Dŵr Cymru Welsh Water

Environmental Assessment of Afon Tywi Drought Order (8201-3)

Final

March 2019

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*As part of a share purchase agreement in August 2015, Cascade Consulting (Environment & Planning) Ltd transferred its business to Ricardo plc. All employees transferred to Ricardo Energy & Environment, a trading name of Ricardo-AEA Ltd which is a wholly owned subsidiary of Ricardo plc. The work described in this report spanned the pre-acquisition and post-acquisition period and throughout this time the consultants involved maintained a continuity of service both as employees of Cascade Consulting and then subsequently as employees of Ricardo Energy & Environment.

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NON-TECHNICAL SUMMARY

INTRODUCTION AND PURPOSE OF THIS REPORT

Welsh Water's Drought Plan provides a comprehensive statement of the actions Welsh Water will consider implementing during drought conditions to safeguard essential water supplies to customers and minimise environmental impact. It encompasses a number of drought management options that will only be implemented if and when required and includes drought permit / order options.

A drought permit or order is a management action that, if granted, can allow more flexibility to manage water resources and the effects of drought on public water supply and the environment.

The objective of this report is to provide an independent and robust assessment of the potential environmental effects of implementing a drought order at Afon Tywi, over and above those arising due to natural effects of drought and those which would occur under "normal" abstraction licence conditions.

The Afon Tywi is located in Welsh Water's Tywi CUS Water Resource Zone (WRZ) which extends from the Vale of Glamorgan in the east, to the west of Camarthenshire, and northwards past Llanwytrd Wells. Water from Afon Tywi is abstracted at the Nantgaredig intake for the local Capel Dewi Water Treatment Works (WTW) or to the Lower Lliw pumped storage reservoir for storage prior to re-abstraction, treatment (at Felindre WTW) and delivered in to the supply network. The Afon Tywi is a component of the Afon Tywi SSSI/SAC and is adjacent Bishops Pond SSSI and Cwm Doethie – Mynydd Mallaen SAC, therefore consideration has been given to the potential impacts of drought order implementation on the features and species of these designated sites.

The assessment also considers how the proposed drought order may affect the environment in combination with the effects of other existing abstraction licences, environmental permits and other drought management plans.

This report is a 'shelf-copy' report which would be updated to support an application to the Welsh Ministers for the Afon Tywi drought order, which may be required by Welsh Water in the future.

PROPOSED DROUGHT ORDER DETAILS

In order to protect public water supplies within Welsh Water's Tywi CUS WRZ in the event of a future severe drought, Welsh Water would make an application to Welsh Ministers for a drought order to vary the conditions of abstraction from Afon Tywi.

If granted, the drought order involves a change in the abstraction conditions at the

Nantgaredig intake to relax the requirement to maintain the downstream flow at an instantaneous daily minimum of 136Ml/d. Instead, the downstream flow requirement of 136Ml/d would be temporarily assessed as a 7-day rolling average, with the daily instantaneous minimum flow requirement temporarily reduced to 116Ml/d. This would enable Welsh Water to more efficiently target a rolling average downstream flow of 136Ml/d, whilst reducing the need to over-release at times of very low flow due to the time of travel between the reservoir and the downstream abstraction intake (24 hours or more) and the difficulties of predicting the next day's gauged flows.

Extreme low flows requiring additional regulation releases to support the maintained flow are only likely in summer and autumn months. Welsh Water has determined, through water resources modelling, that this drought order is most likely to be required during the period from September to November inclusive. The drought order will help to conserve storage in Llyn Brianne Reservoir at times of severe drawdown.

The revised abstraction arrangements would legally be authorised for three months (September-November) but would be removed sooner if water resources have returned to adequate levels to safeguard future water supplies, as agreed with the Welsh Ministers and Natural Resources Wales (NRW).

NEED FOR THE DROUGHT ORDER

Application for a drought order is a precautionary approach. Due to the time needed to determine a drought order application, Welsh Water will potentially apply for a drought order more frequently than it will be used.

The justification for the drought order sought will be set out in a "Needs Statement". This will be produced by Welsh Water at the time of a potential future application, and will form part of the full drought order application.

ALTERNATIVE SOURCES CONSIDERED

Details of alternative sources considered by Welsh Water will be completed at the time of application for the drought order at Afon Tywi. This will demonstrate justification for the proposed drought option details applied for.

POTENTIAL IMPACTS OF DROUGHT ORDER IMPLEMENTATION

The scope of the assessment has been defined by a screening and scoping exercise.

Summary of the Hydrological Assessment

The assessment has concluded that there is a **minor** impact on flows (at minimum flows only) in the Afon Tywi as a result of implementing the drought order. These hydrological impacts are assessed as leading to **minor** impacts on the physical environment of the river, including water quality.

Summary of the Environmental Features Screening

Environmental assessment is required and included for features where screening has identified a major or moderate impact.

Screening identified WFD status and Community Assessment / Habitats Directive designated habitats and species, SSSI designated features and Environment (Wales) Act Section 7 species, invasive flora and fauna, and landscape and visual amenity as environmental features for which an environmental assessment was required.

The assessment has concluded that there are **moderate** impacts on fish, and **minor** impacts on freshwater pearl mussels, macroinvertebrates, macrophytes, and phytobenthos. The assessment also concluded minor impacts on the Afon Tywi SSSI.

The HRA Screening could not conclude that implementation of a drought order would not result in likely significant effects on the twaite and allis shad, brook and river lamprey and bullhead populations within the Afon Tywi SAC.

Cumulative Impacts

No cumulative effects of implementing the drought order with existing licences, consents and plans are currently anticipated. However, this should be reviewed at the time of any future application for a drought order at Afon Tywi.

MITIGATION AND MONITORING

The environmental assessment has identified significant impacts of implementation of a drought order at Afon Tywi. Consequently, in line with the DPG, an Environmental Monitoring Plan has been proposed. Potential mitigation measures have also been proposed and further discussion with NRW is required in order to develop suitable mitigation measures.

CONCLUSIONS

In summary, it has been concluded that the environmental effects on river flows, water quality and ecology of implementing a drought order at Afon Tywi during September to November inclusive, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **minor.**

Contents

Non-Technical Summary

1 INTRODUCTION

1.1 PURPOSE OF THE ENVIRONMENTAL ASSESSMENT

The objective of this Environmental Assessment Report (EAR) is to provide an independent and robust assessment of the potential environmental effects of the implementation of a drought order by Dŵr Cymru Welsh Water (Welsh Water) to relax the maintained requirement below the Nantgaredig intake on the River Tywi so that the instantaneous daily flow requirement is reduced from 136Ml/d to 116Ml/d. Water abstracted from the Afon Tywi is used to provide public water supplies to Welsh Water's Tywi CUS Water Resource Zone (WRZ) (see Section 2.1).

This EAR is a 'shelf-copy' report which would be updated in the event that Welsh Water needs to make an application during any future drought to Natural Resources Wales (NRW) for a drought order at Afon Tywi. A drought order is a management action that, if granted, can help ensure essential water supplies are maintained to homes and businesses. The circumstances under which a drought order may be required is set out in the Welsh Water Drought Plan.

The assessment presented in this EAR considers the effects of implementation of the drought order over the months of September to November inclusive, the period for which Welsh Water has determined it might require a drought order for this water source. The purpose of the assessment is to determine the environmental impacts of the drought order over and above any effects arising from natural drought conditions.

The study area and focus of this environmental assessment of the Afon Tywi drought order, covers the following waterbodies:

- Afon Tywi – Llyn Brianne to conf with Deothie (GB110060036380)
- Afon Tywi - conf with Doethie to conf with Llandovery Bran (GB110060036350)
- Afon Tywi – conf with Llandovery Bran to conf Cothi (GB110060036250)
- Afon Tywi – conf with Cothi to spring tidal limit (GB110060029290)

This EAR includes discussion of the following:

- an assessment of the likely changes in river flow / water level regime due to implementing the proposed drought order (**for a summary, see Section 4 of this report**)
- identification of the environmental features that are sensitive to these changes and an assessment of the likely impacts on these features (**see Section 5 of this report**)

- identification of mitigation measures that may be required to prevent or reduce impacts on sensitive features (**see Section 6 of this report**)
- recommendations for baseline, in-drought and post-drought order monitoring requirements (**see Section 10 of this report**).

The environmental assessment has been conducted in accordance with Government regulations and using the Welsh Government / NRW Drought Plan Guideline[1] (DPG); specifically Section 5 and Appendices I and J, and Welsh Government / Defra / NRW / Environment Agency guidance on drought permits and drought orders[2].

Consideration has been given to the potential impacts of drought order implementation on statutory designated sites, including those designated under international law (Habitats Directive, Birds Directive and the Ramsar Convention) and national legislation (notably Sites of Special Scientific Interest (SSSIs).

In accordance with the DPG, the assessment also considers how the proposed drought order may affect the environment in combination with the effects of existing abstraction licences, environmental permits and other relevant activities and plans. This is discussed further in Sections 3 and 7.

1.2 SUPPORTING STUDIES

The DPG identifies in Section 5.4 that EARs are required as supporting documents to any drought permit or drought order application. The circumstances for which an environmental assessment is required are set out in **Box 1** below.

Box 1: Drought Plan Guidance - requirement for environmental assessment

The DPG requires that all features that could be affected by implementation of a drought order /permit are listed in the EAR and that an assessment is made of how sensitive each feature is to the likely changes in hydrology, hydrogeology and geomorphology, due to implementing the drought order /permit.

The DPG requires a detailed environmental assessment for applications where sensitive features are likely to be subject to a major or moderate impact, or a minor impact where this applies to environmentally designated features. Further environmental assessment is **not** required for those drought orders / permits where there is certainty that there are no such impacted sensitive features.

This environmental assessment is based on data available at the time of writing and

[1] Natural Resources Wales (2017) *Water Company Drought Plan Technical Guideline*. Available at https://cdn.naturalresources.wales/media/684414/final-wc-drought-plan-guidance-2017.pdf?mode=pad&rnd=131656713580000000, Accessed 04 February 2019.
[2] Welsh Government / Defra / Natural Resources Wales / Environment Agency (2015) *Apply for a drought order or emergency drought order*, https://www.gov.uk/government/collections/apply-for-a-drought-permit-drought-order-or-emergency-drought-order Accessed 21 December 2018.

includes the environmental features and data types determined by Box 1 in Appendix I of the DPG (except where these are considered not to be relevant to this drought order). Data were requested from key consultees (including NRW).

Where appropriate, this report also identifies areas where there are deficiencies in data availability and makes recommendations for future data / information gathering and monitoring. Welsh Water will continue to engage closely with NRW to ensure that adequate and sufficient data / information are collated and kept up-to-date in subsequent years to inform future environmental assessments.

1.3 CONSULTATION

Consultation is identified as an essential exercise in the preparation of the EAR. In preparing this 'shelf-copy' EAR for a drought order at Afon Tywi, consultation with regulators and wider stakeholders has been undertaken to gain feedback on potential adverse effects, gather data and discuss any required monitoring and / or mitigation measures.

Further consultation will be also be undertaken at the time of any future applications for the drought order.

1.4 STRUCTURE AND CONTENT OF THE REPORT

This EAR comprises the following sections:

Section 1: Introduction

Section 2: Background to the Drought Order

Section 3: Approach

Section 4: Hydrology and the Physical Environment

Section 5: Environmental Features Assessment

Section 6: Mitigation

Section 7: Cumulative Impacts

Section 8: Summary of Residual Impacts

Section 9: Impacts on Statutory Designated Sites

Section 10: Environmental Monitoring Plan (EMP)

Section 11: Conclusions

2 BACKGROUND TO THE DROUGHT ORDER

2.1 WELSH WATER'S SUPPLY SYSTEM

Welsh Water supplies water to more than 3 million people. The Welsh Water supply area covers the majority of Wales and a small part of England. It is split into 24 WRZ's (see **Figure 2.1**).

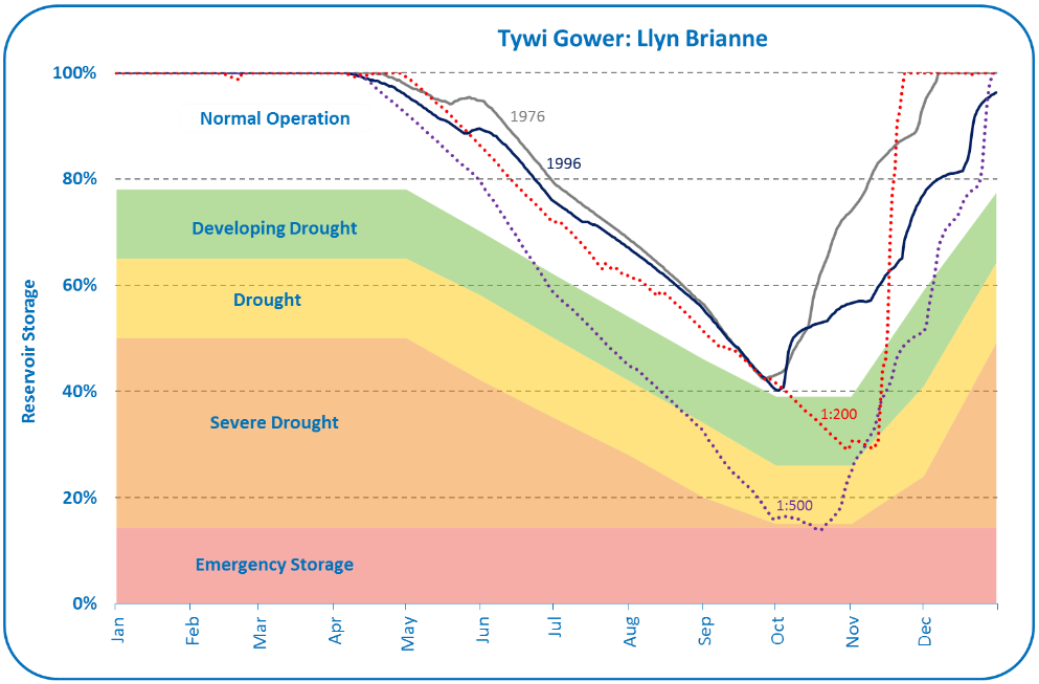
Figure 2.1 Welsh Water Water Resource Zones

The Afon Tywi is located in the Tywi WRZ, which extends from the Vale of Glamorgan in the east, to the west of Camarthenshire, and northwards past Llanwytrd Wells.

The trigger levels for applying for a drought order at Afon Tywi are based on water levels in Llyn Brianne Reservoir falling into the Severe Drought Action Zone below a defined threshold level as shown in **Figure 2.2** (orange shading labelled 'severe drought'). Welsh Water's assessment in its draft Drought Plan 2020 indicates that drought conditions severe enough to require an application for this drought option are unlikely to occur more frequently than at a return period of around once every 200 to

500 years. Fuller details of the work undertaken to assess this risk are provided in Annex 1 to the draft Drought Plan 2020.

Figure 2.2 Tywi WRZ : Llyn Brianne Reservoir Drought Action Zones and Historic Droughts



2.2 DESCRIPTION OF EXISTING ARRANGEMENTS AT AFON TYWI

Welsh Water's licence (number 22/60/3/0035) to abstract water under the Water Resources Act from the Afon Tywi at the Nantgaredig river intake and the Section 20 Operating Agreement between NRW and Welsh Water includes the following conditions:

- 82,964.5 million litres (Ml) authorised to be abstracted per annum.
- At an average daily abstraction rate of 227.3Ml/d.
- The low flow of the Afon Tywi is regulated by controlled releases from Llyn Brianne impounding reservoir. These controlled releases consist of the following:

  a) A statutory compensation water discharge of 68Ml/d at those times when regulation releases are not being made

  b) Regulation releases to support the abstraction at Nantgaredig intake are required, depending on remaining flow in the river as measured at the downstream NRW Capel Dewi flow gauge:

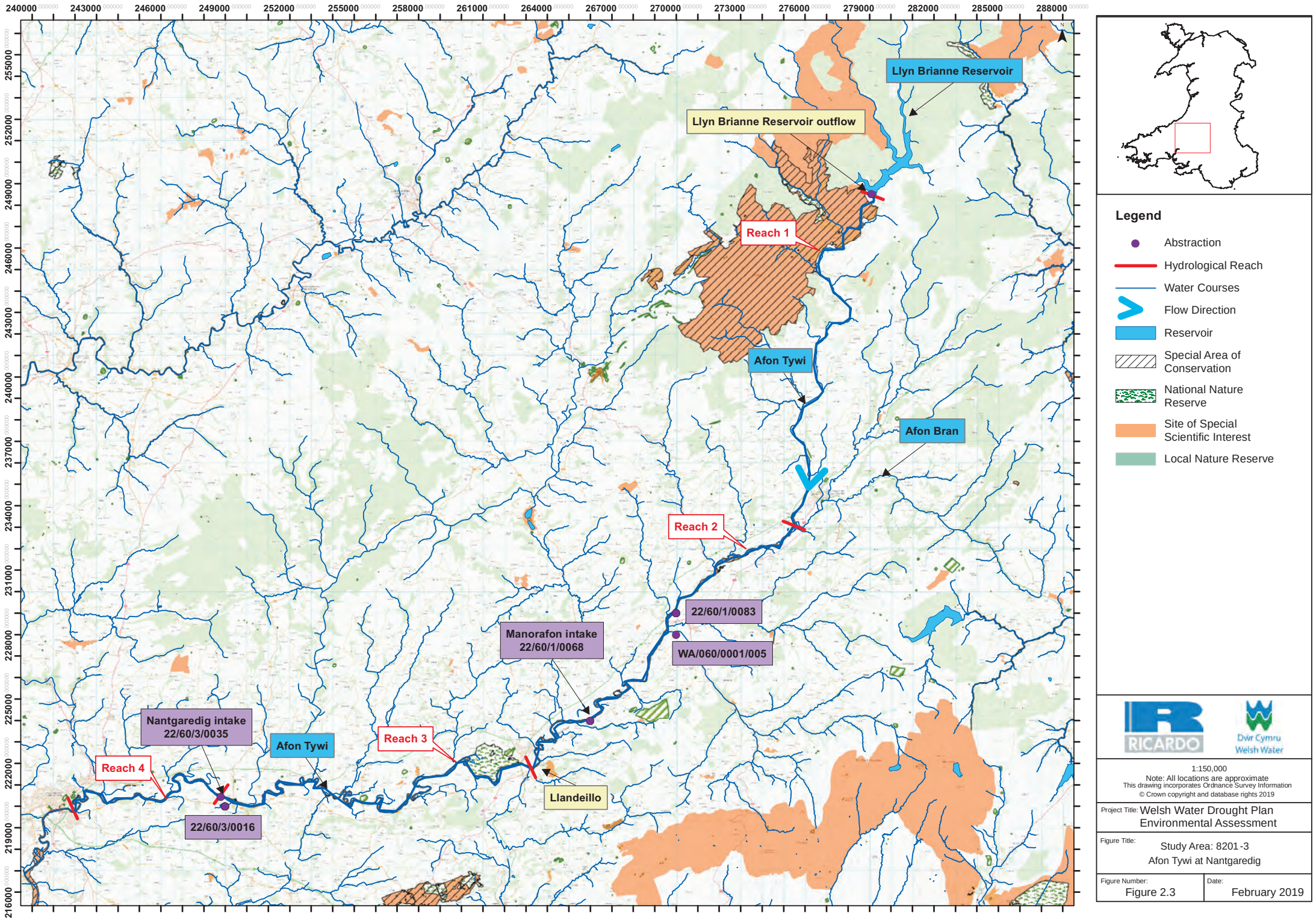
i. At remaining flows measured at 681Ml/d or above, no regulation releases are required to support full daily abstraction.

ii. At remaining flows measured between 681Ml/d and 136Ml/d, regulation releases are required to support abstraction on a put-and-take basis. The maximum rate of abstraction during the day must not exceed the regulation release rate in the previous day.

iii. At remaining flows measured at or below 136Ml/d, the remaining flow becomes a hands-off flow of 136Ml/d and additional controlled releases are required to support the hands-off flow, in addition to those to support abstraction on a put-and-take basis.

The abstraction for potable supply is made from the Afon Tywi at the Nantgaredig intake, and is pumped to either the local Capel Dewi Water Treatment Works (WTW) for treatment or to Lower Lliw pumped storage reservoir for storage prior to reabstraction, treatment at Felindre WTW and delivery into the supply network. The time of travel from Llyn Brianne Reservoir to Nantgaredig is estimated to be typically around 24 hours, increasing to 36 hours at very low flows.

The study area is illustrated on **Figure 2.3**.



Legend

- Abstraction
- Hydrological Reach
- Water Courses
- Flow Direction
- Reservoir
- Special Area of Conservation
- National Nature Reserve
- Site of Special Scientific Interest
- Local Nature Reserve

RICARDO

Dŵr Cymru Welsh Water

1:150,000

Note: All locations are approximate

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Study Area: 8201-3 Afon Tywi at Nantgaredig

Figure Number: Figure 2.3

Date: February 2019

2.3 WELSH WATER'S DROUGHT PLANNING PROCESS

Water companies in England and Wales are required to prepare and maintain Statutory Drought Plans under Sections 39B and 39C of the Water Industry Act 1991, as amended by the Water Act 2003, which set out the management and operational steps a water company will take before, during and after a drought. The Water Industry Act 1991 defines a drought plan as '*a plan for how the water undertaker will continue, during a period of drought, to discharge its duties to supply adequate quantities of wholesome water,* with *as little recourse as reasonably possible to drought orders or drought permits*'.

The Drought Direction (Wales) 2017 states that revised Drought Plans should be submitted according to the following schedule:

> *4(b) for a revised drought plan –*
>
> *if section 39B(6)(a) of the Act applies, within 6 months after the date on which the material change of circumstances occurs; and*
>
> *if section 39B(6)(c) of the Act(c) applies, no later than 4 years after the date on which its drought plan, or its last revised drought plan, is published.*

2.4 STATEMENT OF THE NEED FOR DROUGHT ORDER

This section will be completed at the time of application for a drought order.

2.5 DROUGHT ORDER– REGULATORY ARRANGEMENTS

In periods of unusually low rainfall, when water resources become scarce, the Water Resources Act 1991, as amended by the Environment Act 1995 and the Water Act 2003, allows for three mechanisms for temporarily augmenting water supplies from rivers, lakes, reservoirs and groundwaters: drought permits; ordinary drought orders; emergency drought orders.

Drought permits are granted by NRW, and allow a water company powers to abstract from specified water sources, or to modify or suspend the conditions set out in existing abstraction licences. Drought orders are granted by the Welsh Ministers and give powers either to a water company or to NRW to abstract from specified water sources, or to modify or suspend the conditions set out in existing abstraction licences, but also to allow the discharge of water to specified places, modify or suspend conditions relating to a discharge or prohibit or limit particular non-essential uses of water as set out in the Drought Plan (Wales) Direction 2017. Emergency drought orders grant the same powers as a drought order, but in addition, confer powers to prohibit or limit water uses as specified by the water company and allow the set up and supply of water by means of standpipes and/or water tanks or rota cuts.

Drought permits and orders may be granted for a period of up to six months and they can be extended for up to a further six months.

As part of the drought order/permit application process, water companies are required to prepare an Environmental Report setting out anticipated effects of the proposal, including the effect on other abstractors and sufficient information to inform assessments, where applicable, in relation to the Habitats Directive, Countryside and Rights of Way Act (CRoW), and the Water Framework Directive (WFD).

Further information on the requirements for the environmental assessment and reporting according to legislation and national guidance are provided in Section 3.

2.6 REVIEW OF ALTERNATIVE OPTIONS

This section will be completed at the time of application for a drought order, setting out the alternative options to the drought order that Welsh Water has considered in addressing the risks to essential public water supplies due to drought.

2.7 PROPOSED DROUGHT ORDER DETAILS

In order to protect essential public water supplies within Welsh Water's Tywi CUS WRZ in the event of a future severe drought, Welsh Water may need to make an application to NRW for a drought order to vary the conditions of its abstraction licence from Afon Tywi.

The drought order involves a change in the abstraction conditions at the Nantgaredig intake to relax the requirement to maintain the downstream flow at an instantaneous daily minimum of 136Ml/d. Instead, the downstream flow requirement of 136Ml/d would be temporarily assessed as a 7-day rolling average, with the daily instantaneous minimum flow requirement temporarily reduced to 116Ml/d. This would enable Welsh Water to more efficiently target a rolling average downstream flow of 136Ml/d, whilst reducing the need to over-release at times of very low flow due to the time of travel between the reservoir and the downstream abstraction intake (24 hours or more) and the difficulties of predicting the next day's gauged flows.

Extreme low flows requiring additional regulation releases to support the maintained flow are only likely in summer and autumn months, considered to not extend outside the period September to November. This has been confirmed by Welsh Water's water resources modelling. The drought order will help to conserve storage in Llyn Brianne Reservoir at times of severe drawdown.

The drought order will influence the Afon Tywi from the Llyn Brianne reservoir outflow to the tidal limit.

Table 2.1 Afon Tywi Existing and Proposed Drought Order Abstraction

Abstraction Water Source	NGR	Normal Abstraction	Proposed Drought Order Abstraction	Benefit Ml/d
Afon Tywi		Welsh Water's licence (number 22/60/3/0035) to abstract water under the Water Resources Act from the Afon Tywi at Nantgaredig river intake includes the following conditions: . 82,964.5 million litres (Ml) authorised to be abstracted per annum. . At an average daily abstraction rate of 227.3Ml/d. . The low flow of the Afon Tywi is regulated by controlled releases from Llyn Brianne impounding reservoir. These controlled releases consist of the following: a. A statutory compensation water discharge of 68Ml/d at those times when regulation releases are not being made b. Regulation releases to support the abstraction at Nantgaredig intake are required, depending on remaining flow in the river as measured at the downstream NRW Capel Dewi flow gauge: . At remaining flows measured at 681Ml/d or above, no regulation releases are required to support full daily abstraction. . At remaining flows measured between 681Ml/d and 136Ml/d, regulation releases are required to support abstraction on a put-and-take basis. The maximum rate of abstraction during the day must not exceed the regulation release rate in the previous day. . At remaining flows measured at or below 136Ml/d, the remaining flow becomes a hands-off flow of 136Ml/d and additional controlled releases are required to support the hands-off flow, in addition to those to support abstraction on a put-and-take basis.	The drought order involves a change in the abstraction conditions at the Nantgaredig intake to relax the requirement to maintain the downstream flow at an instantaneous daily minimum of 136Ml/d. Instead, the downstream flow requirement of 136Ml/d would be temporarily assessed as a 7-day rolling average, with the daily instantaneous minimum flow requirement temporarily reduced to 116Ml/d.	14Ml/d

[Note: it will probably be necessary to remove the NGR for any public domain version]

2.8 DROUGHT ORDER PROGRAMME

Drought orders may remain in force for a period of up to six months, and they can be extended for up to a further six months. However, the period of implementation for this drought order is restricted to September to November, as confirmed by water resources modelling carried out by Welsh Water.

Prevailing weather conditions and rainfall in the intervening period may delay the requirement for applications, or even result in no requirement to apply. An order may be granted but not actually implemented if weather conditions improve or, equally, the order may only be partially implemented.

2.9 DROUGHT ORDER BASELINE

It is important for the assessment to establish the environmental "baseline" conditions that would exist in drought conditions but in the absence of the drought order being implemented. For the purposes of this assessment, the "without drought order" baseline includes daily abstractions from Welsh Water's Afon Tywi intake at Nantgaredig and regulation releases from Llyn Brianne to support the abstraction and maintained flow downstream of the intake as required under the existing licence conditions.

3 APPROACH

3.1 INTRODUCTION

The DPG states that the environmental report must include:

i. the likely changes in flow, level, channel/riparian form and sediment due to implementing the action;
ii. the features that are sensitive to these changes;
iii. potential impacts on sensitive features;
iv. a plan of baseline, in-drought and post-drought monitoring; and
v. mitigation or compensation measures that may be required

Items i and ii above were subject to an initial screening process as part of the scoping exercise. Section 3.2 below describes the approach taken. This has provided the relevant study area and a list of features scoped into the environmental assessment which are the subject of this EAR.

Section 3.3 describes how the environmental assessment has been undertaken, including discussion of the general approach, guidance used, provision of data, assessment methodologies and consideration of mitigation and monitoring. Limitations to the environmental assessment are described in Section 3.4, 4 and 5.

To set the context of the studies, it should be noted that EAR considers the environmental impacts of implementing a drought order during the worst environmental conditions (natural drought) that the order could be implemented in.

In accordance with the DPG and the Habitats Regulations, the assessment considers how the proposed drought order may affect the environment in combination with the effects of other existing abstraction licences, environment permits and other plans. This includes assessment of the potential cumulative effects of the following:

- Welsh Water's existing abstraction licences that operate within the hydrological zone of influence of the drought option, as well as other abstraction and discharge consents
- Assessment of cumulative impacts of the drought order with other Welsh Water supply side and drought permit / order options within the hydrological zone of influence (including both intra- and inter- zone options)
- Other plans and projects of relevance, including:
    - Welsh Water's WRMP schemes which are scheduled to be implemented and become operational within the time period of the revised Drought Plan (i.e. before 2025)

- Drought options from other neighbouring water company Drought Plans, Natural Resource Wales Drought Plans
- National Policy Statements for Wastewater and Renewable Energy Infrastructure.

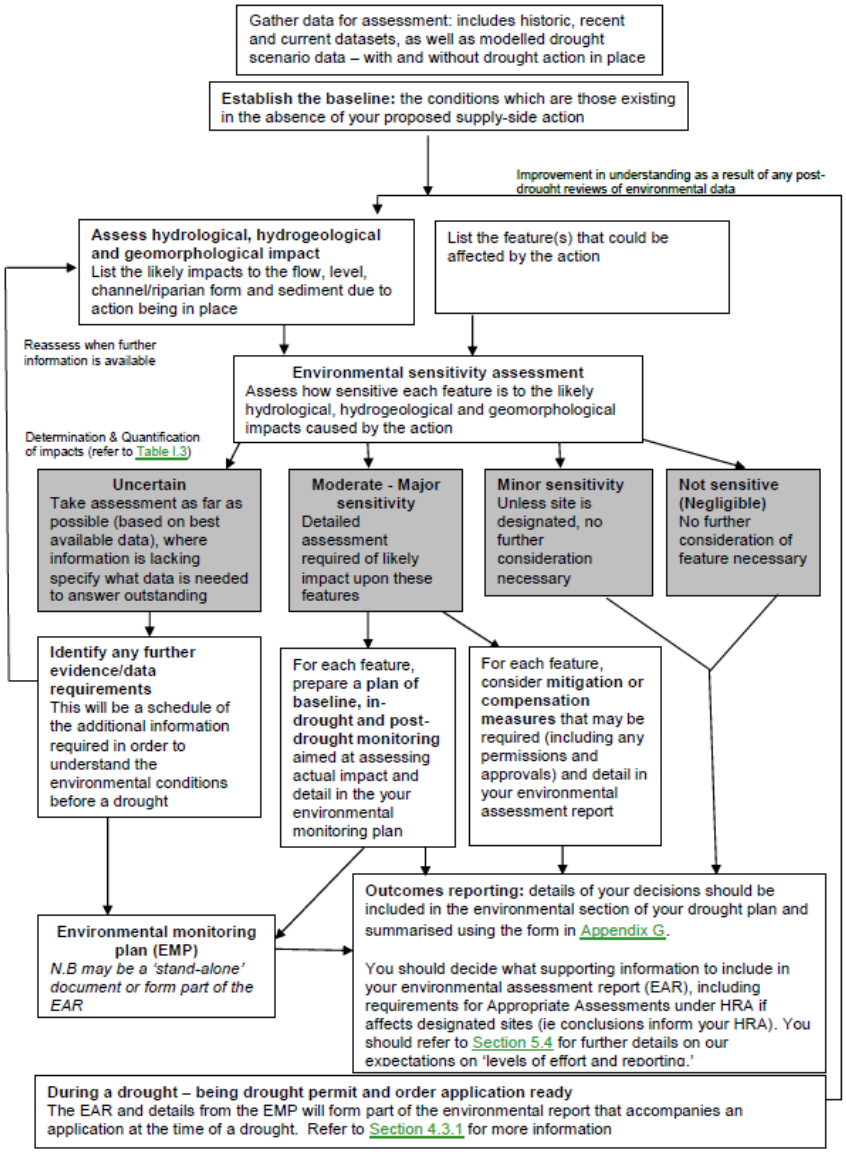
This is discussed further in Section 7.

3.2 APPROACH TO SCREENING AND SCOPING

3.2.1 Screening

Screening was undertaken using the DPG; specifically Section 5 and Appendix I. Figure 2 of the DPG (replicated in **Figure 3.1** below) identifies the environmental impact activities required.

Figure 3.1 Environmental Impact Activities Identified in the Drought Plan Guideline



The screening fulfils the requirement to "Assess how sensitive each feature is to the likely hydrological, hydrogeological and geomorphological impacts caused by the action". Stage 1 (hydrological impact) fulfils the requirement to "List the likely impacts to the flow, level, channel/riparian form and sediment due to action being in place". Stage 2 (environmental sensitivity) fulfils the requirement to "list the feature(s) that could be affected by the action" and to "Assess how sensitive each feature is to the likely hydrological, hydrogeological and geomorphological impacts caused by the action"

It is important to acknowledge the basis of the assessment; i.e. impacts of drought order implementation should be considered in the context of what would occur without drought order implementation (see Sections 2.2, 2.7 and 2.9).

The approach to undertaking Stages 1 and 2 is described below.

Stage 1 – Hydrological and Hydrogeological Impact

Consideration is required (by the DPG) of the likely impacts on the hydrology, hydrogeology and geomorphology of every river reach, wetland or lake area influenced by the proposed drought management action, specifically:

- identify the drought conditions which trigger the proposed action;
- identify any changes that the action is likely to bring about, specifying their length, severity and location in relation to existing natural and artificial features;
- describe the likely conditions in the absence of the proposed action;
- describe how the likely conditions would differ with the action in place compared to the same (or analogous) watercourse under natural conditions; and
- identify the extent of the area affected by the planned actions.

The hydrogeological and hydrological information is used together with information on the other environmental features in the study area from Stage 2 - Environmental Sensitivity (see below) to identify the environmental risk of implementing the drought order.

Although the DPG informs the hydrometric data to be used as part of environmental features for consideration within the environmental assessment (see Box 1 Appendix I of the DPG), it does not provide a methodology for identifying the hydrological impact. A bespoke assessment has therefore been undertaken.

The full hydrological assessment approach is set out in **Appendix A**.

The output from these studies provides an understanding of the scale of change in the

hydrological characteristics as a result of implementing the drought order. Where changes have been identified, the potential significance of adverse or beneficial impacts has been assessed.

Quantitative and qualitative measures have been used to grade the impacts on surface waters. The assessment has identified the potential severity of impact based on the following criteria:

- **Positive or Negative Impact** – all impacts are considered to be negative unless otherwise stated in the feature assessment.
- **Extent** – the extent of the impact is covered as part of the magnitude consideration.
- **Magnitude** – the magnitude of the impact is identified as**:**
  - *High*: There is a long-term large-scale (i.e. catchment) change in the physical environment.
  - *Medium*: There is a short-term large-scale change or long-term short-scale (i.e. reach) change in the physical environment, however, no changes in the overall integrity of the physical environment.
  - *Low*: There is a short-term small-scale change in the physical environment, but its overall integrity is not impacted.
  - *Negligible*: No perceptible change in the physical environment.
- **Duration** – the duration of impact is considered to be for 6 months, which is the duration for which a drought option is implemented, unless otherwise stated.
- **Reversibility** – all hydrological impacts are considered to be reversible**.**
- **Timing and Frequency** – the drought option could be implemented at any point in the year, unless otherwise stated. The assessment is based upon the operation of a single drought order, with subsequent applications for a drought order required to consider cumulative effects of multiple drought order.
- **Probability** – all impacts are considered to be probable, unless otherwise stated.

The hydrological impact assessment is described fully in **Appendix B**.

Section 4 provides a summary of the hydrology and physical environment assessment as a result of implementing the Afon Tywi drought order.

Stage 2 - Environmental Sensitivity

With the extent and level of flow impact mapped, using GIS and other data sources, potentially sensitive receptors (sites / features) located within the extents of impact have been identified. Potentially sensitive features investigated in the screening have been drawn from Box 1 in Appendix I of the DPG. These include:

- designated biodiversity sites (Local Nature Reserve (LNR), National Nature Reserve (NNR), Marine Protected Areas, National Parks, Areas of Outstanding Natural Beauty (AONB), SSSI, Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar) and Environment (Wales) Act Section 7 species / habitats which are located on or within 500m of the impacted reaches;
- protected species;
- ecological communities (fish, bryophytes & lichen, macro-invertebrates, macrophytes, algae) and, where identified, Water Framework Directive (WFD) status of designated waterbodies which contain the impacted reaches;
- invasive non-native species;
- sensitive ecological features as advised by NRW;
- wider features which should be taken into account in determining the potential impacts of drought option implementation – specifically socio-economic & health, amenity & aesthetics, recreation, navigation, architectural & archaeological heritage.

Each of the identified sensitive receptors within the extent of impact have been listed, alongside a brief summary of their potential susceptibility to flow impacts. For designated sites, this has included an indication as to whether the sites have water dependent qualifying interests.

The environmental sensitivity of each site has been identified according to the ecological and nature conservation interests of the area and, in particular, the proximity of and / or connectivity with the designated protected area. Each site has been assessed according to whether the extent of hydrological influence includes or is considered to affect a designated or protected site. Designated or protected sites outside the extent of hydrological influence are considered not to be influenced by the drought order.

The outcome of Stage 1 and Stage 2 of the screening exercise are presented in Sections 4 and 5 respectively.

3.2.2 Scope

The screening exercise establishes the study area for the Afon Tywi drought order together with identification of relevant, sensitive environmental features within those study areas (based on the risk of them being impacted by the drought order during the period of its operation).

As set out in **Figure 3.1**, the environmental sensitivity screening identifies the outcome for each listed feature. Four outcomes are possible from the screening: uncertain; moderate-major sensitivity; minor sensitivity; not sensitive (negligible);

and identifies appropriate next steps. Sections 4.2 and 5.2 present the findings which show that a number of features were identified as either: 1) uncertain; 2) moderate-major sensitivity; or 3) minor sensitivity in a designated site and in accordance with the DPG are features for which further assessment work will be required. These features alone form the scope of monitoring, environmental assessment, and consideration of mitigation actions.

The DPG states that environmental assessment, mitigation and / or monitoring is not required for features where screening has identified a minor (unless a site is designated) or negligible impact. However, the requirement for assessment, monitoring and / or mitigation has been reviewed on a case-by-case basis. In some cases, mitigation and / or monitoring has been recommended where minor impacts are identified, where considered appropriate on a precautionary basis.

3.3 APPROACH TO ASSESSING IMPACTS, MITIGATION AND MONITORING

3.3.1 General Approach

The assessment approach is in accordance with legislation, national regulations and guidance, including:

- NRW (2017) Water Company Drought Plan Technical Guideline (DPG)
- Welsh Ministers (2017) The Drought Plan (Wales) Direction
- Institute of Environmental Management and Assessment (2004) Guidelines for Environmental Assessment
- Chartered Institute of Ecology and Environmental Management (CIEEM) (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland[3]
- UKWIR (2007, updated 2012) Strategic Environmental Assessment – Guidance for Water Resources Management Plans and Drought Plans. Prepared by Cascade Consulting
- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)
- Council Directive 2009/147/EC of 30 November 2009 on the conservation of wild birds
- The Convention on Wetlands of International Importance especially as Waterfowl Habitat , December 1975
- Conservation of Habitats and Species Regulations 2017

[3] CIEEM, Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial. Freshwater and Coastal. September 2018.

- The Countryside and Rights of Way Act 2000.

All aspects of the drought order of potential environmental significance are considered in the environmental assessment.

The DPG states that a water company should clearly show what evidence and data have been used in decision making, that uncertainties should be identified, and which additional data requirements are provided for through the environmental monitoring plan.

In accordance with the DPG the approach to the assessment addresses the following: i) potential effects on each sensitive receptor; ii) definitions for impacts (adverse / beneficial); iii) the data requirements; iv) assessment methodology (including the treatment of uncertainty where the complete data requirements are not available).

This EAR presents the environmental baseline, i.e. habitats and environmental pressures (including flow and water quality) in the study identified zone of hydrological influence without the drought order in place, utilising a description of the catchment, geomorphology, anthropogenic features and water quality. Key changes to the physical environment as a result of implementing the drought order have been identified and described and, where appropriate, this information is used to frame and support the assessments of features which have been scoped in further to the screening and scoping exercise (see Section 3.2).

3.3.2 Assessment Methodologies

The aim of the Environmental Assessment is to provide:

- A clear summary of the outcome of each assessment (per feature) from which NRW can readily identify the significance of the impact when determining the drought order application
- Identification of those predicted impacts which are to be taken forward to consider additional monitoring and mitigation actions.

The assessment considers the environmental impacts of implementing the drought order against baseline operating conditions of Welsh Water's abstraction licence in advance of drought order implementation. Environmental sensitivity has been assessed considering the context of the timing of drought order implementation. **It is important to acknowledge the basis of the assessment; i.e. impacts of drought order implementation are assessed against what would occur without drought order implementation**.

The impact assessment for sensitive features is feature specific and is dependent on the availability and resolution of available data. Where possible, quantitative assessments have been undertaken. However, for many features, it is acknowledged

that the assessments are qualitative and based on professional judgement, and using, where relevant, experience of local knowledge and reference to literature. This introduces uncertainty into the impact assessment. A precautionary approach has been used to assigning impact significance where data are absent or found not to be robust.

The assessment of impacts on designated sites has been undertaken using professional judgement with reference to conservation objectives and condition status of habitats and species, for which a site has been designated. The ecological assessment has been undertaken recognising the IEMA[4,5] and the CIEEM study guidelines[6]. The assessment of impacts on other environmental receptors e.g. recreation and landscape has been carried out largely by qualitative expert judgement.

Assessment of impacts on specific features has then been undertaken. Specific assessment methodologies have been developed for key environmental features. These are set out in **Appendix C** (assessment methodologies for the ecological assessment of Environment (Wales) Act Section 7 species, designated sites and other flora and fauna).

Other abstractors, including other water company abstractions, are features that have been reviewed within the assessment. This has been undertaken to determine whether other abstractors could potentially be affected by changes to surface water flows and levels as a result of implementation of the drought order.

3.3.3 Mitigation and Monitoring

Section 5.3 of the DPG identifies the specific requirements for mitigation of serious impacts on the environment as a result of implementing a drought management measure. The assessments undertaken in this EAR confirm the features requiring consideration of mitigation and appropriate monitoring triggering mitigation. Appropriate mitigation actions identified are both available and practicable.

The DPG also identifies the specific requirements for monitoring. The assessments undertaken in this EAR inform the features requiring consideration for monitoring prior to, during, or after implementation of the drought order.

The mitigation and monitoring proposals (see Sections 6 and 10) will act as a safeguard that responds and is responsive to both predicted and unpredicted drought impacts. Future data collection and monitoring can then be focused to identify the aquatic ecosystem interaction to better quantify the potential impacts where gaps in the evidence base are identified and ensure the appropriate targeting of monitoring and

[4] IEMA (2004) Guidelines for Environmental Impact Assessment.
[5] IEMA (2011) Special Report – The State of Environmental Impact Assessment Practice in the UK
[6] CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland.

mitigation response. The EMP will need to be finalised in agreement with NRW.

3.4 LIMITATIONS OF THE ASSESSMENT AND UNCERTAINTIES

The DPG states that a water company should clearly show what evidence and data have been used in decision making, that uncertainties should be identified, and which additional data requirements are provided for through the environmental monitoring plan.

The assessment presented in this document draws on available information from surveys and investigations undertaken by Welsh Water, NRW, as well as other bodies over a number of years. Reference has also been made to wider studies from published and grey literature, i.e. academic literature that is not formally published, where appropriate.

Specific details are provided on the quality of the data collected and used in the assessment. Where uncertainties remain with respect to the quantification and prediction of impacts, the limitations and any assumptions made are included in the relevant technical sections (Sections 4 and 5).

Overall, it is considered that the conclusions are based on information that is robust and valid at the time of writing. However, it should be noted that this EAR would be updated to support any future actual application, including a review of data.

4 AFON TYWI DROUGHT ORDER - HYDROLOGY AND THE PHYSICAL ENVIRONMENT

4.1 INTRODUCTION

Consideration of hydrology and the water physical environment sets the context for the potential range of environmental effects of the drought order. **Appendix B** sets out an assessment of the potential impacts on the physical environment of Afon Tywi during the period of implementation of the drought order. The "without drought order" baseline is set out in Section 2.9.

The water physical environment assessment includes consideration of hydrology and hydrodynamics; geomorphology; and water quality. The assessment has three key objectives:

1. It is used to "list likely changes in flow, level, channel/riparian form and sediment due to implementing the action' as required by the DPG and set out in Figure 2 of the DPG
2. It is used to support the screening and assessment of sensitive features (including ecological features and designated sites) as required by the DPG and set out in Section 5 of this report
3. Where sensitive features are the physical environment itself, it provides supporting technical information for their screening and assessment.

Each of these are summarised below.

4.2 SUMMARY OF STAGE 1 SCREENING

This fulfils the DPG requirements of Stage 1 of the screening of potential drought order impacts, identifying the likely changes in flow/ level regime due to implementing the drought order. The specific requirements of the DPG are summarised as:

- identify any changes that the drought order is likely to bring about, specifying their length, severity and location in relation to existing natural and artificial features (e.g. flow, water level, channel dynamics and sediment changes);
- describe the likely conditions in the absence of the drought order;
- describe how the likely conditions would differ with the drought order in place compared to the same (or analogous) watercourse under natural conditions; and
- identify the extent of the area affected by your planned actions.

These requirements are addressed in the following sections.

1. The perceived extent of potential impact:

The study area (see **Figure 2.3**) is identified as the Afon Tywi from the Llyn Brianne reservoir outflow to the tidal limit.

2. The nature and duration of the potential impact:

A description of the likely conditions with the drought order in place, in comparison to the baseline conditions (absence of the proposed action) is provided in **Appendix B**. Given the conditions of the proposed drought order, the key areas for the assessment of the physical environment have been identified as:

- Change in river flows downstream of Afon Tywi.

The **Appendix B** assessment has been summarised in **Table 4.1** in terms of the magnitude and duration of each of these potential physical environment impacts.

3. The length of the potential impact:

The **Appendix B** assessment has been summarised in **Table 4.1** in terms of the timing of each of the potential physical environment impacts. The drought order is most likely to occur during the autumn, considered to not extend outside the period September to November.

4.3 SUMMARY OF POTENTIAL EFFECTS ON THE PHYSICAL ENVIRONMENT

The potential changes to the physical environment (water quality and geomorphology) due to implementation of the drought order are summarised in **Table 4.1.** These impacts are presented in detail in **Appendix B**.

Table 4.1 Summary of Potential Hydrodynamic and Water Quality Impacts of the Drought Order

Reach 1 Afon Tywi from Llyn Brianne Reservoir outflow to the confluence with Afon Bran	
Flows in the Afon Tywi Negligible impacts on occasional days in the period from September to November inclusive	• Reduction in extreme low flows (significantly below Q99) of up to 5.9% on occasional days in the period from September to November inclusive
Reach 2 Afon Tywi from the Afon Bran confluence to Llandeilo Bridge	
Flows in the Afon Tywi ***Negligible*** *impacts on occasional days in the period from September to November inclusive*	• Reduction in extreme low flows (significantly below Q_{99}) of up to 5.6% on occasional days in the period from September to November inclusive
Reach 3 Afon Tywi from Llandeilo Bridge to the Nantgaredig intake	
Flows in the Afon Tywi ***Negligible*** *impacts on occasional days in the period from September to November inclusive*	• Reduction in extreme low flows (significantly below Q_{99}) of up to 4.9% on occasional days in the period from September to November inclusive
Reach 4 Afon Tywi from the Nantgaredig intake to the tidal limit	
Flows in the Afon Tywi ***Minor*** *impacts on occasional days in the period from September to November inclusive*	• Reduction in extreme low flows (significantly below Q_{99}) of up to 14.7% on occasional days in the period from September to November inclusive
Water quality ***Low*** *risk on occasional days in the period from September to November inclusive*	• Low risk of water quality deterioration linked to total ammonia concentration and dissolved oxygen saturation • Low risk of water quality deterioration linked to SRP
Surface water abstractions and risk to abstractors ***Negligible*** *risk on occasional days in the period from September to November inclusive*	• The risk to the surface water abstractions is negligible.
Consented discharges ***Negligible*** *risk on occasional days in the period from September to November inclusive*	• No significant consented discharges
CSOs ***Negligible*** *risk on occasional days in the period from September to November inclusive*	• No significant intermittent discharges

4.3.1 Support to the Screening and Assessment of Sensitive Features

The assessment included in **Appendix B** has provided information to support the screening and assessment of sensitive features in Section 5. This includes information on short and long term (acute and chronic) direct and indirect, cumulative, and permanent and temporary effects. The assessment is also specific on the difference between the drought order impacts and the baseline condition without a drought order in place.

4.3.2 Supporting Technical Information for Assessment of any Physical Environment Sensitive Features

As described in Section 5, several sensitive features relate to the physical environment, rather than ecology or human interaction (e.g. landscape, recreation). The assessment included in **Appendix B** has provided supporting technical information for their screening and assessment in Section 5.

5 AFON TYWI DROUGHT ORDER ENVIRONMENTAL FEATURES ASSESSMENT

5.1 INTRODUCTION

As set out in **Box 1** above, environmental sensitivity screening of the drought order was undertaken in line with the approach recommended by the DPG, and scoping undertaken in line with the methodology described in Section 3.2. The screening and scoping has subsequently been reviewed and refined further to discussions and consultation with NRW (see Sections 1.2 and 1.3). The outcome of this process is described in Section 5.2 which shows that a number of features were identified as either: 1) uncertain; 2) moderate-major sensitivity; or 3) minor sensitivity in a designated site. These features form the scope of environmental assessment, which is further described in Section 5.3.

The features assessment is informed by the assessment of the physical environment presented in Section 4 (which includes hydrology, geomorphology and water quality) and identifies the significance of any potential impacts. Consideration of mitigation actions and monitoring is described in Sections 6 and 10 respectively.

Points of interest referred to throughout the text in Section 5 are indicated on **Figure 2.3**.

5.2 SUMMARY OF STAGE 2 SCREENING AND SCOPING

5.2.1 Designated Sites and Other Sensitive Fauna and Flora

In accordance with the DPG, **Table 5.1** identifies designated biodiversity sites (including LNR, NNR, SSSI, SAC, SPA), Environment (Wales) Act Section 7 species / habitats and other sensitive receptors that could be affected by the drought order. Susceptibility to the flow / level impacts resulting from the drought order (see Section 4) is identified according to whether interest features of the site or the species are water dependent. Sensitivity is then determined according to professional judgment based on susceptibility and the level of hydrological impact at the location.

Table 5.1 Designated Sites and Other Sensitive Receptors Within the Zone of Influence of the Afon Tywi Drought Order

Site/Feature and designation	Hydrological Impact at Location (Major, Moderate, Minor)	Susceptibility to flow and level impacts	Sensitivity (Uncertain, Moderate/ Major, Minor, Negligible)	Further Consideration Required (Yes/No)
Afon Tywi SSSI/SAC	Negligible (Reaches 1-3) Minor (Reach 4)	Designated for supporting a diverse range of transitional landscapes, supporting a number of national scarce and nationally important fish, mammal and invertebrate species through landscape and shingle diversity. The site is considered of national importance for many protected bird species, and holds approximately 4-5% of the total population of the little ringed plover *Charadrius dubius* and 1-2% of the British breeding population for sand martins *Riparia riparia*.	Minor	Yes
Cwm Doethie - Mynydd Mallaen SAC / Cwm Doethie SSSI	Negligible (Reach 1)	The SAC is designated for: Old sessile oak woods with Ilex and Blechnum in the British Isles (western acidic oak woodland). An Annex I habitat that is a primary reason for selection. European dry heaths, an Annex I habitat present as a qualifying feature. western acidic oak woodland is a highly water dependant feature[7] so is potentially susceptible to hydrological impacts.	Negligible	No
Elenydd – Mallaen SPA	Negligible (Reach 1)	The SPA is designated for breeding populations of Red Kite Milvus milvus¸ Merlin Falco columbaris, and Peregrine Falco peregrinus. The species for which the site is designated are not dependent on the aquatic environment.	Negligible	No
Bishops Pond SSSI	Minor (Reach 4)-	Bishops pond is noted to be the best ox-bow lake example in West Wales. Notable for its reed sweet-grass *glyceria maxima* swamp area. The site itself is currently managed as a nature reserve.	Uncertain	Yes
Carmarthen Bay and Estuaries SAC	Downstream Reach 4 (Minor)	The site is designated for six habitat types, including estuaries and intertidal mudflats, as well as Allis and Twaite shad, river and sea lamprey and otter.	Minor	Yes

[7] LIFE Natura 2000 Programme for Wales (2014) Identification of Aquatic (Highly Water Dependent) Natura 2000 features.

Site/Feature and designation	Hydrological Impact at Location (Major, Moderate, Minor)	Susceptibility to flow and level impacts	Sensitivity (Uncertain, Moderate/ Major, Minor, Negligible)	Further Consideration Required (Yes/No)
Notable Species – Fish Twaite shad *Alosa fallax* Sea lamprey *Petromyzon marinus* Brook lamprey *Lampetra planeri* River lamprey *Lampetra fluviatillis* Allis shad *Alosa alosa* Bullhead *Cottus gobio* Sea trout *Salmo trutta trutta* Atlantic salmon *Salmo salar* Eel *Anguilla anguilla*	Negligible (Reaches 1-3) Minor (Reach 4)	The Tywi is currently considered only one of 4 rivers in England and Wales to support twaite shad. The river also supports a strong population of sea trout, allis shad, Atlantic salmon, European eel, river lamprey, sea lamprey, brown trout and bullhead.	Minor	Yes
Notable Species – Mammals Otter *Lutra lutra* Water vole *Arvicola amphibious*	Negligible (Reaches 1-3) Minor (Reach 4)	The Afon tywi is considered one of the best rivers in Wales for otter *Luttra luttra,* and is known to contain water voles *Arvicola amphibious*.	Negligible	No
Notable Species – Invertebrates	Negligible (Reaches 1-3) Minor (Reach 4)	Fresh water pearl mussels *Margaritifera margaritifera* have been recorded in the lower reaches of the river.	Minor	Yes
Notable Species – Macrophytes Water crowfoot *Ranunculus penicillatus*	Negligible (Reaches 1-3) Minor (Reach 4)	Where moderate flow exists within the Afon Tywi macrophytes such as water crowfoot and several species of water starwort are present within the river.	Minor	Yes
Macrophyte community	Negligible (Reaches 1-3) Minor (Reach 4)	The hydrological impacts may reduce the availability of habitats and/or change the composition of the macrophyte community.	Minor	Yes
Benthic macro-invertebrate community	Negligible (Reaches 1-3) Minor (Reach 4)	The hydrological impacts may reduce the availability of habitats and/or change the composition of the macroinvertebrate community.	Minor	Yes
Phytobenthos community	Negligible (Reaches 1-3) Minor (Reach 4)	The hydrological impacts may reduce the availability of habitats and/or change the composition of the phytobenthos community.	Minor	Yes
Invasive flora and fauna Indian balsam *Impatiens gladulifera* Japanese knotweed *Fallopia japonica*	Negligible (Reaches 1-3) Minor (Reach 4)	Himalayan balsam, Japanese knotweed and New Zealand pygmy weed have been recorded as present in the lower reaches of the Afon Tywi.	Minor	Yes

Site/Feature and designation	Hydrological Impact at Location (Major, Moderate, Minor)	Susceptibility to flow and level impacts	Sensitivity (Uncertain, Moderate/ Major, Minor, Negligible)	Further Consideration Required (Yes/No)
Landscape and visual amenity	Negligible (Reaches 1-3) Minor (Reach 4)	Seven areas of important landscape areas are acknowledged within the site. These include; Tywi Valley, Rhandirmwyn valley, rural and lowland landscapes, llyn Brianne reservoir and the Cwm Doethie SSSI site.	Minor	Yes
Recreation	Negligible (Reaches 1-3) Minor (Reach 4)	Recreational opportunities for walkers, bikers, anglers, and boaters.	Moderate	Yes
Archaeology	Negligible (Reaches 1-3) Minor (Reach 4)	Within 500m of the site lies the round barrow 200m ssw of felin-wen-isaf; a prehistoric religious/funeral site.	Negligible	No

5.2.2 WFD Waterbody Status

Error! Reference source not found. identifies the WFD status classification of the WFD waterbodies that may be impacted by implementation of the drought order. Waterbodies classified as overall high / good status / potential, and / or high / good ecological status for fish or macroinvertebrates are likely to be more sensitive to flow impacts. Error! Reference source not found. summarises the risk to WFD status and indicates where further assessment has been carried out as reported in Section 5.3 below.

Table 5.2 WFD Status Classifications

Waterbody Name	**Tywi – Llyn Brianne to conf with Deothie (GB110060036380)**		**Tywi - conf with Doethie to conf with Llandovery Bran (GB110060036350)**		**Tywi – conf with Llandovery Bran to conf Cothi (GB110060036250)**		**Tywi – conf with Cothi to spring tidal limit (GB110060029290)**	
Hydrological Impact at Location (Major, Moderate, Minor, Negligible)	Negligible		Negligible		Negligible		Negligible	
Heavily Modified Waterbody (Y/N)	Yes		Yes		No		No	
RBMP Cycle	RBMP2 (2015)[8]	2018 C2 Interim[9]	RBMP2 (2015)	2018 C2 Interim	RBMP2 (2015)	2018 C2 Interim	RBMP2 (2015)	2018 C2 Interim
Overall Ecological	Moderate	Moderate	Moderate	Moderate	Moderate	Good	Good	Good
Fish	Moderate	Moderate	Good	Good	High	High	Not assessed	Not assessed
Macrophytes and Phytobenthos	Good	Good	Good	High	Not assessed	High	Good	Good
Phytobenthos(Sub-Element)	Good	Good	Good	High	Not assessed	Not assessed	Good	Good
Macrophyte (Sub-Element)	Not assessed	Not assessed	Not assessed	High	Not assessed	High	Not assessed	High
Macro-invertebrates	Moderate	Moderate	Good	High	High	High	High	High
Total P/ Phosphate	High	High	High	High	High	High	High	High
Ammonia	High	High	High	High	High	High	High	High
Dissolved Oxygen	High	High	High	High	High	High	High	High
pH	Moderate	Moderate	High	High	High	High	High	High
Sensitivity (Uncertain, Moderate/ Major, Minor, Not sensitive)	Negligible		Negligible		Negligible		Minor	
Further Consideration Required (Y/N)	No		No		No		Yes	

[8] NRW (2017) https://drive.google.com/file/d/0B2hsDbbdxz1tZHItRU9lNkg1YWs/view
[9] NRW (2018) https://drive.google.com/file/d/14w17jL05sNuToVELqMCK_yc6DdHU7STb/view

5.3 FEATURES ASSESSMENT

5.3.1 Basis of Features Assessment

This section describes and assesses the potential impacts on the sensitive features during the period of implementation of the drought order.

Based on the sensitive features identified in Section 5.2.2, the degree of impact has been assessed and analysed in Section 5.3. Desk-based assessments have been completed for each of the sensitive receptors, where applicable, in order to determine the magnitude of impact in the Afon Tywi drought order hydrological zone of impact. Each feature assessment describes the analyses carried out and a statement of the assessed impact. All impacts are considered to be negative / adverse unless otherwise stated in the feature assessment. The approach is described in Section 3.3.

The hydrological assessment is summarised in Section 4 and is presented in full in **Appendix B**.

5.3.2 Summary of Features Assessment

Table 5.3 presents the overall summary of the significance of potential impacts of the drought order identified from the assessment of designated sites, and other ecologically significant receptors and their relevant reaches. Full details of the features assessment are provided in **Appendix D**. A brief summary of the features assessment is also provided below in Sections 5.3.3 – 5.3.8.

Table 5.3 Summary of Impacts of Drought Order Implementation Pre-Mitigation

Month		J	F	M	A	M	J	J	A	S	O	N	D
Afon Tywi SSSI/SAC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Bishops Pond SSSI		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Carmarthen Bay & Estuaries SAC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Reach 1 Afon Tywi from the Llyn Brianne Reservoir outflow to the confluence with Afon Bran, near Llandovery **Reach 2** Afon Tywi from the Afon Bran confluence to Llandeilo Bridge **Reach 3** Afon Tywi from Llandeilo Bridge to the Nantgaredig intake													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Notable macrophyte species – Yellowish fork-moss, Bog mosses, Water crow-foot		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Risk to WFD waterbody macrophyte status		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Allis and twaite shad	Migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Atlantic salmon	Migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Brown / sea trout	Migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Brook, river and sea lamprey	Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
European eel		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Other fish species – minnow and stone loach		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Phytobenthos		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Landscape	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Recreation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Archaeology	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Reach 4 (Afon Tywi from the Nantgaredig abstraction intake to the tidal limit)													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Notable macrophyte species - Water crow-foot		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Risk to WFD waterbody macrophyte status		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Notable macroinvertebrate species - *Margaritifera margaritifera*		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Allis and twaite shad	Migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Atlantic salmon	Migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Brown / sea trout	Migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Brook, river and sea lamprey	Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
European eel		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Other fish species – minnow and stone loach		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Phytobenthos		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Invasive flora and fauna - *Crassula helmsii*		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Recreation	Landscape	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Recreation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Archaeology	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A

Key to Environmental Effects:

N	Negligible impacts are considered likely
N/A	Outside implementation period
	Minor adverse impacts are considered likely
	Moderate adverse impacts are considered likely
	Major adverse impacts are considered likely
	Potential minor beneficial impacts are considered likely
	Potential moderate beneficial impacts are considered likely

5.3.3 Designated Sites

Table 5.4 presents a summary of the potential impacts of the drought order identified from the assessment of designated sites. The location of each of the designated sites discussed below is set out in **Figure 2.3**.

Table 5.4 Summary of Impacts of Drought Order Implementation on Designated Sites

Feature	Impact	Significance of Impact
Afon Tywi SAC	• Impacts on juvenile river, sea and brook lamprey, brook lamprey (Annex II species for which the SAC has been designated) have been assessed as minor in Reach 4 during drought order implementation	**Minor**
Afon Tywi SSSI	• Impacts on water crowfoot *Ranunculus penicillatus* spp (species of interest within the SSSI) have been assessed as minor in Reach 3 and 4 during drought order implementation.	**Minor**
Bishops Pond SSSI	• The features for which these sites are designated are not anticipated to be in hydrological connectivity with the impacted reach of the Afon Tywi.	**Negligible**
Cwm Doethie – Mynydd Mallaen SAC / SSSI	• The features for which these sites are designated are not anticipated to be in hydrological connectivity with the impacted reach of the Afon Tywi.	**Negligible**
Carmarthen Bay and Estuaries SAC	• Impacts associated with drought order implementation on the features for which the site is designated are considered to be negligible.	**Negligible**

5.3.4 WFD and Community Assessment

This section considers the potential impact on the feature community within each reach as well as identifying the risk of deterioration in status / potential under the WFD.

WFD Definitions

The following definitions are provided for the determination of status under the WFD.

High ecological status - the values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions and show no, or only very minor, evidence of distortion.

Good ecological status - the values of the biological quality elements for the surface

water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.

Moderate ecological status - the values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.

Poor ecological status - waters showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions, shall be classified as poor.

Bad ecological status - waters showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in which large portions of the relevant biological communities normally associated with the surface water body type are absent, shall be classified as bad.

Good ecological potential - there are slight changes in the values of the relevant biological quality elements as compared to the values found at high ecological potential.

Moderate ecological potential - there are moderate changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential.

The Environment Agency[10] identify that a number of different factors need be considered when making an assessment of the ecological potential of HMWBs. Of primary importance is the need to put a specified range of mitigation measures in place to address the effects of the anthropogenic impact. Selected ecological quality elements may also be required to be at GES for the waterbody to be classified as GEP. Where the designated use includes for impacts on flow and flow-related mitigation measures the measured status of the fish and macroinvertebrate communities do not affect the classification of GEP.

Assessment

A summary of the potential impacts of the drought order on macrophyte, macroinvertebrate, phytobenthos and fish communities and WFD status is presented

[10] Environment Agency (2011) Method statement for the classification of surface water bodies v2.0 (external release) Monitoring Strategy v2.0 July 2011

below. Full details, including detailed baseline information, can be found in **Appendix D**.

Macrophytes

Table 5.5 presents a summary of the potential impacts of the drought order identified from the assessment of macrophytes.

Table 5.5 Summary of Impacts of Drought Order Implementation on Macrophytes

WFD Status/ Community	Impact	Significance of Impact
Tywi – conf with Cothi to spring tidal limit (GB110060029290) Current status: High (2018 interim)	• There is a minor risk of short-term deterioration in status of the fish component of the waterbody due to the minor adverse, short-term, temporary and reversible impacts associated with the drought order	**Minor**
Feature	**Impact**	**Significance of Impact**
Reach 1		
Macrophytes	• Reduction in growth as a result of impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Changes to community composition relating to water quality deterioration	**Negligible**
Yellowish fork-moss	• Changes to inundation pattern and splash due to changes in flow.	**Negligible**
Bog mosses *Sphagnum* sp.	• Changes to inundation pattern and splash due to changes in flow.	**Negligible**
Reach 2		
Macrophytes	• Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Changes to community composition relating to water quality deterioration	**Negligible**
Reach 3		
Macrophytes	• Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Changes to community composition relating to water quality deterioration and increased occurrence of epiphytes and algae	**Negligible**
Water crow-foot	• Reduction in growth as a result of impacts on water levels and flows. • Reduction in habitat suitability due to water quality deterioration and increased occurrence of epiphytes and algae	**Negligible**
Reach 4		
Macrophytes	• Reduction in growth as a result of impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Changes to community composition relating to water quality deterioration and increased occurrence of epiphytes and algae	**Minor**

WFD Status/ Community	Impact	Significance of Impact
	• Encroachment of marginal emergent species into the channel	
Water crow-foot	• Reduction in growth as a result of impacts on water levels and flows. • Reduction in habitat suitability due to water quality deterioration and increased occurrence of epithytes and algae	**Minor**

Macroinvertebrates

Table 5.6 presents a summary of the potential impacts of the drought order identified from the assessment of macroinvertebrates.

Table 5.6 Summary of Impacts of Drought Order Implementation on Macroinvertebrates

WFD Status/ Community	Impact	Significance of Impact
Tywi – conf with Cothi to spring tidal limit (GB110060029290) Current status: High	• There is a minor risk of short-term deterioration in status of the macroinvertebrate component of the waterbody due to the minor to moderate adverse, short-term, temporary and reversible impacts associated with the drought order	**Minor**
Feature	**Impact**	**Significance of Impact**
Reach 1 to 3		
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa • Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction is species abundance and/or diversity due to water quality deterioration.	**Negligible**
Reach 4		
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa • Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction is species abundance and/or diversity due to water quality deterioration.	**Minor**
Fresh water pearl mussel	• Reduction is species abundance and/or distribution due to water quality deterioration. • Reduction in habitat suitability due to water quality deterioration and increased occurrence of epiphytes and algae	**Minor**

Fish

Table 5.7 presents a summary of the potential impacts of the drought order identified from the assessment of fish.

Table 5.7 Summary of Impacts of Drought Order Implementation on Fish

WFD Status/ Community	Impact	Significance of Impact
Tywi – conf with Cothi to spring tidal limit (GB110060029290) Current status: Not classified	• Not assessed	**N/A**
Feature	**Impact**	**Significance of Impact**
Reach 1: Afon Tywi from the Llyn Brianne Reservoir outflow to the confluence with Afon Bran, near Llandovery		
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Brook, river and sea lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Minor**
	• Reduced water quality.	**Negligible**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Negligible**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Negligible**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Reach 2: Afon Tywi from the Afon Bran confluence down to Llandeilo Bridge, at Llandeilo		
Allis and twaite shad	• Delays and potential cessation of adult and juvenile migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Negligible**

WFD Status/ Community	Impact	Significance of Impact
	• Reduced water quality.	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Brook, river and sea lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Minor**
	• Reduced water quality.	**Negligible**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Negligible**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows and obstruction caused by sandbag weir.	**Negligible**
	• Reduced water quality.	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Negligible**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Reach 3: Afon Tywi from Llandeilo Bridge to the Welsh Water abstraction intake at Nantgaredig		
Allis and twaite shad	• Delays and potential cessation of adult and juvenile migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Brook, river and sea lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Minor**
	• Reduced water quality.	**Negligible**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Negligible**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows and obstruction caused by sandbag weir.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**

WFD Status/ Community	Impact	Significance of Impact
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Negligible**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Reach 4: Afon Tywi from the Nantgaredig abstraction intake to the tidal limit		
Allis and twaite shad	• Delays and potential cessation of adult and juvenile migrations due to reduced flows.	**Minor**
	• Reduced water quality.	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Minor**
	• Reduced water quality.	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
Brook, river and sea lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Moderate**
	• Reduced water quality.	**Negligible**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Minor**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows and obstruction caused by sandbag weir.	**Minor**
	• Reduced water quality.	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Minor**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**

Phytobenthos

Table 5.8 presents a summary of the potential impacts of the drought order identified from the assessment of phytobenthos.

Table 5.8 Summary of Impacts of Drought Order Implementation on Phytobenthos

WFD Status/ Community	Impact	Significance of Impact
Tywi – conf with Cothi to spring tidal limit (GB110060029290) Current status: Good	• There is a minor risk of short-term deterioration in status of the macroinvertebrate component of the waterbody due to the minor to moderate adverse, short-term, temporary and reversible impacts associated with the drought order	**Minor**
Feature	**Impact**	**Significance of Impact**
Reach 1 to 3		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition • Low risk of increase in SRP affecting phytobenthos community composition and TDI score	**Negligible**
Reach 4		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition • Medium risk of increase in SRP affecting phytobenthos community composition and TDI score	**Minor**

5.3.5 Invasive Flora and Fauna

Table 5.9 presents a summary of the potential impacts of the drought order identified from the assessment of invasive flora and fauna.

Table 5.9 Summary of Impacts of Drought Order Implementation on Invasive Flora and Fauna

Feature	Impact	Significance of Impact
Reach 4 - **Afon Tywi from the Nantgaredig abstraction intake to the tidal limit**		
Invasive Species – *Crassula Helmsii*	The drought order will result in hydrological impacts in extreme drought conditions – therefore impacts associated with New Zealand pygmy weed over and above those observed in a natural drought are likely to be limited.	**Negligible**

5.3.6 Landscape, Archaeology and Recreation

Table 5.10 presents a summary of the potential impacts of the drought order identified from the assessment of landscape, archaeology and recreation.

Table 5.10 Summary of Impacts of Drought Order Implementation on Landscape, Archaeology and Recreation

Feature	Impact	Significance of Impact
Landscape	Flows during a drought will be low such that further reduction in flows due to the drought permit would not result in a further loss of aesthetic value	**Negligible**
Recreation	Impacts on recreation activities (e.g. angling, canoeing, walking) are not anticipated over those from the natural drought conditions	**Negligible**
Archaeology	No water dependant archaeological features are present within the zone of impact.	**Negligible**

6 AFON TYWI DROUGHT ORDER– MITIGATION

The environmental assessment has identified some significant impacts, including minor hydrological impacts, moderate aquatic ecology impacts on fish (lamprey) and minor impacts on designated sites and freshwater pearl mussels.

For those receptors with a potential impact or risk identified as being significant as a result of implementation of the drought order, precautionary monitoring and mitigation measures have been identified, and will be further developed in consultation with NRW.

Mitigation measures are feature, location, species and community specific, and are targeted only to those impacts that arise specifically as a result of drought order implementation (as opposed to those arising due to environmental drought pressures). Similarly, monitoring and the targeting of mitigation measures to impacts that arise specifically as a result of drought order implementation will help identify the responsible party for the specific actions relating to the associated measure. Information attained through monitoring undertaken during future droughts and potential drought order implementation events will provide a tool for discussions regarding best working practices between Welsh Water, NRW and any other interested parties.

The range of mitigation measures that are possible for the features identified fall into three general activity types:

1) measures to reduce impacts at source

2) measures to modify environmental conditions in the river/lake

3) management of sensitive ecological species and communities.

The first activity type looks at mitigation measures that will reduce the pressure at source by reducing the hydrological impact. In the circumstances, the options are limited because the drought order is required to safeguard public water supply. The second activity focuses on mitigation measures that involve undertaking actions within the waterbodies to reduce the pressure at sensitive locations. The third activity type involves direct action to manage impact by movement or management of the receptor / feature itself.

The mitigation measures that could be considered at the on-set of drought, during implementation of the drought order and post-drought order implementation include:

6.1 Potential Generic Mitigation Measures Considered to Address Adverse Effects of the Drought Order

Type of Mitigation	Typical Application
Temporary reduction or cessation of the terms of the Drought Order/Permit	Where continuous water quality monitoring (typically dissolved oxygen) and/or fish distress monitoring indicate a sharp deterioration in aquatic conditions, modifications to abstraction licence conditions under the terms of the order/permit may need to be reduced or cease altogether until conditions have improved. The precise trigger levels for considering such action would be set out in discussion with NRW at the time of application taking account of the time of year and prevailing environmental conditions. Temporary cessation of the implementation of the order/permit may be required as a means of mitigating ecological effect, balanced against the need to safeguard public water supplies.
Fish distress monitoring with triggers and response plan	Regular visual observations carried out on key stretches of rivers or lakes to detect signs of large scale fish distress and agree appropriate mitigation with NRW specific to the conditions identified. This might include temporary oxygenation measures.
Protection of 'spate flows'	Temporary increases in river flows following periods of rain can be important to flush sediment/pollutants from the system or promote fish passage. Where possible, the terms of the drought order/permit could be temporarily reduced/suspended so that these spate flows are preferentially allowed to pass through the system. This decision would need to be taken in dialogue with NRW to take account of the prevailing conditions and considering the merits of encouraging fish migration during a drought.
Reduce fish predation	Consider (where feasible) a limited and targeted reduction of predation risk on fish through either the provision of refugia, in the form of artificial or natural habitat provision or improvement, or the placement of piscivorous bird scarers (in areas remote from residential locations). The merits of each option and subsequent deployment would be subject to review on a case-by-case basis in consultation with NRW.
Physical works	In some cases, temporary physical in-river works such as channel narrowing or provision of refugia could be carried out to mitigate environmental risks. If any physical works are likely to impact fish passage, appropriate mitigation measures will need to be considered as part of the design of the works.
Compensation flows	In some cases, it may be possible to use other sources of water to provide compensation flows within surface water courses to temporarily mitigate the impact of the drought order/permit
Provision of alternative water supplies	If there is a risk of derogation of other abstractors from the drought order/permit, it may be possible for Welsh Water to provide alternative water supplies or lower pumps in boreholes. Provision is otherwise provided in legislation[11] for compensation to be agreed with the abstractor.

A suggested suite of mitigation measures for environmental features with potentially significant impacts relating to implementation of the Afon Tywi drought order are given in **Table 10.1**. For these features, a range of precautionary monitoring and triggers leading to enabling of appropriate mitigation measures are also described.

[11] Schedule 9 of the Water Resources Act (WRA) 1991

7 CUMULATIVE IMPACTS

In accordance with the DPG and the Habitats Regulations, consideration has been given to how the proposed drought order may affect the environment in combination with the effects of existing abstraction licences, environmental permits and other plans. This includes assessment of the potential cumulative effects of the following:

- Welsh Water's existing abstraction licences that operate within the hydrological zone of influence of the drought option, as well as other abstraction licences and discharge permits, as identified in NRW Review of Consents reports;
- Assessment of cumulative impacts of the drought order with other Welsh Water supply-side and drought order options within the hydrological zone of influence (including both intra- and inter- zone options);
- Other plans and projects of relevance, including;
    - Any Welsh Water WRMP schemes which are scheduled to be implemented and become operational within the time period of the Drought Plan (i.e. before 2025).
    - Drought supply-side and drought order / permit options from NRW Drought Plans.
    - National Policy Statements for Wastewater and Renewable Energy Infrastructure.
- Environmental monitoring before, during and after drought order implementation (see Section 10).

If a drought order application is progressed in the future, the potential for cumulative effects will be reviewed and revised to reflect any changes which are relevant to the timing of the drought order specified in the application.

Welsh Water's existing abstraction licences and other abstraction licences and discharge permits

The assessment of hydrological impacts presented in **Appendix B**, and summarised in Section 4, has considered how the proposed drought order may affect the environment in combination with the effects of existing licences and consents. Therefore no relevant licences or consents have been identified as relevant for assessment of cumulative effects.

In—combination effects with the Brianne freshet preservation are not anticipated because use of freshets would be associated with a spate, and during that time flows in the Afon Tywi would not be below 136 Ml/d.

Other relevant Welsh Water drought permit / orders

No cumulative effects of implementing the Afon Tywi drought order with drought order / permit schemes have been identified. However, this should be reviewed at the time of any future application for a drought order at Afon Tywi.

Welsh Water WRMP schemes

No WRMP schemes identified with cumulative impacts.

NRW Drought Plans

No cumulative impacts of options in NRW Drought Plan with a drought order at Afon Tywi are anticipated. However, this should be reviewed at time of future application for a drought order.

National Policy Statements for Wastewater and Renewable Energy Infrastructure

No cumulative schemes have been identified for assessment.

Environmental Monitoring

Recommendations for environmental monitoring before, during and after drought order implementation have been made in the EMP which is presented in Section 10 of this EAR. The EMP has been developed in consultation with NRW.

It is assumed that all monitoring activities will be undertaken with the best interests of the site in mind, and in discussion and agreement with NRW. Where activities which require in-river working are proposed, a method statement for the survey will be prepared and agreed with NRW in advance of the survey.

Assuming rigorous implementation of the method statements, there will be no adverse impacts of the monitoring on hydrology, water quality or ecology, and no adverse impacts of environmental monitoring on the site are anticipated.

8 AFON TYWI DROUGHT ORDER - SUMMARY OF RESIDUAL IMPACTS

The residual impact on environmental features is dependent on the effects observed during environmental monitoring, and the mitigation measures that are taken forward and their timely and effective application once the trigger for their need has been identified. Consequently, at this stage it is not possible to provide an accurate indication as to the residual impacts on environmental features due to implementation of mitigation measures. However, should the mitigation measures be effectively applied in all situations in a timely manner, it is anticipated that the magnitude of impacts, and in some cases the significance of impacts, will be reduced from those summarised in **Table 5.3**.

Should the application of mitigation measures applicable during the drought order implementation period not reduce the impact magnitude or significance, compensatory measures such as restocking will be considered to help ensure pre-drought conditions return and reduce the significance of any post-drought order impacts.

9 HABITATS REGULATIONS ASSESSMENT: STAGE 1 SCREENING

9.1 INTRODUCTION

Under Regulation 63 of the Habitats Regulations, the competent authority (in the case of a drought order in Wales this would be Welsh Ministers, advised by NRW) is required to undertake an Appropriate Assessment of any plan / project which is likely to have a significant effect on a European site, to determine the implications for the site in view of the site's conservation objectives. The Regulations state that a person applying for any such consent (in this case Welsh Water), must provide such information as the competent authority (Welsh Ministers, advised by NRW) may reasonably require for the purposes of the assessment or to enable them to determine whether an appropriate assessment is required.

9.1.1 HRA Stages

Stage 1 – Screening

The first stage in the Habitats Regulations Assessment (HRA) is screening to determine the potential of the drought order to have a likely significant effect (LSEs) on any European site (either alone or in-combination with other plans and projects) and thus if a full 'Appropriate Assessment' of any of the drought order would be required.

An in-combination assessment is carried out to establish the possibility of cumulative or synergistic impacts.

The screening stage identifies if the drought order is likely to have significant effects on European designated site, and requires Appropriate Assessment.

Stage 2 – Appropriate Assessment

Drought orders that are identified during HRA Screening (Stage 1) as having a LSE (either alone or in combination) will be taken forward to Appropriate Assessment. The Appropriate Assessment will consider the impacts of the drought order, against the conservation objectives of a European Site, in order to identify whether there are likely to be any adverse effects on site integrity and site features. The assessment will conclude whether or not the drought order, either alone or in combination with other plans and projects, would adversely affect the integrity of the European site in question. This is judged in terms of the implications of the plan for a site's conservation objectives, which relate to its 'qualifying features' (i.e. those Annex I habitats, Annex II species, and Annex I bird populations for which it has been designated). The responsibility for undertaking the Appropriate Assessment lies with the (Welsh

Ministers, advised by NRW).

Stage 3 – Alternative Options Stage

Where significant adverse effects are identified at the Appropriate Assessment stage, alternative options would be examined to avoid any potential damaging effects to the integrity of the European site.

Stage 4 – Assessment where adverse impacts remain

Stage 4 comprises an assessment of compensatory measures where, in the light of an assessment of Imperative Reasons of Overriding Public Interest, it is deemed that the project or plan should proceed. Imperative Reasons of Overriding Public Interest will only be progressed if no alternatives are identified as part of Stage 3.

9.2 STAGE 1 SCREENING OF AFON TYWI DROUGHT ORDER

The objective of this section is to bring together all relevant information to enable a screening exerise to be undertaken of the impacts of the Afon Tywi drought order on relevant European designated sites.

These assessments have been completed in accordance with the DPG (see Section 3.3).

This section considers each of the Afon Tywi SAC and Carmarthen Bay and Estuaries SAC qualifying features and discusses the potential for the Afon Tywi drought order to influence their status. For species, impacts on populations, range and supporting habitats and species have been considered.

Likely Significant Effects to the Elenydd-Mallaen SPA and Cwm Doethie – Mynydd Mallaen SAC are not anticipated as the majority of the qualifying features are not water dependent. Old sessile oak woods with *Ilex* and *Blechnum* (western acidic oak woodlands) are considered to be a highly water dependent feature[12], however, the impacted reach of the Afon Tywi is at a lower altitude than the area included in the SAC, and is therefore unlikely to be hydrologically connected to the river.

9.2.1 Potential Impacts on Afon Tywi SAC Qualifying Features

In carrying out the screening process, the assessment has considered the main possible sources of effects on the sites arising from the potential drought order, possible pathways to the designated sites and the effects on possible sensitive receptors in the sites. Only if there is an identifiable pathway between the impacted reaches and the designated sites, or individual receptors, is there likely to be an impact and where this is absent those sites have been screened out.

[12] LIFE Natura 2000 Programme for Wales (2014) Identification of Aquatic (Highly Water Dependent) Natura 2000 features.

The screening assessment has also considered the Afon Tywi SAC conservation objectives. The development of conservation objectives is required by the 1992 'Habitats' Directive (92/43/EEC). In accordance with the Habitats Directive, the objectives aim to achieve the 'favourable conservation status' of habitats and species features for which SAC is designated (see **Figure 9.1**).

Site-specific conservation objectives provide a description of what is considered to be the favourable conservation status of the feature within the whole plan area. Conservation objectives for the site have been prepared by NRW.

In addition to the conservation objectives, the Core Management Plan has been used to determine LSEs against each of the specific attributes and targets for each of the qualifying features. A summary of the overall screening conclusion for each feature is provided below, with **Table 9.1** providing the assessment against each attribute and target.

Figure 9.1 Favourable conservation status 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."*

European otter

This species is not expected to be significantly impacted by the drought order implementation. Habitat availability and quality for otter is not anticipated to be significantly altered, as such, it can be concluded that the drought order will not have likely significant effects on the feature.

Twaite shad and allis shad

Twaite shad and allis shad have only been recorded in the lower reaches of the Afon Tywi (as a result of flow and temperature barriers constraining movement upstream[13]). Adult shad migrate upstream from the estuary between March and May to spawn mostly between the tidal limit and Nantgaredig on the Afon Tywi (Reaches 3 and 4), between mid-May and mid-July depending on water temperature. Spawning does occur to a lesser extent upstream into Reach 2. Juvenile shad migrate relatively quickly downstream towards the estuary over the late summer and early autumn, and are likely to have left the non-tidal Afon Tywi by late November. These downstream migrations therefore have the potential to interact with hydrological impacts associated with the autumn months of the drought period. As such, it is concluded that there could be likely significant effects on the populations, and further assessment is required through a Stage 2 Appropriate Assessment.

Brook, river and sea lamprey

Sea lamprey and brook lamprey are recorded throughout the SAC but the distribution of river lamprey is unknown as only single records exist for management units[14]. The management plan identifies sea lamprey as a key species (KS) in Management Unit 1. Brook and river lamprey are classed as 'Sym' features either because they are present in the unit but are of less conservation importance than the key feature; or because they are present in the unit but in small areas/numbers, with the bulk of the feature in other units of the site. There is the potential for reduced flow to result in a decrease in river levels and wetted width throughout the areas of the Tywi where juvenile lamprey species are considered present. This has particular significance for juvenile (ammocoetes and transformer) lamprey habitat which tends to consist of silt in shallow, marginal areas and is utilised year-round. Water quality and temperature changes could also affect migration. As such, it is concluded that there could be likely significant effects to the populations, and further assessment is required through a Stage 2 Appropriate Assessment.

[13] Countryside Council for Wales (2008) Core Management Plan Including Conservation Objectives for Afon Tywi / River Tywi SAC (Special Area of Conservation). Version: 1.1 (Minor map edit, August 2012)
[14] Countryside Council for Wales (2008) Core Management Plan Including Conservation Objectives for Afon Tywi / River Tywi SAC (Special Area of Conservation). Version: 1.1 (Minor map edit, August 2012)

Bullhead

Bullhead are present throughout the hydrological zone of impact. Due to the potential for habitat loss and reduced water quality and reduction in survival from cessation of flow, it is concluded that the drought order will have likely significant effects on the feature, and further assessment is required through a Stage 2 Appropriate Assessment.

Table 9.1 Summary of Likely Significant Effects of Afon Tywi Drought Order Implementation Against Conservation Objectives for the Afon Twyi SAC

Feature	Attribute (taken directly from Natural Resources Wales Conservation Objectives document)	Site Specific Target range and Measures	Potential Impact of Drought Order	LSE?
Twaite and allis shad	Adult run size	No decline in the annual run size greater than would be expected from variations in natural mortality alone	The downstream migration of the juvenile shad over the late summer and early autumn has the potential to interact with hydrological impacts associated with the autumn months of the drought period.	Yes
	Spawning distribution	No decline in spawning distribution		Yes
	Water quality – biological	All classified reaches within the site that contain, or should contain shad under conditions of high environmental quality should comply with the targets given; GQA class B.		Yes
	Water quality - chemical	It has been agreed through the Review of Consents process that RE1 will be used throughout the SAC		Yes
	Flow	Targets equate to those levels agreed and used in the Review of Consents. Shad are particularly sensitive to flow. The ideal regime is one of relatively high flows in March-May, to stimulate migration and allow maximum penetration of adults upstream, followed by rather low flows in June-September, which ensures that the juveniles are not washed prematurely into saline waters and grow rapidly under warmer conditions. The release of freshets to encourage salmonid migration should therefore be discouraged on shad rivers during this period.		Yes
	Temperature	Targets equate to those levels agreed and used in the Review of Consents. Shad are particularly sensitive to temperature. The impact of the hypolymnial release from Llyn Brianne reservoir on the spawning range of shad is being assessed as part of the Review of Consents process. The release of freshets to encourage salmonid migration should therefore be discouraged on shad rivers during this period.		Yes
Sea Lamprey	Distribution within catchment	Any silt beds adjacent to or downstream of suitable spawning sites should contain *Pertromyzon* ammocoetes.	There is the potential for reduced flow to result in a decrease in river levels and wetted width. This has particular significance for juvenile (ammocoetes and transformer) lamprey habitat which tends to consist of silt in shallow, marginal areas and is utilised year-	Yes
	Ammocoete density	Ammocoetes should be present in at least four sampling sites each not less than 5km apart.		Yes

Feature	Attribute (taken directly from Natural Resources Wales Conservation Objectives document)	Site Specific Target range and Measures	Potential Impact of Drought Order	LSE?
	Spawning activity	No reduction in extent of spawning activity year on year	round. There is therefore the potential for a loss or degradation of this habitat. Low flows may also limit upstream passage and hinder downstream passage, leaving both migratory life stages exposed to higher risks of predation and ultimately a reduction in recruitment.	Yes
	Water quality – biological	All classified reaches within the site that contain, or should contain sea lamprey under conditions of high environmental quality should comply with the targets given; GQA class B.		Yes
	Water quality - chemical	It has been agreed through the Review of Consents process that RE1 will be used throughout the SAC		Yes
	Flow	Targets equate to those levels agreed and used in the Review of Consents. Migration of adult sea lamprey is likely to be influenced by tide and river flows. The ideal regime is one of relatively high flows from April – June, to stimulate migration and allow maximum penetration of adults upstream to their spawning beds, followed by lower flows to help larvae disperse across suitable habitat downstream, but not be washed away.		Yes
	Temperature	Targets equate to those levels agreed and used in the Review of Consents. The timing, consistency and duration of adult sea lamprey migration are closely related to temperature. Peak migration usually coincides with temperature above 10oC. The impact of the hypolymnial release from Llyn Brianne reservoir on the spawning range of sea lamprey is being assessed as part of the Review of Consents process.		Yes
Brook Lamprey and River Lamprey	Age/size structure of ammocoete population	Samples < 50 ammocoetes 2 size classes Samples > 50 ammocoetes at least 3 size classes	A reduction in wetted width during extreme low flows could expose areas typically used as spawning habitats resulting in their loss or degradation, and expose eggs prior to their hatching.	Yes
	Distribution of ammocoetes within catchment	Present at not less than 2/3 of sites surveyed within natural range No reduction in distribution of ammocoetes		Yes
	Ammocoete density	Optimal habitat: >10 m^{-2} Overall catchment mean: > 5 m^{-2}		Yes
	Water quality – biological	All classified reaches within the site that contain, or should contain lamprey under conditions of high environmental quality should comply with Biological GQA Class B.		Yes

Feature	Attribute (taken directly from Natural Resources Wales Conservation Objectives document)	Site Specific Target range and Measures	Potential Impact of Drought Order	LSE?
	Water quality – chemical	It has been agreed through the Review of Consents process that RE1 will be used throughout the SAC.		Yes
	Flow	Targets equate to those levels agreed and used in the Review of Consents.		Yes
	Temperature	Targets equate to those levels agreed and used in the Review of Consents. River lamprey spawning in UK rivers starts when water temperatures reach 10-11oC. The impact of the hypolymnial release from Llyn Brianne reservoir on the spawning range of sea lamprey is being assessed as part of the Review of Consents process.		Yes
Bullhead	Adult densities	No less than 0.2 m^{-2} in sampled reaches	Bullhead are present throughout the hydrological zone of influence. The species is flow sensitive and spawning and egg incubation takes place from March to May. Particularly susceptible juvenile life stages may be affected by reduced flows associated with implementation of a drought order.	Yes
	Distribution	Bullheads should be present in all suitable reaches. As a minimum, no decline in distribution from current.		Yes
	Reproduction / age structure	Young-of-year fish should occur at densities at least equal to adults		Yes
	Water quality – biological	All classified reaches within the site that contain, or should contain bullhead under conditions of high environmental quality should comply with Biological GQA Class B.		Yes
	Water quality – chemical	It has been agreed through the Review of Consents process that RE1 will be used throughout the SAC.		Yes
	Flow	Targets equate to those levels agreed and used in the Review of Consents.		Yes
	Temperature	Targets equate to those levels agreed and used in the Review of Consents.		Yes

9.2.2 Potential Impacts on Carmarthen Bay and Estuaries SAC

Carmarthen Bay and Estuaries SAC is designated for the following qualifying features:

- 1110 Sandbanks which are slightly covered by sea water all the time
- 1130 Estuaries
- 1140 Mudflats and sandflats not covered by seawater at low tide
- 1160 Large shallow inlets and bays
- 1310 Salicornia and other annuals colonizing mud and sand
- 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
- 1103 Twaite shad *Alosa fallax*
- 1095 Sea lamprey *Petromyzon marinus*
- 1099 River lamprey *Lampetra fluviatilis*
- 1102 Allis shad *Alosa alosa*
- 1355 Otter *Lutra lutra*

A Core Management Plan is not available for the site, instead an advice package for the European Marine Site as a whole has been produced[15]. Specific attributes and targets are not available for each feature, rather overarching conservation objectives as follows.

Conservation objectives for the habitat features to achieve favourable condition:

- **Range**: the overall distribution and extent of the habitat features within the site, and each of their main component parts is stable or increasing.

- **Structure and function**: the physical biological and chemical structure and functions necessary for the long-term maintenance and quality of the habitat are not degraded. Important elements include;
  - geology,
  - sedimentology,
  - geomorphology,
  - hydrography and meteorology,
  - water and sediment chemistry,
  - biological interactions.

This includes a need for nutrient levels in the water column and sediments to be:

- at or below existing statutory guideline concentrations
- within ranges that are not potentially detrimental to the long term maintenance

[15] Natural Resources Wales (undated) Carmarthen Bay and Estuaries/Bae Caerfyrddin ac Aberoedd European Marine Site Advice provided by Natural Resources Wales in fulfilment of Regulation 37 of the Conservation of Habitats and Species Regulations 2017.

of the features species populations, their abundance and range.

Contaminant levels in the water column and sediments derived from human activity to be:

- at or below existing statutory guideline concentrations
- below levels that would potentially result in increase in contaminant concentrations within sediments or biota
- below levels potentially detrimental to the long-term maintenance of the feature species populations, their abundance or range.

For Atlantic saltmeadows this includes the morphology of the saltmarsh creeks and pans.

- **Typical Species**: The presence, abundance, condition and diversity of typical species is such that habitat quality is not degraded. Important elements include:
  - species richness
  - population structure and dynamics,
  - physiological heath,
  - reproductive capacity
  - recruitment,
  - mobility
  - range

As part of this objective it should be noted that:

- populations of typical species subject to existing commercial fisheries need to be at an abundance equal to or greater than that required to achieve maximum sustainable yield and secure in the long term
- the management and control of activities or operations likely to adversely affect the habitat feature is appropriate for maintaining it in favourable condition and is secure in the long term.

Conservation objectives for the species features to achieve favourable condition:

- **Populations:** The population is maintaining itself on a long-term basis as a viable component of its natural habitat. Important elements include:
  - population size
  - structure, production
  - condition of the species within the site.

As part of this objective it should be noted that;

- Contaminant burdens derived from human activity are below levels that may cause physiological damage, or immune or reproductive suppression

- **Range:** The species population within the site is such that the natural range of the population is not being reduced or likely to be reduced for the foreseeable future.

As part of this objective it should be noted that:

- Their range within the SAC and adjacent inter-connected areas is not constrained or hindered.
- There are appropriate and sufficient food resources within the SAC and beyond.
- The sites and amount of supporting habitat used by these species are accessible and their extent and quality is stable or increasing.

- **Supporting habitats and species:** The presence, abundance, condition and diversity of habitats and species required to support this species is such that the distribution, abundance and populations dynamics of the species within the site and population beyond the site is stable or increasing. Important considerations include;
  - distribution
  - extent
  - structure
  - function and quality of habitat
  - prey availability and quality.

As part of this objective it should be noted that;

- The abundance of prey species subject to existing commercial fisheries needs to be equal to or greater than that required to achieve maximum sustainable yield and secure in the long term.
- The management and control of activities or operations likely to adversely affect the species feature is appropriate for maintaining it in favourable condition and is secure in the long term.
- Contamination of potential prey species should be below concentrations potentially harmful to their physiological health.
- Disturbance by human activity is below levels that suppress reproductive success, physiological health or long-term behaviour.
- For otter there are sufficient sources within the SAC and beyond of high quality freshwater for drinking and bathing.

Using the Carmarthen Bay and Estuaries European Marine Site features map, priority habitat mapping available on Magic, Google Earth aerial imagery, and considering the relative sensitivity to freshwater inputs the following features have been screened out;

sandbanks which are slightly covered by sea water all the time, large shallow inlets and bays, Salicornia and other annual colonizing mud and sand and otter.

Estuaries

The proposed drought order will lead to a reduction in freshwater low flows which could impact the hydrodynamics of the transitional waterbody. The reduction in freshwater flow could result in an increase in the flushing time (due to a reduced residual river flow velocity) and an alteration to the mixing characteristics, leading to a possible increase in saline intrusion distance and migration of the turbidity maximum upstream. There could also be a reduction in connectivity at low spring tide. These changes could result in effects to species composition, distribution and abundance (primarily in the mudflat and saltmarsh habitats, including invertebrate communities) and changes to migration patterns, spawning habitat and fish recruitment. However, these potential effects will be confined to the very upper estuarine section of the Afon Tywi, whereby the influence of freshwater input is likely to be more pronounced. It is therefore concluded that the drought order could give rise to likely significant effects.

Mudflats and sandflats not covered by seawater at low tide

The physical processes within mudflat habitats are not driven by the freshwater inputs to the estuary alone, with tidal influences considered to be a more significant factor in determining the extent and quality of mudflat habitat. As such, the potential impacts of the drought order will mainly arise during low tide. The decrease in freshwater inputs will potentially have an impact on both the sediment and nutrient dynamics within the mudflats. The mudflats support a variety of macroinvertebrate and phytobenthos species, the composition and abundance of which could be altered by the drought order. It is therefore concluded that the drought order could give rise to likely significant effects.

Atlantic salt meadows

Areas of saltmarsh are present in the upper estuary at Morfa Uchaf and further upstream to Trysordy. Sediment grain size is of particular importance to saltmarsh communities and decreased flows could potentially result in changes in the composition of deposited sediment leading to smothering of pioneer communities and a change in nutrient availability, with fewer nutrients being transported into the estuary. In drought conditions the marsh may become hypersaline, with potential desiccation in areas reliant on freshwater seepages and inflow, which could be compounded by the drought order. This could lead to changes in community composition and potential reductions in productivity, the effects of more significance in any brackish zone at the transition between the saline and fresh waters. It is therefore concluded that the drought order could have likely significant effects on the Atlantic saltmarsh habitat.

Twaite and allis shad

The Carmarthen Bay and Estuaries Special Area of Conservation feature condition assessment[16] concluded that the twaite and allis shad populations were in unfavourable condition, primarily due to water quality issues in the estuary. Spawning is known to occur below Nantgaredig, in late summer with the fish migrating through the estuary between March and May which is dependent on water temperatures (10-12^{0}C acts as a trigger for migration). Juveniles migrate downstream to the estuary between August and October. The hydrological impacts of the drought order could therefore interact with these downstream migrations. The estuary is also considered to be an important nursery area before migration to the sea in winter, with the possibility of some juveniles overwintering in the estuary. As such, it is concluded that the drought order could give rise to likely significant effects.

Sea and river lamprey

The Carmarthen Bay and Estuaries Special Area of Conservation feature condition assessment[17] concluded that the sea and river lamprey populations were in unfavourable condition, primarily due to water quality issues in the estuary.

Mature river lamprey migrate upstream into freshwater in the autumn (from October to December[18]), descending to estuarine and marine environments between July and September in smaller rivers**Error! Bookmark not defined.** after three to five years. Upstream migration requires a reasonable flow of water to aid passage past natural and non-natural in-channel barriers. Low flows in the upper estuary may limit upstream passage and hinder downstream passage, leaving both migratory life stages exposed to higher risks of predation and ultimately a reduction in recruitment. River lamprey also use the estuary as feeding areas, and nursery habitat, therefore it should be assumed that juveniles are present throughout the year.

Adult sea lampreys migrate through the estuary between March and June to reach their spawning grounds on the River Tywi. Juvenile sea lampreys migrate through the estuary between December and June, and may feed in the estuary before moving offshore. The drought order is most likely to occur in the autumn, and not outside the period September to November. It is therefore unlikely to significantly affect upstream or downstream migration, but could affect feeding areas and nursery habitats.

It is therefore concluded that the drought order could give rise to likely significant effects to the river and sea lamprey populations.

[16] Natural Resources Wales (2018) Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd Special Area of Conservation: Indicative site level feature condition assessments 2018. NRW Evidence Report Series, Report No: 225, 49pp, NRW, Bangor.
[17] Natural Resources Wales (2018) Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd Special Area of Conservation: Indicative site level feature condition assessments 2018. NRW Evidence Report Series, Report No: 225, 49pp, NRW, Bangor.
[18] Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No.5. English Nature, Peterborough

9.3 STAGE 1 SCREENING: SUMMARY

In summary, likely significant effects have been concluded for both the Afon Tywi SAC and Carmarthen Bay and Estuaries SAC for the following qualifying features:

Afon Tywi SAC:

- Twaite and allis shad
- Brook, river and sea lamprey
- Bullhead

Carmarthen Bay and Estuaries SAC

- Estuaries
- Mudflats and sandbanks not covered by seawater at low tide
- Atlantic salt meadows
- Twaite and allis shad
- Sea and river lamprey

A Stage 2 Appropriate Assessment has been carried out to identify whether the implementation of the drought order will result in adverse effects on the site's conservation objectives and therefore whether the overall site integrity would be compromised. This is reported separately.

9.4 IN-COMBINATION EFFECTS

The Habitats Directive requires a consideration in the assessment of '*any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plan or projects*'.

Consideration of potential plans or projects with in-combination effects is presented in Section 7 and the Stage 2 Appropriate Assessment.

10 ENVIRONMENTAL MONITORING PLAN (EMP)

10.1 INTRODUCTION

The overall scope of the EMP for the Afon Tywi drought order meets the requirements of Section 5.2 (Monitoring) and informs the requirements of Section 5.3 (Mitigation) of the DPG. As required by the DPG, the level of monitoring identified in the EMP is risk-based. The EMP is tailored to the characteristics of the study area and is informed by the knowledge and assessment of environmental sensitivity (presented in Sections 4 and 5 of this EAR). The EMP fulfils several requirements, including:

- Establishing required baseline environmental monitoring and data acquisition to maintain and update the understanding of the environmental baseline conditions and to reduce uncertainties in the assessment.
- Pre-drought order monitoring describes the prevailing environmental conditions prior to drought order implementation. This will inform the implementation and management of any mitigation actions during the drought.
- During-drought order monitoring describes the environmental conditions during the implementation of the drought permit. Surveillance monitoring of sensitive locations, informed by, for example, walkover surveys and pre-drought monitoring, will provide early warnings of any unpredicted environmental impacts and ensure that mitigation actions are operating as designed.
- Post-drought order monitoring describes the recovery of environmental conditions following the cessation of a drought order, and establishes whether the affected ecosystems have recovered to conditions prevailing in the pre-drought order period.

The basis of the development of the EMP is provided in Section 10.2. Monitoring recommendations are set out in Section 10.3.

10.2 BASIS OF THE EMP

Guidance on the objectives and content of the EMP is given in Section 5.2 and Appendix J of the DPG.

The guidance states that:

- Water companies are responsible for understanding the effects of a drought and its drought management actions on the environment and that companies can demonstrate this by assessing the impacts of drought management actions during and after a drought and completing the environment assessment.
- Companies should ensure that adequate arrangements for environmental monitoring are detailed in an EMP within its drought plan.

- The level of monitoring needed should be risk-based. Not all sites will require in-drought and post-drought monitoring.
- Surveys may be needed to support/inform the decisions on environmental sensitivity and likely impact or to ascertain baseline conditions.
- In-drought order monitoring is required to assess the impacts from the implementation of the drought management action and for the management of mitigation actions during a drought.
- Post-drought order monitoring aims to assess a site's recovery.
- Sites with moderate to major environmental risk should focus monitoring on those feature(s) sensitive to the likely impacts from implementing drought management actions. For Habitats Directive sites, data collected will be sufficient to demonstrate there is no adverse effect on the interest features. For SSSIs, data collected will need to be sensitive enough to pick up the likelihood of damage at the site. For WFD sites data collected will be to assess any potential 'deterioration' to status and allow you to comply with the requirements of Articles 4.6 to 4.9.
- Control sites are important to provide a comparison between the 'natural' impacts of the drought and the impacts of the drought management action.
- The EMP should include details of any surveys to support the environmental assessment, in-drought and post-drought data needs, including:
    - the feature/s to be monitored and the methods used
    - the location of survey sites
    - the timing and frequency of monitoring
    - who will undertake the monitoring.
- Separating the 'natural' impacts of a drought from those resulting from the implementation of drought management actions can be complex and made more difficult where data problems and/or a lack of hydro-ecological understanding exists. Water companies must ensure that their EMP is adequate to assess the most significant environmental impacts of its proposed drought actions and associated mitigation measures.
- The EMP needs to be agreed with NRW. Consultation with NRW should be undertaken to ensure that the monitoring proposed within the EMP to assess the potential impacts at these sites is adequate.
- A water company must provide details in the Drought Plan of likely mitigation or compensation needed against serious impacts on the environment or other water users of any proposed drought action. The EMP should assist in identifying sites that may require mitigation. In some cases, mitigation actions may be necessary to prevent derogation of other abstractions (for example, by providing alternative supplies or releasing compensation water into watercourses to limit the impact of

reduced flows).

10.3 MONITORING RECOMMENDATIONS

The EMP describes the nature and extent of the baseline and drought year data that would be required in order to differentiate the impacts resulting solely from the implementation of a drought order with those resulting naturally as a result of the drought itself. The EMP is site specific and the scope is based on the current assessment of the drought order.

Recommendations for pre-drought, in drought and post-drought monitoring, based on the outcome of the current environmental assessment, are provided in **Table 10.1.** and are illustrated on **Figure 10.1**.

Monitoring outside of drought conditions is also recommended to address the baseline data limitations to the environmental assessment identified in this report and ensure a robust baseline exists for all sensitive features.

Data and results from baseline monitoring will increase the robustness of the assessment, and will be incorporated at the time of EAR preparation to support any future application for drought powers. The impact assessment has adopted a precautionary approach where baseline data limitations have been identified.

Control sites are crucial in assessing the ecological impact of flow pressure resulting from water resource activities. They can help determine whether any ecological impact being observed is a result of the water resource activity being investigated, rather than wider environmental influences. Good control sites for hydroecological assessment should be chosen where there are no significant water quality problems or pressures which could undermine relationships between ecology and flow. They must not be affected by the water resource activity being investigated nor have additional water resource activity upstream that could affect the flow regime. It is imperative that they are as similar in nature to the baseline conditions of the impact sites as possible, most importantly stream size and channel gradient. Possible options could include reaches upstream of those impacted, or other watercourses where the watercourses are comparable and not subject to a drought permit/order application. Control sites will need to be identified at the time of application following a review of where drought permit/orders are required to be implemented. Consultation with NRW to determine suitable control sites will be undertaken at the time of application of this drought order.

The following monitoring programme is an initial draft and will be iterated and agreed with NRW prior to EMP implementation. Any updates to the EMP will consider:

- Any potential changes in the assessment of the hydrological, water quality and geomorphological impacts based on baseline conditions at the onset of drought;

- Any potential changes in the assessment of impacts on environmental features based on baseline conditions at the onset of drought; and
- Any changes in assessment and/or monitoring methodologies and biological indices.

Table 10.1 Baseline, Pre, Onset, During and Post Drought Permit Monitoring and Mitigation Recommendations

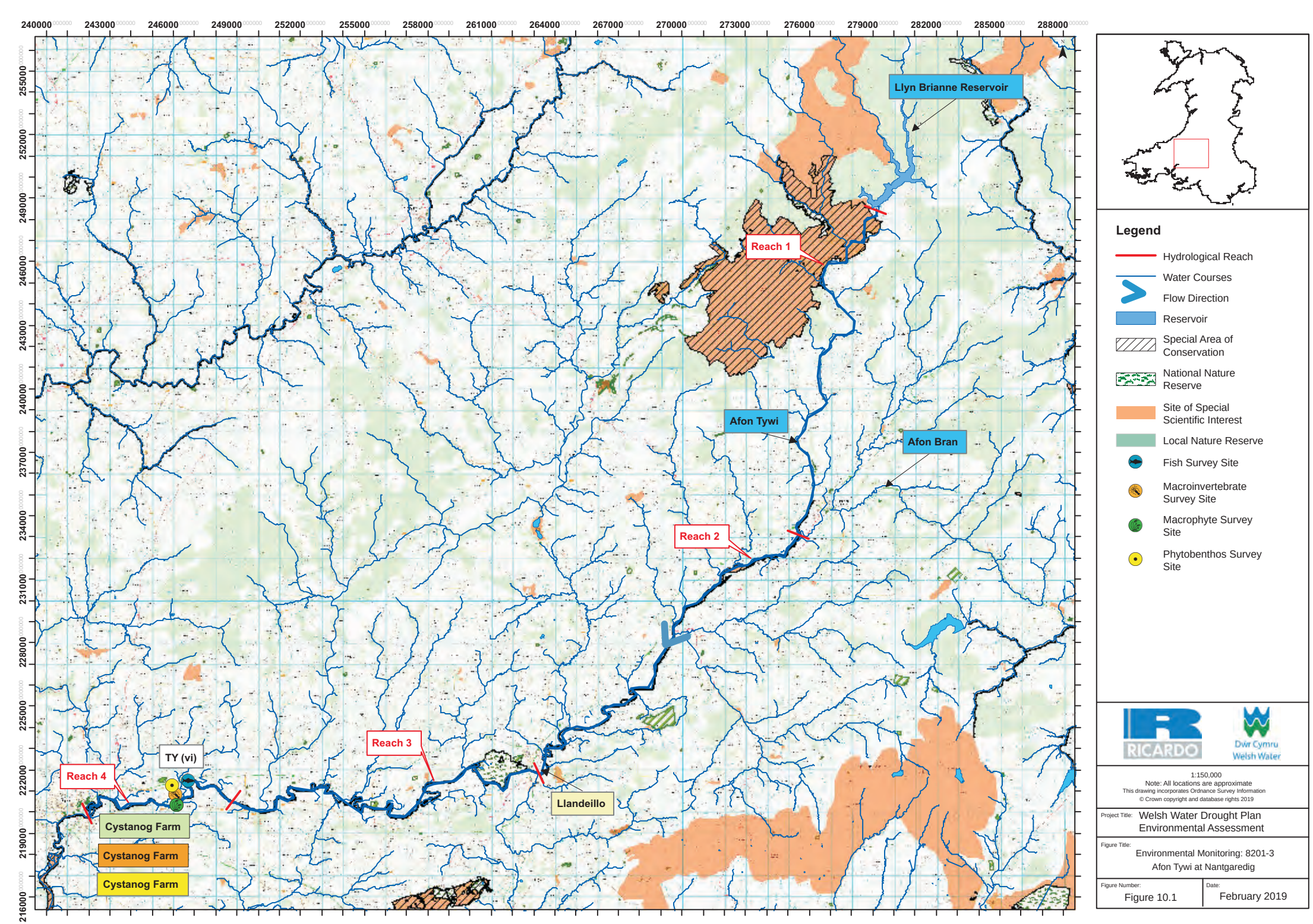
Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	**Monitoring and trigger setting**	**Trigger and monitoring to inform mitigation action**	**Mitigation actions triggered by monitoring**	**Monitoring and post-drought mitigation (where applicable)**	
N/A		Walkover survey during low flow conditions - Mapping of sensitive habitats, communities, species and any monitoring sites that are required in order to improve understanding of the baseline communities.	N/A				Welsh Water
		Spot flow gauging surveys	One site per hydrological reach. Three occasions.	One site per hydrological reach. Three occasions.	N/A	One site per hydrological reach. Three occasions.	Welsh Water
		Biochemical water quality sampling.	One site per hydrological reach. Monthly. Consider continuous monitoring.	One site per hydrological reach. Weekly. Consider continuous monitoring.	N/A	One site per hydrological reach. Monthly, until recovery to pre-drought levels. Consider continuous monitoring.	Welsh Water
Macrophytes **Reach 4**	• Reduction in abundance and distribution of taxa sensitive to nutrient enrichment (SRP) • Increase in detrimental smothering by filamentous algae levels increasing due to an increase in nutrients, increases in water temperature and decreased velocity	The macrophyte community in the impacted reach is reasonably well understood as a result of monitoring carried out by NRW. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Monitoring sites are located at: • Fish Trap Llyn Brianne (Reach 1) • 4 km D/S Nant Y Mwyn, Near Penlan (Reach 1) • Cystanog Farm (Reach 4)	Survey to be undertaken and macrophytes identified (if drought order likely to be implemented in plant growing season June-September). Follow LEAFPACS2 standard methodology [19]. Walkover survey to identify any key sources of nutrient loading. Carry out water quality sampling at the baseline sites including samples for soluble reactive phosphorus.	Walkover of key sections known to be susceptible to lower flows, informed by pre-drought survey. If drought order implementation occurs in June-September, carry out macrophyte surveys at baseline sites. Follow LEAFPACS2 standard methodology for assessing macrophyte communities. Carry out water quality sampling at the baseline sites including samples for soluble reactive phosphorus.	Consider measures to address identified point sources of nutrient loading. Consider scope for addressing any identified sources of nutrient loading from walkover survey, if this would help address water quality risks.	In the two years following drought order implementation and in June to September monitoring period carry out LEAFPACS2 macrophyte surveys at the baseline monitoring sites. To be extended if recovery has not occurred in two years. Significant alteration to macrophyte community composition (as informed by expert judgement, based on baseline data and multivariate statistical analyses) triggers post drought mitigation actions:	Welsh Water

[19] Environment Agency (2011). Surveying freshwater macrophytes in rivers. Operational instruction 131_07. (Unpublished procedures manual)

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
						If existing macrophyte community has significantly deteriorated, consider reseeding /replanting where possible to promote recovery. Replanting of macrophyte community composition to be informed by pre-drought community.	
Freshwater Pearl mussels **Reach 4**	• Reduction is species abundance and/or distribution due to water quality deterioration. • Reduction in habitat suitability due to water quality deterioration and increased occurrence of epiphytes and algae	Broad extensive survey using a bathyscope to determine presence/absence and classify age of population. Three sites in Reach 4. If freshwater pearl mussels are recorded in the impacted reach further monitoring and mitigation is to be specified in discussion with NRW.	TBC	TBC	TBC	TBC	Welsh Water
Fish (river, brook and sea lamprey) **Reach 4**	• Loss of juvenile fish habitat as a result of reduced flow related impacts • Increased mortality (density dependant) as a result of increased predation and competition	The fish community in the impacted reach is reasonably well understood as a result of monitoring carried out by NRW. Surveys to be repeated every three years. To complement any existing NRW monitoring, in discussion with NRW Monitoring sites are located at:	Electric-fishing surveys to monitor juvenile lamprey populations at two sites in the impacted reach. In severe drought conditions, no fish population surveys are advised during drought as this may cause further stress. Walkover of impacted Reach 4: • Identification of key habitats which are at risk of	No fish population surveys are advised during drought as this may cause further stress. Additional walkovers, if situation is expected to deteriorate in stream sections known to contain high fish densities, nursery and cover habitats. Record extent of exposed	If the results of the walkovers deem juvenile lamprey habitat to be at risk of desiccation, the following mitigation action/s may be undertaken: • Targeted installation of woody debris features to provide submerged and overhead cover	Two years of annual post-drought lamprey specific population surveys at baseline monitoring sites (corresponding with a control and impact site/s) to determine any changes in population dynamics both temporally and spatially. The results of the fish population surveys should	Welsh Water

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	**Monitoring and trigger setting**	**Trigger and monitoring to inform mitigation action**	**Mitigation actions triggered by monitoring**	**Monitoring and post-drought mitigation (where applicable)**	
		• NRW Site: Lamprey specific monitoring at site at TY15 (SN4671821494) • Lamprey specific monitoring control site x1 (*site location to be determined by walkover survey/consultation with NRW*)	low flow impacts, particularly juvenile lamprey habitat. Appropriate trigger values would be set for level and flow for spawning habitats based on local circumstances, timing, seasonality and expert opinion.	marginal habitats, bed substrates and estimates of overlaying silt cover. Frequency of walkovers to be determined based on the on-set of environmental drought walkover and expert judgement of the resolution required to monitor the impacts of the drought.	from predation where significant abundances of fish have been identified by walkover surveys. Consider provision of physical deterrents to deter piscivorous birds at significant locations (e.g. scare crows) in consultation with NRW. In extreme cases (where environmental parameters such as dissolved oxygen and temperature allow), consider removal of concentrated abundances of fish deemed to be stranded/at risk, relocating fish to suitable locations outside of the impacted reach within more suitable catchment, but would need to be discussed with NRW to ensure compliance with the Keeping and Introduction of Fish Regulations 2014.	help inform mitigation, targeting habitat restoration where deemed to be appropriate to support and enhance affected populations. Walkover of key fish habitat locations recording the number of juvenile lamprey habitat potentially affected. Record extent of exposed marginal habitats, and composition of the bed substrate and estimates of overlaying silt cover. If the results of the walkovers deem important habitats to be at risk to exposure/ reduction (in extent), the following mitigation action/s may be undertaken: • Targeted installation of woody debris features to provide submerged and overhead cover / flow diversification to create favourable areas for juvenile lamprey.	
Afon Tywi SAC	• Impacts on river lamprey, brook lamprey, and sea lamprey, and bullhead (Annex II species for which the SAC has	Lamprey specific monitoring to be undertaken at the sites identified for the relevant sections above.					

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
	been designated) have been assessed as moderate in Reach 4.						
Phytobenthos **Reach 4**	• Decrease in flow affecting phytobenthos community composition. • Low risk of deterioration to SRP affecting phytobenthos community composition and TDI score. • Increases in filamentous algae smothering the substrate.	Data is absent for the impacted reach. Sampling according to DARES protocol is recommended at one site in Reach 4 and one control site. Sampling to be undertaken in at least 1 year, ideally 2-year baseline, ideally encompassing 1 x "normal" flow year and 1 x "dry" flow year, 2 x sampling per year, in spring and autumn. Surveys to be undertaken at the following NRW sites: • Cystanog Farm • X1 control site located outside of Reach 4	Sampling according to DARES protocol, at baseline survey sites, in spring and autumn.	Sampling according to DARES protocol, at baseline survey sites, in spring and autumn.	No additional measures specified.	Sampling according to DARES protocol, at baseline survey sites, in spring and autumn.	Welsh Water



Legend

- Hydrological Reach
- Water Courses
- Flow Direction
- Reservoir
- Special Area of Conservation
- National Nature Reserve
- Site of Special Scientific Interest
- Local Nature Reserve
- Fish Survey Site
- Macroinvertebrate Survey Site
- Macrophyte Survey Site
- Phytobenthos Survey Site

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1:150,000

Note: All locations are approximate

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Environmental Monitoring: 8201-3 Afon Tywi at Nantgaredig

Figure Number: Figure 10.1

Date: February 2019

11 CONCLUSIONS

This EAR provides an assessment of the potential environmental impacts relating to the implementation of the Afon Tywi drought order. If granted and implemented, the drought order would enable a change in the abstraction conditions at the Nantgaredig intake to relax the requirement to maintain the downstream flow at an instantaneous daily minimum of 136Ml/d. Instead, the downstream flow requirement of 136Ml/d would be temporarily assessed as a 7-day rolling average, with the daily instantaneous minimum flow requirement temporarily reduced to 116Ml/d. This would enable Welsh Water to more efficiently target a rolling average downstream flow of 136Ml/d, whilst reducing the need to over-release at times of very low flow due to the time of travel between the reservoir and the downstream abstraction intake (24 hours or more) and the difficulties of predicting the next day's gauged flows.

The scope of the assessment has been defined by an impact screening and scoping exercise. In accordance with the DPG, the screening exercise involved two stages, a hydrological impact assessment (Stage 1) and the identification of the environmental features that could be affected by the drought order (Stage 2).

The assessment has concluded that there is a **minor** impact on flows (at minimum flows only) in the Afon Tywi as a result of implementing the drought order. These hydrological impacts are assessed as leading to **minor** impacts on the physical environment of the river, including water quality.

An environmental assessment was therefore required and included for features where screening has identified a major or moderate impact. Screening identified WFD status and Community Assessment / Environment (Wales) Act Section 7 Species, designated sites, invasive fauna, landscape, archaeology and recreation as environmental features for which an environmental assessment was required. The assessment has concluded that there are **moderate** impacts on fish, **minor** impacts and freshwater pearl mussels, macroinvertebrates, macrophytes, and phytobenthos. The assessment also concluded minor impacts on the Afon Tywi SSSI.

The HRA Screening could not conclude that implementation of a drought order would not result in likely significant effects on the twaite and allis shad, brook and river lamprey and bullhead populations within the Afon Tywi SAC.

No cumulative effects of implementing the drought order with existing licences, consents and plans are currently anticipated. However, this should be reviewed at the time of any future application for a drought order at Afon Tywi.

The environmental assessment has identified significant impacts of implementation of a drought order at Afon Tywi. Consequently, in line with the DPG, mitigation measures have been proposed and further discussion with NRW is required in order to develop

suitable mitigation measures.

In summary, it has been concluded that the environmental effects on river flows and ecology of implementing a drought order at Afon Tywi, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **moderate-minor**.

APPENDIX A
HYDROLOGY AND HYDROGEOLOGY METHODOLOGY

A.1 HYDROLOGICAL AND HYDROGEOLOGY IMPACT METHODOLOGY (STAGE 1 SCREENING)

Consideration is required (by the DPG[1]) of the likely changes in flow / level regime due to implementing the drought management action, specifically:

- the perceived extent of potential impact
- the nature and duration of the potential impact
- the timing of the potential impact.

The hydrogeological and hydrological information is used together with information on the other environmental features in the study area from Stage 2 - Environmental Sensitivity (see Section 3.2.1 in main report) to identify the environmental risk of the drought order / permit.

Although the DPG informs the hydrometric data to be used as part of environmental features for consideration within the environmental assessment (see Box 1 Appendix H of the DPG), it does not provide a methodology for identifying the hydrological impact.

Cascade has developed a flexible approach[2] to identifying the spatial extent of the study area from hydrological information and characterising the hydrological impact within the study area, in terms of the scale, nature, duration and timing of impacts, although this is only appropriate to apply to reaches that do not dry naturally. A hydrological methodology for watercourses that naturally dry for part of the year is also presented that characterises the hydrological impact within the study area, in terms of the scale, nature, duration and timing of impacts. These are presented below.

Perennially flowing watercourse hydrological methodology

This methodology is applied to watercourses that flow throughout the year and that are potentially impacted on by the drought order / permit.

Core to this approach is the use of relevant long term flow statistics to inform the scale of hydrological impact and thereby delimit the zone of influence in the downstream river system. To determine these, potential reductions in flow resulting from implementation of the drought order / permit are compared with flows without the drought order / permit in place (i.e. the additional abstraction advocated by the drought order / permit over and above the existing abstraction). This helps to determine the scale of potential impact at any particular site/ feature using the matrix in **Figure A.1** or **Figure A.2** depending on the altitude of the waterbody and whether it is classified as lowland or upland[3]. Where possible, the hydrological assessments presented in previous EMPs and EARs of the drought options have been used to

1 Welsh Government / Defra / NRW / Environment Agency (2011). Water Company Drought Plan Guideline. June 2011.
2 Hydrological impact approach used in previous drought plan environmental assessments for water companies including Thames Water, Yorkshire Water and United Utilities
3 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.
The Directions set out the principles of classification of surface water and groundwater bodies, including the use of 80m above Ordnance Datum as the altitude that differentiates water quality requirements for upland and lowland biology. Where there are ambiguities, or thresholds are crossed, upland is assumed to apply to ensure a precautionary assessment.

help identify the spatial extent of the study area from hydrological information and characterising the hydrological impact within the study area.

Figure A.1 Hydrological Assessment Matrix (Upland)

		Summer Q99		
	% reduction in flow	<10%	10-25%	>25%
Summer Q95	<10%	Negligible	Minor	Moderate
	10-25%	Minor	Moderate	Major
	>25%	Moderate	Major	Major

Figure A.2 Hydrological Assessment Matrix (Lowland)

		Summer Q99		
	% reduction in flow	<10%	10-25%	>25%
Summer Q95	<20%	Negligible	Minor	Moderate
	20-50%	Minor	Moderate	Major
	>50%	Moderate	Major	Major

Figure A.1 illustrates that at the time of implementation of a drought order / permit, upland river systems of relevance to each of these proposed options will exhibit high sensitivity to changes in low flow (represented by Q_{95}, summer[4]) and very high sensitivity to changes in extreme low flow (represented by Q_{99}, summer). As illustrated by **Figure A.2**, lowland rivers of relevance to each of these proposed options are considered to be less sensitive to reductions in summer low flows (summer Q_{95}), but similarly sensitive to reductions in extreme summer low flows (summer Q_{99}).

Figures A.1 and **A.2** are appropriate for the assessment of hydrological impacts on low flow regimes in watercourses during the spring, summer and autumn. However, in some cases there is a need to assess the impacts of drought order schemes on watercourses during the winter. For example, a reduction in compensation release may remain in force during the winter high flow period, to increase the probability of reservoir refill prior to the following year's spring/summer drawdown period. During the winter season, watercourses have relatively lower sensitivity to changes in low flow, and moderate sensitivity to changes in moderate flow. This can be reflected by the use of the matrices in **Figures A.3** and **A.4** for the assessment of drought order / permit schemes which are only likely to impact on a watercourse during the winter. The categorisation of impacts as negligible, minor, moderate or major is based on the percentage reduction in year round low flow (Q95) and year round median flow (Q50).

Figure A.3 Hydrological Assessment Matrix (Upland / Winter)

		Year round Q95		
	% reduction in flow	<10%	10-25%	>25%
Year round Q50	<10%	Negligible	Minor	Moderate
	10-25%	Minor	Moderate	Major
	>25%	Moderate	Major	Major

[4] Flow statistics indicate the proportion of days a flow is equalled or exceeded. Therefore Q95 indicates flow equalled or exceeded on 95% of days in the measured record (equivalent to an average of 347 days per year)

Figure A.4 Hydrological Assessment Matrix (Lowland / Winter)

		Year round Q95		
	% reduction in flow	<10%	10-25%	>25%
Year round Q50	<20%	Negligible	Minor	Moderate
	20-50%	Minor	Moderate	Major
	>50%	Moderate	Major	Major

The matrices are used to identify 1) the overall study area – which extends downstream of the abstraction until the hydrological impact has reduced to negligible; 2) reaches with similar scales of impact within the overall study area; and 3) the scale of hydrological impact within each reach. Typically reaches have been delimited by the addition of flow from a significant tributary or discharge; although the similarity of geomorphological characteristics of the reach may also be important in reach specification. The matrices can be applied to a variety of upland or lowland catchments respectively including those dominated by groundwater, and can be applied until the tidal limit.

In addition to the information provided by summary flow statistics in the matrix, information on the timing, duration and relevant seasons of the drought order / permit impacts have been informed by licence details and river gauging data have also been used to characterise the likely nature of the drought order / permit impacts.

If the drought order / permit does not impact on the magnitude of low flows in a watercourse, but does cause changes in the duration of low flow periods (which can be quantified), then the matrix in **Figure A.5** may be appropriate. The assessment is based on the percentage increase in the number of days for which flow is at or below the low flow (Q95) value. Typically this would be the case when the low flow regime in a watercourse downstream of a reservoir is protected by a statutory compensation release from the reservoir, but the reservoir may be drawn down below top water level for longer periods due to increased direct abstraction under the drought order / permit conditions.

If low flows in a watercourse are adversely affected in both magnitude and duration, then the impacts on magnitude are always used to determine the significance of hydrological impacts, using the appropriate matrix from **Figures A.1** to **A.4** inclusive. **Figure A.5** is only used when the impacts on low flows are on duration only.

Figure A.5 Hydrological Assessment Matrix (Low Flow Duration)

Percentage increase in low flow duration	Significance
<5%	Negligible
5-10%	Minor
10-25%	Moderate
>25%	Major

Intermittently flowing watercourse hydrological methodology

This methodology is applied to watercourses, potentially impacted on by the drought order / permit, that flow for most of the time but seasonally or occasionally ceasing to flow in response to decreased water availability e.g. due to increased evapotranspiration or bed seepage. . Such watercourses are identified from previous investigations and available data. Examples of watercourses where this methodology would be applied include winter bournes or watercourses that dry along their route due to losses to underlying aquifers. The impact classification of this methodology is as follows:

- Major - If the drought order / permit resulted in sections drying that did not dry up anyway
- Moderate - If the drought order / permit resulted in sections drying earlier (by more than a week) and / or recovering later (by more than a week) and hence flow reduction occurring in the channel for more than a week
- Minor - If the drought order / permit resulted in sections drying earlier (up to a week) and/or recovering later (by up to a week) and hence flow reduction occurring in the channel for up to a week OR if the drought order / permit were a secondary flow driver (e.g. flow through gravels being primary cause of flow losses rather than the drought order / permit)
- Negligible - No significant impact

In addition to the derived classifications, information on the timing, duration and relevant seasons of the drought order / permit impacts have been informed by licence details, available data and findings of previous investigations. These have been used to characterise the likely nature of the drought order / permit impacts.

Reservoir hydrological methodology

More recently Cascade has developed a similar approach to categorise the significance of hydrological impacts of drought order / permit operations on reservoirs. The assessment requires an estimate of the relative change in duration of reservoir drawdown (i.e. the period for which water in the reservoir is below top water level), and the percentage decrease in the minimum reservoir level reached during the drawdown period. These two parameters are then compared against the reservoir impacts hydrological assessment matrix in **Figure A.6**.

This approach would be a suitable method to assess the impacts of a drought order / permit which involves significant changes to the reservoir water level regime (that would not normally be experienced during a drought without any additional measures implemented). For example, a drought order / permit may involve increasing daily or annual licensed abstraction limits to allow an increased rate of direct abstraction from the reservoir. This may enable some or all of a reservoir's emergency storage volume to be utilised, but is likely to lead to both lower water levels and increased periods of time below top water level.

Figure A.6 Hydrological Assessment Matrix (Reservoir Impacts)

	% Increase in duration of reservoir drawdown			
% Decrease in minimum reservoir level	<5%	5-10%	10-25%	>25%
<5%	Negligible	Negligible	Minor	Moderate
5-10%	Negligible	Minor	Moderate	Major
10-25%	Minor	Moderate	Major	Major
>25%	Moderate	Major	Major	Major

Additional Considerations

For groundwater schemes, hydrogeological data, where available, has been reviewed to inform the study area and duration of any impacts (noting impacts on groundwater may extend beyond the six month period of drought order / permit implementation - see below). An increase in groundwater abstractions would lead to an increased cone of depression in groundwater levels for groundwater abstraction. This impact can affect other non-surface water receptors such as other wells, springs or groundwater dependent ecosystems. It could also mean that surface water impacts would extend upstream of the abstraction point or, in significant instances, to other watercourses some distance from the abstraction.

For groundwater abstractions, the impact of a drought order / permit could extend beyond the six month period (time limited) of abstraction depending on the local hydrogeology of the area. During drought situations, where there is limited recharge to the aquifer system, the abstraction can be mainly at the expense of groundwater stored in the aquifer. This can, in the long run, delay groundwater level recovery and have a knock on effect on baseflow contributions to watercourses. Flows could, therefore, be reduced for longer than the six month period during which the drought order / permit could be implemented and, as such, has been considered as part of the assessment described in this report.

APPENDIX B
HYDROLOGY AND PHYSICAL ENVIRONMENT ASSESSMENT

B1 INTRODUCTION

This appendix assesses the potential impacts on the physical environment of the Afon Tywi (River Towy) catchment during the period of implementation of the drought order.

For the purposes of this assessment, the "without drought order" baseline includes daily abstractions from Welsh Water's Afon Tywi intake at Nantgaredig and regulation releases from Llyn Brianne to support the abstraction and maintained flow downstream of the intake as required under the existing licence conditions. The assessed drought order involves the temporary relaxation of the maintained flow condition downstream of Nantgaredig so that the instantaneous daily flow requirement is reduced from 136Ml/d to 116Ml/d, with a 7-day rolling average maintained flow of 136Ml/d.

B.1.1 Welsh Water's Existing Operations

Welsh Water's licence (number 22/60/3/0035) to abstract water under the Water Resources Act from the Afon Tywi at Nantgaredig river intake (see **Figure B1.1**) includes the following conditions:

- 82,964.5 million litres (Ml) authorised to be abstracted per annum.
- At an average daily abstraction rate of 227.3Ml/d.
- The low flow of the Afon Tywi is regulated by controlled releases from Llyn Brianne impounding reservoir. These controlled releases consist of the following:

  a) A statutory compensation water discharge of 68Ml/d at those times when regulation releases are not being made

  b) Regulation releases to support the abstraction at Nantgaredig intake are required, depending on remaining flow in the river as measured at the downstream Natural Resources Wales (NRW) Capel Dewi flow gauge:

  i) At remaining flows measured at 681Ml/d or above, no regulation releases are required to support full daily abstraction.

  ii) At remaining flows measured between 681Ml/d and 136Ml/d, regulation releases are required to support abstraction on a put-and-take basis. The maximum rate of abstraction during the day must not exceed the regulation release rate in the previous day.

  iii) At remaining flows measured at or below 136Ml/d, the remaining flow becomes a hands-off flow of 136Ml/d and additional controlled releases are required to support the hands-off flow, in addition to those to support abstraction on a put-and-take basis.

The abstraction for potable supply is made from the Afon Tywi at the Nantgaredig intake, and is pumped to either the local Capel Dewi Water Treatment Works (WTW) for treatment or to

Lower Lliw pumped storage reservoir for storage prior to reabstraction, treatment at Felindre WTW and delivery into the supply network. The time of travel from Llyn Brianne to Nantgaredig is estimated to be typically around 24 hours, increasing to 36 hours at very low flows.

B.1.2 Welsh Water's Proposed Drought Order Operations

The drought order involves a change in the abstraction conditions at the Nantgaredig intake to relax the requirement to maintain the downstream flow at an instantaneous daily minimum of 136Ml/d. Instead, the downstream flow requirement of 136Ml/d would be temporarily assessed as a 7-day rolling average, with the daily instantaneous minimum flow requirement temporarily reduced to 116Ml/d. This would enable Welsh Water to more efficiently target a rolling average downstream flow of 136Ml/d, whilst reducing the need to over-release at times of very low flow due to the time of travel between the reservoir and the downstream abstraction intake (24 hours or more) and the difficulties of predicting the next day's gauged flows.

Extreme low flows requiring additional regulation releases to support the maintained flow are only likely in summer and autumn months. Welsh Water has determined, through water resources modelling, that this drought order is most likely to be required during the period from September to November inclusive. The drought order will help to conserve storage in Llyn Brianne Reservoir at times of severe drawdown.

The drought order will influence the Afon Tywi from the Llyn Brianne reservoir outflow to the tidal limit. The study area is shown on **Figure B1.1**.

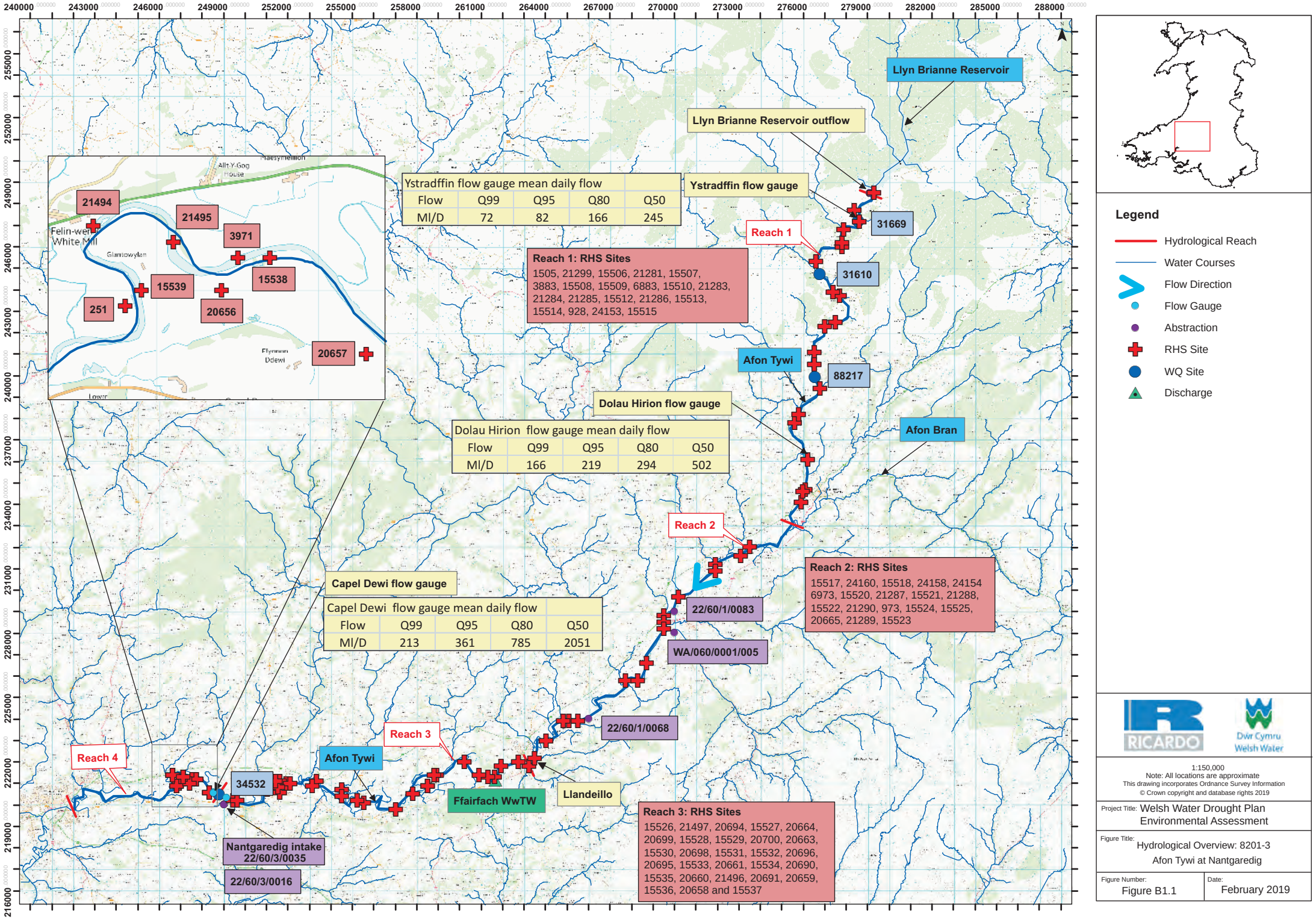
The physical environment includes consideration of hydrology and hydrodynamics; geomorphology; and water quality. The assessment has three key objectives:

1. To "list the likely impacts to the flow, level, channel/riparian form and sediment due to action being in place" as required by the DPG[1] and set out in Figure 2 of the DPG..
2. To support the screening and assessment of sensitive features (including ecological features and designated sites) as required by the DPG and set out in Section 5 of this report.
3. Provide supporting technical information for their screening and assessment where sensitive features are the physical environment itself.

This appendix is set out in the following sections:

Section B.2 Hydrological Impact
Section B.3 Physical Environment Assessment
Section B.4 Physical Environment Impact Summary
Section B.5 Cumulative Impacts

[1] Natural Resources Wales (2017) *Water Company Drought Plan Technical Guideline*. Available at https://cdn.naturalresources.wales/media/684414/final-wc-drought-plan-guidance-2017.pdf?mode=pad&rnd=131656713580000000, Accessed 04 February 2019.



Legend

- Hydrological Reach
- Water Courses
- Flow Direction
- Flow Gauge
- Abstraction
- RHS Site
- WQ Site
- Discharge

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1:150,000
Note: All locations are approximate
This drawing incorporates Ordnance Survey Information

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Hydrological Overview: 8201-3 Afon Tywi at Nantgaredig

Figure Number: Figure B1.1

Date: February 2019

B2 HYDROLOGICAL IMPACT

B.2.1 Reference Conditions

B.2.1.1 Catchment Overview

The Afon Tywi is one of the two longest rivers wholly in Wales (the other being the Afon Teifi), flowing for 120km from its source in the Cambrian mountains to Camarthen Bay east of Pendine Sands. At the tidal limit the catchment area is 1113km[2].

Llyn Brianne impounding reservoir, located approximately 10km downstream of the Afon Tywi source, was constructed in 1972 and provides regulation releases to support abstractions for public water supply downstream at the Nantgaredig intake. The reservoir has a capacity of 64,277Ml and a catchment area of around 85km[2]. A hydro-electric generating station at the base of the dam provides up to 4.3MW of electricity[2].

The underlying geology of the Tywi catchment is alluvium, glacial sands and gravels, resulting in an actively eroding river meandering across a 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. Land-use in the upper mountainous catchment is predominantly forestry and sheep farming, whilst in the middle and lower catchment it is mainly dairy and livestock farming. There is also some limited maize production which has the potential to increase winter sediment loads in the river from field run-off.

The operation of Llyn Brianne Reservoir and the Tywi river regulation scheme is the subject of a Section 20 Operating Agreement between Welsh Water and NRW.

A review of the flows and physical habitat characteristics of the river network downstream of the Llyn Brianne reservoir outflow has identified the study area for this assessment. The study area stretches for a distance of 76km from the Llyn Brianne reservoir outflow to the tidal limit of the Afon Tywi, east of Carmarthen. The downstream limit is not clearly defined as there is no physical barrier to limit the extent of tidal propagation upstream in the river. The extent of tidal influence will, therefore, vary under different stages of the tidal cycle (low tide to high tide; neap tide to spring tide) and with size of freshwater river flows. For the purposes of this assessment, the ordnance survey indication of mean high tide at SN450205 will be used to delimit the downstream extent of the study area.

The study area includes Llyn Brianne Reservoir itself and a length of the Afon Tywi comprising four hydrological reaches, as listed in **Table B2.7** and identified on **Figure B1.1**.

The potential hydrological impact of the drought order has been reviewed for the reservoir and four river reaches and is discussed below.

[2] British Hydropower Association website: http://www.british-hydro.org/installations/l/llyn_brianne.html

B.2.1.2 Baseline Data Availability

Continuous monitoring is undertaken by Welsh Water of its operations at Llyn Brianne Reservoir and the Afon Tywi, including:

- Monthly or weekly Llyn Brianne Reservoir storage volumes, 1984 – 1995.
- Daily Llyn Brianne Reservoir storage volumes, 1996to date.
- Daily outflows from Llyn Brianne Reservoir, 2006 to date.
- Daily abstractions from Nantgaredig intake, Afon Tywi, 1990 to date.

Continuous monitoring of flow in the River Tywi is undertaken by NRW at a number of permanent gauging stations in the catchment. Available data include:

- Ystradffin flow gauge, River Tywi; daily river flow 1983 to date.
- Dolau Hirion flow gauge, River Tywi; daily river flow 1968 to date.
- Capel Dewi flow gauge, River Tywi; daily river flow 1958 to date.

Peak flows are also monitored by NRW at an additional gauge, Ty Castell, a short distance upstream of Capel Dewi at SN491203 (**Figure B1.1**).

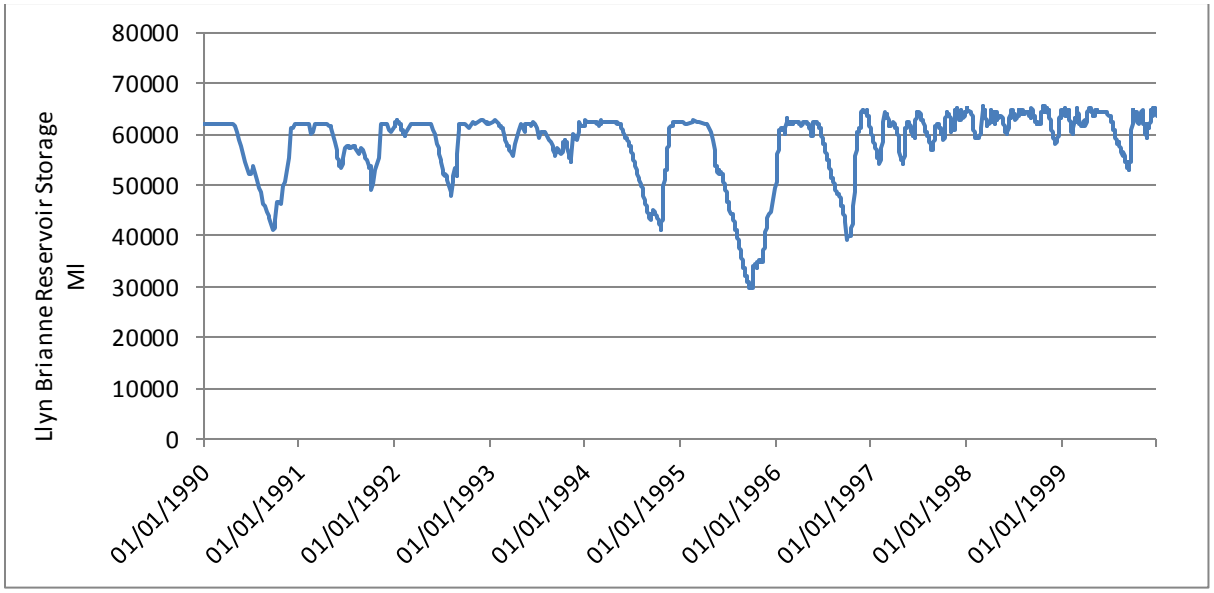
B.2.1.3 Hydrology

Llyn Brianne Reservoir

Llyn Brianne Reservoir was constructed in 1972 in the headwaters of the Afon Tywi. In 1996 the dam crest was raised by 1m, resulting in a storage capacity of 64,277Ml at top water level.. Recorded storage volumes from 1984to 2018 range from 29,280Ml (around 45% of full capacity) to 66,147Ml (around 3% above full capacity, due to overflows taking place).

Figure B2.1 shows the typical pattern of storage in Llyn Brianne Reservoir over a ten-year period from 1990 to 1999.

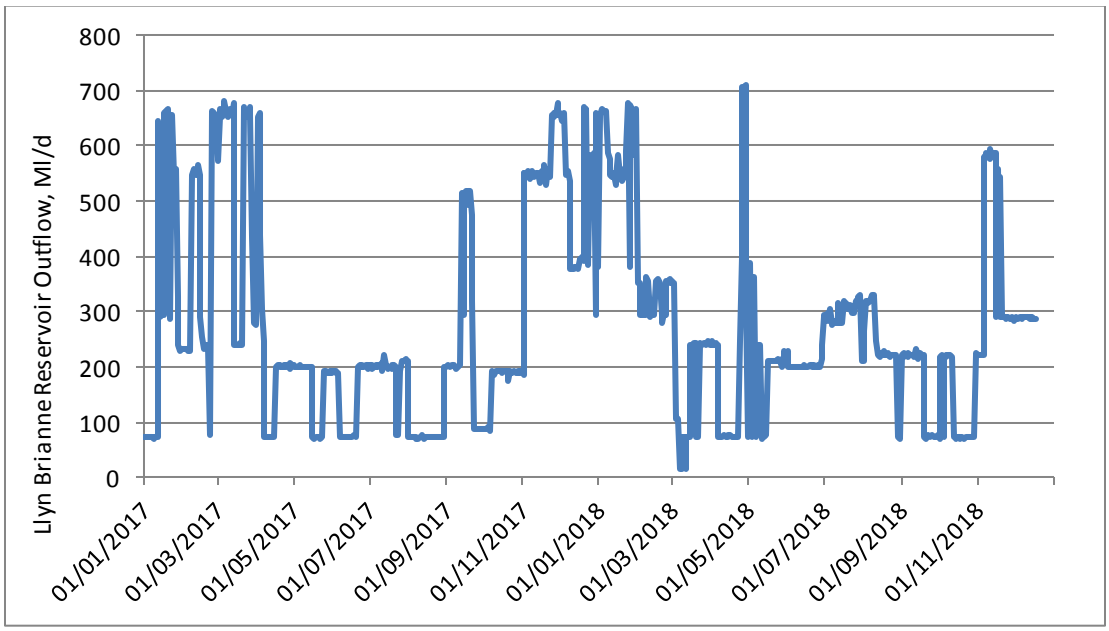
Figure B2.1 Llyn Brianne Reservoir Storage (1990 – 1999)



Daily outflows from Llyn Brianne over the period 2006 to 2018 are variable depending on flow conditions and daily abstractions downstream on the lower Afon Tywi, but are generally in the range 74Ml/d to around 700Ml/d. The measured discharges include compensation and/or regulation releases as well as flows through the hydro-electric turbines.

Figure B2.2 shows a typical pattern of outflows from Llyn Brianne for a two-year period from 2017 to 2018, and illustrates the highly artificial nature of the flow regime in the Afon Tywi immediately downstream of the reservoir.

Figure B2.2 Llyn Brianne Reservoir Outflows (2017 – 2018)



River Tywi at Ystradffin

Flow is measured in the River Tywi at Ystradffin (NGR: SN7855947241), a short distance downstream of the Llyn Brianne reservoir impoundment. A summary of the available daily flow data from 1983 to 2018 is given in **Table B2.1** below.

Table B2.1 Summary of Recorded Mean Daily Flow in River Tywi at Ystradffin (1983 – 2018)

Percentage of time river flow equalled or exceeded	Mean daily flow Ml/d, per month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum flow	2,575	3,845	3,904	2,018	1,598	3,473	2,203	2,022	2,134	5,803	3,335	4,277	5,803
10% (high flow)	1,208	909	685	561	322	303	313	327	359	663	1,006	1,192	719
50%	537	343	242	228	216	229	239	239	240	245	517	449	245
80%	254	186	139	135	118	163	200	198	196	165	192	186	166
90%	174	103	84	95	93	99	101	97	117	103	106	102	99
95% (low flow)	81	91	79	80	85	85	84	82	89	86	84	80	82
99% (extreme low flow)	68	74	73	70	77	75	74	72	72	68	71	67	72
Minimum flow	60	44	47	39	67	32	65	71	64	41	32	59	32

The low flow statistics for the summer period (1 April to 30 September inclusive) are: Summer Q_{95} = 83Ml/d; Summer Q_{99} = 73Ml/d.

Figure B2.3 shows the typical pattern of flows at Ystradffin from 1995 to 1996; the graph shows the influence of the compensation and regulation releases from Llyn Brianne Reservoir, with the lowest flows being approximately equal to the compensation release value of 68Ml/d. The flow duration curve for this location is shown in **Figure B2.4**.

Figure B2.3 River Tywi at Ystradffin Flows (1995 – 1996)

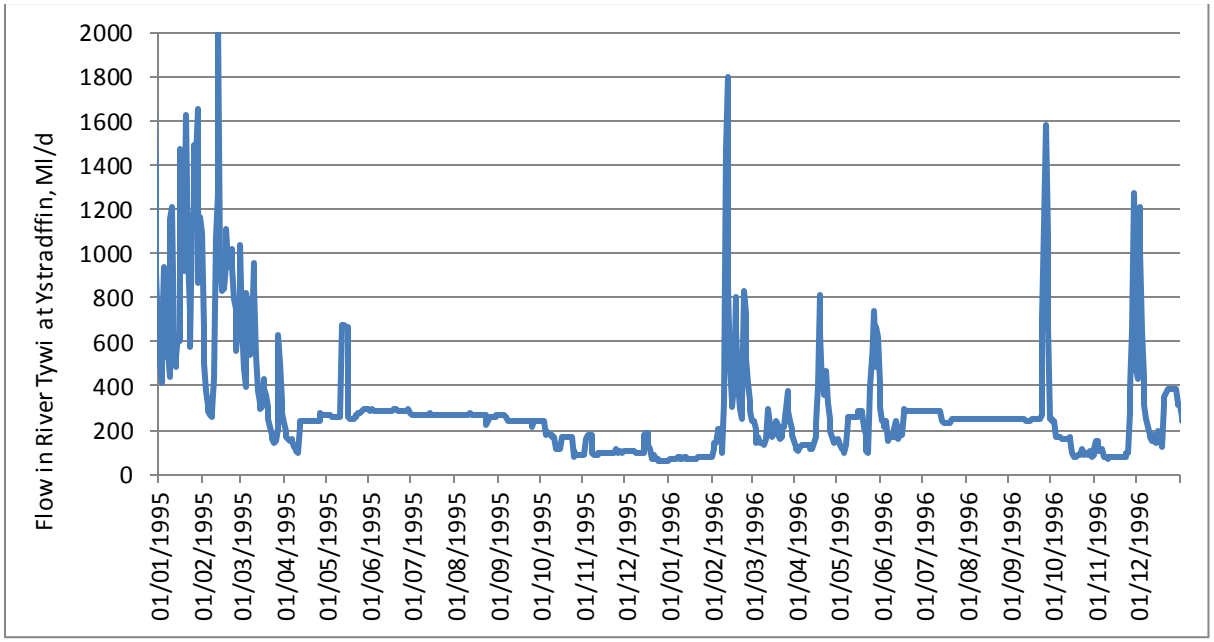
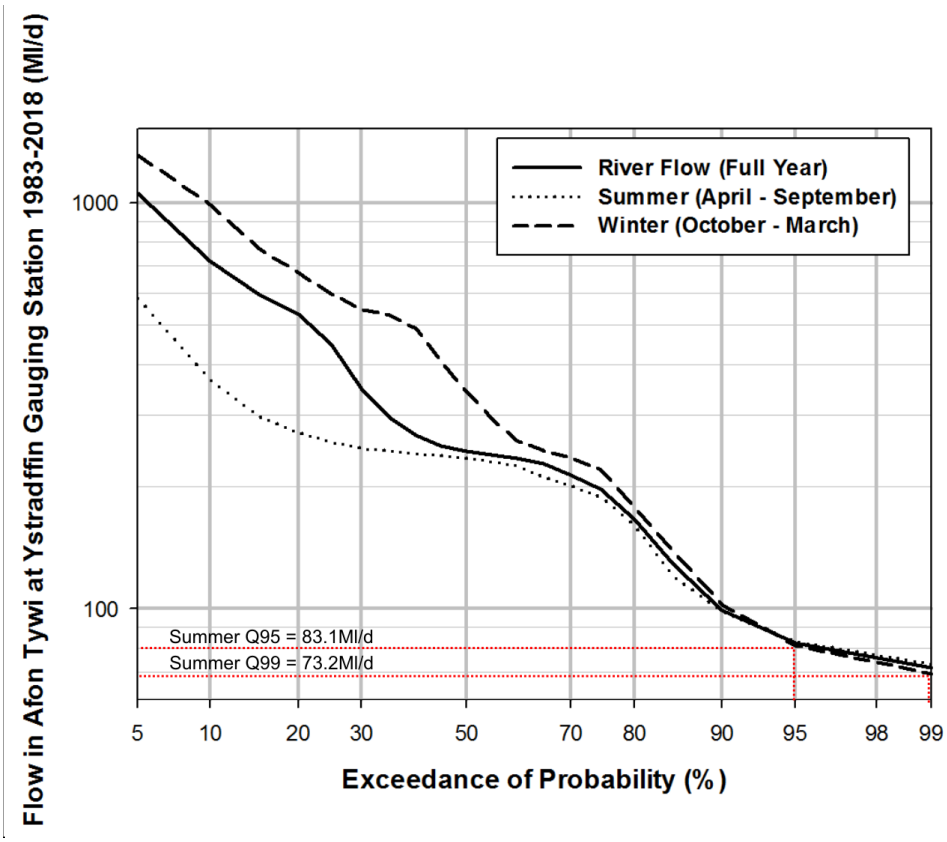


Figure B2.4 River Tywi at Ystradffin Flow Summary (1983 – 2018)



River Tywi at Dolau Hirion

Flow is measured in the River Tywi at Dolau Hirion (NGR: SN7618736244). A summary of the

available daily flow data from 1972 to 2018 is given in **Table B2.2** below.

Table B2.2 Summary of Recorded Mean Daily Flow in River Tywi at Dolau Hirion (1972 – 2018)

Percentage of time river flow equalled or exceeded	Mean daily flow Ml/d, per month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum flow	8,381	11,146	17,539	4,959	3,482	8,986	5,080	7,672	6,225	15,120	13,738	21,773	21,773
10% (high flow)	3,002	2,405	1,844	1,296	1,011	763	795	965	1,219	1,970	2,678	3,429	1,987
50%	1,184	789	603	401	348	327	321	349	387	625	1,045	1,123	502
80%	566	387	307	274	273	255	257	278	277	361	537	528	294
90%	364	286	255	244	234	217	217	241	247	287	360	370	255
95% (low flow)	295	247	223	216	204	182	182	202	211	255	284	298	219
99% (extreme low flow)	204	201	187	173	172	140	113	131	100	216	209	219	166
Minimum flow	146	167	111	141	139	111	56	66	49	125	161	190	49

The low flow statistics for the summer period (1 April to 30 September inclusive) are: Summer Q_{95} = 197Ml/d; Summer Q_{99} = 140Ml/d.

Figure B2.5 shows the typical pattern of flows at Dolau Hirion from 1995 to 1996, and the flow duration curve is shown in **Figure B2.6**.

Figure B2.5 River Tywi at Dolau Hirion Flows (1995 – 1996)

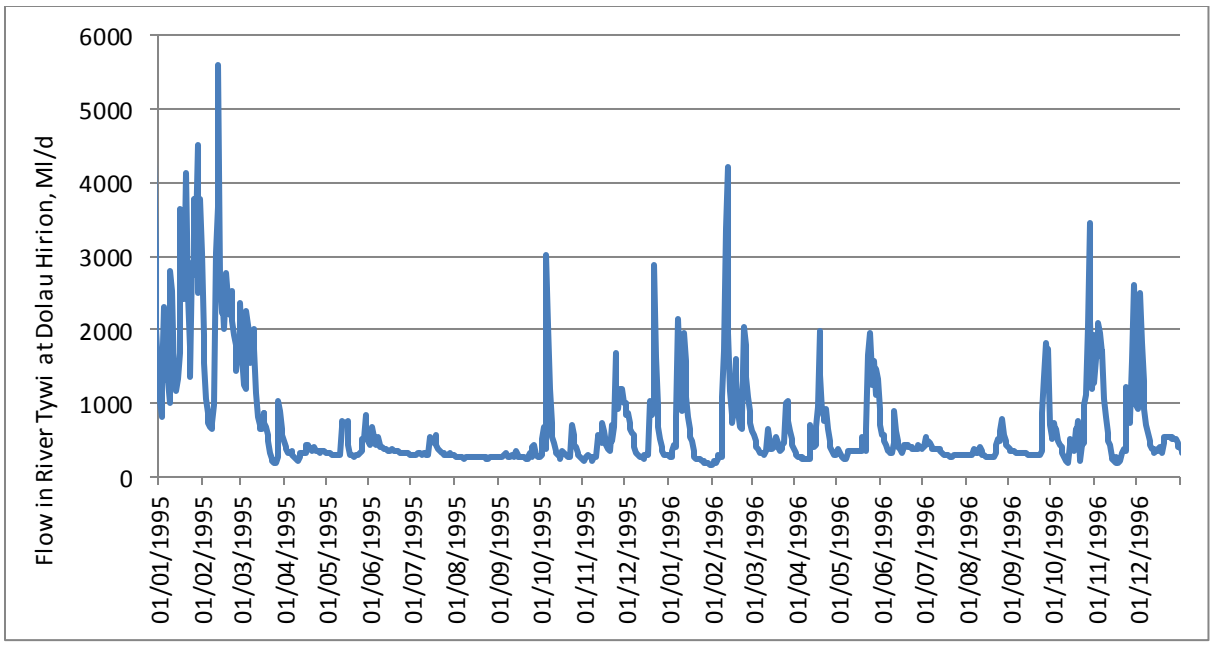
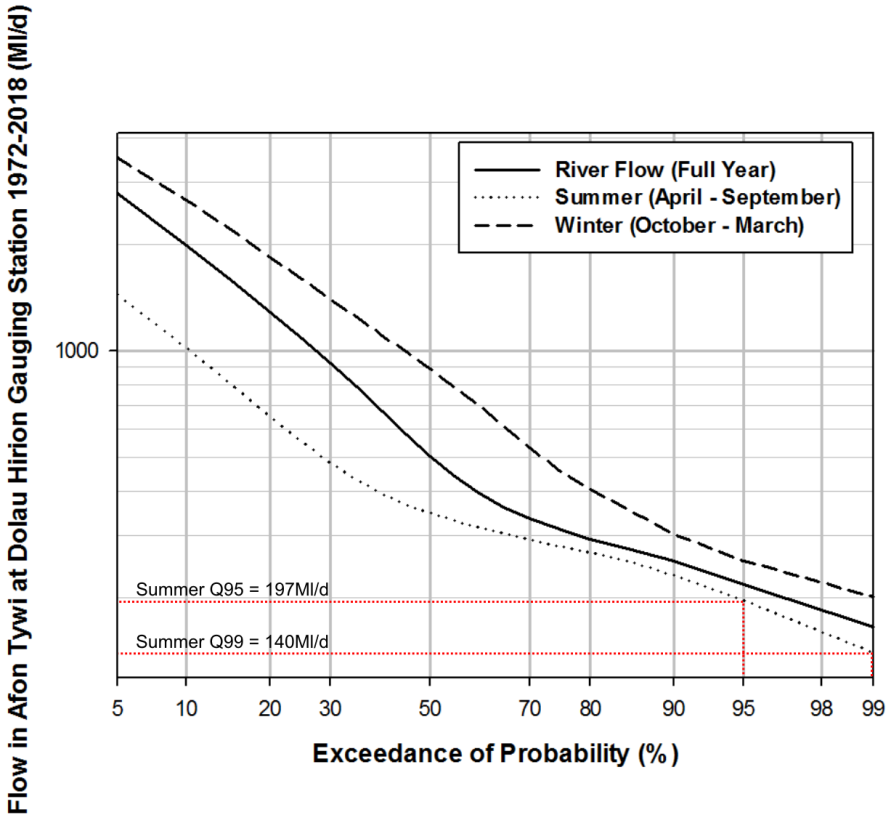


Figure B2.6 River Tywi at Dolau Hirion Flow Summary (1972 – 2018)



River Tywi at Capel Dewi

Flow is measured in the River Tywi at Capel Dewi (NGR: SN4850920576). A summary of the available daily flow data from 1972 to 2018 is given in **Table B2.3** below.

Table B2.3 Summary of Recorded Mean Daily Flow in River Tywi at Capel Dewi (1972 – 2018)

Percentage of time river flow equalled or exceeded	Mean daily flow Ml/d, per month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum flow	28823	32,486	44,824	16,932	14,550	18,420	24,883	23,155	24,413	41,792	30,231	56,799	56,799
10% (high flow)	12,908	9,583	7,469	5,645	3,871	3,081	3,030	3,894	5,149	8,839	11,704	13,565	8,325
50%	4,717	3,394	2,635	1,728	1,166	848	730	968	1,108	2,752	4,412	4,705	2,051
80%	2,428	1,698	1,363	881	634	470	372	433	514	1,119	2,259	2,228	785
90%	1,663	1,234	1,039	678	521	350	270	290	385	762	1,547	1,500	510
95% (low flow)	1,203	1,029	897	565	425	273	225	229	302	518	1,078	1,204	361
99% (extreme low flow)	622	709	714	452	292	191	119	167	210	351	622	877	213
Minimum flow	397	380	415	290	192	78	97	92	153	234	455	520	78

The low flow statistics for the summer period (1 April to 30 September inclusive) are: Summer Q_{95} = 277Ml/d; Summer Q_{99} = 182Ml/d.

Figure B2.7 shows the typical pattern of flows at Capel Dewi from 1995 to 1996, and the flow duration curve is shown in **Figure B2.8**.

Figure B2.7 River Tywi at Capel Dewi Flows (1995 – 1996)

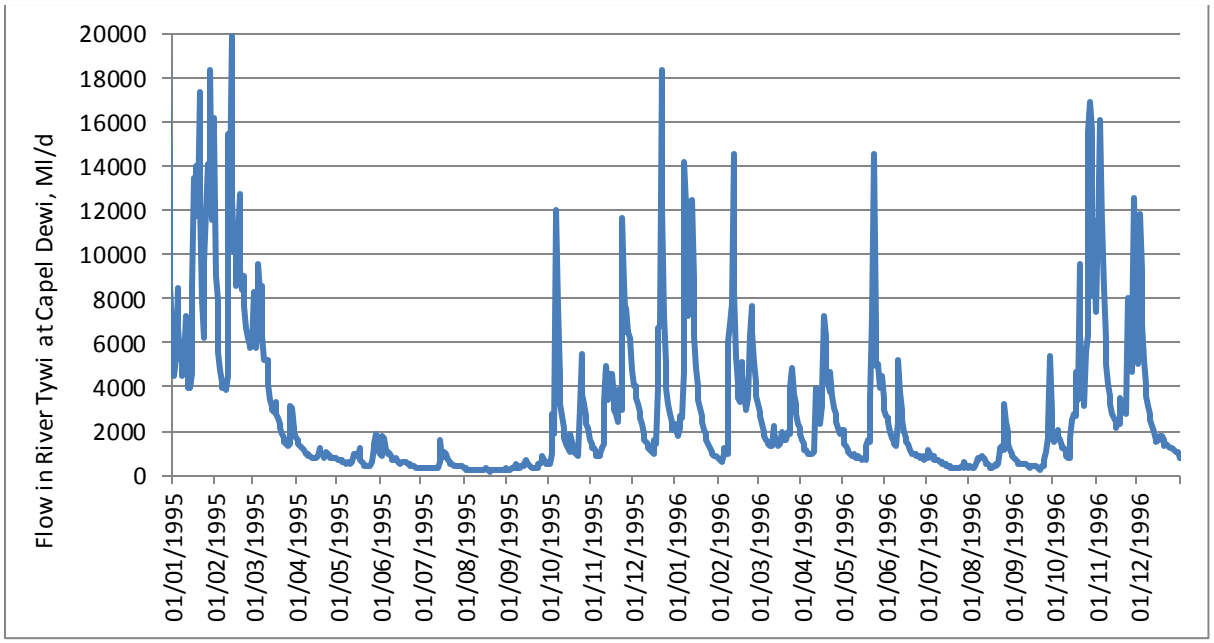
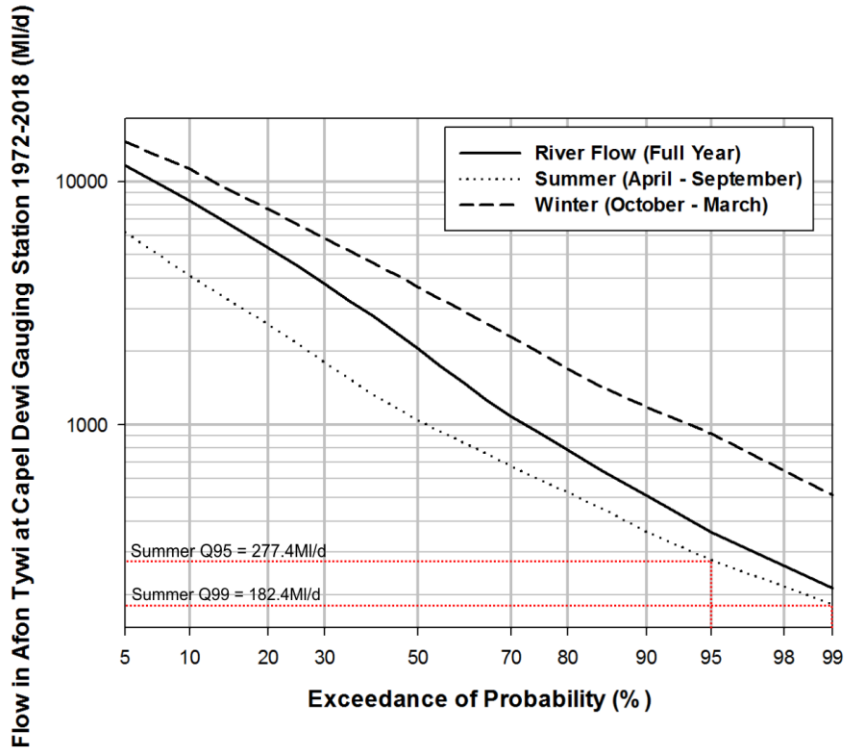


Figure B2.8 River Tywi at Capel Dewi Flow Summary (1972 – 2018)



Note that the flow data sets for the Dolau Hirion and Capel Dewi gauges both include periods

prior to 1972 when Llyn Brianne was constructed and prior to impoundment; however the summary data tables and graphs above only show the relevant period from 1972 onwards.

Daily abstractions from Nantgaredig intake, a short distance upstream of the Capel Dewi flow gauge, generally range from around 35Ml/d to 190Ml/d during the period 1990 to 2018. The maximum licensed daily abstraction is 227.3Ml/d. In practice when the pumps are running constantly the maximum daily abstraction is 200Ml/d, so the regulation release is generally set at 200Ml/d when gauged flow at Capel Dewi drops to the rate at which abstraction must be supported on a put-and-take basis.

Welsh Water also have a licence to abstract water from the Afon Tywi at Manorafon, located a short distance upstream of Llandeilo in the mid reaches of the Afon Tywi (Reach 2 in this assessment). This abstraction is only used in exceptional circumstances, such as in 2018 when Usk reservoir was drawn down to facilitate work on the spillway, and Manorafon was brought into service to support the reservoir.. Abstraction is at a rate of 17Ml/d and the regulation releases would be increased from 200Ml/d to 220Ml/d in order to ensure that this additional abstraction would be fully supported at low flows. The abstraction may be used more in the future for the purpose of facilitating additional regulation from Usk reservoir, to support third party abstractors by commercial agreement.

B.2.2 Hydrological Impact

B.2.2.1 Hydrological Zone of Influence

The study area includes Llyn Brianne Reservoir and the Afon Tywi and comprises four distinct hydrological reaches as shown in **Figure B1.1**:

- Reach 1 is the Afon Tywi from the Llyn Brianne Reservoir outflow to the confluence with Afon Bran, near Llandovery
- Reach 2 is the Afon Tywi from the Afon Bran confluence down to Llandeilo Bridge, at Llandeilo
- Reach 3 is the Afon Tywi from Llandeilo Bridge to the Welsh Water abstraction intake at Nantgaredig
- Reach 4 is the Afon Tywi from the Nantgaredig abstraction intake to the tidal limit.

The potential hydrological impacts of the drought order option have been assessed for these four river reaches, as summarised in **Table B2.4** at the end of this section. The details of the assessment for each reach are presented below.

B.2.2.2 Hydrological Impact Assessment

Llyn Brianne Reservoir

The impact on Llyn Brianne Reservoir would be a marginal increase in levels / storage, relative

to the position without the drought order, due to the reduced outflow which would help to conserve water in storage. The length of time of shoreline exposure would be slightly shorter, compared to the baseline drought scenario, as the reservoir would reach top water level slightly earlier during the winter refill period. This would be considered as a **negligible beneficial** impact and has not been assessed further.

The drought order will result in a reduction in the regulation flow released from Llyn Brianne Reservoir on occasions when the residual flow at Capel Dewi gauge would drop below the maintained flow value of 136Ml/d without additional releases from the reservoir (over and above the volume required to support Welsh Water's abstraction at Nantgaredig on a "put-and-take" basis).

It is not straightforward to quantify what proportion of the summer low and extreme low flow statistics at the Capel Dewi gauge is contributed by these additional reservoir releases during low flow periods, as the Llyn Brianne release data includes all outflows from the reservoir (including flow through the hydro-electric turbines). The flow regime of the entire Afon Tywi catchment is strongly influenced by the presence of the impounding reservoir, regulated downstream abstractions and hydro-electric scheme, so to produce a truly naturalised catchment flow series would require fairly detailed analysis.

However, recent data for 2018 indicates that there were significant low flow periods, particularly during late June to late July, when the residual flow downstream of the Nantgaredig abstraction was almost entirely dependent on additional regulation releases from Llyn Brianne. These flows are below the summer low and extreme low flow statistics of 277Ml/d and 182Ml/d respectively at the Capel Dewi gauge. It is therefore assumed that an additional regulation release of up to 136Ml/d (over and above the amount required to support abstraction on a "put and take" basis) may at times be required. Under the proposed drought order, the release could in theory be reduced by up to 20Ml/d on occasions, to support the lower instantaneous residual flow downstream of Nantgaredig of 116Ml/d. The 7-day rolling average flow requirement of 136Ml/d means that a flow reduction of 20Ml/d could not be implemented consistently for any length of time, however the increased flexibility of the maintained flow requirement would mean that a reduction of 20Ml/d is theoretically possible on any given day during a low flow event.

As a precautionary approach, therefore, we have assumed that the drought order could result in a flow reduction of up to 20Ml/d in the regulation releases made from Llyn Brianne, although this reduction is likely to occur on only a handful of occasions when flows in the Afon Tywi are at their absolute minimum during the period September to November inclusive.

Reach 1 – Afon Tywi from Llyn Brianne Reservoir outflow to the confluence with Afon Bran

No reduction in the summer low or extreme low flow values (Q_{95} and Q_{99}) is anticipated, as additional releases to support the maintained flow downstream of Nantgaredig intake are not required at these flow levels. However, at more extreme low flows below the Q_{99} value which may occur in severe drought conditions, a flow reduction of up to 20Ml/d in the regulation

release rate from Llyn Brianne may occur as a result of the drought order. Typically, the regulation release to support abstraction at Nantgaredig is 200 Ml/d so 336Ml/d (200 + 136) would be required when the residual flow downstream of Nantgaredig needs full support. The maximum flow reduction of 20Ml/d is potentially a 5.95% reduction in flows (regulation releases) immediately downstream of the reservoir. This would be assessed as a **negligible** hydrological impact.

Reach 2 – Afon Tywi from the Afon Bran confluence to Llandeilo Bridge

No reduction in the summer low or extreme low flow values (Q_{95} and Q_{99}) is anticipated, as additional releases to support the maintained flow downstream of Nantgaredig intake are not required at these flow levels. However, a flow reduction of up to 20Ml/d may occur at the most extreme low flow values, on occasions when regulation releases are reduced to support a revised instantaneous daily flow of 116Ml/d downstream of Nantgaredig rather than 136Ml/d.

Flows in Reach 2 in these extreme low flow conditions are dominated by the upstream regulation release volume, however there is some accretion as represented by the gauged flow record at Dolau Hirion. By subtracting the daily release volumes (available from 2006 – 2018) from the gauged values, it is possible to produce a semi-naturalised record for Dolau Hirion, albeit this does not cover some of the drier years prior to 2006. The extreme low flow statistic of this semi-naturalised record is 24Ml/d and when added to the regulation release to support abstraction and maintain the flow downstream flow at Nantgaredig, this typically gives a flow of around 360Ml/d.. The flow reduction in Reach 2, as a result of relaxing the maintained flow condition at Capel Dewi, could therefore on occasions be up to around 5.6%, which would be assessed as a **negligible** hydrological impact, although only occurring during the most extreme low flow periods on those occasions when abstraction is relatively low and the instantaneous daily maintained flow downstream of Nantgaredig is allowed to drop to 116Ml/d.

Reach 3 - Afon Tywi from Llandeilo Bridge to the Nantgaredig intake

No reduction in the summer low or extreme low flow values (Q_{95} and Q_{99}) is anticipated, as additional releases to support the maintained flow downstream of Nantgaredig intake are not required at these flow levels.

There are no measured flows on the Afon Tywi between the Dolau Hirion and Capel Dewi gauges. At Llandeilo Bridge, the catchment area is approximately 295% of that at the Dolau Hirion gauge, so by area-proportion the naturalised Q_{99} extreme low flow could be estimated as being around 71Ml/d at the most extreme low flows. Assuming that this is supplemented by an additional 336Ml/d to support downstream abstractions of up to 200Ml/d at Nantgaredig and the maintained flow of 136Ml/d downstream of the intake, a flow of 407Ml/d could represent a typical low value during a period of regulation releases. Therefore a flow reduction of 20Ml/d could potentially represent a percentage reduction of up to 4.9%. This would be assessed as a **negligible** hydrological impact, although it would only occur at the most

extreme low flows well below the Q_{99} value, when the instantaneous residual flow downstream of Nantgaredig is occasionally allowed to drop to 116Ml/d.

Reach 4 - Afon Tywi from the Nantgaredig intake to the tidal limit

The lower Afon Tywi in Reach 4 is a meandering watercourse with associated features. These include a wide floodplain, oxbow lakes and gravel shoals. The river itself is around 45m wide, with earth or clay vertical banks (about 2m high), or grassed shallower angle banks. Much of the river bed substrate is gravel-cobble sized coarse material with some alluvium and drift deposits present. Flow type in the river is characteristically between run/glide and riffle.

At flows of 136Ml/d or less, the lower Afon Tywi is considered to be under hydrodynamic and hydro-ecological stress. On those occasions when releases from Llyn Brianne reservoir are reduced by 20Ml/d, to support a reduced instantaneous daily maintained flow of 116Ml/d downstream of the Nantgaredig abstraction, this reduction represents a 14.7% reduction in flow which would be assessed as a **minor** hydrological impact, albeit only occurring on occasional days and for less than a week at a time (due to the 136Ml/d rolling average maintained flow requirement). No reduction to the summer low and extreme low flow statistics of Q_{95} and Q_{99} are anticipated, as both these values are above the figure of 136Ml/d below which additional reservoir releases are required (as measured at the Capel Dewi gauge).

At the tidal limit, located 5.7km downstream of the Nantgaredig intake, the catchment area has increased by around 2% relative to the Capel Dewi gauging station and therefore some further flow accretion may be anticipated. However, at the minimum flows (below the Q_{99} flow statistic) at which the impacts of this drought order are experienced, such flow accretion would be marginal. Based on the minimum gauged flows at Capel Dewi, such additional flow accretion would be estimated to be no more than around 2Ml/d. The occasional flow reductions of 20Ml/d due to the lowering of the instantaneous daily maintained flow downstream of Nantgaredig would be equivalent to a 14.5% flow reduction at the tidal limit and therefore the hydrological impact of the drought order at the tidal limit and below would be assessed as **minor**.

Below the tidal limit, two further tributaries contribute freshwater flow to the tidal reach of the Afon Tywi upstream of the boundary of the Carmarthen Bay and Estuaries SAC. The first is the Afon Gwili, with its tidal limit just upstream of the confluence with Afon Tywi (grid reference SN43302150) and a catchment area of 148.06km^2. The second is the Tawelan Brook, with its tidal limit at the confluence with the Afon Tywi (grid reference SN40451945) and a catchment area of 19.13km^2. There are no gauged flows available for these tributaries, however by apportionment using relative catchment areas the flow contribution can be estimated from the gauged flow values at Capel Dewi gauging station. At minimum flows, there is therefore an estimated further 14.1Ml/d of freshwater flow into the Afon Tywi upstream of the SAC boundary. The occasional 20Ml/d flow reduction due to the drought order would therefore represent a 13.3% reduction in flows in this reach, so the hydrological impact would be assessed as **minor**.

Just downstream of the SAC boundary there is a further tributary, Nant Pibwr, with a catchment area of 20.93km^2 at its tidal limit and confluence with the Afon Tywi (grid reference SN40501755). Again there are no gauged flows available, but by apportionment using relative catchment areas with the Capel Dewi flow values the freshwater flow contribution at minimum flows can be estimated to be approximately 1.8Ml/d. In total the minimum freshwater flow into the tidal reach of the Afon Tywi to just below the Nant Pibwr confluence is estimated as 15.9Ml/d. The 20Ml/d flow reduction under the drought order would therefore represent a 13.2% reduction which is assessed as a **minor** hydrological impact.

Estimated impacts on hydraulic parameters

Due to the geomorphological characteristics of the river in this reach, hydrological impacts associated with a reduction in river flows will include a modest reduction in wetted depth and flow velocities, below those observed in the Afon Tywi without the drought order, and a reduction in wetted depth around the numerous unvegetated side bars and mid-channel bars.

Information is available on hydraulic parameters for four representative cross-sections in the vicinity of the Nantgaredig intake. These cross-sections (referenced as 01.015, 01.010, 01.007 and 01.003) were surveyed on behalf of Environment Agency Wales and reported on in the Afon Tywi Habitats Directive Review of Consents Appropriate Assessment Investigative Project (consultation draft dated January 2007). One of the cross-sections, 01.015, is located 85m upstream of the abstraction and therefore represents the lower end of Reach 3, whilst the other three are located 90m, 180m and 300m respectively downstream of the abstraction and are therefore representative of the top end of Reach 4. Data on hydraulic parameters at different flow values in each cross-section was derived from topographic surveys and hydraulic modelling using HEC-RAS software.

For each cross-section, values of velocity, wetted perimeter and maximum water depth corresponding to selected low flow values are provided, from which the relative reduction per unit flow value (m^3/s) can be estimated. This data has been used to estimate velocity, wetted perimeter and maximum water depth by linear extrapolation for the baseline and "with drought option" lowest instantaneous residual flow values (136Ml/d and 116Ml/d or 1.57m^3/s and 1.34m^3/s respectively), in order to estimate the percentage change in these parameters.

The results of this analysis, presented in **Tables B2.4, B2.5** and **B2.6** below, should be treated with a degree of caution due to the linear extrapolation method used to estimate parameter values corresponding to the modelled flow values in this assessment. However, the analysis gives an indication that water velocities, maximum water depths and wetted perimeters downstream of the abstraction may reduce by up to 9.2%, 4.6% and 2.5% respectively, as a result of implementing the drought option.

Table B2.4 Impact of drought option on estimated flow velocities of the Afon Tywi at Nantgaredig

Parameter	Gauged Flow (m^3/s)	Velocity (m/s) in each cross-section			
		Section 01.015	Section 01.010	Section 01.007	Section 01.003
Velocity at flow of 3.10m^3/s	3.1	0.1	0.09	0.12	0.39
Velocity at flow of 1.75m^3/s	1.75	0.08	0.06	0.08	0.32
Change in velocity per m^3/s	1.35	0.01481	0.02222	0.02963	0.05185
Estimated velocity at flow of 1.57m^3/s	1.57	0.07739	0.05609	0.07479	0.31088
Estimated velocity at flow of 1.34m^3/s	1.34	0.07396	0.05095	0.06793	0.29888
Change in velocity due to flow reduction (m/s)	-	-0.00343	-0.00514	-0.00686	-0.01200
Change in velocity due to flow reduction (cm/s)	**-**	**-0.34**	**-0.51**	**-0.69**	**-1.20**
Percentage change in velocity due to flow reduction	**-**	**-4.4%**	**-9.2%**	**-9.2%**	**-3.9%**

Table B2.5 Impact of drought option on estimated maximum water depths of the Afon Tywi at Nantgaredig

Parameter	Gauged Flow (m^3/s)	Maximum water depth (m) in each cross-section			
		Section 01.015	Section 01.010	Section 01.007	Section 01.003
Maximum water depth at flow of 3.10m^3/s	3.1	1.98	1.23	1.13	0.39
Maximum water depth at flow of 1.75m^3/s	1.75	1.89	1.13	1.04	0.31
Change in maximum water depth per m^3/s	1.35	0.06667	0.07407	0.06667	0.05926
Estimated maximum water depth at flow of 1.57m^3/s	1.57	1.87827	1.11697	1.02827	0.29957
Estimated maximum water depth at flow of 1.34m^3/s	1.34	1.86284	1.09982	1.01284	0.28586
Change in maximum water depth due to flow reduction (m)	-	-0.01543	-0.01715	-0.01543	-0.01372
Change in maximum water depth due to flow reduction (cm)	**-**	**-1.54**	**-1.71**	**-1.54**	**-1.37**
Percentage change in max. water depth due to flow reduction	**-**	**-0.8%**	**-1.5%**	**-1.5%**	**-4.6%**

Table B2.6 Impact of drought option on estimated wetted perimeters of the Afon Tywi at Nantgaredig

Parameter	Gauged Flow (m^3/s)	Maximum wetted perimeter (m) in each cross-section			
		Section 01.015	Section 01.010	Section 01.007	Section 01.003
Wetted perimeter at flow of 3.10m^3/s	3.1	41.2	43.1	46.2	33.4
Wetted perimeter at flow of 1.75m^3/s	1.75	40.8	42.4	41.1	29.2
Change in wetted perimeter per m^3/s	1.35	0.29630	0.51852	3.77778	3.11111
Estimated wetted perimeter at flow of 1.57m^3/s	1.57	40.74787	42.30878	40.43539	28.65267
Estimated wetted perimeter at flow of 1.34m^3/s	1.34	40.67929	42.18875	39.56091	27.93251
Change in wetted perimeter due to flow reduction (m)	-	-0.06859	-0.12003	-0.87449	-0.72016
Change in wetted perimeter due to flow reduction (cm)	**-**	**-6.86**	**-12.00**	**-87.45**	**-72.02**
Percentage change in wetted perimeter due to flow reduction	**-**	**-0.2%**	**-0.3%**	**-2.2%**	**-2.5%**

For the Habitats Directive Review of Consents work assessing the impact of the Nantgaredig abstraction on shad spawning in the Afon Tywi downstream of the point of abstraction, extensive bathymetric surveying and hydraulic modelling was undertaken. Data and results from that project will be incorporated into a future review of this EAR.

Habitats Directive Ecological River Flow

Generic flow indicators can also be considered and these include the Habitats Directive Ecological River Flow (HDERF) which is defined in the Afon Tywi Habitats Directive Review of Consents Appropriate Assessment Investigative Project (consultation draft dated January 2007) as follows.

At Dolau Hirion gauging station:

- At flows above Q_{50} the maximum reduction in natural flows is 10%
- Up to 10% reduction in natural flows between Q_{50} and Q_{95}
- Up to 3% reduction in natural flows below Q_{95}.

At Capel Dewi gauging station:

- At flows above Q_{50} the maximum reduction in natural flows is 15%
- Up to 10% reduction in natural flows between Q_{50} and Q_{95}
- Up to 7% reduction in natural flows below Q_{95}.

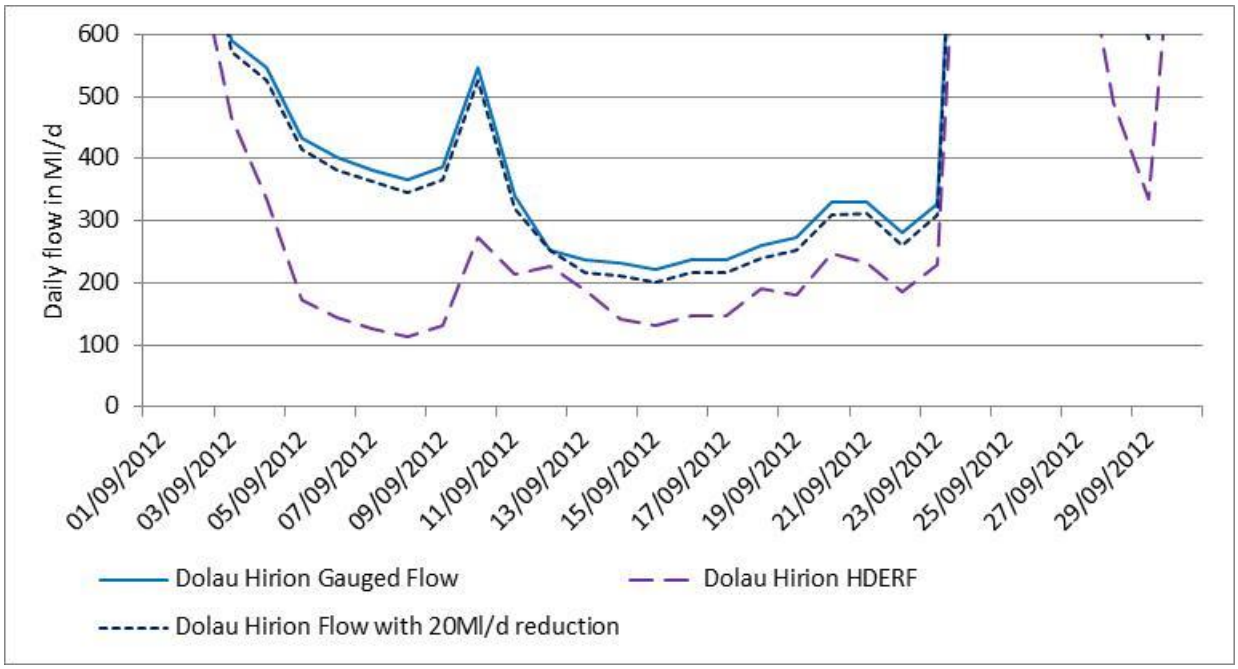
The gauged flow record of the Afon Tywi at Dolau Hirion, semi-naturalised by subtracting daily reservoir releases from Llyn Brianne, was used to determine a HDERF flow series for the river reach downstream of Dolau Hirion for the period 2006 - 2018. Daily HDERF flow values were calculated using the year-round Q_{50} and Q_{95} flow statistics to determine the maximum percentage reductions in natural daily flows as specified above. Similarly, the gauged flow record of the Afon Tywi at Capel Dewi was semi-naturalised by subtracting the daily reservoir releases and adding the daily abstractions at Nantgaredig, also for the period 2006 – 2018, and the daily HDERF flow values calculated according to the above definition. Insufficient data was available to calculate semi-naturalised flow values prior to 2006.

It should be noted that there are issues with the flow naturalisation process during periods of exceptionally low flows, as the semi-naturalised flow record at Capel Dewi contains a number of negative flow values during the exceptionally dry period of July 2018. The naturalisation process has not taken account of minor artificial influences other than the key reservoir releases and Welsh Water abstractions, but also the negative flow values indicate that the flow at Capel Dewi is strongly reliant on the reservoir regulation regime during periods of extreme low flow (and it is possible that in exceptionally dry conditions, some loss of reservoir releases may occur along the 70km stretch of the Afon Tywi from the reservoir outflow to the Capel Dewi gauge).

It is difficult to demonstrate the impact of the drought order using the historical data series, as the period of semi-naturalised data (2006 – 2018) does not include periods of exceptionally low flows during September to November when this drought order is likely to be implemented. However, **Figure B2.9** shows the potential change in flow at Dolau Hirion due to a flow reduction of 20Ml/d during a period of relatively low flows in September 2012. Note that the vertical scale is limited to 600Ml/d in order to highlight the changes in the low flow regime, so higher flows above 600Ml/d are not shown. The HDERF flow series for the Afon Tywi at Dolau Hirion, derived as outlined above, is also shown on the hydrograph.

The graph in **Figure B2.9** indicates that the gauged flow, with or without a daily reduction of 20Ml/d, is generally well above the HDERF due to the influence of the reservoir regulation releases. At Dolau Hirion, during periods of low flow further down the catchment, the daily regulation releases make up a high proportion of gauged flow and therefore occasional reductions in flow of 20Ml/d will not reduce the mean daily flow below the HDERF.

Figure B2.9 Mean Daily Flow in the Afon Tywi at Dolau Hirion Gauging Station, Baseline and with 20Ml/d daily flow reduction (September 2012)

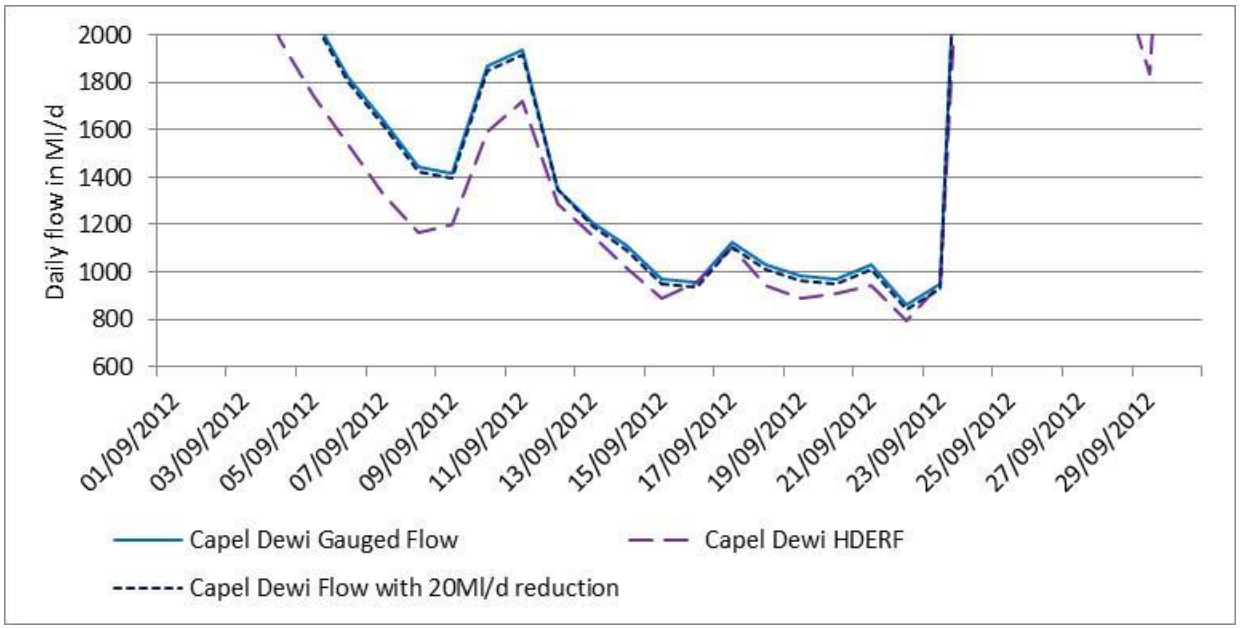


Similarly at Capel Dewi gauge, there are few occasions during 2006 – 2018 when gauged flow drops to the level at which the residual flow must be fully supported by additional releases from Llyn Brianne, and these generally do not occur during the period from September to November when this drought order is likely to be implemented. As an illustration of the potential impact of the drought order, relative to the HDERF flow series, **Figure B2.10** shows the potential change in flow at Capel Dewi due to a flow reduction of 20Ml/d during September 2012. Note that the vertical scale is limited to 600Ml/d - 2000Ml/d in order to highlight the changes in the low flow regime.

The graph in **Figure B2.10** indicates that, in general, mean daily gauged flows at Capel Dewi are above the HDERF, with or without a flow reduction of 20Ml/d. Inspection of the data reveals that during September 2012 there were 3 days when the gauged flow did in fact drop below the HDERF. However the number of days below the HDERF is not increased by the 20Ml/d flow reduction.

At the extreme low flows at which the residual flow at Capel Dewi would need full support from additional reservoir releases from Llyn Brianne, the semi-naturalised flow calculated by adding abstractions and subtracting reservoir releases is likely to be a very low proportion of the residual flow (values of close to, or even below, zero were calculated for July 2018). The daily HDERF flow values are therefore likely to be extremely low during this scenario. An occasional reduction of 20Ml/d is a 14.7% reduction in the residual flow and this is unlikely to cause the flow to drop below the HDERF.

Figure B2.10 Mean Daily Flow in the Afon Tywi at Capel Dewi Gauging Station, Baseline and with 20Ml/d daily flow reduction (September 2012)



Due to the limited period of available data used to assess flows against the HDERF definition, and the difficulties of producing naturalised flow records in a catchment which is highly influenced by the operation of the Llyn Brianne regulating scheme, the above analysis of the impacts of the drought order on the HDERF should be treated with caution.

Further detailed modelling of drought scenarios would be recommended to investigate the impact of this drought order on the daily low flow regime, particularly downstream of the Nantgaredig abstraction intake.

B.2.2.3 Hydrological Impact Summary

Four river reaches have been considered for which the hydrological impact ranges from **negligible to minor**, although the impact only occurs at the most extreme low flows well below the Q_{99} flow value and only on occasional days, as the 7-day rolling average maintained flow of 136Ml/d means that the 20Ml/d reduction in regulation releases could only be maintained for a few days at a time and would need to be balanced by increased releases on subsequent/preceding days. The impacted reaches are shown in **Table B2.7** and establish the full in-channel zone of influence of the drought order for environmental sensitivity screening (see **Figure B1.1**).

Table B2.7 Hydrological and Monitoring Reaches identified in the Study Area

Hydrological Reach		Reach boundary		Reach length	% flow reduction			Hydrological Impact
		Upstream	Downstream		Summer Q_{95}	Summer Q_{99}	"Minimum" flows#	
Llyn Brianne Reservoir		N/A	N/A	N/A	N/A	N/A	N/A	**Negligible beneficial**
1	Afon Tywi	Llyn Brianne Reservoir outflow	Afon Bran confluence	22.7km	0%	0%	**5.9%**	**Negligible (at minimum flows)**
2	Afon Tywi	Afon Bran confluence	Llandeilo Bridge	23.2km	0%	0%	**5.6%**	**Negligible (at minimum flows)**
3	Afon Tywi	Llandeilo Bridge	Nantgaredig intake	24.3km	0%	0%	**4.9%**	**Negligible (at minimum flows)**
4	Afon Tywi	Nantgaredig intake	Tidal limit	5.7km	0%	0%	**14.7%**	**Minor (at minimum flows)**

Extreme low flows based on low flows experienced in summer 2018, and assuming supported abstraction of up to 200Ml/d

B3 PHYSICAL ENVIRONMENT ASSESSMENT

B.3.1 Geomorphology

Geomorphological baseline data is available for 66 RHS surveys within the reaches, the survey data has been summarised below and supplemented by extant aerial imagery, where necessary.

Reach 1 - Afon Tywi from Llyn Brianne Reservoir outflow to the confluence with Afon Bran

Within Reach 1 there are 20 RHS surveys (Survey IDs: 15505, 21299, 15506, 21281, 15507, 3883, 15508, 15509, 6883, 15510, 21283, 21284, 21285, 15512, 21286, 15513, 15514, 928, 24153, 15515). The upper section of Reach 1 is characterised by a narrow valley with a limited floodplain, the river meanders through bedrock spurs in this section, towards the middle section of the reach the valley widens and the floodplain area increases.

Banks are predominantly steep within of Reach 1 (>45°), however are notably shallower at RHS site 3883, 6883, 21286 and 24153. Banks composition is varied, at the upper RHS site 15505, bedrock dominates, however there are also areas of concrete. At this location, the channel is modified and has been reinforced, due to the close location to the reservoir outfall, this is reflected in the HMS (Habitat Modification Score) score of 560 and class of 4 (significantly modified). Downstream in Reach 1, banks are composed of earth and boulder, however there are minor areas of cobble, clay and brick. Flow variation is seen within the reach, rippled flow dominated, however there are areas of chute and smooth flow, upwelling and broken standing waves. At Survey ID 928, almost laminar flow dominated. Bed substrate was dominated by coarse substrate of boulders and cobbles, however areas of pebble and gravel were also observed. There are also areas of bedrock on the bed on the river. Several in-channel depositional features were observed within the reach including 19 unvegetated point bars, one vegetated point bar, one unvegetated mid-bar and one vegetated mid-bar.

The reach is largely pristine/semi-natural, apart from the outfall of the reservoir and at Survey ID 6883 and 21286, the HMS indicates a predominantly unmodified channel. Poaching was observed at Survey ID 21286. However, the lower part of the reach becomes increasingly modified. One RHS site recorded an obviously modified reach (HMS 200, Survey ID 15514) and one RHS site recorded a significantly modified reach (HMS 928, Survey ID 928). Poaching was observed using extant aerial imagery.

Reach 2 – Afon Tywi from the Afon Bran confluence to Llandeilo Bridge

Within Reach 2, there are 18 RHS Surveys (Survey IDs 15517; 24160; 15518; 24154; 24158; 6973; 15520; 21287; 15521; 21288; 15522; 21289; 15523; 21290; 973; 15524; 15525; 20665). The reach is surrounding by a wide valley with a large floodplain, in Reach 2, the river continues to meander.

Banks are predominantly steep within of Reach 2 (>45°), however are notably shallower at

Survey ID 24160. Banks composition is varied, however many of the banks in Reach 2 are dominated by clay, earth and gravel/sand. There are minor areas of cobble and gabions. Flow variation is seen within the reach, rippled and smooth flow dominated, however there are areas of broken waves and upwelling. At Survey ID 973, almost laminar flow dominated. Bed substrate was dominated by coarse substrate of gravel/pebble and pebble, however there are minor components of cobble and sand. Several in-channel depositional features were observed within the reach, including 33 unvegetated point bars, 28 vegetated point bar, 9 unvegetated mid-bar and 11 vegetated mid-bar. Many of the point bars have been dissected, with chute sections common.

The reach is largely predominantly unmodified, however is obviously modified in some sections. Notably Survey IDs 15523 and 21290 were significantly modified. Poaching was observed using extant aerial imagery.

Reach 3 - Afon Tywi from Llandeilo Bridge to the Nantgaredig intake

Within Reach 2, there are 28 RHS Surveys (Survey IDs 15526; 21497; 20694; 15527; 20664; 20699; 15528; 15529; 20700; 20663; 15530; 20698; 15531; 15532; 20696; 20695; 15533; 20661; 15534; 20690; 15535; 20660; 21496; 20691; 20659; 15536; 20658 and; 15537)

Banks are predominantly steep within of Reach 2 (>45°), however are notably shallower at Survey IDs 20661; 20698; 21497; and 21496. Banks composition is varied, however many of the banks in Reach 2 are dominated by clay, earth and gravel/sand. There are minor areas of cobble and gabions. There are isolated sections of riprap (Survey ID 15527). Flow variation is seen within the reach, rippled and smooth flow dominated, however there are areas of broken waves and upwelling. Bed substrate was dominated by coarse substrate of gravel/pebble and pebble, however there are minor components of cobble and sand. At Survey ID 20696, clay dominated. Several in-channel depositional features were observed within the reach including 13 unvegetated point bars, 23 vegetated point bar, 5 unvegetated mid-bar and 7 vegetated mid-bar. Many of the point bars have been dissected, with chute sections common.

The reach is largely predominantly unmodified, however is obviously modified in some sections. Notably RHS Survey IDs 20696 and 21497 were significantly modified. Poaching was observed using extant aerial imagery.

Reach 4 - Afon Tywi from the Nantgaredig intake to the tidal limit

Geomorphology data are available for eight NRW River Habitat Survey (RHS) sites (3971, 15538, 15539, 20655 to 20657, 21494, 21495) in Reach 4.

Review of this NRW RHS data indicates that this stretch of the Afon Tywi is typified by a series of irregular meanders. This is reflected by channel widths primarily ranging from 20 to 40 m and a channel substrate that is predominantly cobble, gravel or pebble. The river is characterised by occasional deepening of river banks caused by sediment slumping into the channel. This is evident at Survey ID 3971, where the river bank has eroded on the left hand

side and a large point bar has formed on the right hand side (which is vegetated). The altitude throughout the reach is 10 m, with isolated tree coverage and characterised by uniform Caradoc geology. The river channel is slightly modified in some places by bridges (Survey IDs 21495 and 20656) and by poaching (Survey IDs 21655 and 20657).

Assessment

Due to the hydrological impacts within the reaches, some variation to geomorphological function is expected. Reach 1 is adapted to high calibre sediment. Due to this, and the upland nature of the reach, the risk of fine grained deposition due to the operation of the drought option is assessed as minor as the high gradients will provide enough energy to allow the transport of fine grained sediment. Any fine grained sediment that is deposited, for example in ponded sections of the reach, will be removed when normal flows return. Reach 4 is also adapted to higher calibre material. For reaches 1 and 4, the impact is assessed as **negligible**.

However, Reaches 2 and 3 have large proportions of finer grained material (clay, sand); there could be a potential increase in fine grained deposition, however fine grained material such as clay requires little energy to remain in transport. Nonetheless, Reaches 2 and 3 contain numerous examples of in-channel deposition; during the normal regime, it appears that the river is above capacity (i.e., carrying too much sediment for the available energy within the river). However given the negligible hydrological impacts in Reaches 2 and 4 risk of increased fine grained sedimentation is assessed as **negligible**.

The impact on wetted width and associated habitat availability will be focused on the shallow sections of the reaches. However, overall, banks are steep and managed in some locations, and therefore the variation in wetted width will be limited and the impact is assessed as **negligible** for Reaches 1 to 4.

B.3.2 Water Quality

This section sets out the baseline water quality and examines changes over time and with respect to river flows. Environmental pressures on river water quality (such as discharges from STWs), which may cause increased deterioration in water quality with the drought order in place, are discussed separately in Section B.3.3.

To support the assessment of potentially sensitive environmental features (see Section 5 of the main report), an understanding has been developed of the water quality of the rivers within the zone of influence of the drought order, including trends over time and with respect to river flow. For WFD classification, the Environment Agency has set out following United Kingdom Technical Advisory Group (UKTAG) evidence what pressures, including water quality pressures, each biological quality element is capable of responding to. For the purposes of assessment here, the supporting water quality parameters are set out: for fish and macroinvertebrates (where identified as sensitive features) as dissolved oxygen saturation and total ammonia concentration; and for macrophytes and algae (phytobenthos / diatoms) (where identified as sensitive features) as soluble reactive phosphorus (SRP). Specifically, for

macrophytes, if the hydrological impacts of drought order implementation have been identified within the main macrophyte growing season (April to September), an assessment of SRP has been undertaken.

Potential impacts on other water quality parameters, such as temperature, have been considered where appropriate (e.g. temperature influences dissolved oxygen and if sufficient information is available on dissolved oxygen and is being reviewed it may not be necessary to undertake a separate temperature assessment). Where data are lacking, the assessment has been undertaken using professional judgement.

NRW routine monitoring data were reviewed to provide an overview of water quality in the zone of impact. In the Afon Tywi catchment, within the extent of influence of the Nantgaredig drought order there are four NRW water quality sampling sites, as detailed in Table (B3.1 and Figure B1.1).

Where data is lacking the assessment has been undertaken using professional judgement. Values at the limit of detection were halved in line with standard NRW practice.

Table B3.1 Details of NRW Water Quality Sampling Points on the Afon Tywi

Reach	Site Name	EA Site Code	Grid reference
1	IRON BRIDGE AT RHANDIRMWYN, LLANDOVERY, DYFED	31610	SN7677044710
1	RIVER TOWY FISH TRAP AT LLYN BRIANNE	31669	SN7857147201
1	TOWY BRIDGE EAST OF CILYCWM	88217	SN7654239917
4	RIVER TOWY AT NANTGAREDIG INTAKE	34532	SN4875520464

These reaches fall within the Tywi SAC and as such have been be compared against the specific conservation objectives. The specific water quality objectives for this SAC are given in **Table B3.2**.

Table B3.2 – Tywi SAC specific water quality objectives

Dissolved Oxygen	Biological Oxygen demand	Total ammonia	Unionised ammonia	pH	Hardness	Dissolved copper	Total Zinc
80	2.5	0.25	0.021	6-9	<10 >10 and <50 >50 and <100 >100	5 22 40 112	30 200 300 500

Reach 1 – Afon Tywi from Llyn Brianne Reservoir outflow to the confluence with Afon Bran

Water quality analysis for this reach (affected by a major hydrological impact) has been undertaken based on the data available at the water quality monitoring sites listed in **Table B3.1**.

pH and Temperature

Average pH and maximum temperature for the three sites are summarised in **Table B3.2** below.

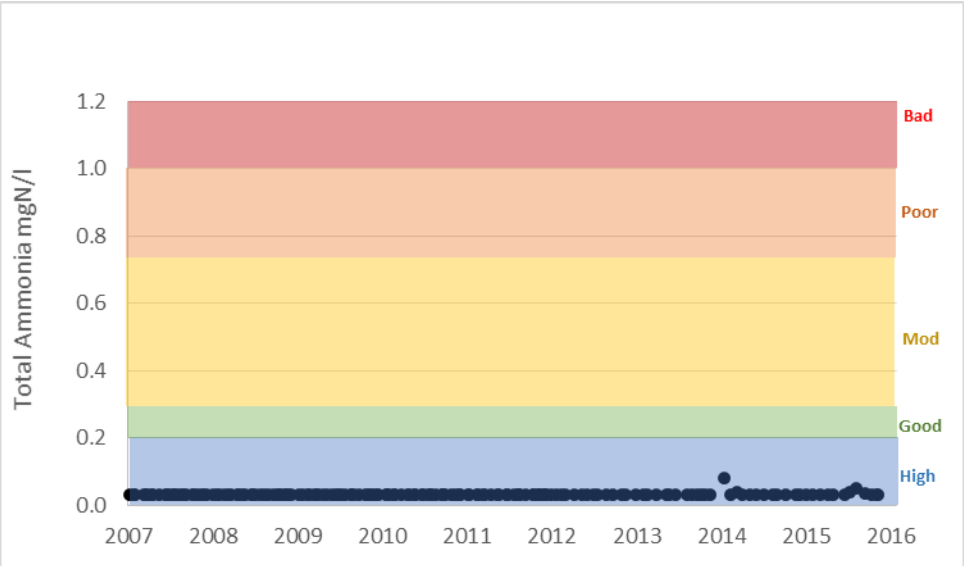
Table B3.2 pH and Maximum Temperate at NRW Water Quality Sampling Points in Reach 1 on the Afon Tywi

Site name	Average pH	Maximum temperature
IRON BRIDGE AT RHANDIRMWYN, LLANDOVERY, DYFED	6.6	14.3
RIVER TOWY FISH TRAP AT LLYN BRIANNE	6.5	14.5
TOWY BRIDGE EAST OF CILYCWM	7	14.5

Total Ammonia Concentrations

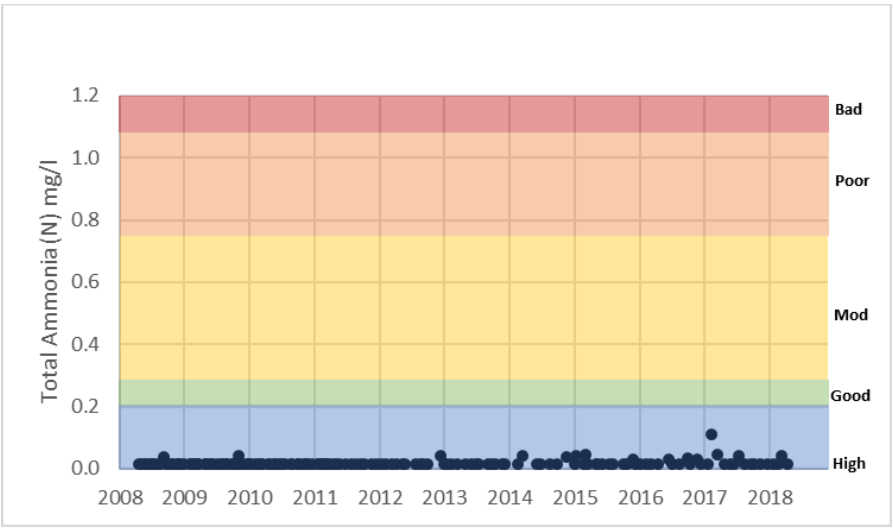
Total ammonia concentration data from Afon Tywi at Iron Bridge at Rhandirmwyn were reviewed and presented in **Figure B3.1** against the relevant WFD standards for an upland low alkalinity river. Total ammonia concentration measurements at Afon Tywi at Iron Bridge at Rhandirmwyn were compliant with the WFD standard to support high status (0.2 mg/l) for fish and invertebrates for an upland low alkalinity river. There is no association between flow and dissolved oxygen concentrations.

Figure B3.1 Total Ammonia Concentrations at Afon Tywi at Iron Bridge at Rhandirmwyn, Incorporating Appropriate WFD Status Bands



Total ammonia concentration data from Afon Tywi Fish Trap at Llyn Brianne were reviewed and presented in **Figure B3.2** against the relevant WFD standards for an upland low alkalinity river. Total ammonia concentration measurements at Afon Tywi Fish Trap at Llyn Brianne were compliant with the WFD standard to support high status (0.2 mg/l) for fish and invertebrates for an upland low alkalinity river. There is no association between flow and total ammonia concentrations.

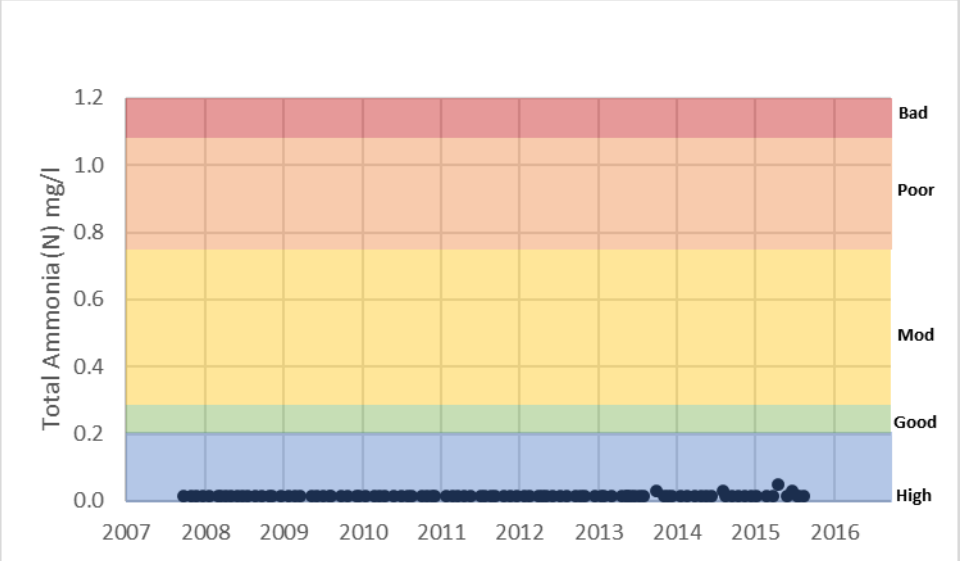
Figure B3.2 Total Ammonia Concentrations at Afon Tywi Fish Trap at Llyn Brianne, Incorporating Appropriate WFD Status Bands



Total ammonia concentration data from Afon Tywi at Towy Bridge East of Cilycwm were reviewed and presented in **Figure B3.3** against the relevant WFD standards for an upland low alkalinity river. Total ammonia concentration measurements at Afon Tywi at Towy Bridge

East of Cilycwm were compliant with the WFD standard to support high status (0.2 mg/l) for fish and invertebrates for an upland low alkalinity river. There is no association between flow and total ammonia concentrations.

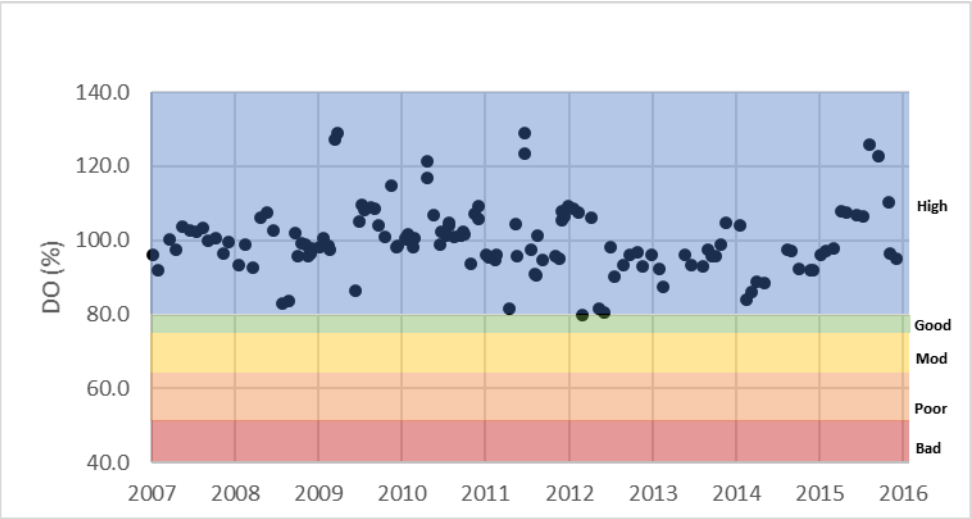
Figure B3.3 Total Ammonia Concentrations at Afon Tywi at Towy Bridge East of Cilycwm, Incorporating Appropriate WFD Status Bands



Dissolved Oxygen Saturation

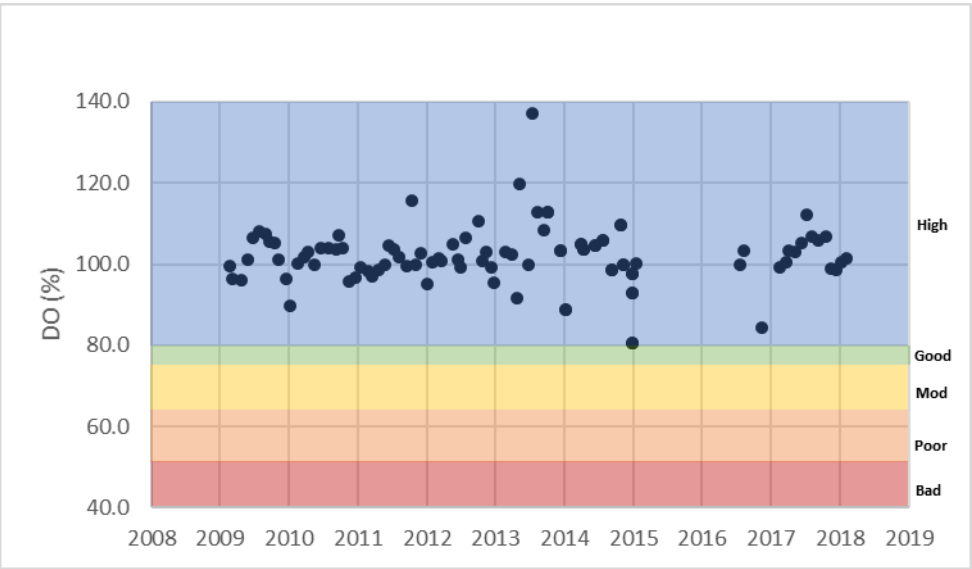
Dissolved oxygen saturation data from Afon Tywi at Iron Bridge at Rhandirmwyn were reviewed and presented in **Figure B3.4** against the relevant WFD standards for an upland low alkalinity river. Dissolved oxygen saturation measurements at Afon Tywi at Iron Bridge at Rhandirmwyn were compliant with the WFD standard to support high status (80% saturation) for fish and invertebrates for an upland low alkalinity river. There is no association between flow and dissolved oxygen concentrations.

Figure B3.4 Dissolved Oxygen Saturation at Afon Tywi at Iron Bridge at Rhandirmwyn, Incorporating Appropriate WFD Status Bands



Dissolved oxygen saturation data from Afon Tywi at Fish Trap At Llyn Brianne were reviewed and presented in **Figure B3.5** against the relevant WFD standards for an upland low alkalinity river. Dissolved oxygen saturation measurements at Afon Tywi Fish Trap at Llyn Brianne were compliant with the WFD standard to support high status (80% saturation) for fish and invertebrates for an upland low alkalinity river. There is no association between flow and dissolved oxygen concentrations.

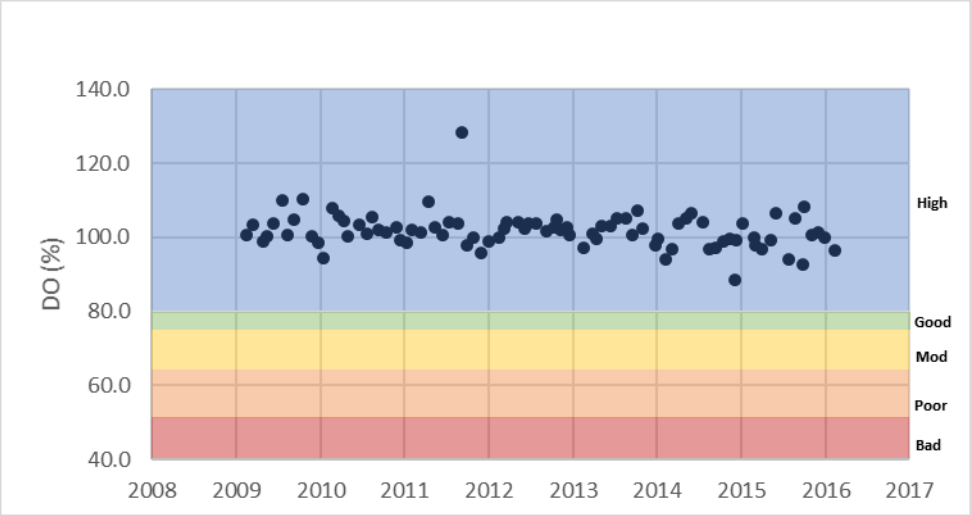
Figure B3.5 Dissolved Oxygen Saturation at Afon Tywi Fish Trap at Llyn Brianne, Incorporating Appropriate WFD Status Bands



Dissolved oxygen saturation data from Afon Tywi at Towy Bridge East of Cilycwm were reviewed and presented in **Figure B3.6** against the relevant WFD standards for an upland low alkalinity river. Dissolved oxygen saturation measurements at Afon Tywi at Towy Bridge

East of Cilycwm were compliant with the WFD standard to support good/high status (75-80% saturation) for fish and invertebrates for an upland low alkalinity river. There is no association between flow and dissolved oxygen concentrations.

Figure B3.6 Dissolved Oxygen Saturation at Afon Tywi at Towy Bridge East of Cilycwm, Incorporating Appropriate WFD Status Bands



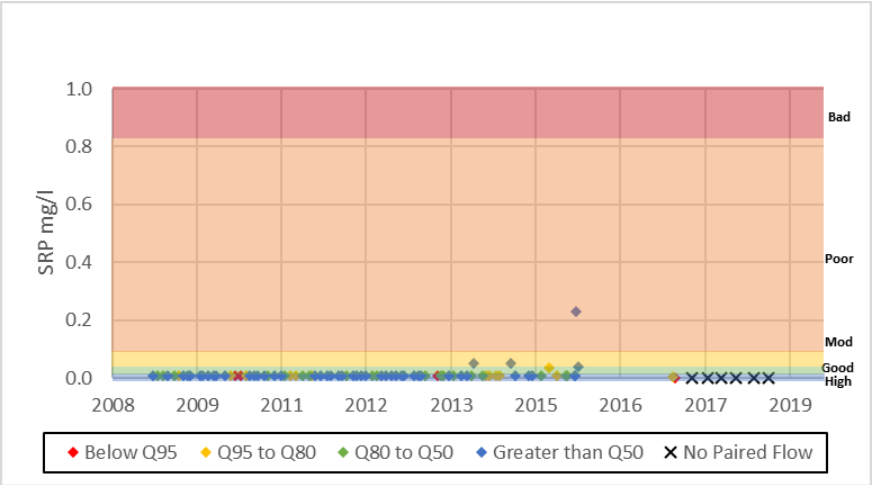
Soluble Reactive Phosphorus Concentrations

All soluble reactive phosphorus concentrations at Afon Tywi at Iron Bridge at Rhandirmwyn were below the limit of detection (0.02 mg/l).

Soluble reactive phosphorus concentrations at Afon Tywi at were reviewed and data are presented in **Figure B3.7** against the relevant WFD site specific standards provided by the EA[3]. Soluble reactive phosphorus concentrations at Afon Tywi at Fish Trap At Llyn Brianne were mostly consistent with the WFD standard to support high or good status (0.021 – 0.044 mgP/l) for fish and invertebrates for an upland low alkalinity river, occasionally falling short of this standard and crossing into the 'poor' (1 instance) and moderate (1 instance) status bands. No association with river flows is apparent at this location.

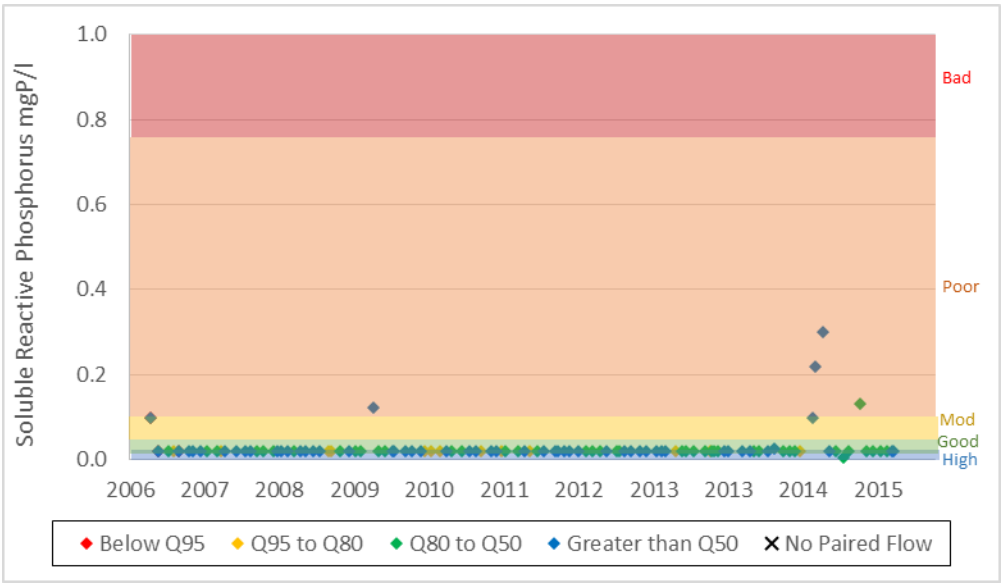
[3] The Water Environment (Water Framework Directive) (England and Wales) Directions 2015. ISBN 978-0-85521-192-9.

Figure B3.7 Soluble Reactive Phosphorus at Afon Tywi at Fish Trap At Llyn Brianne, Incorporating Appropriate WFD Status Bands



Soluble reactive phosphorus concentrations at Afon Tywi at Towy Bridge East of Cilycwm were reviewed and data are presented in **Figure B3.8** against the relevant WFD site specific standards provided by the EA. Soluble reactive phosphorus concentrations at Afon Tywi at Towy Bridge East Of Cilycwm were mostly consistent with the WFD standard to support high or good status (0.021 – 0.044 mgP/l, respectively) for fish and invertebrates for an upland low alkalinity river, occasionally falling short of this standard and crossing into the 'poor' (3 instances) and moderate (2 instances) status bands. No association with river flows is apparent at this location.

Figure B3.8 Soluble Reactive Phosphorus at Afon Tywi at Towy Bridge East of Cilycwm, Incorporating Appropriate WFD Status Bands



Biological Oxygen Demand

Biological Oxygen Demand (BOD) concentration in the Afon Tywi was reviewed against the Tywi SAC targets. BOD concentrations at the three sample locations above mostly compliant with the Tywi SAC BOD targets (2.5 mg/l) however there were infrequent instances where this was exceeded. While no association with flow was apparent the sampling notes indicate the peaks in BOD are predominantly attributed to rainfall. No monitoring data were available beyond 2015.

Reach 2 – Afon Tywi from the Afon Bran confluence to Llandeilo Bridge

No water quality data was available for this reach (affected by a moderate hydrological impact).

Reach 3 - Afon Tywi from Llandeilo Bridge to the Nantgaredig intake

No water quality data was available for this reach (affected by a minor hydrological impact).

Reach 4 - Afon Tywi from the Nantgaredig intake to the tidal limit

Water quality analysis for this reach (affected by a major hydrological impact) has been undertaken based on the data available at the water quality monitoring site listed in **Table B3.1**.

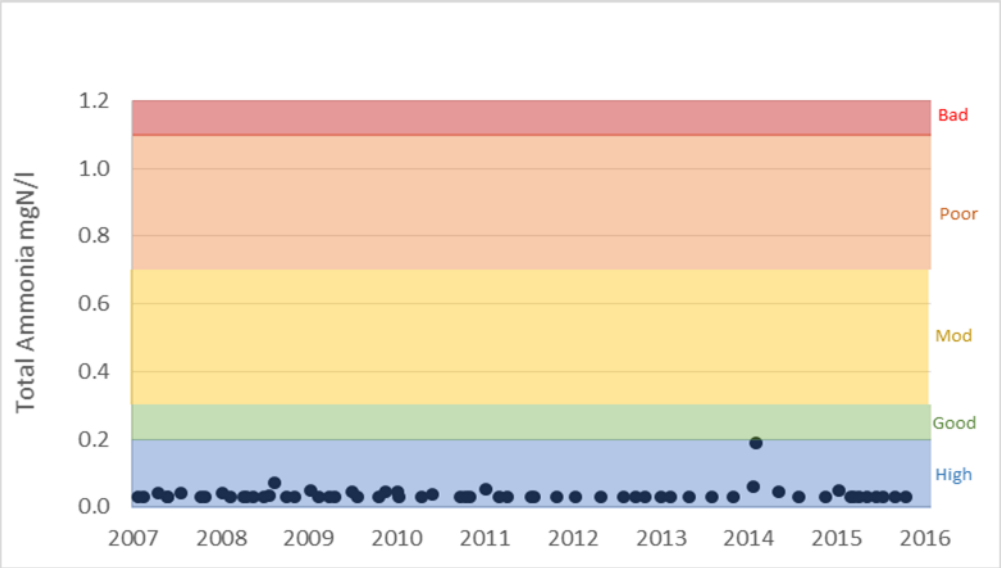
pH and Temperature

Average pH in the Afon Tywi at Nantgaredig 7.5 while the maximum water temperature at this site was 19°C.

Total Ammonia Concentration

Total ammonia concentration data from Afon Tywi at Nantgaredig Intake were reviewed and presented in **Figure B3.9** against the relevant WFD standards for an upland low alkalinity river. Total ammonia concentration measurements at Afon Tywi at Nantgaredig Intake were compliant with the WFD standard to support high status (0.2 mg/l) for fish and invertebrates for an upland low alkalinity river. There is no association between flow and dissolved oxygen concentrations.

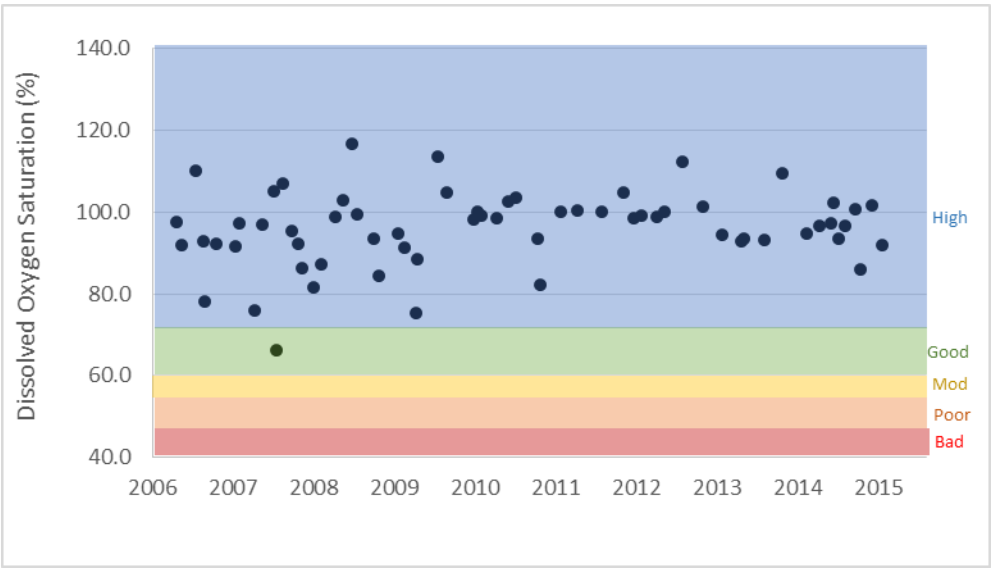
Figure B3.9 Total Ammonia Concentrations at Afon Tywi at Nantgaredig Intake, Incorporating Appropriate WFD Status Bands



Dissolved Oxygen Saturation

Dissolved oxygen saturation data from Afon Tywi at Nantgaredig were reviewed and presented in **Figure B3.10** against the relevant WFD standards for a upland high alkalinity river. Dissolved oxygen saturation measurements at Afon Tywi at Nantgaredig were compliant with the WFD standard to support good/high status (60-75% saturation) for fish and invertebrates for a lowland high alkalinity river. There is no association between flow and dissolved oxygen concentrations.

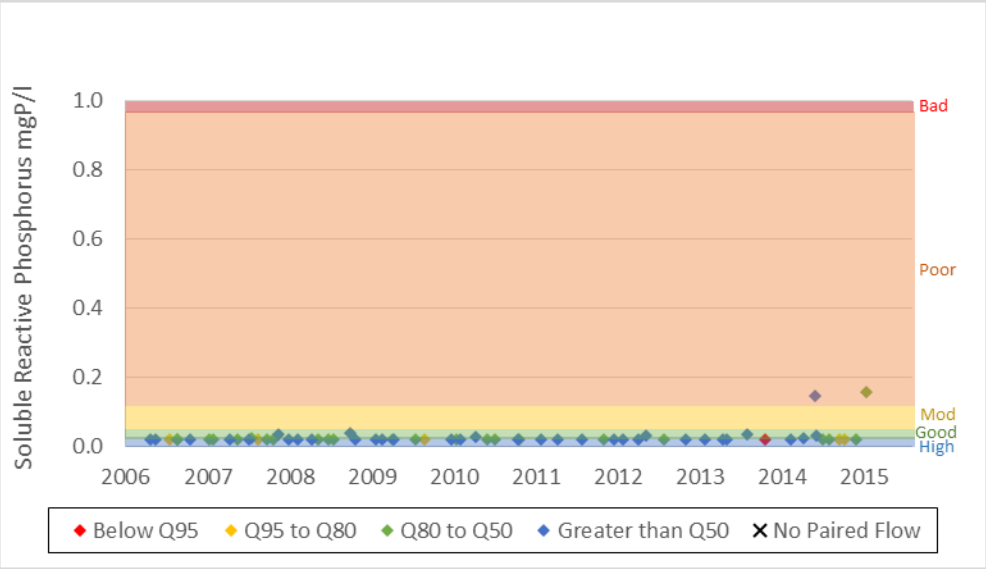
Figure B3.10 Dissolved Oxygen Saturation at Afon Tywi at Nantgaredig, Incorporating Appropriate WFD Status Bands



Soluble Reactive Phosphorus Concentrations

Soluble reactive phosphorus concentrations at Afon Tywi at Nantgaredig were reviewed and data are presented in **Figure B3.11** against the relevant WFD site specific standards provided by the EA[4]. Soluble reactive phosphorus concentrations at Afon Tywi at Nantgaredig were mostly consistent with the WFD standard to support high or good status (0.021 – 0.044 mgP/l, respectively) for fish and invertebrates for a lowland high alkalinity river, occasionally falling short of this standard and crossing into the 'poor' (2 instances) status band. No association with river flows is apparent at this location.

Figure B3.11 Soluble Reactive Phosphorus at Afon Tywi at Nantgaredig, Incorporating Appropriate WFD Status Bands



Biological Oxygen Demand

Biological Oxygen Demand (BOD) concentration in the River Towy was reviewed against the Tywi SAC targets. BOD concentrations were consistently compliant with the Tywi SAC BOD targets (2.5 mg/l). While no association with flow was apparent the sampling notes indicate the peaks in BOD are predominantly attributed to rainfall. No monitoring data were available beyond 2015 at this location.

Water Quality Summary

Assessment of risk of water quality deterioration as a result of the Nantgaredig drought order has been undertaken considering the water quality as well as the nature of the hydrological impact within Reaches 1, 2, 3 and 4.

No risk to water quality as a results of drought order implementation is anticipated in Reaches

[4] The Water Environment (Water Framework Directive) (England and Wales) Directions 2015. ISBN 978-0-85521-192-9.

1-3 due to the negligible hydrological impacts.

Total ammonia concentrations were thoroughly consistent with the standard to support high status for fish and invertebrates throughout Reach 4. Therefore, the risk of water quality deterioration with respect to total ammonia is assessed to be **low** in Reach 4. Similarly, dissolved oxygen concentrations were consistent with the standard to support high status for fish and invertebrates throughout Reach 4. With respect to the risk of water quality deterioration associated with SRP, this was assessed as being **low** in Reach 4.

These reaches fall within the Tywi SAC and as such have been compared against the specific conservation objectives. Reaches 1-4 were compliant with the targets for dissolved oxygen, un-ionised and total ammonia and pH. In Reach 1 BOD is predominantly compliant with the SAC objective however concentrations were exceeded once. It is therefore assumed that the risk to deterioration against the SAC targets is **low** in Reach 1. In the absence of water quality data for Reaches 2 and 3 and the presence of multiple small STWs in Reach 2 it is assumed the risk to the SAC objectives in reaches 2 and 3 is **low (uncertain)**. Reach 4 was consistently compliant for BOD.

B.3.3 Environmental Pressures

B.3.3.1 Flow Pressures

Surface Water Abstractions

During a drought, abstractions put pressure on flow by removing water from rivers and groundwater aquifers and potentially exacerbating natural low flows. As a result of a drought order, there may be less water available in the zone of influence for licence holders to abstract, and any abstractions that do occur may reduce the amount of surface water available – affecting the wetted perimeter of the habitat, velocities within the wetted area and the ability to dilute any pollutants entering the system. For surface water abstractions, this includes consumptive abstraction and partially consumptive / non-consumptive abstraction – where some or all of the water is returned to the river locally after use, with the potential to reduce flow in the river if the discharge is downstream of the abstraction.

An overview of licensed surface water abstractions is given below based on information received from NRW (see **Table B3.3**). There are two significant licensed abstractions in Reach 2 in addition to Welsh Water's abstraction licence at Manorafon intake upstream of Llandeilo (licence number 22/60/01/0068). The Manorafon intake is rarely used and is therefore unlikely to be affected by this drought order, however its use in the future use may increase, in order to support abstractors downstream of Usk reservoir. There is one small agricultural licensed abstraction in Reach 4 in addition to Welsh Water's abstraction licence at Nantgaredig intake (licence number 22/60/3/0035). The risk to surface water abstractions in Reach 2 is **negligible** due to the effect of the drought order. There is a **negligible** impact on the abstraction for agriculture and industry within Reach 4 (license number 22/60/3/0016).

Table B3.3 Abstractions in Area of Influence of the Afon Tywi Drought Order

Licence Number	Use	Daily abstraction limit (Ml/d)	Location		Risk to the surface water abstractions
			NGR	Zone of influence (<500m)	
WA/060/0001/005	Cooling, Dairy Industry	3.18	SN7029	Reach 2	Negligible
22/60/1/0083	Industrial	2.73	SN7029	Reach 2	Negligible
22/60/1/0068	Manorafon intake - Public water supply	36.4	SN6624	Reach 2	Negligible
22/60/3/0016	Agriculture and industry	0.05	SN4920	Reach 4	Negligible

B.3.3.2 Water Quality Pressures

Discharges put pressure on water quality during a drought as lower than normal river flows mean that there is less water available to dilute discharges such as final effluent from STWs. Discharges impacting the oxygen balance and ammonia concentration in the river reaches have been reviewed. Significant pressures (discharges of over 0.5Ml/d, **Table B3.4**) are shown on **Figure B1.1**, within the study area there is one significant pressure (Ffairfach Waste Water Treatment Works, WwTW). Any discharges may be considered as beneficial to river flow but may also pose risks to water quality (noting that only abstractions are considered as flow pressures in the section above).

Treated effluent from Ffairfach WwTW is a significant consented discharge (**Table B3.4**) in the study area located in Reach 3, however, increased environmental impacts to the Afon Tywi associated with discharge are unlikely during the drought order. This is a result of sufficient flow accretion having occurred prior to the Ffairfach WwTW discharge point, so that any changes in flows due to the drought order are minimal. The risk from consented discharges in **negligible** in Reaches 2 & 4 and in Reach 3 due to the effect of the drought order and single significant consented discharge (Ffairfach WwTW). There are no water quality pressures within the zone of influence in Reach 1.

B.3.3.3 Combined Sewer Overflows (CSOs)

There are 10 intermittent discharges in the zone of influence (<500m) which are listed in **Table B3.5;** all of which are considered to be of **negligible** risk in Reaches 2 to 4. There are no intermittent discharges within the zone of influence in Reach 1.

Table B3.4 Summary of Water Quality Pressures

Permit no.	Site name	Location	Max daily total (Ml/d)	Dry weather flow (Ml/d)	BOD: 5 Day ATU (mg/l)	Ammoniacal N (mg/l)	Suspended Solids @ 105 C (mg/l)	Zone of influence (<500m)	Consideration of water quality pressure (during baseline low flow conditions)
BG0040001 [BG0040002]	Llangadog STW, Llangadog	SN6989028140		0.43	20	10	30	Reach 2	Negligible
BJ0078601	Bethlehem STW	SN6816025200		0.01	75	0	95	Reach 2	Negligible
BN0103601 [BP0239802]	Cwm Ifor STW, Manordeilo, Llandeilo, Dyfed	SN6629024940	0.19	0.09	50	0	60	Reach 2	Negligible
BH0065401 [BN0194103]	Ffairfach WwTW	SN6164121126		0.85	35	10	53	Reach 3	Minor
BJ0078801	Golden Grove STW	SN5891921384	0.09	0.01	40	20	60	Reach 3	Negligible

Table B3.5 Summary of Intermittent Discharges

Permit no.	Site name	Location	Max daily total (Ml/d)	Dry weather flow (Ml/d)	BOD: 5 Day ATU (mg/l)	Ammoniacal N (mg/l)	Suspended Solids @ 105 C (mg/l)	Zone of influence (<500m)	Consideration of water quality pressure (during baseline low flow conditions)
BH0054601	Llanwrda Sewage Pumping Station	SN7130030700	Unknown					Reach 2	Negligible
BP0263301	Ashfield Row Pumping Station, Ashfield Row, Llangadog	SN6945028150	Unknown					Reach 2	Negligible
BP0113301	Rhosmaen Pumping Station	SN6410023900	Unknown					Reach 2	Negligible
BP0018401	Llandeilo Temporary Storm Water	SN6346022360	Unknown					Reach 2	Negligible
BN0194104	Sawmills Yard CSO, Station Road. Llandeilo	SN6336922847	Unknown					Reach 2	Negligible

Permit no.	Site name	Location	Max daily total (Ml/d)	Dry weather flow (Ml/d)	BOD: 5 Day ATU (mg/l)	Ammoniacal N (mg/l)	Suspended Solids @ 105 C (mg/l)	Zone of influence (<500m)	Consideration of water quality pressure (during baseline low flow conditions)
BN0194102	Brooklands Terrace Llandeilo CSO	SN6320023100	Unknown					Reach 2	Negligible
BP0115401	Primary School CSO, Bethlehem Road, Ffairfach	SN6309421544	Unknown					Reach 3	Negligible
BP0115701	Llandeilo CSO	SN6278022010	Unknown					Reach 3	Negligible
BP0209801	Tanerdy CSO, Carmarthen	SN4229020760	Unknown					Reach 4	Negligible
BH0053405	Parc Hinds Sewage Pumping Station, Carmarthen	SN4194020440	Unknown					Reach 4	Negligible

B4 PHYSICAL ENVIRONMENT IMPACT SUMMARY

Potential impacts on the physical environment associated with the Afon Tywi Nantgaredig Drought Order are summarised in **Table B4.1.**

Table B4.1 Summary of Potential Changes to the Physical Environment of the Impacted Reach from Implementation of Afon Tywi Nantgaredig Drought Order

Afon Tywi (Reach 1)	
Flows in the Afon Tywi ***Negligible*** *impacts on occasional days in the period from September to November inclusive*	• Reduction in extreme low flows (significantly below Q_{99}) of up to 5.9% on occasional days in the period from September to November inclusive
Afon Tywi (Reach 2)	
Flows in the Afon Tywi ***Negligible*** *impacts on occasional days in the period from September to November inclusive*	• Reduction in extreme low flows (significantly below Q_{99}) of up to 5.6% on occasional days in the period from September to November inclusive
Afon Tywi (Reach 3)	
Flows in the Afon Tywi ***Negligible*** *impacts on occasional days in the period from September to November inclusive*	• Reduction in extreme low flows (significantly below Q_{99}) of up to 4.9% on occasional days in the period from September to November inclusive
Afon Tywi (Reach 4)	
Flows in the Afon Tywi ***Minor*** *impacts on occasional days in the period from September to November inclusive*	• Reduction in extreme low flows (significantly below Q_{99}) of up to 14.7% on occasional days in the period from September to November inclusive
Water quality ***Low*** *risk on occasional days in the period from September to November inclusive*	• Low risk of water quality deterioration linked to total ammonia concentration and dissolved oxygen saturation • Low risk of water quality deterioration linked to SRP
Surface water abstractions and risk to abstractors ***Negligible*** *risk on occasional days in the period from September to November inclusive*	• The risk to the surface water abstractions is negligible.
Consented discharges ***Negligible*** *risk on occasional days in the period from September to November inclusive*	• No significant consented discharges
CSOs ***Negligible*** *risk on occasional days in the period from September to November inclusive*	• No significant intermittent discharges

B5 CUMULATIVE IMPACTS

The focus of this Environmental Assessment Report (EAR) is the Afon Tywi Nantgaredig drought order. The assessment, as described in previous sections, has considered how the proposed drought order may affect the environment in combination with the effects of existing licences and consents. In accordance with the DPG, the assessment also considers the potential cumulative effects of Welsh Water implementing other drought orders within a similar timeframe. The potential for options to act in combination is set out in **Table B5.1**.

Consideration has also been given to the potential for cumulative impacts of drought options implemented by neighbouring water companies (see **Table B5.1**). The assessment of the potential for cumulative impacts of Welsh Water's supply side and drought order / permit options with drought options listed in neighbouring water companies' drought plans has also been undertaken as part of the Strategic Environmental Assessment (SEA) of Welsh Water's Draft Statutory Drought Plan. The SEA was informed by the most recent information available on the neighbouring water companies' drought plans.

Table B5.1 Cumulative Impacts of the Afon Tywi Nantgaredig Drought Order with other Drought Options

Organisation	Potential In-combination Impacts	Further Consideration Required (Yes/No)
Welsh Water - other drought options in the Tywi Conjunctive Use System WRZ / River Tywi catchment	8201-1 (Reduce the compensation releases from Crai Reservoir) – The impacts of this option do not occur within the same catchment and therefore no in-combination effects are anticipated.	No
	8201-4 (Reduce the compensation releases from Brianne Reservoir) – This option involves a 50% reduction in the compensation releases from Llyn Brianne reservoir, to assist with winter refill. This would only be applicable when no regulation releases were necessary because of high natural flows in the lower Tywi and therefore would not be implemented in combination with the relaxation of the maintained flow below Nantgaredig. No in-combination effects would therefore occur.	No
Natural Resources Wales - Drought options in the River Tywi catchment	No previous drought order applications have been made in the South West Wales region.	No

APPENDIX C
ENVIRONMENTAL FEATURES ASSESSMENT METHODOLOGY

A.1 ENVIRONMENTAL FEATURES ASSESSMENT METHODOLOGIES

The assessments undertaken in the EARs will use available environmental data. The following methodologies detail the preferred approach to impact assessment for the sensitive receptors identified in the screening process.

However, in certain circumstances the supporting data on hydrological conditions, habitat availability and species occurrence may not be currently available. In these cases, other supporting data will be used, where available, and the assessment will be undertaken using expert judgement. An example may be where flow-induced river habitat for fish would ideally be defined through the total wetted area, depth and flow velocities to describe the habitat preferences of a species and its lifestages. Where these data are currently unavailable, the use of habitat walkover, RHS and / or aerial survey data may be used in combination with judgements on the hydrological change resulting from the drought option (e.g. reduction in river flows) to arrive at a statement on habitat reduction and consequent impact on the fish species. The analysis will detail the increased uncertainty prevalent in the approach and will therefore adopt a precautionary approach to impact prediction (possibly assigning a higher impact where fewer substantiating data are available).

The gaps in data and evidence will be noted and monitoring proposals established.

Assessment sheets are included for the following features:

- Flow pressures
- Water quality pressures.
- WFD Status: Fish
- WFD Status: Aquatic macroinvertebrates
- Environment (Wales) Act Section 7 species, designated sites and other sensitive fauna and flora.

FLOW PRESSURES

Potential Effects

In support of understanding the physical environment and the risk assessment in the zone of influence of each drought option, a review will be undertaken of additional flow pressures from licensed surface water and groundwater abstractions. Relevant pressures have been identified and risk assessed in terms of in-combination flow impacts from implementation of a drought option. Abstractions have the potential to exacerbate low river flows or, in the case of groundwater-dominated catchments where rivers seasonally run dry (ephemeral watercourses), to increase the length of river that is dry and the period of time for which it remains so, potentially beyond the period for which the drought option is in place.

As a result of a drought option, there may be less water available in the zone of influence (rivers and groundwater bodies) for licence holders to abstract, and any abstractions that do occur reduce the amount of surface water available – affecting the wetted perimeter of the habitat, velocities within the wetted area and the ability to dilute any pollutants entering the system. For surface water abstractions, this includes consumptive abstraction and partially consumptive/non-consumptive abstraction – where some or all of the water is returned to the river locally after use, with the potential to reduce flow in the river if the discharge is downstream of the abstraction.

Definition of Risk

Continuously flowing watercourses

In order to define the potential risk to flow from river and groundwater abstractions in a readily understandable manner, a series of criteria have been defined. The assessment is informed by long term gauged flow data. The impact of the drought option will be considered against baseline 'drought' conditions (without drought option implementation). The assessment will use the following criteria, based on the potential severity of the risk to river water quality and flow during an ongoing drought.

- High: A major reduction in low river flows, including the influence of the drought option - typically >25% reduction in summer Q95 (with drought option in place)
- Medium: A moderate risk to low river flows (as above) , including the influence of the drought option - typically 10-25% reduction in summer Q95 (with drought option in place)
- Low: A minor risk to low river flows, including the influence of the drought option - typically <10% reduction in summer Q95 (with drought option in place)
- Negligible: Indicative of no significant change from the "without drought" option baseline situation.

Ephemeral watercourses

In line with the methodology for hydrology, an alternative approach to risk is required for

watercourses that naturally dry for part of the year that are potentially impacted upon by the drought option. Such watercourses are identified from previous investigations and available data. The assessment will use the following criteria, based on the potential severity of the risk to river water quality and flow during an ongoing drought.

- High: If the abstraction resulted in sections drying (with drought option in place) that would not (without drought option in place)
- Medium: If the abstraction resulted in sections drying earlier (by more than a handful of days) and/or returning to flow later (by more than a handful of days) and hence flow reduction occurring in the channel for more than just a handful of days (with drought option in place)
- Low: If the abstraction resulted in sections drying earlier (by just a handful of days) and/or returning to flow later (by just a handful of days) and hence flow reduction occurring in the channel for more than just a handful of days OR if the abstraction were a secondary flow driver (e.g. flow through gravels being primary cause of flow losses rather than the drought permit) (with abstraction in place)
- Negligible: Indicative of no significant change from the "without drought" option baseline situation.

Data Requirements

- Relevant zone of influence (as identified from screening)
- Surface water and groundwater abstraction licences in the zone of influence
- River flow representative of the zone of influence (daily gauged flow and spot flow surveys) – all available records
- Flow predictions and zones of hydrological impact for each drought option.

Assessment Methodology and Uncertainty

1. Identify relevant abstraction licences within the zone of hydrological impact for the drought option: both groundwater abstractions from the aquifer(s) impacted by the drought option (confined and unconfined) and surface water abstractions from the impacted river reaches.

Groundwater abstractions

2. For groundwater abstractions, identify which aquifer they abstract from and key characteristics of the aquifer (confined/unconfined) if available. List relevant details from each abstraction licence including licence number, holder, use, depth abstracted from and maximum daily abstraction rate.
3. Use depths of abstraction to identify which of these abstractions are likely to be affected by reduced groundwater levels in the aquifer with the drought option in place. If depth information is not available, take a precautionary approach and assume all abstractions within the relevant area (or, if known, from the relevant aquifer) are affected.
4. Calculate the maximum volume of groundwater abstractions from each aquifer at low flows (i.e. the sum of abstractions of sufficient depth from the aquifer) with a drought option in place.

5. Use expert judgement to assess the in-combination significance of these groundwater abstractions on river flows in impacted reaches (both continuously flowing and ephemeral watercourses), based on known (measured or modelled) relationships between groundwater levels and river flows in that area and the definition of risk set out above.

Surface water abstractions – continuously flowing watercourses

6. Assign relevant abstraction licences to an impacted river reach, and list relevant details from the licence including licence number, holder, use, type (consumptive or non-consumptive), location (mainstem or tributary) and daily maximum abstraction rate (including any Hands-Off Flow restrictions). Identify which of these abstractions are likely to be affected by reduced water levels in the river with the drought option in place.
7. Calculate the maximum volume of surface water abstractions in each reach at low flows (i.e. the sum of consumptive, unrestricted abstractions on the main stem of the river) as a proportion of summer Q95 river flow with a drought option in place.
8. Assess the in-combination significance of these pressures on river flow with respect to hydrological assessment methodologies described in Section 2.2.2 of the main report.
9. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.

Surface water abstractions – ephemeral watercourses

10. Assign relevant abstraction licences to an impacted river reach, and list relevant details from the licence including licence number, holder, use, type (consumptive or non-consumptive), location (mainstem or tributary) and daily abstraction maximum (including any Hands-Off Flow restrictions). Identify which of these abstractions are likely to be affected by reduced water levels in the river with the drought option in place.
11. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.

All abstractions

12. For both groundwater and surface water abstractions, incorporate any flow pressure risks identified as significant into the assessment of impacts on significant features and the selection of appropriate mitigation measures for the drought option.

WATER QUALITY PRESSURES

Potential Effects

In support of the physical environment understanding and risk assessment in the zone of influence of each drought option, a review will be undertaken of additional water quality pressures from consented surface water discharges. Discharges put pressure on water quality during a drought as lower than normal river flows mean that there is less water available to dilute discharges such as final effluent from STW. A drought option may exacerbate these low flows and contribute to a reduction in water quality, with potentially detrimental impacts on sensitive features in the impacted reach. Discharges impacting the oxygen balance and ammonia concentration (to support fish and macroinvertebrates, where these are identified as sensitive features) and soluble reactive phosphorus (SRP) concentration (to support macrophytes and algae, where these are identified as sensitive features) in the river have been reviewed.

Intermittent discharges from combined sewer overflows (CSOs) may also contribute to a reduction in water quality during an environmental drought. CSOs relieve strain on the sewers during storm events by temporarily diverting water into nearby watercourses to prevent sewer flooding. As there is usually a time lag between discharges from CSOs and rises in river levels during a storm event, the potential exacerbation of low flows by the drought option may decrease the amount of water immediately available to dilute CSO discharges, leading to a temporary reduction in river water quality if a storm event occurs during implementation of the drought option.

Definition of Risk

Continuously flowing watercourses

In order to define the potential risk to water quality from discharges into the river in a readily understandable manner, a series of criteria have been defined. The assessment will use the following criteria, based on the potential severity of the risk to water quality during an ongoing drought.

- High: A major risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); and exacerbation of the risk by the flow reduction from the drought option
- Medium: A moderate risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation of a minor risk by the flow reduction from the drought option
- Low: A minor risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation to a minor risk by the flow reduction from the drought option
- Negligible: Indicative of no significant risk without the drought option nor exacerbation of risk by the flow reduction from the drought option

Ephemeral watercourses

In line with the methodology for hydrology, an alternative approach to risk is required for

watercourses that naturally dry for part of the year that are potentially impacted upon by the drought option. Such watercourses are identified from previous investigations and available data. The assessment will use the following criteria, based on the potential severity of the risk to river water quality during an ongoing drought.

- High: A major risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); and exacerbation of the risk if the drought option resulted in sections drying (with drought option in place) that would not (without drought option in place)
- Medium: A moderate risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation of a minor risk by the flow reduction from the drought option occurring in the channel for more than just a handful of days.
- Low: A minor risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation to a minor risk by the flow reduction from the drought option occurring in the channel for just a handful of days.
- Negligible: Indicative of no significant risk without the drought option nor exacerbation of risk by the flow reduction from the drought option

Data Requirements

- Relevant zone of influence (as identified from screening)
- Surface water discharge consents in the zone of influence (including numeric water quality and flow conditions)
- Routine NRW / Environment Agency riverine water quality monitoring data for the water quality determinands dissolved oxygen saturation, SRP concentration and total ammonia concentration for relevant monitoring sites in the zone of influence and significant tributaries
- River flow representative of the zone of influence (daily gauged flow and spot flow surveys) – all available records
- Flow predictions and zones of hydrological impact for each drought option
- CSO locations and previous assessments of intermittent discharges from Welsh Water.

Assessment Methodology and Uncertainty

1. Identify sensitive features (fish, macroinvertebrates, macrophytes and algae) which may be impacted by the drought option. Use this information to determine whether assessment of oxygen balance, ammonia concentration and/or SRP concentration is required.
2. Identify all discharge consents within the zone of hydrological impact for the drought option.
3. Assign relevant discharge consents to an impacted reach, and list relevant details from the consent including consent number, holder, use, location (mainstem or tributary) and relevant numeric

consent conditions (Dry Weather Flow, BOD, ammonia (N), total phosphorous)[1].

4. Identify those discharge consents which relate to effluent from Welsh Water's sewage treatment works (STWs).

Continuously flowing watercourses

5. Model the maximum current contribution of each STW to BOD, ammonia (N) and total phosphorous concentrations (as relevant) in the river at low flows (based on the water quality consents, DWF and upstream flows).
6. Model the maximum potential increase in each STW's contribution to river BOD, ammonia (N) and total phosphorous concentrations (as relevant) at low flows as a result of the drought option (based on the water quality consents, DWF, upstream flows and maximum flow reduction from drought option).
7. Assess the potential risk that the STW could pose to river ammonia quality (using the consented discharge condition total ammonia) using modelled data and the appropriate matrix below. This combines an acknowledgement of existing conditions and potential variation as a result of the drought option.

Upland low alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [a]	<0.2mgN/l	Minor	Moderate
	≥0.2mgN/l	Moderate	Major

[a] Standards are WFD high/good threshold for ammonia (N) of 0.2mg/l for upland low alkalinity rivers[2].

Lowland high alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [b]	<0.3mgN/l	Minor	Moderate
	≥0.3mgN/l	Moderate	Major

[b] Standards are WFD high/good threshold for ammonia (N) of 0.3mg/l for lowland high alkalinity rivers[3].

8. Assess the potential risk that the STW could pose to river oxygen balance (using the consented discharge condition BOD) using modelled data and the matrix below. This combines an acknowledgement of existing conditions and potential variation as a result of the drought option.

Upland low alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to BOD concentrations at low flows [c]	<1mg/l	Minor	Minor
	1-3mg/	Minor	Moderate
	≥3mg/l	Moderate	Major

[c] Standards are WFD high/good threshold for BOD of 3mg/l and good/moderate threshold of 4mg/l for upland low alkalinity rivers[4].

Lowland high alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to BOD concentrations at low flows [d]	<1mg/l	Minor	Minor
	1-4mg/	Minor	Moderate
	≥4mg/l	Moderate	Major

[d] Standards are WFD high/good threshold for BOD of 4mg/l and good/moderate threshold of 5mg/l for lowland high

[1] Note that not all STWs have water quality consents relating to ammonia or total phosphorous (depends on size and location of STW). Consents are set with respect to total phosphorous rather than SRP.

[2] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

[3] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

[4] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

alkalinity rivers[5].

9. Assess the potential risk that the STW could pose to river phosphorous quality (using the consented discharge condition total phosphorous) using modelled data and the matrix below. This combines an acknowledgement of existing conditions and potential variation as a result of the drought option. Consents are set with respect to total phosphorous rather than SRP (on which WFD river standards are based), therefore this approach conservatively assumes that all phosphorous from STWs is reactive and has direct implications for ecology in the river.

Upland low alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [e]	<0.2mgN/l	Minor	Moderate
	≥0.2mgN/l	Moderate	Major

[e] Standards are WFD high/good threshold for SRP of 0.02mg/l and good/moderate threshold of 0.04mg/l for upland low alkalinity rivers[6].

Lowland low alkalinity river[7]		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [f]	<0.03mgN/l	Minor	Moderate
	≥0.03mgN/l	Moderate	Major

[f] Standards are WFD high/good threshold for SRP of 0.03mg/l and good/moderate threshold of 0.05mg/l for lowland low alkalinity rivers[8].

Upland/ lowland high alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [g]	<0.05mgP/l	Minor	Moderate
	≥0.05mgP/l	Moderate	Major

[g] Standards are WFD high/good threshold for SRP of 0.05mg/l and good/moderate threshold of 0.12mg/l for upland/ lowland high alkalinity rivers[9].

10. Identify those discharges which relate to effluent from Welsh Water's combined sewer overflows (CSOs).
11. If required, carry out qualitative analysis using previous assessments of intermittent discharges to evaluate whether any CSOs are likely to present a significant water quality pressure as a result of the drought option.
12. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.
13. Incorporate any water quality pressure risks identified as significant into the assessment of impacts on significant features and the selection of appropriate mitigation measures for the drought option.

Ephemeral watercourses

14. Calculate the maximum concentrations of BOD, ammonia (N) and SRP (as relevant) in the final effluent of each STW under consented conditions (i.e. concentrations in the river with no natural dilution).

5 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

6 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

7 Note that "Lowland low alkalinity" is a category that only exisits for SRP standards, and not for total ammonia or BOD.

8 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

9 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

15. Identify those discharges which relate to effluent from Welsh Water's combined sewer overflows (CSOs).
16. If required, carry out qualitative analysis using previous assessments of intermittent discharges to evaluate whether any CSOs are likely to present a significant water quality pressure as a result of the drought option.
17. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.
18. Incorporate any water quality pressure risks identified as significant into the assessment of impacts on significant features and the selection of appropriate mitigation measures for the drought option.

WATER FRAMEWORK DIRECTIVE STATUS: FISH

Potential Effects

For WFD river waterbodies within the zone of influence of the drought option, where screening of the drought option has identified that the fish element of biological status is *High* or *Good*, the potential impact is to be investigated. This investigation is specific to the risk of deterioration below the *Good* status band to the *Moderate* status band, as advised by NRW / Environment Agency.

Definition of Impacts

In order to define the potential WFD status impacts for fish in a readily understandable manner, a series of criteria have been defined. The assessment will use the following criteria, based on the potential severity of the drought option impacts during an ongoing drought.

- Major: A major impact is one that results in deterioration in the WFD classification of the waterbody, or specifically the fish biological element of the classification.
- Moderate: A moderate impact on fish status occurs when the fish population is predicted to be materially influenced, including effects on density, abundance or community composition, but where no deterioration in WFD classification is predicted. Consideration should be given to the scale of the impact and the potential for recovery of the populations.
- Minor: A minor impact occurs when there is a predicted impact on fish abundance, density or community composition that is within the usual variability for the site and which will recover within a short timescale.
- Negligible: A negligible impact is one where the predicted impact will not result in a detectable change in the fish population.

Data Requirements

Fish status baseline assessment requires data from standard NRW / Environment Agency monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Fish data should include species presence, abundance and density. Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area (width and depth) as follows:

- Relevant study area (as identified in the screening report)
- Hydrology at or close to the monitoring sites to link to fish data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records
- Meteorology (where flow data insufficient) from available NRW / Environment Agency rain gauges
- Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys
- Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area.

Assessment Methodology and Uncertainty

The WFD classification for the waterbody will be identified and the reasons for classification established from the NRW / Environment Agency. The data used to support the assessment will be reviewed to ensure that the classification is accurate.

Baseline conditions for sites within the zone of influence of the drought option will be established through existing data. These will include graphing the hydrology, water quality, habitat and fish variation temporally over the monitored period.

The analysis will consider the relationship between fish status and the supporting environmental variables over the period, with an emphasis on changes to fish status and environmental conditions between low, average and high flow years. The purpose of the analysis is to establish whether fish status responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, climate, quality (dissolved oxygen and temperature) and/or habitat quality and availability.

Having established the baseline conditions and variability outside the drought option conditions (care will be taken to avoid using periods in the baseline analysis within which a drought option may have been in operation), a prediction will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from application of the drought option. This will be undertaken for the hydrological data by overlaying the drought option flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought option. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water depth.

Once the flow, habitat and water quality drought option predictions have been established, their implications for existing fish species will be assessed. The flow and habitat environmental envelope of the key fish species is known. The predicted changes in supporting environmental variables (flow, depth, velocity, habitat quality, dissolved oxygen levels and temperature) due to the drought option will be assessed against the fish population data. Where the supporting environmental variables for fish species are modified to take them outside of their preferred envelope it can be assumed that there will be a moderate or major impact on that fish population. Consideration will be given to the potential for density dependent mortality where data show that the fish population has an existing good density, and where the drought option reduces habitat availability significantly The assessment will consider the scale and longevity of any fish status impacts. The WFD classification is calculated on a 3 year rolling basis. A deterioration in classification would require a long term (2+ breeding seasons) and significant effect on fish population structure to allow prediction of a deterioration in status.

Where data are not available the assessment will be undertaken using expert judgement and drawing on broad-scale evidence from other similar catchments if applicable.

The prediction of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or

surveillance data are used for impact assessment purposes. Lastly the environmental envelopes within which fish species can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. The assessment must therefore be undertaken in recognition that the outcome prediction will be subject to large potential variability. The study will therefore adopt a precautionary approach, with potential impact highlighted where doubt exists. Monitoring and mitigation proposals for the drought option can then be specified so that, should an option be enacted, the actual impact can be recorded and adaptive mitigation/management of the option undertaken to safeguard where possible the fish populations.

WATER FRAMEWORK DIRECTIVE STATUS: MACROINVERTEBRATES

Potential Effects

For Water Framework Directive (WFD) river waterbodies within the zone of influence of the drought option, where screening of the drought option has identified that the aquatic macroinvertebrate component of ecological status is *High* or *Good*, the potential impact is to be investigated. This investigation is specific to the risk of deterioration below the *Good* status band to the *Moderate* status band.

Definition of Impacts

In order to define the potential WFD status impacts for aquatic macroinvertebrates in a readily understandable manner, a series of criteria have been defined. The assessment will use the following criteria, based on the potential severity of the drought option impacts during an ongoing drought.

- Major: A major impact is one that results in deterioration in the WFD classification of the waterbody, or specifically the macroinvertebrate biological element of the classification.
- Moderate: A moderate impact on macroinvertebrate status occurs when the macroinvertebrate community is predicted to be materially influenced, including reduction in the LIFE score, or in community density +/or abundance, but where no deterioration in WFD classification is predicted. Consideration should be given to the scale of the impact and the potential for recovery of the community.
- Minor: A minor impact occurs when there is a predicted impact on macroinvertebrate abundance, density or composition that is within the usual variability for the site and which will recover within a short timescale.
- Negligible: A negligible impact is one where the predicted impact will not result in a detectable change in the macroinvertebrate community.

Data Requirements

The baseline for macroinvertebrates will be established from existing data together with a comparison of species flow preference and taxon abundance. The analysis will provide an assessment of the community type and its sensitivity.

Macroinvertebrate status baseline assessment requires data from standard NRW / Environment Agency monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Macroinvertebrate data should include the LIFE and BMWP scores, together with abundance and density data where available. Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area (width and depth) and other environmental variables as follows:

- Relevant study area (as identified by screening)
- Hydrology at or close to the monitoring sites to link to macroinvertebrate data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records
- Meteorology (where flow data insufficient) from available NRW / Environment Agency

rain gauges

- Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys, to calculate HQA / HMS.
- Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area.

Assessment Methodology and Uncertainty

Having established the baseline, the relative changes expected as a result of the drought actions (in relation to normal drought conditions) in river hydrology, geomorphology and water quality will be identified (see WFD fish assessment). An assessment will then been made of the habitat requirements of the key riverine macroinvertebrate communities present, using existing knowledge of their range of preferences. Depending on the resolution of baseline data available, detailed statistical analysis of the datasets may be possible. However, in some cases, where relatively limited spatial and/or temporal datasets are available, the impact assessment of the drought actions will be based on qualified expert judgement of the potential effects of the predicted changes in the environmental variables on the macroinvertebrate communities. The analysis is supplemented by consideration of the implications of environmental change on the key macroinvertebrate metrics, including LIFE scores.

The WFD macroinvertebrate classification for the water body will be identified and the reasons for classification established from the NRW / Environment Agency. The data used to support the assessment will be analysed to ensure that the classification is accurate.

Baseline conditions for sites within the zone of influence of the drought option will be established through existing data. These will include graphing the hydrology, water quality, and macroinvertebrate (ASPT and LIFE scores) variation temporally over the monitored period.

The analysis will consider the relationship between macroinvertebrate status and the supporting environmental variables over the period, with an emphasis on changes to status and environmental conditions between low, average and high flow years. The purpose of the analysis is to establish whether status responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, climate, quality (dissolved oxygen and temperature) and/or habitat quality and availability.

Having established the baseline conditions and variability outside the drought option conditions (care will be taken to avoid using periods in the baseline analysis within which a drought option may have been in operation), a prediction will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from application of the drought option. This will be undertaken for the hydrological data by overlaying the drought option flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought option. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water depth. These data may have been developed for the WFD fish status assessment and duplication of effort will be avoided.

Once the flow, habitat and water quality drought option predictions have been established, their implications for the existing macroinvertebrate community will be assessed. The linkage between flow and habitat environmental envelope for upland macroinvertebrate communities is subject to continuing debate but has been shown to be linked (see for example, Dunbar et al 2009; 2010). The predicted changes in supporting environmental variables (flow, habitat quality) due to the drought option should be assessed against the macroinvertebrate community LIFE scores. Consideration will be given to the relationships between flow, habitat and LIFE scores in the DRIED-UP research papers. The predicted relative change in Q_{95} low flow value for the drought option should be compared to the Q_{95}/reduction in LIFE score; HQA/reduction in LIFE score in Dunbar *et al* 2010 to develop an approximation of the scale of change in macroinvertebrate community that could be expected.

The assessment will consider the scale and longevity of any macroinvertebrate community impacts. The WFD classification is calculated on a 3 year rolling basis. A deterioration in classification would require a long term and significant effect on macroinvertebrate community structure to establish prediction of a deterioration in status.

Where data are not available the assessment will be undertaken using expert judgement and drawing on broad-scale evidence from other similar catchments within the reservoir group.

The prediction of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or surveillance data are used for impact assessment purposes. Lastly the environmental envelopes within which the macroinvertebrate community can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. For macroinvertebrates the evidence base for the prediction of flows and changes to LIFE score remain subject to significant debate. The assessment must therefore be undertaken in recognition that the outcome prediction will be subject to large potential variability. The study should therefore adopt a precautionary approach, with potential impact highlighted where doubt exists. Monitoring and mitigation proposals for the drought option can then be specified so that, should an option be enacted, the actual impact can be recorded and adaptive mitigation/management of the option undertaken to safeguard where possible the macroinvertebrate community.

NOTABLE SPECIES, DESIGNATED SITES AND OTHER SENSITIVE FAUNA AND FLORA

Potential Effects

Where screening of the drought option has identified that a notable species or designated site is present within the zone of influence of the drought option and screening has indicated that it is sensitive to the impacts of the drought option, the potential impact is to be investigated. Notable species are defined as Environment (Wales) Act Section 7 species or species with significant ecological sensitivity in the specified locality including species listed on IUCN red list and those not included in the red list which are nonetheless uncommon. This investigation will consider the habitat preferences of the species and its lifestages (if appropriate) and the impacts of the variation in flow (and consequent physical habitat and ecosystem) on these preferences. Potential effects are associated either 1) directly to a reduction in river flow; or 2) a reduction in water quality; 3) secondary effects of reduced velocity, for example on sediment characteristics.

Definition of Impacts

In order to define the potential impacts for sensitive ecological features in a readily understandable manner, a series of criteria have been defined. The significance of impacts upon the sensitive ecological feature will be identified following the Institute of Ecology and Environmental Managements (CIEEM) Ecological Impact Assessment (EcIA) guidance[10]. The potential significance of the impacts is identified using the following:

- **Value of the Ecological Receptor** – each ecological receptor is attributed a geographic value based upon its legislative and conservation status, as identified in Table 1.

Table 1 Value of Ecological Receptor

Ecological Value	Example
International	Existing or warranting designation as a e.g SPA and/or of significant conservation status for Europe (e.g European Protected Species (EPS)).
National	Existing or warranting designation as a SSSI and/or of significant conservation status for England (i.e. identified as a NERC / Environment Act (Wales) Section 7 species).
Regional	Habitats or species valuable at a regional level and/or of significant conservation status for the region (e.g viable breeding populations of Nationally Scarce species).
County	For example, existing or warranting designation as a County Wildlife Site (CWS) and/or of significant conservation status for the county (e.g viable breeding populations of species of county/metropolitan rarities).
District	For example, habitats or species of significant conservation status for the district (e.g viable breeding populations of species listed as rare in the district or borough).
Parish (local)	Species whose presence is considered to appreciably enrich biodiversity within the context of the parish or local neighbourhood, including as a local recreational/educational resource.
Site (within zone of influence only)	Species which are so low grade or widespread so as to be considered as not contributing to biodiversity value outside the boundaries of the site.

- **Positive or Negative Impact** – all impacts are considered to be negative unless

[10] CIEEM (2018) *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine.* Chartered Institute of Ecology and Environmental Management, Winchester.

otherwise stated in the feature assessment.

- **Extent** – the extent of the impact is covered as part of the magnitude consideration.

- **Magnitude** – the magnitude of the impact is identified using the criteria identified in **Table 2**

Table 2 Magnitude of Impact

Impact Magnitude	Description
High	There is a long-term large-scale (i.e. catchment) change in the ecological receptor and/or changes in the overall integrity of the ecological receptor.
Medium	There is a short-term large-scale change or long-term short-scale (i.e. reach) change in the ecological receptor, however no changes in the overall integrity of the ecological receptor.
Low	There is a short-term small-scale change in the ecological receptor, but its overall integrity is not impacted.
Negligible	No perceptible change in the ecological receptor.

- **Duration** – the duration of impact is considered to be for 6 months, which is the duration for which a drought option is implemented, unless otherwise stated.

- **Reversibility** – all impacts are considered to be reversible unless they are identified to have a likely impact upon the overall integrity of the ecological receptor.

- **Timing and Frequency** – the drought option could be implemented at any point in the year, however the different life stages of the sensitive ecological features will be taken into account. The assessment is based upon the operation of a single drought permit, with subsequent applications for a drought permit required to consider cumulative effects of multiple drought permits.

- **Probability** – all impacts are considered to be probable, unless otherwise stated.

Once the value of the ecological receptor, magnitude of impacts and other parameters listed above have been identified, these are used to inform the assessment of significance of impact on the ecological receptor.

Data Requirements

Sensitive ecological features baseline review requires data from standard NRW / Environment Agency monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Data should include species presence, abundance and density. It is likely that most fisheries data will be for O and O+ lifestages, with some indication of older echelons. Environmental supporting data should include habitat availability, hydrology and water quality as follows:

- Relevant study area (as identified in the screening report)
- Hydrology at or close to the monitoring sites to link to fish data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records

- Meteorology (where flow data insufficient) from available NRW / Environment Agency rain gauges
- Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys
- Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area
- Habitat preferences for the given sensitive ecological features will be described, against which habitat change can be assessed.

Assessment Methodology and Uncertainty

The NERC / Environment (Wales) Act Section 7 species status for the watercourses will be identified and the reasons for its inclusion in the NERC / Environment (Wales) Act Section 7 established from the relevant bodies (start with NRW / Environment Agency). The data used to support the Environment (Wales) Act Section 7 assessment will be reviewed to ensure that it is accurate.

Baseline conditions for sites within the zone of influence of the drought option will be established through existing data. These should include graphing the hydrology, water quality, habitat and fish variation temporally and, if multiple sites, spatially over the monitored period. The analysis will consider the relationship between sensitive ecological feature lifestages and the supporting environmental variables over the period, with an emphasis on changes to status and environmental conditions between low, average and high flow years. The purpose of the analysis is to establish whether the sensitive ecological features population responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, climate, quality (dissolved oxygen and temperature) and/or habitat quality and availability.

Having established the baseline conditions and variability outside the drought option conditions (care will be taken to avoid using periods in the baseline analysis within which a drought permit may have been in operation), a prediction will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from application of the drought option conditions. Ideally this will be undertaken for the hydrological data by overlaying the drought option flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought option. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water depth. In many cases these data are currently unlikely to exist and proxy measures such as RHS and/or aerial survey data will be used.

Once the flow, habitat and water quality drought option predictions have been established, their implications for the sensitive ecological features will be assessed. The flow and habitat environmental preferences of the sensitive ecological features will be described. The predicted changes in supporting environmental variables (flow, depth, velocity, habitat quality, dissolved oxygen levels and/or temperature) due to the drought option should be assessed against the sensitive ecological features population data.

Where data are not available the assessment will be undertaken using expert judgement and

drawing on broad-scale evidence from other similar catchments.

The prediction of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or surveillance data are used for impact assessment purposes. Lastly the environmental preferences within which species can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. The assessment must therefore be undertaken in recognition that the outcome prediction will be subject to large potential variability. The study will therefore adopt a precautionary approach, with potential impacts highlighted where doubt exists. Monitoring and mitigation proposals for the drought option can then be specified so that, the actual impact can be recorded and adaptive mitigation/management of the option undertaken to safeguard where possible the sensitive ecological features populations.

Habitat Preferences

Habitat Preferences		**Unfavourable Habitat**	**Potential Impacts**
Type/ Age Class	**Description**		
Atlantic salmon *Salmo salar* and Brown/Sea trout *Salmo trutta*			
Spawning	• Clean and unconsolidated gravels typically in the transitional area between pools and riffles where the flow is accelerating and depth is decreasing	-	Deposition of silt Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth
Nursery (fry and parr life stage)	• Shallow areas with a low water velocity and pebble substrate, often at the margins of riffles	• Deep and/or high velocity habitats.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake Deterioration in water quality
Adults	Deep habitats that provide shelter including one or more of the following: • submerged structures • undercut banks • overhanging vegetation <50cm above the water surface • water surface turbulence causing a broken surface • Deep pools downstream of obstacles and sufficient water quantity through structures to enable passage across obstacles.	• Open and shallow habitats, but will use these during migration to reach spawning gravels. • Habitats upstream of significant obstructions.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake Increased significance of barriers to impede migration as a result of decreased flows Deterioration in water quality
Brook lamprey *Lampetra planeri*			
Spawning	• Clean, unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	- -	Deposition of silt Reduction in velocity, depth or wetted width resulting in exposure of river bed Increased water velocity and depth
Nursery	• Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. • Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	**Description**		
			Deterioration in water quality
Adults	• Cover (stones and vegetation) in the vicinity of spawning gravels.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
River lamprey *Lampetra fluviatilis*			
Spawning	• Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.	-	Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	• Suitable estuarine conditions, that is free from pollution and with suitable prey species available. • Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers.	• Areas with significant pollution or limited prey availability. • Habitats upstream of significant obstructions.	Increased significance of barriers to impede migration as a result of decreased flows
			Increased risk of entrainment into water intake
			Deterioration in water quality
Sea lamprey, *Petromyzon marinus*			
Spawning	• Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.	-	Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	• Suitable estuarine conditions, that is free from pollution and with suitable prey species available. • Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers.	• Areas with significant pollution or limited prey availability. • Habitats upstream of significant obstructions.	Increased significance of barriers to impede migration as a result of decreased flows
			Increased risk of entrainment into water intake
			Deterioration in water quality
Bullhead, *Cottus gobio*			
Spawning	• Coarse, hard substrate of gravel and stones.	• Deep, silty watercourses with high flow velocities and little or no cover.	Deposition of silt
			Reduction in velocity, depth and/or wetted width
			Increased water velocity and depth

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	**Description**		
Nursery	• Shallow, stony riffles		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adult	• Sheltered sections created by woody debris, tree roots, leaf litter, macrophyte cover or larger stones.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
European eel, *Anguilla anguilla*			
Juvenile (<30cm)	• Wetland habitats within 30km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.	• Low productivity watercourses with dominance of coarse substrates and low macrophyte cover and diversity. • Habitats upstream of significant obstructions.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adult (>30cm, female >45cm)	• Deep, slow flowing watercourses and wetland habitats within 80km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased significance of barriers to impede migration as a result of decreased flows
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Barbel *Barbus barbus*			
Spawning	• Run/glide flow • Less than 50cm deep • Velocities greater than 0.5m/s • Substrate composed of clean and uncompacted gravel	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Marginal shallow bays set back from or within margins of main channel • Depths between 1cm and 30cm • No discernible to minimal flow • Substrate composed of >30% gravel and sand with low silt content • Lack of or very little riparian shading		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	• Commonly associated with stretches of clean gravel and macrophyte beds, showing a preference to relatively fast-flowing stretches in the middle reaches of large rivers. • The species also occupies deep water habitats at the foot of weirs,		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Impedance to movement upstream
			Increased water velocity and depth
			Increased risk of entrainment into water intake

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	**Description**		
	in the lee of large woody debris, rock ledges or other obstructions on the river bed.		Deterioration in water quality Increased water velocity and depth
Fine-lined pea mussel, *Pisidium tenuilineatum* and depressed river mussel *Pseudanodonta complanata*			
All life stages	• Fine sediments of lowland rivers and canals,	• High velocity watercourses with coarse substrates.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
White-clawed crayfish *Austropotamobius pallipes*			
All life stages	• Slow-flowing sections of stony rivers • Boulder riffles in chalk or clay streams • Submerged tree roots • Debris dams • Crevices in old or damaged submerged brickwork, stonework, cracked concrete or rotten wooden structures • Un-mortared stone revetting which protects banks from erosion • Stands of submerged and emergent aquatic plants • Old gravel workings and chalk pits • Good water quality	• Uniform clay channels • Areas of deep or soft silt • Dense filamentous algae • Narrow fast-flowing channels • Areas of sand and gravel, or bedrock, which are lacking in cobble or boulder (though they may feed in or commute through these areas) • Pebble or cobble shingle regularly exposed by changing river levels • Areas of armoured bed where the substrate is compacted by the river flow • Acidic streams or ochreous drainage • Poor water quality or salinity	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake Transfer of non-native species or disease Deterioration in water quality

APPENDIX D
ENVIRONMENTAL FEATURES ASSESSMENT

D1 INTRODUCTION

This appendix presents information regarding the environmental features associated with the Afon Tywi drought order. Baseline data and the impact assessments are presented for the environmental features that form part of the scope of the assessment (established by the screening exercise described in Section 3.2.2 of the Environmental Assessment Report (EAR), the results of which are summarised in Section 5.2). The features assessment presented in full below is summarised in Section 5.3 of the EAR. Points of interest referred to throughout the text are indicated in **Figure D1.1**.

The approach to the assessment addresses the following: i) potential effects on each sensitive receptor; ii) definitions for impacts (adverse / beneficial), i.e. the significance criteria (quantitative and / or qualitative measures used to grade the severity of impacts of the drought order for the impact criteria major, moderate, minor, negligible; following the requirements of the Drought Plan Guidance (DPG)); iii) the data requirements; iv) assessment methodology (including the treatment of uncertainty where the complete data requirements are not available).

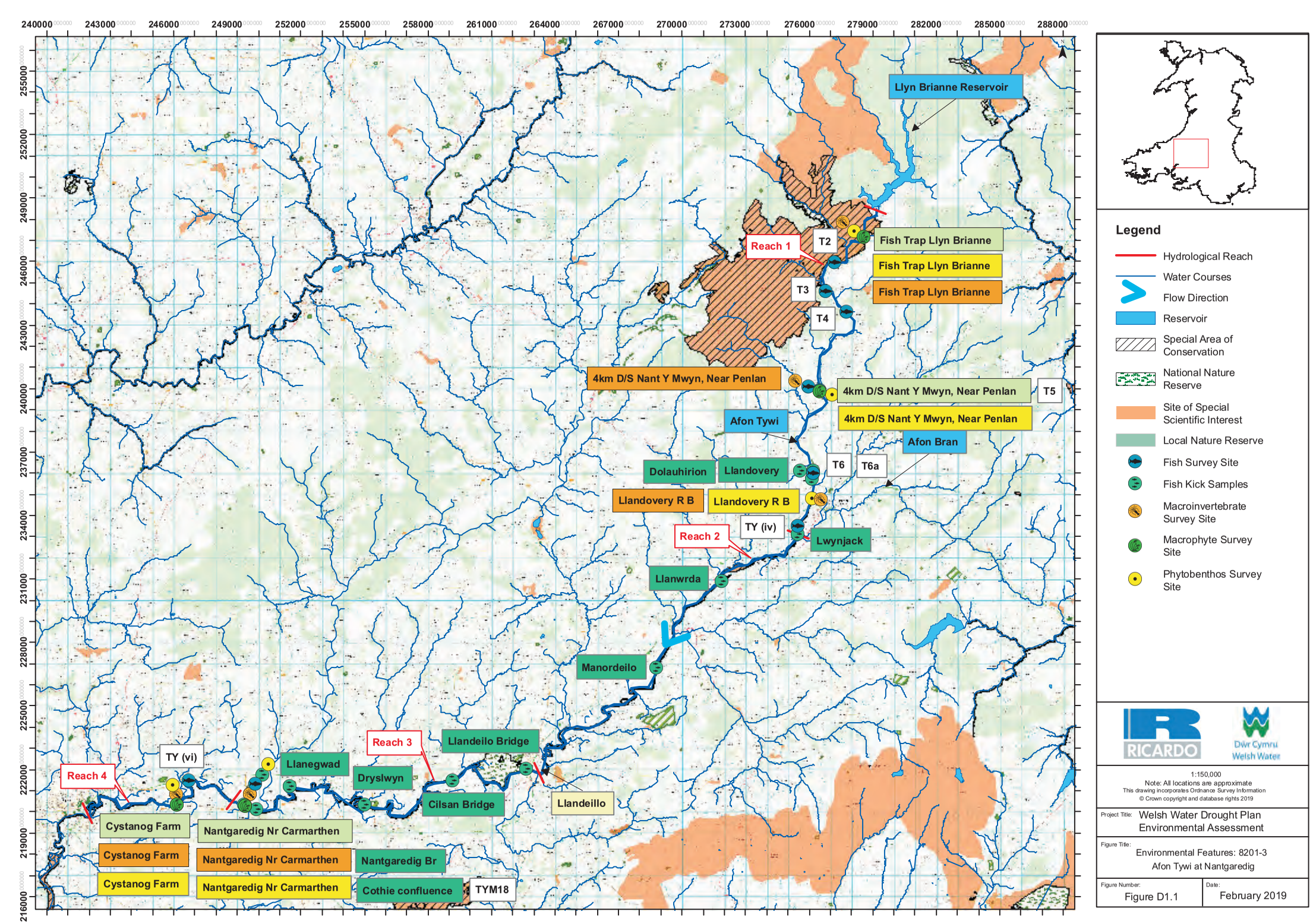
The assessment of environmental features is informed by the assessment of the physical environment (which includes hydrology and hydrodynamics; geomorphology; and water quality), this is summarised in Section 4 presented in full in **Appendix B**.

The ecological assessment has been undertaken recognising the Institute of Environmental Management and Assessment (IEMA)[1][2] and the Chartered Institute of Ecology and Environmental Management (CIEEM) study guidelines[3]. The assessment of impacts on other environmental receptors e.g. recreation and landscape has been carried out largely by qualitative expert judgement. Specific assessment methodologies for key environmental features are set out in **Appendix C**.

Desk-based assessments have been completed for each of the sensitive receptors, where applicable, in order to determine the magnitude of impact in the relevant river reaches for the Afon Tywi drought order. Each feature assessment describes the analyses carried out and a statement of the assessed impact. All impacts are considered to be negative / adverse unless otherwise stated in the feature assessment.

This appendix is set out in the following sections:

[1] IEMA (2004) Guidelines for Environmental Impact Assessment.
[2] IEMA (2011) Special Report – The State of Environmental Impact Assessment Practice in the UK
[3] CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland.



Legend

- Hydrological Reach
- Water Courses
- Flow Direction
- Reservoir
- Special Area of Conservation
- National Nature Reserve
- Site of Special Scientific Interest
- Local Nature Reserve
- Fish Survey Site
- Fish Kick Samples
- Macroinvertebrate Survey Site
- Macrophyte Survey Site
- Phytobenthos Survey Site

RICARDO

Dŵr Cymru Welsh Water

1:150,000

Note: All locations are approximate

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Environmental Features: 8201-3 Afon Tywi at Nantgaredig

Figure Number: Figure D1.1

Date: February 2019

D2 DESIGNATED SITES

D.2.1 Afon Tywi SSSI/SAC

D.2.1.1 Baseline

The Afon Tywi Special Area of Conservation (SAC) is designated for its important populations of Annex II species. Annex II species that are a primary reason for selection of this site are:

- 1103 Twaite shad *Alosa fallax*.
- 1355 Otter *Lutra lutra*.

Annex II species present as a qualifying feature, but not a primary reason for site selection:

- 1095 Sea lamprey *Petromyzon marinus*.
- 1096 Brook lamprey *Lampetra planeri*.
- 1099 River lamprey *Lampetra fluviatilis*.
- 1102 Allis shad *Alosa alosa*.
- 1163 Bullhead *Cottus gobio*.

The Afon Tywi supports a large spawning population of twaite shad, which is considered to be self-sustaining. Spawning sites occur throughout the lower reaches of the river between Carmarthen and Llangadog, with most spawning occurring downstream of Llandeilo.

The Afon Tywi is one of the best rivers in Wales for otters. There are abundant signs of otters and they are regularly observed on the river. However, there is evidence of only low levels of breeding within the SAC.

The Site of Special Scientific Interest (SSSI) is of interest for containing a diverse range of transitional landscapes, supporting a number of national scarce and nationally important fish, mammal, and invertebrate species. The site is also considered to be of national importance for its protected bird species as it holds approximately 4-5% of the total population of the little ringed plover *Charadrius dubius* and 1-2% of the British breeding population for sand martin *Riparia riparia*. Additional species of interest within the SSSI include: water crowfoot *Ranunculus penicillatus* spp., and invertebrate communities which inhabit shingle gravels.

D.2.1.2 Assessment

Hydrological impacts as a result of drought order implementation have been assessed as negligible in Reaches 1 to 3, and minor in Reach 4 (see Appendix B, Section B2.2). However, impacts will only occur during the most extreme low flows well below the Q_{99} flow value and only on occasional days, as the 7-day rolling average maintained flow of 136Ml/d means that

the 20Ml/d reduction in regulation releases could only be maintained for a few days at a time and would need to be balanced by increased releases on subsequent/preceding days.

Twaite shad (Annex II species that is a primary reason for selection) and allis shad (an Annex II species present as a qualifying feature) are present within Reaches 3 and 4. Sea lamprey, river lamprey, brook lamprey, and bullhead (Annex II species present as a qualifying feature) are present within Reaches 1 to 4. Impacts on these fish species have been assessed as negligible to moderate in Reaches 1 to 4 (see Section D3.3). Therefore, based on the implementation of the drought order , the overall impact on the Afon Tywi SAC is assessed as **minor adverse**.

European otter is a mobile species that can adapt to changes in river levels and may potentially benefit from easier predation of fish species, consequently they are not considered further.

Water crowfoot species are present in Reaches 3 and 4, and due to the species' sensitivity to changes in flow and nutrient levels, impacts have been assessed as negligible to minor (see Section D3.1.2). No impacts to little ringed plover or sand martin, which are features of interest of the Afon Tywi SSSI, are anticipated because although they are associated with the riparian environment, they are highly mobile species that are not fully dependent on the aquatic environment or water levels. Therefore, impacts on the macrophyte community mean the overall impact on the Afon Tywi SSSI is assessed as **minor adverse**.

D.2.2 Bishops Pond SSSI

D.2.2.1 Baseline

Bishops Pond is the best ox-bow lake example in West Wales, and is notable for its reed sweet-grass *Glyceria maxima* swamp area. Other notable species include bur reed *Sparganium erectum*, unbranched bur reed *Sparganium emersum*, and adders tongue fern *Ophioglossum vulgatum*.

The site at Bishops Pond is locally important for breeding birds including mute swan *Cygnus olor*, mallard *Anas platyrhynchos*, coot *Fulica atra*, moorhen *Gallinula chloropus*, dipper *Cinclus cinclus,* and the kingfisher *Alcedo atthis*.

Bishops Pond is a traditional stocked coarse fishery and contains tench *Tinca tinca*, pike *Esox lucius*, perch *Perca fluviatilis*, roach *Rutilus rutilus*, eel *Anguilla anguilla*, three-spined stickleback *Gasterosteus aculeatus,* and minnow *Phoxinus phoxinus*.

D.2.2.2 Assessment

It is unknown if there is hydrological connectivity between Bishops Pond and the Afon Tywi, however as impacts of the drought order will only occur at extreme summer low flows and will not reduce the Q_{95} or Q_{99} values, it is likely that any impacts above those caused by natural drought will be negligible. The bird community present is likely to utilise habitats present as part of a wider territory as they are highly mobile, as such will only be subject to negligible

impacts. Implementation is unlikely to affect the breeding success of the birds present above the impacts which will occur as a result of natural drought. Therefore, impacts to breeding bird populations are likely to be negligible.

The macrophyte community and notable species listed in the SSSI citation are associated with marginal habitats and as such can tolerate periodic desiccation. Therefore, impacts over and above those which will occur due to natural drought are considered to be **negligible**.

D.2.3 Carmarthen Bay and Estuaries SAC

D.2.3.1 Baseline

Carmarthen Bay and Estuaries SAC is designated for the following qualifying features:

- 1110 Sandbanks which are slightly covered by sea water all the time
- 1130 Estuaries
- 1140 Mudflats and sandflats not covered by seawater at low tide
- 1160 Large shallow inlets and bays
- 1310 Salicornia and other annuals colonizing mud and sand
- 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
- 1103 Twaite shad *Alosa fallax*
- 1095 Sea lamprey *Petromyzon marinus*
- 1099 River lamprey *Lampetra fluviatilis*
- 1102 Allis shad *Alosa alosa*
- 1355 Otter *Lutra lutra*

D.2.3.2 Assessment

The proposed drought order will lead to a reduction in freshwater low flows which could impact the hydrodynamics of the transitional waterbody. The reduction in freshwater flow could result in an increase in the flushing time (due to a reduced residual river flow velocity) and an alteration to the mixing characteristics, leading to a possible increase in saline intrusion distance and migration of the turbidity maximum upstream. There could also be a reduction in connectivity at low spring tide. These changes could result in effects to species composition, distribution and abundance (primarily in the mudflat and saltmarsh habitats, including invertebrate communities) and changes to migration patterns, spawning habitat and fish recruitment. However, these potential effects will be confined to the very upper estuarine section of the Afon Tywi, whereby the influence of freshwater input is likely to be more pronounced.

The physical processes within mudflat habitats are not driven by the freshwater inputs to the estuary alone, with tidal influences considered to be a more significant factor in determining the extent and quality of mudflat habitat. As such, the potential impacts of the drought order will mainly arise during low tide. The decrease in freshwater inputs will potentially have an

impact on both the sediment and nutrient dynamics within the mudflats. The mudflats support a variety of macroinvertebrate and phytobenthos species, the composition and abundance of which could be altered by the drought order.

Areas of saltmarsh are present in the upper estuary at Morfa Uchaf and further upstream to Trysordy. Sediment grain size is of particular importance to saltmarsh communities and decreased flows could potentially result in changes in the composition of deposited sediment leading to smothering of pioneer communities and a change in nutrient availability, with fewer nutrients being transported into the estuary. In drought conditions the marsh may become hypersaline, with potential desiccation in areas reliant on freshwater seepages and inflow, which could be compounded by the drought order. This could lead to changes in community composition and potential reductions in productivity, the effects of more significance in any brackish zone at the transition between the saline and fresh waters.

The Carmarthen Bay and Estuaries Special Area of Conservation feature condition assessment[4] concluded that the twaite and allis shad populations were in unfavourable condition, primarily due to water quality issues in the estuary. Spawning is known to occur below Nantgaredi, in late summer with the fish migrating through the estuary between March and May which is dependent on water temperatures (10-12^{0}C acts as a trigger for migration). Juveniles migrate downstream to the estuary between August and October. The hydrological impacts of the drought order could therefore interact with these downstream migrations. The estuary is also considered to be an important nursery area before migration to the sea in winter, with the possibility of some juveniles overwintering in the estuary.

The Carmarthen Bay and Estuaries Special Area of Conservation feature condition assessment[5] concluded that the sea and river lamprey populations were in unfavourable condition, primarily due to water quality issues in the estuary.

Mature river lamprey migrate upstream into freshwater in the autumn (from October to December[6]), descending to estuarine and marine environments between July and September in smaller rivers**Error! Bookmark not defined.** after three to five years. Upstream migration requires a reasonable flow of water to aid passage past natural and non-natural in-channel barriers. Low flows in the upper estuary may limit upstream passage and hinder downstream passage, leaving both migratory life stages exposed to higher risks of predation and ultimately a reduction in recruitment. River lamprey also use the estuary as feeding areas, and nursery habitat, therefore it should be assumed that juveniles are present throughout the year.

Adult sea lampreys migrate through the estuary between March and June to reach their

[4] Natural Resources Wales (2018) Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd Special Area of Conservation: Indicative site level feature condition assessments 2018. NRW Evidence Report Series, Report No: 225, 49pp, NRW, Bangor.
[5] Natural Resources Wales (2018) Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd Special Area of Conservation: Indicative site level feature condition assessments 2018. NRW Evidence Report Series, Report No: 225, 49pp, NRW, Bangor.
[6] Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura2000 Rivers Ecology Series No.5. English Nature, Peterborough

spawning grounds on the River Tywi. Juvenile sea lampreys migrate through the estuary between December and June, and may feed in the estuary before moving offshore. The drought order is most likely to occur in the autumn, and not outside the period September to November. It is therefore unlikely to significantly affect upstream or downstream migration, but could affect feeding areas and nursery habitats.

The impacts associated with implementation of the drought order over and above those which will occur due to natural drought are considered to be **negligible**.

Summary

The potential impacts of the Afon Tywi Reservoir drought order on the designated sites are summarised in **Table D2.2**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability; see Section 4.3 of the main report) and the sensitivities of the key species of the designated sites. The impacts presented in **Table D2.2** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D2.2 Summary of Impacts on Designated Sites

Feature	Impact	Significance of Impact
Afon Tywi SAC	• Impacts on juvenile river, sea and brook lamprey, brook lamprey (Annex II species for which the SAC has been designated) have been assessed as minor in Reach 4 during drought order implementation	**Minor**
Afon Tywi SSSI	• Impacts on water crowfoot *Ranunculus penicillatus* spp (species of interest within the SSSI) have been assessed as minor in Reach 3 and 4 during drought order implementation.	**Minor**
Bishops Pond SSSI	• The features for which these sites are designated are not anticipated to be in hydrological connectivity with the impacted reach of the Afon Tywi.	**Negligible**
Cwm Doethie – Mynydd Mallaen SAC/ SSSI	• The features for which these sites are designated are not anticipated to be in hydrological connectivity with the impacted reach of the Afon Tywi.	**Negligible**
Carmarthen Bay and Estuaries SAC	• Impacts associated with drought order implementation on the features for which the site is designated are considered to be negligible.	**Negligible**

D3 WFD STATUS AND COMMUNITY ASSESSMENT

D.3.1 Macrophytes

D.3.1.1 Baseline

Baseline data has been provided by Natural Resources Wales (NRW) for four macrophyte monitoring sites on the Afon Tywi: Fish Trap Llyn Brianne site and 4km D/S Nant Y Mwyn in Reach 1; Nantgaredig Nr Carmarthen in Reach 3; Cystanog Farm in Reach 4. Due to the paucity of data within the impacted reach, historic survey results from 2003 and results from Nantgaredig Nr Carmarthen site immediately upstream of Reach 1 have been included to

provide additional context.

Reaches 1 and 2 are located in the Tywi - Llyn Brianne to confluence with Doethie (GB110060036380) and Tywi - conf with Doethie to conf with Llandovery Bran (GB110060036350) WFD waterbodies respectively; for which the macrophyte and phytobenthos combined component are currently classified as being of Good status in the 2018 cycle 2 interim classification. Reaches 3 and 4 are located in the Tywi - confluence with Cothi to spring tidal limit (GB110060029290) WFD water body; for which the macrophyte and phytobenthos combined component is currently classified as being of Good status in the 2018 cycle 2 interim classification.

Considering the spatial and temporal constraints on the baseline information, which are not considered to be sufficient to characterise the whole watercourse, care must be taken in their interpretation. In addition to the possible changes to environmental conditions and therefore macrophyte communities over time, the changes in macrophyte survey methods for the development of the LEAFPACS classification system (i.e. expanded recorded taxa list, particularly in relation to riverine bryophytes) in the intervening period mean that the data available may not represent as complete a record of the macrophyte community as would be gathered by current macrophyte monitoring protocols.

The description and assessment provided below is based on the assumption that the data available provides a relatively reliable representation of the likely communities present within the impacted reaches.

Macrophyte analysis results were provided by NRW using the standard LEAFPACS2 methodology[7] in accordance with the requirements of the Water Framework Directive (WFD). This methodology is based on the principle that different combinations, quantities, and numbers of macrophytes are associated with different flow conditions and nutrient availability in a river. The LEAFPACS2 method assesses the condition of river macrophyte communities using data on presence and abundance of species and groups of species recorded during a standard survey comprising a 100m river section. These indices are briefly described below:

(i) River Macrophyte Nutrient Index (RNMI): an index of eutrophication (high scores indicate enriched conditions);

(ii) Number of macrophyte taxa which are truly aquatic, i.e. hydrophytes (NTAXA);

(iii) Number of functional groups of macrophyte taxa which are hydrophytes (NFG): an assessment of the structural diversity of the plant community; and

(iv) Percentage cover of all green filamentous algal taxa over the whole of the surveyed river sections (ALG).

In addition to the above scores, River Macrophyte Hydraulic Index (RMHI), observed Mean

[7] WFD-UKTAG (2014) UKTAG river assessment method – macrophytes and phytobenthos (River LEAFPACS2).

Trophic Rank (MTR), and Macrophyte Flow Ranking (MFR) scores were also provided. **Table D3.1** provides a summary of RMNI, MTR and MFR scores recorded at sites within the study reach. RMNI and RMHI are biotic indices used to determine the nutrient preference and flow preference of macrophyte communities respectively, and are updated versions of the MTR and MFR biotic indices. To calculate RMNI scores, macrophyte communities are identified and assessed on a scale of 1 to 10 based on individual species cover values and their combined preference for nutrient enrichment. High scores are associated with communities in eutrophic waters, low scores are associated with oligotrophic waters. Following the same premise communities with high RMHI scores are associated with low energy flow velocities and low scores are associated with high energy flow velocities. **Table D3.2** and **Table D3.3** identify the interpretation of MFR and MTR scores.

Table D3.1 Macrophyte Survey Sites on the Afon Tywi

Site/Station Name	Reach	Site/Station Location	Sample Date	MTR	MFR	RMNI	RMHI
Fish Trap Llyn Brianne	1	SN7859947169	Aug 2003	73.3	3.4	3.35	4.68
			Jul 2007	86.7	3.25	2.7	4.08
4km D/S Nant Y Mwyn, Near Penlan	1	SN7653739887	Jul 2003	81.1	3.64	3.45	4.57
			Aug 2007	78.9	3.53	3.98	4.96
Nantgaredig Nr Carmarthen	3	SN4935620284	12-Aug-03	50	3	6.32	6.48
			09-Aug-07	50.6	3.13	5.81	5.95
			12-Sep-12	64	3.2	5.41	5.93
			02-Jul-14	55.9	2.89	5.59	5.87
Cystanog Farm	4	SN461650325	19-Aug-03	33.3	2.86	7.18	6.95
			09-Aug-07	51.3	2.63	6.24	6.24

Table D3.2 Interpretation of MFR Scores Used for this Assessment

MFR Score	Interpretation of Score
1	Community preferring slow flow velocity
2	Community preferring slow to moderate flow velocity
3	Community preferring moderate flow velocity
4	Community preferring moderate to fast flow velocity
5	Community preferring fast flow velocity

Table D3.3 Interpretation of MTR Scores (from Holmes *et al.*, 1999[8])

MTR Score	Interpretation of Score
<25	Site is badly damaged by eutrophication, organic pollution, toxicity or is physically damaged.
25-65	Site is likely to be either eutrophic or at risk of becoming eutrophic
>65	Site is unlikely to be eutrophic

Reaches 1 and 2 – upper Afon Tywi

RMNI scores in Reach 1 of the Afon Tywi range from 2.7 to 3.98, and indicate oligotrophic to mesotrophic conditions. Scores were slightly higher further downstream at the 4km D/S Nant Y Mwyn site. MTR scores in the Afon Tywi were very high and comparable across the impacted reaches, with a range of 73.3 to 86.7. This is indicative of macrophyte communities not affected by nutrient enrichment.

RMHI scores in Reach 1 of the Afon Tywi range from 4.08 to 4.98, indicating macrophyte communities associated with moderate to high energy flow velocities. This is consistent with the upland nature of the impacted reaches. This is also shown by the MFR scores which indicate communities with a preference for moderate to fast flow velocities.

The macrophyte community is dominated by bryophytes with good species diversity across both survey sites in Reach 1. Emergent species, submerged vascular plants and algae were present but not extensive at the survey sites in Reach 1. No baseline macrophyte data was received for Reach 2, so communities present are assumed to be similar to those present in Reach 1.

Reaches 3 and 4 – lower Afon Tywi

RMNI scores in Reaches 3 and 4 range from 5.41 to 7.18, and indicate mesotrophic to eutrophic conditions. RMNI scores were higher at the downstream Cystanog Farm site in Reach 4, and were elevated during 2003 at both sites. MTR scores in the Afon Tywi range from 33.3 to 64.0. The majority of scores are indicative of a community that is either eutrophic or at risk of becoming eutrophic. The highest score of 64, recorded at the Nantgaredig Nr Carmarthen site in 2012, is very high as scores of >65 indicative of a community not impacted by nutrient enrichment. The lowest score was recorded at the Cystanog farm site in 2003 and is notably lower than the majority of MTR results from both sites.

RMHI scores in Reaches 3 and 4 range from 5.87 to 6.95, indicating a macrophyte community associated with slow to moderate flowing conditions. This is consistent with the lowland nature of the reach. This is also shown by the MFR scores, which indicate a community with a

[8] Holmes, N T H, Newman, J R, Chadd, S, Rouen, K J, Saint, L and Dawson, F H (1999) *Mean Trophic Rank: A Users Manual.* R&D Technical Report E38, Environment Agency, Bristol.

preference for slow to moderate flows.

The macrophyte community in Reaches 3 and 4 are dominated by bryophytes with good species diversity across both survey sites. Emergent species, submerged vascular plants, and algae were present but not extensive in at the survey sites in reaches 3 and 4. The bryophyte dominated community contained some acidic indicator species, and is adapted to slow to moderate flow conditions.

Notable species

Three notable bryophytes were identified from NRW monitoring data: yellowish fork-moss *Dichodontium flavescens*, an unidentified bog moss *Sphagnum* species, and a water crowfoot *Ranunculus* (*Batrachian*) species. Details of the designations and records of percentage cover are shown in **Tables D3.4** and **D3.5** respectively.

Water crowfoot *Ranunculus* (*Batrachian*) spp. are susceptible to changes in flow rates and water quality due to specific habitat requirements. *Ranunculus* spp. was recorded at survey sites in Reaches 3 and 4, with peak cover of 2.5-5% at the Nantgaredig Nr Carmarthen site in 2003.

Yellowish fork-moss was only recorded on one occasion, with low abundance at the 4km D/S Nant Y Mwyn in Reach 1. Yellowish fork-moss most frequently occurs on gravel and silted rocks by streams and rivers where there is some base-enrichment, as well as on lake margins where stands can be large, but it also occurs in a range of other wet or damp habitats[9].

Bog mosses *Sphagnum* sp. are found in a wide range of permanently damp or wet habitats, including fens, pools, blanket bogs, valley mires, and beside flushes or running watercourses.

Table D3.4 Notable Macrophyte Designations

Species	Common name	Designation	Reporting category	Designation description
Dichodontium flavescens	Yellowish fork-moss	Nationally scarce	Rare and scarce species (not based on IUCN criteria)	Occurring in 16-100 hectares in Great Britain.
Sphagnum sp.	Bog mosses	Annex 5	Habitats Directive	Animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures.

[9] British Bryophyte Society (2010) Mosses and Liverworts of Britain and Ireland a field guide. Species information Page 361: Dichodontium pellucidum/flavescens Transparent/Yellowish Fork-moss. Key 212,232

Table D3.5 Notable Macrophyte Records within the Impacted Reaches

Site/Station Name	Sample Date	Percentage cover (%)		
		Dichodontium flavescens	*Sphagnum* sp.	Ranunculus (Batrachian) spp.
Fish Trap Llyn Brianne	Aug 2003	-	0 - 0.1	-
	Jul 2007	-	0.1 - 1	-
4km D/S Nant Y Mwyn, Near Penlan	Jul 2003	0 - 0.1	-	-
	Aug 2007	-	-	-
NANTGAREDIG NR CARMARTHEN	Aug 2003	-	-	2.5 < 5
	Sep 2012	-	-	< 0.1
CYSTANOG FARM	Aug 2003	-	-	< 0.1

D.3.1.2 Assessment

Hydrological impacts as a result of drought order implementation have been assessed as negligible in Reaches 1 to 3, and minor in Reach 4 (see **Appendix B**, Section B2.2). However, impacts will only occur during the most extreme low flows well below the Q_{99} flow value and only on occasional days, as the 7-day rolling average maintained flow of 136Ml/d means that the 20Ml/d reduction in regulation releases could only be maintained for a few days at a time and would need to be balanced by increased releases on subsequent/preceding days.

The assessment of impacts on the macrophyte community should be considered in the context of the watercourse under drought and experiencing an extreme low flow event. Baseline data indicates that the macrophyte communities in the hydrological zone of influence of the drought order are bryophyte dominated, and are adapted to a wide range of flow velocities across the impacted reaches from slow to fast. Reduction in flows could affect macrophyte communities in a number of ways:

- Reduction in velocity favouring species adapted to slower flow conditions.
- Desiccation of macrophytes due to reduced wetted width and water depth.
- Encroachment of marginal emergent species into the channel.
- Reduction or movement of the splash zone from where this usually occurs, both at the edges of the channel and around in-stream features such as boulders and exposed bedrock, leading to desiccation of species present within these areas, particularly bryophytes.
- Proliferation of filamentous algae due to decreases in velocity, increases in water temperature, and water quality deterioration.
- Shading of macrophytes by epiphytic algae, due to decreases in velocity, increases temperature, water quality deterioration.

The risk of water quality deterioration associated with soluble reactive phosphorus (SRP) is negligible for Reaches 1-3 and low for Reach 4. This could encourage some macrophyte growth and potentially increase the occurrence of more opportunistic taxa, epiphytes and filamentous algae. In turn, this could affect macrophyte condition or potentially community composition if slower growing species or those that prefer lower nutrient conditions are outcompeted.

The macrophyte communities present contain a high proportion of bryophytes which are generally well adapted to tolerate desiccation and rewetting, and communities can take a long time to react to changes in environmental conditions[10].

The impacts of the drought order implementation are expected to result in negligible impacts on flow in Reaches 1-3. The impacts of the drought order on the macrophyte communities of Reaches 1-3 are expected to be **negligible**.

In Reach 4 drought order will result in a reduction in extreme low flows (significantly below Q_{99}) on occasional days for up to a week at a time during the September to November period, assessed as a minor hydrological impacts, therefore limiting the potential for changes to community structure over and above the impacts occurring during the natural drought. It is expected that any effects on the macrophyte community would be reversed following return to the normal hydrological regime. The macrophyte community in Reach 4 is associated with slow to moderate flowing conditions. The impacts of the drought order on the macrophyte communities of Reach 4 are expected to be **negligible**.

Notable species

Yellowish fork-moss is likely to be susceptible to changes in water level and wetted width as described for the macrophyte community above. However, hydrological impacts in Reach 1 are expected to be negligible and impacts on yellowish fork-moss are therefore assessed as negligible

Bog mosses *Sphagnum* sp. do not typically grow in flowing habitats, and as such will not be susceptible to changes in flow velocity. However due to dependence on wet and damp marginal habitats, they may be susceptible to reductions in wetted width and depth. Nevertheless, as bog mosses are not dependent on being submerged, the timing of impacts outside of the growing season, and the resilience of bryophytes to temporary desiccation, the impacts are likely to be **negligible**.

Water crow-foot species are typically associated with moderate to fast flowing habitats, and as such are sensitive to changes in flow rates. Water crowfoot species will be subject to the same impacts relating to reduced flow as described for the macrophyte community as a whole. The reduction in flow in combination with increased SRP concentrations may result in an increase in epiphytic algae growth which, in extreme cases, can smother water crow-foot and reduce

[10] Demars, B. O. L. and Britton, A. (2011). Assessing the impacts of small scale hydroelectric schemes on rare bryophytes and lichens. *Scottish Natural Heritage and Macaulay Land Use Institute Funded Report. Scottish Natural Heritage Commissioned Report No.421*

growth rates. Stable summer flows are important in maintaining the condition of water crow-foot and inhibiting the build-up of epiphytic algae. Consequently, impacts to water crowfoot species in Reaches 3 and 4 as a result of implementation are expected to be **negligible** and **minor adverse** respectively.

Summary

The potential impacts of the Afon Tywi drought order on the macrophyte community are summarised in **Table D3.6**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability; see Section 4.3 of the main report) and the sensitivities of the macrophyte community. The impacts presented in **Table D3.6** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.6 Summary of Impacts on Macrophyte Community

Feature	Impact	Significance of Impact
Reach 1		
Macrophytes	• Reduction in growth as a result of impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Changes to community composition relating to water quality deterioration	**Negligible**
Yellowish fork-moss	• Changes to inundation pattern and splash due to changes in flow.	**Negligible**
Bog mosses *Sphagnum* sp.	• Changes to inundation pattern and splash due to changes in flow.	**Negligible**
Reach 2		
Macrophytes	• Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Changes to community composition relating to water quality deterioration	**Negligible**
Reach 3		
Macrophytes	• Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Changes to community composition relating to water quality deterioration and increased occurrence of epiphytes and algae	**Negligible**
Water crow-foot	• Reduction in growth as a result of impacts on water levels and flows. • Reduction in habitat suitability due to water quality deterioration and increased occurrence of epiphytes and algae	**Negligible**
Reach 4		
Macrophytes	• Reduction in growth as a result of impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Changes to community composition relating to water quality deterioration and increased occurrence of epiphytes and algae • Encroachment of marginal emergent species into the channel	**Minor**

Water crow-foot	• Reduction in growth as a result of impacts on water levels and flows. • Reduction in habitat suitability due to water quality deterioration and increased occurrence of epithytes and algae	**Minor**

Impacts of drought order implementation on the macrophyte communities of the reaches have been summarised as **negligible** in Reaches 1-3. Consequently, there is a **negligible** risk of short term deterioration of the macrophytes component of the Tywi - Llyn Brianne to confluence with Doethie (GB110060036380), Tywi - conf with Doethie to confluence with Llandovery Bran (GB110060036350) and Tywi – conf with Llandovery Bran to conf Cothi (GB110060036250)WFD waterbodies. In addition, there is **minor** risk of short term deterioration of the macrophyte component of the Tywi - confluence with Cothi to spring tidal limit (GB110060029290) water body.

D.3.2 Macroinvertebrates

D.3.2.1 Baseline

Baseline data has been provided by NRW for six macroinvertebrate monitoring sites on the Afon Tywi, including four in Reach 1 (U/S R.B. Nr Llwyndinawed, 4km D/S Nant Y Mwyn, Near Penlan, Llandovery R B, Fish Trap Llyn Brianne) one in Reach 3 (Nantgaredig Nr Carmarthen), and one in Reach 4 (Cystanog Farm) The data provided includes standard biotic indices associated with flow rate and water quality: Biological Monitoring Working Party (BMWP) score, Average Score Per Taxon (ASPT) scores, and Lotic Invertebrate Flow Evaluation (LIFE) index. The scores for LIFE, ASPT and BMPW in the period 2005 to 2015 inclusive are shown in **Figures D3.1 – D3.2, Figures D3.3 – D3.4**, and **Figures D3.5 – D3.6** respectively.

The LIFE scores in Reach 1 were high and comparable across all monitoring sites with a range from 7.5 to 8.67 and an average of 7.86 across all sites between 2005 and 2015. This indicates the presence of taxa that favour predominately fast velocity habitats and have a high sensitivity to reductions in flow velocity.

LIFE scores Reaches 3 and 4 of the Afon Tywi ranged from 6.96 to 8.19 with an average of 7.72 between 2005 and 2015. This indicates the presence of invertebrate families that favour predominately moderate to fast velocity habitats with a high sensitivity to reductions in flow velocity. There appears to be a slight overall increase in LIFE scores from 2005 to 2015 with the exception of a notably low score at the Cystanog Farm site in 2010.

Figure D3.1 Observed Family LIFE Scores for Reach 1 of the Afon Tywi

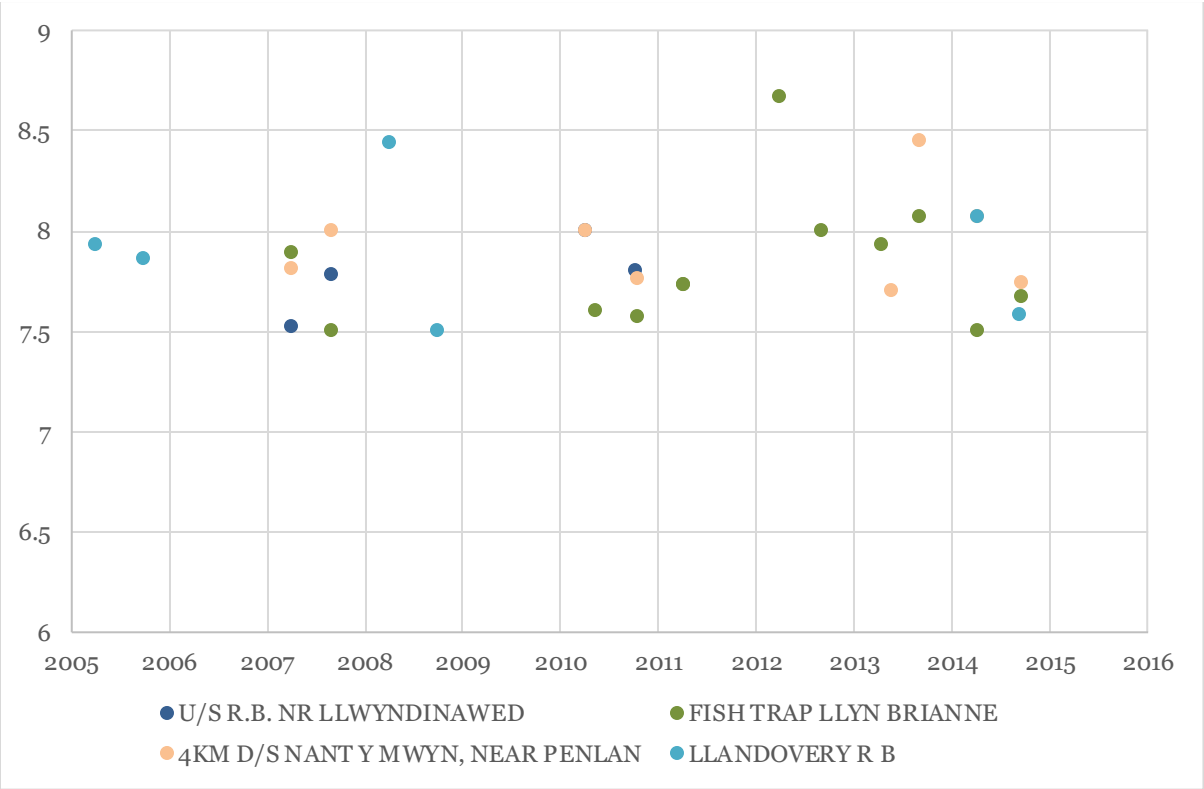
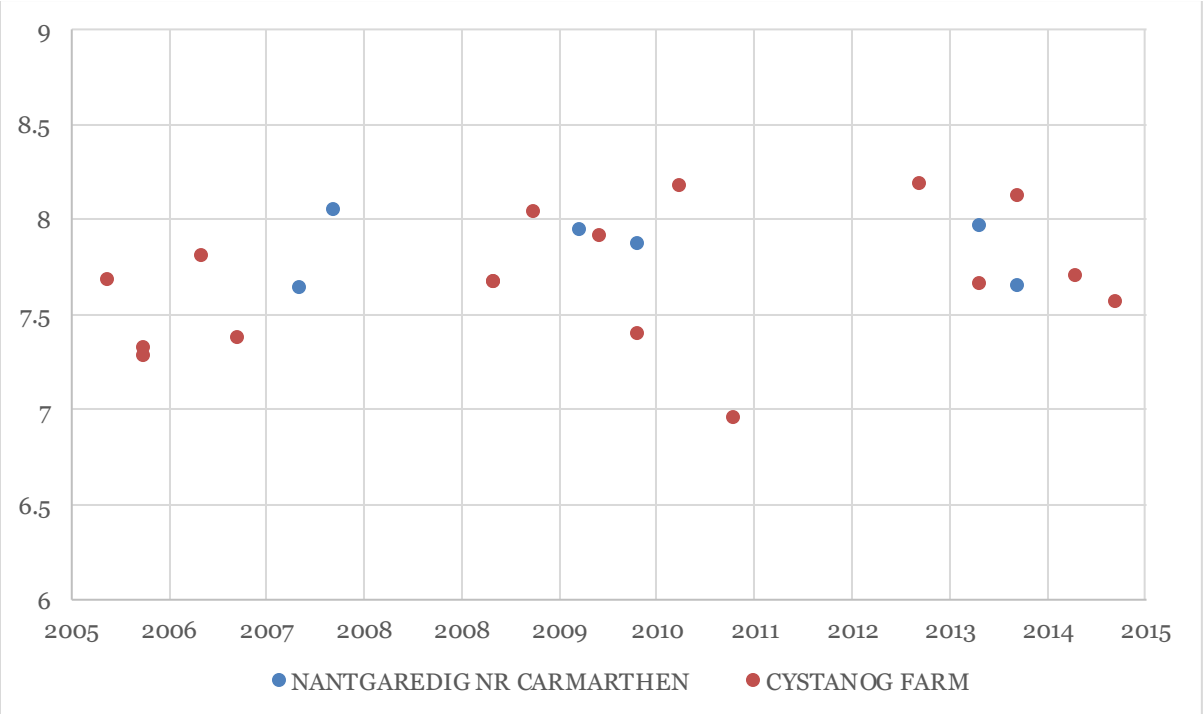


Figure D3.2 Observed Family LIFE Scores Reaches 3 and 4 of the Afon Tywi



There are no quality bands for BMWP scores and ASPT scores. However, as a guide, BMWP scores of 200 with ASPT values above six are indicative of rivers of exceptionally good quality, while BMWP scores of 100 with ASPT values of five are indicative of reasonably good water

quality.

ASPT scores in Reach 1 were high across and comparable across all monitoring sites with a range from 4.63 to 7.1 with an average of 6.40, which indicates exceptional water quality and the presence of community with high sensitivity to changes in water quality. ASPT scores were most variable at the Fish Trap Llyn Brianne site in Reach 1, which shows intermittent reductions in ASPT scores in autumn 2007 and 2010.

BWMP scores in Reach 1 were highly variable, with a range from 37 to 170 and an average of 116 across all monitoring sites. This is indicative of moderate but variable water quality and species diversity, with macroinvertebrate communities subject to minor anthropogenic impacts. There appears to be an overall trend of decreasing BMWP scores from 2005 to 2015. The Fish Trap Llyn Brianne site in Reach 1 has significantly lower and more variable BMWP scores then monitoring points in lower reaches, indicating fluctuations in water quality and species diversity.

ASPT scores in Reaches 3 and 4 of the Afon Tywi were high across both sites with a range from 6 to 7 with an average of 6.47, which indicates exceptional water quality and the presence of community with high sensitivity to changes in water quality. BWMP scores in Reaches 3 and 4 were highly variable, with a range from 104 to 244 and an average of 177 across both monitoring sites. This is indicative of good to exceptional water quality and good species diversity, with macroinvertebrate communities only subject to minimal anthropogenic impacts.

Figure D3.3 Observed Family APST Scores for Reach 1 of the Afon Tywi

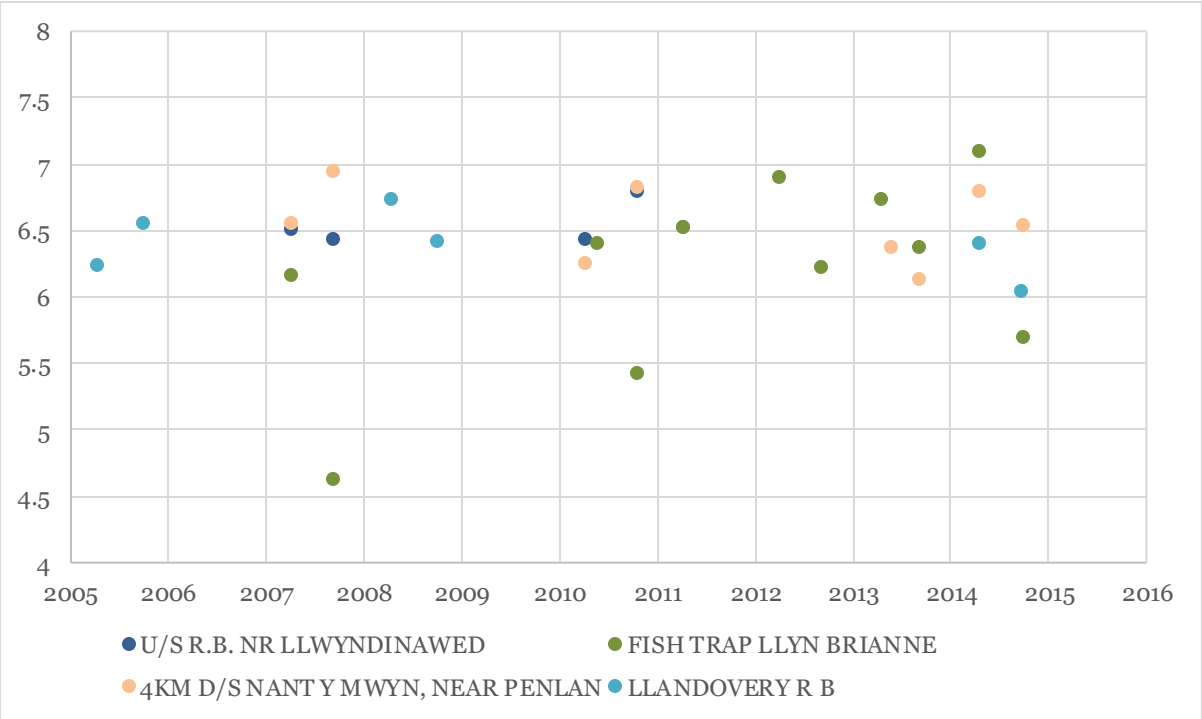


Figure D3.4 Observed Family BMWP Scores for Reach 1 of the Afon Tywi

Figure D3.5 Observed Family ASPT Scores for Reaches 3 and 4 of the Afon Tywi

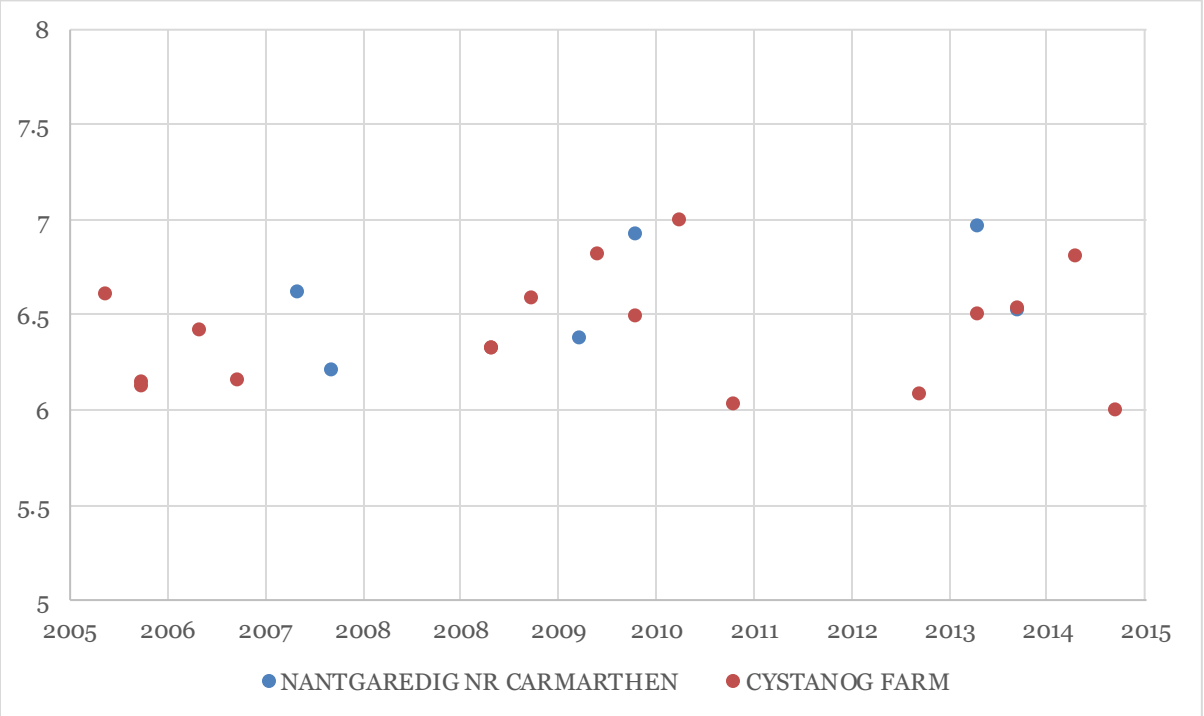
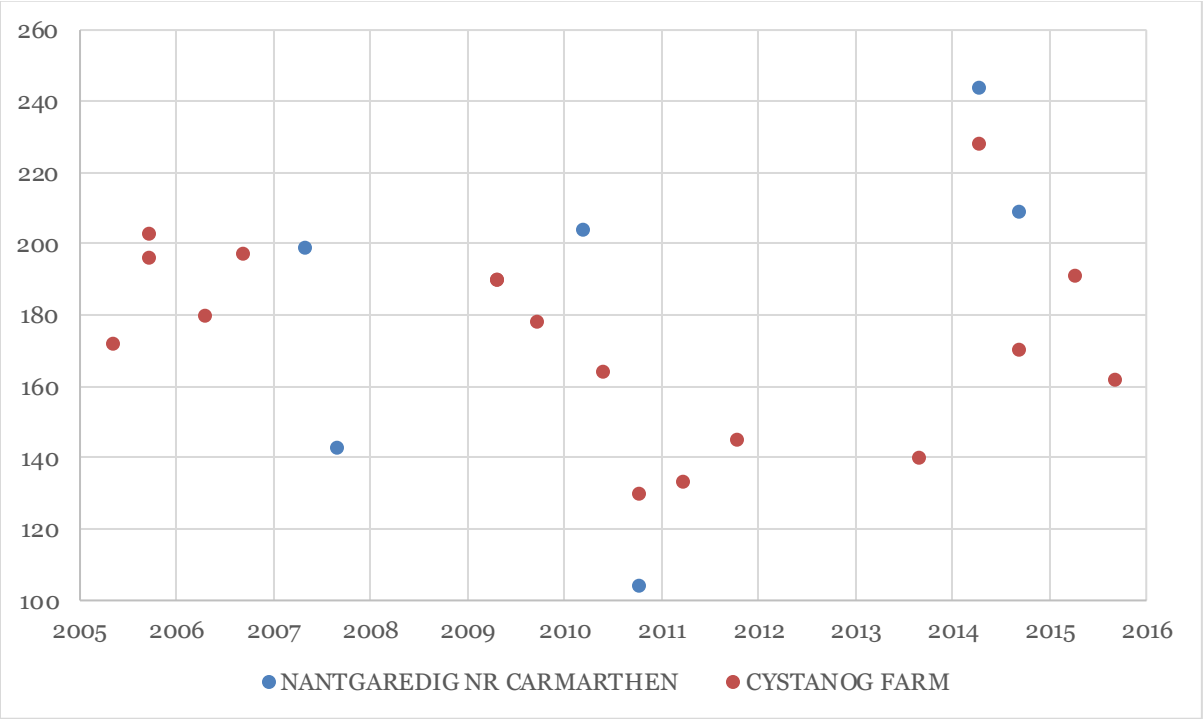


Figure D3.6 Observed Family BWMP Scores for Reaches 3 and 4 of the Afon Tywi



Notable species

The citation for the Afon Tywi SSSI[11] reports that freshwater pearl mussel *Margaritifera margaritifera* have historically been recorded in the lower part of the river. However, the current status of the population is unclear, and they are possibly extinct in the catchment[12] [13]. If present, freshwater pearl mussels are likely to be confined to the stretch of river between Nantgaredig and Carmarthen[14] [15]. Therefore, as a precautionary approach for the purpose of this assessment freshwater pearl mussels are considered to be present in Reach 4.

The Afon Tywi SSSI citation reports that the IUCN red list near threatened common club tail dragonfly *Gomphus vulgatissimus* is present in the river, however it was not recorded in the monitoring data received from NRW. As the drought order will have hydrological impacts along the length of the river, it has been included in the assessment as a precautionary approach.

[11] Countryside Council for Wales (1998) Site of Special Scientific Interest citation: Afon Tywi
[12] Killeen, I.J. (1999) The Status and Distribution of the Freshwater Pearl Mussel (Margaritifera margaritifera [L., 1758]) in Wales: 1998/99 Survey of the Afon Taf and Afon Tywi. CCW Contract Science Report
[13] Killeen, I.J. (2007) A survey of welsh rivers supporting populations of the freshwater pearl mussel Margaritifera margaritifera (L., 1758). CCW Contract Science No. 770.
[14] Killeen, I.J. (1999) The Status and Distribution of the Freshwater Pearl Mussel (Margaritifera margaritifera [L., 1758]) in Wales: 1998/99 Survey of the Afon Taf and Afon Tywi. CCW Contract Science Report
[15] Killeen, I.J. (2007) A survey of welsh rivers supporting populations of the freshwater pearl mussel Margaritifera margaritifera (L., 1758). CCW Contract Science No. 770.

Table D3.7 Notable Macroinvertebrate Designations

Species	Designation	Reporting Category	Designation description
Freshwater pearl mussel *Margaritifera margaritifera*	Habitats Directive	Annex 2 - non-priority species	Animal and plant species of Community interest whose conservation requires the designation of special areas of conservation.
	Habitats Directive	Annex 5	Animal and plant species of Community interest whose taking in the wild and exploitation may be subject to management measures.
	NERC Act 2006 - Species of Principal Importance in Wales (section 42)	Biodiversity Lists - Wales	Species "of principal importance for the purpose of conserving biodiversity" covered under Section 42 (Wales) of the NERC Act (2006).
	The IUCN Red List of Threatened Species (2010)	Endangered	Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating.
	Wildlife and Countryside Act Schedule 5	Schedule 5, Section 9	Species protected against intentional killing, injury, disturbance, and damage or destruction of a place of rest
Common club tail dragonfly *Gomphus vulgatissimus*	Near Threatened	Red listing based on 2001 IUCN guidelines	Taxa which do not qualify for Lower Risk (conservation dependent), but which are close to qualifying for Vulnerable. In Britain, this category includes species which occur in 15 or fewer hectads but do not qualify as Critically Endangered, Endangered or Vulnerable.

D.3.2.2 Assessment

Hydrological impacts as a result of drought order implementation have been assessed as negligible in Reaches 1 to 3, and minor in Reach 4 (see **Appendix B**, Section B2.2). However, impacts will only occur during the most extreme low flows well below the Q_{99} flow value and only on occasional days, as the 7-day rolling average maintained flow of 136Ml/d means that the 20Ml/d reduction in regulation releases could only be maintained for a few days at a time and would need to be balanced by increased releases on subsequent/preceding days.

As the drought order is anticipated to result in minimal reductions in wetted width (up to -2.5%) in Reach 4 only, the risk of marginal habitat loss (utilised by some macroinvertebrate taxa) is likely to be low, short-term and reversible. However, species in these marginal sediments, such as molluscs, may become stranded and ultimately die. Reductions in velocity up to -9.2% in Reach 4 only may increase stress amongst flow sensitive taxa, resulting in their loss from the reach. As the LIFE scores for the sites in Reach 4 indicate taxa with a preference for moderate to fast flows, it is likely that in the short-term this impact will modify the macroinvertebrate community, with a loss of species which prefer fast flows and the potential proliferation of invertebrates which favour slower flows.

The risk of water quality deterioration due to dissolved oxygen is negligible in Reaches 1-3 and low in Reach 4. The BMWP and ASPT scores indicate the presence of macroinvertebrate communities with a high proportion of taxa sensitive to decreases in dissolved oxygen. Temporary reductions in these scores suggest the community is adapted to short term deteriorations in water quality, before recovering in following seasons. There is a minor risk

in Reach 4 that this impact could modify the macroinvertebrate community, resulting in a reduction in abundance of species which require high oxygen levels (such as stonefly and mayfly species) and proliferation of taxa which can tolerate lower dissolved oxygen levels. The risk of water quality deterioration due to ammonia is also low for all impacted reaches. A number of crustacean taxa such as the freshwater shrimps (Gammaridae) are particularly sensitive to ammonia. However, as the risk of water quality deterioration related to ammonia and dissolved oxygen is low, there is unlikely to be significant impacts to the macroinvertebrate community.

The drought order will result in a reduction in extreme low flows only (significantly below Q_{99}) for the September to November period, therefore, limiting the potential for changes to community structure over and above the impacts occurring during the natural drought. It is expected that any effects on the macroinvertebrate community would be reversed following return to the normal hydrological regime. Recovery following cessation of the drought order will be aided by the presence of the less impacted Reaches 1-3 and the un-impacted tributaries of the Afon Tywi which will provide a source for the downstream migration (drift) and recolonisation of macroinvertebrates.

Overall, impacts on the macroinvertebrate community are assessed as **negligible** for Reaches 1 to 3, and **minor adverse** for Reach 4.

Notable species

Freshwater pearl mussels have previously been recorded in the Afon Tywi. If present within the impacted reaches, freshwater pearl mussels may be affected by the drought order, however, without information on locations and population densities it is not possible to accurately assess the magnitude of impacts on this receptor. Taking a precautionary approach, the assessment below assumes the presence of Freshwater pearl mussels within flow sensitive areas of the channel within Reach 4.

Freshwater pearl mussels live buried or partly buried in coarse sand and fine gravel in clean, oligotrophic, fast-flowing and unpolluted rivers and streams. As a result, they are susceptible to reductions in flow velocities, as it increases the suitability for formation of algal mats and reduces interstitial water column mixing.

The reduction in flow and wetted width as a result of the drought order may result in the uncovering of shallow riffle areas and the aggregation of detrital silt potentially causing death of mussels due to desiccation and reduced habitat area / suitability for both adult and juvenile mussels. Therefore, due to reduction in flow and wetted width and potential changes to algal coverage due to the low risk of increased SRP (see Appendix B), the impacts on freshwater pearl mussels, over and above those occurring during a natural drought are assessed as **minor adverse** and irreversible (as the population present is unlikely to be recruiting in Reach 4).

Summary

The potential impacts of the Afon Tywi drought order on the macroinvertebrate community

are summarised in **Table D3.8**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability; see Section 4.3 of the main report) and the sensitivities of the macroinvertebrate community. The impacts presented in **Table D3.8** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.8 Summary of Impacts on Macroinvertebrate Community

Feature	Impact	Significance of Impact
Reach 1 to 3		
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa • Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction is species abundance and/or diversity due to water quality deterioration.	**Negligible**
Reach 4		
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa • Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction is species abundance and/or diversity due to water quality deterioration.	**Minor**
Fresh water pearl mussel	• Reduction is species abundance and/or distribution due to water quality deterioration. • Reduction in habitat suitability due to water quality deterioration and increased occurrence of epiphytes and algae	**Minor**

Impacts of drought order implementation on the macroinvertebrate communities of the impacted reach has been summarised as **negligible** to **minor** adverse, short-term, temporary and reversible (note irreversible impacts for freshwater pearl mussel in Reach 4). Consequently, there is a **negligible** risk of short term deterioration of the macroinvertebrate component of the Tywi - Llyn Brianne to confluence with Doethie (GB110060036380), Tywi - conf with Doethie to confluence with Llandovery Bran (GB110060036350) WFD waterbodies and and Tywi – conf with Llandovery Bran to conf Cothi (GB110060036250), and a **minor** risk of short term deterioration of the macroinvertebrate component of the Tywi - confluence with Cothi to spring tidal limit (GB110060029290) water body.

D.3.3 Fish

D.3.3.1 Baseline

The hydrological zone of influence of the Afon Tywi drought order includes the Afon Tywi from Llyn Brianne reservoir to the tidal limit and is split into four reaches. Reaches 2 to 4 are part of the Afon Tywi SAC and SSSI, and these designations recognise the exceptional range of fish species present in the catchment. The Habitats Directive Annex II species that is a primary reason for selection of the Afon Tywi SAC is twaite shad *Alosa fallax*. Allis shad *Alosa alosa*, bullhead *Cottus gobio*, brook lamprey *Lampetra planeri*, river lamprey *Lampetra fluviatilis*

and sea lamprey *Petromyzon marinus* are also included in the citation as Annex II species present as qualifying features, but not a primary reason for site selection. In addition, the Afon Tywi is famous for its run of sea trout (known as sewin), with this population of typically large fish is considered to be nationally important both in terms of conservation value and as an angling resource.

A general baseline was provided in the Environmental Monitoring Plan (EMP) for Afon Tywi (SW1)[16]. This text has been revised and updated to take into account recent NRW fish survey data, and an updated summary baseline is provided below. In the sections which follow, the existing data and its limitations are described followed by a general description of the species assemblage across the hydrological zone of influence and then more detailed descriptions of individual species status (where possible).

Existing data

A paucity of fisheries monitoring data was highlighted in the 2007 EMP[16] and recommendations for detailed additional monitoring were included, however only limited further monitoring has been undertaken in the interim. Limited lamprey-specific electric fishing and shad egg monitoring has been undertaken by NRW in recent years, alongside ongoing routine salmonid monitoring. Data resulting from a lamprey survey of the Tywi catchment undertaken by APEM in 2004[17] was analysed in the EMP and is also summarised below. Adult shad migration monitoring was undertaken in 2005, however data was not made available.

Fish survey data from a number of sites within the hydrological zone of influence were provided by NRW following a data request to inform this assessment. Data from these juvenile salmonid sampling sites (data from approximately the last ten years) are outlined in **Table D3.9**, along with the sampling years. In addition to these surveys undertaken on the main stem of the Tywi (hydrologically impacted reaches), NRW fish survey data made available from surveys on the adjoining tributaries throughout Reach 1 -4 have been subject to high level assessment (species presence/absence/life stage) in order to understand the importance of the Tywi as a migratory route.

[16] Cascade (2007). DCWW. Provision of an Environmental Monitoring Plan. Environmental Monitoring Plan for Afon Tywi at Nantgaredig (SW1). Final. 6th June 2007. Produced for DCWW by Cascade in association with APEM.
[17] APEM (2005). Lamprey survey on the Rivers Tywi, Teifi and Cleddau. Review of Consents Report No. 7.

Table D3.9 Recent NRW Routine Juvenile Salmonid Monitoring Sites, Locations and Sampling Years

Reach	NRW Site Name (Code)	Location	Sample Years
Reach 1 (Afon Tywi from the Llyn Brianne Reservoir outflow to the confluence with Afon Bran, near Llandovery)	T2 (full width and part width surveys)	SN7722545984	2011, 2013 - 2016
	T3	SN7680044600	2011, 2013, 2014, 2016
	T4	SN7775643608	2006, 2011, 2013 - 2016
	T5	SN7652539895	2006, 2011, 2013 - 2018
	T6	SN7620036000	2011, 2014, 2015, 2017, 2018
	T6a	SN7621136014	2014, 2016
	TY (iv)	SN7550033500	2006
Reach 2 (Afon Tywi from the Afon Bran confluence down to Llandeilo Bridge, at Llandeilo)	TYM12a	SN7180931006	2014-2017
Reach 3 (Afon Tywi from Llandeilo Bridge to the Welsh Water intake at Nantgaredig)	TYM18	SN4933420284	2006
Reach 4 (Afon Tywi from the Nantgaredig abstraction intake to the tidal limit)	TY (vi)	SN4669821455	2006

No continuous, long-term datasets are available for salmonid sites within the hydrological zone of influence, and sites have not been sampled consistently either across years or in terms of methodology[18], reducing spatial and temporal comparability. Only one semi-quantitative survey at site T2 in 2013 provides density estimates. However, there is recent (2015-2017) data from a number of NRW survey sites and the geographical coverage gives a useful insight into the likely species assemblage within the hydrological zone of influence.

The location of the one lamprey-specific monitoring site sampled by NRW within, and in the vicinity of, the hydrological zone of influence is given in **Table D3.10** below.

Table D3.10 Lamprey-specific Monitoring Locations

Hydrological Reach	Site Name	Location	Sampling Year/s
1	None		
2	None		
3	None		
4	TY15 (NRW)	SN4671821494	2014

Shad egg monitoring using kick sampling was undertaken at 19 sites on the main stem of the

[18] Sites have been sampled using single run semi-quantitative and three-run quantitative as well as timed single run (CPUE) methodologies in some cases.

Afon Tywi between 2012 and 2015 (although not all sites were sampled in all years) and locations are provided in **Table 3.11** below.

Table 3.11 Kick Sampling Locations of NRW Shad Egg Monitoring on the Afon Tywi 2012 - 2015

Hydrological Reach	NRW Site N°	Site Name	Location (NGR)	Sampling Years
Reach 1	15	Dolauhirion	SN7620036100	2014
	14	Llandovery	SN7613435746	2012, 2014
	13	Lwynjack	SN7548833138	2012,2014, 2015
Reach 2	12	Llanwrda	SN7186730893	2014, 2015
	11	Manordeilo	SN6875926802	2012,2014, 2015
Reach 3	10	Llandeilo Bridge	SN6265321991	2012,2014, 2015
	9	Cilsan Bridge	SN5916821463	2014, 2015
	8	Dryslwyn	SN5503120345	2012,2014, 2015
	7	Llanegwad	SN5150021200	2012
	6	Cothie confluence	SN4990220108	2012,2014, 2015
	5	Nantgaredig Br	SN4930020300	2012,2014, 2015
Reach 4	4a	Habitat 8	SN4714621161	2014, 2015
	4	White Mill	SN4674021494	2012,2014, 2015
	3	Glantowylan	SN4690021000	2012,2014, 2015
	2b	Habitat 5	SN4681220700	2014, 2015
	2a	Habitat 4	SN4636320537	2014, 2015
	2	Penddaulwyn	SN4623120402	2012, 2014
	16	Tidal limit	SN4478020495	2012,2014, 2015
N/A (3km downstream	1	Llangunnor	SN4240020300	2012

In addition, more general monitoring of SAC features and the Atlantic salmon population is undertaken as part of SAC condition assessment and principal salmon river monitoring respectively. The combination of these data allows a relatively good understanding of the species assemblage and Atlantic salmon populations at the catchment-scale, but gives little resolution at the reach scale.

Condition assessment of the Afon Tywi SAC features carried out in 2008 by CCW[19] revealed that all listed fish species were in unfavourable condition, however this precautionary assessment was largely due to uncertainty resulting from a lack of survey data.

'Principal' Atlantic salmon *Salmo salar* rivers (numbering 64 in England and Wales) are assessed annually, with the most recent report[20] published in 2016. The Afon Tywi is classified as a principal salmon river. The status of individual river stocks in England and Wales is evaluated annually against their stock conservation limits (CLs) and management targets (MTs). In England and Wales, CLs have been developed that indicate the minimum spawning

[19] CCW (2008). Core Management Plan Including Conservation Objectives for Afon Tywi/River Tywi Special Area of Conservation. Version: 11. Date: 15 April 2008.
[20] Cefas. 2016. Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2015. Preliminary assessment prepared for ICES, March 2016.

stock levels below which stocks should not be allowed to fall. The CL for each river is set at a stock size (defined in terms of eggs deposited) below which further reductions in spawner numbers are likely to result in significant reductions in the number of juvenile fish produced in the next generation. In reviewing management options and regulations, NRW also use an over-arching management objective that a river's stock should be meeting or exceeding its CL in at least four years out of five (i.e. >80% of the time) on average. A management target (MT) is set for each river, representing a spawning stock level for managers to aim at in order to meet this objective.

The Afon Tywi is classified as currently 'At risk' (<5% probability of meeting the management objective) with a predicted classification of 'Probably at risk' (5 - 50% probability of meeting the management objective) in 2020. This classification is significant for this assessment as it highlights the current vulnerability of the Atlantic salmon population of the Tywi catchment. Maintaining migratory corridors and spawning and nursery areas for Atlantic salmon is recognised as particularly important in this instance.

The 'Tywi - Llyn Brianne to confluence with Doethie' waterbody (GB110060036380) was assessed as being at moderate status for fish in 2015. The 'Tywi - conf with Doethie to conf with Llandovery Bran' waterbody (GB110060036350) was assessed as being at good status for fish in 2015. The 'Tywi - confluence with Cothi to spring tidal limit' waterbody (GB110060029290) was not assessed for fish in 2015.

Data limitations

There is uncertainty surrounding the status of fish populations present including protected species (e.g. shad species, bullhead and lamprey species). Where data is available, spatial coverage is limited, particularly in Reach 2 (a single survey site) and there is inconsistency in terms of monitoring techniques and sampling years.

In addition, there are limitations in terms of the NRW data made available. Salmonid density estimates are only available for one site in one year (T2 in 2013). In addition, few lamprey-specific surveys have been undertaken within or near to the hydrological zone of influence, with no density estimates available other than for site TY15 in 2014.

The shad egg monitoring data made available provides a good indication of the likely spatial extent of spawning within the Afon Tywi, but does not provide any measure of population status or inter-annual change.

The precautionary principle has therefore been used, where necessary, in the following assessment, which assumes that significant populations of the species listed above exist in all reaches.

In order to obtain a suitable baseline, a suite of electric fishing surveys as well as shad and lamprey-specific monitoring in one year with adequate coverage of the hydrological reach would be required as a minimum. A suitable monitoring programme was described in the

EMP[16].

Species composition

Seven fish species have recently been recorded within the hydrological zone of influence; Atlantic salmon, bullhead and twaite shad (all NERC Act Section 41 and Habitats Directive Annex II species), brown/sea trout *Salmo trutta* (NERC Act Section 41 species), European eel *Anguilla anguilla* (NERC Act Section 41 species and IUCN Red List 'Critically Endangered'), minnow *Phoxinus phoxinus* and stone loach *Barbatula barbatula*. Unidentified lamprey (*Lampetra* sp.) ammocoetes[21] have also been recorded in NRW surveys. This is due to the fact that brook and river lamprey ammocoetes are indistinguishable in the field[22]. Both species are thought to be present. There are no recent records of either sea lamprey or allis shad in the data made available for the Tywi catchment, however, sea lamprey have been recorded at the Tywi fish counter[23]. Both species are included in this assessment as part of a precautionary approach.

Allis and twaite shad

The EMP[16] states that shad egg deposition monitoring undertaken in 2005 suggested that the upstream boundary of migration in the Afon Tywi was Nantgaredig (the boundary of Reaches 3 and 4). Subsequent kick sampling monitoring between 2012 and 2015 recorded shad eggs as far upstream as Manordeilo (SN6875926802) in Reach 2, however, the data suggest that the bulk of shad spawning in the Afon Tywi occurs between the tidal limit and Nantgaredig. The full results of kick sampling monitoring are provided in **Table 3.12** below.

Table 3.12 Kick Sampling Data from NRW Shad Egg Monitoring on the Afon Tywi 2012 - 2015

Hydrological Reach	NRW Site N°	Site Name	N° shad eggs per kick sample		
			2012	2014	2015
Reach 1	15	Dolauhirion	-	0	-
	14	Llandovery	0	0	-
	13	Lwynjack	0	0	0
Reach 2	12	Llanwrda	-	0	0
	11	Manordeilo	85	0	0
Reach 3	10	Llandeilo Bridge	13	31	0
	9	Cilsan Bridge	-	0	11
	8	Dryslwyn	0	0	0
	7	Llanegwad	12	-	-
	6	Cothie confluence	11	6	0
	5	Nantgaredig Br	100	20	24

[21] Lamprey larvae are known as ammocoetes. When ammocoetes mature prior to migration (either to estuaries for river lamprey or upstream to spawn for brook lamprey) they are known as transformers.
[22] Harvey J & Cowx I (2003). Monitoring the River, Brook and Sea Lamprey, *Lampetra fluviatilis*, *L. planeri* and *Petromyzon marinus*. Conserving Natura 2000 Rivers Monitoring Series No.5, English Nature, Peterborough.
[23] European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Supporting documentation for the Third Report by the United Kingdom under Article 17 - Species: S1095 - Sea lamprey (Petromyzon marinus)

Hydrological Reach	NRW Site N°	Site Name	N° shad eggs per kick sample		
			2012	2014	2015
Reach 4	4a	Habitat 8	-	250	12
	4	White Mill	39	141	10
	3	Glantowylan	11	465	1
	2b	Habitat 5	-	106	64
	2a	Habitat 4	-	264	39
	2	Penddaulwyn	618	22	-
	16	Tidal limit	13	112	117
N/A (3km downstream	1	Llangunnor	0	-	-

The data from kick sampling monitoring is qualitative and does not allow any measure of inter-annual variation. However, the data in **Table 3.12** appears to show a general reduction in egg deposition over the sampling years. This is consistent with the 'unfavourable' status assigned to shad in the condition assessment for the Afon Tywi SAC[19].

There are no records of allis or twaite shad within the NRW electric fishing data made available, however, both species are assumed to be present in Reaches 2, 3 and 4 as part of a precautionary approach. Shad are thought to enter the lower Afon Tywi between March and May depending on estuarine water temperature and spawning tends to occur in May and June on the main stem of the river. There is a general downstream migration of juvenile shad in late summer and early autumn, with the majority having left the non-tidal river by November.

Atlantic salmon

The available data suggest that all four reaches of the hydrological zone of influence host juvenile Atlantic salmon populations. Semi-quantitative data from Site T2 in Reach 1 in 2013 suggests fry (0+) and parr (>0+) densities equivalent to National Fisheries Classification (NFC) Grades[24] E and D respectively. Observed numbers recorded during juvenile salmonid surveys indicate abundance varies over time and according to reach. The most recent surveys undertaken within the hydrological zone of influence in Reach 1 recorded both salmon fry and parr, indicating this reach of the river continues to support the juvenile life stages of the species. Atlantic salmon are also present in a number of the tributaries which enter all four reaches of the Tywi. Overall, this indicates the Afon Tywi is an important migratory corridor for both ascending adults and returning smolt and kelt. The majority of migrating adult Atlantic salmon are likely to enter the river between May and October, with peaks in numbers linked directly to rainfall and increased flows.

Smolt migration tends to occur between late March and late May/early June depending on temperature and rainfall, whilst kelts return to the estuary immediately after spawning in

[24] For salmonids, a grading system is used based on the original Fisheries Classification System called the National Fisheries Classification (NFC). The electric fishing data are analysed to produce a juvenile salmon and trout density score for each site, using average values from the early 1990s as a baseline. The proportion of sites falling into different salmon abundance Classes (A to F) provides a measure of the health of the juvenile salmon populations for each river. Sites are typically grouped into those that are at or above average (Classes A to C), below average (Class D) and well below average or fishless (Classes E or F).

December or early January.

Brook, River and Sea lamprey

Sea lamprey have been recorded on the Afon Tywi as far upstream as the Llandovery Bran[19], despite the species being entirely absent from the available NRW monitoring data across the catchment, including lamprey-specific monitoring in 2004. The species are however recorded at the Tywi fish counter in Natgaredig (located at the border of Reach 3 and 4), and it assumed the species are present throughout the hydrological zone of influence.

Brook and river lamprey are thought to be widespread in the catchment (although targeted monitoring suggests relatively poor densities in areas of optimal habitat) and are therefore assumed to be present in Reaches 1 to 4. No data was made available relating to the status of lamprey species within the hydrological zone of influence, and so no further assessment is possible.

Brown/sea trout

The available data suggest low juvenile densities throughout Reaches 1-4 of the Afon Tywi within the hydrological zone of influence. The low densities of brown trout recorded in 2018 are not unexpected given the habitat preferences of the species which tends to utilise spawning and nursery habitat in the headwaters and tributaries rather than the main stem of the river. This is confirmed by the higher densities recorded in a number of the tributaries which enter all four reaches of the Tywi. In addition to brown trout, the Afon Tywi is noted for its run of sea trout and Reaches 1 to 4 are likely to constitute an essential migratory pathway for the species. Due to a paucity of data specific to sea trout, it is also assumed that spawning and nursery habitat in the main Afon Tywi is also utilised on a significant basis.

Bullhead

Bullhead are present throughout Reaches 1 to 4, however the status of the species is unknown beyond the 'unfavourable' classification in the 2008 Afon Tywi SAC condition assessment[19]. Density data is available for only one sampling occasion (site T2 in 2013), which suggested a density of 9.29 per 100m^2, well below the 20/100m^2 target for SAC favourable conservation status in upland streams[25]. Whilst density data is largely unavailable, the presence of bullhead throughout Reaches 1 to 4 suggests significant populations exist throughout the hydrological zone of influence, in line with designation as a qualifying feature of the Afon Tywi SAC.

European eel

There are very few records of European eel within the data made available, however the species are recorded throughout Reach 1-3. The most recent surveys in 2015 and 2017 in Reach 2 record juvenile individuals, indicating successful recruitment of the species in to the catchment in recent years. Eel are therefore considered to be present in low densities

[25] Cowx, I.G. & Harvey, J.P. (2003). Monitoring the Bullhead, *Cottus gobio*. Conserving Natura 2000 Rivers Monitoring Series No. 4, English Nature, Peterborough.

throughout Reaches 1 to 4.

Ecological value of fisheries receptors

Allis and twaite shad, brook, river and sea lamprey and bullhead are NERC Act Section 41 and Habitats Directive Annex II species that are either a) a primary reason for selection of; or b) a species present as a qualifying feature of the Afon Tywi SAC and are considered to be of international importance.

Atlantic salmon (NERC Act Section 41 and Habitats Directive Annex II species), brown/sea trout (NERC Act Section 41 species) and European eel (NERC Act Section 41 species and IUCN Red List 'critically endangered' species) are considered to be of national importance. Other fish species present are considered to be of site only importance.

D.3.3.2 Assessment

Hydrological impacts as a result of drought order implementation have been assessed as negligible in Reaches 1 to 3, and minor in Reach 4 (see Appendix B, Section B2.2). However, impacts will only occur during the most extreme low flows well below the Q_{99} flow value and only on occasional days, as the 7-day rolling average maintained flow of 136Ml/d means that the 20Ml/d reduction in regulation releases could only be maintained for a few days at a time and would need to be balanced by increased releases on subsequent/preceding days.

Hydrological variability in rivers can have a significant influence on the distribution of fish. When extreme low flows, or prolonged periods of low flow, are experienced, for example under continued water abstraction during drought conditions, the resultant changes in the hydrological regime can have significant impacts on resident fish communities. Abstraction of water from a river or stream reduces the wetted area and volume with the potential for subsequent impacts on fish populations as a result of, for example, intra- and inter-specific interactions (e.g. increased competition for optimal habitat and food)[26,27], reduced water quality and reduced reproductive success, growth and condition[28].

Potential impacts relating to habitat loss, water quality and migration are of relevance. These are discussed for key fish species in the sections which follow with particular focus on those aspects of fish ecology (e.g. migrations and juvenile life stages) most susceptible during the likely summer and autumn (taken to be April to December) impact period.

Whilst mortality under these conditions may occur, fish species have evolved mechanisms in order to cope with low flow conditions, for example, avoidance behaviour (i.e. moving downstream as water levels drop) or the ability to persist in pooled areas of deeper water. However, flow sensitive species such as Atlantic salmon and bullhead are nonetheless

[26] Magoulick, D.D. (2000). Spatial and temporal variation in fish assemblages of drying stream pools: the role of abiotic and biotic factors. Aquatic Ecology 34, 29-41
[27] Davey A.J.H. & Kelly D.J. (2007). Fish community responses to drying disturbances in an intermittent stream: a landscape perspective. Freshwater Biology 52, 1719–1733.
[28] Magoulick, D.D. and Kobza, R.M. (2003). The role of refugia for fishes during drought: a review and synthesis. Freshwater Biology 48, 1186-1198.

susceptible to reduced flows.

Allis and twaite shad

Migration

Adult shad migrate upstream from the estuary between March and May to spawn mostly between the tidal limit and Nantgaredig on the Afon Tywi (Reaches 3 and 4), between mid-May and mid-July depending on water temperature. Spawning does occur to a lesser extent upstream into Reach 2. Juvenile shad migrate relatively quickly downstream towards the estuary over the late summer and early autumn, and are likely to have left the non-tidal Afon Tywi by late November. These downstream migrations therefore have the potential to interact with hydrological impacts associated with the autumn months of the drought period. Increased flow is not considered to be as important a cue as for migratory salmonids, however minimum flows are required in order for free passage to occur at barriers to migration. Very low flows may impact upon downstream migration, thereby increasing mortality due to increased predation and stress. The impact is considered to be of low magnitude, short-term, temporary and reversible. The impact on juvenile shad migration is therefore considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November.

Water quality

The risk of water quality deterioration due to dissolved oxygen, ammonia and SRP is negligible in Reaches 1-3 and low in Reach 4. Allis and twaite shad are less susceptible to water quality impacts such as reduced dissolved oxygen and increased water temperature than salmonids and impacts are expected to be limited. The impact on shad species is therefore considered to be **minor adverse** in Reach 4 and **negligible** in Reaches 1 to 3 from September to November.

Spawning and juvenile habitat

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore potential for a loss or degradation of juvenile habitat. During a temporary, short term reduction in flow associated with the implementation of the drought order, juvenile shad are likely to relocate to areas of suitable habitat if river levels decrease, however competition and stress would increase. Spawning occurs between mid-May and July; outside of the drought order implementation period. Juvenile shad are known to vacate the Afon Tywi as temperatures decrease in early autumn, so the drought order may impact this life stage. The impact is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on juvenile shad habitat is therefore considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November**.**

Atlantic salmon

Atlantic salmon migration

The Afon Tywi within the hydrological zone of influence is an important migratory corridor for Atlantic salmon. The majority of migrating Atlantic salmon are likely to enter the hydrological zone of influence later in the year (from September to December), and there is the potential for drought order-related impacts on flow to effect the timing of this migration. The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature; outside of the drought order implementation period. Periods of increased flow are considered to be a primary cue in initiating Atlantic salmon migration. Whilst salmon are unlikely to attempt upstream migration during periods of extreme low flow, short term, temporary reductions during minimum flows whilst fish are in the system could further delay movement, thereby increasing mortality due to increased predation and stress. The impact is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on adult Atlantic salmon migration is therefore considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November.

Water quality

The risk of water quality deterioration due to dissolved oxygen, ammonia and SRP is negligible in Reaches 1-3 and low in Reach 4. Potential water quality impacts as a result of a reduction in flow are likely to act in tandem with a reduction in habitat to increase stress and subsequent loss of condition. Atlantic salmon are susceptible to poor water quality; particularly dissolved oxygen and water temperature. The effects of reduced water quality are particularly likely to impact the sensitive juvenile life stages. The impact on water quality has been assessed as being up to low magnitude, and the impact on Atlantic salmon is therefore considered to be **minor adverse** in Reach 4 and **negligible** in Reaches 1 to 3 from September to November.

Juvenile Atlantic salmon habitat and spawning life stage

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore the potential for a loss or degradation of juvenile habitat along with gravel spawning habitat. Provided minimum low flows are available, juvenile Atlantic salmon are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase. Spawning occurs in winter between November and January; therefore coinciding with the drought order implementation period. The gravel redds of any early spawning fish may be directly impacted by a Drought Order through desiccation of eggs and/or loss of sensitive spawning habitats. However, due to the drought order implementation period being largely outside of the main December to January spawning period for salmonids, the impact is considered to be of low magnitude, short-term, temporary and reversible. The impact on juvenile Atlantic salmon habitat and spawning life stage is therefore considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November.

<u>Brook, river and sea lamprey</u>

Juvenile (ammocoete and transformer) lamprey habitat

There is the potential for reduced flow to result in a decrease in river levels and wetted width throughout the areas of the Tywi where juvenile lamprey species are considered present. This has particular significance for juvenile (ammocoetes and transformer) lamprey habitat which tends to consist of silt in shallow, marginal areas and is utilised year-round. Habitat may already be limited and ammocoetes under stress during periods of low flow. Whilst flow reductions are not considered to exceed 14.7% (up to Minor hydrological impacts), further impacts associated with the drought order may increase stress and competition, potentially resulting in mortality to this sensitive juvenile life stage. Based on a precautionary approach, flow reductions of as little as 4.9-5.9 % (as assessed for Reaches 1-3) cannot be ruled out as adversely impacting upon juvenile lamprey. Therefore, the impact on juvenile lamprey is considered to be of medium magnitude, short-term, temporary and reversible throughout Reaches 1 to 4. The impact on juvenile lamprey is considered to be **minor adverse** in Reaches 1-3 and **moderate adverse** in Reach 4.

Water quality

Low to medium risks for a deterioration in dissolved oxygen, ammonia and SRP are assumed for Reaches 1-4 and are not expected to have a significant impact on brook, river or sea lamprey which are not particularly sensitive to these impacts. The impact on brook, river and sea lamprey is therefore considered to be **negligible** in Reaches 1 to 4.

Migration of river and sea lamprey

Mature river lamprey migrate upstream into freshwater in the autumn (from October to December[29]). River lamprey ammocoetes metamorphose after three to five years in freshwater and then descend to estuarine and marine environments between July and September in smaller rivers**Error! Bookmark not defined.**. Upstream migration requires a reasonable flow of water to aid passage past natural and non-natural in-channel barriers. Low flows may limit upstream passage and hinder downstream passage, leaving both migratory life stages exposed to higher risks of predation and ultimately a reduction in recruitment. Both upstream and downstream migration windows coincide with the drought order implementation period. The impact on adult and juvenile migration of river lamprey is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on river lamprey migration is therefore considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November.

Mature sea lamprey migrate upstream into freshwater in April and May prior to spawning. Sea lamprey ammocoetes metamorphose after approximately five years in freshwater and then descend to marine environments between July to September[30]. Similar to river lamprey, adult sea lamprey require reasonably high flows between April and June in order to aid upstream passage, and are at risk of similar impacts associated with a drought order. Only the juvenile

[29] Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No.5. English Nature, Peterborough
[30] Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No.5. English Nature, Peterborough

migration window coincides with the early stages of the drought order implementation period. The impact on juvenile sea lamprey migration is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on juvenile sea lamprey migration is therefore considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November.

Bullhead

Bullhead are present throughout the hydrological zone of influence. The species is flow sensitive and spawning and egg incubation takes place from March to May. Particularly susceptible juvenile life stages are therefore likely to be affected by reduced flows (and likely reduced water quality) associated with implementation of a drought order. The impact is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on bullhead is therefore considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November.

Brown/sea trout

Sea trout migration

The Afon Tywi hosts a nationally significant sea trout run, and the hydrological zone of influence constitutes an important migratory corridor to spawning grounds located predominantly in the upper river and tributaries. It is likely that the majority of migrating sea trout would enter the river from September to November (although the run can start in early spring); therefore coinciding with drought order implementation period. The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature; outside of the drought order implementation period. Periods of increased flow are considered to be a primary cue for initiating sea trout migration. Whilst sea trout are unlikely to migrate during periods of extreme low flow, short term, temporary reductions during minimum flows whilst fish are in the system could further delay migration, thereby increasing mortality due to increased predation and stress. The impact is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on adult sea trout migration is therefore considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November.

Water quality

The risk of water quality deterioration due to dissolved oxygen, ammonia and SRP is negligible in Reaches 1-3 and low in Reach 4.. Potential water quality impacts as a result of a reduction in flow are likely to act in tandem with a reduction in habitat to increase stress and subsequent loss of condition. Brown/sea trout are susceptible to poor water quality and particularly dissolved oxygen and water temperature. The effects of reduced water quality are likely to impact particularly sensitive juvenile life stages. The impact is considered to be of low magnitude, short-term, temporary and reversible. The impact on brown/sea trout is therefore considered to be **minor adverse** in 4 and **negligible** in Reaches 1 to 3 from September to November.

Juvenile brown/sea trout habitat and spawning life stage

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore the potential for a loss or degradation of juvenile habitat along with gravel spawning habitat. Provided minimum low flows are available, juvenile brown/sea trout are likely to relocate to areas of suitable habitat if river levels decrease, however competition and stress would increase. Spawning occurs in winter between November and January; therefore coinciding with the drought order implementation period. The gravel redds of any early spawning fish may be directly impacted by a Drought Order through desiccation of eggs and/or loss of sensitive spawning habitats. However, due to the drought order implementation period being largely outside of the main December to January spawning period for salmonids, the impact is considered to be of low magnitude, short-term, temporary and reversible. The impact on juvenile brown/sea trout habitat and spawning life stage is therefore considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November.

European eel

Elver enter rivers in early spring and a general upstream migration occurs throughout the year. Elver migration is not linked to periods of increased flow and low flow conditions are unlikely to impact migration. The downstream migration of mature (silver) eel tends to occur between September and December in most rivers, and increased flow is considered to be an important migratory cue. There is therefore the potential for drought order-related impacts on flow to affect the timing of this migration. Whilst adult eel are unlikely to migrate during periods of low flow, short term, temporary reductions during minimum flows could further delay migration, thereby increasing mortality due to increased predation and stress. European eel of a wide age range are likely to be present in low densities throughout the Afon Tywi, but the species is tolerant of high temperatures and relatively poor water quality and is considered resilient to drought conditions. The impacts on European eel are therefore limited to silver eel migration and are considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November.

Other fish species

Minnow and stone loach spawning and egg incubation occurs within the period April to September. These vulnerable life stages are likely to be particularly susceptible to impacts associated with the early stages of the drought order implementation period, including desiccation of gravel spawning habitats and increased stress and predation. The impact is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on other fish species is therefore considered to be **minor adverse** in Reach 4, and **negligible** in Reaches 1 to 3 from September to November.

Summary

The potential impacts of the Afon Tywi drought order on the fish community are summarised in **Table D3.13**. The impacts, and their magnitude, have been based on the hydrological

impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability; see Section 4.3 of the main report) and the sensitivities of the fish community. The impacts presented in **Table D3.13** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.13 Summary of Impacts on Fish Community

Feature	Impact	Significance of Impact
Reach 1: Afon Tywi from the Llyn Brianne Reservoir outflow to the confluence with Afon Bran, near Llandovery		
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Brook, river and sea lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Minor**
	• Reduced water quality.	**Negligible**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Negligible**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Negligible**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Reach 2: Afon Tywi from the Afon Bran confluence down to Llandeilo Bridge, at Llandeilo		
Allis and twaite shad	• Delays and potential cessation of adult and juvenile migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Brook, river and sea lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Minor**
	• Reduced water quality.	**Negligible**

Feature	Impact	Significance of Impact
Reach 1: Afon Tywi from the Llyn Brianne Reservoir outflow to the confluence with Afon Bran, near Llandovery		
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Negligible**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows and obstruction caused by sandbag weir.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Negligible**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Reach 3: Afon Tywi from Llandeilo Bridge to the Welsh Water abstraction intake at Nantgaredig		
Allis and twaite shad	• Delays and potential cessation of adult and juvenile migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Brook, river and sea lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Minor**
	• Reduced water quality.	**Negligible**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Negligible**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows and obstruction caused by sandbag weir.	**Negligible**
	• Reduced water quality.	**Negligible**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Negligible**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**

Feature	Impact	Significance of Impact
Reach 1: Afon Tywi from the Llyn Brianne Reservoir outflow to the confluence with Afon Bran, near Llandovery		
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Reach 4: Afon Tywi from the Nantgaredig abstraction intake to the tidal limit		
Allis and twaite shad	• Delays and potential cessation of adult and juvenile migrations due to reduced flows.	**Minor**
	• Reduced water quality.	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Minor**
	• Reduced water quality.	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
Brook, river and sea lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Moderate**
	• Reduced water quality.	**Negligible**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Minor**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows and obstruction caused by sandbag weir.	**Minor**
	• Reduced water quality.	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Minor**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**

Impacts of drought order implementation on the fish communities of the impacted reach has been summarised as **negligible** to **moderate** adverse, short-term, temporary and reversible. Consequently, there is a **negligible** risk of short term deterioration of the fish component of the Tywi - Llyn Brianne to confluence with Doethie (GB110060036380), Tywi - conf with Doethie to confluence with Llandovery Bran (GB110060036350) and and Tywi – conf with Llandovery Bran to conf Cothi (GB110060036250) WFD waterbodies. In addition, there is **minor** risk of short term deterioration of the fish component of the Tywi - confluence with Cothi to spring tidal limit (GB110060029290) water body.

D.3.4 Phytobenthos

D.3.4.1 Baseline

Baseline data has been provided by NRW for five diatom monitoring sites on the Afon Tywi including three in Reach 1, one in Reach 3, and one in Reach 4 (see Table D3.14).

The data provided were used to calculate TDI4 Scores according to the DARLEQ system. Percentage Motile Valves and Percentage Organic Tolerant Valves were also calculated using the DARLEQ tool. Scores are provided in **Table D3.14**

Table D3.14 DARLEQ Metrics for Phytobenthos Data from the Afon Tywi

Site/Station Name	Reach	Site/Station Location	Sample Date	River TDI3	River TDI4	Motile%
Fish Trap Llyn Brianne	1	SN7859947169	Apr 2007	18.22	18.5	6
			Sep 2007	9.03	9.23	58
			May 2013	19.37	-	-
			Sep 2013	18.66	-	7
			Apr 2014	22.5	23.17	0
			Sep 2014	20.08	21.34	2
4km D/S Nant Y Mwyn, Near Penlan	1	SN7653739887	May 2013	21.12	25.23	1
			Sep 2013	15.84	-	0
			Apr 2014	25.25	25.37	2
			Sep 2014	15.79	17.37	0
Llandovery RB	1	SN7615034800	Apr 2014	29.22	29.26	3
			Sep 2014	10.46	13.33	1
Nantgaredig Nr Carmarthen	3	SN4935620284	May 2007	35.73	37.41	18
			Sep 2007	35.24	37.12	28
			Mar 2010	29.79	31.13	17
			Oct 2010	54.35	55.49	55
			Apr 2014	39.29	39.64	30
Cystanog Farm	4	SN461650325	Mar 2010	40.98	40.86	34
			Oct 2010	50.86	44.67	32
			Apr 2014	54.8	54.71	59
			Sep 2014	39.9	38.99	13

Phytobenthos communities at all sites in Reach 1 were relatively diverse, with taxa present generally typical of upland relatively high velocity rivers without significant acidification. Across all sites in Reach 1, TDI3 scores ranged from 9.03 to 29.22 and TDI4 scores ranged from 9.23 to 29.26. These low scores indicate oligotrophic conditions in Reach 1. The majority of samples from monitoring sites in Reach 1 contain a low proportion of motile diatom taxa, indicating stable rocky substrates with a low sediment load. The exception is a sample from September 2007 at the Fish Trap Llyn Brianne, which has a significantly increased proportion of motile taxa indicating an increase in silt/sediments in the water course at this time.

Phytobenthos communities at all sites in Reaches 3 and 4 returned higher TDI3 and TDI4

scores than Reach 1. In Reaches 3 and 4, TDI3 scores ranged from 29.79 to 54.8 and TDI4 scores ranged from 31.13 to 55.49. These scores indicate mesotrophic conditions throughout Reaches 3 and 4, showing higher nutrient levels than the upper part of the river in Reach 1. The majority of samples from monitoring sites on the Afon Tywi contain a moderately high proportion of motile diatom taxa, indicating more mobile substrates than Reach 1 with a higher sediment load. The phytobenthos communities present in Reach 2 are likely to be similar to Reach 3.

D.3.4.2 Assessment

Hydrological impacts as a result of drought order implementation have been assessed as negligible in Reaches 1 to 3, and minor in Reach 4 (see Appendix B, Section B2.2). However, impacts will only occur during the most extreme low flows well below the Q_{99} flow value and only on occasional days, as the 7-day rolling average maintained flow of 136Ml/d means that the 20Ml/d reduction in regulation releases could only be maintained for a few days at a time and would need to be balanced by increased releases on subsequent/preceding days.

Impacts on the phytobenthos assemblages of the Afon Tywi within Reaches 1 to 4 could occur due to the operation of the drought order, including changes in community composition due to decreases in flow, changes to grazing pressure, increases in nutrient level, increases in water temperature, and increases in filamentous algae smothering the substrate. Due to the short lifecycle of algal species, phytobenthos communities can respond to rapidly to environmental change and a response in phytobenthos community composition to the reduction in flows due to the drought order would be expected.

Implementation of the drought order is expected to result in a negligible risk of deterioration to SRP in Reach 1-3 and a low risk in Reach 4, which in turn may affect the phytobenthos community and associated WFD status. Due to the minor hydrological risk and low risk of SRP deterioration in Reach 4, impacts on the phytobenthos community are likely to be **negligible** for Reaches 1 to 3 and **minor adverse** in Reach 4.

Due to the rapid response of phytobenthos communities to environmental variables, this effect is expected to be short lived, with communities recovering rapidly following return to the normal hydrological regime.

Summary

The potential impacts of the Afon Tywi drought order on the phytobenthos community are summarised in **Table D3.15**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability; see Section 4.3 of the main report) and the sensitivities of the phytobenthos community. The impacts presented in **Table D3.15** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.15 Summary of Impacts on Phytobenthos Community

Feature	Impact	Significance of Impact
Reach 1 to 3		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition • Low risk of increase in SRP affecting phytobenthos community composition and TDI score	**Negligible**
Reach 4		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition • Medium risk of increase in SRP affecting phytobenthos community composition and TDI score	**Minor**

Impacts of drought order implementation on the phytobenthos communities of the impacted reach has been summarised as **negligible** to **minor adverse**, short-term, temporary and reversible. Consequently, there is a **minor** risk of short term deterioration of the phytobenthos subcomponent of the Tywi - Llyn Brianne to confluence with Doethie (GB110060036380), Tywi - confluence with Cothi to spring tidal limit (GB110060029290) and and Tywi – conf with Llandovery Bran to conf Cothi (GB110060036250) WFD water bodies, and a **negligible** risk of short term deterioration of the phytobenthos subcomponent of the, Tywi - conf with Doethie to confluence with Llandovery Bran (GB110060036350) waterbody.

D4 INVASIVE FLORA AND FAUNA

D.4.1 Himalayan Balsam and Japanese Knotweed

D.4.1.1 Baseline

New Zealand pygmy weed *Crassula Helmsii* was present in low abundance at the Nantgaredig Nr Carmarthen site in 2003, but was not recorded at subsequent surveys or at the other macrophyte monitoring sites in Reaches 1 or 4.

Himalayan balsam *Impatiens glandulifera* and Japanese knotweed *Fallopia japonica* are reported to be present on the lower reaches of the Afon Tywi, but were not recorded during NRW macrophyte surveys at Nantgaredig Nr Carmarthen or Cystanog Farm or at macrophyte monitoring sites on the upper Afon Tywi in Reach 1.

D.4.1.2 Assessment

If New Zealand pygmy weed is present in Reach 4, then the minor hydrological impact and low risk of increased SRP concentrations may result in an increase in abundance and or distribution of the species. New Zealand pygmy weed can grow prolifically in high nutrient conditions, often forming vegetative mats and outcompeting native vegetation. However, as the drought order will only result in hydrological impacts in extreme drought conditions, impacts associated with New Zealand pygmy weed over and above those observed in a natural drought are likely to be limited. Consequently, impacts on distribution of New Zealand pygmy weed are assessed as being **negligible**.

D5 LANDSCAPE AND RECREATION

D.5.1 Landscape

D.5.1.1 Baseline

The Afon Tywi downstream of Llandovery meanders through a wide, gravel based floodplain. Land uses are predominantly mixed livestock and dairy rearing in these lower reaches (Environment Agency Wales, 1999). Tree cover along the Tywi is generally sparse. Partly as a result of this, active bank erosion is a feature of the river, and many old oxbow lakes remain to enhance the landscape and conservation value (Environment Agency Wales, 1999). The landscape is considered of particular importance and has been noted as a Special Landscape Area (SLA).

The impacted reach falls within the southern Ceredigion uplands SLA[31]. The SLA forms the southern part of the Cambrian Mountains complex within Ceredigion. The landscapes present are characterised by open upland plateau, with shallow rolling slopes and valleys. Added interest is given by the series of wet flushes, boggy depressions, pools and small lakes, and evidence of glacial activity.

D.5.1.2 Assessment

Landscape and visual amenity impacts due to reduced water levels may be visible from public rights of way, footpaths, cycle routes and river crossings. However, the impact on flows will be temporary and will be ameliorated once the drought has passed. As hydrological impacts are only predicted to occur during extreme drought conditions, implementation of the drought order is not expected to lead to any significant landscape impacts, and these are assessed as **negligible**.

D.5.2 Recreation

D.5.2.1 Baseline

Thee Tywi valley provides excellent recreational opportunities, especially for walkers, horse riders, cyclists, anglers and boaters. The upper section of the river around Reaches 1 and 2 are popular with kayakers.

The Tywi is recognised as the premier sea trout river in England and Wales, but is also important for salmon and brown trout. The majority of the fishing along the Afon Tywi is controlled by 10 angling clubs and a number of private fishery owners that make up the Carmarthenshire Fishermens Federation.

D.5.2.2 Assessment

Any reduction in wetted depth may influence the water-dependent activities such as angling.

[31] Ceredigion County Council (2010) Designation of Special Landscape Areas

However, hydrological impacts will only occur during extreme drought conditions, so water levels will be naturally low and impacts will be temporary in nature. Therefore, impacts to recreation are considered to be **negligible**.

D.5.3 Archaeology and Cultural Heritage

The area as a whole is rich in sites of historical and archaeological importance. Within 500m of the site lies the round barrow 200m south-southwest of Felin-Wen-Isaf, a prehistoric religious/funeral site. There are 23 Scheduled Ancient Monuments located in proximity to the Tywi within the zone of hydrological influence. These include round barrows and Roman sites, but do not involve features considered to be impacted by any change in river flow.

Archaeology and cultural heritage will, therefore, be subject to **negligible** impacts due to the operation of the Drought Order.

Table D5.1 Summary of Impacts on Landscape, Recreation, and Archaeology

Feature	Impact	Significance of Impact
Landscape	• Flows during a drought will be low such that further reduction in flows due to the drought order would not result in a further loss of aesthetic value	**Negligible**
Recreation	• Impacts on recreation activities (e.g. angling, canoeing, walking) are not anticipated over those from the natural drought conditions	**Negligible**
Archaeology	• No water dependant archaeological features are present within the zone of impact.	**Negligible**