for 20 years Catchment Sensitive Farming has been operating for a number of years (how many not sure) The AONB SITA funded project which NE has contributed WFD towards for the past 2 years (£165,000 so far) much of which has gone on practical work to reduce sediment and nutrient levels within the river has been running for 3 years.	Comment	Included in new section describing measures available and their extent on the Clun
75	I am not sure that 'The number of initiatives currently under way in the Clun is a vivid indication of the real interest in addressing the issues that the catchment faces. However it also presents a logical challenge in aligning and co-ordinating the implementation of change' is true, it is not the number of initiatives that is the problem but the lack of staff resources on the ground and at a senior level to coordinate activity and a lack of leadership from NE/EA at the senior level to direct action.	Comment	Statements edited (in response to this and other similar comments) to: • *The logistical challenges associated with aligning and coordinating change on the ground and how available resources can be best utilised.* • *The need for leadership to coordinate all catchment activities.*
76	Table 1.2 I really think we need another column to outline the caveats and constraints of these models and data sets	Comment	Comments and references to relevant papers included in Table
77	2.1 'The youngest mussels are estimated to be 50 years old indicating that recruitment has not taken place for a long time.' – indicates the likelihood that there was a recruiting population 50 yrs ago i.e. 1960s	Text edit	Changed
	So we might look at what the land use and land management might of been at that time and preceding this date.	Comment	No change. No data currently available for this. Would require analysis of historic aerial photography from Cambridge University aerial photography library
78	2.1.1 'The main reasons for unfavourable condition have been identified as follows: • excessive silt loading from upstream sources; • impacts of alder disease and accelerated bank erosion, and • intensification and diversification of land management practices and nutrient enrichment' Would be useful to reference where this statement comes from?		Updated. Information provided by NE FWPM lead
79	4 - Catchment Character 'One of the key challenges facing the Strategy is that the part of the Clun with habitat that is particularly suited to the Pearl mussel (the SAC) is at the very bottom end of the river'. – I am not sure about this statement – it is true that this is where they are currently surviving but is it true that this is the most suited? Obviously something has happened that means that the population up stream of the SAC has lost FWPMs but is it at this moment in time the 'most suited' bearing in mind the inputs received from upstream. If the consultants believe that this is the case it would be good to identify the catchment characteristic that over-rides the increased sediment and nutrient levels to make this the most suited location.	Comment	Statement removed. Previous studies have shown that flows are an important aspect in controlling catchment distribution of the species

80	The Characteristics section fails to mention the underlaying gravels that re-charge the river – this is considered with the Atkin's hydrological studies report page 41 and 42 'Surface – groundwater interactions' where it states that Although the Silurian rocks are considered to have low potential as a groundwater resource, it is evident that groundwater present in mudstones and shales as well as in overlying Quaternary deposits can form an important local resource. Furthermore the relatively high baseflow index (BFI) of 0.510 indicates that groundwater also provides an important contribution to streams and rivers. There are very few historical spot flow measurements within the upper Clun catchment. A single flow measurement was undertaken at Upper Dyffryn (NGR SO 2251 8212) in July 2005. The other point where flows have been measured in the past is located at Newcastle (NGR SO 2510 8200) which is 2.9 km downstream. There are five flow measurements at this location. The available data are plotted in Figure 3.6. From Figure 3.6, it can be seen that the majority of flow measurements on the River Clun at Newcastle have been undertaken in summer (July or August). On these occasions, the recorded flow ranged from 0.01 to 0.06 $m3s^{-1}$. On one occasion (1993), a flow measurement was made in March and on this occasion; a higher flow of 0.09 $m3s^{-1}$ was recorded. On 13 July 2005, spot flow measurements were undertaken at both Upper Dyffryn and Newcastle, enabling comparison to be made along the reach of the upper Clun. The details from the measurements are shown in Table 3.13. It can be seen that the river widens and deepens downstream. On the day on which it was measured, there was flow accretion downstream. Looking at the difference in flows between the two sites and the record of spot flows at Newcastle shown in Figure 3.6, it appears that the channel at Upper Dyffryn would be likely to dry on occasion in the summer months (anecdotal evidence suggests that during drought periods such as 1976, the Clun upstream of Newcastle on Clun does dry out). The upper Clun catchment covers a small area (approx. 40 km2) and the Silurian rocks are likely to have limited storage. There are a number of springs mapped on the OS maps which occur along the river valley. Most of the springs appear to be located on steep slopes and linked to patches of drift deposits or thick sandstones within the Clun Forest Formation. As these more permeable layers are generally of limited extent and often hydraulically isolated, it is likely that they are fed by a relatively small recharge area. It is thought that much of the recharging water would discharge locally via short flow paths and unless linked to a larger system fed by bedrock cracks and joints, the springs would be likely to be ephemeral. Lower in the catchment, the river valley becomes wider and flatter. The alluvial, river terrace and head deposits become more prevalent downstream of Upper Dyffryn, particularly so in the vicinity of Newcastle, where the Folly Brook tributary joins the River Clun. It is possible that the highly permeable superficial deposits provide storage which influences river flows. Although there is little information relating to the upper Clun catchment, in the adjacent catchment of the upper Teme it is reported that there can be significant water movement between the river channel and the adjoining gravel deposits. This is considered to be a natural process which under very low flow conditions leads to some short sections of the river channel running dry before water re-emerges from the gravel deposits (Environment Agency 2013).	Comment	Relevant catchment characterisation section updated with a summary relevant to the catchment scale importance of groundwater
81	The groundwater recharge to the river may be critical to maintaining adequate water flows at low flow periods (exacerbated by land management issues such as reduction in semi-natural habitats, land drainage, road drainage and soil compaction). It is critical for us to understand where in the catchment an adequate base flow is maintained during low flow periods, is it just within the SAC or does it extend upstream, and if so, how far upstream and does this include any of the tributaries.	Comment	No change. Recommendations made in hydrology report for Upper Clun would need to be adopted for this to be fully evaluated.
82	'A walkover survey of the channel of the River Clun identified bank erosion through natural fluvial processes as an important source of sediment to the river, occurring along 13% of the river length. Poaching by cattle was seen along 4% of the river. Surface runoff was also seen to be a sediment source, but most of the land adjacent to the river in this area is grazed, and there are few field drains present. 70% of the river is lined by trees, which help to stabilise the banks. 29% of the river was lined with appropriate fencing and riparian buffer strips were only present on around 5% of the river.'	Comment	Information taken from a walkover survey by Jacobs for Natural England. GIS data held on NE database
83	I would really like to see the details of this walk over survey – have they got this information mapped? Is this saying that 29% has fencing and buffer strips and another 5% has just buffer strips? The figures by themselves are meaningless and would be better to compare the statistics in relation to how much of the	Comment	

	water course is bounded by agriculture, i.e. only requires buffer strips, and how much is adjoined by grazing land, where fencing is required where grazing levels are too high or cattle have access to the stream for water – A question we need to ask is do we want to fence the whole of the river?		
84	Workshop Material Best case Scenario – I am extremely concerned at the use of the wording here e.g.	Comment	Description changed as part of final combined scenario assessment
85	The long term target cannot be met (This makes even the most committed conservationist wonder 'why bother'). It is also important that we do not place such a reliance on the outputs from the modelling without first recognising that this is just a model which is intended to assist with decisions and resource allocation and show ranges not absolutes. In addition the measures used in the farmscoper assessment are based on current AES measures without reference to any new measure that may be available in the new AES scheme.	Comment	Description changed. One of the main objectives of the investigation is to assess how achievable the targets are. Assessment to be updated to assess how sensitivity of model outputs to uncertainty to be used to assess whether and how outcomes change
101	I think that somewhere at the beginning of the plan there should be a section outlining the reason for the plan, including a section about why the pearl mussel is important. This was something I included in my management plan of July 2010 (copy attached).	Text edit	Updated
102	I also think that it is important to include a section on the lifecycle of the pearl mussel in the plan (also included in my management plan) as it helps to put the relationship of the mussel with the rest of the river into context.	Text edit	Updated
103	1.3 I agree with Jeff that we should use the term measures rather than options	Text edit	Changed
104	1.8 This plan needs to be the overarching one that we are all working to with others which may be more specific or include more community bias sitting underneath it.	Figure edit	Stakeholder map updated as far as possible
105	Not sure about the last bullet point. What does it mean – 'plans presented here'?	Text edit	Removed
106	Figure 1.1 probably needs to include the Water Body Action Plan. It's important to know where that fits.	Figure edit	Agreed. Awaiting response and confirmation from EA
107	2.1.1 The main reason for unfavourable condition is the declining pearl mussel numbers. The bullet points identify some of the reasons but I don't think these have been taken from the condition tables which is confusing.	Text edit	Changed based on information provided by NE
108	2.2 Final paragraph. I am concerned that annual averages aren't good enough. Particularly for silt when one particularly bad episode could smother a population.	Comment	Comment included in section on targets
109	B.3. As 2.1.1 above	Comment	Changed based on information provided by NE
110	B.5 The bullet points reinforce my concern about annual averages	Comment	Comment only. No change

A.5. CLA

Comments		Type of comment	Response
86	Clun Nutrient Management Plan The Country Land and Business Association (CLA) is a national organisation embracing the owners and occupiers of all types of rural land and business in England and Wales. It represents the interests of the owners of some 34,000 land holdings and rural businesses. The Midlands region represents over 6,000 members. The River Clun SAC is covered by the Midlands Region of the CLA. CLA members include every size and type of holding, from estate owners to the smallest land holding of less than a hectare. The membership encompasses all traditional agricultural and forestry from the most sophisticated dairy and arable enterprises, pigs and poultry, through to highly more extensive livestock systems. The majority of our landowning membership is made up of family farm owner-occupiers many of whom have diversified into other business activities in response to the downturn in farm incomes. The CLA also represent the interests of owners of other types of rural businesses including, for example: forestry enterprises, mineral and aggregate operators and owners, hotels, golf courses, tourist enterprises, equestrian establishments, a myriad small rural enterprises and also institutional land owners such as water companies, pension funds, and development companies. The CLA represents the wide diversity of the rural community and is the only single organisation able to do so in quite so comprehensive a manner. We are glad of the opportunity to be an active partner in any consultation exercises or decision making processes in which rural business and the communities form part. Introduction The rural economy is dependent on good water quality for supporting wildlife, fishing and other recreational activities. Good water quality is required by land managers to water their stock, to irrigate their crops and for drinking, even from private supplies. Over recent years the Nitrates Directive has been a significant driver to reduce nitrate pollution of water courses. Water quality will continue to be important for land managers through the Water Framework Directive's (WFD) requirement in all European Union countries to achieve "good ecological status" and the introduction of tests for "wholesomeness" under the Private Water Supplies Regulation 2009. The main issue for farmers and land managers is diffuse pollution of water from nitrates, phosphates, sediment and pesticides. Pollution from all four has fallen since 2003 nonetheless; the industry has made huge strides that should be recognised with the total number of pollution incidents in 2006 falling by more than a third (35 percent). The CLA strongly support the need for development in the Clun and we understand that the nutrient management plan is required for the protection of the Pearl Mussels. The towns, villages and communities in the Clun catchment need to grow as stated in the Shropshire Council Local Plan, it is important that these villages and settlements are not allowed to become fossilized, these settlements must retain their vitality and viability by allowing development of dwellings and employment. So that these communities can grow there needs to be improved sewage treatment, and developments in the wider catchment should be allowed if they can show they are contributing little to the overall phosphate in the catchment.	Comment	Comment. No change
87	The CLA comments are as follows: Clun Nutrient Management Plan	Comment	No change
88	This should not document should not be called a nutrient management plan as the purpose of the document is to reduce nutrients in the catchment, the document could be titled a phosphate and sediment reduction strategy	Comment	This is the name of the process the document supports. However title changed to make it explicit that the document ultimately sets out the NMP evidence base

89	The Clun Nutrient management plan does not take extreme weather related incidents into consideration. These extreme weather events will cause run off and sediment and this is out of the control of farmers and advisers, and cannot be dealt with through a regulatory approach.	Comment	Agreed. Targets are for 'average' annual conditions. Comment included in targets section
90	Awareness of pollution and the rapid rise in the cost of fertilisers have encouraged land managers to be more cautious in their use of nutrients through nutrient planning, such as precision farming techniques and using the Tried and Tested approach which has been developed by the CLA and industry partners. See www.nutrientmanagement.org for further details and to access the paper-based tool to plan nutrient applications.	Comment	Comment included in plan
91	These approaches leave much lower nutrient residues that can be potentially leached or eroded, and they save money. Farmers and land managers only apply the nutrients that the crop require as this makes financial sense, but it is important that farmers receive the latest advice and information on this issue.	Comment	Plan updated with information provided
92	Overall water quality has been steadily improving. This is clear from the fall in the number of serious pollution incidents and the increase in the total number of miles of rivers in favourable condition.	Comment	Agreed. No change
93	It can take over 10 years to see reductions in diffuse pollution due to land use changes and the nutrient management plan needs to recognise this.	Comment	Plan updated with information
94	3.1 Phosphate -The draft nutrient management plan should recognise the long-term trends in the reduction of phosphorus fertiliser, feed use and manure production. Use of phosphate has declined by 67% on grassland and 51% on tillage land since 1990, while phosphate from manures has reduced by 20% between 1990 and 2012. The Clun catchment was a pilot catchment for the Catchment Sensitive Farming initiative which started in 2005 and will have contributed to the decrease in phosphate in the water. It is now accepted practise in the agricultural industry to carry out soil nutrient analysis to avoid applying expensive fertiliser to nutrient rich soils, this will lead to further reductions in phosphate in the river over time. The average amount of phosphate in the river is 0.03mg/l this is a very low level and this could not have been achieved without the action of land managers and farmers reducing diffuse pollution.	Comment	Plan updated with information provided
95	To achieve a level of 0.02mg/l phosphours, further measure may need to be put in place farmers and land managers will need the continuing support of Catchment Sensitive Faming, environmental stewardship and other schemes if land use change is required. Farms are businesses and they need to be economically viable. Some measures to reduce sediment and phosphate entering the river may make these businesses unviable and these businesses will need further financial support.	Comment	Plan updated with information provided
96	Long term measures to improve water quality by improving soil management, structure and organic matter in the soil will see reductions in diffuse pollution but only after a decade and the plan needs to recognise this.	Comment	Plan updated with information provided
97	Figure 3.3 should show the seasonal phosphate variations in date order start at April 2012 and end at March 2013.	Figure edit	No change. Figure shows phosphate concentrations over longer time period.
98	Figure 3.7 The axis of the graph need to be corrected. The CLA feels that the Clun should not be compared to the river Ehen in Cumbria as it is a very different catchment.	Comment	Changed. Figure caption updated to emphasise that the River Ehen and Clun are different
99	Figure 5.1 page 28 shows the decrease in livestock numbers in the catchment but the document does not recognise that this will contribute to the decrease of nutrients in the water.	Comment	Changed. Following consultation with Defra, the 2000 census data have been removed from the Plan as they are not comparable with the 2010 data that only includes commercial holdings.
100	Page 30 Issue 5 figure 5.3 shows a doubling of arable land since 1990. This data was taken from CORINE data set, however the agricultural census data on page 66 and 67 shows a decrease of arable between 2000 and 2010 the two data sets area inconsistent. As much of the catchment is in the Shropshire Hills Environmentally Sensitive Areas (ESA) where the basic management prescription for the ESA was to ensure there was no increase in arable land the CORINE data seems to be misleading. With the majority of the ESA agreements expire in 2014 it is surprising that the Clun Nutrient Management plan concludes there has been a doubling in the arable area in the catchment as the ESA agreement holders had agreed not to increase arable land. The CLA would suggest that the agricultural census data on pages 66 and 67 is used for the model as well feel this reflects what is happening in the catchment.	Comment	The CORINE and agricultural census 2000 data are not used in the modelling. Models use PSYCHIC, which is based on the 2010 agricultural census. They are included to provide context. Plan updated to make it explicit.

A.6. Environment Agency

Comments		Type of comment	Response
111	General comments:		
	Constraints and limitations of data have not been explored.	Text edit	Specific sections on data limitations included
	Confusion with some aspects/terminology of Favourable Condition Targets and Conservation Objectives.	Text edit	Updated
	Mistakes in text and layout throughout the document. Poor use of graphs to clearly explain data. References are missing. Have commented on some of these issues in text.	Text edit	Where comments have been provided, these have been changed
	General feeling that it is difficult to comment on a very draft/incomplete document.	-	Report updated
	Actions and recommendations needed.	Text edit	New section included
	There is no section on limitations of data.	Text edit	New sections included
112	Appendix A: What is all this information doing in an appendix?	Figure edit	Maps built into main report as well as in the Appendix
113	Table of figures: There is a general lack of clarity shown in the figures. The figure captions are often inadequate to describe the graph or table. Colours often don't impart much information. Suggestions for improvement: Make sure all figures have a purpose. Check figure can be understood looking at the figure and caption in isolation. All lines/colours adequately explained in the caption or on the figure. Check if figure be simplified and still impart the same information. Check that if a page is photocopied or printed in grayscale, the figure can still be understood.	Figure edit	Figure captions extended as requested. Colours changed where possible but intended as a digital report
114	1.Purpose of plan General Clarification is required as to whether they are Conservation Objectives or FCT. Document flits between these two and GES Check grammar and spelling.	Text edit	Changed and clarified from NE input
115	1.2 - This information needs to be referenced	Text edit	Changed
116	1.3 “Provide a long term...”- Is the correct understanding - plan for nutrient management not management plan for SAC	Text edit	Changed
	Wording of aim/objectives	Text edit	Changed
	Start with population growth predicted in area	Text edit	Changed
	Identify nutrient issues specifically	Text edit	Clarified
	Part of the document is missing - so cannot agree that actions are in place	Comment	Agreed. No change
117	1.3 “and that predicted growth...”- Is this really the aim of the report. There are issues missing if this is a document aiming to restore the Clun SAC to favourable condition. Report is primarily about planning and development?	Text edit	Changed. Rewording to clarify and emphasise nutrient management
118	1.3 “Good Ecological...”- Not failing at the moment. Need a comment regarding protected areas and High Ecological Status.	Text edit	Statement removed
119	1.5 “overleaf” – below?	Text edit	Changed.
120	1.5 unnumbered table - This Table doesn't match document structure	Text edit	Changed.
121	1.7 - Document doesn't set this out	Text edit	Section updated to specify consultation. New section on consultees

122	1.7 "Environment agency's..." -This is only a small part of it. This is about nutrient reduction, and measures required to reduce levels to those defined as favourable for this site, i.e. the SAC	Text edit	Changed
123	1.8 "the plan..." - Already at GES	Text edit	Changed
124	1.8 in bulletes "WFD" – ...?	Text edit	This has been addressed by a previous comment
125	Table 1-2 - more descriptive caption?	Text edit	Changed
126	Table 1-2 "WISKI" - WIMS	Text edit	Changed
127	Table 1-2 "three turbidity sondes" - Only refer to two in text - Clungunford and Leintwardine	Text edit	Changed
128	Table 1-2 "multi-agency catchment..."- Not part of CSF but funded through EA Clun project	Text edit	Changed
129	Table 1-2 "nearest weather station" - Where is this?	Text edit	Aldon. Changed
130	Table 1-3 - What about RHS survey assessment by Ian	Text edit	Included
131	Figure 1-1 – This figure just appears. Little explanation in text	Text edit	Reference to figure included in text
132	Part one – Evidence... There appears to be occasions when turbidity and suspended solids are being treated as the same measurement in the plan. Obviously suspended solids refers to small solid particles which remain suspended in liquid and is measured in mg/L. Turbidity however, is the cloudiness of the water generally due to suspended solids, and is measured by the scattering of light by the particles (which will vary due to particle properties) in NTU units. Due to this turbidity is usually correlated to, but does not equal suspended solids. Moreover, this correlation will vary in space and time and must be ground-truthed before turbidity correlation is attempted as a proxy for suspended solids. In the NMP (e.g. page 20) turbidity is referred to as mg/L in the text (in figure 3-8 it is NTU) and that the favourable condition limit for turbidity is 10mg/L, when this is the conservation objective for suspended solids.	Section rewrite	Analysis undertaken to confirm assumption and included in report
133	2.1 "historic records..." - Please reference this record, would be good to understand context of abundant		Changed to remove confusion as no specific records beyond descriptions by catchment stakeholders
134	2.1 There was a suggestion that the ceasing of silt removal (appeared to be gravel removal and dredging to drain land/clear bridges?) in the 1970s was linked to a decline in mussels which were healthy before this time. The 1970s was about 40 years ago; however, most individuals in the Clun population were thought to be around 60***** years old. This suggests that the last mussels that recruited to the Clun population were glochidia in the 1950s. Since recruitment is likely to have tailed off as conditions worsened, rather than ceasing in one go it is likely that conditions began to decline in the 1940/1950s. Possibly this is linked to a drive to increase land production after the Second World War? *** [the text of NMP suggests youngest mussels are 50 years old which may be the correct figure]**	Comment	Comments added to Plan in relevant section
135	2.1 "The youngest mussels..." - References		Changed
136	Figure 2-1 - A line graph may give a better idea of time scale of decline?	Figure edit	Changed
137	Figure 2-1 "population" - Estimated?	Text edit	Changed
138	2.1.1. "unfavourable condition..." - Also flows changes, etc. Are these all reasons or just those relevant to NMP?	Comment	No change. Reasons highlighted relevant to nutrients and sediment only
139	2.1.1. - Mix up of terminology e.g. WFD, turbidity, suspended solids	Text edit	Changed where relevant
140	2.1.1. point 1 - References?	Text edit	Updated based on information provided by NE
141	2.1.1. "washout during high flows" - Flows should be mentioned in list of reasons for unfavourable condition, rather than as an impact of nutrients and sediment?	Comment	Indirectly linked to nutrient impacts so included
142	2.2 "Favourable condition targets" - A table with all of the targets would be useful here. Could then discuss the relevant ones in detail.	Figure edit	Only targets relevant to NMP are presented
143	2.2 "table" - Is this the right word?	Text edit	Changed

144	2.2 "upland headwaters" - Need to reference information	Text edit	Statement removed
145	2.2 "populations" - Reads strangely. Sounds initially like you mean resident populations of FWPM - suggest population centres	Text edit	Removed word populations
146	2.2 - Specific monitoring needs to be requested and be funded. Statutory monitoring is four times a year and not at right detection levels at present.	Comment	Comment included in document
147	2.2 "phosphate targets" - This needs to be separate to the WFD/ESI monitoring	Comment	Comment included in document
148	2.2 - Don't mix orthophosphate and phosphate	Text edit	Checked and changed where relevant
149	2.2 "suspended solids..." - These are not the same thing.	Text edit	Removed
150	3. map 3 - Referencing Maps might be clearer if these were included within the main document	Figure edit	Changed as suggested
151	3. "further details..." - List of monitoring points/data rather than further details	Text edit	Changed
152	3. "this section compares" - ....?	Text edit	Changed
153	3. "best"- define best? longest, or longest and most complete?	Text edit	Changed. Removed word best
154	3.1.1. What is the WFD figure?	Text edit	Changed to Habitats Directive figure
155	3.1.1. "annual average" - how many samples? Influence on data spread?	Text edit	Changed. Table with number of samples provided
156	3.1.1. - Refer to Leintwardine	Text edit	Changed
157	3.1.1. "WFD target..." - which target?	Text edit	Changed to Habitats Directive figure
158	3.1.1. "Concentration" - mean concentration	Text edit	Changed
159	Figure 3-1 - Detection limit changed in 2011 and so samples prior to this period will not have been analysed to a lower detection level. This is likely to skew results and therefore comparing historic data has to be carried out with caution	Comment	Comment included in plan
160	Figure 3-1 - Is there any explanation for outliers?	Comment	High values more than 1.5x the IQR
161	Figure 3-1 caption – Is this the WFD target to get to Excellent Status? Should refer to Good status Suggest changing lines, e.g. solid, dashed, dotted to exable understanding in black and white. Considering questions in meeting a caption with more of an explanation might be useful e.g. **Annual orthophosphate in the River Clun at Leintwardine from 1995 to 2012. Mean indicated by black square, grey box indicates 75% confidence intervals [?], black line indicates 95% confidence intervals [?] and circle indicates data outside these confidence limits. The blue solid line is the long term conservation objective (0.01 mg/L). The green dashed line is the short term objective (0.02 mg/L). The red dotted line is the WFD target [what target?] for orthophosphate in the river**	Text edit	Figure caption clarified
162	Figure 3-2 y-axis - Is this phosphate or orthophosphate?	Figure edit	Changed
163	Figure 3-2 - Missing data - have ST not provided? Need to provide explanation	Text edit	Clarified in caption
164	3.1.2. "The highest concentration..." - ...?	Text edit	Changed
165	3.1.2. "There is a distinct..." - Which is..., should explain why.	Text edit	Removed
166	3.1.2. - grammar and phrasing	Text edit	Rephrased and changed
167	Figure 3-3 - Detection limit issue	Figure edit	Agree. No change. Best available data and standard EA methodology applied
168	Figure 3-3 - number of samples? How does this effect data? Not comparing like with like - need to clarify	Figure edit	Table including number of samples included upfront
169	Figure 3-4 - If this is the Garn then we only have 3 samples for 2012	Figure edit	Figure rempved and data tabulated instead to capture some of the existing data limitations and to make it photocopiable
170	Figure 3-4 - There are no data for this site in 2012. Sampled between 2002 and 2008 only	Figure edit	
171	Figure 3-4 caption – Should indicate goes from top to bottom of catchment in caption. Probably don't need to point out that the grey is the annual average, no other data set present on graph. Need to indicate figures of targets and make sure distinguishable if photocopied.	Figure edit	
172	3.2.1. "table" - Is this a referenced table?	Text edit	Changed
173	Figure 3-5 y axis - Should be TON in label?	Figure edit	Figure removed and data tabulated to highlight data issues
174	Figure 3-5 - Few data for 2010 and 2011		

175	Figure 3-6 - Few data for 2010 and 2011 Aug has only been sampled once in this period		
176	3.2.3. “Figure 3.7” - suggest moving figure closer		
177	3.3 “Sediment” - Suggest this is divided into a main suspended solids section with comparisons with Favourable Condition Target. Then a turbidity section as these are two different measurements. Can explain limitations of these data.		
178	3.3 - The link between sediment and turbidity should be treated with caution. Turbidity can show suspended matter but not specifically sediment. Furthermore, there should be recognition that there are limitations to the sonde data ie bullhead in the cage, position of the sonde and so interpretation in isolation is not robust science	Text edit	Changed. General section rewrite has covered these issues.
179	3.3 - where is the map?	Figure edit	
180	3.3 “rainfall” - Where from?	Text edit	
181	3.3 - I don't think it is necessary to put a comparison of the Ehen in this report.	Comment	
182	3.3 “turbidity level...” - Turbidity is measured in NTU, mg/L is measurement of suspended solids. Target is for suspended solids not turbidity.	Comment	
183	3.3 “high rainfall” - How much?	Comment	
184	3.3 “turbidity levels are...” - Favourable condition target for suspended solids	Comment	
185	3.3 - For what time period? Has there been events to raise the April turbidity level? This does need qualifying more	Comment	
186	Figure 3-7 - Remove upper Clun from graph (only 3 samples taken in 2012) and change Y axis to nitrogen	Figure edit	Figure removed and data tabulated to highlight data issues
187	Figure 3-7 - No data for 2012 at Beambridge, site last sampled in 2008	Figure edit	
188	Figure 3-7 - Kemp data - just one site or all combined	Figure edit	
189	Figure 3-7 y-axis - Caption says TON, graph says phosphate	Figure edit	
190	Figure 3-8 hourly rainfall - Where is this data from? Why not daily rainfall? Why is largest number at the bottom of the axis?	Figure edit	Figure redrawn
191	Figure 3-8 crop cover - Relevant? appears to have been copied from another part of document	Text edit	Text emphasises the importance of this data
192	Figure 3-8 – turbidity - What is the Turbidity Target? Please give a figure in NTU in text.	Text edit	Changed. General section rewrite has covered these issues.
193	Figure 3-8 Ehen turbidity - Is the Clun and the Ehen comparable?	Text edit	
194	Figure 3-8 Caption - Inadequate caption. Need to explain graphs. Some information could be given once in a caption rather than in each graph title and then again in a legend.	Text edit	
195	Figure 3-9 - Turbidity or suspended solids? If turbidity, should be in NTU There is not a turbidity target, what is FWPM target? Would need to calibrate, i.e. comparing SS, Turbidity and rainfall in automatic sampler	Text edit	
196	4. “one of the key...”	Text edit	Removed
197	4. unnumbered table, river flow box “intensification...” - How does this fit in with timing of last recruitment to the Clun FWPM population?	Text edit	No change. No data available to describe pre and post war landscape character
198	4. unnumbered table, river flow box Dredging, gravel removal, etc. has lots more implications, not sure if these have a place here or not: Gravel removal and dredging mobilises fine material that has settled Dredging causes over-deepening, straightening and modification of the natural river morphology. This is linked to an increase in erosion, a decoupling of the river-floodplain relationship, a decrease in heterogeneity of the river and loss of habitat (also important for hosts). Draining land by dredging drainage ditches causes extremes of flow in the river, rather than letting the land act as a sponge – sucking up excess water during heavy rain and releasing water during drought supplementing flows.	Text edit	Information included as new section under Pressures

	FWPM can be physically damaged by instream works Gravel is important in the egg, alevin and juvenile life stages of salmonids, a decrease in salmonid habitat can adversely impact FWPM which use them as hosts. In theory the natural flows of the river should mobilise and remove naturally eroded fine material from the system in a way local FWPM adapted to.		
199	5.3 "Diffuse..." - May need to divide into DEFRA and CORINE sections. Can then explain differences and limitations in each data set. Data collected from aerial photographs suggests... Data collected from farm reporting suggests... Can any differences be explained?	Text edit	Changed. General section rewrite has covered these issues.
200	5.3 "table 5.4 shows..." - Would the % areas of these robust farm types be more useful for comparison, since refer to holdings being of different sizes?	Text edit	
201	Table 5-2 - What does asterisk refer to?	Text edit	
202	5.3.1.- What is the reason for the decline in livestock numbers?	Text edit	
203	5.3.2. "figure 5.2." - Permitted numbers, need to explain limitations of data.	Text edit	
204	5.3.3.- Need explanation in text as to where data has come from and what any limitations are.	Text edit	
205	5.3.3. "An additional..." - Can this be included in graph?	Text edit	
206	Figure 5-3 - Graph doesn't tie in with data	Figure edit	
207	Table 5-3 caption "the colours reflect cover" - How?	Figure edit	Caption updated
208	Figure 5-4 - unreadable if printed/photocopied in grey scale	Figure edit	Figure removed and data tabulated instead
209	Figure 5-5 b - So is arable most important source of sediment? Are roads most important pathway?	Comment	Comment included in text
210	5.4 Dead trees also provide habitat both as standing dead wood and instream woody debris. Play role in nutrient exchange between riparian and aquatic habitats. Shade out algae and reduce temperature of water both very important to FWPM. Benefits both to FWPM and their hosts.	Comment	Comment included in text
211	5.4 "natural organic..." - not sure that otters are the best example of a species that benefits from natural organic matter.	Text edit	Removed
212	5.4 bullets "The need to extend..." - has also resulted in a lack of buffer zones and fencing in some areas	Text edit	Changed to suggestion
213	5.4 bullets - Natural regeneration may be difficult in some places due to lack of trees in area providing seed material? Trampling of banks is itself a source of bank erosion and introduction of excessive sediment	Text edit	Changed to suggestion
214	5.4 bullets "new" - Has been in Clun catchment since mid-1990s?	Text edit	Changed to suggestion
215	5.4 bullets "at present there is no..." - Doesn't make sense... Could change to something like: At present there is no known cure for the disease. Coppicing extends the life of a tree, rather than eliminating the disease	Text edit	Changed to suggestion
216	5.4 bullets "non-native species..." - Doesn't make sense... And doesn't include other invasive species on Clun Could change to something like:	Text edit	Changed to suggestion

	Non-native species such as Himalayan balsam, giant hogweed, and Japanese knotweed form monocultures which shade out native species. These can provide bank protection during their growing season, however, they also expose large unvegetated areas to erosion when they die back in winter.		
217	Table 5-4a - Where and when were these pictures taken? At the very least need to know month, year and where in Clun (i.e. in SAC?).	Figure edit	Changed
218	6.1.2.1 "largest source..." - Is this only from stocked land directly from livestock, or it is also from arable land that has been fertilised with manure?	Approach	Agreed TBC
219	6.1.2.3 "arable farming..." - Would animal derived fertiliser used on arable land come under here?		
220	6.1.2.4 "OsWwTW" - What does this stand for?	Text edit	Specified . On-site Wastewater Treatment Works
221	Figure 6-1 - Meaning of vertical lines and numbers mean not clear from caption Appendix could be a place for a more comprehensive explanation of what graphs show if this would take too long to explain in text.	Figure edit	Figure redrawn and appendix developed further
222	Figure 6-3 - What is Ids?	Text edit	Intermittent discharges
223	Figure 6-4 - Why does poultry have an asterisk? Possibly explain in caption each a percentage of 64% Might be clearer to have an initial pie chart and then a table with a breakdown.		Caption updated to specify. Includes 2010 + growth to 2013. Pie chart removed and table with calculations provided to clarify
224	Figure 6-5 - Unreadable if printed/photocopied in gray scale. Lydbury suspect data.	Figure edit	Lydbury data changed
225	Figure 6-7b - Unreadable if printed/photocoped in gray scale Can't see most recent data due to legend placement	Figure edit	Changed and simplified
226	Figure 6-9b - Little difference between these colours if printed/photocopied in grey scale	Figure edit	Changed
227	Figure 6-10 - Unreadable if printed/photocopied in greyscale.	Figure edit	Removed from report
	Is apportionment for phosphorus or phosphate?	Text edit	Changed as per suggestion
	Suggest a more descriptive caption would be useful. e.g. Source apportionment of phosphate, nitrate and sediment in hypothetical average farm types?	Text edit	Changed as per suggestion
228	6.3.1. bullets - Need to reference this data. Was walkover survey for the whole of the Clun? Erosion in the SAC was estimated at about 5% during one walkover.	Text edit	Included in list as per suggestion
229	6.3.3. "below the favourable..." - Favourable condition target is for suspended solids	Text edit	Addressed through section rewrite
230	6.3.3. - Is this suspended solid or turbidity data?	Text edit	Addressed through section rewrite
231	Figure 6-11 - Turbidity is not measured in mg/L. Differences between sondes may be due to problems. Data limitations.	Text edit	Addressed through section rewrite
232	Appendix A list of maps - Maps? Difficult to comment on parts of document due to incompleteness	Figure edit	Maps now included
233	B.1. "The river clun..." - What about population in the River Tamar? Need to reference these claims	Text edit	Removed
234	B.2. "symbiotic relationship" - This has been suggested (i.e. water quality), but usually considered parasitic - what does infected salmonid gain?	Text edit	Added as per comment
235	B.2. "brown or sea trout" - brown trout usually considered to be the species name?	Text edit	Changed
236	B.2. - Need to provide references for all of this information.	Text edit	No change. Refer to Natural England 2010
237	B.2. "Juveniles are mostly..." - riffles usually well sorted with little fine sediment? Need to reference this. Boulder-stabilised refugia, which contain enough sand for burrowing, are ideal microhabitats for juvenile mussels (Hastie et al., 2000).	Text edit	Changed as per suggestion
238	B.3. "'favourable condition'..." - Suggest adding this to main text	Text edit	Already included in main text so removed from Appendix
239	B.3. - This is copied from the main text.	Text edit	Already included in main text so removed from Appendix

	Why does it also need to be in an appendix?		
240	B.4.1. "Historic records..." - reference?		No change
241	B.4.1. "As English Nature report..." - Reference?		No change
242	B.5. bullets - Text and picture copied from main text - why does this need to be an appendix too?	Text edit	Removed from Appendix
243	D.2. turbidity graph - Target is 10 mg/L suspended solids. No turbidity target has been proposed.	Text edit	Changed. General section rewrite has covered these issues.
244	D.3. turbidity graph - Target is 10 mg/L suspended solids. No turbidity target has been proposed.	Text edit	Changed. General section rewrite has covered these issues.

A.7. NFU

Comments		Type of comment	Response
245	This document will not be available for public consultation and there has been limited consultation with industry bodies via the NFU and CLA. Farmers have not yet had an opportunity to comment on the sources of diffuse pollution and the practicality of applying further measures to farm businesses.	Comment	No change
246	There will be considerable costs of implementation for farm businesses and the community. For some struggling farm businesses affected by the plan this will add considerable costs which may in turn affect business viability.	Comment	Text included in document
247	Many initiatives focused on water quality improvement and agricultural advice are on-going within the Clun catchment. Local farmers have a long history of engagement with ESA, other agri-environment schemes, CSF and the AONB projects.	Comment	Text included in document
248	Therefore much has already been achieved and in order for this plan to carry weight with the agricultural community their contribution to water quality improvement ought to be acknowledged and quantified.	Comment	Statement provided is included in report. Most work indicates current gains are small
249	The paper states in section 1.2 that the Freshwater Pearl Mussel is functionally extinct and that the mussels will only survive for a further 15 years if steps are not taken to conserve them. Measures have already been taken to reduce diffuse pollution from agriculture over many years within the Clun catchment. This has resulted in falling N and P trends within the catchment.	Comment	Text to this effect included in document
250	There will be a time lag between the implementation of new measures and beneficial effects on water quality which unfortunately may not assist FWPM recovery.	Comment	Text to this effect included in document
251	An assessment of whether Favourable Condition targets can be met is urgently required. The paper does not currently address this issue and this means that the plan is flawed. Achievement of the targets set out in the NMP may not be feasible given the increasing human population of 7000-7500 people who live in the catchment and approximately 200 agricultural businesses located in the catchment.	Comment	Included in the report as one of the main objectives of the NMP
252	So, there are three questions which must be answered: • Is it technically feasible to meet the water quality targets? • What are the economic costs to the local community and rural economy of achieving these targets? • Given that the population is functionally extinct, will meeting the water quality targets result in a recruiting Freshwater Pearl Mussel population?	Comment	Managing catchments and river systems to these targets is going to be highly challenging, but the proposed approach to application of these targets restricts their management impact. It is considered achievable but challenging to meet the 0.02 mg/l P target of 43% reduction in P and will work with all stakeholders to deliver this. No assessment has been made on the costs required to achieve the targets. The next stage will be to develop an action plan with partners which should provide broad costings. Although the population is considered to be “non-functional” with no evidence of recent juvenile recruitment, this does not mean that it is not recoverable. If water quality and habitat conditions

			are restored we should see a slow recovery in the population.
253	Partial achievement of the targets may not affect pearl mussel abundance and recovery. However this would carry significant economic costs and will act as a break upon economic growth and community development. It is important to recognise that if the FWPM were not present in the river Clun the water quality would not be a concern and the river would be meeting usual WFD requirements. There has been a significant reduction in phosphate levels which are now around 0.029mg/l. A significant proportion of this change will be due to changes in agricultural practices and reduced stocking rates across the catchment.	Comment	No change
254	Appendix B FWPM states that "in general, freshwater pearl mussel sites are characterised by a small proportion of arable land in the catchment (<10%). Within the Lower Clun area, close to 50% of the area is under arable production". Unfortunately this may demonstrate that the catchment is no longer capable of offering appropriate FWPM habitat.	Comment	No change
255	It is clear that target conditions cannot be met, therefore further research needs to be undertaken into what conditions can support a FWPM population?	Comment	See comments on FWPM targets below. We have recommended the need for the tighter targets (0.01mg-l P and 1.5 mg-l N) are reviewed in the light of response of FWPM to interim reductions in P, N and silt.
256	It is not reasonable to expect a community to go through economic and social disadvantage in order to put in place measures aimed at meeting unattainable targets.	Comment	The Clun is an internationally significant River for freshwater pearl mussel; therefore, we have statutory responsibilities to ensure the Clun is returned to favourable condition. As a Natura 2000 site there are likely to be economic and political consequences if this is not achieved. To achieve the goal of restoration of the river, and the provision of good habitat for both FWPM and salmonids, it is essential for all parties to buy into a shared vision to drive the strategy forward. The main challenge facing practitioners in the catchment is to reverse this decline and that of other species whilst maintaining a vital and vigorous farming economy. The Clun SAC is dependent on upstream influences, we therefore need a catchment wide solution. We believe the key to achieving this is adequately resourced partnerships working at a sub-catchment scale. Although, the issues have a habitat/species focus, there are wider economic and societal benefits to be gained by returning the Clun to favourable condition and improvements in water quality generally. Numerous community consultation events recognise the intrinsic value of the Clun in terms of its: • wildlife, • a place to explore and play

			• its economic value as a tourism resource • a water resource • its negative economic impact on downstream communities at times of flood.
257	Modelling tools Five different modelling tools were used to assess source apportionment, mitigation methods and soil erosion. Each model's merits are commented upon. 4.1 SAGIS model The SAGIS modelling tool quantifies pollutant loads to surface waters for 12 assigned sources comprising both point and diffuse sources. The pollutant loads generated in SAGIS are converted, through the SIMCAT (Simulation Catchment) model, to concentrations using estimates of flows within watercourses. The flow estimates are obtained from the Low Flows Model, 2000. It can therefore be seen that three models have been used to assess the source apportionment of nutrients in the River Clun Catchment. Data input into these models are not from measured or observed datasets, therefore errors between modelled source apportionment and actual observed sources are highly likely.	Comment	The SAGIS model is currently the EA and UKWIR industry-standard approach. The model is calibrated to observed data sets where possible. Model outputs are indeed dependent on some of the assumptions and data availability. This will be addressed in the final document by ranges based on different assumptions
258	Calibration graphs were provided for phosphorus but the key was missing and origin of the data was not clear. Calibration was not provided for nitrogen concentration, modelled stream flows or contribution from individual watercourses/tributaries.	Comment	Updated in report. Although no modelling of nitrogen has been undertaken some mass balance checks have been undertaken to provide some form of calibration as requested. Streamflows are not modelled but measured
259	Previous assessment of output from the River Kemp (North Clun Catchment) SIMCAT model by Hafren Water, during 2012 has shown that Low Flows 2000 dramatically over-estimated the flow in the watercourse. A flow duration curve provided by the Environment Agency for the River Kemp indicated a Q_{95} of 13 l/s at the sewage treatment works (STW) outfall point. Observed flow in the River Kemp, adjacent to the STW outfall, was recorded at approximately 10 l/s during February 2009, at this time of year flows are anticipated to be well above the Q_{95}. In September 2012 the flow was observed at <2 l/s, significantly less than the indicative modelled summer low (Q_{95} of 13 l/s) and discharge from the STW was at 2-5 l/s. It is also understood that flow immediately upstream of Bishops Castle STW outfall is known to cease during most summer periods (Mr Beamond, Oakeley Farm) therefore at these times STW contributions to the flow in the watercourses increases to 100%.	Comment	No change. SAGIS is an annual model. Focus of the project is on the SAC rather than areas around the STW in the Kemp. All assessments show that Low Flows Enterprise works well at catchment scale although these data are not used in the Clun SAGIS model. In addition, the model has a nationally agreed calibration process that check that flows and loads are adequately represented and that modelled concentrations are robust.
260	It is, therefore, clear that modelled low flow in this instance was a significant over-estimate with, ramifications for the assessment of point source and diffuse dilution and, ultimately, source apportionment.	Comment	Flow data used are measured data.
	It is also reported (Kileen, 2009) that flow upstream of Newcastle-upon-Clun ceases at times, and this may be true of other small tributaries in the catchment.	Comment	Flows at Newcastle-upon-Clun stopped in 1976
261	Good knowledge of the flow upstream of point sources is fundamental to the understanding of contributions from such point sources. As a result of the use of inaccurate modelled up-stream flows, it is possible that point source contribution has been significantly under-estimated within the River Kemp and possibly the wider River Clun Catchment of which it is part.	Comment	Agreed. The focus of the Clun SAC NMP is the lower reaches of the River. One of the main Clun SAGIS model calibration points is the downstream end of the River Kemp. There are a number of flow calibration points all of which are based on measured rather than modelled data.

262	This leads to little confidence in the accuracy of source apportionment within the Clun NMP area, in particular of nitrate from STWs.	Comment	Nitrate apportionment updated using alternative methods that confirm previous findings
263	Similar concerns exist relating to the output of nitrate concentration data from the River Kamp SIMCAT model. The relative concentration of TIN (Total Inorganic Nitrate, comprising nitrate, nitrite and ammonia) in the River Kemp was assessed by Hafren Water (2012) and was compared to observed TIN concentrations at monitoring points downstream of the STW discharge. SIMCAT predicted a TIN concentration at the lowest point within the River Kemp of 5.02 mg/l. The observed concentration presented in the Clun NMP is ~8.3 mg/l (2012), this shows a ~40% variance.	Comment	The NMP is a catchment scale study and considers how issues such as those in the Kemp are transmitted downstream to the SAC
264	In the absence of actual data, Low Flow 2000 modelled data is the best estimate available however, it is no substitute for monitoring data. It is requested that a sound understanding of flow within the catchment is obtained through monitoring as this is fundamental to the understanding of transport of sediment and nutrients.	Comment	Flow data used in the assessment included as an Appendix in the report
265	We appreciate this is a draft copy, however, inadequate information is provided on Figure 6.1 to assess the model's performance, ie no key, therefore it currently serves no purpose. In Section 6.1.1 it is stated that "the model was checked against observed flow and phosphate concentration data". This data was not provided in Appendix H and no calibration data was provided. We request access to the results and calibration of SAGIS modelling.	Comment	Appendix provided in update
266	It is stated within Table 1.1 that SAGIS provides a tool to assess apportionment and to uphold the principle of the 'polluter pays'. This viewpoint is not helpful in this situation and comments should relate to the science used to resolve source apportionment rather than bringing in political aspects to what should be a scientific report. Professor Bob Harris (Secretariat Demonstration Test Catchments Programme (DTC), DEFRA and a resident of Upper Clun Catchment) has stated that "the traditional approach to water pollution of 'polluter pays' is not appropriate for managing 'diffuse pollution'; in today's consumer society it could be argued that the polluter is ….. us"[1]. Food production pressures are placed upon individual farmers by society, political and economics of the industry.	Comment	Table edited
267	<u>FARMSCOPER model</u> It is not clear what variables are included within the FARMSCOPER modelling tool. The following bullet question remain after digesting this section of the NMP report: ▪ Are all arable and livestock farms within the catchment assumed to be managed in the same way?	Comment	Clarification in report provided that FARMSCOPER is used in a scoping sense only
268	Different farming practices between farms should be acknowledged.		Agreed. No data currently available
269	▪ Is local topography considered?	Comment	FARMSCOPER is used as a scoping tool only and local topography is not implicit. Clarification provided in updated report
270	▪ Does the model account for presence or absence of land drains?	Comment	The tool has been run assuming no under-drainage to capture the main character of the catchment. Clarification provided in updated report

1 Having our cake and eating it – solving the conundrum of growing food whilst protecting the water environment. Abstract for oral presentation, Geological Society, London, October 2013

271	▪ Are existing mitigation measures, such as Higher Level management Scheme (HLS), Entry Level management Scheme (ELS) and Catchment Sensitive Farming(CFA), to reduce sediment/nutrients run-off included.	Comment	No. Clarification to be provided in updated report
272	▪ Are temporal and seasonal variations in stocking densities included.	Comment	Only those that are included within the tool. Clarification provided in updated report
273	▪ Are farm types differentiated such as indoor wintered/outdoor wintered/dairy/beef?	Comment	No. Tool used in a scoping sense only at this stage. Clarification provided in updated report
274	▪ What are the associated errors with this modelling tool?	Comment	The tool describes generalities of management. Clarification provided in updated report
275	▪ What is the source of data used in the FARMSCOPER 'Clun Upland Farm' and 'Clun Lowland Farm'?	Comment	The generalities of farm types were identified during a stakeholder workshop. Type farm values for 'LFA Upland Grazing' and 'Winter Combinable' as given within FARMSCOPER are then used. Clarification provided in updated report
276a	The Farmscoper options for the Clun catchment that appear in the Appendix are also questionable: • It assumes that "plant areas of farm with wild bird seed/nectar mix" can reduce sediment by between 5 and 10%. So, on the upland table it becomes the most effective measure for sediment reduction. We don't understand how this can be the most effective measure when it has to be established and fertilised like a crop. If it doesn't establish as planned farmers could be left with bare patches over winter. Therefore widespread uptake of this option in grassland areas could increase rather than reduce sediment runoff.	Comment	In FARMSCOPER, this approach is equivalent to a buffer strip and fertilisation is not an assumed element of management
276b	• The three most effective measures for phosphorus are; "establish and maintain artificial wetlands" (this could mean silt traps?), "use dry cleaning techniques to remove solid waste" and "capture of dirty water in a dirty water store". These probably would not be relevant for most upland holdings in the Clun catchment.	Comment	FARMSCOPER used as scoping tool only. Options relevant to any upland grazing farm where animals are housed over winter. Precise options promoted at farm scale would be dependent on nature of stock housing and management
276c	• Two of the most damaging measures are things that may help diffuse pollution management in this area; "reduce the length of the grazing day/season" and "reduce field stocking rates when fields are wet".		Although duration of grazing is reduced this would increase the length of time stock are housed which is significantly higher risk in terms of nutrient export by concentrating sources in one location
277	The modellers have put the poultry sector and combinable crops together. This would be acceptable if the model were just focusing on poultry manures. However there are likely to be arable farmers in the area who do not use poultry manure. We do not understand why such an assumption has been made.	Comment	No assumption that all combinable cropping is based on poultry manure. An assumption that has been made is that all poultry manure generated in the catchment is used within the catchment.
278	**5. Monitoring data** It is considered that the range (duration and locations of collection) of monitoring data collated and assessment thereof is inadequate for the scale of assessment required to devise a fair and accurate NMP. We believe a better understanding will help focus mitigation measures resulting in a more effective outcome.	Comment	Recommendations for additional monitoring are included in updated report
279	*Monitoring network* - a suggested monitoring network for the Clun Catchment was detailed in Atkins, 2012, River Clun Restoration Strategy, Table 3.3. The following comments refer to this table: ▪ It is not stated whether monitoring refers to a single logger at Leintwardine or multiple locations across the catchment. It is not known if this has been implemented. It is considered that adequate monitoring must be undertaken to provide an assessment of **existing** conditions before a fair NMP can be developed with confidence in outcomes.	Comment	Single location at Leintawrdine provides a catchment scale assessment of flows. Report updated to specify

280	It is also stated that "continuous records [are] required to monitor the infrequent events that are known to move the majority of sediment and pollutants". Has continuous monitoring been installed to date?	Comment	The continuous monitoring at Leintwardine provides an hourly estimate of flow in the river. Report updated to clarify
281	▪ We strongly agree with the point that monthly spot flow monitoring [is] needed to develop ratings between flow and level. Currently understanding of the flow-sediment relationship within this catchment is not adequate however it is considered pivotal to improving water quality in the River Clun.	Comment	Recommendation included
282	*River flow gauging* The River Clun does not have a permanent gauging station. Although flow gauging data was not presented in the NMP, it is understood that spot sampling was undertaken by Kileen in 2009 in the Upper Clun (as part of the assessment for translocation of the FWPM) in the Upper Clun Catchment and 15 other spot gauging samples are detailed between 1989-2005 (Atkins, River Clun Restoration Plan, March 2012. All gauging was undertaken during July and August with two exception (one in October and one in March). It can be seen that flowing gauging during winter months is under-represented. *Stream flow*: Figures 3-8 - flow is detailed as (area weighted), but it is not clear how this data was derived, ie monitoring or modelled? These small datasets are considered inadequate to characterise flow throughout the catchment and the associated nutrient transport and concentrations within the River Clun Catchment.	Comment	Flows in the model and as part of the assessment are based on a continuous record at Leintwardine representing both the Upper Teme and Clun rivers. This has been area weighted to provide an estimate of flows in the Clun catchment. An Appendix setting out this approach to be included in report
283	*Turbidity* It is understood that three sondes have been installed in the River Clun between 2012 and 2013. However, data is only presented from the River Clun at Clungunford and Leintwardine.	Comment	Clarified in report
284	The period of data collection (Apr/May 2012-Mar 2013) incorporates the wettest year on record hence is considered by Hafren Water to represent atypical of flow and sediment loads. The use of this data therefore to base a nutrient and sediment management plan on would seem unsound. No acknowledgement of the unusual weather conditions was given within the report and the effect this may have on the monitoring results and any interpretation / conclusions that can be drawn.	Comment	Report updated with comment
285	We appreciate that it was unfortunate that monitoring was contracted for the wettest year on record but consider an additional 12 months of monitoring over more 'typical' conditions are necessary to provide an accurate and defensible understanding of the issues and sources.	Comment	Report updated with comment
286	A better understanding of the contribution of each tributary is also required for targeted mitigation measures.	Comment	Report updated with suggestions
287	*Vegetation assessment* It is noted that the walkover vegetation surveys were undertaken in winter months for the NMP (ie January to March 2013). Therefore repeated qualitative comments of 'over-grazing', which appear several times in associated reports, are not considered valid as it is not possible to accurately determine the quality and diversity of natural or semi-natural vegetation at this time of year. Comments regarding the state of grazing/vegetation cover should be qualified to ensure repeatable assessment in future.	Comment	Reworded in report
288	It is known that Himalayan Balsam, a contributory factor to bank erosion, it dies off at this time of year and its presence cannot be accurately assessed. It was indicated that spring/ summer walk-over surveys should be undertaken to accurately identify invasive plant species (Jacobs 2013).	Comment	Himalayan balsam identified as pressure. It is understood that there is a student project looking into this
289	*Sediment*: It is known that the majority of sediment is mobilised from land to watercourses during high rainfall events but no assessment has been made of quantities/percentages occurring during specific conditions (ie rainfall intensity and time of year). Surely this is fundamental to the understanding of sediment load?	Comment	Analysis included in updated report
290	**6. Data sources** Databases	Comment	Updated report clarifies datasets and includes all publically available data. Annual census data is not publically available and there are issues with

	Land cover assessment - Data from Corine is used to assess changes to land. The dataset covers the period 1990 to 2006 hence is not considered to hold the most up to date data. Data from the MAFF/DEFRA census which is annual would have provided more accurate and up-to-date information on land-use and, therefore, land cover, at a local-scale. There is conflicting data regarding the percentage of the River Clun Catchment under arable use. It is stated as 20% (Table 4-3) whereas agricultural census data for the Clun Catchment indicates 15% by area.		changing methodologies through time based inclusion/exclusion of commercial and non-commercial holdings.
291	**7. Evidence and supporting data** a) <u>Pearl mussels - favourable conditions target</u> The targets presented within the NMP are so low that we must question whether they are achievable. The previous P target for FWPM recruitment has recently been revised downwards from the original orthophosphate target on 0.03mg/l. It is vital that we understand why this has been done. The Clun currently meets the 0.03mg/l target and is close to meeting the short term target of 0.02mg/l. Therefore could it be that P is not the main factor in FWPM recruitment?	Comment	Water chemistry is widely quoted in literature when environmental parameters for optimum mussel survival are under discussion. The critical water quality parameters affecting recruitment are BOD (biological oxygen demand), calcium and phosphate levels. Bauer (1988) observed that adult mortality was correlated with nitrate concentrations and that increased levels of phosphate, calcium and BOD were correlated with decreasing juvenile survival and establishment of juveniles. The main focus of concern with water chemistry requirements of the freshwater pearl mussel has been on nutrients, both oxidised nitrogen and more particularly ortho-phosphate. Many of the older publications have published various limits for these parameters, and the levels have been treated in absolute terms, as if they are levels of toxicity rather than levels leading to conditions that are not tolerable in a sustainable population (eutrophication triggers). Bauer (1988) referred to healthy populations in European adult mussels at P values of 0.03mg/l, but lack of juvenile mussels in central European rivers meant that this was an assumption based on eutrophication triggers, rather than a direct measurement of tolerance by the most sensitive part of the life cycle (juveniles). The short-term target for phosphorus (0.02mg-l P) recommended in the plan reflects the urgent need to tackle P levels to improve conditions for the remaining adult mussel population. The long-term aspirational targets for P and N are aimed at improving conditions to allow juvenile recovery. In coming up with these targets we have consulted leading experts from the UK and Europe on setting appropriate water quality targets for FWPMs. This has been based on evidence of the water quality conditions from recruiting populations with juveniles

			compared with those populations that are not recruiting. In 2010 we also published an evidence base review of setting nutrient targets for rivers (Mainstone 2010). The approach we have taken in setting nutrient targets for FWPMs is in line with the evidence review undertaken and the recently published revised common standards guidance for setting targets for river SSSIs. Of vital importance at this stage is that the median value of 0.03 mg l^{-1} taken from Bauer (1988) that has been widely quoted is incorrect and if it continues to allow for deterioration of water quality levels to this value there will be very serious but legal declines continuing into the future. References: Bauer, G., 1988. Threats to freshwater pearl mussel L. in central Europe. Biol. Cons. 45, 239-253. Geist, J. & Auerswald, K., 2007. Physiochemical stream bed characteristics and recruitment of the freshwater pearl mussel (Margaritifera margaritifera). Freshwater Biology, 52, 2299-2316. Hastie, L.C., Boon, P.J. & Young, M.R., 2000. Physical microhabitat requirements of freshwater pearl mussels, Margaritifera margaritifera (L.). Hydrobiologia, 429, 59-71. Mainstone, C.P., 2010. An evidence base for setting nutrient targets to protect river habitat. Natural England Research Report, No. 034. Natural England. Moorkens, E.A., 2000. Conservation management of the freshwater pearl mussel Margaritifera margaritifera. Part 2: Water quality requirements. Irish Wildlife Manuals No. 9 Series Editor: F. Marnell. Skinner, A., Young, M. & Hastie, L. (2003). Ecology of the Freshwater Pearl Mussel. Conserving Natura 2000 Rivers. Ecology Series No. 2. English Nature, Peterborough.
292	We also question whether the longer term target of 0.01mg/l is achievable in a living and working catchment in the 21st century. The catchment has a population of approximately 7500 and an agricultural industry with a range of sectors. Has such a large drop in P concentrations ever been achieved elsewhere in England?	Comment	We have recommended that the 0.01 mg/l P and 1.5 mg/l N targets are adopted as the long term aspirational targets that we will work towards. The need for these tighter target will be reviewed in the light of response of FWPM to interim reductions in P, N and silt. Adopting a phased and targeted approach to diffuse and point source changes and monitoring of FWPM will identify whether the long term target is needed

<table>
<tr><td></td><td></td><td></td><td>or achievable. Even so, there is still likely to be a need for de-intensification/land use change over a large area. There is therefore a significant remaining risk. It may be necessary to accept permanently impaired condition in respect of nutrient status in the R. Clun given the achievability of the targets is uncertain even in the long-term.</td></tr>
<tr><td>293</td><td>The target of 1.4mg/l for Total Oxidised Nitrogen is also very concerning (many brands of mineral water would not achieve this!). This would require a reduction of 2.6mg/l or 273% to achieve it. Has a technical feasibility been carried out alongside an impact assessment on agricultural production within the catchment?</td><td>Comment</td><td>See comments above.

The percentage reduction required would be 68% and not 273%.</td></tr>
<tr><td>294</td><td>Evidence on the existing conditions at Leintwardine have not been presented in the report which is readily available to stakeholders (NMP Plan (Atkins, 2013), River Clun Restoration Plan (Atkins 2012). Stakeholders require evidence that the essential conditions for Freshwater Pearl Mussels (FWPMs) remain within the SAC. Many of these are beyond stakeholders control, for example, water depth, flow, tree cover, salmonid population. If conditions are shown to be viable then stakeholders will have confidence that any investment they make may have positive results.</td><td>Comment</td><td rowspan="2">Natural England published the River Clun Restoration Plan (Atkins 2012) and undertook a hydrological assessment of the Clun (Atkins 2013) that looked at the habitat condition of the lower and upper Clun and the suitability for FWPM. These are published on the Shropshire Hills AONB partnership’s website. These studies show that condition in the SAC (flow, water depth etc.) are suitable to maintain FWPMs</td></tr>
<tr><td>295</td><td>Information that would aid this confidence is discussed below:

<u>Water conditions</u>
A range of water depth and flow velocities are required by the FWPM:

Is the flow regime in the SAC within the suitable range as indicated below?

▪ Water depth 0.1 - 2 m
▪ Velocities 0.1 - 2 m/s
▪ Optimum 0.3 - 0.4 m
0.25 - 0.75 m/s (Vannone and Minshall, 1982)

How often do flows >2 m/s occur.</td><td>Comment</td></tr>
<tr><td>296</td><td><u>Geographical distribution in UK</u>
England and Wales have 1 ‘recruiting’ population each whereas Scotland has ‘functional’ populations in 50 rivers, mainly in the Highlands. It was noted by Cosgrave et al (2000) that FWMP are extinct in most lowlands of Scotland.

It is noted that Highland SAC areas generally have the following characteristics:

▪ Very low population densities
▪ Extensive farming
▪ High semi-natural land cover

These are not characteristics observed in the Clun Catchment.</td><td>Comment</td><td>English pearl mussel rivers can be (albeit rather simplistically) divided into two main types, isolated rural rivers – ideally high in a catchment and downstream of a lake, and lowland rivers with mussel populations in deeper water in the middle to lower reaches of the river. A study of typical rural Irish populations found the catchments to be typically oligotrophic in nature, with very low natural levels of phosphate, and poor buffering capacity to anthropogenic inputs. In these rivers, if intensification / fertilisation of land resulted in a median ortho-phosphate value of 0.03 mg l^{-1}, most serious eutrophication would result and conditions for juvenile mussels would be untenable. However, larger lowland rivers have mussels in deeper water, with high banks and transfer of ortho-phosphate to damaging macrophyte and algal growth is less likely. In very poor remnant populations in these larger rivers, there is evidence of a decoupling of remaining live mussels with their juvenile habitat.</td></tr>
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			This is where the risk assessment of potential juvenile habitat is needed, to identify habitat which may have had adult mussels and juveniles in the past, but has deteriorated in recent times, with residual adults downstream in deeper, slower flowing water. The ortho-phosphate levels needed to be maintained in juvenile habitat, even in lowland rivers, is likely to be considerably more stringent than those needed to keep the deeper sections free of eutrophication damage. In juvenile habitat in either river type a median value of 0.03 mg l^{-1} is likely to be too high, but in the rivers that remain oligotrophic such as the Ehen it is close to an order of magnitude too high.
297	*Substrate* It is understood that substrate at Leintwardine contains significant volumes of fine sediment. At what rate will this fine sediment clear if further deposition is reduced, or should the river bed be modified in a timely fashion to be suitable for FWPM recruitment?	Comment	The likely time for recovery is based on how long it will take to lose fine sediments from the riverbed by movement through normal flows and floods once the supply from the catchment has been cut off. E.g. of fine sediment is present but not compacted = 5 years; compacted find sediment = 10 years.
298	*Critical parameters affecting recruitment (Skinner et al, 2003)* ▪ Phosphate (P) <0.03 mg/l ▪ Nitrogen (N) 1.0-1.5 mg/l ▪ Conductivity (EC) 100-120 µS It is expected that these parameters have been identified as they are the conditions where recruiting population exist elsewhere such as in the Highlands. It is stated that more recent parameters P = <0.01 mg/l are required, we would like additional information to clarify why this is now a more generally accepted figure.	Comment	See comments on FWPM targets above.
299	Phosphate nutrient loads have been discussed in the various assessments of FWPM populations since 1988. All sources comment on an annual load, however no reference is made to maximum tolerable concentrations for short periods of time (with the exception of sediment load). The concentration quoted above may therefore be significantly lower than that tolerable to FWPM during high runoff events or over a spring period for example. These concentrations are representative of the prevailing conditions at study sites, and as such are most likely therefore not intended to be used as 'clean-up' criteria.	Comment	Many of the older publications have published various limits for these parameters, and the levels have been treated in absolute terms, as if they are levels of toxicity rather than levels leading to conditions that are not tolerable in a sustainable FWPM population. As phosphorus is normally the limiting factor in algal productivity it is considered to be the key damaging parameter in dissolved water chemistry. Elevated phosphorus levels interfere with competitive interactions between higher plant species and between higher plants and algae, leading to dominance by attached forms of algae and a loss of characteristic plant species (which may include lower plants such as mosses and liverworts). The respiration of artificially large growths of benthic or floating algae may generate large diurnal sags in dissolved oxygen and poor substrate conditions (increased siltation) for fish and invertebrate species.

			It is the manifestation of high nutrient levels and in particular the eutrophication response that matters (and subsequent impact to most sensitive part of the life cycle (juveniles)).
300	<u>Water quality data and interpretation</u> It is understood that a significant P source is already present within the river bed sediment and that there is currently enough P within sediment to maintain existing P concentrations for some 30 years.	Comment	No data currently available to evaluate this process. National Environment Agency project considering this issue
301	Different assessment periods have been used to calculate monthly averages for N and P (2007-2012) and annual averages (1995-2012) however the reasoning behind this is not explained. Spatial data presented in Appendix C.3 contains data from 2012 and 2008, and the reasoning for presenting spatial data from such different sample collection dates is not explained and can only lead to a lack of confidence in the assessment.	Comment	2007-2012 is the post Bishops Castle STW stripping
302	Overall it is generally considered that there is an over-reliance on data from modelling and not enough assessment and interpretation of monitored datasets.	Comment	Updated assessments based on monitoring data provided. Updated report clarifies use of modelling vs monitoring data
303	<u>*Phosphate*</u> Figure 3.1 (Atkins, October 2013) shows a notable downward trend in the concentration of phosphate at Leintwardine, since 2004. Within the report the continued decrease in P was largely attributed to the phosphate stripping at Bishops Castle STW in 2007 and Bucknell STW in 2010. This statement neglects to acknowledge the contribution of improved nutrient management undertaken by landowners and the uptake of existing agri-environmental schemes.	Comment	Document updated to reflect comment
304	<u>STWs</u> Discharge consents and data has been obtained by Hafren Water directly from Severn Trent Water for the works in the Clun Catchment. <u>*Nitrate*</u> Analysis of the discharge consents indicates that there are no consent limits set for nitrate and as a result only ammonia concentrations are monitored and not nitrate. As there is no direct relationship between the concentration of ammonia and nitrate in discharges for STWs (Mark Craig, Severn Trent Water), it is concluded that the nitrate load cannot be accurately estimated for the purpose of modelling and, therefore, apportionment cannot be determined.	Comment	Updated catchment-scale assessment provided in report based on industry standard estimates and measured monitoring data. Compares favourably with catchment-scale SIMCAT modelling.
305	Water quality monitoring data indicates that nitrate concentrations in the River Kemp are significantly above those observed at all other monitoring points within the Clun catchment. It is noted that based on consented Dry Weather Flow (DWF) Bishops Castle and Lydbury North STW's contribute 57% by flow of the total STW contribution to the River Clun Catchment.	Comment	
	It is observed that nitrate concentrations at Purslow on the River Kemp, in which both Bishops Castle and Lydbury North STW's discharge, are approximately double that observed anywhere else in the catchment (Table C.3). As discussed earlier, SIMCATwas found to under-estimate the TIN concentration at the lowest reach of the River Kemp by ~40%. We believe that this is as a result of significant under-estimation of nitrate concentrations in discharge from the STWs.	Comment	
306	It is, therefore, considered highly likely that the contribution or nitrate from STW's elsewhere in the catchment are significantly under-estimated, hence the conclusion that 1% nitrate is from STW sources would appear inaccurate and not reflective of the observed monitoring data.	Comment	
307	Within the Surface Water, NVZ methodology (DEFRA, 2012) developed by DEFRA it states that if the dilution ratio is <1:10 it is possible that point source could account for more than 80% of the nitrate pollution at a specified monitoring point. Our assessment of Bishops Castle STW indicated that the dilution ratio which was commonly <1:10. Confirming that, at least in the Upper Catchment of the River Kemp, N contribution from STW's is significantly greater than 1%.	Comment	The assessment of nitrogen provides a catchment based view of apportionment rather than considering the upper Kemp

308	<u>*Septic tanks*</u> A study was undertaken in the Upper Clun on the Waste Water Infrastructure (*Fildes, 2011*). It was concluded that "*the majority of households surveyed with self-managed treatment systems were classified as having a high potential impact on local water quality*"	Comment	Comment included in report
309	It is noted that the observed P concentration of 0.029 mg/l (River Clun, 2012) is considered low by the Environment Agency (Environment Agency, 2011, River Quality, http://www.environmentagency-gov.uk/homeandleisure/37811.aspx)	Comment	Comment included
310	<u>Salmonids</u> A minimum requirement of > = 5 salmonid fish per 100 m^2 is reported to sustain FWPM numbers (WWF, Sweden, 2009). It is also known that FWPM favour either brown trout or salmon (WWF, 2009, Restoration of FWPM streams) and that a salmon or trout can only be infected with glochidia larvae once during their lifetime. Host numbers of salmonids within the UK are also known to be at an all-time low for several factors.	Comment	Densities of fish should be those that are typical for the natural trophic status of each individual river. Where there are specific problems affecting fish populations, such as barriers to migration or high summer temperatures, low host numbers can be a limiting factor for mussel population recruitment. Perhaps it is not the density of possible hosts that is most important, rather the total number of available hosts. Work done by Geist (2006) shows that brown trout under yearlings are not an absolute requirement; the greater capacity of older fish to carry glochidia can to some extent compensate if the older fish have not previously been in contact with the mussels. Research work under taken at FBA captive rearing programme also shows that fish previously infected can also carry glochidia the following year (although at reduced levels). The fish trials at FBA also show that available fish host species for the Clun population include both brown trout and Atlantic salmon. Many of the factors that have a negative impact on mussels also affect their fish hosts. Small changes can have large negative effects since they effect both the mussel and its host fish. Therefore, by addressing factors such as nutrient enrichment and siltation of river substrates will not only benefit the pearl mussel but also their host fish. References: Geist, J., Porkka, M., & Kuehn, R. (2006). The status of host fish populations and fish species richness in European freshwater pearl mussel (*Margaritifera margaritifera*) streams. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 16, 251–266.

311	It was not possible to obtain data relating current populations of salmon or trout from any of the consultant reports on the River Clun SAC and River Teme SSSI. It is not therefore clear if the current salmonid population of the Clun is sufficient to sustain and increase the FWPM population and is the population of juvenile salmonid sufficient bearing in mind that they can only carry the larvae once. This information would again give stakeholders confidence that any financial outlay they make as part of the NMP will result in positive outcomes for the FWPM population.	Comment	The River Clun currently meets the WFD requirements for fisheries and is classed as “high status”.
312	**Nitrogen Apportionment** There were no clear outputs from SAGIS calibrated to monitoring data. In order to cross-reference modelled data with observed data each monitoring point should be calibrated. As stated the only graph presented associated with calibration of the SAGIS model lacked a key and did not detail the source of monitored data. Water Companies are not required to monitor nitrogen, in the form of nitrates, discharged from their STW’s, therefore the SAGIS output cannot be calibrated and hence the resultant apportionment is also not calibrated. On Clun Upland (CUF) vs Clun Lowland (CLF) graphs (p40) the CUF is shown to lose 200 kg/Ha nitrate for arable land and no sediment. Whereas CLF arable losses are reported as 200 kg sediment/Ha and only 140 kg N/Ha. It is not clear why these values are so different. It is known that atmospheric deposition can make significant contributions to surface water concentrations. For example, it is known that atmospheric deposition of N in the River Taw Catchment, Devon contributes 1 mg/l to N concentration in the Taw Estuary (Source/ref). It is important to know what the calculated atmospheric deposition of P and N for the Clun Catchment is and if this has been incorporated into the source apportionment Should a similar contribution of N (1 mg/l) be apparent in the Clun Catchment, this would significantly affect the of likelihood of achieving the favourable targets indicated above.	Comment	Updated report provides all calibration information. SAGIS is not used for nitrogen assessment. Updated assessment based on monitoring data included in revised report. Assessment of atmospheric deposition included. Atmospheric deposition has been identified as an issue in meeting N targets in lakes
313	<u>Other points not raised in the draft NMP or supporting documents that are fundamental to the recruitment of FWPM</u> <u>Access to salmonids</u> It was stated that the weir at Leintwardine Bridge ‘failed’ for fish passibility (JBA Consulting, Restoring the River Teme SSSI – A River Restoration Plan, January 2013). If this statement is true and access to salmonids is not improved all measures to improve nutrient and sediment loads in the Clun would be wholly ineffective in increasing the FWPM population.	Comment	NMP focuses on nutrients and sediment. No change. Both the River Clun and Teme Restoration Plans have identified a number of structures in the catchment that fail WFD requirement for fish migration. The Environment Agency will be undertaking remediation measures on obstacles/barriers such as weirs that limit the distribution and migration of salmonids within the catchment so as to meet WFD requirements.
314	<u>*pH of water*</u> The required range of pH is 6.2-7.5. The pH of water at Leintwardine is not commented upon in the report.	Comment	NMP focuses on nutrients and sediment. Included as an Appendix for reference
315	<u>*Aluminium & calcium*</u> FWPM’s are also sensitive to Aluminium and Calcium. Concentrations of these determinands at Leintwardine are not presented in the NMP or associated reports?	Comment	NMP focuses on nutrients and sediment. No data available at Leintwardine on aluminium or calcium
316	<u>*Poaching*</u> The main reason for pearl mussel population decline is stated as “unnaturally high levels of sediment, nutrients and pesticides within the river system” (*Atkins, 2012b, Restoration strategy*). This and associated reports do not acknowledge the impact of population decimation suffered in the	Comment	No change

	1970s-1980s by pearl fishers and poachers. *English Nature Report 1993* and confirmed by local knowledge *(Carol Griffiths, NFU Chair, Ludlow).* Has an assessment of the long term population impacts of wholesale FWPM removal been made? It seems likely that the decline of the FWMP is linked to historic poaching and that agricultural impacts may not be the main factor in their decline.		
317	*<u>Pesticides</u>* Pesticides are repeatedly commented upon in reports but no evidence has been presented therefore we assume no monitoring and assessment has been undertaken.	Comment	NMP focuses on nutrients and sediment. No pesticides data available at Leintwardine
318	*<u>Soils</u>* Soils within the catchment are predominantly fine, silty soils derived from glacial deposits and re-worked floodplain materials. By their nature these are easily transported by fluvial processes and a notable proportion of sediment load results from natural fluvial process. Sediment load data was not appended, therefore could not be assessed.	Comment	Figure 6.12 shows how sediment loads vary during the study period
319	It should also be noted that the bed of River Clun has traditionally been dredged to remove sediment build up.	Comment	New section on river management under pressures
320	The FWPM population was savagely reduced in the 70's–80's by pearl fishing and poaching. More evidence and therefore confidence is required that the population can recover in conditions that could be achieved in the River Clun catchment, and not conditions prevailing in Scottish Highland catchments, which clearly cannot be achieved in this setting.	▪	We recognise that achieving water quality conditions to maintain a FWPM population on the River Clun is highly challenging. The present population is confined to lower stretches of the Clun and any action will have to operate across the entire catchment to address water quality issues. We intend to develop and implement a conservation strategy for FWPM population in the R. Clun which aims at reducing the risk to the population until suitable conditions in the river and catchment can be restored to maintain a self-sustaining population. This strategy will include the NMP and significantly it will address the risk of catastrophic loss of FWPM through more direct interventions in the SAC to maintain the existing population; translocation and or captive breeding of some of the population.
321	It is incredible that the farming community may be asked to make significant changes to their management practices on the basis of a flawed plan that cannot be achieved.		Thanks for your response but we do not agree that this view generally reflects the majority of stakeholder responses to the plan and discussion at the workshop held in October 2013. We will endeavour to work constructively with the agricultural sector and NFU to address the issues identified in the NMP.
322	Given the issues highlighted above we think that Natural England should pause to reassess the NMP. It must be revised before decisions are taken on potential future measures. The NFU questions whether an NMP of this sort is appropriate for the Clun catchment!		There is a need to address a wider range of options to address water quality issues and achieve a sustainable population of FWPM in the Clun catchment rather than rely on the NMP. See also responses above.
323	What can be done? The River Clun Catchment has changed significantly over time and in particular the last century with changes in agricultural management, mechanisation of transport and highway infrastructure and overall population. Comparison of catchments with recruiting populations of FWPM (nationally and internationally) suggest that due to the current catchment characteristics of the River Clun, it is no longer able to provide the required water quality conditions for FWPM. This is as a result of human population demands which include the requirement for food production.		The present population is confined to lower stretches of the Clun and any action will have to operate across the entire catchment to address water quality issues. We are aiming to identify and restore more limited reaches of the upper catchment first to provide the required water quality conditions (provided other conditions are suitable – e.g. flows

			and substrate) before moving to the catchment as a whole.
324	From the assessments of the River Clun and River Teme Catchments the primary restoration focus appears to be sediment load reduction. Therefore measures could be taken to focus on river morphology and sediment load reduction in the lower Clun around the FWPM. Active management of the FWPM beds (using techniques such as gravel aeration and silt curtains) may prove to be more effective than catchment wide approaches. Management measures must be undertaken with the full backing of the riparian landowner and appropriate management incentives must be made available to landowners via NELMS.		Sediment load reduction will be a key focus for restoration efforts on the Clun as identified in the River Restoration Plan and NMP. The NMP identifies principle sources of silt as coming from land management with 85% coming from catchment diffuse sources and 15% bank erosion. Measures have been proposed with the aim of reducing catchment wide pressures and largely fall into two categories, either reducing the source of the problem or intercepting the problem (i.e. sediment or nutrients) along the pathway between its source and the river so it does not damage the habitat. If pearl mussel conservation is considered alongside improvements in WQ for other species and habitats, reduction of the source of the problem clearly is more sustainable and has wider conservation and society benefits. We would questioned your assumption that active management of the FWPM beds would be more effective than catchment wide approaches in dealing with sediment load and siltation issues. The techniques you suggest are not ones we would recommend in this instance and are not a sustainable solution. Gravel aeration would be only used to restore river reaches once the sediment supply from the catchment has been addressed. Silt curtains are more commonly employed when management works are likely to disturb substrate and release large amounts of sediment impacting on downstream habitat. Employing silt curtains in a river like the Clun would also be problematic due to its flashy nature. Any management measures undertaken will be undertaken on a voluntary basis through management incentives and advice.
325	If measures cannot be taken to grow FWPM populations the impacts on the local community must be balanced with the chances of managing a viable population. At what point does the population become unviable? The NMP already states that the population is functionally extinct. Natural England must give careful consideration to this issue.		We will continue to monitor the FWPM population and its response to prevailing conditions. Although the current population is classed as "non-functioning" (no recent juvenile recruitment and an aging adult pop.) this does not mean its "non-recoverable".

			We intend to develop and implement a conservation strategy for FWPM population in the R. Clun which aims at reducing the risk to the population until suitable conditions in the river and catchment can be restored to maintain a self-sustaining population. This strategy will include the NMP and significantly it will address the risk of catastrophic loss of FWPM through more direct interventions in the SAC to maintain the existing population; translocation and or captive breeding of some of the population.

Appendix B. Maps

Map 1 – Catchment and location map

Map 2 – WFD water bodies

Map 3 – Topography

Map 4 – Slope

Map 5 – Geology

Map 6 – Soils

Map 7 – Hydrometric monitoring

Map 8 – Distance to watercourse and connectivity

Map 9 – Current land use

Map 10 – Less favoured area and NVZ designation and agricultural land classification

Map 11 – Agri-environment coverage in the catchment

Map 12 – Resource protection measures in the catchment

Map 13 – Water quality monitoring network in the Clun catchment

Map 14 – Population pressures summary map (STWs, septic tanks, CSOs and storm overflow tanks)

Map 15 – CLAD arable + additional aerial photo

Map 20 – SAGIS model setup

Map 16 – PSYCHIC phosphate hotspot mapping

Map 17 – NEAP-N nitrate hotspot mapping

Map 18 – PSYCHIC sediment hotspot map

Map 19 – Defra soil erosion risk methodology hotspot map

Map 20 – SCIMAP field hotspot map

Map 21 – SCIMAP watercourse hotspot map

Appendix C. Freshwater Pearl Mussel

C.1. Species details

The freshwater pearl mussel (*Margaritifera margaritifera*) is considered the most endangered species in the European Union, with 90% of individuals being lost in the 20th Century. The EC Habitats Directive lists the freshwater under Annex II (species whose conservation requires the designation of special conservation areas) and Annex V (species whose taking in the wild and exploitation may be subject to management measures). The most recent European IUCN red list classifies *Margaritifera margaritifera* as "critically endangered" (Cuttelod *et al.*, 2011). Large populations are now restricted to Ireland, Scotland and Scandinavia. The UK is estimated to be holding approximately 40% of the entire complement of EU individuals. In England, most populations are 'functionally extinct' in that they consist of a relatively small number of old specimens with no substantial evidence of recent recruitment. The River Clun falls into this category. At present only the River Ehen in Cumbria is considered to support a viable freshwater pearl mussel population in England.

C.2. Habitat requirements

The freshwater pearl mussel is one of the longest-lived invertebrates known, and individuals can survive for over 100 years. The mussels live buried or partly buried in coarse sand and fine gravel in rivers and streams that are typically clean, oligotrophic and fast flowing.

Freshwater pearl mussels requires clean waters and a thriving salmonid population to survive. The species has a symbiotic/parasitic relationship with Atlantic salmon *Salmo salar* and brown trout *Salmo trutta* during the annual reproductive phase, on reaching maturity at age 10-15 years.

There is a general acceptance that the pearl mussel prefers oligotrophic conditions (poor in nutrients), pH 7.5 or less and with low overall conductivity; few populations exist in calcareous waters.

Adult mortality has been correlated with nitrate concentrations, and increased levels of phosphate and calcium have been correlated with decreasing survival and establishment of juveniles (Bauer, 1988). Research has suggested that nitrate levels must not exceed 1.0 – 1.5 mg/l, phosphate should be less than 0.03 mg/l and conductivity must not exceed 100 – 120 µS cm^{-1}.

The typical substrate preference is small sand patches stabilised amongst large stones or boulders in fast-flowing streams and rivers. The majority of adult mussels live in dense beds in substrates of mixed cobble, stone and sand at the tail end of pools or in the moderate flow channels of river bends. Juveniles are mostly associated with riffles, usually well sorted with little fine sediment. Boulder-stabilised refugia, which contain enough sand for burrowing, are ideal microhabitats for juvenile mussels (Hastie *et al*., 2000).

Pearl mussels are likely to be most vulnerable to human influences at the stage where they leave the host fish and establish in the sediment. The juveniles are far less tolerant than the adults. Levels greater than 30 mg/l of suspended solids have been noted as the limit of tolerance by adults although levels consistently above 10 mg/l should give cause for concern.

Mussel aggregations in many rivers in England and Wales are associated with areas of shade, normally created by overhanging herbaceous vegetation, scrub and bankside trees with little or no bank erosion.

Table C1. Review of the water quality requirements of freshwater pearl mussel

Parameter	Units	Killeen (2009)[*]	WWF (2009)	Skinner (2003)	Oliver (2000)	Bauer (1988)
pH	-	6.5 – 7.0	>6.2	<7.5	6.5 - 7.2	-
Total Phosphorus	mg/l	<0.005	<0.005-0.015	<0.03	<0.03	<0.03
Nitrate	mg/l	0.2-0.4[∞]	<0.125	<1.0	<1.0	<0.5
BOD	mg/l	<1	-	-	<1.3	1.4
Conductivity	µs/cm	40-50	-	<100	<100	<70
Turbidity	NTU	-	<1 FNU	-	-	-
Dissolved Oxygen	%	-	-	-	90-110%	-
Water Temperature	degs C	-	<25°C	-	-	-

[*]Study of River Ehen, the only recruiting river in England. ∞TON rather than NO3

C.3. Surveys

C.3.1. Historic data

Historic records from the 1970s report that freshwater pearl mussel was abundant in the River Clun between Leintwardine and Clungunford. Recent unconfirmed anecdotal information suggests that they may have also been known from higher up the catchment.

An English Nature report of 1993 stated that two pearl fishers had systematically scoured the river in the 1980's and that large mounds of shells were deposited at the river edge.

C.3.2. 1995

The first systematic survey of freshwater pearl mussel populations in the River Clun was carried out in 1995. This survey found 2,227 mussels in the reach between Jay Bridge and Leintwardine and estimated the catchment population to be in the order of 4,000 - 5000 individuals (Oliver & Killeen 1996).

C.3.3. 2000-01

A survey by the Environment Agency in 2000-2001 estimated the catchment population to be 3,334 individuals. The population was thought to be sufficiently concentrated to be considered viable (Oliver & Killeen, 1995).

C.3.4. 2005

A brief survey of the river in July 2005 (Killeen 2005) found very few mussels upstream of Jay Bridge where several hundred were found in previous surveys. Locations where freshwater pearl mussels had disappeared coincided with areas where cattle had open access to the river.

C.3.5. 2007-08

Surveys in September 2007 and June 2008 estimated the population had declined to 2,500 individuals, equivalent to a 26% loss in the 6 years since 2000-2001. The greatest losses were from the section upstream of Jay Bridge where there has been a 34% loss (from 665 to 436 individuals) and from Jay Bridge to the tributary, where there has been a 36% loss (from 44 to 285 individuals). In the 7/8 years since the last survey, an average of approximately 100 mussels per year has been lost. If it is a case of that these mussels are only dying of old age and not through incidences of severe damage leading to kills of all ages, then the best scenario is that the population will only continue to lose 100 mussel per year, and will completely die out in 25 years.

C.3.6. 2013

A repeat survey in 2013 concluded that there has been at least a 50% loss of mussels since 2007/2008. The mussels were in extremely poor condition, very few were well buried i.e. many were almost fully out of the substrate with their foot retracted rather than the normal situation with the foot anchoring the mussels into the substrate. A retracted foot can be caused by high stress levels leading to muscle deterioration. They displayed a very poor level of filtration, and most were covered in mud and diatom growths (see photo of typical appearance). Some mussels were stress tested with tongs – and they showed very little resistance to opening, these would be classed as stressed or very stressed. Well over 25 mussels were found lying on their side on the substrate surface. Whilst some were still alive, most were moribund (on the verge of dying) and some were already being eaten by *Gammarus*.

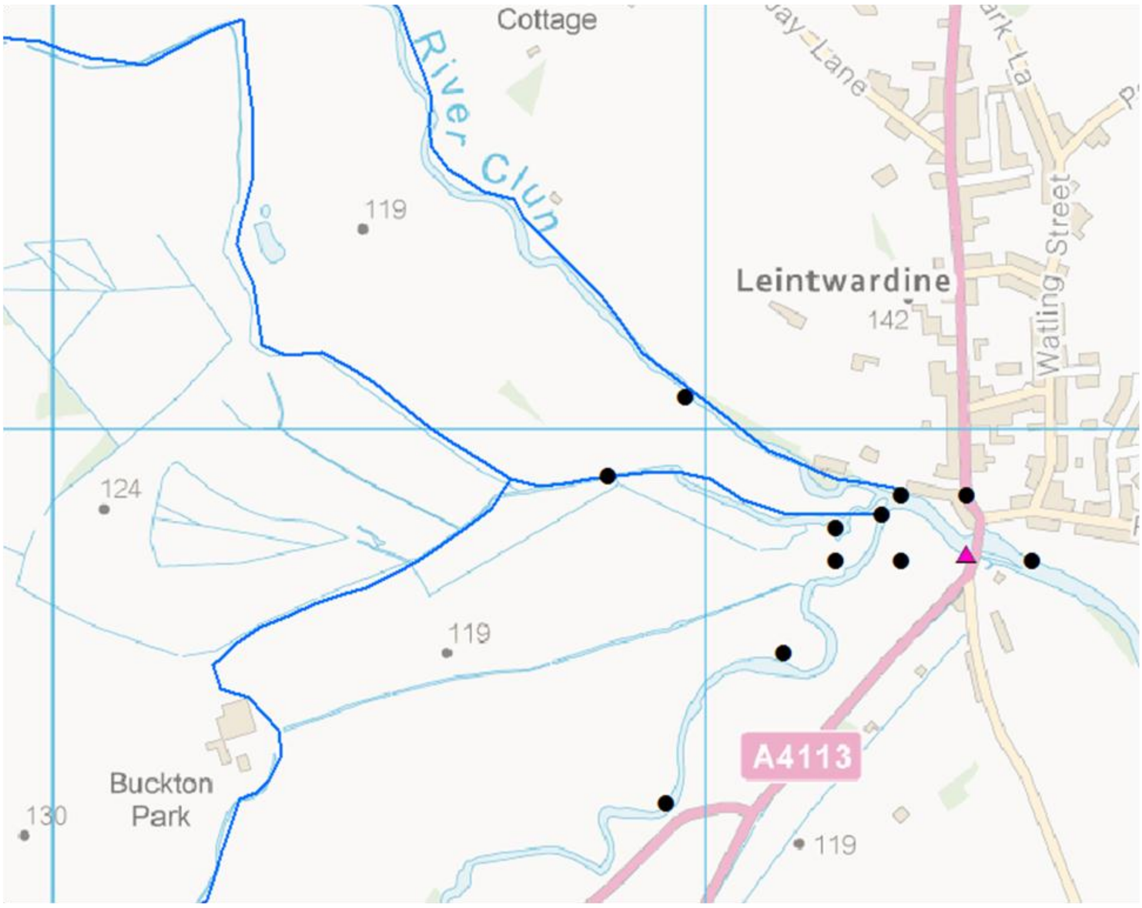
C.3.7. Summary

The conclusion from these surveys is that the integrity of the SAC is not being maintained. Most visual observations have indicated that the river and its substrate are in poor condition and had deteriorated. Numbers have declined significantly in numbers over the last 15-20 years, there is no recruitment, and the species' prospects of survival in the short to medium term are very low and the probability of potentially imminent extinction is high and requires the fastest response that is possible.

At the current rate of decline, it is estimated that the species will become extinct in the catchment by 2028 (Atkins 2012a). The 2028 date assumes a linear decline. Recent surveys may indicate an increase in the rate of decline. Given the highly stressed state of the population and critically low numbers, Clun freshwater pearl mussels may also now be vulnerable to one-off extinction events. For example, FWPM are known to be lying on the substrate rather than embedded within. Flooding could see wash out into the River Teme downstream or onto riverbanks.

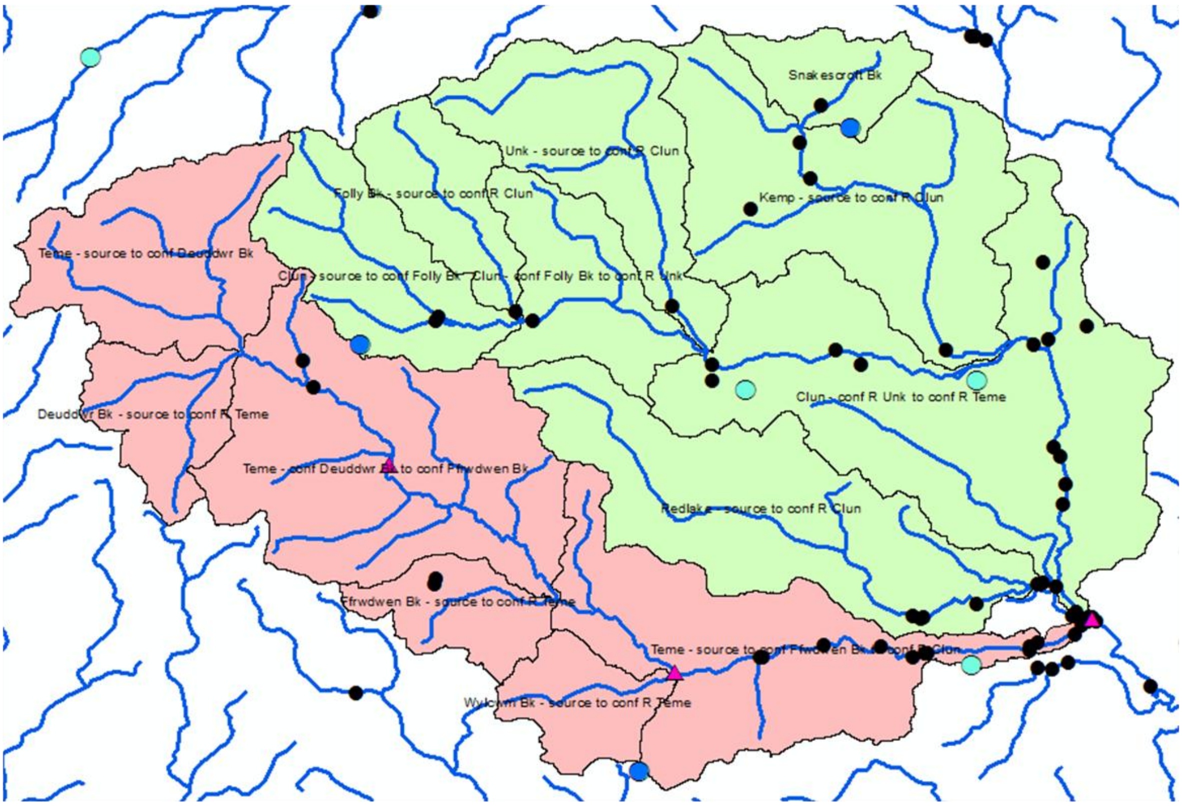
Appendix D. Flow estimation in the Clun catchment

D.1. Location of EA water level and spot flow monitoring around Leintwardine



The location used to develop a flow timeseries for the River Clun is the pink triangle in the figure above. This location is downstream of the confluence between the Clun and the Upper Teme

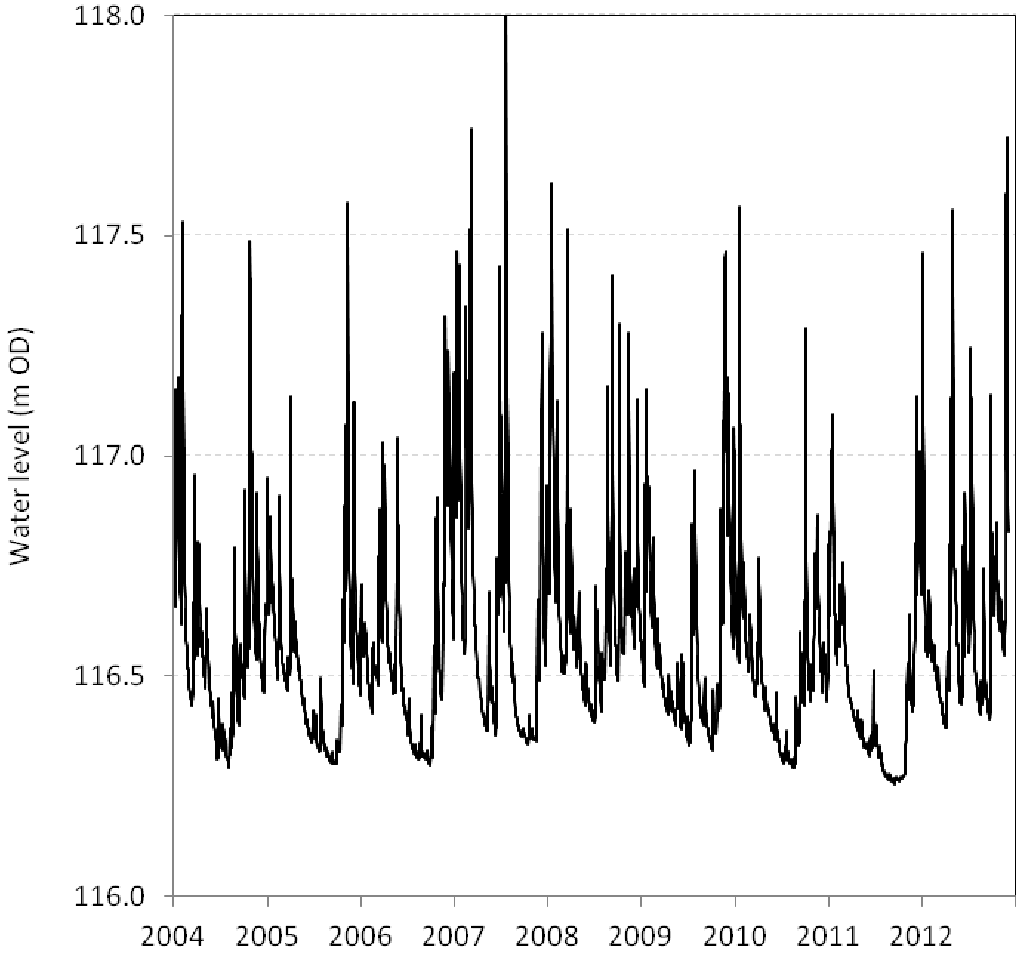
D.2. Map showing the catchments of the River Clun (green) and Upper Teme (pink)



D.3. Table summarising the areas of different component water bodies of the Clun and Upper Teme catchments

EA_WB_ID	WB_NAME	Area	Catchment totals	% of total
GB109054043950	Redlake - source to conf R Clun	4,721	27,127	62%
GB109054043980	Clun - conf Folly Bk to conf R Unk	1,926		
GB109054043990	Clun - conf R Unk to conf R Teme	7,662		
GB109054044000	Clun - source to conf Folly Bk	2,334		
GB109054044020	Folly Bk - source to conf R Clun	1,439		
GB109054044040	Unk - source to conf R Clun	2,931		
GB109054044060	Kemp - source to conf R Clun	5,101		
GB109054044061	Snakescroft Bk	1,013		
GB109054044940	Wylcwm Bk - source to conf R Teme	1,122	16,549	38%
GB109054044950	Ffrwdwen Bk - source to conf R Teme	1,130		
GB109054044960	Teme - source to conf Ffwdwen Bk to conf R Clun	4,453		
GB109054044980	Deuddwr Bk - source to conf R Teme	1,353		
GB109054044990	Teme - conf Deuddwr Bk to conf Ffrwdwen Bk	5,503		
GB109054045000	Teme - source to conf Deuddwr Bk	2,988		
	TOTAL	43,676		

D.4. Water level time series data

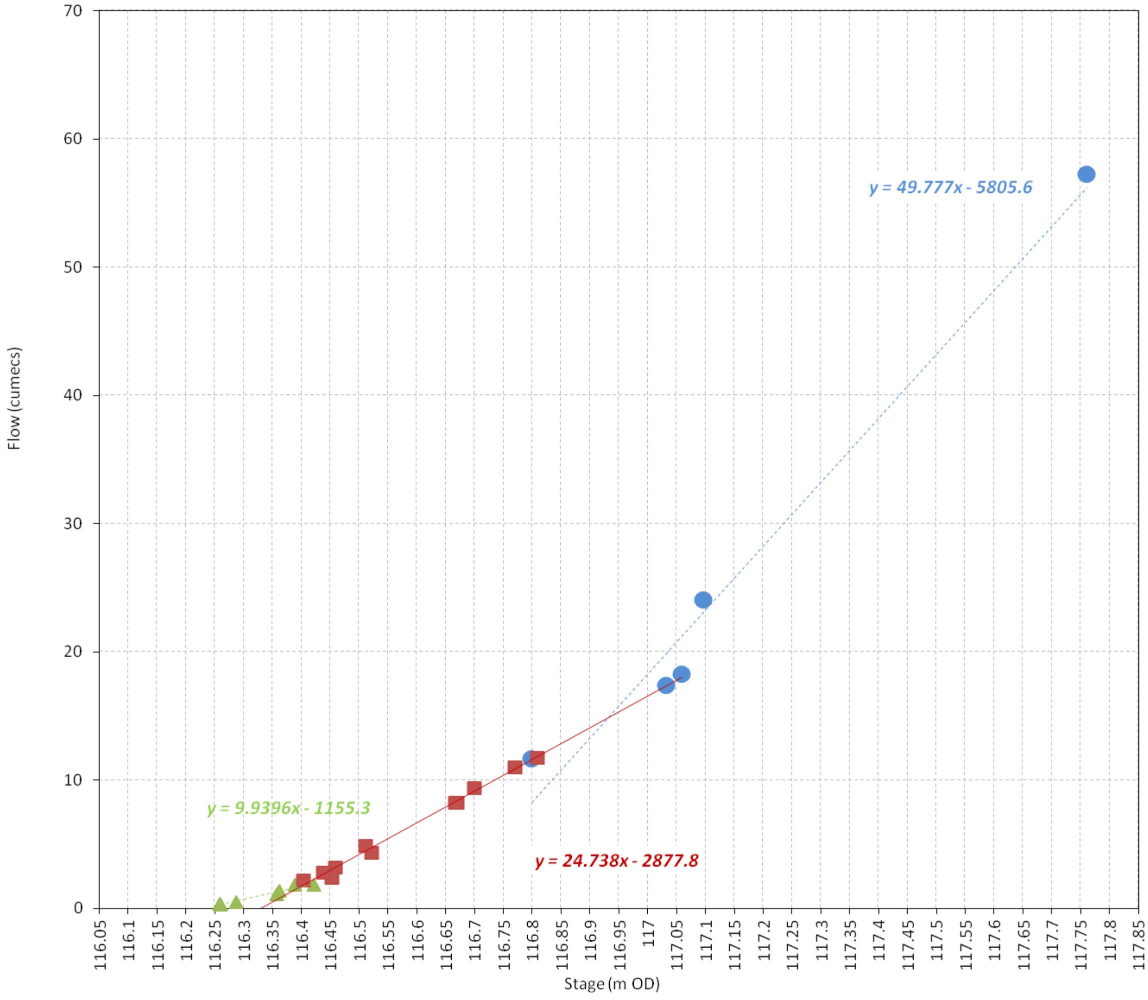


D.5. Spot flow data

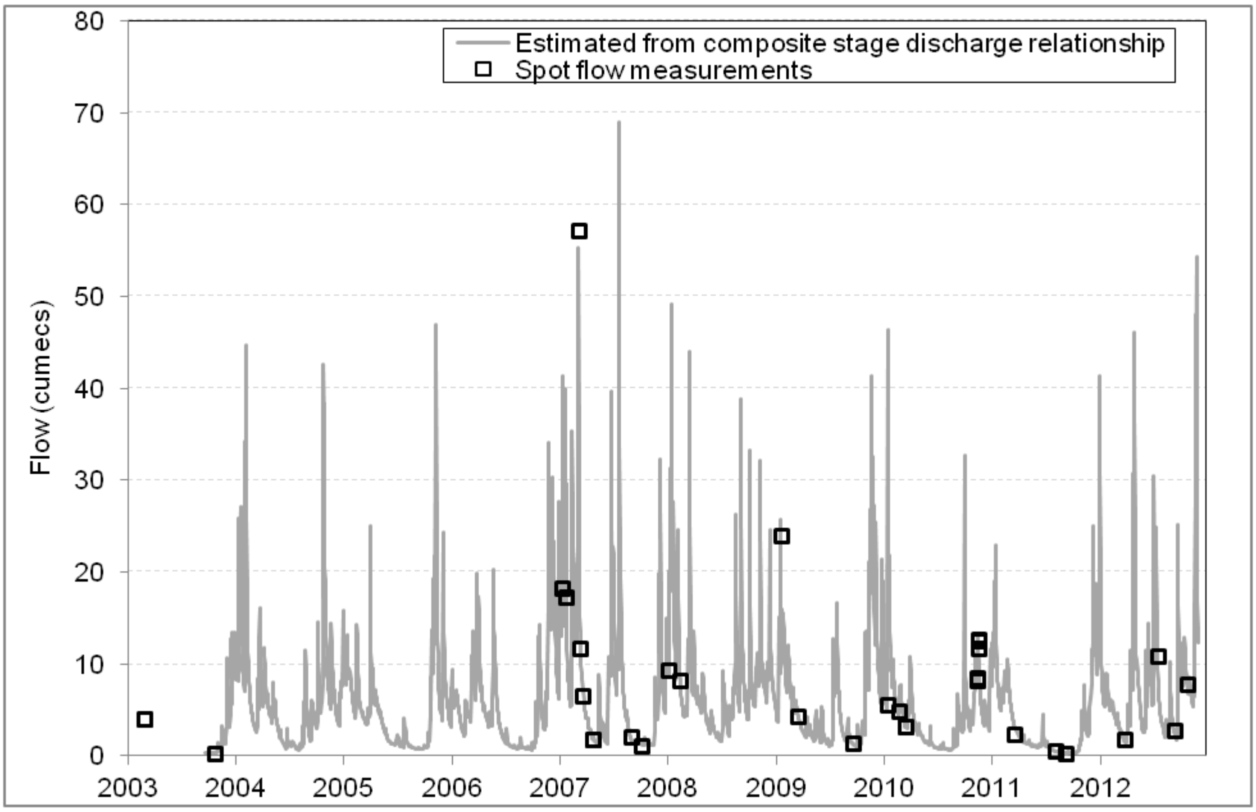
Station name,LEINTWARDINE
Station number,"2132"
External number,
River,TEME
Operator, -
NGR,SO
Easting,"4040"
Northing,"7381"
Parameter-name,Flow
Parameter Type,FQ
Time series name,2132.FQ.Gaugings
Time series unit,m
Time level,High-resolution
Time series type,Instantanenous value
Equidistant time series,no
Time series value distance,---
Time series quality,Production
Time series measuring method,-
Period of record in file: 29/08/1974 00:00:00 to 27/10/2012 00:00:00

Date Time	SG [m]	FQ [m3/s]	Cross section [m2]	Mean velocity [m/s]	Width [m]	Mean depth [m]
29/08/1974 00:01	.	0.43	---	---	---	---
11/03/1981 13:10	1.29	38.6	36.18	1.07	---	---
18/11/1983 00:02	0.36	1.24	---	---	---	---
13/07/1984 00:16	0.32	0.798	---	---	---	---
27/07/1984 00:09	0.26	0.406	---	---	---	---
29/06/1993 11:30	0.451	6.03	---	0.49	---	---
07/07/1993 11:10	0.391	1.55	---	0.21	---	---
12/08/1993 14:40	0.38	1.44	---	0.15	---	---
06/09/1993 14:00	0.3	0.661	---	0.08	---	---
15/06/1994 16:15	0.41	1.68	---	0.23	---	---
21/06/1994 14:00	0.362	1.55	---	0.28	---	---
19/10/1994 13:10	0.354	1.33	---	0.34	---	---
27/03/1995 10:00	0.585	6.31	---	0.31	---	---
04/04/1995 10:50	0.439	3.13	---	0.17	---	---
07/06/1995 10:05	0.358	1.23	---	0.29	---	---
04/08/1995 15:00	0.246	0.451	---	0.62	---	---
09/08/1995 14:15	0.25	0.36	---	0.06	---	---
25/08/1995 15:20	0.24	0.318	---	0.17	---	---
04/07/1996 13:30	0.337	1.1	---	0.14	---	---
04/07/1996 14:00	.	0.269	---	---	---	---
04/07/1996 14:01	.	0.269	---	---	---	---
29/08/1996 13:20	.	0.02	---	---	---	---
29/08/1996 13:41	0.295	0.428	---	0.07	---	---
16/09/1996 13:30	.	0.007	---	---	---	---
08/01/1997 10:35	.	0.685	---	0.59	---	---
04/02/1997 15:10	---	0.698	---	0.6	---	---
18/04/1997 16:25	---	0.333	---	0.41	---	---
15/08/1997 14:30	---	0.105	---	0.19	---	---
14/07/1999 10:30	0.34	1.09	---	0.3	---	---
31/03/2000 09:30	.	3.31	---	0.39	---	---
31/03/2000 10:16	.	2.61	---	0.31	---	---
08/12/2000 12:51	1.9	97.1	---	---	---	---
08/12/2000 13:41	1.91	92.5	---	---	---	---
25/02/2003 11:30	0.503	4.16	---	0.22	---	---
25/02/2003 13:30	0.502	4.06	---	0.21	---	---
21/10/2003 10:15	0.258	0.32	4.21	0.08	16.6	0.25
09/01/2007 12:20	1.08	18.3	20.9	0.88	11.3	1.85
22/01/2007 14:15	1.06	17.4	24.4	0.71	12	2.03
06/03/2007 13:00	1.76	57.3	39.3	1.46	15	2.62
13/03/2007 12:00	0.8	11.7	28	0.42	13.5	2.07
20/03/2007 12:35	0.645	6.61	24.4	0.27	12.5	1.95
25/04/2007 15:12	0.422	1.9	8.01	0.24	21.5	0.37
25/04/2007 15:45	0.422	1.84	6.33	0.29	13.6	0.47
31/08/2007 13:00	0.385	2.2	19.85	0.11	12.93	1.54
05/10/2007 13:30	0.358	1.12	2.68	0.42	11.2	0.24
03/01/2008 14:15	0.701	9.39	26.79	0.35	14.32	1.87
13/02/2008 13:45	0.67	8.24	22.5	0.37	14.31	1.57
19/01/2009 13:45	1.1	24.1	30.3	0.79	14.5	2.09
17/03/2009 14:54	0.521	4.36	7.31	0.6	21.6	0.34
22/09/2009 12:30	0.362	1.41	13.9	0.1	11.6	1.2
15/01/2010 12:45	0.553	5.6	19.8	0.28	11.8	1.68
24/02/2010 15:00	0.512	4.92	23.38	0.21	13.6	1.72
17/03/2010 13:15	0.46	3.28	22.11	0.15	13.25	1.67
17/03/2010 13:45	0.46	3.23	21.91	0.15	13.11	1.67
16/11/2010 11:05	0.667	8.24	23.55	0.35	12.7	1.85
16/11/2010 11:25	0.668	8.58	23.73	0.36	12.8	1.85
19/11/2010 13:55	0.811	12.8	26.8	0.48	13	2.06
19/11/2010 14:00	0.809	11.8	26.5	0.44	12.8	2.07
19/11/2010 14:10	0.808	12.6	26.3	0.48	12.7	2.07
23/03/2011 14:00	0.454	2.44	16.05	0.15	12	1.34
08/08/2011 09:25	0.289	0.541	1.37	0.39	10.5	0.13
12/09/2011 08:32	0.259	0.396	1.29	0.31	10.6	0.12
29/03/2012 12:00	0.389	1.84	18.77	0.1	12.75	1.47
18/07/2012 09:29	0.771	11	28	0.39	14	---
13/09/2012 12:10	0.438	2.84	19.98	0.14	13.26	---
26/10/2012 12:06	0.658	7.87	23.05	0.34	14.2	---

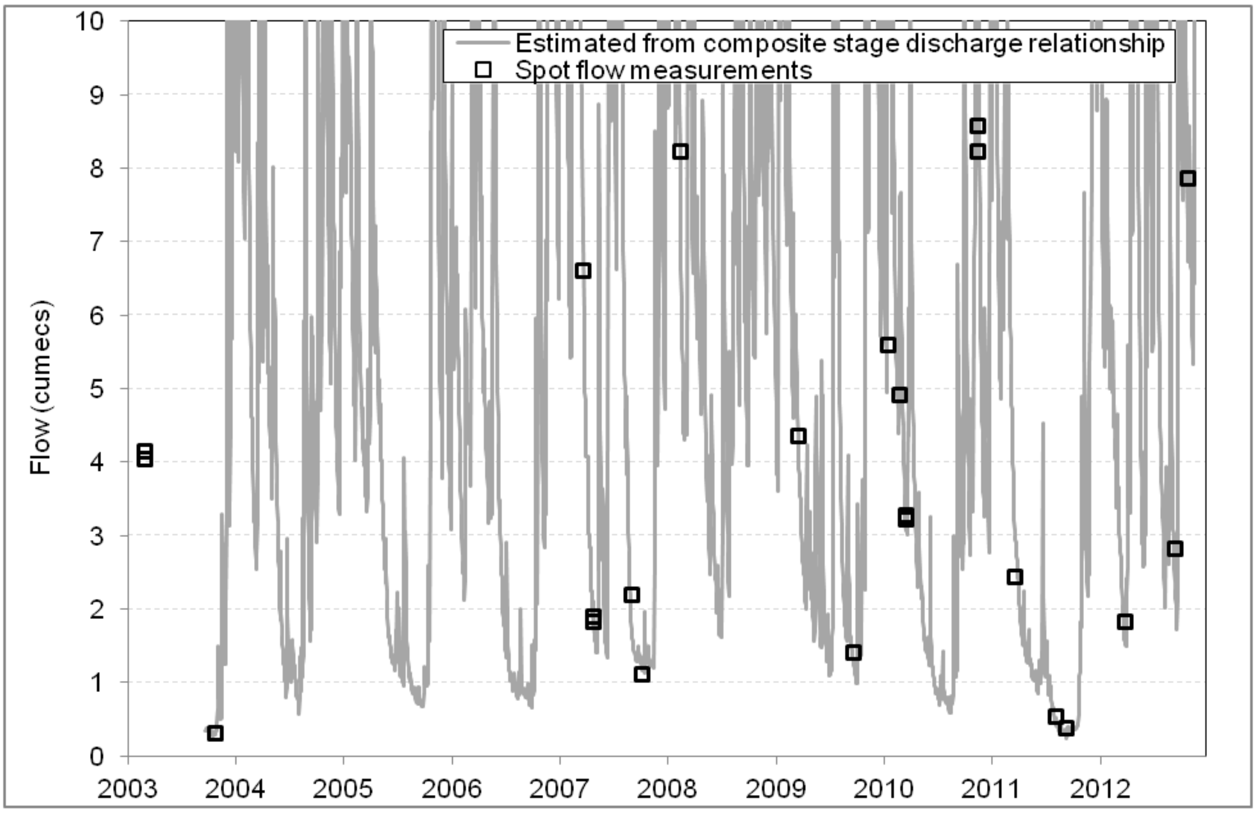
D.6. Composite stage-discharge relationships for the River Clun and Upper Teme at Leintwardine



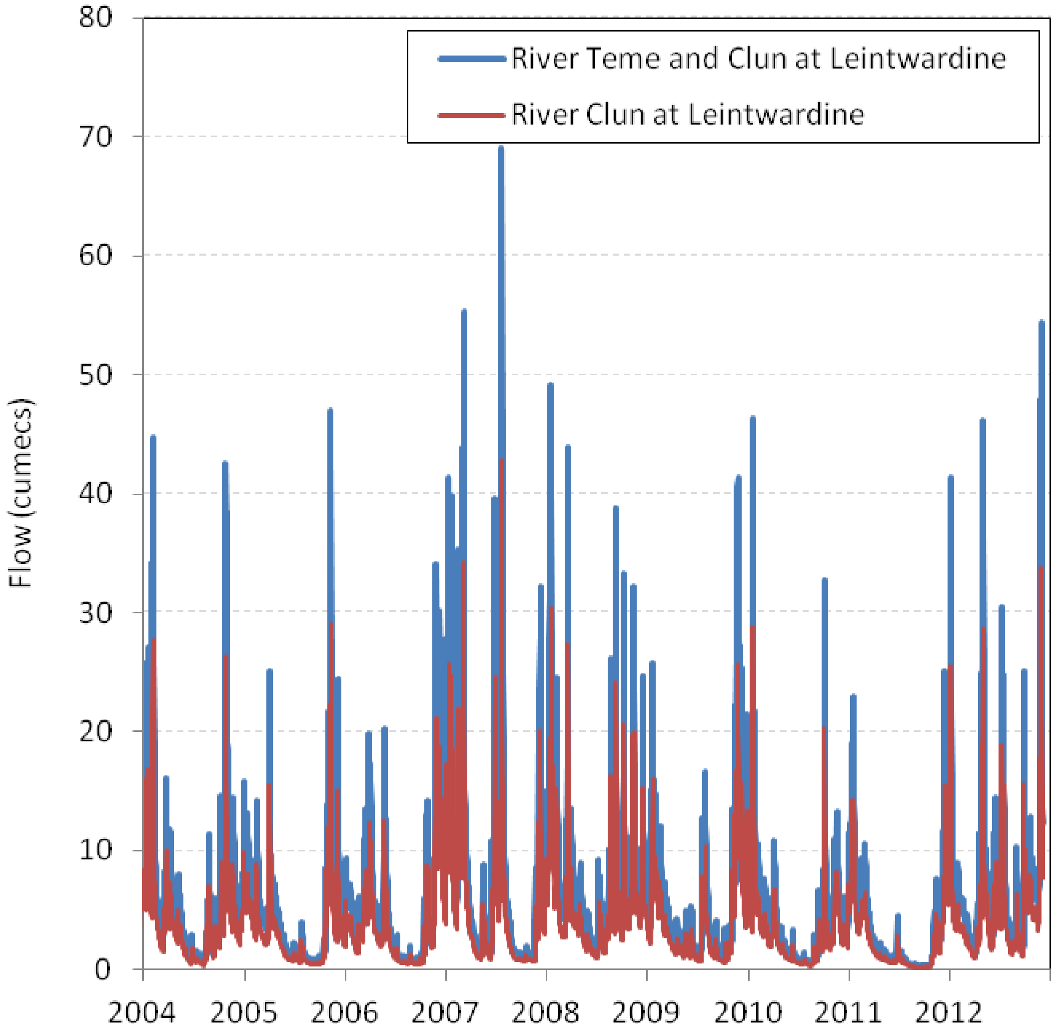
D.7. Test of how adequately spot flows are estimated using the composite stage-discharge relationship



D.8. Low flows check



D.9. Final flow time series and apportionment of flows in Clun vs Upper Teme based on area weighting (Appendix D3)



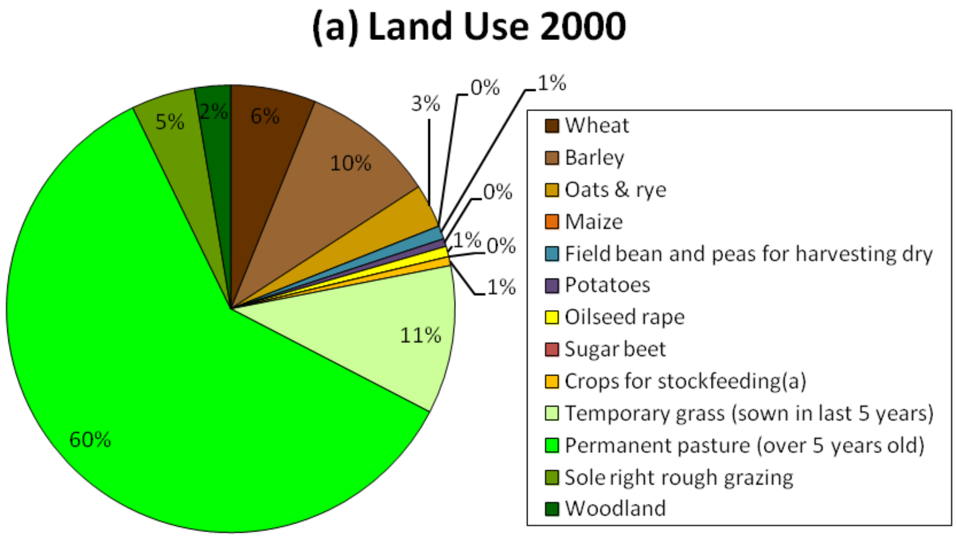
Appendix E. Land use

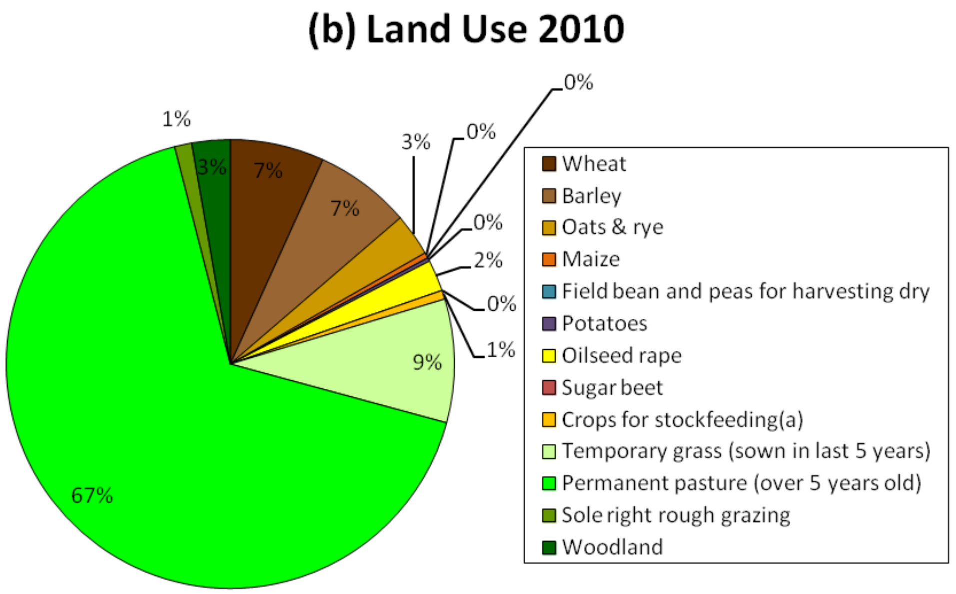
E.1. Defra agricultural census data

Crop type	Area (hectares)	
	2000	2010
Wheat	1,266	1,366
Barley	1,994	1,396
Oats & rye	649	617
Maize	#	80
Field bean and peas for harvesting dry	199	#
Potatoes	115	52
Oilseed rape	156	456
Sugar beet	0	0
Crops for stockfeeding(a)	133	129
Land use	**Area (hectares)**	
	2000	**2010**
Temporary grass (sown in last 5 years)	2,205	1,795
Permanent pasture (over 5 years old)	12,393	13,461
Sole right rough grazing	952	250
Woodland	536	557
Livestock type	**Number of livestock**	
	2000	**2010**
Cattle	17,863	13,914
Pigs	0	159
Sheep	167,258	119,282
Fowl(b)	482,357	287,784

Data for 2000 includes commercial and non-commercial holdings. Data for 2010 excludes non-commercial holdings and is therefore not comparable to 2000 data.

E.2. Pie-chart of catchment

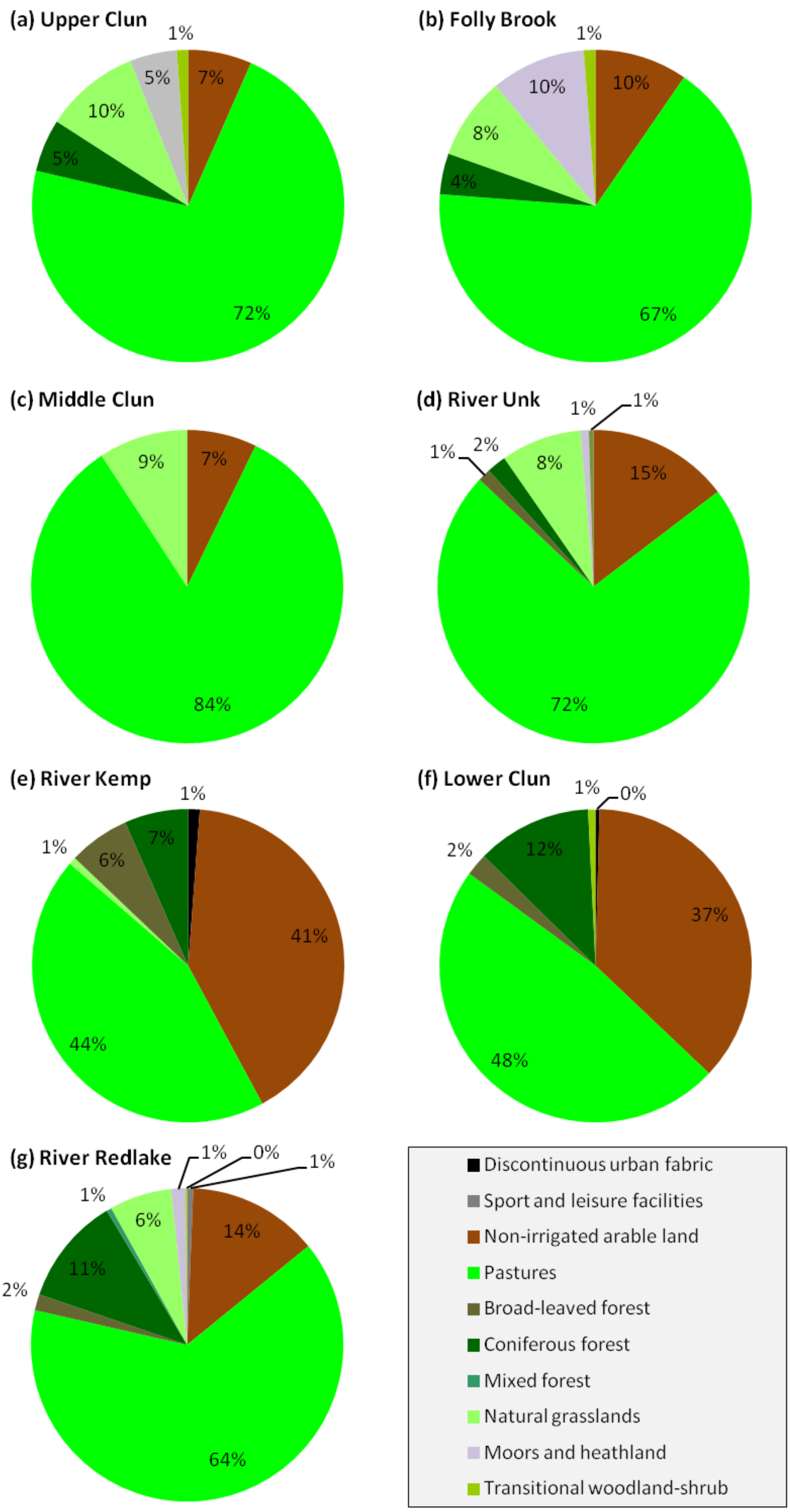




E.3. Defra agricultural census 2010 data for sub-catchments of the River Clun

	WFD Waterbody ID	R Clun - source to conf Folly Bk	Folly Bk - source to conf R Clun	R Clun - conf Folly Bk to conf R Unk	R Unk - source to conf R Clun	R Kemp - source to conf R Clun	R Redlake - source to conf R Clun	R Clun - conf R Unk to conf R Teme	Total
		GB109054044000	GB109054044020	GB109054043980	GB109054044040	GB109054044060	GB109054043950	GB109054043990	-
	Name	Upper Clun	Folly Brook	Middle Clun	River Unk	River Kemp	R Redlake	Lower Clun	Catchment
	Area (ha)	2,333	1,451	1,907	2,945	6,051	4,938	7,601	27,226
	Area (acres)	5,623	3,498	4,595	7,098	14,582	11,900	18,319	65,614
Crop type	Wheat	0	0	#	98	636	#	445	**1 366**
	Barley	#	#	#	185	537	98	457	**1 396**
	Oats & rye	#	#	#	#	280	#	202	**617**
	Maize	0	0	0	0	#	0	#	**80**
	Field bean and peas for harvesting dry	0	0	0	#	0	#	#	**#**
	Potatoes	#	0	0	0	#	0	#	**52**
	Oilseed rape	0	0	0	#	#	#	187	**456**
	Sugar beet	0	0	0	0	0	0	0	**0**
	Crops for stockfeeding[(a)]	#	#	#	#	53	#	23	**129**
Land use	Temporary grass (sown in last 5 years)	190	#	229	236	596	#	384	**1 795**
	Permanent pasture (over 5 years old)	1 584	1 016	1 806	2 022	2 143	1 958	2 933	**13 461**
	Sole right rough grazing	#	0	#	#	#	82	53	**250**
	Woodland	68	8	19	83	106	49	224	**557**
Livestock type	Cattle	1 390	610	2 058	1 823	3 668	1 517	2 847	**13 914**
	Pigs	#	0	#	#	#	#	#	**159**
	Sheep	14 901	12 053	15 615	17 030	17 115	17 387	25 181	**119 282**
	Fowl[(b)]	#	#	#	#	60 862	997	225 815	**287 784**

E.4. Sub-catchments land cover summary pie charts (from CORINE 2006)



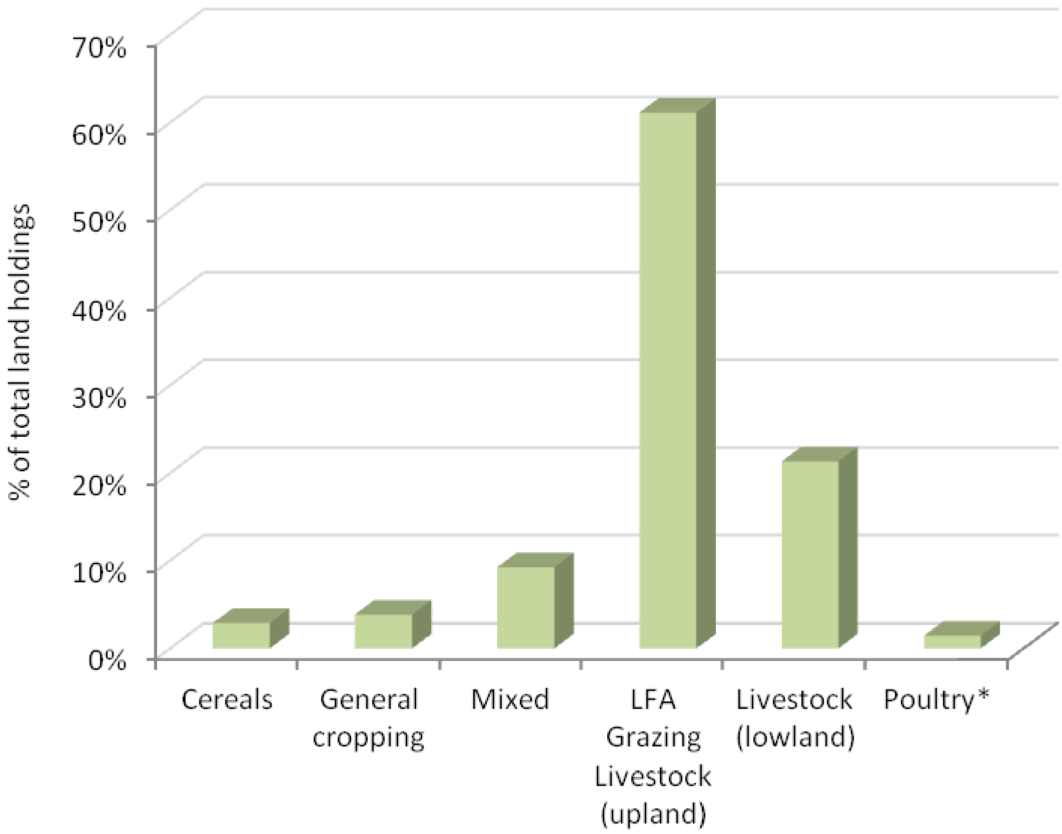
E.5. Defra robust farm types in the Clun catchment

Counts of Holdings by Farm Type in the Clun River's Sub-catchments, as at June 2010.

Name Of Sub-catchment	Robust Type of Holding	No. Of Holdings
Folly Bk - source to conf R Clun	GENERAL CROPPING	#
Folly Bk - source to conf R Clun	LFA GRAZING LIVESTOCK	9
Folly Bk - source to conf R Clun	MIXED	#
R Clun - conf Folly Bk to conf R Unk	GENERAL CROPPING	#
R Clun - conf Folly Bk to conf R Unk	LFA GRAZING LIVESTOCK	18
R Clun - conf Folly Bk to conf R Unk	MIXED	#
R Clun - conf Folly Bk to conf R Unk	UNCLASSIFIED	#
R Clun - conf R Unk to conf R Teme	CEREALS	#
R Clun - conf R Unk to conf R Teme	GENERAL CROPPING	8
R Clun - conf R Unk to conf R Teme	HORTICULTURE	#
R Clun - conf R Unk to conf R Teme	LFA GRAZING LIVESTOCK	19
R Clun - conf R Unk to conf R Teme	LOWLAND GRAZING LIVESTOCK	27
R Clun - conf R Unk to conf R Teme	MIXED	11
R Clun - conf R Unk to conf R Teme	SPECIALIST POULTRY	#
R Clun - conf R Unk to conf R Teme	UNCLASSIFIED	#
R Clun - source to conf Folly Bk	GENERAL CROPPING	#
R Clun - source to conf Folly Bk	LFA GRAZING LIVESTOCK	22
R Kemp - source to conf R Clun	CEREALS	6
R Kemp - source to conf R Clun	DAIRY	#
R Kemp - source to conf R Clun	GENERAL CROPPING	#
R Kemp - source to conf R Clun	LFA GRAZING LIVESTOCK	6
R Kemp - source to conf R Clun	LOWLAND GRAZING LIVESTOCK	17
R Kemp - source to conf R Clun	MIXED	8
R Kemp - source to conf R Clun	UNCLASSIFIED	#
R Redlake - source to conf R Clun	CEREALS	#
R Redlake - source to conf R Clun	DAIRY	#
R Redlake - source to conf R Clun	GENERAL CROPPING	#
R Redlake - source to conf R Clun	HORTICULTURE	#
R Redlake - source to conf R Clun	LFA GRAZING LIVESTOCK	33
R Redlake - source to conf R Clun	LOWLAND GRAZING LIVESTOCK	#
R Redlake - source to conf R Clun	SPECIALIST PIGS	#
R Redlake - source to conf R Clun	SPECIALIST POULTRY	#
R Redlake - source to conf R Clun	UNCLASSIFIED	#
R Unk - source to conf R Clun	CEREALS	#
R Unk - source to conf R Clun	LFA GRAZING LIVESTOCK	19
R Unk - source to conf R Clun	MIXED	#

Source: Defra's 2010 June Census of Agriculture and Horticulture.
# denotes where values have been suppressed because they consist of less than five holdings to prevent individual holdings from being identified.

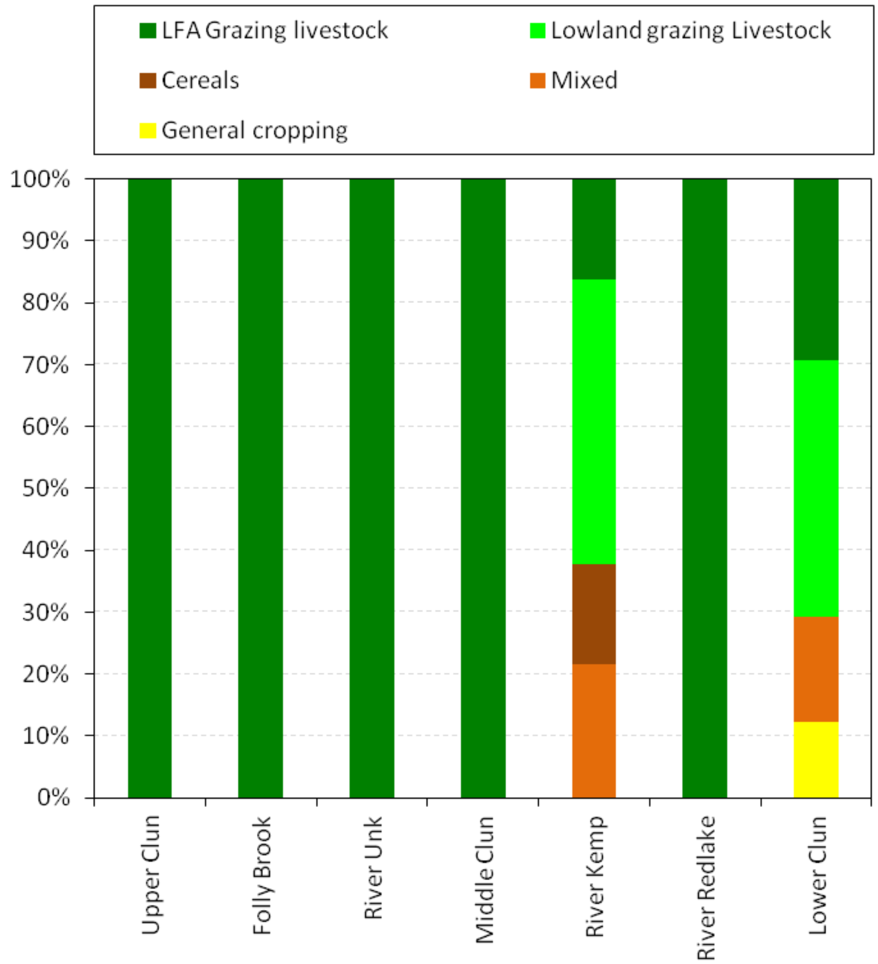
E.6. Summary of number of land holdings in the Clun catchment by Defra Robust Farm type



E.7. Defra robust farm types in Clun sub-catchments

	Upper Clun	Folly Brook	River Unk	Middle Clun	River Kemp	River Redlake	Lower Clun	TOTAL
Cereals					6			**6**
General cropping							8	**8**
Mixed					8		11	**19**
LFA Grazing livestock	22	9	19	18	6	33	19	**126**
Lowland grazing Livestock					17		27	**44**
Poultry*			1		1	1		**3**
TOTAL	**22**	**9**	**19**	**18**	**37**	**33**	**65**	**203**

	Upper Clun	Folly Brook	River Unk	Middle Clun	River Kemp	River Redlake	Lower Clun	TOTAL
Cereals	0%	0%	0%	0%	16%	0%	0%	**3%**
General cropping	0%	0%	0%	0%	0%	0%	12%	**4%**
Mixed	0%	0%	0%	0%	22%	0%	17%	**9%**
LFA Grazing livestock	100%	100%	100%	100%	16%	100%	29%	**62%**
Lowland grazing Livestock	0%	0%	0%	0%	46%	0%	42%	**22%**
Poultry*	0%	0%	5%	0%	3%	3%	0%	**1%**



Appendix F. Mechanisms to address water pollution

F.1. Summary table

Scheme	Description, relevance to the Clun Restoration Strategy and contact details
Entry Level Stewardship (ELS) [national grant scheme]	Eligibility: Whole-farm environmental improvement scheme. Agreements last for five years. A certain level of points is required for payments. The following are activities relevant to the Restoration Strategy for which points are available: • hedgerow and ditch management; • protection of trees in fields; • buffer strips and field margins; • beetle banks, field corners, wild bird cover; • protection of soils; • management of permanent grassland; • mixed stocking; <http://www.naturalengland.org.uk/ourwork/farming/funding/es/els/default.aspx>
Higher Level Stewardship (HLS) [national grant scheme]	Eligibility: Implemented in conjunction with the ELS or OELS. Payments for sympathetic management of land of significant environmental interest, with capital grant options also available. Agreements are tailored to individual circumstances, with options available for soil and water management and for the creation, restoration and maintenance of habitats such as: • hedgerows and woodlands • arable/grassland areas • watercourses (funding for fencing and maintenance) • heathland and moorland • species-rich grassland • wetlands <http://www.naturalengland.org.uk/ourwork/farming/funding/es/hls/default.aspx>
England Catchment Sensitive Farming (CSF) [national advice and capital grant scheme]	The Teme is a priority catchment for CSF, a scheme targeted at reducing diffuse pollution. Advice available from CSF officers. Capital grants available for improvements such as • fences and gates; • water facilities for grazing livestock; • management of runoff and drainage water; • tracks, bridges, tree planting adjacent to watercourses, and so on For further information contact the CSF for the Teme catchment. Details can be found at http://www.naturalengland.org.uk/ourwork/farming/csf/contacts.aspx#CSFcontacts
Environmentally Sensitive area Scheme (ESA)	The River Clun catchment had a catchment-specific ESA scheme between *** and **. The ESA scheme offered tiered financial incentives for landowners to manage land more sympathetically for landscape and biodiversity. In terms of nutrient and sediment the following prescriptions are relevant: • Tier 1a – Applies to all land. No increase in arable and fodder crops. Do not increase existing application rates of organic or inorganic fertiliser. • Tier 1b – Applies to extensive permanent grassland and rough grazing. Do not plough or reseed land. Do not apply any inorganic fertiliser, pig or poultry manure or slurry. Apply only farmyard manure produced on the farmland limit application to 12.5 tonnes/hectare. • Tier 2a. Reversion of improved grassland to extensive permanent grassland. As Tier 1b. • Tier 2b. Reversion of improved grassland to rough grazing. Do not apply farmyard manure • Tier 3a – Reversion of arable land to permanent grassland. During the first 12 months do not apply organic or inorganic fertiliser. Do not exceed an average annual stocking rate of 1.4 livestock units (LU) per hectare.

	• Additional tiers are available for managing Conservation Headlands, Woodland or public access. Supplements area available for hedgerow management and rewetting.
Water Framework Directive Funding [national funding scheme]	A funding stream targeted at improving the health of the nation's rivers, lakes and estuaries and help achieve compliance with the Water Framework Directive. This includes the Catchment Restoration Fund to civil society groups. Examples of projects currently being delivered by Natural England, the Coal Authority, the Wildlife Trusts, The Rivers Trust, Defra's Non-Native Invasive Species Secretariat and Local Action Group under this scheme include: • restoration of rivers and lakes • tackling diffuse rural pollution such as fencing water course and building cattle bridges • tackling invasive non-native species such as Himalayan balsam and signal crayfish • In the case of Natural England's projects, there is particular attention focused on water bodies within SSSIs, SACs and Natura 2000 sites. <http://www.defra.gov.uk/environment/quality/water/legislation/water-framework-directive/>
SITA/NE freshwater pearl mussel project	A three year freshwater pearl mussel conservation project starting in 2011 specifically aimed at improving the Clun SSSI/SAC. It supports farmers within the SSSI/SAC and upstream to manage pressures at the riverbank by creating riparian buffers strips, providing controlled livestock watering, planting of riverbank trees and blocking of land drains.

F.2. Delivery mechanisms

To secure the environmental outcomes required, this plan sets out the measures that could be implemented to achieve the required reductions in phosphorus concentrations and contribute towards favourable condition within the SAC. Alongside these measures, the Plan sets out potential delivery mechanisms through which the measures could be delivered.

Mechanisms (that is, the policy, legal and financial tools available through which to implement the measures) are available on a sliding scale of approaches, ranging from a soft approach such as awareness raising to change behaviours and voluntary actions / incentives, to a harder approach that uses the various legislative tools and supporting regulations to require actions of people within the catchment in order to achieve the outcomes required.

It is not appropriate to rely on a single delivery mechanism to deliver the phosphorus reductions needed to bring the SAC back to favourable condition. A mixture of policy instruments will be needed to promote a culture of best environmental practice into the future to ensure that the measures are implemented sustainably.

Some delivery mechanisms are available nationally, for example point source measures are controlled nationally through the Environment Agency's discharge consent process and measures to help control diffuse sources are available through Natural England's Entry Level Stewardship scheme. However, there is a further spatial element to the range of delivery mechanisms available; for example the Review of Consents process was focused at permitted discharges with particular emphasis on designated rivers, and on the diffuse side Catchment Sensitive Farming and Higher Level Stewardship are available in certain pockets of the countryside where there is a particular pressure or need, e.g. SAC / SSSIs. For the purposes of this plan, both the national and "local" delivery mechanisms have been considered.

There is also uncertainty over future delivery mechanisms, which may change the level of support available to implement measures for diffuse pollution. It may also change the regulatory baseline – for example any changes to the Common Agricultural Policy (CAP) through the CAP reform process.

The modelling within this plan identifies the phosphorus reductions possible from applying measures to point sources (at the significant discharging features within the Clun SAC catchment) and to diffuse sources (within the agricultural sector). The measures identified fit broadly into three categories for delivery: Advice & behaviours; Schemes & incentives; and Regulations.

F.2.1. Advice and behaviours

F.2.1.1. Natural England catchment advisers

Natural England has a series of local advisers in place on a county-basis who advise landowners and managers on various agricultural and land management related issues including biodiversity, conservation, archaeology and heritage and water protection. Part of their task is to work with farmers to identify options within environmental stewardship that could be taken up to protect any of these features.

F.2.1.2. England Catchment Sensitive Farming Delivery Initiative

The England Catchment Sensitive Farming Delivery Initiative (ECSFDI) is also funded through the Rural Development Programme for England, overseen by DEFRA, and implemented by a partnership between the Environment Agency and Natural England. Targeted to certain priority areas (which the Clun is considered to be), the ECSFDI is specifically focused on reducing diffuse pollution from agricultural practices through delivering advice to farmers and financial support for capital schemes. Advice is delivered through Catchment Sensitive Farming Officers (CSFOs) who visit famers and offer advice on the various funding mechanisms and advise on the incentives that exist to help address environmental issues arising from farming practices. http://www.naturalengland.org.uk/ourwork/farming/csf/default.aspx

F.2.1.3. Campaign for the farmed environment

The Campaign for the Farmed Environment (CFE) was originally established to encourage farmers to voluntarily mitigate the removal of compulsory set aside. Its purpose now is to encourage farmers and land managers to “protect and enhance the environmental value of farmland, through measures that sit alongside productive agriculture”. It is an advice delivery mechanism that advises farmers on measure implementation to protect soil and water whilst benefiting wildlife through a network of regional advisors. Key theme areas in which CFE promotes measures include: arable conservation management; grassland conservation management; soil management; nutrient management; and crop protection management.

http://www.cfeonline.org.uk/home/

F.2.1.4. Environmental Stewardship Training and Information Programme (ETIP)

ETIP is an advice delivery initiative implemented by Natural England to enhance the environmental performance of Entry Level Stewardship, recognising that environmental outcomes of ELS would be enhanced by spatial targeting of advice, and thereby ensuring local pressures and issues are addressed.

The ETIP programme offers farm visits on a one-to-one basis between farmer and an independent agricultural contractor (agronomist). Additionally, advice is delivered through farm walks and workshops. Through this mechanism, farmers are offered advice and encouraged to take up the correct measures relevant to local level issues and farm-type specific impacts. The ETIP contract finishes at the end of the 2013-2014 financial year so this advice will no longer be offered.

F.2.2. Schemes & incentives

F.2.2.1. Environmental Stewardship

The Environmental Stewardship Schemes (ESS) is part of the Rural Development Programme for England (RDPE). Administered by Natural England, it aims to provide support to land managers to maintain the land in a certain way that benefits the landscape, biodiversity or habitats. There are currently several levels of ESS: Entry Level Stewardship (ELS); Organic Entry Level Stewardship (OELS); Upland Entry Level Stewardship (UELS); and Higher Level Stewardship (HLS).

The current scheme particularly relevant to resource protection activities is Higher Level Stewardship which provides additional support for land management measures that are more relevant to nutrient management and water pollution, for example land management measures including: arable reversion; winter cover crops; management of maize crops to reduce soil erosion; in-field grass areas to prevent erosion and run off; 12m buffer strips on water courses; watercourse fencing; tramline management; beetle banks; livestock management; wide riparian buffer strips; and nil fertilizer supplement.

Funding is also available to cover capital items such as fencing, relocation of gates, cross-drains under farm tracks, hard base for livestock drinker and feeders, cattle drinking bays and troughs etc.

This delivery mechanism will be important to consider as it seeks to change the long term practices to those that are more suited to improving the quality and sustainability of existing wildlife habitats, whilst also creating new habitats where required. It should be noted that the current Rural Development Programme ends in December 2013 and a new environmental land management scheme (NELMS) is expected to start from January 2015 onwards.
http://www.naturalengland.org.uk/ourwork/farming/funding/default.aspx

F.2.2.2. Forestry Commission English Woodland Grant scheme

The English Woodland Grant Scheme provides financial support for establishment and maintenance of woodland schemes. Funding could be available for establishment of riparian woodland or other land-based planting schemes that serve to disrupt the pathway of sediment run off for example. Grants available are targeted at both improving existing woodland but also creating new woodland.

http://www.forestry.gov.uk/ewgs

F.2.2.3. Water Company Improvement Schemes

Water companies are increasingly turning to catchment based measures to reduce the need for traditional water treatment engineering. Many water companies are now working with land managers and farmers, either directly or through agronomists, to identify measures to protect water quality and thereby reducing the need for clean water treatment and wastewater management. Depending on the measures required, financial support is made available either through environmental stewardship or through direct water company funding.

F.2.3. Regulations

F.2.3.1. Cross compliance

In order for farmers to receive their Single Farm Payment they must demonstrate they have met some baseline standards for agriculture – "cross compliance". This comprises two key components that have to be met – Good Agricultural and Environmental Condition (GAEC) and Statutory Management Requirements (SMRs). One of the requirements of GAEC is for farmers to demonstrate that they are protecting soils and water, by:

- Producing a Soil Protection Review (a record of soil characteristics and risks and an outline of measures taken to manage these risks, with evidence of annual review)
- Not spreading fertiliser and organic manure within 2m of a water course, or to land within 1m from the top of the bank of a water course
- Avoiding leaving recently cropped or harvested land in a state that risks run-off over winter
- Considering erosion and run off risk when leaving uncultivated stubbles in fields.

F.2.3.2. Codes of Good Agricultural Practice (COGAP)

COGAP is essentially a guidance document to help farmers protect the environment with respect to soil, air and water pollution. It sets out management activities and behaviours to help control phosphorus losses from farm activities, including farm scale soil, nutrient and manure management plans; considering phosphorus levels in feed against the animal's requirements. Through these plans and measures, the codes help control the water pollution impacts of farm practices and run-off.

The COGAP, although a guidance document, are driven by a regulatory angle in that parts form a Statutory Code under Section 97 of the Water Resources Act 1991. It is therefore important that farmers are aware of this Code.

F.2.3.3. Anti-pollution works notices

Anti-pollution works notices can be issued by the Environment Agency under Section 161 of the Water Resources Act 1991 for incidences of soil pollution, and therefore in this way can contribute towards helping with phosphorus pollution issues. They are not an appropriate regulatory tool to control phosphorus application and usage.

F.2.3.4. Safeguard Zones & Water Protection Zones

IF a drinking water is at risk, with high confidence, then a Safeguard zone will be designated. This is a non-statutory tool but identifies where the EA and key stakeholders such as the water companies, will work with landowners and managers to encourage the voluntary uptake of catchment management measures to reduce pollutants in the drinking water. If this approach is not successful, or if the environmental outcomes envisaged are not realised, then a Water Protection Zone could be pursued. A WPZ is a statutory designation and allows the banning of certain substances and activities within that zone, enforced by the Secretary of State.

F.2.3.5. Nitrate Vulnerable Zones

Nitrate Vulnerable Zones (NVZs) are a regulatory tool that places requirements on farmers to take additional measures to protect air, soil and water from nitrates, including:

- Plans for the use of nitrogen fertiliser and livestock manure
- Risk maps for areas to which manure is to be spread
- Compliance with field limits, crop nitrogen requirement limits, closed periods and spreading controls for manufactured nitrogen fertilisers and organic manures
- Compliance with livestock manure N (nitrogen) farm limit
- Adequate storage capacity for livestock manures
- Records of the nitrogen applied to fields and whole farms.

Although NVZ regulations are targeted towards nitrates, some of the measures contained within the regulations will assist in controlling agricultural phosphate losses too.

F.2.4. Additional funding and delivery mechanisms

F.2.4.1. Water Framework Directive Improvement Fund

In April 2011, the Secretary of State announced the allocation of £92 million over four years with the specific objective to improve the health of our rivers, lakes and estuaries by addressing water quality issues, removing barriers to fish migration and removing invasive non-native species to help achieve Water Framework Directive objectives. This money will be allocated to projects that contribute towards WFD outcomes and are implemented between 2011 and 2015. Projects considered for funding include those that: remove invasive non-native species; clear up pollution; and remove barriers to fish migration.

F.2.4.2. Catchment Restoration Fund

£28m of funding has been allocated by DEFRA over three years (from 2012/13) to the Catchment Restoration Fund (CRF) to civil society groups for implementation of water body improvement projects. These projects will contribute to bringing water bodies to Good Status and are over and above measures in River Basin Management Plans.

http://www.defra.gov.uk/environment/quality/water/legislation/water-framework-directive/

The CRF opens up the funding to bids from third sector organisations in the hope to encourage businesses, local authorities and community groups to join forces with charitable organisations in order to secure funding for improvement ideas on rivers. The CRF is currently closed to bids for 2013- see http://www.environment-agency.gov.uk/research/planning/136182.aspx for the latest information on the fund.

F.2.4.3. Planning Control and Developers Contributions

Section 106 of the Town and Country Planning Act (1990) requires developers seeking planning permission to incorporate within their proposals supplementary plans that help meet the needs of the community by securing contributions towards community infrastructure. This includes financial contributions to community facilities such as open spaces, which can include urban green spaces and riparian land.

This mechanism could be used to deliver some pathway disruption techniques and enhancements along river corridors.

F.2.4.4. European Funding

The European Commission fund a number of other large scale programmes, including: LIFE+; Regional Convergence; Competitiveness and Cooperation (including INTERREG); and Framework Programme.

http://ec.europa.eu/environment/funding/intro_en.htm

Funding is available through the European Regional Development Fund (ERDF) for Water Management projects that: Improve the quality of water supply and treatment, including cooperation in the field of water management; Support integrated, sustainable and participatory approaches to management of inland and marine waters, including waterway infrastructure; and adapting to climate change effects related to water management.

F.2.4.5. Natural England SSSI Funding

A small amount of money is available each year from Natural England for works within SSSIs. This includes funding through the Conservation and Enhancement Scheme which affords discretionary payments to fund costs of specific management to deliver favourable condition of the nature conservation interest on land of outstanding scientific interest. The mechanism can fund both capital works and management programmes (over a five year agreement period). This is a useful fund to consider where other sources of funding are not available e.g. outside HLS areas but it is important to note that 50% match funding is required for public bodies and some organisations.

http://www.naturalengland.org.uk/grantsfunding/findagrant/conservationandenhancementscheme.aspx

Appendix G. Environment Agency water quality sampling in the Clun catchment

G.1. Catalogue

Water body Reference	SMPT_REF	SMPT_SNAME	EASTING	NORTHING	STATUS	LST_SAMPLD	TYPE	REGION	OP	SS
GB109054043980	20356950	NEWCASTLE STW FE (NEW)	325290	282040	Open	18/06/2012	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - WATER COMPANY	MI	Yes	Yes
GB109054043980	20357100	R.CLUN AT NEWCASTLE B4368 BRIDGE	324900	282000	Open	03/12/2012	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	No
GB109054043980	21083210	BRYN Y CAGLEY HALL CLUN STP FE	327440	282790	Open	12/09/1995	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043980	21119900	NEWCASTLE STW FE (OLD)	324980	282260	Closed	02/06/1995	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - WATER COMPANY	MI	No	Yes
GB109054044000	20357445	CLUN DS OF THE GARN	323920	281916	Open	09/05/2012	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	Yes
GB109054044000	20359560	AMBLECOTE COTTAGES CLUN STP FE	318380	284900	Open	08/04/1997	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054044000	20359970	ANCHORAGE & 2 MOBILE HOMES STP, FE	317630	284920	Open	16/02/2011	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20349700	R.CLUN CONFLUENCE WITH R.TEME	339984	274050	Open	03/12/2012	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	Yes
GB109054043990	20350160	CLUNGUNFORD BOREHOLE FINAL (NEW)	339200	278500	Open	03/04/1992	GROUNDWATER - COMPOSITE	MI	No data provided	No data provided
GB109054043990	20350170	CLUNGUNFORD BOREHOLE NUMBER 2 RAW	339200	278501	Open	15/11/2007	GROUNDWATER - BOREHOLE	MI	No data provided	No data provided
GB109054043990	20350190	BIRD ON THE ROCK TEA ROOMS STP, TE FE	339370	278550	Open	22/04/2005	SEWAGE & TRADE COMBINED - UNSPECIFIED	MI	No data provided	No data provided
GB109054043990	20350210	4,5,6 CHURCH VIEW COTTAGES STP FE	339380	278550	Open		SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20350220	CHURCH VIEW STP CLUNGUNFORD STP FE	339400	278600	Open	15/12/2006	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20350230	4 PROPOSED PROPERTIES STP, ABCOTT BRN,FE	339000	278590	Open	10/08/2001	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20350240	ABCOTT MANOR CLUNGUNFORD STP FE	339320	278700	Open	22/05/1998	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20350340	1-4 COUNCIL HOUSES CLUNGUNFORD STP FE	339780	278740	Open		SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20350390	FIVE NEW PROPERTIES AT NORTH YARD,STP FE	339450	278980	Open	22/04/2005	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20350480	UPPER GUNNAS CLOSE CLUNGUNFORD STP FE	339650	279170	Open	22/08/2007	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20350960	QUARRY HOUSE ASTON ON CLUN STP FE	339350	280400	Open	14/12/1995	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20351630	R.CLUN AT BEAMBRIDGE	338819	281355	Open	15/12/2008	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	Yes
GB109054043990	20351890	B/H AT OAKER, ASTON-ON-CLUN, X03/08	338430	281600	Open	31/07/2012	GROUNDWATER - BOREHOLE	MI	No data provided	No data provided
GB109054043990	20352760	CLUNBURY STW, FE	337340	280730	Open	06/09/2010	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - WATER COMPANY	MI	No relevant data	No relevant data
GB109054043990	20352905	CLUN AT CLUNBURY	337077	280743	Open	24/02/2009	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	No	No

Water body Reference	SMPT_REF	SMPT_SNAME	EASTING	NORTHING	STATUS	LST_SAMPLD	TYPE	REGION	OP	SS
GB109054043990	20353050	COUNCILS HOUSES AT CLUNBURY STP FE	336900	280500	Open	19/12/2005	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20353500	R.CLUN AT B4385 BRIDGE PURSLOW	336000	280500	Open	08/01/2013	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	Yes
GB109054043990	20354180	CLUNTON STP FE	333600	281200	Open	Last sample	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20354190	R.CLUN AT CLUNTON	333490	281210	Open	31/01/1997	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	No	Yes
GB109054043990	20355020	CLUN STW, FE	330920	280980	Open	26/07/2012	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - WATER COMPANY	MI	Yes	Yes
GB109054043990	20355025	CLUN STW, STORM SEWAGE	330880	280970	Open	24/01/1988	SEWAGE DISCHARGES - SEWER STORM OVERFLOW - WATER COMPANY	MI	No	No
GB109054043990	20355250	R.CLUN CARPARK FOOTBRIDGE US A488 BRIDGE	329938	280791	Open	03/12/2012	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	Yes
GB109054043990	20380040	HOPTON CASTLE STP FE	336700	278000	Open	22/05/1998	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20380060	LAND AT 15 HOPTON CASTLE STP FE	336380	278160	Open		SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20380090	13 & 14 HOPTON CASTLE STP FE	336420	278510	Open		SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20591060	CLUNGUNFORD BOREHOLE FINAL (OLD)	339500	278600	Open	09/11/1989	GROUNDWATER - COMPOSITE	MI	No data provided	No data provided
GB109054043990	20591065	CLUNGFORD BOREHOLE NUMBER 1 RAW	339500	278601	Open	09/03/1995	GROUNDWATER - BOREHOLE	MI	No data provided	No data provided
GB109054043990	20591070	CLUNGUNFORD B/H NO.3 RAW	339500	278700	Open	15/11/2007	GROUNDWATER - BOREHOLE	MI	No data provided	No data provided
GB109054043990	20591150	5 PROPERTIES STP, CHAPEL ROAD, FE	339790	278810	Open	09/08/2010	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20591170	4 CANAL COTTAGES STP FE	339810	278730	Closed		SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20591180	CHAPEL ROAD CLUNGUNFORD STP FE	339800	278600	Open	10/11/2010	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20606360	BROOME FARM DEVELOPMENTS BROOME STP FE	340080	280840	Open	01/11/2011	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20606370	BARNS AT BROOME FARM BROOME STP FE	339980	280880	Open	30/10/2000	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20626190	ASTON ON CLUN STW FINAL EFFLUENT	339180	281420	Open	27/07/2012	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - WATER COMPANY	MI	Yes	Yes
GB109054043990	20626240	ASTON HALL STP FE	339200	281700	Closed	21/11/1994	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20626260	BROOKFIELD COTTAGES ASTON ON CLUN STP FE	339250	281750	Closed	21/11/1994	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20626270	ASTON BROOK ASTON ON CLUN	339300	281700	Open	10/01/1992	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	No	No
GB109054043990	20626280	BROOME ROAD STP FE	339300	281800	Open		SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided

Water body Reference	SMPT_REF	SMPT_SNAME	EASTING	NORTHING	STATUS	LST_SAMPLD	TYPE	REGION	OP	SS
GB109054043990	20626300	HOPESAY SCHOOL ASTON-ON-CLUN STP FE	339200	282000	Open	14/03/1991	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20626345	HOPESAY BROOK AT FOOTBRIDGE	339116	282436	Open	24/02/2009	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	No	No
GB109054043990	20626930	RECTORY COTTAGE STP, FE	338950	283340	Open	23/03/2005	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20626990	DEWLINGS AT OLD BARNS HOPESAY STP FE	339170	283340	Open	11/03/1998	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20855040	THE CROWN INN STP, FE	333480	281320	Open	19/04/2005	SEWAGE & TRADE COMBINED - UNSPECIFIED	MI	No data provided	No data provided
GB109054043990	20855050	BROOK COTTAGE STP, CLUNTON, FE	333500	281400	Open	19/04/2005	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043990	20905250	10 CHURCH BANK CLUN STP FE	330020	280390	Open	30/11/1995	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No data provided	No data provided
GB109054043950	20367420	R.REDLAKE AT JAY	338900	274800	Open	12/12/2012	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	Yes
GB109054043950	20368150	BUCKNELL STW, FE	336170	274470	Open	27/07/2012	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - WATER COMPANY	MI	Yes	Yes
GB109054043950	20368510	BUCKNELL PUMPING STATION OVERFLOW	335850	273870	Open	-	SEWAGE DISCHARGES - SEWER STORM OVERFLOW - WATER COMPANY	MI	no relevant data	no relevant data
GB109054043950	20368515	BUCKNELL PUMING STATION EMERGENCY OF	335850	273870	Open	-	SEWAGE DISCHARGES - PUMPING STATION - WATER COMPANY	MI	no relevant data	no relevant data
GB109054043950	20368540	R.REDLAKE AT BUCKNELL BRIDGE	335700	273800	Open	04/12/1997	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	No	Yes
GB109054043950	20369430	R.REDLAKE AT CHAPLE LAWN	331820	276260	Open	31/10/1997	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	No	no relevant data
GB109054043950	20369480	QUINCE COTTAGE STP FE, CHAPEL LAWN	331560	276320	Open	19/04/2005	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No records provided	No records provided
GB109054043950	20369500	CHAPEL LAWN STP FE	331500	276400	Open	11/12/1995	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No records provided	No records provided
GB109054043950	20370020	R.REDLAKE NEW INVENTION	329400	276700	Open	10/08/1982	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	No	Yes
GB109054043950	20443290	NO 4 MERCEL COTTAGES STP, FE	337170	275060	Open	01/02/2006	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No records provided	No records provided
GB109054043950	20443300	NO 7 MERCEL COTTAGES STP, FE	337160	275080	Open	19/11/2002	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No records provided	No records provided
GB109054043950	20465500	ENGLISH COTTAGE OBLEY STP FE	333000	277660	Open	22/05/1998	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No records provided	No records provided
GB109054043950	20367190	JAY FISH FARM EFFLUENT	339220	274890	Closed	17/11/1994	AGRICULTURE - FISH FARMING - NOT WATER COMPANY	MI	No records provided	No records provided
GB109054044020	21133110	FOLLY BROOK B4368 NEWCASTLE ON CLUN	324560	282280	Open	03/12/2012	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	No
GB109054044020	21133160	NEWCASTLE BOREHOLE RAW	324500	282300	Open	21/04/1986	GROUNDWATER - BOREHOLE	MI	No records provided	No records provided
GB109054044040	20912450	R.UNK AT BICTON	328900	282300	Open	11/11/1998	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	No	Yes
GB109054044040	20912455	R.UNK AT THE MINOR ROAD BRIDGE AT BICTON	328960	282310	Open	03/12/2012	FRESHWATER - UNSPECIFIED	MI	Yes	No
GB109054044060	20669300	R.KEMP AT PURSLOW NEW BRIDGE	336400	281100	Open	08/01/2013	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	Yes

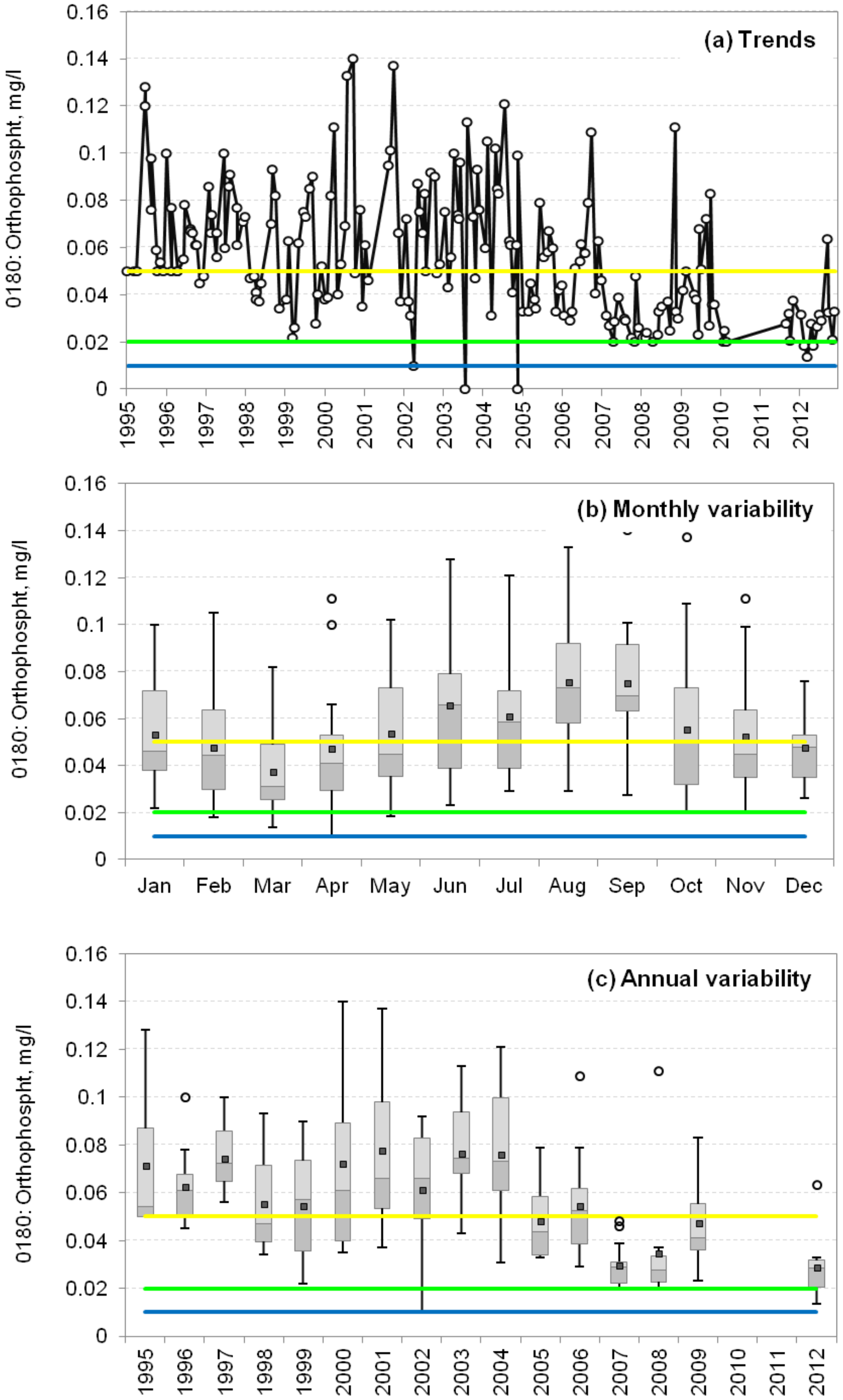
Water body Reference	SMPT_REF	SMPT_SNAME	EASTING	NORTHING	STATUS	LST_SAMPLD	TYPE	REGION	OP	SS
GB109054044060	20669390	FORD COTTAGE STP, KEMPTON, FE	335880	283130	Open	06/12/2002	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No records provided	No records provided
GB109054044060	20670890	DOMESTIC PROPERTY AT 9 BROCKTON STP FE	332810	285760	Open	19/10/2007	SEWAGE DISCHARGES - FINAL/TREATED EFFLUENT - NOT WATER COMPANY	MI	No records provided	No records provided
GB109054044060	20670900	R.KEMP AT BROCKTON	332700	285800	Open	27/11/2012	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	Yes
GB109054044060	20671050	R.KEMP AT ACTON (BIO SP PT)	332400	286300	Open	24/05/1994	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	No relevant data	No relevant data
GB109054044060	20671100	R.KEMP AT MINOR ROAD BRIDGE	332410	286928	Open	09/01/2013	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	Yes
GB109054044060	20671405	R.KEMP AT COLEBATCH BRIDGE A488	332000	287350	Open	09/01/2013	FRESHWATER - NON CLASSIFIED RIVER POINTS	MI	Yes	Yes

G.2. Best data records

Water body Reference	SMPT_REF	SMPT_SNAME	EASTING	NORTHING	STATUS	LST_SAMPLD	OP	SS
GB109054043980	20357100	R.CLUN AT NEWCASTLE B4368 BRIDGE	324900	282000	Open	03/12/2012	Yes	No
GB109054044000	20357445	CLUN DS OF THE GARN	323920	281916	Open	09/05/2012	Yes	Yes
GB109054043990	20349700	R.CLUN CONFLUENCE WITH R.TEME	339984	274050	Open	03/12/2012	Yes	Yes
GB109054043990	20351630	R.CLUN AT BEAMBRIDGE	338819	281355	Open	15/12/2008	Yes	Yes
GB109054043990	20352905	CLUN AT CLUNBURY	337077	280743	Open	24/02/2009	No	No
GB109054043990	20353500	R.CLUN AT B4385 BRIDGE PURSLOW	336000	280500	Open	08/01/2013	Yes	Yes
GB109054043990	20354190	R.CLUN AT CLUNTON	333490	281210	Open	31/01/1997	No	Yes
GB109054043990	20355250	R.CLUN CARPARK FOOTBRIDGE US A488 BRIDGE	329938	280791	Open	03/12/2012	Yes	Yes
GB109054043990	20626270	ASTON BROOK ASTON ON CLUN	339300	281700	Open	10/01/1992	No	No
GB109054043990	20626345	HOPESAY BROOK AT FOOTBRIDGE	339116	282436	Open	24/02/2009	No	No
GB109054043950	20367420	R.REDLAKE AT JAY	338900	274800	Open	12/12/2012	Yes	Yes
GB109054043950	20368540	R.REDLAKE AT BUCKNELL BRIDGE	335700	273800	Open	04/12/1997	No	Yes
GB109054043950	20369430	R.REDLAKE AT CHAPLE LAWN	331820	276260	Open	31/10/1997	No	no relevant data
GB109054043950	20370020	R.REDLAKE NEW INVENTION	329400	276700	Open	10/08/1982	No	Yes
GB109054044020	21133110	FOLLY BROOK B4368 NEWCASTLE ON CLUN	324560	282280	Open	03/12/2012	Yes	No
GB109054044040	20912450	R.UNK AT BICTON	328900	282300	Open	11/11/1998	No	Yes
GB109054044040	20912455	R.UNK AT THE MINOR ROAD BRIDGE AT BICTON	328960	282310	Open	03/12/2012	Yes	No
GB109054044060	20669300	R.KEMP AT PURSLOW NEW BRIDGE	336400	281100	Open	08/01/2013	Yes	Yes
GB109054044060	20670900	R.KEMP AT BROCKTON	332700	285800	Open	27/11/2012	Yes	Yes
GB109054044060	20671050	R.KEMP AT ACTON (BIO SP PT)	332400	286300	Open	24/05/1994	No relevant data	No relevant data
GB109054044060	20671100	R.KEMP AT MINOR ROAD BRIDGE	332410	286928	Open	09/01/2013	Yes	Yes
GB109054044060	20671405	R.KEMP AT COLEBATCH BRIDGE A488	332000	287350	Open	09/01/2013	Yes	Yes

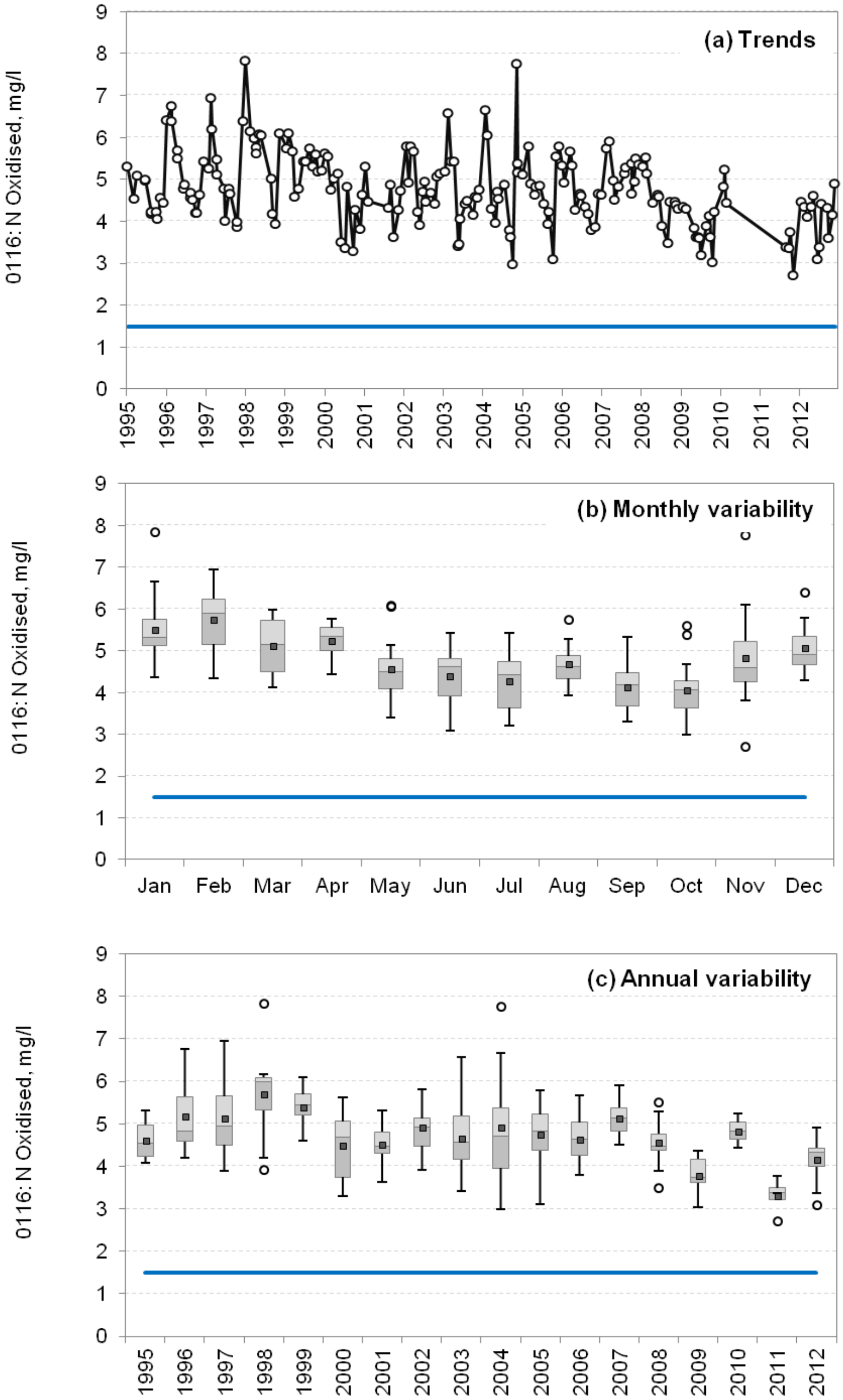
G.3. Complete records for the River Clun SAC at Leintwardine

G.3.1. Phosphate



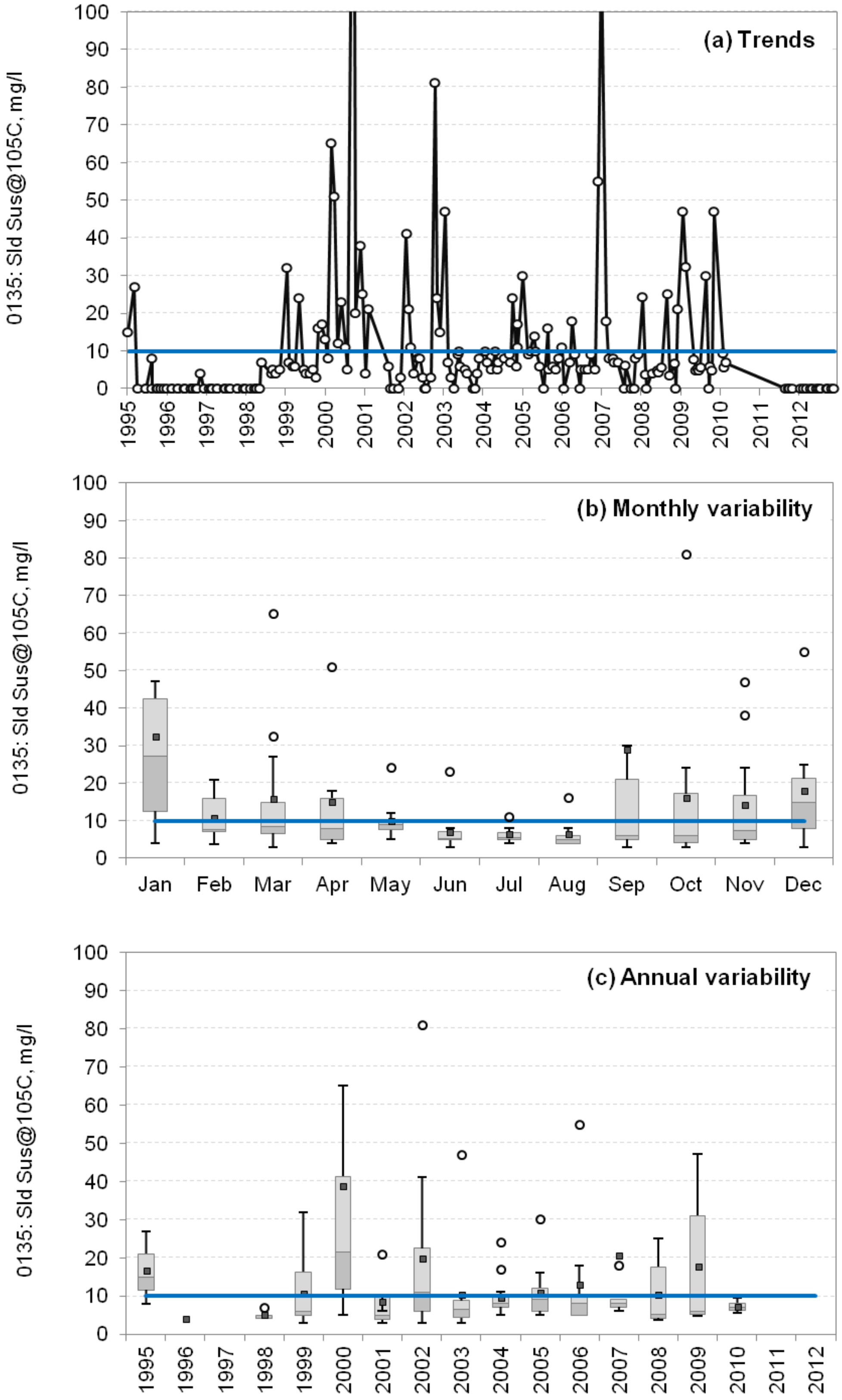
The boxes represent the inter-quartile range and the midline of the box the median. The black circles represent outliers. Whiskers represent the maximum and minimum values falling within the range Q1-IQR*1.5 to Q3+IQR*1.5. The pale blue line is the long term favourable condition target. The green line is the short term favourable condition target. The yellow line is the boundary between WFD Good and Moderate classes that the Environment Agency is working towards as part of the WFD. (Source of data: Environment Agency).

G.3.2. Nitrogen



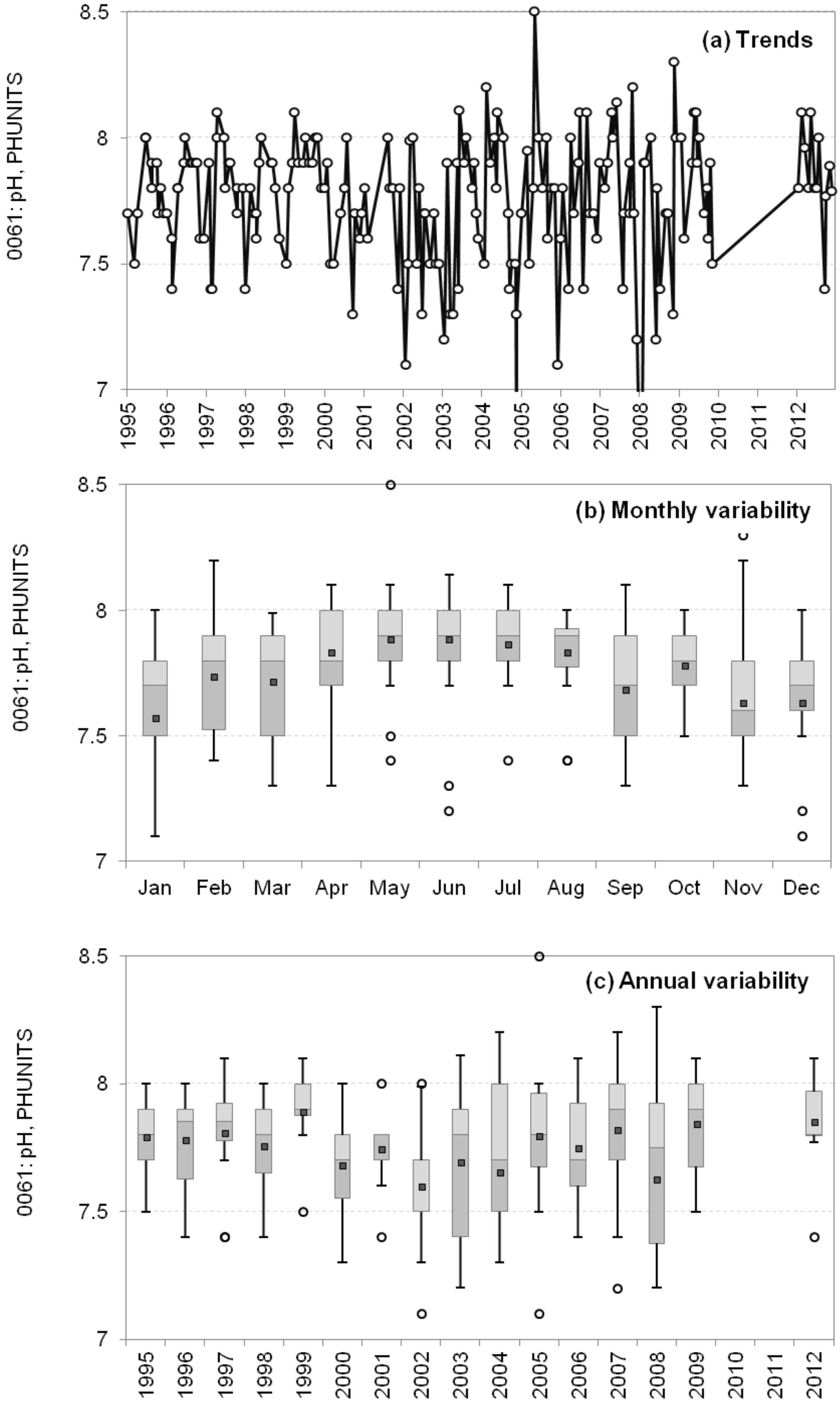
The boxes represent the inter-quartile range and the midline of the box the median. The black circles represent outliers. Whiskers represent the maximum and minimum values falling within the range Q1-IQR*1.5 to Q3+IQR*1.5. The pale blue line is the long term favourable condition target (Source of data: Environment Agency).

G.3.3. Suspended solids



The boxes represent the inter-quartile range and the midline of the box the median. The black circles represent outliers. Whiskers represent the maximum and minimum values falling within the range Q1-IQR*1.5 to Q3+IQR*1.5. The pale blue line is the long term favourable condition target (Source of data: Environment Agency).

G.3.4. pH

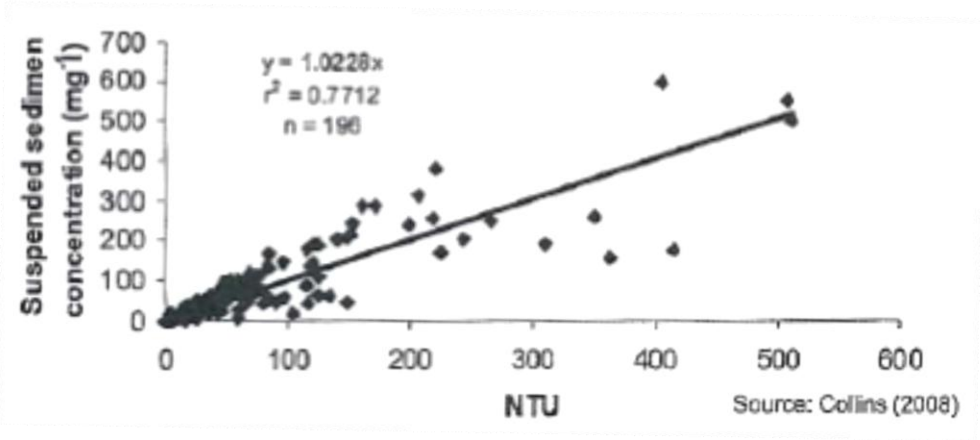


The boxes represent the inter-quartile range and the midline of the box the median. The black circles represent outliers. Whiskers represent the maximum and minimum values falling within the range Q1-IQR*1.5 to Q3+IQR*1.5. The pale blue line is the long term favourable condition target (Source of data: Environment Agency).

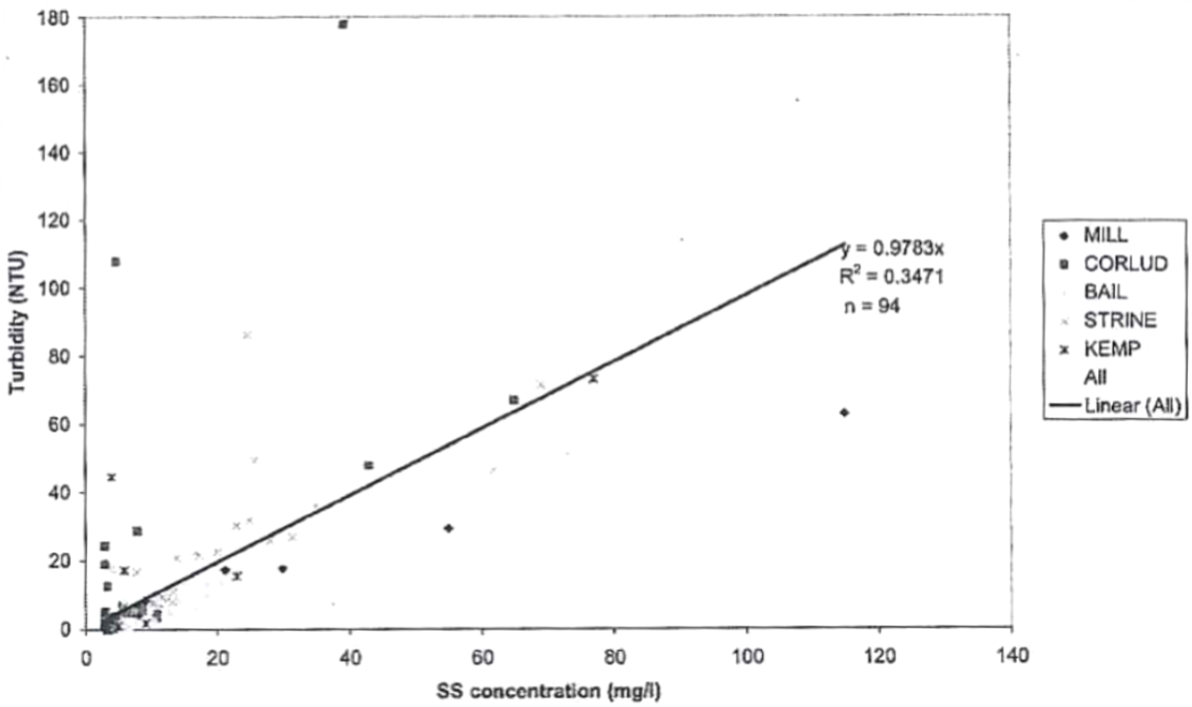
Appendix H. Turbidity data

H.1. Picture of a turbidity sonde similar to that used by the EA

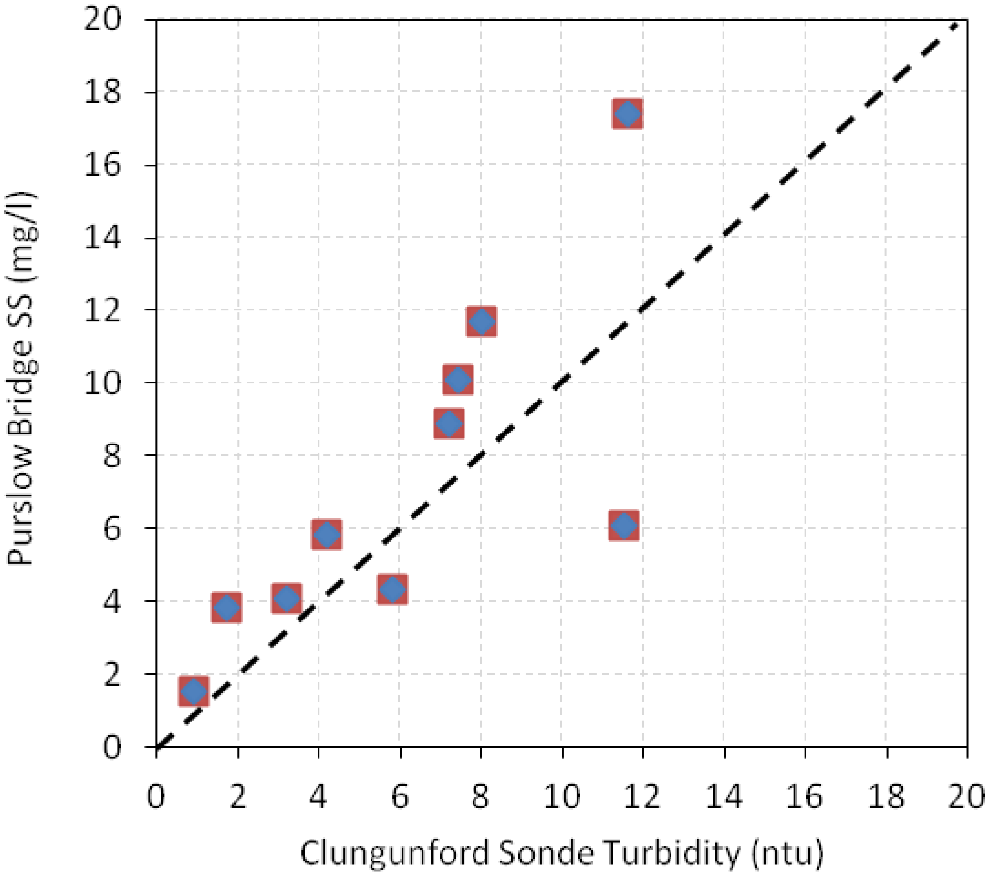
H.2. Suspended solids and turbidity relationship for the River Frome (Collins, 2008)



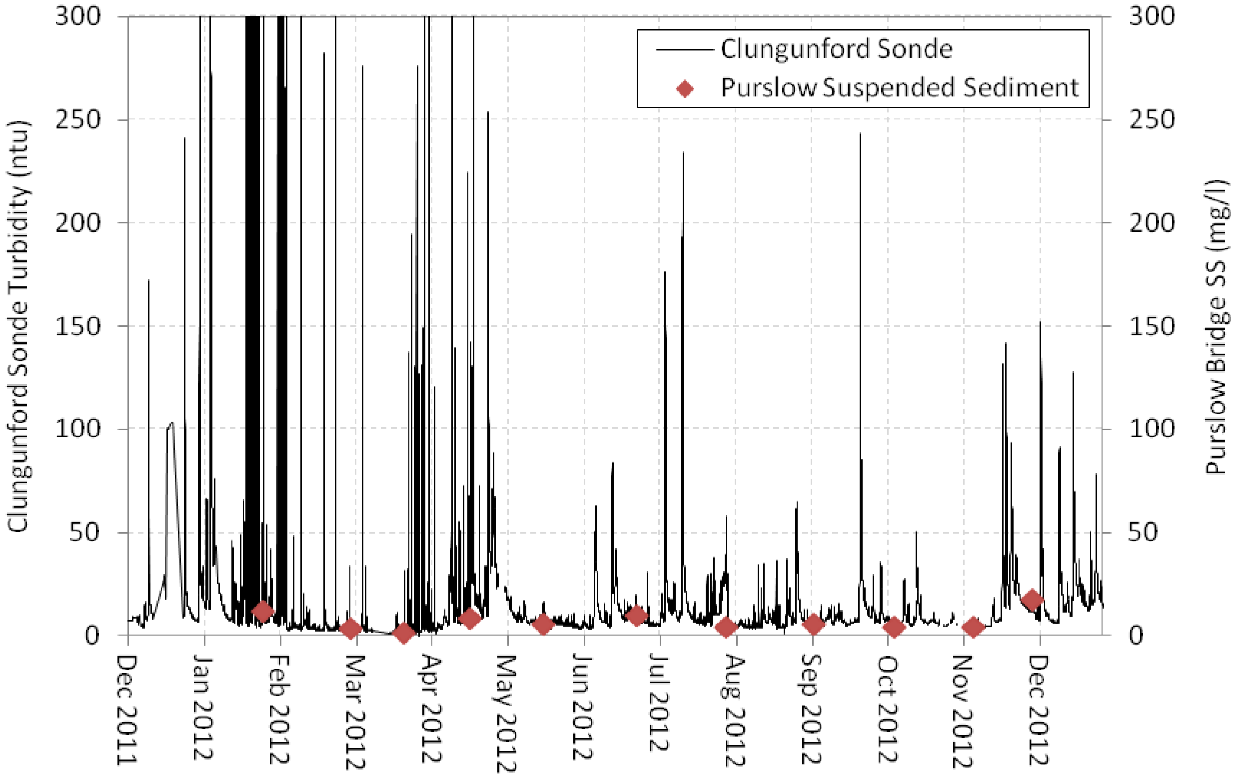
H.3. Suspended solids and turbidity relationship for sites in the River Teme, including MILL Lane at Leintwardine in the River Clun catchment (WRC, 2010)



H.4. SS vs turbidity (Clungunford and Purslow)

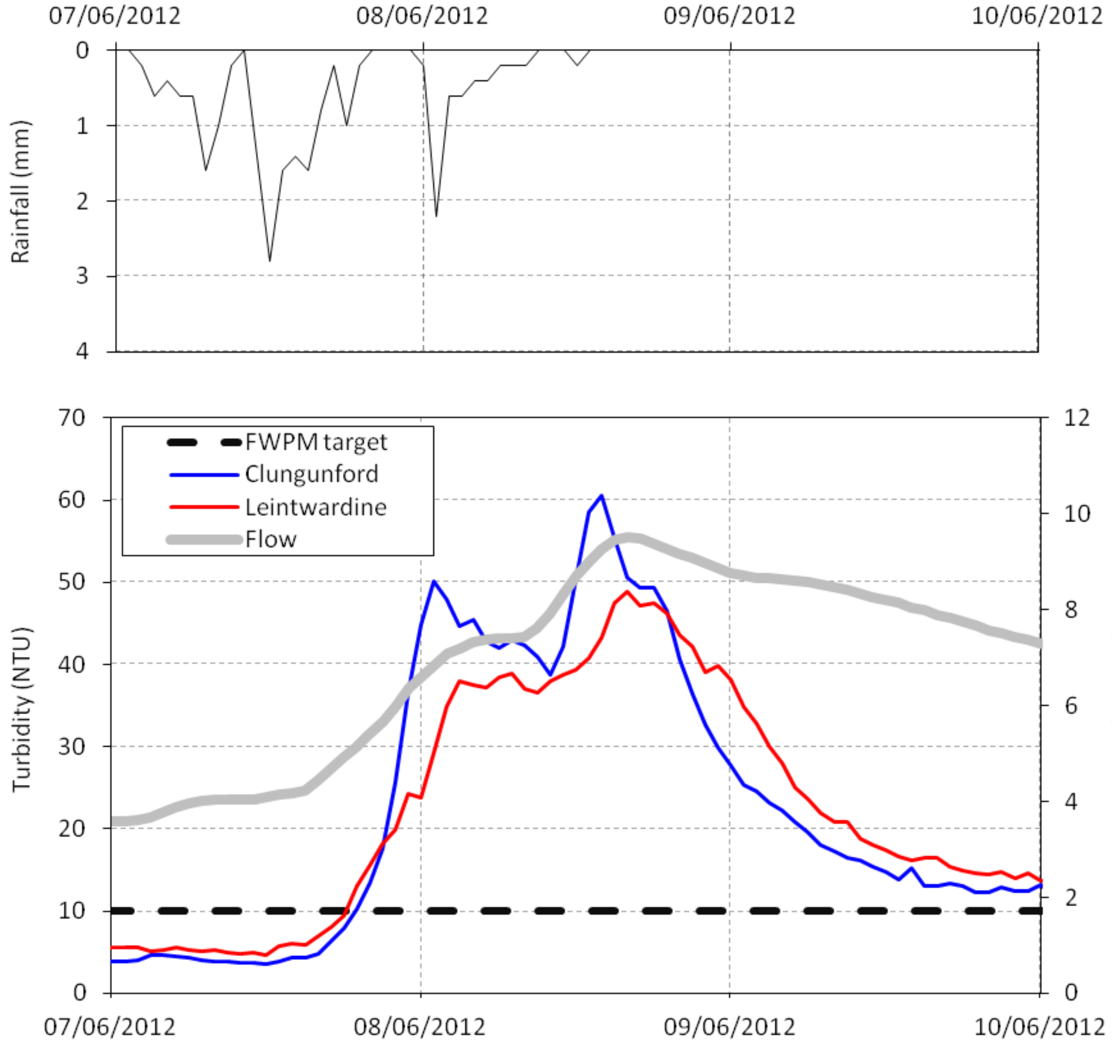


H.5. Spot samples vs continuous turbidity monitoring

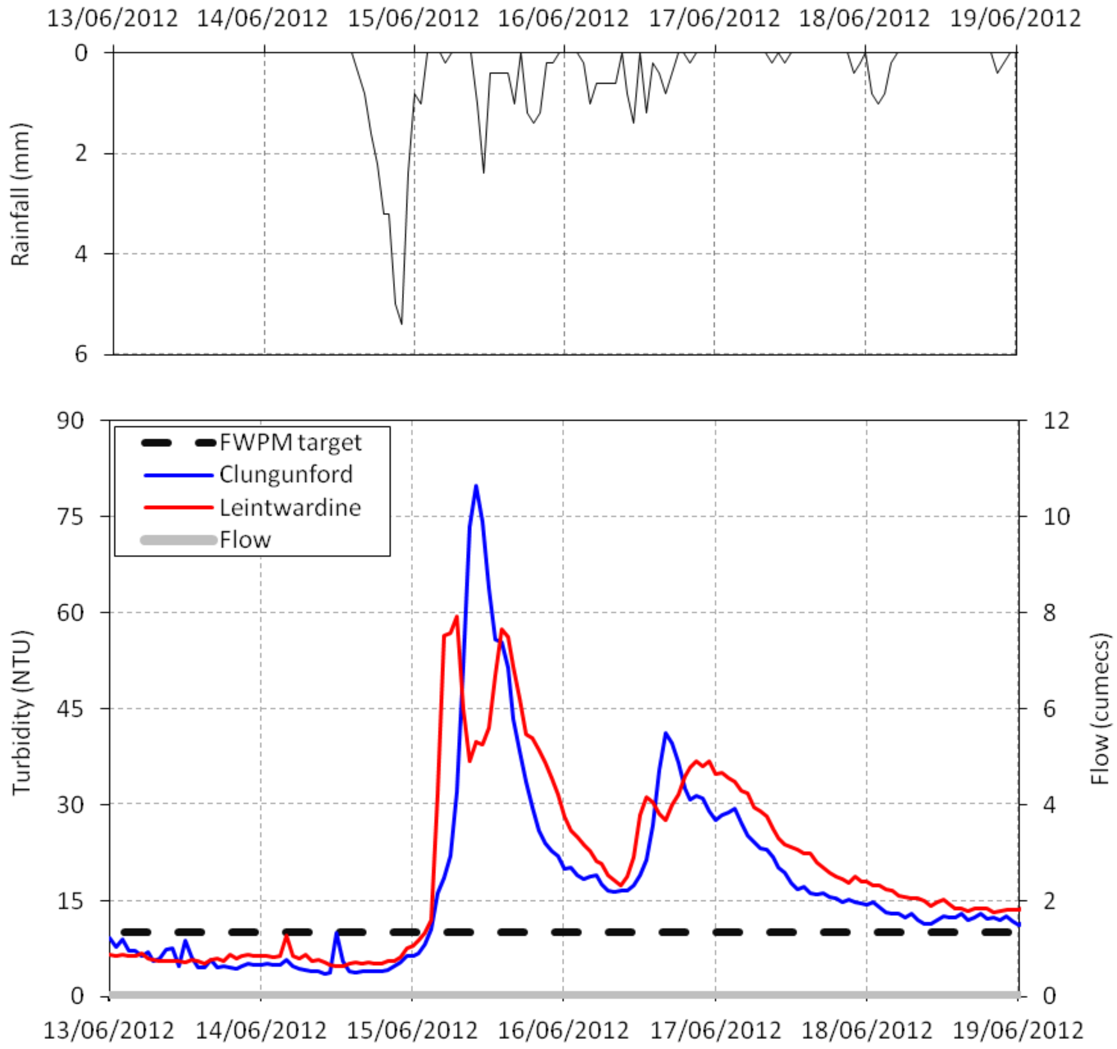


Appendix I. Turbidity events

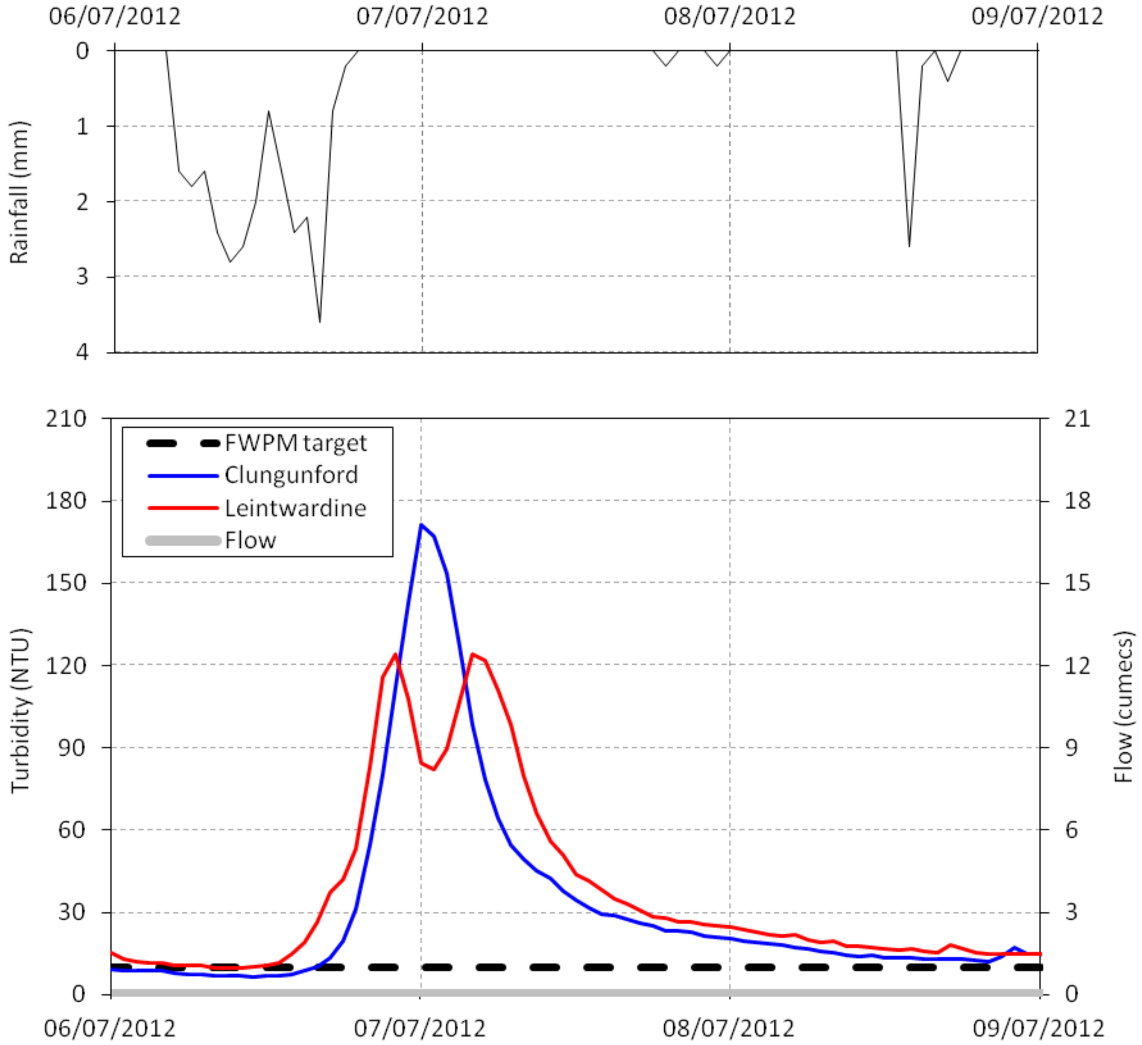
I.1. 8th June 2012



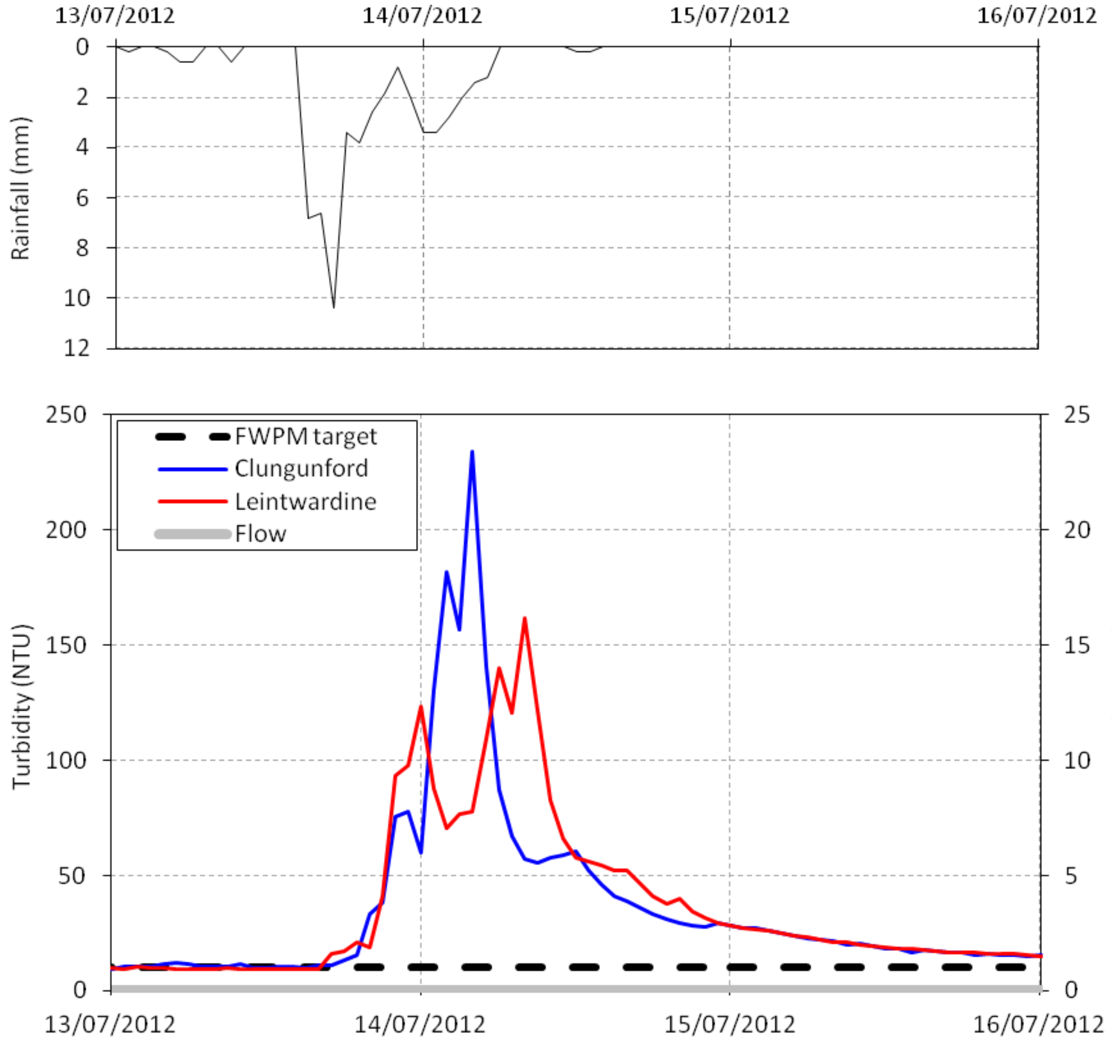
I.2. 15 June 2012



I.3. 7th July 2012



I.4. 14th July 2012



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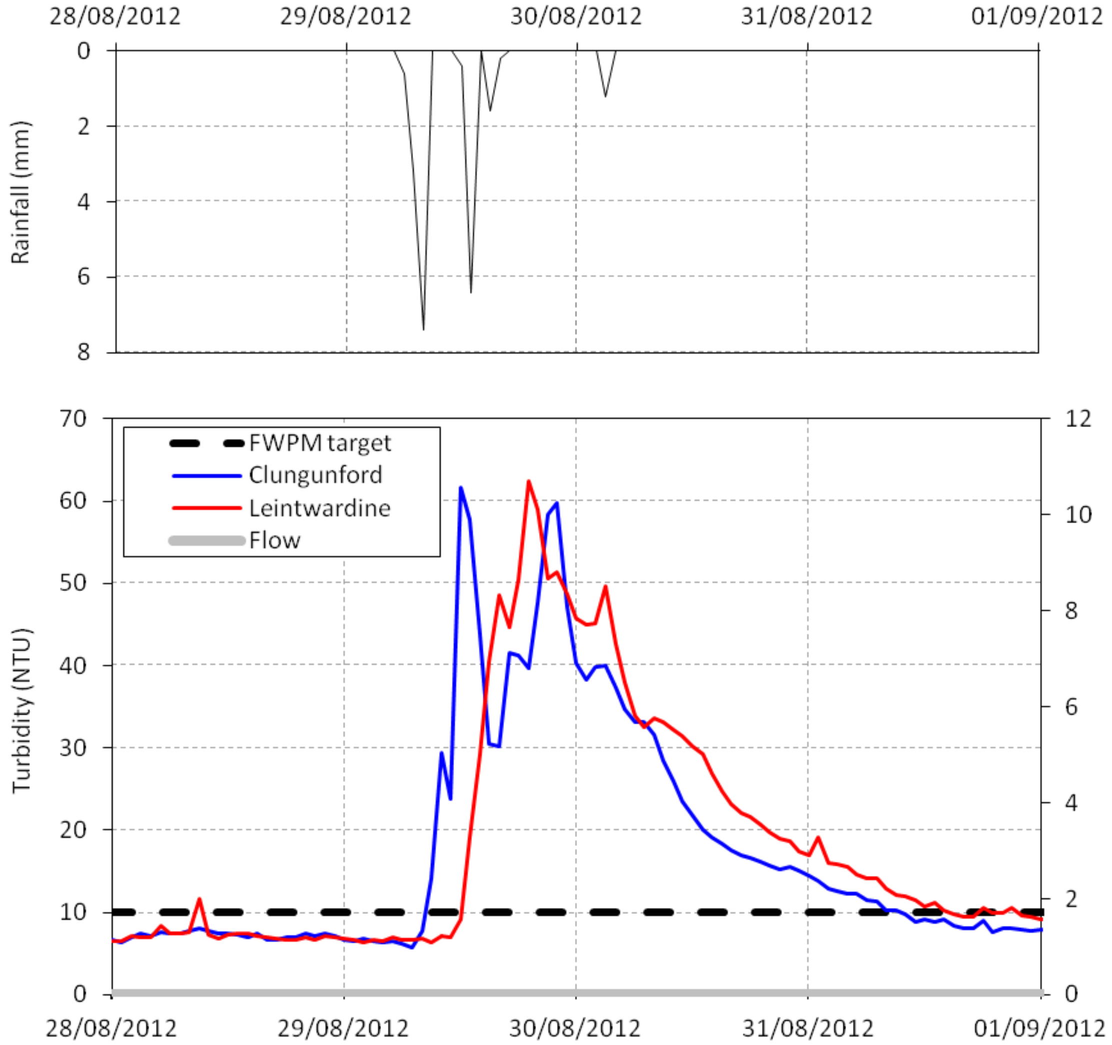
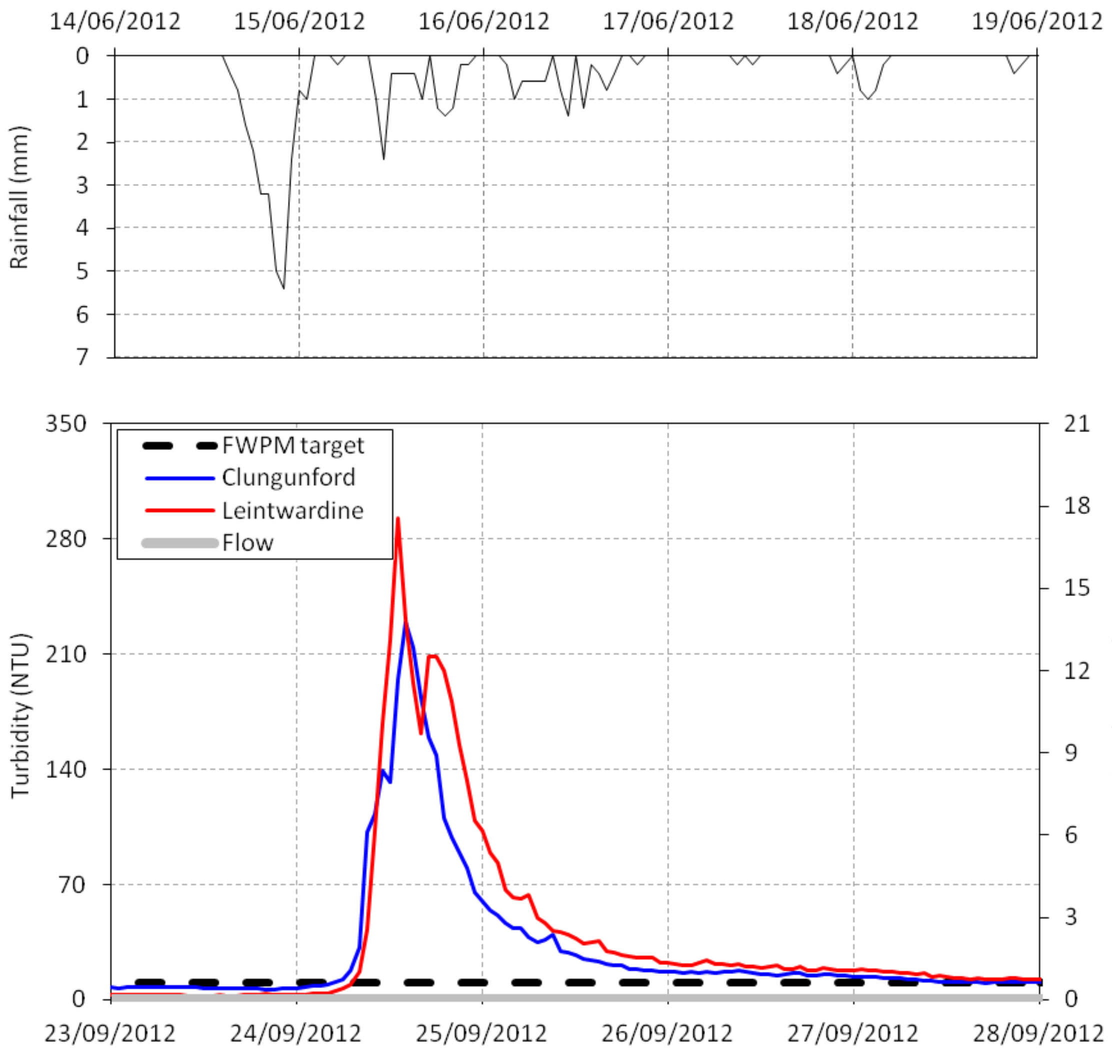
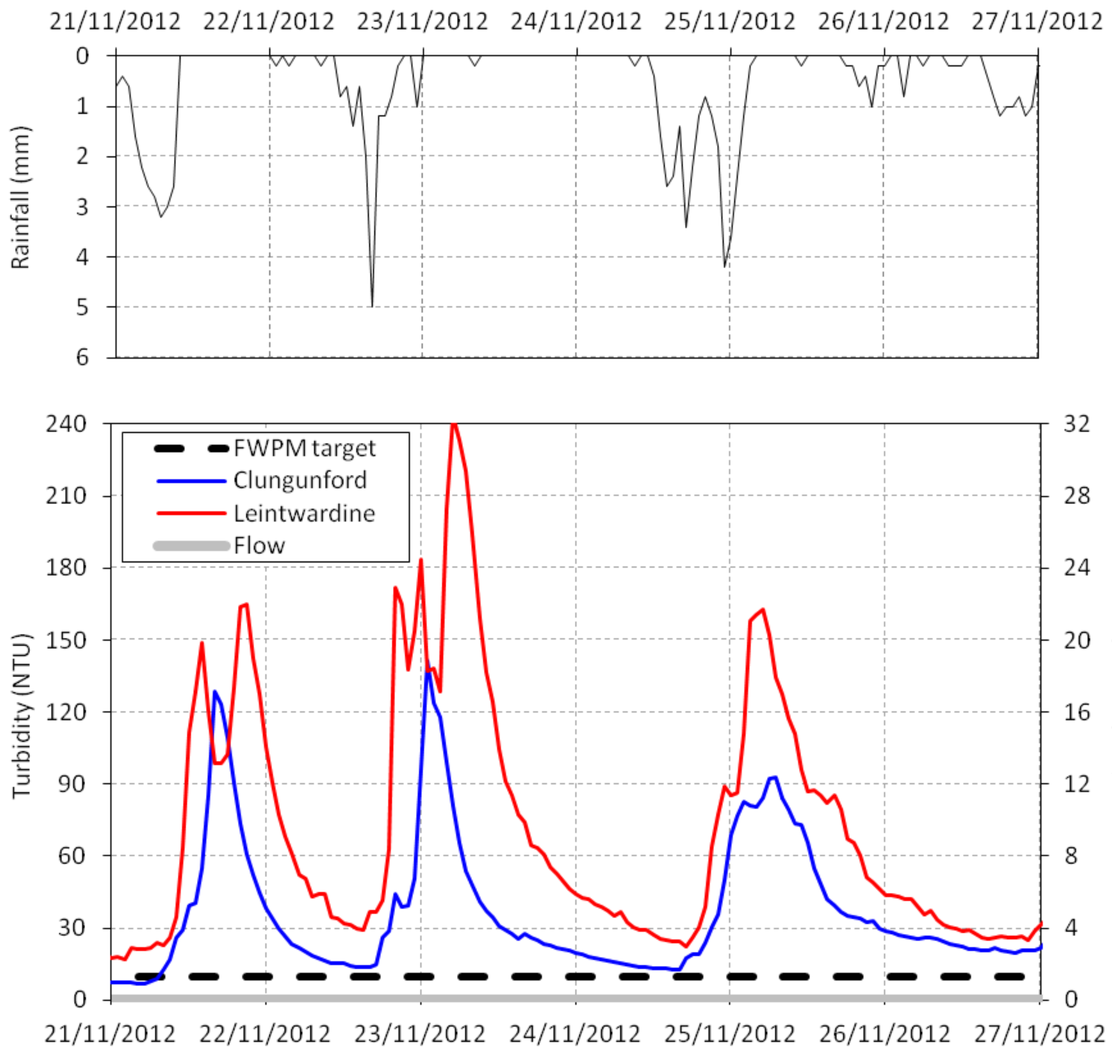


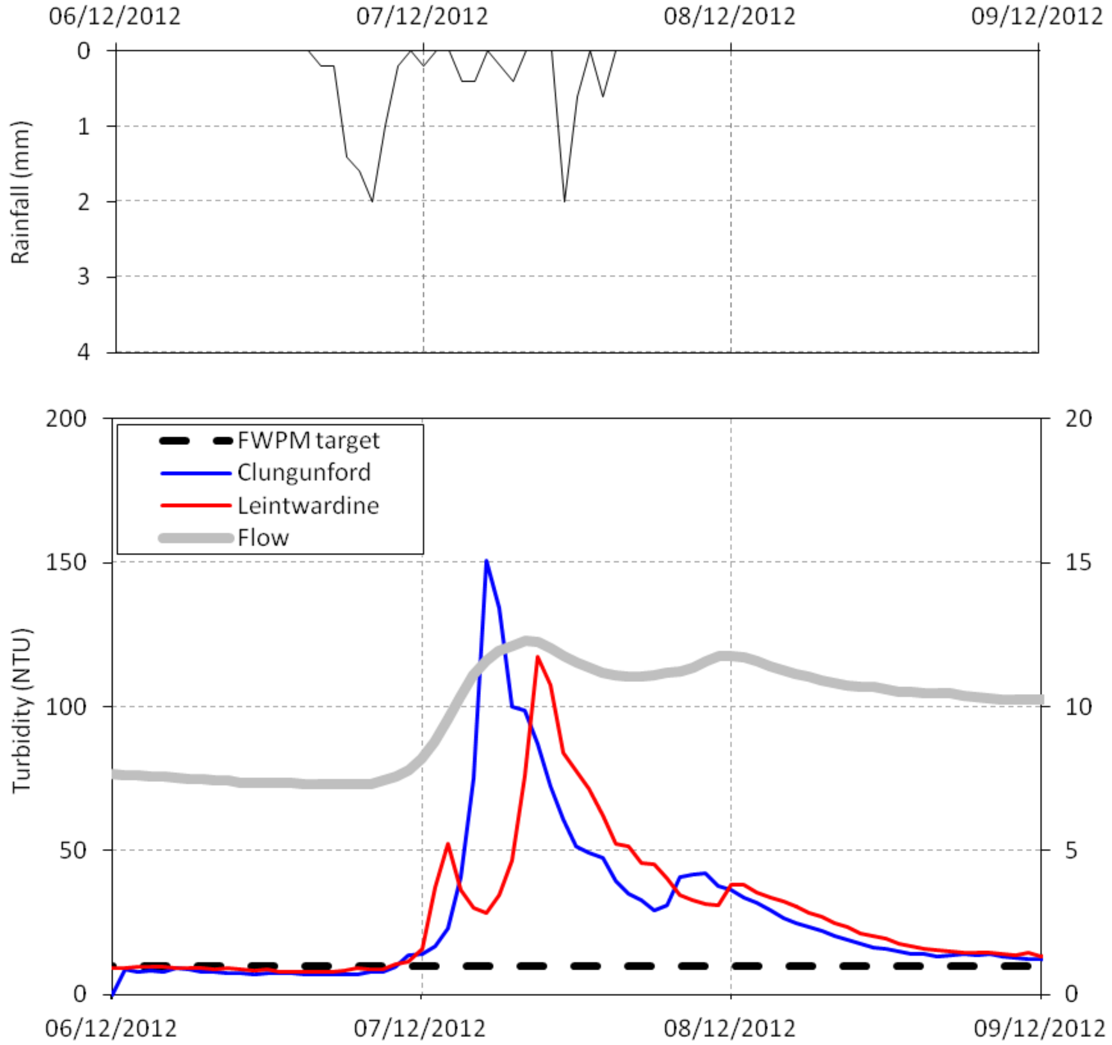
I.6. 24th September 2012



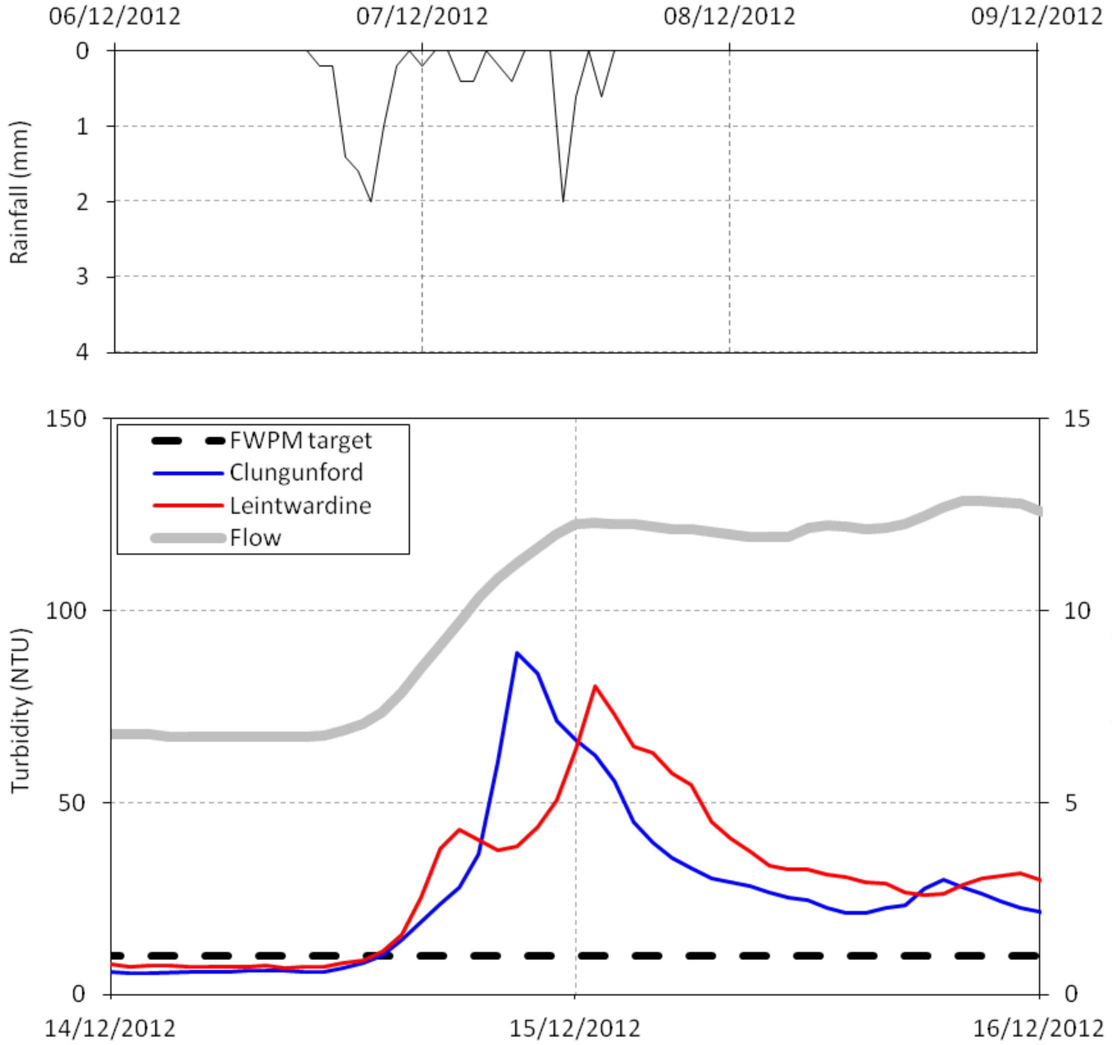
I.7. 21st – 27th November 2012



I.8. 7th December 2012



I.9. 14th December 2012



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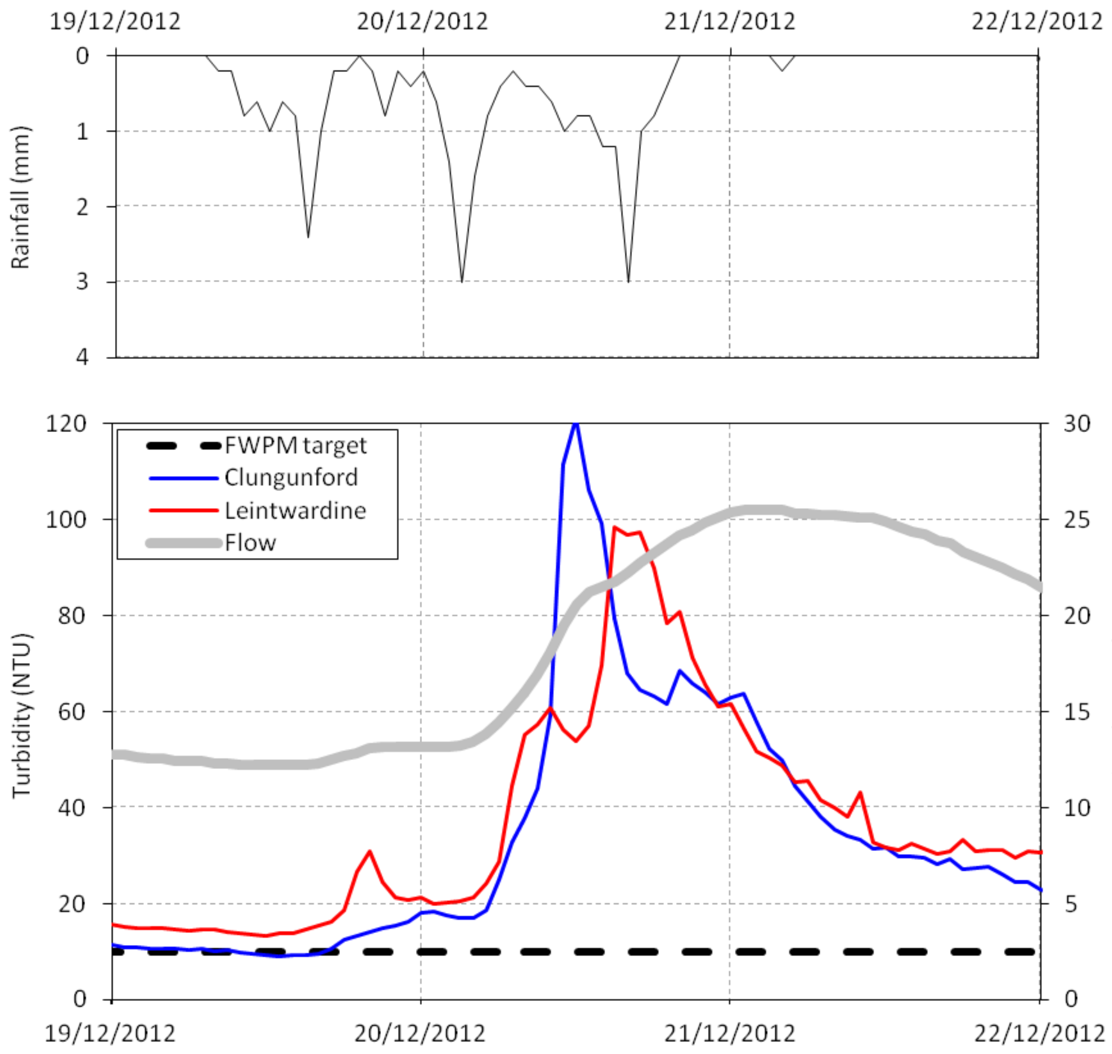
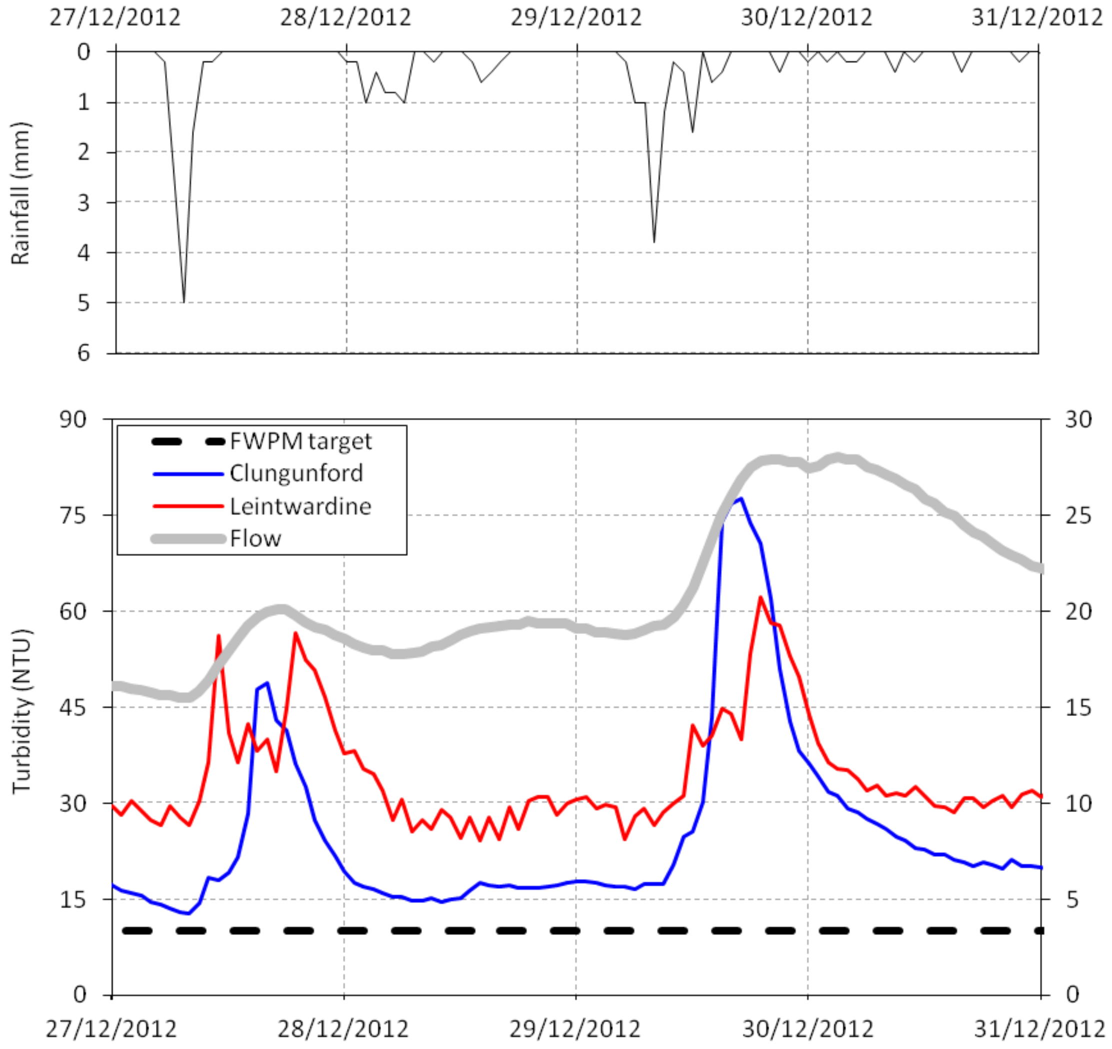


I.11. 27th – 31st December 2012



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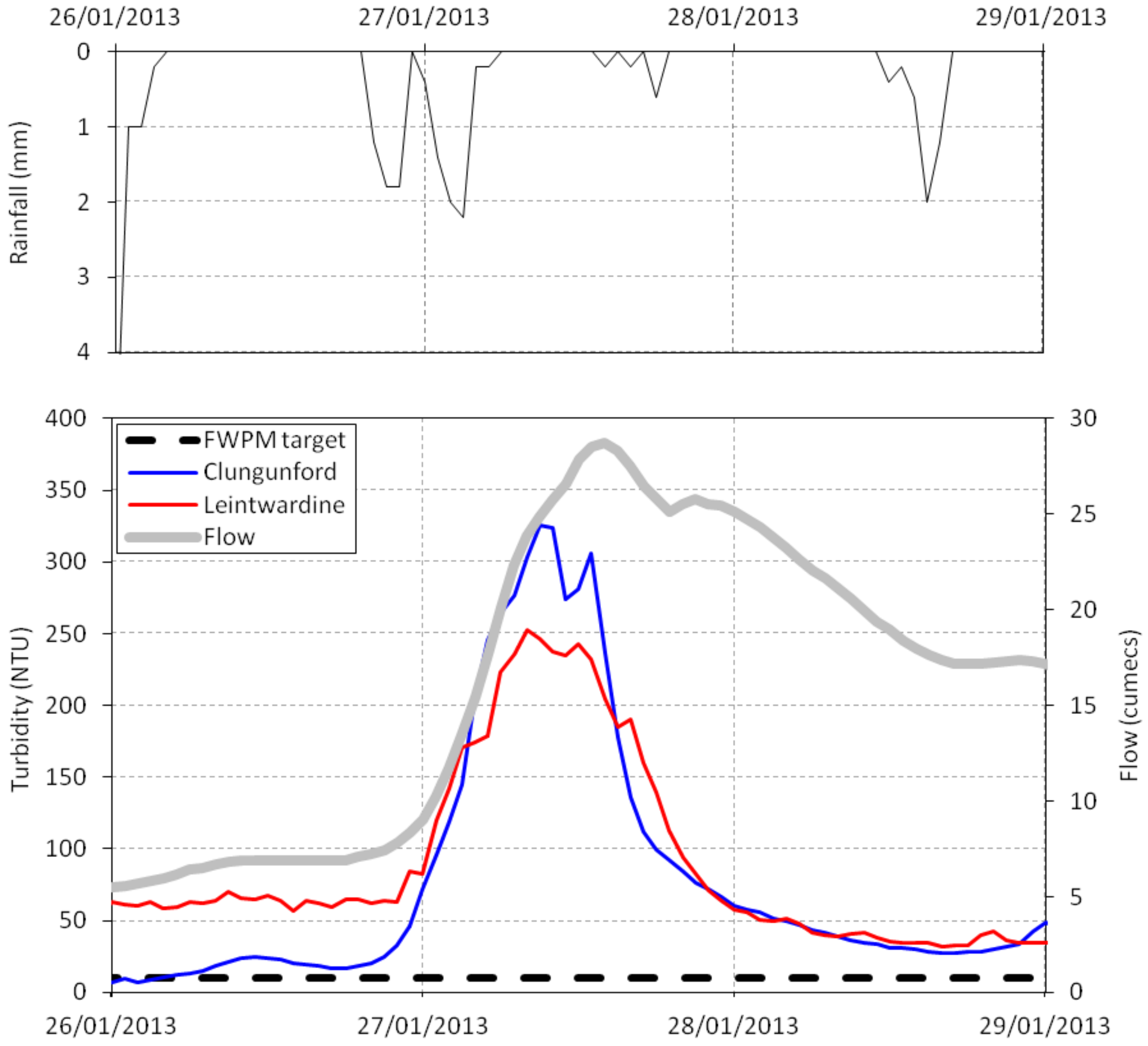
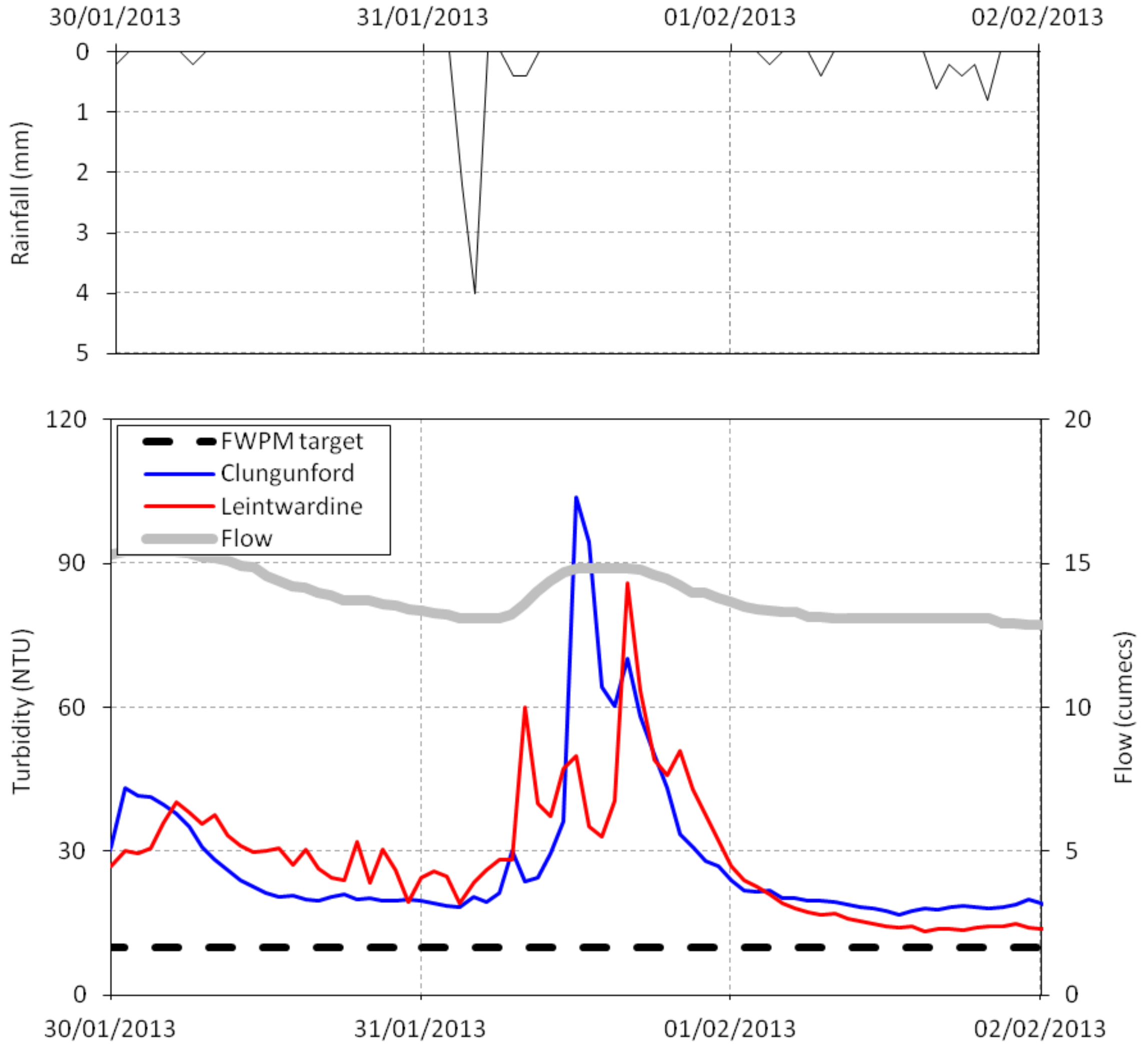
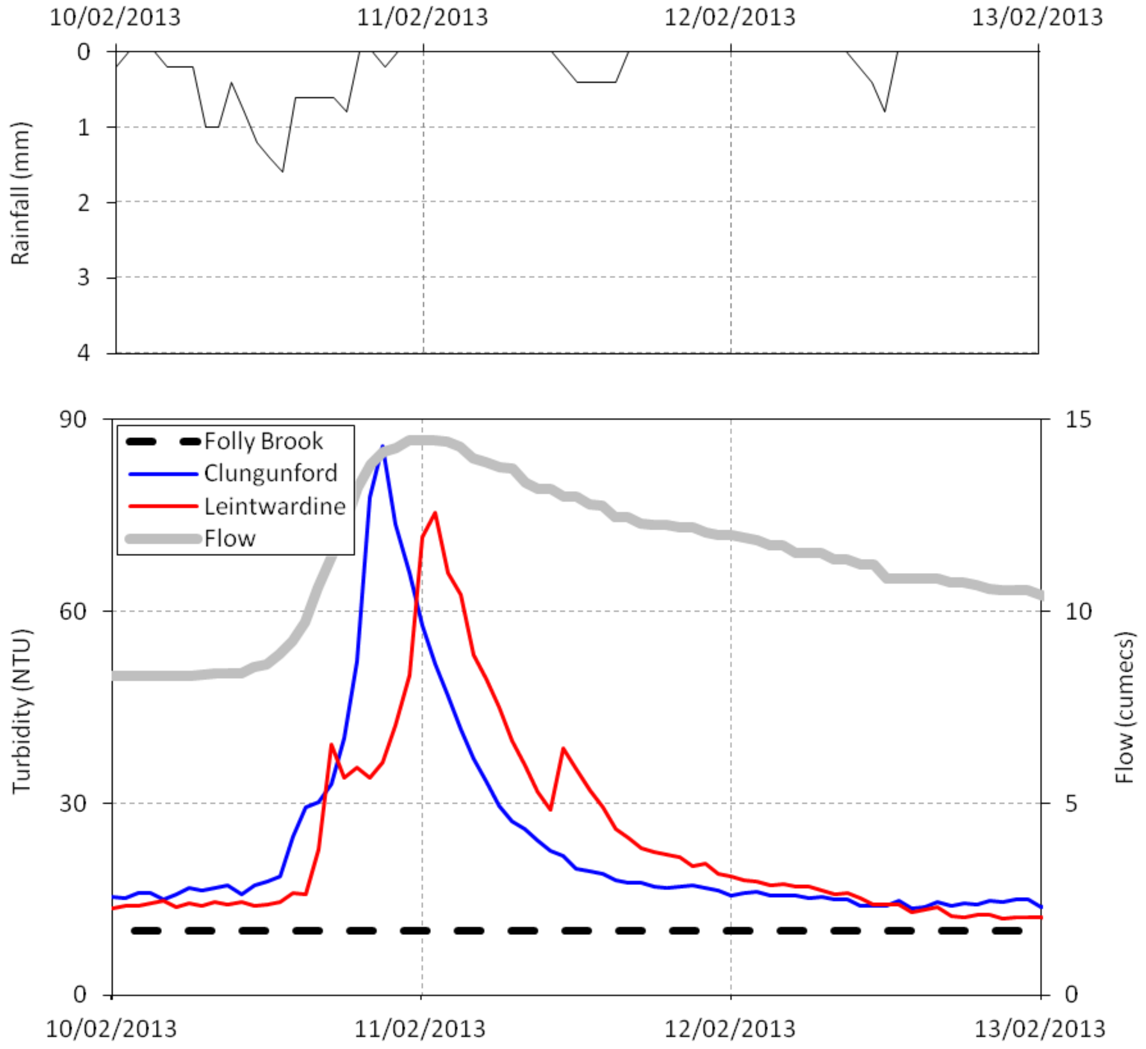


I.13. 31st January 2013



I.14. 10th February 2013



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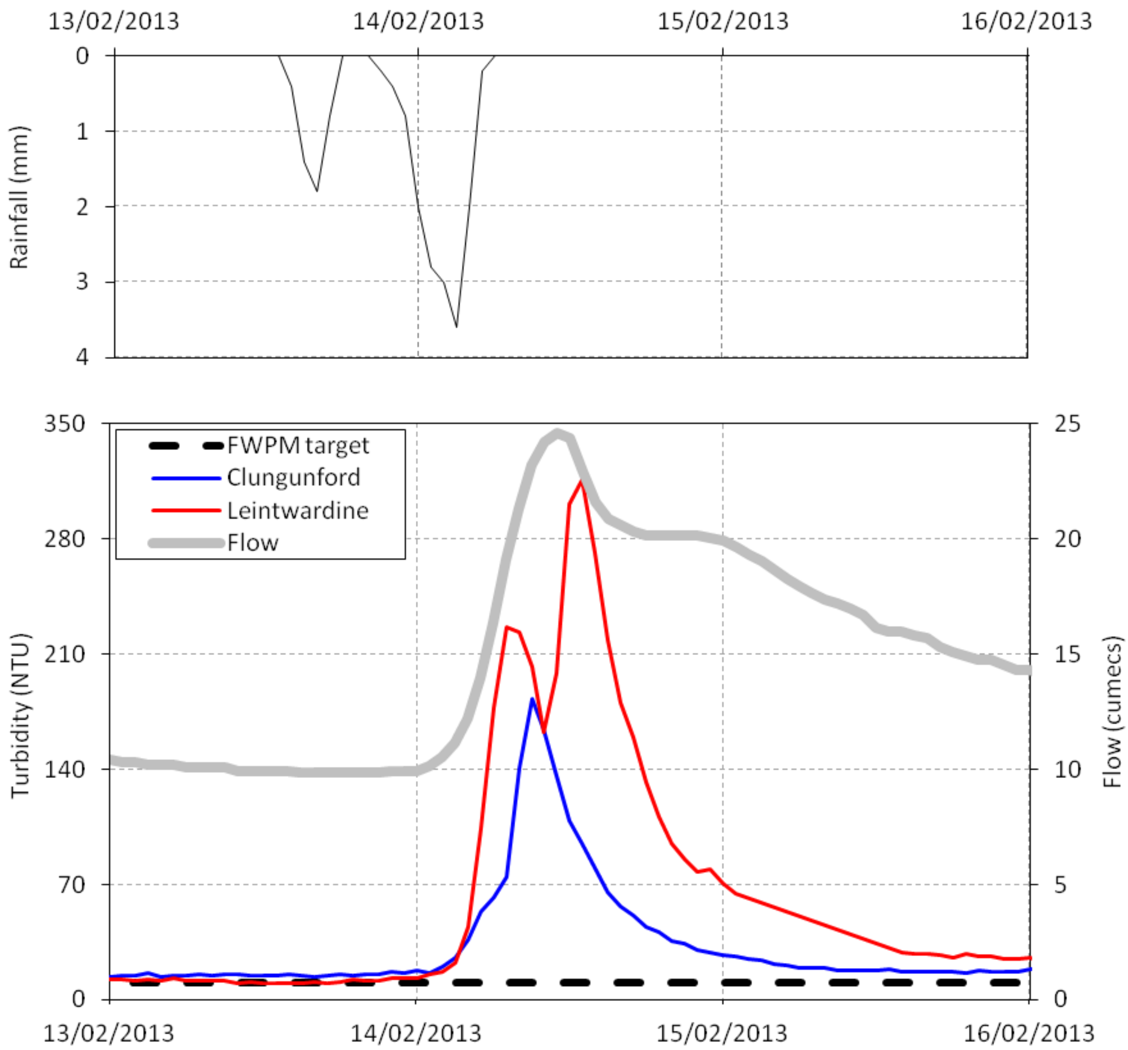

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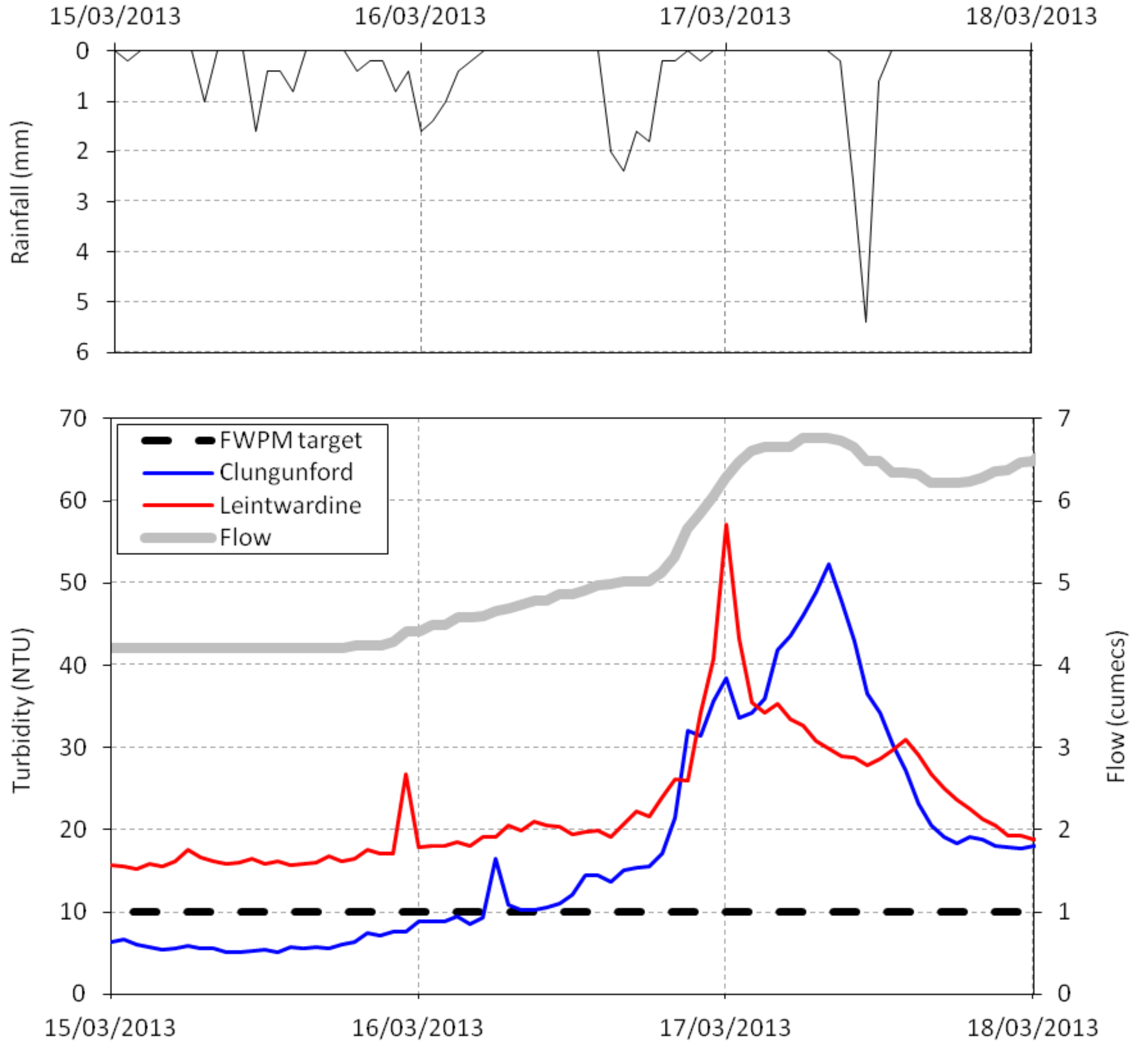

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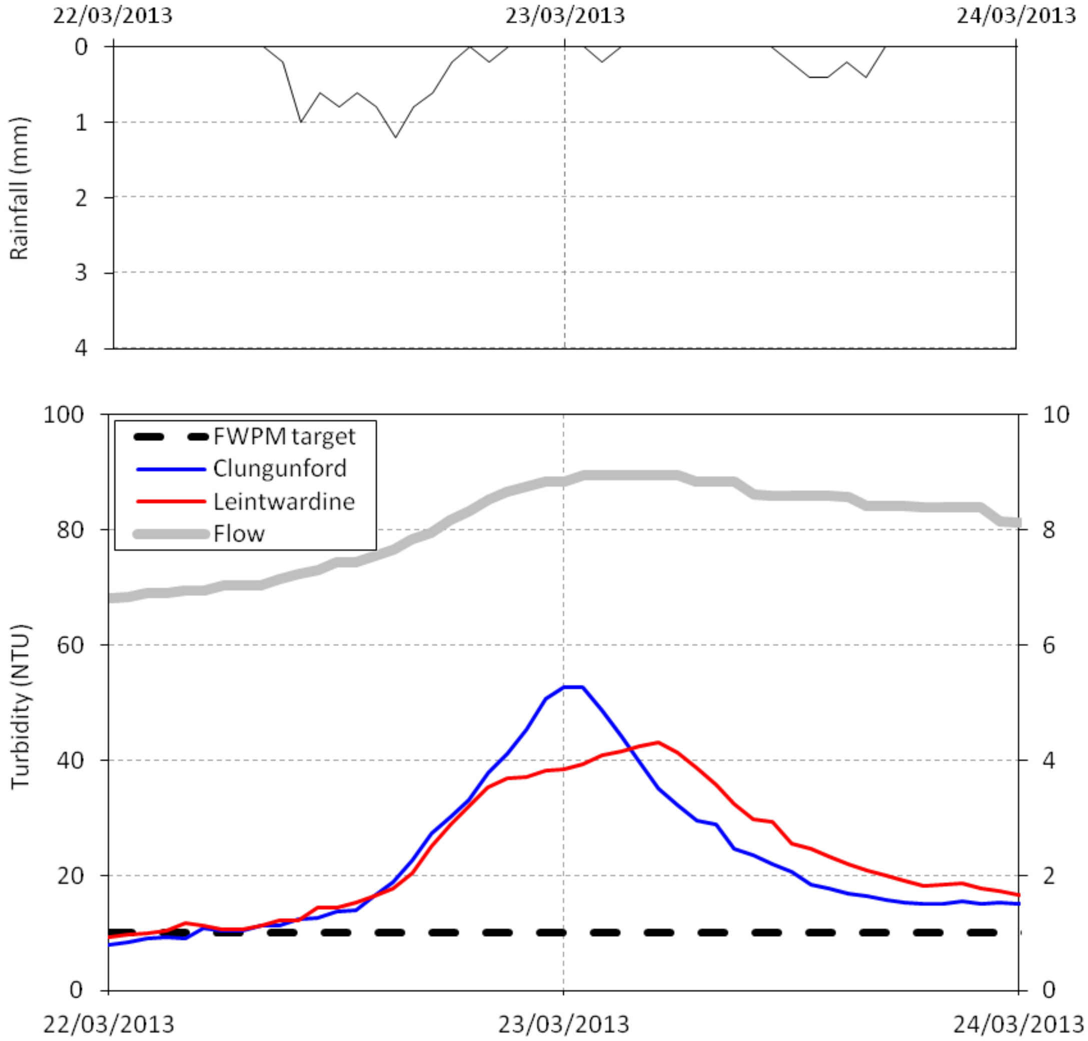


Appendix J. Pressures tables

J.1. Consented discharges

EFF_SMPT_USER_REF	AGR_EFFECTIVE	EFF_DESC	AGR_REC_WATER	Easting	Northing
	13/05/1963		NOT DEFINED	324500	282500
	25/07/1963		REDLAKE RIVER	331000	276000
20353050	09/09/1969		RIVER CLUN	336900	280600
20350220	15/10/1969		RIVER CLUN	339400	278600
20350240	10/09/1987		RIVER CLUN	339320	278700
20606360	24/11/2008	Secondary Treated Sewage Effluent	BROOME BROOK	340080	280840
20465500	18/05/1990		TRIB OF RIVER REDLAKE	333000	277660
20799650	29/07/1992		TRIB OF SNAKESCROFT BROOK	332570	288460
20626990	17/11/1992		TRIB OF RIVER CLUN	339170	283340
20350480	28/04/1993		RIVER CLUN	339790	279080
20350960	23/05/1994	Secondary treated sewage effluent containing no trade effluent	RIVER CLUN	339350	280400
20368510	10/04/1995		RIVER REDLAKE	335850	273870
20368515	10/04/1995	SEWAGE IN AN EMERGENCY	RIVER REDLAKE	335850	273870
20693990	01/01/2010	TREATED SEWAGE EFFLUENT	RIVER KEMP	335100	285600
20693995	01/01/2010	STORM SEWAGE VIA REED BED	RIVER KEMP	335100	285600
20905250	21/12/1995		TRIB OF RIVER CLUN	330000	280380
20359560	30/11/1995		RIVER CLUN	318380	284900
20350340	29/01/1996		TRIB OF RIVER CLUN	339780	278740
20350210	14/11/1997		RIVER TEME	339380	278550
20380090	14/11/1997		TRIB OF RIVER CLUN	336420	278510
20671430	31/12/1997		RIVER KEMP	331910	287260
20606370	30/01/1998		TRIB OF RIVER CLUN	339940	280911
20350390	05/12/2002	BIOLOGICALLY TREATED SEWAGE EFFLUENT CONTAINING NO TRADE EFFLUENT	RIVER CLUN	339450	278980
20792160	01/01/2010	Final Effluent ONLY - contains no element of storm sewage	SNAKESCROFT BROOK	332770	287740
20792165	01/01/2010	Final Effluent - with an element of storm sewage	SNAKESCROFT BROOK	332770	287740
20855040	17/04/2001	BIOLOGICALLY TREATED SEWAGE EFFLUENT	TRIB OF RIVER CLUN	333490	281320
20352760	02/05/2010	Biologically treated sewage effluent containing no trade effluent	RIVER CLUN	337340	280730
20799670	17/03/2004	BIOLOGICALLY TREATED SEWAGE EFFLUENT CONTAINING NO TRADE EFFLUENT	UNDERGROUND STRATA	332600	288400
20368150	21/04/2010	TREATED SEWAGE EFFLUENT	RIVER REDLAKE	336420	274200
20355025	27/04/2004	Storm sewage	RIVER CLUN	331060	281010
20355020	01/01/2010	SECONDARY TREATED SEWAGE EFFLUENT	RIVER CLUN	331060	281010
20356950	01/01/2010	SECONDARY TREATED SEWAGE EFFLUENT	RIVER CLUN	325130	282100
20626190	01/01/2010	SECONDARY TREATED SEWAGE EFFLUENT	ASTON BROOK	339130	281460
20591150	17/11/2005	Treated domestic sewage effluent	UNNAMED TRIB OF RIVER CLUN	339770	278740
20693999	17/05/2006	SEWAGE IN AN EMERGENCY	UNNAMED TRIB RIVER KEMP	335060	285480
	27/05/1977		UNDERGROUND STRATA	333700	281400
	02/04/2012		UNDERGROUND STRATA	326000	286400

J.2. Septic tanks

WFD Water body			Number	% catchment total	Estimated population served
Upper Clun	GB109054044000	R Clun - source to conf Folly Bk	55	12	411
Folly Brook	GB109054044020	Folly Bk - source to conf R Clun	23	5	172
Middle Clun	GB109054043980	R Clun - conf Folly Bk to conf R Unk	27	6	202
River Unk	GB109054044040	R Unk - source to conf R Clun	27	6	202
Lower Clun	GB109054043990	R Clun - conf R Unk to conf R Teme	147	32	680
River Kemp	GB109054044060	R Kemp - source to conf R Clun	91	20	1,099
River Redlake	GB109054043950	R Redlake - source to conf R Clun	86	19	643

J.3. Estimated growth in the Clun catchment to 2027 and additional population and flows

Settlement	Overall growth target 2011-2027	Completions 2011- 2013	Commitments 2011-2013	Net growth figure	Population equivalent?	Additional flow		Assumed connection
						(m3/day)	(m3/year)	
Bucknell	75	4	2	69	151.8	21.7	7,915	Mains Sewerage
Clun	100	7	1	92	202.4	28.9	10,554	Mains Sewerage
Aston on Clun Hopesay Broome Horderley, Beambridge Long Meadow End Rowton Round Oak cluster	15	1	2	12	26.4	3.8	1,377	A third on mains, two thirds non mains
Clungunford	25	2	0	23	50.6	7.2	2,638	Non mains
SUB-TOTAL	**215**	**14**	**5**	**196**	**431.2**	**61.6**	**22,484**	**-**

Settlement	Overall growth target 2006-2027	Completions and commitments 2006-2013	-	Net growth figure	Population equivalent?	(m3/day)	(m3/year)	Assumed connection
Bishop's Castle	150	88	-	62	142.6	20.4	7,436	Mains Sewerage
SUB-TOTAL	**150**	**88**	**-**	**62**	**142.6**	**20.4**	**7,436**	**-**

Final net growth for settlements in the Clun catchment	**258**	**574**	**82**	**29,920**	**-**

J.4. Estimated employment growth in the Clun catchment to 2027 and additional population and flows

Settlement	Site	Site Area (ha)	Anticipated Development Footprint (35%) (ha)	Square Metres per Employee	Estimated Numbers to be Employed to 2027 (persons)	Additional flow (m3/day)	Additional flow (m3/year)	Assumed connection
Bishops Castle	Bishops Castle Business Park	2.75	0.96	35	275	39	14,339	Mains sewerage
Bucknell	Timber Yard / Station Yard	1.08	0.38	35	110	16	5,736	Mains sewerage
Lydbury North	Former Garage Site	0.24	0.08	35	20	3	1,043	Mains sewerage

Final employment growth in the River Clun catchment	**4.07**	**1.42**	**105**	**405**	**58**	**21,118**	**-**

J.5. Poultry information

<table>
<tr><th colspan="2">Sub-catchment</th><th>2012 (bird places)</th><th>End-2013 (bird places)</th><th>Notes</th></tr>
<tr><td>1</td><td>River Unk</td><td>65,000
(6 cycles per annum)</td><td>160,000
(6 cycles per annum)</td><td>All waste spread within Clun catchment. Broilers</td></tr>
<tr><td>2</td><td>River Kemp</td><td>40,000
(1 cycle per annum)</td><td>250,000
(2.5 cycles per annum)</td><td>All waste spread within Clun catchment. Expansion in 2013
Eggs 2012/Pullets 2013</td></tr>
<tr><td>3</td><td>Redlake</td><td>295,000
(6 cycles per annum)</td><td>295,000
(6 cycles per annum)</td><td>Waste processed in anaerobic digester and spread to land subsequently. Broilers</td></tr>
<tr><td>4</td><td>Middle Clun</td><td>0</td><td>180,000
(6 cycles per annum)</td><td>Yet to be built. Broilers</td></tr>
<tr><td></td><td>TOTALS</td><td>400,000</td><td>885,000</td><td>Two licences double the poultry P load in the catchment</td></tr>
<tr><td>5</td><td rowspan="2">External sources</td><td>263,000</td><td rowspan="2">Unknown</td><td>1 crop - 270 tonnes (Broilers)</td></tr>
<tr><td>6</td><td>280,000</td><td>1 crop – 300 tonnes (Broilers)</td></tr>
</table>

Appendix K. SAGIS model technical note

K.1. Introduction

UKWIR, SEPA and the Environment Agency have funded the development of a source apportionment GIS model (SAGIS) to quantify the loads of pollutants to surface waters in the UK from 12 point and diffuse sources including wastewater treatment works discharges, intermittent discharges from sewerage and runoff, agriculture, soil erosion, mine water drainage, septic tanks and industrial inputs (UKWIR project WW02). Loads are converted to concentrations using the SIMCAT water quality model which is incorporated within SAGIS so that the contribution to in-stream concentrations from individual sources can be quantified. This approach allows an assessment of the extent by which substance concentrations may be at risk of exceeding Environmental Quality Standards (EQSs) and an apportionment of the substance concentration by source, thereby enabling a proportioning of responsibility for improving water quality in accordance with the “polluter pays” principle.

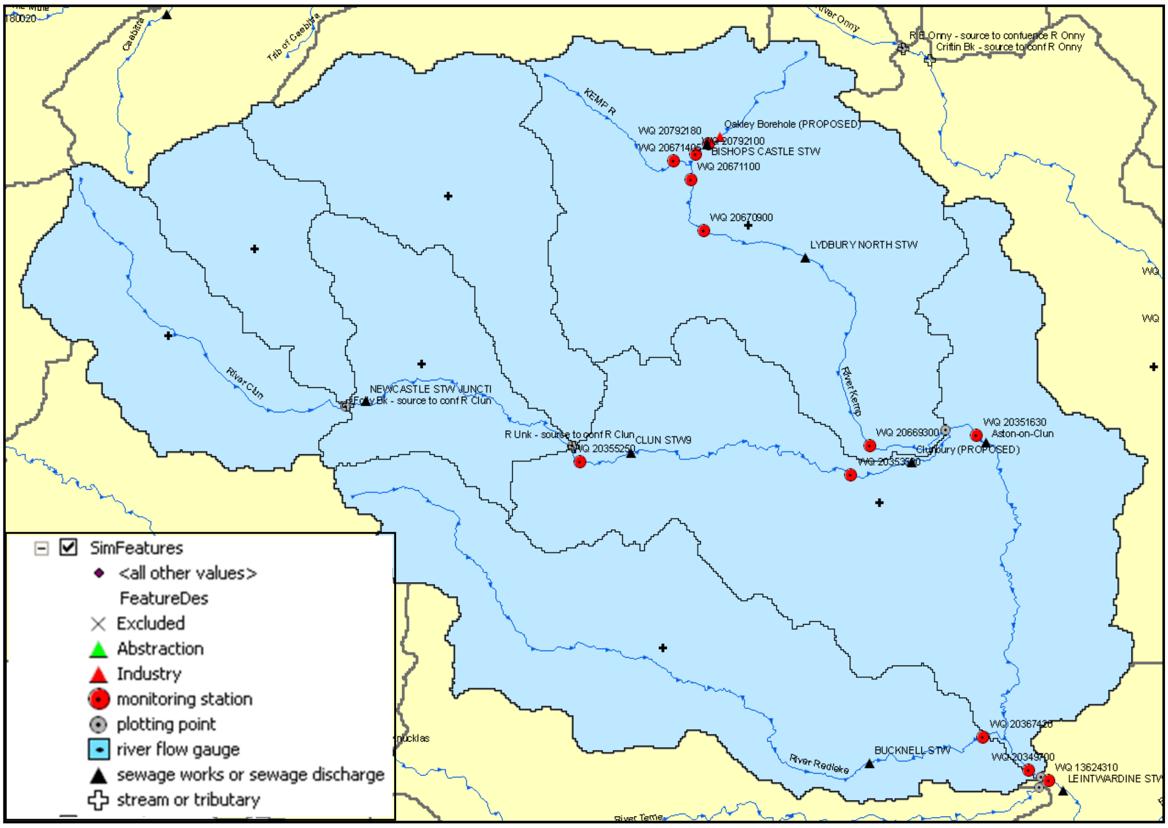
This Appendix describes the refinement and calibration of the SAGIS model for the Clun catchment that was used in the NMP. This involves checking that the features within the study areas are represented correctly with respect to their spatial location and supporting data. Model performance has been checked against observed flow and phosphorus concentration data. Where necessary, flow and phosphorus calibration has been carried out to improve model performance.

K.2. Model performance and refinement

SAGIS models for the whole of England and Wales were originally developed using national datasets to provide consistent outputs that can be used to provide information for national planning (e.g. in relation to priority hazardous substances). For regional and local use it is recognised that checking against local information and knowledge is required along with addition of detailed local data sets. Further model checking and calibration is also necessary to ensure that the model performance is acceptable.

K.2.1. Model structure

The location of features within the Clun catchment was checked (as shown within Figure 1) and was found to be correct.



K.2.2. Flow calibration

The first stage of flow calibration involved ensuring the flows from the sewage treatment works were represented accurately. Flow data from sewage treatment works within the catchment was provided by Severn Trent Water (Table K1). This was checked against the flow data already held within the SAGIS model, and flows at the four key sewage treatment works (Bishops Castle, Clun, Lydbury North and Bucknell) was updated accordingly (Table K1).

Table K1: Flow data for sewage treatment works from Severn Trent Water.

Sewage Treatment Works	Population served	Mean flow (Ml/d)	Standard Deviation flow (Ml/d)	DWF (Ml/d)	Data source	Measured data duration
Bishops Castle	1943	0.608	0.396	0.546	Measured	2010-2012
Clun	690	0.160	0.044	0.119	Measured	2010-2012
Lydbury North	285	0.143	0.108	0.126	Measured	2010-2012
Bucknell	834	0.273	0.143	0.280	Measured	2010-2012
Newcastle-on-Clun	152	0.034	0	na*	Estimated	-
Aston-on-Clun	187	0.042	0	na*	Estimated	-
Clunbury	40	0.09	0	na*	Estimated	-

**none given on consent*

As the River Clun catchment is small, there were no flow gauging stations with observed flows held within the SAGIS model for the catchment. Therefore, observed flows were provided by the Environment Agency for two gauging stations: River Clun at Leintwardine (just before the end of the River Clun catchment), and River Teme at Tenbury (further downstream on the River Teme).

Following update of flows at the four key sewage treatment works, the SAGIS model was run and observed mean and Q95 flows at the gauging stations were compared to the modelled mean and Q95 flows, and ratios between observed and modelled flows calculated (Table K2).

Table K2: Comparison of observed to modelled flows.

	Flows (Ml/d)	
River Clun at Leintwardine	**Mean**	**Q95**
Observed	341	38
Modelled	296.19	35.305
River Teme at Tenbury		
Observed	1216	128
Modelled	1153.6	143.62
	Ratio (observed / modelled)	
River Clun at Leintwardine	1.151288025	1.076334797
River Teme at Tenbury	1.05409154	0.891240774

As the modelled flows were not within ±10% of the observed flows, the ratios calculated between the observed and modelled flows were used to update the mean and Q95 water body flows within the SAGIS model (specifically the CaldiffuseFlow and CalHeadwater Flow tables within the Regional Database). For the water bodies in which the ratios had been calculated, the specific ratio was used, and for all other water bodies the median of the two ratios was used (Table K3).

Table K3: Ratios applied to update water body flows.

Water body	**Ratio**	
	Mean	**Q95**
GB109054043990	1.151288025	1.076334797
GB109054044510	1.05409154	0.891240774
All other water bodies	1.102689782	0.983787786

Following the water body flow updates, the SAGIS model was run and again the observed mean and Q95 flows at the gauging stations were compared to the modelled mean and Q95 flows (Table K4).

Table K4: Comparison of observed to modelled mean and Q95 flows.

	Flows (Ml/d)	
River Clun at Leintwardine	**Mean**	**Q95**
Observed	341	38
Modelled	330.25	35.752
River Teme at Tenbury		
Observed	1216	128
Modelled	1268.1	141.58
	Ratio (observed / modelled)	
River Clun at Leintwardine	1.032551098	1.062877601
River Teme at Tenbury	0.958914912	0.904082498

As the modelled flows were all within ±10% of the observed flows (ratios 0.90 to 1.10) no further updates to the flows were required (Table K4). Figure K2 shows the downstream plot of modelled and observed flows along the River Clun and River Teme following flow calibration.

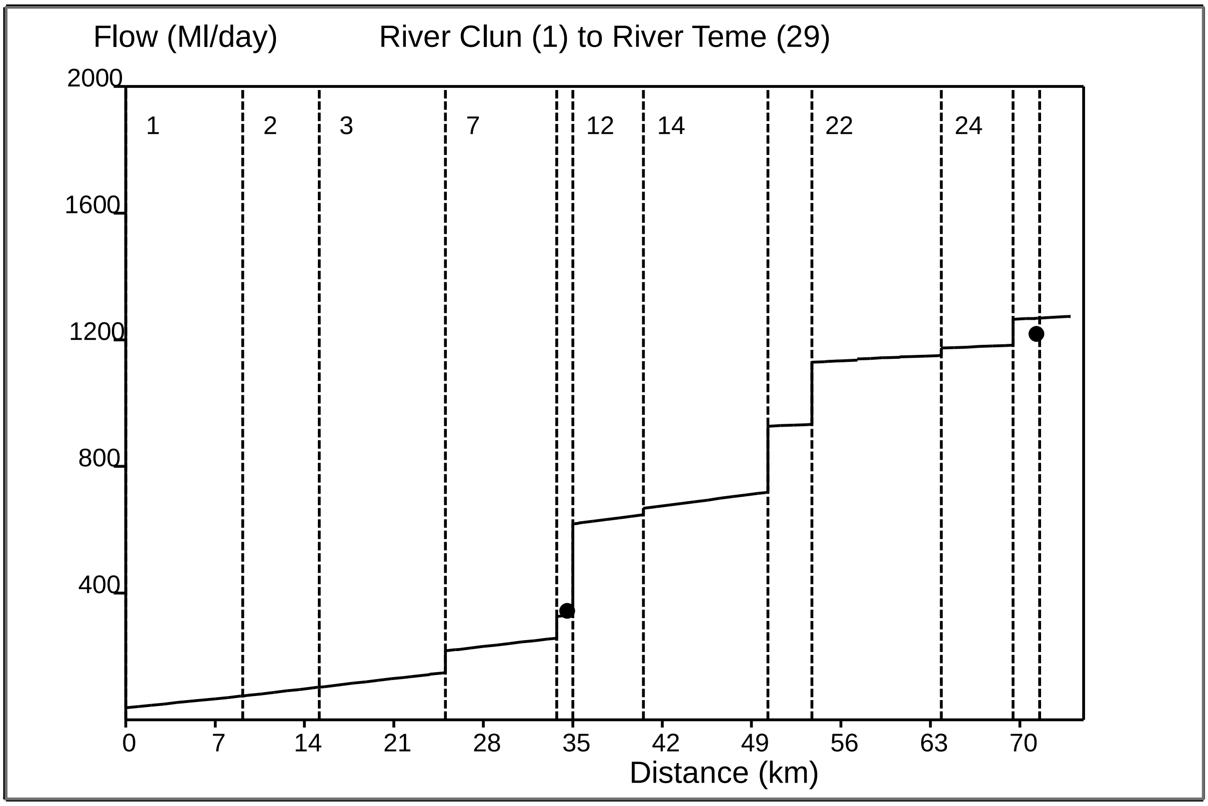


Figure K2: Modelled and observed flows along the River Clun and River Teme. The solid black line indicates the modelled flow and the black dots the observed flow.

K.2.3. Phosphate calibration

The first stage of phosphorus calibration involved ensuring the PO4 concentration of discharges at the sewage treatment works within the River Clun catchment were represented accurately. PO4 concentrations from sewage treatment work discharges were provided by Severn Trent Water (Table K5) and were updated within the SAGIS model. As only a mean PO4 concentration was provided for Clunbury sewage treatment work, the standard deviation value was calculated using the calculated coefficient of variation from the original data within SAGIS at this sewage treatment work.

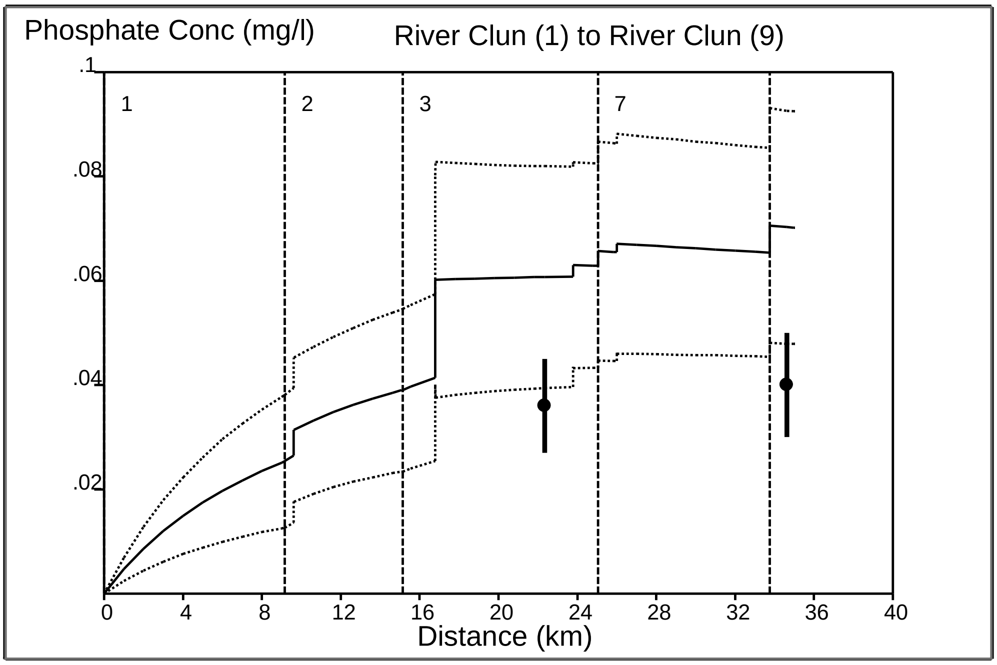
Table K5: PO_4 discharge data for sewage treatment works provided by Severn Trent Water.

Sewage Treatment Works	Mean PO_4 concentration (mg/l)	Standard Deviation PO_4 concentration (mg/l))	Data source	Data duration
Bishops Castle	0.46	0.31	Measured	2007-2012 (post-strip)
Clun	5.23	1.19	Measured	2006-2008
Lydbury North	2.84	1.5	Measured	2006-2008
Bucknell (pre-strip)	4.42	1.74	Measured	2006-2008
Newcastle-on-Clun	4.63	3.61	Estimated	1995-2008
Aston-on-Clun	5.22	2.07	Estimated	2006-2008
Clunbury	5.22	4.20	Estimated	-

Following the model update, the SAGIS model was run and modelled PO4 concentrations compared to observed PO4 concentrations at three river water quality monitoring locations for which monitoring data was available from the Environment Agency (Tables K6 and K7 (initial iteration), and, Figures K3 and K4). These three monitoring locations were chosen as they were at the lower end of the River Clun catchment.

Table K6: River water quality monitoring locations used for model calibration provided by the Environment Agency.

Monitoring station	River	Mean PO_4 concentration (mg/l)	Upper confidence limit (PO_4 mg/l)	Lower confidence limit (PO_4 mg/l)
WQ 20669300	River Kemp	0.042	0.057	0.027
WQ 20353500	River Clun	0.036	0.045	0.027
WQ 20349700	River Clun	0.040	0.050	0.030



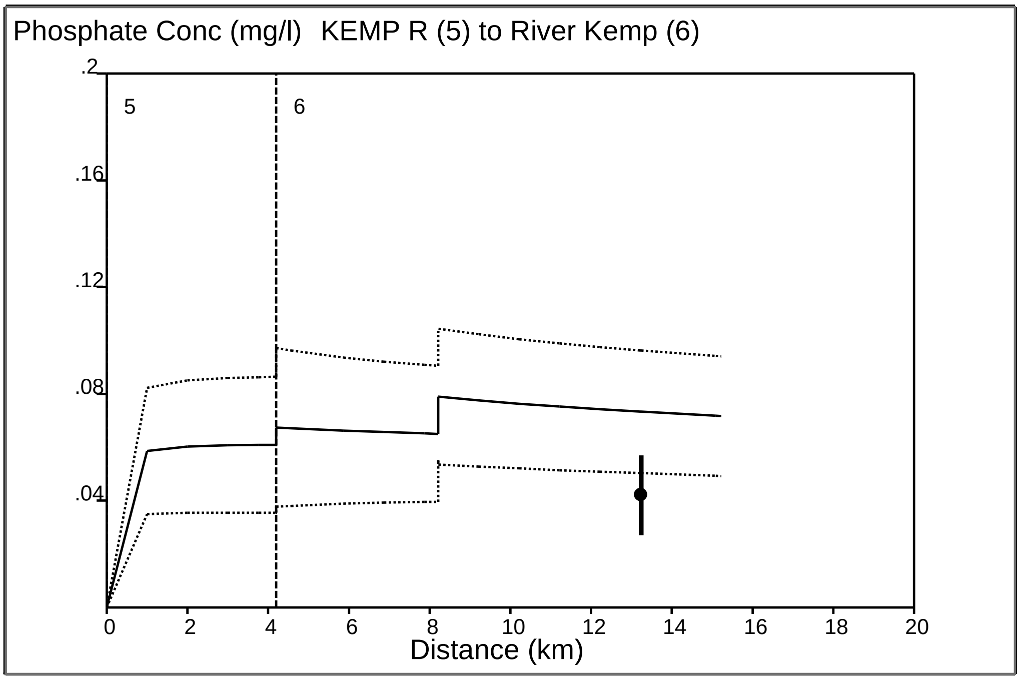


Figure K3: Modelled and observed PO_4 concentrations along the River Clun (top graph) and along the River Kemp (bottom graph) prior to calibration. The solid black line indicates the modelled concentration with the dashed lines indicating the confidence limits. The black dot and lines indicate the observed mean (dot) concentration and confidence limits (lines).

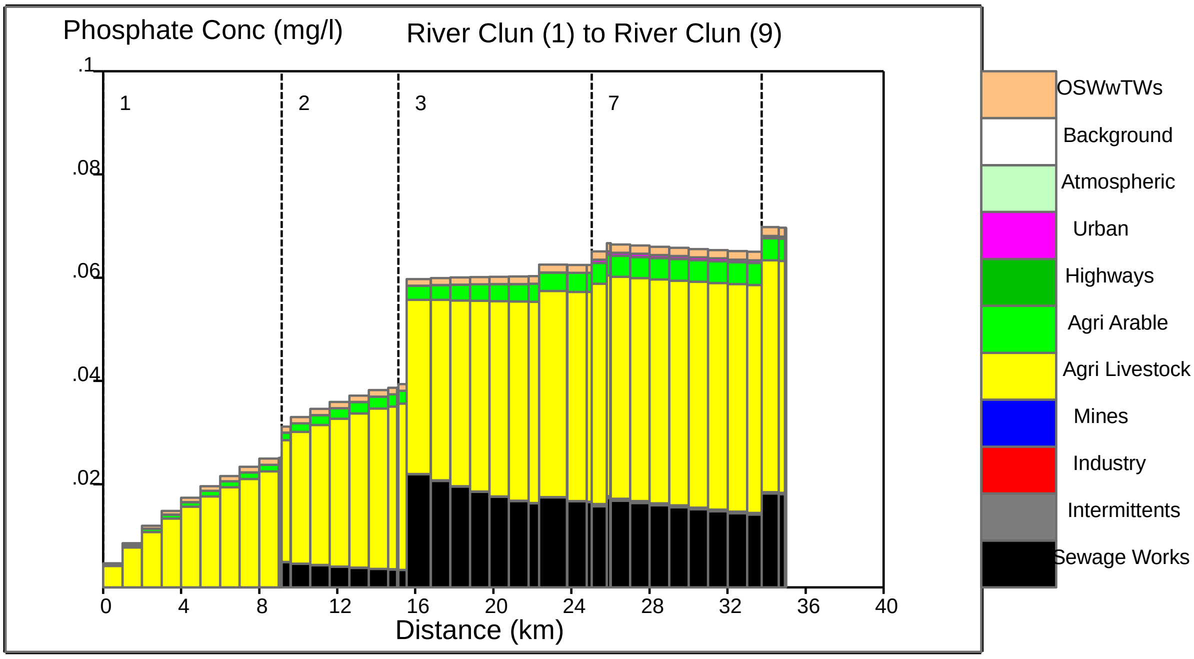
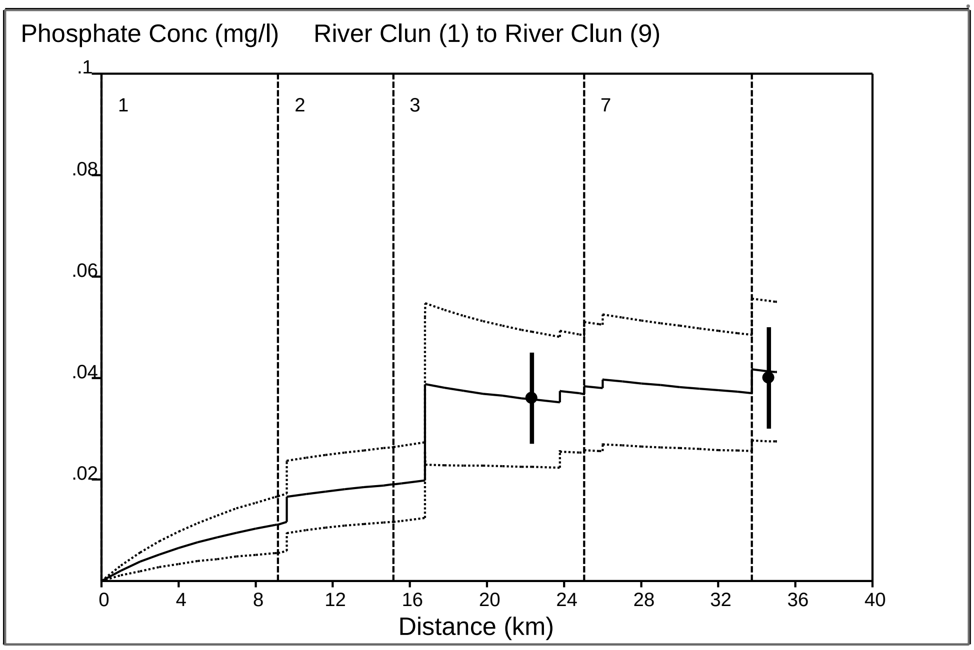


Figure K4: Downstream source apportionment of PO_4 concentrations along the River Clun prior to calibration.

It was apparent that the model was over-predicting PO_4 concentrations. Therefore, PO_4 inputs from the three major diffuse sources within the catchment (agricultural livestock, agricultural arable and septic tanks (OSWwTWs)) (Figure K4) were reduced iteratively (three times) based on the median ratio of the observed to modelled mean PO_4 concentrations at the three monitoring locations (Table K7, ratio from initial, update 1 and update 2), until the model was predicting PO_4 concentrations which were very close to the observed monitoring data (Table K7, final iteration and Figures K5 and K6)). This follows the methodology on calibration developed by the Environment Agency.

Table K7: Iterations of water quality monitoring calibration.

Iteration	Monitoring station	Modelled mean PO_4 concentration	Median ratio observed/modelled
Initial	WQ 20669300	0.0733	0.573
	WQ 20353500	0.0607	
	WQ 20349700	0.0703	
Update 1	WQ 20669300	0.0507	0.828
	WQ 20353500	0.0418	
	WQ 20349700	0.0484	
Update 2	WQ 20669300	0.0460	0.921
	WQ 20353500	0.0375	
	WQ 20349700	0.0434	
Final	WQ 20669300	0.0436	**0.969**
	WQ 20353500	0.0358	
	WQ 20349700	0.0413	



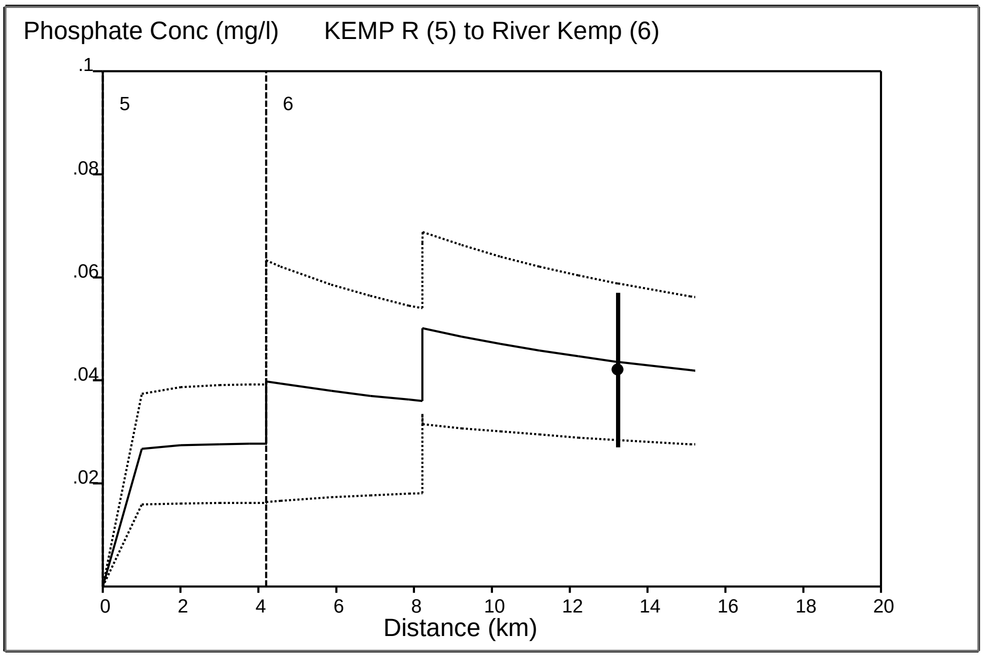


Figure K5: Modelled and observed PO_4 concentrations along the River Clun (top graph) and the River Kemp (bottom graph) after calibration. The solid black line indicates the modelled concentration with the dashed lines indicating the confidence limits. The black dot and lines indicate the observed mean (dot) concentration and confidence limits (lines).

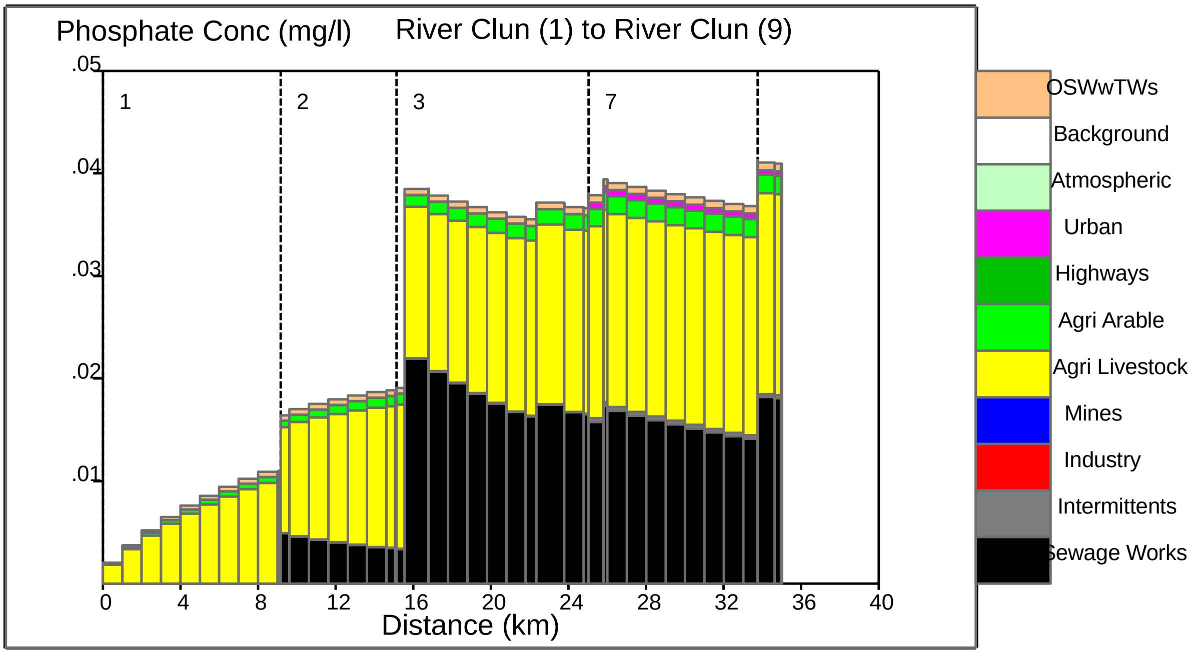


Figure K6: Downstream source apportionment of PO_4 concentrations along the River Clun after calibration.

Appendix L. Estimation of river bank erosion loads

In the absence of the detailed field data required to adequately measure river bank erosion we have estimated loads based on a series of simple assumptions. A walkover survey of the channel of the River Clun undertaken by Jacobs Babtie (2006) identified bank erosion through natural fluvial processes as an important source of sediment to the river and was occurring along 13% of the river length. This information has been used to estimate the annual sediment loads from bank erosion in the Clun catchment as follows:

a) The 13% of river length estimated by Jacobs Babtie has been extended to the whole rive to estimate the area subject to erosion.
b) The Clun is approximately 22km in length of which 13% (or 2,860m) is assumed to be subject to erosion.
c) A precautionary approach is adopted whereby erosion is assumed to occur on both banks of the same river that gives a catchment estimate of 5,720m or river bank subject to erosion.
d) For the purpose of the calculation it is assumed that the banks are all 1m high giving a bank area subject to erosion of 5,720m^2.
e) We also assume that erosion is occurring at the same rate on all banks equivalent to 0.05m/yr. This gives a total volume of bank sediment generated every year of 286m^3. This has been taken as a realistic estimate of bank recession that would be equivalent to the river growing in width by 1m every 10 years at eroding locations.
f) The total load has been calculated using a bulk density for silty soils of 1.6 tonnes/m^3. This gives a total load of sediment from bank erosion of 458 tonnes.
g) The total estimated sediment load passing Leintwardine on an annual basis is 3,331 tonnes. 458 tonnes of bank erosion is equivalent to 14% of this load.

A spreadsheet tool (front- end shown below) has been developed to assess the sensitivity of results to different assumptions and can be updated with actual field measurements in the future.

STEP 1 - Choose the soil type that best describes your river bank

	g/cm^3	
Sand and gravel	1.6 - 2.2	
Silt	1.6 - 2.0	
Soft clay	1.7 - 2.0	
Stiff clay	1.9 - 2.3	
Peat	1.0 - 1.4	
MY SOIL DENSITY	1.6	millions g/m^3 or tonnes/m^3

STEP 2 - Map or estimate the length of eroding bank

Length of river affected (both banks)	5,720	m

STEP 3 - Estimate the annual recession of the banks and the bank height affected

Approximate annual recession	0.05	m
Estimated mean bank height	1.00	m

STEP 4 - MY RESULTS

Volume of soil	286	m^3
Mass of soil	458	Tonnes
Total sediment load	3,331	Tonnes
% riverbank erosion (source apportionment)	14%	Tonnes

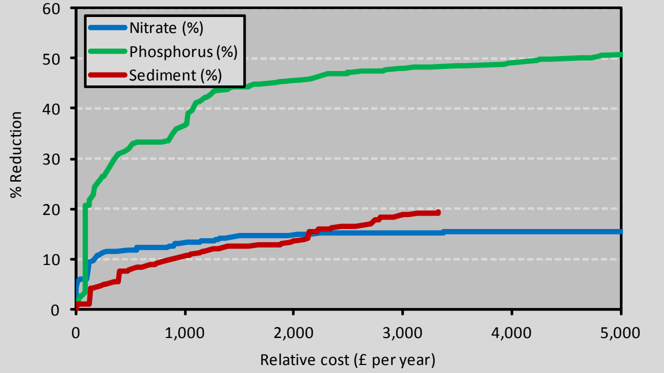
Appendix M. FARMSCOPER optimiser summaries

M.1. Upland grazing farm

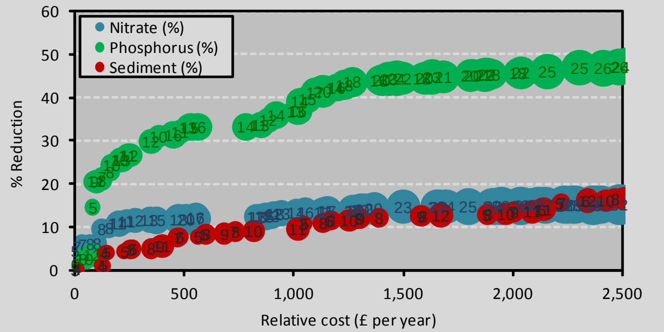
Farm type: Upland grazing (LFA)
Climate: 901 - 1200mm
Soil type: Free draining

	% reduction			% reduction		
	Nitrate	**Sediment**	**Phosphorus**	**Nitrate**	**Sediment**	**Phosphorus**
A. What are the maximum potential reductions?	15	19	51	15	19	51
B. How efficient are different measures?						
19 - Make use of improved genetic resources in livesto	1	0	1	0 - 5	0	0 - 5
22 - Use a fertiliser recommendation system	1	0	0	0 - 5	0	0 - 5
23 - Integrate fertiliser and manure nutrient supply	1	0	0	0 - 5	0	0 - 5
25 - Do not apply manufactured fertiliser to high-risk ar	2	0	0	0 - 5	0	0 - 5
26 - Avoid spreading manufactured fertiliser to fields at	0	0	0	0 - 5	0	0 - 5
32 - Do not apply P fertilisers to high P index soils	0	0	0	0	0	0 - 5
35 - Reduce the length of the grazing day/grazing seas	0	4	0	-5 - 0	0 - 5	-5 - 0
36 - Extend the grazing season for cattle	0	-4	0	0 - 5	-5 - 0	0 - 5
37 - Reduce field stocking rates when soils are wet	0	1	0	-5 - 0	0 - 5	-5 - 0
38 - Move feeders at regular intervals	0	4	2	0 - 5	0 - 5	0 - 5
39 - Construct troughs with concrete base	0	4	2	0 - 5	0 - 5	0 - 5
570 - Minimise the volume of dirty water produced (ser	0	0	0	0 - 5	0	0
60 - Site solid manure heaps away from watercourses/	0	0	1	0 - 5	0	0 - 5
61 - Store solid manure heaps on an impermeable bas	1	0	6	0 - 5	0	5 - 10
62 - Cover solid manure stores with sheeting	0	0	1	0 - 5	0	0 - 5
68 - Do not apply manure to high-risk areas	0	0	1	0 - 5	0	0 - 5
72 - Do not spread FYM to fields at high-risk times	0	0	1	0 - 5	0	0 - 5
76 - Fence off rivers and streams from livestock	2	0	9	0 - 5	0	5 - 10
78 - Re-site gateways away from high-risk areas	0	4	2	0 - 5	0 - 5	0 - 5
80 - Establish new hedges	0	0	0	0 - 5	0 - 5	0 - 5
81 - Establish and maintain artificial wetlands - steadir	1	0	12	0 - 5	0	>10
101 - Protection of in-field trees	0	0	0	0 - 5	0 - 5	0 - 5
103 - Management of in-field ponds	0	1	0	0 - 5	0 - 5	0 - 5
106 - Plant areas of farm with wild bird seed / nectar fl	0	10	3	0 - 5	5 - 10	0 - 5
110 - Uncropped cultivated areas	1	0	0	0 - 5	0	0 - 5
118 - Locate out-wintered stock away from watercours	0	1	0	0 - 5	0 - 5	0 - 5
119 - Use dry-cleaning techniques to remove solid was	3	0	14	0 - 5	0	>10
120 - Capture of dirty water in a dirty water store	4	0	20	0 - 5	0	>10

C. How do benefits vary with cost?



D. How easy is it to implement?



M.2. Lowland arable farm

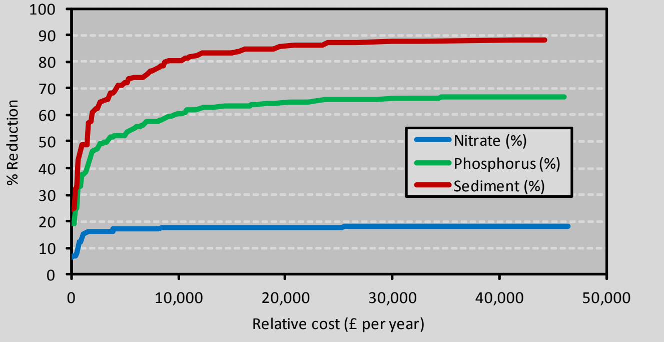
Farm type: Winter Combinable
Climate: 901 - 1200mm
Soil type: Free draining

	Nitrate	Sediment	Phosphorus	Nitrate	Sediment	Phosphorus
A. What are the maximum potential reductions?	18	67	88	18	67	88

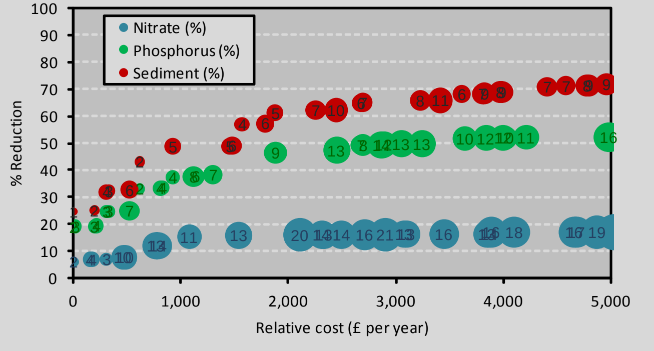
B. How efficient are different measures?

8 - Cultivate compacted tillage soils	2	19	25	0 - 5	>10	>10
9 - Cultivate and drill across the slope	1	13	18	0 - 5	>10	>10
10 - Leave autumn seedbeds rough	1	1	1	0 - 5	0 - 5	0 - 5
11 - Manage over-winter tramlines	1	7	10	0 - 5	5 - 10	5 - 10
13 - Establish in-field grass buffer strips	0	18	25	0 - 5	>10	>10
14 - Establish riparian buffer strips	0	7	10	0 - 5	5 - 10	5 - 10
15 - Loosen compacted soil layers in grassland fields	2	19	25	0 - 5	>10	>10
78 - Re-site gateways away from high-risk areas	0	8	10	0 - 5	5 - 10	5 - 10
80 - Establish new hedges	0	0	0	0 - 5	0 - 5	0 - 5
101 - Protection of in-field trees	0	0	0	0 - 5	0 - 5	0 - 5
103 - Management of in-field ponds	0	2	2	0 - 5	0 - 5	0 - 5
105 - Management of field corners	0	7	10	0 - 5	5 - 10	5 - 10
106 - Plant areas of farm with wild bird seed / nectar fl	0	18	25	0 - 5	>10	>10
107 - Beetle banks	0	7	10	0 - 5	5 - 10	5 - 10
108 - Uncropped cultivated margins	0	7	10	0 - 5	5 - 10	5 - 10
110 - Uncropped cultivated areas	0	1	2	0 - 5	0 - 5	0 - 5
111 - Unfertilised cereal headlands	0	6	8	0 - 5	5 - 10	5 - 10
112 - Unharvested cereal headlands	0	6	8	0 - 5	5 - 10	5 - 10
114 - Take field corners out of management	0	7	10	0 - 5	5 - 10	5 - 10
117 - Use correctly-inflated low ground pressure tyres	1	7	10	0 - 5	5 - 10	5 - 10

C. How do benefits vary with cost?



D. How easy is it to implement?



Appendix N. FARMSCOPER technical note

Introduction

This Technical Note describes how FARMSCOPER will be used as part of the River Clun Nutrient Management Plan (NMP). The proposed approach consists of a series of steps developed based on the outcomes of a project workshop in June 2013 and a review of similar work undertaken elsewhere. Where relevant, sample outputs from FARMSCOPER are provided.

FARMSCOPER

FARMSCOPER – FARM SCale Optimisation of Pollutant Emission Reductions (Goodhay and Antony, 2010) is a Defra-funded tool that collates more than a decade of UK scientific research on farm scale pollutant loads and the effects of different mitigation methods on losses of phosphorus, nitrogen and sediment.

FARMSCOPER provides estimates of the costs and effectiveness of different measures on each of the Defra Robust Farm Types. Where more detailed farm information are available, these can also be used. Over 100 mitigation methods, including those listed in the latest Defra Mitigation Method User Guide (Defra Project ES0203), are included within the tool.

FARMSCOPER produces farm scale outputs that can be scaled up to provide estimate of agricultural diffuse pollution and the effectiveness of potential mitigation methods at the catchment scale.

Step 1 - What are the main farm types within the catchment?

The first step was to decide the farm types in the catchment. During the June 2013 Clun NMP meeting to discuss the diffuse pollution scenarios, two main farm types were identified based on the 'Less Favoured Area' (LFA) boundary as follows:

a) Farms within the Less Favoured Area (LFA) are mainly improved and semi-improved grassland grazed by sheep and beef. This farm is hereafter termed the 'Clun livestock farm'. It is equivalent to the 'LFA Grazing' Defra Robust Farm Type and is described in FARMSCOPER as 'Upland Grazing' (see Table M1).

b) Farms outside the LFA are mainly arable consisting mainly of winter and spring-sown cereal, with some root crops and potatoes. This farm is hereafter termed the 'Clun arable farm.' It is equivalent to the 'Cereals' Defra Robust Farm Type and is described in FARMSCOPER as 'Mixed combinable with manure' (see Table M1).

Figure M1 shows the extent of the LFA relative to the sub-catchments and arable landcover. Most arable land is located outside the LFA area as described above. This shows that all or the majority of the Upper Clun, Middle Clun, Folly Brook, Unk and Redlake WFD water bodies are within the LFA and therefore we assume that farms in these subcatchments are 'Clun Livestock farms', and therefore farms in the other subcatchments are 'Clun arable farms'. Table M2 shows the sub-catchment agricultural census data comparing the sub-catchments within the Clun. The last two columns provide the sum for the subcatchments that are within the LFA i.e. the Clun arable' farm type and those outside of the LFA i.e. the 'Clun livestock' farm type. This is then the data that is used within FARMSCOPER for each of the farm types for the subsequent steps.

In addition, a local pilot farm is being considered to provide a 'real world' example to test the approach and assess how FARMSCOPER might be used for future farm-facing management in the River Clun catchment. It is important to note that it is unlikely that this example will be able to be included in the plan for data protection and confidentiality reasons but will provide informal ground-truthing of the FARMSCOPER tool.

Step 2 – How do we interface FARMSCOPER and SAGIS?

The second step is to decide how we will run the results from FARMSCOPER in the SAGIS model. SAGIS apportions sources according to arable and livestock sources. The Clun farm types identified in the workshop compare favourably with these classes allowing measure reductions at each of the farm types to be implemented to the SAGIS model based on the assumption that all arable and livestock farms in the catchment **are the same.**

Step 3 - What are the characteristics of the main farm types in the catchment? What losses of phosphorus, nitrogen and sediment losses can we expect?

Using the farm types that have identified in step 1 we can then run FARMSCOPER for each of the Clun farm types to determine the losses of phosphorus, nitrogen and sediment that would be expected. The characteristics of the Clun upland grazing and lowland arable farms are shown in Table M3. The following information has been extracted for each farm type;

a) The **total farm losses** of phosphorus, nitrogen and sediment allow the comparison of different farm types (Table M4) in the Clun catchment. For example, the largest nitrate and sediment losses result from the lowland arable farm type (Table M4); the Clun arable farm generates at least 10 times more nitrogen and 3 times more sediment than the Clun livestock farm (Table M4).
b) The **per hectare losses** of phosphorus, nitrogen and sediment for Clun farm types are shown in Figure M2. For the Clun arable farm type, 75% of the phosphorus loss results from manure application. In upland grazing systems, over 50% of the phosphorus losses in the upland farm are from nutrients voided by animals.

Step 4 –What reductions in nutrient and sediment contributions have existing measures delivered?

The coverage of different catchment measures within the Clun catchment has been mapped as part of the NMP. This includes catchment or riparian measures/prescriptions that are associated with Environmental Stewardship (ES), Environmentally Sensitive Area (ESA) and Area of Outstanding Natural Beauty (AONB) schemes. The Severn Rivers Trust have also delivered a series of in-river schemes. Coverage of different schemes in the Clun catchment is shown in Figure M3. No mapping data are currently available describing the activities of the Catchment Sensitive Farming (CSF) although these are due to be produced later in the calendar year.

Figure M4 provides further detail of catchment measures coverage by mapping only the measures that are ‘likely to improve soil and water quality’ according to a recent review by Natural England. Tables M5 and M6 then summarise the extent of the different measures throughout the Clun sub-catchments to quantify the percentage of the total catchment area that they cover. This information can then be used to assess the effects measures have had on water quality to date.

Step 5 – What reduction in nutrient and sediment loads can we achieve for each farm type? At what range of costs? What cost neutral reductions can we achieve?

FARMSCOPER provides an estimate of the cost of implementing measures from a farmer’s perspective. In some instances these are negative which indicates measures will ultimately save costs to the farmer.

It is possible to run the FARMSCOPER optimiser to assess the balance between the different groups of measures that are applicable to the farms types you are looking at, the relative reductions in phosphorus, nitrogen and sediment they will deliver and the costs to the landowner.

An extract of the output from the FARMSCOPER optimiser is provided in Table M7 for the Clun arable farm. A total of 356 different combinations of mitigation measures have been assessed by FARMSCOPER to identify the range of reductions that are possible at different costs. The data are then presented as a table with increasing costs relative to sets of measures and reductions in phosphorus, nitrogen and sediment delivered. The option closest to cost neutrality in Table M7 (no additional costs to the farmer) is ‘Set 257’. FARMSCOPER suggests that implementation of the cost neutral measures set out in Table 8 will provide reductions of 23% of N, 64% of P and 86% (highlighted in yellow in Table M6).

Step 6 – Is this sufficient to deliver the conservation objectives? If not, what additional actions are required and how much will it cost to deliver the necessary reductions?

In this step, the best-case cost-neutral % reductions predicted by FARMSCOPER for the arable and livestock farms will be applied to the SAGIS baseline model for the Clun catchment. This will determine whether cost-neutral reductions will deliver the medium or long-term favourable condition targets for Freshwater Pearl Mussel (FWPM) and, if not, what further reductions are required.

FARMSCOPER optimiser output shown in Table M7 will be used to match the further reductions required to likely costs that will be associated with these measures. These costs will then be scaled up to the catchment scale.

Step 7 – How realistic are these options? What constraints exist to promoting these measures locally? What are the most effective measures to target for delivery?

In this step, the measures identified by FARMSCOPER will be 'ground-truthed' to reflect local experience of working in the catchment. As an example, Table M8 provides a list of the measures identified by FARMSCOPER that will significantly reduce phosphorus losses from an upland grazing farm. Table M8 provides the predicted losses if they are implemented individually or in-combination as a suite of measures. The local circumstances of farming may mean that some of these are easier to promote than others. It will be necessary to determine based on local experience how realistic suites of measures identified are. This will be done in consultation with local land management advisers working off data similar to that given in Table M8. The FARMSCOPER optimiser can be rerun removing any measures that are not thought to be realistic, to come up with a revised list of measures to assess what reductions will realistically be possible.

Table M1. Farm types in the Clun catchment relative to Defra and FARMSCOPER classifications

Clun Farm Type	Defra Robust Farm Type	FARMSCOPER Farm Type	Commentary	SAGIS sector
Lowland (arable)	Cereals	Mixed combinable	Arable farm with a lot of winter cereals, but some spring cereals and legumes grown in rotation. It receives FYM and / or slurry.	Arable
Upland (LFA Grazing)	LFA grazing	Upland grazing	Farms with more than two-thirds of their total SGM in cattle and sheep (except holdings classified as dairy). A farm is classified as in the LFA if 50% or more of its total area is in the EC Less Favoured Area (both Disadvantaged and Severely Disadvantaged).	Livestock

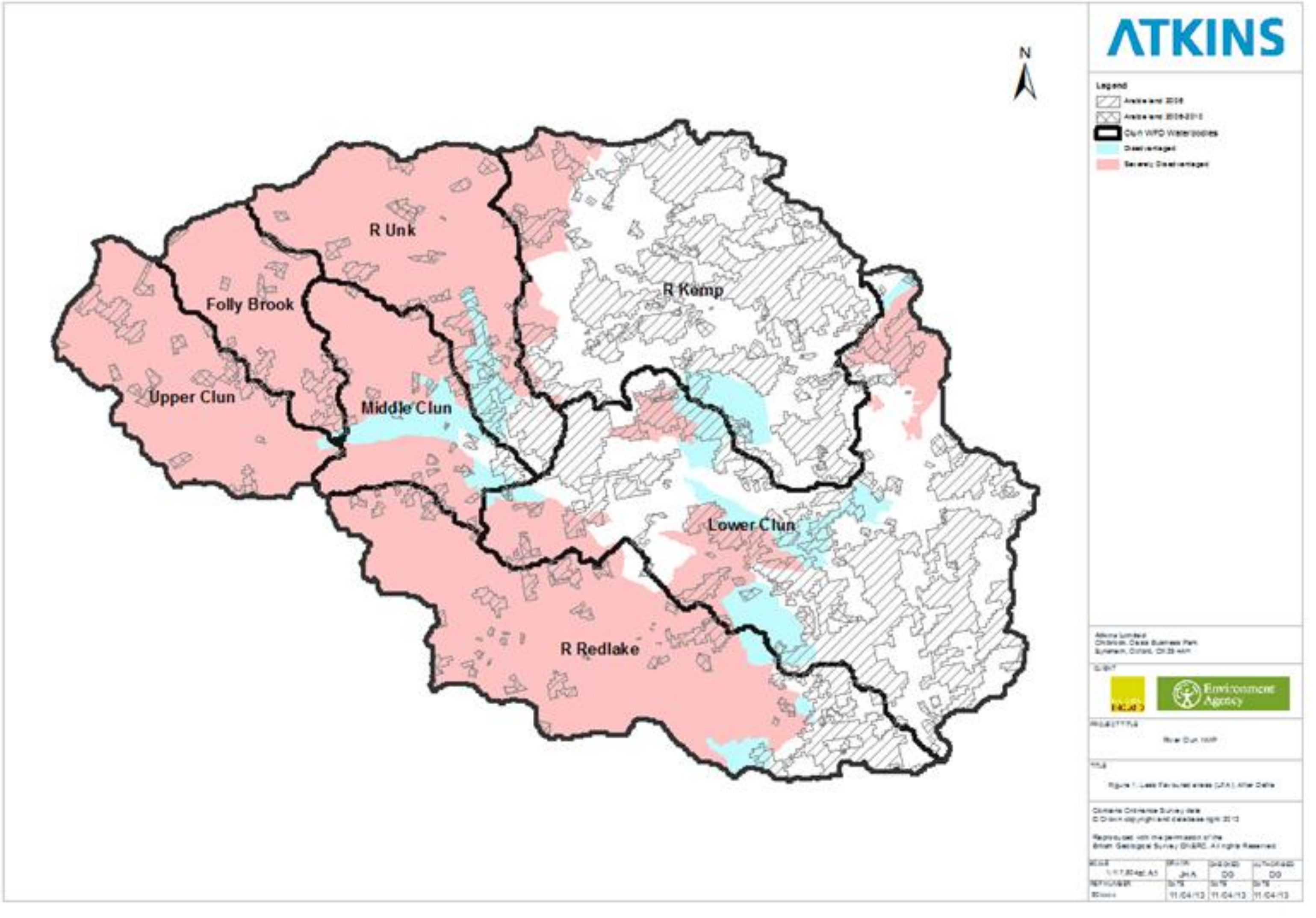


Figure M1. Extent of the LFA in the catchment relative to arable land and WFD water bodies

	WFD Waterbody ID	R Clun - source to conf Folly Bk	Folly Bk - source to conf R Clun	R Clun - conf Folly Bk to conf R Unk	R Unk - source to conf R Clun	R Kemp - source to conf R Clun	R Redlake - source to conf R Clun	R Clun - conf R Unk to conf R Teme	TOTAL		
		GB109054044000	GB109054044020	GB109054043980	GB109054044040	GB109054044060	GB109054043950	GB109054043990			
	Name	Upper Clun	Folly Brook	Middle Clun	River Unk	River Kemp	R Redlake	Lower Clun	Catchment	Within LFA	Outside LFA
	Area (ha)	2,333	1,451	1,907	2,945	6,051	4,938	7,601	27,226	13,574	13,652
	Area (acres)	5,623	3,498	4,595	7,098	14,582	11,900	18,319	65,614	32,713	32,901
Crop type	Wheat	0	0		98	636		445	**1 366**	**98**	**1 081**
	Barley				185	537	98	457	**1 396**	**284**	**994**
	Oats & rye					280		202	**617**	**0**	**481**
	Maize	0	0	0	0		0		**80**	**0**	**0**
	Field bean and peas for harvesting dry	0	0	0		0				**0**	**0**
	Potatoes		0	0	0		0		**52**	**0**	**0**
	Oilseed rape	0	0	0				187	**456**	**0**	**187**
	Sugar beet	0	0	0	0	0	0	0	**0**	**0**	**0**
	Crops for stockfeeding[a]					53		23	**129**	**0**	**75**
Land use	Temporary grass (sown in last 5 years)	190		229	236	596		384	**1 795**	**655**	**980**
	Permanent pasture (over 5 years old)	1 584	1 016	1 806	2 022	2 143	1 958	2 933	**13 461**	**8 385**	**5 076**
	Sole right rough grazing		0				82	53	**250**	**82**	**53**
	Woodland	68	8	19	83	106	49	224	**557**	**227**	**330**
Livestock type	Cattle	1 390	610	2 058	1 823	3 668	1 517	2 847	**13 914**	**7 399**	**6 515**
	Pigs		0						**159**	**0**	**0**
	Sheep	14 901	12 053	15 615	17 030	17 115	17 387	25 181	**119 282**	**76 987**	**42 296**
	Fowl[b]					60 862	997	225 815	**287 784**	**997**	**286 677**

Table M2. Agricultural census data for the Clun catchment

Table M3. Generic FARMSCOPER data for the two main farm types in the Clun catchment

	Clun Upland Farm	Clun Lowland Farm
Arable Cropping (extent, ha)		
Winter Wheat (Milling)	-	102
Winter Barley (Malting)	-	21
Spring Barley	-	23
Winter OSR	-	31
Peas	-	15
Grassland (extent, ha)		
Permanent Pasture	62	0
Rotational Grassland	5	0
Rough Grazing	79	5
Beef (headage)		
Cows and Heifers	22	-
Heifers in Calf (2 years +)	3	-
Heifers in Calf (< 2 years)	1	-
Other Cattle (headage)		
Bulls (2 years +)	1	-
Cattle (2 years +)	11	-
Cattle (1 - 2 years)	14	-
Cattle (< 1 year) & Calves	20	-
Sheep (headage)		
Sheep	358	-
Lambs (< 1 year)	339	-

Table M4. Predicted losses of Phosphorus, Nitrate and Sediment from Clun catchment farm types

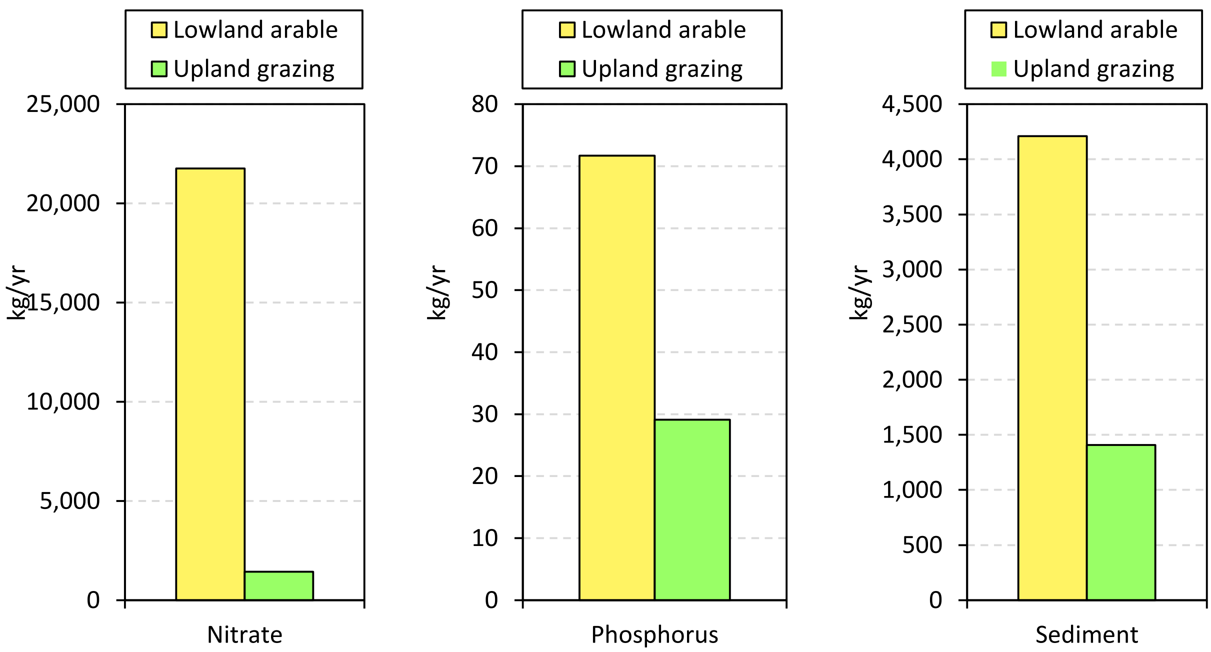
(a) Lowland arable

	Nitrate (kg)	Phosphorus (kg)	Sediment (kg)
Arable	21,617	19.5	4,168
Rough Grazing	20	0.1	42
Other	119	52.1	0
TOTAL	**21,756**	**71.7**	**4,210**

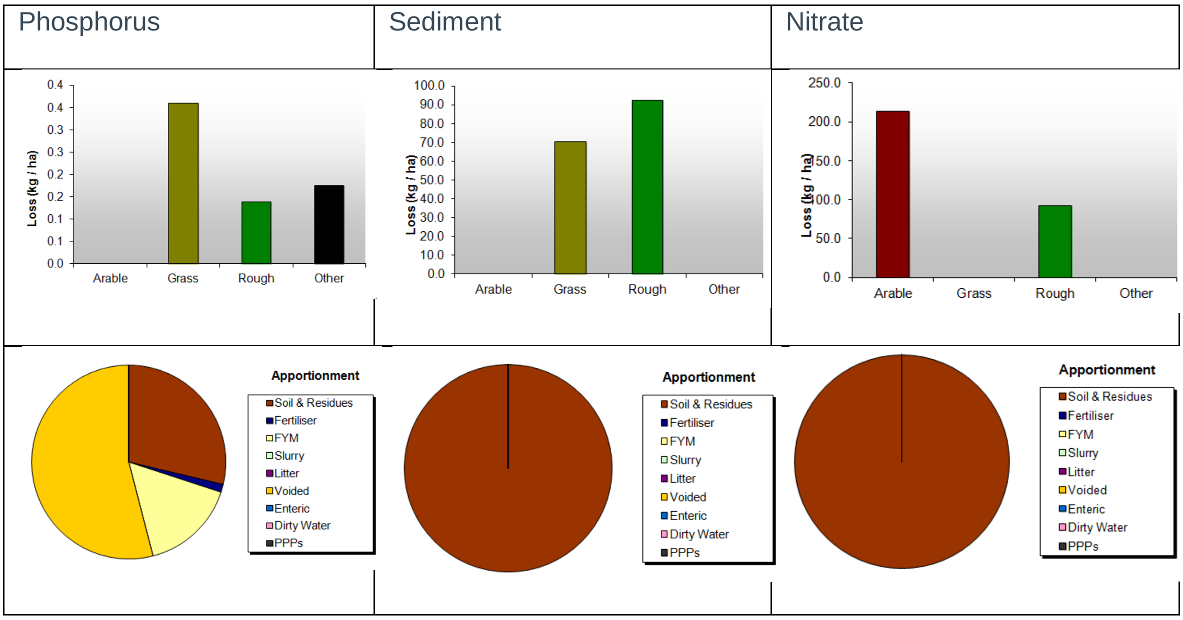
(b) Upland Grazing

	Nitrate (kg)	Phosphorus (kg)	Sediment (kg)
Grass	948	12.6	742
Rough Grazing	394	2.0	666
Other	87	14.5	0
TOTAL	**1,429**	**29.1**	**1,408**

(c) Clun farm type comparison - graphical summary



Clun Upland Farm



Clun Lowland Farm

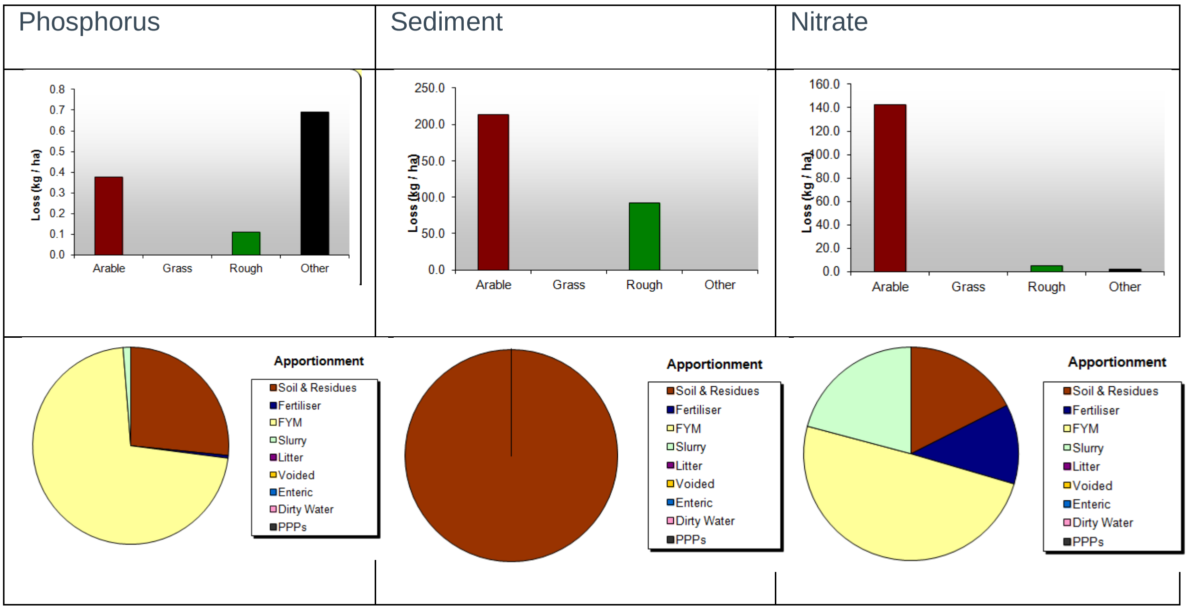


Figure M2. Apportionment of farm sources for Clun farm types

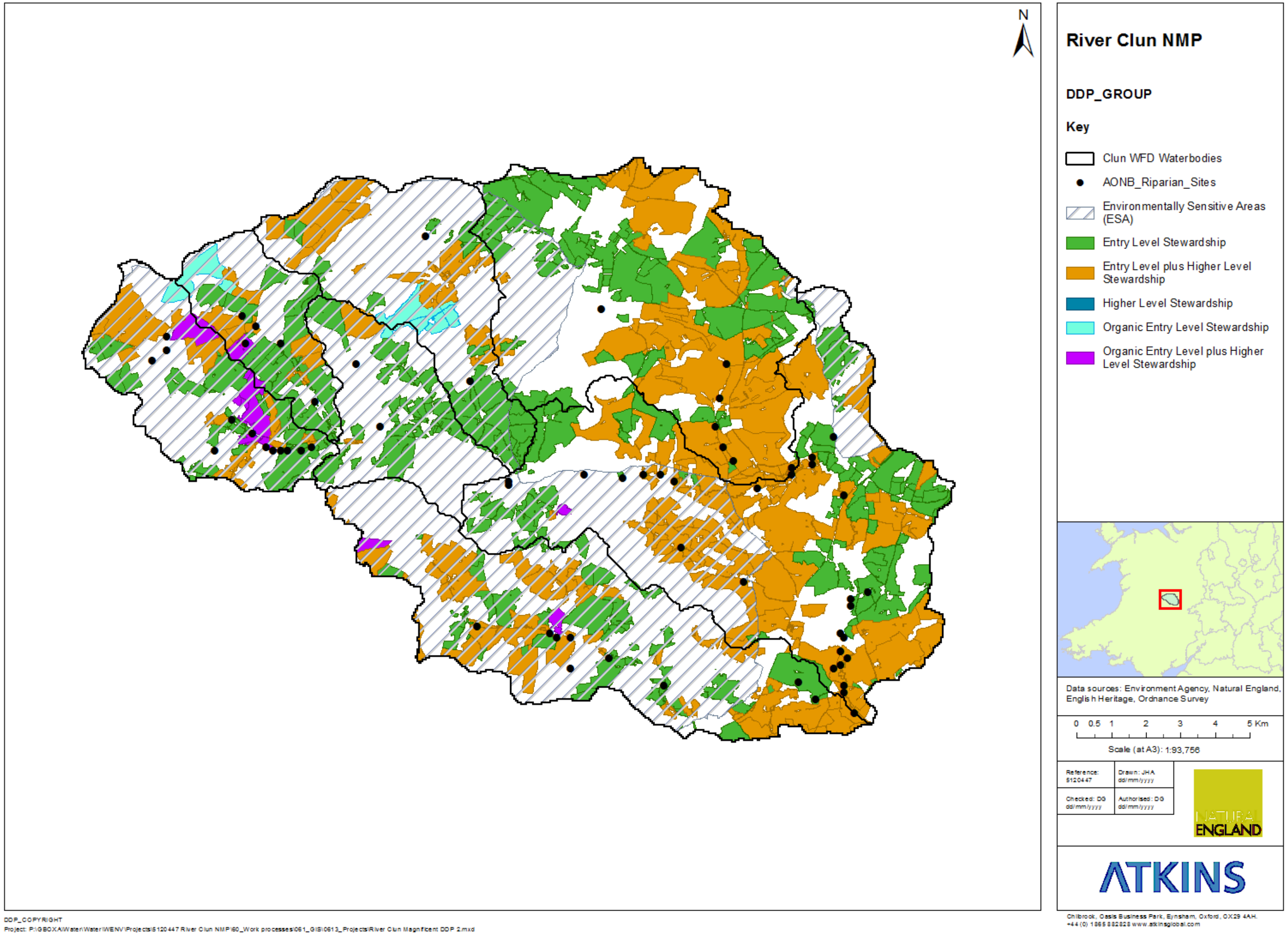


Figure M3. Coverage of ESA, ES and AONB in the Clun catchment

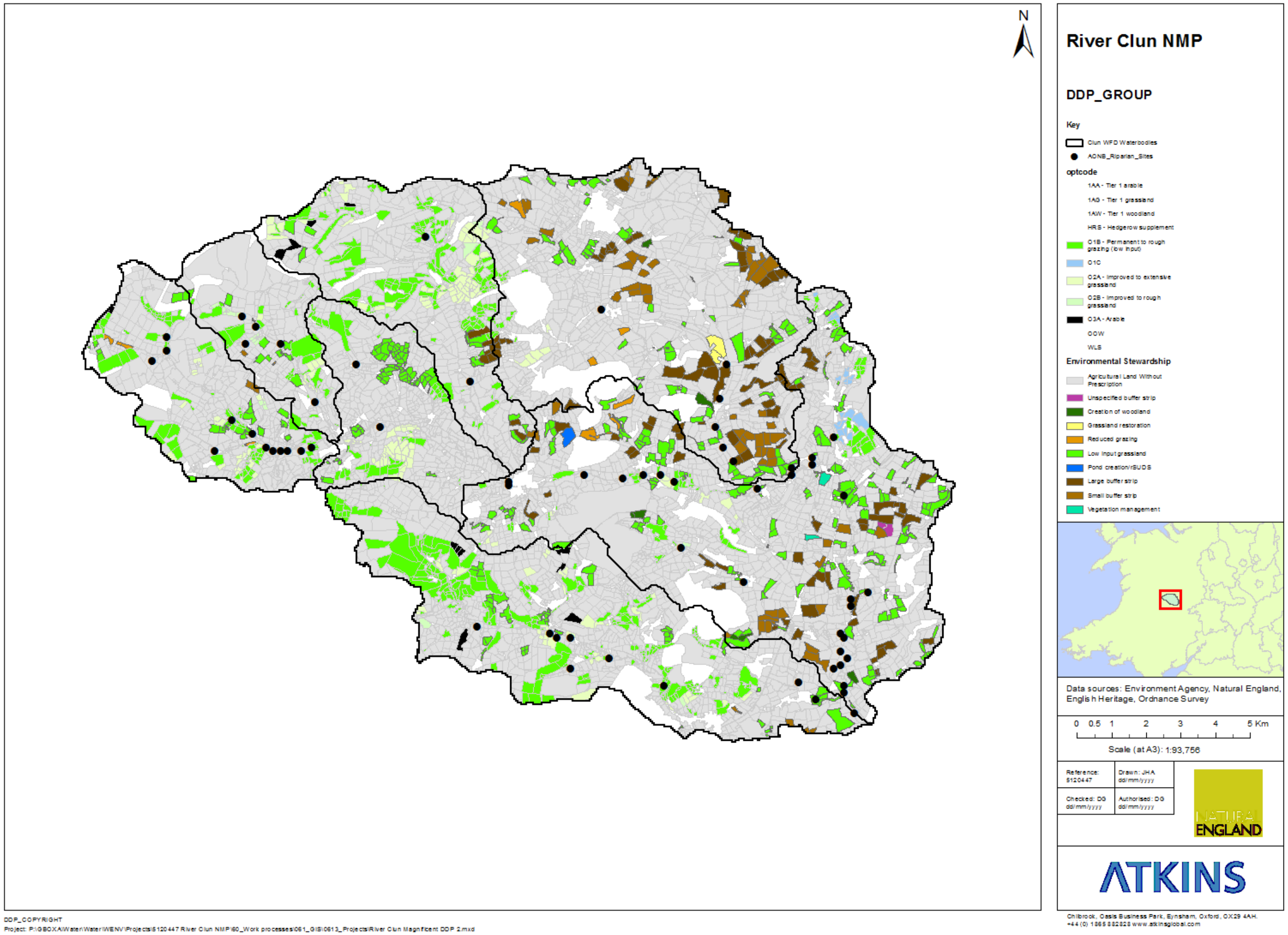


Figure M4. Coverage of ESA, ES and AONB measures in the Clun catchment likely to improve soil and water quality

Option	Option Description	Folly Brook	Middle Clun	Lower Clun	Upper Clun	River Kemp	River Redlake	River Unk	CATCHMENT TOTAL(ha)	CATCHMENT TOTAL (%)
1AA	**All arable land**	348	257	228	74	200	520	492	2,118	7.78%
1AG	**Ley Grasses under 5 years old**	189	572	522	860	242	1,765	1,090	5,240	19.25%
1AW	**Woodland (within all land)**	390	0	4	5	0	18	11	428	1.57%
HRS	**Hedgerow restoration supplement**	2	5	5	1	0	18	0	32	0.12%
O1B	**Permanent Grassland**	324	187	301	366	33	1,674	695	3,581	13.15%
O1C	**Extensive permanent grassland**	0	0	108	0	0	0	0	108	0.40%
O2A	**Reversion of improved grassland to extensive permanent grassland**	31	193	36	51	100	218	308	936	3.44%
O2B	**Reversion of improved grassland to rough grazing**	19	0	3	7	13	11	59	113	0.41%
O3A	**Reversion of arable land to permanent grassland**	0	0	1	11	0	70	40	122	0.45%
O3B	**Conservation headlands**	0	0	5	0	0	0	0	5	0.02%
OOW	**Woodland Enhancement**	0	8	2	9	2	7	5	34	0.12%
WLS	**Wet area supplement**	0	0	0	0	0	0	10	10	0.04%
	TOTAL	**1,303**	**1,222**	**1,213**	**1,383**	**590**	**4,301**	**2,711**	**12,725**	**46.74%**

Table M4. Summary of extents of different ESA tiers and prescriptions in the Clun catchment

Option Description	Folly Brook	Middle Clun	Lower Clun	Upper Clun	River Kemp	River Redlake	River Unk	CATCHMENT TOTAL(ha)	CATCHMENT TOTAL (%)
Creation of woodland	0	0	22	0	16	0	0	38	0.14%
Grassland restoration	0	0	0	0	28	0	0	28	0.10%
Large buffer strip	0	0	300	0	500	0	44	843	3.10%
Livestock removal	0	0	37	9	20	0	0	67	0.24%
Low input grassland	56	150	601	77	288	230	93	1,496	5.50%
Other	794	45	1,773	783	1,356	521	343	5,616	20.63%
Pond creation/rSUDS	0	0	15	0	0	0	0	15	0.05%
Small buffer strip	3	0	105	6	347	12	4	477	1.75%
Unspecified buffer strip	0	0	23	0	0	0	0	23	0.09%
Vegetation management	0	0	14	0	0	0	0	14	0.05%
TOTAL	**854**	**196**	**2,889**	**875**	**2,554**	**763**	**484**	**8,616**	**31.65%**

Table M5. Summary of the extents of different Environmental Stewardship options in the Clun catchment

	Cost (£)			% Reduction		
	Fixed	Variable	Total	N	P	Sed
Set 250	8,330	-10,642	-2,312	16.7	63.1	80.7
Set 251	6,244	-8,447	-2,203	14.6	63.2	85.6
Set 252	5,140	-7,340	-2,199	24.5	30.1	79.6
Set 253	4,448	-6,426	-1,978	24.5	41.2	84.2
Set 254	8,356	-9,939	-1,584	18.7	66.3	85.8
Set 255	5,860	-7,271	-1,411	16.3	65.4	80.2
Set 256	5,098	-5,959	-861	24.6	42.4	85.7
Set 257	**6,244**	**-5,846**	**397**	**22.8**	**64.2**	**85.6**
Set 258	8,682	-8,023	659	16.3	65.3	79.5
Set 259	8,442	-7,496	946	25.0	65.0	82.7
Set 260	2,697	-1,578	1,119	24.7	41.6	85.8
Set 261	8,032	-6,426	1,606	25.0	63.8	81.5
Set 262	7,866	-6,164	1,702	18.7	62.7	84.3
Set 263	8,106	-6,227	1,879	13.6	66.3	83.4
Set 264	4,797	-2,825	1,972	20.3	42.8	87.7

Table M6. Sample output from the FARMSCOPER optimiser, highlighting the cost neutral measures and the potential reductions in N, P and sediment that could be delivered

Measure ID and description		Reduction in farm P loss
61	Store solid manure heaps on an impermeable base and collect effluent	5.6%
76	Fence off rivers and streams from livestock	9.3%
81	Establish and maintain artificial wetlands - steading runoff	12.3%
119	Use dry-cleaning techniques to remove solid waste from yards prior to cleaning	13.6%
120	Capture of dirty water in a dirty water store	9.6%
	In combination	**39.5%**

Table M7. Sample output from the FARMSCOPER optimiser showing the list of measures that will deliver significant (>5%) reductions in P losses from the Clun upland farm

Appendix O. NFU and CLA comments on second draft

O1. NFU comments on second draft

NB: these comments were received after the project was finished and as such they have not been addressed in the final version (v5). They are appended here as information only to be addressed by the Environment Agency and Natural England as the NMP is taken forward.

Date:	21 March 2014
Ref:	
Contact:	Sarah Faulkner
Tel:	01952 400500

Draft River Clun SAC Nutrient Management Plan - Comments from NFU West Midlands

Thank you for giving the NFU West Midlands Region the opportunity to comment on the Draft River Clun SAC Nutrient Management Plan. The NFU is a professional body which represents the interests of 75% of all farmers and growers. Our views are on behalf of the farming and land management sector in general.

We are pleased to see that the current draft has included many of our comments and suggestions from the previous consultation. We have the following comments on the document:

Reductions in N, P and Suspended solids

Given the reductions in P, N and suspended solids outlined in the document, we are still concerned that it will not be possible to achieve these reductions without considerable impacts on the local community.

We remain concerned about the view that “there is still likely to be a need for de-intensification/land use change over a large area” (p177) in order to achieve reductions.

It is helpful that you have acknowledged on page 177 (in response to our previous comments) that “it may be necessary to accept permanently impaired condition in respect of nutrient status in the River Clun given the achievability of the targets is uncertain even in the long term”. This should be acknowledged in the executive summary so that all readers are aware that this is the case.

Clearly we remain concerned about the line in the Executive Summary which states that “Meeting the long term phosphate target of 0.01 mg/l is likely to require reversion in the order of half of the Clun catchment.” This is obviously going to cause concern among the local farming community.

P targets

The plan places too much importance on meeting the numerical P target. Ecology takes time to recover and there is evidence in the literature that “legacy” P stored, accumulated and released can mask improvements in water quality as a result of reduced diffuse pollution. Predicted improvements in-stream concentrations and nuisance algae have often not occurred following reductions of P loadings (see Jarvie et al 2013 – Phosphorus Mitigation to Control River Eutrophication: Murky Waters, Inconvenient Truths, and “Postnormal” Science). Uncertainties are large and the FWPM is dependent on a range of other environmental factors, P targets are only part of the story. The NMP is solely focused on nutrients but other dependent factors should be more clearly acknowledged.

Economic and social benefits of implementation
The executive summary and the Way Forward table (p140) both refer to the ancillary benefits of the delivery of catchment management measures. The plan will need to be far more specific about what these are in order to engage communities and farmers with the plan.

FARMSCOPER
We feel that there needs to be a consistent explanation of the use of Farmscoper throughout the document. References to the top 5 measures require further explanation to make it clear that plan does not call for a blanket approach to the implementation of these measures. There is still work to do to refine the modelling at a farm-scale as the measures are theoretical and based on catchment-wide assumptions.

The wording in the executive summary and part three (conclusions) should also make it clearer that these "Top 5" measures are not being advocated across the catchment in a blanket approach. At the moment it reads as though this is the case.

The wording on p113 gives a good explanation of how Farmscoper outputs ought to be used. However this is a large document and it could easily be missed.

It would also be helpful to have more information on the sensitivity of FARMSCOPER. I.e. results indicate that a reduction of 0.02mg/l can be achieved using scenario 7 and 15, however the margin for error is +/-0.01 mg/l.

Modelling and past improvement
The modelling uses worst-case scenarios and assumes no prior implementation of the diffuse pollution measures, this does not take account of fertiliser reductions, reduced livestock numbers and uptake of other measures such as watercourse fencing. There needs to be a specific section noting the progress that has been made by the industry in the last c.20 years, even if it is difficult to quantify the impact. This is important if you wish to engage the local farming community with the plan.

Changes in practice and an awareness of pollution together the rising costs of fertilisers are acknowledged in 5.1.5, but this could be strengthened throughout the document.

SAGIS
STW apportionment calculations are based on mean outflows. High discharge events (of both flow and elevated concentration) will significantly increase the annual output. SAGIS doesn't consider these.

PSYCHIC
Sediment loads within the River Clun are based on the assumptions of PSYCHIC. We are pleased that you have acknowledged the need for better spatial and long term data in objective 5.

Pressures
5.1.5.3. The statement in the second paragraph contradicts the figures in 3.9.1. Given that the arable area reduced under the ESA, it is unlikely that an additional 1,232ha was ploughed between 2006 and 2012. Could it be that this land use change is related to normal crop rotations? Did the overall level of permanent pasture and temporary grass remain stable during the same period? What is the annual breakdown? This needs to be clarified so that we can tell if this really is an additional 1,232ha or if it is a result of rotations.

5.1.6. As raised in our previous comments we strongly disagree with the statement in the first bullet point " The need to extend productive farm land has reduced the majority of the Clun's riparian tree habitat to a single line of trees perched along the bank edge". This is unlikely to have happened within living memory. In recent years there have been significant areas of fencing along the river and many farmers have installed wide buffer strips via agri-environment schemes. Tree planting has also been supported by many initiatives in the Clun. Therefore the recent trend has been toward sensitive manage of the bank side, but this is not mentioned in this section. The bullet point about a "heavily grazed environment" also fails to acknowledge the impacts of bankside fencing and tree planting.

5.1.8. Recent EA studies have shown that silt removal can be beneficial in some catchments but this is not acknowledged in this section. In the past silt was regularly removed from the river and this may have been beneficial to the pearl mussel population. The explanation of dredging in this section is not specific to the Clun catchment. An assessment of how sensitive silt removal may benefit the pearl mussel has not been undertaken.

7.2 Diffuse Sources
7.2.5.2. NVZ measures
The paper does not include an adequate explanation of how and why you have used NVZ measures for the modelling. There needs to be an explanation of what NVZs are and how they are designated.

The document indicates that the annual average nitrogen level is around 4mg/l. This is far lower than the threshold of 50mg per litre (mg/l) nitrate which would trigger an NVZ designation. Therefore it is not clear why the modelling looks at the use of NVZ measures, given that the current declining trends mean there is no prospect of designation being triggered in the catchment. Please be aware that local farmers would be very concerned about the economic impacts of the implementation of an NVZ in the area.

During our recent meeting you indicated that you were most concerned about algal blooms in the Clun and their impact on the pearl mussel. One of the negative impacts of an NVZ would be the closed period. This would mean that all farmers had to empty slurry stores in the period following the closed period. This would provide a large release of nutrient which may feed spring algae growth. This could potentially make the algae problems worse for a short period which could potentially be detrimental to the pearl mussel.

7.2.6.1.4 Other diffuse source measures
We are relieved that you have acknowledged that reversion of parts of the catchment to woodland is not a realistic scenario. We agree that this would have high level socio economic impacts on the local community.

Objective 5. Investigations p 139
Q. Poultry manure. The investigation should also take account of the benefits of spreading poultry manure. Incorporating organic matter can help to build soils structures and reduce susceptibility to erosion.

R. Field Drains. This investigation must also assess the economic importance of the existing drainage infrastructure.

U. We are concerned about the action outlined in Objective 5 U (p139) which suggests a formal assessment of land use change covering the pre-war period to the present day is required. How would this be useful? If it is not possible to take account of past best practice measures, how can land use change be correlated to FWPM populations? Would it simply be used to demonstrate that agriculture has changed since the 1940s and that pearl mussels have declined and therefore validate the assumptions regarding land use change. Things have changed since the 1940s as a result of government policy that was geared towards achieving food security for a growing population. However, as we said during our recent meeting, improvements over the last c.20 years are consistently ignored. We don't see how this investigation could be robust or add anything to the understanding of the present-day situation.

Pear Mussel Rivers
Page 178 (response to NFU comments) gives some interesting information about pear mussel rivers, however this information is not related to the River Clun. Does the Clun fall into the second

category and has the risk assessment of juvenile populations been carried out. It does not appear on page 139.

Active management of pearl mussel beds (p. 185)
We are disappointed that you have been so dismissive of our suggestion that active management of the pearl mussels be considered. We still think that an assessment of practical and innovative measures to conserve the pearl mussel beds needs to be incorporated into the plan. These are legitimate questions that are likely to be raised by the local community, therefore a full explanation of why in channel management is not appropriate must be incorporated into the main plan.

Flooding
More information is required to understand the impact of flood events to the FWPM and to focus resources. We are concerned that catchment measures may not be effective if the population is irreparably affected by flooding.

O2. CLA comments on second draft

NB: these comments were received after the project was finished and as such they have not been addressed in the final version (v5). They are appended here as information only to be addressed by the Environment Agency and Natural England as the NMP is taken forward

Steve Foster
Water Framework Directive, Diffuse Pollution
Senior Environment Officer
Midlands Regional Office,
Sapphire East,
550 Streetsbrook Road,
Solihull,
West Midlands, B91 1QT

Dear Steve,

Response to the Clun Nutrient Management Plan

The Country Land and Business Association (CLA) is a national organisation embracing the owners and occupiers of all types of rural land and business in England and Wales. It represents the interests of the owners of some 34,000 land holdings and rural businesses. The Midlands region represents over 6,000 members.

CLA members include every size and type of holding, from estate owners to the smallest land holding of less than a hectare. The membership encompasses all traditional agricultural and forestry from the most sophisticated dairy and arable enterprises, pigs and poultry, through to highly more extensive livestock systems. The majority of our landowning membership is made up of family farm owner-occupiers many of whom have diversified into other business activities in response to the downturn in farm incomes.

The CLA also represent the interests of owners of other types of rural businesses including, for example: forestry enterprises, mineral and aggregate operators and owners, hotels, golf courses, tourist enterprises, equestrian establishments, a myriad small rural enterprises and also institutional land owners such as water companies, pension funds, and development companies.

The CLA represents the wide diversity of the rural community and is the only single organisation able to do so in quite so comprehensive a manner. The River Clun SAC is covered by the Midlands Region of the CLA and we are glad of the opportunity to be an active partner in any consultation exercises or decision making processes in which rural business and the communities form part. We are pleased to see that the current draft has included many of our comments and suggestions from the previous consultation. We have the following comments on the document.

Introduction

The rural economy is dependent on good water quality for supporting wildlife, fishing and other recreational activities. Good water quality is required by land managers to water their stock, irrigate their crops and for drinking, even from private supplies.

Over recent years the Nitrates Directive has been a significant driver to reduce nitrate pollution of water courses. Water quality will continue to be important for land managers through the Water Framework Directive’s (WFD) requirement in all European Union countries to achieve “good ecological status and the introduction of tests for “wholesomeness” under the Private Water Supplies Regulation 2009.

The main issue for farmers and land managers is diffuse pollution of water from nitrates, phosphates, sediment and pesticides. Pollution from all four has fallen since 2003, nonetheless the industry has made huge strides that should be recognised with the total number of pollution incidents in 2006 falling by more than a third (35 percent).

The plan failed to recognise that agriculture is an integral element of the environment, with land managers as custodians. Over emphasis on environmental protection risks creating a biodiversity rich landscape with no businesses, thereby choking the economic vitality of our rural areas. This cannot be sensible.

The River Clun

The CLA strongly support the need for development in the Clun and we understand that the nutrient management plan is required for the protection of Pearl Mussels. The towns, villages and communities in the

Clun catchment need to grow as stated in the Shropshire Council Local Plan, it is important that these villages and settlements are not allowed to become fossilized, and must retain their vitality and viability by allowing development of dwellings and employment.

In order for these communities to grow there needs to be improved sewage treatment/phosphate stripping at Lydbury North and Clun. Developments in the wider catchment should be allowed if they can show they are contributing little to the overall phosphate in the catchment.

Please note that the FWPM's are not the primary reason for SAC designation – also otters, crayfish, bullheads, lampreys and salmon.

The CLA comments are as follows:

Clun Nutrient Management Plan

This part of the document should not be called a Nutrient Management Plan, it is an evidence and scoping document. The Nutrient Management Plan should be the action plan that Natural England, Environment Agency, Water Companies, Shropshire Council and farmers work together to draw up. It should be made very clear in this document that this is not the Nutrient Management Plan but the evidence to support a Nutrient Management Plan.

Extreme weather events will cause run off and sediment which is out of the control of farmers and advisers, and cannot be dealt with through a regulatory approach.

Awareness of pollution and the rapid rise in the cost of fertilisers have encouraged land managers to be more cautious in their use of nutrients through nutrient planning, such as precision farming techniques and using the *Tried and Tested* approach which has been developed by the CLA and industry partners. See www.nutrientmanagement.org for further details and to access the paper-based tool to plan nutrient applications.

These methods leave much lower nutrient residues that can be potentially leached or eroded, and save money. Farmers and land managers only apply the nutrients that the crop requires, this makes financial sense, but it is important that farmers receive the latest advice and information on this issue.

Overall water quality has been steadily improving. This is clear from the fall in the number of serious pollution incidents and the increase in the total number of miles of rivers in favourable condition. It can take over 10 years to see reductions in diffuse pollution due to land use changes and the nutrient management plan needs to recognise this.

Page 14: The 'way forward' section does not mention the action plan or the restoration and conservation strategy which is currently being developed.

Page 20: The CLA wants reassurance that models are not used as evidence but rather as a tool to inform the evidence paper. The modelling work that has been undertaken at a catchment scale level is based on average farms and this must be tested with individual farmers in the catchment.

Page 22: The CLA would like more information about the Hydrological investigations of a potential relocation site for freshwater pearl mussels that was undertaken by Atkins 2013.

Page 27 Freshwater Pearl Mussel

The CLA do have some concerns that the freshwater pearl mussel population is not viable and will not be functional in the long term. Page 16 states the population is non functional /'functionally extinct'. Appendix C freshwater pearl mussels - states that most freshwater pearl mussels are moribund and that some were being eaten by Gammarus. The CLA would like to see further investigation into Gammarus predation of the pearl mussel. The CLA is very concerned that freshwater pearl mussels are almost extinct and it is estimated they will only survive for another 20 years. Implementation to tackle diffuse pollution will take too long and the freshwater pearl mussels will be extinct. The CLA would also like further research into how the pearl mussels have coped with the 2014 floods, and the numbers that now in the Clun SAC.

The CLA is also concerned about the lack of salmonids data as freshwater pearl mussels must have salmonids for their reproduction.

This evidence based document does not mention the removal of some of the Shropshire freshwater pearl mussel population to Ennerdale, Cumbria or how that population faired during the dry years of 2011 and 2012. The following link explains how 90% of the population died because of oxygen levels dropped. http://www.bbc.co.uk/nature/18627801. The CLA would like to know how many of the Shropshire freshwater pearl mussels have survived in Ennerdale and what proportion of freshwater pearl mussels were moved there. Also, it would be useful to have an update about the freshwater pearl mussels in the River Usk and how Natural resources Wales are managing them.

Catchment Character

The Clun Nutrient Management plan recognises that the soils in the catchment are silty and prone to move, leading to more sediment. The report makes reference to the work that has been carried out to fence watercourses and the establishment of buffer strips but this is data from 2006 - over 8 years ago.

Page 42 The CLA would like to see further investigation into the amount of woodland in the Clun catchment, the pie chart indicates there is only three percent of woodland in the catchment; large areas of woodland would not be recorded on the Defra agricultural census. When viewing google maps there are large areas of woodland not recorded on Map 15.

Map 11 clearly shows currently that the whole catchment is covered by environmental stewardship, the CLA are concerned that there will not be the same cover of environmental stewardship in the future.

Catchment Sensitive farming page 51

The Clun catchment was a pilot catchment for the Catchment Sensitive Farming initiative which started in 2005 and has contributed to the decrease in phosphates in the water. It is important to show how farmers have used the capital grant schemes in this area. Many farmers have applied for river fencing; the document should state how much river fencing has taken place and the projects that have been funded through CSF as these will all help to reduce diffuse pollution.

4.1 Phosphate

The CLA are pleased that the document recognises that the current levels of phosphates in the river are very low and falling, and the mean annual concentrations have been 0.03mg/l

The draft nutrient management plan should recognise the long-term trends in the reduction of phosphorus fertiliser, feed use and manure production. Use of phosphate has declined by 67% on grassland and 51% on tillage land since 1990, while phosphate from manures has reduced by 20% between 1990 and 2012. Please see a link to the resent document published by Defra on fertiliser use, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/192605/fertiliseruse-report2012-25apr13.pdf. It is now accepted practise in the agricultural industry to carry out soil nutrient analysis to avoid applying expensive fertiliser to nutrient rich soils, this will lead to further reductions in phosphate in the river over time.

To achieve a level of 0.02mg/l phosphorus, further measures may need to be put in place. Farmers and land managers will need the continuing support of Catchment Sensitive Farming, environmental stewardship and other schemes if land use change is required. Farms are businesses and they need to be economically viable. Some measures to reduce sediment and phosphate entering the river may make these businesses unviable leading to a need for further financial support.

Long term measures to improve water quality by improving soil management, structure and organic matter in the soil will see reductions in diffuse pollution but only after a decade; the plan needs to recognise this. The CLA is concerned that the long term goal of 0.01mg/l is unrealistic and we seek reassurance that this is a long term objective.

4.2 Nitrogen

The amount of total oxidised Nitrogen does not seem to vary much throughout the year (figure4.6) one would assume that total oxidised nitrogen would be much lower in the summer, considering plants would be using the nutrients.

5.1.2: The CLA would like to see further investigation into the impacts of rural septic tanks on the catchment as there are 450 private treatment plants in the catchment.

5.1.5.3: The CLA want to know why the report suggests that more soil is lost from winter cereals than spring cereals as there would be more bare soil with spring cereals.

Page 74 Land Cover Map 15; It is clear that most of the white “not classified areas” are woodland thus altering the proportion of land use in the catchment.

Source Apportionment

By showing the source apportionment as a percentage even when phosphate percentage reduces, the apportionment will still be the same. The data will never truly reflect decreases in source apportionment because as each sector reduces equally, the pie chart will stay the same.

Page 82 The data of phosphate concentration for four of Severn Trent’s sewage works is based on data from 2008 and Clunbury is based on an estimation.

The CLA would like to see further monitoring of the sewage works to obtain current data rather than relying on data which is 6 years old. The second paragraph should read figure 6.3 not 6.4. Map 16 PSYCHIC Phosphate shows a high risk area for phosphate loss at the top of the Clun catchment and it would be useful to understand why this is a high risk area, as it is a grassland.

There needs to be monitoring at Seven Trent sewages works for the amount of total oxidised nitrogen being released rather than the data being based on assumptions. Map 17 NEAP-N and Map 16 do not seem consistent:

Page 91 The document reports that "Jacobs Babtie (2006) undertook a walkover survey of the channel of the River Clun and identified bank erosion through natural fluvial processes as an important source of sediment to the river, occurring along 13% of the river length. Poaching by cattle was seen along 4% of the river. Surface runoff was also seen to be a sediment source. 70% of the river is lined by trees, which help to stabilise the banks. 29% of the river was lined with appropriate fencing and riparian buffer strips were only present on around 5% of the river." 5.1.6. states" The need to extend productive farm land has reduced the majority of the Clun's riparian tree habitat to a single line of trees perched along the bank edge". As 70% of the river is lined with trees how much additional tree cover does NE and EA think the catchment needs? In the future, Natural England should support farmers and landowners to plant more trees to stabilise the bank. The Clun catchment needs further support to tackle the issue of phytophthora in the alder trees as this is contributing to bank side erosion, funding should be available through initiatives like CSF and funding for riverside tree planting.

How much fencing does the catchment have now compared to 2006 when 29% of the river had appropriate fencing - has this now increased because of Environmental Stewardship and the Catchment Sensitive farming initiative? The walkover survey shows that farmers are tackling diffuse pollution and the CLA would like to see further walkovers to investigate livestock fencing and phytophthora.

Monitoring data Page 99

The report states "Monitoring data indicates that a large proportion of the total sediment recorded in the River Clun SAC at Leintwardine is sourced downstream of Clungunford and that only a small proportion of the total sediment load is likely to be generated in upstream tributaries such as the Folly Brook. Monitoring data would appear to suggest that, on an annual basis, more than two thirds of the overall sediment load passing through the River Clun SAC is generated downstream of Clungunford "

If two thirds of the sediment load that passes through the Clun SAC is generated downstream of Clungunford then this has to be the area that Natural England should concentrate on in the future. If the evidence is correct then projects such as catchment sensitive farming should be concentrating on areas such as the Red Lake river catchment see page 51.

Options Appraisal

Page 119, please could you provide us with further details on how planting grassland with wild bird seed and nectar flower mixtures can reduce sediment in the water course.

None of the measures in FARMSCOPER reduce Nitrate levels as the nutrient management plan shows there needs to be a 66% decrease in nitrogen (page 101)

Page 124; most of the measures listed in the scenarios are already good farming practice which the majority of the farmers are implementing. Farmers are already using nutrient management tools.

The options appraisal relies on 100 percent uptake of different options and this is unachievable. The CLA would like assurances that the scenarios carried out in the option appraisals are just theoretical measures to show nutrient reductions and that the action plan going forward will be guided by all stakeholders.

The CLA would like to see FARMSCOPER tested at a farm level to check that the assumptions made at a catchment level are correct at a farm level. Moving forward, the plan has to ensure it has a sound evidence base, modelling tools such as FARMSCOPER are only as good as the evidence base. The CLA would also like assurances that as new models and evidence become available, the nutrient management plan is updated.

The plan wants to see a fifty percent reduction in the suspended solids by 2027, this will increase financial burdens on farmers in the catchment with farmers and landowners seeing no increased income for carrying out these measures. The river already has high levels of sediment which is affecting the freshwater pearl mussels, and the CLA would like to know how NE and EA will solve this issue in the short term, as it will take many years for the sediment to be removed naturally from the river when the freshwater pearl mussels need a reduction in sediment urgently. CLA would like to be kept informed about the restoration and conservation plan for the freshwater pearl mussels.

The majority of farmers in the Clun catchment are upland farmers who experience low financial returns,, although some of the measures to reduce phosphate and sediment may save farmers a little money other measures will cost more money. How will these upland farmers afford this? Will there be grant funding to assist the farmers in achieving the water quality measures the SAC requires?

CLA are concerned that the reductions in P, N and suspended solids outlined in this document, will not be possible to achieve without considerable impacts on the local community. We remain concerned about the view that “there is still likely to be a need for de-intensification/land use change over a large area” (p177) in order to achieve reductions.

The CLA would like the Environment Agency and Natural England to look at the possibility of using ecosystem services as a way of reducing nutrients in the Clun catchment. This would mean that farmers would be paid for producing clean water for the freshwater pearl mussels. As the freshwater pearl mussels are very valuable then the payment to produce clean water should reflect this.

Conclusion

The draft nutrient plan must allow time for the impact of recently introduced land use policies and measures to be established and assessed through sampling. Farmers and land managers should not be asked to carry out additional practises until benefits from other practices have been assessed.

Much of the catchment is in an ESA where the basic management prescription is to ensure there is no increase in arable areas. The agreements finish in 2014 when farmers will have the opportunity to change the use of their land. Farmers and land managers will need additional support in reducing the nitrogen, phosphorus and sediment in the catchment when this scheme ends.

The CLA stresses that land managers need to be involved in this process and need to be able to understand the science and benefits from the actions they will be required to carry out.

The CLA would suggest the use of incentives rather than regulation to encourage land use change where it is necessary to deal with some aspects of diffuse pollution of water.

Please contact me if you would like to discuss this further.

Yours sincerely

Donna Tavernor
Rural Adviser

CLA Midlands

David Gasca
Atkins
Chilbrook
Oasis Business Park
Eynsham
Oxford
OX29 4AH

david.gascatucker@atkinsglobal.com
01865 882828
01865 734267
01865 883060