Draft Drought Plan 2019-2024

Published for consultation 2018

SEVERN TRENT

Contents page

For this public domain version of this document we have redacted the following section as it contains sensitive security and commercial information:

7 IROPI/ feasible alternative options

We have also replaced the names of certain sites with Site A, Site B etc where required in this document and in the associated reports.

Separate reports associated with this plan

- Non-technical summary (this will be a separate document on our website)
- Strategic environmental assessment (SEA) of the drought plan (this will be a separate document on our website but the detailed appendices will be available on request)
- Habitats Regulations Assessment (HRA) of the drought plan (available on request)
- A Water Framework Directive (WFD) assessment (available on request).

Executive summary

This is a draft version of Severn Trent Water's statutory drought plan. This drought plan will cover the period 2019-24. It is an update to the plan we published in February 2014. We produce drought plans to explain how we will manage both supplies and demand for water during a drought in our region. Our plan aims to balance the interests of customers, the environment and the wider economy. The plan helps us and our stakeholders to make the right decisions at the right time and shows how we will provide a continuous supply of water to our customers during a drought.

For the purposes of this plan we define a drought as a period when there is significantly less water available than normal[1] for a period of three months or more. Whether the effects of any particular drought are focused primarily on the environment, on public water supply or on other water users in the wider economy will depend on the individual characteristics of each drought. All droughts differ in severity, extent and duration. Droughts are naturally occurring events and we cannot plan to prevent them from happening. Instead, we plan to minimise the impacts of droughts when they do occur.

The main improvements and changes between this plan and the 2014-19 plan are that we have:

1. Made revisions to reflect the latest Environment Agency drought planning guidelines issued in December 2015 and the associated guidance notes. This guidance covers topics such as:
    a. Strengthening the links between drought plans and water resources management plans (WRMPs)
    b. The risk of invasive non-native species
    c. The Water Framework Directive (WFD)
    d. Droughts that are more extreme than those in our current record
    e. Resilience of the water industry.
2. Learned more about some of the drought management actions that are in our 2014-19 plan.
3. Updated the environmental reports and carried out ongoing monitoring that would be needed to support future drought permit or drought order applications at the sites identified within the plan. Because we carry out this environmental monitoring at all potential drought permit/ order sites and have a rolling programme of producing full environmental assessment reports (EARs) we consider that we are as application ready as we can be.
4. Updated drought triggers for reservoirs due to recalibration/ extension of the inflow series we use in our modelling.

[1] We consider that there is less water available than 'normal' when any of our drought triggers, such as reservoir storage, are in trigger zone C or below – we explain our drought triggers, drought trigger zones and associated actions further in section 2.1

5. Taken account of any relevant information that comes from collaborative work we are involved in e.g. the Water Resources in the East (WRE) group.

We have planned our system so that it can withstand any drought that is as severe as those we have seen over the last 95 years and up to a 1 in 200-year event. We have also tested our investment proposals against a range of plausible future droughts not seen in the historic record that have quantified probabilities for drought severity and duration. We are confident that our plans represent a good balance between cost, environment and resilience to severe droughts. Our stochastic drought modelling indicates that we are resilient to a 1 in 200-year drought without the need for emergency drought orders.

Integration with Dee Valley Water's drought plan

Current position

1. The existing Severn Trent Water drought plan runs from February 2014 to February 2019
2. The existing Dee Valley Water drought plan covers the period July 2015 to July 2020.

This plan is an update to the Severn Trent Water plan that we published in February 2014. This drought plan covers the same geographical area as that plan. Severn Trent Water Ltd (STWL) purchased Dee Valley Water in February 2017. Prior to this, the timescales for the two separate companies' drought plans were different. We propose to bring the drought plans into alignment in the following way:

- In February 2018 we will publish a draft drought plan that will be an update to the 2014 plan. It will cover the geographical region within the River Severn and River Trent catchments including Powys
- We will finalise the drought plan for the Severn and Trent catchments by February 2019
- In March 2019 (as per the agreed Welsh Government timescales) we will publish a draft Dee Valley drought plan. This will also discuss how we manage droughts in Powys. Note that, until this 'Welsh' drought plan is finalised, we will continue to use the drought plan mentioned in bullet point 2 to manage droughts within Powys
- By July 2020 we will finalise our Dee Valley and Powys drought plan. Note that this plan will then primarily be a 'Welsh' drought plan but will also describe drought management in Chester
- Once the Dee Valley and Powys plan is finalised that will trigger a change to our Severn Trent drought plan and we will amend that so that it covers all of our English area including Chester.

We will continue to manage drought effectively for all of our customers throughout this period and our customers are unlikely to notice any difference. For instance, the Powys section of the 'Welsh' drought plan will be very similar to how we manage Powys in our existing 2014 drought plan and we expect the Chester section of our 'English' drought plan will be very similar to the Chester section of the 2015 Dee Valley drought plan. We note that there are no drought management actions in this plan that are geographically specific to Wales and we have produced this plan in way that is consistent with NRW, as well as EA, drought planning guidance.

1 Introduction

1.1 About Severn Trent

Our vision is to be the most trusted water company by 2020, delivering an outstanding customer experience, best value service and environmental leadership. We are one of the largest water companies in the country and our purpose is to serve our communities and build a lasting water legacy. We do this by providing high quality drinking water and sewerage services (taking wastewater away) in the Midlands and Wales. For further information on our business, please visit www.stwater.co.uk.

1.2 What is a drought?

Droughts are naturally occurring events. There is no single definition of drought but all droughts involve an extended period of lower than average rainfall. Whether the impact of any particular drought falls on the environment, on public water supply or on other water users in the wider economy will depend on the individual characteristics of each drought. All droughts differ in severity, extent and duration. The effect of droughts will also be different depending on whether the majority of the water sources affected are rivers, reservoirs or groundwater.

For the purposes of this drought plan, we are referring to an event that lasts a minimum of two or three months. This means that a few days or weeks of particularly hot and / or dry weather do not constitute a drought. Periods of this sort will class as heatwaves if there are prolonged periods of higher than average temperatures. Heatwaves can cause water companies short term issues by drawing down levels in treated water reservoirs. However, events like this are too short term to fall within the scope of this plan.

We expect climate change to lead to more extreme climatic events in the future – these will include severe droughts as well as severe flooding events. Extreme droughts are low likelihood, but high consequence, events.

1.3 What is a Drought Plan?

Droughts are naturally occurring events and we plan to minimise the impacts that they might have. We produce a drought plan to explain how we will manage both supplies and demand for water during a drought in our region. Our plan aims to balance the interests of customers, the environment and the wider economy. The plan helps us and our stakeholders to make the right decisions at the right time and shows how we will provide a continuous supply of drinking water to our customers during a drought.

Under Sections 39B and 39C of the Water Industry Act 1991, as amended by the Water Act 2003, we are legally required to prepare and maintain a drought plan. This drought plan sets out how Severn Trent Water will “continue, during a period of drought, to discharge its duties to supply adequate quantities of wholesome water, with as little recourse as reasonably possible to drought orders or drought permits.” This definition is consistent with the Water Industry Act 1991.

We are also required to consult with the public on the content of the plan, assess the representations we receive and prepare our statement of response within 15 weeks of the draft plan publication date.

We have based the structure of this plan on the recommended structures provided in:

- Appendix C: Recommended structure for a water company drought plan in the EA guidance 'Further supplementary information' dated April 2016
- Appendix C of the draft 2017 NRW Water Company Drought Plan Technical Guideline.

The EA and NRW recommended structures are very similar to each other. The structure of our plan draws heavily on both of these.

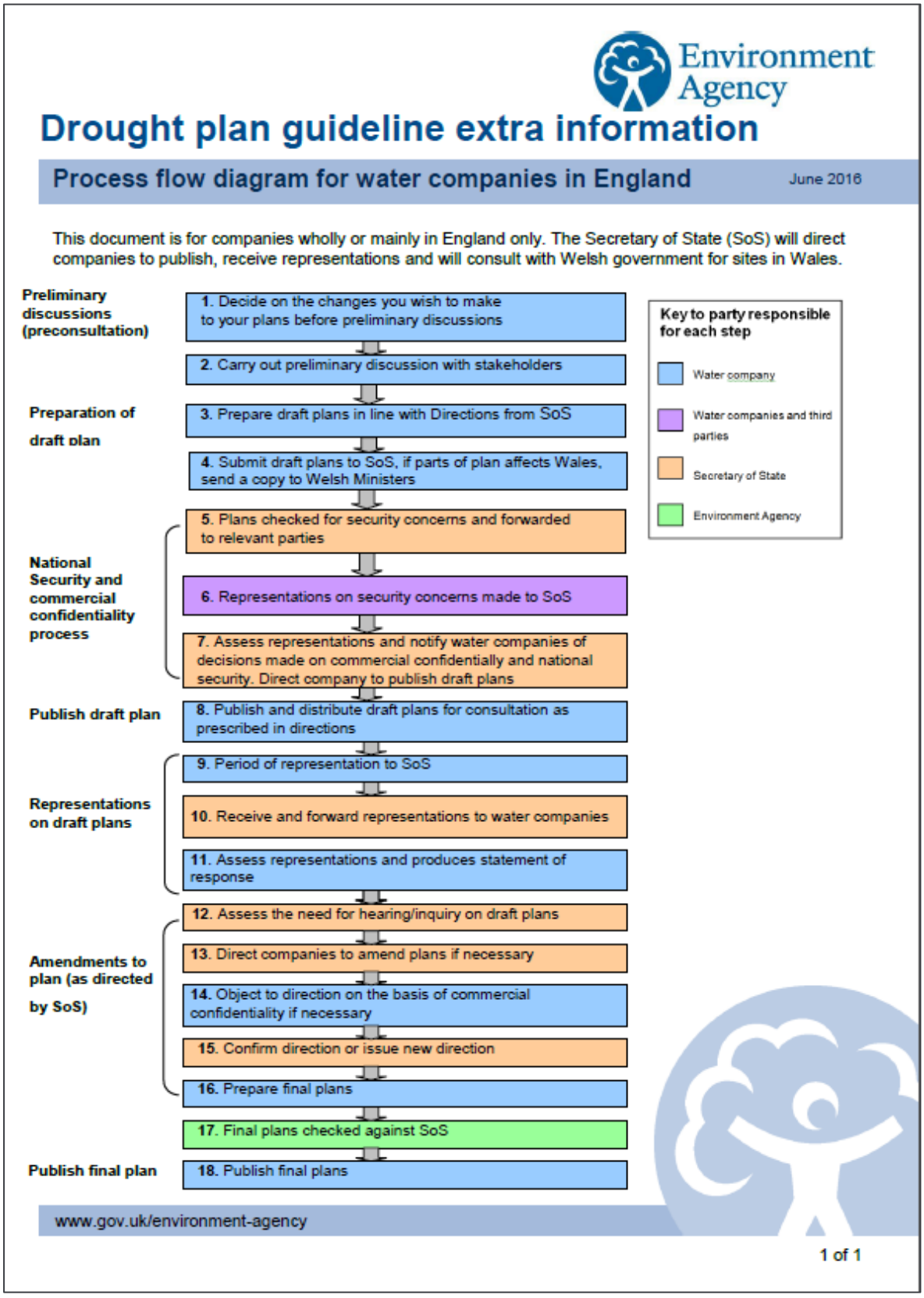
1.3.1 Consistency with the EA and NRW drought plans

When preparing our draft drought plan we have considered and referred to the 2016 National Drought Framework produced by the Environment Agency (EA). We have also referred to the EA area and/ or NRW drought plans as appropriate and where they are available. We can confirm that there is consistency between the EA/NRW drought plans that we have reviewed and our own plans.

1.4 Overview of process

The EA guidance note 'Drought plan process flow diagram' dated June 2016 provides a useful overview of the Drought plan process. We have reproduced it below:

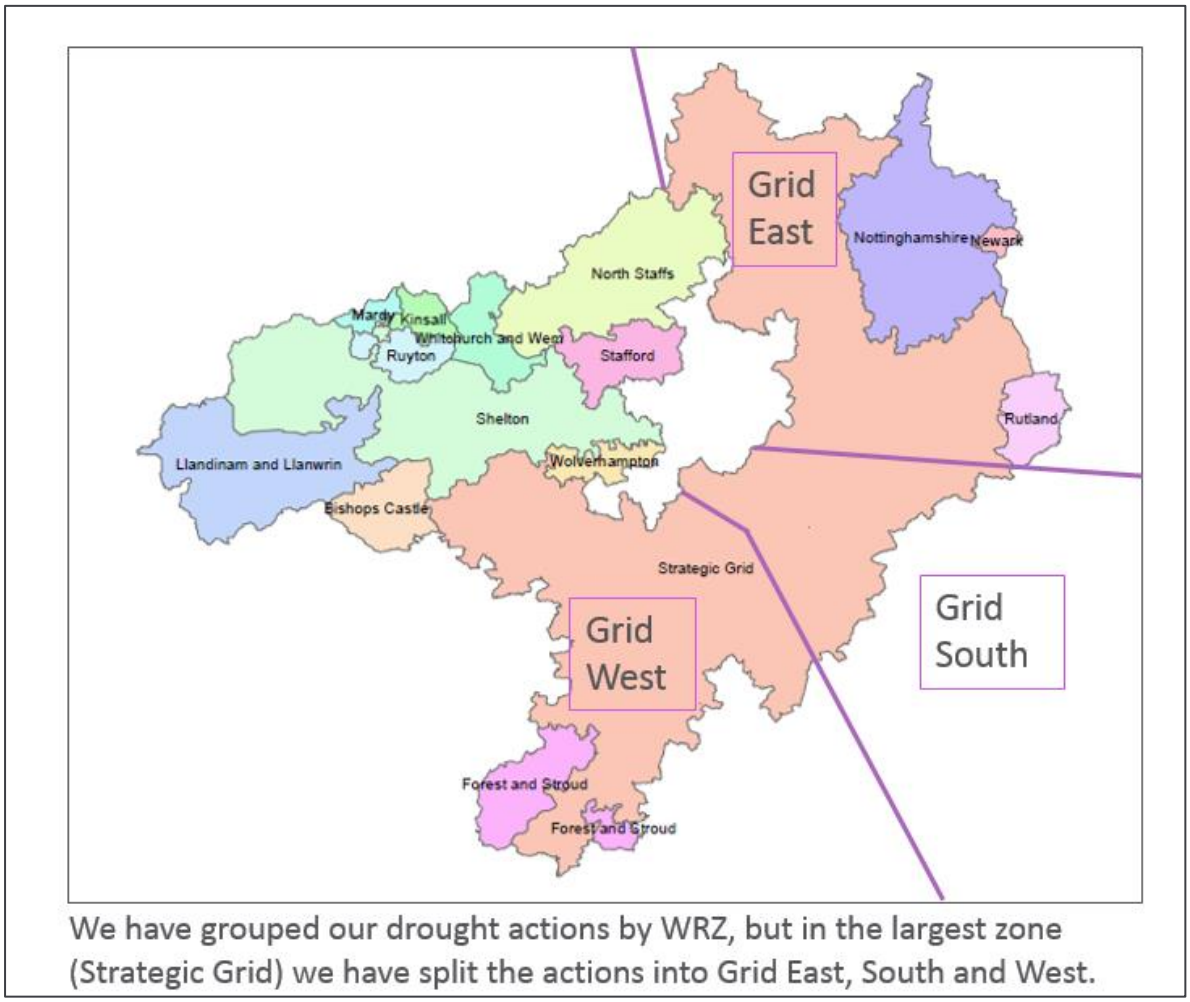
Figure 1 – Process flow diagram from EA guidance



1.5 Our Water resource zones (WRZs)

We have reviewed whether the water resources zones (WRZs) that we used in our previous plans are still appropriate. We have concluded that they are still appropriate zones in which to manage our water resources. So we will continue to use the same WRZs described in our WRMP and our 2014-19 drought plan. The map below shows the location of these WRZs:

Figure 2 - Map showing our 15 water resource zones (WRZs) and where our different drought triggers apply



1.6 Baseline water resources situation, levels of service and customer views

We have described our baseline water resources situation in our 2014 Water Resources Management Plan (WRMP14), our draft WRMP and in the annual review information that we provide to the EA and Defra. As a company we produce other plans that overlap to some extent with drought management. For example, we produce water resource management plans (WRMPs) and business plans. We have included a table in section 7.3 that describes why we produce these other plans and summarises what they contain. As stated in that table, this drought plan is not an investment plan. Any assessment of, or proposal for, investment for drought resilience is in our business plan or WRMP.

1.6.1 Levels of service

Our stated levels of service set out the standard of service that our customers can expect. The levels of service stated for this drought plan are consistent with those recognised by Ofwat at the Price Review of 2014 (PR14). These levels of service that our customers can expect as a response to drought are:

- We will restrict our customers' use of water, on average, no more than three times every 100 years. This applies to both temporary use bans (TUBs) and non-essential use bans (NEUBs). We explain these in section 3.1.5.
- We consider that rota cuts/ standpipes for our customers are unacceptable. Note that rota cuts and standpipes are often referred to as 'level 4 restrictions' or emergency drought (order) measures. As we would only need to consider using such measures in an extremely severe drought we do not have a planned frequency for them.

These stated levels of service are consistent with those we have quoted in previous Severn Trent publications, such as our 2014-19 drought plan and are consistent with the draft WRMP that we published on our website in February 2018. We set out the sensitivity of our system (in terms of deployable output) to different levels of service in our draft WRMP. The table below shows the modelled frequency* of customer restrictions:

Table 1: Modelled frequency of restrictions on customers' use

	Number of events in the record from water resources modelling simulation	Length of record (years)	Frequency per 95 year length of record (%)	Company stated LoS frequency
Temporary use ban (TUB)	2 (1976 and 1984 both affecting Elan Valley group)	95	3.3	Not more than 3 in 100
Non-essential use ban (NEUB)	1 (1984 for Elan Valley)	95	1.1*	Not more than 3 in 100
Rota cuts/ standpipes	0	95	0	Not acceptable/ no planned frequency

** This is the frequency of this occurring in our baseline DO model run – it will differ in other modelled scenarios and does not change the stated company levels of service. Although the 1995-96 drought does not appear in this table we have shown the modelled results for this drought in section 2.5 (testing our drought triggers).*

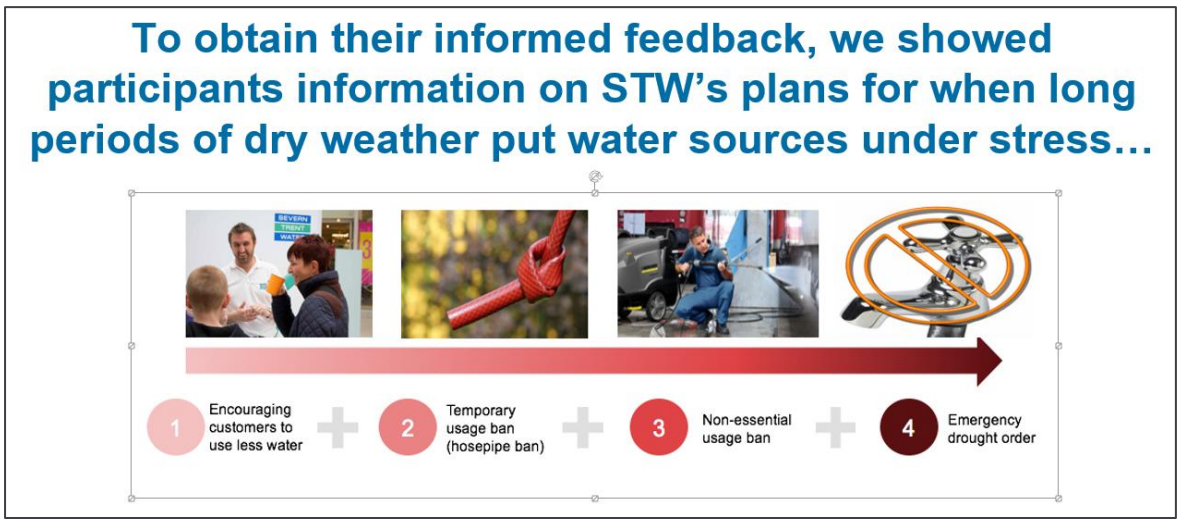
Our company wide levels of service are based on water resources modelling that we have carried out using flow series which extend from 1920 to 2014. We have provided more detail on how we use this flow record in section 2. This drought plan makes no explicit allowance for the impacts of future climate change. This is consistent with our 2014-19 drought plan. However, we have carried out a rigorous assessment of climate change for our draft WRMP.

1.6.2 Customer and stakeholder views

We have sought the views of our customers and stakeholders on drought resilience. For example, to inform our PR19 submission we carried out the following work:

1. Willingness to Pay (WTP) work – this is similar to the work we carried out for WRMP14. The WTP research we carried out prior to PR19 showed that our customers were willing to pay £3.8m to half the risk of standpipes. This may sound like a large amount of money but it was actually smaller than the WTP values for some of the other improvements we asked customers about
2. Immersive research – we did not carry out research like this for WRMP14 but this has many advantages over the other approaches as it means we can 'immerse' selected customers in more detail so that they are properly informed before we ask them for their views on these (often technical and complex) issues. This work also allows customers to better consider competing priorities. The figure below is from the immersive research we carried out into the topic of drought:

Figure 3 – Material used for PR19 immersive customer views' research



In summary the customers we engaged generally felt that:

- Drought is not an issue they anticipate will affect the UK
- Due to the perceived minimal impact of temporary use ban (TUB) restrictions, the expected frequency is mostly seen as acceptable
- They do not see non-essential use bans (NEUBs) as having direct impact on them, but worry about the impact on businesses
- Level 4 is seen as extreme, although probably proportionate and very unlikely to occur (we described the frequency of this as 'never (once every 200 years)'.

We think that this useful and in-depth customer insight work has shown that the current levels of service we provide and those that we plan for in our drought plan and WRMP are in line with customer views and expectations.

As suggested in the 2017 Water Resources Planning Guidelines (WRPGs), we considered using the UKWIR (United Kingdom Water Industry Research) risk based planning report directly in our customer research in relation to drought resilience. We did not think that this work was suitable for the WTP

phase of our work but we have adapted elements of it to assist with our immersive research. We are aware that there are challenges involved in helping customers to better understand the likelihood of extreme drought events.

In addition to this customer engagement work we have shared our extreme drought scenario work, described in section 2, with our Water Forum. Our Water Forum includes experts in this field. We have also presented our drought resilience work at WRMP external stakeholder forum meetings. For example, we held one of these multi stakeholder WRMP19 events in Coventry on 6 October 2017. We provide more details on the extensive stakeholder engagement we have carried out in our draft WRMP.

One of the organisations represented at our stakeholder events is the Consumer Council for Water (CCWater). CCWater is a statutory consumer body for the water industry in England and Wales. In addition to gathering views from CCWater we have sought customers' views on the priority that they place on never having standpipes/ rota cuts. We have done this in different phases. We carried out some work of this sort in preparation for our WRMP14 but we adapted our approach in the research we did to support our PR19 plans. For example, our PR19 WTP work focused on emergency drought measures such as rota cuts and standpipes whereas the PR14 work asked about restrictions on hosepipe use. We expected customers to have stronger views on rota cuts and standpipes than they did on 'hosepipe ban' frequency.

1.7 Pre-draft and draft consultation details

We sent a pre consultation email on 10 February 2017 to interested parties, neighbouring water companies and statutory consultees. These organisations included:

- CCWater (Consumer Council for Water)
- CRT (Canals and River Trust)
- Defra
- Environment Agency
- Local authorities
- Non household retailers
- Ofwat
- Natural England
- Non household water retailers
- NRW (Natural Resources Wales)
- Welsh Government.

We requested early views on the issues these organisations want us to address in our plan. We asked for these responses no later than the 24 March 2017. We have accounted for these responses, produced this draft drought plan and submitted it to the Secretary of State in February 2018. Once we receive permission we will publish the draft plan for public consultation.

We are running our public consultation on this drought plan from 13th June 2018 for eight weeks until 8th August 2018. We will produce our statement of response (SoR) within seven weeks of the public consultation ending. This will then meet the requirement for companies to publish their SoR within 15 weeks of publishing our draft plan. This SoR will show how we have responded to the comments we have received. For example, we may also produce a revised draft drought plan which highlights which sections we have amended as a result of the public consultation. In addition, there may also be comments which we discuss in the SoR but which do not require specific changes to the Drought Plan text. We intend to publish our final 2019-24 drought plan before the end of February 2019.

2 Drought scenarios and drought triggers

2.1 Historic droughts and other drought scenarios

When preparing this plan we have considered a wide range of drought scenarios. For example, all of our PR19 modelling, which uses our historic record, includes flows across our region from 1920 to 2014. Companywide the 1975-76 drought is the most extreme in our hydrological and hydrogeological (where present) record. This is the drought that we have based our current plans on. However, we have also looked at what the impacts might be if we were to experience a more severe drought than the 1975-76 drought and the other drought events present in our baseline modelling period e.g. 1933-35, 1995-96.

If we experience a drought more extreme than the droughts we currently plan for it could lead to emergency measures such as standpipes in the street or rota cuts for our customers. As we said in section 1.6.1, we do not plan for rota cuts or standpipes. In an extremely severe drought we would consider using them but we do not have a planned frequency for this level of service. If a severe drought in our region continued long enough it could cause us to run out of raw water. This worst case scenario would leave our customers without running water and unable to perform essential tasks such as drinking water and toilet flushing. This would undoubtedly cause profound public health, reputational, financial, social and environmental problems for Severn Trent and the region as a whole.

We have used three techniques to investigate how our water resource system copes with a variety of droughts including a range of severities and durations. Section 3.4 of the current Water Resources Planning Guidelines (WRPGs) states that:

"As a minimum you should assess your plan against the worst drought on record."

In our case this includes droughts observed between 1920 and 2014. Our approach considers not only the worst droughts in the 1920 to 2014 record but also:

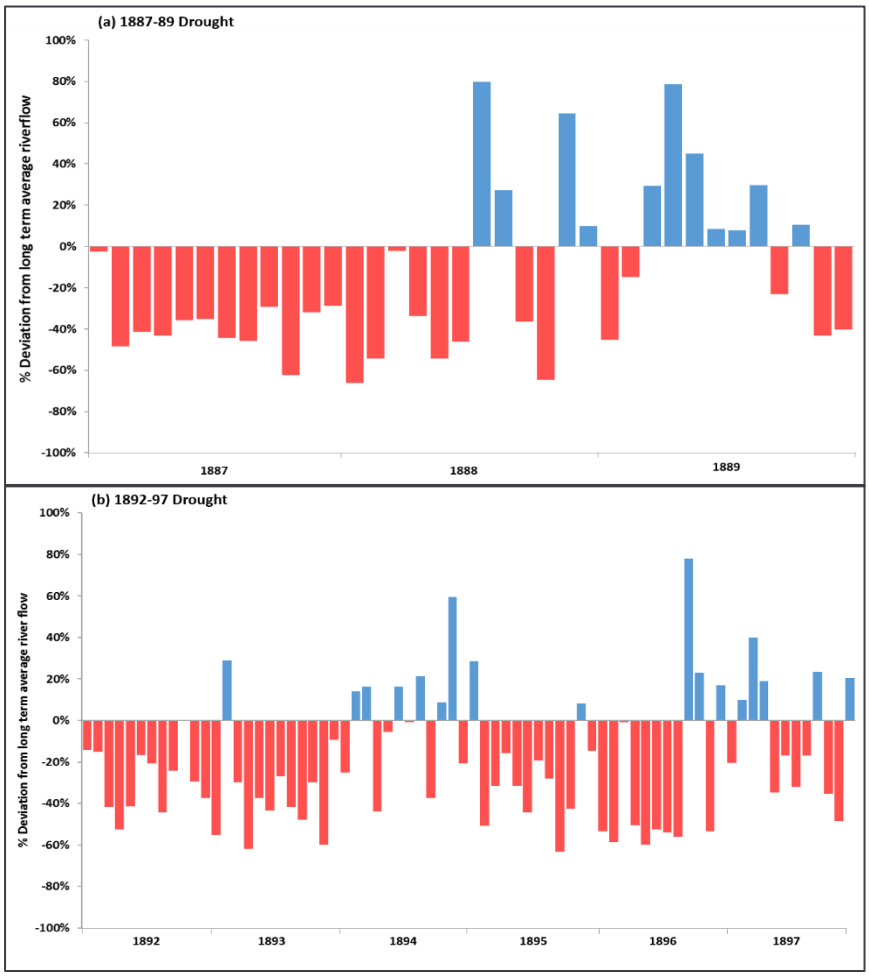
- Late 19th Century droughts.
- Drought response surfaces (we describe what these are in section 2.1.2).
- Stochastically generated drought scenarios (we describe what these are in section 2.1.3).

2.1.1 Late 19th Century droughts

Our baseline modelling to assess deployable output uses 95 years (1920-2014) of climate data and this period captures a number of historic droughts (1921, 1933-34, 1975-76). This allows us to test how our current water resource system would respond if those events were to occur within our 25 year planning period (2020-2045). However, as each drought is unique (in duration and severity), it is important to understand how our system responds to different droughts. We simulated what could happen to our current system if we had a repeat of the long dry periods that occurred between the 1880s and 1910s. We know through Research and Development (R&D) work with the University of Liverpool that some of these droughts were more severe or lasted for longer than the droughts observed in our 95 year observed record. Part of this R&D work involved the co-funding of a PhD project which used historic climatic data to improve our understanding of drought characteristics, propagation and impacts on water resources across the Severn Trent region. This research has better enabled us to quantify this challenge.

Our analysis of historic climate data identified two notable droughts- (1) 1887-89 and (2) 1892-97. The 1887-89 drought ranks as one of the most severe 24 month droughts in the 1884 – 2014 record in our region (Figure 4). Between January 1887 and December 1889 25 of the 36 months have flows below the long-term average conditions. Whilst the 1887-89 drought was identified as a severe flow deficit event the 1892-97 drought was one of the longest duration events observed in our region (Figure 4).We used historic records of rainfall available across our region dating back to 1884 to create a 131 year dataset to investigate the impact of the identified historic droughts. We used this rainfall data to model river flows using the same rainfall-runoff modelling approach we use in all of our WRMP and drought planning work. We also used groundwater models with the historic climate data to reconstruct groundwater levels and borehole deployable output for the extended analysis period. We then used this modelled river flow and groundwater data in our water resource system model (Aquator) to assess whether the historic droughts had an impact on deployable output. Results of this extended modelling showed that the late 19th Century events did not reduce the deployable output values calculated using our 95 year baseline record. However, our extended 1884-2014 modelling results did highlight the severity of these earlier droughts. For example, we would have had to implement temporary use bans in 1896 and 1897, the final two years of the 1892-1897 drought. As this work is based on a limited number of rain gauges, there is more uncertainty than there is in our current 95 year record. Therefore, we are only using these droughts as scenarios to test our water resources system rather than part of our baseline deployable output modelling.

Figure 4 - Late 19th Century Drought events- (a) 1887-89 and (b) 1892-97

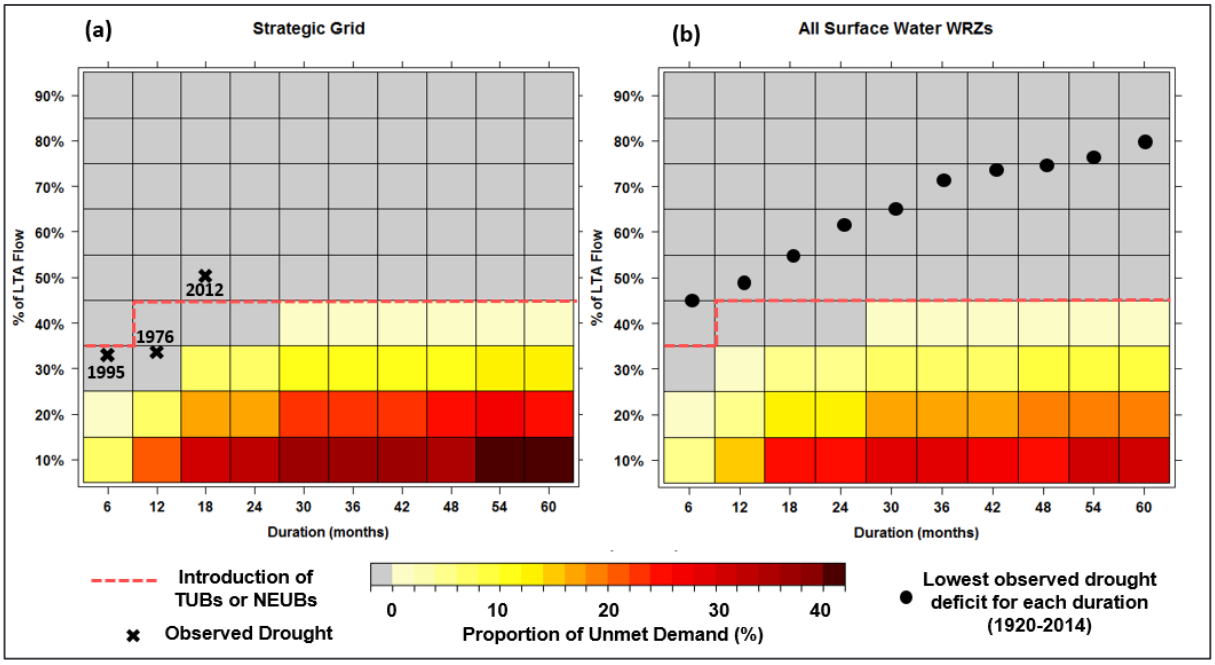


2.1.2 Drought Response Surfaces

The EA produced a report in 2016 entitled "Understanding the performance of water supply systems during mild to extreme droughts". We have used the approach outlined in the report to show the impact on customers of droughts with different durations and different river flow deficits (severities). A river flow deficit is a way of saying how much drier a drought is compared with average conditions. For example, if a certain six month period has half as much water flowing down a river than average we would refer to this as a 50% of long term average (LTA) river flow deficit. Figure 5 below illustrates this. Each of the 81 boxes represents a different drought scenario. For example, the box in the bottom right represents the exceedingly unlikely scenario in which there is only 10% of average river flow for 60 months (5 years). By contrast the box in the top left is the much more likely scenario of having 90% of average river flow for six months.

In the example below (Figure 5) we have used colour coding to show the proportion of demand that would not be met for each of the 81 drought scenarios. The grey boxes show that all water demands can be met whilst the boxes shaded from yellow to dark red indicate the proportion of demand that would be not met under each drought scenario. We have developed drought response surfaces for the WRZs that we model in Aquator. As this approach requires Aquator modelling we did not use it for the other (groundwater only) WRZs. These other WRZs are more drought resilient (see section on drought risk composition). We consider that producing drought response surfaces would be disproportionately complex for the WRZs that have high drought resilience.

Figure 5: Drought Response Surface for the (a) Strategic Grid WRZ and (b) all surface water WRZs



We developed these drought response surfaces by using synthetic droughts for severity and duration characteristics. These synthetic droughts had durations of between 6 and 60 months with river flow deficits between 10% (most severe) and 90% (least severe) of the long-term average conditions. We created 81 synthetic drought scenarios using our baseline observed data from 1920 and 2014. We produced these synthetic droughts by selecting a month known to have been part of a drought e.g. January 1976, February 1995 etc. for each month of the year to develop a "drought profile" to represent river flow characteristics during a drought which could then be scaled to reflect each of the duration/severity scenarios. Under each scenario the drought begins in April with a varying end month to reflect the drought duration e.g. a 6 month drought would have an end date of September. We used this process to create scenarios for the 64 river catchments we use in our Aquator water resources model.

We then used each scenario to model whether supply can meet demand. We plotted the results of this onto a grid using a range of colours to represent the impacts. We added additional information to the drought response surfaces to show the characteristics of past significant droughts (see Figure 5) and the lowest observed river flow deficit for all durations between 6 and 60 months (see Figure 5). This information provides useful context for how plausible the synthetic drought scenarios are compared to observed events. We have used elements of the UKWIR Drought Vulnerability Framework project when preparing our drought plan and draft WRMP.

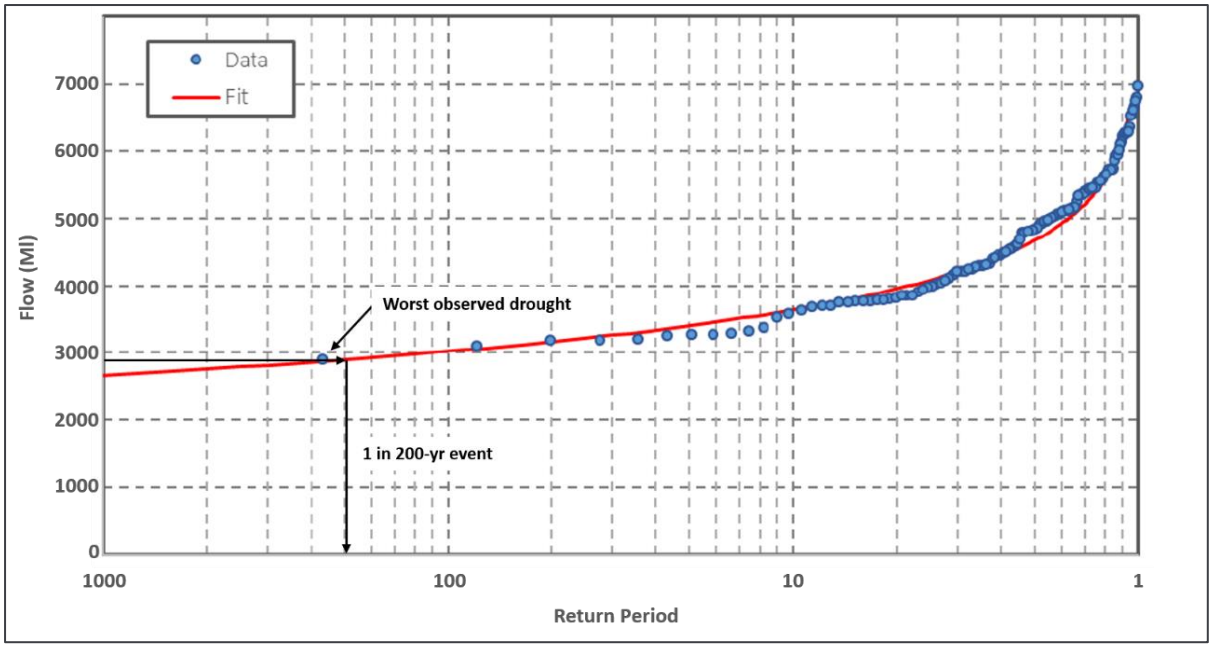
2.1.3 Stochastic Drought Scenarios

In order to test how our water resources system responds to droughts that are worse than those observed in our baseline and in the 19th Century analysis we adopted an additional approach. The approach we selected was the creation of a number of stochastically generated drought 'what if' scenarios that haven't happened but plausibly could. The WRMP 2019 Methods – Risk Based Planning:

Guidance (UKWIR, 2016) has informed the techniques we have used to develop our stochastic drought scenarios. We created our scenarios using a stochastic weather generator to develop 200 'what if' drought scenarios. Stochastic weather generation is a modelling technique which uses the relationship between climate drivers and our observed rainfall data over the 20th Century. We then used these 200 sets of rainfall data and corresponding evapotranspiration data to model river flows using the same rainfall-runoff methods used for our baseline DO assessment and the 19th Century drought assessment. We also used the stochastic rainfall and evapotranspiration data to model groundwater level changes within spreadsheets. We then transposed these data onto Source Performance Diagrams (explained more in section 2.2.3) to determine the corresponding borehole deployable output.

To select drought scenarios which are more severe than observed events we used extreme value analysis (EVA) techniques to assign return periods to observed droughts and to estimate the return periods of more severe events. The graph in Figure 7 shows an example of how we have used these techniques. This example is for 18 month duration droughts but we have also used similar techniques for droughts of different durations. The blue circles represent actual river flows accumulated over an 18 month period for each year across the 130 year flow record. We derived the red line statistically from the observed data and used it to estimate the return periods of 18 month droughts up to 1 in 1000 year events. We used the same type of EVA approach to estimate the return periods of 24 month and 30 month droughts with return periods up to 1 in 1000 years.

Figure 6: Example of Extreme Value Analysis to estimate drought return periods



The EVA enabled us to estimate what the total accumulated river flows would be across our region for droughts with a specific event duration and return period (severity). For example, in Figure 6 an 18month duration 1 in 200 year event has an estimated 18 month flow total of 2900 Ml. We then searched the 200 stochastic flow scenarios to identify a similar 18 month accumulated flow value. We repeated this process a number of times to identify suitable droughts to test our water resources system for droughts with duration characteristics of 18, 24 and 30 months and for return periods (drought severity) up to approximately 1 in 1000 years. From the 200 stochastic scenarios, we selected

30 for analysis in our Aquator model. See Figure 7 for an overview of our stochastic drought scenario generation and modelling.

We have also added borehole deployable output values in to our Aquator model to account for changes in output from our groundwater sources (see Figure 7). As the surface and groundwater drought stochastic scenarios were developed using differing methods the borehole deployable output values have a smaller range of return periods (1 in 200 years and 1 in 500 years) than the surface water scenarios. In our Aquator modelling the surface water scenarios with a return period greater than 1 in 500 years are all modelled using 1 in 500 year groundwater DO values. As there is little variability between the stochastic groundwater DO values we consider this a suitable modelling approach.

Our modelling results indicated that for a range of drought scenarios between 1 in 190 years to 1 in 330 years there is a small reduction in DO in the Forest and Stroud WRZ. This is a reduction of 2 Ml/d. In all other WRZs these drought scenarios had no reduction in DO from the baseline 1920-2014 modelling. We found that larger decreases in deployable output occurred for scenarios with return periods between 1 in 500 years and 1 in 1000 years with a maximum deployable output reduction of approximately 200 Ml/d (mega litres, or million litres, per day) for a 1 in 1000 year 24 month drought. We have presented a selection of drought scenario DO values in Tab 10 of our WRMP data tables.

We note that drought is a complex phenomenon. The events we have selected for analysis provide an understanding of how future severe droughts could impact our water resource system however the results should only be regarded as estimates. This is recognised by the EA guidance on the completion of WRMP19 tables which describes some of the more extreme scenario values they expect to be in WRMP tab 10 as “a series of estimates”. Although this is true we will continue to stay abreast of relevant R&D and innovation as techniques, modelling and knowledge improves. We will reflect these advances in our future plans. Whilst two drought events could have the same return period and duration (e.g. a 1 in 500 18 month event) the unique characteristics of these droughts could result in different water supply impacts. However, by analysing a large number of drought scenarios with varying drought characteristics we are able to better understand a range of potential impacts and provide challenging drought scenarios for our investment modelling.

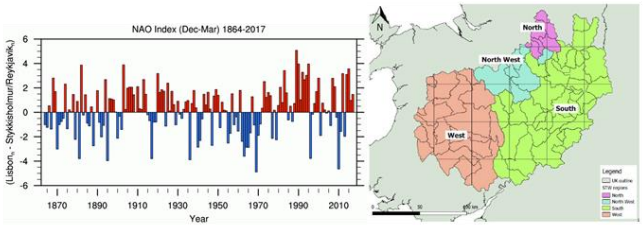
We also note that there is some uncertainty in estimating the return periods of our extreme droughts. Whilst extreme value analysis is a very useful method, return period estimates are dependent on a number of factors including data length and the choice of statistical analysis approaches. We have improved the robustness of our EVA estimates by using our extended flow records developed through the 19th Century drought analysis. This provided 130 years of data rather than the 95 years of our baseline data. The longer dataset provided a wider range of flow conditions including a larger number of droughts which has resulted in a better quantification of drought return periods.

We have worked in close collaboration with South Staffordshire Water (SSW) to ensure we assess the impact of extreme droughts in a way that is consistent with this neighbouring company. It is particularly important that we are consistent with SSW in work of this sort as we both operate within the River Trent and River Severn hydrological catchments. We share one source on the River Severn (shared South Staffordshire asset) and we share our Aquator models and output too. We have also been in contact with Dwr Cymru Welsh Water (DCWW) to compare consistency between our stochastic drought inflows for the Elan Valley Reservoirs. In addition we continue to work with

neighbouring water companies such as Thames Water, Anglian Water and other stakeholders in groups such as WRE (Water Resources in the East) and WRSE (Water Resources in the South East).

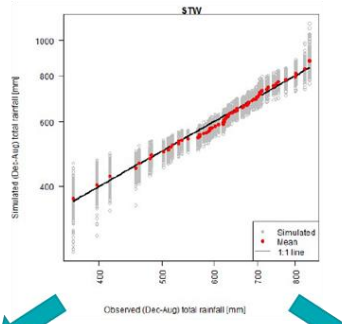
Figure 7: Stochastic Drought Analysis Flow Diagram

Stochastic Drought Analysis Flow Diagram



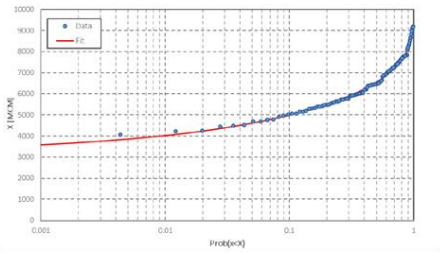
Statistical relationship between observed rainfall across our region and climate drivers used to develop weather generator model.

Observed rainfall records covering our region from 1920 to 1990 (71 years) are used by the weather generator to create 200 'what ifs' that contain a number of drought phases that are more severe than in the observed records.



Surface Water

The 200 rainfall and evapotranspiration scenarios are used to model river flow across the 64 catchments in our region using the rainfall-runoff model Hysim.



Extreme value analysis is used to estimate the return period of droughts with specific durations e.g. 18-, 24- and 30-months. Each return period and drought duration will have an associated 'target' river flow total. The 200 scenarios are searched for these 'target' river flows to identify 30 scenarios with return periods between 1 in 200 and 1 in 1000 years.

Ground Water

The observed rainfall (P) and evapotranspiration (PET) records are analysed to estimate accumulated values for droughts with return periods between 1 in 200 and 1 in 500 years with durations of 18-, 24- and 60-months. These target values are used to identify 6 corresponding droughts within the 200 'what if' rainfall scenarios.

The P-PET data for the worst case historical droughts, and the corresponding 6 synthetic droughts, are used with the groundwater GR2 models to determine changes in groundwater levels from droughts.

Changes in Deployable Output at the groundwater sources are calculated from the modelled groundwater level change and the transposition on to the source performance diagram, to indicate a range of DO changes for drought scenarios with return periods between 1 in 200 and 1 in 500 years.

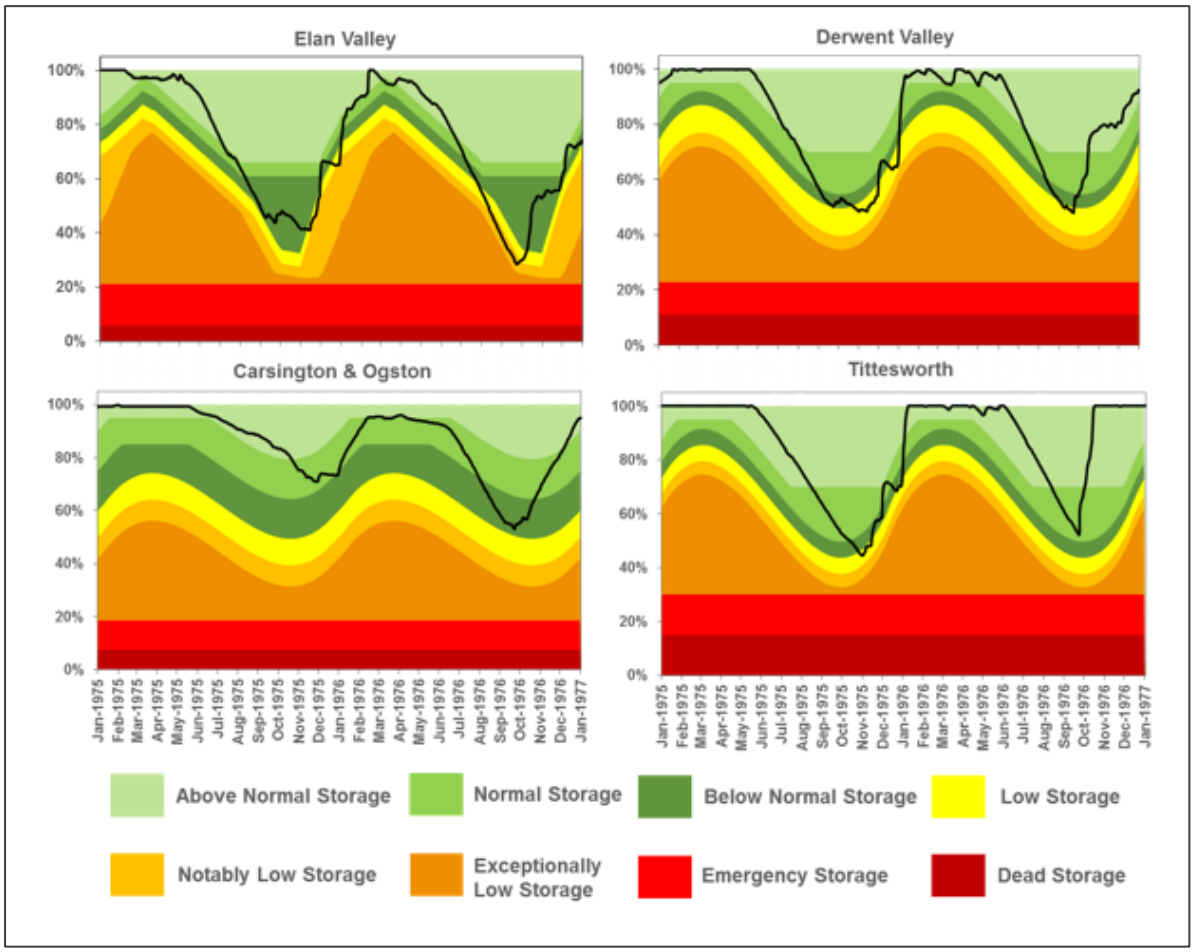
30 scenarios modelled in Aquator to provide a range of deployable output values. This allows us to better understand how droughts with different severity and durations can impact on water resources.

2.1.4 Design Drought

The 2017 Water Resource Management Plan Guidelines state that our base supply forecast should be based on a design drought which should be either (1) our worst drought on record or (2) a more challenging event. Our base supply forecast uses our baseline flow record (1920-2014) therefore, our design drought is our worst historic drought; 1975-76. Analysis of our baseline flow record and our extended 19th Century record indicated that accumulated river flows in the 18 months from April 1975 to September 1976 were the lowest across our region. The selection of our worst historic drought was also informed by our stochastic drought modelling results which identified a very minor change in DO between the baseline data (1920-2014) and a 1 in 200 year stochastic event (-2 Ml/d). We observed significant reductions in DO for droughts with return periods between 1 in 500 years and 1 in 1000 years but we consider that using these events is unsuitable for our base supply forecast.

In addition to our modelled findings, our customer research to date has indicated that customers show little appetite to pay for increased drought resilience, however, our customer research is ongoing (see section 1 for more information). Figure 8 shows the modelled storage levels in four of our reservoirs during the design drought. We have plotted these with our drought trigger zones to highlight the impact of this event on the water resource system. These results show that this drought has the greatest impact on the Elan Valley and Derwent Valley reservoirs.

Figure 8: Reservoir Storage during Design Drought



2.1.5 Risk Composition

We have developed our drought resilience work using the WRMP 2019 Methods – Risk Based Planning: Guidance (UKWIR, 2016). A key component of this guidance is the need to state our risk composition. This composition indicates how we have incorporated drought resilience into our WRMP and drought plan analysis.

Figure 9: Our risk composition- "Resilience Tested" Plan

Table Source: WRMP 2019 Methods – Risk Based Planning: Guidance (UKWIR, 2016)

Risk Composition	What is it?	Specifics of what is Involved (supply, demand, investment)
1 – The 'Conventional' Plan	Estimates of supply capability are based on the historic record, perturbed for climate change. Any testing of droughts outside of the historic record is done using a simple 'top down' method and is only done to examine supply / demand risk under more extreme conditions (i.e. sensitivity analysis only). Uses a simple representation of dry year/normal year demand.	*Supply* – conventional 'Deployable Output' (DO) or historically based timeseries. *Demand* – dry year/normal year estimates. *Investment* – inputs to the Decision Making Tool (DMT) are based on analysis of the historic record and the investment programme therefore represents the 'best value' response to maintaining Levels of Service and resilience against the historic record.
2 – The 'Resilience Tested' Plan	Companies use 'Drought Events' to test the Plan and look at the implications of alternative/more severe droughts on the 'best value' investment programme. These 'Drought Events' can be derived using a variety of top down methods, but their 'plausibility' (approximate level of severity) is checked using *metrics* of rainfall, aridity or hydrology. More complex representation of demand *variability* can be tested.	*Supply* – conventional plus 'event based' DO or timeseries. *Demand* - conventional, or can use demand/weather models to create equivalent demands for generated events. *Investment* – Events are used to test the programme; either by comparing the resilience of similar NPV programmes, or to look at the cost implications of achieving LoS commitments and resilience to droughts outside of the historic record.
3 – The 'Fully Risk Based' Plan	Companies use modelling methods to evaluate a full range of drought risks to their supply system, supported by more sophisticated approaches to matching this with demand *variability*. This is used to generate a 'best value' WRMP at a level of resilience that is linked to Levels of Service and the Drought Plan.	*Supply* – companies use generated data sets to explore the yield response to drought severity and patterns. Inputs to system-simulation DMTs are based on probabilistic sampling of the drought response. *Demand* - demand variability to drought is incorporated, although methods/complexity can vary. *Investment* the Plan is developed to represent the 'best value' response to overall drought risk, according to the Company's stated LoS and drought resilience.

We consider that our plan is at least at risk composition 2, as it is a "resilience tested" plan (see Table 2). In addition to our baseline supply forecast we have used our stochastic drought events to test our plan and examine the implications of more severe droughts on our investment programme through the decision making we describe in our dWRMP. This choice of risk composition reflects the complexity needed as part of our wider decision making approaches (see appendices D and E of our dWRMP for more information).

We used the stochastic drought analysis outlined above to investigate drought resilience across all of our conjunctive use WRZs (Strategic Grid, Nottinghamshire, Forest and Stroud, North Staffordshire, Shelton and Wolverhampton) and some of our groundwater only zones (Newark, Stafford, Bishops Castle and Mardy). We consider that the zones outlined above have a "resilience tested" risk composition. We did not carry out the stochastic drought assessment across the remaining groundwater only WRZs (Whitchurch and Wem, Llandinam and Llanwrin, Ruyton, and Kinsall) and they are therefore risk composition 1- "conventional plan". These WRZs were not included in the stochastic drought assessment as these zones to have low vulnerability to drought. The deployable outputs in these zones are not typically constrained by water level but by other constraints, such as pump depth, due to the nature of the sandstone aquifers. This follows the same approach as our climate change assessment in these groundwater only zones. The WRZs not included in this assessment account for a very small percentage (approximately 2%) of our overall company level DO.

Table 2: Risk composition used for each WRZ

Water Resource Zone	Risk composition	Comment
Strategic Grid	Composition 2 - "resilience tested"	Conjunctive use WRZ
N. Staffs	Composition 2	Conjunctive use WRZ
Forest and Stroud	Composition 2	Conjunctive use WRZ
Shelton	Composition 2	Conjunctive use WRZ
Wolverhampton	Composition 2	Conjunctive use WRZ
Nottinghamshire	Composition 2	Conjunctive use WRZ
Newark	Composition 2	Groundwater only WRZ – we assessed that these could be vulnerable to drought
Stafford	Composition 2	As above
Bishops Castle	Composition 2	As above
Mardy	Composition 2	As above
Whitchurch and Wem	Composition 1- "conventional plan"	Groundwater only WRZ – we assessed this WRZ as having low drought vulnerability
Llandinam and Llanwrin	Composition 1	As above
Ruyton	Composition 1	As above
Kinsall	Composition 1	As above
Rutland	n/a	Entirely supplied by bulk import – see appendix A of our dWRMP for more information on these.

2.1.6 Drought interventions and their impact

Tab 10 of the WRMP data tables provides a link between the WRMP and Drought Plan. Within this section of the WRMP tables we report a range of deployable output values from our drought resilience modelling. We based these DO numbers on a number of model runs which includes DO for historic droughts in our baseline data (1920-2014) and for a number of stochastic drought scenarios with return periods between 1 in 200 years and 1 in 1000 years. In both cases we report DO values for three

conditions- (1) no demand saving restrictions, (2) with demand saving restrictions e.g. demand savings linked to Temporary Use Bans (TUBs), and (3) with drought permit/order interventions e.g. measures taken during a drought to increase water abstractions above permitted limits. Modelling DO under these varying conditions allows us to understand and quantify the benefit of demand saving measures and drought permit/ order interventions under a range of drought conditions. We outline all of the drought trigger zones and associated interventions/ actions in section 2 and section 7.2.

Our baseline supply forecast does not include drought permits or drought order interventions but it does include several 'lower level' drought actions. For example, we list several drought management actions in our drought plan that we consider when we are in drought trigger zones C or D. For example, our drought plan contains some options that involve reversal of flow along a bidirectional link. Where we model these links as bi-directional in Aquator, this option is built into our base DO. Another example of drought management actions being part of our baseline DO is actions that involve 'maximise source X'. Operationally, during wet or average years we may choose not to use a certain source if we have other, possibly, cheaper, sources of water but in a drought we would use it if our drought action team decide we need it. Our Aquator modelling represents this scenario by using low cost sources first but, when resources become scarcer, it overrides the financial considerations and uses sources based on their availability instead of their cost. We note that there are other drought management actions such as 'raise awareness internally' or 'speak to EA/ neighbouring companies' that are important actions but do not necessarily bring direct yield benefits. We provide a table in section 7.2 of this plan that shows which actions have yield benefits and what we estimate these to be.

2.1.7 Drought Resilience Statement

We have planned our system so that it can withstand any drought that is as severe as those we have seen over the last 95 years and up to a 1 in 200-year event. We have also tested our investment proposals against a range of plausible future droughts not seen in the historic record that have quantified probabilities for drought severity and duration. We are confident that our plans represent a good balance between cost, environment and resilience to severe droughts. Our stochastic drought modelling indicates that we are resilient to a 1 in 200-year drought without the need for emergency drought orders.

2.2 Triggers, Data sources and arrangements

There are a number of indicators that a drought period is developing. The following indicators affect the hydrological conditions within our region:

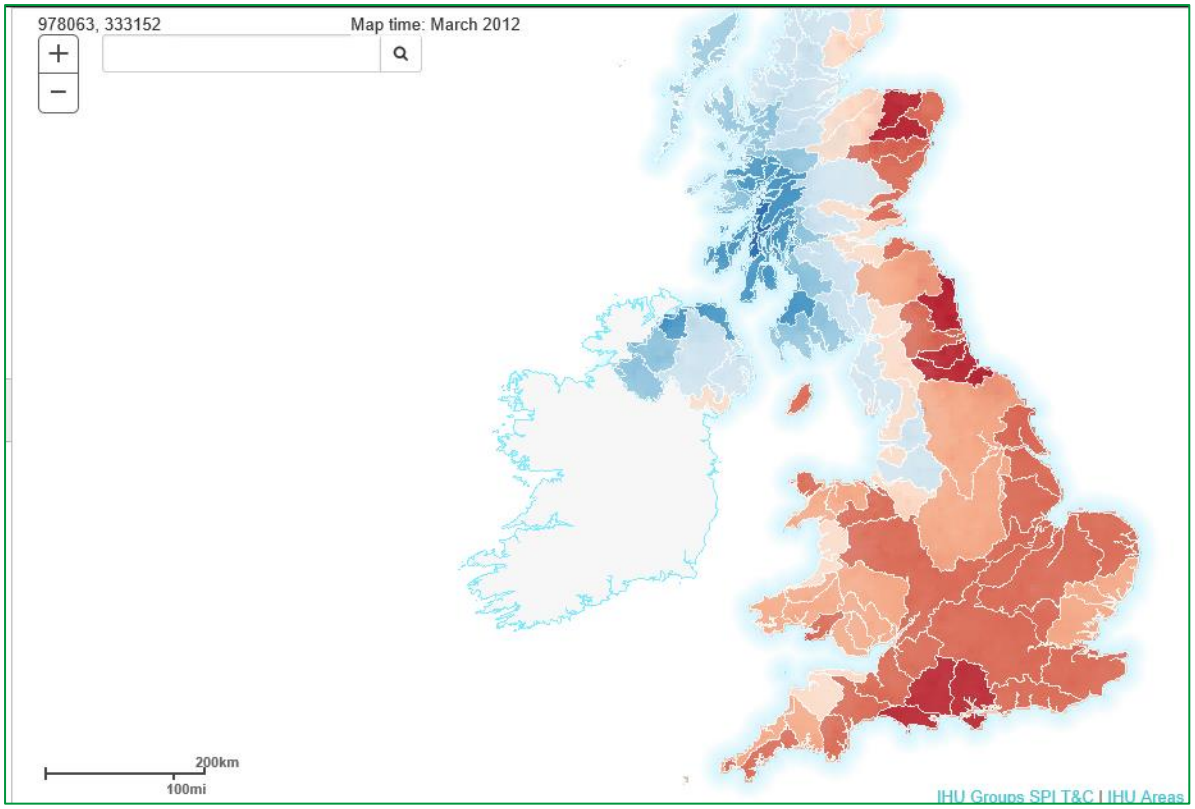
- Rainfall deficits, particularly comparisons against long term averages (we discuss this further in section 3.3.3)
- Soil moisture deficit (SMD) - high soil moisture deficits occur when soils are dry. This indicates that drought conditions may be building and demand could increase
- Low river flows; however, our resource rivers are, with only one exception, supported by impounding or pumped fill reservoirs. It is because of this that our operations can generally survive a short sharp drought, such as the one in 2003, when river flows fell markedly
- Falling groundwater levels

- Falling reservoir storage.

We are grateful to both the EA and NRW for providing us with some of the information listed above. For example, the EA provides us with regular flow data at many locations and NRW provides flows for sites such as the Wye at Redbrook. Should we wish to vary any of these arrangements then we will contact the relevant organisations. It is important to all parties that we continue to share the most accurate and up to date information that is available. This collaborative working helps us to make decisions with the best information possible.

We also use publicly available data such as that found in the Centre for Ecology and Hydrology (CEH) UK drought portal (see references for link). The figure below shows a map from this portal in which we have selected the March 2012 spatial data:

Figure 10 – Drought portal information on CEH portal



As part of our normal operations we monitor the indicators listed above and we also monitor:

- Levels of customer demand
- Leakage and
- The quantities of abstraction at surface and groundwater sources, for instance we monitor the amount of our annual licence that we have used.

2.2.1 Surface water triggers

We manage droughts by using reservoir drought triggers in the following three water resource zones (WRZs):

- Strategic Grid
- Nottinghamshire and
- North Staffordshire

Taken together, these three WRZs make up over 85% of the total population of our region. We have derived drought action triggers for the major reservoirs in our Strategic Grid and North Staffordshire WRZs. We also include the Nottinghamshire WRZ here as it receives a significant supply from the Strategic Grid. Therefore the water resources position in the Nottinghamshire zone depends upon the resources position in the Strategic Grid. We describe the approach that we take in our other WRZs in section 2.2.2.

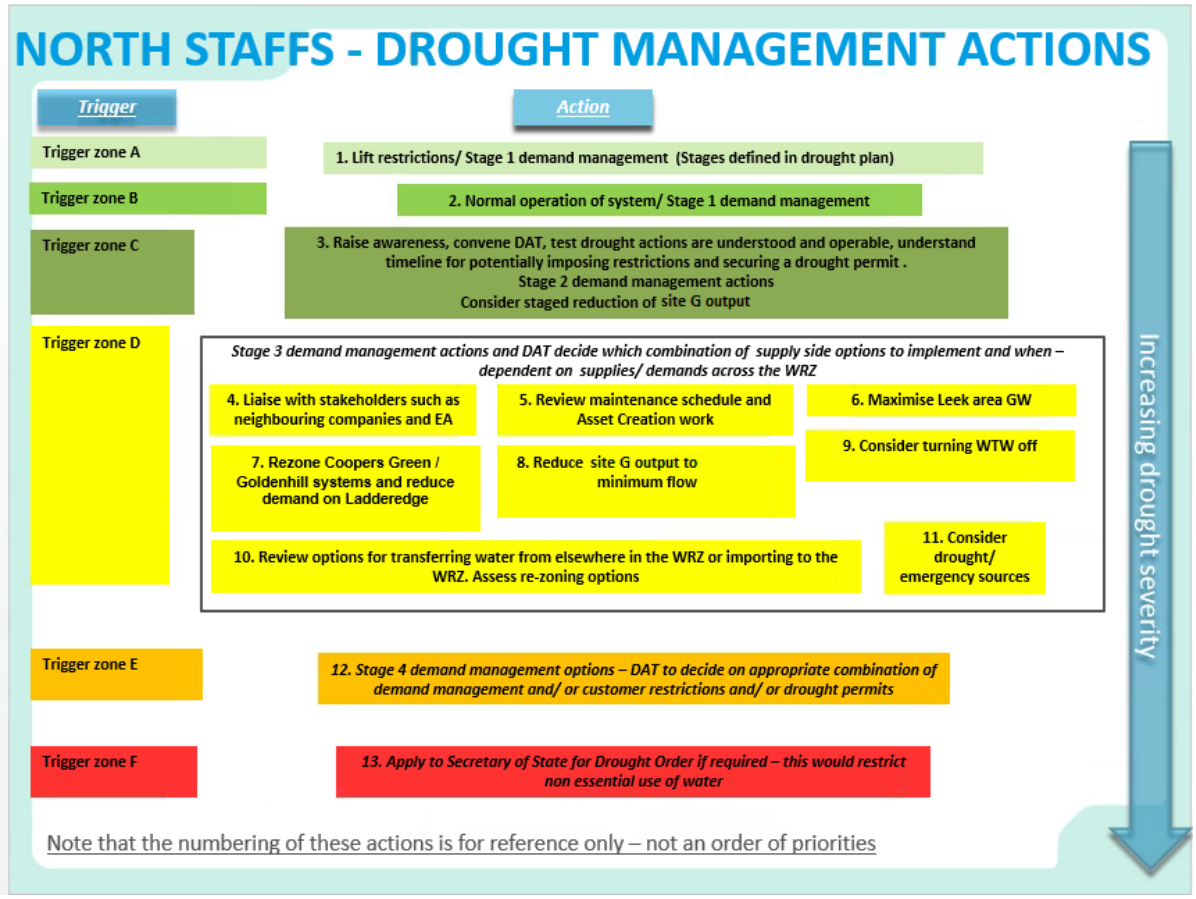
In the three WRZs listed above we regard the variation in reservoir storage as the fundamental, operational measure of any drought situation. We base our drought triggers on this (an example of these drought trigger zones can be seen later in this section and the complete set are presented in section 7.2).

We use surface water sources as drought action triggers only when they are of strategic importance. We consider that our larger raw water reservoirs or reservoir groups are strategic whereas our smaller sources are not. For example, we own and operate numerous service reservoirs which store treated water and provide supply for localised areas. These assets are not strategic in nature and it is not appropriate for us to use them as drought triggers.

In order to take the appropriate drought management action at the correct time we monitor reservoir levels and quickly identify when any of these levels enter into the specified trigger zones. As a drought situation develops there is a risk that storage will fall through the predefined trigger zones. However, we are proactive and instigate a number of operational responses to try to head off any issues before storage falls too far. This is part of our BAU (Business As Usual) operations. Taking this action early does not guarantee that storage will recover but it puts us in the best possible position if the lack of rainfall were to continue. The responses we take when as a result of indicators crossing triggers are both supply-side and demand-side. This means that they either increase the amount of water that we have available or reduce the amount that we need to supply.

Figure 11 illustrates the operational measures we may take in North Staffordshire as Tittesworth reservoir storage reduces and passes through the trigger zones. We have provided a summary of all surface water data triggers and drought management actions in section 7.2.

Figure 11 - Decision flowchart showing drought management actions for North Staffordshire



Since we published our 2014 drought plan we have reviewed our reservoir drought trigger zones. Figure 12 shows the drought trigger zones for Tittesworth reservoir in North Staffordshire:

Figure 12 - Graph showing drought trigger zones for North Staffordshire

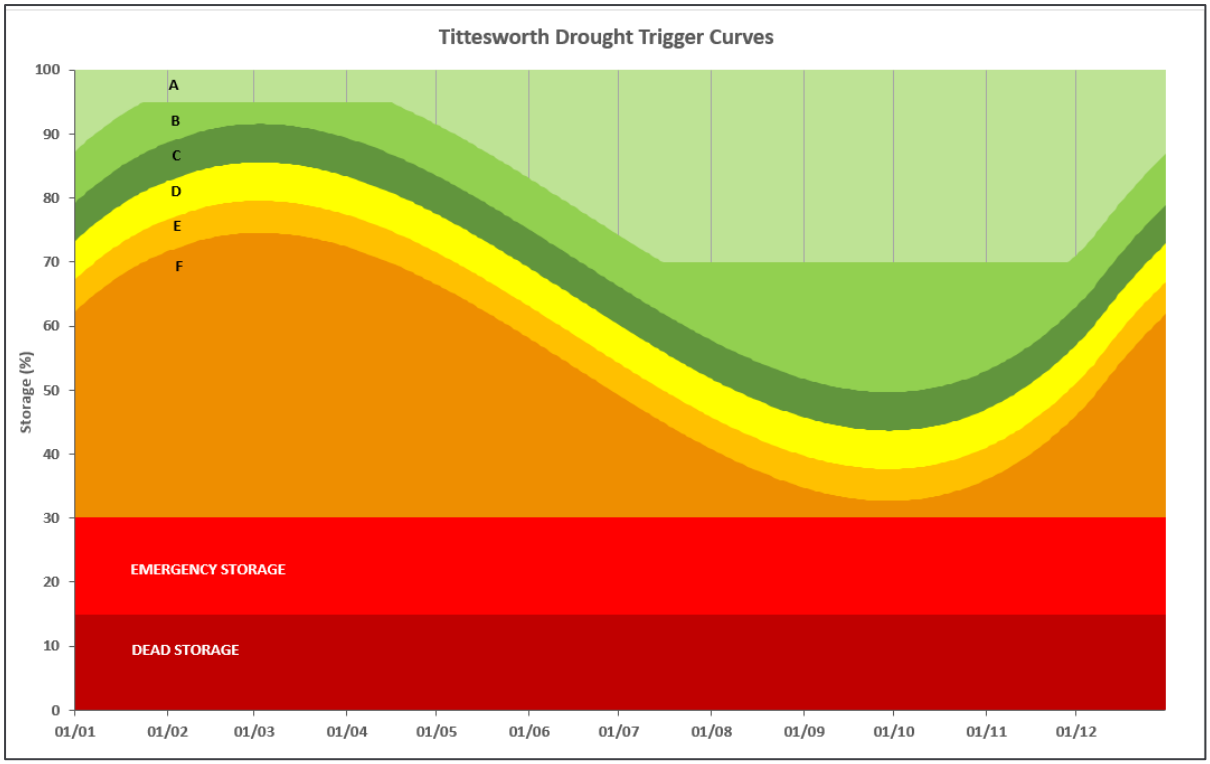


Table 3 - Table showing definitions of the drought trigger zones

Drought trigger zone	Comment
A	Above normal* - storage is above average for the time of year.
B	Normal *- storage is in the average range for the time of year.
C	Below normal* - storage is below average for the time of year.
D	Low storage - storage is low for the time of year.
E	Notably low storage* – storage is notably low for the time of year. If storage is in this zone for more than 7 days between April and October we expect to implement a TUB. On average, we would not expect more than 3 of these in 100 years. We may also need to implement drought permits in this zone.
F	Exceptionally low storage* – storage is exceptionally low for the time of year. In this zone we consider, and potentially implement, drought orders to restrict non-essential demand.
Emergency storage	If storage ever reached this level we would refer to our emergency contingency plans rather than the drought plan.

**Although these terms are similar to those used in EA water resources situation reports the way that the triggers have been derived and the associated return periods are different.*

The reason for drought trigger zones is to alert the business and our stakeholders when we expect to implement drought management options. In particular we use them to trigger potential implementation of temporary use bans (TUBs), drought permits and/ or drought orders. Since we produced our 2014-19 drought plan we have reviewed and updated the drought triggers that we use.

To review our reservoir drought triggers we used a water resource model called Aquator. Updating our drought triggers is one of many improvements and updates that we have made to our water resources planning capability since PR14.

This company-wide Aquator model includes all five of the reservoirs or reservoir groups for which we produced revised trigger curves. These are:

- Carsington and Ogston
- Derwent Valley
- Elan Valley
- Tittesworth and
- Draycote.

We have used the updated drought trigger curves for all our PR19 water resources modelling. This modelling informs not only this drought plan and our internal drought management processes but also our WRMP and business plan submissions which we are preparing for PR19.

The process we followed had the following stages:

i. Review of approach used to inform PR14 modelling. This compared our method with another method being used in the industry and concluded that the approach we used for PR14 better met our requirements

ii. Analysis of the Aquator modelled results for the 95 year run with no demand restrictions applied on customers. It was essential for this run not to have demand restrictions in as it would mean that the previous curves would have an effect on the generation of the new, improved curves

iii. Comparison and verification of the curves to take account of:

    - modelled crossing frequency of curves
    - target crossing frequency, which is based upon our stated levels of service,
    - overall system behaviour (in terms of percentiles) and
    - historical records of drawdown

iv. Internal 'sense check' of the curves against operational experience and knowledge. We then used these finalised trigger curves to produce the trigger zones shown above and in section 7.2.

One example of a significant change to the trigger curves we are now using compared with the 2014 ones is that we now have a much larger trigger zone E for Draycote than we previously did. We think that this is an improvement as the revised Draycote zone E now has more days' storage in it to allow us to take meaningful drought management actions.

Appendix 7.4 describes the review we carried out to determine what levels we should use for the dead/ emergency storage in our (strategic) raw water reservoirs.

2.2.2 Triggers in water resource zones that do not have reservoir triggers

In the 12 WRZs that have no reservoir triggers we use a different approach. One of these WRZs is our Forest and Stroud water resource zone (WRZ). This zone does not rely directly on reservoir storage and it receives raw water from our River Wye abstraction at Wyelands and from groundwater sources. Although we usually refer to this river abstraction as Wyelands some documents refer to it as the Lydbrook abstraction. Both names refer to the same abstraction. During wet or average conditions we abstract up to 55 Ml/d at this site but our maximum abstraction becomes restricted if storage in the Elan Valley reservoirs is low and the 'hands off flow' conditions in our licence are triggered by low flows at Redbrook gauging station (GS) falls.

Table 4 illustrates the licence conditions that currently govern this abstraction. However, note that revised licence conditions will apply from 1st April 2018 onwards. These new conditions were agreed as part of our work with UWAG (Usk and Wye Abstraction Group) before we published our WRMP14. This was a collaborative working group which comprised of Dwr Cymru Welsh Water (DCWW), the Environment Agency (EA), Natural Resources Wales (NRW), the Canals and Rivers Trust, the Wye and Usk Foundation and ourselves, Severn Trent Water. Through this group each party aligned their modelling assumptions in order to agree a future regime of abstraction and discharges in the River Wye catchment. This meant that we met the requirement of the Habitats Directive driven RoC (Review of Consents). We have mentioned this RoC here for information but it does not directly affect how we manage drought.

Table 4 - Rules governing our River Wye abstraction

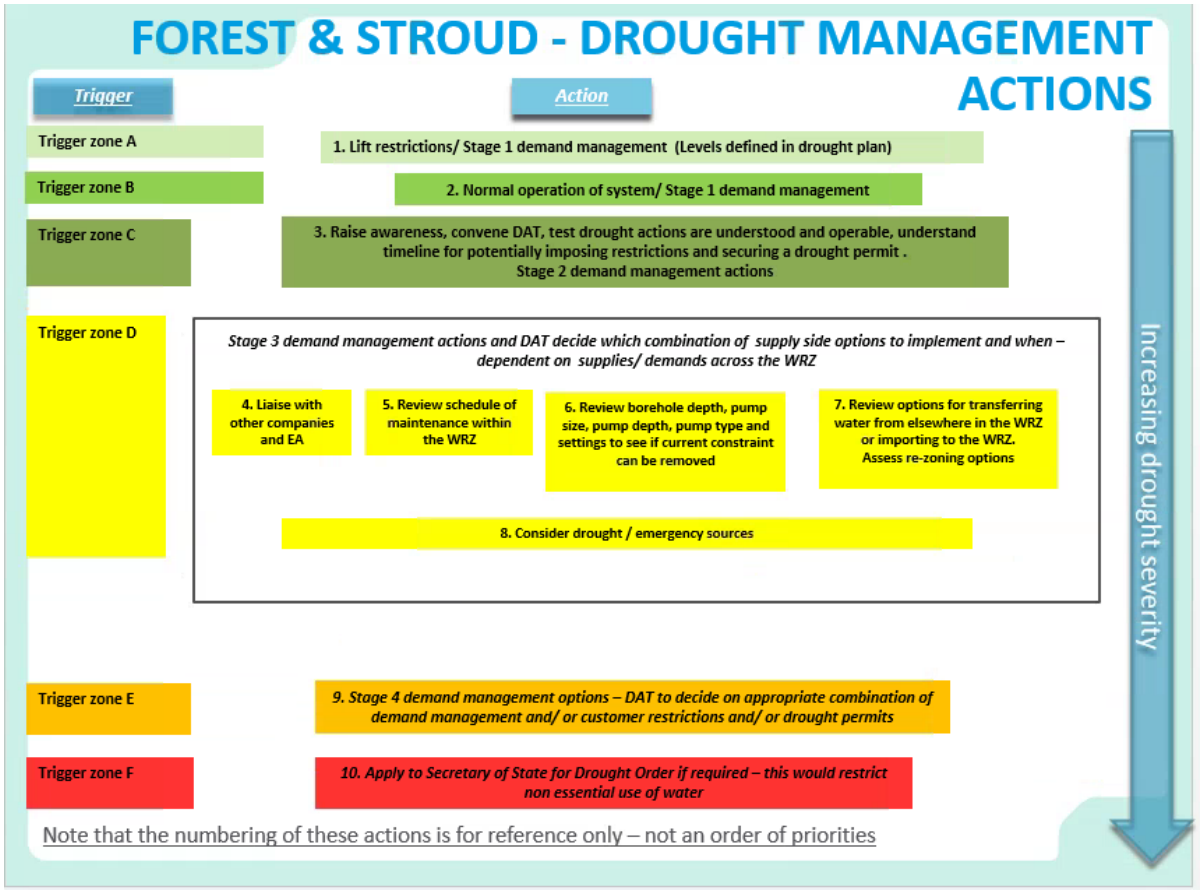
Redbrook GS Flow (Ml/d)	Elan Storage	Regulation release for Lydbrook (M/d)	Maximum Lydbrook abstraction (Ml/d)	Max Transfer to Ross	Max Transfer to STW
> 1,400	Independent of storage	Not required	55.0	9.1	45.9
1,209 – 1,400			45.5	9.1	36.4
< 1,209	Zones 1 & 2	27.3	45.5	9.1	36.4
	Zone 3		39.8	9.1	30.7

The combined outputs of the groundwater sources in this WRZ are not sufficient to meet demand. If we forecast that there is a high drought risk to the groundwater sources in our Forest and Stroud WRZ, it becomes more important that our Wyelands abstraction is not limited.

This river abstraction is limited when river flows at the Redbrook gauging station are low. Our abstraction licence at Wyelands is also linked to the storage in the Elan Valley reservoirs. However, any decision our drought action team (DAT) makes for this WRZ will be triggered primarily by the river and groundwater levels. The storage in the Elan Valley reservoirs is only a secondary trigger.

We have described our 'normal' operation in this WRZ earlier. The following decision flow chart shows our approach to making drought management decisions and the drought triggers that we use in our Forest and Stroud WRZ:

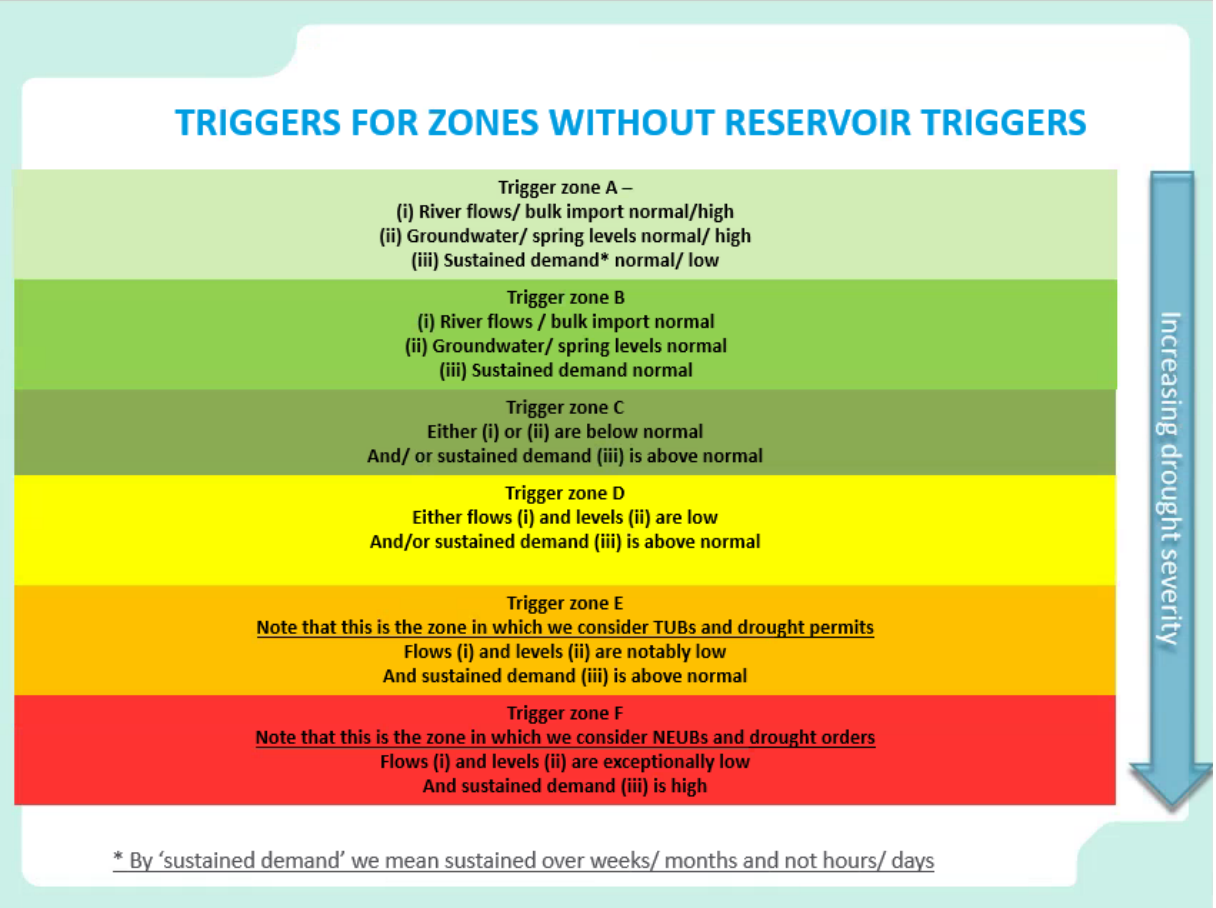
Figure 13 - Decision flowchart showing drought management actions for the Forest and Stroud water resource zone



These drought management options include the Wyelands drought order, which we have described in more detail in section 3.3.4 of this plan. We have included more detail for these and all of our drought management actions in the completed tables in section 7.2.

We have developed some high level 'triggers' for the Forest and Stroud WRZ and for the other 11 WRZs that do not have reservoir triggers. We have included these in the figure below:

Figure 14 – Illustrative triggers for WRZs without reservoir triggers performance

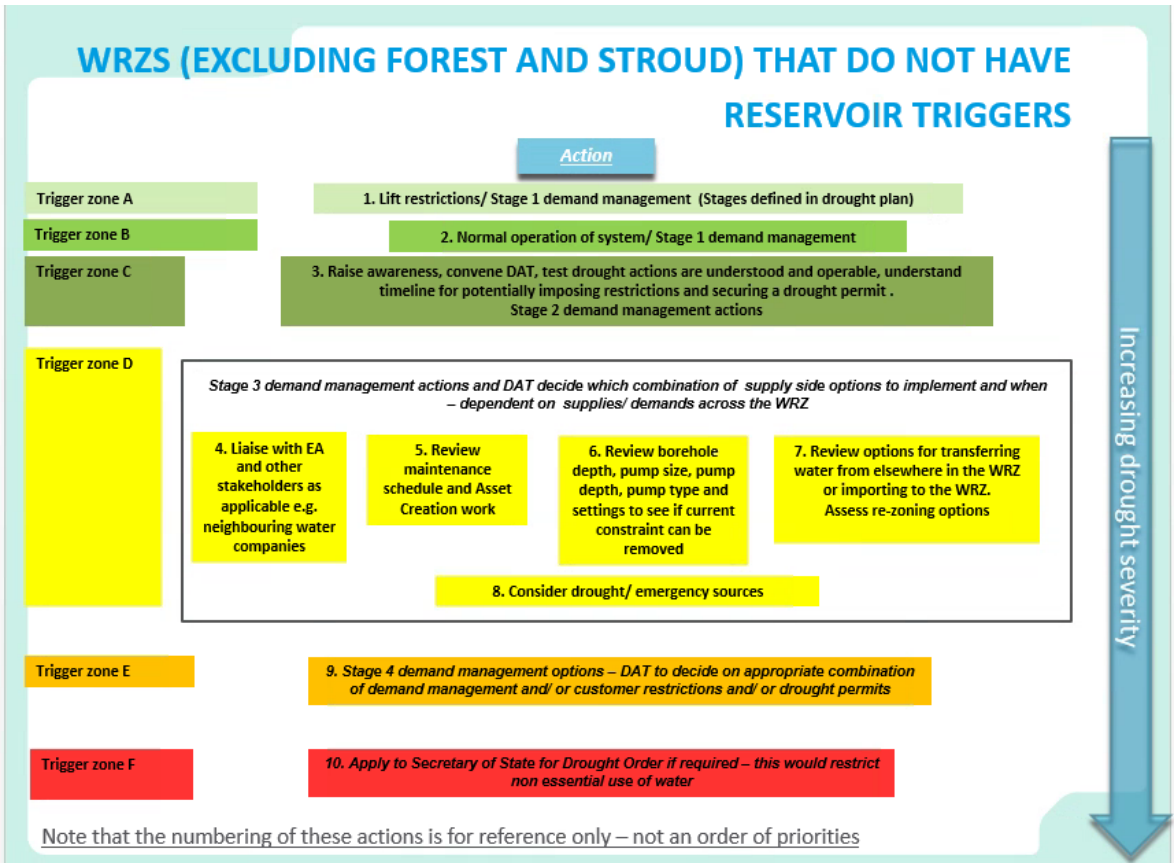


The 11 WRZs not yet mentioned are as follows:

- Bishops Castle
- Kinsall
- Llandinam and Llanwrin (which is entirely in Wales)
- Mardy
- Newark
- Rutland
- Ruyton
- Stafford
- Shelton (part of which is in Wales)
- Whitchurch and Wem
- Wolverhampton

These 11 WRZs predominantly receive their supply from either groundwater, bulk imports, river abstractions or a combination of these sources. The only difference between these WRZs and the Forest and Stroud WRZ is that we do not expect to need a drought order to increase supply in any of these WRZs. Our approach to making drought management decisions at specified triggers in these 11 WRZs is shown in the following flow chart:

Figure 15 - Decision flow chart showing drought management actions for our other water resource zones



We have included more detail for these drought management actions in the completed tables in section 7.2.

2.2.3 Groundwater triggers

Although, we track groundwater levels and consider them to be useful drought indicators, we do not formal groundwater triggers in the way we do for reservoirs. Although, as shown in figure 14 we have high level equivalents that serve a similar purpose. This is because individual groundwater sources have too localised an impact for us to use them as strategic triggers. The way that groundwater sources respond to droughts is very different to the way that surface water sources respond. So although we still account for drought risk in these sources, we manage the risk in a slightly different way.

The mechanism that we use to manage groundwater drought risk involves a combination of monitoring, judgment and decision making. We consider the present and forecast conditions and how effective any action would be. The decision flow chart in section 2.2.2 illustrates this process. We would not expect a single low level to trigger significant drought management actions. Groundwater sources have a determined minimum reliable output and in most cases drought actions are dictated by an increase in local demand beyond this level or the deteriorating performance of other assets/storage. The process for monitoring groundwater and making decisions applies to all of our groundwater sources, including those in our 'groundwater-only' water resource zones.

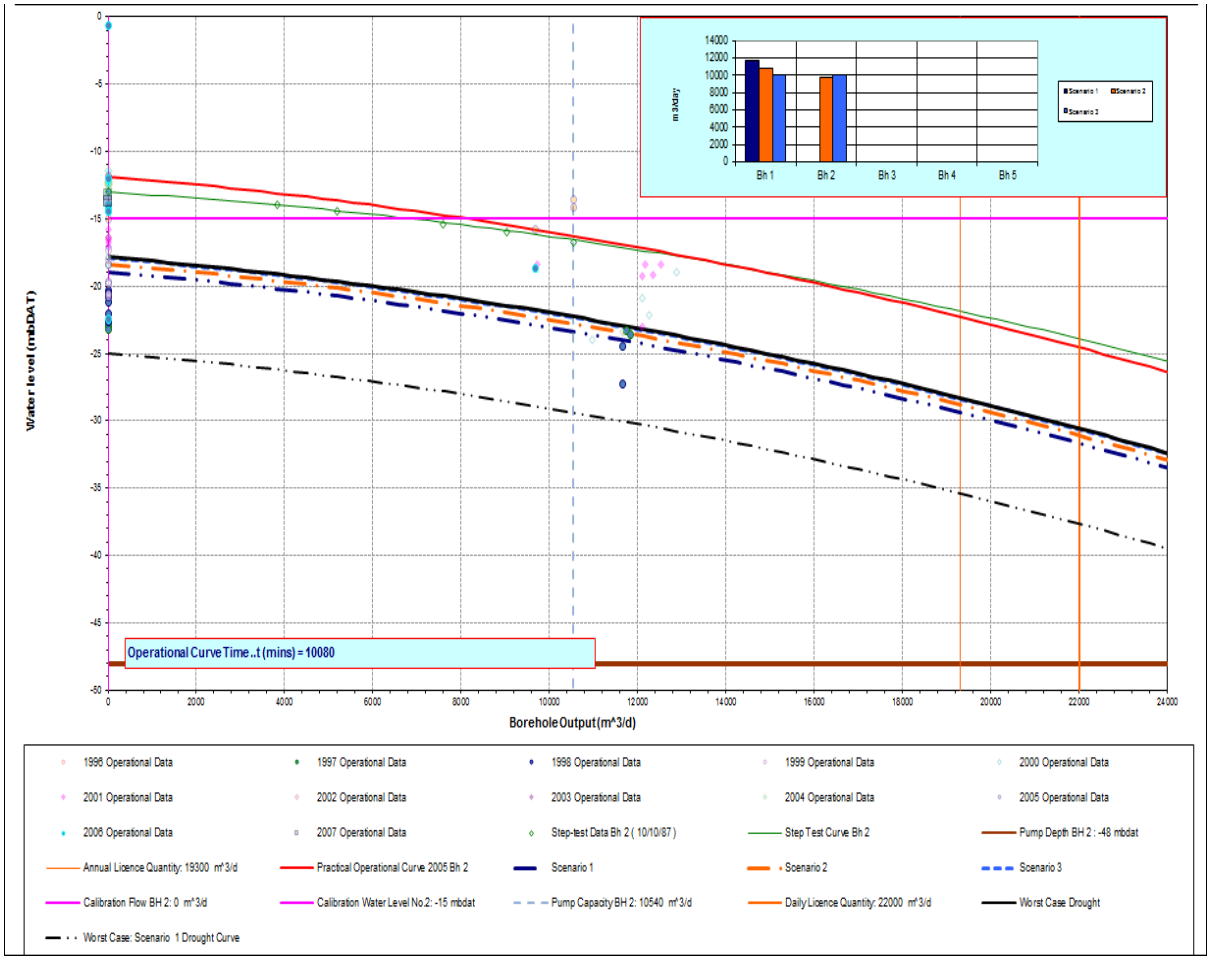
We use a combination of telemetry and manual dips to monitor our groundwater sources. We also use external sources of information on groundwater levels to monitor approaching drought conditions. For example, we use information from the Centre for Ecology and Hydrology (CEH) or EA websites that show the groundwater picture for the Midlands region. We use data from regionally representative observation boreholes, such as Heathlanes, to support our drought indicator monitoring. When levels in observation boreholes start to cross into "below normal" conditions (as detailed in the Water Situation Report), we inform our DAT.

We have some flexibility in how we operate groundwater sources. Most of our pumps are 'fixed speed' which means that the instantaneous flow is constant but we can vary the number of hours in a day that we operate them for. If demand increases in a dry year or a drought year we would expect to run these pumps for longer to maintain levels in our service reservoirs. We also have some flexibility within WRZs or within individual groundwater sources there may be multiple boreholes from which we can pump water. We switch between these to meet demand and react to outages and other operational factors such as cost.

As a general rule our sandstone sources are more drought resilient than our limestone sources. For context, we abstract much more from sandstone than we do from limestone. When the drought risk is heightened we present groundwater level information to our DAT on a map to show where the risks to supply from our groundwater sources are greatest. When our groundwater team notices any drought problems relating to our groundwater they raise these concerns at our DAT.

As part of our PR19 work we have validated and updated all of our groundwater DOs and source performance diagrams (SPDs). These SPDs plot operational and drought water levels against site output. They help to provide a qualitative assessment of risk. We have included an example SPD below:

Figure 16 – Illustrative source performance diagram (SPD) – Borehole in Staffordshire



This SPD is for a borehole in Staffordshire. The transition from zone A to F on the SPD is not absolute as the performance of many groundwater sites is dependent on the operational use of the borehole. The predicted drought curve (and trigger levels) may be influenced by the number of boreholes in operation, the duration of pumping, the pumping rates at that specific time and also regional influences.

It is important to remember that many of our groundwater sources are not constrained by level. The majority of our groundwater sources are located in Permo-Triassic sandstone and this does not exhibit significant variations in water level. As a result we consider that these sources are resilient to groundwater drought impacts. Generally, the difference in water level between wet and the most severe drought years is in the order of 5m to 7m. Therefore the risk of these groundwater levels falling below the current drought bounding curve (i.e. moving into Drought Management Action Stage D, or below), is minimal.

In most cases, even if groundwater levels fall below the drought bounding curve, the output of the source will not decline. For example, where the source is licence constrained; groundwater levels may fall tens of metres below the drought bounding curve before the constraint changes from being the licence, to being a physical aquifer constraint (such as Deepest Advisable Pumped Water Level).

For our groundwater DO assessments we have followed current best practice. This is as outlined in both the 1995 UKWIR A Methodology for the Determination of Outputs of Groundwater Sources (95/WR/01/2) and 2000 UKWIR Unified Methodology for the Determination of Deployable Output (00/WR/18/1). We have assessed our groundwater sources' deployable output in the worst drought season and the worst case drought week. We have taken this approach for all of our groundwater sources across the company and use the same approach in both England and Wales. We address the topic of droughts that are more extreme than any we have experienced in the past and how they affect our groundwater sources earlier in this plan (section 2.1).

2.3 Forecasting

As part of our business as usual (BAU) activity we produce forecasts of how we expect water resources to change in the month ahead. For example we do this for key reservoir sources such as the Derwent Valley reservoir group. We circulate these water availability packs monthly and we share the raw water availability section of this with the EA. When we produce these packs we use all of the latest hydrological and operational information we have as well as weather forecasts from sources such as the met office. In addition, we refer to the latest hydrological outlook (see reference to website in references section).

2.4 Links to actions/measures with timing information

We have described the actions we consider when resources fall into certain drought trigger zones in section 2.2 and section 3. We have included all of the reservoir drought trigger zones and the associated drought management actions in the appendix 7.2.

In order to retain flexibility we do not specify exactly when we would take each drought management action. We allow our DAT to choose which action or combination of actions is most suitable when resources are in a specific drought zone. For the majority of drought actions we do not specify exactly how long they would take to implement as this may vary depending on factors like customer demands, outages and water availability in different locations. However, there are some drought management actions such as drought permits/ order and customer restrictions where we have given estimates of lead in times and/ or implementation timings. Refer to sections 3.1 and 3.3 for this information.

2.5 Testing our drought triggers

Modelling various drought events including those on the observed record and synthetic droughts provides us with a number of scenarios to test our drought triggers and proposed actions (as described in section 2.1). The following three sub-sections present plots of modelled reservoir storage data with our drought trigger zones for reservoirs across our Strategic Grid and North Staffs WRZs using three different drought scenarios. Each drought event has unique characteristics which allow us to evaluate how our drought triggers and proposed actions perform under different scenarios. For this analysis we have selected an event from our baseline modelling period (1995/96), a historic drought (1887/88) and a stochastically generated 1 in 200-year 30 month drought.

2.5.1 Baseline Data

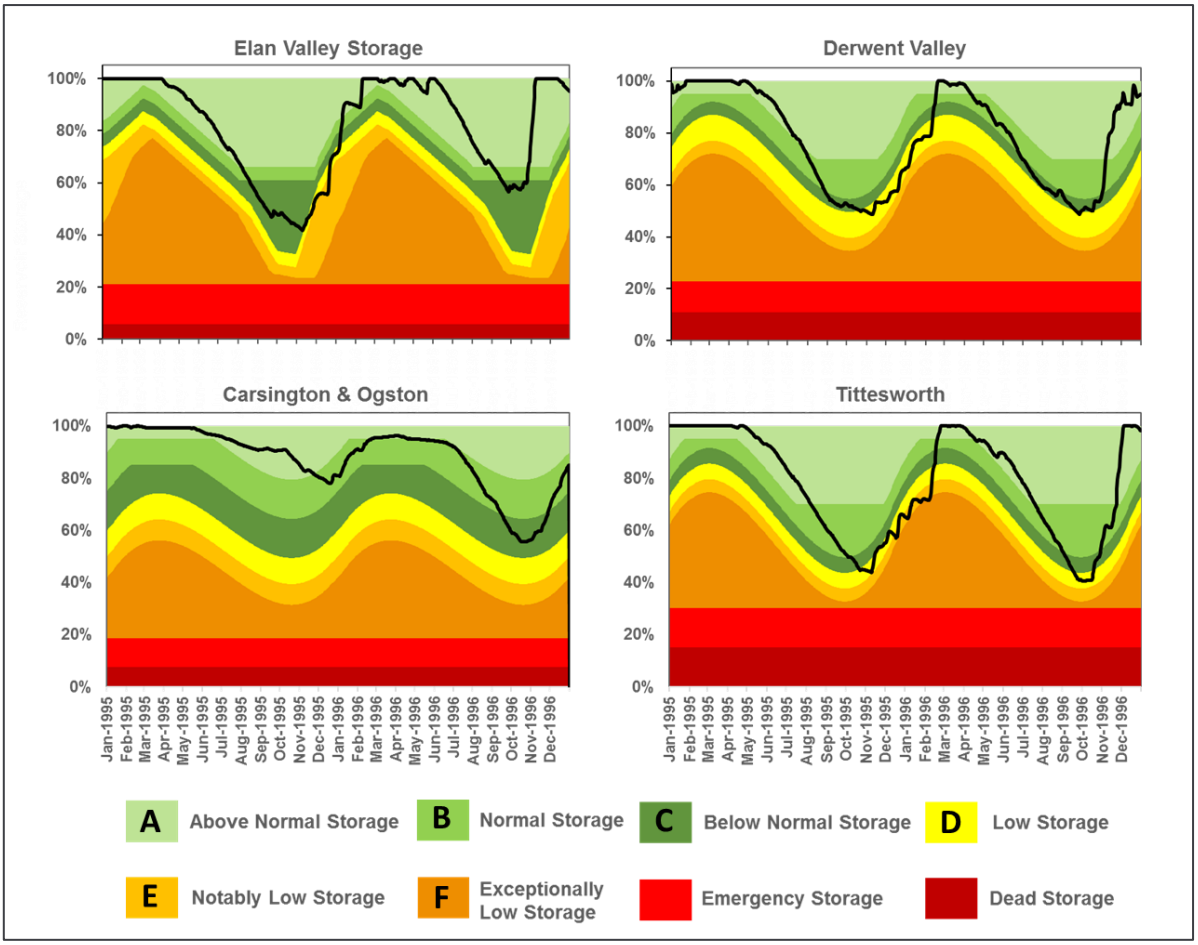
Figure 17 below presents the modelled storage of the Elan Valley, Derwent Valley, Carsington/ Ogston and Tittesworth Reservoirs during the 1995/96 drought. These plots highlight the variation of drought

impacts on our reservoirs with notable impacts on storage on the Elan Valley Reservoirs and Tittesworth Reservoir. Storage in the Elan Valley Reservoirs enters drought trigger E for 15 days in December 1995. Proposed drought actions under trigger zone E include the implementation of a TUB if reservoir storage enters trigger zone E for at least 7 days however, we limit the introduction of TUBs to the start of April to the end of October. In this scenario we would not impose a TUB on customers but would carry out other "stage 4" demand management actions as well as maintain our supply-side drought options which are associated with our drought trigger zone D (see Appendix 7.2 for more detail).

Modelled storage in Tittesworth Reservoir drops throughout 1995 reaching a minimum storage of 44% (drought trigger D) in October 1995. Despite some storage recovery during the autumn/winter of 1995/96 drought trigger zone F is crossed for 8 days in January 1996. At this stage drought measures in the North Staffordshire WRZ include applying for a drought order to introduce a non-essential use ban (NEUB) if appropriate. In this scenario it is likely that we would not impose a NEUB due to the time of year that trigger F is crossed but we would continue to monitor the situation very closely and be prepared to submit a drought order application to the Secretary of State.

In the Derwent Valley Reservoirs modelled storage reaches a minimum of 48% and remains within drought trigger zone D from October 1995 to February 1996. Drought management actions under trigger zone D include considering the use of our drought supply sources and reducing water treatment works output. In this scenario (Figure 17) the drought impacts on modelled storage in Carsington/ Ogston Reservoirs is less severe reaching trigger zone C. The drought actions associated with in trigger zone C include "stage 2" demand management actions and the convening of the Drought Action Team (DAT). Note that the black lines (which represent modelled storages in the figure below) reflect the impact of the drought actions we have mentioned in this plan with the exception of the drought permits and the drought/ emergency sources.

Figure 17 - Modelled reservoir storage and drought triggers for the 1995/96 drought

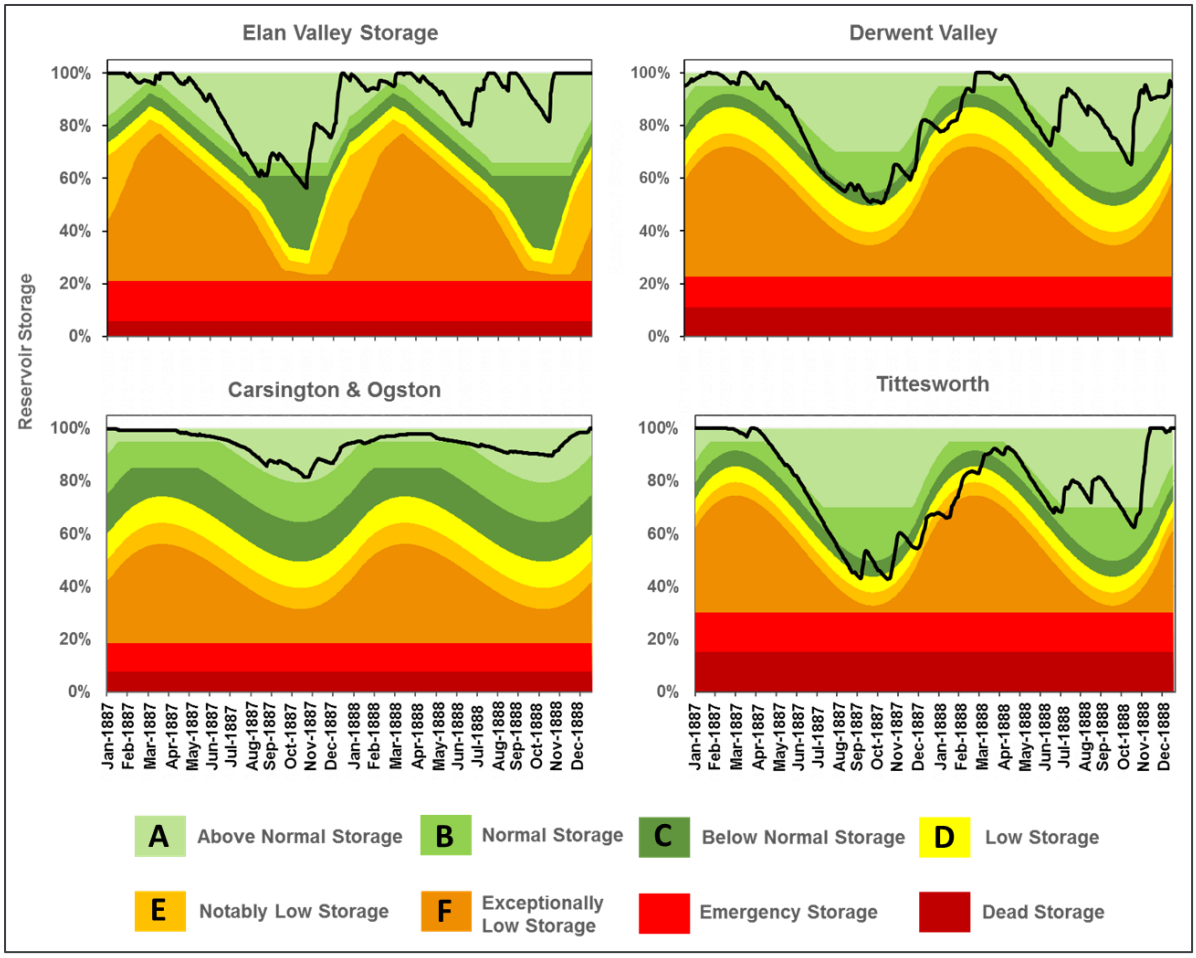


2.5.2 Historic Drought

Figure 18 shows the modelled reservoir storage for four reservoirs during the 1887/89 drought this scenario was selected because innovative research in collaboration with the University of Liverpool highlighted the severity of this drought event in the north of our region (see section 2.1.1 for more information). This is reflected in the modelled reservoir storage of both the Derwent Valley and Tittesworth Reservoirs. During this event Tittesworth reservoir modelled storage reaches drought trigger F for 17 days in January 1888. As outlined in section 2.5.1 our drought actions under trigger F include the option to impose NEUBs if appropriate. Again in this scenario it is likely that we not impose a NEUB due to the timing of the reservoir storage entering trigger zone F but would have an application ready to submit in order to impose a NEUB if storage level throughout January continued to decrease.

In the Derwent Valley Reservoirs modelled storage remains in drought trigger zone C for much of 1887 and entering zone D during the winter recharge period in January and February 1888. In this scenario there are no notable drought impacts on the storage levels in the Elan Valley and Carsington/ Ogston Reservoirs. This highlights the how the spatial variation of droughts in our region can have different impacts on our supply system.

Figure 18 - Modelled reservoir storage and drought triggers for the 1887/89 drought



2.5.3 Stochastic Drought

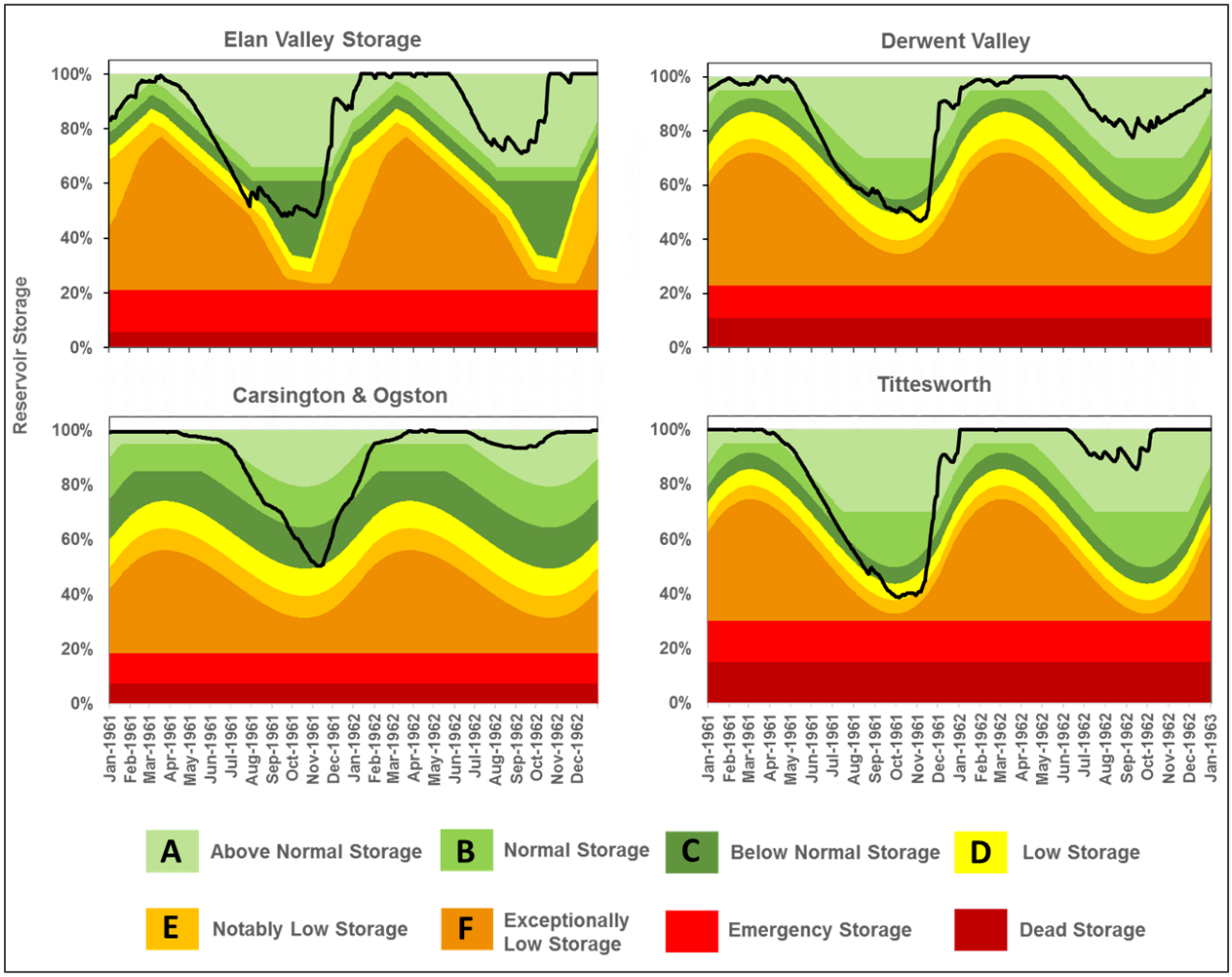
Figure 19 shows the modelled reservoir storage during a stochastically generated 1 in 200-year return period 30-month drought (see section 2.1.3 for more information). In the Elan Valley Reservoirs modelled storage falls rapidly crossing into drought trigger zone D in July 1961 reaching trigger zone E for 1 day at the end of July 1961. This is insufficient time to impose a TUB which is the management action linked to trigger zone E. There are a variety of drought management actions associated with drought trigger zone D including a review of scheduled works maintenance and changing operations at site G and the Reservoirs at site U to support storage in the Elan Valley reservoir system (more information can be found in Appendix 7.2). From August 1961 modelled storage in the Elan Valley Reservoirs improves remaining in trigger zone D until November 1961.

In the Derwent Valley Reservoirs modelled storage falls throughout 1961 crossing into drought trigger zone D in October 1961 and reaching a minimum storage of 46% in November 1961. Storage remains in trigger zone D for approximately 30 days. Possible drought management actions associated with trigger zone D include a number of options to maintain reservoir storage and the use of alternative supplies. Tittesworth Reservoir modelled storage also crosses and remains in drought trigger zone D for a substantial period from September 1961. In the North Staffordshire WRZ trigger zone D drought management actions include reducing output from Site L and reviewing water import options. Tittesworth Reservoir storage enters drought trigger zone E for 13 days in October 1961. This falls

within the criteria for implementing a TUB under the management action associated with drought trigger E. However, as this occurs at the very end of TUB implementation period (the start of April to the end of October) under this scenario we are unlikely to introduce a TUB but would implement other drought management actions linked to drought trigger D and discuss further actions that could be taken to minimise further reductions in reservoir storage.

Modelled reservoir storage in Carsington/ Ogston reaches its lowest level (50%) of the three scenarios presented in section 2.5. Modelled storage remains in drought trigger C for 4 months from September to December 1961. Under drought trigger C drought management actions include stage 2 demand management, the convening of DAT and a review of drought management actions.

Figure 19 - Modelled reservoir storage and drought triggers for a stochastic 1 in 200-year drought



3 Drought management actions

There are several actions we can take to manage the effects of a drought. We broadly split these into two groups: demand-side and supply-side. The supply-side actions increase the amount of water we have available during a drought. The demand-side actions are one that reduce the demand from our customers for water during a drought.

3.1 Demand-side actions

Our drought management action flow charts show how we would expect to phase in the different demand management options available to us. In addition, section 5 of this plan shows how decreasing reservoir storage triggers an escalation from 'Stage 1 demand management' to 'Stage 4 demand management'. Section 5 also provides detail on how we would increase our focus on demand management progressively in line with our communications strategy.

We consider that demand-side actions can be applied anywhere in our supply region. However, we will select the appropriate combination of options and target them depending on the extent to which different parts of our region are affected by drought. The following list shows some of the options available to us:

- Raise awareness within the company, convene DAT and alert works managers
- Liaise with the Environment Agency (EA) and other stakeholders about emerging drought and flexibility of available options
- Closely monitor demand, flows and abstraction/ releases
- Increase leakage detection
- Increase water conservation campaign (e.g. extra distribution of water saving devices, water audits for non-household customers).
- High profile promotion of meter option
- Media appeals for customer restraint

And, in the most severe drought conditions:

- Temporary water use restrictions, which are discussed in section 3.2 and, ultimately
- Restrictions on non-essential use through a drought order.

We consider that pressure optimisation and working with our customers to encourage the efficient use of water are routine activities that we carry out as part of our normal operation. This equates to 'Stage 1' demand management as defined in section 5. The water conservation campaign mentioned above is over and above our 'normal' water efficiency work. We have provided details of our water efficiency and leakage activities in the following sections.

3.1.1 Promoting Water Efficiency

We produce information leaflets and documents about how we are managing supplies and demand which are available on request or downloadable from our website www.severntrent.co.uk

We have run proactive and extensive campaigns promoting water efficiency since 1996. We have focused on those areas where we think we can achieve the most benefit. For domestic customers this includes toilet flushing, gardening and frost protection. We have also focused on education with the aim of engaging 700,000 customers by 2020. We have used multiple communication channels. This includes media, literature, advertising, the internet, face to face, and telephone contact, Facebook and Twitter. Our campaigns are a key component of the company's communications which aim to reduce long term demand by our customers. We will continue our extensive promotion of water efficiency.

In 2017, we ran a specific media campaign to understand whether additional promotion can drive more customer interest in water saving and increase uptake and installation of water saving products. Results of this activity are being used to update future communications strategies.

3.1.1.1 AMP 5

During AMP5, Ofwat set water efficiency targets for the industry which was in three parts

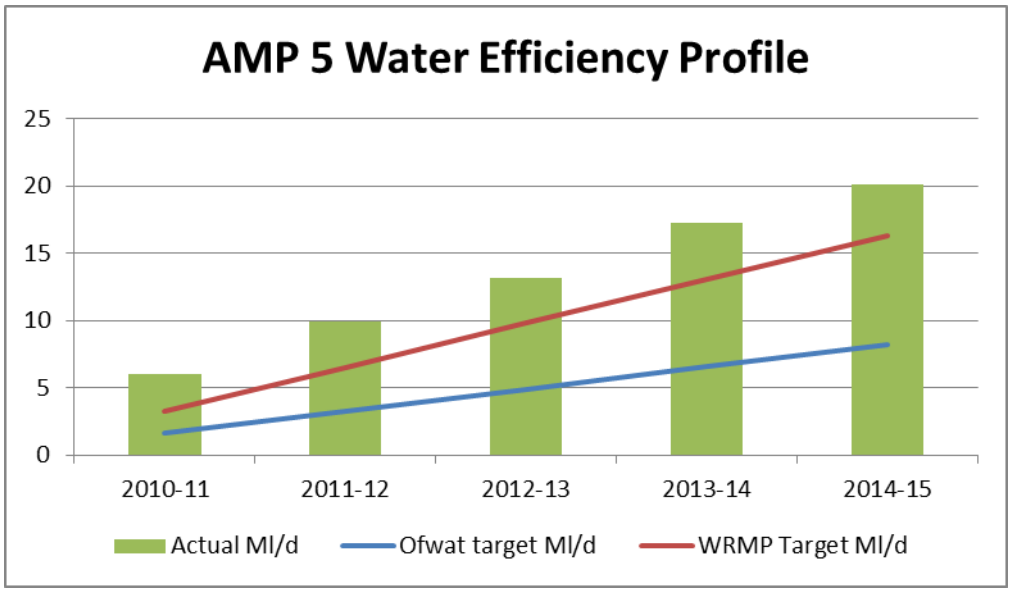
- A volumetric target which is an annual target to save an estimated one litre of water per property per day through water efficiency activity, during the period 2010-11 to 2014-15
- A requirement to provide information to consumers on how to use water more wisely
- A requirement that each company actively helps to improve the evidence base for water efficiency.

We outperformed our Ofwat target of 8.2Ml/d for the AMP by 11.94Ml/d delivering cumulative savings of 20.14Ml/d.

We were active members of the Water Efficiency Evidence Base steering group, and are now a key part of the newly formed National Water Efficiency Strategy Group and chair the Water Efficiency Collaborative Research Fund.

We led a collaborative project with Unilever aimed at better understanding shower use and effective interventions to reduce the volume of water used during showering.

Figure 20- AMP5 water efficiency profile

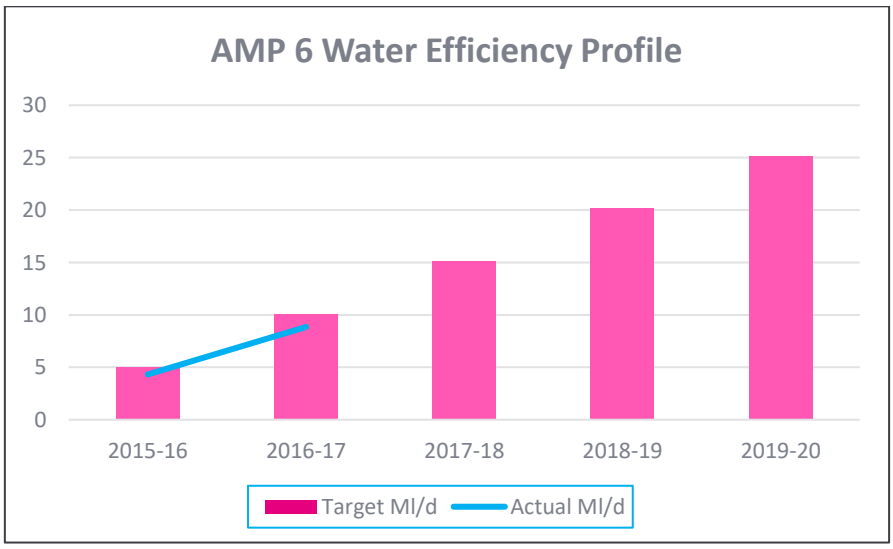


3.1.1.2 AMP6

For AMP 6 we set our own much more ambitious target to deliver 25Ml/d during the AMP which included 7Ml/d with our non-household customers. However, due to the introduction of retail competition for non-household customers in England we have transferred activity from our non-household programme to the household programme. We are not currently delivering any non-household customers water efficiency activity but are reviewing our strategy to assess possible compliant options to work with retailers.

We are continuing to target the 25Ml/d of savings during AMP6 even if this is solely with our household customers.

Figure 21- AMP6 water efficiency profile



Our activities include:

- Providing free water saving products to our customers.
- Providing subsidised higher value products to our customers (e.g. water butts and shower heads).
- Working with social housing providers to reduce water consumption in social housing properties by providing free water saving products to these organisations.
- Introducing a free water saving audit which includes the free installation of free water saving products to our household customers which we intend to roll out across the company in future years.
- Providing information to our customers on how to use less water. This includes a comprehensive self-audit calculator which offers tips on how to reduce consumption and recommends free water saving products to our customers.
- Providing an educational programme to schools and adult groups which aims to deliver long-term behaviour change and a change in water using habits.
- We also continue to contribute to improving the evidence base by measuring the savings delivered by our home install programme.
- Incentivising developers to build properties to high water efficiency standards (the optional 110 l/p/d (litres per person per day) standard in part G of the building regulations).

3.1.1.3 Trials

In 2017 we worked with a social housing provider and a 3rd party on a trial of 1000 social housing properties carrying out water efficiency audits and installing water savings products free of charge to the tenants. Partnering with the social housing organisation achieved a higher uptake than our standard household audit programme. We are now scaling up this programme in this and future AMP periods.

We have also continued our successful water efficiency audit and install programme – free of charge to customers – having completed over 20,000 in the past two years. With the ambition of completing 20,000 annually for the remainder of the AMP period.

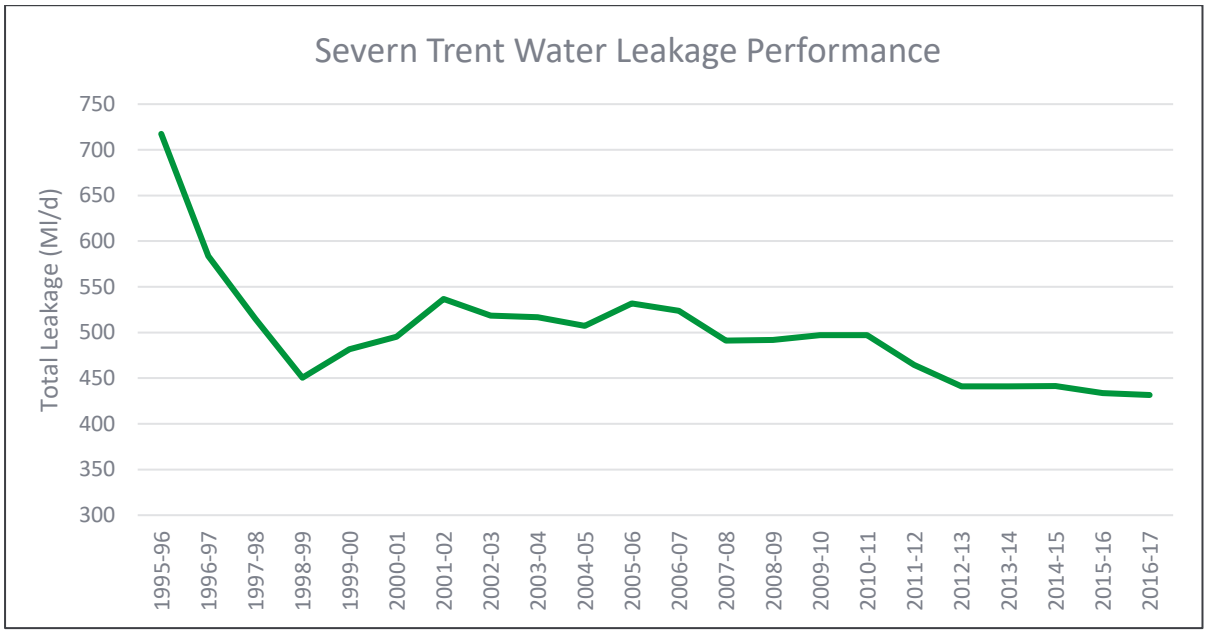
3.1.1.4 AMP 7 and Beyond

As part of our business plan preparations, we have reviewed the savings we assume from water efficiency activity and have improved their accuracy and, where possible, used measured savings. This review has led to a fall in savings assumed. On a like for like basis we intend to maintain a similar level of water efficiency savings in the next three AMP periods. We will deliver this with our household customers.

3.1.2 Reducing Leakage on our network

Leakage currently makes up around 23% of the total water we put into supply. We have a strong track record of reducing leakage, and over the past 10 years this has helped us to meet the water needs of a growing population without having to increase the amount of water we abstract and put into supply. Our leakage reduction activities will have reduced leakage by around 72Ml/d (15%) over the ten years between 2010 and 2020. Figure 22 shows the record of total leakage in our region since 1996. The overall trend is one of falling leakage. This graph shows that, despite the fact that our network has grown in size over this period, leakage is now at its lowest ever level.

Figure 22- Company total leakage since 1996



As part of our 2018 draft WRMP, we propose to reduce leakage by a further 66Ml/d (15%) over five years between 2020 and 2025. This is driven in part by our need to generate more headroom to accommodate the impacts of climate change uncertainty, and to provide a significant contribution to offsetting the AMP8 supply / demand impacts of preventing environmental deterioration to achieve Water Framework Directive objectives. This level of leakage reduction is extremely ambitious, and is part of what we believe to be a 'no-regret' package of AMP7 leakage, metering and demand management measures. The 15% target is the economic level of leakage reduction needed for AMP7, and contributes to our wider package of demand management and supply improvement investment proposals that we derived using our supply / demand investment modelling.

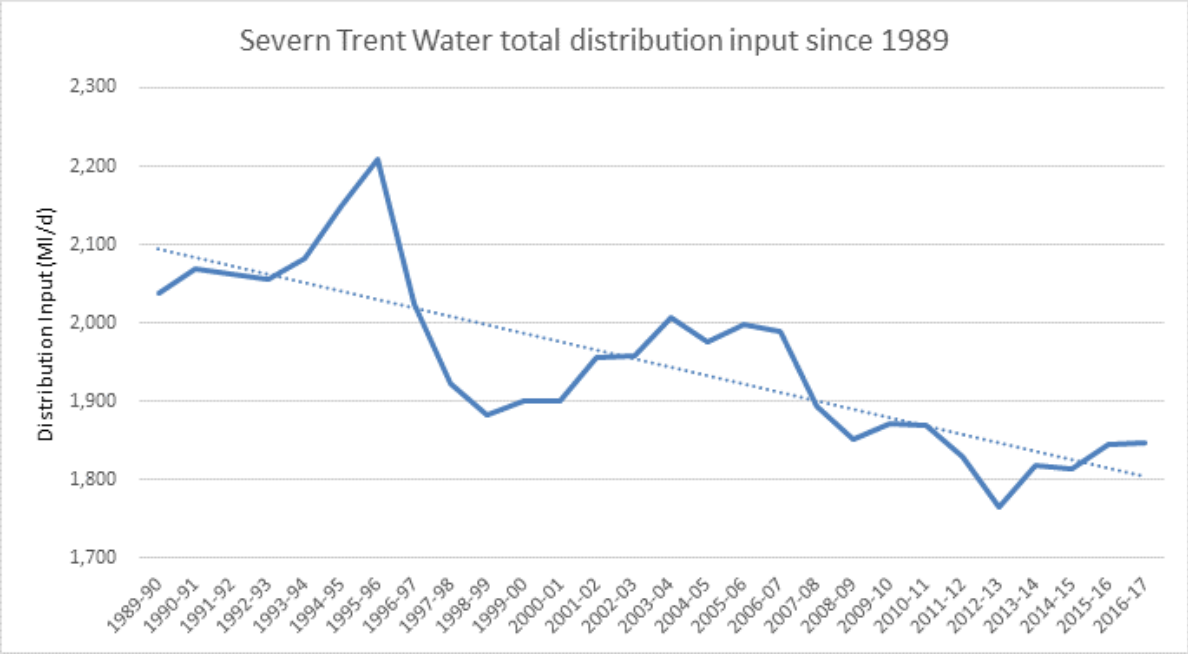
Every five years we update our long term economic level of leakage assessment as part of the WRMP process. Our traditional approach to setting leakage reduction targets in previous WRMPs has been led by an economic appraisal of the costs and benefits of reducing leakage in the context of the overall supply / demand needs. In zones where there is a forecast supply / demand deficit, then we have considered leakage reduction as part of the least-cost package of measures to resolve that deficit, along with water resources and other demand management measures.

Our experience from PR14 led us to realise that we need to be more ambitious when assessing our leakage reduction options. As we have developed our latest draft WRMP and draft drought plan, we have been working with a wide range of stakeholders to understand their views and priorities. Throughout this stakeholder engagement, we have heard a clear expectation that we need to do more to reduce leakage on our network. At the same time, our regulators have set an ambition that the industry needs to continue to drive leakage down and, during 2017, Ofwat set an expectation that companies will reduce leakage by at least 15% by 2025.

We have used leakage scenario planning to explore whether a traditional economic level of leakage approach can deliver our stakeholders' expectations and to quantify how we would meet Ofwat's leakage challenge. Through this scenario approach we have been able to understand where we need to improve and innovate our leakage find and fix activities and become more cost effective.

Distribution input is the amount of water we put into supply and we use this as a measure of the company wide demand for water. The following graph shows an overall decline in distribution input across our region since 1989. Increasing household demand has been more than offset by our water efficiency activities, our leakage reduction programme and declining demand from commercial customers. The decline in use by commercial customers is caused by a decline in the prominence of heavy industry.

Figure 23 - Severn Trent Water distribution input from 1989 to 2017



If our drought indicators are in trigger zone C we will place an extra emphasis on leakage. We refer to this again in the escalation of messages table in section 5.2. It is difficult to generalise about exactly how much further we could reduce leakage in a drought as it will depend on the severity or extent of the drought and our leakage performance as we enter the drought period. However, we will divert our staff from other tasks onto leakage work and we can also hire in external contractors if necessary.

3.1.3 Effects on Fire service

There are a small number of actions we take that could affect fire hydrants. The most obvious of these is that we when we lower pressure during a drought to reduce leakage. In this reduced pressure scenario we will mitigate the potential problems for the fire service in the following ways:

- As happens during non-drought periods we will communicate with the fire service during incidents - this is usually via our 24hr call centre.

- If appropriate, we advise them of alternative locations to take a supply from that have higher pressure/ flow. For example, we may suggest that they connect to a larger main or bypass anything (PRV) that is creating a head loss.
- In addition, if needed, we will send a Severn Trent technician to the area to assist.
- In the future we intend to be more proactive so we will inform the fire service which areas we will lower pressure in before we do it.

3.1.4 Bulk imports and exports

We have common boundaries with seven other water companies and bulk supply agreements with five of these companies. The following table summarises the strategic bulk supply agreements that we hold with neighbouring water companies.

Table 5: Bulk supplies with neighbouring water companies

Neighbouring company	Location	Basic details of transfer	How would this supply operate in a drought?
Anglian Water	East Midlands into our Strategic Grid and Rutland WRZs	We import up to 18 Ml/d of treated water from Anglian Water	There are no drought conditions in this agreement but, if entered a drought, we would engage with Anglian Water and, if we are able to, we may reduce our import.
Dŵr Cymru Welsh Water (DCWW)	Export from our Forest and Stroud WRZ	We provide DCWW with up to 9 Ml/d of treated water. This volume is supported by regulation releases from the Elan Valley.	This is not usually variable in a drought. However, in a drought we would communicate with all other water companies to help with message consistency and to see if we can assist each other.
Dŵr Cymru Welsh Water (DCWW)	Import from the Elan Valley reservoirs	DCWW provide partially treated water to our Strategic Grid WRZ.	This import reduces when storage in the Elan Valley reservoirs crosses specified storage triggers.
South Staffordshire Water	Import of treated River Severn water to the Wolverhampton WRZ	We import up to a peak daily rate of 48 Ml/d.	The River Severn is a regulated river and the shared South Staffordshire asset abstraction can be limited by specific low flows and licence conditions and the terms of operating agreements.
United Utilities	Our Shelton WRZ	We have an agreement that states we can receive a supply of treated water from UU in case of an emergency failure of our ability to supply customers in this area.	Extreme drought is a potential reason for calling on this import but its primary aim is to provide resilience to other sources in this WRZ for a relatively short period of time.
Yorkshire Water Services	Derwent Valley reservoirs	We export up to 60 Ml/d of untreated water to Yorkshire Water Services take up to 60 Ml/d from our Derwent Valley reservoirs.	The quantity that we export (and the amount we treat ourselves) reduces as reservoir storage reduces.

3.1.5 Temporary water use restrictions

If extended drought conditions mean that reservoir storage or other drought indicators are in drought trigger zone E, we may need to temporarily restrict certain uses of water. Before making a decision to impose restrictions our DAT will review current resources and how the outlook is likely to change. For example, DAT will use the reservoir storage projections that we described in section 2.3.

Prior to the *Water Use (Temporary Bans) Order 2010*, water companies were only allowed to restrict the use of a hosepipe if it was to water a garden or wash a private car. Since 2010 water companies have had wider and more far reaching powers to restrict water use. It is worth clarifying that we refer to temporary use bans (TUBs) in this plan although we may use the phrase 'hosepipe ban' in other communications. We have changed our terminology to better reflect the current legislation. As well as being able to bring in TUBs if we need to we can also apply for a drought order to bring in a non-essential use ban (NEUB). For clarity, we define:

- A temporary use ban (TUB) as a way in which we can reduce customer demand for water during a drought by banning specified activities;
- A non-essential use ban (NEUB) as a more severe measure to reduce demand by banning even more specified activities, including commercial uses of water.

We would only consider imposing temporary water use restrictions between April and October because they would have little impact outside of that period. It is worth noting that, whilst drought orders/ NEUBs and drought permits require that we demonstrate exceptional shortage of rainfall, this is not true for TUBs. The legislation governing TUBs allows a water company to impose a TUB if "it is experiencing, or may experience, a shortage of water for distribution". A drought is one reason for such as shortage but it is not the only possible cause. We have listed the activities that we will restrict using a TUB or NEUB in the following sections of this plan.

3.1.5.1 Temporary use bans (TUBs)

The following table shows the 11 activities that the legislation now allows us to restrict under a temporary use ban (TUB) and it also shows the exceptions that we will make to this:

Table 6 - Table showing which activities we will restrict under a TUB and the exceptions we expect to make

Activity restricted by TUBs	Statutory Exception	Discretionary Exceptions	Notes
1) Watering a garden using a hosepipe	Using a hosepipe to water a garden for health or safety reasons. NB In this category, the definition of "a garden" includes "an area of grass used for sport or recreation". Therefore it should be noted that watering areas of grass, which are used for sport or recreation, is covered by a Statutory Exception for health & safety only in relation to the active	1) To Blue Badge holders on the grounds of disability. 2) Use of an approved drip or trickle irrigation system fitted with a pressure reducing valve (PRV) and timer. 3) To customers on the company's Vulnerable	The whole of the sports pitch can still be watered using other methods. Some companies may wish to grant a Discretionary Concessional Exception to allow the use of a hosepipe to water other grassed areas used for sport where

	strip/playing area, not the entire ground.	Customers List who have mobility issues but are not in possession of a Blue Badge.	there is no health and safety risk.
2) Cleaning a private motor-vehicle using a hosepipe	A "private motor-vehicle" does not include (1) a public service vehicle, as defined in section 1 of the Public Passenger Vehicles Act 1981(c), and (2) a goods vehicle, as defined in section 192 of the Road Traffic Act 1988(d)	1) To Blue Badge holders on the grounds of disability. 2) Use of hosepipe in the course of a business to clean private motor vehicles where this is done as a service to customers. 3) To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge.	Taxis and minicabs are not considered to be public service vehicles and so are subject to bans[2].
3) Watering plants on domestic or other non-commercial premises using a hosepipe	Does not include watering plants that are (1) grown or kept for sale or commercial use, or (2) that are part of a National Plant Collection or temporary garden or flower display.	1) To Blue Badge holders on the grounds of disability. 2) Use of a hosepipe in the course of a business to clean private motor vehicles where this is done as a service to customers. 3) To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge.	The water restriction does not apply to the watering of plants that are grown or kept for sale or commercial use by horticultural businesses e.g. plant nurseries etc.
4) Cleaning a private leisure boat using a hosepipe	(1) cleaning any area of a private leisure boat which, except for doors or windows, is enclosed by a roof and walls. (2) Using a hosepipe to clean a private leisure boat for health or safety reasons.	1) Commercial cleaning 2) Vessels of primary residence 3) Cases where fouling is causing increased fuel consumption 4) Engines designed to be cleaned with a hosepipe.	-

[2] The position that taxis are not classed as public service vehicles is as follows. The current legislation (Section 76(2)(b) of the Water Industry Act 1991) allows TUB restrictions to be imposed on "*private motor vehicles*". The definition of a private motor vehicle in the Water Use (Temporary Bans) Order 2010 (Regulation 5) excludes public service vehicles as defined by Section 1 of the Public Passenger Vehicles Act 1981. This definition includes vehicles not adapted to carry more than eight passengers and "*used for carrying passengers for hire or reward at separate fares in the course of a business of carrying passengers*." Each element of this definition must be satisfied. In other words, it must be a vehicle which: is not adapted to carry more than eight passengers; ... used for carrying passengers for hire or reward; ... at separate fares; ... in the course of a business. In the case of taxis, elements 1,2 and 4 are satisfied, but (usually) not 3. A taxi, unlike a bus, does not (usually) carry passengers at separate fares. There is a fare for the journey undertaken rather than separate fares for each passenger in the vehicle.
Further, in the DfT document (dated November 2011) Public Service Vehicle Operator Licensing Guide for Operators, there is a statement that "*separate fares mean an individual payment by each passenger to the driver, conductor or agent of the operator for the journey undertaken*" This is not how taxis operate, so they therefore fall within the definition of private motor vehicle in the WIA. Taxis will be licensed by the local authority, but is clear from the DfT guidance that if they don't carry passengers at separate fares, they do not require a PSV licence, because they are not PSVs as defined.

5) Filling or maintaining a domestic swimming or paddling pool	(1) filling or maintaining a pool where necessary in the course of its construction. (2) filling or maintaining a pool using a hand-held container which is filled with water drawn directly from a tap. (3) filling or maintaining a pool that is designed, constructed or adapted for use in the course of a programme of medical treatment. (4) filling or maintaining a pool that is used for the purpose of decontaminating animals from infections or disease. (5) filling or maintaining a pool used in the course of a programme of veterinary treatment. (6) filling or maintaining a pool in which fish or other aquatic animals are being reared or kept in captivity.	None	1) Hot tubs are not classed as pools 2) Pools with religious significance are not domestic pools 3) Pools used by school pupils for swimming lessons should be excluded: they are covered by Drought Order legislation
6) Drawing water, using a hosepipe, for domestic recreational use	None	None	-
7) Filling or maintaining a domestic pond using a hosepipe	Filling or maintaining a domestic pond in which fish or other aquatic animals are being reared or kept in captivity	1) Blue Badge holders on the grounds of disability 2) To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge	Filling and topping up of a pond by fixed and buried pipes is not restricted
8) Filling or maintaining an ornamental fountain	Filling or maintaining an ornamental fountain which is in or near a fish-pond and whose purpose is to supply sufficient oxygen to the water in the pond in order to keep the fish healthy	None	-
9) Cleaning walls, or windows, of domestic premises using a hosepipe	Using a hosepipe to clean the walls or windows of domestic premises for health or safety reasons	1) To Blue Badge holders on the grounds of disability 2) Commercial cleaning 3) To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge 4) Where very low water use technologies are employed and approved by the water company	1) The use of water-fed poles for window cleaning at height is permitted under the H&S statutory exception 2) The restrictions do not apply where the cleaning apparatus is not connected to mains supply
10) Cleaning paths or patios using a hosepipe	Using a hosepipe to clean paths or patios for health or safety reasons	1) To Blue Badge holders on the grounds of disability 2) Commercial cleaning 3) To customers on the company's Vulnerable	-

		Customers List who have mobility issues but are not in possession of a Blue Badge 4) Where very low water use technologies are employed and approved by the water company	
11) Cleaning other artificial outdoor surfaces using a hosepipe	Using a hosepipe to clean an artificial outdoor surface for health or safety reasons	1) To Blue Badge holders on the grounds of disability 2) Commercial cleaning 3) To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge 4) Where very low water use technologies are employed and approved by the water company	1) The use of water-fed poles for window cleaning at height is permitted under the H&S statutory exception 2) The restrictions do not apply where the cleaning apparatus is not connected to mains supply

The table above shows that some of the exceptions listed above are necessary for us to comply with legislative requirements (statutory exceptions) but others are at our discretion (discretionary exceptions). The discretionary exceptions that we have included in the table above includes all of the 'discretionary universal exceptions' and some of the 'suggested discretionary concessional exceptions' shown in table 3.2 of the 2013 UKWIR *Code of practice and guidance on water use restrictions* (see appendix for full reference). What this means is that we have granted more exceptions than the minimum industry standard. We have done this to minimise the impacts of restrictions on specific groups such as customers on our 'vulnerable customers list'.

We contributed to the development of the 2013 UKWIR *Code of practice and guidance on water use restrictions* (CoP). The Water UK board signed off this CoP in July 2013. The 2013 CoP is an update to the 2009 version. The 2013 version includes learning from the drought which ended in 2012 during which seven companies in the South and East of England implemented restrictions. It is also consistent with the current legislation and regulatory policy. We support and follow the principles of the 2013 CoP which are to:

- Ensure a consistent and transparent approach
- Ensure that water use restrictions are proportionate
- Communicate clearly with customers and the wider public/ users
- Consider representations in a fair way

Following the 2013 Code of Practice also helps us to delay the economic impacts of restrictions on business customers for as long as we can. By following this CoP we will also 'phase' in restrictions on use in a way that is consistent with other companies in the UK.

In most drought scenarios we think that the clearest way to impose restrictions on customers is on a company wide basis. However, if circumstances mean that this is not in our customers' best interests, we want to keep open the option of imposing restrictions in discrete areas. We do not believe that our customers, or the environment, would benefit if restrictions on use were imposed in parts of our region unaffected by drought conditions. We would choose these areas by considering how a specific drought was affecting our region and we would choose areas that are easy to define and communicate. We think that it is unlikely that we would need to apply TUBs at this scale but it is possible. If we did this and later needed to widen the spatial extent of the restrictions, we expect that the TUB would then apply to the whole company.

We are aware that imposing customer restrictions at a sub-zonal level is arguably inconsistent with the definition of a WRZ as provided in section 3.2 of the April 2017 *water resources planning guidelines (WRPGs*). This section of the guidelines states that:

"Within a WRZ all parts of the supply system and demand centres (where water is needed) should be connected so that all customers in the WRZ should experience the same risk of supply failure and the same level of service for demand restrictions. There will be limitations to achieving these due to the specific characteristics of a distribution network but significant numbers of customers should not experience different risks of supply failure within a single WRZ."

However, leaving the option of sub-zonal restrictions open provides several benefits:

- It will ensure greater customer support and understanding
- When communicating with our customers we want to use boundaries that our customers are familiar with
- We can target restrictions whilst accounting for the latest information on demands, temporary engineering works, outages or other changes to our 'normal' production and distribution processes
- It allows us to target the restrictions to where they are most needed given the prevailing information.
- We keep any inconvenience to our customers to an absolute minimum
- We minimise the economic impacts of the restrictions.

3.1.5.2 Non-essential use bans (NEUBs)

Table 7 - Table showing which activities we will restrict under a NEUB and the exceptions we expect to make

Activity restricted by NEUBs	Statutory exception	Discretionary exceptions
Purpose 1: watering outdoor plants on commercial premises	The purpose specified does not include watering plants that are: (a) grown or kept for sale or commercial use; or (b) part of a National Plant Collection or temporary garden or flower display	Use of an approved drip or trickle irrigation system fitted with a PRV and timer
Purpose 2: filling or maintaining a non-domestic	The purpose does not include: (a) filling or maintaining a pool that is open to the public;	None

swimming or paddling pool	(b) filling or maintaining a pool where necessary in the course of its construction; (c) filling or maintaining a pool using a hand-held container which is filled with water drawn directly from a tap; (d) filling or maintaining a pool that is designed, constructed or adapted for use in the course of a programme of medical treatment; (e) filling or maintaining a pool that is used for the purpose of decontaminating animals from infections or disease; (f) filling or maintaining a pool that is used in the course of a programme of veterinary treatment; (g) filling or maintaining a pool in which fish or other aquatic animals are being reared or kept in captivity; (h) filling or maintaining a pool that is for use by pupils of a school for school swimming lessons. Note that a pool is not open to the public if it may only be used by paying members of an affiliated club or organisation.	
Purpose 3: filling or maintaining a pond	The purpose does not include: (a) filling or maintaining a pond in which fish or other aquatic animals are being reared or kept in captivity (b) filling or maintaining a pond using a hand-held container which is filled with water drawn directly from a tap	1) To Blue Badge holders on the grounds of disability 2) To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge
Purpose 4: operating a mechanical vehicle-washer	Operating a mechanical vehicle-washer for health or safety reasons	On bio security grounds
Purpose 5: cleaning any vehicle, boat, aircraft or railway rolling stock	Cleaning any vehicle, boat, aircraft or railway rolling stock for health or safety reasons	None
Purpose 6: cleaning non-	Cleaning of any exterior part of a non-domestic building or a non-	None

domestic premises	domestic wall for health or safety reasons	
Purpose 7: cleaning a window of a non-domestic building	Cleaning a window of a non-domestic building using a hosepipe for health or safety reasons	None
Purpose 8: cleaning industrial plant	Cleaning industrial plant using a hosepipe for health or safety reasons	None
Purpose 9: suppressing dust	Suppressing dust using a hosepipe for health or safety reasons	None
Purpose 10: operating cisterns (in unoccupied buildings)	None	None

If we need to impose TUBs or NEUBs customers can contact us to ask for exemptions or for more information. After we receive these representations we will consider these and whether it is appropriate for us to vary our policy to discretionary exceptions. If we impose restrictions and we become aware that some customers are not complying we will try to work with them to understand why this is. If this does not work then we will explore the enforcement options open to us. However, we expect that by demonstrating that we are reducing leakage and doing everything that we can, that the overwhelming majority of our customers will also 'do their bit'.

As we described in section 1.6 our stated levels of service are that we expect to impose restrictions three times every 100 years. When talking to customers we do not distinguish between a TUB and a NEUB. However, as our decision flow charts show we would not impose a NEUB until drought trigger zone F. This means that we will not impose a NEUB unless we have already imposed a TUB. The table of modelled and stated frequency of TUBs and NEUBs we included in section 1.6 shows that there can be a difference between stated levels of service and the modelled.

Our baseline deployable output (DO) modelling of the 95 year period from 1920 to 2014 shows that the two most critical droughts in our region in terms of causing TUBs or NEUBs are those that included the following years: 1976 and 1984. Our water resource modelling shows that these are the droughts when we would have needed to impose customer restrictions. Our modelling also shows that reservoirs such as the Derwent Valley reservoir group and Tittesworth reservoir cross the TUB and NEUB triggers but they do so outside of 'summer' period in which we would impose restrictions. These 'winter' crossings at Tittesworth and Derwent occur in the 1933-34 and the 1995-96 droughts.

Figure 24: Tittesworth modelled baseline DO storage entering drought trigger zones E and F in the 1995-96 'winter'

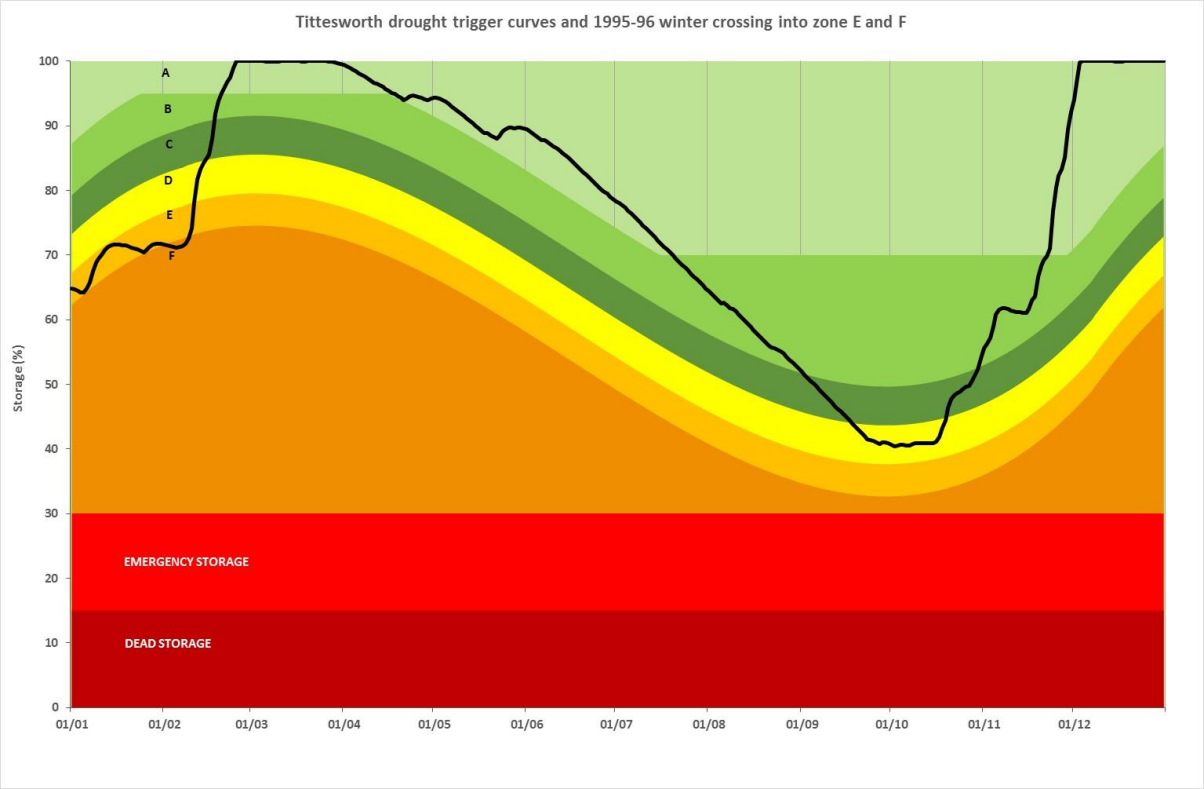
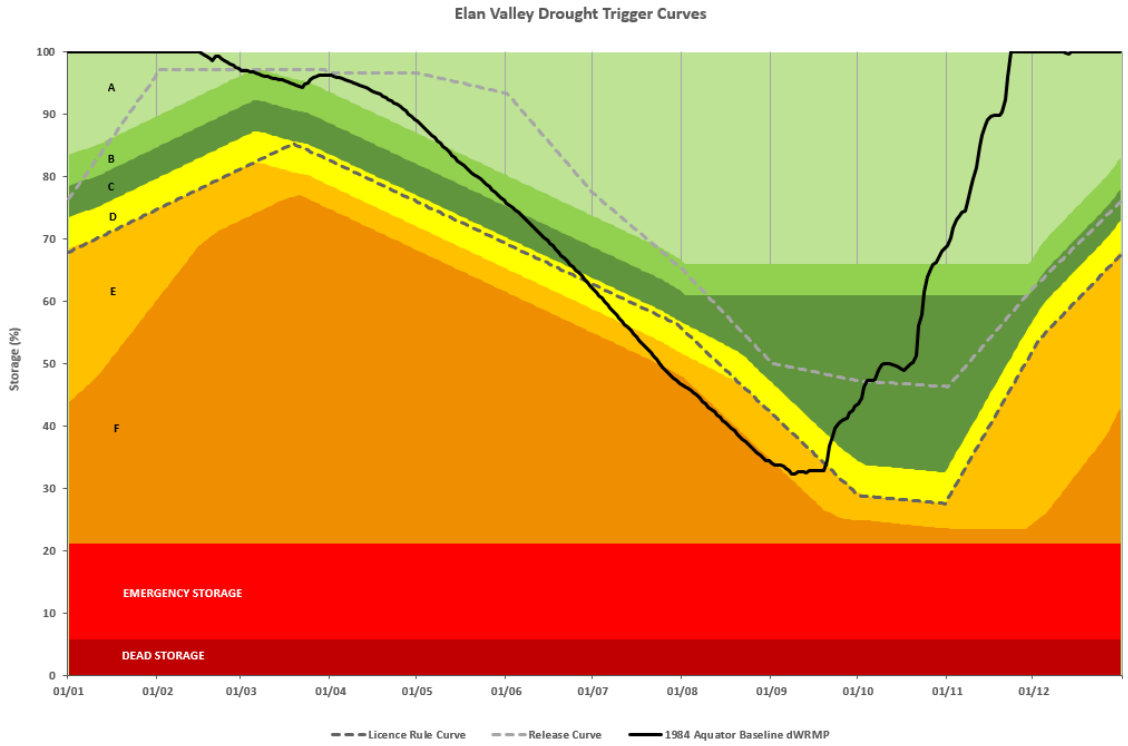


Figure 25: Elan Valley modelled baseline DO storage entering drought trigger zones E and F in the 1984 'summer'



The modelled TUB and NEUB frequency shown above is consistent with the levels of service we state to customers as both are 3 in 100 or less.

We have considered the results of UKWIR research as well as company specific factors when deciding what reduction in demand to expect as a result of temporary water use restrictions. The 2007 UKIWR report (*Drought and demand: modelling the impact of restrictions on demand during drought*) suggested that a full hosepipe ban could reduce demand in the summer by between 5% and 9.5%. There is some uncertainty associated with these results and they were gained from companies in the South East of England, where average water consumption is significantly higher than in our region. We believe that a 5% demand saving is a reasonable assumption for demand savings across the Severn Trent region. This reduction in demand is consistent with our previous drought plan. It is also consistent with the Aquator modelling we carry out in support of our water resources management plan (WRMP).

We plan on the basis that we will not impose a TUB if reservoir storage or other indicators have been in zone E for less than 7 days and that we would need a 'lead in' time of 14 days before we introduce restrictions on our domestic customers. This timescale allows sufficient, but not excessive, time for this engagement with our customers. We understand that there is no other formal process for objecting to restrictions imposed under a TUB, unless a customer requests a judicial review under the Human Rights Act. If any customers have any concerns about how and when we might restrict use we would welcome them to approach us at any time. We have given more detail on our communication plan and associated engagement in section 5.2.

The compensation payments that we make to customers for interruptions to their supplies are as specified by condition Q of our Instrument of Appointment. This makes provision for compensation to household customers and business customers. These payments are to compensate customers for any loss of supply and not specifically those caused by droughts.

These payments apply regardless of whether there is a drought and we will not make any extra payments to customers if we apply restrictions in line with our stated levels of service. However, like all companies, we are not required to pay compensation to customers if the circumstances are so exceptional that, in Ofwat's view, it would be unreasonable to expect the interruption to supply to be avoided. Further information on the Guaranteed Standards Scheme (GSS) payments is available from the Ofwat website (accessible via the link in section 7.1).

We would always follow the appropriate regulations and standards in relation to compensating customers or other organisations potentially affected by our actions. However, there may be times during a drought when we would like to go above and beyond these standards. We would make these decisions during a drought by taking into account the specific circumstances of each case.

3.1.6 Emergency drought orders/ emergency plans

We do not class droughts as emergencies unless there is a major environmental or other acute incident requiring activation of multi-agency major incident response arrangements or a serious threat of emergency drought orders.

Legally, emergency drought orders allow companies to "prohibit or limit the use of water for such purposes as (they) see fit" and to supply water by means of stand-pipes or water tanks. The timing of applications and the determination on these applications is the same as for ordinary drought orders. However, emergency drought orders are granted for a period of up to three months and may only be extended to last a maximum total of five months. Emergency drought orders are often described in the water industry as 'level 4 restrictions'.

This drought plan covers the actions we might require up to the classification of an emergency. At this stage we will activate our emergency plans to deal with a loss of supply and maintaining essential water supplies. Due to their sensitivity our emergency plans are not publicly available but they describe the measures we would consider during emergency scenarios. Scenarios of this type are outside the scope of a drought plan. However, it is vital to stress that the probability of a drought causing such plans to be implemented is extremely low.

3.1.7 Additional permissions needed

In addition to the drought permits and drought orders described above there are other permissions that we may need during a drought. For example, we mention the need for an EA permission to carry out works in a flood plain to enable our River Churnet drought permit in section 3.3.1 of this plan. We have a column in the tables in section 7.2 that shows all of the permissions/ constraints associated with the demand and supply-side actions we have available to us.

3.2 Supply-side actions

This plan not only includes measures for reducing demand during droughts but also ways in which we can increase our supplies of water. Since we published our 2014-19 drought plan there are some supply-side actions which we know are no longer available. For example, in the North Staffs WRZ we had an option that involved recommissioning Meir but, due to water quality reasons, we have revoked this abstraction licence and we no longer own the site. As this is no longer a viable drought option we have removed it from our plan. There are also some options that we have included in this drought plan that we did not include in our 2014 plan. As described in the following section, we now consider that we have more drought/ emergency sources available than we included in our 2014 plan.

3.2.1 Drought / Emergency Sources

As we are considering more extreme droughts in this plan to those we considered in our 2014 plan we think that it is essential to explore a wider range of potential drought sources. We currently consider the following to be drought sources that may provide a supply-side benefit in a drought (or another emergency that threatens our ability to supply piped water supplies to all of our customers):

- Birmingham groundwater and Shardlow/ Witches Oak intake on R. Trent
- Blackbrook reservoir
- Linacre reservoir group
- Monksdale borehole
- Norton emergency borehole

- Beechtree emergency borehole
- Witcombe reservoir
- Stanley Moor borehole
- Esgaireira reservoir.

3.2.1.1 Deploying these sources

Some of the sources listed above could be deployed at short notice whereas others have a long lead in time and would require (temporary) infrastructure, environmental assessments, hydrological studies and water quality assessments. The following table shows how 'ready' each of these drought/ emergency sources is:

Table 8: Potential requirements to deploy our drought/ emergency sources

Source	WRZ that would benefit	Estimated Peak Yield (Ml/d)	Estimated Average Yield (Ml/d)	What is needed to get it into supply	Comments/ Timescale
Norton borehole	Strategic Grid (West)	n/a	0.7	Standard internal processes for bringing into supply a source that has monthly water quality samples taken but is not normally used for public supply.	Virtually ready for use. Note the estimated yield is given in the table in section 7.2.1
Beechtree borehole	Strategic Grid (West)	18.0	0.9	As above.	As above.
Birmingham groundwater and Shardlow/ Witches Oak intake on the River Trent.	Strategic Grid (East)	Daily max licence for the abstraction is 65 Ml/d but we are very unlikely to abstract this quantity.	8.9 (due to 5 year total on Birmingham groundwater)	Need to test water quality of the boreholes and maintain/ install infrastructure to discharge and subsequently re-abstract at Witches Oak intake on the River Trent. Also need to ensure infrastructure is built/ upgraded to take water from Witches Oak to treatment at Site E	Expect it would take in excess of 6-9 months to bring this into supply. If our WRMP19 selects an option to use the Birmingham Groundwater for supplying Birmingham then this will no longer be a drought/ emergency source. We are very unlikely to ever abstract 65 Ml/d at Witches Oak due to the 5 year licence and the fact that there would not be 65 Ml/d 'spare' treatment at Site E.
Blackbrook reservoir	Strategic Grid (East)	14.5	6	Need to test water quality of the reservoir and build infrastructure to either transfer to Site B or, less likely, install	Expect it would take in excess of 9-12 months to bring this into supply. Same issue as above in that if it were selected for

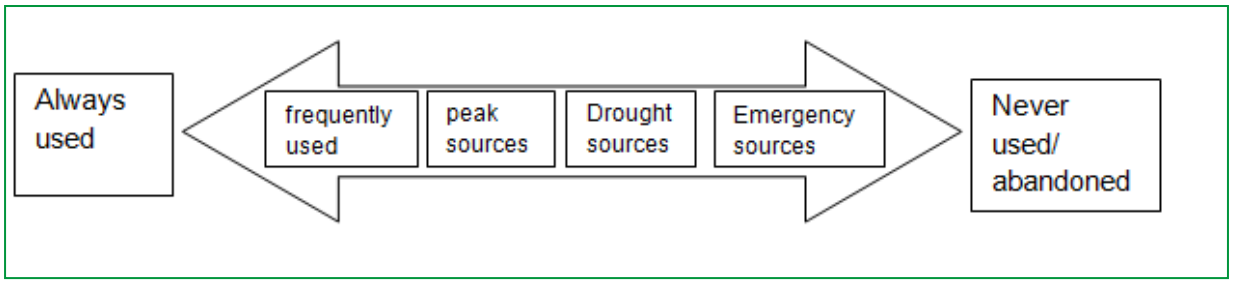
				on-site treatment and construct infrastructure to get treated water into our grid.	WRMP purposes it would no longer give drought resilience.
Linacre reservoir group	Strategic Grid (East)	9	6.8	Need to test water quality of the reservoir and build infrastructure for on-site treatment and construct infrastructure to get treated water into our grid.	Expect it would take in excess of 12 months to bring this into supply. Same issue as above in that if it were selected for WRMP purposes it would no longer give drought resilience.
Monksdale borehole	Strategic Grid (East)	2	1.5	Need to test water quality of the raw water, build on-site treatment and construct infrastructure to get treated water into our grid.	Due to the long lead-in time to deploy, the modest yield available (on an annual average basis) and the lack of environmental data available we expect to need this source less frequently than we would use NEUBs. It would require a drought with a return period of, or in excess 1 in 200 years to require a measure like this. Therefore it is more of an emergency source than a drought source.
Stanley Moor borehole	Strategic Grid (East)	2.2	0.5	As above.	As above.
Witcombe reservoir	Strategic Grid (South) – with possibility of supply to Forest & Stroud via existing transfers	8.7	1.4	As above.	As above.
Esgaireira reservoir	Llandinam & Llanwrin	n/a	1.1	New treatment on site plus new distribution infrastructure or pipe to Llandinam and alteration to treatment process.	As above and we also note that this source is located in WRZ with high drought resilience.

It is important to note that the drought resilience we described in section 2.1.7 does not rely on our ability to use any of the sources listed in the table above. As a result, if we decide to use sources such as Linacre or Blackbrook as WRMP19 options we would still be resilient to a 1 in 200 year drought without the need for level 4/ emergency drought order measures.

We note that there is actually a continuum between the sources that we use the most and those which we never use. This means that although it is fairly straightforward to tell which sources are at either end of this spectrum it is less obvious what to call the sources that fall in between these two categories. For example, there are a number of groundwater sources that we use to support river flows during periods of low flows. We operate these sources too frequently to class them as 'drought sources', but not frequently enough for them to be classed as constant sources of supply.

The timescales and requirements of a drought management option are different to those of an emergency plan option. We discuss our emergency contingency planning process in section 3.1.6. Although our drought action flow diagrams (in section 7.2) state that we would "consider use of drought/ emergency sources" when we enter trigger zone D, the long lead in time means that we would be very unlikely to fully implement these actions until we had entered into drought trigger zone E/F. As described in section 1.6 we do not expect to enter into drought trigger zone F in the 95 year record that we model in Aquator. We discuss the WFD implications of using these sources in section 4.4 of this plan as well as in the separate WFD assessment that accompanies this plan.

Figure 26: Frequency that we expect to use our various sources



We assess the feasibility and viability of all of our sources including drought and emergency sources. If we find that sources cannot be of value to us in the future, we have a site abandonment procedure that releases the source, and its abstraction licence, for alternative and more productive use.

3.3 Drought orders and permits

There are some plausible drought scenarios when we will need to apply to the Environment Agency for drought permits or the Secretary of State/ Welsh Ministers for drought orders. We have prepared our drought plan so that we will need to implement these measures as infrequently as is reasonably possible. In this section when we talk about drought orders we refer to ordinary drought orders and not emergency drought orders. We explained our approach to emergency drought orders in section 3.1.6.

The main differences between drought orders and drought permits are that:

1. Drought permits allow companies to take water from specified sources and vary or suspend abstraction licence conditions
2. Drought orders do this, but also allow companies to discharge water to specified places and to modify or suspend discharges or filtering/ treating of water
3. Drought permits are normally determined within 12 days of the application
4. Drought permits are determined by the EA
5. Drought orders are determined by the Secretary of State/ Welsh Ministers
6. Drought orders are normally determined within 28 days
7. Drought orders allow water companies to restrict non-essential uses of water for their domestic and commercial customers

3.3.1 Drought orders

The Secretary of State or the Welsh Ministers can grant a drought order if they are satisfied that either:

- a serious deficiency of water supplies exists or is threatened or
- there is a serious threat to any flora or fauna

and

- this has been caused by an exceptional shortage of rainfall

In our water resources modelling we assume that a restriction on these non-essential uses lowers summer customer demand by an extra 5%. This means that, in combination with the temporary use restrictions applied to domestic customers, we model a 10% reduction in demand.

This value is consistent with the reduction in demand associated with a drought order shown in the *2007 UKWIR report Drought and demand: potential for improving the management of future droughts*. The cumulative or in combination reduction in demand of 10% is towards the lower end of the range of values quoted in other industry publications. This is appropriate to our company specific circumstances as our customers use less water on average than the customers of most of the other water companies in England and Wales.

We assume 28 days as the time required for Defra to grant a drought order to restrict the use of commercial customers. However, it does not follow that there must be an equivalent volume of reservoir storage in zone F to supply 28 days of average or peak demand. This is because as reservoir storage falls through the zones above we will implement actions to reduce the demand on the reservoir or reservoir group. For example, during the low storage experienced at Draycote reservoir in 2011-12 we were able to reduce the net outflow from Draycote reservoir to zero.

In our modelling we assume that when reservoir storage enters drought trigger zone E (which is defined in section 2.2) for more than seven days, we will:

- reduce the modelled demand by 5%

We also assume that if storage enters drought trigger zone F our modelled demand will:

- reduce by 10%

These reductions only occur if the modelled storage enters these zones in the summer (April to October inclusive) months as during winter there would be no significant reduction in demand. The 180 day duration for demand reductions is consistent with that assumed for a hosepipe ban when we prepared our draft water resources management plan, our 2014 WRMP and our 2014 drought plan. These demand reductions apply for a period of 180 days, unless storage recovers sufficiently before this period has finished.

We do not have a curve in our model solely for when we implement drought permits. Despite this we can predict when they are likely to occur by looking at the time of year, the reservoir current storage and our projections for future reservoir storage. If we think that there is a reasonable chance that we would need a drought order or permit we would engage with the relevant stakeholders at an early stage. For example, during the drought that ended in 2012 we contacted the Midlands Region EA to agree what we would need to provide to support any drought permit application. The following table illustrates some indicative scenarios:

Table 9 - Indicative drought permit application scenarios

Time of year	Current reservoir storage	Projected future reservoir storage	Is a winter or summer drought permit application likely?
Winter/ Spring/ early summer – (November to July inclusive)	Zone E	Projections indicate that storage will remain in zone E or reduce further	Yes, although we would not apply for a summer drought permit unless we had imposed a TUB
Winter/ Spring/ early summer – (November to July inclusive)	Zone E	Projections indicate that storage will increase to zone D or above within 28 days	No, this would be unnecessary
Late summer/ Autumn (August to October inclusive)	Zone E	Projections indicate that storage will remain in zone E or reduce further	Yes, but it is unlikely that our projections would indicate this as winter inflows are usually high
Late summer/ Autumn (August to October inclusive)	Zone E	Projections indicate that storage will increase to zone D or above within 28 days	No, this would be unnecessary

Although we expect to implement drought permits after we have restricted domestic customers' use and before we use drought orders to restrict commercial demand it is not critical to the modelling when this occurs. This is because drought permits trigger neither additional reductions in demand nor any change to our levels of service as we will have already applied restrictions on customer use. The impact on deployable output of drought permits when averaged across the 91 years is negligible. For short term projections of the impacts of drought permits on reservoir storage we would use an appropriate technique (such as Aquator or a spreadsheet) to model the probable inflows and demands on the reservoir or reservoirs in question. We would then debate scenarios such as reservoir storage with or without a drought permit at DAT meetings. We address the potential impact on the environment of drought permits or orders in section 4 of this plan.

By allowing us to restrict the non-essential uses listed in section 3.1, drought orders provide us with powers to manage the demand of more of our non-household customers. We may also apply for a drought order rather than a drought permit in locations where we consider there needs to be a

decision on the grounds of imperative reasons of over-riding public interest. Decisions of this type are taken by the Government rather than the EA.

Currently we think that there are two specific locations where we may apply for a drought order for this reason. These two locations are:

- The River Wye at Wyelands. The River Wye is a Special Area of Conservation (SAC) and therefore covered by the Habitats Directive (HD). As discussed in section 3.3.4.7, our drought order here would request a temporary variation to the conditions of our existing abstraction licence. The triggers for this application are summarised in section 2.2.2.
- The River Severn at site G, if the EA has already applied for a drought order.

In addition, we described our approach to a potential drought permit and/or drought order on the River Churnet in section 3.3.4.5 of this plan.

3.3.2 Lead in times for drought permits and drought orders

The lead in time that we will require to prepare our drought permit or drought order applications will depend on how much information we have readily available at the time. We estimate that we will require at least seven days lead in time for us to finalise our application. However if we are considering applying for either a drought permit or drought order we will have been collating the supporting information required. This means that some of this lead in time could occur whilst the drought indicators are still in trigger zone D. In section 4.2 we explain that we are routinely gathering the supporting environmental information that we need as part of a drought permit/ order application. Therefore, we are confident that we could quickly make an application if necessary.

3.3.3 Drought permits

Drought permits allow us to take water from specified sources and vary or suspend conditions in abstraction licences to enable us to continue providing water for public consumption. This is a supply-side drought management option as it can increase the amount of water available to abstract. The EA will grant drought permits if it is satisfied that:

- a serious deficiency of supplies of water in any area exists or is threatened and
- the reason for this is an exceptional shortage of rainfall

Although companies need to demonstrate a “serious deficiency of supplies” and “exceptional shortage of rainfall” to obtain either a drought order or permit, there are no exact definitions of either term. This is because each drought and situation is different. To provide the industry with clarity the EA produced a guidance note entitled ‘Exceptional shortage of rain: Principles for the assessment of drought orders and permits’. We have reproduced this note in section 7.3. In summary, this note states that the EA will consider the following matters when assessing drought orders or permits:

- technical analysis methods
- period of analysis
- geographic extent of analysis
- other meteorological and hydrometric measures
- relationship to the serious deficiency question
- relationship to water company system
- other sources of information

- presentation

This guidance note helps to define what the EA would expect without being excessively prescriptive. For example it states that there should be no set definition of exceptional shortage of rain and it states that the technical methods "can include return period analysis". We believe that this note sets out a sensible and pragmatic approach. We also note that we routinely analyse and monitor some of the information mentioned in this note as part of our internal drought communications. It is important that we monitor localised as well as regional (rainfall) data. One way in which we can assess whether a rainfall deficit is exceptional is to refer to the CEH portal (see figure 10).

A drought permit will normally be in force for a maximum period of six months, but those six months can start at any time of the year. Drought permits can be extended if necessary. However, it is an understanding between the EA and water companies that a drought permit, starting in summer, would be accompanied by a reduction in domestic customer demand through a temporary use ban (TUB). We describe the potential environmental impacts and the assessments we have carried out in section 4 of this plan.

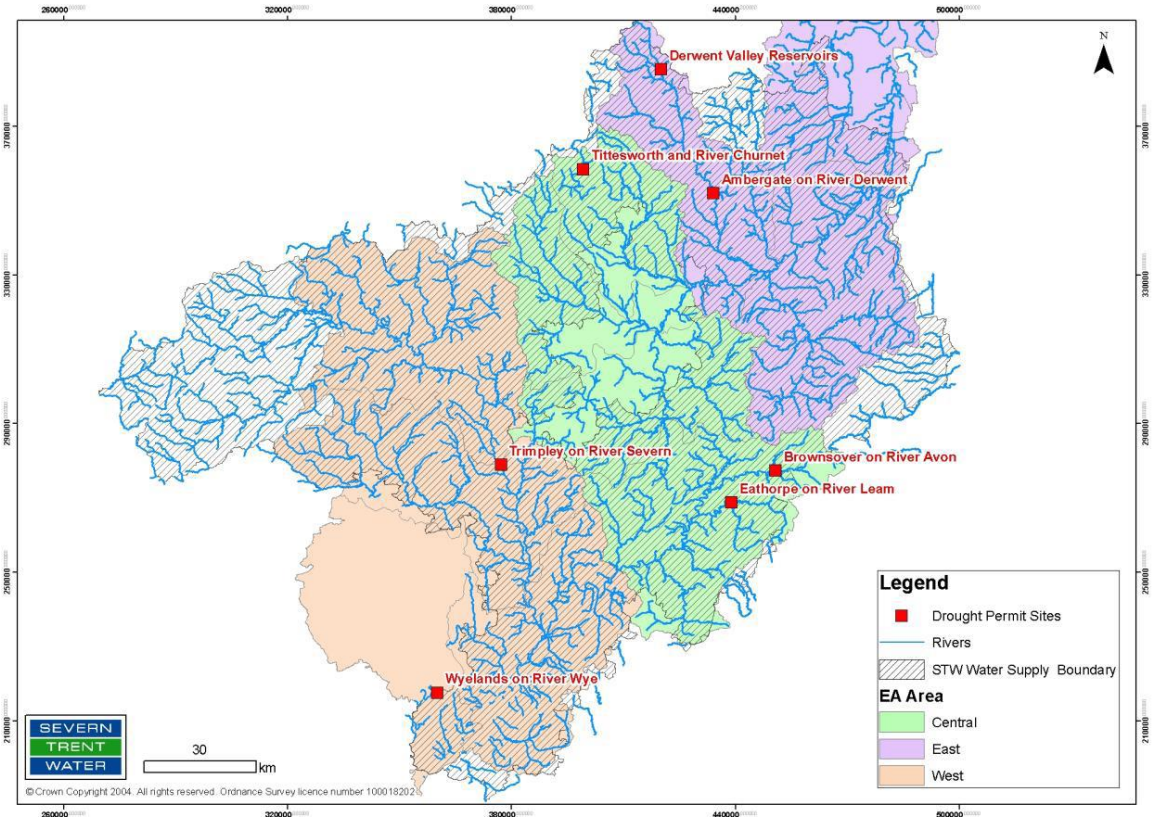
3.3.4 Potential drought permit and order sites

In a drought we may have to apply for drought permits or drought orders at the following locations:

- Avon & Leam
- Derwent
- River Churnet
- Wyelands
- Site G

The map below shows these locations:

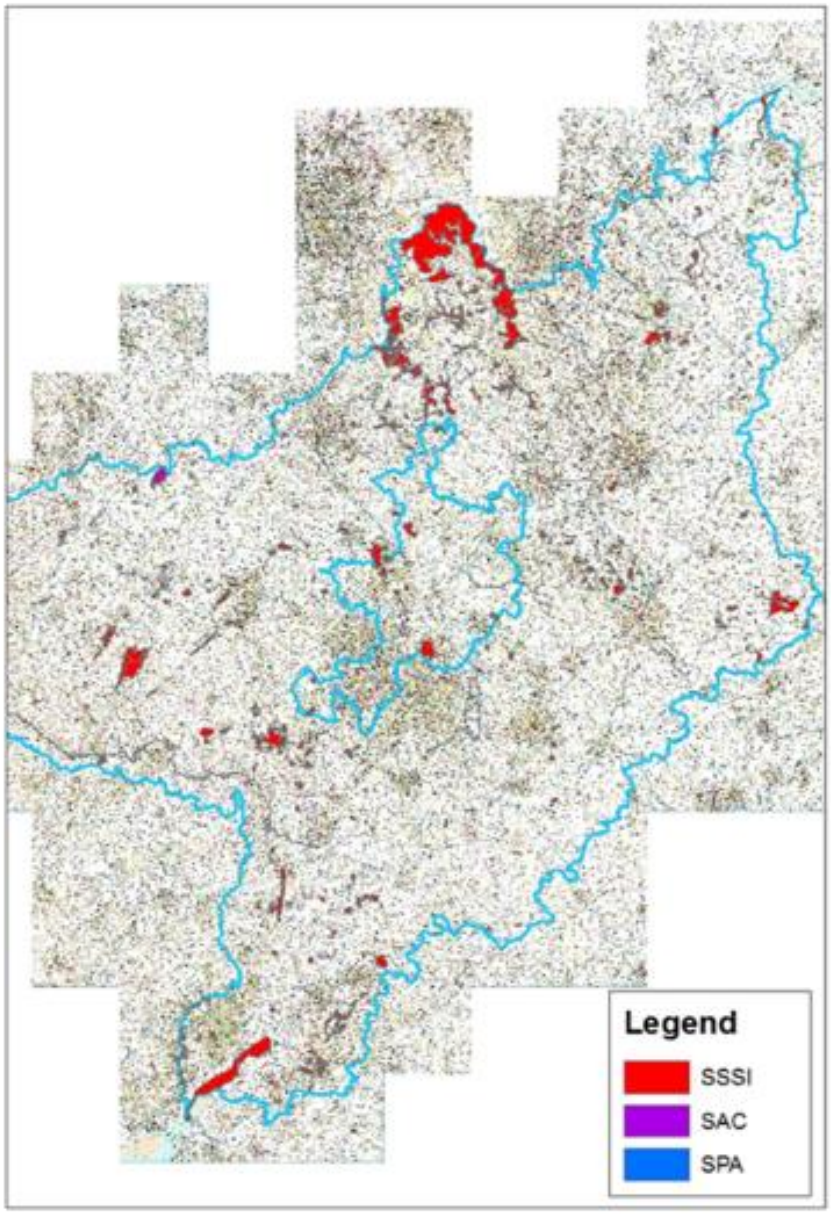
Figure 27 – Map showing location of potential drought permit and drought orders



These locations are unchanged from our previous drought plans and, as a result, we have carried out extensive work on Environmental Assessments for these drought permits/ orders and we have carried out the associated monitoring for several years in the catchments that include all of these sites.

However, we don't entirely rule out the need for drought permits/ orders that we don't currently list. The reason we cannot entirely rule this out is that in a drought more extreme than any we have previously experienced we do not know exactly how, where or when the effects will be most apparent. As a result we want to keep these options open if very extreme or unexpected events or series of events occur. For additional context, the map below shows the location of sites of special scientific interest (SSSIs), special areas of conservation (SACs) and special protection areas (SPAs) that are in our region:

Figure 28 – Map showing location of designated sites in our region



3.3.4.1 River Leam and River Avon

In 'normal' conditions our abstraction licences mean that:

- We cannot abstract at Eathorpe between May and mid-September unless Draycote reservoir storage is below the summer abstraction thresholds.
- We have to operate so that, if the flow in the River Leam at Princes Drive Weir in Leamington drops beneath 18.2Ml/d, we only abstract at Willes Meadow the same amount of water that we released from Draycote reservoir the previous day.
- We cannot abstract from the River Avon if the flow at Stareton gauging station is equal to or below 45 Ml/d.

This drought permit will:

- Authorise abstraction at Eathorpe on the River Leam to Draycote Reservoir at any time of year when the lower storage condition at Draycote Reservoir would normally prohibit such abstraction
- Relax the flow condition in the River Leam at Princes Drive Weir in Leamington from 18.2 Ml/d to 12.2 Ml/d
- Reduce the hands-off flow in the River Avon at Stareton of 45 Ml/d to 35 Ml/d exclusively to allow us to transfer additional water from the River Avon at Brownsover into Draycote reservoir.

3.3.4.2 Derwent Reservoirs

In 'normal' conditions our abstraction licences mean that we:

- Abstract approximately 75% of the annual licensed quantity from the reservoirs for our use.
- Approximately 25% is for Yorkshire Water's use.
- We should provide a minimum compensation flow of 54 Ml/d from Ladybower reservoir (when the River Derwent flow at Derby is above 340 Ml/d).

This drought permit will:

- Reduce the aggregate quantity of compensation water from Ladybower Reservoir to the River Derwent and the River Noe/ Jaggers Clough flows from 74 Ml/d (or 92 Ml/d when flow at Derby is <340 Ml/d) to 51 Ml/d.
- Reduce compensation water from Ladybower Reservoir from 54 Ml/d to 34 Ml/d.

3.3.4.3 River Derwent at Ambergate

In 'normal' conditions our abstraction licences mean that we can:

- Abstract up to 62,100 Ml annually from the river at Ambergate
- We have included the daily maximum abstraction rate in table 10.

This drought permit will:

Authorise the abstraction of up to 320 Ml/d at Ambergate when the flow in the River Derwent at Derby is not less than 500 Ml/d, rather than the present flow threshold of 680 Ml/d.

We have taken the table below from the River Derwent and Derwent Valley environmental report which we discuss in section 4.1.2. This table summarises the changes that these two drought permit applications would seek to make.

Table 10 – Derwent and Derwent Valley drought permits

System	Mean daily flow controls at St. Mary's Bridge Derby (Ml/d)		Permissible Abstractions (Ml/d)	Total Upper Derwent compensatory flow requirement (Ml/d)			
	Normal	Drought Permit	Normal & Drought Permit	Yorkshire Bridge		Below Noe Confluence	
				Normal	Drought Permit	Normal	Drought Permit
Derwent Valley Reservoir System	≤340	≤340	245 (daily average value)	≥72	≥34	≥92	≥51
	>340	>340		≥54	≥34	≥74	≥51
Ambergate	>680	>500	320	n/a	n/a	n/a	n/a
	≤680	≤500	≤15	n/a	n/a	n/a	n/a
	≤340	≤340	0	n/a	n/a	n/a	n/a

3.3.4.5 River Churnet

In 'normal' conditions, our abstraction licences mean that we must:

- Provide at least 14.8 Ml/d compensation flow from Tittesworth Reservoir (including Solomon's Hollow)
- Not abstract more than to 16,000 Ml annually from the reservoir.

In addition, we currently have an abstraction licence for Abbey Green borehole. However, as we do not use this source for public water supply we are working with the EA to revoke our Abbey Green abstraction licence. Regardless of whether we retain an abstraction licence at Abbey Green, if we are granted a drought permit and/or drought order it will allow us to:

- Reduce the compensation flow at Tittesworth Reservoir (including Solomon's Hollow) from a minimum of 14.8 Ml/d to a minimum of 8 Ml/d
- Abstract up to 6.8 Ml/d from the Abbey Green borehole to discharge a compensation flow into the River Churnet 1.8 km downstream of Tittesworth reservoir
- No longer release a total minimum discharge of 19.32 Ml/d from a combination of Tittesworth Reservoir (including Solomon's Hollow) and Deep Hayes.

Only one stretch of waterway is likely to have reduced flows under the proposed drought permit/ order:

- A 1.8 km stretch of the River Churnet below the Tittesworth reservoir and down to the Abbey Green borehole discharge point.

The environmental impacts of this drought permit/ order are covered in the Churnet environmental report. We describe the purpose and content of our environmental reports in section 4.1.

Should we require this drought management option we would:

1) Either apply to the EA for a drought permit to reduce the compensation flow from Tittesworth and to abstract from Abbey Green borehole for river augmentation purposes. In addition, we would also apply to the EA for an Environmental Permitting Regulations EPR permit for the discharge from Abbey Green borehole to the river
2) Or we would apply to Defra for a drought order to reduce the compensation flow from Tittesworth, abstract from Abbey Green borehole for river augmentation purposes and discharge from Abbey Green borehole to the river (Drought orders can contain provisions authorising discharges).

In both scenarios we would apply for an EA authorisation to carry out works in a flood plain. We would need this to build the pipe bridge we used in 2013/14 RSA trials to aerate the discharged water. We have illustrated how this worked in the following photograph:

Figure 29– Churnet pipe bridge

3.3.4.6 Site G

In 'normal' conditions the flow in the Severn at Bewdley is greater than 850 Ml/d and our abstraction licences mean that:

- We can abstract a daily maximum of 211 Ml/d at site G

However, we can also abstract an additional 20 Ml/d as we have transferred this from our shared South Staffordshire asset licence. So, in 'normal' conditions, the total daily maximum is 231 Ml/d but, we usually abstract less than this. The key constraint at site G during a drought is that our maximum daily abstraction reduces from 211 Ml/d down to 91 Ml/d during maximum regulation of the River Severn, and to a maximum of 9,100 Ml during the first 100 days of regulation (the figures are 111 Ml/d daily and 11,100 Ml with the 20 Ml/d currently transferred to site G from the shared South Staffordshire asset). The table below illustrates these restrictions upon our abstraction:

Table 11– Site G drought permit/ order

	River Severn Regulation State	Site G	Site G + 20 Ml/d from the shared South Staffordshire asset
Daily	**Bewdley >850 Ml/d**	211 Ml/d	231 Ml/d
Seasonal	**First 100 days regulation (then pro-rata)**	9,100 Ml	11,100 Ml
Daily	**Maximum regulation**	91 Ml/d	111 Ml/d
Annual	**Maximum regulation**	33,346 Ml/year	40,646 Ml/year

We expect to apply for this drought permit/ order if we have to reduce our abstraction at site G due to the maximum regulation condition in the abstraction licence. A reduction in abstraction at site G will have the greatest impact on our operation if there is the requirement to support the Elan Valley asset S flow to site U in Birmingham from the River Severn. This is most likely to occur if the Elan Valley Reservoirs storage is below the Elan Valley Licence Rule curve and flow to site U has been reduced so that we need River Severn support to supply the demand on site U.

The proposed drought permit/ order will suspend:

- The daily abstraction restriction under maximum regulation.
- The constraint limiting abstraction over the first 100 days of river regulation (special conditions 2b and 2c of the site G licence).
- The joint licence constraints at site G and the shared South Staffordshire asset, under maximum regulation. The daily maximum of 303 Ml/d (max regulation) will revert to 431Ml/d, and the seasonal limits equivalent to 273 Ml/d (licence No 110 and 163) and 303 Ml/d (licence No.110, 163 and 584) will be removed.

If the period of the drought permit/ order extends beyond 100 days of river regulation we will review the situation with the EA in the light of likely future demand on site G and current storage in site T and the Elan Valley reservoirs. We have described this as a drought permit/order as the fact that the R. Severn estuary is a HD site means that we may require a drought order, rather than a permit, even if the EA has not applied for a drought order itself. In the event that the EA has already applied for a drought order on the River Severn then we would need to apply for a drought order at site G. This drought order will:

- Reverse the 5% reduction on abstraction that would have been introduced by the EA's River Severn drought order
- Potentially make the other temporary changes that we would apply for in a drought permit application.

3.3.4.7 Wyelands

We described how we operate this source in both 'normal' and drought conditions in section 2.2.2.

We expect that this drought order will:

- Authorise the abstraction of up to 45.5 Ml/d at Wyelands when the flow in the River Wye at Redbrook is less than 1209 Ml/d and Elan Reservoirs storage is below the Elan Storage Licence Rule Curve.
- If DCWW is also experiencing severe drought conditions we may apply to increase our Wyelands abstraction to 48.5 Ml/d in order to transfer and extra 3Ml/d to DCWW.

4 Environmental impacts, SEA and HRA

As mentioned in section 3.3.1 there are some specific locations where we may apply for either a drought permit or a drought order. Section 4.1 provides some details of the environment assessments that we would use in support of these applications. We also consider the environmental impacts of all the other drought measures included in this plan within the associated SEA.

The Strategic Environmental Assessment Directive (2001/42/EC) requires a formal environmental assessment of certain categories of plans and programmes which are likely to have significant effects on the environment. Government has transposed the Directive into appropriate Regulations to apply to England and Wales. We are the responsible authority and have to judge whether our drought plans fall within the scope of the SEA Directive. We carried out an SEA for our 2014 Drought Plan and we have done so for this plan too. This SEA will report on the likely significant environmental effects of implementing this plan. We have produced this SEA and will publish it alongside this draft drought plan.

We have also undertaken a Habitat Regulations Assessment (HRA) for this draft drought plan. This assesses the likely effects of the drought plan on European sites, alone or in combination with other plans. This HRA considers whether actions in a drought plan would adversely affect the integrity of any European sites. The consultation on the SEA and HRA is separate to the draft drought plan consultation although there is some cross over, for example, in terms of the sites affected.

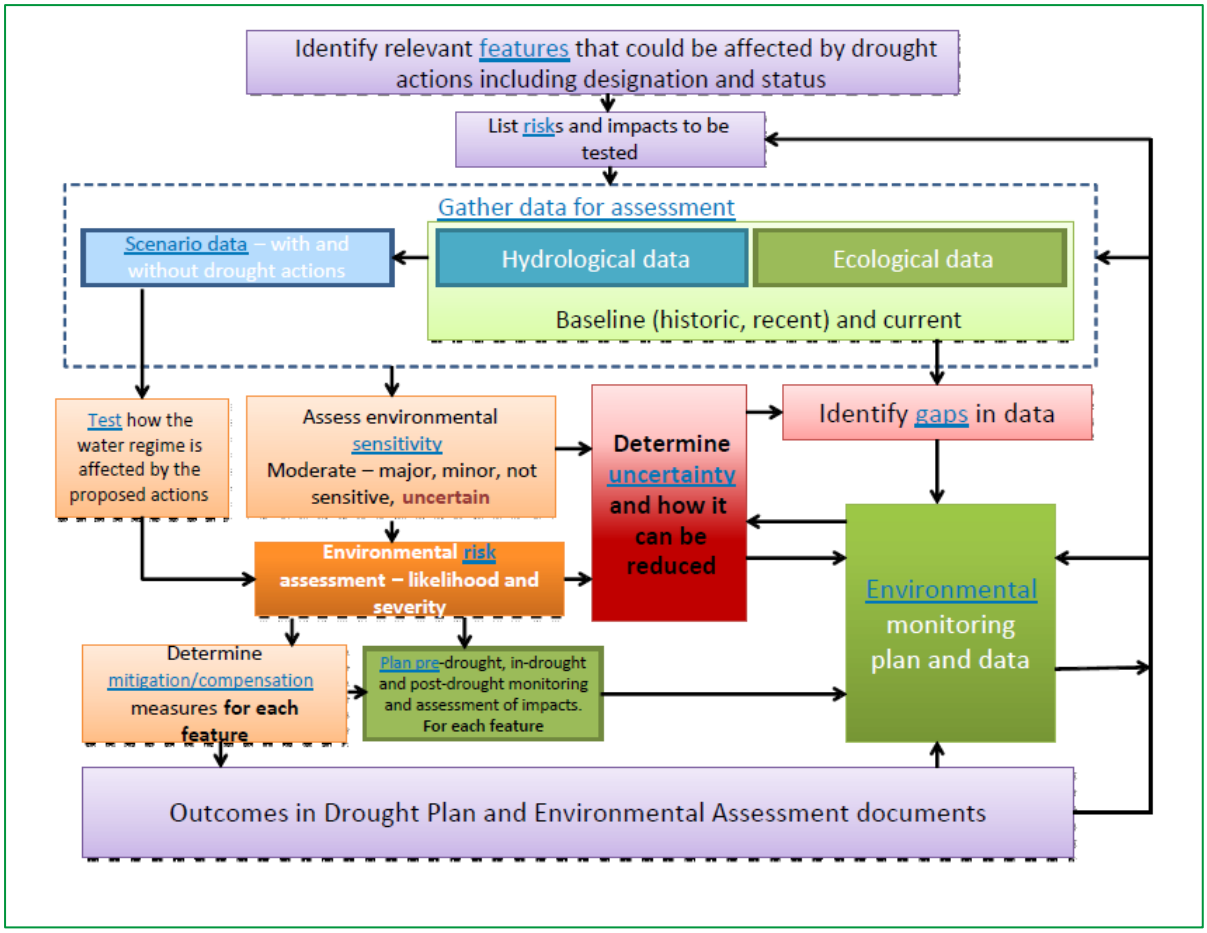
4.1 Environmental assessment reports (EARs)

The 2015 EA drought plan guidance states that we should provide:

"An environmental assessment showing the likely effects of the permit or order on the environment".

One of our responses to this is to produce EARs to assess the possible environmental impacts of the potential drought permit / order sites we listed in section 3.3.1. The figure below is from the EA 2016 document 'Environmental Assessment for Water Company Drought Plans' and gives an overview of the environmental assessment process:

Figure 30– EA flow chart of how to prepare drought permit



Since we published our 2014 drought plan we have completed the EARs for our site G and Wyelands abstractions. We have received feedback from our regulators and other stakeholders on both of these reports and we have incorporated these comments into the finalised reports. We finalised:

- The site G EAR in Feb 2017 (which was 3 years after the project start up meeting).
- The Wyelands EAR in September 2015 (which was 2 years after project start up).

During the process of producing these reports we have learned that they are complex assessments and we should not underestimate the time that they take to produce. We have concluded that we need a programme for updating these EARs that keeps them fit for purpose and as current as possible but ensures that we only make wholesale changes when significant changes occur either in the catchments themselves or within the applicable legislation/ regulations. We note that we carry out ongoing monitoring at each of the drought permit/ order sites and this will highlight to ourselves and the EA the occurrence of any 'step changes'.

We are aware of the EA 2016 document entitled 'drought permit and order ready' and the EA expectation for water companies to be as close to "drought permit/order application ready as is pragmatic for all of the permits and orders in your plan." Because we carry out ongoing monitoring at all of the permit/ order sites and due to the timescales involved in producing full updates of our EARs we consider that we are as application ready as is pragmatic.

One difference between these EARs and those we produced to accompany our 2014-19 drought plan is that the drought plan guidance asks us to focus more on droughts of a greater severity than those

in our current record. We described in section 2.1 how we have modelled these more extreme drought to support this drought plan and our draft WRMP. We have used this modelling of more extreme drought scenarios to select an extreme drought for each of the catchments (Derwent, Churnet, Avon/ Leam/ Severn and Wye.) As we have modelled the impact of the drought permits/ orders on flows in our historic record as well as in a severe drought event derived from our stochastic drought analysis; for each catchment we have covered a full range of plausible drought scenarios.

4.1.1 Environmental assessment reports (EAR) - River Leam and River Avon; Derwent reservoirs; River Derwent; River Churnet

We have described what these drought permit/ orders will do in section 3.3. We produce EARs to assess the possible environmental impacts of drought permit/ orders. We note that these EARs assess the incremental impact of the drought permit/ orders on the environment and not the impact of the drought itself. We expect to complete these EARs in 2018 but we note that this timescale will vary depending upon how many reviews and revisions are required in order to produce reports that meet both our internal requirements and those of regulators such as the EA and Natural England. These EARs, or non-technical summaries of them, are available on request.

4.1.2 Environmental assessment report (EAR) – site G

We have described what this drought permit/ order will do in section 3.3.1. We produce EARs to assess the possible environmental impacts of this drought permit/ order. We note that the EAR is to assess the incremental impact of the drought permit/ order on the environment and not the impact of the drought itself. We expect to complete this EAR in 2020 but we note that this timescale will vary depending upon how many reviews and revisions are required in order to produce a report that meets both our internal requirements and those of regulators such as the EA and Natural England. This EAR or a non-technical summary of it are available on request but the primary conclusions are:

"In the event that a Drought Permit at site G was implemented in advance of a River Severn Drought Order being implemented, it was determined there would be no effect of the site G Drought Permit/Order acting alone on the riverine reaches, since any effects would be counterbalanced by additional regulation releases. There is a very small risk of reduced freshwater inflows to the Severn Estuary under such a scenario but any such effects would be expected to be of extremely short duration and very unlikely to occur.

In the event that a site G Drought Order were to be implemented after implementation of a River Severn Drought Order, the results indicate a low to negligible impact on river flow and riverine habitats; flows are reduced at times of drought but the baseline scenario also shows similar reductions indicating that the changes are due to the normal flow recession that would be expected during a dry period.

This is in line with the conclusions of the in-combination assessment presented in the Environment Agency River Severn Drought Order report (Environment Agency, 2013)."

This EAR also notes that, although STWL applied for a site G DP in September 1984 it was never used as site T and the Elan reservoirs started to refill.

4.1.3 Environmental assessment report (EAR) – Wyelands

We have described what this drought permit will do in section 3.3.1. We produce EARs to assess the possible environmental impacts of this drought permit. We note that the EAR is to assess the incremental impact of the drought permit on the environment and not the impact of the drought itself. We expect to complete this EAR in 2020 but we note that this timescale will vary depending upon how many reviews and revisions are required in order to produce a report that meets both our internal requirements and those of regulators such as the EA and Natural England. This EAR or a non-technical summary of it are available on request but the primary conclusions are:

"In the event that a drought order at Wyelands was implemented without drought permit/order operation of DCWW sources (Scenario 2), there would be no effects upstream of the Wyelands abstraction for most receptors (negligible impacts were predicted for fish, angling and protected rights upstream of Wyelands), and only negligible impacts were predicted for all receptors in reaches downstream of Wyelands. In the event that a drought order at Wyelands was implemented in combination with drought permit/order operation of DCWW sources (Scenario 3), there could be effects upstream and downstream of the Wyelands abstraction. These impacts are predicted to range from negligible to moderate impact significance, depending on the receptor. The moderate impacts are predicted for the following receptors:

Moderate impacts are predicted on hydrology, water quality, water temperature and physical habitat both upstream and downstream of the Wyelands abstraction under Scenario 3.
Moderate impacts are predicted on juvenile eel (Apr-Sept), salmon fry (Apr-Aug), salmon parr (Jan-Dec), and Twaite shad spawning (May-Jun) upstream and downstream of the Wyelands abstraction under Scenario 3.

Moderate impacts are predicted on depressed river mussel downstream of the Wyelands abstraction under Scenario 3.
Moderate impacts are predicted on the yellow mayfly between June and October downstream of the Wyelands abstraction under Scenario 3.
Moderate impacts are predicted on macrophytes between April and September downstream of the Wyelands abstraction under Scenario 3.

Given that neither a Wyelands-only nor an in combination drought order has been applied for previously, impacts could not be established from the historic record of biological monitoring. Rather, the modest effects on biological receptors are predicted from the generally small or localised effects on water quality and physical habitat. Nevertheless, there is inevitable uncertainty in such estimates and therefore, high risk receptors have been identified, and monitoring and mitigation measures proposed."

4.2 Environmental data provision and monitoring plan

As part of our drought management work we have collected, and continue to collect, environmental data at all of our potential drought permit/ order sites. For each site there is a Site Investigation Plan (SIP) which we share with the EA for comment. We share this to ensure we do not duplicate work between us. These agreed monitoring plans will allow us to assess the environmental impact of any changes to our normal operations that we make as a result of the drought. This phase of monitoring is often referred to as 'baseline' monitoring to distinguish it from 'in-drought' or 'post-drought' monitoring. Our environmental monitoring records:

- The feature(s) we monitor
- The location of survey sites
- The timing and frequency of monitoring
- Who undertakes the monitoring.

The SIP details sites to monitor for:

- Spot flow
- Permanent flow
- Macro invertebrates
- Fish
- The river habitat as part of a RHS (river habitats survey)
- The habitat during habitat walkovers and
- White clawed crayfish.

For each year monitored we have produced a stand-alone monitoring report, which we use to track whether significant changes (step changes) have occurred.

4.3 Mitigation measures, compensation requirements

As we described in section 3, we are investing significant resources every year to manage customer demands, promote water efficiency and reduce leakage. We have committed to devote even more resources to demand management during a drought. This work reduces the likelihood of needing drought permits or drought orders. However, when we have exhausted all of the demand management options available we will have to use supply-side measures like drought permits. However, as described in section 3.1.5, we would not impose water use restrictions between November and March as we do not think they would be an effective way of reducing demand.

When we implement any drought management action we seek to avoid any adverse environmental damage. In addition to trying to prevent any environmental harm from occurring we have also considered numerous environmental mitigation measures. Some of these mitigation measures are generic and can apply to any location where we may apply for a drought permit/ order.

The following list shows generic mitigation measures that we will consider if we have to implement a drought permit or drought order:

- Fish rescue
- Aeration (for example, of discharges)
- Reduction of other abstractions, if possible

- Freshet releases (these are releases of water from reservoirs for environmental purposes)
- Other forms of flow augmentation (potentially from rarely used / emergency / resilience sources)
- Increase the frequency / coverage of monitoring – this constitutes 'in- drought' monitoring
- Ensure there is adequate 'post-drought monitoring'
- Habitat restoration.

The list above is neither exhaustive nor prescriptive. This means that we may not necessarily need all of these measures in every drought. It also means that if there are measures not listed here that will provide an environmental benefit then we may still implement them. We will decide on the precise combination of measures that is most appropriate to the circumstances of any given drought. We will discuss any necessary mitigation measures with the EA during the drought permit application process to determine the most appropriate monitoring and mitigation regime.

We have not included compensation in the list of mitigation measures above as we do not think that any of our proposed drought permits / orders will cause adverse impacts that our mitigation does not address. However, we are open to discussions on this topic during or after a drought because every drought is different and we would want to account for the specific circumstances of each case.

The mitigation measures that we propose using are appropriate for the level of impact predicted and the importance of the receptor. We design our measures to minimise the impacts occurring as a result of maintained, or increased, abstraction during a drought. As a result we would expect the majority of them only to be in place for the duration of the drought permit/ order.

The mitigation measures we implement will mitigate the impacts of the drought permit or drought order and not the impacts of the drought itself.

We have also carried out more detailed site specific assessments of mitigation measures in each of the environmental assessment reports we described in section 4.1.

For example, section 5 of the environmental assessment report (EAR) for the Derwent describes mitigation. It illustrates how we plan to:

- Understand the baseline condition of the hydrology and ecology at the location
- Set appropriate monitoring and
- Mitigate against any adverse impacts if they occur.

In the Avon and Leam EAR we propose additional monitoring and mitigation measures to reduce all potential impacts to a minor negative level of significance, where possible. This EAR describes measures which include:

- *"A repeat habitat walkover survey and spot gauging will facilitate the identification of temporal minimum flow requirement thresholds for all species and life stages. This will facilitate assessment of the minimum flow required to protect fish populations during key periods of sensitivity, whilst still optimising the supply resource;*

- *Temporary return to normal abstraction rates in the event of a pollution incident, evidence of ecological distress, or evidence of serious detrimental environmental consequences on downstream watercourses;*
- *Funding of appropriate reasonable measures (e.g. habitat restoration) in the event of ecological damage occurring on watercourses affected by increased abstraction; and*
- *Provision of appropriate assistance and / or funding of reasonable additional measures to protect habitats and sites or species of special ecological interest affected by the DP.*"

We also provide the detail of our mitigation measures in the other completed environmental assessment reports i.e. the Churnet and the River Severn and River Wye EARs. We have provided the full references for these reports in section 7.

In the unlikely event that we need to use any of the drought/ emergency sources apart from Norton and Beechtree Lane described in table 8 and table 27, the long lead in time will allow time to carry out a hydrological and environmental assessment. We will consider what, if any, mitigation is necessary as part of these environmental assessments.

4.4 Consideration of Water Framework Directive (WFD) article 4.6

Article 4.6 of the WFD provides an exemption for temporary deterioration of water bodies caused by "exceptional" events with "natural causes". Extreme droughts could fall into these categories but as we cannot prevent droughts from occurring, this plan needs to consider whether any of the actions that we, Severn Trent Water, take could cause temporary deterioration. On this topic, the 2017 EA 'Environmental assessment in water company drought plans' supplementary guidance, recommends that drought plans should:

- "*clearly identify all actions that could cause temporary deterioration using appropriate assessment methods*
- *clearly describe why the circumstances are exceptional using hydrological data and any other relevant indicators*
- *clearly justify why an action that causes temporary deterioration is preferable to the alternatives*
- *include details of planned mitigation to minimise the impacts of such actions before during and after*
- *set out what action you will take to restore the water body following the drought*."

We have addressed all of these points within:

- the relevant parts of section 4 of this drought plan
- the SEA, HRA and WFD assessments that accompany this plan
- the Environmental Assessment Reports (EARs) described in section 4.1

For ease of reference we have summarised how and where we have addressed these points in the following table:

Table 12– How we have considered the actions in this plan against WFD deterioration

Action	Does this cause temporary WFD deterioration?	Where do we provide more details?	Other comments
All actions from business as usual, standard demand management through to TUBs and NEUBs, awareness raising and supply/ transfer options covered in our Baseline DO modelling	No	The SEA/ HRA discuss all of our drought options. There is also some information in section 4 and section 7 of this plan.	These don't apply here because they are reasonably foreseeable.
Drought permits (Churnet, Avon/ Leam and Derwent)	Unlikely	The primary source of information for these is the EAR reports (both the existing versions and the ones we are currently preparing). The data sources above also apply. Mitigation is covered in section 4.3 of this plan	There is a low likelihood of needing these permits and we would not apply for them unless we had to.
Supply-side drought orders (Site G / Wyelands)	Potentially	The data sources above apply.	There is an even lower likelihood that we would apply for these and they are very much last resort options. When we are in this territory we will have started or be about to consult our emergency plans.
Drought/ emergency sources	Potentially	Section 3.2.1 & 7.2.1	We have not assessed the WFD impacts of these but, as there is such a long lead in time before we may need to use them, we would have time to do so. If we need these options our emergency plans will be active.

5 Management and communications strategy

5.1 Management structure/ roles and responsibilities

It is essential that we have a clear management chain and line of communication. This is necessary so we can make informed decisions quickly and effectively, and can agree and implement these actions. Overall control of our response to a drought is managed by our Drought Action Teams (DATs). We have four different levels of DAT:

- Operational bronze
- Operational silver
- Tactical DAT
- Strategic DAT

We judge which level of DAT we need to convene by monitoring levels of raw water against our drought triggers (described in section 2.2). If resources are in:

i. Trigger zones A or B and tracking normally we manage through our normal operating rhythm
ii. Trigger zones A or B but trending towards zone C, we will manage our system via operational bronze DAT
iii. Trigger zone C we will manage our system via operational silver DAT
iv. Trigger zone D we will manage our system via tactical DAT
v. Trigger zone E or below we will manage our system via strategic DAT

5.1.1 Operational bronze DAT

This team meets fortnightly if condition (ii) above applies. We have set out the composition of this DAT in the following table:

Table 13 – Bronze Drought Action Team (DAT)

DAT member	Role
Strategic Asset Management - Water Resources Lead (Chair)	Overall responsibility for managing the response to a drought whilst in trigger zone A or B
Principal Hydrologist	Provides technical advice on hydrology and licensing
Water Resources and Production Manager	Controls interventions on the grid and daily production requirements
Strategic Network Optimisation Advisors	Support water resources and production manager
Hydrology and Modelling Analysts	Provide technical advice on hydrology and modelling
(Principal/ Senior) Hydrogeologist(s)	Provides technical advice on hydrogeology and groundwater assets

5.1.2 Operational silver DAT

Our Silver DAT is the same team that we refer to internally as the Strategic Grid Steering Group. Despite the name, this group also manages companywide issues and not just ones in the Strategic Grid WRZ. We have set out the composition of this DAT in the following table:

Table 14 – Operational silver Drought Action Team (DAT)

DAT Member	Role
Head of Network Control (Chair)	Overall responsibility for managing the response to a drought and network management
Head of Strategic Asset Management (Chair)	Responsibility for strategic asset planning and water resource management planning
Head of Asset Creation Non-Infra	Responsible for engineering projects on our non-infrastructure assets
Strategic Asset Management - Water Resources Lead	Leads on implementation of drought plan measures
Strategic Grid and Resilience Manager	Advice on grid resilience and capacity head of asset management
Area Production Operations Lead (for the areas affected)	Responsible for managing water production operations
Principal Hydrologist	Provides technical advice on hydrology and licensing
Hydrology and Modelling Analysts	Provide technical advice on hydrology and modelling
(Principal/ Senior) Hydrogeologist(s)	Provides technical advice on hydrogeology and groundwater assets
Process Design Engineering Lead	Advice and sign off on water treatment processes
Network control – water resources lead	Supports Head of Network Control
Water Resources and Production Manager	Controls interventions on the grid and daily production requirements
Operation Control Centre – Response Lead	Supports Head of Network Control
Head of Regulatory Performance and Assurance – if needed	Responsible for contact with EA and environmental permitting
Customer Strategy and Experience – if needed	Responsible for customer experience
External Communications – if needed	Responsible for all external customer communications

5.1.3 Tactical DAT

The Strategic Grid Steering Group expands to become the tactical DAT if any sites enter drought trigger zone D. We have set out the composition of this DAT in the following table:

Table 15 – Tactical Drought Action Team (DAT)

DAT Member	Role
Head of Network Control (Chair)	Overall responsibility for managing the response to a drought and network management

Head of Strategic Asset Management (Chair)	Responsibility for strategic asset planning and water resource management planning
Head of Asset Creation Non-Infra	Responsible for engineering projects on our non-infrastructure assets
Strategic Asset Management - Water Resources Lead	Leads on implementation of drought plan measures
Strategic Grid and Resilience Manager	Advice on grid resilience and capacity head of asset management
Operation Control Centre – Response Lead	Supports Head of Network Control
Network control – water resources lead	Supports Head of Network Control
Water Resources and Production Manager	Controls interventions on the grid and daily production requirements
Area Production Operations Lead (for the areas affected)	Responsible for managing water production operations
Principal Hydrologist	Provides technical advice on hydrology and licensing
Hydrology and Modelling Analysts	Provide technical advice on hydrology and modelling
(Principal/ Senior) Hydrogeologist(s)	Provides technical advice on hydrogeology and groundwater assets
Security and Resilience Lead	Responsible for security, emergency plans, incident management, engaging with mutual aid and Local Resilience Forums
Legal Counsel (Legal) – if needed	Responsible for legal issues
Customer Strategy and Experience – if needed	Responsible for customer experience
External Communications – if needed	Responsible for all external customer communications
Head of Regulatory Performance and Assurance – if needed	Responsible for contact with EA and environmental permitting
Water Regulations and Public Health Lead – if needed	Responsible for water quality considerations

5.1.4 Strategic DAT

This is the highest level of DAT and it is chaired by the Production Director or an appropriate deputy. The silver, tactical and strategic DATs include senior managers who have expertise in water resources, water treatment, water quality and communications. These managers are supported by extensive technical expertise from within their departments. Strategic DAT includes **all** of the members of tactical DAT as well as the people listed in the following table:

Table 16 – Strategic Drought Action Team (DAT)

DAT Member	Role
Production Director (Chair of Strategic DAT)	Overall responsibility for managing the response to a drought
Head of Customer Network Operations	Responsible for managing the distribution network in our region
Deputy Chief Engineer (represents Chief Engineer)	Responsible for engineering and providing a 2nd line assurance of DAT decisions
Deputy General Counsel (Legal)	Responsible for legal issues
Head of Finance and Performance Production	Responsible for financial and performance issues
Head of Customer Strategy and Experience	Responsible for customer experience
Head of Asset Creation Infrastructure	Responsible for engineering projects on our Infrastructure asset
Head of Communications	Responsible for all communications

Our DATs allow us to monitor and evaluate the effectiveness of our drought management actions. It also provides the benefit that it is a forum for technical discussions as well as for understanding the implications to our communication activities. By ensuring consistent internal and external drought messages we are in a stronger position to join-up our communications with those of our relevant stakeholders.

5.1.4.1 Annual Review

This drought plan does not only apply during drought years. We have a regular 'raw water availability' agenda item at our Strategic Grid Steering Group. This helps to remind staff of the processes described in this plan, to assess the need for any further proactive mitigating actions and to ensure that our drought plan remains both current and achievable.

5.2 Communications plan

It is vital that we have a clear communications route to our customers and other stakeholders so that we communicate the correct messages at the correct time. This section of our plan sets out the communications plan that we would follow at different stages before, during and after a drought.

Effective communications can help to reduce demand in a drought, for example, by raising customer awareness of the limited availability of water resources. Conversely, poorly prepared messages can have a detrimental effect on the public response to appeals for restraint.

We use the DAT to prevent this from happening. For instance, the communications team attend DAT meetings and work with the DAT to provide clear briefings for internal communication, ensuring our employees communicate appropriate messages and advice to customers. External methods of communication available to us include social media, leafleting, mailed letters, radio and/or television, local and national press, social media and by updating our website.

5.2.1 Stakeholders

The following table provides a list of stakeholders that we expect to communicate with during a drought. In this list, we have included all of the groups mentioned in appendix I of the EA guidelines regardless of whether these are statutory or non-statutory consultees. Although we expect to contact most of the non-statutory groups in a drought there may be circumstances when we do not need to specifically contact every one of these groups. This list is not exhaustive and we may contact other bodies not included in this table:

Table 17 - Stakeholders that we expect to contact in a drought

Group	Stakeholder
Domestic and commercial customers	Private customers
	Non household retailers
	Consumer Council for Water
	Citizens Advice Bureau
Regulators	Drinking Water Inspectorate (DWI)
	Welsh Government
	Ofwat
	Defra
	Ministry of housing community and local government (MHCLG)
	Environment Agency
	Natural Resources Wales/ Cyfoeth Naturiol Cymru
	Natural England
Environmental and other relevant interest organisations and groups	Local wildlife groups and campaign groups
	Waterwise
	Local fisheries bodies and groups
	Angling Trust
	Campaign to Protect Rural England
	RSPB
	WWF
	Friends of the Earth
Local authorities and political representatives	Councils
	MPs
	MEPs
Representative bodies	Primarily Water UK but also others such as: Confederation of British Industry, NFU, Chambers of Trade and Commerce, Countryside Landowners and Business Association, Horticultural Trade Association
Community based institutions and organisations	Parish Councils
	Town Councils
Water companies	For example, neighbouring water companies like Yorkshire Water, Anglian Water, South Staffordshire Water, DCWW, United Utilities and Thames Water.
Public services	Fire Service
	Health Authorities
	Police services
	Local Resilience Forums (LRFs)
Press and media	Newspapers
	TV

	Radio
Sports and interest groups	Angling clubs
	Canoe/ boating clubs
Waterways and navigation	Canal and Rivers Trust
	Canal authorities
Other relevant water undertakers	

In addition to the public consultation, we invited the following statutory stakeholders to comment on this draft drought plan:

- Environment Agency
- Natural Resources Wales/ Cyfoeth Naturiol Cymru
- Ofwat
- Secretary of State/Welsh Ministers
- Any licensed or appointed water supplier which supplies water in the Severn Trent region via our supply system.

Once Strategic DAT has recommended that we impose restrictions on our customers' water use we will send regular briefing statements to Defra, CCWater and Ofwat. If drinking water quality could be affected, we will contact the DWI. All such communications will be approved by Strategic DAT.

We will report on the situation regularly to Water UK particularly if other UK water utilities are suffering similar drought problems. It is important that Water UK co-ordinate any reporting of the national situation and present it in a consistent manner in the national news media. Regular conference calls will ensure this is handled consistently.

Similarly, we will involve other external bodies if supplies are under extreme risk. For example, if tankering to outlying areas becomes necessary, we may ask the police and county highways departments for advice. We will make contact with the Local Resilience Forums (LRFs) to ensure full public awareness of the situation.

5.2.2 Escalation of messages

Communications will

- Show customers that their contribution to water efficiency is worthwhile
- Explain to customers in simple terms how they can save water
- Demonstrate to customers that we are doing our bit to manage water resources wisely

Table 18- Escalation of messages

Stage of Communication	Trigger
Stage 1- first fall in resources • Ongoing water efficiency communications continue as per normal water efficiency campaign plan Includes standard marketing of • Save-a-flushes • Water butts and other products (e.g. shower heads, timers) • Guide to saving water (print and web) • Education activity • Opportunistic media and PR	Reservoir storage/ other indicators moving towards zone C
Stage 2 – projections show likelihood of continued fall in resources • Specific and targeted focus on promoting water efficiency through regional media, exploiting existing relationships • Social media campaigns, e.g. ask customers for their best water saving tips • Extra emphasis on leakage. We provided some illustrative information on the quantities of leakage reduction we could achieve in section 3.1. We will start this extra emphasis on leakage in stage 2 but will continue with this work in stage 3 and 4. • We will showcase our work in finding and fixing leaks, promotion of leakline, reporting leaks online and report a leak app. • Show good examples of our customers taking action to reduce consumption • Working with the gardening industry to promote saving water in the garden • Frost awareness PR • Work with WaterWise, Water UK and other water companies to ensure joined up and consistent messaging • Working closely with non-household retailers to understand their predicted water use profiles over the coming weeks	DAT convened/ indicators in zone C
Stage 3 – one to two weeks leading to proposed restrictions on use • Specific focus in the regional media on water usage and efficiency • Possible radio campaign showing what we do and what customers can do • This would include paid for elements of advertising, including features and promotions • Possible increased activities such as water efficiency product giveaways via radio and TV • Higher profile of water saving on the website, including front page banner • Increased use of social media including Facebook and Twitter campaign • Press features on water resources activity, summarising how we plan for dry spells and how customers can help • Water efficiency adverts in newspapers • Formal media appeals to conserve water • Possible sponsorship of weather section in print, tv and radio media	DAT decision/ indicators in zone D or E

• Participate in any joint national media campaigns on water efficiency • One to one media briefings • Setting out what actions are likely to happen over the coming days/weeks so that nothing comes as a surprise to people • Close liaison with stakeholders and regulators to maintain "no surprises" • Close working with other water companies – consider joint statements and adverts • Asking large commercial customers if there is scope for them to reduce demand	
Stage 4 – restrictions imminent or in place • We plan to give a notice period (14 days) to customers before we put any restrictions in place • We will use at least two local newspapers as well as social media and our website to advertise restrictions. • We will give details of how customers can make representations • Daily updates on water resources levels to manage high volumes of reactive interest • Intense local broadcast activity – All traditional media (TV / radio / newspapers) as well as social media. This activity will reach far more people than those who see the adverts in the local newspapers and on our website • Advertising in the media in areas where there is a known supply/demand imbalance • Close contact with stakeholders on a regular basis • Withdrawal of softer messaging to avoid any confusion as hard messaging introduced.	DAT decision/ indicators in zone E or zone F
Stage 5 – removal of restrictions • Strong message in the media - thank you to our customers for their help at this time • Close liaison with stakeholders to ensure messaging is consistent	DAT decision/ indicators in zone A

When we communicate with customers during a drought or a period of extremely hot weather we are able to measure the number of people accessing information on our website, the number of tweets that people click to request further information and the number of water efficiency packs that we distribute. We also know how many people different newspapers or radio programmes reach and we record what communications activities we do and when. In addition to this we measure how demand changes across the company and over time.

However, there is not always an obvious correlation between the extent and type of communications work and the demand for water. This makes monitoring the effectiveness of our communications a challenging exercise. For example, in response to periods of hot weather we increase the amount of proactive media work that we did. In addition, we also devote additional resources to our leakage reduction work. We describe this in more detail in section 3.1.2.

Waterwise published a report in July 2013 on the 2010-12 drought (see appendix for full reference) and one conclusion of this was that "*The impacts on the public of communications and promotion are difficult to measure but by most measures, there seems to have been a positive reaction both in terms*

of action and understanding". This supports our point that it is not easy to measure the effectiveness of this type of communications.

5.2.3 Private supplies

We have prepared this drought plan to show how we intend to provide our customers with water during drought. However, we are aware that some people in our region depend on 'private supplies'. For example, householders or businesses may have their own borehole. If a drought adversely affects these people then we encourage them to contact us. If this scenario arises we will consider how we can help without putting our own customers' supplies at risk.

5.3 Lessons learned from previous droughts

We have not had to restrict our customers' use of water since the 1995-96 drought. Therefore when we look to learn from our experiences of previous droughts, this is the drought we often refer back to. For example, when we analyse reservoir storage information we frequently show the actual drawdown records from 1995 and 1996 as these are useful comparators. As a result of this two year drought we restricted the use of all of our customers in 1995 and the use of approximately half of them in 1996.

As well as implementing this form of demand management we also sought to increase the supplies available to us. Although there have been several changes since 1996, for example legislation has changed, we think that we can still learn lessons from this unusually dry period. In the 1995-96 drought we applied for a Drought Order relating to the refill of the Derwent Valley and Carsington reservoirs. In 1996 we applied for a drought permit for the Derwent catchment but we withdrew our application due to changed weather conditions. In the Churnet Valley we were granted a drought order from December 1995 to June 1996 to aid the winter refill of Tittesworth reservoir. We used Abbey Green borehole to compensate the River Churnet in a way similar to how we may do so if we needed a drought permit here in the future. However, we are aware that different legal and regulatory requirements exist now and we address these in the Churnet environmental report.

Since the 1995-96 drought we undertook a comprehensive review of the areas where providing a reliable supply was most difficult. Since then we have invested significantly to improve our infrastructure. As described in section 3.1 our investment and the commitment of our staff have reduced leakage to its lowest ever. Other examples of where we have invested in our network since 1996 include enhancements to the network by duplication or upsizing of mains and provision of new local booster pumps. We assigned the investment to where it would have the most impact in making our sources more robust in terms of treatment and deployability.

We continue to invest in the construction of permanent infrastructure. We target this investment in proportion to the risk of loss of supply during extreme events such as droughts. As we prepare our PR19 submission we continue to assess what we need to invest to provide the optimal level of resilience for our customers. When we talk about resilience in this context we mean making our network better able to cope with the challenges posed by extreme events that are beyond the control of Severn Trent.

To help us manage our drought communications in the most effective way we collected local demand data at sub-daily time intervals during previous drought years. We have collected valuable information, some examples of which are shown below:

- In summer 1995, peak demands in local networks tended to occur at 9 o'clock in the evening, which we assume was associated with use of sprinklers and hose pipes for garden watering
- For small areas of mainly detached houses the ratio of peak flow to mean daily flow was over 7 to 1
- For small areas of terraced and semi-detached properties the ratio was 3.6 to 1
- For a mixed suburban area of properties, the ratio was 2.6 to 1
- Nationally, customer awareness campaigns during 2006 demonstrated the benefits of media awareness campaigns in reducing total demand, despite no restrictions on use in our region. One of the most effective ways of reducing peak demands is to reduce dependence upon the public water supply by gardeners. This can be achieved through encouraging alternative practices.

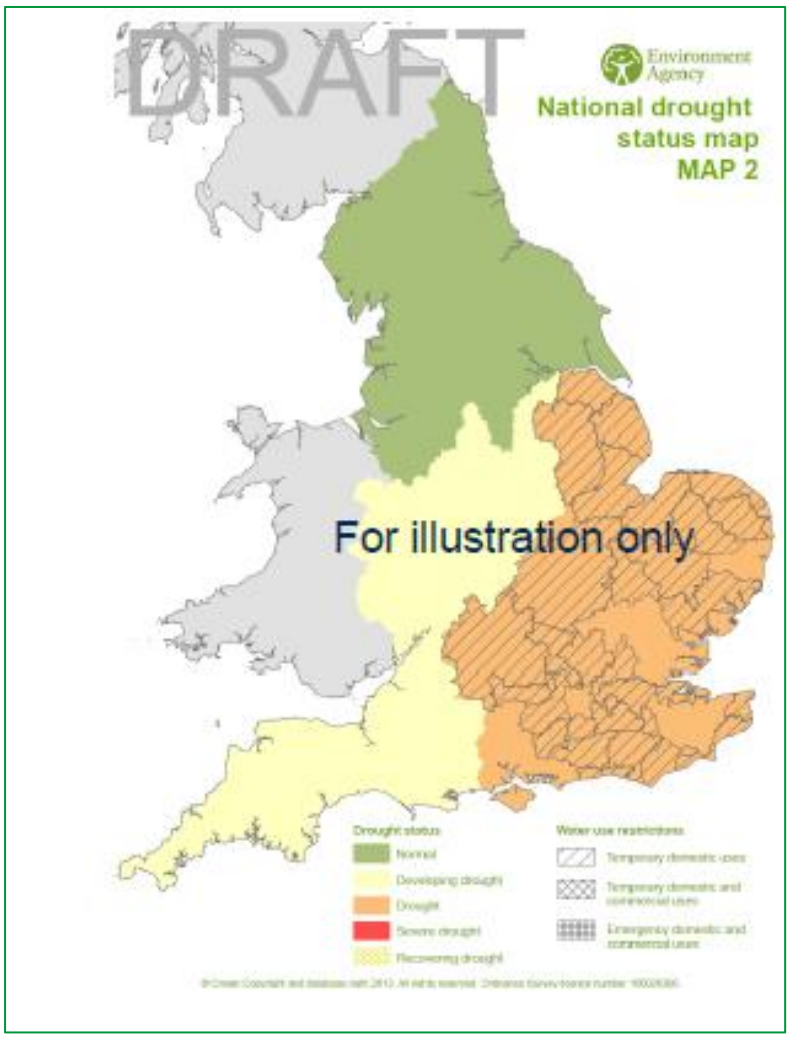
As described above we have learned lessons from managing previous droughts and used this knowledge to prepare this plan. We learned some specific and some general lessons from implementing various drought management actions since 2014. The following table summarises these lessons and provides references to the relevant part of this drought plan:

Table 19- Lessons learned since previous drought plan

Lessons learned since publication of our 2014-19 drought plan	Section of Drought Plan
We need updated environmental reports to accompany any drought permit/ order application and, as described in section 4, we realise that the timescales for these are longer than we had estimated in 2014.	4
We have more 'drought/ emergency sources' available now than we included in our 2014-19 drought plan.	3
We have revised the drought actions from our 2014 plan and removed ones we know are no longer available to us.	Reflected in flow charts and tables (section 2 and appendix)
We have an improved understanding of the EA's requirements for drought permit/ order applications especially in relation to the associated environmental reports/ monitoring requirements. For example, we know more about the water quality issues and what needs to be in place before we can use Abbey Green borehole to support flow in the River Churnet.	3 and 4

We remain committed to learn, review and improve our processes and will do so if/ when we experience droughts in the future. For example, we note that in the 2015 EA 'National drought framework' the EA states that it will use the www.gov.uk website to publish drought maps. As described in the communication plan section we will work closely on communications with the EA and, where appropriate, we will direct queries to this source of information. The figure below illustrates how these might look:

Figure 31- EA drought maps



6 Post-drought actions

We define the end of a drought as when our water resources availability has returned to 'normal'. Indicators of the end of a drought are that:

- There have been several months of average or above average rainfall (winter rainfall usually provides greater recharge).
- Reservoir storage has recovered, for example, storage in the majority of reservoirs is above the appropriate trigger curves (these curves are shown in sections 2 and 7).
- River flows have returned to normal.
- Groundwater levels have returned to the normal range.

We will analyse these and other relevant indicators (such as those described in section 2) before we conclude that conditions have returned to 'normal'. Due to the long term impacts that droughts can have, for example on our groundwater sources, there may be a significant delay before we can say definitively that a drought is over. We will liaise with the EA, NRW and Water UK/other companies before we formally declare a return to 'normal' conditions. We will consult with other stakeholders if necessary before declaring a drought is over. This is part of the consistency in messaging that our communications plan discussed.

Once normal conditions have resumed and all restrictions lifted, our DAT will undertake a review of our drought management processes against those as outlined in this drought plan. There will be a post-drought review to learn lessons, review the effectiveness of our drought planning, communications, drought and environmental management. If we have used customer restrictions, drought permits or drought orders we will review these in detail. Should there be any information relevant to our WRMP work or to other areas of the company then we will pass this directly to those teams.

Following the drought that ended in 2012 we engaged with other companies and stakeholders. For example, we contributed to a Water UK drought resilience workshop on 23 July 2012 as well as the joint Water UK and EA workshop 'Drought resilience – Securing the future' on 16 August 2012. We have maintained links with the National Drought Group (NDG) ever since 2012. These links involve both drought communications as well as more technical hydrological and hydrogeological situation reports.

7. Appendices

7.1 Appendix - glossary

- AMP – asset management plan for investment in water industry assets
- AMP5 – the period in which the 5th asset management plan occurs i.e. 2010 to 2015
- AMP6 - the period in which the 6th asset management plan occurs i.e. 2015 to 2020
- AMP7 - the period in which the 7th asset management plan occurs i.e. 2020 to 2025
- CCWater - Consumer Council for Water
- CEH - Centre for Ecology and Hydrology
- Defra – Department for Environment Forestry and Rural Affairs
- DO – deployable output (this is a measure of how much water we have to meet demand)
- dWRMP – draft water resources management plan
- EA – Environment Agency
- GSS - Guaranteed Standards Scheme
- Ml/d – mega litre per day – a mega litre is one million litres
- NEUB – Non essential use ban
- NRW – Natural Resources Wales
- Ofwat - Water Services Regulation Authority – this is the economic regulator for the water industry in England and Wales
- PR19 – periodic review/ price review 2019
- RSA – restoring sustainable abstraction
- TUB – temporary use ban
- UKWIR – United Kingdom Water Industry Research
- WG – Welsh Government
- WRMP14 – Water resources management plan 2014
- WRMP19 – Water resources management plan 2019
- WRZ – Water resources zone

7.1.2 Appendix - References

- 411957_Draycote_Reservoir_APEM_FINAL_Report_ 2012
- Cropston & Swithland Reservoirs Water Quality Survey Report - Severn Trent Water APEM Reference 414412 November 2015
- CEH (centre for ecology and hydrology) drought portal https://www.eip.ceh.ac.uk/apps/droughts/
- Drought Direction 2011, Defra
- Drought Plan (England) Direction 2016, Defra
- Drought Plan Regulations 2005, Defra
- Environment (Wales) Act 2016
- Environment Agency, How to write and publish a drought plan (Defra & Environment Agency, 2015) – also reference to as the drought plan guidelines
- Environment Agency, Appendix C: Recommended structure for a water company drought plan in the EA guidance 'Further supplementary information' - April 2016
- Environment Agency, Drought plan process flow diagram' - June 2016

- Environment Agency, Environmental Assessment for Water Company Drought Plans, May 2016
- Environment Agency, 'Environmental assessment in water company drought plans' supplementary guidance, October, 2017
- Environment Agency, 'Drought plan and WRMP links', revised November 2016
- Environment Agency, WRMP19 Table instructions REVISED May 2017 v16
- Environment Agency, Drought permit and order application ready, November 2016
- Environment Agency, monthly water situation reports and weekly rainfall and river flow summaries for England: https://www.gov.uk/government/collections/water-situation-reports-for-england
- Environment Agency's National Drought Framework https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440728/National_Drought_Framework.pdf July 2016
- Environment Agency's East Midlands Drought Action Plan, June 2017
- Environmental Assessment of Plans and Programmes Regulations 2004
- Flood and Water Management Act 2010 where s. 36 amends the Water Industry Act 1991 by substituting a new s.76
- Habitats Directive IROPI guidance 2012, Defra https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/82647/habitats-directive-iropi-draft-guidance-20120807.pdf
- Hydrological outlook UK http://www.hydoutuk.net/latest-outlook/
- Natural Resources Wales (NRW) - Water Company Drought Plan Technical Guideline, August 2017
- UK Government, Water Industry Act 1991
- UK Government, Water Act 2003 where s.63 inserts new sections 39B & 39C into the Water Industry Act 1991 and s.62 inserts new sections 37B-D into the Water Industry Act 1991
- UK Government, Water Act 2014 where s. 28(4) inserts an amendment to s. 39B into the Water Industry Act 1991, and s. 28(5) inserts a new section 39D into the Water Industry Act 1991
- UK Government, Water Use (Temporary Bans) Order 2010
- United Kingdom Water Industry Research (UKWIR)/ EA 2000 - A unified methodology for the determination of deployable output from water sources
- UKWIR, FINAL report Decision making process – guidance, 2016
- UKWIR WRMP 2019 Methods - Risk-Based Planning 16WR0211
- UKWIR drought vulnerability framework, draft output seen as part of the steering group, 2017
- Water UK/ UKWIR) Managing Through Drought: Code of Practice and Guidance for Water Companies on Water Use Restrictions (2013)
- Welsh Government, Wellbeing of Future Generations Act 2015
- Welsh Government, 01 - Welsh Government Drought Plan Guiding Principles 25-Oct-2017 - Published 2017 English
- Welsh Government, 02A - The Drought Plan (Wales) Direction 2017 - English - 25-Oct-2017
- Wildlife and Countryside Act 1981 as amended by the Countryside and Rights of Way Act 2000, Section 28G

7.2 All drought triggers, associated drought actions and consideration of yield benefits

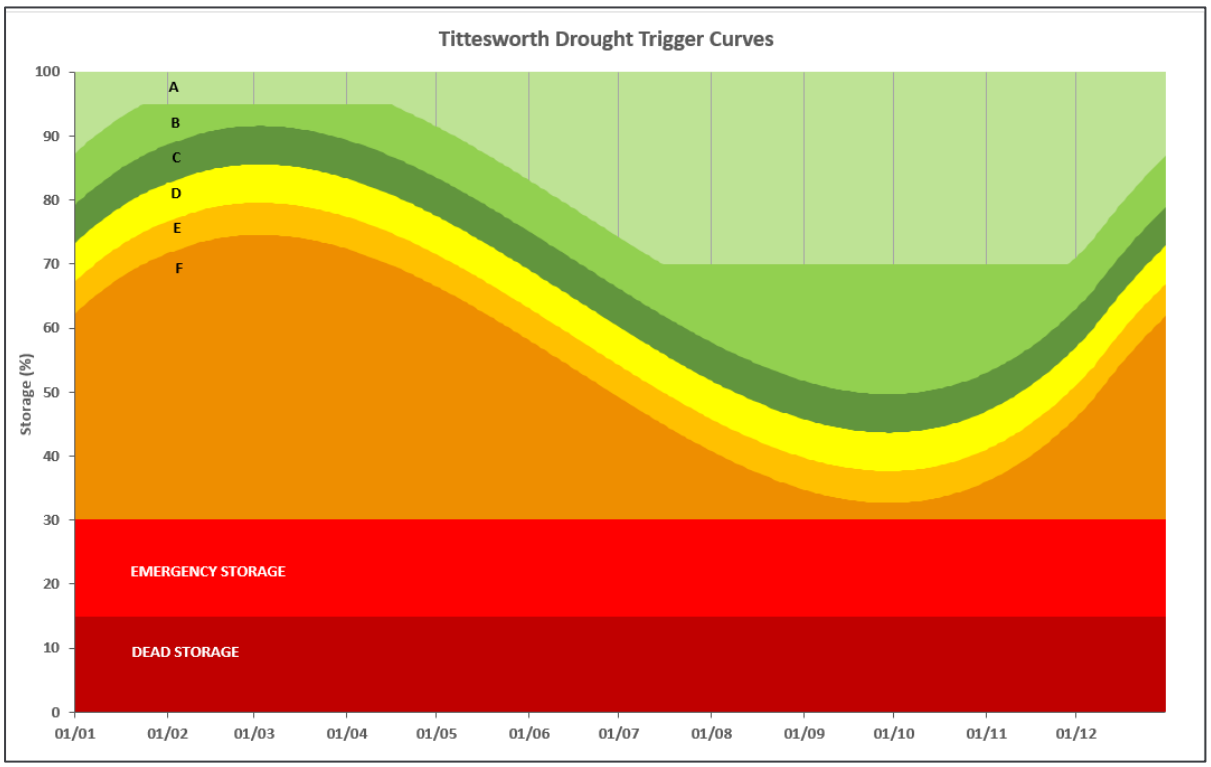
Section 2 of this plan shows the drought management actions and the triggers for North Staffordshire, the Forest and Stroud and for our groundwater only WRZs. For completeness we have listed these drought management actions again as well as providing the triggers and actions for all of the WRZs below:

Table 20: Companywide – demand-side actions

Demand-side action to help maintain supply	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Brief description of action – see table 18 for full details	'Normal' demand management activity	More focused/ targeted demand/ leakage management	1 or 2 weeks from restrictions on use	Restrictions imminent/ in place	Removal of restrictions
Trigger for this action (or the preceding action that leads to this action)	If moving towards trigger C	Indicators in zone C	Indicators in zone D or E	DAT decision/ Indicators in zone E or F	DAT decision/ Indicators returned to zone A/B
Yield/ DO of the action	None	Depends on extent and on customer behaviour. Estimated as between 0 and 2% demand reduction	The 0-2% range is our estimate for the impact of this activity in both stage 2 and stage 3.	Up to 5% demand reduction for a TUB and a further 5% reduction for NEUB	None
Location	Companywide or area/ zone affected by drought	Same as for stage 1	Same as for stage 1	Same as for stage 1	Same as for stage 1
Implementation timetable (time from trigger to implementation, time of year and duration)	None – this is BAU	<1 week	Indicators must be in zone E for > 1 week between April and mid-October before we consider imposing restrictions	Approximately 1 -2 weeks	<1 week
Any permissions we need or constraints that apply	None	None	None	None – internal DAT decision	None – internal DAT decision
Risks associated with this action eg effects on the environment, social and economic factors and	None	None	None	Refer to earlier sections describing TUBs and NEUBs and associated	None

uncertainties associated with timing, quantity, quality or cost				exemptions/ vulnerable customers	

North Staffordshire



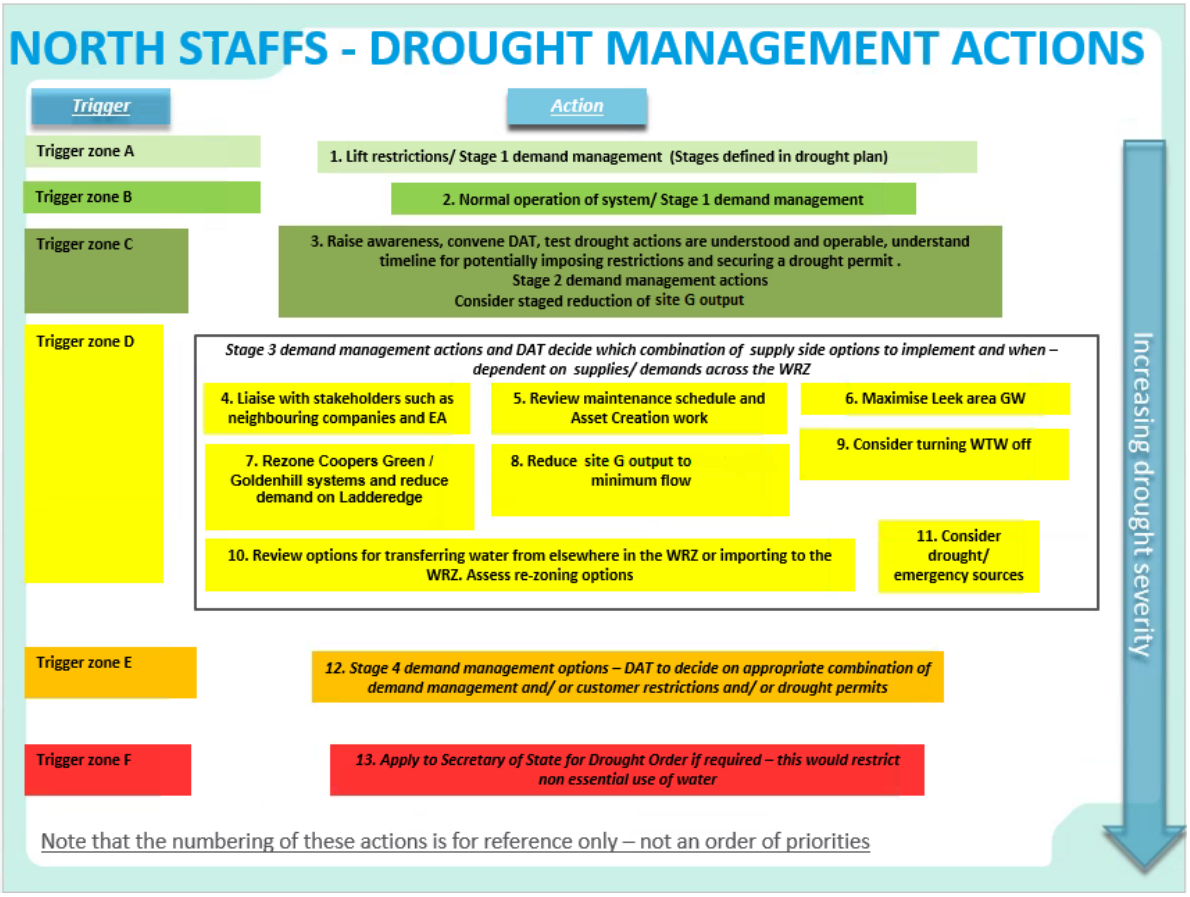


Table 21- Drought management action impacts

Supply-side action to help maintain supply	Actions 1-5	Actions 6-9	Action 10	Action 11	Action 12	Action 13
Description of action	Essentially these are increasing our readiness	These are essentially maximising/ balancing existing sources	Transfers/ re zoning options	Drought/ emergency sources	Churnet drought permit	Churnet drought order – see section 3.3.4.5 for details
Trigger for this action (or the preceding action that leads to this action)	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram
Yield/ DO of the action	None	No extra DO because included in base modelling	No extra DO because included in base modelling	We have not identified any of these in this WRZ so n/a	No DO increase	DO increase 4 Ml/d (based on modelling carried out since dWRMP published)
Location	N. Staffs WRZ	N. Staffs WRZ	N. Staffs WRZ and nearby WRZs	As above	See figure 27	See figure 27

Implementation timetable (time from trigger to implementation, time of year and duration)	<1 week	<1 week	Depends on option chosen and if new infrastructure is needed	As above	One week to finalise application . EA decision expected within 12 days.	We assume 28 days required for Defra to decide on a drought order application
Any permissions we need or constraints that apply	None	Internal DAT decision	As above	As above	Internal DAT decision & EA permission	Internal DAT decision & Defra permission
Risks associated with this action e.g. effects on the environment, social and economic factors and uncertainties associated with timing, quantity, quality or cost	None	None	As above	As above	Refer to earlier sections describing effects of this drought permit.	Refer to earlier sections describing effects of this drought permit/ order.

Forest and Stroud

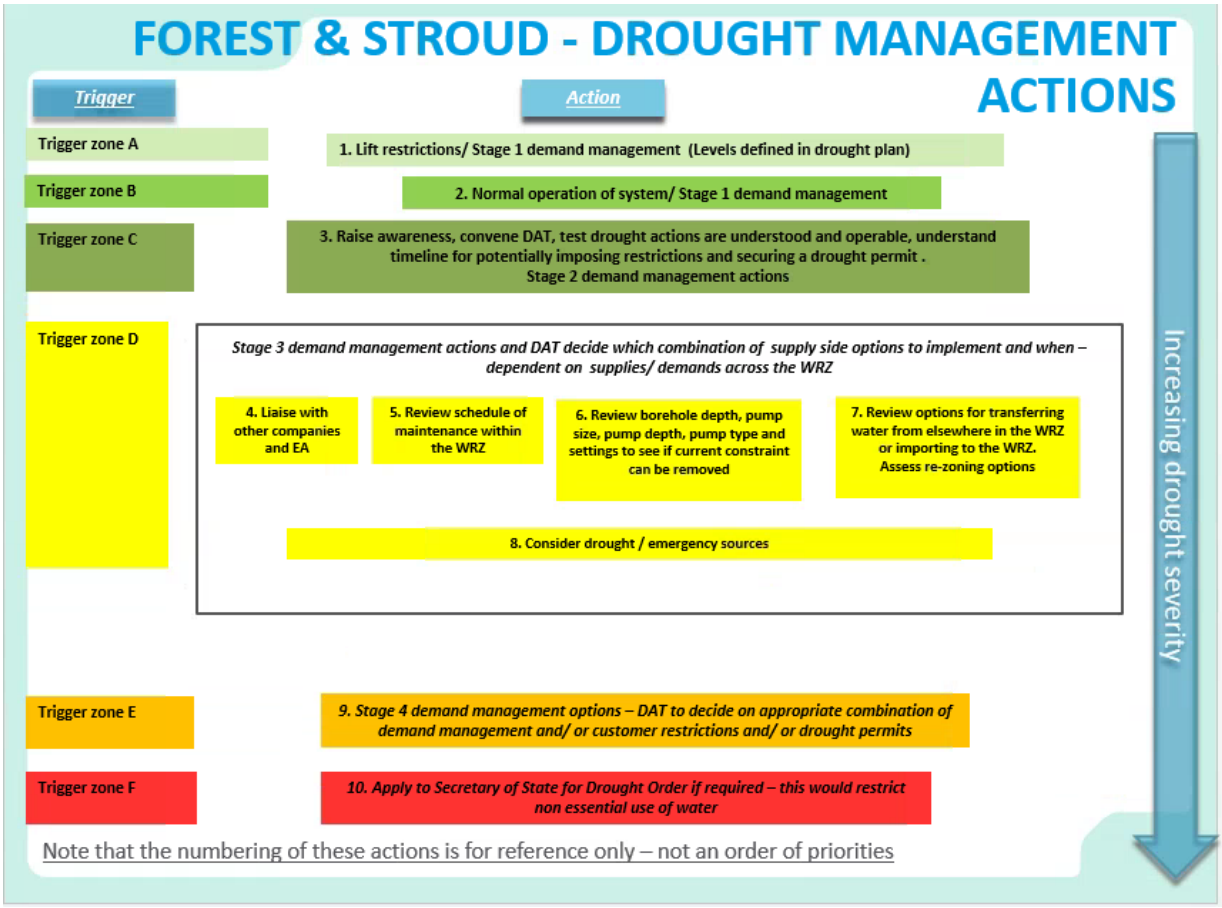


Table 22- Drought management action impacts

Supply-side action to help maintain supply	Actions 1-6	Action 7	Action 8	Action 9	Action 10
Description of action	Essentially these are increasing our readiness	Transfers/ re zoning options	Drought/ emergency sources	We have not identified any of these in this WRZ so n/a	Wyelands drought order
Trigger for this action (or the preceding action that leads to this action)	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As above	As shown in flow diagram
Yield/ DO of the action	None	No DO increase because included in base DO	We have not identified any of these in this WRZ but refer to comment about Witcombe in Grid table	As above	No DO increase – as shown in table 10 of dWRMP tables
Location	F&S WRZ	F&S WRZ and nearby WRZs	As above	As above	Wyelands/Site K – see figure 27

Implementation timetable (time from trigger to implementation, time of year and duration)	<1 week	<1 week	As above	As above	We assume 28 days required for Defra to decide on a drought order application
Any permissions we need or constraints that apply	None	Internal DAT decision	As above	As above	Internal DAT decision & Defra permission
Risks associated with this action e.g. effects on the environment, social and economic factors and uncertainties associated with timing, quantity, quality or cost	None	None	As above	As above	Refer to earlier sections describing effects of this drought order.

WRZs (excluding Forest and Stroud) that do not have reservoir triggers

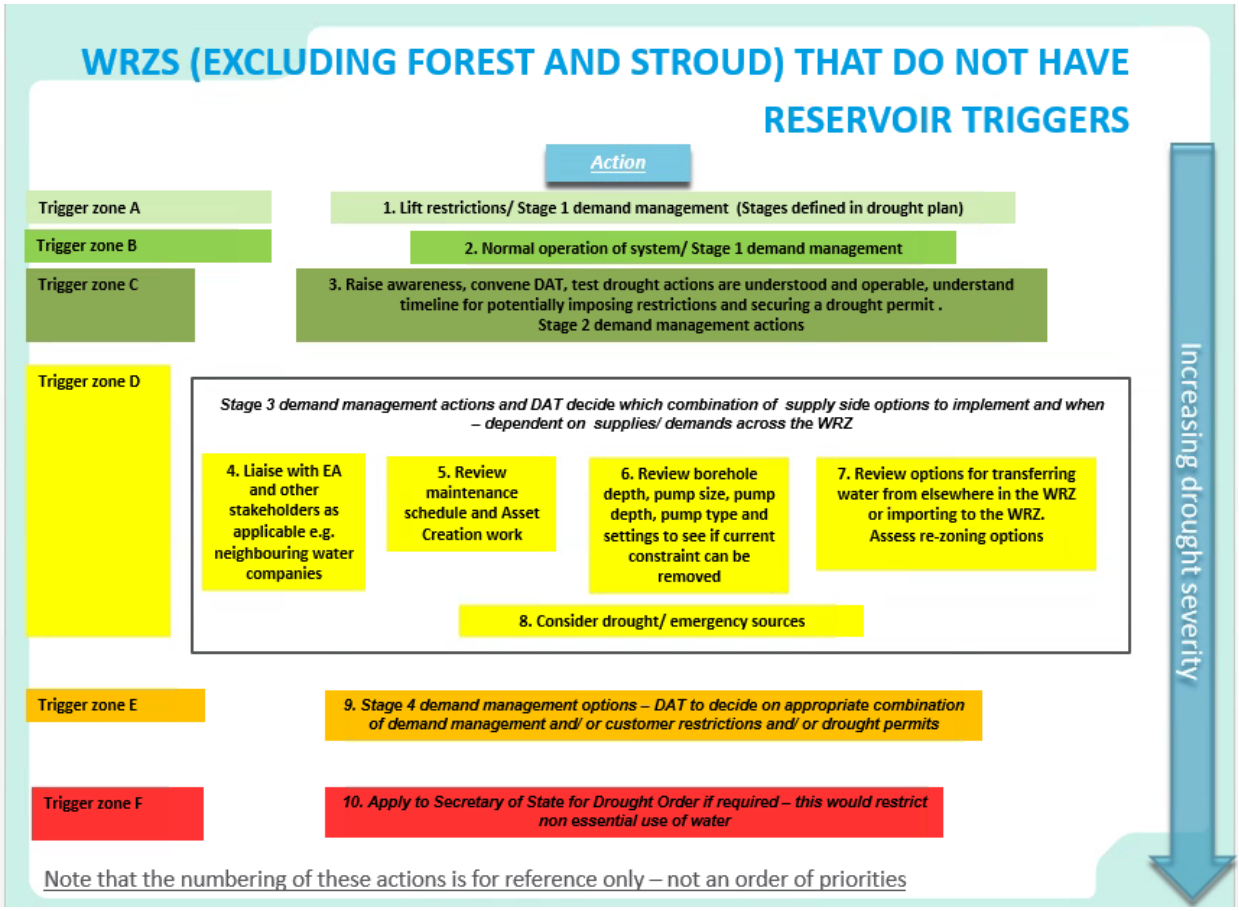
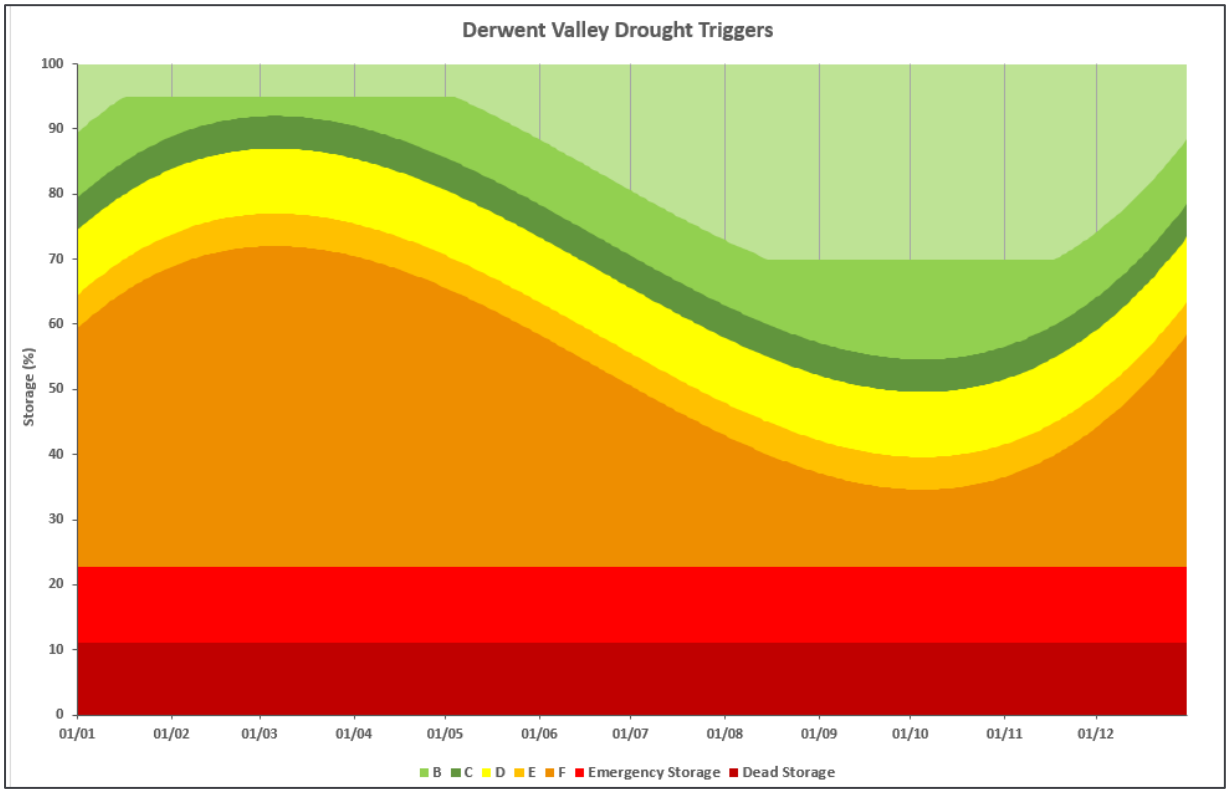


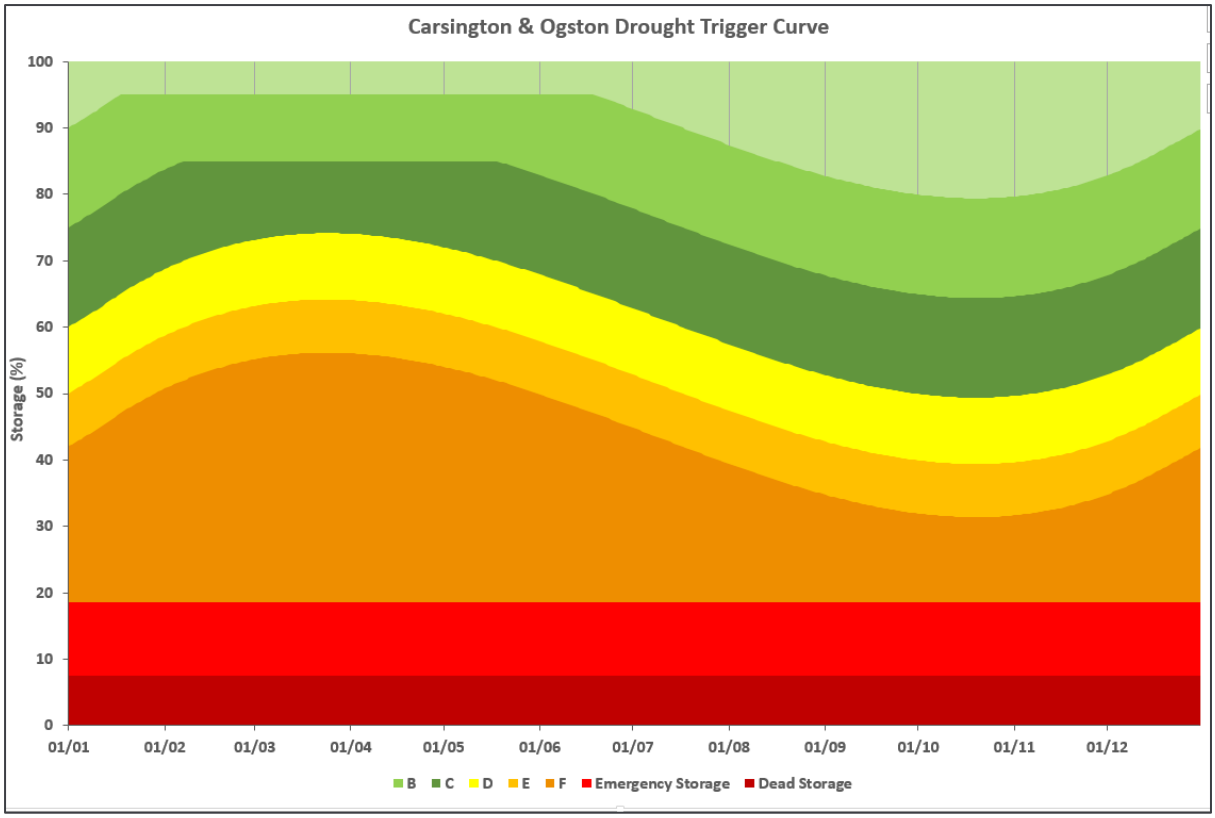
Table 23- Drought management action impacts

Supply-side action to help maintain supply	Actions 1-5	Action 6	Action 7	Action 8	Action 9 & 10
Description of action	Essentially these are increasing our readiness	Review borehole constraints/ re zoning options	Transfers/ re zoning options	Drought/ emergency sources	We have not identified any drought orders/ permits in these WRZs so n/a
Trigger for this action (or the preceding action that leads to this action)	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As above
Yield/ DO of the action	None	Depends on option chosen	No extra DO because included in base modelling	Llandinam WRZ contains Esgaireira Reservoir. Assumed yield is not greater than the daily licence of 1.1 Ml/d. N/A for other WRZs	As above

Location	WRZ in question	WRZ in question	WRZ in question	Llandinam WRZ	As above
Implementation timetable (time from trigger to implementation, time of year and duration)	<1 week	<1 week	<1 week	In excess of 12 months	As above
Any permissions we need or constraints that apply	None	Internal DAT decision	None	Refer to table 8	As above
Risks associated with this action e.g. effects on the environment, social and economic factors and uncertainties associated with timing, quantity, quality or cost	None	None	None	As above	As above

Strategic Grid East





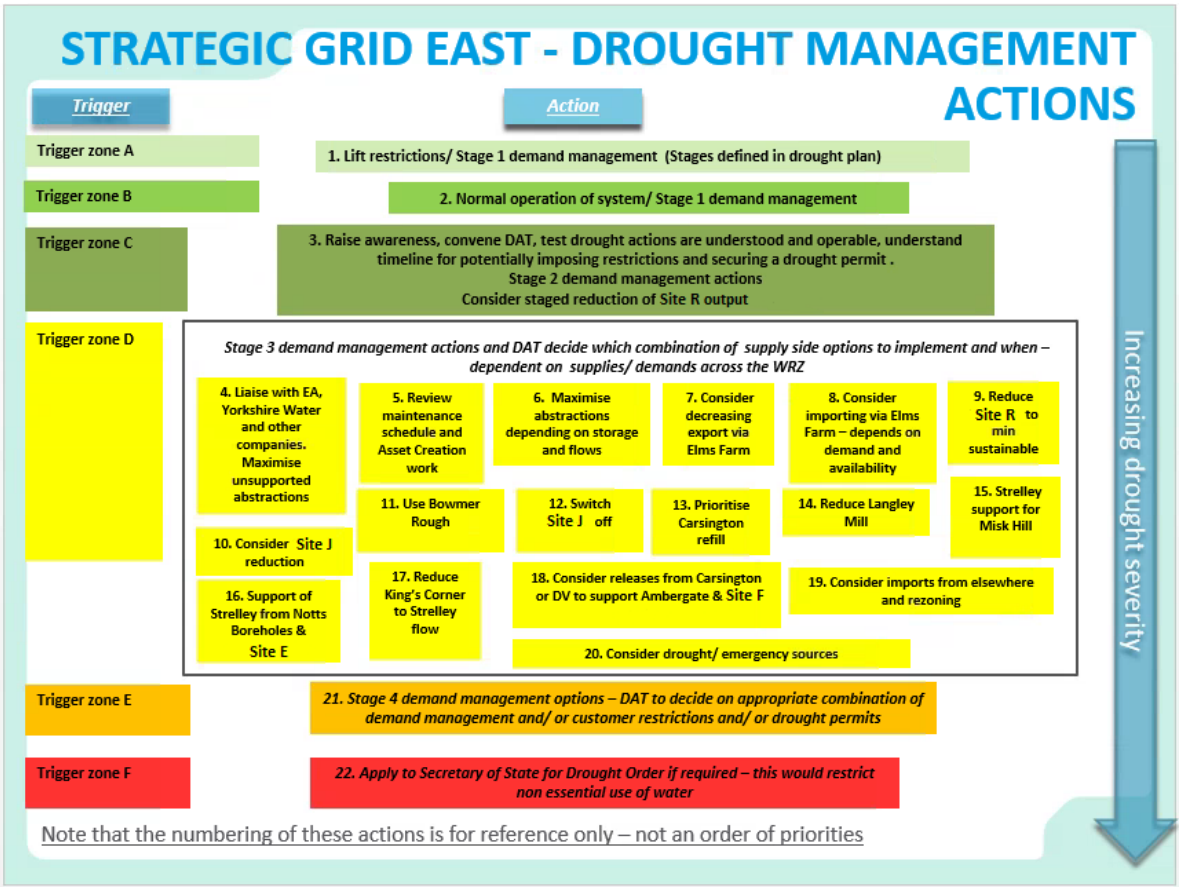
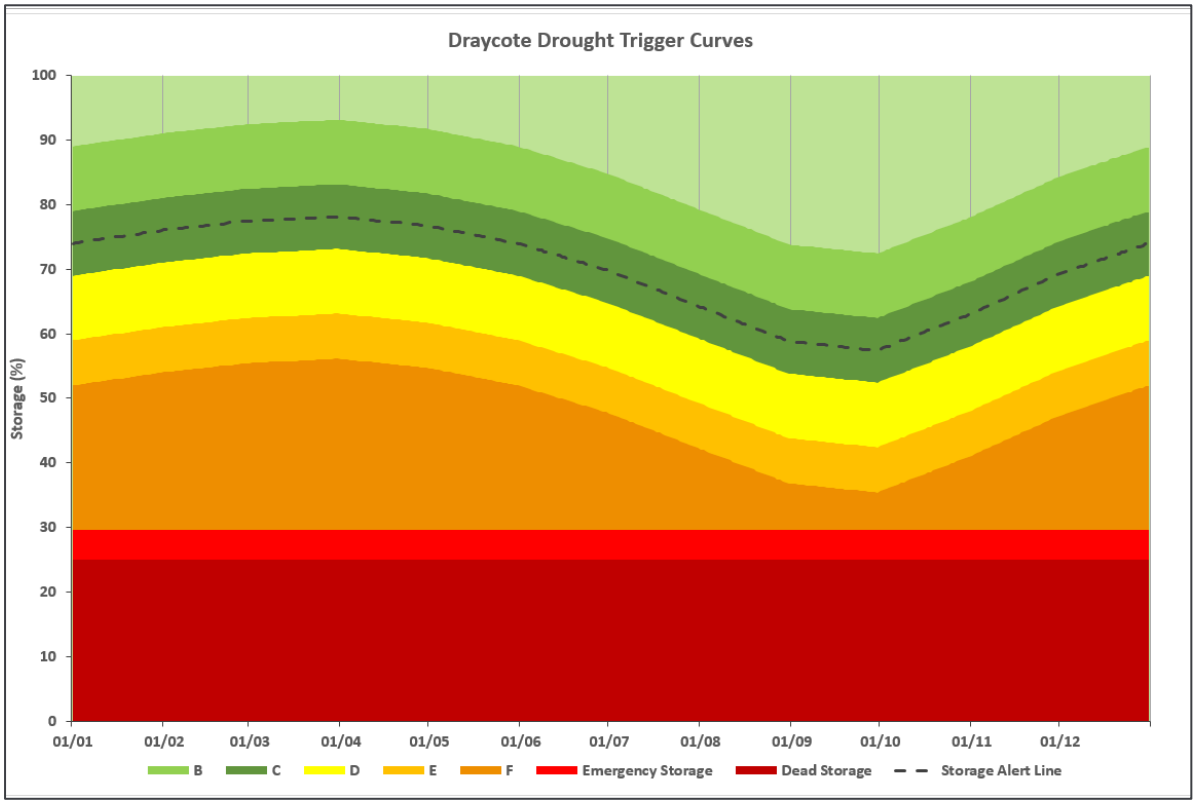


Table 24- Drought management action impacts

Supply-side action to help maintain supply	Actions 1-5	Action 6-18	Action 19	Action 20	Action 21 & 22
Description of action	Essentially these are increasing our readiness	These are essentially maximising/ balancing existing sources	Transfers/ re zoning options	Drought/ emergency sources	Action 21 could involve the Derwent Valley and R. Derwent drought permits. There are no drought orders identified so action 22 is n/a
Trigger for this action (or the preceding action that leads to this action)	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram
Yield/ DO of the action	None	No extra DO because included in base modelling	No extra DO because included in base modelling	As shown in table 8	No DO increase – as shown in table 10 of dWRMP tables
Location	Grid WRZ (East)	Grid WRZ (East)	WRZ(s) in question	As shown in table 8	See figure 27
Implementation timetable (time from trigger to implementation, time of year and duration)	<1 week	<1 week	<1 week	In excess of 12 months	One week to finalise drought permit application. EA decision expected within 12 days.
Any permissions we need or constraints that apply	None	Internal DAT decision	None	Refer to table 8	Internal DAT decision & EA permission
Risks associated with this action e.g. effects on the environment, social and economic factors and uncertainties associated with timing, quantity, quality or cost	None	None	None	As above	Refer to earlier sections describing effects of this drought permit.

Strategic Grid South



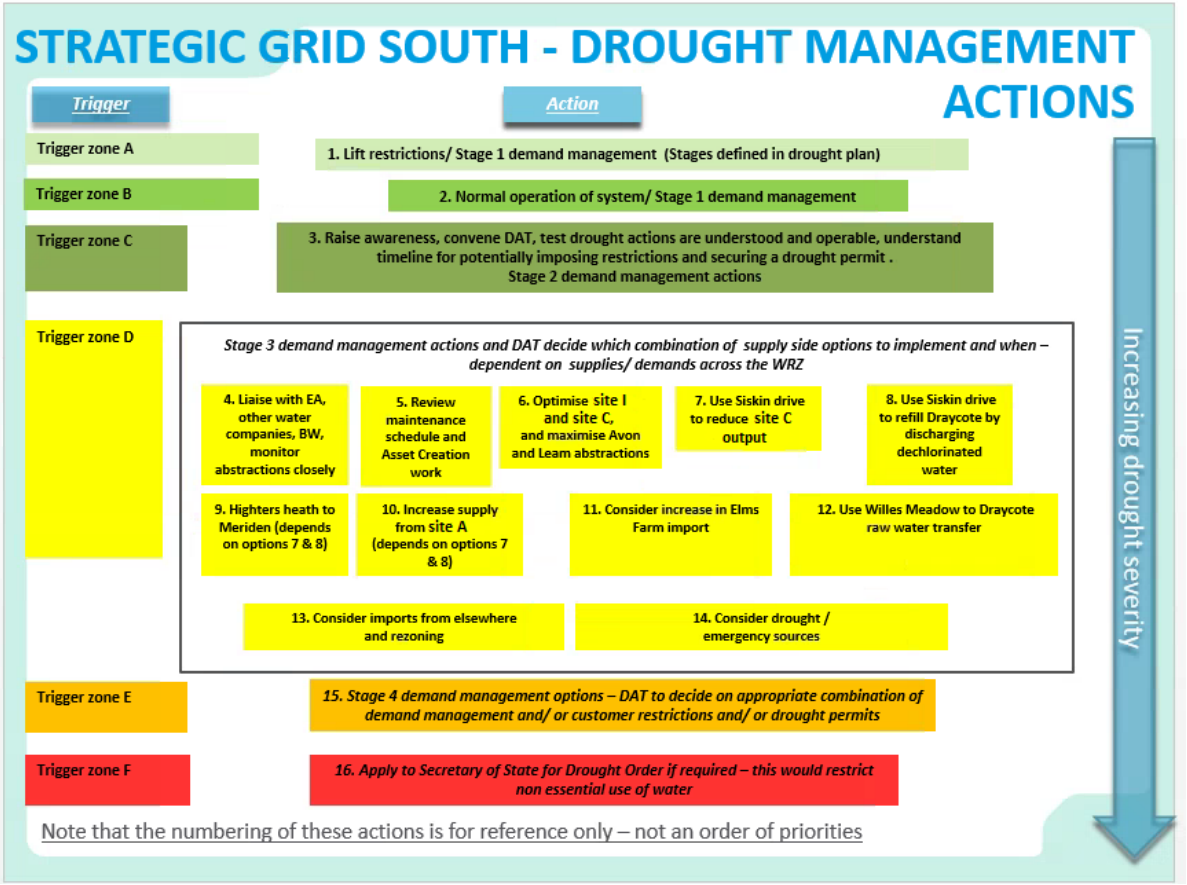
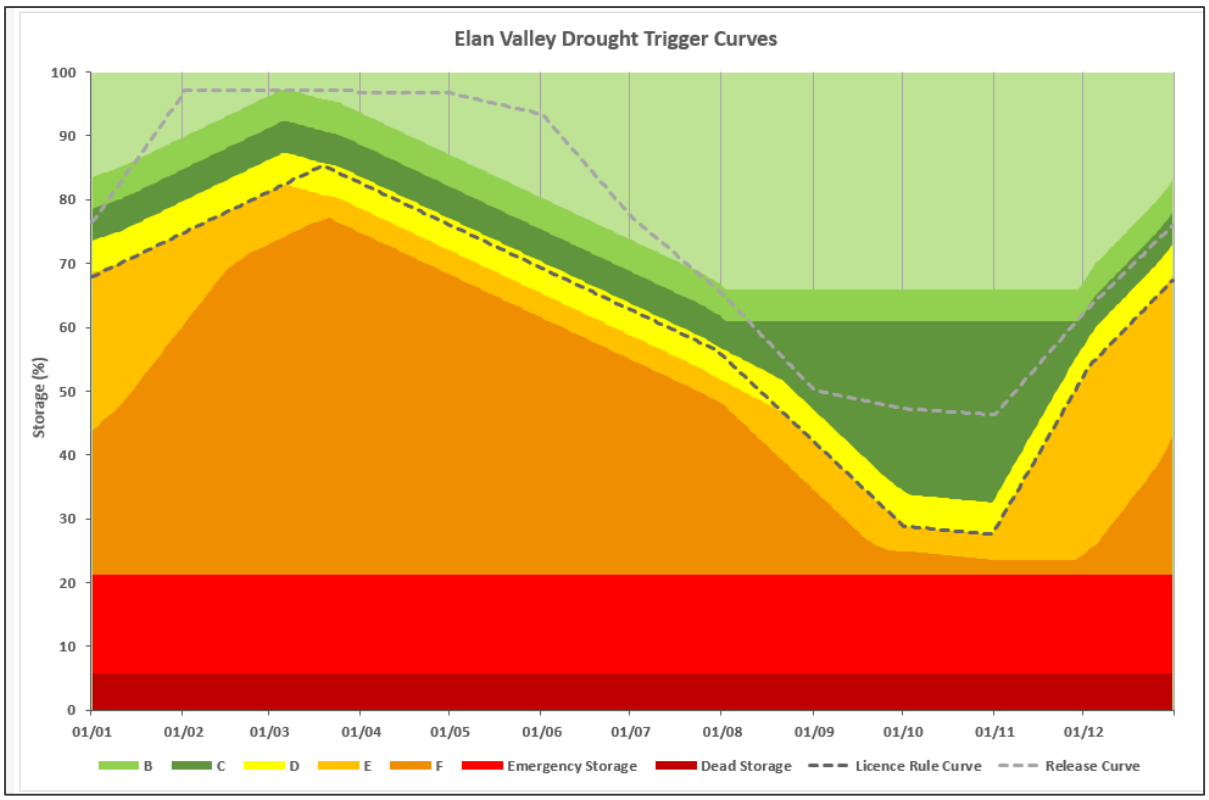


Table 25- Drought management action impacts

Supply-side action to help maintain supply	Actions 1-5	Action 6, 7, 9-12	Action 8	Action 13	Action 14	Action 15 & 16
Description of action	Essentially these are increasing our readiness	These are essentially maximising / balancing existing sources	Use Siskin and discharge dechlorinated water to Draycote reservoir	Transfers/ re zoning options	Drought/ emergency sources - Witcombe	Action 15 could involve the Avon and R. Leam drought permit. There are no drought orders identified so action 16 is n/a
Trigger for this action (or the preceding action that leads to this action)	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram
Yield/ DO of the action	None	No extra DO because included in base modelling	Depends on availability of treated water in the rest of the Grid WRZ	No extra DO because included in base modelling	As shown in table 8	No DO increase – as shown in table 10 of dWRMP tables
Location	Grid WRZ (South)	Grid WRZ (South)	Draycote reservoir	WRZ(s) in question	As shown in table 8	See figure 27
Implementation timetable (time from trigger to implementation, time of year and duration)	<1 week	<1 week	Approx. 2-3 weeks	<1 week	In excess of 12 months	One week to finalise drought permit application. EA decision expected within 12 days.
Any permissions we need or constraints that apply	None	Internal DAT decision	EA consent re. discharge and internal DAT decision	None	Refer to table 8	Internal DAT decision & EA permission
Risks associated with this action e.g. effects on the environment, social and economic factors and uncertainties associated with timing, quantity, quality or cost	None	None	As occurred during the 2010-12 drought we would agree an appropriate sampling programme and seek EA approval before we commenced this action	None	As above	Refer to earlier sections describing effects of this drought permit.

Strategic Grid West



STRATEGIC GRID WEST - DROUGHT MANAGEMENT ACTIONS

Trigger	Action
Trigger zone A	1. Lift restrictions/ Stage 1 demand management (Stages defined in drought plan)
Trigger zone B	2. Normal operation of system/ Stage 1 demand management
Trigger zone C	3. Raise awareness, convene DAT, test drought actions are understood and operable, understand timeline for potentially imposing restrictions and securing a drought permit . Stage 2 demand management actions
Trigger zone D	*Stage 3 demand management actions and DAT decide which combination of supply side options to implement and when – dependent on supplies/ demands across the WRZ* 4. Liaise with other companies and EA 5. Review schedule of maintenance at major works 6. Liaise with SSW over projected use of River Severn 7. Provide weekly forecasts of Severn abstraction to EA. 8. Consider use of site G to support site U & maintain storage in Elan Valley Reservoirs. 9. Consider reducing / stopping site U export to site A 10. Consider import to Birmingham from site A 11. Consider import to Birmingham from Grid via Meriden / Highters Heath link main. 12. Consider pumping Tack Lane into site H. 13. Optimise use of site G and shared south Staffordshire asset. 14. Consider Beechtree Lane and/ or Norton emergency boreholes to supply EVA 15. Reduce site H abstraction 16. Consider increased use of unsupported river abstraction 17. Consider imports from elsewhere and rezoning 18. Consider drought/ emergency sources
Trigger zone E	*19. Stage 4 demand management options – DAT to decide on appropriate combination of demand management and/ or customer restrictions and/ or drought permits*
Trigger zone F	*20. Apply to Secretary of State for Drought Order if required – this would restrict non essential use of water*

Increasing drought severity

Note that the numbering of these actions is for reference only – not an order of priorities

Table 26- Drought management action impacts

Supply-side action to help maintain supply	Actions 1-5	Action 6-16 excluding 14	Action 17	Action 14 & 18	Action 19 & 20
Description of action	Essentially these are increasing our readiness	These are essentially maximising/ balancing existing sources	Transfers / re zoning options	Drought/ emergency sources	Action 19 & 20 could involve the site G drought permit/ orders.
Trigger for this action (or the preceding action that leads to this action)	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram	As shown in flow diagram
Yield/ DO of the action	None	No extra DO because included in base modelling	No extra DO because included in base modelling	As shown in table 8	DO increase of 8 Ml/d – as shown in table 10 of dWRMP tables
Location	Grid WRZ (West)	Grid WRZ (West)	WRZ(s) in question	As shown in table 8	See figure 27
Implementation timetable (time from trigger to implementation, time of year and duration)	<1 week	<1 week	<1 week	In excess of 12 months	One week to finalise drought permit application. EA decision expected within 12 days. 28 days required for Defra to decision
Any permissions we need or constraints that apply	None	Internal DAT decision	None	Refer to table 8	Internal DAT decision and/ or EA permission and/or Defra permission
Risks associated with this action e.g. effects on the environment, social and economic factors and uncertainties associated with timing, quantity, quality or cost	None	None	None	As above	Refer to earlier sections describing effects of this drought permit/ order.

7.2.1 Table showing additional information for the drought/ emergency listed in section 3.2.1.1

Table 27- Drought/ emergency sources

WRZ	Drought measure (excluding measures contained within the Aquator Baseline modelling and also excluding TUBs, NEUBs,	Comment

	drought permits/ orders)	
N. Staffs	None	n/a
Grid	Witcombe reservoir	We assume licence constrained but we'd undertake flow gauging and/ or a hydrological yield assessment if we were seriously thinking of using it. We would also carry out a detailed assessment of the potential environmental and WFD impacts. Because there is a such a long lead in time before we could ever need to use these options we would have the time needed and we would have already instigated increased 'in drought' monitoring at several locations across our region.
Grid	Monksdale boreholes	As above
Grid	Stanley Moor boreholes	As above
Grid	Norton emergency boreholes	As above. In addition, we can't split out a daily/ peak max for the emergency part of this licence as much of the overall daily total of 24 Ml/d is used BAU for public supply. The real constraint to this emergency supply is the 5 year maximum.
Grid	Beechtree Lane emergency boreholes	We assume licence constrained but we'd undertake a hydrogeological yield assessment and/ or a detailed assessment of the potential environmental and WFD impacts if we were seriously thinking of using it.
Grid	Blackbrook reservoir	We calculated a dry year hydrological yield of 6 Ml/d by using Q70 inflows, 10 % unusable storage, compensation flow of 0.136 Ml/d and a critical period of 18 months (548 days). We also used the minimum cumulative 548 day inflows and that also gave a 'yield' of 6 Ml/d so this adds to the reliability of the Q70 estimate. We'd undertake flow gauging/ a hydrological yield assessment and a detailed assessment of the potential environmental and WFD impacts if we were seriously thinking of using it.
Grid	Linacre reservoir group	We assume licence constrained but we'd undertake flow gauging/ a hydrological yield assessment and a detailed assessment of the potential environmental and WFD impacts if we were seriously thinking of using it. Note that this is a North East EA abstraction licence.
Grid	Birmingham groundwater and Shardlow/ Witches Oak intake on the River Trent.	We assume licence constrained by the 5 year total but we'd undertake flow gauging/ a hydrological yield assessment and a detailed assessment of the potential environmental and WFD impacts if we were seriously thinking of using it.
Notts	None	Covered by the Strategic Grid East actions that affect the Grid to Notts transfer.
Llandinam & Llanwrin	Esgaireira Reservoir	We assume licence constrained but we'd undertake flow gauging/ a hydrogeological yield assessment and a detailed assessment of the potential environmental and WFD impacts if we were seriously thinking of using it. Note that this is a NRW abstraction licence.
All of the other WRZs	None	n/a

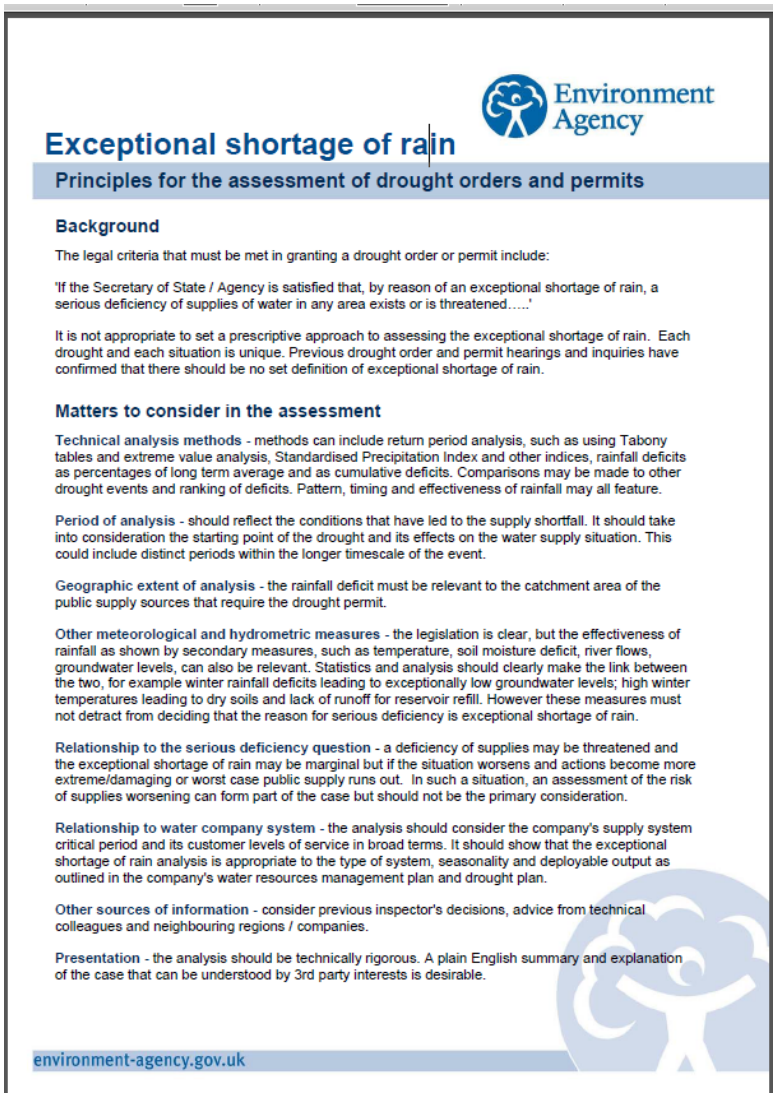
7.3 Table showing the purpose of the other plans we produce that could affect our ability to manage drought

The table below shows the different types of plan that we produce that relate in some way to drought planning. It also summarises the purpose of each of these reports:

Table 28- Other plans that we produce

Plan	Purpose of plan	Comment
Business plan	This plan sets out what we expect to invest across the business over the next 5 years and beyond. It covers clean water, waste water, customer service and it shows what the impact of our proposed investment programme would have on customers' bills and company returns. We submit these plans to Ofwat for them to make a determination on what to allow within price limits. This means that they decide on how much we can charge our customers in the next 5 years. Supply demand and resilience to events like droughts are components within our company wide business plan.	We update these every 5 years.
Drought plan	This is an operational plan to show how we will manage supplies and demands for water in a prolonged dry period.	We review these annually and update them within 5 years.
Emergency plans	These plans describe what we will do in an emergency situation. This may be caused by a more extreme drought than we have ever experienced but could also become applicable after a major flood, asset failure and potential loss of services to customers. This plan includes arrangements to use emergency measures such as tankers and bottled water.	These plans are not published in the public domain due to their sensitivity.
Water resources management plan (WRMP)	The plan explains our proposals for making sure we have enough water available, in the right place and at the right time to supply our customers in an affordable and sustainable way over the next 25 years. Although there is an overlap between a WRMP and a drought plan, the WRMP is a more strategic longer term plan.	We update these every 5 years.

Environment Agency 2016 note on exceptional shortage of rainfall



Environment Agency

Exceptional shortage of rain

Principles for the assessment of drought orders and permits

Background

The legal criteria that must be met in granting a drought order or permit include:

'If the Secretary of State / Agency is satisfied that, by reason of an exceptional shortage of rain, a serious deficiency of supplies of water in any area exists or is threatened.....'

It is not appropriate to set a prescriptive approach to assessing the exceptional shortage of rain. Each drought and each situation is unique. Previous drought order and permit hearings and inquiries have confirmed that there should be no set definition of exceptional shortage of rain.

Matters to consider in the assessment

Technical analysis methods - methods can include return period analysis, such as using Tabony tables and extreme value analysis, Standardised Precipitation Index and other indices, rainfall deficits as percentages of long term average and as cumulative deficits. Comparisons may be made to other drought events and ranking of deficits. Pattern, timing and effectiveness of rainfall may all feature.

Period of analysis - should reflect the conditions that have led to the supply shortfall. It should take into consideration the starting point of the drought and its effects on the water supply situation. This could include distinct periods within the longer timescale of the event.

Geographic extent of analysis - the rainfall deficit must be relevant to the catchment area of the public supply sources that require the drought permit.

Other meteorological and hydrometric measures - the legislation is clear, but the effectiveness of rainfall as shown by secondary measures, such as temperature, soil moisture deficit, river flows, groundwater levels, can also be relevant. Statistics and analysis should clearly make the link between the two, for example winter rainfall deficits leading to exceptionally low groundwater levels; high winter temperatures leading to dry soils and lack of runoff for reservoir refill. However these measures must not detract from deciding that the reason for serious deficiency is exceptional shortage of rain.

Relationship to the serious deficiency question - a deficiency of supplies may be threatened and the exceptional shortage of rain may be marginal but if the situation worsens and actions become more extreme/damaging or worst case public supply runs out. In such a situation, an assessment of the risk of supplies worsening can form part of the case but should not be the primary consideration.

Relationship to water company system - the analysis should consider the company's supply system critical period and its customer levels of service in broad terms. It should show that the exceptional shortage of rain analysis is appropriate to the type of system, seasonality and deployable output as outlined in the company's water resources management plan and drought plan.

Other sources of information - consider previous inspector's decisions, advice from technical colleagues and neighbouring regions / companies.

Presentation - the analysis should be technically rigorous. A plain English summary and explanation of the case that can be understood by 3rd party interests is desirable.

environment-agency.gov.uk

7.4 - Review of usable storage

Review of usable storage in raw water reservoirs to inform Severn Trent Water's 2019 Water Resources Management Plan (WRMP19) and 2019 Drought Plan

Background

We published our previous draft WRMP plan for consultation in May 2013. We published our initial statement of response (SoR) in November 2013 and we then updated our SoR in January 2014. We published our final WRMP14 in June 2014.

During our 2014 dWRMP consultation, Natural Resources Wales (NRW) made the following comment: "*We recommend that the company provides more information about reservoir emergency storage, when it was last calculated and how it was calculated. The amount of emergency storage will affect deployable output. It is important that the company revises its emergency storage in the strategic grid after incorporating the sustainability reductions that change how the Elan reservoirs are operated. This may affect the amount of deficit in this zone.*"

Our response was '*The dead and emergency storage values that we currently use in our Aquator model are consistent with those shown in previous WRMPs and drought plans. For example, our estimates have not changed since our 2006 drought plan. Although these values are our best current estimates and used the information available to us at the time we do not have a full audit trail. As a result we have started a review of the dead and emergency storage in all of our strategic raw water reservoirs. This review will tell us whether our current estimates are accurate or if we can improve them. However this is not a quick process. We think that the most accurate and thorough way to do this is to try to quantify whether water at different depths is treatable. However, as parameters such as dissolved oxygen will vary depending on how full the reservoir is a single survey will not give us a full picture. As DCWW own the Elan reservoirs we will need to work with them in order to update the emergency storage volumes. Once we have completed our review of dead and emergency storage in all of our strategic raw water reservoirs we will assess what the impact of this is on DO in our strategic grid. Although we are aware that '30 days storage' has been used as an estimate for emergency storage we are not aware of any specific guidance or UKWIR good practice for estimating dead storage. We need to know the proportion of dead storage so that we can add '30 days storage' on top on this. We don't think that this issue requires us to alter our draft WRMP.*'

Between 2014 and 2018 we have reviewed:

- The position of the lowest valves in these reservoirs
- Bathymetric information
- Historic/ anecdotal knowledge of draw downs
- Water quality and treatability data
- Whether we can use models to improve our estimates.

We give more detail on each of these reviews later but the table below provides the estimates of dead and emergency storage that we have used for the modelling that informs our 2019-24 Drought Plan and our WRMP19. Note that the emergency storage percentage includes the dead storage. As an example, we estimate that 69.9% of the storage in Tittesworth is usable before we reach emergency storage:

Table 29 – Dead and emergency storage used in our Aquator water resources modelling:

	Assumed dead storage in Aquator (%)	Current emergency storage in Aquator (%)	Any changes since our 2014 drought plan?	Comment
Tittesworth	15	30.1	Yes	We have updated the emergency storage but not changed the dead storage.
Draycote	25	29.5	Yes	We have updated the emergency storage but not changed the dead storage.
Carsington and Ogston combined	7.5	18.6	Yes	We have updated the emergency storage but not changed the dead storage.
Derwent Valley combined	11	22.8	Yes	We have updated the emergency storage but not changed the dead storage.
Elan Valley combined	5.8	21.2	No	This was high priority before PR14 and we agreed what the correct

				emergency and dead storages should be in 2014 as a result of negotiations with UWAG. We discuss this UWAG work later in this review.
Charnwood combined	18.2	25.8	Yes	We have updated the emergency storage but not changed the dead storage.
Dove combined	13.3	31.6	Yes	We have updated the emergency storage but not changed the dead storage.
Site A combined	20	39.4	Yes	We have updated the emergency storage but not changed the dead storage.
Site T	5	18	No	We have confirmed with the EA that this is the appropriate emergency storage to use. No changes to dead storage. This is not a direct public water supply source for STWL.
Vyrnwy	7.6	14.3	No	We have kept the same emergency storage and dead storage as we used for PR14. This is not a direct public water supply source for STWL.

We have undertaken a project to review our current assumptions on dead and emergency storage for the raw water reservoirs listed in the table above. This project will inform our 2019 drought plan and WRMP. We will also consider any next steps or actions we need to carry out before PR24.

The scope of this review includes:

- Strategic raw water reservoirs

It does not include:

- Treated water reservoirs
- Bankside storage reservoirs such as Willes Meadow

Review of emergency storage

As described in the 2000 EA/ UKWIR unified methodology, emergency storage in reservoirs is *"a reserve store for droughts worse than the worst historic*." We have updated the values for emergency storage with the latest information in our water resources model that we are using to produce our 2019 plans. Once these plans are finalised and agreed we will update our operational/ drought action triggers so that these too refer to the correct, updated level of emergency storage.

We calculated emergency storage (ES) at each reservoir as:

Demands on the reservoir (Ml/d) x Number of days = ES (Ml)

The demands on the reservoir depend on whether the reservoir has any regulatory/environmental releases, as well as the demand on the reservoir for public water supply (PWS), this can be offset by any guaranteed inflows to the reservoir. We have calculated the PWS demands on our reservoirs based on historic demands in the autumn of dry/drought years. We have used 30 days of supply to calculate emergency storage. This is the industry standard and was the suggested number in the "1997 reassessment of water company yields guidance". We have given a worked example below:

Foremark

*Demand = 100Ml/d to PWS + 0.41Ml/d Compensation - 25Ml/d from river = 75.41 Ml/d * 30 days = 2262.3 Ml*

Dead Storage = 1979Ml Therefore ES+DS = 4241Ml

Review of dead storage

We updated the Elan Valley emergency storage and dead storage as part of the UWAG (Usk and Wye Abstraction Group) work we did before we published our WRMP14. This group comprised of Dwr Cymru Welsh Water (DCWW), the Environment Agency (EA), Natural Resources Wales (NRW), the Canals and Rivers Trust and the Wye and Usk Foundation. This group allowed productive collaboration and meant that each party could align their modelling assumptions in order to agree a future regime of abstraction and discharges in the River Wye catchment. This meant that we met the requirement of the Habitats Directive driven RoC (Review of Consents).

The process above only applied to the Elan Valley reservoirs as they were the only reservoirs within the Wye catchment. For the other reservoirs in the scope of this project we followed the following steps:

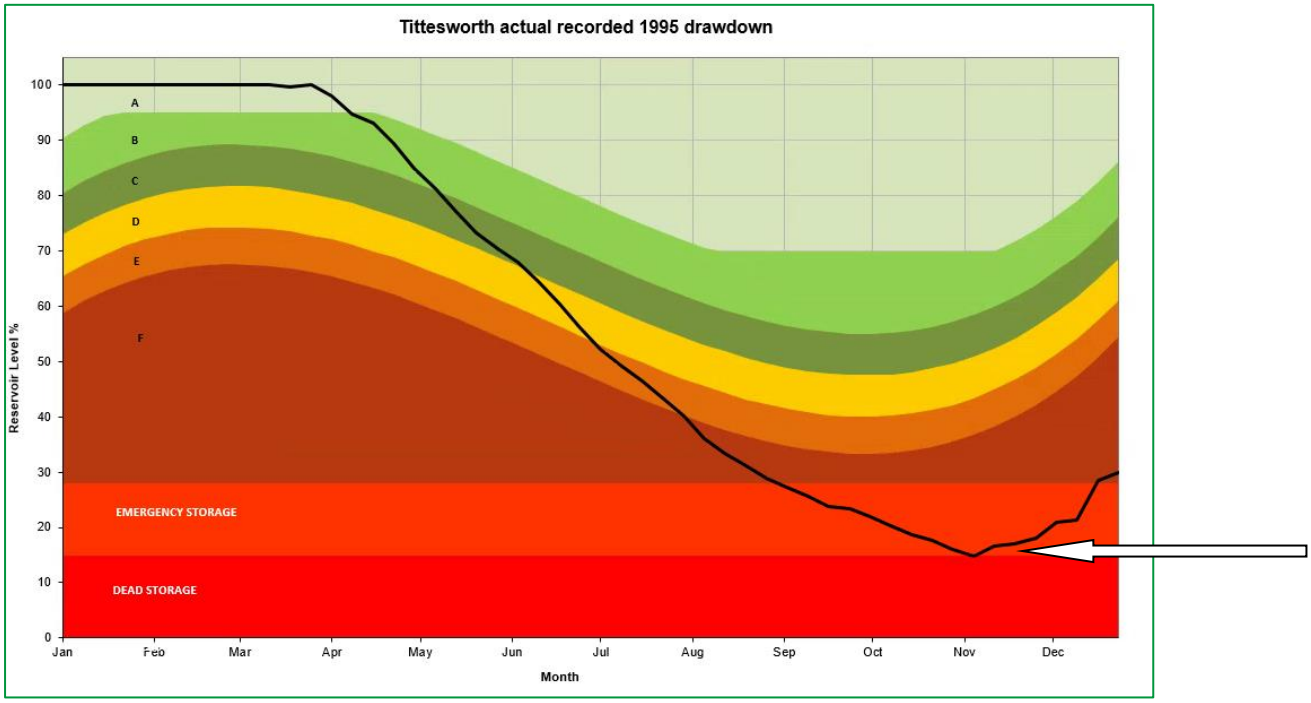
i. Review of lowest valve positions – We consulted our reservoir engineers and obtained information regarding the lowest/ deepest draw off valve levels for each reservoir in scope. This information showed that the position of the lowest valve was not the factor that determined where dead storage was for any of the reservoirs. This is not surprising as the majority of reservoirs have scour valves which are designed to draw the reservoirs down to almost empty. We realise that there could be water quality and environmental considerations involved with using these valves but we concluded that valve location was not the dead storage constraint for any reservoir in scope. In addition, if we were in a severe drought scenario, we could use temporary pumps to take water from below the level of the 'normal' draw off valves.

ii. Bathymetric survey data – Regardless of the infrastructure allowing us to draw the reservoirs down to a certain level we then reviewed the latest information we have on the volume of silt in these reservoirs. During 2017 we shared this data with NRW and the EA that showed the volumes of silt that we estimate are in these reservoirs. These estimates are from bathymetric surveys. We compared our dead storage assumptions with these silt volumes and, for all of

the reservoirs in scope, the dead storage volume was higher than the volume of silt. As a result we did not alter any dead storage estimate. Had these surveys shown a higher volume of silt than our dead storage then we would have increased the dead storage allowance accordingly. Our reservoir team (which carries out all of the work necessary to comply with the Reservoirs Act) have a programme to survey our reservoirs on a minimum 10 yearly cycle.

iii. Historic/anecdotal drawdown information – We have consulted with relevant staff to understand if they remember any relevant information on how we operated in previous droughts. The most severe drought in terms of low reservoir levels that staff could recall was the 1995-96 drought. This is the last time we had to impose customer use restrictions as a result of drought. The graph below shows that, in 1995, the storage in Tittesworth reservoir fell to what we currently assume is the dead storage.

Anecdotally, the reason storage did not fall further was not that we could not treat the water. However, this is based on the recollection of only one (former) member of staff. It is also worth bearing in mind that the water quality standards that we operate to today are much more stringent than they were in the 1990s. As a result, we have not changed the dead storage assumption at Tittesworth as we have taken a precautionary approach. Unless we have conclusive proof that what we currently consider to be dead storage is actually usable then we are not going to change our estimates. We think that this approach is preferable to reducing the dead storage allowance without a valid reason.



iv. Review of water quality/ treatability – we considered whether the treatability of raw water was the constraint on dead storage for the in scope reservoirs. This internal review drew on expertise from our Innovation/ R&D team as well as our treatment process team. When we carried out a bathymetric survey on Draycote reservoir in 2012 we also tested for certain

water quality parameters at different depths in the water column. One of the outputs from this study is shown below:

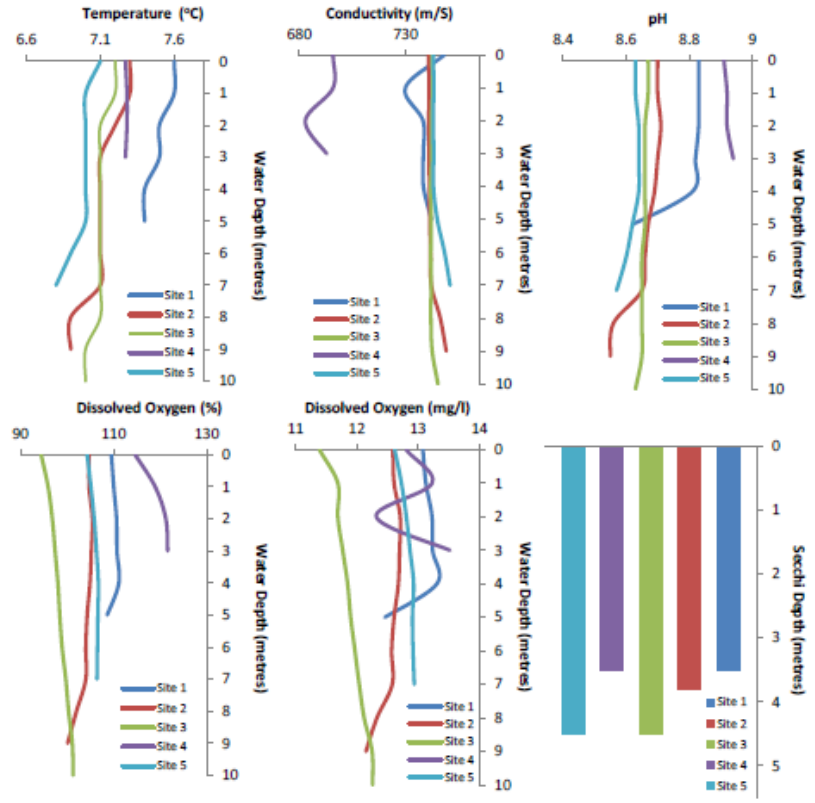


Figure 8. Water quality depth profiles of temperature, conductivity, pH, dissolved oxygen and secchi depth measures in Draycote Reservoir in March 2012.

In addition, we collated information on what the thresholds for treatment are at different water treatment works (WTWs) in relation to turbidity, pH, Ammonia and Manganese. When we reviewed these thresholds and the results collected in March 2012 we found that working out how treatable the 'dead volume' at any reservoir will be when it has low storage during a hot/ dry period is far from straightforward. For example, the treatability is dependent on the interaction of the eutrophic status of the reservoir, mixing, temperature and sun.

We have also identified challenges that relate to differences between night, day and summer and winter. For instance, the challenges associated with treating water from the 'dead volume' during the winter are likely to be elevated suspended solids and during the summer elevated dissolved metals (especially manganese), ammonia, algae (and algal organic matter), diurnal pH changes, elevated zooplankton and possibly enhanced cyanotoxins. A definitive assessment of usable storage would also have to take into account assets or processes such as barley straw and de-stratification that we use to ameliorate negative water quality impacts and their efficiency under low water volumes. Additionally, we may need to look at the concentration of fish in the diminishing water volume – leading to elevated ammoniacal products, fish death and elevated bacterial loading.

We concluded from this work that it would be valuable to carry out a similar water quality survey to that we carried out at Draycote when a reservoir was heavily drawn down. In Mid-

September 2015, dry weather and high demand caused combined storage in Cropston/ Swithland reservoirs to fall below 40%. We took this opportunity to take samples and we undertook a survey at Cropston reservoir on the 19th October 2015 and at Swithland on the 20th October 2015 at the locations shown below:

Figure 2.1 Sampling sites on Cropston Reservoir.

Figure 2.2 Sampling sites on Swithland Reservoir.

We analysed water samples for the following at the lowest available limits of detection (LOD):

- Total Nitrogen as N (mg/l);
- Total Phosphorus as P (mg/l);
- Ammoniacal Nitrogen as N (mg/l);

- Nitrite as N (mg/l);
- Total Oxidised Nitrogen as N (mg/l);
- Orthophosphate, reactive as P (mg/l);
- Kjeldahl Nitrogen as N (mg/l);
- Turbidity (NTU);
- Iron, Total & Dissolved (µg/l);
- Manganese, Total & Dissolved (µg/l);

We had hoped that gathering this information specific to Cropston and Swithland reservoir would allow us to tell whether our existing assumptions for dead (and emergency) storage were still appropriate. We looked at whether it was possible to accurately, and with a high degree of confidence, extrapolate the water quality data we collected to determine what the untreatable volume of water is in Cropston and Swithland. We were not able to state with confidence that we could extrapolate these results for these reservoirs. Therefore, we were even less confident that extrapolating from these data to say what was useable at other reservoirs would be accurate or appropriate. Due to the complexities described we are taking a precautionary approach and not altering our dead storage estimates.

v. Review of a water quality modelling approach – we explored the potential of a modelling approach to determining water quality at different depths in different states of draw down. As with any modelling exercise, we would only have confidence in the output if we are able to robustly calibrate the model. We have collected some data as described earlier for reservoirs when their storage is significantly above our current emergency and dead storage. Without any data points obtained during droughts we did not think that we could achieve a satisfactory calibration. We do not think we can get this data to calibrate the model without the reservoir concerned being severely drawn down during a hot and dry period. As we want to ensure our customers have secure supplies we do not want to draw any key reservoir down to this level for a trial in order to calibrate a model. However, if any reservoir does fall to a particularly low level then we will carry out the appropriate water quality tests.

Conclusions and recommendations

a) We have updated our emergency storage assumptions as described earlier in this report.
b) We concluded that we do not have sufficient evidence to change our dead storage estimates with confidence so we have left them unchanged.
c) Because there is no conclusively proven direct correlation between reservoir level and water quality, we can't express indicative treatment thresholds as fixed reservoir levels.
d) We consider this question to be one best tackled as part of an industry wide (UKWIR) project as this issue will also apply to other water companies.