

Revised draft

Drought Plan 2020:

Annex 1r –

Pembrokeshire WRZ

November 2019

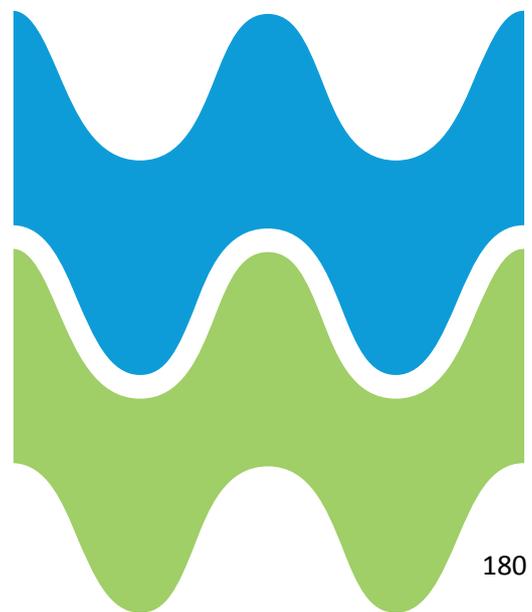


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1. Pembrokeshire (CUS) – WRZ Reference no. 8206

1.1. Pembrokeshire Water Resources Overview

The Pembrokeshire WRZ covers the far south west corner of Wales, stretching from Pendine Sands in the east, to the Pembrokeshire Coastal National Park in the west, and from the villages of Manorbier in the south to Newport in the north (see Figure 1).

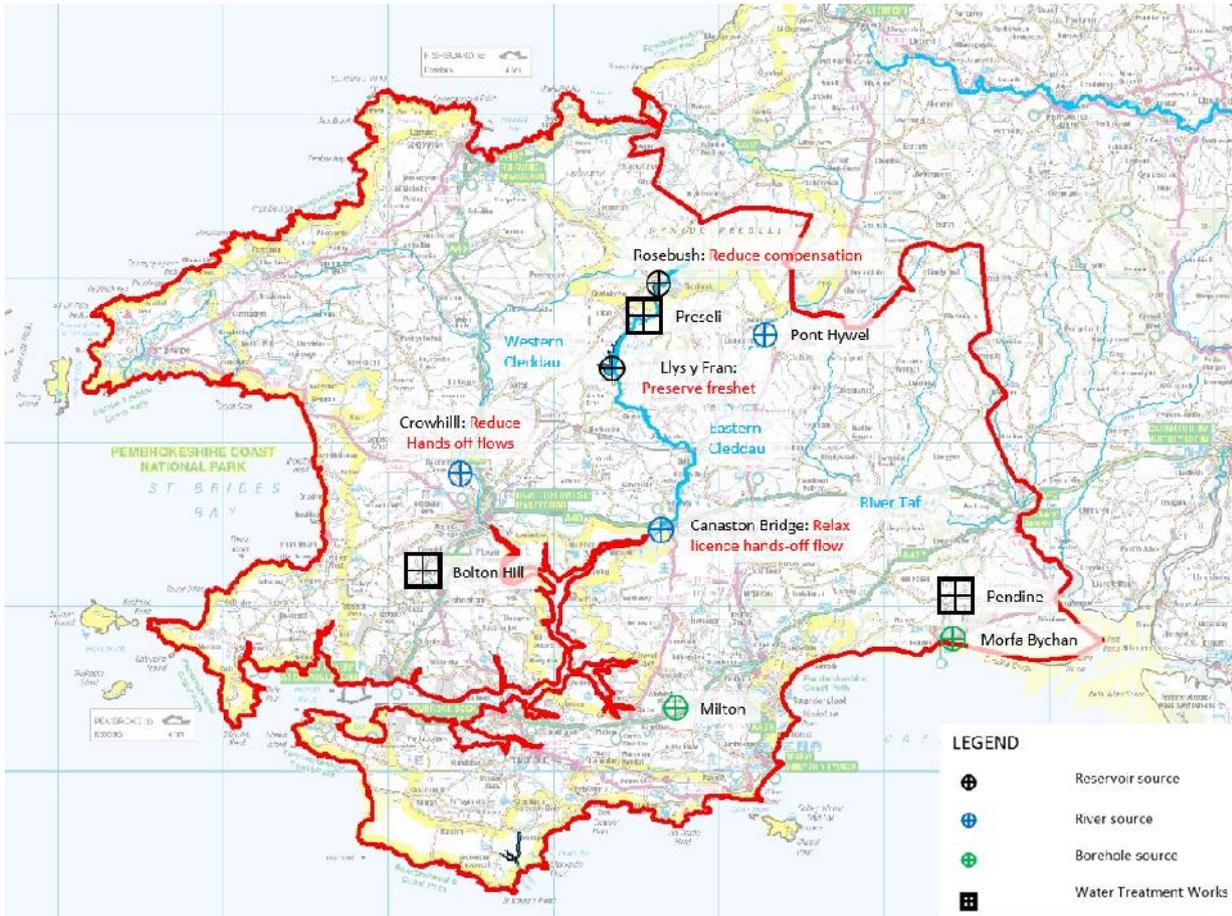


Figure 1 - Map of the Pembrokeshire WRZ

As listed in Table 1, the water resources within the zone consist of two impounding reservoirs (Rosebush and Llysyfran), three river abstractions (Crowhill, Canaston, and Pont Hywel), one borehole (Morfa Bychan), and one spring (Valley Court). Bolton Hill treatment works is supplied by Canaston Bridge Raw Water Pumping Station (RWPS) on the Eastern Cleddau and Crowhill RWPS on the Western Cleddau. In addition to treated water for domestic customers, the Canaston Bridge – Crowhill - Bolton Hill arrangement supplies untreated water to the oil refineries south and north of Milford Haven.

As river flows decline on the Eastern Cleddau, our abstraction at Canaston Bridge is supported by releases of water from Llysyfran Reservoir, an action which is undertaken more frequently following changes made to the terms of our abstraction licence. Tighter environmental standards have also taken effect at our Crowhill abstraction, the consequences of which are that we have to abstract more at Canaston Bridge which in turn means we have to regulate more from Llysyfran.

Site Name	Licence No.	Source Type	Status
Preseli Reservoir	22/61/04/0001	Impounding Reservoir	Operational
Llys-Y-Fran Reservoir	22/61/04/0038	Impounding Reservoir	Operational
Western Cleddau at Crowhill	22/61/03/0001	River Intake	Operational
Eastern Cleddau at Canaston	22/61/04/0010	Regulated River Intake	Operational
Pont Hywel Intake	22/61/04/0003	River Intake	Operational
Pendine Borehole	Licence Exempt	Groundwater Abstraction	Operational
Valley Court	WA/061/0004/0006	Spring chamber	Operational
Milton Boreholes	Licence Exempt	Groundwater Abstraction	Mothballed

Table 1 - Licensed sources in the Pembrokeshire WRZ

The other treatment works in the zone is Preseli, which is supplied from Rosebush reservoir. If storage in Rosebush is low, Preseli works can be supported with water pumped from Llysyfran whilst Rosebush can be supported with water from a river intake on the Eastern Cleddau at Pont Hywel. This supply from this source is limited due to recent restrictions placed upon the abstraction licence in order to leave more water in the environment.

Pendine borehole supplies the eastern part of the WRZ with support able to be provided from the Bolton Hill system.

The sources are operated conjunctively to make best use of the available water during years of average and below average rainfall.

There are no imports of water into nor exports of water from the zone.

1.2.Drought Triggers

The drought status of the zone is assessed by the reservoir storage position at any time in relation to the Drought Action Zones (DAZs), defined for Llysyfran and Rosebush as shown in Figure 2 and Figure 3 respectively. Given the changes detailed above to our abstraction licences, the storage position of Llysyfran reservoir becomes the critical determinant of drought status. The use of the DAZs are described in more detail in Chapter 2 of the main report. Figures 2 and 3 also show the drawdowns we experienced in 2018.

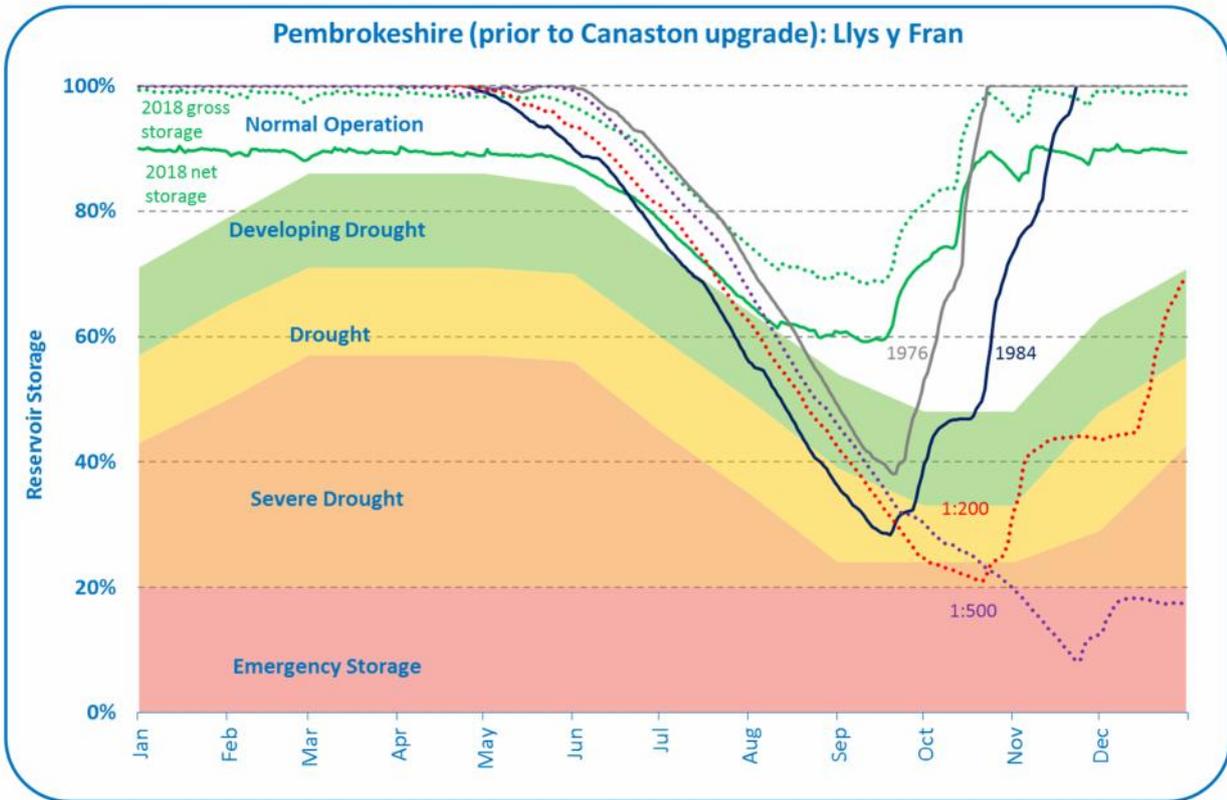


Figure 2 - Llys y Fran Drought Action Zone and results of scenario testing without Canaston upgrade

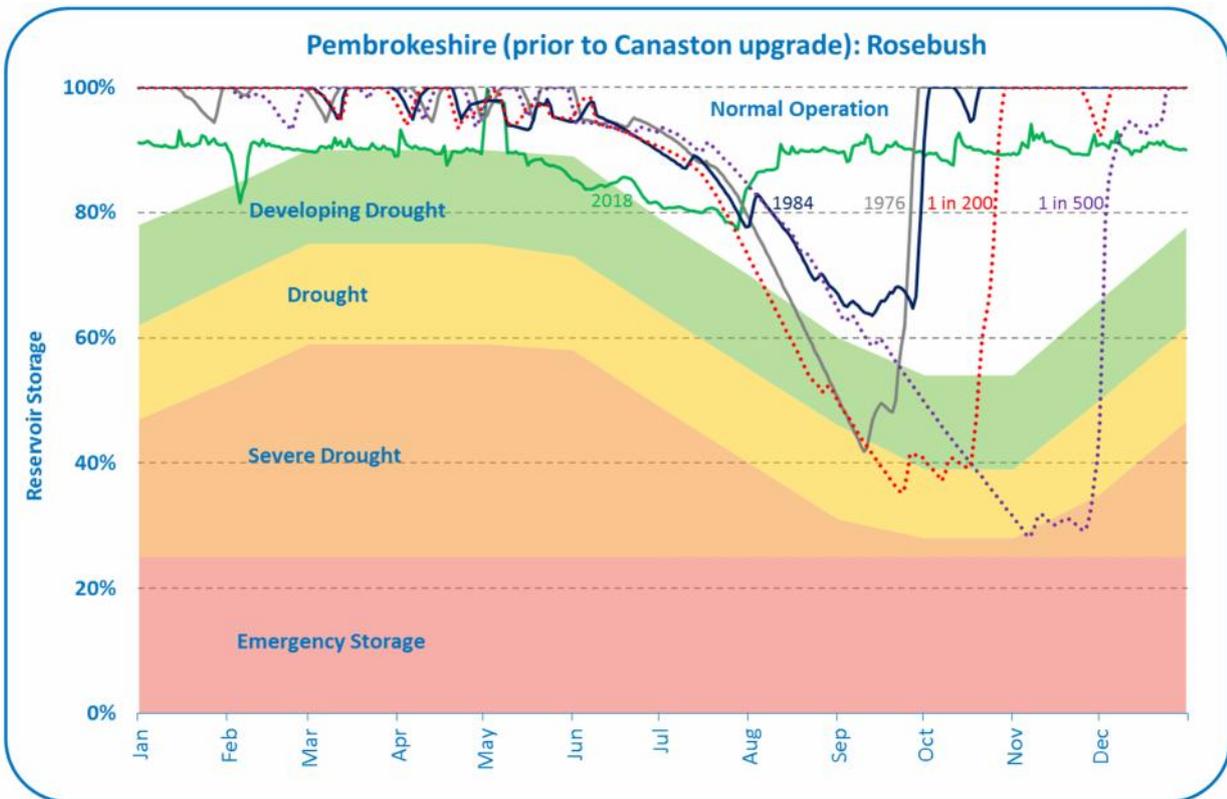


Figure 3 - Rosebush Drought Action Zone and results of scenario testing without Canaston upgrade

1.3. Assessment of Drought Risk

1.3.1. Scenario Testing

Drought risk for the zone has been undertaken through assessment of the storage position in Llysyfran and Rosebush reservoirs against the DCLs we have defined for each, as shown in **Figure 2** and **Figure 3**. The baseline flow record used for our deployable output scenario testing covers the period 1958 – 2015 and so encompasses the known drought events of 1976, 1984, 1989 and 1995.

Figure 2 shows the expected performance of Llysyfran reservoir storage (prior to a planned scheme to upgrade Canaston Bridge) in the most severe events in our historic record against examples of more extreme droughts taken from the stochastically generated record. The plots show that in a 1984 type event, which for West Wales was slightly drier than the conditions experienced in 1976, we would need to implement temporary use bans to help preserve resource. The testing also shows that in events of an approximate 1:200 year return period drought or beyond we will cross into the Severe Drought action zone may cross into the Emergency Storage action zone.

Figure 4 compares the performance of Llysyfran reservoir storage (with the upgrade of Canaston Bridge in place) with the same events as **Figure 2**: 1976 and 1984 from our historic record and examples of more extreme droughts taken from the stochastic record. The plots show that the resilience of the zone is much improved by the upgrade in place; temporary use bans will not need to be implemented in a 1984 type event and even extreme drought events of an approximate 1:500 year return period drought (i.e. a drought that has a 0.2% chance of occurring in any year) will not necessarily result in the imposition of widespread pressure management and local water rationing on our customers.

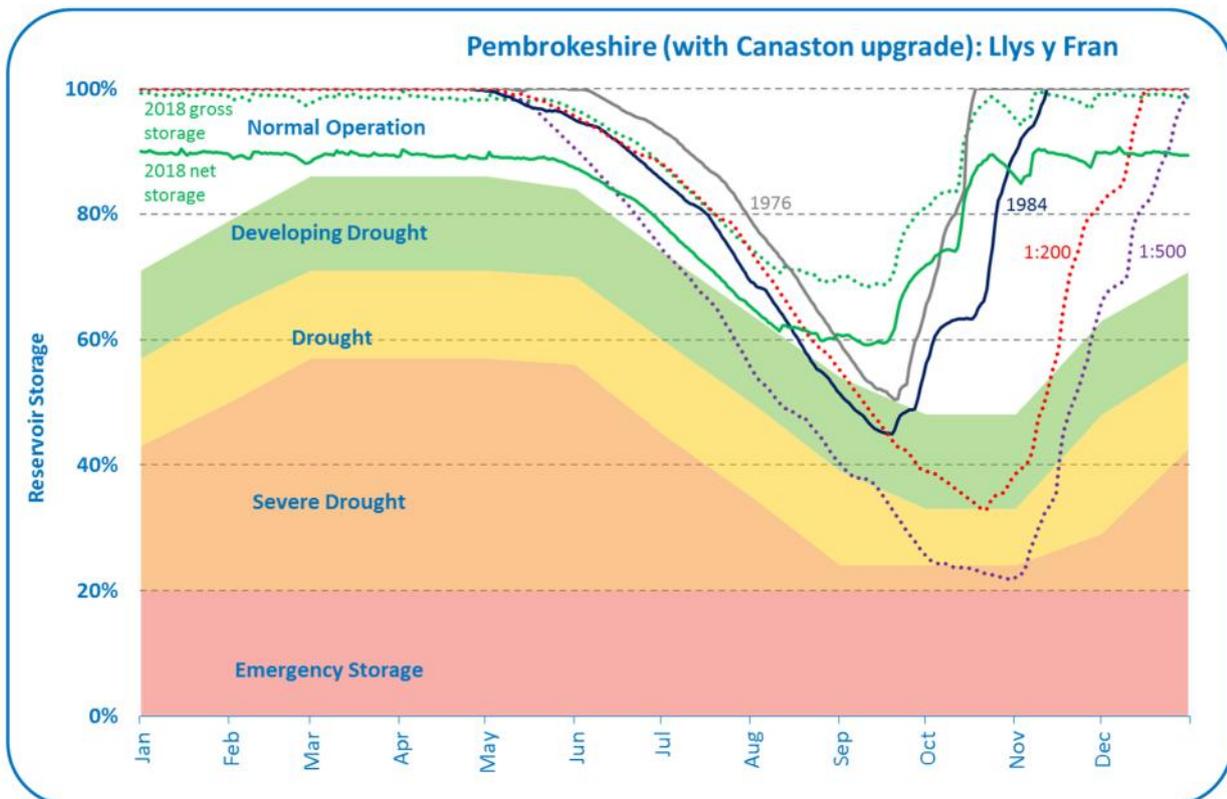


Figure 4 - Llys y Fran Reservoir Drought Action Zones showing the results of scenario testing with Canaston upgrade

We aim to have delivered the required upgrades to our Canaston Bridge pumping station by 2022/23. In the interim, robust measures are therefore required to mitigate against the risk of a severe drought in the period prior to its completion. For this Drought Plan we have therefore retained a number of supply side options that would require application to Welsh Government and Natural Resources Wales for Drought Orders to allow us to take additional water from the environment. Full details of these are set out in Section 0. Once the Canaston Bridge upgrade scheme has been delivered, it will be prudent to consider whether the suite of options retained for preserving resource in severe drought conditions can be rationalised, and unnecessary schemes removed from consideration.

To minimise the risk of needing extreme supply side measures during these severe drought events, we need to ensure careful management of our water resources as reservoir storages may fall to levels that have not been experienced before. How we will achieve this is set out in Section 1.4 below.

1.3.2. Drought Response Surface

As application of the Drought Vulnerability Framework screening methodology indicated the Water Resource Zone was deemed to be of a high drought risk, advanced statistical techniques were used to generate more extreme drought events to test our systems against. The generation of a stochastic set of reservoir inflows for Llysyfran and Rosebush followed the DVF method 1a, whereby long-length time series of inflows are produced using novel weather generation techniques.

From these new time series (c 10,000 years in length) sampling of the record was undertaken to produce 'Drought Libraries' of 500 years' worth of 6, 12, 18, 24 and 48 month drought events, of varying return periods between 1:50 and 1:5000.

The Drought Libraries were then run through our WRAPSim water resource model, which outputted time series data of reservoir stocks to produce the Drought Response Surfaces. River flows were also outputted from the WRAPSim models, for examining the value of Drought Actions and Drought Permits. Full details of the approach taken in Pembrokeshire are given in Appendix 1.

To understand the current drought risk facing the zone, and to further assess the benefit of the preferred water resource scheme to upgrade the pumps at Canaston Bridge in terms of reducing/removing this risk, we have produced Drought Response Surfaces for the zone with and without the upgrade in place.

The Drought Response Surfaces in Figure 5 and Figure 6 shows that the zone is broadly vulnerable to droughts of a 1:100 return period (ie a drought with a 1% chance of occurring in any given year) or more severe. Our Emergency Storage provision is forecast to be breached once six month rainfall deficits of 50% or more of the long term average are experienced.

Furthermore, the Drought Response Surface reveals that the risk of entering emergency storage is significantly greater for droughts that end in October. This contrast is greatest for six month droughts, where events ending in September are unlikely to spend more than a week in emergency storage, whereas droughts of the same duration ending in October could potentially remain in emergency storage for a month. We would usually expect Llysyfran and Rosebush to start refilling in October; the Drought Response Surface therefore demonstrates the vulnerability of the zone to droughts which extend into the refill period.

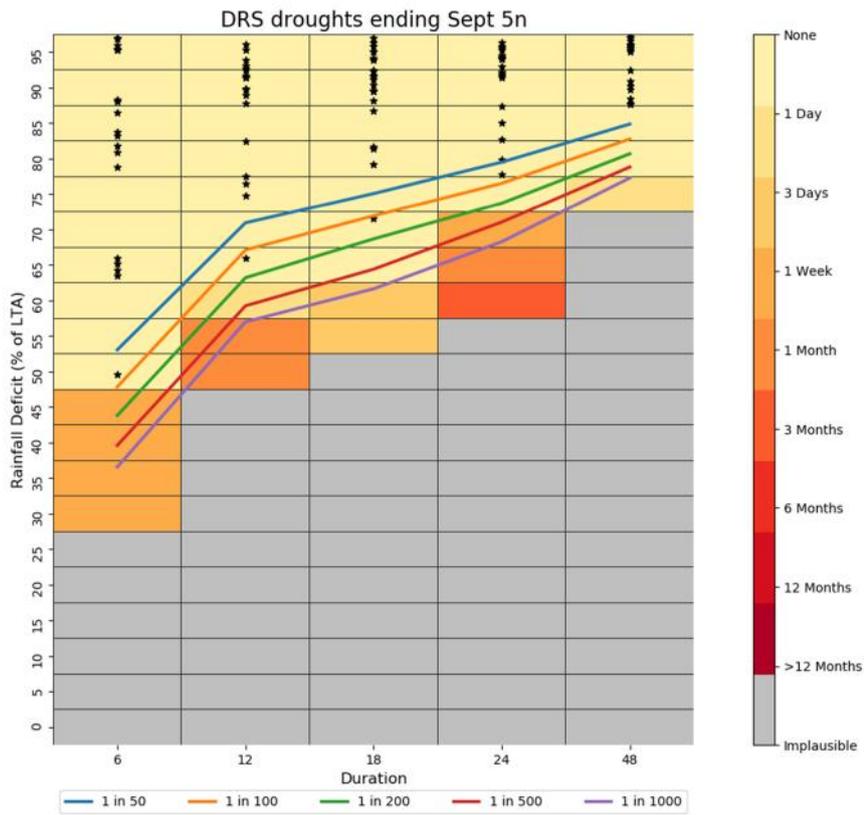


Figure 5 - DRS Pembrokeshire for droughts ending September without WRMP19 scheme

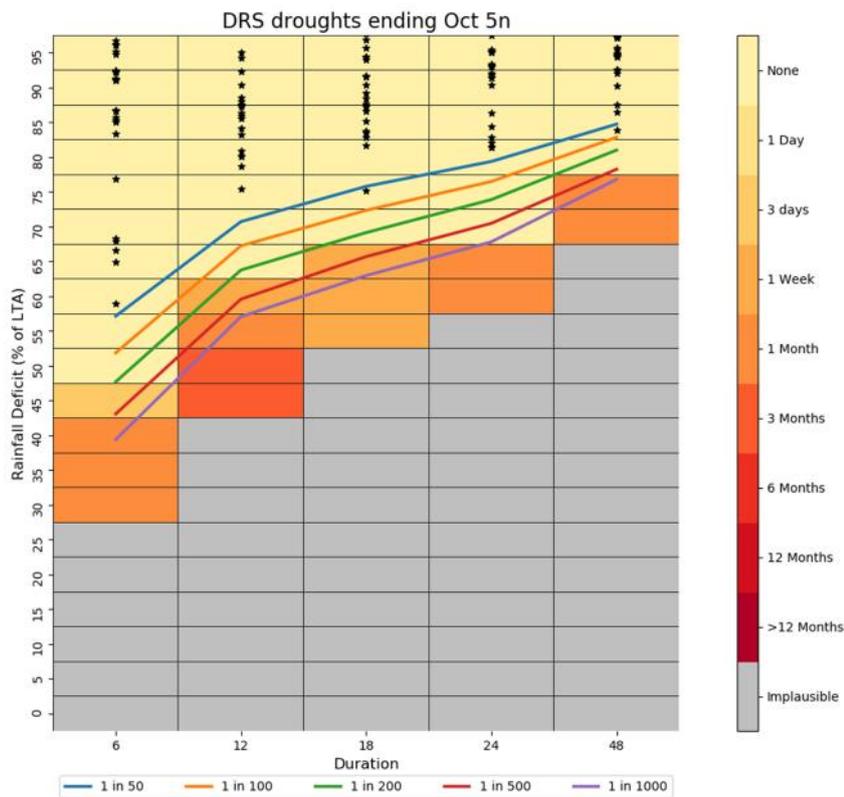


Figure 6 - DRS Pembrokeshire for droughts ending October without WRMP19 scheme

Figure 7 shows the Drought Response Surface of the zone with our WRMP19 scheme to upgrade Canaston Bridge pumping station in place. The benefit to zonal drought resilience is immediately obvious, as it would take an event of a severity greater than 1:1000 before there is a risk of interruption to customer supplies resulting from insufficient raw water resource.

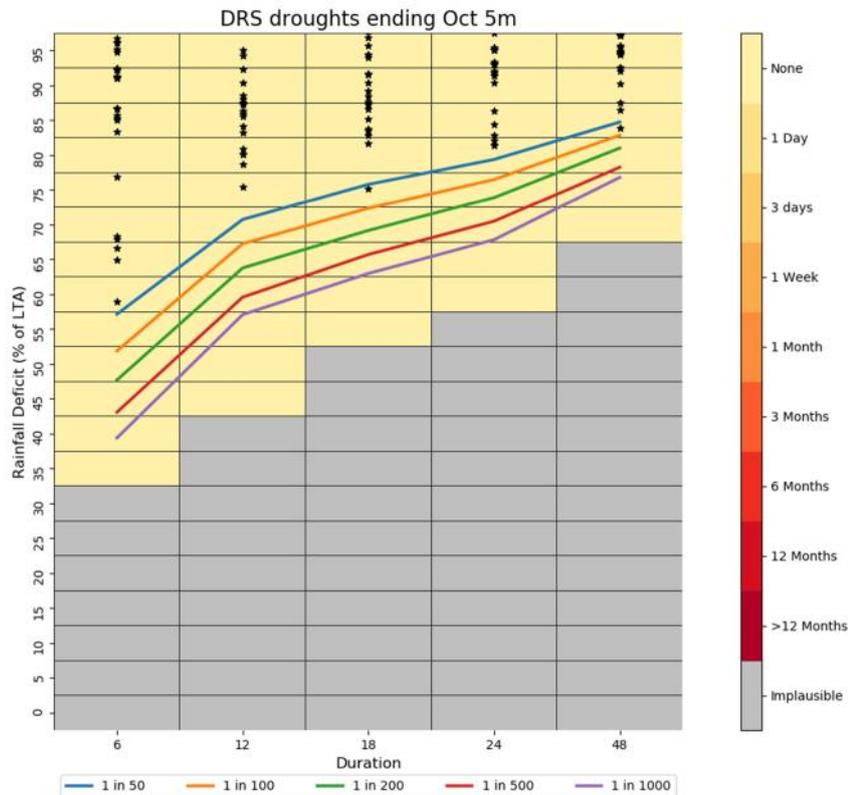


Figure 7 - DRS Pembrokeshire for droughts ending October with the WRMP19 scheme in place

Figure 8 shows the Drought Response Surface of the zone under a climate change scenario with our WRMP19 scheme to upgrade Canaston Bridge pumping station in place. It can be seen that the scheme provides continued resilience to the severe droughts that may become more frequent under climate change and that the minimal residual vulnerability is to prolonged, multi year periods of below average rainfall.

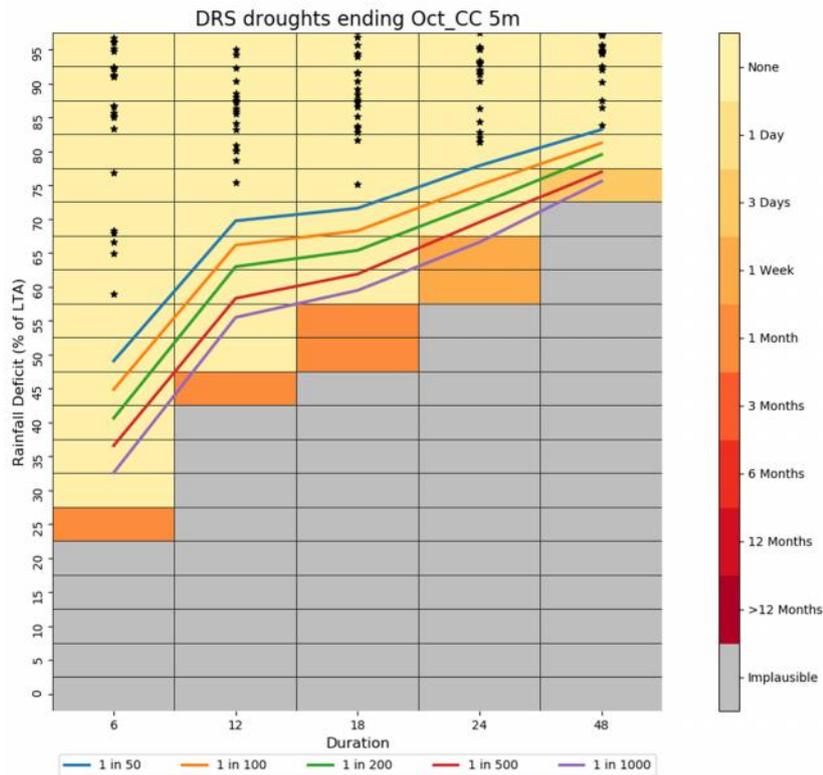


Figure 8 - DRS Pembrokeshire for droughts ending October under a climate change scenario with the WRMP19 scheme in place

1.4. Drought Management of the WRZ

As the current zonal resilience does not meet the 1:200 year target then our water resource management philosophy is to be precautionary in nature and ensure we operate our water resources conservatively with respect to our control curves. Preparation for actions will be taken well in advance of them being required, and implementation will be prompt, in order to minimise the risk of failure to maintain supplies to our customers during the most extreme droughts.

The following sections describe the operation of the zone as we move into a drought period and the actions that we will take to ensure that we minimise the impact on our customers. In the event of severe drought, options to increase the quantity of water resource available for public water supply will probably be required – these are outlined, with supporting summary information on the requirements of those options.

1.4.1. Normal Action Zone

Raw water operations

During normal weather conditions we optimise our sources to minimise the cost of operations. When natural flows in the Eastern Cleddau are sufficiently high, there is no requirement to make regulation releases from Llysyfran. When this is the case, the total abstraction across Canaston Bridge and Crowhill is managed to minimise the pumping cost from the sources, typically resulting in greater use of Canaston Bridge, and higher peak rates of abstraction to avoid peak energy tariffs.

As the flow in the Eastern Cleddau declines in spring, regulation releases are required from Llysyfran. When this is the case, the total abstraction across Canaston Bridge and Crowhill is managed to minimise the requirement for releases from Llysyfran. This is achieved by maximising the use of Crowhill RWPS, in order to minimise the demand for water from Canaston Bridge at Bolton Hill. By changing the pumping pattern at Canaston Bridge, the peak rate of abstraction at Canaston is minimised. This mode of operation minimises the rate of release required from Llysyfran and hence protects storage in the reservoir.

When dry weather persists in Pembrokeshire and river flow and reservoir inflow declines, we switch the optimisation of our system to maximise the preservation of water resource. As reservoir storage in Rosebush declines we commence pumping from our Pont Hywel RWPS to support storage in the reservoir. If storage continues to decline, we also start to pump water from Llysyfran to Preseli treatment works, reducing the demand on Rosebush reservoir and protecting storage.

Treated water operations

To maximise the use of cheaper sources of water when our water resources are not a constraint, we extend the area of the gravity supply from Preseli WTW across the St Davids peninsula, supplying customers at Simpson Cross, Roch, and Solva. When operated in this way, water from Bolton Hill extends only as far as Crundale, just north of Haverfordwest.

As dry weather persists, we change this mode of operation to increase the supply area of Bolton Hill, and hence reduce the demand from Preseli WTW on Rosebush Reservoir, by ensuring that the gravity supply to St Davids is reduced. The supply area of Preseli WTW is reduced such that it only extends as far as Clarbeston, with a treated water pumping station being brought into use that allows water from Bolton Hill to supply the St Davids peninsula. To further protect storage in the zone, we also ramp up leakage efforts to minimise losses in the network. Leakage efforts are targeted according to the balance of resource between Llysyfran and Rosebush.

1.4.2. Developing Drought Action Zone

To maintain as high a drought resilience as possible, we make all available changes to our operation relatively early to protect reservoir storage for later in the year, such that the zone is fully optimised to preserve water resources before entering developing drought. We will continue to ramp up our efforts to further minimise leakage when entering Developing Drought and will target these to the supply area of either Bolton Hill or Preseli works depending on whether resource is more critical in Llysyfran or Rosebush respectively.

When in the Developing Drought Action Zone, we will prepare to bring our mothballed **boreholes at Milton, to the east of Pembroke Dock, back into supply**. In the vicinity of the boreholes is our raw water main conveying water from Canaston Bridge to industrial demand at Pembroke. By pumping from the boreholes in to the raw water main, the boreholes could potentially augment the supply from Canaston Bridge to the industrial demand, reducing the rate of abstraction at Canaston Bridge and consequently preserving resource at Llysyfran. In addition to considering mothballed sources, we would start early assessments of available supply side options that would require drought orders.

1.4.3. Drought Action Zone

Before entering the drought action zone, all changes to the operation of the zone will have been undertaken to fully optimise, balance, and preserve available water resources across the zone.

In addition to extensive communications campaigns to reduce water use, implementing Temporary Use Bans, and maximising leakage efforts, we will commence preparations to request permission from NRW and Welsh Government to take more water from the environment. To support these requests, we will commence environmental monitoring in line with our Environmental Assessment Reports (Appendices 26, 27, 28 and 29) and submit our applications for the options identified in Section 0

1.4.4. Severe Drought Action Zone

As reservoir storage enters the Severe Drought Action zone, subject to receiving the necessary permissions from NRW and Welsh Government, we will implement our Drought Order schemes. As set out in Section 0, the options available to us are: 1) reduce the compensation release from Rosebush reservoir by 50%, 2) retention of Llys y Fran freshet bank for public water supply. These options all have the effect of preserving storage in our reservoirs which will enable us to maintain customer supplies for longer.

1.4.5. Emergency Storage

Our planning for drought includes a reserve supply of water known as 'Emergency Storage'. This volume is designed to meet around 30 additional days of customer demand, as well as meeting any environmental requirements. Reaching the stage where this is the only storage we have remaining in our reservoirs is an indication that we are in an exceptional drought event and we may need to implement extreme supply side measures such as water rationing in order to preserve supplies for as long as possible.

To enact these extreme measures we would need to apply to Welsh Government for an Emergency Drought Order that would allow us total discretion on the uses of water that may be prohibited or limited including the implementation of rationing measures such as the use of standpipe filling points, rota cuts in water supply or widespread pressure management. These are last resort actions, which at any other time we would deem unacceptable, and would only be used when all other reasonable drought measures have been implemented.

1.5. Supply-side drought management action

The following tables (Table 2 to Table 3) provide the information required by Appendix G of NRW's Water Company Drought Plan Technical Guideline (Dec 2017). The tables summarise the key information from within the associated Environmental Assessment Reports (EARs) including any potential environmental impacts, risks to the scheme implementation and any necessary mitigation that may be required.

As we plan to use a mothballed source during a drought we will undertake the necessary environmental assessments to understand the potential for deterioration in water body status. This work will be completed post the finalisation of our Drought Plan 2020.

Action Implementation Assessment	Name:	Reduce the Compensation release from Preseli Reservoir by 50%: EAR 8206-2
	Trigger(s)	Storage in Preseli Rosebush Reservoir crosses into Severe Drought Action Zone.
	Deployable Output or yield of the action	0.91 MI/d yield
	Likelihood	< 1:100 without upgraded Canaston Bridge RWPS. Around 1:200 to 1:500 with upgraded Canaston Bridge RWPS.
	Location	Rosebush Reservoir
	Implementation timetable	Preparation time: We assume a decision from Welsh Government within 28 days of submitting the Drought Order application. The practical implementation of the option could be effected immediately. Time of year effective: The implementation of this option is restricted from August to November. Duration: Valid for the duration stated
	Risks associated with action	The application, as applied for, is not approved. Reduction in required compensation has potential environmental impacts. These will be assessed through the EAR submitted with the application.
	Other considerations	N/A
Environmental Assessment: alone & in-combination	Risk to the Environment	Reduced flow in the Afon Syfynwy. The hydrological assessment has concluded that there is a major impact on flows in the Afon Syfynwy as a result of implementing the drought order. These hydrological impacts are assessed as leading to minor impacts on the physical environment of the river, including water quality. The environmental assessment has concluded there are major-moderate impacts on fish, and moderate impacts on macroinvertebrates, macrophytes and phytobenthos. The HRA Stage 1 Screening concluded likely significant effects on the brook and river lamprey, and bullhead populations within the Cleddau Rivers SAC / SSSI.
	Summary of likely environmental impacts	It has been concluded that the environmental effects on river flows, water quality and ecology of implementing a drought order at Preseli during August to November inclusive, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be major. The HRA has concluded there would be 'no adverse effect' upon the protected species.
	Potential In-combination Impacts	8206-7 (Llys-y-Fran use of freshet bank) – the extent of any impact of the Preseli drought order extends until the upper end of Llys-y-Fran Reservoir. As the impacts of the 8206-7 Llys-y-Fran drought order extends from the outlet of the reservoir, the impacted areas of the two schemes are mutually exclusive. There are no cumulative effects of these two drought orders on the downstream water environment. No further consideration required.
	Baseline information used	Hydrological data: <ul style="list-style-type: none">) Daily Rosebush Reservoir levels: 2003 to date.) Weekly or daily Rosebush storage volumes: 1995 to date (excluding 2002-2003).) Daily abstractions from Rosebush Reservoir: 1994 to date.) Weekly or daily Llys-y-Fran Reservoir levels: 1993 to date.) Daily mean compensation release flows from Rosebush Reservoir: 2005 to date Ecological data: <ul style="list-style-type: none">) NRW WFD data Macroinvertebrates – 3 sites within reach) Environment Agency Water Habitats Directive review 2007 Fisheries

	<ul style="list-style-type: none">) NRW baseline Spring and Autumn 2015 Diatom survey data
Summary of additional monitoring requirements	<ul style="list-style-type: none">) Spot flow gauging's) Biochemical water sampling) Fish surveys (including salmon, brown trout, lamprey, bullhead, eel)) Macrophyte Surveys) Macroinvertebrate surveys
Mitigation & Compensation measures	<p>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:</p> <ul style="list-style-type: none">) Temporary reduction or cessation of the terms of the Drought Order/Permit) Fish distress monitoring with triggers and response plan) Protection of 'spate flows') Reduction of fish predation) Physical in-river works) Provision of alternative compensation flows) Provision of alternative water supplies if other water users are at risk of derogation. <p>Potential mitigation measures have also been proposed and further discussion with NRW is required in order to develop suitable mitigation measures.</p>
Impact on other activities	<p>A reduction in flows on the Afon Syfynwy has minor impact to recreation and landscape visual amenity. Because flows would be naturally low at the time of the drought permit, significant impact are not expected, and would be temporary in nature. The drought order is not expected to impact local archaeological monuments.</p>
Any permissions or approvals required and constraints that apply	<p>Mitigation measures may require a Flood Risk Activity Permit, however, some proposed measures may be undertaken when registered for exception. Mitigation measures may also require an application to use fishing instruments (other than rod and line) and/or remove fish from inland waters (Form FR2). As the supply option is associated with designated sites, the option and/or mitigation measures may require an assent from NRW.</p> <p>No other permission or approval needed beyond the WG decision to grant use of this drought option and the permits required from NRW to allow us to undertake the required pre, during and post scheme implementation monitoring.</p>

Table 2 - Option 8206-2 Reduce the Compensation release from Preseli Reservoir

Action Implementation Assessment	Name:	Use of freshet bank for public water supply – Llys y Fran: EAR 8206-7
	Trigger(s)	Storage in Llys y Fran Reservoir crosses into Severe Drought Action Zone.
	Deployable Output or yield of the action	425 MI yield
	Likelihood	< 1:100 without upgraded Canaston Bridge RWPS. Around 1:200 to 1:500 with upgraded Canaston Bridge RWPS.
	Location	Llysyfran Reservoir
	Implementation timetable	Preparation time: We assume a decision from Welsh Government within 28 days of submitting the Drought Order application. The practical implementation of the option could be effected immediately. Time of year effective: The implementation of this option is restricted from October to December. Duration: Valid for the duration stated
	Risks associated with action	The application, as applied for, is not approved. Reduction in available Freshet bank has potential environmental impacts. These will be assessed through the EAR submitted with the application.
Other considerations	N/A	
Environmental Assessment: alone & in-combination	Risk to the Environment	Reduced Freshet releases into the Afon Syfynwy. The hydrological assessment has concluded there is a negligible impact on river flows as a result of implementing the drought order. Consequently, there are negligible impacts on the physical environment of the river, including water quality.
	Summary of likely environmental impacts	It has been concluded that the environmental effects on river flows, water quality and ecology of implementing a drought order at Llys-y-Fran (freshet release) during October to December, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be negligible.
	Potential In-combination Impacts	8206-2 (Preseli) – the extent of any impact of the Rosebush drought order extends until the upper end of Llys-y-Fran Reservoir. As the impacts of the Llys-y-Fran drought order extends from the outlet of the reservoir, the impacted areas of the two schemes are mutually exclusive. There are no cumulative effects of these two drought orders on the downstream water environment. No further consideration required.
	Baseline information used	Hydrological data: <ul style="list-style-type: none">) Llys-y-Fran weir flow gauge: daily river flow record from 1994 to present (weekly data available for 1993 to 1994)) Llys-y-Fran weir flow gauge: intermittent spot gauging data (level, velocity and wetted parameters such as wetted width and cross sectional area)) Measurement of the managed outflows made by Welsh Water from Llys-y-Fran Reservoir into the Afon Syfynwy: daily metered flow from 2004 to present) Canaston Bridge flow gauge: daily river flow record from 1960 to present) Canaston intake abstraction: daily metered flow from 1995 to present) Intermittent spot gauging data
	Summary of additional monitoring requirements	Spot flow gaugings
	Mitigation & Compensation measures	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:

		<ul style="list-style-type: none">) Temporary reduction or cessation of the terms of the Drought Order/Permit) Fish distress monitoring with triggers and response plan) Protection of 'spate flows') Reduction of fish predation) Physical in-river works) Provision of alternative compensation flows) Provision of alternative water supplies if other water users are at risk of derogation. <p>Potential mitigation measures have also been proposed and further discussion with NRW is required in order to develop suitable mitigation measures.</p>
	Impact on other activities	A reduction in available freshet bank for release on the Afon Syfynwy has negligible impact to recreation, archaeology and landscape visual amenity.
	Any permissions or approvals required and constraints that apply	No other permission or approval needed beyond the WG decision to grant use of this drought option and the permits required from NRW to allow us to undertake the required pre, during and post scheme implementation monitoring.

Table 3 - Option 8206-7 Use of Llys y fran freshet bank for public water supply