Dŵr Cymru Welsh Water

Environmental Assessment of Llwynon Reservoir Drought Permit (8109-1)

Final

March 2019

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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 permit at Llwynon Reservoir, over and above those arising due to natural effects of drought and those which would occur under "normal" abstraction licence conditions.

Llwynon Reservoir is located within Welsh Water's SEWCUS – Llwynon / Sluvad / Court Farm (8109) WRZ and supplies water under gravity towards Cardiff. The Taf Fawr flows through Llwynon Reservoir and both are located in the Brecon Beacons National Park. There are four Sites of Special Scientific Interest (SSSIs) located within the zone of influence; these include Daren Fach, Penmoelallt, Cwm Taf Dechan Woodlands and Cwm Glo A Glyndyrys. Therefore consideration has been given to the potential impacts of drought permit implementation on these designated sites.

The assessment also considers how the proposed drought permit 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 Natural Resources Wales (NRW) for a drought permit at Llwynon Reservoir, which may be required by Welsh Water in the future.

PROPOSED DROUGHT PERMIT DETAILS

In order to protect public water supplies within Welsh Water's SEWCUS – Llwynon/ Sluvad / Court Farm (8109) WRZ in the event of a future severe drought, Welsh Water would make an application to NRW for a drought permit to vary the conditions of abstraction from Llwynon Reservoir.

The drought permit would authorise a temporary change to the abstraction licence conditions at Llwynon Reservoir by reducing the non-consumptive fisheries

abstraction from Llwynon Reservoir to the Taf Fawr (which is in effect the compensation release) by 50% from 18.2 Ml/d to 9.1 Ml/d. This will conserve the longevity of reservoir storage for use for direct supply during a drought and improve the probability of reservoir winter refill. The drought permit will influence the downstream Taf Fawr and its continuation, the River Taff.

The reduction in compensation release has the potential to be implemented year round. This is based on modelling of Llwynon Reservoir's performance under normal operating conditions in dry summers, together with Welsh Water's experience of operating the source. Welsh Water's modelling has indicated that the likely duration of the drought permit would be around 2-4 months.

The fisheries abstraction water is used by Welsh Water for fish-rearing. The fish-rearing operation will have to be scaled-down or suspended during implementation of the drought permit. As the operation is run by Welsh Water there are no consequences for third parties from the drought permit. The drought permit is most likely to occur during the autumn and winter period, and is considered not to extend outside the period September to November. This has been confirmed by Welsh Water's water resources modelling.

The revised abstraction arrangements would be authorised 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 Natural Resources Wales.

NEED FOR THE DROUGHT PERMIT

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

The justification for the drought permit 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 permit application.

ALTERNATIVE SOURCES CONSIDERED

Details of alternative sources considered by Welsh Water will be completed at the time of application for the drought permit at Llwynon Reservoir. This will provide justification for the application for the proposed drought option.

POTENTIAL IMPACTS OF DROUGHT PERMIT IMPLEMENTATION

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

Summary of the Hydrological Assessment for the Taf Fawr and River Taff

The assessment has concluded that there is a **major** impact on river flows as a result of implementing the drought permit. There are **major** impacts on the physical environment of the river, including water quality.

Summary of the Environmental Features Screening for the Taf Fawr and River Taff

Environmental assessment is 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, invasive fauna and landscape and recreation as environmental features for which an environmental assessment was required. The assessment has concluded that there are **major-minor** impacts on aquatic ecology specifically: major impacts on fish, minor impacts on macroinvertebrates, macrophytes and phytobenthos.

Cumulative Impacts

The drought permit at Pontsticill Reservoir (8119-1) is likely to be implemented concurrently with reduced compensation from Llwynon Reservoir and both options influence the River Taff downstream of the Taf Fechan / Taf Fawr confluence. In-combination effects are anticipated on fish, macroinvertebrates and macrophytes.

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

MITIGATION AND MONITORING

The environmental assessment has identified significant impacts of implementation of a drought permit at Llwynon Reservoir. 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, the environmental effects on river flows, water quality and ecology of implementing a drought permit at Llwynon Reservoir, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **major.**

Contents

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 permit by Dŵr Cymru (Welsh Water) by temporarily modifying the abstraction licence conditions for the Llwynon Reservoir in order to enable a reduction in the non-consumptive fisheries abstraction to the Taf Fawr (which is in effect the compensation release) by 50%, from 18.2 Ml/d to 9.1 Ml/d. This will conserve the longevity of reservoir storage for use in direct supply during a drought and improve the probability of reservoir winter refill. The drought permit will influence the Taf Fawr and River Taff. Water abstracted from the Llwynon Reservoir is used to provide public water supplies to the South East Conjunctive Use System (SEWCUS) – Llwynon / Sluvad / Court Farm (8109) 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 permit at Llwynon Reservoir. A drought permit 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 permit 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 permit over the months of September to November inclusive, the period for which Welsh Water has determined it might require a drought permit for this water source. The purpose of the assessment is to determine the environmental impacts of the drought permit over and above any effects arising from natural drought conditions.

The study area and focus of this environmental assessment of the Llwynon drought permit, covers the following waterbodies:

- Afon Taf Fawr - (GB109057033170) – source to confluence of Taf Fechan
- River Taff (GB109057033100) – confluence of Taf Fechan to confluence of Afon Cynon

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 permit (**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 permit monitoring requirements (**see Section 9 of this report**).

The environmental assessment has been conducted in accordance with Government regulations and using the Welsh Government / Natural Resource Wales 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]. A revised drought plan guideline was published by the Environment Agency in December 2015, however these assessments are conducted in accordance with the 2011 DPG as required by the Welsh Government.

Consideration has been given to the potential impacts of drought permit 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 permit 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 the implementation of a drought permit /order are listed in the EAR and that an assessment is made of feature sensitivity 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 majorly or moderately impacted: where environmentally designated features are present any minor impact also requires assessment. Further environmental assessment is **not** required for those drought permits / orders where there is certainty that there are no such impacted sensitive features.

[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

This environmental assessment is based on data available at the time of writing and 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 permit). 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 permit at Llwynon Reservoir, 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 permit.

1.4 STRUCTURE AND CONTENT OF THE REPORT

This EAR comprises the following sections:

Section 1: Introduction

Section 2: Background to the Drought Permit

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: Environmental Monitoring Plan (EMP)

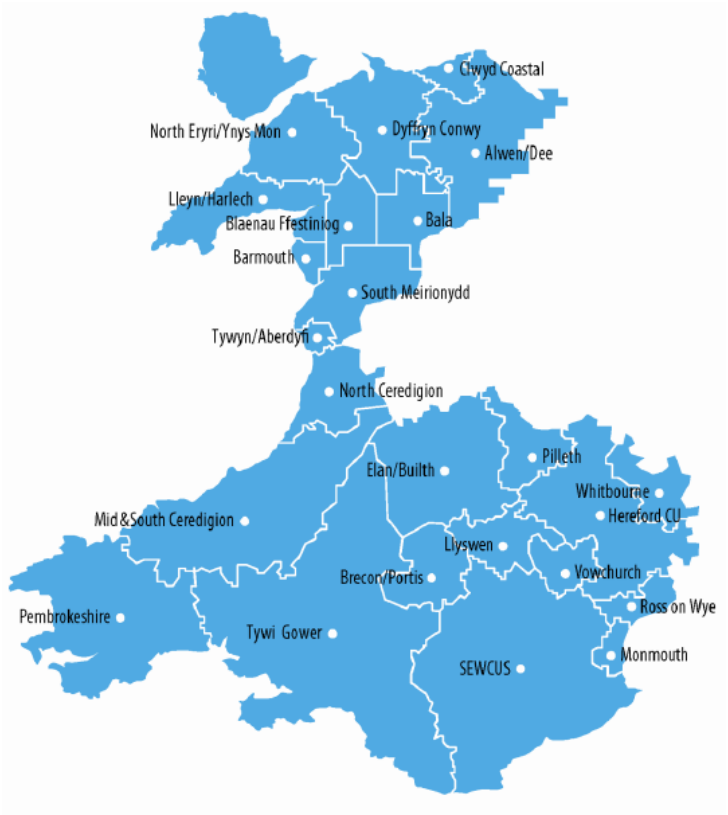
Section 10: Conclusions

2 BACKGROUND TO THE DROUGHT PERMIT

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



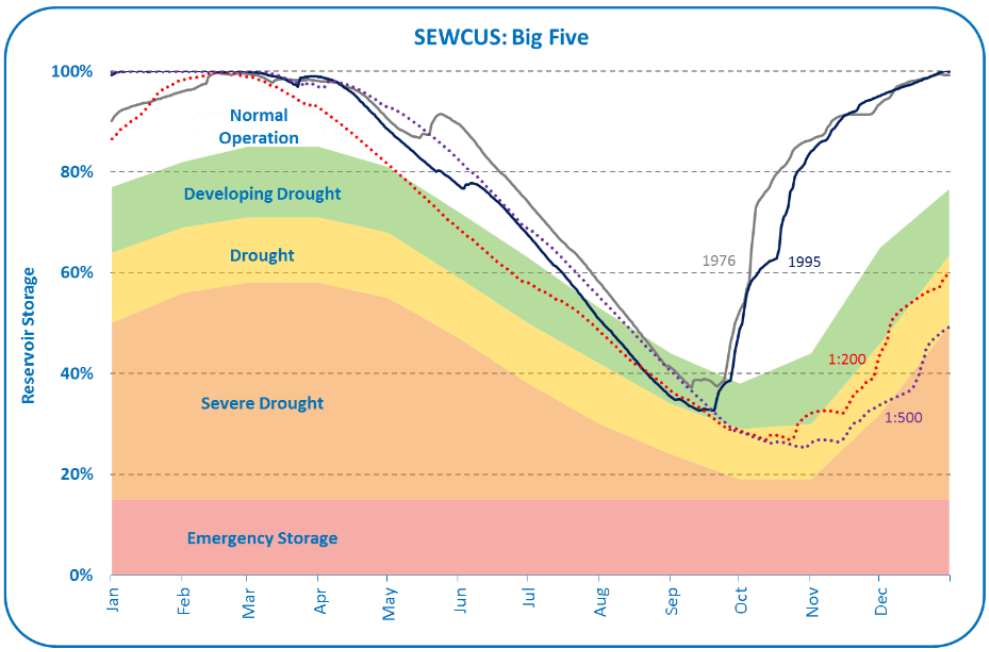
Llwynon Reservoir is located within the SEWCUS – Llwynon/ Sluvad / Court Farm (8109) WRZ. The Llwynon Reservoir supplies water under gravity towards Cardiff. There are several other abstractions within this WRZ including the abstraction from the River Usk at Prioress Mill via Llandegfedd Reservoir which supplies Sluvad WTW and pumped north towards Pontypool and south westerly towards Cardiff. The abstraction from the River Wye at Monmouth Court Farm WTW deliver water south towards Newport, Cardiff and south easterly towards Chepstow.

The triggers for applying for a drought permit at Llwynon Reservoir are 1) if demand restrictions are in operation, and demand in sub-zone SEWCUS Llwynon / Sluvad / Court Farm is still above 280 Ml/d for the potable water output[3], or 2) storage has declined into the severe drought zone for the Big 5 drought diagram as shown on **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

[3] Assuming 160 Ml/d output from Sluvad, 110 Ml/d output from Court Farm, and Llwynon delivering an average of 11 Ml/d

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 South East Conjunctive Use System (SEWUS) WRZ Drought Action Zones and Historic Drought



2.2 DESCRIPTION OF EXISTING ARRANGEMENTS AT LLWYNON RESERVOIR

Welsh Water's licence (number: 21/57/21/0001) to abstract water for consumptive use in potable supply under the Water Resources Act at Llwynon Reservoir includes the following conditions:

- 34,100 million litres (Ml) authorised to be abstracted per annum in aggregate total from the Taf Fawr Reservoirs:
  - Beacons Reservoir
  - Cantref Reservoir
  - Llwynon Reservoir.

Welsh Water hold an additional licence (number: 21/57/21/0004) to abstract water for non-consumptive use under the Water Resources Act at Llwynon Reservoir which includes the following conditions:

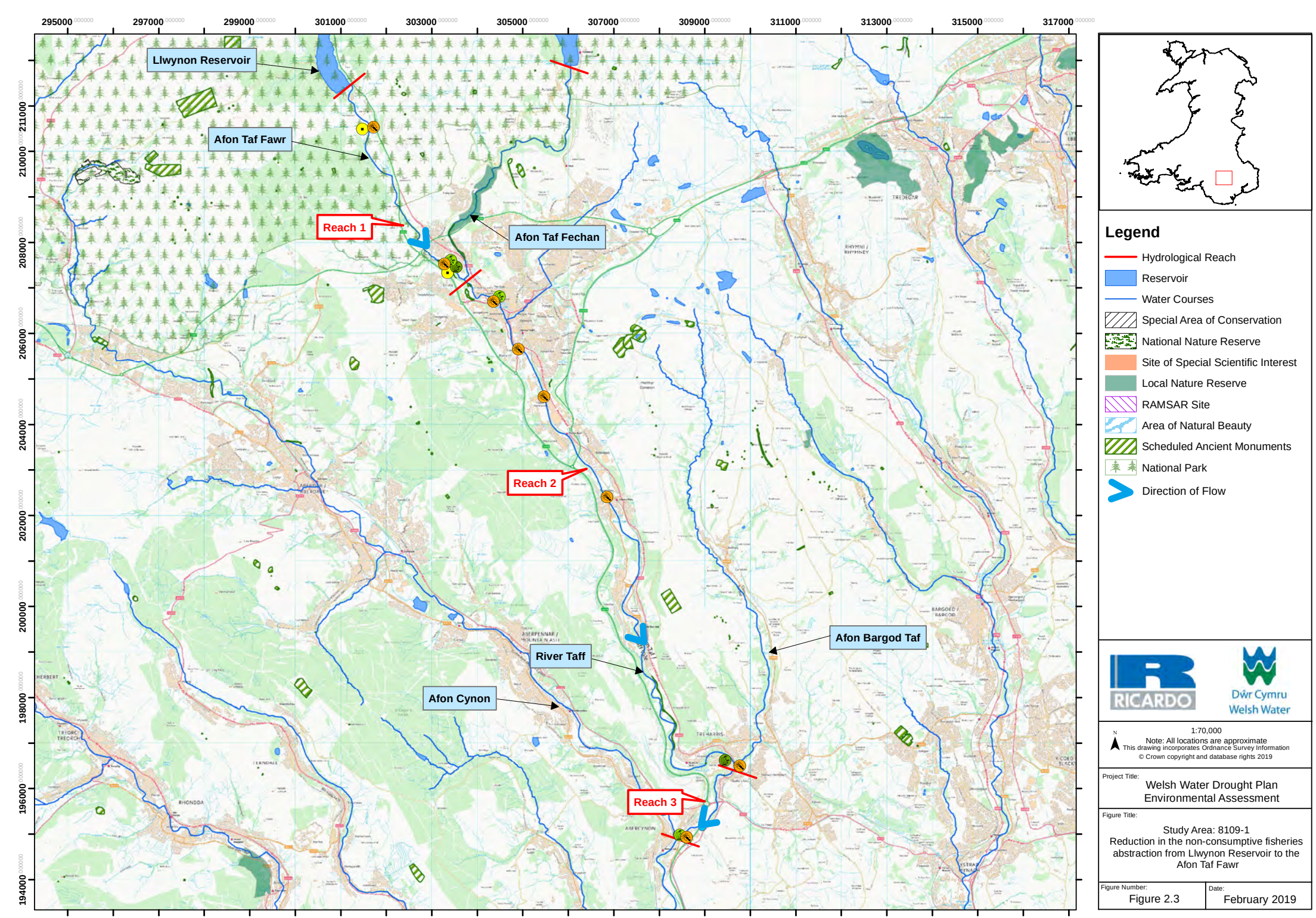
- Not more than 18,921.6 Ml per annum
- At an abstraction rate not exceeding 51.84 Ml/d[4].

[4] 1 Ml/d is 1 million litres per day.

The non-consumptive use abstraction is authorised to be used for fish-rearing for re-stocking purposes and power production, and the land on which it is authorised for use is the site of the old water treatment works (WTW) immediately downstream of the impoundment. From here, the abstracted water is discharged back to the Taf Fawr. An additional clause in this licence ensures that the amount of water entering the Taf Fawr at this point meets a required continuous compensation flow of 18.18Ml/d. The fisheries and power production abstraction water is, therefore, the compensation water from Llwynon Reservoir to the Taf Fawr.

The abstraction for potable supply is made directly from the reservoir and piped by gravity to Llwynon WTW for treatment. Distribution is by main under gravity towards Cardiff.

The study area is illustrated on **Figure 2.3**.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Llwynon Reservoir
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Reach 1
Afon Taf Fechan
Reach 2
River Taff
Afon Cynon
Afon Bargod Taf
Reach 3
RHONDDA
TREHARRIS
RHYMNI / RHYMNEY
BARGOED / BARGOD
ABERPENNAR / MOUNTAIN ASH
ABERDARE / ABERDÂR
TREORCHY / TREORCI
HERBERT
TYLORSTOWN
ABERCYNON
Legend
Hydrological Reach
Reservoir
Water Courses
Special Area of Conservation
National Nature Reserve
Site of Special Scientific Interest
Local Nature Reserve
RAMSAR Site
Area of Natural Beauty
Scheduled Ancient Monuments
National Park
Direction of Flow
RICARDO
Dŵr Cymru
Welsh Water
1:70,000
Note: All locations are approximate
This drawing incorporates Ordnance Survey Information
© Crown copyright and database rights 2019
Project Title:
Welsh Water Drought Plan
Environmental Assessment
Figure Title:
Study Area: 8109-1
Reduction in the non-consumptive fisheries abstraction from Llwynon Reservoir to the Afon Taf Fawr
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 permits or drought orders*'.

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 PERMIT

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

2.5 DROUGHT PERMIT – 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 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 permit, 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 permit, setting out the alternative options to the drought permit that Welsh Water has considered in addressing the risks to essential public water supplies due to drought.

2.7 PROPOSED DROUGHT PERMIT DETAILS

In order to protect public water supplies within Welsh Water's SEWCUS – Llwynon/ Sluvad / Court Farm (8109) WRZ in the event of a future severe drought, Welsh Water would make an application to NRW for a drought permit to vary the conditions of abstraction from Llwynon Reservoir.

If granted, the drought permit would involve a proposed reduction in the non-consumptive fisheries abstraction from Llwynon Reservoir to the Taf Fawr (which is in effect the compensation release) by 9.1 Ml/d, from 18.2 Ml/d to 9.1 Ml/d. This will conserve the longevity of reservoir storage for use in direct supply during a drought and improve the probability of reservoir winter refill.

The drought permit conditions could be required year round to maintain reservoir storage during a drought and to ensure adequate reservoir refill. This is based on modelling of Llwynon Reservoir's performance under normal operating conditions in dry summers and subsequent winters, together with experience of operating the source.

The drought permit is most likely to occur during the autumn and winter period, considered to not extend outside the period September to November. This has been confirmed by Welsh Water's water resources modelling.

Table 2.1 Llwynon Reservoir Existing and Proposed Drought Permit Abstraction

Abstraction Water Source	NGR	Normal Abstraction	Proposed Drought permit Abstraction	Benefit Ml/d
Llwynon Reservoir	SO 01180 11410	Welsh Water's licence (21/57/21/0001) to abstract water for consumptive use in potable supply under the Water Resources Act at Llwynon Reservoir includes the following conditions: •34,100 million litres (Ml) authorised to be abstracted per annum in aggregate total from the Taf Fawr Reservoirs: • Beacons Reservoir • Cantref Reservoir •Llwynon Reservoir. Welsh Water hold an additional licence (21/57/21/0004) to abstract water for non-consumptive use in fisheries under the Water Resources Act at Llwynon Reservoir which includes the following conditions: Not more than 18,921.6 Ml per annum At an abstraction rate not exceeding 51.84Ml/d.	The drought option involves a proposed reduction in the non-consumptive fisheries and power generation abstraction from Llwynon Reservoir to the Taf Fawr (which is in effect the compensation release) by 9.1 Ml/d, from 18.2 Ml/d to 9.1 Ml/d. This will conserve the longevity of reservoir storage for use in direct supply during a drought and improve the probability of reservoir winter refill.	9.10 Ml/d

2.8 DROUGHT PERMIT PROGRAMME

Drought permits 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, while the reduction in compensation release has the potential to be implemented year round, it is most likely to be implemented during the period September to November inclusive. This is based on modelling of Llwynon Reservoir performance under normal operating conditions in dry summers, together with Welsh Water's experience of operating the source. Therefore for the purposes of this assessment the period of implementation for this drought permit is assumed to be restricted to the period September to November inclusive.

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

2.9 DROUGHT PERMIT 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 permit being implemented. For the purposes of this assessment, the "without drought permit" baseline includes a licence to abstract water at Llwynon Reservoir with 6637.16 Ml authorised to be abstracted per annum, at a rate not exceeding 18.18 Ml/d and a non-consumptive fisheries abstraction (statutory compensation release) of 18.2 Ml/d at all times.

3 APPROACH

3.1 INTRODUCTION

The DPG states that the environmental report must include:

i. 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 for the drought permit assessment 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.

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

In accordance with the DPG and the Habitats Regulations, the assessment considers how the proposed drought permit 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 permit 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 and NRW Drought Plans
- National Policy Statements for Wastewater and Renewable Energy Infrastructure.

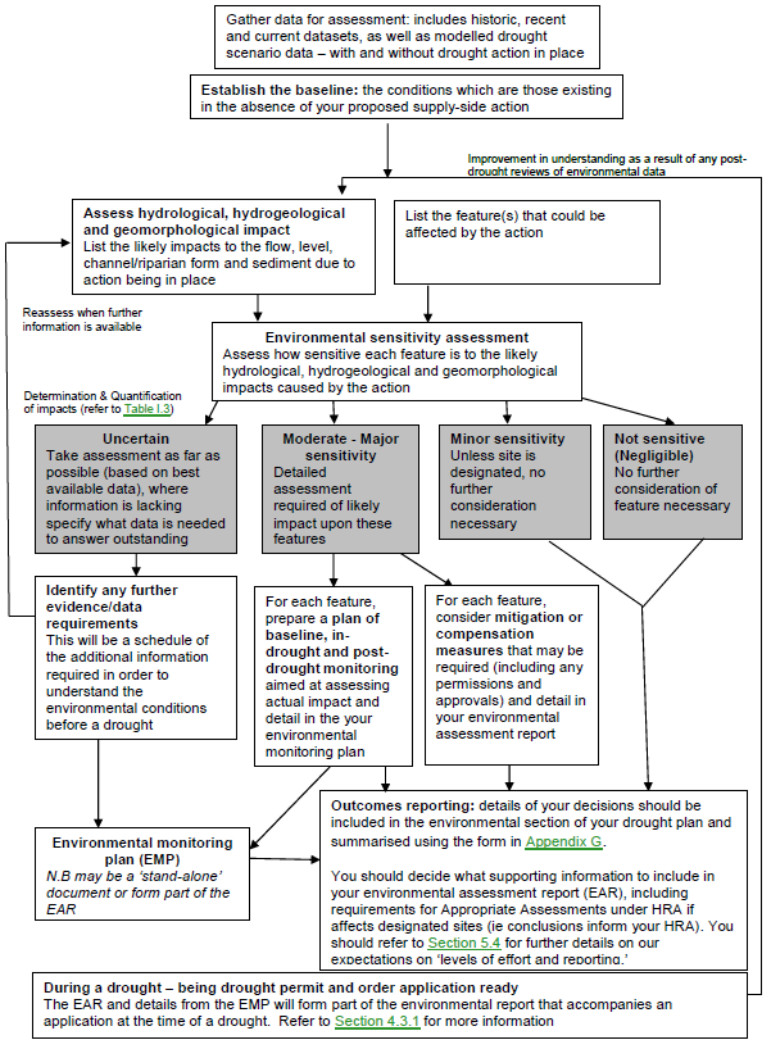
This is discussed further in Section 7.

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 permit implementation should be considered in the context of what would occur without drought permit 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 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 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 permit. 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 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.

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 a drought permit at Llwynon Reservoir.

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 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.

As set out in **Figure 3.2** 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 permit.

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 Llwynon Reservoir drought permit together with identification of relevant, sensitive environmental features within those study areas (based on the risk of them being impacted by the drought permit during the period of its operation).

The environmental sensitivity screening identifies the outcome for each listed feature. DPG Figure 5 categorises four outcomes 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.

For each feature identified, the assessment methodology used in the EAR to identify the magnitude and significance of impact has been defined (see Section 3.3 below).

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.

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[5] UKWIR (2007, updated 2012) Strategic Environmental Assessment – Guidance for Water Resources Management Plans and Drought Plans.
- 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

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

- Conservation of Habitats and Species Regulations 2017
- The Countryside and Rights of Way Act 2000.

All aspects of the drought permit 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 permit 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 permit 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 permit 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 permit against baseline operating conditions of Welsh Water's abstraction licence in advance of drought permit implementation. Environmental sensitivity has been assessed considering the context of the timing of drought permit implementation. **It is important to acknowledge the basis of the assessment; i.e. impacts of drought permit implementation are assessed against what would occur without drought permit 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[6,7] and the CIEEM study guidelines[8]. 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 permit.

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 permit.

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

[6] IEMA (2004) Guidelines for Environmental Impact Assessment.
[7] IEMA (2011) Special Report – The State of Environmental Impact Assessment Practice in the UK
[8] 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 and 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 LLWYNON RESERVOIR DROUGHT PERMIT - 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 permit. **Appendix B** sets out an assessment of the potential impacts on the physical environment of the Llwynon Reservoir abstraction during the period of implementation of the drought permit. The "without drought permit" 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 permit impacts, identifying the likely changes in flow / level regime due to implementing the drought permit. The specific requirements of the DPG are summarised as:

- identify any changes that the drought permit 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 permit;

- describe how the likely conditions would differ with the drought permit 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 Llwynon Reservoir, the Taf Fawr and River Taff.

2. The nature and duration of the potential impact:

A description of the likely conditions with the drought permit 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 permit, the key areas for the assessment of the physical environment have been identified as:

- Change in river flows of the Taf Fawr and River Taff

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 permit is most likely to occur during the autumn and winter period, 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 permit 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 Permit During Summer

Llwynon Reservoir	
Water level in Llwynon Reservoir *Minor (positive) impacts*	• Marginal increase in levels/storage and 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.
Afon Taf Fawr (Reach 1)	
Flows in the Afon Taf Fawr *Major impacts during the period September – November inclusive*	• Up to 50% reduction in low flows, with up to 10% and 15% reductions in wetted width and wetted depth respectively
Water quality in the Afon Taf Fawr *High risk*	• Risk of low dissolved oxygen levels associated with low flow and increased temperature, and to soluble reactive phosphorous and ammonia.
River Taff (Reach 2)	
Flows in the River Taff *Moderate impacts (September) or minor impacts (October - November)*	• Up to 16% reduction in summer extreme low flows and up to 14% reduction in winter low flows, with up to 10% reductions in wetted width/wetted depth
Water quality in the River Taff *Medium risk*	• Medium risk to soluble reactive phosphorous, low risk to dissolved oxygen levels associated with low flow and increased temperature
Surface water abstractions and risk to abstractors *Minor risk*	• Minor risk to private abstraction in reach 2 due to small magnitude of maximum licensed quantity
Consented discharges *Negligible risk*	• No significant discharges
River Taff (Reach 3)	
Flows in the River Taff *Minor impacts (September) or negligible impacts (October - November)*	• Up to 11% reduction in summer extreme low flows and up to 7 % reduction in winter low flows, with less than 5% reductions in wetted width/wetted depth
Water quality in the River Taff *Negligible risk*	• No risk of low dissolved oxygen levels associated with low flow and increased temperature

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 permit impacts and the baseline condition without a drought permit 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 LLWYNON RESERVOIR DROUGHT PERMIT ENVIRONMENTAL FEATURES ASSESSMENT

5.1 INTRODUCTION

As set out in **Box 1** above, environmental sensitivity screening of the drought permit 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 9 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 permit.

The Taf Fawr flows through Llwynon Reservoir and both are located in the Brecon Beacons National Park. There are four Sites of Special Scientific Interest (SSSIs) located within the zone of influence; these include Daren Fach, Penmoelallt, Cwm Taf Dechan Woodlands and Cwm Glo A Glyndyrys. Therefore consideration has been given to the potential impacts of drought permit implementation on these designated sites.

Susceptibility to the flow / level impacts resulting from the drought permit (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 Llwynon Reservoir Drought Permit

Site/Feature and designation	Hydro-logical Impact at Location (Major, Moderate, Minor)	Susceptibility to flow and level impacts	Sensitivity (Uncertain, Moderate/ Major, Minor, Negligible)	Further Consideration Required (Yes/No)
Taf Fawr and the River Taff				
Daren Fach SSSI	Major (Reach 1)	The SSSI consists of an open scrub on low limestone cliffs with screes and native woodland on the gentler slopes. The primary feature of interest is Whitebeam *Sorbus* spp. on the southern end of the Daren Fach crags. *Sorbus leyana* together with a specimen of *S. rupicola* grow in association with ash, yew and holly. The site has no water dependant features or hydrological connectivity to the impacted reach.	Negligible	No
Penmoelallt SSSI	Major (Reach 1)	A mixed woodland of ash, oak, wych elm and small-leaved lime overlying Carboniferous Limestone. The rare Ley's whitebeam grows on a small escarpment within the wood. The site has no water dependant features or hydrological connectivity to the impacted reach.	Negligible	No
Cwm Taf Fechan Woodlands SSSI	Major (Reach 1)	This woodland SSSI is noted for mixed deciduous woodland and plant communities and bryophytes in the splash zone of the river. The site is within 500m but is located on the Taf Fechan so is upstream of the impacted reach.	Negligible	No
Cwm Glo a Glyndyrys SSSI	Moderate (summer) Minor (winter) (Reach 2)	This SSSI is of special interest for marshy grassland, species-rich neutral grassland, acid grassland and association with woodland and heath. Although the marshy grassland may be a water-dependent feature, the A470 is considered to act as a barrier to hydrological connectivity between the hydrologically impacted reach and the SSSI.	Negligible	No
Macrophyte community	Negligible - Major	Reduction in flows and level as a result of the drought permit could reduce the overall extent of habitat availability for freshwater macrophytes in the study area.	Moderate	Yes
Notable Macrophytes Beck pocket moss *Fissidens rufulus*	Negligible - Major	This species grows submerged on rocks generally in depths over 30cm in the faster flowing rapids, although not in areas that are turbulent even when the water is low. It is therefore dependent on the water environment, although the magnitude of impact is uncertain.	Uncertain	Yes
Benthic macro-inverebrate communities Caddisfly *Metalype fragilis*	Negligible - Major	The hydrological impacts are anticipated to reduce the availability of habitats or lead to exposure of benthic macroinvertebrate habitats and reduce habitat suitability by altering habitat suitability for flow sensitive species.	Moderate	Yes

White-clawed Crayfish *Austropotamobius pallipes*	Negligible - Major	White-clawed crayfish were historically present within the Rvier Taff catchment but were not recorded in targeted surveys on behalf of Welsh Water in 2010 or 2011[9] and are assumed to be absent from the site.	Negligible	No
Marsh fritillary *Euphydryas aurinia*	Negligible - Major	Marsh fritillary are not dependent on the aquatic environment and as such are not considered to be susceptible to impacts of the drought permit	Negligible	No
Notable Species – Fish Atlantic salmon *Salmo salar* Bullhead *Cottus gobio* River lamprey *Lampetra fluviatus* Brook lamprey *Lampetra planeri* Sea lamprey *Pteromyzon marinus* Brown and sea trout *Salmo trutta*	Negligible - Major	A range of fish is likely to be present in the Llwynon Reservoir, such as minnow (*Phoxinus phoxinus*), stone loach (*Barbatula barbatula*) and stickleback (*Gasterostreus* sp.). Brown trout (*Salmo trutta*) are known to be present in Llwynon Reservoir, the Taf Fawr and the River Taff. Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*) and other migratory species can also travel up the length of the River Taff now that there is a fish pass on Treforest Weir (installed in 2003), approximately 1 km south of Pontypridd. It is likely that river lamprey (*Lampetra fluviatilis*), brook lamprey (*Lampetra planeri*) and sea lamprey (*Petromyzon marinus*) were once present in the Taf Fawr and the River Taff and it is possible that the construction of fish passes at many of the weirs along the River Taff have also enabled the migration of river and sea lamprey within accessible reaches. Bullhead (*Cottus gobio*) have also been recorded in the River Taff	Major	Yes
Phytobenthos community	Negligible - Major	The phytobenthos community is likely to be sensitive to changes in flow as a result of the drought permit.	Moderate	Yes
Notable Species – Mammals Otter *Lutra lutra*	Negligible - Major	Otters are considered to be well established in the River Taff catchment with evidence to suggest that they are successfully breeding. They are thought to utilise the entire length of the Taff from Cardiff Bay to the reservoirs in the upper catchment which provide excellent habitat. Otter are dependent on the water environment, using it as habitat for foraging and resting. They are believed to be resilient to changes in flow and are not expected to be significantly impacted by the implementation of the drought option against a baseline of reduced flows characteristic of a drought.	Negligible	No

[9] Amec (2012) Environmental Assessment of Ponsticill Reservoir Drought Permit. Technical report to Dwr Cymru Welsh Water.

Notable Species – amphibians Great crested newt *Triturus cristatus*	Negligible - Major	A search of NBN revealed that whilst Great crested newts are present in the wider area particularly around Methyr Tydfil, however there are no records within 500m of the impacted reaches. In addition to this Great crested newts breed in still water including ponds and ditches and are typically absent from flowing water or large water bodies with fish populations. Therefore no impacts on great crested newt are anticipated as a result of the drought permit.	Negligible	No
Invasive flora and fauna	Negligible - Major	Invasive plant species utilise flow of the watercourse for dispersal but are not reliant on it. Implementation of the drought permit is unlikely to increase the risk of dispersal of invasive plant species.	Negligible	No
Landscape and visual amenity	Negligible - Major	Llwynon Reservoir and the Taf Fawr are located within Brecon Beacons – the overall landscape and visual amenity of this area is appealing. The reduction of the compensation release may affect the landscape and visual amenity value of the site by reducing the quantity of water cascading down the mountainous stream. This will only be temporary and will be ameliorated once the drought has passed.	Uncertain	Yes
Recreation	Negligible - Major	Recreational activities in the area include angling, riding, cycling, walking and canoeing. Any reduction in wetted width and depth may influence water-dependent recreational activities. However, water levels will be naturally low in times of drought and impacts will be temporary in nature.	Uncertain	Yes
Archaeology	Negligible - Major	There are eight scheduled ancient monuments including canal bridges and iron works, located at the bottom of the valleys in close proximity to the Taf Fawr and the River Taff in the study area. However, none of the eight scheduled ancient monuments are considered to be dependent on, or influenced by, flows or water levels in the Taf Fawr and the River Taff.	Negligible	No

5.2.2 WFD Waterbody Status

Table 5.2 identifies the WFD status classification of the WFD waterbodies that may be impacted by implementation of the drought permit. 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. **Table 5.2** 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	Llwynon Reservoir (GB30940648)		Taf Fawr - source to conf Taf Fechan (GB109057033170)		Taff- conf Taf Fechan to conf Afon Cynon (GB109057033100)	
Hydrological Impact at Location (Major, Moderate, Minor, Negligible)	Minor (Positive)		Major (Reach 1),		Moderate/Minor (Reach 2), Negligible (Reach 3)	
Heavily Modified Waterbody (Y/N)	Yes		Yes		Yes	
RBMP[10] Cycle	RBMP2 (2015)[11]	2018 C2 Interim[12]	RBMP2 (2015)	2018 C2 Interim	RBMP2 (2015)	2018 C2 Interim
Overall Biological	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Fish	Not assessed	Not assessed	Moderate	Moderate	Moderate	Not assessed
Macrophytes and Phytobenthos	Not assessed	Not assessed	Good	Good	Not assessed	Not assessed
Phytobenthos (Sub-Element)	Not assessed	Not assessed	Not assessed	Good	Not assessed	Not assessed
Macrophyte (Sub-Element)	Moderate	Moderate	Not assessed	Not assessed	Not assessed	Not assessed
Phytoplankton	High	High	Not assessed	Not assessed	Not assessed	Not assessed
Macro-invertebrates	Not assessed	Not assessed	Moderate	Good	High	High
Total P/ Phosphate	Moderate	Moderate	Not assessed	High	High	High
Ammonia	Not assessed	Not assessed	Not assessed	High	High	High
Dissolved Oxygen	Good	Good	Not assessed	High	High	High
pH	Not assessed	Not assessed	Not assessed	High	High	High
Sensitivity (Uncertain, Moderate/ Major, Minor, Not sensitive)	Not sensitive		Moderate		Moderate	
Further Consideration Required (Y/N)	No		Yes		Yes	

5.3 FEATURES ASSESSMENT

5.3.1 Basis of Features Assessment

This section describes and assesses the potential impacts on the sensitive features

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

during the period of implementation of the drought permit.

Based on the sensitive features identified in Section 5.2.1, 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 relevant river reaches for the Llwynon Reservoir drought permit. 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.

5.3.2 Summary of Features Assessment

Table 5.3 presents the overall summary of the significance of potential impacts of the drought permit 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 – 5.3.5.

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

Month		J	F	M	A	M	J	J	A	S	O	N	D
Reach 1 –Taf Fawr (Llwynon Reservoir outflow to the confluence with Taf Fechan)													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N	N	N/A
Notable macrophyte species –*Fissidens rufulus*		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		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
Risk to WFD waterbody macrophyte/phytobenthos status		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N	N	N/A
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Notable macroinvertebrate species –*Metalype fragilis*		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	N	N	N/A
Atlantic Salmon	Upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N			N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Spawning and juveniles (loss of habitat)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Brown / Sea trout	Spawning, egg survival, and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Reduced water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				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/A
Other fish species- Minnow, Stone loach and Three-spined stickleback		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N	N	N/A
Risk to WFD waterbody fish status		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Landscape and Visual Amenity		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Recreation	Angling	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Other recreational activities	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 2 – River Taff (confluence with Taf Fechan to the confluence with Afon Taf Bargoed													
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 –*Fissidens rufulus*		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
Risk to WFD waterbody macrophyte/phytobenthos 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
Atlantic Salmon	Upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N			N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Spawning and juveniles (loss of habitat)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				
Brown/ sea trout	Spawning, egg survival, and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Reduced water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
	Upstream migration	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/A
Other fish species- Minnow, Stone loach and Three-spined stickleback		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N	N	N/A
Risk to WFD status for fish		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Landscape and Visual Amenity		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
Recreation	Angling	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N	N	N	N/A
	Other recreational activities	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 3 – River Taff (confluence with Afon Taf Bargoed to the confluence with Afon Cynon)													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Notable macrophyte species –*Fissidens rufulus*		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
Risk to WFD waterbody macrophyte/phytobenthos 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
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Atlantic Salmon	Upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N	N	N/A

Month		J	F	M	A	M	J	J	A	S	O	N	D
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Spawning and juveniles (loss of habitat)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N	N	N/A
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N	N	N/A
Brown/ sea trout	Spawning, egg survival, and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N/A	N/A
	Reduced water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A
	Upstream migration	N/A	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- Grayling		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Other fish species- Minnow, Stone loach and Three-spined stickleback		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N	N	N/A
Risk to WFD status for fish		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				N/A
Landscape, Recreation and 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/A	Outside implementation period
N	Negligible impacts are considered likely
	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 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 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.

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.

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[13] 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 good ecological status for the waterbody to be classified as good ecological potential. 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 permit on macrophyte, macroinvertebrate, phytobenthos and fish communities and WFD status is presented below. Full details, including detailed baseline information, can be found in **Appendix D**.

Macrophytes

Table 5.4 presents a summary of the potential impacts of the drought permit identified from the assessment of macrophytes.

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

Table 5.4 Summary of Impacts of Drought Permit Implementation on Macrophytes

Reach 1 –Taf Fawr: Llwynon Reservoir outflow –Taf Fechan confluence		
WFD Waterbody		**Significance of Impact**
Taf Fawr - source to conf Taf Fechan (GB109057033170) Current status: Good	• There is a negligible risk of short-term deterioration in status of the macrophyte component, due to the drought permit.	**Negligible**
Feature	**Impact**	**Significance of Impact**
Macrophytes	• Reduction in growth as a result of major to moderate 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. • Increase in filamentous algae levels due to increased nutrients or water temperature and decreased velocity	**Minor** (September only) **Negligible** (October & November)
Fissidens rufulus	• Changes to inundation pattern and splash due to changes in flow. • Increase in competition from filamentous algae due to increased nutrients or water temperature and decreased velocity.	**Minor** (September only) **Negligible** (October & November)
Reach 2 – River Taff: Taf Fechan confluence to Afon Taf Bargoed confluence **Reach 3 – River Taff: Afon Taf Bargoed confluence to Afon Cynon confluence**		
WFD Waterbody		**Significance of Impact**
Taff- conf Taf Fechan to conf Afon Cynon (GB109057033100) Current status: Not assessed	Not assessed	**N/A**
Feature	**Impact**	**Significance of Impact**
Macrophytes	• Reduction in growth as a result of moderate 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.	**Negligible**
Fissidens rufulus	• Changes to inundation pattern and splash due to changes in flow. • Increase in competition from filamentous algae due to increased nutrients or water temperature and decreased velocity.	**Negligible**

Macroinvertebrates

Table 5.5 presents a summary of the potential impacts of the drought permit identified from the assessment of macroinvertebrates.

Table 5.5 Summary of Impacts of Drought Permit Implementation on Macroinvertebrates

Reach 1 –Taf Fawr: Llwynon Reservoir outflow –Taf Fechan confluence		
WFD Waterbody		**Significance of Impact**
Afon Taf Fawr - source to conf Taf Fechan (GB109057033170) Current status: Good (2018 interim)	• There is a negligible risk of short-term deterioration in status of the macroinvertebrate component, due to the drought permit.	**Negligible**
Feature	**Impact**	**Significance of Impact**
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats • Reduction in species diversity and abundance as a result of reduced recruitment.	**Minor**
Metalype fragilis	• Reduction in habitat area and suitability	**Minor**
Reach 2 – River Taff: Taf Fechan confluence to Afon Taf Bargoed confluence **Reach 3 – River Taff: Afon Taf Bargoed confluence to Afon Cynon confluence**		
WFD Waterbody		**Significance of Impact**
Taff- conf Taf Fechan to conf Afon Cynon (GB109057033100) Current status: High	• There is a negligible risk of short-term deterioration in status of the macroinvertebrate component, due to the drought permit.	**Negligible**
Feature	**Impact**	**Significance of Impact**
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats	**Negligible**

Fish

Table 5.6 presents a summary of the potential impacts of the drought permit identified from the assessment of fish.

Table 5.6 Summary of Impacts of Drought Permit Implementation on Fish

WFD Waterbody		**Significance of Impact**
Taf Fawr - source to conf Taf Fechan (GB109057033170) Current status: Moderate	• There is a risk of short-term deterioration in status of the fish component due to the drought permit.	**Major**
Reach 1 – Taf Fawr (Llwynon Reservoir outflow to the confluence with Taf Fechan)		
Feature	**Impact**	**Significance of Impact**
Atlantic salmon	• Delays and potential cessation of migration due to reduced flows.	**Major**
	• Reduced water quality.	**Major**
	• Loss of spawning and juvenile habitat as a result of reduced river levels.	**Major**
Bullhead	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
Brown/sea trout	• Delays and potential cessation of migration due to reduced flows.	**Major**
	• Reduced water quality	**Major**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Moderate**
Other fish species - Grayling	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Other fish species (not inc. grayling)		**Major**
WFD Waterbody		**Significance of Impact**
Taff- conf Taf Fechan to conf Afon Cynon (GB109057033100) Current status: Moderate	• There is a risk of short-term deterioration in status of the fish component due to the drought permit.	**Minor**
Reach 2 – River Taff (confluence with Taf Fechan to the confluence with Afon Taf Bargoed		
Feature	**Impact**	**Significance of Impact**
Atlantic salmon	• Delays and potential cessation of migration due to reduced flows.	**Minor**
	• Reduced water quality.	**Minor**
	• Loss of spawning and juvenile habitat as a result of reduced river levels.	**Moderate** (September only)
Bullhead	• Reduction in spawning and juvenile survival due to habitat loss.	**Moderate** (September only)
Brown/sea trout	• Delays and potential cessation of migration due to reduced flows.	**Moderate**
	• Reduced water quality	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Moderate** (September only)
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Minor**
Other fish species - Grayling	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Other fish species (not inc. grayling)		**Moderate**
Reach 3 – River Taff (confluence with Afon Taf Bargoed to the confluence with Afon Cynon)		

Feature	Impact	Significance of Impact
Atlantic salmon	• Delays and potential cessation of migration due to reduced flows.	**Negligible**
	Reduced water quality.	**Negligible**
	• Loss of spawning and juvenile habitat as a result of reduced river levels.	**Minor** (September only)
Bullhead	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor** (September only)
Brown/sea trout	• Delays and potential cessation of migration due to reduced flows.	**Minor**
	• Reduced water quality	**Negligible**
	• 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.	**Negligible**
Other fish species	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor** (September only)

Phytobenthos

Table 5.7 presents a summary of the potential impacts of the drought permit identified from the assessment of phytobenthos.

Table 5.7 Summary of Impacts of Drought Permit Implementation on Phytobenthos

WFD Waterbody		Significance of Impact
Taf Fawr - source to confTaf Fechan (GB109057033170) Current status: Good (2018 interim)	There is a negligible risk of short-term deterioration in status of the phytobenthos component, due to the drought permit.	**Negligible**
Taff - confTaf Fechan to confAfon Cynon (GB109057033100) Current status: Not assessed	Not assessed	**N/A**
Feature	**Impact**	**Significance of Impact**
Reach 1, 2 and 3		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition • Minor-moderate increase in SRP affecting phytobenthos community composition and TDI score	**Negligible-Minor**

5.3.4 Landscape, Heritage and Recreation

Table 5.8 presents a summary of the potential impacts of the drought permit identified from the assessment of landscape and recreation.

Table 5.8 Summary of Impacts of Drought Permit Implementation on Landscape, Heritage and Recreation

Feature		Susceptibility to flow and level impacts	Significance of Impact
Reach 1, 2 and 3			
Landscape	Visual amenity	Llwynon Reservoir and the Taf Fawr are located within Brecon Beacons – the overall landscape and visual amenity of this area is appealing. The reduction of the compensation release may affect the landscape and visual amenity value of the site by reducing the quantity of water cascading down the mountainous stream. This will only be temporary and will be ameliorated once the drought has passed.	**Negligible**
Recreation	Angling	Flows during a drought will be low and not conducive to angling. The further reduction in flows due to the drought permit would not be likely to further reduce the angling quality of the reach.	**Negligible**
	Water dependant recreational activities	Any reduction in wetted width and depth may influence water-dependent recreational activities. However, water levels will be naturally low in times of drought and impacts will be temporary in nature.	**Negligible**

6 LLWYNON RESERVOIR DROUGHT PERMIT – MITIGATION

The environmental assessment has identified some significant impacts, including major hydrological impacts, major water quality impacts, major to moderate aquatic ecology impacts on fish.

For those receptors with a potential impact or risk identified as being significant as a result of implementation of the drought permit, 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 permit 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 permit 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 permit implementation events will provide a tool for discussions regarding best working practices between Welsh Water 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 permit 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 permit and post-drought permit implementation include:

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

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[14] 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 Llywynon drought permit are given in **Table 90.1**. For these features, a range of precautionary monitoring and triggers leading to enabling of appropriate mitigation measures are also described.

[14] Schedule 1 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 permit 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, including those identified in NRW Review of Consents reports;
- Assessment of cumulative impacts of the drought permit with other Welsh Water supply-side and drought permit 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 that 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 other neighbouring water company Drought Plans and NRW Drought Plans.
    - National Policy Statements for Wastewater and Renewable Energy Infrastructure.
- Environmental monitoring before, during and after drought permit implementation (see Section 9).

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

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

No relevant licences or consents have been identified as relevant for assessment of cumulative effects.

Welsh Water drought permit / orders at other Welsh Water abstraction sites

The drought permit at Pontsticill Reservoir (8119-1) is likely to be implemented concurrently with reduced compensation from Llwynon Reservoir and both of these drought options influence the River Taff from the confluence of the Taf Fawr / Taf Fechan down to the confluence with the Afon Cynon (Reaches 2 and 3 in this assessment), therefore in-combination effects are anticipated.

The cumulative impacts of both options together would lead to an overall reduction in flow of 18.2Ml/d below the confluence at the top of Reach 2 (a reduction in compensation of 9.1Ml/d from each of the two reservoirs, Pontsticill and Llwynon). The in-combination impacts are estimated to occur for no more than 4 months. The summer cumulative impact for Reach 2 would be major, for Reach 3 moderate and Reach 4 minor. The winter cumulative impact for Reach 2 would be major, for Reach 3 minor and for Reach 4 minor (see **Appendix B**, Section B5 for more details).

The cumulative impacts on fish in Reach 2 are assessed as **major**, and **moderate** impacts are anticipated on macrophytes and macroinvertebrates (see **Appendix D**, Section D4 for more details).

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

Welsh Water's WRMP schemes

No WRMP schemes identified with cumulative impacts.

Drought options from other neighbouring water company Drought Plans and NRW Drought Plans

No cumulative impacts of options in Natural Resources Wales Drought Plans or neighbouring water company drought plans and a drought permit at Llwynon Reservoir are anticipated, however, this should be reviewed at time of future application for a drought permit.

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 permit implementation have been made in the EMP which is presented in Section 9 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 that 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 LLWYNON RESERVOIR DROUGHT PERMIT - 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 permit 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 permit impacts.

9 ENVIRONMENTAL MONITORING PLAN (EMP)

9.1 INTRODUCTION

The overall scope of the EMP for the Llwynon Reservoir drought permit meets the requirements of Section 5.2 (Monitoring) and informs the requirements of Section 5.3 (Mitigation) of 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 permit monitoring describes the prevailing environmental conditions prior to drought permit implementation. This will inform the implementation and management of any mitigation actions during the drought.
- During-drought permit 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 permit monitoring describes the recovery of environmental conditions following the cessation of a drought permit, and establishes whether the affected ecosystems have recovered to conditions prevailing in the pre-drought permit period.

The basis of the development of the EMP is provided in Section 10.2.1. Monitoring recommendations are set out in Section 10.2.2.

9.2 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 permit 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 permit 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 (in relation to any proposals that may affect any SACs, SPAs, NNRs, SSSIs or RAMSAR sites) 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).

9.3 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 permit 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 permit.

Recommendations for pre-drought, in drought and post-drought monitoring, based on the outcome of the current environmental assessment, are provided in **Table 9.1** and are illustrated on **Figure 9.1**.

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 permit.

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 9.1 Baseline, Pre, Onset, During and Post Drought Monitoring and Mitigation

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		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
Fish (including salmon, brown trout, lamprey, bullhead, eel) **Reaches 1-3**	Decreased growth, alteration to feeding and migration Loss of important habitats (spawning gravels, nursery habitat, resting pools) Increased mortality (density dependant) as a result of increased predation and competition Stranding of individuals as a result of a reduction in velocity Fragmentation of habitats and increased significance of obstacles/barriers Changes in flows and water levels may delay or prevent	Fisheries surveys were undertaken on behalf of Welsh Water in 2017 in the impacted reaches[15]. NRW also hold a longer term dataset for some sites on these reaches. Surveys to be repeated every three years. To complement any existing NRW monitoring, in discussion with NRW. Monitoring sites are located at: • Reach 1 – T003a / L1 • Reach 2 - T006 / L2 • Reach 3 - L3 If any lamprey are recorded during standard electric fishing surveys then further monitoring must be undertaken. Quantitative, lamprey-specific electric fishing surveys targeting known optimal and sub-optimal habitat identified during preliminary walkover.	Electric-fishing surveys to monitor fish populations at one site in each of the impacted reaches. One site in each of the impacted reaches. In severe drought conditions, no fish population surveys are advised during drought as this may cause further stress. Walkover of key sections known to be susceptible to lower flows: • Identification of key habitats which are at risk of fragmentation. • Identification of key structures which may provide a barrier at lower flows. • Identification of key spawning locations recording the number of redds potentially affected, undertaken during the salmonid winter spawning period (depending on permit	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 to contain high fish densities, spawning, nursery and cover habitats. Record extent of exposed marginal habitats, spawning 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. Targeted fish passage	Targeted installation of woody debris features to provide fish with the habitat required to support feeding and development (growth). If the results of the walkovers deem spawning gravels to be at risk to siltation, the following mitigation action/s may be undertaken: • Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)[16] • Targeted installation of woody debris features to increase localised flow velocity/scour at impacted spawning gravels (to aid sediment transport	Two years of annual post-drought fish 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 help inform mitigation targeting habitat restoration where deemed to be appropriate to support and enhance affected populations. Walkover of key spawning locations recording the number of redds potentially affected, undertaken during the winter spawning period. Record extent of exposed marginal habitats, spawning habitats, composition of the bed	Welsh Water

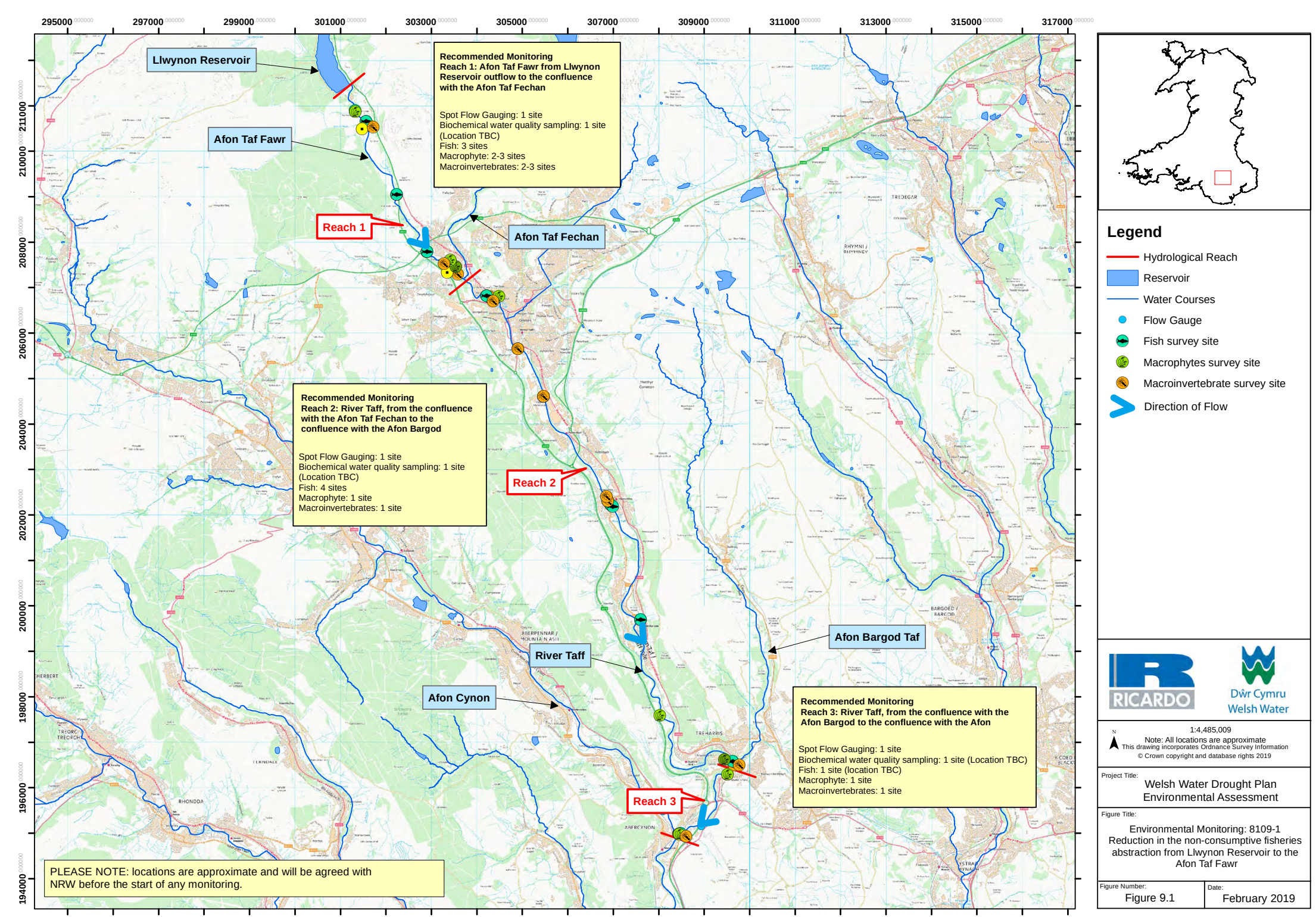
[15] Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2017 to 2018: Llwynon and Pontsticill Reservoirs, August 2018
[16] Wild Trout Trust Habitat Management Sheet – Gravel Cleaning http://www.wildtrout.org/sites/default/files/library/Gravel_Cleaning_Apr2012_WEB.pdf

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring Key locations	On-set of environmental drought Monitoring and trigger setting	During Drought Permit Implementation Period Trigger and monitoring to inform mitigation action	 Mitigation actions triggered by monitoring	Post Drought Permit Monitoring and post-drought mitigation (where applicable)	Responsibility
	passage over barriers to migration Mortality as a result of water quality deterioration (oxygen stress, gill clogging) Alteration to species distribution and abundance as a result of water quality deterioration.		being implemented during the salmonid winter spawning period). Record extent of exposed marginal habitats, spawning habitats, composition of the bed substrate and estimates of overlaying silt cover. Approximation of the number of each fish species (e.g. 10s, 100s) in each ponded reach, where safe and practical to do so. Measure dissolved oxygen, conductivity and temperature in the field using calibrated handheld equipment. Appropriate trigger values would be set for level and flow for spawning habitats based on local circumstances, timing, seasonality and expert opinion.	assessment of barriers /obstructions to fish passage and any associated fish passes should be undertaken to ascertain if they pose an increased risk to the free movement of fish during key migration periods. Frequency of fish passage assessments 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. Measure dissolved oxygen, conductivity and temperature in the field using calibrated handheld equipment. Deployment of automated water quality equipment that continuously monitors for dissolved oxygen.	and increase water depth for spawning depth) 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 increase flow heterogeneity/scour and marginal cover in shallow areas of the channel[17] • Deployment of aeration equipment in key reaches that have standing or slow flowing water with low oxygen levels. • Targeted installation of woody debris features to provide submerged and overhead cover from predation where significant abundances of fish have been	substrate and estimates of overlaying silt cover. If the results of the walkovers deem spawning gravels to have suffered from siltation, the following mitigation action/s may be undertaken: Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)[18] Targeted installation of woody debris features to: • increase flow heterogeneity/scour and marginal cover in shallow areas of the channel[19] • increase localised flow velocity/scour at impacted spawning gravels (to aide sediment transport and increase water depth for spawning depth) If the results of the walkovers deem important habitats to be at risk to exposure/ reduction (in extent), the following	

[17] Wild Trout Trust Chalkstream Habitat Manual – Use of Large Woody Debris http://www.wildtrout.org/sites/default/files/library/Large_Woody_Debris.pdf
[18] Wild Trout Trust Habitat Management Sheet – Gravel Cleaning http://www.wildtrout.org/sites/default/files/library/Gravel_Cleaning_Apr2012_WEB.pdf
[19] Wild Trout Trust Chalkstream Habitat Manual – Use of Large Woody Debris http://www.wildtrout.org/sites/default/files/library/Large_Woody_Debris.pdf

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)	
					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. Modify any impacted fish passes (where possible) to ensure passage is maintained during key migration periods (e.g. agree to provide an appropriate proportion of flow into the pass to enable passage). Consider 'Trap &	mitigation action/s may be undertaken: • Targeted fish passage assessment of barriers/obstructions to fish passage and any associated fish passes should be undertaken to ascertain if they pose an increased risk to the free movement of fish during key migration periods, i.e. during juvenile eel migration (spring/summer). • Modify any impacted fish passes (where possible) to ensure passage is achievable during key migration periods (e.g. agree to provide an appropriate proportion of flow into the pass to enable passage). Where fish passage is not currently provided at a barrier, investigate appropriate methods of improving passage (e.g. fish passage design and installation).	

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)	
					Transport' of concentrated abundances of migrating fish accumulated below impassable barrier/s to spawning grounds upstream of the impacted reach (where environmental parameters such as dissolved oxygen and temperature allow). Alternatively, mitigation should seek to protect any populations 'trapped' as a result of the barrier/s until flows increase for example by using aeration (if dissolved oxygen levels are low) or preventing predation (see Increased Mortality impact mitigation actions outlined above). Deployment of aeration equipment in key reaches that have standing or slow flowing water with low oxygen levels.		


Llwynon Reservoir
Afon Taf Fawr
Reach 1
Afon Taf Fechan
Recommended Monitoring
Reach 1: Afon Taf Fawr from Llwynon Reservoir outflow to the confluence with the Afon Taf Fechan
Spot Flow Gauging: 1 site
Biochemical water quality sampling: 1 site (Location TBC)
Fish: 3 sites
Macrophyte: 2-3 sites
Macroinvertebrates: 2-3 sites
Recommended Monitoring
Reach 2: River Taff, from the confluence with the Afon Taf Fechan to the confluence with the Afon Bargod
Spot Flow Gauging: 1 site
Biochemical water quality sampling: 1 site (Location TBC)
Fish: 4 sites
Macrophyte: 1 site
Macroinvertebrates: 1 site
Reach 2
Afon Bargod Taf
River Taff
Afon Cynon
Recommended Monitoring
Reach 3: River Taff, from the confluence with the Afon Bargod to the confluence with the Afon
Spot Flow Gauging: 1 site
Biochemical water quality sampling: 1 site (Location TBC)
Fish: 1 site (location TBC)
Macrophyte: 1 site
Macroinvertebrates: 1 site
Reach 3
PLEASE NOTE: locations are approximate and will be agreed with NRW before the start of any monitoring.
295000
297000
299000
301000
303000
305000
307000
309000
311000
313000
315000
317000
211000
210000
208000
206000
204000
202000
200000
198000
196000
194000
TREDEGAR
RHYMNI / RHYMNEY
BARGOED / BARGOD
ABERPENNAR / MOUNTAIN ASH
TREHARRIS
ABERCYNON
RHONDDA
TREORCHY / TREORCI
TREFOREST
Legend
Hydrological Reach
Reservoir
Water Courses
Flow Gauge
Fish survey site
Macrophytes survey site
Macroinvertebrate survey site
Direction of Flow
RICARDO
Dŵr Cymru Welsh Water
N
1:4,485,009
Note: All locations are approximate
This drawing incorporates Ordnance Survey Information
© Crown copyright and database rights 2019
Project Title:
Welsh Water Drought Plan Environmental Assessment
Figure Title:
Environmental Monitoring: 8109-1 Reduction in the non-consumptive fisheries abstraction from Llwynon Reservoir to the Afon Taf Fawr
Figure Number:
Figure 9.1
Date:
February 2019

10 CONCLUSIONS

This EAR provides an assessment of the potential environmental impacts relating to the implementation of the Llwynon Reservoir drought permit. If granted and implemented, the drought permit would enable Welsh Water to reduce the non-consumptive fisheries abstraction from Llwynon Reservoir to the Taf Fawr by 50% from 18.2 Ml/d to 9.1 Ml/d.

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 permit (Stage 2).

The hydrological / hydrogeological impact assessment has identified impacts ranging from **major to negligible** on the Taf Fawr and River Taff. There are also impacts ranging from **major to negligible** 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, invasive fauna and landscape and Recreation as environmental features for which an environmental assessment was required. The assessment has concluded that there are **major - minor** impacts on aquatic ecology, specifically: major impacts on fish and minor impacts on macroinvertebrates and macrophytes.

The drought permit at Llwynon Reservoir is likely to be implemented concurrently with reduced compensation from Pontsticill Reservoir (8119-1) and both options influence the River Taff downstream of the Taf Fechan / Taf Fawr confluence. In-combination effects are anticipated on fish, macrophytes and macroinvertebrates. This should be reviewed at the time of any future application for a drought permit at Llwynon Reservoir.

The environmental assessment has identified significant impacts of implementation of a drought permit at Llwynon Reservoir. 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, water quality and ecology of implementing a drought permit at Llwynon Reservoir, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **major.**

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 Llwynon Reservoir and the downstream Afon Taf Fawr and River Taff catchment during the period of implementation of the drought permit.

For the purposes of this assessment, the "without drought permit" baseline includes the continuation of Welsh Water's existing abstraction and compensation arrangements at Llwynon Reservoir, with the statutory compensation rate set to 18.2Ml/d. The assessed drought permit assumes a reduced rate of compensation of 9.1Ml/d.

B.1.1 Welsh Water's Existing Operations

Welsh Water's licence (number 21/57/21/0001) to abstract water for consumptive use in potable supply under the Water Resources Act at Llwynon Reservoir (see **Figure B1.1**) includes the following conditions:

- 34,100 million litres (Ml) authorised to be abstracted per annum in aggregate total from the Taf Fawr Reservoirs:
  - Beacons Reservoir
  - Cantref Reservoir
  - Llwynon Reservoir.

The abstraction for potable supply is made directly from the reservoir and piped by gravity to Llwynon WTW for treatment. Distribution is by main under gravity towards Cardiff.

Welsh Water hold an additional licence (number 21/57/21/0004) to abstract water for non-consumptive use in fisheries and for hydropower under the Water Resources Act at Llwynon Reservoir which includes the following conditions:

- Not more than 6,637.16 Ml per annum for fish farming
- At an abstraction rate not exceeding 18.18 Ml/d[1] for fish farming.
- Not more than 18, 921,6000 Ml per annum for power production
- At an abstraction rate not exceeding 51.84 Ml/d for power production
- Total aggregate quantity of water authorised to be abstracted should not exceed: 51.84 Ml/d and 18,921.6 Ml per annum .

The non-consumptive use abstraction is authorised to be used for fish-rearing for re-stocking purposes and hydropower, and the land on which it is authorised for use is the site of the old water treatment works (WTW) immediately downstream of the impoundment. From here, the abstracted water is discharged back to the Afon Taf Fawr. An additional clause in this licence ensures that the amount of water entering the Afon Taf Fawr at this point meets a required

[1] 1 Ml/d is 1 million litres per day.

continuous compensation flow of 18.18Ml/d. The fisheries abstraction water is, therefore, the compensation water from Llwynon Reservoir to the Afon Taf Fawr.

B.1.2 Welsh Water's Proposed Drought Permit Operations

The drought permit involves a proposed reduction in the non-consumptive fisheries abstraction from Llwynon Reservoir to the Afon Taf Fawr (which is in effect the compensation release) by 50% from 18.2 Ml/d to 9.1 Ml/d. This will conserve the longevity of reservoir storage for use in direct supply during a drought and improve the probability of reservoir winter refill. The hydro-electric abstraction would not be altered. The drought permit will influence the downstream Afon Taf Fawr and its continuation, the River Taff.

The reduction in compensation release has the potential to be implemented year round, although it is most likely to be implemented during the period September to November inclusive. This is based on modelling of Llwynon Reservoir performance under normal operating conditions in dry summers, together with Welsh Water's experience of operating the source.

The study area is shown on **Figure B1.1**.

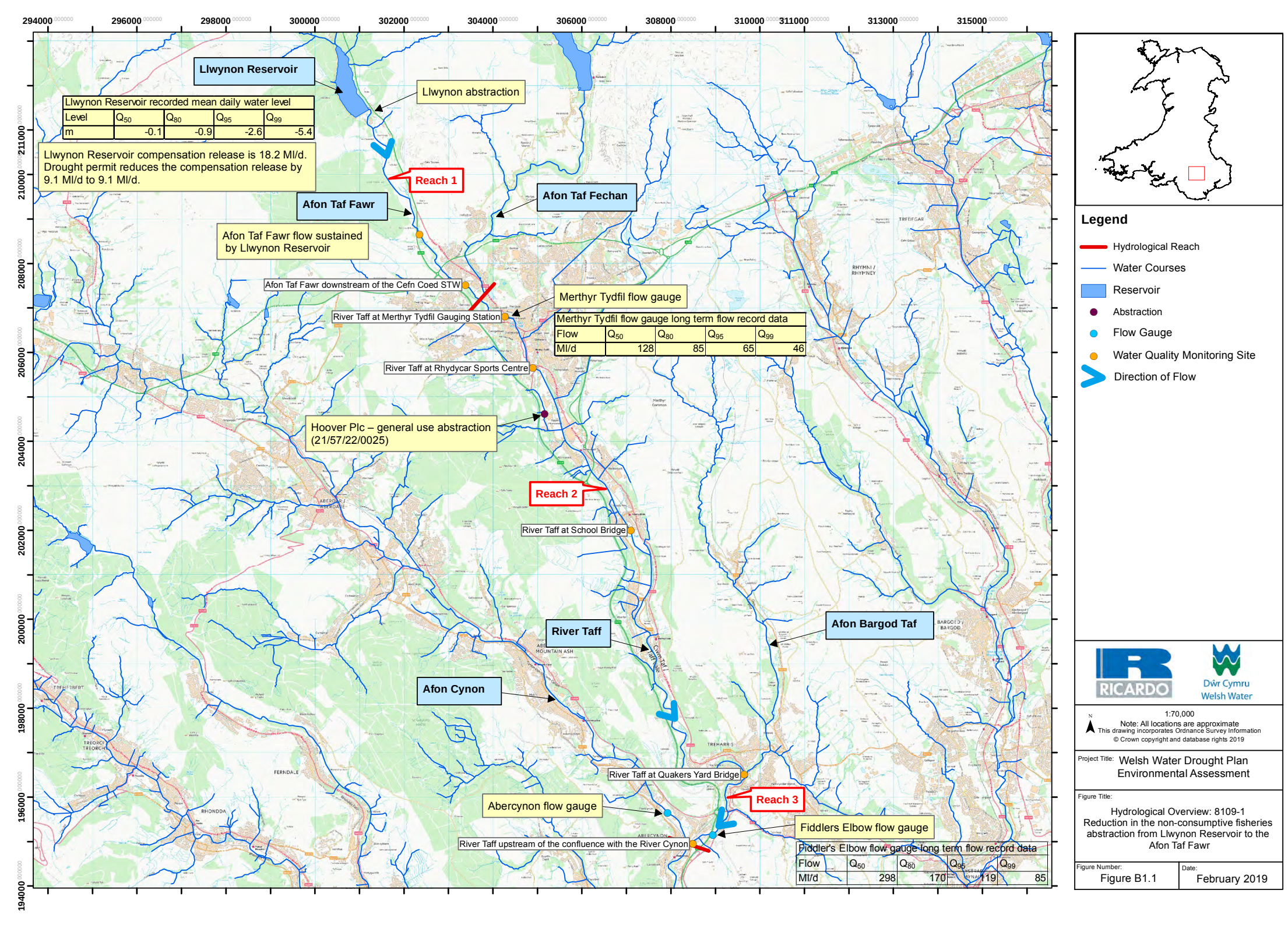
The physical environment includes consideration of hydrology and hydrodynamics; geomorphology; and water quality. The assessment has three principle objectives:

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[2] 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.

This appendix is set out in the following sections:

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

[2] 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.


Llwynon Reservoir
Llwynon abstraction
Llwynon Reservoir recorded mean daily water level
Level | Q_{50} | Q_{80} | Q_{95} | Q_{99}
m | -0.1 | -0.9 | -2.6 | -5.4
Llwynon Reservoir compensation release is 18.2 Ml/d. Drought permit reduces the compensation release by 9.1 Ml/d to 9.1 Ml/d.
Reach 1
Afon Taf Fawr
Afon Taf Fechan
Afon Taf Fawr flow sustained by Llwynon Reservoir
Afon Taf Fawr downstream of the Cefn Coed STW
River Taff at Merthyr Tydfil Gauging Station
Merthyr Tydfil flow gauge
Merthyr Tydfil flow gauge long term flow record data
Flow | Q_{50} | Q_{80} | Q_{95} | Q_{99}
Ml/d | 128 | 85 | 65 | 46
River Taff at Rhydycar Sports Centre
Hoover Plc – general use abstraction (21/57/22/0025)
Reach 2
River Taff at School Bridge
River Taff
Afon Bargod Taf
Afon Cynon
River Taff at Quakers Yard Bridge
Reach 3
Abercynon flow gauge
Fiddlers Elbow flow gauge
River Taff upstream of the confluence with the River Cynon
Fiddler's Elbow flow gauge long term flow record data
Flow | Q_{50} | Q_{80} | Q_{95} | Q_{99}
Ml/d | 298 | 170 | 119 | 85
294000
296000
298000
300000
302000
304000
306000
308000
310000
311000
313000
315000
211000
210000
208000
206000
204000
202000
200000
198000
196000
194000
Legend
Hydrological Reach
Water Courses
Reservoir
Abstraction
Flow Gauge
Water Quality Monitoring Site
Direction of Flow
RICARDO
Dŵr Cymru Welsh Water
1:70,000
Note: All locations are approximate
This drawing incorporates Ordnance Survey Information
© Crown copyright and database rights 2019
Project Title: Welsh Water Drought Plan Environmental Assessment
Figure Title: Hydrological Overview: 8109-1 Reduction in the non-consumptive fisheries abstraction from Llwynon Reservoir to the Afon Taf Fawr
Figure Number: Figure B1.1
Date: February 2019

B2 HYDROLOGICAL AND HYDROGEOLOGICAL IMPACT

B.2.1 Reference Conditions

B.2.1.1 Catchment Overview

The Afon Taf Fawr starts on the southern slopes of the Brecon Beacons and flows south, via a series of three reservoirs: Beacons Reservoir, Cantref Reservoir and finally Llwynon Reservoir. The River Taff is a large river catchment (510 km^2 total drainage area from upstream of the Taf Fawr Reservoirs to Cardiff Bay) in south Wales.

Llwynon Reservoir embankment holds back a maximum usable storage of 4,882Ml with a surface area of 60ha (at top water level) at an altitude of around 260m. The 43.8 km^2 catchment draining into the reservoir has high rainfall on upland heath.

The fisheries abstraction water forms the compensation release from Llwynon Reservoir. The compensation release sustains flow in the Afon Taf Fawr and River Taff year round by 18.2Ml/d. There are no significant tributaries on the Afon Taf Fawr downstream of the impoundment until the confluence with the Afon Taf Fechan. The compensation releases from Llwynon Reservoir will be a substantial proportion of the flow during low flow periods.

The Afon Taf Fawr is a significant tributary of the upper River Taff, upon which the drought permit may have a significant hydrological impact. Flow in the upper River Taff is influenced by the impoundment of Pontsticill Reservoir and compensation release requirements to the Afon Taf Fechan. A number of major tributaries flow into the River Taff. The Afon Bargod Taf meets the River Taff approximately 16km downstream of the Afon Taf Fechan and Afon Taf Fawr confluence and the Afon Cynon and River Rhondda are downstream of this (see **Figure B1.1**). The hydrological impacts of the drought permit on the River Taff will reduce successively downstream of each tributary. Effects of the drought permit on the River Taff are considered not to extend downstream beyond the confluence with the Afon Cynon.

A review of the flows and physical habitat characteristics of the river network around Llwynon Reservoir has identified the study area for this assessment (see **Figure B1.1**). The study area includes the reservoir itself along with the Afon Taf Fawr to its confluence with the Afon Taf Fechan, and their continuation below the confluence as the River Taff; comprising three distinct hydrological reaches, as listed in **Tables B2.6** and **B2.7** and identified on **Figure B1.1**.

The potential hydrological impact of the drought permit has been reviewed separately for the reservoir and each of the three hydrological reaches and is discussed in Section B.2.2.

B.2.1.2 Baseline Data Availability

Continuous monitoring is undertaken by Welsh Water to monitor its operations at Llwynon Reservoir, including:

- Daily Llwynon water level data, 2005 - 2015.
- Daily abstractions from Llwynon Reservoir, 2007 to date.

The monitoring of compensation releases from Llwynon Reservoir is undertaken by Welsh Water at a flow gauge downstream of the impoundment on the Afon Taf Fawr:

- Daily mean compensation flows to the Afon Taf Fawr from 1931 to date.

The compensation flume in which reservoir outflow is measured is only capable of carrying flows up to about 1m^3/s; any outflows above this rate, including spills when the reservoir is at full capacity, are discharged separately through a flood channel. Some daily data is available for the flood channel flows (2005 – 2010).

Continuous monitoring of flow on the River Taff is undertaken by NRW at a number of locations downstream of the Afon Taf Fawr / Afon Taf Fechan confluence.

Available flow data include:

- NRW river flow gauge on the River Taff at Merthyr Tydfil; daily river flow from 1978 to 2015
- NRW river flow gauge on the River Taff at Fiddler's Elbow; daily river flow from 1973 to 2015
- NRW river flow gauge on the River Taff at Pontypridd; daily river flow from 1970 to 2014.

The reference conditions of the Llwynon Reservoir and upper River Taff catchment are summarised below.

B.2.1.3 Hydrology

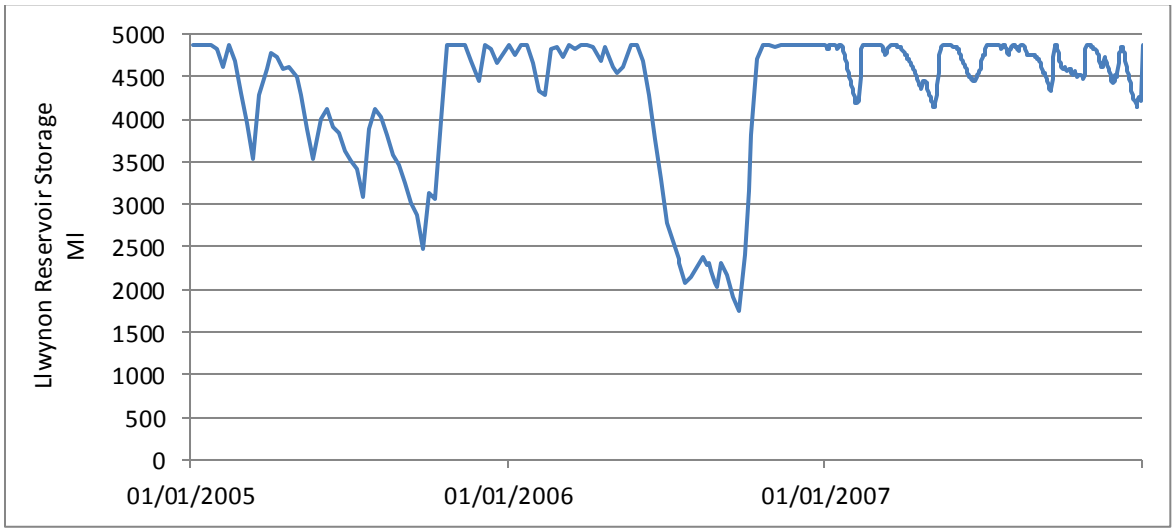
Llwynon Reservoir

Water levels in Llwynon Reservoir range from 6.8m below weir crest to 0.8m above weir crest over the period 2005 – 2009. A summary of monthly water levels over this period is given in **Table B2.1** below. **Figure B2.1** illustrates a typical pattern of reservoir storage over a 3-year period from 2005 to 2007.

Table B2.1 Summary of Recorded Mean, Maximum and Minimum Daily Water Level in Llwynon Reservoir (2005 – 2009)

Percentage of time water level equalled or exceeded	Mean daily level, m above weir crest, per month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum level	0.8	0.1	0.2	0.0	0.1	0.0	0.3	0.2	0.3	0.1	0.3	0.1	0.8
10% (high level)	0.2	0.1	0.1	-0.1	0.0	-0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1
50%	0.0	-0.1	0.0	-0.5	-1.1	-0.6	0.0	-0.1	-0.3	-0.6	0.0	-0.1	-0.1
80%	-0.1	-0.7	-0.2	-1.0	-2.3	-1.4	-1.8	-0.2	-0.9	-1.1	-0.3	-0.8	-0.9
90%	-0.5	-1.1	-0.7	-1.3	-2.7	-1.9	-3.1	-2.6	-3.4	-1.5	-0.5	-1.2	-1.5
95% (low level)	-0.7	-1.2	-1.0	-1.8	-2.8	-2.3	-5.1	-5.4	-5.2	-2.3	-0.7	-1.2	-2.6
99% (extreme low level)	-1.0	-1.3	-2.0	-2.8	-3.0	-2.7	-5.8	-5.9	-6.5	-3.9	-0.8	-1.3	-5.4
Minimum level	-1.2	-1.3	-2.6	-2.8	-3.0	-3.1	-5.9	-6.0	-6.8	-5.1	-0.8	-1.4	-6.8

Figure B2.1 Llwynon Reservoir Storage, 2005 - 2007



Afon Taf Fawr at Llwynon Reservoir

Flow is measured in the Afon Taf Fawr downstream of the Llwynon Reservoir impoundment; the measurement includes flows through the compensation flume up to a flow rate of about 86Ml/d. Overflows from the reservoir above this rate are measured in a separate flood channel. Prior to 1974, however, the measurement included both compensation and overflows. A summary of the available daily flow data from 1931 to 1973 is given in **Table B2.2** below.

Table B2.2 Summary of Recorded Mean, Maximum and Minimum Daily Flow in Afon Taf Fawr at Llwynon Reservoir (1931 – 1973)

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	2141.9	1683.1	2192.0	2038.2	1208.7	1226.0	1792.8	1370.3	1842.9	2143.6	2223.9	2960.1	2960.1
10% (high flow)	495.5	364.5	227.4	218.5	127.7	85.5	86.3	182.1	218.5	323.2	418.4	482.5	281.3
50%	94.0	54.3	35.9	32.7	30.3	29.4	28.6	31.8	33.5	35.9	66.3	85.4	35.9
80%	31.5	29.8	23.5	21.1	18.8	17.9	15.8	20.8	21.3	21.1	28.3	35.3	22.3
90%	27.9	21.1	18.8	18.7	13.7	12.4	11.8	13.7	18.3	16.2	18.8	29.4	18.1
95% (low flow)	19.0	18.8	18.1	18.1	10.9	11.2	10.0	11.8	13.0	10.3	13.7	21.8	12.4
99% (extreme low flow)	18.1	11.2	11.2	11.0	9.1	9.8	9.3	9.5	9.5	9.5	9.5	18.1	9.5
Minimum flow	17.1	8.6	9.3	8.8	8.8	8.6	8.6	4.1	8.6	7.3	6.6	12.4	4.1

The low flow statistics for the summer period (1st April to 30th September inclusive) are: Summer Q_{95} = 11.5Ml/d; Summer Q_{99} = 9.3Ml/d.

Figure B2.2 shows the typical pattern of flows from Llwynon Reservoir from 1971 to 1973, and the flow duration curve for the period 1931 - 1973 is shown in **Figure B2.3**.

Figure B2.2 Afon Taf Fawr at Llwynon Reservoir Flows (1971 – 1973)

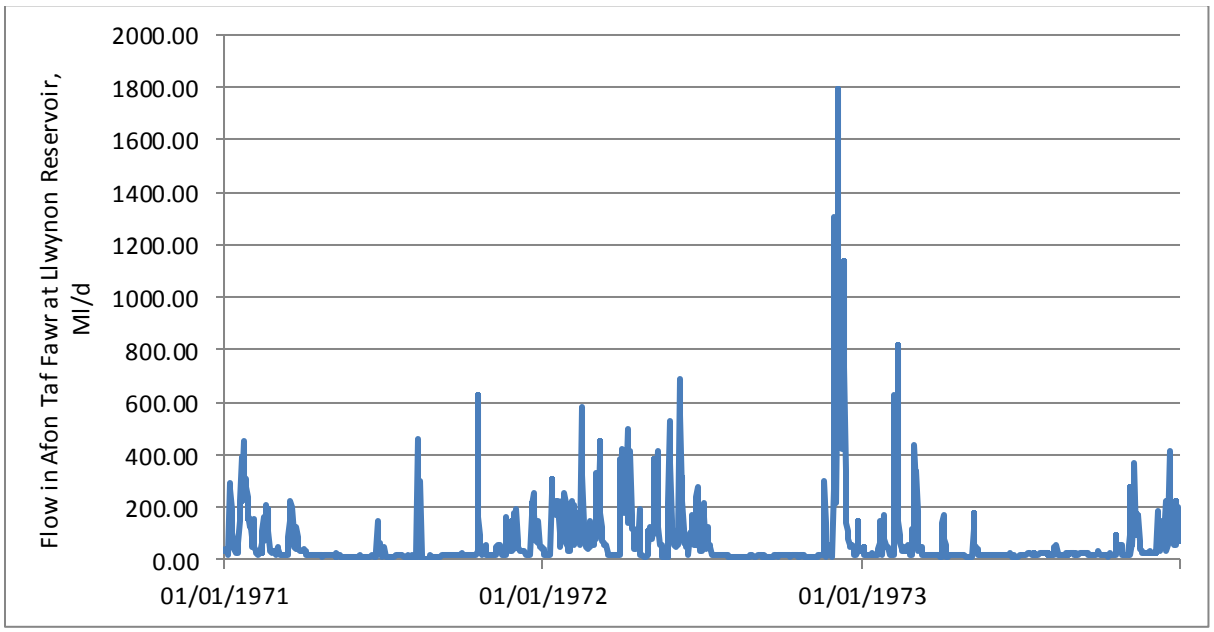
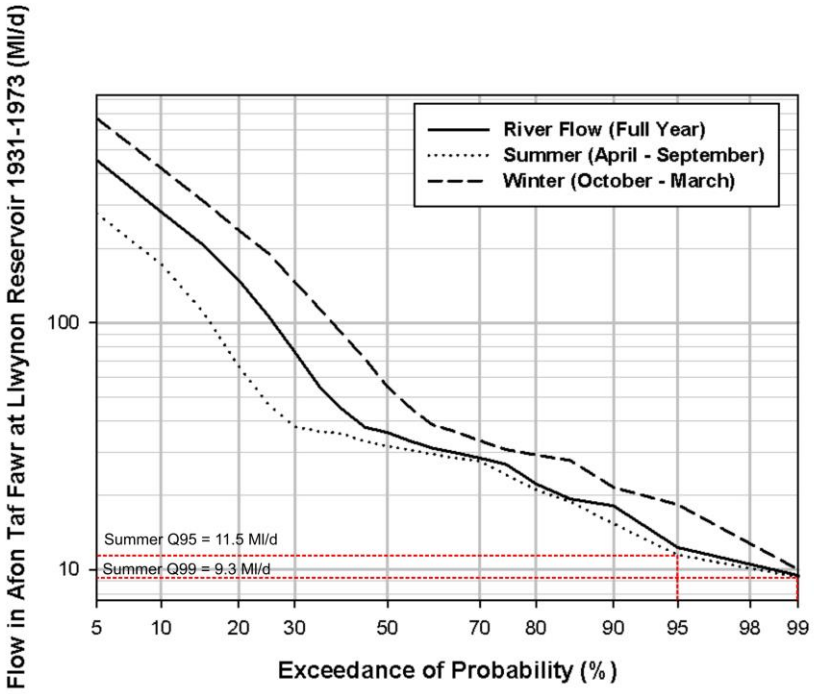


Figure B2.3 Afon Taf Fawr at Llwynon Reservoir Flow Summary (1931 – 1973)



River Taff at Merthyr Tydfil

NRW continuously monitor river level on the River Taff at the Merthyr Tydfil flow gauging station (NGR: SO043068) at an altitude of 170.6m AOD. The available flow record extends from 1978 to 2015, and is summarised in **Table B2.3**.

Table B2.3 Summary of Recorded Mean, Maximum and Minimum Daily Flow in the River Taff at Merthyr Tydfil gauging station (1978 - 2015)

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	5124	7880	6048	2220	2894	2713	2713	7266	6610	7430	4743	11405	11405
10% (high flow)	1547	1080	777	486	322	229	216	340	368	834	1280	1452	805
50%	323	182	165	121	104	93	83	87	92	168	276	297	128
80%	130	113	106	94	81	74	68	67	68	91	118	122	85
90%	109	103	95	84	73	68	62	62	60	74	102	104	72
95% (low flow)	101	94	87	77	70	64	57	56	55	63	92	97	65
99% (extreme low flow)	91	87	81	69	66	54	41	28	31	44	73	76	46
Minimum flow	77	78	72	61	59	46	31	24	25	41	58	64	24

The low flow statistics for the summer period (1st April to 30th September inclusive) are: Summer Q_{95} = 60.8Ml/d; Summer Q_{99} = 39.7Ml/d.

Figure B2.5 shows the typical flow patterns in the River Taff for the notable drought period of 1995 to 1996. The flow duration curve for this location is shown in **Figure B2.6**.

Figure B2.5 River Taff at Merthyr Tydfil (1995 - 1996)

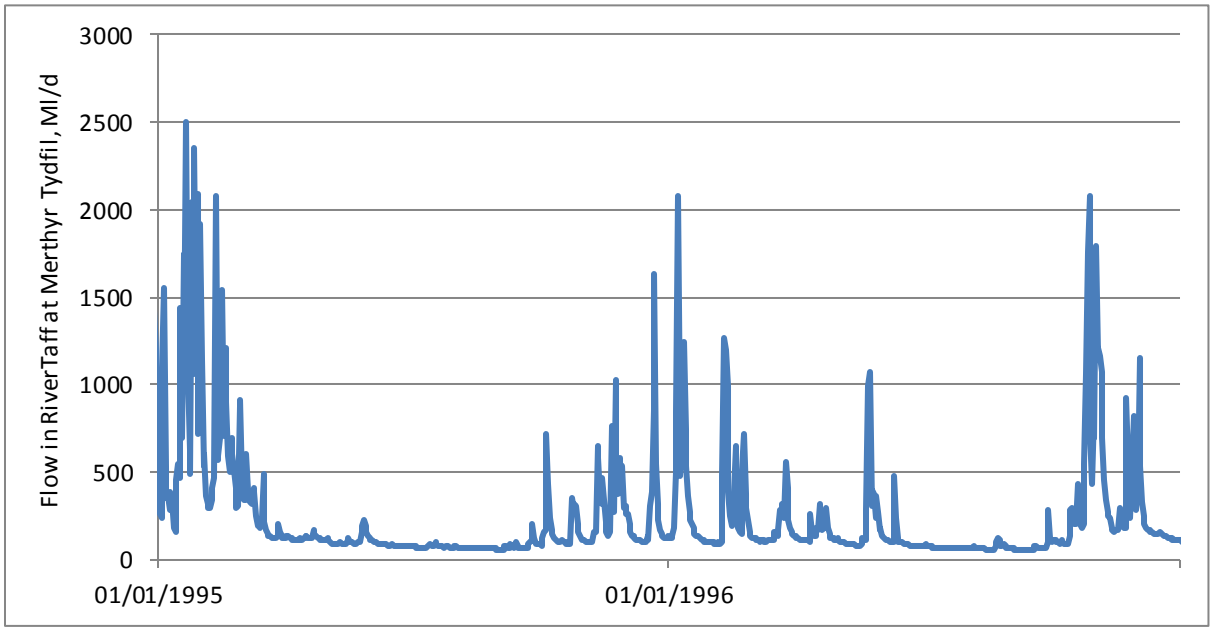
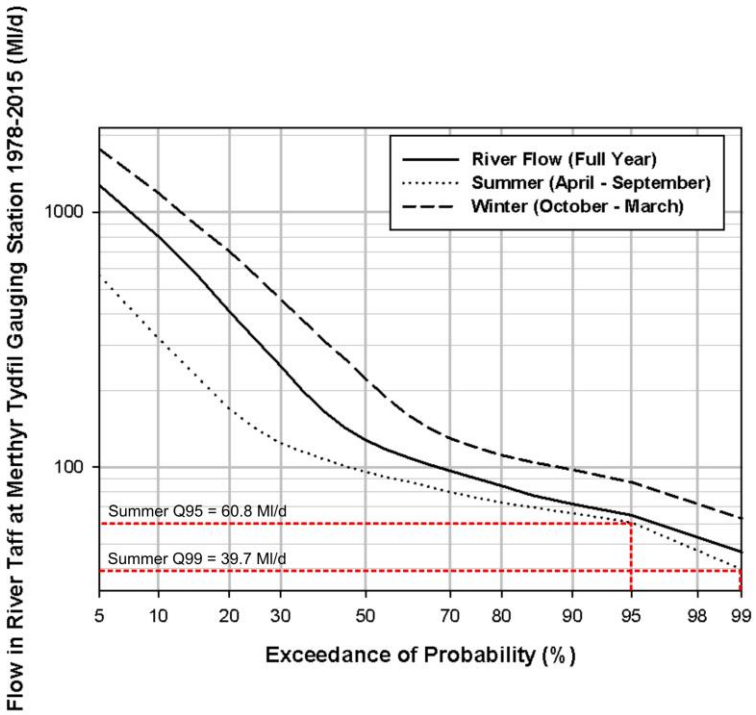


Figure B2.6 River Taff at Merthyr Tydfil Flow Summary (1978 – 2015)



River Taff at Fiddler's Elbow

NRW continuously monitor river level on the River Taff at the Fiddler's Elbow flow gauging station (NGR: ST089951) at an altitude of 82.5m AOD. The available flow record extends from 1973 to 2015, and is summarised in **Table B2.4**.

Table B2.4 Summary of Recorded Mean, Maximum and Minimum Daily Flow in the River Taff at Fiddler's Elbow gauging station (1973 - 2015)

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	8295	12727	9867	3059	4510	3957	4320	4588	11837	12861	8051	14472	14472
10% (high flow)	2549	1950	1340	855	593	434	398	571	767	1391	2016	2251	1410
50%	744	473	391	289	226	192	166	168	186	351	588	610	298
80%	350	287	248	204	171	148	130	121	127	176	277	294	170
90%	285	251	218	176	150	135	117	106	104	140	226	243	139
95% (low flow)	234	223	194	162	141	122	105	88	93	111	200	220	119
99% (extreme low flow)	168	198	169	139	130	101	77	54	63	85	142	187	85
Minimum flow	142	141	158	118	114	85	71	48	54	78	94	144	48

The low flow statistics for the summer period (1st April to 30th September inclusive) are: Summer Q_{95} = 107.1Ml/d; Summer Q_{99} = 72.2Ml/d.

Figure B2.7 shows the typical flow patterns in the River Taff for the notable drought period of 1995 to 1996. The flow duration curve for this location is shown in **Figure B2.8**.

Figure B2.7 River Taff at Fiddler's Elbow (1995 - 1996)

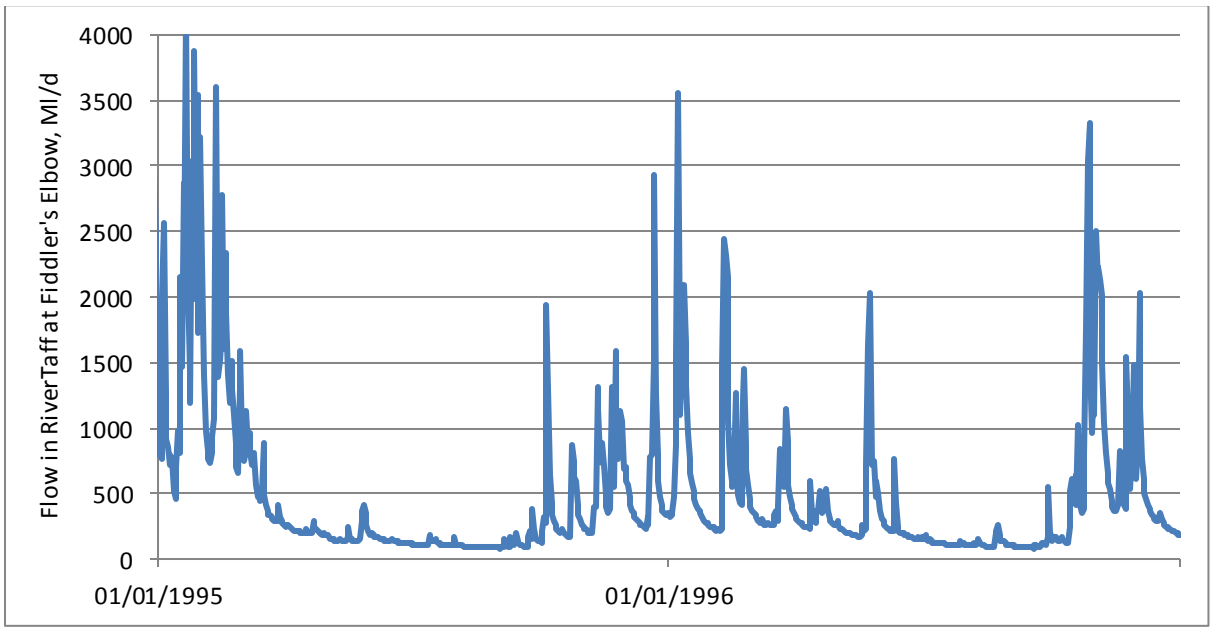
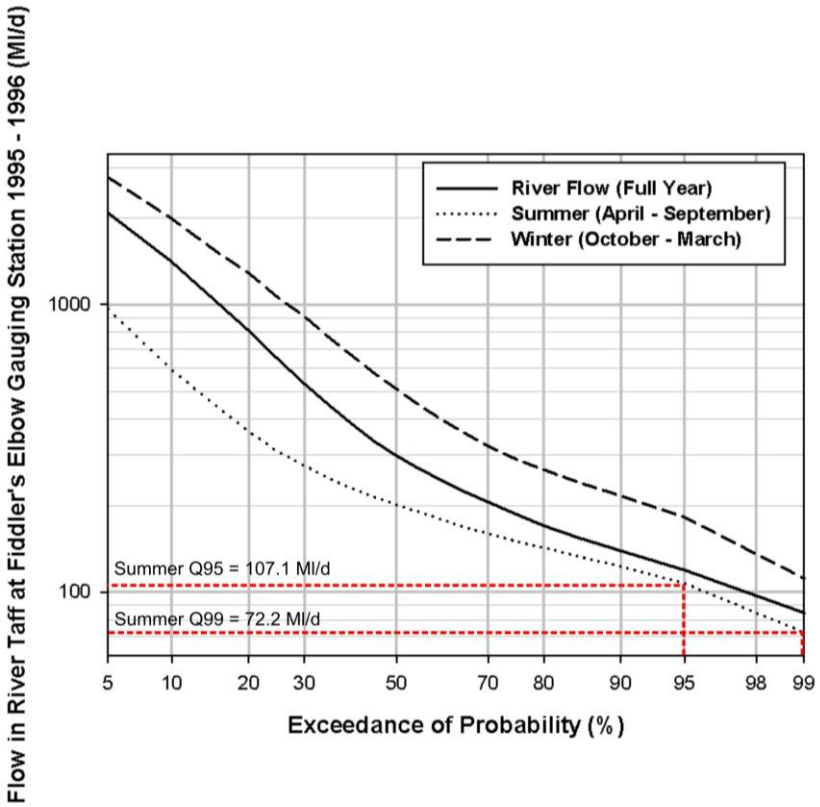


Figure B2.8 River Taff at Fiddler's Elbow Flow Summary (1995 - 1996)



B.2.2 Hydrological and Hydrogeological Impact

B.2.2.1 Hydrological Zone of Influence

The study area includes the Afon Taf Fawr from the Llwynon Reservoir outflow down to the confluence with the Afon Taf Fechan, and the continuation as the River Taff from the Afon Taf Fechan confluence down to the Afon Cynon confluence, comprising three distinct hydrological reaches as shown in **Figure B1.1**:

- Reach 1 is the Afon Taf Fawr from Llwynon Reservoir outflow to the confluence with the Afon Taf Fechan.
- Reach 2 is the River Taff, from the confluence with the Afon Taf Fechan to the confluence with the Afon Bargod.
- Reach 3 is the River Taff, from the confluence with the Afon Bargod to the confluence with the Afon Cynon.

The potential hydrological impacts of the drought permit option have been assessed for Llwynon Reservoir itself and for the three separately identified river reaches, as summarised in **Tables B2.6** and **B2.7** at the end of this section.

The details of the assessment for each reach are presented below.

B.2.2.2 Hydrological Impact Assessment

Llwynon Reservoir

The impact on Llwynon Reservoir would be a marginal increase in levels / storage, relative to the position without the drought permit, due to the reduced compensation 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 **minor positive** impact and has not been assessed further.

Assessment of River Reach Impacts

Analysis of previous drought permit applications and compensation flow records for Llwynon and Pontsticill Reservoirs indicates that reduced compensation was implemented for either or both of the two reservoirs on approximately the following dates[3]:

- 20/6/1984 -30/11/1984
- 24/8/1989 – 24/12/1989
- 23/12/2003 – 13/1/2004

We have therefore removed these periods from the daily flow records at each of the key locations, in order to recalculate the relevant flow statistics without the influence of reduced upstream flows due to actual drought permit implementation. The adjusted key flow statistics are shown in **Table B2.5**. In general the difference from the baseline flow statistics is relatively small, although the summer Q_{99} flow values are significantly higher with the effects of historic compensation flow reductions removed.

Table B2.5 Key Flow Statistics with Historic Drought Permit Effects Removed

Location	Adjusted Key Flow Statistics			
	Year Round Q50	Year Round Q95	Summer Q95	Summer Q99
River Taff at Merthyr Tydfil	128.7	66.5	62.8	56.2
River Taff at Fiddler's Elbow	299.8	124.4	113.2	86.4

River cross-sectional survey and spot flow gauging data were previously obtained for one location on the Afon Taf Fawr (Reach 1) and three locations on the River Taff (Reach 2) in 2010, with the aim of developing empirical relationships between flow and channel parameters, including mean section velocity, cross-sectional area, wetted width and depth. However, following a review of the data it was not possible to develop such a relationship, due

[3] Dŵr Cymru Welsh Water Llwynon and Pontsticill Reservoirs Drought Permit Support – Environmental Assessment of Llwynon Reservoir Drought Permit, AMEC, April 2012.

to the small number of data points and the relatively small range of flows over which the data was collected. Instead an alternative approach was developed using the cross-sectional survey data and Manning's equation; full details of the analysis are given in the previous environmental assessment of the Llwynon Reservoir drought permit[4]. The results were used to estimate the percentage changes in mean section velocity, cross-sectional area, wetted width and depth in each reach (excluding Reach 3), and a brief summary is included the assessment below.

Reach 1 – Afon Taf Fawr from Llwynon Reservoir outflow to the confluence with Afon Taf Fechan

The Afon Taf Fawr in Reach 1 is a mountain river between the impoundment at Llwynon Reservoir and the confluence with the Afon Taf Fechan in Merthyr Tydfil.

There are no significant tributaries in this reach, therefore at times when storage in Llwynon Reservoir is below top water level the compensation flow is a high proportion of the flow. A reduction of 9.1Ml/d in the statutory compensation release rate of 18.2Ml/d therefore represents a 50% reduction in the flow in Reach 1, regardless of the time of year. During the winter refill period when catchment flows are generally increasing, there may be some flow accretion along the reach (with catchment area increasing by about 39% between the reservoir outflow and the downstream end of Reach 1), and the percentage flow reduction would therefore be less at the lower end of Reach 1. However the flow reduction at the top of the reach will remain at 50% unless the reservoir reaches top water level and begins to spill again.

The hydrological impact of the drought permit on Reach 1 is therefore assessed as **major** for both the summer drawdown period (September) and the autumn/winter refill period (October – November) while the drought permit remains in force.

The analysis of cross-sectional survey data using Manning's equation[5] suggested that for the lower end of the Afon Taf Fawr:

- Mean section velocity would reduce by ~5-15%
- Cross-sectional area would reduce by ~20% (Q_{95} and Q_{99}) and ~10% (Q_{50})
- Wetted width would reduce by ~10% (Q_{95} and Q_{99}) and ~5-10% (Q_{50})
- Maximum depth would reduce by 10-15% (Q_{95} and Q_{99}) and ~5-10% (Q_{50}).

Reach 2 – River Taff, from the confluence with Afon Taf Fechan to the confluence with Afon Bargod Taf

The River Taff in Reach 2 remains an upland river and is constrained by a steep-sided, heavily

[4] Dŵr Cymru Welsh Water Llwynon and Pontsticill Reservoirs Drought Permit Support – Environmental Assessment of Llwynon Reservoir Drought Permit, AMEC, April 2012.
[5] Dŵr Cymru Welsh Water Llwynon and Pontsticill Reservoirs Drought Permit Support – Environmental Assessment of Llwynon Reservoir Drought Permit, AMEC, April 2012.

urbanised valley.

The flow gauging station at Merthyr Tydfil is located near the upper end of this reach. Based on the adjusted flow statistics in **Table B2.5**, an upstream flow reduction of 9.1Ml/d represents reductions of 14.5% and 16.2% in the summer Q_{95} and Q_{99} respectively, and reductions of 7.1% and 13.7% in the year round Q_{50} and Q_{95} respectively. The hydrological impact of the drought permit on Reach 2 has therefore been assessed as **moderate** for the summer period (September) and **minor** for the autumn/winter refill period (October – November).

At the lower end of the reach, the catchment area has increased by around 42% relative to the Merthyr Tydfil gauging station location; using the relative catchment areas to estimate flow statistics at the downstream end of Reach 2 (from the adjusted values in **Table B2.5** for Merthyr Tydfil) would result in the following approximate values: summer Q_{95}=89Ml/d; summer Q_{99}=80Ml/d; year-round Q_{95}=94Ml/d; year-round Q_{50}=183Ml/d. The flow reduction of 9.1Ml/d therefore represents reductions of 10% and 11% in the summer Q_{95} and Q_{99} respectively, and reductions of 5% and 9.7% in the year round Q_{50} and Q_{95} respectively, which would be assessed as a minor impact for the summer period and a negligible impact for the autumn/winter refill period, at the downstream end of Reach 2.

The analysis of cross-sectional survey data using Manning's equation suggested that for all percentiles at three of the survey locations in this reach, the reductions in mean section velocity, wetted width and wetted depth are all less than 10%, and at the lower end of Reach 2 the reductions in these parameters are all less than 5%.

Reach 3 - River Taff, from the confluence with Afon Bargod Taf to the confluence with Afon Cynon.

The River Taff in Reach 3 retains the characteristics of Reach 2. A minor tributary, the Afon Bargod Taf, joins the River Taff at the upstream limit of Reach 3, contributing 29km^2 of catchment area.

The flow gauging station at Fiddler's Elbow is located near the lower end of this reach, however as Reach 3 is of relatively short length and there are no major tributaries between the confluences with the Afon Bargod Taf and the Afon Cynon, the Fiddler's Elbow flow statistics have been taken as representative of the reach as a whole. Based on the adjusted flow statistics in **Table B2.5**, an upstream flow reduction of 9.1Ml/d represents reductions of 8% and 10.5% in the summer Q_{95} and Q_{99} respectively, and reductions of 3% and 7.3% in the year round Q_{50} and Q_{95} respectively. The hydrological impact of the drought permit on Reach 2 has therefore been assessed as **minor** for the summer period and **negligible** for the autumn/winter refill period.

At the end of Reach 3 a major tributary, the Afon Cynon, joins the River Taff and contributes around a further 43Ml/d at low flows (Q_{95}) and 32Ml/d at extreme low flows (Q_{99}), during the summer period of April to September inclusive. A 9.1Ml/d flow reduction therefore represents

reductions of 5.8% and 7.7% in the summer Q_{95} and Q_{99} respectively in the River Taff flow below the confluence. The hydrological impact of the drought permit on the River Taff downstream of the Afon Cynon confluence is therefore negligible, and the river below this point has therefore been excluded from further assessment.

B.2.2.3 Hydrological Impact Summary

Three river reaches have been considered for which the assessed hydrological impacts range from **negligible** to **major**. The impacted reaches are shown in **Tables B2.6** and **B2.7** and establish the full in-channel zone of influence of the drought permit for environmental sensitivity screening (see **Figure B1.1**).

The hydrological impact on Llwynon Reservoir itself has been assessed as **minor positive**.

Table B2.6 Hydrological and Monitoring Reaches identified in the Study Area – Summer Impact (September)

Hydrological Reach		Reach boundary		Reach length	% flow reduction		Hydrological Impact - Summer
		Upstream	Downstream		Summer Q_{95}	Summer Q_{99}	
Llwynon Reservoir		n/a	n/a	n/a	n/a	n/a	**Minor positive**
1	Afon Taf Fawr	Llwynon Reservoir	Afon Taf Fechan confluence	5.8km	50%	50%	**Major**
2	River Taff	Afon Taf Fechan confluence	Afon Bargod Taf confluence	16.6km	14.5%	16.2%	**Moderate**
3	River Taff	Afon Bargod Taf confluence	Afon Cynon confluence	2.6km	8%	10.5%	**Minor**

Table B2.7 Hydrological and Monitoring Reaches identified in the Study Area – Winter Impact (October – November)

Hydrological Reach		Reach boundary		Reach length	% flow reduction		Hydrological Impact - Winter
		Upstream	Downstream		Year round Q_{50}	Year round Q_{95}	
Llwynon Reservoir		n/a	n/a	n/a	n/a	n/a	**Minor positive**
1	Afon Taf Fawr	Llwynon Reservoir	Afon Taf Fechan confluence	5.8km	50%	50%	**Major**
2	River Taff	Afon Taf Fechan confluence	Afon Bargod Taf confluence	16.6km	7.1%	13.7%	**Minor**
3	River Taff	Afon Bargod Taf confluence	Afon Cynon confluence	2.6km	3%	7.3%	**Negligible**

B3 PHYSICAL ENVIRONMENT ASSESSMENT

B.3.1 Geomorphology

B.3.1.1 Reference conditions

Geomorphological data is provided by River Habitat Surveys (RHS) and supplemented by extant aerial imagery. Within Reach 1, there are four RHS surveys, located at the following distance downstream from the start of the reach: Site ID 39645, 1km; Site ID 4021, 1.16km; Site ID 36406, 2.52km and; Site ID 38443, 4.88km. Within Reach 2, there are 11 RHS surveys, located at the following distance downstream: Site ID 14661, 0.28km; Site ID 14460, 1.97km; Site ID 1063, 3.29km; Site ID 14459, 3.50km; Site ID 14458, 4.97km; Site ID 14457, 6.44km; Site ID 14456, 7.98km; Site ID 14455, 9.61km; Site ID 14454, 10.76km; Site ID 14453, 12.29km and; Site ID 14452, 13.72km. Within Reach 3, there are three RHS surveys, located at the following distance downstream: Site ID 14451, 0.24km; Site ID 33619, 1.21km downstream and; Site ID 14450, 1.55km. The RHS surveys are summarised below. Further detail on the morphology of the river channel was obtained from a number of walkover surveys and spot flow gauging exercises undertaken during 20106.

Reach 1 Afon Taf Fawr from Llwynon Reservoir outflow to the confluence with Afon Taf Fechan

The Afon Taf Fawr in Reach 1 is a sinuous river. The channel is moderately steep, falling 50m in 5.8 km, a gradient of 0.50°. The river flows through an upland floodplain up to 200m wide over alluvial deposits. No significant tributaries join the river in this reach. Land-cover is heath, rough grazing and commercial forestry, with grassland in the valley floor. Riparian tree cover is isolated to continuous along the reach.

The channel is shallow and ranges in width from 12 – 32 m, generally increasing downstream. Banks are steep in localised areas (e.g., Site ID 4021), and are dominantly comprised of earth or cobble, however there are areas of rip-rap at discrete locations. Bed substrate is dominated by larger grain size fractions, with both cobble and boulder – grade substrate observed. Two unvegetated point bars were observed in the reach at Site ID 39645 and 38443, and a vegetated island observed using extant aerial imagery.

The reach is a typical riffle-pool river, in total 27 riffles and six pools were observed. Flow variation was also observed, and although rippled flow dominated at Site ID 4021, smooth (20%) flow, and areas of upwelling (20%) and chute (10%) flow were also observed.

The reach is initially significantly modified due to the reservoir, at Site ID 39645, the Habitat Modification Score (HMS) is 1170. Downstream, at Site ID 4021 and 36406, the HMS score decreases to 60 and 165, respectively, and the channel is predominantly unmodified. However, towards the confluence with the Afon Taf Fechan, channel modification increases to 710, and

[6] Dŵr Cymru Welsh Water Llwynon and Pontsticill Reservoirs Drought Permit Support – Environmental Assessment of Llwynon Reservoir Drought Permit, AMEC, April 2012.

the channel is significantly modified. Modification within the reach includes,

Reach 2 River Taff, from the confluence with Afon Taf Fechan to the confluence with Afon Bargod Taf

The channel is moderately steep in Reach 2, falling a further 80m in 16.6km, a gradient of 0.28°. The river flows through a steep-sided valley with limited floodplain (typically less than 100m wide) over alluvium deposits. Urban and industrial development is extensive alongside the river banks throughout the reach with extensive channel modification. Riparian tree cover is semi continuous to continuous along the reach.

The channel is wide and shallow, varying greatly downstream, from 4m to 33m bankfull width. Banks are predominantly steep, and composed of brick, concrete or earth. However, areas of gabion, bedrock and rip rap were also observed. There are localised areas of shallower banks. Bed substrate is dominated by boulder and cobble within the reach, however areas of pebble, gravel/pebble, peat and bedrock were also observed. Peat was the dominant substrate at one RHS reach (Site ID 14456).

The reach is a typical riffle-pool river, within the reach three pools and 27 riffles were observed. Rippled flow dominated the RHS survey sites, however, areas of smooth flow and upwelling were also observed. In-channel deposition was also observed at the RHS survey sites and seven unvegetated point bars and four vegetated point bars were observed.

The channel is significantly to severely modified for much of the reach, with HMS scores ranging from 735 to 2640. Modifications within the reach include several weirs, realignment, resectioning and bank reinforcement. Several bridges were observed within the reach. However, pristine conditions were observed at one RHS site (Site ID 14453).

Reach 3 River Taff, from the confluence with Afon Bargod Taf to the confluence with Afon Cynon

The channel is moderately steep in Reach 3, and falls a further 10m over 2.6km, a gradient of 0.20°. Surrounding land-use is dominated by parkland and becomes increasingly urbanised downstream. Riparian tree cover is semi-continuous to continuous throughout the reach.

The channel is wide, and ranges from 23 – 30m in width. Bank are shallow, however there are localised areas of steep bank within the reach. The banks composition is dominated by earth, however sections of bedrock, cobble, concrete and brick were also observed.

The reach is a typical riffle-pool river, within the reach one pool and five riffles were observed. Rippled flow dominates the RHS survey sites, however areas of upwelling, broken water and smooth flow was also observed.

The channel ranges from predominantly unmodified (Site ID 14451, HMS score 95) to severely modified (Site ID 14456, HMS score 1690). Modifications within the reach include weirs, resectioning, reprofiling and bank reinforcement. Several bridges were observed within the

reach.

B.3.1.2 Assessment

Reduction in flow and associated reductions in wetted width and depth, has the potential to impact sediment transport and geomorphology within the reaches. However, as banks are steep for most of the reaches, the impact on wetted width is expected to be localised and more prevalent in Reach 1 due to the higher impact on flows in Reach 1 due to the drought option. The reaches are adapted to transporting high calibre sediment of boulders and cobble, which is likely to occur in higher flows when the reservoirs are spilling. The high flows will not be affected by the drought option, and there would be limited material in transport during low flow conditions. Therefore, the drought option will have negligible impacts on bedload transport. However, there could be an increased chance of fine sediment deposition due to the reduced capacity of the river due to the drought option, though this is considered unlikely. This is due to the limited supply of fine sediment in the catchment as shown by the bed substrate data, and the gradients of the reaches, which are relatively steep. Due to the steep gradients there will be enough energy in the system to transport fine sediment. Siltation may be localised, for example, behind weir structures, however any silt that is deposited will be mobilised when higher flows return. The modified portions of the reaches will not be impacted by desiccation, and impacts would be localised to bank areas comprised of earth. Desiccation of banks could cause increased erosion when high flows return. However, a significant impact is considered highly unlikely, given the relatively short duration of flow reductions (i.e., six months or less), and the coarse nature of the substrate (i.e., mostly cobbles and boulders) at most locations along the reach.

Overall, geomorphological impacts are considered minor for Reach 1 and negligible in Reaches 2 and 3.

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 permit 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 permit, including trends over time and with respect to river flow. For WFD classification, the Environment Agency has set out[7] following UKTAG evidence[8] what pressures, including how each biological quality element responds to water quality pressures. For the purposes of assessment here, the supporting water quality

[7] Environment Agency (2011) Method statement for the classification of surface water bodies v2.0 (external release) Monitoring Strategy v2.0 July 2011 Table 2
[8] UK Technical Advisory Group on the Water Framework Directive (2008) Recommendations on Surface Water Classification Schemes for the purposes of the Water Framework Directive December 2007 (alien species list updated – Oct 2008 and Nov 2008). Appendix 1

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 permit 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.

Ten years of NRW routine monitoring data were reviewed to provide an overview of water quality in the zone of impact). On the Afon Taf Fawr, within the extent of influence of the drought permit (Reach 1), there is one NRW water quality sampling site and on the River Taff (Reach 1-3) there are six NRW water quality sampling sites (**Table B3.1** and **Figure B1.1**). Data are available for these sites (2006 to 2015) and include measurements of a suite of parameters.

Where data are 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 River Taff (see Figure B1.1)

Reach	Site Name	NRW Site Code	Grid reference
1	Afon Taf Fawr downstream of the Cefn Coed STW	17135	SO0338007520
	River Taff at Merthyr Tydfil Gauging Station	17184	SO0427006800
2	River Taff at Rhydycar Sports Centre	68442	SO0490005650
	River Taff at Abercanaid Bridge	17012	SO0542004810
	River Taff at School Bridge	17011	SO0710002000
3	River Taff at Quakers Yard Bridge	17009	ST0965096510
	River Taff upstream of the confluence with the River Cynon	68444	ST0850094950

Reach 1 (Afon Taf Fawr from Llwynon Reservoir outflow to the confluence with Afon Taf Fechan)

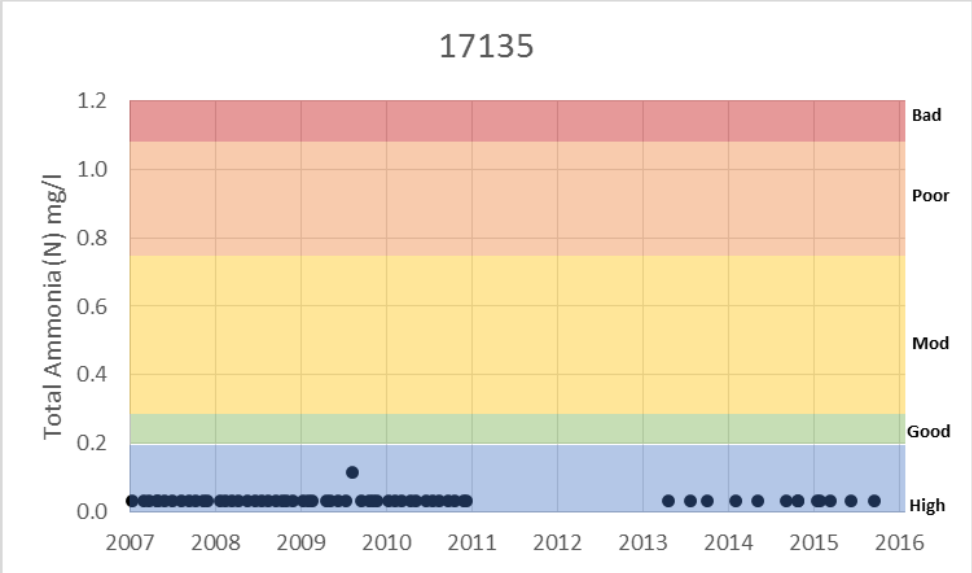
Data are available for Afon Taf Fawr downstream of the Cefn Coed STW (site 17135) and River Taff at Merthyr Tydfil Gauging Station (site 17184). Both monitoring points are located in the lower Reach.

The average pH at Afon Taf Fawr downstream of the Cefn Coed STW over the ten year review period was 7.9 and the maximum water temperature was 15.1°C. The average pH at River Taff at Merthyr Tydfil Gauging Station over the ten year review period was 7.9 and the maximum water temperature was 16.9°C.

Total ammonia concentration

Total ammonia concentration was reviewed and data are presented in **Figure B3.1** for Afon Taf Fawr downstream of the Cefn Coed STW and **Figure B3.2** for River Taff at Merthyr Tydfil Gauging Station against the relevant WFD standards for an upland low alkalinity river[9].

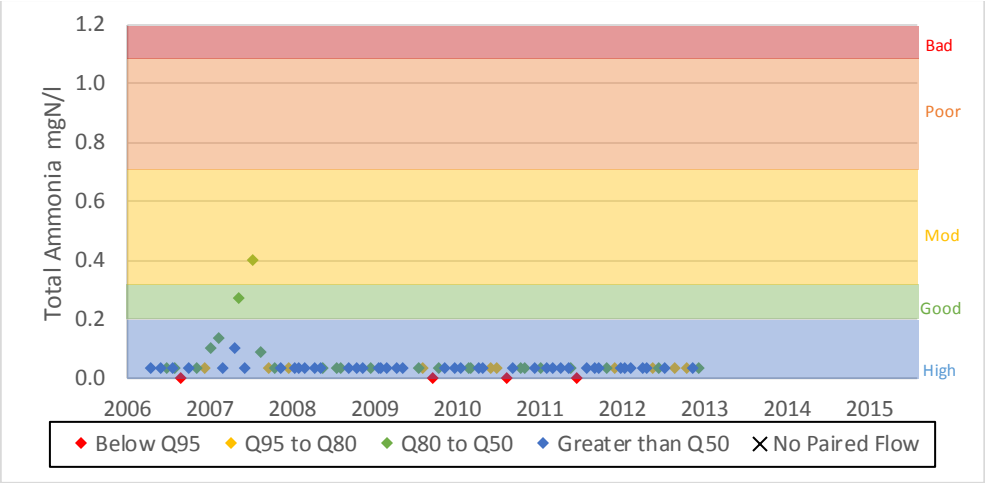
Figure B3.1 Total Ammonia in the Afon Taf Fawr Downstream of the Cefn Coed STW, Incorporating Appropriate WFD Status Bands



Total ammonia concentrations in the Afon Taf Fawr downstream of the Cefn Coed STW (see **Figure B3.1**) were all consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l). No seasonality is apparent.

[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.

Figure B3.2 Total Ammonia in the River Taff at Merthyr Tydfil Gauging Station, Incorporating Appropriate WFD Status Bands

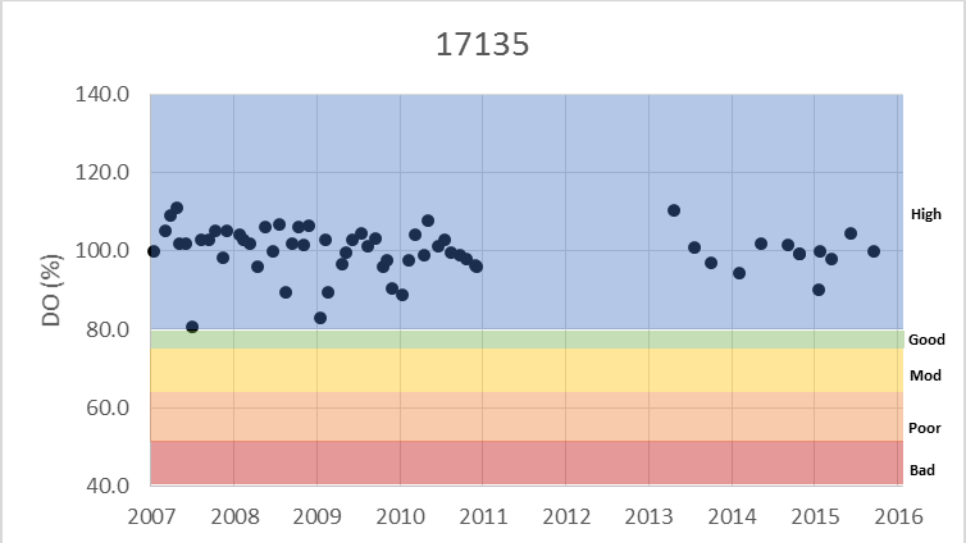


Total ammonia concentrations in the River Taff at Merthyr Tydfil Gauging Station (see **Figure B3.2**) were predominantly consistent with the WFD standard to support good status for fish and invertebrates (0.2mg/l). One instance is observed below this on 18/04/2008 with 0.4mgN/l.

Dissolved oxygen saturation

Dissolved oxygen saturation was reviewed and data are presented in **Figure B3.3** for Afon Taf Fawr downstream of the Cefn Coed STW and **Figure B3.4** for River Taff at Merthyr Tydfil Gauging Station against the relevant WFD standards for an upland low alkalinity river[10].

Figure B3.3 Dissolved Oxygen Saturation in the Afon Taf Fawr Downstream of the Cefn Coed STW, Incorporating Appropriate WFD Status Bands

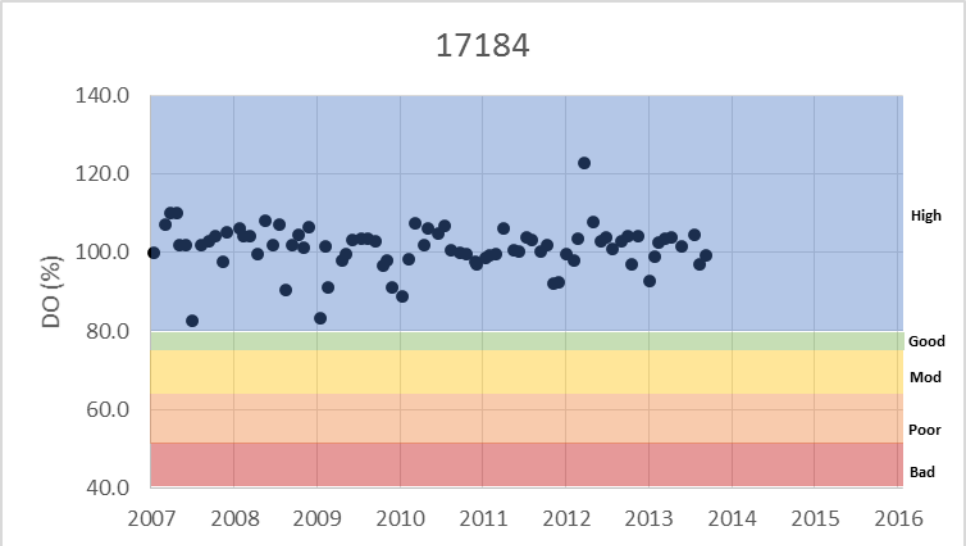


Dissolved oxygen saturation measurements in the Afon Taf Fawr downstream of the Cefn Coed

[10] The Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations 2015.

STW were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

Figure B3.4 Dissolved Oxygen Saturation in the Afon Taf Fawr downstream of the Cefn Coed STW, Incorporating Appropriate WFD Status Bands



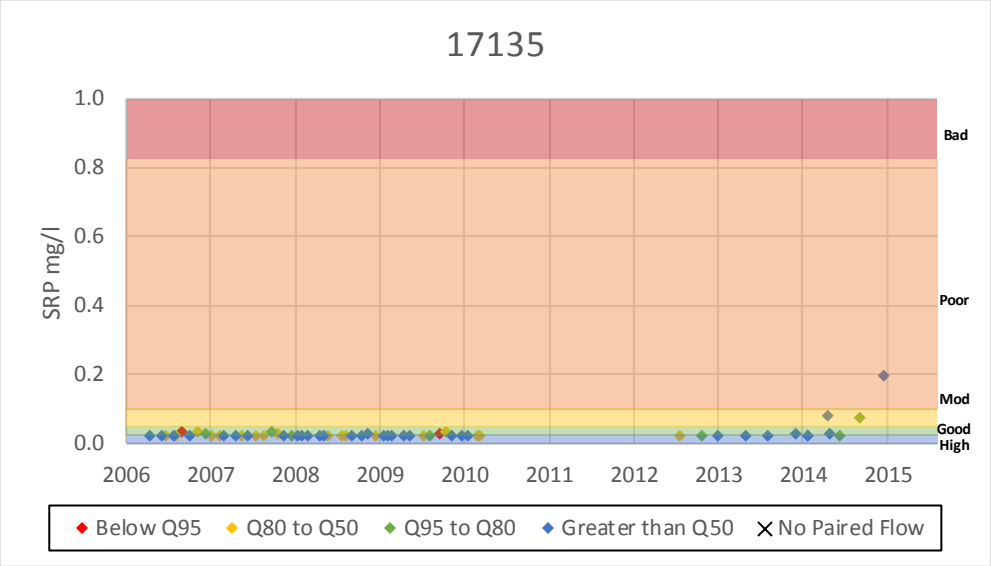
Dissolved oxygen saturation measurements in the Afon Taf Fawr downstream of the Cefn Coed STW were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

Soluble Reactive Phosphorus

Soluble reactive phosphorus concentration for monitoring on the Afon Taf Fawr downstream of the Cefn Coed STW and the River Taff at Merthyr Tydfil Gauging Station was reviewed and data are presented in **Figure B3.5** and **Figure B3.6** respectively against the relevant site specific WFD standards[11].

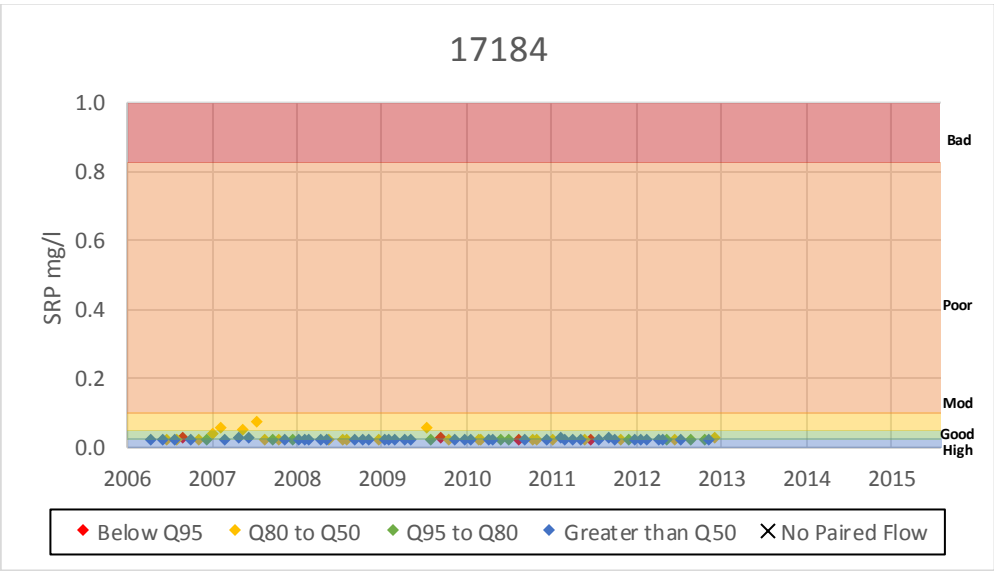
[11] The Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations 2015.

Figure B3.5 Soluble Reactive Phosphorus Concentration in the Afon Taf Fawr Downstream of the Cefn Coed STW, Incorporating Appropriate WFD Status Bands



Soluble reactive phosphorus concentrations in the Afon Taf Fawr downstream of the Cefn Coed STW were mostly consistent with the WFD standard to support good status for diatoms and macrophytes (0.07mgP/l). Poor status is noted in three instances: 23/01/2015 with 0.08mgP/l; 15/06/2015 with 0.072mgP/l and 23/09/2015 with 0.195mgP/l.

Figure B3.6 Soluble Reactive Phosphorus Concentration in the River Taff at Merthyr Tydfil Gauging Station, Incorporating Appropriate WFD Status Bands



Soluble reactive phosphorus concentrations in the Afon Taf Fawr downstream of the Cefn Coed STW were mostly consistent with the WFD standard to support good status for diatoms and macrophytes (0.07mgP/l). Poor status is noted in three instances: 23/01/2015 with 0.08mgP/l; 15/06/2015 with 0.072mgP/l and 23/09/2015 with 0.195mgP/l.

Reach 2 (River Taff, from the confluence with Afon Taf Fechan to the confluence with Afon Bargod Taf)

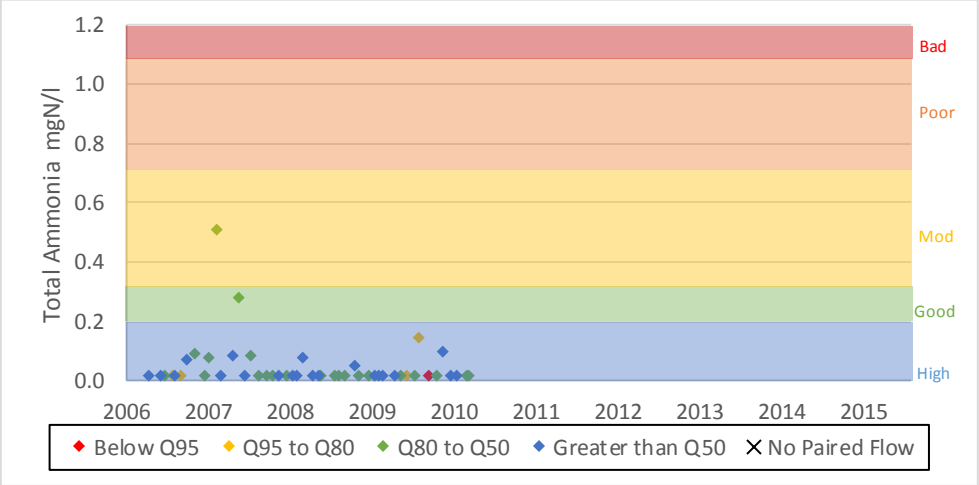
Data are available for River Taff at Rhydycar Sports Centre (site 68442), River Taff at Abercanaid Bridge (site 17012) and River Taff at School Bridge (site 17011). The former two monitoring points are located in the upper Reach while the latter site is located in the mid-Reach section.

The average pH in the River Taff at Rhydycar Sports Centre over the ten year review period was 8.04 and the maximum water temperature was 14.5°C. The average pH in the River Taff at Abercanaid Bridge over the ten year review period was 7.96 and the maximum water temperature was 14.6°C. The average pH in the River Taff at School Bridge over the ten year review period was 7.86 and the maximum water temperature was 15.6°C.

Total ammonia concentration

Total ammonia concentration was reviewed and data are presented in **Figure B3.7** for River Taff at Rhydycar Sports Centre, **Figure B3.8** for River Taff at Abercanaid Bridge and **Figure B3.9** for River Taff at School Bridge against the relevant WFD standards for an upland low alkalinity river[12].

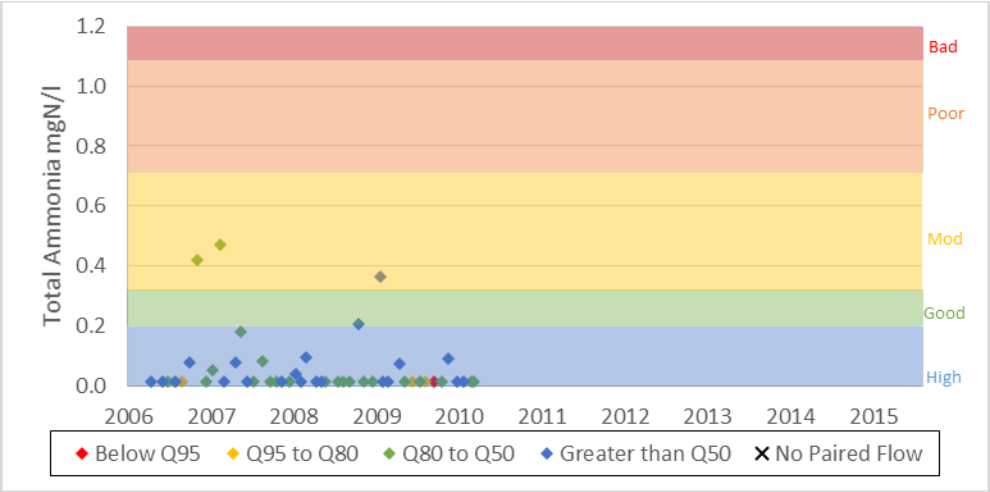
Figure B3.7 Total Ammonia in the River Taff at Rhydycar Sports Centre, Incorporating Appropriate WFD Status Bands



Total ammonia concentrations in the River Taff at Rhydycar Sports Centre (see **Figure B3.1**) were predominantly consistent with the WFD standard to support good status for fish and invertebrates (0.3mg/l). One instance below this standard is note on 21/11/2007 with 0.5mgN/l. This assessment is limited by reduced data availability at this location.

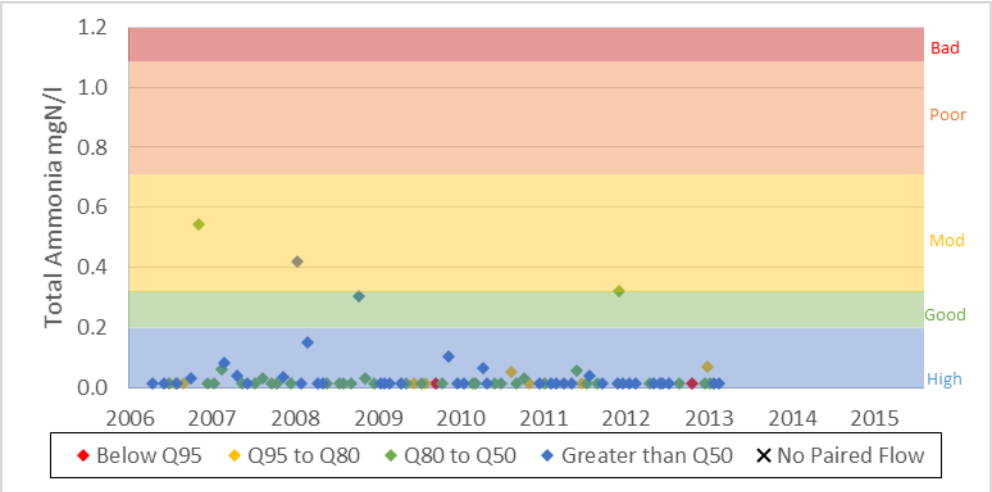
[12] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

Figure B3.8 Total Ammonia in the River Taff at Abercanaid Bridge, Incorporating Appropriate WFD Status Bands



Total ammonia concentrations in the River Taff at Abercanaid Bridge (see **Figure B3.8**) were predominantly consistent with the WFD standard to support good status for fish and invertebrates (0.2mg/l). Three instances are observed below this standard: 0.42mgN/l on 14/08/2007; 0.5mgN/l on 21/11/2007 and 25/10/2009 with 0.36mgN/l.

Figure B3.9 Total Ammonia in the River Taff at School Bridge, Incorporating Appropriate WFD Status Bands

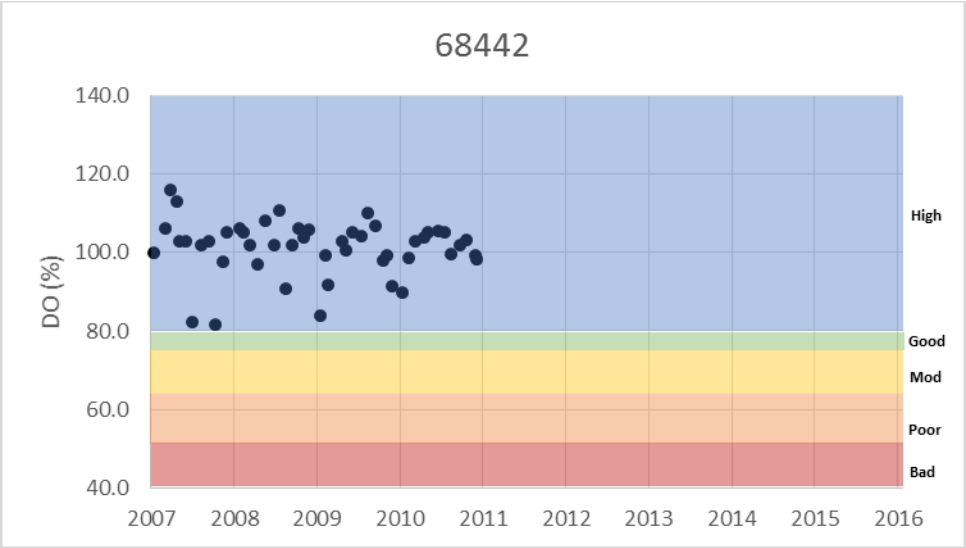


Total ammonia concentrations in the River Taff at School Bridge (see **Figure B3.9**) were predominantly consistent with the WFD standard to support good status for fish and invertebrates (0.2mg/l). Two instances are observed below this standard: 0.54mgN/l on 14/08/2007 and 0.42mgN/l on 20/10/2008. No association is apparent between river flows and ammonia concentration.

Dissolved oxygen saturation

Dissolved oxygen saturation was reviewed and data are presented in **Figure B3.10** for River Taff at Rhydycar Sports Centre, **Figure B3.11** for River Taff at Abercanaid Bridge and **Figure B3.12** for River Taff at School Bridge against the relevant WFD standards for an upland low alkalinity river[13].

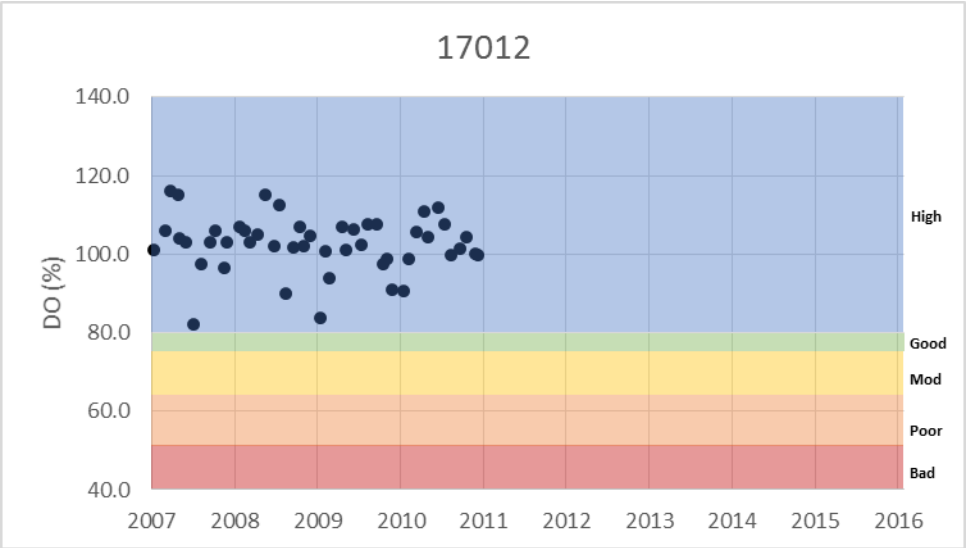
Figure B3.10Dissolved Oxygen Saturation in the River Taff at Rhydycar Sports Centre, Incorporating Appropriate WFD Status Bands



Dissolved oxygen saturation measurements in the River Taff at Rhydycar Sports Centre were all consistent with the WFD standard to support high status for fish and invertebrates (80%). No seasonality or changes in quality over time are apparent. This assessment is limited by reduced data availability.

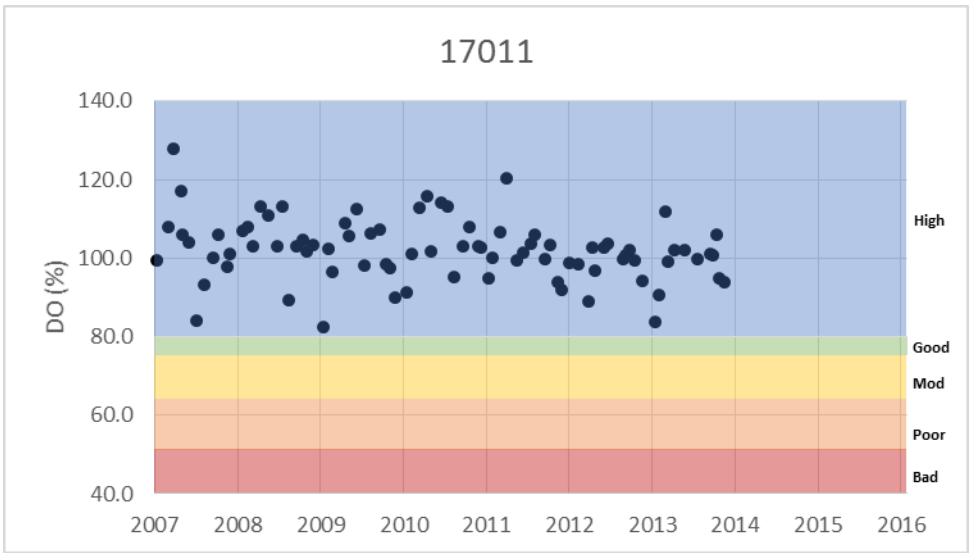
[13] The Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations 2015.

Figure B3.11 Dissolved Oxygen Saturation in the River Taff at Abercanaid Bridge, Incorporating Appropriate WFD Status Bands



Dissolved oxygen saturation measurements in the River Taff at Abercanaid Bridge were all consistent with the WFD standard to support high status for fish and invertebrates (80%). No seasonality or changes in quality over time are apparent. This assessment is limited by reduced data availability.

Figure B3.12 Dissolved Oxygen Saturation in the River Taff at School Bridge, Incorporating Appropriate WFD Status Bands

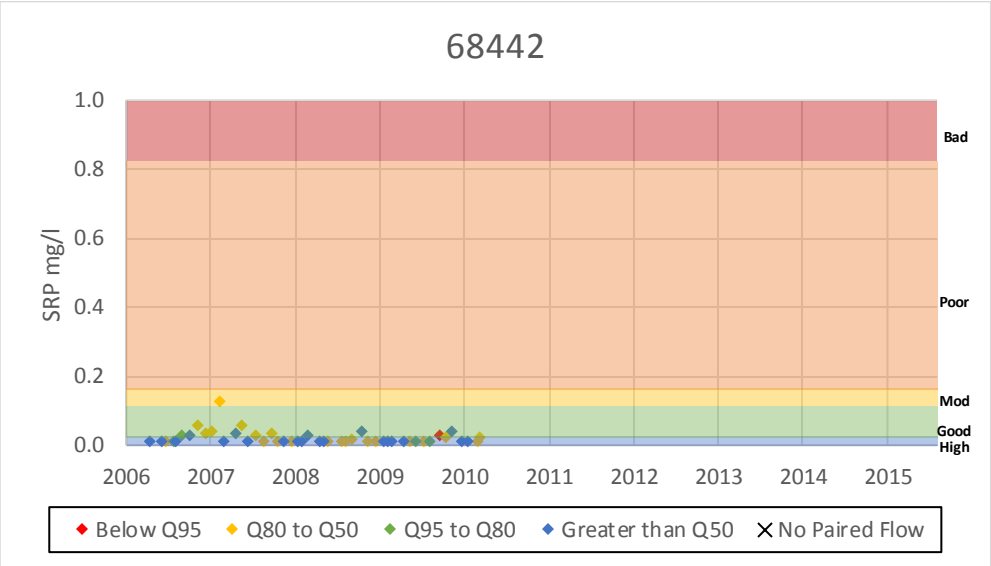


Dissolved oxygen saturation measurements in the River Taff at School Bridge standard to support high status for fish and invertebrates (80%). No seasonality or changes in quality over time are apparent. This assessment is limited by reduced data availability.

Soluble Reactive Phosphorus

Soluble reactive phosphorus concentration for monitoring on the River Taff at Rhydycar Sports Centre, River Taff at Merthyr Tydfil Gauging Station and River Taff at School Bridge was reviewed and data are presented in **Figure B3.13, Figure B3.14** and **Figure B3.15** respectively against the relevant site specific WFD standards provided by the EA[14].

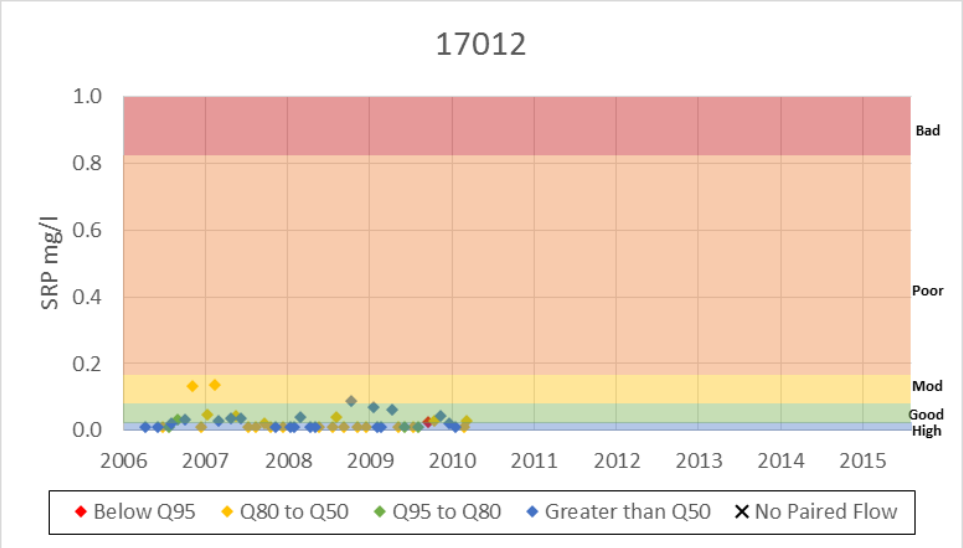
Figure B3.13Soluble Reactive Phosphorus Concentration in the River Taff at Rhydycar Sports Centre, Incorporating Appropriate WFD Status Bands



Soluble reactive phosphorus concentrations in the River Taff at Rhydycar Sports Centre were mostly consistent with the WFD standard to support good status for diatoms and macrophytes (0.07mgP/l). Values below this standard are noted in once instance on 21/11/2007 with 1.3mgP/l. A slight association between river flows and SRP concentration are apparent with lower flows resulting in higher SPR concentration.

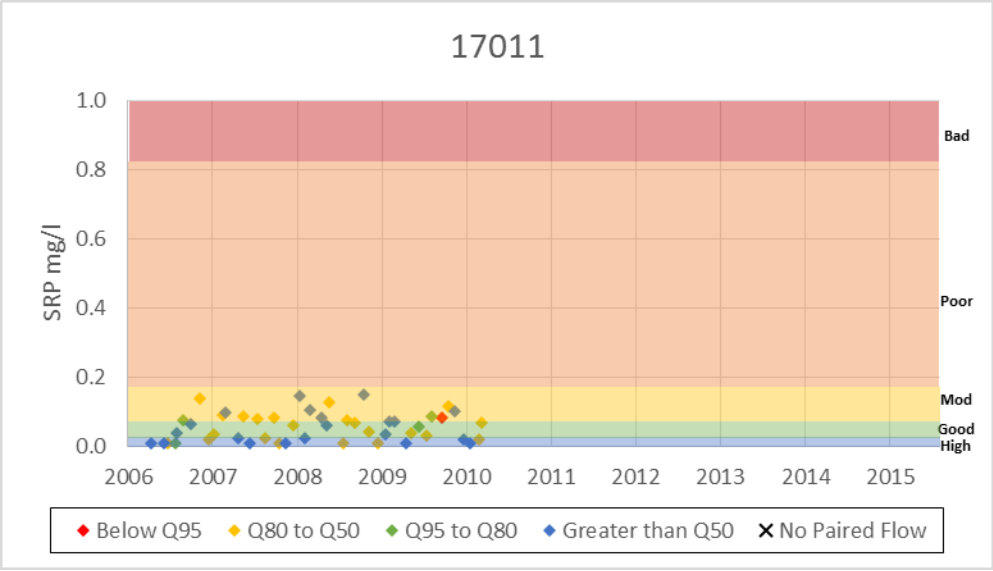
[14] The Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations 2015.

Figure B3.14Soluble Reactive Phosphorus Concentration in the River Taff at Abercanaid Bridge, Incorporating Appropriate WFD Status Bands



Soluble reactive phosphorus concentrations in the River Taff at Abercanaid Bridge were mostly consistent with the WFD standard to support good status for diatoms and macrophytes (0.07mgP/l). Values below this standard are noted in three instances: 0.09mgP/l (21/07/2009); 0.133mgP/l (14/08/2007) and 0.137mgP/l (21/11/2007).

Figure B3.15Soluble Reactive Phosphorus Concentration in the River Taff at School Bridge, Incorporating Appropriate WFD Status Bands



Soluble reactive phosphorus concentrations in the River Taff at School Bridge were mostly consistent with the WFD standard to support good status for diatoms and macrophytes (0.07mgP/l). Values below this standard are noted in 40% of instances (19 occurrences). No seasonality or association with low flows is apparent. This assessment is limited by reduced data availability.

Reach 3 (River Taff, from the confluence with Afon Bargod Taf to the confluence with Afon Cynon)

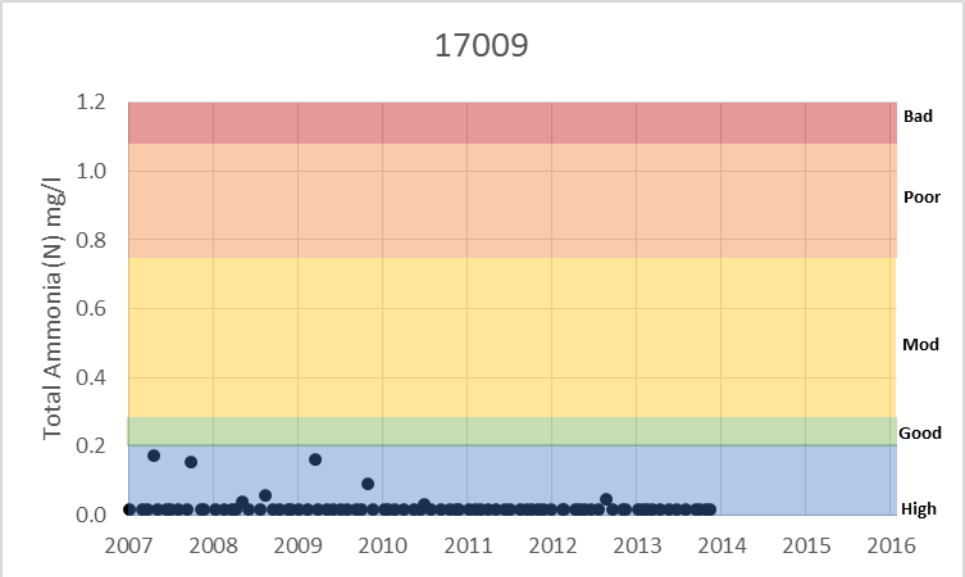
Data are available for River Taff at Quakers Yard Bridge (site 17009) and River Taff upstream of the confluence with the River Cynon (site 68444). The former monitoring point is located in the upper Reach while the latter site is located in the lower Reach.

The average pH in the River Taff at Quakers Yard Bridge over the ten year review period was 8.04 and the maximum water temperature was 16.7°C. The average pH in the River Taff at Abercanaid Bridge over the ten year review period was 8.02 and the maximum water temperature was 16.4°C.

Total ammonia concentration

Total ammonia concentration was reviewed and data are presented in **Figure B3.16** for River Taff at Quakers Yard Bridge and **Figure B3.17** for River Taff upstream of the confluence with the River Cynon against the relevant WFD standards for an upland low alkalinity river[15].

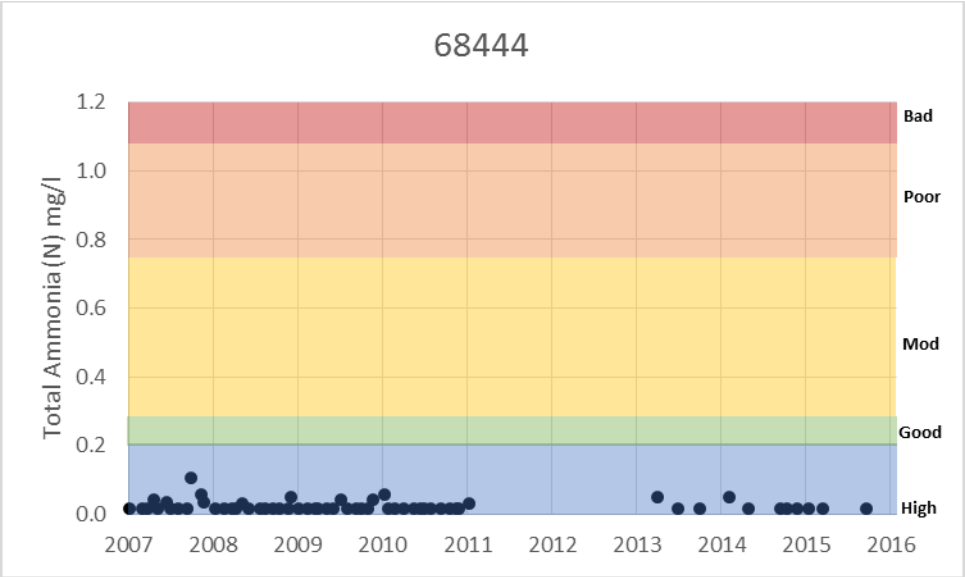
Figure B3.16Total Ammonia in the River Taff at Quakers Yard Bridge, Incorporating Appropriate WFD Status Bands



Total ammonia concentrations in the River Taff at Quakers Yard Bridge (see **Figure B3.16**) were all consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l). No seasonality is apparent or change in quality over time is apparent.

[15] The Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations 2015.

Figure B3.17Total Ammonia in the River Taff Upstream of the Confluence with the River Cynon, Incorporating Appropriate WFD Status Bands



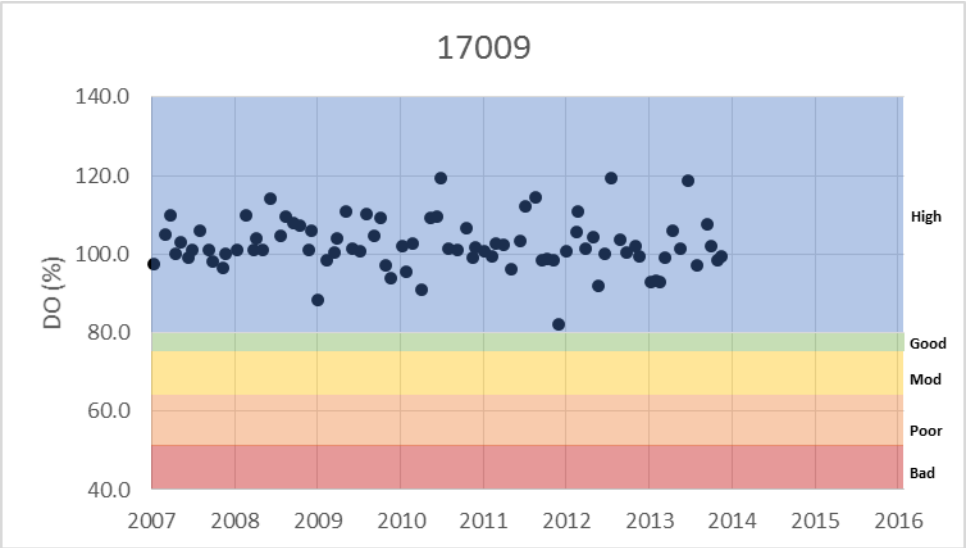
Total ammonia concentrations in the River Taff upstream of the confluence with the River Cynon (see **Figure B3.17**) were all consistent with the WFD standard to support good status for fish and invertebrates (0.2mg/l).

Dissolved oxygen saturation

Dissolved oxygen saturation was reviewed and data are presented in **Figure B3.18** for River Taff at Quakers Yard Bridge, **Figure B3.19** for River Taff upstream of the confluence with the River Cynon against the relevant WFD standards for an upland low alkalinity river[16].

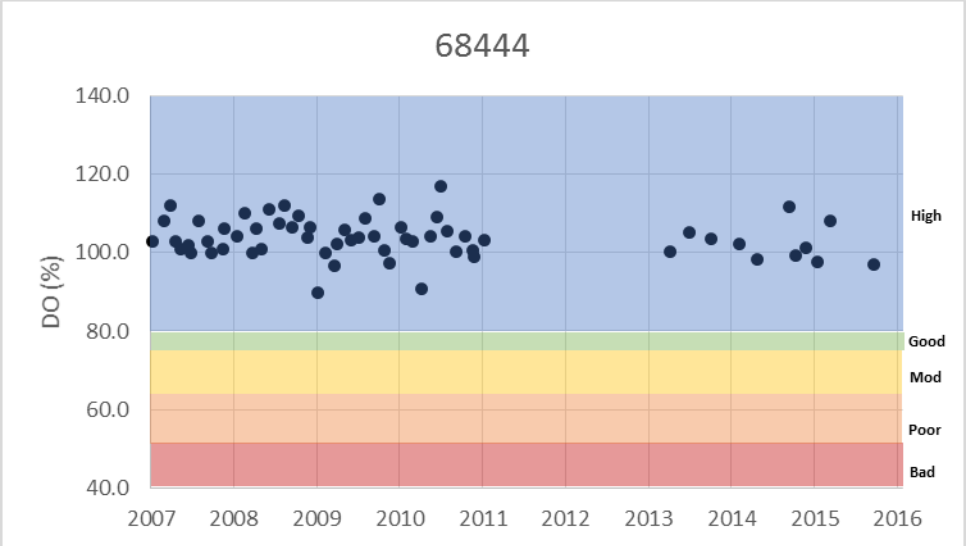
[16] The Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations 2015.

Figure B3.18Dissolved Oxygen Saturation in the River Taff at Quakers Yard Bridge, Incorporating Appropriate WFD Status Bands



Dissolved oxygen saturation measurements in the River Taff at Quakers Yard Bridge were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

Figure B3.19Dissolved Oxygen Saturation in the River Taff Upstream of the Confluence with the River Cynon, Incorporating Appropriate WFD Status Bands



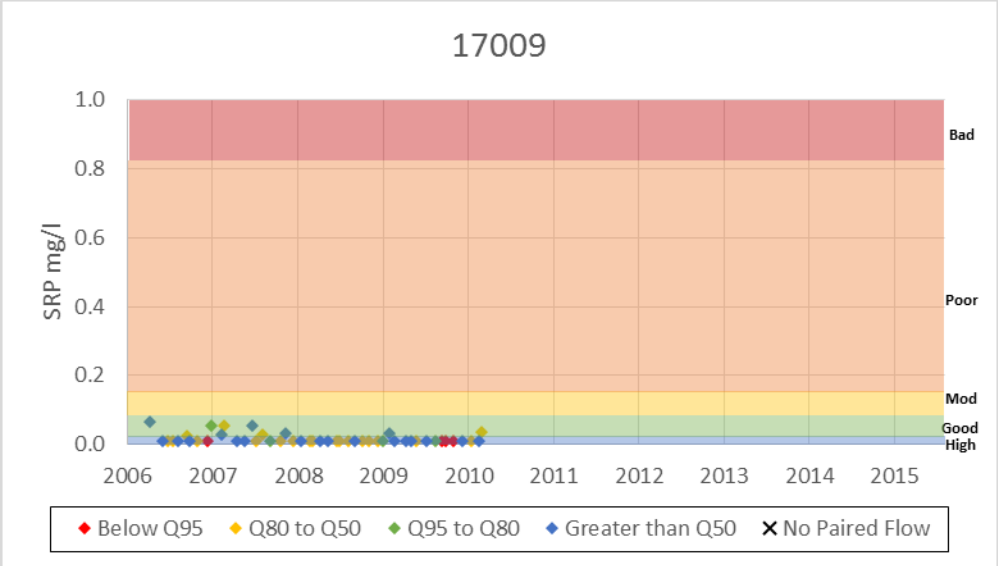
Dissolved oxygen saturation measurements in the River Taff upstream of the confluence with the River Cynon were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

Soluble Reactive Phosphorus

Soluble reactive phosphorus concentration for monitoring on the River Taff at Quakers Yard

Bridge and River Taff upstream of the confluence with the River Cynon was reviewed and data are presented in **Figure B3.20** and **Figure B3.21** respectively against the relevant site specific WFD standards provided by the EA[17].

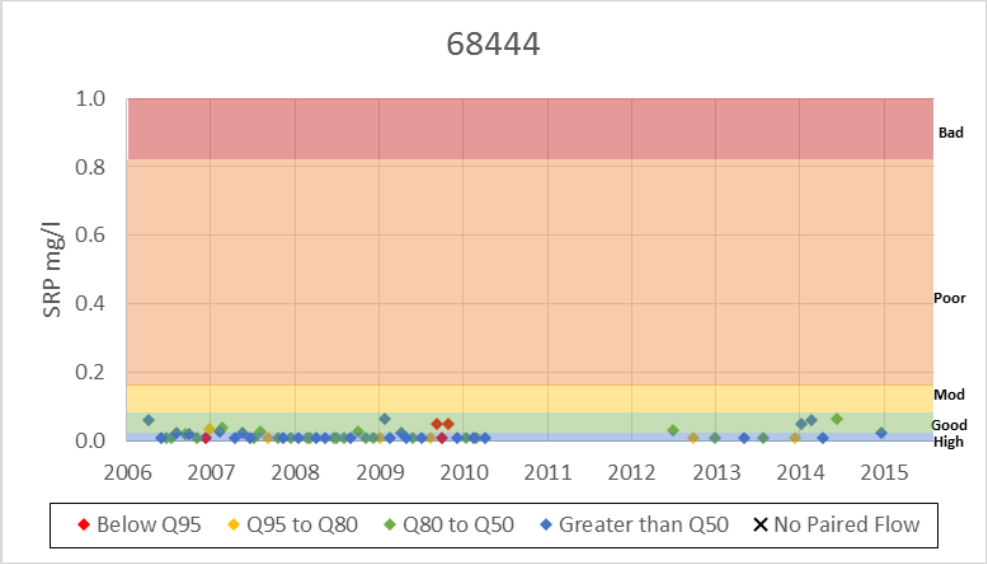
Figure B3.20 Soluble Reactive Phosphorus Concentration in the River Taff at Quakers Yard Bridge, Incorporating Appropriate WFD Status Bands



Soluble reactive phosphorus concentrations in the River Taff at Quakers Yard Bridge were consistent with the WFD standard to support good status for diatoms and macrophytes (0.07mgP/l). No association between river flows and SRP concentration is apparent. This assessment is limited by reduced data availability.

[17] The Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations 2015.

Figure B3.21 Soluble Reactive Phosphorus Concentration in the River Taff Upstream of the Confluence with the River Cynon, Incorporating Appropriate WFD Status Bands



Soluble reactive phosphorus concentrations in the River Taff upstream of the confluence with the River Cynon were all consistent with the WFD standard to support good status for diatoms and macrophytes (0.07mgP/l). No association between river flows and SRP concentration is apparent. This assessment is limited by reduced data availability.

B.3.2.1 Water Quality Summary

Assessment of risk to water quality as a result of the Llwynon drought permit is limited by the spatial and temporal extent of the data available.

Total ammonia concentrations were viable with the standard to support high status for fish and invertebrates for Reaches 1 and 3 and good status for Reach 2 of the Llwynon drought permit. Seasonal variability in total ammonia concentration was low. The risk of a reduction in flow resulting from drought permit implementation to total ammonia concentration levels within the zone of influence is considered **medium** in Reach 1, **low** in Reach 2 and **negligible** in Reach 3. Dissolved oxygen saturations were predominantly consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Llwynon drought permit. It is hence considered that the drought permit would pose a **high** in Reach 1, **low** in Reach 2 and **negligible** risk in Reach 3 to dissolved oxygen saturation to support high status for fish and macroinvertebrates. Soluble reactive phosphorus concentrations were consistent with the standard to support good status for macrophytes throughout the zone of influence of the Llwynon drought permit. It is hence considered that the drought permit would pose a **medium** in Reaches 1 and 2 and **negligible** risk in Reach 3 to soluble reactive phosphorus concentrations to support good or high status for macrophytes.

B.3.3 Environmental Pressures

B.3.3.1 Flow Pressures

There are two licensed surface water abstraction in the study area in Reach 2. Licence number 21/57/22/0025, held by Hoover Plc, is used to abstract water from the River Taff (NGR SO05160462), approximately 2km downstream of the Merthyr Tydfil flow gauging station, for general use up to a maximum of 1.82Ml/d or 509.15Ml/year, at any time of year. As the maximum abstraction quantity is only around 3.2% of the extreme low summer flow (Q_{99}), and the reduction in Q_{99} due to the drought permit is estimated to be around 16.2%, then this abstraction is not considered to be at significant risk of adverse impact due to the drought permit, and is not considered further.

The Cyfartha Leat abstraction (licence number WA/057/0021/0011 has recently been licensed. However the abstraction has a Q_{99} Hands off Flow based off Merthyr Tydfil gauging station and it is assumed that at the time of a future drought permit application that flows would be below the Hands Off Flow limit, and is not considered further.

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, soluble reactive phosphorus and ammonia concentration in the river reaches have been reviewed. Significant pressures (discharges of over 0.5Ml/d) are shown on **Figure B1.1**. 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).

There are four significant consented discharges in the study area. Details of each discharge are outlined in **Table B3.2**.

A total of 32 CSOs have been identified within the zone of influence of this drought plan: none on Reach 1; 23 on Reach 2 and nine on Reach 3. Available discharge data indicates these locations would have a negligible impact on water quality within their respective reaches. Risk to water quality from CSOs is therefore deemed **negligible**.

Table B3.2 Consented Discharges in Area of Influence of the Llwynon Drought Permit

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)**	**Consideration of water quality pressure** (during baseline low flow conditions)
AN0033701	Cynon Sewage Treatment Works	ST0814992997	Not Specified	19.7	Not Specified	Not Specified	40	Negligible
AG0004601	Cilfynydd Wastewater Treatment Works	ST0835693551	Not Specified	Not Specified	Not Specified	Not Specified	Not Specified	Negligible
AN0216701	An Emergency Overflow and Washout at Peny Bryn Depot, Merthyr Tydfil	SO0530007500	Not Specified	Not Specified	Not Specified	Not Specified	100	Negligible
AN0247201	Llwynon Water Treatment Plant	SO0120011230	500	Not Specified	Not Specified	Not Specified	Not Specified	Negligible

B4 PHYSICAL ENVIRONMENT IMPACT SUMMARY

Potential impacts on the physical environment associated with the Llwynon Reservoir Drought Permit are summarised in **Table B4.1.**

Table B4.1 Summary of Potential Changes to the Physical Environment of the Impacted Reaches from Implementation of Llwynon Reservoir Drought Permit

Llwynon Reservoir	
Water level in Llwynon Reservoir *Minor (positive) impacts*	• Marginal increase in levels/storage and 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.
Afon Taf Fawr (Reach 1)	
Flows in the Afon Taf Fawr *Major impacts during the period September – November inclusive*	• Up to 50% reduction in low flows, with up to 10% and 15% reductions in wetted width and wetted depth respectively
Water quality in the Afon Taf Fawr *High risk*	• Risk of low dissolved oxygen levels associated with low flow and increased temperature, and to increased soluble reactive phosphorous and ammonia.
River Taff (Reach 2)	
Flows in the River Taff *Moderate impacts (September) or minor impacts (October - November)*	• Up to 16% reduction in summer extreme low flows and up to 14% reduction in winter low flows, with up to 10% reductions in wetted width/wetted depth
Water quality in the River Taff *Medium risk*	• Medium risk to soluble reactive phosphorous, low risk to dissolved oxygen levels associated with low flow and increased temperature
Consented discharges *Negligible risk*	• No significant discharges
River Taff (Reach 3)	
Flows in the River Taff *Minor impacts (September) or negligible impacts (October - November)*	• Up to 11% reduction in summer extreme low flows and up to 7 % reduction in winter low flows, with less than 5% reductions in wetted width/wetted depth
Water quality in the River Taff *Negligible risk*	• No risk of low dissolved oxygen levels associated with low flow and increased temperature

B5 CUMULATIVE IMPACTS

The focus of this EAR is the Llwynon Reservoir drought permit. The assessment, as described in previous sections, has considered how the proposed drought permit 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 permits / 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 permit / order 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 Llwynon Reservoir Drought Permit with other Drought Options

Organisation	Potential In-combination Impacts	Further Consideration Required (Yes/No)
Welsh Water - other drought options in the SEWCUS Llwynon / Sluvad / Court Farm WRZ"	8109-4 (Emergency abstraction from the Afon Lwyd at New Inn) – The impacts of this option do not occur within the same catchment and therefore no in-combination effects are anticipated.	No
Welsh Water - other drought options in the River Taff catchment"	8119-1 (Reduced compensation releases from Pontsticill Reservoir) – This option is likely to be implemented concurrently with reduced compensation from Llwynon Reservoir and both options influence the River Taff downstream of the Afon Taf Fechan / Afon Taf Fawr confluence, therefore in-combination effects are anticipated.	Yes (see assessment below in Section B5.1)
	8112-1 (Emergency abstraction from the Afon Rhondda Fawr at Treherbert) – This option will reduce the flows in the River Taff downstream of the confluence with the Afon Rhondda Fawr. As the effects of the Llwynon Reservoir option are assessed as being negligible downstream of the Afon Cynon confluence, which is 6.5km upstream of the Afon Rhondda Fawr confluence, no significant in-combination effects are anticipated.	No

B.5.1 Cumulative Hydrological Effects of 8109-1 Llwynon Reservoir and 8119-1 Pontsticill Drought Permits

Welsh Water's water resources modelling of stochastic drought scenario[18] has indicated that it is likely that this option would be implemented concurrently with option 8119-1 (reduced compensation from Pontsticill Reservoir). Both of these drought options influence the River Taff from the confluence of the Afon Taf Fawr / Afon Taf Fechan down to the confluence with the Afon Cynon (Reaches 2 and 3 in this assessment). Therefore we have briefly assessed the

[18] Dŵr Cymru Welsh Water Llwynon and Pontsticill Reservoirs Drought Permit Support – Environmental Assessment of Pontsticill Reservoir Drought Permit, AMEC, April 2012.

cumulative impacts of both options together, i.e. an overall reduction in flow of 18.2Ml/d below the confluence at the top of reach 2 (a reduction in compensation of 9.1Ml/d from each of the two reservoirs, Pontsticill and Llwynon).

Reach 1 – Afon Taf Fawr from Llwynon Reservoir outflow to the confluence with Afon Taf Fechan

There is no additional effect on the Afon Taf Fawr from the reduced compensation flow from Pontsticill Reservoir, so the hydrological impact on this reach remains at **major** as for the Llwynon Reservoir drought option considered alone.

Reach 2 – River Taff, from the confluence with Afon Taf Fechan to the confluence with Afon Bargod Taf

An overall reduction in flow of 18.2Ml/d in the flow at the upper end of Reach 2 represents reductions of 29% and 32% in the summer low flow statistic (Q_{95}) and extreme low flow statistic (Q_{99}) respectively, based on the adjusted flow record for Merthyr Tydfil flow gauge (see **Table B2.5**). In the winter refill period, the combined flow reduction of 18.2Ml/d is a 14% reduction in the year round moderate flow statistic (Q_{50}) and a 27% reduction in the year round low flow statistic (Q_{95}) (see **Table B2.3**). Therefore the hydrological impact on Reach 2 of both drought options together is assessed as being **major** for all times of year.

The analysis of cross-sectional survey data by AMEC[19] using Manning's equation suggested that for the upper end of Reach 2 (survey site at Merthyr Tyfil gauging station):

- Mean section velocity would reduce by ~10% (Q_{95} and Q_{99}) and ~5% (Q_{50})
- Cross-sectional area would reduce by ~20% (Q_{95} and Q_{99}) and ~10% (Q_{50})
- Wetted width would reduce by ~5% (Q_{95} and Q_{99}) and <5% (Q_{50})
- Wetted depth would reduce by ~10-15% (Q_{95} and Q_{99}) and ~5% (Q_{50})

Reach 3 - River Taff, from the confluence with Afon Bargod Taf to the confluence with Afon Cynon

In Reach 3, based on the adjusted flow statistics for Fiddler's Elbow flow gauge, a flow reduction of 18.2Ml/d represents reductions of 16% and 21% in the summer low flow statistic (Q_{95}) and extreme low flow statistic (Q_{99}) respectively. Therefore the hydrological impact on reach 3 of both drought options together is assessed as being **moderate** during the summer period (September).

In the winter refill period, the combined flow reduction is a 6% reduction in the year round moderate flow statistic (Q_{50}) and a 15% reduction in the year round low flow statistic (Q_{95}). Therefore the hydrological impact on reach 3 of both drought options together is assessed as

[19] Dŵr Cymru Welsh Water Llwynon and Pontsticill Reservoirs Drought Permit Support – Environmental Assessment of Pontsticill Reservoir Drought Permit, AMEC, April 2012.

being **minor** during the autumn/winter reservoir refill period (October – November).

As the impacts are clearly more significant with both drought options in place, a further reach has been added to determine whether the impacts do in fact extend further downstream in the River Taff.

Reach 4 - River Taff, from the confluence with Afon Cynon to the confluence with Afon Rhondda Fawr

At the end of Reach 3 a major tributary, the Afon Cynon, joins the River Taff and contributes around a further 43Ml/d at low flows (Q_{95}) and 32Ml/d at extreme low flows (Q_{99}), during the summer period of April to September inclusive. The combined 18.2Ml/d flow reduction therefore represents reductions of 12% and 15% in the summer Q_{95} and Q_{99} respectively in the River Taff flow below the confluence. The year round contribution to flow in Reach 4 from the Afon Cynon is a moderate flow of 187.5Ml/d (Q_{50}) and a low flow (Q_{95}) of 48.5Ml/d, and the flow reduction in the River Taff at the top of Reach 4 is therefore 4% of the Q_{50} flow and 11% of the Q_{95} flow. The hydrological impact of the two drought options together on Reach 4 has therefore been assessed as **minor** for both the summer and autumn/ winter periods.

Immediately downstream of the Afon Rhondda Fawr confluence, flows in the River Taff are measured at the Pontypridd gauging station. The relevant flow statistics are as follows (with the effects of previous drought permits removed): Summer Q_{95}=294.6Ml/d; Summer Q_{99}=216.9Ml/d; Year round Q_{50}=950.4Ml/d; Year round Q_{95}=325.7Ml/d. An upstream flow reduction of 18.2Ml/d represents reductions of 6% and 8% in the summer Q_{95} and Q_{99} respectively, and reductions of 2% and 6% in the year round Q_{50} and Q_{95} respectively. The hydrological impact of the drought permit on the River Taff downstream of the Afon Rhondda confluence is therefore negligible, and the river below this point has therefore been excluded from further assessment.

Table B5.2 Hydrological and Monitoring Reaches identified in the Study Area – Summer Cumulative Impact with Option 8119-1 (Pontsticill Reservoir)

Hydrological Reach		Reach boundary		Reach length	% flow reduction		Hydrological Impact - Summer
		Upstream	Downstream		Summer Q_{95}	Summer Q_{99}	
Llwynon Reservoir		n/a	n/a	n/a	n/a	n/a	**Minor positive**
1	Afon Taf Fawr	Llwynon Reservoir	Afon Taf Fechan confluence	5.8km	50%	50%	**Major**
2	River Taff	Afon Taf Fechan confluence	Afon Bargod Taf confluence	16.6km	29%	32%	**Major**
3	River Taff	Afon Bargod Taf confluence	Afon Cynon confluence	2.6km	16%	21%	**Moderate**
4	River Taff	Afon Cynon confluence	Afon Rhondda Fawr confluence	6.5km	12%	15%	**Minor**

Table B5.3 Hydrological and Monitoring Reaches identified in the Study Area – Winter Cumulative Impact with Option 8119-1 (Pontsticill Reservoir)

Hydrological Reach		Reach boundary		Reach length	% flow reduction		Hydrological Impact - Winter
		Upstream	Downstream		Year round Q_{50}	Year round Q_{95}	
Llwynon Reservoir		n/a	n/a	n/a	n/a	n/a	**Minor positive**
1	Afon Taf Fawr	Llwynon Reservoir	Afon Taf Fechan confluence	5.8km	50%	50%	**Major**
2	River Taff	Afon Taf Fechan confluence	Afon Bargod Taf confluence	16.6km	14%	27%	**Major**
3	River Taff	Afon Bargod Taf confluence	Afon Cynon confluence	2.6km	6%	15%	**Minor**
4	River Taff	Afon Cynon confluence	Afon Rhondda Fawr confluence	6.5km	4%	11%	**Minor**

Water Quality and Geomorphological Impacts

For Reaches 1 to 3, the hydrological impact of the implementation of both the Llyn Llwynon compensation flow (8109-1) and the Pontsticill regulation release (8119-1) drought permits at the same time will be of a greater magnitude than the Llyn Llwynon regulation release (8109-1) on its own. This may result in an increase in the magnitude of water quality changes. The risk of the Llyn Llwynon compensation flow (8109-1) drought permit to ammonia has been assessed as **moderate** in Reaches 1 and 2 and **negligible** in Reaches 3 and 4. Dissolved oxygen saturation levels have been assessed as **major** in Reaches 1 and 2 and **negligible** in Reaches 3 and 4. Soluble reactive phosphorous levels are considered to be at **moderate** risk in Reaches 1 to 2 and negligible in Reaches 3 and 4 due to the operation of the Llyn Llwynon compensation flow (8109-1) drought permit.

There are no additional effects on the Afon Taf Fawr from the reduced compensation flow from Pontsticill Reservoir, so the geomorphological impact on Reach 1 remains at **minor** as for the Llwynon Reservoir drought option considered alone. Due to the implementation of both drought permits, the cumulative impacts on the geomorphology within Reach 2 is assessed as **minor**. There could be a decrease in wetted width, especially in shallow sections of the

channel and potentially an increase in fine grained sedimentation behind weirs. Although this is considered unlikely due to the lack of fine sediment in the catchment, due to the major hydrological impact, there will be some minor changes in geomorphological functioning of the river e.g., wetted width change. When high flows return, any fine sediment deposited will be transported. The cumulative impact on Reaches 3 and 4 is considered **negligible**.

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 larger 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 Llwynon Reservoir compensation flow drought permit. 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 EAR and 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 in **Appendix D** are indicated on **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 permit for the impact criteria major, moderate, minor, negligible; following the requirements of the DPG); iii) the data requirements; iv) assessment methodology (including the treatment of uncertainty where the complete data requirements are not available).

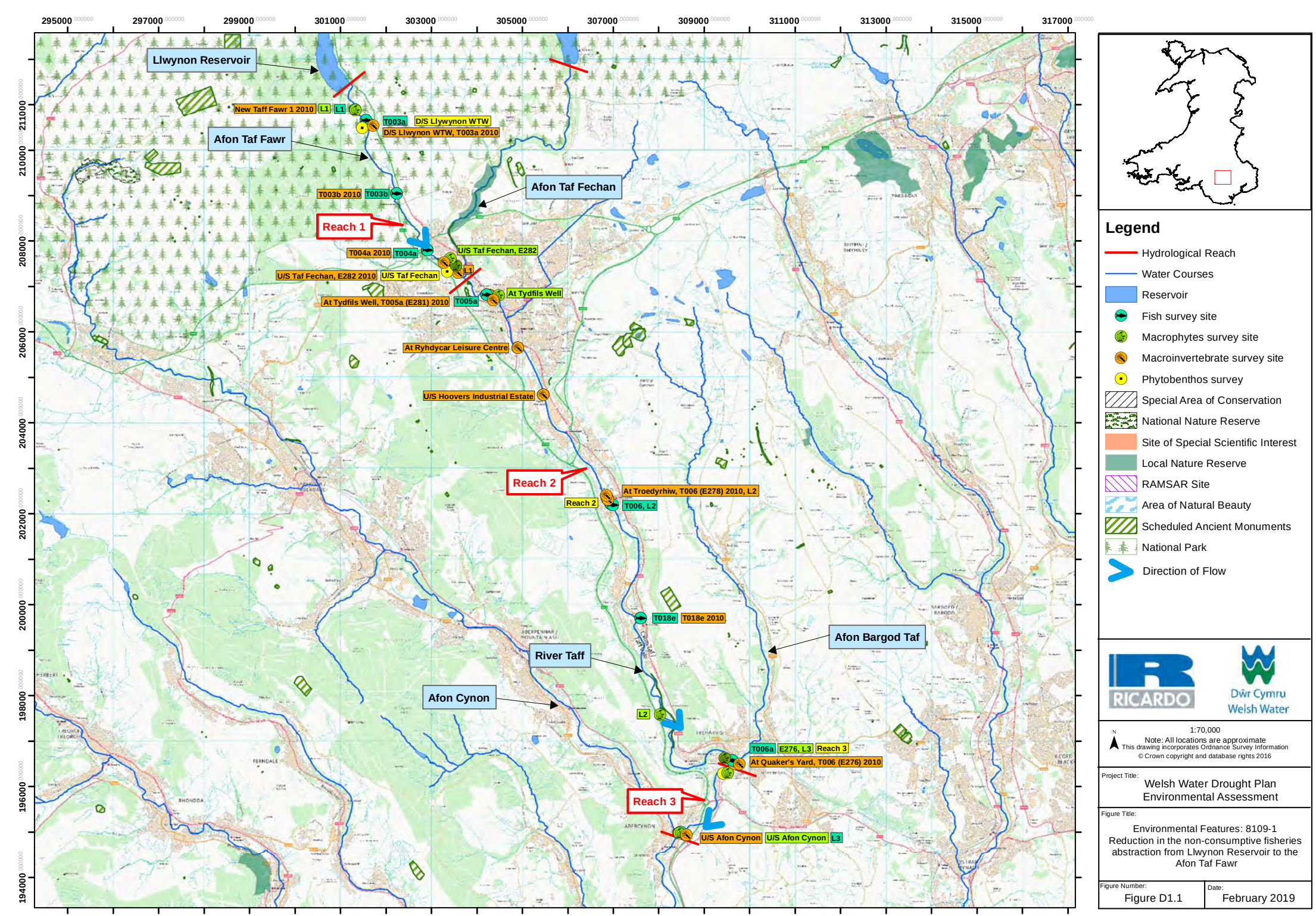
The assessment of environmental features is informed by the assessment of the physical environment (which includes hydrology and hydrodynamics; geomorphology; and water quality), this is summarised in Section 4 presented in full in **Appendix B**.

The ecological assessment has been undertaken recognising the Institute of Environmental Management & 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 Llwynon Reservoir compensation flow drought permit. 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 (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland.



Legend

- Hydrological Reach
- Water Courses
- Reservoir
- Fish survey site
- Macrophytes survey site
- Macroinvertebrate survey site
- Phytobenthos survey
- Special Area of Conservation
- National Nature Reserve
- Site of Special Scientific Interest
- Local Nature Reserve
- RAMSAR Site
- Area of Natural Beauty
- Scheduled Ancient Monuments
- National Park
- Direction of Flow

RICARDO

Dŵr Cymru Welsh Water

1:70,000

Note: All locations are approximate

Project Title:

Welsh Water Drought Plan Environmental Assessment

Figure Title:

Environmental Features: 8109-1 Reduction in the non-consumptive fisheries abstraction from Llwynon Reservoir to the Afon Taf Fawr

Figure Number:	Date:
Figure D1.1	February 2019

D2 WFD STATUS AND COMMUNITY ASSESSMENT

D.2.1 Macrophytes

D.2.1.1 Baseline

Baseline information received from Natural Resources Wales (NRW) included four sampling occasions at the U/S Taf Fechan site on the Taf Fawr in Reach 1, one visit at the At Tydfils Well site on the River Taff in Reach 2, and three visits at the U/S Afon Cynon in Reach 3 (see **Figure D1.1**).

The most recent surveys were undertaken in 2017 within the hydrological zone of influence by APEM (on behalf of Welsh Water)[4]. This included one site Reach 1 (L1 – D/S of the Llwynon Reservoir), Reach 2 (L2 – U/S Treharris) and Reach 3 (L3 - D/S Quakers Yard).

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.

Macrophyte results were provided by NRW using the standard LEAFPACS2 methodology[5] 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 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 (RMNI): 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

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

Table D2.1 LEAFPACS metrics: NRW macrophyte sampling sites on the Taf Fawr and Afon Taff.

Site	Reach	Grid Reference	Year	MFR	MTR	RMNI
U/S TAF FECHAN	1	SO-03332-07522	2004	2.71	52.5	5.63
			2005	3.00	60.0	5
			2006	3.25	64.8	4.7
			2007	2.93	59.5	4.98
AT TYDFILS WELL	2	SO-04270-06800	2004	2.53	49.4	5.83
U/S AFON CYNON	3	ST-08452-94977	2005	2.73	44.8	5.9
			2006	2.75	41.9	6.06
			2007	2.42	45.7	5.87

[4] Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2017 to 2018: Llwynon and Pontsticill Reservoirs, August 2018
[5] WFD-UKTAG (2014) UKTAG river assessment method – macrophytes and phytobenthos (River LEAFPACS2).

In Reach 1 a peak count of 23 macrophyte taxa were recorded at the U/S Taf Fechan site in 2007 (of which 15 were hydrophytes). The species diversity was lower at the Tydfils Well site with 15 macrophyte taxa recorded (of which 12 were hydrophytes). The results for Reach 3 showed similar diversity to Reach 1 with a peak count of 22 macrophyte taxa recorded at the U/S Afon Cynon site in 2007 (of which 13 were hydrophytes).

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.

RMNI scores at the U/S Taf Fechan site in Reach 1 were between 4.7 and 5.63, indicating mesotrophic conditions. The samples taken at the Tydfils Well and U/S Afon Cynon Sites in Reach 2 and 3 respectively were higher with RMNI scores ranging from 5.83 to 6.06; this suggests higher nutrient levels than Reach 1 but with a macrophyte community also indicative of mesotrophic conditions.

In 2011 monitoring was undertaken at five sites on the Taf Fawr and five sites on the River Taff (**Figure D1.1**) using the LEAFPACS methodology, on behalf of Welsh Water[6]. Surveys were undertaken over two seasons, firstly in August and then repeated in October. Surveys in October were intended to detect broad changes in the structure of the plant community between the seasons and therefore bryophytes were not surveyed to the same level of detail, only recording those occurring at over 1% cover. Furthermore, high flows during the October surveys restricted access to deeper / high velocity areas of some sites. LEAFPACS scores from these surveys are provided in **Table D2.2**.

The channel flora of all sites was dominated by bryophyte species, typical of upland rivers with relatively high velocities.

[6] AMEC (2012), Environmental Assessment for Llwynon Reservoir drought permit. *Technical report to Dwr Cymru Welsh Water.*

Table D2.2 LEAFPACS Metrics: Macrophyte Sampling Sites on the Taf Fawr and River Taff 2010 and 2011[7]

Site Ref	NGR	Survey date	RMNI	RMHI	No. aquatic taxa	No. Functional groups	Algal Cover
Taf Fawr							
E282	SO-03380-07520	02-Aug-2010 (AMEC)	5.8	5.8	16	7	20
	SO-03380-07520	27-Jun-2011 (AMEC)	5.4	5.6	14	6	0.5
	SO-03380-07520	06-Oct-2011 (AMEC)	5.3	5.4	13	6	1
Afon Taff							
E276	ST-09593-96621	04-Aug-2010 (AMEC)	6.7	6.4	14	6	70.5
	ST-09593-96621	29-Jun-2011 (AMEC)	6.4	6.3	17	7	50
	ST-09593-96621	07-Oct-2011 (AMEC)	6.7	6.4	12	5	60

Overall, the 2012 assessment concludes that the macrophyte communities recorded are representative of Type B-V and C-VIII rivers[8]; the two types are intermixed without an obvious upstream-downstream pattern but with the B-V slightly more common. The differences probably reflect local variations in flow and shade. The C-VIII sections are mostly sub-type C-VIIIb ('Moderate-gradient shale/sandstone rivers below uplands') with some C-VIIIc ('Base-rich, meso-oligotrophic, upland rivers'). The principal difference between these types is the presence of significant numbers of limestone boulders and cobbles. This is reflected in the latter type by greater presence of more calcareous bryophytes and algae, including *Hildenbrandia rivularis*, *Cinclidotus fontinaloides*, and *Hygroamblystegium* species and the scarcity of more acidic species such as *Racomitrium aciculare* and *Fontinalis squamosa*. The B-V sections fall into type B-Va ('Mesotrophic upland hard limestone/sandstone rivers'), and differ from the C-VIII types by the lower extent and diversity of bryophytes and a greater range of fringing wetland species.

The report also concludes that the scores represent a relatively low nutrient system and are generally typical of the rivers in this part of Wales.

The 2017 macrophyte results (see Table D2.3) were provided by NRW using the standard LEAFPACS2 methodology[9] in accordance with the requirements of the Water Framework Directive (WFD). In comparison to the surveys undertaken on behalf of Welsh Water in 2010 and 2011, the number of taxa and the number of aquatic species were much lower in 2017 in all reaches. As observed in 2010 and 2011, the RMNI scores were indicative of a system characterised by low nutrient levels.

[7] AMEC (2012), Environmental Assessment for Llwynon Reservoir drought permit. *Technical report to Dwr Cymru Welsh Water*
[8] Holmes, N.T.H., Boon, P. & Rowell, T. (1999). *Vegetation communities of British rivers, a revised classification.* JNCC, Peterborough.
[9] WFD-UKTAG (2014) UKTAG river assessment method – macrophytes and phytobenthos (River LEAFPACS2).

Table D2.3 LEAFPACS metrics: Apem macrophyte sampling sites on the Taf Fawr and River Taff.

		Matrix				Environmental Variables	
Reach	Site Location (NGR, downstream extent))	RMNI	NTAXA	NFG	ALG	Total % Cover of Macrophytes	Total % cover of filamentous algae
L1	SO 01327 10872	4.47	9.0	3.0	0.5	30	3
L2	ST 08026 97586	5.75	10.0	4.0	0.5	8	2
L3	ST 09515 96294	5.16	5.0	3.0	0.5	4	2

Notable Species

The Nationally Scarce beck pocket moss *Fissidens rufulus* was recorded in small quantities in one section of the Taf Fawr and two sections on the main River Taff. This species grows submerged on rocks generally in depths over 30cm in the faster flowing rapids, although not in areas that are turbulent even when the water is low. Microscopic examination is needed to separate this species from other submerged *Fissidens* species, of which the usually smaller *Fissidens viridulus* is also present in the system. This makes it difficult to assess their frequencies relative to each other but *Fissidens rufulus* seems to be the more frequent of the two on the River Taff[10].

D.2.1.2 Assessment

The assessment of impacts on the macrophyte community should be considered in the context of the watercourse under baseline conditions. Baseline data indicates that the macrophyte communities in the hydrological zone of influence of the drought permit are bryophyte dominated, adapted to high to moderate velocities. Reduction in flows could affect macrophyte communities in a number of ways:

- Reduction in velocity favouring species adapted to slower flow conditions
- Proliferation of filamentous algae due to decreases in velocity / increases in water temperature
- Shading of macrophyte stands by epiphytic algae, due to decreases in velocity/increases in water temperature
- Desiccation of macrophyte beds due to reduced wetted width and water depth

[10] AMEC (2012), Environmental Assessment for Llwynon Reservoir drought permit. *Technical report to Dwr Cymru Welsh Water.*

- 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.

The additional moderate / minor risk of water quality deterioration associated with soluble reactive phosphorous could encourage macrophyte growth and 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. There is already a high relative proportion of filamentous algae (*Cladophora* species) at some monitoring sites.

Hydrological impacts as a result of drought permit implementation in Reach 1 are anticipated to be major adverse all year round when the reservoir is below spill level, including a reduction of 50% of the summer low flows (Q_{95}) and summer extreme low flows (Q_{99}) with corresponding reductions in wetted depths / wetted widths during the summer and autumn period.

Due to the potential extent of change to wetted area, velocities, splash and humidity, during the main macrophyte growing season, operation of the drought permit has the potential to affect the condition, composition and extent of macrophyte communities. Low flows may also favour the proliferation of filamentous algae species due to changes in velocity and water temperature. However, bryophytes are generally well adapted to tolerate desiccation and rewetting and communities can take a long time to react to changes in environmental conditions[11].

The operation of the drought permit will result in major hydrological impacts from September to November in Reach 1, with a 50% reduction in summer Q_{95} and Q_{99}. The effects of the drought permit on the macrophyte community would therefore be limited to the end of the main growing season. Given the limited duration of the drought permit it is expected that any effects on the macrophyte community would be reversed following return to the normal hydrological regime. Therefore the impacts of the drought permit on the macrophyte communities of Reach 1 are expected to be **minor** adverse, short term, and reversible in September and **negligible** in October and November.

Hydrological impacts on Reach 2 are expected to be moderate (September only) with a lesser reduction in summer low and extreme low flows than Reach 1 (14.5% of the summer Q_{95} and 16.2% of the summer Q_{99}). Hydrological impacts will be minor in October and November. The effects on the macrophyte community are likely to be similar to those in Reach 1. The effects of the drought permit on the macrophyte community would be limited to the end of the main growing season. Therefore the impact of the drought order on macrophytes communities in

[11] 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*

Reach 2 is expected to be **negligible.**

Hydrological impacts on Reach 3 are expected to be minor (September only), with a reduction in summer low and extreme low flows (Q95 and Q99) of 8% and 10.5% respectively. Hydrological impacts will be negligible during October and November. The effects of the drought permit on the macrophyte community would be limited to the end of the main growing season. Therefore the impact of the drought permit on macrophytes communities in Reach 3 is expected to be **negligible**.

Notable Species

The nationally scarce moss *Fissidens rufulus* was present on one monitoring site on the Taf Fawr and two monitoring sites on the main River Taff in 2010-11. *Fissidens rufulus* grows on partially or submerged limestone substrate by rivers, it is considered susceptible to reductions in water level as it may become exposed as water levels fall. The reduction in water levels as a result of the drought permit will result in a reduction in habitat suitability and area, with the possibility of mortality due to prolonged desiccation. Given the species habitat preference it is likely to be regularly exposed above the water level under normal drought. Given the ability of bryophytes to tolerate a degree of desiccation, the sub-optimal conditions occurring in a natural drought, and the limited length of the drought permit, likely impacts of operation of the drought permit on this species is assessed as **minor** within Reach 1 during September, and **negligible during October and November.** Impacts are assessed in Reaches 2 and 3 during as **negligible**.

Summary

The potential impacts of the Llwynon Reservoir compensation flow drought permit on the macrophyte community are summarised in **Table D2.4**. 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 D2.4** represent the worst case impacts of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

Table D2.4 Summary of Impacts on Macrophyte Community

Reach 1 –Taf Fawr: Llwynon Reservoir outflow –Taf Fechan confluence		
Feature	**Impact**	**Significance of Impact**
Macrophytes	• Reduction in growth as a result of major to moderate 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. • Increase in filamentous algae levels due to increased nutrients or water temperature and decreased velocity	**Minor** (September) **Negligible** (October & November)
Fissidens rufulus	• Changes to inundation pattern and splash due to changes in flow. • Increase in competition from filamentous algae due to increased nutrients or water temperature and decreased velocity.	**Minor** (September only) **Negligible** (October & November)
Reach 2 – River Taff: Taf Fechan confluence to Afon Taf Bargoed confluence **Reach 3 – River Taff: Afon Taf Bargoed confluence to Afon Cynon confluence**		
Macrophytes	• Reduction in growth as a result of moderate 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.	**Negligible**
Fissidens rufulus	• Changes to inundation pattern and splash due to changes in flow. • Increase in competition from filamentous algae due to increased nutrients or water temperature and decreased velocity.	**Negligible**

There is a risk of short-term deterioration in status of the macrophyte component, for the Afon Taf Fawr – source to conf Taf Fechan waterbody (GB109057033170) and the Taff- conf Taf Fechan to conf R Cynon (GB109057033100), due to the drought permit. Impacts of drought permit implementation on the macrophyte communities of the impacted reaches have been summarised as negligible to minor adverse, short-term, temporary and reversible. Consequently, the macophyte component of these waterbodies is considered to be at **negligible** risk of short term deterioration for Reaches 1-3.

D.2.2 Macroinvertebrates

D.2.2.1 Baseline

Baseline information received from NRW included eight sites within the impacted reaches; two sites on the Taff Fawr in Reach 1 (D/S Llwynon WTW and U/S Taf Fechan), five sites on the River Taff in Reach 2 (At Tydfils Well, At Rhydycar Leisure Centre, U/S Hoovers Industrial Estate, At Troedyrhiw, and At Quaker's Yard), and one site on the River Taff in Reach 3 (U/S Afon Cynon; see **Figure D1.1**). Data for sites D/S Llwynon WTW and U/S Taf Fechan has been recently provided from NRW however biotic indices were not available. This data will need to be added to the assessment during a future update when indices are available.

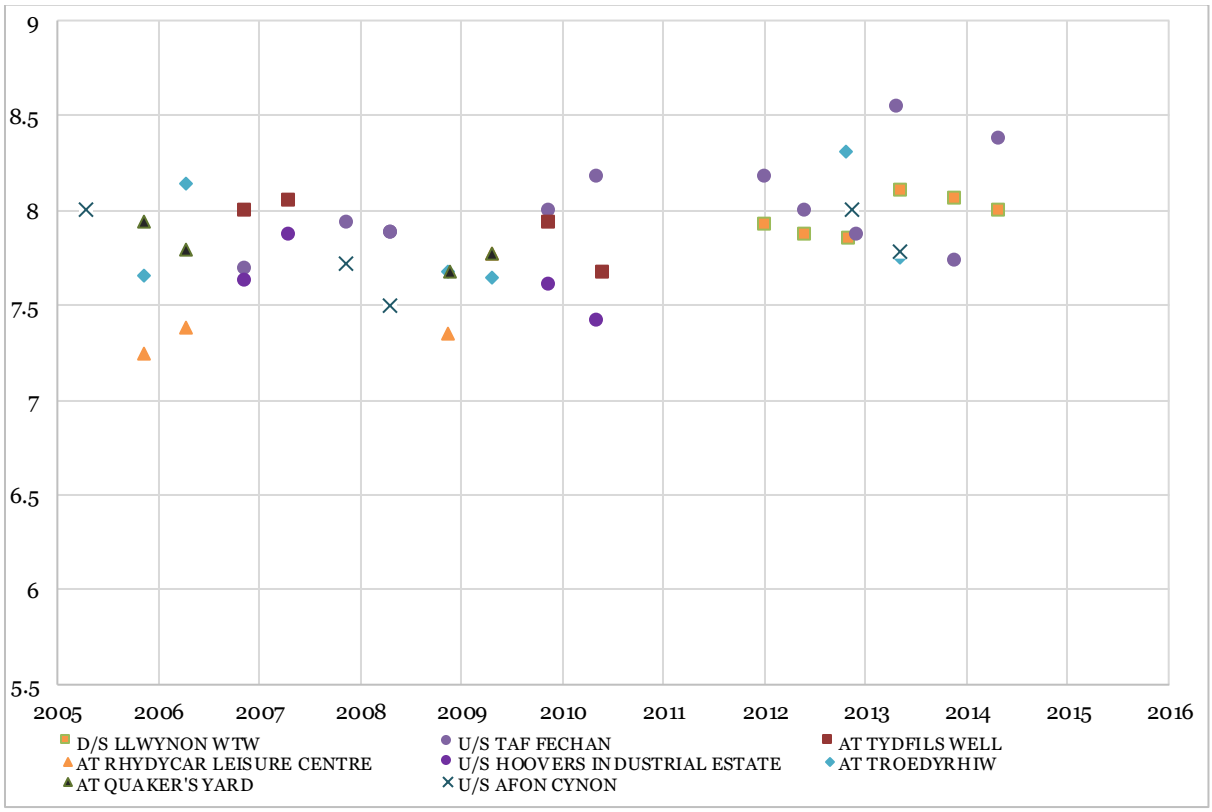
The most recent surveys were undertaken in 2017 within the hydrological zone of influence by APEM (on behalf of Welsh Water)[12]. This included one site Reach 1 (L1 – D/S of the Cefn-

[12] Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2017 to 2018:Llwynon and Pontsticill Reservoirs, August 2018

Coed-y-cymmer), Reach 2 (L2 – U/S Troed-y-rhiw) and Reach 3 (U/S Abercynon).

Sampling was conducted following the standard NRW protocol involving a three-minute kick / sweep sample encompassing all the available instream habitats in proportion to their occurrence[13]. For data collected between 2006 and 2017 macroinvertebrates were identified in some cases to species level and the abundances recorded as actual values. These datasets are used to calculate a series of standard biotic indices: Biological Monitoring Working Party (BMWP) scores; Average Score Per Taxon (ASPT) scores; Lotic Invertebrate Flow Evaluation (LIFE); and number of taxa. There are no quality bands for BMWP scores and ASPT scores. However, as a guide, BMWP scores of 200 with ASPT values above 6 are indicative of rivers of exceptionally good quality, while BMWP scores of 100 with ASPT values of 5 are indicative of reasonably good water quality. LIFE scores around 6 represent a macroinvertebrate community that primarily comprises species favouring slow-flowing conditions and scores over 8 generally represent a community primarily comprised of species favouring faster-flowing conditions. NRW data for LIFE, ASPT and BMWP scores are graphically presented in **Figures D2.1**, **D2.2** and **D2.3**.

Figure D2.1 Observed Family LIFE Scores within the River Taf



In the Reach 1 on the Taff Fawr macroinvertebrate assemblages present comprise mainly species that strongly favour fast flows with LIFE scores ranging from 7.7 to 8.55 and an average across both sites of 8.01. LIFE scores for sampling sites on Reach 2 also indicate the presence

[13] Environment Agency (1999) *Procedures for Collecting and Analysing Macroinvertebrate Samples* (Issue 2.0), Environment Agency BT001.

of macroinvertebrate communities associated with fast flows with a range from 7.24 to 8.31 and an average of 7.31. The results for Reach 3 are similar to Reach 2 with a range of LIFE scores from 7.35 to 8 and an average of 7.73. Overall, family LIFE scores were comparable across all monitoring sites and indicate the presence of communities which favour fast flows.

Figure D2.2 Observed ASPT Scores within the River Taf

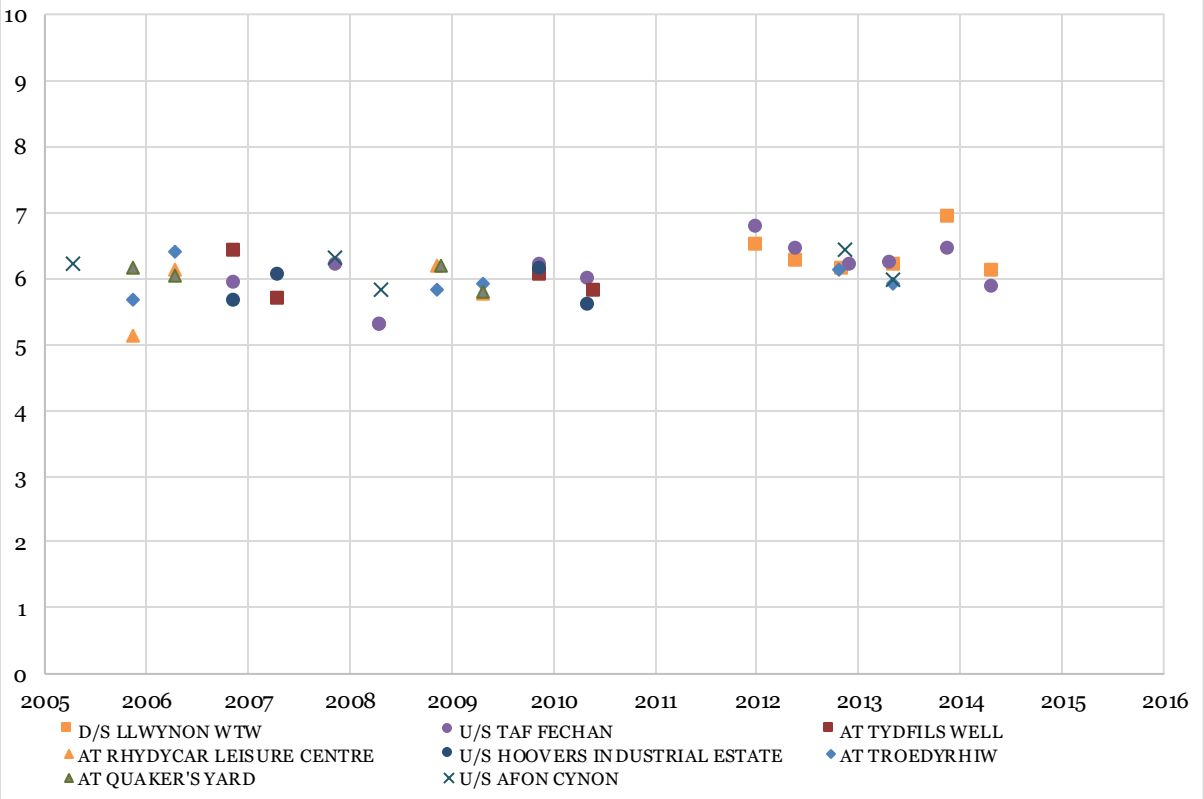
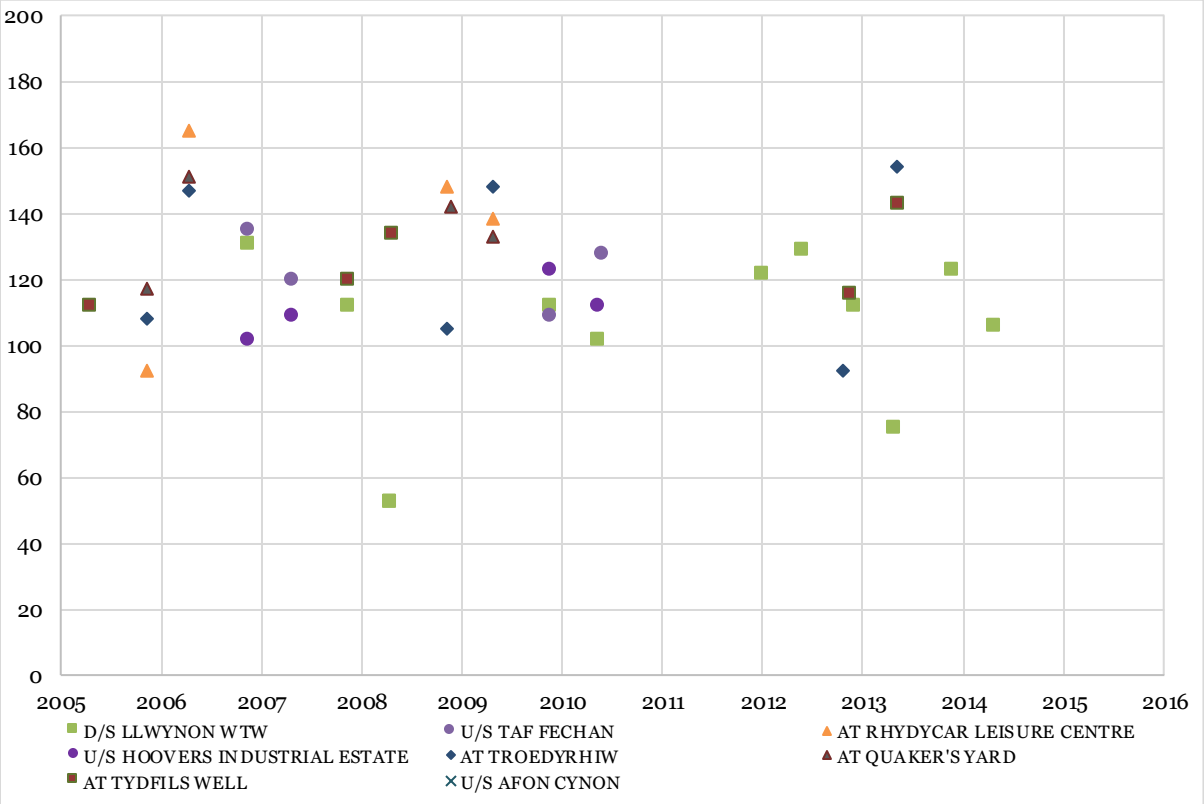


Figure D2.3 Observed BMWP Scores within the River Taf



The ASPT scores provide a measure of the existing water quality of the environment based on the tolerances of macroinvertebrate species present. The higher ASPT scores identify a community that is representative of good water quality and lower ASPT scores are representative of poor water quality.

For the sampling sites in the impacted reaches, the ASPT scores range from 5.11 to 6.94 with an average across all sites of 6.06, which indicates moderate to very good water quality. In the Reach 1 on the Taff Fawr macroinvertebrate assemblages present are comprised mainly of species that favour high oxygen levels with ASPT scores ranging from 5.3 to 6.94 with an average across both sites of 8.01. ASPT scores for sampling sites on Reach 2 indicate the presence of macroinvertebrate communities associated with moderate to good water quality, with a range from 5.11 to 6.43 and an average of 5.94. The results for Reach 3 are similar to Reach 2 with a range of ASPT scores from 5.83 to 6.44 and an average of 5.94. The highest ASPT scores were recorded at the D/S Llwynon WTW site with a range from 6.11 to 6.94 recorded in 2014 and 2013 respectively. The ASPT scores indicate the presence of invertebrate families that favour clean water with higher oxygen levels.

The composition and abundance of the macroinvertebrate communities at the sampling locations are indicative of moderate to high diversity.

The BMWP scores indicate variable water quality, ranging from 53-165 with an average of 119,

which is indicative of poor to good water quality. There are anomalous BMWP scores of 53 and 75 from 2008 and 2013 at the D/S Llwynon WTW site, these are significantly lower than others from the site and are likely to be the result of unknown influences or water quality pressure. There is no associated reduction in LIFE scores for these surveys so it is unlikely to be related to changes in the flow regime. The lower BMWP and ASPT scores are indicative of a macroinvertebrate community that has been subject to anthropogenic impacts, whilst more recent data indicate higher water quality and less anthropogenic influence.

In addition to data collected by NRW, baseline data for the study reach has been collected on behalf of Welsh Water[14]. Surveys were undertaken in summer 2010, July 2011 and October 2011. Locations of the survey sites are illustrated in **Figure D1.1.** Surveys were undertaken at 15 sites on the Taff Fawr and 12 sites on the River Taff. These data were used to calculate a series of standard biotic indices: BMWP scores; ASPT scores; LIFE; and number of taxa.

The 2012 EAR[15] reported that, analysis of the BMWP scores indicates biological water quality is generally classed as good or, more often, very good in the Taf Fawr and River Taff. The samples were dominated by river flies, ephemeroptera, plecoptera and trichoptera, as would be expected of such rivers although the surveys have recorded a small number of species indicative of still or slow flowing water and which would not normally be considered characteristic of rivers and streams. These include an immature planorbid snail (in Taff Fawr, site New Taff Fawr 1), the large chydorid water-flea *Eurycercus lamellatus* (in Taff Fawr T003a), the marsh beetle (Scirtidae) larva (in Taff Fawr E282), and common frog tadpoles (Taff Fawr T003a & T003b). Whilst some of these may at least occur naturally in low numbers in pools or other slack parts of rivers, they may also have taken advantage of reduced flows earlier in 2010 and 2011 in the rivers concerned. These species appeared to be mainly present in the Afon Taf Fawr. Scores for 2012 monitoring are provided in **Table D2.5**.

[14] AMEC (2012), Environmental Assessment for Llwynon Reservoir drought permit. *Technical report to Dwr Cymru Welsh Water.*
[15] AMEC (2012), Environmental Assessment for Llwynon Reservoir drought permit. *Technical report to Dwr Cymru Welsh Water.*

Table D2.5 Total Taxa, BMWP Scores, Scoring Taxa and ASPT Scores for Sites Surveyed in 2010 and 2011.

River	Entec Site ref (Nearby EAW site)	BMWP	No. of Scoring Taxa	ASPT	LIFE (Family)
Taf Fawr	New Taff Fawr 1 2010	55	12	4.5	7.4
	2011su	86	15	5.7	7.8
	2011au	91	17	5.3	7.6
	t003a 2010	74	13	5.7	6.8
	2011su	93	16	5.8	7.2
	2011au	111	17	6.5	6.7
	T003b 2010	101	17	5.9	8
	2011su	119	18	6.6	8.1
	2011au	117	21	5.5	7.9
	T004a 2010	73	12	6	8.5
	2011su	93	14	6.6	5.2
	2011au	94	16	5.8	5.2
	E282 2010	112	18	6.2	5.1
	2011su	125	18	6.9	5.2
	2011au	94	15	6.2	5.1
River Taff	T005a (E281) 2010	108	18	6	7.7
	2011su	103	17	6.1	7.8
	2011au	117	19	6.1	7.8
	T006 (E278) 2010	108	17	6.3	7.8
	2010su	90	15	6	7.9
	2010au	91	17	5.3	7.6
	T018e 2010	114	17	6.7	7.8
	2011su	100	17	5.9	8
	2011au	137	26	5.9	7.6
	T006a (E276) 2010	147	24	6.1	7.3
	2011su	126	20	6.3	7.5
	2010au	136	23	5.9	7.4

The most recent baseline data for the hydrological reach has been collected by Apem on behalf of Welsh Water. Surveys were undertaken in spring and autumn of 2017. The data from the 2017 surveys indicates that the assemblages of macroinvertebrates at the sampling locations were generally dominated by species sensitive to chemical water pollution although less sensitive taxa were also fairly well represented. The biotic indices show that the vast majority of the macroinvertebrate communities preferred high current velocities (i.e. sensitive to low flows)

Table D2.6 Total Taxa, BMWP Scores, ASPT, and LIFE scores for Sites Surveyed in 2017

	L1		L2		L3	
NGR	SO 03580 07298		SO 06884 02310		ST 08443 94974	
Date	30/05/ 2017	12/09 /2017	30/05/ 2017	12/09/ 2017	30/05/ 2017	12/09/ 2017
Total no. of taxa	31	29	44	59	50	55
BMWP Score	107	112	148	169	154	197
ASPT	5.94	6.22	6.43	5.83	5.92	5.97
LIFE score (family)	7.75	7.53	7.30	7.46	7.80	7.44

Notable Species

The nationally scarce caddisfly, *Metalype fragilis* was recorded (from Taf Fawr T003b) in autumn 2011. This caseless caddisfly has been recorded from highly calcareous rivers and large streams in England and Wales and is a restricted species[16].

The native white-clawed crayfish *Austropotamopobius pallipes* was historically present within the Taff catchment but was not recorded in targeted surveys on behalf of Welsh Water in 2010 or 2011[17]. It is assumed that the population in this area of the catchment has dwindled or been subject to catastrophic collapse due to disease or competition by invasive species. White-clawed crayfish are, therefore, not considered a receptor for the purposes of this assessment.

D.2.2.2 Assessment

As the drought permit will result in a reduction in flows and wetted depth / width, it is likely that many of the flow sensitive taxa will be temporarily lost from the reach, including many stonefly, mayfly, and caddisfly taxa such as Rhyacophilidae, Heptageniidae, Perlidae, Leuctridae, and Taeniopterygidae. As the LIFE scores for the sites in all reaches indicated taxa with a preference for 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 proliferation of invertebrates which favour slow flows.

Marginal habitats are the most sensitive to flow reduction, with many slow-flow favouring species such as molluscs utilising this habitat. Depending on the rate of flow reduction, species in these marginal sediments may become stranded and ultimately die.

[16] Wallace, I.D. (1991) A Review of the Trichoptera of Great Britain. Research & Survey in Nature Conservation. No. 32. Nature Conservancy Council
[17] AMEC (2012), Environmental Assessment for Llwynon Reservoir drought permit. *Technical report to Dwr Cymru Welsh Water.*

The reduced flows could also result in a short-term change to composition of the substrate, with finer substrates potentially deposited. Although this is a temporary impact, in the short-term, this could result in the smothering of individuals[18] and changes to habitat suitability for taxa that require clear stony substrates, which could result in a reduction in species diversity.

Overall, considering the composition of the baseline macroinvertebrate community, the short-term, temporary and reversible hydrological impacts of the drought permit and the effective recolonisation strategies of macroinvertebrate species, impacts on the macroinvertebrate community are assessed as **minor** for Reach 1 due to potential impacts on emergence and recolonisation. Impacts are considered to be **negligible** for Reaches 2 and 3 for the drought permit implementation period of September to November inclusive.

Notable Species

The Nationally Scarce caddisfly *Metalype fragilis* was detected at one site in Reach 1. The potential effects of the drought permit on this species within Reach 1 are considered to represent a **minor** impact during September and negligible during October and November.

Summary

The potential impacts of the Llwynon Reservoir compensation flow drought permit on the macroinvertebrate community are summarised in **Table D2.6**. 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 macroinvertebrate community. The impacts presented in **Table D2.6** represent the worst case impacts of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

Table D2.6 Summary of Impacts on Macroinvertebrate Community

Reach 1 –Taf Fawr: Llwynon Reservoir outflow –Taf Fechan confluence		
Feature	**Impact**	**Significance of Impact**
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats • Reduction in species diversity and abundance as a result of reduced recruitment.	**Minor**
Metalype fragilis	• Reduction in habitat area and suitability	**Minor**
Reach 2 – River Taff: Taf Fechan confluence to Afon Taf Bargoed confluence **Reach 3 – River Taff: Afon Taf Bargoed confluence to Afon Cynon confluence**		
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats	**Negligible**

[18] Ryan, P. A. (1991) Environmental effects of sediment on New Zealand streams: A review. *New Zealand Journal of Marine and Freshwater Research* 25 pp 207 - 221.

There is a risk of short-term deterioration in status of the macroinvertebrate component, for the Afon Taf Fawr – source to conf Taf Fechan waterbody (GB109057033170) and the Taff-conf Taf Fechan to conf R Cynon (GB109057033100), due to the drought permit. Impacts of drought permit implementation on the macroinvertebrate communities of the impacted reaches have been summarised as negligible to minor adverse, short-term, temporary and reversible. Consequently, the macroinvertebrate component of these waterbodies is considered to be at **negligible** risk of short term deterioration for Reaches 1-3.

D.2.3 Fish

D.2.3.1 Baseline

The most recent surveys were undertaken in 2017 within the hydrological zone of influence by both APEM (on behalf of Welsh Water) [19] and NRW. In 2010 and 2011, the Afon Taf Fawr and Afon Taff within the hydrological zone of influence, were subject to intensive fisheries monitoring as part of a programme of ecological surveys (recommended in the Environmental Monitoring Plan for Llwynon Reservoir (SE20)[20]) commissioned by Welsh Water to fulfil the first iteration of the environmental assessment of Llwynon Reservoir drought permit[21] in 2012. Fisheries monitoring undertaken by HIFI in 2010 and 2011 is described in ENTEC (2010)[22] and AMEC (2012)[23], respectively. Fisheries monitoring has also historically been undertaken on the Afon Taf Fawr and Afon Taff by NRW (previously EAW). Relevant previous studies and recent NRW fish survey data have been reviewed and analysed and an updated summary baseline is provided below.

Existing Data

APEM surveys undertaken in 2017 consisted of three fully-quantitative electric fishing surveys. No HABSCORE data from these surveys was available for this assessment. One survey site was located on the Afon Taf Fawr (Reach 1), and two on the Afon Taf (Reach 2 and 3). The most recent NRW survey undertaken in 2017 consisted of one semi-quantitative electric fishing survey respectively on the Taf Fawr at site T004.

The fisheries monitoring undertaken by HIFI in 2010 and 2011 consisted of a suite of surveys in a study area providing reasonable coverage of the predicted extent of hydrological influence of the proposed drought permit. Monitoring consisted of standard electric fishing surveys at five sites in Reach 1 and five sites in Reach 2[24]. Reach 3 consists of a relatively short section of

[19] Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2017 to 2018:Llwynon and Pontsticill Reservoirs, August 2018
[20] Cascade (2007). Environmental Monitoring Plan for Llwynon Reservoir (SE20). A report for Dŵr Cymru Welsh Water. May 2007.
[21] AMEC (2012). Llwynon and Pontsticil Reservoirs Drought Permit Support. Environmental Assessment of Llwynon Reservoir Drought Permit. A report for Dŵr Cymru Welsh Water. April 2012.
[22] ENTEC (2010). Llwynon and Pontsticill Reservoirs Drought Permit Support: Environmental Monitoring Report. A report for Dŵr Cymru Welsh Water. November 2010.
[23] AMEC (2012). Llwynon and Pontsticil Reservoirs Drought Permit Support. Environmental Assessment of Llwynon Reservoir Drought Permit. A report for Dŵr Cymru Welsh Water. April 2012.
[24] Reach 1: New Fawr 1 (SO 0130011100), T003a (SO 0160010600), T003b (SO 0220009000), T004 (SO 030078) and E282 (SO 0340007500). Reach 2: T005a (SO 0430006800), E279 (SO 0550004600), T006 (SO 0680002300), T018e (ST 0760099700) and T006a (ST 0960096600).

the Afon Taff and no survey sites were located within it. Detailed methodologies are provided in the relevant reports **Error! Bookmark not defined.**.

Fish survey data from a number of salmonid survey sites within the hydrological zone of influence were provided by NRW following a data request to inform this assessment (see **Table D2.7)**. While relatively long-term datasets were provided for some of the seven sites detailed in **Table D2.7**, sites have not been sampled consistently either across years or in terms of methodology[25]. However, the data provide a useful insight into the likely species assemblage within the hydrological zone of influence and complements the more detailed data collected by HIFI in 2010 - 11.

Table D2.7 NRW Fisheries Monitoring Sites, Locations and Sampling Years

Hydrological Reach	NRW Site Name (Code)	Location	Sample Years
1	T003a	SO0156110658	2007, 2011, 2012
	T003b	SO0223409053	2006, 2007
	T004	SO0290507795	1997, 2000 – 2010, 2012 -2015, 2017
2	T005a	SO0421106819	1997, 2000, 2005 – 2007, 2012
	T006	SO0694802221	1997, 2000, 2001, 2005 – 2007, 2012
	T006a	ST0962496581	1997, 2000, 2001, 2005 – 2007, 2012
	T018e	ST0760099700	2001, 2005 - 2007
3	None	-	-

'Principal' Atlantic salmon *Salmo salar* rivers (numbering 64 in England in England and Wales) are assessed annually with the most recent report[26], published in 2015. The River Taff (along with the Ely) 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 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 spawning 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 Taff and Ely are classified as currently 'At risk' (<5% probability of meeting the management objective) with a predicted classification of 'Probably at risk' (5 – 50% probability

[25] Semi-quantitative and quantitative electric fishing surveys as well as five-minute timed run surveys have been undertaken. Timed run electric fishing does not allow density estimates to be calculated.
[26] Cefas. 2017. Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2014. Preliminary assessment prepared for ICES, April 2017.

of meeting the management objective) by 2022. The 2017 CL achieved just 17%; the lowest level since 2009.

This classification is significant for this assessment as it highlights the current vulnerability of the Atlantic salmon population of the Taff catchment. Following water quality improvements and significant investment in fish passage at previously impassable structures, improvements in salmon recruitment have occurred but the population remains reliant on a low number of returning adults which are susceptible to increased or additional pressures during migration and spawning. Maintaining migratory corridors and spawning and nursery areas for Atlantic salmon is recognised as particularly important in this instance.

The Afon Taf Fawr - source to conf. Taf Fechan waterbody (GB109057033170) (designated as a Heavily Modified Waterbody), associated with Reach 1, was assessed as being at moderate status for fish in 2009 and 2015. The 2018 cycle 2 interim fish classification was assessed as achieving good status[27]. The R Taff - conf Taf Fechan to conf. R Cynon waterbody (GB109057033100) (designated as a Heavily Modified Waterbody), associated with Reach 2 and 3, was assessed as being at poor status for fish in 2009. The status of the fish element for the GB109057033100 waterbody was not available for 2015 or 2018 (interim) classifications.

Data Limitations

Fish survey data for juvenile Atlantic salmon is complicated by the fact that significant stocking of juveniles has occurred as mitigation for the Cardiff Bay Barrage and so it is not possible to accurately identify when/if *in situ* spawning first occurred in the Afon Taff Fawr. There is therefore uncertainty surrounding the status of Atlantic salmon. The available data are, however, sufficient to provide an understanding of the fish assemblage and recent trends in recruitment.

A conservative approach has been used which assumes that populations of the relevant species are present in the hydrological zone of influence and that worst-case impacts would occur.

Species Composition

Nine fish species have been recorded within the hydrological zone of influence on the Afon Taff Fawr and Afon Taff, including Atlantic salmon, bullhead *Cottus gobio* (both 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'), grayling *Thymallus thymallus*, perch *Perca fluviatilis*, minnow *Phoxinus phoxinus*, stone loach *Barbatula barbatula* and three-spined stickleback *Gasterosteus aculeatus*.

The Afon Taff has been impassable to migratory species for *circa* 200 years as a result of

[27] Interim cycle 2 2018 status - Based on Natural Resources Wales 2018 Cycle 2 Interim Classification Data - https://drive.google.com/file/d/14w17jL05sNuToVELqMCK_yc6DdHU7STb/view

impounding infrastructure associated with the heavy industry in the valleys. Significant fish passage improvements over the past two decades have resulted in improved fish passage across the Taff catchment with anecdotal evidence of adult Atlantic salmon migration into, and spawning in, the Afon Taff Fawr[28].

No lamprey species (Petromyzontidae sp.), have been recorded during any fisheries monitoring, almost certainly due to the presence of barriers to migration and poor water quality associated with the area's industrial past limiting the species.

Atlantic Salmon

A long-term dataset from NRW site T004 (Reach 1) was made available and Atlantic salmon fry and parr densities for most years between 1997 and 2017 are presented in **Table D2.8**. NRW survey methods vary between quantitative and semi-quantitative depending on the survey driver, resulting in semi-quantitative surveys potentially providing a lower density estimate than quantitative. Densities from a less comprehensive dataset for sites T005a (Reach 2) have also been provided in **Table D2.8** to provide an indication of likely spatial trends within the hydrological zone of influence. Despite long-term data sets, timed run data only is available for sites T006 and T006a which provides presence/absence rather than density data.

Table D2.8 Salmon Fry and Parr Densities and Equivalent NFCS Grades[29] at NRW Sites T004 and T005a

Sample year	NRW monitoring site T004		NRW monitoring site T005a	
	0+ density (NFC Grade)	>0+ density (NFC Grade)	0+ density (NFC Grade)	>0+ density (NFC Grade)
1997	0.00 (F)	0.00 (F)	10.00 (D)	12.50 (B)
2000	0.00 (F)	0.00 (F)	0.00 (F)	1.67 (E)
2001	0.00 (F)	0.56 (E)	-	-
2002	0.00 (F)	0.00 (F)	-	-
2003	0.00 (F)	0.00 (F)	-	-
2004	0.00 (F)	0.68 (E)	-	-
2005	0.00 (F)	0.41 (E)	0.00 (F)	26.67 (A)
2006	0.00 (F)	0.00 (F)	7.50 (E)	0.00 (F)
2007	0.00 (F)	0.00 (F)	19.17 (D)	3.33 (D)
2008	0.00 (F)	0.24 (E)	-	-
2009	0.00 (F)	1.70 (E)	-	-
2010	0.00 (F)	0.00 (F)	-	-
2012	0.00 (F)	0.00 (F)	2.00 (E)	0.67 (E)
2013	0.00 (F)	0.00 (F)	-	-
2014	0.15 (E)	0.00 (F)	-	-
2015	0.61 (E)	0.61 (E)	-	-
2017	0.00 (F)	0.3 (E)	-	-

[28] For example, http://www.theopike.com/new-life-for-the-taff/ Accessed 16/05/2016
[29] 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).

*All surveys fully quantitative except 1997-2001, 2012 & 2017 (one-run semi-quantitative surveys) which may be a factor in a lower density estimate.

It should also be noted that significant stocking has occurred since the construction of Cardiff Bay Barrier and it is not absolutely certain that natural reproduction is occurring. The available data suggest that juvenile Atlantic salmon are present throughout the hydrological zone of influence. Data from site T004 in Reach 1 (the upper reaches of Afon Taf Fawr) shows Atlantic salmon parr present in 2001, 2004, 2005, 2008, 2009, 2015 and 2017. Whilst the NRW data notes the records of salmon parr in 2001, 2004, 2005, 2008 and 2009 are of a stocked origin, the presence of 0+ fry recorded at T004 in 2014 and 2015 may represent natural recruitment has occurred in recent years.

Whether the result of stocking or natural spawning, fry and parr densities at site T004 were poor (Grades E) in the few years where Atlantic salmon were recorded. Densities were highly variable (Grades A to F) at site T005a but it is unclear whether this is an artefact of stocking or due to other factors.

The most recent surveys undertaken in Reach 2 recorded Atlantic salmon parr, indicating this reach of the Taff supports the juvenile development of the species. Further downstream in Reach 3, salmon were absent in 2017, however this is the only available survey data for Reach 3. Surveys on the two tributaries which enter the Taff in Reach 3 (Afon Bargoed Taff and the Afon Cynon) by NRW in 2012 (site name T006a[30]) recorded both salmon fry and parr, indicating the adjoining watercourses in Reach 3 may be an important source of habitat for the species.

Monitoring undertaken by HIFI suggests that Atlantic salmon were largely absent from all survey sites in 2010 and low densities of fry were present at most sites in 2011, however, fry presence was considered to be the result of stocking (of fed fry) by Environment Agency Wales[21].

HABSCORE analysis was not undertaken in AMEC (2012)[21] due to the fact that Atlantic salmon were considered 'unable to access the survey reach; those captured were probably stocked fish, thus [the] population [was] unrelated to habitat variables'.

A precautionary principle is used in the following assessment assuming that Atlantic salmon spawning occurs intermittently in the Afon Taff Fawr.

Bullhead

A long-term dataset from NRW site T004 (Reach 1) was made available and bullhead densities for most years between 2003 and 2015 are presented in **Table D2.9**. The data suggest considerable variability in density between years with figures both significantly above and well below the 20/100m^2 target for SAC favourable conservation status in upland streams[31].

[30] NRW site ID: 15340, location NGR: ST0962496581
[31] Cowx, I.G. & Harvey, J.P. (2003). Monitoring the Bullhead, *Cottus gobio*. Conserving Natura 2000 Rivers Monitoring Series No. 4, English Nature, Peterborough.

Table D2.9 Bullhead Densities at NRW Site T004 (Reach 1)

Sample year	Bullhead density (per 100m²)
2003	27.78
2005	48.18
2007	27.78
2008	7.21
2009	10.18
2010	11.36
2012	4.50
2013	11.31
2014	4.62
2015	23.33
2017	Present *(density not recorded)*

*All surveys fully quantitative except 2012 and 2017 (one-run semi-quantitative survey) which may be a factor in a lower density estimate.

No individual length data were made available for NRW surveys, however, high densities of bullhead were recorded at all sites within the hydrological zone of influence by HIFI in 2010 and 2011 with evidence of recruitment (0+ individuals <50 mm) throughout[21] suggesting a self-sustaining, healthy population. Further surveys in 2017 by APEM also recorded both juvenile and adult bullhead throughout Reaches 1 – 3, indicating the species continues to recruit and develop successfully throughout the hydrological zone of influence in recent years.

Brown / Sea Trout

The available data suggest that juvenile brown trout are present throughout the hydrological zone of influence with the species recorded in all monitoring locations and samples. The most recent surveys undertaken by APEM in 2017 recorded both fry and parr life stages, along with adult fish throughout the hydrological zone of influence, indicating recent spawning success and development of fish into the later life stages. Data from monitoring undertaken by HIFI in 2010 and 2011 suggest that brown/sea trout fry (0+) densities were generally poor (mostly Grades D and E) in Reaches 1 and 2 (**Table D2.10**). Data derived from the same HIFI monitoring suggest considerable spatial and temporal variation in parr (>0+) densities (Grades A to E).

Table D2.10 Brown/Sea Trout Fry and Parr Density Estimates (and Equivalent NFC Grades) from HIFI Monitoring in 2010 and 2011

Site Name / River / Reach		2010 Population Density Estimate (Equivalent NFC Grade)		2011 Population Density Estimate (Equivalent NFC Grade)	
		0+	>0+	0+	>0+
Afon Taff Fawr (Reach 1)	New Fawr 1	1.02 (E)	1.06 (E)	2.23 (E)	12.47 (B)
	T003a	0.00 (F)	1.78 (E)	0.00 (F)	1.89 (E)
	T003b	3.13 (D)	3.44 (D)	4.78 (D)	9.55 (C)
	T004	4.22 (D)	6.17 (C)	3.72 (D)	25.08 (A)
	E282	25.48 (B)	18.80 (B)	26.25 (B)	29.53 (A)
Afon Taff (Reach 2)	T005a	6.28 (D)	10.82 (C)	3.28 (D)	8.10 (C)
	E279	2.26 (E)	2.27 (D)	1.61 (E)	1.54 (E)
	T006	3.11 (D)	3.56 (D)	8.61 (C)	5.82 (C)
	T018e	5.40 (D)	16.84 (B)	3.42 (D)	12.14 (B)
	T006a	1.95 (E)	7.85 (C)	1.85 (E)	3.21 (D)

A long-term dataset from NRW site T004 (Reach 1) was made available and brown/sea trout fry and parr densities for most years between 1997 and 2015 are presented in **Table D2.11**. Densities from a less comprehensive dataset for sites T005a (reach 2) have also been provided in **Table D2.11** to provide an indication of likely spatial trends within the hydrological zone of influence. Despite long-term data sets, timed run data only is available for sites T006 and T006a which provides presence/absence rather than density data.

Data provided by NRW for site T004 corroborates both the fact that there is considerable inter-annual variation in juvenile brown/sea trout densities. 0+ fry densities are generally below average (NFC Grades C to E), peaking in 2001-2003 and again in 2015. >0+ densities were above average and greatest in 2001-2005, before decreasing to below average levels in 2012. >0+ densities have increased in recent years, with the 2017 survey recording good densities of fish, indicating recruitment has been successful in the year preceding the latest survey.

Table D2.11 Brown/Sea Trout Fry and Parr Densities and Equivalent NFCS Grades at NRW sites T004 and T005a

Sample year	NRW monitoring site T004		NRW monitoring site T005a	
	0+ density (NFC Grade)	>0+ density (NFC Grade)	0+ density (NFC Grade)	>0+ density (NFC Grade)
1997	0.00 (F)	10.00 (C)	4.17 (D)	1.67 (E)
2000	10.56 (C)	13.89 (B)	18.33 (B)	2.5 (D)
2001	7.78 (D)	20.00 (B)	-	-
2002	5.56 (D)	18.33 (B)	-	-
2003	13.33 (C)	16.67 (B)	-	-
2004	3.05 (D)	15.27 (B)	-	-
2005	4.45 (D)	19.43 (B)	2.50 (E)	0.00 (F)
2006	0.00 (F)	9.31 (C)	15.83 (C)	5.00 (C)
2007	1.11 (E)	13.89 (B)	0.00 (F)	5.00 (C)
2008	0.00 (F)	8.89 (C)	-	-
2009	2.04 (E)	8.14 (C)	-	-
2010	4.22 (D)	6.17 (C)	-	-
2012	2.03 (E)	2.48 (D)	1.67 (E)	1.33 (E)
2013	0.23 (E)	9.73 (C)	-	-
2014	1.23 (E)	3.39 (D)	-	-
2015	8.79 (C)	9.7 (C)	-	-
2017	0.9 (E)	8.3 (B)	-	-

*All surveys fully quantitative except 1997-2001, 2012 & 2017 (one-run semi-quantitative surveys) which may be a factor in a lower density estimate.

The available data therefore suggest that the Afon Taff catchment generally supports fair to poor 0+ brown trout densities and fair to good densities of >0+ brown trout. The slight increase in classification status between juvenile age classes suggests that survival of fish from their first year is good. It is therefore possible that there is a bottleneck in terms of available spawning or parr habitat which subsequently limits recruitment. However, with regard to parr, this was not corroborated in the outputs of HABSCORE analysis in AMEC (2012)[21] at the study sites, which revealed significant variation (both significantly higher and lower than predicted) in terms of habitat utilisation and no clear pattern of high parr densities across sites.

Whilst no data were made available regarding sea trout populations in the Afon Taff catchment, fish trap data described in the NRW catchment summary for the Taff and Ely[32] indicates sea trout stocks are at risk, with spawner estimates decreasing significantly over the 1991-2014 period.

European Eel

The available data suggest that European eel are uncommon within the hydrological zone of influence with few records within the available data. The most recent surveys undertaken in 2017 by APEM recorded post-juvenile life stages in Reach 3 only, indicating limited

[32] Natural Resources Wales. 2015. Know Your Rivers - Salmon and Sea Trout Catchment Summary Rivers Taff and Ely

recruitment over the last year or two.

Other Fish Species

A number of other species of fish were recorded in Reach 3 in 2017, including sub-adult life stages of grayling, perch and minnow. Along with minnow, stone loach were also recorded in Reach 1, whilst stickleback were present in Reach 2. Stone loach were also recorded in relatively high densities at most sites within the hydrological zone of influence in 2010 and 2011. Three-spined stickleback were recorded by HIFI in low densities at two sites only; T006 in 2010 and T018e in 2011. There are no records within the NRW dataset provided. This suggests that the species is present in low densities in isolated areas within the hydrological zone of influence.

Ecological value of fisheries receptors

Atlantic salmon, bullhead (both NERC Act Section 41 and Habitats Directive Annex II species), brown/sea trout (a NERC Act Section 41 species) and European eel (a NERC Act Section 41 species and IUCN Red List 'critically endangered' species) are considered to be of National importance. Grayling, perch, minnow, stone loach and three-spined stickleback are considered to be of local importance only.

D.2.3.2 Assessment

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)[33,34], reduced water quality and reduced reproductive success, growth and condition[35].

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 impact periods; summer/autumn (conservatively taken to include April to November) and winter (December to March).

Reach 1 (Afon Taff Fawr below Llwynon Reservoir) is predicted to undergo a reduction in flow of up to 50% with a drought permit and, whilst mortality under these conditions may be significant, fish species have evolved mechanisms in order to cope with low flow conditions,

[33] 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
[34] 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.
[35] 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.

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, brown trout and bullhead are, nonetheless, susceptible to reduced flows.

Atlantic Salmon

Atlantic Salmon Migration

Reaches 1, 2 and 3 on the Afon Taff are likely to constitute an important migratory pathway for Atlantic salmon (both upstream-migrating adults and out-migrating smolt). Anecdotal evidence suggests that the majority of Atlantic salmon migration into the Afon Taff is likely to occur relatively late (probably from October to December) and therefore a drought permit occurring from September to November has the potential to impact this element of the Atlantic salmon lifecycle. The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature; outside the drought permit implementation period. Periods of increased flow are considered to be a primary cue in initiating Atlantic salmon migration and very low flows are likely to delay migration, thereby increasing mortality due to increased predation and stress. This is of particular importance on the Afon Taff where migrating Atlantic salmon have to negotiate a number of significant weirs where passage efficiency is reduced under low flows. The impact on river flow in Reach 1 has been assessed as being major adverse during September to November and the impact on Atlantic salmon migration is considered to be of high magnitude short-term, temporary and reversible. The impact on river flow in Reach 2 has been assessed as being moderate adverse in September (outside the migration period), and minor from October to November and the impact on Atlantic salmon migration is considered to be of low magnitude short-term, temporary and reversible. The impacts on flow in Reach 3 are assessed as negligible during October and November. Due to potential delays caused by a reduction in flow the impact on Atlantic salmon migration is therefore considered to be **major adverse** in Reach 1 October to November; **minor adverse** in Reach 2 in October and November and Reach 3 in September; and **negligible** in Reach 3 during October and November. .

Water Quality

Potential water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) as a result of a reduction in flow are likely to act in tandem with a reduction in available habitat and delays to migration to increase stress and subsequent loss of condition. Atlantic salmon are susceptible to poor water quality and particularly dissolved oxygen and water temperature. Water quality impacts have been assessed as major adverse in Reach 1 and the impact on Atlantic salmon is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on Atlantic salmon is therefore considered to be **major** adverse in Reach 1, **minor** adverse in Reach 2 and **negligible** in Reach 3 due to a potential reduction in water quality.

Juvenile Atlantic Salmon

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. Due to the likely timing of a drought permit, gravels containing alevins and/or early-stage fry (likely to occur in April and May) are not considered to be affected. The impact is therefore considered to be of high magnitude in Reach 1, short-term, temporary and reversible. The impact on juvenile Atlantic salmon is therefore considered to be **major adverse** in Reach 1 September-November, **moderate adverse** in Reach 2 in September, and **minor adverse** in Reach 2 in October-November and Reach 3 in September, and negligible in Reach 3 October-November.

Bullhead

Bullhead are likely to be 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 will therefore not be affected by reduced flows (and likely reduced water quality) associated with implementation of a drought permit. The species is known to be particularly flow sensitive and reduced flows (and likely reduced water quality) associated with implementation of a drought permit may have a significant impact on bullhead populations. A reduction in flow of up to 50% in Reach 1 is likely to have a significant impact on bullhead populations in particular. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on bullhead is therefore considered to be **major adverse** in Reach 1 September-November, **moderate adverse** in Reach 2 in September and **minor adverse** in Reach 2 in October-November and Reach 3 in September.

Brown / Sea Trout

Sea Trout Migration

Reaches 1, 2 and 3 are likely to constitute an important migratory pathway for sea trout (both upstream-migrating adults and out-migrating smolt). The majority of upstream adult sea trout migration into the Taff catchment is likely to occur from July to November; coinciding with the implementation of a drought permit. Flow increases are a primary cue for adult sea trout migration and the magnitude and duration of periods of increased flow would likely to be reduced as a result of a drought permit. Minimum flows are also required in order for adult sea trout to navigate past barriers to migration such as weirs. This is of particular relevance on the Afon Taff where numerous significant weirs have to be negotiated by migrating sea trout. Very low flows are likely to delay or halt migration, thereby increasing mortality due to increased predation and stress.

The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature, outside the drought permit implementation period.

The impact on river flow in Reach 1 has been assessed as being major and the impact on adult sea trout migration is considered to be of high magnitude, short-term, temporary and reversible. The impact on adult sea trout migration is therefore considered to be **major adverse** in Reach 1, **moderate adverse** in Reach 2 in September, and **minor adverse** in Reach 2 in October-November and Reach 3 in September due to potential delays/increased predation risks caused by a reduction in flow.

Water Quality

Potential water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) as a result of a reduction in flow are likely to act in tandem with a reduction in habitat and delays to migration 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 particularly impact sensitive juvenile lifestages. Water quality impacts have been assessed as major adverse in Reach 1 and the impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on brown/sea trout is therefore considered to be **major adverse** in Reach 1, **minor adverse** in Reach 2 and **negligible** in Reach 3 due to a potential reduction in water quality.

Juvenile Brown / Sea Trout

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. Due to the likely timing of a drought permit, gravels containing alevins and/or early-stage fry (likely to occur in April and May) are not considered to be affected. The impact on juvenile brown/sea trout is therefore considered to be **major adverse** in Reach 1, **moderate adverse** in Reach 2 in September, and **minor adverse** in Reach 2 in October-November and Reach 3 in September.

<u>European Eel</u>

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 there is therefore the potential for a significant impact on the out-migration of mature (silver) European eel. European eel are likely to be present in low densities throughout the catchment but the species is tolerant of high temperatures and relatively poor water quality and is considered relatively resilient to drought conditions. The impacts on European eel are therefore limited to silver eel migration and this is considered to be **moderate adverse** in Reach 1, **minor adverse** in Reach 2 and **negligible** in Reach 3 from September to November. Impacts on other European eel life stages are considered to be **negligible** in all reaches.

Other Fish Species

Grayling, perch, minnow, stone loach and three-spined stickleback spawning and egg incubation occurs in spring and summer; largely outside of the drought permit implementation period. However, the sensitive life-stages of these species are susceptible to impacts associated with low flows and water quality deterioration during the drought permit implementation period. Grayling constitute an important angling resource in the lower reaches of the hydrologically impacted zone of influence, with the species recorded in 2017 in Reach 3 only. The impact on grayling is therefore considered to be **negligible** in Reach 1 and 2, and **minor adverse** in Reach 3. The impact on other fish species (not including grayling) is considered to be **major adverse** in Reach 1, **moderate adverse** in Reach 2, and **minor adverse** in Reach 3 in September.

Summary

The potential impacts of the Llwynnon Reservoir drought permit on the fish community are summarised in **Table D2.12**. 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 D2.12** represent the worst case impacts of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

Table D2.12 Summary of Impacts on Fish Community

Feature	Impact	Significance of Impact
Reach 1 – Taf Fawr (Llwynon Reservoir outflow to the confluence with Taf Fechan)		
Atlantic salmon	• Delays and potential cessation of migration due to reduced flows.	**Major**
	• Reduced water quality.	**Major**
	• Loss of spawning and juvenile habitat as a result of reduced river levels.	**Major**
Bullhead	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
Brown/sea trout	• Delays and potential cessation of migration due to reduced flows.	**Major**
	• Reduced water quality	**Major**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Moderate**
Other fish species - Grayling	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Other fish species (not inc. grayling)		**Major**
Reach 2 – River Taff (confluence with Taf Fechan to the confluence with Afon Taf Bargoed		
Atlantic salmon	• Delays and potential cessation of migration due to reduced flows.	**Minor**
	• Reduced water quality.	**Minor**
	• Loss of spawning and juvenile habitat as a result of reduced river levels.	**Moderate** (September only)
Bullhead	• Reduction in spawning and juvenile survival due to habitat loss.	**Moderate** (September only)
Brown/sea trout	• Delays and potential cessation of migration due to reduced flows.	**Moderate**
	• Reduced water quality	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Moderate** (September only)
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Minor**
Other fish species - Grayling	• Reduction in spawning and juvenile survival due to habitat loss.	**Negligible**
Other fish species (not inc. grayling)		**Moderate**
Reach 3 – River Taff (confluence with Afon Taf Bargoed to the confluence with Afon Cynon)		
Atlantic salmon	• Delays and potential cessation of migration due to reduced flows.	**Negligible**
	Reduced water quality.	**Negligible**
	• Loss of spawning and juvenile habitat as a result of reduced river levels.	**Minor** (September only)
Bullhead	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor** (September only)
Brown/sea trout	• Delays and potential cessation of migration due to reduced flows.	**Minor**
	• Reduced water quality	**Negligible**
	• 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.	**Negligible**
Other fish species - Grayling	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor** (September only)
Other fish species (not inc. grayling)		

There is a risk of short-term deterioration in status / potential of the fish component of the Afon Taf Fawr - source to conf Taf Fechan (GB109057033170) waterbody associated with Reach 1, and the R Taff - conf Taf Fechan to conf R Cynon (GB109057033100) waterbody

associated with Reach 2 and 3 due to the potential implementation of the drought permit. Impacts of drought permit implementation on the fish communities associated with Reach 1 have been summarised as moderate to major adverse, short-term, temporary and reversible. Consequently, the fish component of the Afon Taf Fawr - source to conf Taf Fechan (GB109057033170) waterbody is considered to be at **major risk** of short-term deterioration. Impacts of drought permit implementation on the fish communities associated with Reach 2 and 3 have been summarised as negligible to moderate adverse, short-term, temporary and reversible. The R Taff - conf Taf Fechan to conf R Cynon (GB109057033100) waterbody is considered to be at **minor risk** of short-term deterioration.

D.2.4 Phytobenthos

D.2.4.1 Baseline

Phytobenthos data were provided by NRW for two sites located within the study area: D/S Llwynon Wtw and U/S Taf Fechan, both within Reach 1 on the Afon Taf Fawr (see **Figure D1.1**). Monitoring was undertaken during spring and autumn during 2013 and 2014. No monitoring data were available for Reach 2 and Reach 3.

Considering the temporal constraints on the baseline information, care must be taken in their interpretation.

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 D2.12**

Table D2.12 DARLEQ Metrics for Phytobenthos Data from the Afon Taf Fawr

Site	Date	TDI3	TDI4	% Motile	% Organic tolerant
D/S Llwynon Wtw	16/04/2013	34.72	-	18	12
	26/09/2013	36.41	-	4	2
	14/04/2014	34.8	36.43	6	4
	16/09/2014	30.22	30.14	3	2
U/S Taf Fechan	25/04/2013	36.09	-	15	10
	12/09/2013	60.36	-	3	2
	14/04/2014	40.75	44.24	1	1
	16/09/2014	56.95	54.91	2	2

Phytobenthos communities at both sites were relatively diverse, with similar taxa present, generally typical of upland, relatively high velocity rivers without significant acidification. Samples from the site downstream of Llwynon water treatment works showed a community dominated by *Achnanthidium minutissimum*, a species common and often abundant in upland streams with mobile substrates. This species is also relatively tolerant to high metal concentrations. Species typical of the mid reaches of upland rivers, such as *Remeria sinuata* and *Gomphonema* species were more prevalent within the samples from the site upstream of the Taf Fechan, with a relatively high abundance of *Rhoicosphenia abbreviata* at this site in

autumn 2013 suggesting that relatively high levels of filamentous algae may have been present at the time of sampling.

TDI3 and TDI4 scores suggest relatively low nutrient levels downstream of Llwynon WTW, suggesting oligo-mesotrophic conditions, with higher scores at the site upstream of the Taf Fechan confluence suggesting mesotrophic – eutrophic conditions. Relatively low proportions of phytobenthos tolerant of organic pollution suggests that organic enrichment is relatively low and other sources of phosphate such as diffuse pollution may account for the relatively high TDI scores.

D.2.4.2 Assessment

Impacts on the phytobenthos assemblages of the Afon Taf Fawr and River Taff within Reaches 1, 2 and 3 could occur due to the operation of the drought permit, 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 permit would be expected.

WFD EQR metrics for phytobenthos (TDI4 in DARLEQ)[36] are designed to detect differences in nutrient levels, particularly SRP. Implementation of the drought permit in Reaches 1, 2 and 3 is expected to result in moderate / minor impacts to soluble reactive phosphorous, which in turn may affect the phytobenthos community and associated WFD status. Impacts on the phytobenthos community are likely to be **minor** in Reaches 1 and 2 and **negligible** in Reach 3.

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 Llwynon Reservoir compensation flow drought permit on the phytobenthos community are summarised in **Table D2.13**. 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 phytobenthos community. The impacts presented in **Table D2.13** represent the worst case impacts of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

36 WFD-UKTAG (2014) Phytobenthos: Phytobenthoss for Assessing River and Lake Ecological Quality (River DARLEQ2)

Table D2.13 Summary of Impacts on Phytobenthos Community

Feature	Impact	Significance of Impact
Phytobenthos	• Decrease in flow affecting phytobenthos community composition • Minor increase in SRP affecting phytobenthos community composition and TDI score	Minor

There is a risk of short-term deterioration in status of the WFD phytobenthos component of the Taf Fawr - source to conf Taf Fechan (GB109057033170) and R Taff - conf Taf Fechan to conf R Cynon (GB109057033100) waterbodies due to the drought permit. Impacts of drought permit implementation on the phytobenthos communities of the impacted reaches have been summarised as minor adverse, short-term, temporary and reversible. Consequently, the phytobenthos component of these waterbodies is considered to be at **minor** risk of short term deterioration.

D3 LANDSCAPE AND RECREATION

D.3.1 Landscape

D.3.1.1 Baseline

Llwynon Reservoir and part of the Taf Fawr are located within Brecon Beacons National Park and are surrounded by wooded valleys. The overall landscape and visual amenity of this area is varied and appealing and as a result, tourism is economically very important. Footpaths run along the valley sides through conifer plantations some distance from Taf Fawr, and along the west bank of Llwynon Reservoir. Downstream of the confluence with the Taf Fechan in Merthyr Tydfil, the study area is characterised by urban and industrial development. The Taff trail runs adjacent to the River Taff from Merthyr Tydfil to Cardiff. A national cycle route also follows the River Taff from Merthyr Tydfil.

D.3.1.2 Assessment

A review of the hydrological implications of implementing a drought permit has identified major / moderate / minor hydrological impacts in Reaches 1 and 2 on the Taf Fawr and River Taff. The impacts include a significant reduction in surface water baseflow, wetted width and wetted depth below those observed in surface watercourses within the area of influence without the drought permit. Therefore landscape and visual amenity impacts may be visible from public rights of way, footpaths, cycle routes and river crossings. However the impact on flows will only be temporary and will be ameliorated once the drought has passed. Flows during drought conditions will naturally be low therefore the implementation of the drought permit is not expected to lead to any material additional landscape and visual amenity impacts and are assessed as **negligible**.

D.3.2 Recreation

D.3.2.1 Baseline

Llwynon Reservoir and the majority of the Taf Fawr are located within Brecon Beacons National Park which presents year-round attractions for hiking, cycling, canoeing, fishing and birdwatching. The Taff trail and a national cycle route links the more populated part of the study area to the reservoirs, the Taf Fechan and Brecon Beacons National Park.

D.3.2.2 Assessment

Major / moderate hydrological impacts have been identified in Reaches 1 and 2 on the Taf Fawr. Any reduction in wetted width and depth may influence water-dependent activities such as angling and canoeing. However, water levels will already be naturally low in times of drought and will already have curtailed these recreational activities prior to the drought permit implementation. Any impacts will be temporary in nature and will be ameliorated once the drought has passed. Impacts are therefore assessed as **negligible** for Reaches 1 and 2. The drought permit has been assessed as having minor / negligible impacts on Reach 3 in the River Taff, and no impacts on recreational activities are anticipated.

D4 CUMULATIVE ASSESSMENT

This section describes and assesses the potential cumulative impacts on the sensitive features during the period of implementation of both the Llwynon drought permit and Pontsticill drought permit (8119-1). Full details of impacts and detailed baseline information of the impacted reaches, can be found in Section D2.

Reach 1 has no cumulative impacts with the Pontsticill drought permit as it is above the confluence with the Taf Fawr, therefore, no additional effects are expected above those described in Section D2 and it is not considered further in the cumulative impact assessment.

Macrophytes

Baseline

The baseline macrophyte data is described in Section D2.1.1 for impacted Reaches 2 and 3. No Baseline data is available from NRW for the additional cumulative Reach 4. Given the location and habitats present, the macrophyte community in Reach 4 is considered to be similar to those in Reach 3 and susceptible to the same environmental pressures.

Assessment

Impacts on the macrophyte communities present will be through the same pathways as described in Section D.2.1, but due to increased hydrological impacts will be of greater magnitude.

Cumulative hydrological impacts on Reach 2 are expected to be major during the period

September to November with a reduction of 48% of year round Q_{50} and Q_{95}. The impacts on the macrophyte community of this reach will be as described in Section D2.1.2 but with a greater impact magnitude due to increased hydrological impacts. This will result in increased risk of changes to community composition due to reduced flow rates and habitat loss due to reduction in wetted width. In addition to a risk of increased occurrence of filamentous algae due to reduced flow, rate, increased temperature, and water quality deterioration. Impacts in Reach 2 are considered to be **minor** adverse during September only.

Cumulative hydrological impacts on Reach 3 are expected to be moderate in September, with a reduction in summer low and extreme low flows (Q95 and Q99) of 16% and 21% respectively. The in combination effects with the Pontsticill drought permit will result in increased magnitude of impacts relating to reduction in growth and distribution of sensitive species, and changes to community composition due to reduction in habitat availability and suitability. Consequently, impacts on the macrophyte community of this reach are therefore considered to be **minor**, adverse, short term and reversible during September only.

Cumulative hydrological impacts on Reach 4 are expected to be minor year round with negligible risk of water quality deterioration. As the macrophyte community is likely to be similar to what is present in Reach 3 the community will be subject to the impacts described in Section D2.1.2. Therefore, impacts in Reach 4 are considered to be **negligible**.

Macroinvertebrates

Baseline

The baseline macroinvertebrate data is described in Section D2.2.2 for impacted Reaches 2 and 3. No baseline data is available from NRW for the additional cumulative Reach 4. Given the location and habitats present the macroinvertebrate communities in Reach 4 are considered to be similar to those in Reach 3 and sensitive to the same environmental pressures.

Assessment

Impacts on the macroinvertebrate communities present will be through the same pathways as described in **Appendix D**, but due to increased hydrological impacts will be of greater magnitude.

Cumulative hydrological impacts on Reach 2 are expected to be major (year round) with a reduction of 48% of year round Q_{50} and Q_{95}. The impacts on the macroinvertebrate community of this reach will be as described in Section D2.1.2 but with a greater impact magnitude due to increased hydrological impacts. This will result in increased risk of changes to community composition from loss of flow sensitive species due to reduced flow rates, and habitat loss due to reduction in wetted width. There are also increased impacts relating to a higher risk of water quality deterioration which has been assessed as high for dissolved oxygen and medium for ammonia. This is likely to results in a further reduction in abundance and distribution of

sensitive species. Consequently, impacts in Reach 2 are considered to be **minor** adverse, short term, and reversible.

Cumulative hydrological impacts on Reach 3 are expected to be moderate in September, with a reduction in summer low and extreme low flows (Q95 and Q99) of 16% and 21% respectively. The in combination effects with the Pontsticill drought permit will result in increased magnitude of impacts relating to reduction in abundance and distribution of sensitive species, and changes to community composition due to a minor reduction in habitat availability and suitability. The risk of water quality deterioration is considered to be negligible as a result no additional impacts to macroinvertebrates are anticipated. Cumulative impacts on the macroinvertebrate community of Reach 3 are considered to be **minor**, adverse, short term and reversible during September only.

Cumulative hydrological impacts on Reach 4 are expected to be minor year round with negligible risk of water quality deterioration. As the macroinvertebrate community is likely to be similar to Reach 3 the community will be subject to the same impacts described in Section D2.1.2. Therefore, impacts in Reach 4 are considered to be **negligible**.

Fish

Baseline

The baseline fish monitoring data is described in Section D2.3.1 for impacted Reaches 2 and 3. No baseline data is available from NRW for the additional cumulative Reach 4. Given the location and habitats present, the fish communities in Reach 4 are considered to be similar to those in Reach 3 and sensitive to the same environmental pressures. Whilst the Afon Cynon is not part of the hydrologically impacted zone of influence, the major tributary joins the River Taff at the upstream end of Reach 4, with surveys in 2008[37] and 2012[38] containing both fry and parr life stages of Atlantic salmon and brown/sea trout. This highlights the potential for the Afon Cynon to support juvenile salmonid recruitment and the importance of maintaining passage in cumulative Reach 4.

Assessment

Impacts on fish populations present mirror those described in Section D2.3.2, but, due to increased hydrological impacts, will be of increased magnitude. The combination of the two drought permits effectively increases the length of river subject to significant (major) impacts on fish from Reach 1 only (approximately 4km) to Reaches 1 and 2 (approximately 15km) under cumulative hydrological impacts.

Cumulative hydrological impacts on Reach 2 are expected to be major throughout the drought permit implementation period (September to November) with a reduction of 48% of year-round Q_{50} and Q_{95}. The impacts on the fish assemblage of this reach would be as described in

[37] NRW survey site ID: 15287, site name: T018c
[38] NRW survey site ID: 15198, site name: T011

Section D2.1.2 but with a greater impact magnitude due to increased hydrological impacts. This will result in increased risk of changes to community composition and the loss of flow and water quality-sensitive species such as Atlantic salmon, brown/sea trout and bullhead due to reduced flow rates and habitat loss due to reduction in wetted width. Consequently, impacts on Atlantic salmon, brown/sea trout and bullhead in cumulative Reach 2 are considered to be **major adverse**. When considered in combination with major impacts in Reach 1, the length of river subject to major impacts means that the ability of the Taff catchment to recover may be affected as natural recolonisation is likely to be compromised. There may also be a significant impact on the population integrity of the historically heavily pressured and recovering Atlantic salmon and sea trout populations. Impacts may therefore be long-term and irreversible.

In-combination impacts on other fish species are also considered **major adverse** in cumulative Reach 2. The in-combination effects on silver eel migration are considered to be **moderate adverse** in cumulative Reach 2.

Cumulative hydrological impacts on Reach 3 are expected to be moderate in summer, with a reduction in summer low and extreme low flows (Q_{95} and Q_{99}) of 16% and 21% respectively. Hydrological impacts in winter have been assessed as minor with reductions of the Q_{50} and Q_{95} by 6% and 15% respectively. The in-combination effects with the Pontsticill drought permit therefore exceed those of the Llwynon Reservoir drought permit in isolation. Whilst the magnitude of impacts would increase in-combination, the nature of those impacts remains in line with those presented in Section D2.3.2. Cumulative impacts on Atlantic salmon, brown/sea trout and bullhead in cumulative Reach 3 are therefore considered to be **moderate adverse**, short term and reversible.

In-combination impacts on other fish species are also considered **moderate adverse** in cumulative Reach 3. The in-combination effects on silver eel migration are considered to be **minor adverse** in cumulative Reach 3.

Cumulative hydrological impacts on Reach 4 are expected to be minor year round with negligible risk of water quality deterioration. The fish assemblage is assumed to be similar to Reach 3 with potential impacts mirroring those set out in Section D2.3.2. Cumulative impacts on the fish assemblage in Reach 4 are therefore considered to be **minor adverse**, short term and reversible.

Phytobenthos

Baseline

The baseline fish monitoring data is described in Section D2.2.3 for impacted Reaches 2 and 3. No Baseline data is available from NRW for the additional cumulative Reach 4. Given the location and habitats present the fish communities in Reach 4 are considered to be similar to those in Reach 3 and sensitive to the same environmental pressures.

Assessment

Impacts on the phytobenthic assemblages of the Taf Fawr and River Taff within Reaches 2 could occur due to the cumulative impacts of operation of the both the Llwynon and Pontsticill drought permits, 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 permit would be expected.

WFD EQR metrics for phytobenthos (TDI4 in DARLEQ)[39] are designed to detect differences in nutrient levels, particularly SRP. Implementation of the drought permit in Reach 2 is expected to result in moderate/minor impacts to soluble reactive phosphorous, which in turn may affect the phytobenthos community and associated WFD status. Impacts on the phytobenthos community are likely to be **minor** in Reach 2 and **negligible** in Reaches 3 and 4.

Due to the rapid response of phytobenthic communities to environmental variables, this effect is expected to be short lived, with communities recovering rapidly following return to the normal hydrological regime.

Landscape, Heritage and Recreation

Cumulative hydrological impacts to the River Taff are not considered likely to significantly increase the impacts to landscape and recreation described in Section D4. Therefore, impacts to landscape, heritage and recreation as a result of implementation of the drought permit is considered to be **negligible** in Reaches 2, 3, and 4.

[39] WFD-UKTAG (2014) Phytobenthos: Phytobenthos for Assessing River and Lake Ecological Quality (River DARLEQ2)