CORE MANAGEMENT PLAN INCLUDING CONSERVATION OBJECTIVES

FOR

Afon Tywi / River Tywi SAC

Noddir gan
Lywodraeth Cymru
Sponsored by
Welsh Government

Version	Date	Summary of changes made	Approved by
Version 2	September 2022	• Updated NRW branding and format • Updated units based on WFD waterbodies (original 7 units changed to 4 units). • Reformatting of Unit and Feature Tables to improve clarity. • Clarification of the relationship between Conservation Objectives and Performance Indicators. • Performance Indicators moved into an Appendix. • Inclusion of water quality standards provided in the updated CSM guidance for rivers 2016. • New Appendix 2 with full details of water quality standards. • Revision of Conservation Objectives and Performance Indicators for the fish features. • General content updated (from original 2008 version) in 2014.	Caroline Drayton
Version 1	April 2008		Tracey Lovering

Contents

Preface

This document provides the main elements of Natural Resources Wales' management plan for the site(s) named. It sets out what needs to be achieved on the site(s), and advice on the action required. This document is made available through Natural Resources Wales' website and may be revised in response to changing circumstances or new information. This is a technical document that supplements summary information on the Natural Resources Wales' website.

One of the key functions of this document is to provide Natural Resources Wales' statement of the Conservation Objectives for the relevant Special Area of Conservation (SAC) and Special Protection Area (SPA) site(s). This is required to implement the changes through the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 in addition to the existing Conservation of Habitats and Species Regulations 2017. As a matter of Welsh Government Policy, the provisions of those regulations are also to be applied to Ramsar sites in Wales.

Vision for the site

This is a descriptive overview of what needs to be achieved for conservation on the site. It brings together and summarises the Conservation Objectives (part 4) into a single, integrated statement about the site.

The purpose of the designation of SAC and SPA sites is to help secure the maintenance or restoration of habitats and species to favourable conservation status *for the foreseeable future*. Given that we foresee a changing climate, despite the uncertainty of the nature, degree and timing of those changes, we must address the need to ensure the resilience of each site to that changing environment. This will be achieved in the first instance by ensuring favourable condition of the important features, since a healthy feature is likely to be more resilient to the effects of climate change than one which is already stressed. Secondly, consideration must be given to those structures, functions and processes which maintain or boost the resilience of ecosystems to climate stress, including the avoidance, reduction or mitigation of other stress factors such as invasive species, nutrient enrichment, habitat and population fragmentation.

This site forms part of a wider network, and is ecologically connected with its surroundings and with other designated sites in the region. Although the focus of this document is on the individual site, the conservation objectives and management requirements need to be considered in the wider context. A connected network of sites is more robust than sites in isolation, and more resilient to pressures such as climate change.

Our vision for the Afon Tywi SAC is to maintain or, where necessary, restore the river to high ecological status, including its largely unmodified and undisturbed physical character, so that all of its special features will be able to sustain themselves in the long-term as part of a naturally functioning ecosystem. Allowing the natural processes of erosion and deposition to operate without undue interference and maintaining or restoring connectivity will maintain the physical river habitat, which forms the foundation for this ecosystem. The quality and quantity of water, including natural flow variability, and the quality of adjacent habitats will be maintained or restored to a level necessary to maintain the features in favourable condition for the foreseeable future. In places such as urban environments where natural processes are likely to cause significant damage to the public interest, artificial control measures are likely to be required.

The special fish species found in the river, both residents such as the bullhead and brook lamprey, and migratory species such as shad, river & sea lamprey, will be present in numbers that reflect a healthy and sustainable population supported by well-distributed good quality habitat. The migratory fish will be able to complete their migrations and life cycles largely unhindered by artificial barriers such as weirs, pollution, or depleted flows.

The abundance of prey and widespread availability of undisturbed resting and breeding sites will allow a large otter population to thrive. They will continue to be found along the entire length of the river and its main tributaries.

The presence of the Afon Tywi SAC and its special wildlife will enhance the economic and social values of the area by providing a high quality environment for ecotourism, outdoor activities and peaceful enjoyment by local people and visitors. The river catchment's functions of controlling flooding and supplying clean water will be recognised and promoted through appropriate land management. The many oxbows and paleochannels distributed across the floodplain are rejuvenated at the times the river floods while at the same time they serve to contain the flood waters and to clean the water before it returns to the main river. Providing a mosaic of semi-natural wetland and woodland habitats within a predominantly pastoral landscape will contribute to this function. The numerous tributaries are also important in helping to maintain the populations of many of the site's special features – all the fish species and the otter. The river will continue to be a focus for education to promote increased understanding of its biodiversity and the essential life support functions of its ecosystems.

Site description

Area and Designations Covered by this Plan

Grid reference: SN687263 (mid), SN761347 (top), SN405179 (bottom)

Unitary authority: Carmarthenshire County Council

Area (hectares): 363.45 ha

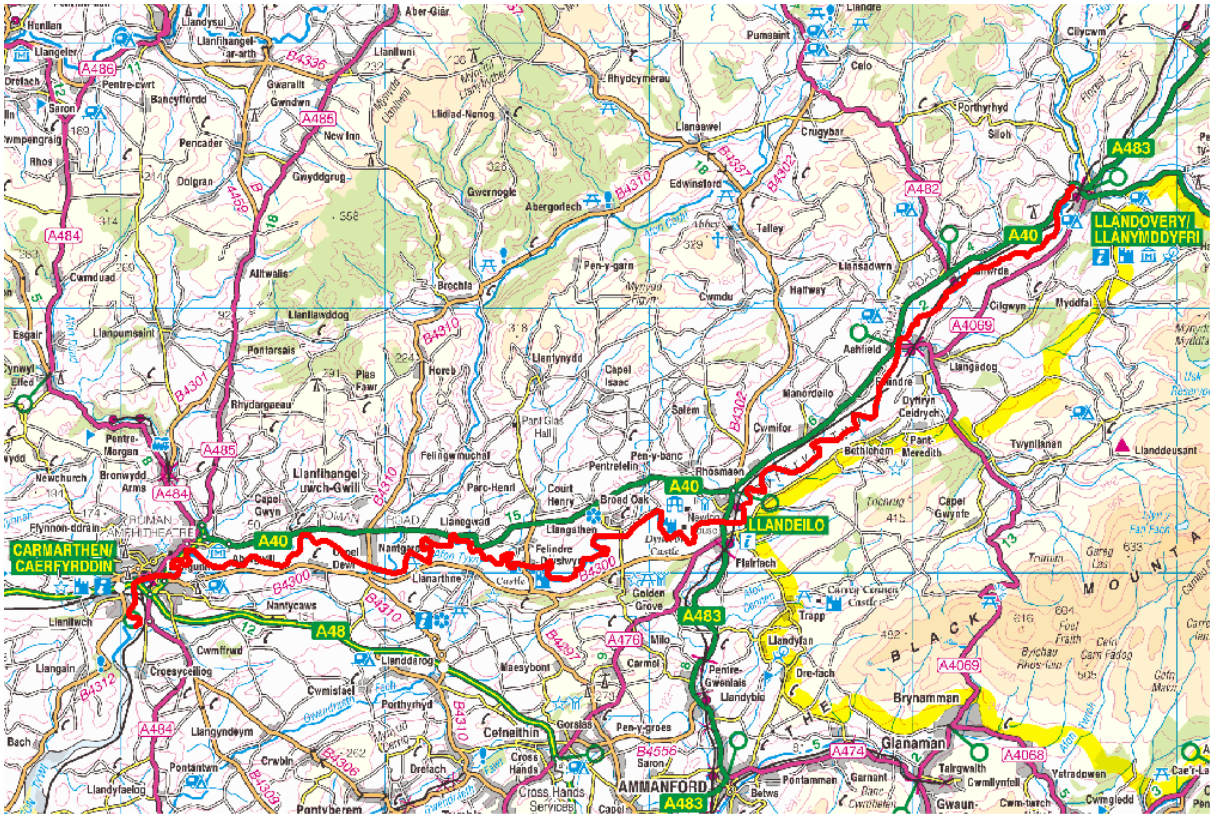
Designations covered:

Afon Tywi / River Tywi SSSI (part)

Afon Tywi / River Tywi SAC

Detailed maps of the designated sites are available on the Natural Resources Wales web site.

A summary map showing the coverage of this document is shown below.



Outline Description

The Afon Tywi rises in the Cambrian Mountains and flows south for some 10km before entering Llyn Brianne reservoir. The reservoir was constructed in the early 1970s to regulate water flows in the Tywi, enabling abstraction for public supply at Nantgaredig. From Llyn Brianne the Tywi falls steeply through mountain valleys for a further 20km before reaching the upper boundary of the SAC at Llandovery Road Bridge. The river then flows in a broadly south-westerly direction to Llandeilo, and then westerly through Carmarthen to outfall into Carmarthen Bay at Llansteffan. The Afon Tywi SAC boundary terminates in the tidal reaches just south of Carmarthen, where it enters the Carmarthen Bay & Estuaries SAC.

The freshwater reaches of the Tywi are some 110km long, with just short of 80km designated as SAC. Within the SAC its course is more characteristic of a mature river, falling just 65m between Llandovery and the sea. The valley, formed by the movement of glaciers during the last ice age, has a classic U-shape, steep sided, with a wide, flat bottom. Its underlying geology of alluvium, glacial sands and gravels has resulted in an actively eroding river meandering across its wide floodplain, with generally sparse tree cover along the banks. This has led to the formation of extensive shingle shoals, ox-bow lakes and former river terraces. A number of significant tributaries flow into the designated reach, including the Llandovery Bran, Afon Dulais, Sawdde, Cennen, Cothi and Gwili.

As a meandering river, the boundary of Afon Tywi SAC is necessarily a fluid one. It incorporates the whole of the main river channel between Llandovery road bridge and the southern boundary with Carmarthen Bay and Estuaries SAC below Carmarthen. Everything lying between the left bank and the right bank is part of the SAC including all in-channel features, such as unvegetated shingle banks. Some shingle banks can become vegetated to the point that they can form a new banktop boundary. At some points along the river the designated site also includes areas of broad-leaved woodland, and old backwaters of the river.

The ecological structure and functions of the site are dependent on hydrological and geomorphological processes (often referred to as hydromorphological processes), as well as the quality and connectivity of riparian habitats. The more mobile species, such as migratory fish and otters, may also be affected by factors operating outside the site.

Hydrological processes, in particular river flow and water chemistry, determine a range of habitat factors of importance to the SAC features, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen levels and water temperature. Maintenance of both high ‘spate’ flows and base-flows is essential. Reductions in flow may reduce the ability of the adults of migratory fish to reach spawning sites. The flow regime should be as near to natural as constraints will allow to support the functioning of the river ecosystem. The solid geology of the upper reaches and tributaries result in catchments which respond quickly to rainfall. The area has an extremely high annual average rainfall with variations both spatially and seasonally. Annual average rainfall is highest in the Black Mountains and the Cambrian Mountains, at 2,420mm and 2,008mm respectively. Rainfall decreases

down the valley sides and into the bottoms, with lowest rainfall occurring in the coastal areas. The topography of the area is such that catchments respond quickly to rainfall events, with rapid changes in river levels along their lengths.

Base flows in the Tywi are enhanced by releases from Llyn Brianne, though diurnal variations occur below the abstraction at Nantgaredig, pumping being mainly at night and over the weekends. This notwithstanding, the catchment is protected from low summer and drought flows.

Geomorphological processes of erosion by water and subsequent deposition of eroded sediments downstream create the physical structure of the river habitats. For the greater part, the river meanders over a flat valley floor, re-working previously deposited river sediments and unconsolidated drift materials of sands, tills and gravels deposited during and after the last ice age. These deposits are frequently exposed in small river cliffs, displaying evidence of the historical development of the river basin. Though rock sections are uncommon, the orientation of the river course indicates that it is controlled by features in the underlying solid geology such as faults or folds in the rocks of the valley floor.

The Tywi is a highly mobile river, meandering across the floodplain in its middle and lower reaches. Active erosion and deposition takes place from Llandovery all the way to Carmarthen, with gravel movement, pool filling, bank erosion and siltation occurring throughout. Large floods are responsible for larger-scale changes in channel character, while periods with higher frequencies of moderate floods are responsible for maintaining instability and large-scale movement of gravel bars and banks. The sensitivity of the river to change varies along its length, both in terms of the sequence of floods and human interventions. In addition, increases in extreme events as a result of climate change has implications for enhanced geomorphic activity.

These processes help to sustain the river ecosystem by allowing a continued supply of clean gravels and other important substrates to be transported downstream. In addition, the freshly deposited and eroded surfaces, such as shingle banks and earth cliffs, enable processes of ecological succession to begin again, providing an essential habitat for specialist, early successional species. Processes at the wider catchment scale generally govern processes of erosion and deposition occurring at the reach scale, although local factors such as the effect of grazing levels on riparian vegetation structure may contribute to enhanced erosion rates.

In general, management that interferes with natural geomorphological processes, for example preventing bank erosion through hard revetments or removing gravel, are likely to be damaging to the coherence of the ecosystem structure and functions. Although gravel availability along the Tywi has reduced, there are many private gravel extraction sites, with commercial extraction taking place at Llwynjack below Llandovery. It has not been quantified how much these extractions and the Llyn Brianne dam have contributed to the reduction in gravel availability. Other human interventions which have impacted on the geomorphology of the river include flood banks, river stabilisation, bank protection and construction of the railway embankment, which acts as a barrier to channel migration.

Riparian habitats, including bank sides and habitats on adjacent land, are an integral part of the river ecosystem. Diverse and high quality riparian habitats have a vital role in maintaining the SAC features in a favourable condition. The type and condition of riparian vegetation influences shade and water temperature, nutrient run-off from adjacent land, the availability of woody debris to the channel and inputs of leaf litter and invertebrates to support in-steam consumers. Light, temperature and nutrient levels influence in-stream plant production and habitat suitability for the SAC features. Woody debris is very important as it provides refuge areas from predators, traps sediment to create spawning and juvenile habitat and forms the base of an important aquatic food chain.

Otters require sufficient undisturbed riparian habitat for breeding and resting sites. It is important that appropriate amounts of tree cover, tall vegetation and other semi-natural habitats are maintained on the riverbanks and in adjacent areas, and that they are properly managed to support the SAC features. This may be achieved for example, through managing grazing levels, selective coppicing of riparian trees and restoring adjacent wetlands. The mobility of the Tywi has resulted in the formation of significant areas of off-channel habitat in the form of ox-bows, wet woodlands, willow scrub etc. These are predominantly away from the main channel, and form important areas for otter to rest-up in or support breeding sites. In the urban sections the focus may be on maintaining the river as a communication corridor but this will still require that sufficient riparian habitat is present and managed to enable the river corridor to function effectively.

Habitat connectivity is an important property of river ecosystem structure and function. Many of the fish that spawn in the river are migratory, depending on the maintenance of suitable conditions on their migration routes to allow the adults to reach available spawning habitat and juvenile fish to migrate downstream. For resident species, dispersal to new areas, or the prevention of dispersal causing isolated populations to become genetically distinct, may be important factors.

Artificial obstructions including weirs and bridge sills can reduce connectivity for some species. In addition, reaches subject to depleted flow levels, pollution, or disturbance due to noise, vibration or light, can all inhibit the movement of sensitive species. The dispersal of semi-terrestrial species, such as the otter, can be adversely affected by structures such as bridges under certain flow conditions, therefore these must be designed to allow safe passage. The continuity of riparian habitats enables a wide range of terrestrial species to migrate and disperse through the landscape. Connectivity should be maintained, or restored where necessary, to ensure access for the features to sufficient habitat within the SAC.

External factors operating outside the SAC, may also be influential, particularly for the migratory fish and otters. Otters may be affected by developments that affect resting and breeding sites outside the SAC boundary.

Outline of Past and Current Management

The majority of the catchment is rural, urbanised areas are restricted to Llandovery, Llandeilo and Carmarthen. Land use is greatly influenced by geology and topography. In the mountainous upper catchment forestry and sheep farming is dominant, whilst dairy and livestock farming takes place in the middle and lower reaches. A limited amount of arable farming occurs in the middle and lower reaches, including maize for ensiling, and this has the potential to increase sediment loads in the river from field run-off over the winter period. There has been a major change from hay to silage production and increased grass production as well as an increase in the use of artificial fertilizers.

The line of the A40 trunk road and B4300 mirror the course of the Tywi on either side of the valley, coming in close proximity to the river in a number of places. The Heart of Wales railway line from Llanelli to Shrewsbury crosses the river at Llandeilo, Llangadog and Llanwrda, with significant lengths of track adjacent to the river. Below Llandeilo the river is further restricted by the remains of the old disused railway track that runs from here down to Whitemill and beyond.

The Llyn Brianne dam was constructed in 1972 and whilst providing a compensation river flow from its base, also provides a complete barrier in the river channel upstream of Ystradffin. The compensation flow from the Llyn Brianne reservoir works in conjunction with a regulation release for abstraction at Nantgaredig, for public water supply. This makes the Tywi a highly regulated river. Gravel extraction downstream of Llandovery also affects the natural functioning of the river.

Management Units

The area covered by this plan has been divided into management units to enable practical communication about features, objectives, and management. This will also allow us to differentiate between the different designations where necessary. In this plan the management units have been based on Water Framework Directive River Basin Management Plan waterbody boundaries.

Maps showing the management units referred to in this plan can be viewed on the Welsh Government's website Map Data Cymru.

The following table confirms the relationships between the management units and the designations covered.

NRW Internal reference	SAC Management Unit	SSSI	Waterbody IDs within unit
NRW1	7580	Afon Tywi SSSI	GB110060036350
NRW2	7579	Afon Tywi SSSI	GB110060036250
NRW3	7578	Afon Tywi SSSI	GB110060029290
NRW4	734	Afon Tywi SSSI	GB531006013400 (Transitional)

Position within an ecological network

The Afon Tywi flows into the Carmarthen Bay and Estuaries SAC and both sites are designated for otter, twaite shad allis shad, river lamprey and sea lamprey. These species use the marine, transitional and freshwater parts of both these sites, underlining the close relationship between them and therefore the requirement to manage these sites accordingly.

The Tywi also has close links to other protected sites at the top of its catchment; the Cwm Doethie Mynydd Mallaen SAC and the Elenydd Mallaen SPA both border the Tywi and rely on the river for certain aspects of their characteristic biodiversity. The Cwm Doethie Mynydd Mallaen SAC for example, relies on the Afon Tywi to maintain humidity and spray zones associated with certain oceanic bryophyte species which are an integral part of the sessile oak woods feature of the SAC. Mynydd Du SSSI is a large site occupying the headwaters of major tributaries such as the Sawdde and Clydach. At a smaller scale a substantial proportion of Dinefwr Estate SSSI lies within the floodplain of the Tywi while Bishop's Pond SSSI is an old oxbow and is therefore connected to the river in flood conditions.

Management of sites adjacent to the Tywi, and vice versa, require consideration of the close links between them. Rivers receive water, sediment and any other associated chemicals and materials, from their respective catchments. The river subsequently feeds into the marine environment, meaning terrestrial, riverine and marine protected sites within the Tywi catchment, must be managed and considered as one system. These close links are reflected in these plans and the associated River Basin Management Plan (RBMP).

The Features

Confirmation of Features

SAC feature (Annex I habitats and Annex II species)	Primary Reason for Site Selection?	Relationships, nomenclature etc
Twaite shad Alosa fallax	Yes	EU Species Code 1103
European otter Lutra lutra	Yes	EU Species Code 1355
Allis shad Alosa alosa	No	EU Species Code 1102 Management for this feature is effectively the same as for twaite shad
Sea lamprey Petromyzon marinus	No	EU Species Code 1095
Brook lamprey Lampetra planeri	No	EU Species Code 1096
River Lamprey Lampetra fluviatilis	No	EU Species Code 1099
Bullhead Cottus gobio	No	EU Species Code 1163

SSSI features are listed in the table below.

Designated Feature	Relationships, nomenclature etc
Little ringed plover *Charadrius dubius*	
Sand martin *Riparia riparia*	
Shingle invertebrates	
Club-tailed dragonfly *Gomphus vulgatissimus*	
Twaite shad Alosa fallax	Managed as a SAC feature
Allis shad Alosa alosa	Managed as a SAC feature
European otter Lutra lutra	Managed as a SAC feature

Designated Feature	Relationships, nomenclature etc
Assemblage of RDB and/or Nationally Scarce vascular plants	
Multi-fruited river-moss *Cryphaea lamyana*	
Scarce Turf-moss *Rhytidiadelphus subpinnatus*	
Running water	
Saltmarsh	

Features and Management Units

This section sets out the relationship between the designated features and each management unit. This is intended to provide a clear statement about what each unit should be managed for, taking into account the varied needs of the different special features. All features are allocated to one of seven classes in each management unit. These classes are:

Key Features

KH - a 'Key Habitat' in the management unit i.e. the habitat that is the main driver of management and focus of monitoring effort, perhaps because of the dependence of a key species (see KS below). There will usually only be one Key Habitat in a unit but there can be more, especially with large units.

KS – a 'Key Species' in the management unit, often driving both the selection and management of a Key Habitat.

Geo – an earth science feature that is the main driver of management and focus of monitoring effort in a unit.

Other Features

Sym - habitats, species and earth science features that are of importance in a unit but are not the main drivers of management or focus of monitoring. These features will benefit from management for the key feature(s) identified in the unit. These may be classed as 'Sym' (sympathetic) features because:

(a) they are present in the unit but may be of less conservation importance than the key feature; and/or

(b) they are present in the unit but in small areas/numbers, with the bulk of the feature in other units of the site; and/or

(c) their requirements are broader than and compatible with the management needs of the key feature(s), e.g. a mobile species that uses large parts of the site and surrounding areas: and/or

(d) key features (KH, KS) are closely associated with these features, and the conservation of key features depends on them being managed appropriately.

Nm - an infrequently used category where features are at risk of decline within a unit as a result of meeting the management needs of the key feature(s), i.e. under Negative Management. These cases will usually be compensated for by management elsewhere in the plan,and can be used where minor occurrences of a feature would otherwise lead to apparent conflict with another key feature in a unit.

Mn - Management units that are essential for the management of features elsewhere on a site e.g. livestock over-wintering area included within designation boundaries, buffer zones around water bodies, etc.

x – Features not known to be present in the management unit.

In order to ensure consistency in management/regulation of the Afon Tywi via this plan as well as the corresponding River Basin Management Plan (RBMP), the management units for the SAC have been re-aligned to coincide with waterbodies used in the RBMP.

The table below sets out the relationship between the features and management units identified in this plan.

SAC unique unit number	**7580**	**7579**	**7578**	**734**
NRW internal reference number	NRW 1	NRW 2	NRW 3	NRW 4
Corresponding old units (pre 2014)	1	1,2,3,4 and 5	5 and 6	7
Position in site	Most upstream unit (Llandovery section)	Incorporates Llandeilo, Manordeilo and Llangadog.	Whitemill section	Most downstream unit (Carmarthen section-tidal)
WFD waterbody number	GB110060036350	GB110060036250	GB110060029290	GB531006013400 (Transitional)
SAC Features				
Twaite shad	Sym	**KS**	**KS**	**KS**
Allis shad	Sym	Sym	Sym	Sym
Sea lamprey	**KS**	**KS**	Sym	Sym
Brook lamprey	Sym	Sym	Sym	Sym
River lamprey	Sym	Sym	Sym	Sym
Bullhead	Sym	Sym	Sym	Sym
European otter	**KS**	**KS**	**KS**	**KS**
SSSI Features				
Little ringed plover *Charadrius dubius*	**KS**	**KS**	**KS**	Sym
River shingle invertebrates	Sym	Sym	Sym	Sym

SAC unique unit number	7580	7579	7578	734
Sandmartin *Riparia riparia*	Sym	Sym	Sym	Sym
Club-tailed dragonfly *Gomphus vulgatissimus*	Sym	Sym	Sym	Sym
Assemblage of RDB and/or Nationally Scarce vascular plants	Sym	Sym	Sym	Sym
Multi-fruited river-moss *Cryphaea lamyana*	x	x	x	Sym
Scarce Turf-moss *Rhytidiadelphus subpinnatus*	x	x	Sym	x
Running water	Sym	Sym	Sym	Sym
Saltmarsh	x	x	x	Sym

Conservation Objectives

Background to Conservation Objectives:

a. Outline of the legal context and purpose of conservation objectives.

Conservation objectives for individual SACs and SPAs are required by the 1992 'Habitats' Directive (92/43/EEC) as implemented through the Conservation of Habitat and Species Regulations 2017 (As amended). The aim of the Habitats Directive is the maintenance, or where appropriate the restoration, of the 'favourable conservation status' (FCS) of habitats and species listed in the Annexes to the Directive (see Box). Therefore FCS provides the overarching framework for defining the conservation objectives for individual SACs.

Although neither the Birds Directive nor the Ramsar Convention refer to FCS, Natural Resources Wales considers that the overall aim of both those legal instruments is sufficiently similar to FCS to make it practical and proportionate to use the same guiding principle when establishing the conservation objectives for SPAs and Ramsar sites, as well as SACs. Therefore the Habitats Directive definition of FCS is considered to provide the overarching framework for conservation objectives for all SACs, SPAs and Ramsar sites in Wales.

Favourable conservation as defined in Articles 1(e) and 1(i) of the Habitats Directive

"The conservation status of a natural habitat is the sum of the influences acting on it and its typical species that may affect its long-term natural distribution, structure and functions as well as the long term survival of its typical species. The conservation status of a natural habitat will be taken as favourable when:

its natural range and areas it covers within that range are stable or increasing, and

the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and

the conservation status of its typical species is favourable.

The conservation status of a species is the sum of the influences acting on the species that may affect the long-term distribution and abundance of its populations. The conservation status will be taken as 'favourable' when:

population dynamics data on the species indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and

the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and

there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis."

The achievement of FCS is not an objective that applies at the level of the individual sites. Rather it is a wider objective to which each individual site contributes. Therefore the conservation objectives for an individual site are intended to express what is considered to be that site's appropriate contribution to achieving FCS. Since SACs are the most important mechanism in the Habitats Directive for achieving FCS, and the sites represent the most important areas for conservation of the Annex I habitat types and Annex II species, the objectives for each individual SAC should seek to ensure that the site makes a substantial contribution which properly reflects its importance in a local, national and European context and the particular reasons why the site was selected for inclusion in the UK National Sites Network of SACs. A similar approach is taken to setting conservation objectives for SPAs and Ramsar sites.

Achieving the conservation objectives of individual sites requires appropriate management and the control of factors which are influencing, or may influence the features.

The conservation objectives have a number of specific roles:

- Communication
  The conservation objectives should help convey to stakeholders what are the reasons for the designation and what it is intended to achieve.
- Site planning and management
  The conservation objectives guide management of sites, to maintain or restore the designated habitats and species. They provide the basis for identifying what management is required both within the site boundary, and outside it, where achieving the objectives requires action to be taken outside the site.
- River Basin Management Planning
  Conservation Objectives for aquatic and water dependent SAC and SPA features are also used as the "standards and objectives" referred to in Article 4 (1c) of the Water Framework Directive (WFD) (2000/60/EC). In 2009, Welsh Ministers decided that where SAC and SPA conservation objectives are more stringent than 'Good Ecological Status' (GES) as defined in the WFD, they (and the standards they contain) are the objectives referred to in Article 4(1c) of the WFD.
- Assessing plans and projects
  Article 6(3) of the 'Habitats' Directive requires the assessment of proposed plans and projects in view of a site's conservation objectives. Subject to certain exceptions, plans or projects may not proceed unless it is established that they will not adversely affect the integrity of sites. There are similar requirements for the review of existing decisions and consents. Note that the assessment of plans and projects should be made in view of the entirety of the conservation objectives for the site, including the performance indicators.

- *Monitoring and reporting*
  In addition to foregoing purposes, conservation objectives provide the basis for defining the evidence that will be used for assessing the condition of a feature and the status of factors that affect it. That evidence is contained in a sub-set of conservation objectives called ‘performance indicators’. The performance indicators are those conservation objectives which are quantifiable and measurable, and which provide the basis for monitoring and reporting. The performance indicators are set out in an Appendix to this document.

The conservation objectives in this document reflect Natural Resources Wales’ current information and understanding of the site and its features and their importance in an international context. The conservation objectives are subject to review by Natural Resources Wales in the light of new knowledge.

b. Format of the conservation objectives

Each conservation objective is a composite statement defining a site-specific aspiration for each designated feature. This composite statement contains clauses that correspond to all the elements of FCS, namely:

For habitat features:

- Extent should be stable in the long term, or where appropriate increasing;
- Quality (including in terms of ecological structure and function) should be being maintained, or where appropriate improving;
- Populations of the habitat’s typical species must be being maintained or where appropriate increasing;
- Factors affecting the extent and quality of the habitat and its typical species (and thus affecting the habitat’s future prospects) should be under appropriate control.

For species features:

- The size of the population should be stable or increasing, allowing for natural variability, and sustainable in the long term;
- The distribution of the population should be being maintained;
- There should be sufficient habitat, of sufficient quality, to support the population in the long term;
- Factors affecting the population or its habitat should be under appropriate control.

The elements above constitute a generic checklist or guide to the elements that should normally be included in the conservation objectives, in order to ensure that the site makes an effective and appropriate contribution to achieving favourable conservation status for the habitats and species for which it is designated.

There is one conservation objective for each designated feature listed in part 3. In some cases, where there are distinct areas or forms of a designated habitat or separate populations of a designated species within a site, the conservation objective is sub-divided into different sections to enable different aspirations to be expressed for different occurrences of the features within the site.

As well as describing the aspirations for the condition of the feature, each conservation objective contains a statement that the factors which significantly affect the feature are under appropriate control.

Climate change has the potential to affect the range and viability of the features of the SAC, as well as invasive or alien species, within the catchment of the Afon Tywi. Studies done as part of the Habitats Directive Review of Consents (HDRoC) process on the Afon Tywi, showed that shad will likely benefit from climate change due to increasing water temperatures making areas beyond Llandeilo more suitable for spawning and egg development. The same could be said for all three lamprey species, purely based on likely temperature increases and increased suitable spawning habitat, on the main river. Gains in terms of available habitat have the potential to be offset by increased risks of alien species colonising the Afon Tywi and its tributaries as well as increased risk of pollution associated with more frequent droughts. Management of the river will need to adapt to these challenges but natural processes will dominate the river's changing characteristics as a result of climate change.

Some features of the Tywi SAC are also listed as features of the adjoining Carmarthen Bay and Estuaries SAC. Both shad features along with river and brook Lamprey are listed for both SACs due to their life-cycles involving both a freshwater and marine phase (anadromous). Otter is also a feature for both SACs.

Conservation Objectives for Features 1-4:

Feature 1: Twaite shad Alosa fallax (EU Species Code 1103) and Allis shad Alosa alosa (EU Species Code 1102)

Feature 2. Sea lamprey *Petromyzon marinus* (EU Species Code: *1095*)

Feature 3. Brook lamprey *Lampetra planeri* (EU Species Code : *1096*) and River lamprey *Lampetra fluviatilis* (EU Species Code : *1099*)

Feature 4. Bullhead *Cottus gobio* (EU Species Code : *1163)*

There are generic conservation objectives for physical habitat and water quality, and for population attributes, relevant to **Allis shad, Twaite shad, sea lamprey, river lamprey, brook lamprey and bullhead,** which are defined below and should be met.

Generic Conservation Objectives for the physical habitat and water quality.

Quality (including in terms of ecological structure and function) should be being maintained, or where appropriate improving.
 	
There should be sufficient habitat, of sufficient quality, to support the population in the long term.
	Flow regime, water quality and physical habitat including substrate quality should be at least maintained in, or restored as far as is possible to, a near-natural state, in order to support the ecosystem structure and function across the whole area of the SAC.
	
	The standards for the elements of **flow** should be met as defined in Appendix 1 and Appendix 3. Flows should be at what is considered near-natural for a watercourse of this type. Near-natural flow regime is defined as the characteristic pattern of a river's flow quantity, timing and variability in un-impacted conditions. The five components of flow: magnitude, frequency, duration, timing and rate of change influence the ecological integrity of the river ecosystem.
	
	Flow will not be depleted by abstraction or physical modifications to the extent that:
	• spawning or nursery sites of features, are damaged or destroyed.
	• access to feature's spawning habitat is hindered.
	• outward migration of features species is hindered.
	
	The standards for the elements of **water quality** should be met as defined in Appendix 2. Potential sources of pollution will be considered in assessing plans and projects, and measures will be taken to control such pollution so as to meet levels that do not degrade the ecology of the river.
	
	Physical habitat should be at least maintained in, or restored as far as is possible to, a near-natural state, in order to support the ecosystem structure and function across the whole area of the SAC. This includes the;
	- *Structure and composition of the riparian vegetation*
	  ○ The native tree cover, which should include sufficient regenerating, mature and over-mature trees and standing dead wood.
	  ○ Dead wood should not be removed from the river.
	  ○ The bankside vegetation should feature native plant communities supported by near-natural land-use adjacent to the river.
	- *Physical river processes and features* - high degree of naturalness should be retained which is governed by dynamic processes resulting in a variety of physical habitat features, including a

	range of substrate types, variations in flow, channel width and depth, in-channel and side channel sedimentation features, erosion features and both in-channel and bankside vegetation cover. - Predominantly unmodified ecological and hydromorphological processes and characteristics, should be at least maintained or restored where necessary. - Physical modifications, including, but not limited to, revetments on alluvial rivers, using stone, concrete or waste materials, unsustainable gravel extraction, addition or release of excessive quantities of fine sediment, will be avoided where they impact on the capability of each species feature to occupy the full extent of its natural range. - Natural factors such as waterfalls, which may limit the natural range of a species features, or dispersal between naturally isolated populations, should not be modified. - Artificial widening or deepening of channels, and extensive reinforcement of banks, should be avoided where they affect the function and viability of a habitat. - No new barriers causing an impact on the capability of each species feature to occupy the full extent of its natural range, will be permitted. Existing, artificial barriers causing an impact should be modified as necessary to allow passage, e.g. weirs, bridge sills, acoustic barriers. No physical structures should impact on the connectivity of the habitat. There should be no man made barriers to the free movement of water, sediment and aquatic organisms that may affect the river-bed structure and hydrology downstream. - The river plan, form and profile should be predominantly un-modified and characteristic of the river type. The river should support stable or increasing populations of features, in characteristic proportions. In many circumstances, a natural channel may move in response to extreme floods - this is a positive conservation attribute. **Existing invasive non-native species** which threaten the conservation status of the SAC features will be controlled where feasible. No new introductions of invasive non-native species should occur. The standards for **siltation** should be met as defined in Appendix 1. Levels of suspended solids should be such that fish spawning or nursery habitats are not degraded.

	For species only; All known **breeding, spawning and nursery sites** of species features should be maintained as suitable habitat as far as possible, or restored to suitable habitat (except where natural processes cause them to change). As a minimum, all waterbodies should be meeting **Good Ecological Status** under the Water Framework Directive. More stringent targets will be applicable for some determinands (see Performance Indicators section). All river SSSI habitat features should meet favourable condition. In some cases the SAC habitat may not be underpinned by a river habitat SSSI feature. In this case, the target is to maintain and restore the characteristic physical features of the river channel, banks and riparian zone consistent with favourable condition of the SAC features.

Generic Conservation Objectives for population attributes.

The distribution of the population should be being maintained or where appropriate increasing.	The natural range of the feature in the SAC is neither being reduced nor is likely to be reduced for the foreseeable future. The natural range is taken to mean those reaches where predominantly suitable habitat for each life stage exists over the long term. Suitable habitat is defined in terms of near-natural hydrological and geomorphological processes and forms e.g. suitable flows to allow upstream migration, depth of water and substrate type at spawning sites, and ecosystem structure and functions e.g. food supply. Suitable habitat need not be present throughout the SAC but where present must be secured for the foreseeable future. Natural factors such as waterfalls may limit the natural range of individual species. Existing artificial influences on natural range, such as physical barriers to migration, should be modified where possible, to allow passage
There should be sufficient habitat, of sufficient quality, to support the population in the long term.	Water quality should not be injurious to any life stage. All reaches within the site that contain, or should contain twaite shad, allis shad, sea lamprey, brook lamprey, river lamprey or bullhead under conditions of high environmental quality will comply with the targets given. While the current SAC boundary encompasses core areas of habitat for twaite shad, allis shad, sea lamprey, brook lamprey, river lamprey or bullhead, the long term security and resilience of the population is

	dependent on suitable habitat both within and outside of the protected site boundary.
The size of the population should be stable or increasing, allowing for natural variability, and sustainable in the long term.	The population will be at least maintained or increasing and there will be evidence of recent recruitment. Extent and quality of available spawning habitat should be sufficient to maintain the population levels.
Factors affecting the population or its habitat should be under appropriate control.	Factors affecting the population or its habitat (including fishing, poaching, siltation, air pollution, abstraction, entrainment, discharges and reservoir releases) should be under appropriate control.

Conservation objective for Feature 5:

European otter (*Lutra lutra)* (EU Species Code: *1355*)

The size of the population should be stable or increasing, allowing for natural variability, and sustainable in the long term.	The population of otters in the SAC is stable or increasing over the long term and reflects the natural carrying capacity of the habitat within the SAC, as determined by natural levels of prey abundance and associated territorial behaviour.
The distribution of the population should be being maintained, or where appropriate increasing.	The natural range of otters in the SAC is neither being reduced nor is likely to be reduced for the foreseeable future. The natural range is taken to mean those reaches that are potentially suitable to form part of a breeding territory and/or provide routes between breeding territories. The whole area of the Tywi SAC is considered to form potentially suitable breeding habitat for otters. The size of breeding territories may vary depending on prey abundance. The population size should not be limited by the availability of suitable undisturbed breeding sites. Where these are insufficient they should be created through habitat enhancement and where necessary the provision of artificial holts. No otter breeding site should be subject to a level of disturbance that could have a negative effect on breeding success. Where necessary, potentially harmful levels of disturbance must be managed.
There should be sufficient habitat, of sufficient quality, to support the population in the long term.	The safe movement and dispersal of individuals around the SAC is facilitated by the provision, where necessary, of suitable riparian habitat, and underpasses, ledges, fencing etc at road bridges and other artificial barriers.
Factors affecting the population or its habitat	Water quality parameters, as defined in Appendix 2 must be met. There should be no reduction in availability of

should be under appropriate control.	otter prey (e.g. eel), as a result of anthropogenic activities or factors.

Assessment of status and management requirements

This section provides:

- A summary of the assessment of the status of each feature.
- A summary of the management issues that need to be addressed to maintain or restore each feature.

Status and Management Requirements of Feature 1: Twaite shad *Alosa fallax* and Allis shad *Alosa alosa*

Status of Feature 1

This feature is currently in **unfavourable (unclassified)** condition (Garret et al, 2012) based on the flow attribute failing its target.

The population attribute (spawning distribution), water quality (biological quality, chemical quality & suspended solids) all passed the targets. The population cannot be fully assessed by only using annual spawning extent as it is not possible to determine each species at the egg stage. River hydromorphology and morphology were not assessed.

Condition trend has not been assessed; however previous assessment also recorded condition as unfavourable.

Factors affecting this feature are, on the whole, under control however the Tywi catchment is under pressure from water quality issues caused by diffuse pollution.

The report by Garrett *et al* (2012) reported the spawning distribution of shad as being favourable, based on kick sampling carried out between 2007 and 2012. This represents a change from the previous spawning assessment in 2007 (Noble *et al*, 2007), which reported this attribute as unfavourable.

Physical barriers to migration are now largely absent from the Tywi as Llangadog weir has become broken down enabling easier passage by all fish species. Issues currently being resolved by the Habitats Directive Review of Consents process are considered to be ‘under control’, meaning they are no longer affecting the status of this feature. It should be noted that this is based on site units as listed prior to 2013.

However, overall condition of both shad species populations on the Tywi is reported as unfavourable, due to a failure to meet the flow targets for a large enough proportion of the year. This is despite passing water quality targets and spawning distribution targets, as above.

Management Requirements of Feature 1

The impacts of barriers to migration and flow depletion are highlighted in the assessment of conservation status for these features.

Artificial physical barriers are probably the single most important factor in the decline of shad in Europe. Impassable obstacles between suitable spawning areas and the sea can eliminate breeding populations of shad. Both species (but particularly allis shad) can make migrations of hundreds of kilometres from the estuary to spawning grounds in the absence of artificial barriers. Existing fish passes designed for salmon are often not effective for shad. Any new provisions need to take their requirements into account. The impact of existing barriers in the Tywi should be assessed on a case-by-case basis. Physical modification of barriers is required where depth/velocity/duration of flows is unsuitable to allow passage. Llangadog Creamery weir is considered to be the most significant barrier to fish migration in the Tywi. Consideration was being given to reduce or remove the effect of this barrier. However the weir has recently deteriorated to such a condition as to allow passage for fish features to go on unhindered.

The River Tywi is a regulated river, with flows at certain times of the year primarily controlled by releases from Llyn Brianne. The reservoir controls releases of water for hydropower generation and the principal potable abstraction at Nantgaredig, and a seasonal abstraction at Manorafan. In addition, NRW retains control over a ‘9092 Ml management reserve’(i.e. a volume of water available within Llyn Brianne), which can be used for ecological flows. These flows are most often used as freshets for fisheries management purposes in the spring and autumn to support migration of salmonids.

The impact of flow depletion downstream of major abstractions was assessed in the Habitats Directive HDRoC process. The outputs of the hydraulic model suggest that changes to water depth and water velocities occurring as a result of the abstraction at Capel Dewi are unlikely to impact upon the ability of adult shad to migrate through the lower reaches of the river, or on juvenile habitat downstream of the abstraction. However the diurnal operation of the pumps does expose marginal habitat and therefore has the potential to strand eggs or expose sediments supporting spawning habitat.

Dwr Cymru Welsh Water and NRW have undertaken investigations to understand how the diurnal operation of the abstraction pumps could affect the shad population. As a result of these investigations, a solution was agreed to amend the abstraction licence to reduce the volume of water abstracted and to alter the pumping regime during the shad spawning season. These changes reduce the risk of shad eggs in the shallow margins being desiccated when the pumps are switched on. The new

licence was issued and effective from April 2018, with the shad- specific flow conditions effective from December 2018.

There are also requirements for screening of intakes to reduce or remove the impact of impingement and entrainment on juvenile fish migrating downstream. Entrainment in water abstractions directly impacts on population dynamics through reduced recruitment and survival rates. Information on likely rates of entrainment of shad eggs and juveniles is required before acceptable levels can be assessed. The screening arrangements at the DCWW intakes at Manorafon and Nantgaredig were assessed as part of the Habitats Directive HDRoC process and screens have been updated, to address the risk of entrainment.

Llyn Brianne is a deep reservoir that exhibits thermal stratification in the spring/summer. Releases of water from the reservoir are from a fixed discharge depth of 65 m, which is below the stratification layer and results in cold water being released into the Tywi. This results in reduced temperature conditions in the main river Tywi at certain times of year. For instance, hypolimnial releases from the reservoir during summer months average 6-8^{o}C and can lower river temperatures for 55 km below the reservoir outflow (Smith, 2005).

Allis and twaite shad are temperature dependent in critical phases of their life history. Both species are anadromous, migrating from the sea into rivers as adults to spawn. The timing of adult migrations appears to be primarily dependent upon temperature, with migration triggered at estuarine water temperatures of 11-12^{o}C (Aprahamian, 1988) and secondarily by river flow and tides. Peak migration activity occurs at water temperatures of 11-14^{o}C, usually between April and June. Spawning varies regionally, but typically takes place in water temperatures of above 15^{o}C between May and July. Eggs are sensitive to water temperatures below 16-18^{o}C. Water temperatures of above 18^{o}C throughout June and July are therefore considered ideal for successful shad egg incubation.

Temperature is also believed to be important in triggering migration of shad larvae towards the estuary, for example, with most juvenile thought to migrate from the River Wye into the Severn estuary once water temperatures fall below 19^{o}C (Aprahamian *et al,* 1998). Research on shad spawning within the Tywi SAC suggests that temperature could be a limiting factor in the distribution of shad adults throughout the Tywi catchment. However, recent modelling studies have shown that the effects of the Llyn Brianne hypolimnial releases are not a limiting factor to shad populations within the river. Any limitations of shad distribution due to temperature are therefore considered to be natural, rather than anthropogenically influenced (Knights, 2014).

The use of freshet releases from Llyn Brianne to stimulate salmonid smolt migration in the spring and adult migration in the autumn are also potentially damaging. Cold water releases in the spring could delay the migration of adult shad into the system, while autumn releases can flush juvenile shad into the estuary before they are sufficiently developed to cope with changing salinity regimes. This is magnified due to the majority of shad spawning occurring in the lower reaches of the Tywi.

Water Framework Directive monitoring has reported the ecological status for the various waterbodies relevant to the Tywi SAC. Ecological status applies to surface

water bodies and is based on the following quality elements: biological quality, general chemical and physico-chemical quality, water quality with respect to specific pollutants (synthetic and non-synthetic), and hydromorphological quality. There are five classes of ecological status (high, good, moderate, poor or bad). Ecological status and chemical status together define the overall surface water status of a waterbody.

In the Tywi catchment, approximately half of the waterbodies scored moderate and half scored good in the 2015 classifications, with all four waterbodies designated as SAC units scoring good. Whilst these results are not designed to direct the management of individual features, they nevertheless give a general picture of the status of the river.

Shad eggs and juveniles are known to be sensitive to elevated suspended solids and high nutrient concentrations. In-river engineering works, which have the potential to generate high silt loads under low flow conditions are regulated through NRW's Flood Defence Consent process. An embargo on works between May and late July operates within the catchment. Diffuse inputs from agricultural sources are the main cause of nutrient enrichment. The Water Framework Directive provides a driver to tackle diffuse inputs. Catchment sensitive farming initiatives, Glastir and NRW's Sustainable Fisheries Project are encouraging the use of buffer strips to reduce these impacts.

Noise/vibration e.g. due to impact piling, drilling, salmon fish counters present within or in close proximity to the river can create a barrier to shad migration. Barriers resulting from vibration, chemicals, low dissolved oxygen and artificially high sediment levels must be prevented at key times (generally April to July).

The extent and quality of suitable shad habitat must be maintained. Spawning habitat is defined as stable, clean gravel/pebble-dominated (approximately 70%) substrate without an armoured layer and with <10% fines in the top 30 cm. Water depth during the spawning and incubation periods should be 50-75 cm. Holding areas are defined as pools of at least 200 cm depth, with cover from features such as undercut banks, vegetation, submerged objects and surface turbulence.

Anglers occasionally fish for shad, and they are sometimes taken in quite large numbers. Further research is necessary to define sustainable levels of angling. If this shows there is cause for concern a temporary cessation of fishing activity in the vicinity of known spawning grounds during the spawning period should be considered, particularly where shad are known to be taken regularly. Exploitation of shad is protected via Schedule 5 of the Wildlife and Countryside Act.

Commercial fishermen also take shad as a by-catch. Changes in fishing methods need to be promoted to minimize captures, while both anglers and trawler men should be encouraged to return alive any individuals caught.

Artificially enhanced densities of other fish may introduce unacceptable competition or predation pressure and the aim should be to minimise these risks in considering any proposals for stocking.

Status and Management Requirements of Feature 2: Sea lamprey *Petromyzon marinus*

Status of Feature 2

This feature is currently in **unfavourable** condition (Thomas et al, 2011) based on population distribution and flow targets.

The trend in condition is described as unclassified, based on the paucity of monitoring data available for this species.

Factors affecting this feature are, on the whole, under control, however the Tywi catchment is under pressure in terms of water quality issues caused by diffuse pollution. Migration barriers such as Llangadog Weir have, in recent years, broken down allowing much better passage by fish including lamprey.

Sea lamprey monitoring undertaken in 2004 failed to find juvenile sea lamprey at any sites either on the main river Tywi or any of the tributaries. Therefore the Afon Tywi SAC failed the targets for spawning sites and lamprey larvae distribution. Data on lamprey distribution were collected by Environment Agency Wales (EAW) during National Fisheries Monitoring Programme electrofishing surveys conducted from 2007-2010 in the Afon Tywi. These surveys employed the LIFE protocol of electrofishing for lamprey via a quadrat, using quantitative and semi-quantitative analysis. Data was also gathered via a DIDSON sonar device and this was also factored into analysis of lamprey condition on the Tywi (Thomas *et al*, 2011).

Three *Petromyzon* ammocoetes were recorded throughout the EAW Monitoring Programme along with one transformer.

Between 2009 and 2011, the DIDSON was deployed annually from between March and June. These data allowed a total run of sea lamprey migrating past the monitoring point to be estimated in both years and were 1,135 in 2009 and 2,680 in 2010. There are limitations to the DIDSON including lateral range, recording single individuals multiple times as well as uncertainties over lamprey missing the beam near the water surface (Davies, 2016).

Sea lamprey therefore fail the population attribute based on Common Standards Monitoring (CSM) and can be considered as being in unfavourable condition. However, this result should taken in the light of limitations to the survey technique and the fact that sea lamprey ammocoetes may be residing in parts of the riverbed that are currently inaccessible for survey. More work is required to investigate sea lamprey survey methodologies, in the future. DIDSON results hint to sea lamprey using the Tywi to an as yet unknown degree. Sea lamprey are seen spawning every year by fisheries bailiffs working for NRW and this suggests continuing presence of the species in known good spawning areas. Similarly for shad above, flow targets for this species also failed but water quality targets passed in the second round of reporting. Adult spawning activity, river hydromorphology and morphology were not assessed.

Management requirements

The impact of barriers should be assessed on a case-by-case basis. Physical modification of barriers is required where depth/velocity/duration of flows is unsuitable to allow passage. Llangadog weir was considered to be the most significant barrier to fish migration within the Tywi SAC. However, it no longer presents a significant barrier due to partial collapse and will likely further deteriorate providing even more access in the future.

The impact of acoustic (i.e. noise/vibration) and sediment/chemical barriers arising from plans or projects should also be assessed. When arising from construction or other development related activities it may be necessary to restrict the timing of such activities.

The impact of flow depletion downstream of major abstractions was assessed in the HDRoC process. The outputs of the hydraulic model suggest that changes to water depth and water velocities occurring as a result of the abstraction at Nantgaredig are unlikely to impact upon; the ability of adult lamprey to migrate through the lower reaches of the river; spawning habitat downstream of Capel Dewi; or juvenile habitat downstream of the abstraction. However the diurnal operation of the pumps does expose marginal habitat and therefore has the potential to strand juveniles or expose juvenile sediment habitat. However, the mobility of ammocoetes likely offers them considerable protection from such effects via the ability to avoid areas prone to exposure. Lamprey also make considerable use of the river's tributaries, as well as extensive areas upstream of Nantgaredig, all of which are unaffected by the abstraction.

There are also requirements for screening of intakes to reduce or remove the impact of impingement and entrainment on juvenile fish migrating downstream. Entrainment in water abstractions directly impacts on population dynamics through reduced recruitment and survival rates. Information on likely rates of entrainment of lamprey ammocoetes is required before acceptable levels can be assessed. The screening arrangements at the DCWW intakes at Manorafon and Nantgaredig were assessed as part of the HDRoC (RoC) process and have been modified to prevent adverse effects in the future.

See Feature 1 above for WFD status assessment results.

The extent and quality of suitable sea lamprey habitat must be maintained. Elevated levels of fines (particles <0.83mm) within spawning substrates can interfere with egg survival. Spawning habitat consists of well-oxygenated gravel/pebble substrate of >10cm depth in a range of water depths (0.2 to 1.5m). Sea and river lamprey tend to spawn in deeper water than brook lamprey. Nursery habitat consists of open-structured, aerated, silty and sandy substrates between 2 and 40cm depth generally in shallow (<0.5m) slack-water channel margins.

Status and Management Requirements of Feature 3:

Brook lamprey *Lampetra planeri* and river lamprey *Lampetra fluviatilis*

Status of Feature 3

Lampetra species are currently in **unfavourable** condition (Thomas et al, 2011) based on a failure of the flow attribute. All the population attribute targets were met e.g. distribution, age structure and ammocoete abundance.

Trend in condition is described as maintained, based on previous (Harvey et al, 2006) and current condition assessments (Thomas et al, 2011).

Factors affecting this feature are, on the whole, under control, however the Tywi catchment is under pressure in terms of water quality issues caused by diffuse pollution.. Migration barriers such as Llangadog weir have, in recent years, broken down allowing much better passage by fish including lamprey.

Brook/river lamprey monitoring undertaken in 2004 showed that overall catchment mean larvae density considerably exceeded the JNCC target threshold[1]. The populations were considered to be healthy with a good recruitment of 0+ ammocoetes in most areas in 2004. However the distribution of larvae within the catchment failed the performance indicator and it is for this reason together with the impacts from flow depletion (see below) that their status was recorded as unfavourable in 2004 (APEM, 2005).

Monitoring undertaken as part of the EAW's National Fisheries Monitoring Programme from 2007 to 2010 (see details for sea lamprey above) assessed distribution, ammocoete density and age structure against Common Standards Monitoring targets, for *Lampetra* species. A total of 492 *Lampetra* ammocoetes, 9 brook lamprey transformers, and 3 sea lamprey ammocoetes (total 505) individuals were recorded in the 29 of the 30 survey sites in the catchment. Optimal habitat was found in 24 out of 30 sites (80%) and sub-optimal habitat at 20 sites (67%), with only one site which was unsuitable for survey. *Lampetra* larvae were present in all catchment zones, at 97% of all sample sites and 73% of optimal sites. Targets set for the population attribute of the CSM protocol for lampreys were assessed. The age structure, distribution within the catchment and larvae density targets were met for both river and brook lamprey. Overall condition is however unfavourable, due to failure to meet the flow targets (Habitats Directive Ecological River Flow).

It is not possible to distinguish between the two species during monitoring, due to the reliance on juvenile stages (ammocoetes or larvae), though anecdotal evidence suggests that both species are likely to be present in many reaches. More information on the relative abundance of these two species in different parts of the Tywi SAC is desirable. Records of spawning adult river lamprey would be particularly useful.

Management requirements

The extent and quality of suitable habitat for brook and river lamprey must be maintained. Elevated levels of fines (particles <0.83mm) within spawning substrates can interfere with egg survival. Spawning habitat consists of well-oxygenated gravel/pebble substrate of >10cm depth in a range of water depths (0.2 to 1.5m). Sea and river lamprey tend to spawn in deeper water than brook lamprey. Nursery habitat consists of open-structured, aerated, silty and sandy substrates between 2 and 40cm depth generally in shallow (<0.5m) slack-water channel margins.

The impact of flow depletion downstream of major abstractions was assessed in the HDRoC process. The outputs of the hydraulic model suggest that changes to water depth and water velocities occurring as a result of the abstraction at Nantgaredig are unlikely to impact upon; the ability of adult lamprey to migrate through the lower reaches of the river; spawning habitat downstream of Nantgaredig; or juvenile habitat downstream of the abstraction. However the diurnal operation of the pumps does expose marginal habitat and therefore has the potential to strand juveniles or expose juvenile sediment habitat. The mobility of ammocoetes likely offers them considerable protection from such effects via the ability to avoid areas prone to exposure. Lamprey also make considerable use of the river's tributaries, as well as extensive areas upstream of Nantgaredig, all of which are unaffected by the abstraction.

Entrainment in water abstractions directly impacts on population dynamics through reduced recruitment and survival rates. Information on likely rates of entrainment of lamprey ammocoetes is required before acceptable levels can be assessed.

See Feature 1 above for WFD status assessment results.

These species are likely to benefit from positive management for the other SAC features, and may see further improvement in condition as a result. On-going monitoring will allow a better understanding of population fluctuations, distributional changes etc.

Status and Management Requirements of Feature 4: Bullhead *Cottus gobio*

Status of Feature 4

Bullhead are currently in **unfavourable** condition (Thomas et al, 2011) based on a lack of population data and failure of flow targets, as per other SAC fish features.

Condition trend is described as unknown due to the lack of previous condition assessments.

Factors affecting this feature are, on the whole, thought to be under control, however the Tywi catchment is under pressure in terms of water quality issues caused by diffuse pollution. Migration barriers such as Llangadog weir have, in recent years, broken down allowing much better passage by fish including bullhead.

Previously, bullhead condition on the Tywi could only be estimated from anecdotal evidence of bycatch from salmonid electrofishing efforts in the catchment. More quantitative analysis of the bullhead population allowing a more meaningful measure of bullhead condition trend to be reported is desirable.

Data for the Afon Tywi has been collected from the EAW National Fisheries Monitoring Programme in 2007-2011. A minimum total of 2,212 bullheads were recorded by EAW during the National Fisheries Monitoring Programme in the Afon Tywi catchment in a total of 151 surveys at 98 different sites. NRW now have 11 temporal sites in the Tywi Catchment which are monitored annually, Only 1 of these sites are within the SAC boundary (site TY38). Throughout the 5 years of monitoring, bullheads have been present at all sites for 4 out of 5 years

Overall the population appears to be anecdotally healthy, but there is still a lack of information to inform an up-to-date assessment based on CSM parameters for population. In reporting cycle 2 the condition is described as unfavourable due to failing flow standards, the trend is described as “unclassified” because no assessment was made of the population.

Management requirements

Vertical drops of >18-20 cm are sufficient to prevent upstream movement of adult bullheads. They will therefore prevent re-colonisation of upper reaches affected by lethal pollution episodes, and will also lead to constraints on genetic interactions that may have adverse consequences. New instream structures should be avoided, whilst the impact of existing artificial structures needs to be evaluated.

The extent and quality of suitable bullhead habitat must be maintained. Elevated levels of fines can interfere with egg and fry survival. Spawning habitat is defined as un-silted coarse (gravel/pebble/ cobble) dominated substrate: males guard sticky eggs on the underside of stones. Larger stones on a hard substrate providing clear

spaces between the stream bed and the underside of pebbles/cobbles are therefore important.

The importance of submerged higher plants to bullhead survival is unclear, but it is likely that where such vegetation occurs it is used by the species for cover against predators. Weed cutting should be limited to no more than half of the channel width in a pattern of cutting creating a mosaic of bare substrate and beds of submerged plants. Slack-water areas provide important refuges against high flow conditions. Suitable refuges include pools, submerged tree root systems and marginal vegetation with >5 cm water depth.

Bullheads are particularly associated with woody debris in lowland reaches, where it is likely that it provides an alternative source of cover from predators and floods. It may also be used as an alternative spawning substrate. Debris dams and woody debris should be retained where characteristic of the river/reach. Woody debris removal should be minimised, and restricted to essential activities such as flood defence.

Maintenance of intermittent tree cover in conjunction with retention of woody debris helps to ensure that habitat conditions are suitable. Some reaches may naturally have lower tree cover. Cover may also be lower in urban reaches.

Bullhead densities have been found to be negatively correlated with densities of non-native crayfish, suggesting competitive and/or predator-prey interactions. Non-native crayfish should be absent from the SAC.

The presence of artificially high densities of salmonids and other fish will create unacceptably high levels of predatory and competitive pressure on juvenile and adult bullhead. Stocking of fish should be avoided in the SAC.

Escapes from fish farms are a form of uncontrolled introduction and should be prevented by effective screening on all intakes and discharges.

Bullheads are relatively sedentary and interactions between populations in different parts of the catchment and in different catchments are likely to be limited, suggesting the existence of genetically discrete populations. Since they are of no angling interest, deliberate transfers between sites are unlikely to have been undertaken in the past, such that the genetic integrity of populations is likely to be intact. There should be no stocking/transfers of bullhead unless agreed to be in the best interests of the population.

In general, management for other SAC features is expected to result in favourable habitat for bullhead, through improvements in water quality and flow regime and maintenance of suitable physical habitat.

Status and Management Requirements of Feature 5: European otter *Lutra lutra*

Status of Feature 5

Otter are currently in **favourable** condition (Morgan, 2005) based on distribution.

Condition trend is currently unknown, although anecdotally is thought to be maintained.

Factors affecting this feature are, on the whole, under control, however the Tywi catchment is under pressure in terms of water quality issues caused by diffuse pollution.

The conservation status of otters in the Tywi SAC is determined by monitoring their distribution, breeding success, and the condition of potential breeding and feeding habitat outlined in the Performance Indicators. Future monitoring efforts ideally focus the search for suitable habitat within 5km of the SAC boundary, if possible. This will focus efforts on a smaller number of sites which could then be followed by further ground-truthing and site revisions.

The current condition of Otter can be considered favourable, but with scope for further improvement, if habitat and other natural factors can be maintained and enhanced.

Management requirements

A survey undertaken in 2004 (Morgan, 2005) identified 101 breeding sites within the Tywi catchment, based on the European Commission's LIFE Natura Programme methodology (Liles, 2003). Of these 14 were in use, with a further 87 having potential (Morgan, 2005).

The report suggested the catchment should be capable of supporting at least 22 breeding pairs, based on one breeding female per 20km stretch of river. It is possible that, if all the breeding sites achieve optimal habitat conditions and fish and amphibian stocks are secured, the catchment may then support further breeding animals. However, the amount of compression of home ranges that otters will accept cannot as yet be determined (Morgan, 2005).

Management should aim to ensure that there is sufficient undisturbed breeding habitat to support an otter population of a size determined by natural prey availability and associated territorial behaviour. The involvement of river users and land managers will be important in improving potential breeding habitat near to the river. Agri-environment schemes provide possible mechanisms for maintaining suitable sites, such as lightly grazed woodlands, areas of dense scrub, and tussocky fens with purple moor-grass. The low lying nature of the floodplain render large areas unsuitable as breeding sites, and it is likely that the tributaries and marginal areas

away from the designated boundaries provide the major potential e.g. relict channels, scrub and woodland.

Food availability is an important factor. Fish biomass should stay within expected natural fluctuations. A potential problem appears to be the decline in eel populations, and similar concerns are apparent with respect to amphibian numbers on a UK scale.

A number of particular threats to the otter have been identified on the catchment, not least the number of road mortalities that have occurred. There is also considerable room to improve the bankside habitat along the main length of the Tywi and some of the tributaries. This presents difficulties on the main river, as its mobile nature and flood magnitude create problems with fencing to exclude stock.

Measures to ensure the safe movement of otters around the catchment will be promoted, in particular the provision of ledges, tunnels and fencing on new road bridge schemes. Where bridges are being repaired or replaced, or at especially bad locations for otter road deaths, such features may be retro-fitted.

Pollution of rivers with toxic chemicals, such as PCBs, was one of the major factors identified in the widespread decline of otters during the last century. There should be no increase in pollutants potentially toxic to otters.

Action plan: summary

This section takes the management requirements outlined in Section 5 a stage further, assessing the specific management interventions required on each management unit. A summary of the information held in Natural Resources Wales' Actions Database for sites.

Actions in Natural Resources Wales' actions database

NRW Internal Reference Number	Unique SAC Unit Number	Unit Name	Summary of Conservation Management Issues	Action needed?
NRW4	000734	NRW4 - Carmarthen Reach	Reduction in flows downstream of the DCWW Capel Dewi intake during pumping, lead to potential drying of habitat for juvenile fish species. Invasive species, including Himalayan balsam and Japanese knotweed are present throughout the reach. They suppress local biodiversity and can lead to bank instability.	Yes
NRW3	007578	NRW3 - Whitemill Reach	This unit is subject to a reduction in flows downstream of the DCWW Nantgaredig intake during pumping (night pumping), lead to potential drying of habitat for spawning and juvenile fish species (Regulation flow is continuous from Brianne but abstraction occurs only at night). The RoC process has examined these impacts, with a resulting change to the abstraction licence to minimise impacts to shad during their spawning season. Potential for disruption of migration cues for fish species. Invasive species, including Himalayan balsam and Japanese knotweed are present throughout the reach. They suppress local biodiversity and can lead to bank instability.	Yes

NRW Internal Reference Number	Unique SAC Unit Number	Unit Name	Summary of Conservation Management Issues	Action needed?
NRW2	007579	NRW2 - Llandeilo Reach	This unit stretches from Nantgaredig u/s to beyond Llanwrda. Land use in the area will be contributing to diffuse inputs of nutrients into the river and controls should be put in place using the available statutory instruments. Areas around Cilsan Bridge show signs of nutrient enrichment. The river itself is heavily regulated via releases from Llyn Brianne although this unit sees a consistent regulation flow. Temperatures of the river may be suppressed because of regulation releases from Llyn Brianne. Invasive species pose a threat to this and the other units in the form of plants such as Japanese knotweed and Himalayan Balsam. Non-native signal crayfish have been found in tributaries of the river near Llandeilo.	Yes
NRW1	007580	NRW1 - Llandovery Reach	This unit represents the suspected spawning limit for shad and other features such as sea lamprey. Llywnjack Farm operates a gravel extraction within this unit. This unit also represents the unit most at influence from the hypolimnial discharge from Llyn Brianne and as such can be expected to be cooler over summer months, than one would expect under natural conditions.	Yes

Glossary

This glossary defines some of the terms used in this **Core Management Plan**. Some of the definitions are based on definitions contained in other documents, including legislation and other publications of Natural Resources Wales and the UK nature conservation agencies.

Action	A recognisable and individually described act, undertaking or **project** of any kind, specified in section 5 or 6 of a **Core Management Plan** or **Management Plan**, as being required for protecting, managing or enhancing one or more of the **features** for which a site is designated.
Attribute	A quantifiable and monitorable characteristic of a **feature** that, in combination with other such attributes, describes its **condition**.
Common standards	See **JNCC common standards.**
Condition	A description of the state of a feature in terms of qualities or **attributes** that are relevant in a nature conservation context. For example, the condition of a habitat usually includes its extent and species composition and might also include aspects of its ecological functioning, spatial distribution and so on. The condition of a species population usually includes its total size and might also include its age structure, productivity, relationship to other populations and spatial distribution. Aspects of the habitat(s) on which a species population depends may also be considered as attributes of its condition. Condition is considered favourable when all the conservation objectives are being met.
Conservation management	Acts or undertaking of all kinds, including but not necessarily limited to **actions,** taken with the aim of achieving the **conservation objectives** of a site. Conservation management includes the taking of statutory and non-statutory measures, it can include the acts of any party and it may take place outside site boundaries as well as within sites. Conservation management may also be embedded within other frameworks for

	land/sea management carried out for purposes other than achieving the conservation objectives.
Conservation objective	The expression of the desired state of a **feature,** expressed as a composite statement defining the **condition** that we wish the feature to be in. Each feature has one conservation objective.
Core Management Plan	A Natural Resources Wales document containing the conservation objectives for a site and a summary of other information contained in a full site **Management Plan**.
Factor	Anything that has influenced, is influencing or may influence the **condition** of a **feature**. Factors can be natural processes, human activities or effects arising from natural process or human activities. They can be positive or negative in terms of their influence on features, and they can arise within a site or from outside the site. Physical, socio-economic or legal constraints on management of the site can also be considered as factors.
Favourable condition	See **condition**.
Favourable conservation status	The Habitats Directive definition of **Favourable Conservation Status** (FCS) is given in full in section 4.
Feature	The species population, habitat type or other entity for which a site is designated. The ecological or geological interest which justifies the designation of a site and which is the focus of **conservation management.**
Integrity	See **Site integrity.**
JNCC common standards	A set of principles developed jointly by the UK nature conservation agencies to help ensure a consistent approach to monitoring and reporting on the features of sites designated for nature conservation, supported by guidance on identification of attributes and monitoring methodologies.

Key Feature	The habitat or species population within a **management unit** that is the primary focus of management and **monitoring** in that unit.
Management Plan	The full expression of a designated site's legal status, **vision**, **features**, **conservation objectives**, **performance indicators** and management requirements. A complete management plan may not reside in a single document, but may be contained in a number of documents (including in particular **the Core Management Plan**) and sets of electronically stored information.
Management Unit	An area within a site, defined according to one or more of a range of criteria, such as topography, location of **features**, tenure, patterns of land/sea use. The key characteristic of management units is to reflect the spatial scale at which site management and **monitoring** can be most effectively organised. They are used as the primary basis for differentiating priorities for conservation management and monitoring in different parts of a site, and for facilitating communication with those responsible for management of different parts of a site.
Monitoring	An intermittent (regular or irregular) series of observations in time, carried out to show the extent of compliance with a formulated standard or degree of deviation from an expected norm. In monitoring of sites designated for habitat and species conservation, the formulated standard is the quantified expression of favourable **condition** based on **attributes**.
Operational limits	The levels or values within which a **factor** is considered to be acceptable in terms of its influence on a **feature**. A factor may have both upper and lower operational limits, or only an upper limit or lower limit. For some factors an upper limit may be zero.
Performance indicators	A subset of the conservation objectives that are quantifiable and measurable. They consist of **attributes** and factors together with their associated target values (or ranges of values) which provide the standard against which information from **monitoring** and other sources

	is used to determine the degree to which the **conservation objectives** for a **feature** are being met.
Plan or project	**Project:** Any form of construction work, installation, development or other intervention in the environment, the carrying out or continuance of which is subject to a decision by any public body or statutory undertaker. **Plan**: a document prepared or adopted by a public body or statutory undertaker, intended to influence decisions on the carrying out of **projects.** Decisions on plans and projects which affect SAC, SPA and Ramsar sites are subject to specific legal and policy procedures.
Site integrity	This is defined in Welsh Government policy as the coherence of a site's ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it is designated.
Site Management Statement	**(SMS)** The document containing Natural Resources Wales' views about the management of a site issued as part of the legal notification of an SSSI under section 28(4) of the Wildlife and Countryside Act 1981, as substituted.
Special Feature	See **feature**.
Specified limits	The levels or values for an **attribute** which define the degree to which the attribute can fluctuate without creating cause for concern about the **condition** of the **feature**. The range within the limits corresponds to favourable, the range outside the limits corresponds to unfavourable. Attributes may have lower specified limits, upper specified limits, or both.
Unit	See **management unit.**
Vision Statement	The statement conveying an impression of the whole site in the state that is intended to be the product of its **conservation management.** A 'pen portrait' outlining the

conditions that should prevail when all the **conservation objectives** are met. A description of the site as it would be when all the **features** are in **favourable condition**.

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Appendix 1. Performance indicators

These performance indicators are a sub-set of the conservation objectives and describe the evidence, including in particular evidence to be obtained from monitoring of sites and features, that will be used to inform judgements about whether or not the conservation objectives are being met.

The assessment of plans and projects should be made in view of the entirety of the conservation objectives, including the performance indicators.

Generic performance indicators for twaite shad, allis shad, sea lamprey, brook lamprey, river lamprey and bullhead.

Performance indicators for physical habitat and water quality attributes

Attribute	Attribute rationale & other comments	Specified limits
A. Extent or Distribution	River habitats are dynamic and the extent can vary in response to natural environmental conditions. However, anthropogenic factors can have detrimental effects on the habitat and/or species distribution. **Method of assessment** - Mapping of the extent of the habitat and/or species distribution and comparison with the baseline.	The extent and distribution of this habitat type is broadly consistent with that as shown as being key habitats (KH) or a sympathetic feature the feature table on pages 15 above . There should be no decrease in the total area of the habitat. Some fluctuation in the overall extent and distribution of the habitat at the expense of other semi-natural habitats is acceptable as this is both natural and indeed desirable. No evident loss through anthropogenic causes.
B. Quality or Habitat		
B.1 Water flow	Flow affects a range of habitat factors of critical importance to characteristic flora and fauna, including current velocity, water depth, wetted area, substrate quality, dissolved oxygen (DO) and water temperature. **Method of assessment** – gauging station data & expert assessment from NRW	The flow target is given in Appendix 3. A total of 10 days of continuous non-compliance in any one year, or 20 days of non-compliance overall in any one year should be considered as the maximum considered acceptable. Also there should be non-compliance over a

Attribute	Attribute rationale & other comments	Specified limits
	Hydrologists. 6 years of daily flow data should be assessed.	total river length of no more than 5% of a 'reach'.
B.2 Water Quality	**Method of assessment** – data from three years of routine monitoring sites within each 'reach' should be obtained. Assessment against targets should be calculated using all samples within that 3 year period unless otherwise specified (based on the assumption that the frequency of sampling is monthly).	Specific targets for individual waterbodies are given Appendix 2.
B.2.6 Macroinvertebrates	Macroinvertebrates form a major part of the biological community of rivers and are sensitive to a range of environmental pressures. **Method of assessment**: Macroinvertebrate data. Species-level data recommended where possible. Ecological status under the WFD assessment using the WHPT, AWICS and PSI tools should be assessed.	Following targets should be met; a. general macroinvertebrates assessment – WHPT (Whalley Hawkes Paisley Trigg (WHPT) method for assessing river invertebrate communities) classification result should meet High Ecological Status. b. AWICS (acidification tool) – AWICS classification results should meet High Ecological Status. Applies to low alkalinity reaches only. c. PSI (siltation tool) - When the PSI (Proportion of Sediment-sensitive Invertebrates) index is formally adopted under WFD target is that High Ecological Status should be met. Until formally adopted target is for the mean EQI for the assessment 'reach' should be 0.9 or more.
B.3 Siltation	Siltation is one of the most widespread pressures on rivers in farmed landscapes. **Method of assessment** – siltation targets are derived from RHS or Proportion of Sediment-sensitive Invertebrates (PSI) may be used. Field observations may also be used.	No unnaturally high levels as indicated by; • 'silting' highlighted in section P ('Overall characteristics – major impacts') of the River Habitat Survey (RHS) form, or • One-third or more of the total number of RHS 'spot-checks' in the 'reach' have silt ('SI') as the predominant channel substrate.
B.4 Habitat structure	Watercourses with a high degree of naturalness will be governed by dynamic processes which result in a variety of physical habitat	

Attribute	Attribute rationale & other comments	Specified limits
	features, including a range of substrate types, variations in flow, channel width and depth, in-channel and side-channel sedimentation features, erosion features and both in-channel and bankside vegetation cover.	
B.4.1 Channel planform	Channel form should be generally characteristic of river type, with predominately unmodified planform. **Method of assessment** – assess planform using map data, aerial survey data, historical records and local knowledge.	≤ 5% of the "reach" should be artificial, re-aligned or constrained.
B.4.2 Habitat Modification	Modifications to the river habitat can cause detrimental effects to the flow, levels of sedimentation, physical structure etc. **Method of assessment** - Habitat Modification Score (HMS) is a metric derived from the RHS data.	≥65% or more of condition monitoring sites should fall within the *semi-natural* HMS class 1, with the remainder *predominantly unmodified* (class 2). No (or minimal) deterioration from the last monitoring cycle.
B.4.3 Bank vegetation naturalness	Majority of bank vegetation should be characteristically natural. **Method of assessment –** RHS score for bank vegetation naturalness.	Mean SERCON score for the "reach" of 4 or 5.
B.4.4 Riparian zone vegetation naturalness	Majority of riparian vegetation should be characteristically natural. **Method of assessment –** RHS score for riparian zone vegetation naturalness.	Mean score for the "reach" of 4 or 5.
B.4.5 Large woody debris	Dead wood within streams/rivers plays an important role in increasing habitat diversity, providing shelter for fish, supplying a food source for aquatic invertebrates and slowing the passage of nutrients downstream. **Method of assessment** –River Habitat Survey (RHS) Data. At least 5 RHS sites should be examined for this target – if fewer than 5 sites are available,	Within each "reach": • EITHER 75% or more RHS sites have large woody debris 'Present' • OR 10% or more of RHS sites have large woody debris 'Extensive'

Attribute	Attribute rationale & other comments	Specified limits
	assessment 'reach' should be amalgamated. Targets should not be applied to 'reaches' where there is naturally occurring low tree cover e.g. an upland river, or where it is removed for reasons of overriding public safety.	
B.4.6 Physical structures	Artificial in-channel structures (such as weirs, dams, sluices, fords, groynes and culverts) may constitute barriers to the free movement of water, sediment and aquatic organisms, and may affect river-bed structure and hydrology downstream. **Method of assessment** - Use expert judgement to assess the "reach". Data sources may include: * Local/management personnel/expert assessment * Hydromorphological and walk-over surveys * River Habitat Survey (RHS) * Air photos * Fisheries personnel * Special surveys assessing structures * River Obstructions (EA dataset) * Rapid assessment methodology to assess obstacles to fish migration (SNIFFER project WFD 111)	Structures should have no effect (or minor effect) on migration, sediment transport and/or habitat structure in the 'reach'. Assessments should include the upstream 'ponding' effects that artificial structures have on flow patterns and habitat structure.
B.5 Negative indicator species	Non-native species constitute a major threat to river systems through competition, introduction of disease etc. **Method of assessment**: assess data from macrophyte surveys, local records etc.	No high impact alien species. established (i.e. self-sustaining populations) within the SAC boundary. High impact alien species defined at UKTAG classification of alien species working paper v8.pdf (wfduk.org). Non-native species or locally absent species should not cause an impact on site integrity.

Performance indicators for feature 1: twaite shad and allis shad.

Performance indicators for features' condition.

Attribute	Attribute rationale & other comments	Specified limits
Distribution	Distribution in the catchment should be appropriate to the natural geomorphology. Brook and river lamprey should be present in all areas of the catchment to which they have natural access. A decline in the known distribution should be of concern. **Method of assessment** – annual kick sampling for eggs. Mapping of the extent of spawning and comparison with the baseline.	Extent should reflect distribution under near-natural conditions. As a minimum twaite shad and allis shad should be present in suitable habitat and there will be no decline in spawning distribution within the SAC boundary. There will be no artificial barriers to migration within the catchment.
Adult run size	**Method of assessment** – Fish counters; hydroacoustic counters; video equipment. Further research required on suitability of methods that do not affect shad migration.	Adult run size should reflect natural conditions. NRW operate an acoustic and video fish counter at Ty Castell flow gauging station immediately upstream of the Capel Dewi WTW intake. There should be no decline in the annual run size greater than would be expected from variations in natural mortality alone.
Juvenile density	**Method of assessment** – seine netting in lower rivers and estuaries	Should not differ significantly from those expected under near-natural conditions.
Presence of adult spawning shad	**Method of assessment** - Visual observation from reliable sources.	Discretionary target: Evidence of spawning activity

Performance indicators for factors affecting the feature

Factor	Factor rationale and other comments	Operational Limits
F1. Fish stocking	Stocking is undesirable within a designated site due to the risk to changes in the habitat and/or natural fish population via feeding behaviour, predation, disease transfer, etc.	No stocking/transfers of fish species at excessively high densities (refer to the WFD list of alien/locally absent species (but not to be used exclusively).
F2. Invasive non-native species	Locally absent species and invasive non-native species (INNS).	No invasive non-native species likely to cause impairment of shad populations. No introduction of other species (including INNS) which may impact shad populations.
F3. Shad stocking	Stocking of shad may cause genetic damage to the population or otherwise reduce population fitness.	No stocking/transfers of allis and/or twaite shad unless agreed to be in the best interests of the population.
F4. Screening	The entrainment of juvenile and adult fish can lead to a loss of the population. This can be avoided through the use of screens at appropriate locations. It is also important that screens are used to prevent the escape of fish from fish farms and fisheries connected to rivers.	Effective screening on all intakes (fish farms and hydropower) and discharges.

Performance indicators for feature 2: sea lamprey.

Performance indicators for features' condition.

Attribute	Attribute rationale & other comments	Specified limits
Distribution (Spatial extent)	Distribution in the catchment should be appropriate to the natural geomorphology. Sea lamprey should be present in all areas of the catchment to which they have natural access. A decline in the known distribution should be of concern.	Extent should reflect distribution under near-natural conditions. As a minimum sea lamprey should be present in suitable habitat and there will be no decline in larval distribution within the SAC boundary. There will be no artificial barriers to migration within the catchment.

	Method of assessment – Larval lamprey are sampled by electrofishing. Other techniques are under development.	
Adult annual run size	Spawning locations may move within and between sites due to natural processes or new sites may be discovered over time. This attribute provides evidence of successful spawning and distribution trends, and will be applied to spawning sites known to have been utilised within the previous 10 years, and historical sites considered still to have suitable habitat. **Method of assessment** Direct observations of spawning sites. Trapping using fyke nets or specially designed traps.	Annual run size should reflect that expected under near-natural conditions.

Performance indicators for factors affecting the feature

Factor	Factor rationale and other comments	Operational Limits
F1. Fish stocking	Stocking is undesirable within a designated site due to the risk to changes in the habitat and/or natural fish population via feeding behaviour, predation, disease transfer, etc. The presence of artificially high densities of salmonids and other fish will create unacceptably high levels of predatory and competitive pressure on juvenile sea lampreys.	No stocking of other fish species at excessively high densities.
F2. Exploitation	Lampreys have recently become popular in the UK as bait for pike fishing. There are also indications that UK populations are sought after as a delicacy in Europe, where stocks are declining.	Zero exploitation. Exploitation is not acceptable within SACs.
F3. Lamprey stocking	It is uncertain whether there are significant genetic differences between lamprey populations of the same species. Any agreed introductions should involve local stock as a precaution.	No stocking/transfers of lampreys unless agreed to be in the best interests of the population.
F4. Screening	The entrainment of juvenile and adult fish can lead to a loss of the population. This can be avoided through the use of screens at	Effective screening on all intakes (fish farms and hydropower) and discharges.

Factor	Factor rationale and other comments	Operational Limits
	appropriate locations. It is also important that screens are used to prevent the escape of fish from fish farms and fisheries connected to rivers.	
F6. Invasive non-native species	Locally absent species and invasive non-native species (INNS)	No invasive non-native species likely to cause impairment of sea lamprey populations. No introduction of other species (including INNS) which may impact sea lamprey populations.

Performance indicators for feature 3: brook lamprey and river lamprey.

These two species are generally indistinguishable for the purposes of monitoring; however management requirements are similar.

Performance indicators for features' condition.

Attribute	Attribute rationale & other comments	Specified limits
Distribution (Spatial extent)	Distribution in the catchment should be appropriate to the natural geomorphology. Brook and river lamprey should be present in all areas of the catchment to which they have natural access. A decline in the known distribution should be of concern. **Method of assessment** – mapping of the extent of spawning and comparison with the baseline. Larval lamprey are sampled by electrofishing.	Extent should reflect distribution under near-natural conditions. As a minimum brook lamprey and river lamprey should be present in suitable habitat and there will be no decline in spawning distribution within the SAC boundary. There will be no artificial barriers to migration within the catchment. Brook lamprey and river lamprey should be present in not less than 50% of all sampling sites surveyed within the natural range. Where brook lamprey and river lamprey have been found in the past they should be present in 90% of sampling sites if suitable habitat remains.

Attribute	Attribute rationale & other comments	Specified limits
Larval density	The relative condition of lamprey populations can be defined by classifying the density of lamprey larvae **Method of assessment** – electric fishing (lamprey method).	Abundance (mean density) of Lampetra spp larvae in the catchment in suitable habitat should be greater than 5 m^{-2}
Age/size structure	This gives an indication of recruitment to the population over the several years preceding the survey. Failure of one or more years recruitment may be due to either short or long term impacts or natural factors. The population demographic structure should demonstrate successful recruitment. **Method of assessment** – age cohort histograms generated from elecrofishing survey (lamprey methodology) data.	There should be evidence of recent recruitment in each assessment unit. For individual sample sites where: Samples of 20-50 larvae should contain at least two distinct size classes. Samples of > 50 larvae should contain at least three distinct size classes. For individual sites where fewer than 20 larvae are caught, compliance with this target should not be assessed.
Adult annual run size	**Method of assessment** – Direct observations of spawning sites. Trapping using fyke nets or specially designed traps. (DIDSON is not suitable for assessing river lamprey)	Annual run size should reflect that expected under near-natural conditions.

Performance indicators for factors affecting the feature

Factor	Factor rationale and other comments	Operational Limits
F1. Fish stocking	Stocking is undesirable within a designated site due to the risk to changes in the habitat and/or natural fish population via feeding behaviour, predation, disease transfer, etc. The presence of artificially high densities of salmonids and other fish will create unacceptably high levels of predatory and competitive pressure on juvenile lampreys and adult brook lamprey.	No stocking of other fish species at excessively high densities.
F2. Exploitation	Lampreys have recently become popular in the UK as bait for pike fishing. There are also indications that UK populations are sought after as a delicacy in Europe, where stocks are declining.	Zero exploitation. Exploitation is not acceptable within SACs.
F3. Lamprey stocking	It is uncertain whether there are significant genetic differences	No stocking/transfers of lampreys unless

Factor	Factor rationale and other comments	Operational Limits
	between lamprey populations of the same species. Any agreed introductions should involve local stock as a precaution.	agreed to be in the best interests of the population.
F4. Screening	The entrainment of juvenile and adult fish can lead to a loss of the population. This can be avoided through the use of screens at appropriate locations. It is also important that screens are used to prevent the escape of fish from fish farms and fisheries connected to rivers.	Effective screening on all intakes (fish farms and hydropower) and discharges.
F6. Invasive non-native species	Locally absent species and invasive non-native species (INNS)	No invasive non-native species likely to cause impairment of lamprey populations. No introduction of other species (including INNS) which may impact lamprey populations.

Performance indicators for feature 4: bullhead.

Performance indicators for features' condition

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Attribute	Attribute rationale & other comments	Specified limits
Spatial extent	Bullheads can be widely distributed in clear, fast flowing streams. They can occur in very small channels (less than 1m wide) where they may be the only fish present. **Method of assessment** – Electrofishing surveys, kick sampling, hand searches. Incidental records may be obtained from other standard monitoring surveys e.g. fisheries surveys, biological kick sampling for water quality monitoring samples.	Should be present in naturally suitable habitat throughout the designated site. As a minimum bullhead should be present in suitable habitat and there will be no decline in spawning distribution within the SAC boundary. There will be no artificial barriers to movement within the catchment.

Attribute	Attribute rationale & other comments	Specified limits
Population	Method of assessment for all sub-attributes– single pass electrofishing from mid/late August/October or by-catch records from electrofishing surveys where bullhead are not the target species.	
Population density	The density of the bullhead population should be assessed in order to identify any significant reductions indicative of unfavourable condition. **Method of assessment** - Records from electrofishing surveys	There should be no reduction in densities from baseline. As a minimum no less than 0.2 m^{-2} in upland rivers (source altitude >100m) and 0.5 m^{-2} in lowland rivers (source altitude ≤100m).
Recruitment	Changes in fish populations can be driven by variability in recruitment. It is important to have evidence of recent recruitment of the species as it gives an indication of a healthy population structure. **Method of assessment** - Length-frequency analysis of records from electrofishing surveys.	There is evidence of recent recruitment for juvenile bullheads in each 'reach' by the presence of 0+ bullheads.

Performance indicators for factors affecting the feature

Factor	Factor rationale and other comments	Operational Limits
F1. Invasive non-native species	Locally absent species and invasive non-native species (INNS)	No invasive non-native species likely to cause impairment of bullhead populations (e.g. non-native crayfish). No introduction of other species (including INNS) which may impact bullhead populations.
F2. Fish stocking	Stocking is undesirable within a designated site due to the risk to changes in the habitat and/or natural fish population via feeding behaviour, predation, disease transfer, etc.	No stocking / transfers of other fish species at excessively high densities.

Factor	Factor rationale and other comments	Operational Limits
F3. Stocking / transfer of bullhead	Stocking or transfer of bullheads from other catchments can cause issues of competition and/or introduce diseases which could affect the bullhead population.	No stocking / transfer of bullhead unless agreed to be in the best interests of the population.
F4. Screening	The entrainment of juvenile and adult fish can lead to a loss of the population. This can be avoided through the use of screens at appropriate locations. It is also important that screens are used to prevent the escape of fish from fish farms and fisheries connected to rivers.	Effective screening on all intakes (fish farms and hydropower) and discharges.

Performance indicators for Feature 5:

European otter

Attribute	Specified limits	Comments
A1. Distribution	Otter signs present at 70% of Otter Survey of Wales sites (CCW, 2005)	The Otter Survey of Wales undertaken in 2002 surveyed 86 reference sites in the Tywi catchment, of which 77% were positive. This continued an upward trend in signs from 14% in 1977; 68% in 1984; 69% in 1991. The next survey is planned in 2009, but CCW are currently considering a rolling programme of sub-catchment survey every 2 years using Otter Survey of Wales full survey sites. The 3 sub-catchments[1] identified in Morgan (2005) would therefore be surveyed once in every six years. The 3 sub-catchments are: Sub-catchment A -estuary to Abergwili Sub-catchment B -Capel Dewi to Llandovery Sub-catchment C-Llandovery to Nant-ystalwyn.
A2. Breeding activity	2 reports of cub/family sightings, or 2 reports of cub, lactating or	Based on current information 5 centres of breeding activity have been estimated within the SAC. These sit with a reach of 67km and therefore exceed the estimate of 1 breeding female per 20km. However each of

Attribute	Specified limits	Comments
	pregnant female road casualties at least 1 year in 3.	these centres includes the confluence of at least 1 major tributary, whose contribution is not take into account.
A3. Actual and potential breeding sites	No decline in number and quality of mapped breeding sites in sub-catchments Ref: as above	In the Tywi catchment, 101 actual or potential breeding sites have been identified, distributed throughout the catchment on the main river and tributaries.

Appendix 2. Water Quality Standards

(as revised in Common Standards Monitoring guidance for Rivers, JNCC 2016)

River SACs designated under the Habitats Regulations 2017 (UK Gov, 2017) overlap river water bodies designated under Water Framework Directive Regulations (NRW, 2015; UK Gov, 2015). The water quality standards that apply come from the source legislation – i.e. for the water body the WFD Regulations standards and for a SAC the Habitats Regulations standards. Note that the words targets and standards are used under the various documents that sit under these two Regulations. We have interpreted these to mean the same thing and for this document we will use the term standard unless directly quoting from a specific document. Water quality standards for Special Area of Conservation (SAC) rivers are set via agreement at a UK level and presented in the JNCC Common Standards Monitoring (CSM) guidance (JNCC 2016).

However, having two sets of standards for the same area of river can lead to confusion as to which apply in a given situation. This Appendix sets out the standards for water quality attributes for river water bodies in the Afon Tywi SAC. Where they are more stringent, WFD Regulation 2017 standards are adopted as the CSM standards.

Note that for the transitional (estuarine) waterbody GB531006013400, specific water quality standards are not yet available. Therefore the standard for this waterbody is to achieve WFD Good Ecological Status.

Organic pollution

Table A2.1a provides the values for the physio-chemical attributes to be applied across all river types. Standards apply throughout the assessment unit, not just at sparsely distributed monitoring sites.

The standards for DO, BOD and un-ionised ammonia are the same for all river water bodies whereas the standard for total ammonia varies according to river type and previous WFD Regulations classification for ammonia (Table A2.1a). For the 90%ile total ammonia the CSM target is 0.25mg/l. However, if High Status under WFD is being reached for a water body for certain river types then the more stringent WFD standard at 0.2mg/l is applied. This is due to the no deterioration principle. Total ammonia standards for each waterbody are given in Table A2.1b.

Table A2.1a. Organic pollution standards for SAC rivers.

Organic pollution attribute	Unit	Test Statistic	Target
Dissolved Oxygen (DO)	% saturation	10%ile	≥85
Biochemical Oxygen Demand (BOD)	mg l^{-1}	Mean calculated over a 3-year period	≤1.5
Total Ammonia	mg l^{-1}	90%ile	Varies by water body. See Table A2.1b.
95%ile un-ionised ammonia	mg l^{-1}	95%ile	≤0.025

Table A2.1b. Total Ammonia standards for river water bodies in the Afon Tywi SAC.

***** Reason for total ammonia standard: some water bodies that meet WFD high status for ammonia have the WFD high target of 0.2 mg l^{-1}, all other water bodies have the CSM target of 0.25 mg l^{-1}.

Water Body ID	Water Body Name	Total Ammonia (90%ile, mg l^{-1})	Reason for total ammonia standard*
GB110060029290	Tywi - confluence with Cothi to spring tidal limit	0.2	WFD (high)
GB110060036250	Tywi (Llandovery Bran to Cothi confl)	0.2	WFD (high)
GB110060036350	Tywi - conf with Doethie to conf with Llandovery Bran	0.2	WFD (high)

Reactive phosphorus

Phosphorous standards are set according to altitude, alkalinity, and river size, with the tightest targets in low alkalinity, high altitude headwater areas, reflecting natural variation (JNCC 2016). River Habitat Survey (EA, 2003) river flow categories are used to determine river size.

The process also includes an alignment procedure to ensure that standards are never less stringent than the Water Framework Directive (WFD) phosphorus standard for the same water body. If the WFD standard is more stringent than the CSM standard then the WFD standard applies.

Individual phosphorus standards for all waterbodies in the Afon Tywi SAC are given in Table A2.2. As explained previously, the WFD phosphate standard has been applied where it is more stringent than CSM targets.

Table A2.2 Phosphorus standards and typology for river waterbodies in the Afon Tywi SAC. * Phosphorus standard to be applied to annual and growing season means. Standard calculated from annual mean expressed in µg L-1 SRP. ** Reason for phosphorus standard: CSM (near natural/max allowable) are derived from the CSM guidance for Rivers and WFD (good/high) from the relevant Water Framework Directive standard.

Water Body ID	Water Body Name	SAC Manage-ment Unit	Phospho-rus standard* (µg l^{-1})	Reason for phosphorus standard**	CSM_ Alt type	CSM_Al k type	River size
GB11006 0029290	Tywi - confluence with Cothi to spring tidal limit	7578	21	WFD (high)	low Alt <80m	low Alk <50mgl	large river
GB11006 0036250	Tywi (Llandovery Bran to Cothi confl)	7579	20	CSM (near natural)	low Alt <80m	low Alk <50mgl	river
GB11006 0036350	Tywi - conf with Doethie to conf with Llandovery Bran	7580	13	WFD (high)	low Alt <80m	low Alk <50mgl	river

Trophic diatom index

The standard should be equivalent to WFD high ecological status using the current version of the diatom classification tool (via light microscopy). This is a tool developed to measure increases in nutrient concentrations through assessing degree of change in floristic composition in benthic diatoms (algae) in streams and rivers.

Acidification

This standard only applies to assessment units whose water body type is classified as siliceous or peat. Other types have good buffering ability and so will not be affected by acidification. See tables 4a and 4b for standards for all water bodies in the Afon Tywi SAC.

Only one WFD water body in the Afon Tywi SAC is is classed at risk of acidification (Hankin *et al*. 2014). However, to comply with CSM guidance, acid targets have been applied for all river water bodies. **Note that monitoring and reporting will only be carried out for water bodies classified as either 'at risk' or 'probably at risk'.** If ANC data is available then water bodies should be assessed against the ANC standard but if ANC data is not available then pH should be used.

Table A2.4a Acidification targets for SAC rivers.

*Acid Neutralising Capacity; ** Dissolved Organic Carbon

Targets for acidification	Method of assessment
ANC*: Mean ANC for all waters > 80 pH (Clear waters with DOC**<10 mg L-1): mean > 6.54 pH (Humic waters with DOC>10 mg L-1): mean > 5.1	Analysis of water chemistry data from environment agencies. At least 36 samples (3 years of data) are required, which must include winter samples.

Table A2.4b. Acidification targets for river waterbodies in the Afon Tywi SAC.

Water Body ID	Water Body Name	Acidification risk	Acid Neutralising Capacity (ANC)	pH
GB110060029290	Tywi - confluence with Cothi to spring tidal limit	Probably not at risk	>80	>6.54
GB110060036250	Tywi (Llandovery Bran to Cothi confl)	Probably not at risk	>80	>6.54
GB110060036350	Tywi - conf with Doethie to conf with Llandovery Bran	At risk	>80	>6.54

Appendix 3. Flow standards

The flow target used in the Environment Agency (EA) Resource Assessment and Management Framework (RAM) utilises the Habitats Directive Ecological River Flow (HDERF) objective during the key fish migration period in April to June. The maximum permissible percentage reduction from naturalised flow levels during this period is given in the table below.

HDERF1 - River flow thresholds for SAC/SSSI rivers

Environmental Weighting Band (sensitivity)	Maximum % reduction from daily naturalised flow at >Qn50	Maximum % reduction from daily naturalised flow at Qn50-95	Maximum % reduction from daily naturalised flow at <Qn50
Very High	10	10	1-5
High	15	10	5-10

For reaches below reservoirs, the effect of abstraction from storage is excluded from the assessment, so that the target flow is a 'benchmark' flow, incorporating the reservoir compensation release, rather than a naturalised flow. At times of low flow, compensation releases may increase the flow downstream of the reservoir above natural levels. There may also be effects resulting from reduced water temperature.

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