Affinity Water

Drought Management Plan 2023

Appendices

Security Notice

This document has been written in compliance with our security policy so that no redaction is required for publication. Codes have been used to preserve the security of our production locations.

Contents

List of figures

List of tables

Introduction

This document provides the technical appendices which support our Drought Plan. These provide technical and background information to show how our Drought Plan has been developed or provide a greater level of detail than is suitable for our main Drought Plan document. This ensures that our Drought Plan remains a manageable, user-friendly document which can be used as an operational manual to effectively manage risks caused by drought events.

The appendices have been set out in the following structure:

Appendix 1 provides background information on how we monitor water resources and droughts, showing how we chose the key wells/observation boreholes for each of our three regions. It provides the hydrographs for these key wells and provides further information about them, including comparisons to hydrographs for rivers in our region, as well as river photos.

Appendix 2 provides information on the methodologies we use to carry out short term and short to medium term water resource forecasting.

Appendix 3 provides information on how we carried out a review of past drought events and historic recessions, to understand the amount of time it could take between reaching different drought zones.

Appendix 4 provides examples of drought events which have been produced through stochastic modelling carried out for our Water Resources Management Plan (WRMP), and compares these to worked examples with annotated drought actions.

Appendix 5 provides information about our supply and demand drought management actions with associated triggers.

Appendix 6 provides further information on demand restrictions; temporary use bans (TUBs), and non-essential use bans (NEUBs), which has been agreed with the Water Resource South East (WRSE) group.

Appendix 7 provides information on how we carried out the selection and screening process to produce our list of drought permits.

Appendix 8 provides summaries of our environmental assessment reports which have been produced to support drought permit applications, should these be required.

Appendix 9 provides information on the environmental monitoring we carry out to support our drought permit applications.

Appendix 10 provides information on our river restoration programme.

1 Monitoring droughts and water resources

1.1 Criteria/screening of key observation boreholes

This section provides the key considerations or criteria which were used to select our key observation boreholes for use in our drought management plan. The table below shows how we would use screening questions to check whether our key observation boreholes are suitable for use in drought monitoring and predictions, and to screen out boreholes which were not suitable as they did not fulfil the criteria.

We take 65% of our water from groundwater sources (mainly Chalk[1]) and 35 % from a combination of water from the River Thames (around 30 %) and our import from Grafham Water reservoir (around 5 %). The level of abstraction from the River Thames is managed based on our abstraction licences for EGHA, WALT, CHERT and HWFS, the deployable output (DO) of the individual water treatment works (WTW) and the demand on the network. The permitted abstraction does not vary with the flow of the River Thames, as it does for Thames Water Utilities (TWUL), as their abstraction is governed by the Lower Thames Operating Agreement (LTOA). As a result, our DMP focuses on the behaviour of our groundwater sources. Assessment of monitoring data from the River Thames at Kingston Lock is proposed (an Environment Agency monitoring point), to provide a regional picture of the drought situation evolution, since a drought situation is likely to affect the region and therefore require a coordinated response between water companies.

For the purposes of our previous Drought Plan (2019), five indicator boreholes were used to define whether we were experiencing a drought event. Three of these boreholes are located in Central Region (Chalfont Centre, Elsenham Nurseries and Lilley Bottom, with Lilley Bottom generally used to determine our overall position) whilst a single key observation borehole is used for our East and Southeast regions, Lady Lane and Wolverton respectively. For the previous Drought Plan (2019), this network of key wells was assessed as providing appropriate assessment with sufficient confidence about whether the relevant supply region was in drought, based on the position of the groundwater level compared to individual borehole drought zones.

For this round of drought planning, a review of the current indicator boreholes has been undertaken, in line with the questions set out in *Table 1*.

[1] For more details on the classification of Chalk lithology, please see Woods,M, (2006). UKChalkGroup stratigraphy (Cenomanian–Santonian) determined from borehole geophysical logs. Quarterly Journal of Engineering Geology and Hydrogeology, 39, 83–96, https://doi.org/10.1144/1470-9236/05-007

Table 1: Example questions for key well review

No.	QUESTION	Yes/No	Why?
1	Is the borehole representative of an aquifer from which we abstract? Which Chalk unit does the borehole represent in terms of lithology and groundwater level?		
2	Where is the borehole located in terms of topography? (i.e. valley bottom, higher ground, interfluve)		
3	Are we confident in the quality of the data that we get from monitoring this borehole?		
4	Are there any key gaps in the monitoring record of this borehole?		
5	Have we experienced a range of historic minima and maxima at the borehole?		
6	Does the borehole design allow for all drought zones to be experienced?		
7	Have there been any changes in trend characteristics over time and in particular since the publication of the last plan?		
8	Is the key borehole significantly influenced by external factors such as abstraction?		
9	Is the behaviour of the borehole predictable and uniform?		
10	Does the borehole behaviour link to regional resource availability?		
11	Does the borehole also feature on other Affinity Water planning platforms?		
12	Does the borehole respond to recharge (or the lack of it) in a systematic way? How long does it take to reach between the various drought zones and what is the lag time between the various observation boreholes?		
13	Are borehole levels well correlated with environmental conditions (river flows)?		

A strong focus of our new Drought Plan is its environmental ambition and so we carried out an exercise to explore what our chalk streams might look like during different groundwater level periods. This is important, since the introduction of the 'Environmental Stress' drought trigger (discussed more in later sections) is designed to focus attention on the environmental impacts of low groundwater levels, which

would typically occur before we start to experience potential supply deficits. We did this in three main ways:

- Plotting river flows in certain catchments against nearby key wells, to show that the chalk groundwater levels are the primary control on chalk stream baseflows (See Appendix 1.5).
- Based on (1), annotating the hydrographs of key wells to visually depict how the flow regime changes at set locations (see Appendix 1.6).
- Validating our decision to principally classify our Central region drought risk based on the Lilley Bottom drought status, with support from other key wells by comparing hydrograph trends (see Appendix 1).

The analysis shows that, generally, gauged river flows respond predictably to regional chalk groundwater level trends. This is important because it shows that the key wells that we have selected are well positioned to inform not just the company drought risk from a resource availability perspective, but also the environmental stress due to drought. This facilitates the implementation of early interventions with the specific aim of environmental education and protection, designed to help soften the impact of increasingly serious drought conditions. Section 1.5 below illustrates the impacts that changing chalk groundwater levels have on river baseflow conditions. It highlights the fragility of these precious ecosystems, the importance of taking mitigating actions early (as set out in later sections), but also the extent to which flows are dominated by recharge (or lack of it).

As set out in point 3, we have compared the hydrograph responses to recharge (or the lack of it) at the proposed key wells in Central region to that of Lilley Bottom. The results are summarised in Table 2 below. As shown, Lilley Bottom well represents on average the groundwater level conditions through our Central region, and for this reason this borehole has been selected as the 'lead' key well for our Central region.

Table 2: Summary of key well hydrograph responses compared to Lilley Bottom

KEY WELL	CATCHMENT	BOREHOLE LOCATION	VARIATION COMPARED TO LILLEY BOTTOM
Lilley Bottom	Mimram	Upper catchment/valley bottom	NA
Chalfont Centre	Misbourne	Mid/catchment/Valley side	1-2 months earlier response to recharge and dry periods compared to Lilley Bottom

KEY WELL	CATCHMENT	BOREHOLE LOCATION	VARIATION COMPARED TO LILLEY BOTTOM
Ashley Green	Chess	Upper catchment/Interfluve	1 month on average earlier response to recharge and dry periods compared to Lilley Bottom
Elsenham Nurseries	Stort/Cam	Interfluve	1-2 months lag compared to Lilley Bottom
Little Bordeaux Farm	Cam	Upper catchment/valley bottom	Similar to Lilley Bottom, although more flashy following rainfall, due to location in river valley

1.2 Our chosen key wells

This section provides further information on each of our chosen key observation boreholes. The maps below provide the locations of each of the boreholes in our three regions, and the tables show how each of our key observation boreholes was screened using the questions set out in Table 1, to ensure they met the criteria for use in our Drought Plan. An explanation of how these criteria have been met is also provided.

Groundwater levels at our key wells rise and fall in a predictable way following rainfall events, making them good indicators of groundwater resource availability. Since a significant proportion of the baseflow element of chalk streams in our area is derived from chalk groundwater, it is not surprising that river flows in the nearby catchments follow a similar pattern to groundwater level changes at these key wells. This means they can be used as good indicators of the stresses that droughts can pose to these precious watercourses, whilst highlighting the dominant role that recharge (or lack of it) plays in driving river flow changes.

Close liaison with the Environment Agency during and after the 2017-2019 drought event and a subsequent review for this DMP, suggest that the River Cam catchment (in our Stort Community) may have been more notably drought impacted in this particular drought when compared to other chalk stream catchments in our Central region. This river (along with the Ivel, Hiz, Rhee and Purwell) flows north down the chalk escarpment, through Bedfordshire and Cambridgeshire, to join the River Great Ouse near Ely. In comparison, the chalk stream tributaries of the Rivers Lea and Colne flow south following the dip of the chalk within the Thames Basin towards the River Thames. As a result, a new key well (Little Bordeaux Farm) has been added, with the specific aim of reflecting the water supply/environmental status of the River Cam catchment and River Cam itself. This new monitoring point is a shallow borehole which is thought to be hydraulically connected to the chalk.

Understanding the drought status of this catchment is particularly important because of the requirement for us to provide river support to the River Cam when flows are low.

Ashley Green has also been added as a key well since the previous Drought Plan. This site is located on the interfluve between the Chess and Bulbourne catchments and displays a faster response to recharge compared to Lilley Bottom (similar to Chalfont Centre). It has the advantage of featuring in the Herts. and North London (HNL) Environment Agency monthly water resources situation report, which increases the cross-organisational consistency of messaging for stakeholders. Ashley Green is also better related to flows in the River Chess than Chalfont Centre, due to its closer proximity.

1.2.1 Maps of key wells

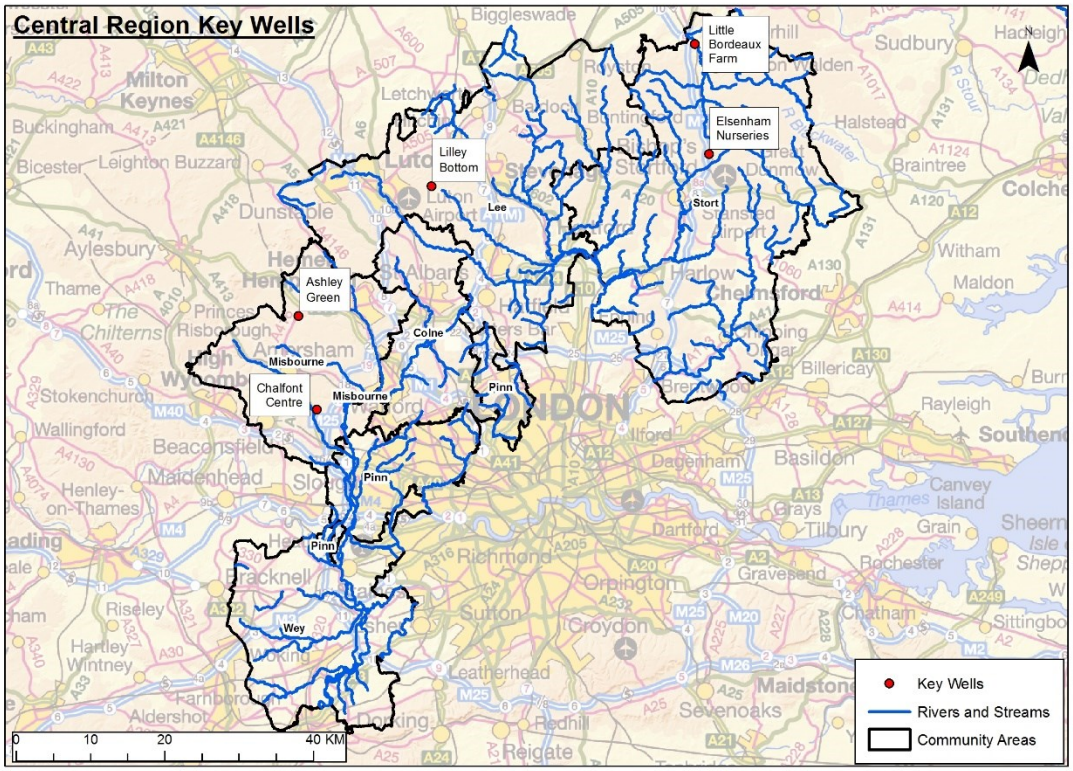


Figure 1: Central Region Key Wells

Figure 2: East Region Key Wells (Brett community is labelled)

Figure 3: Southeast Region Key Wells

1.2.2 Further information – key wells/observation boreholes

Table 3 below provides a summary of the information considered as part of the review of our key observation boreholes, showing the questions which were used in the screening process, and how these have been answered for each of the key wells chosen for the Plan. Key details of each of the boreholes are provided below. We have provided more detail for Little Bordeaux Farm and Ashley Green as these are new key wells as part of this Drought Plan.

Lilley Bottom

Lilley Bottom is located within the Central region in the headwaters of the Mimram catchment, off Lilley Bottom Road. The borehole is 11.2 m deep and intersects the New Pit Chalk. Table 3 provides a review of the borehole as an indicator of Central region drought status.

Elsenham Nurseries

Elsenham Nurseries borehole is located within the Stort catchment. The borehole is 61.26 m deep and intersects the Lewes Chalk. Table 3 provides a review of the borehole as an indicator of Central region drought status.

Chalfont Centre

Chalfont Centre observation borehole is located on the valley side of the Misbourne catchment. The borehole is 76.2 m deep into the Lewes Nodular Chalk. Table 3 provides a review of the borehole as an indicator of Central region drought status.

Little Bordeaux Farm

The 2019 drought event required record levels of augmentation from our SPRF and UTTL sources combined, to sustain low river flows in the Cam at Great Chesterford gauging station. From December 2024, a new licence will come into effect for the two sources. Although there are ongoing discussions with the Environment Agency around the conditions of the new licence, it is likely to require more frequent river support. In recognition of the potential impacts of low flows in the Cam on regional water resources and because Lilley Bottom groundwater level is not as well correlated with the northward flowing Chalk streams, we have now included a borehole in the Cam catchment as a key well. This borehole is Little Bordeaux Farm.

We have a comprehensive groundwater and surface water monitoring network in the Cam catchment and this, combined with the Environment Agency monitoring network, aids operational decision making and informs regulator to water company conversations. Analysis suggests that Little Bordeaux Farm is the most representative borehole of the conditions that impact the River Cam hydrology. It is shallow and sunk into the superficial deposits (an aquifer significant for supporting river flows locally) and is also in close proximity to the river. This makes the borehole well placed to bridge the gap between the unpredictability of river flow and predictable nature of Chalk groundwater levels.

The low baseflow index (BFI) for the Cam (0.66) suggests that the contribution of Chalk groundwater to river baseflow is less than that of the Chalk streams that flow through the Chilterns, and that the river is therefore more vulnerable to periods of dry

weather. This means that forecasting groundwater level trends at Little Bordeaux Farm can provide an indication of river flow trends and therefore operational impacts; during periods of very low rainfall, additional evaluation of flow data will need to be carried out to best inform drought prospects.

Ashley Green

Ashley Green OBH is located on the interfluve between the Chess and Bulbourne catchments. The borehole is 100 m deep into the Chalk, cased to 20 m with plain steel and open hole thereafter. There is an 8 m clay with flints cover recorded, but the open hole section of the borehole mainly represents groundwater level in the Lewes Nodular and New Pit Chalk units (the main aquifer units that meet the demands of public water supply abstraction), whilst finishing in the Holywell Nodular Chalk. This might also be a contributing factor to the generally faster groundwater level response observed in this borehole compared to others that are only screened in one Chalk unit rather than multiple.

Lady Lane

Lady Lane is the key observation borehole for our East Region. It is located on the valley side of the Upper Brett catchment. The borehole is 94.5 m deep, finishing in the Upper Chalk (likely the Lewes Nodular unit). There are layers of Boulder Clay, sand and gravel and sandy clay overlying the Chalk and water level is often between 32 and 35 metres below datum, hydraulically confined by the Boulder Clay. These are similar hydraulic conditions to the areas further south in the Brett and Stour catchments where our groundwater abstractions are located.

Wolverton New OBH

Wolverton New observation borehole is used as the key monitoring borehole for our Southeast Region. It is located in the upper reaches of the Alkham river valley, drilled 25 m deep into the New Pit Chalk.

Table 3: Summary of screening questions and answers for each key observation borehole chosen for our Drought Plan and water resource monitoring purposes

	QUESTION	LILLEY BOTTOM	ELSENHAM NURSERIES	CHALFONT CENTRE	LITTLE BORDEAUX FARM	ASHLEY GREEN	LADY LANE	WOLVERTON NEW
1	**Is the borehole representative of an aquifer from which we abstract (primarily New Pit and Lewes Nodular units)? Which Chalk unit does the borehole represent in terms of lithology and groundwater level?**	Yes. The borehole is 11.2 m deep into the New Pit Chalk and cased to 2.6 m with plain steel. Below this, it is open hole installation to the base of the borehole.	Yes. The borehole is 61.26 m deep into the Lewes Nodular Chalk.	Yes. The borehole is 76.2 m deep into the Lewes Nodular Chalk and cased to 8 m with plain steel. Below this, it is open hole installation to the base of the borehole.	Yes. The borehole is 7.62 m deep into the gravel, although this is in good hydraulic connectivity with the underlying New Pit Chalk and so represents the level of this unit. This is the principal aquifer from which we abstract.	Yes. The borehole is 100 m deep into the Chalk, cased to 20 m with plain steel. There is an 8 m Clay with flints cover overlying the Chalk, but the open hole section of the borehole mainly represents groundwater level in the Lewes and New Pit Chalk units, whilst finishing in the Holywell Nodular Chalk.	Yes. The borehole is 94.5 m deep, finishing in the Upper Chalk, probably the Lewes Nodular unit. There are layers of boulder clay, sand and gravel and sandy clay on top of this, and water level is often between 32 and 35 metres below datum, hydraulically confined by the boulder clay.	The borehole is 25 m deep, into the New Pit Chalk, which is the primary aquifer from which we abstract in the area.
2	**Where is the borehole located in terms of topography? (i.e. valley bottom, higher**	Upper part of the Mimram valley	The borehole is located on the interfluve of the Stort/Cam catchment.	The borehole is located on the side of the Misbourne valley.	The borehole is located in the bottom of the Cam river valley.	The borehole is located on the interfluve between the Chess and Bulbourne catchments.	The borehole is located on the valley side of the Brett catchment.	The borehole is located in the upper reaches of the Alkham river valley.

	QUESTION	LILLEY BOTTOM	ELSENHAM NURSERIES	CHALFONT CENTRE	LITTLE BORDEAUX FARM	ASHLEY GREEN	LADY LANE	WOLVERTON NEW
	ground, interfluve)							
3	**Are we confident in the quality of the data that we get from monitoring this borehole?**	Yes. The data is collected, quality assured and provided by the Environment Agency.	Yes. The data is collected by Affinity Water via a telemetered logger. In addition to monthly dips by the Environment Agency, manual dips are taken by Affinity Water at least on a quarterly basis and the logger is calibrated accordingly	Yes. The data is collected by Affinity Water via a telemetered logger. In addition to monthly dips by the Environment Agency, manual dips are taken by Affinity Water at least on a quarterly basis and the logger is calibrated accordingly	Yes. The data is collected by Affinity Water via a telemetered logger. In addition to monthly dips by the Environment Agency, manual dips are taken by Affinity Water at least on a quarterly basis and the logger is calibrated accordingly	Yes. The data is collected, quality assured and provided by the Environment Agency.	Yes. The data is collected by Affinity Water using a telemetered logger and validated with manual dips at least on a quarterly basis.	Yes. The data is collected, quality assured and provided by the Environment Agency.
4	**Are there any key gaps in the monitoring record of this borehole?**	No. Almost all monthly data is available since 1979 when the record began. There is a minor gap in winter 2000/2001 during a high groundwater level period due to the foot and mouth outbreak but this does not impact the	Data collection started in 1966 but was not recorded during the 1976 drought event.	No. Almost all monthly data is available since 1975 when the record began. Data through the early 1980's is patchy but a good record is available since this period.	No. Almost all monthly data is available since 1963. Data was absent over the 1976 drought period but a good record exists since this date.	Generally, the monitoring record is complete. There is a minor gap in winter 2000/2001 during a high groundwater level period due to the foot and mouth outbreak but this does not impact the borehole record	Data has been collected since 1991 and has spanned several drought and flood events. There have been several long gaps in the monitoring period however, due to the infrequency of dips prior to 2012. These have been infilled with a	No. Almost all monthly data is available since 1995 when the record began.

	QUESTION	LILLEY BOTTOM	ELSENHAM NURSERIES	CHALFONT CENTRE	LITTLE BORDEAUX FARM	ASHLEY GREEN	LADY LANE	WOLVERTON NEW
		borehole record for drought monitoring purposes.				for drought monitoring purposes.	dashed line in the hydrograph (Figure 9).	
5	**Have we experienced a range of historic minima and maxima at the borehole?**	Yes. The highest recorded groundwater levels in the monitoring period occurred in spring 2001 whilst the lowest groundwater levels in the monitoring period occurred in December 1997. Drought zone 3 is positioned just below December 1997 levels.	Yes. The highest recorded groundwater levels in the monitoring period occurred in spring 2001 whilst the lowest groundwater levels in the monitoring period occurred in February 1998. Drought zone 3 is positioned just below February 1998 levels.	Yes. The highest recorded groundwater levels in the monitoring period occurred in spring 2001 whilst the lowest groundwater levels in the monitoring period occurred in October 1997 and October 1976. Drought zone 3 is positioned just below October 1997 levels.	Yes. The highest recorded groundwater levels in the monitoring period occurred in spring 2001 whilst the lowest groundwater levels in the monitoring period occurred in December 1990. Drought zone 3 is positioned just below December 1990 levels.	Yes. The lowest recorded levels occurred in March 2012 whilst the highest recorded groundwater levels in the monitoring period occurred in spring 2001 and spring 2014.	The highest groundwater levels in the monitoring period probably occurred in winter/spring 2001 (dip data was not collected due to the foot and mouth outbreak but this was the recorded groundwater level peak for most monitoring boreholes where data is available). The lowest groundwater levels in the monitoring period occurred in June 1997.	The highest groundwater levels in the monitoring period probably occurred in winter/spring 2001 and spring 2014. Around 45.5 mAOD, the borehole water level flattens, due to discharge further down-valley. The lowest groundwater levels in the monitoring period occurred in November 1996. Drought zone 3 is positioned

	QUESTION	LILLEY BOTTOM	ELSENHAM NURSERIES	CHALFONT CENTRE	LITTLE BORDEAUX FARM	ASHLEY GREEN	LADY LANE	WOLVERTON NEW
								just below this level.
6	**Does the borehole design allow for all drought zones to be experienced ?**	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	**Have there been any changes in trend characteristics over time and in particular since the publication of the last plan?**	Over the monitoring period, groundwater levels have fluctuated around the long term average (LTA) curve[2] for each hydrograph but have always recovered to similar levels following similar recharge events. This suggests that there is no long term decline of regional groundwater levels. Analysis suggests that from the early-mid 1990's, groundwater level changes were more volatile compared to the 1980's. This is likely to result from differing recharge patterns, potentially linked to climate change. Following the sustainability reduction in the Misbourne catchment in the abstraction year 2017-2018, groundwater levels at Chalfont Centre have been generally higher than before (i.e. 2019 was generally considered a more severe drought than 2017 but levels at Chalfont Centre were lower in 2017). This is due to the fact that Chalfont Centre is located down hydraulic gradient of the source that reduced its abstraction.						
8	**Is the key borehole significantly influenced by external factors such**	No. The borehole is likely to be within the cone of depression of one of our upper Mimram abstraction	No. The borehole is located at a significant distance from our groundwater abstractions. The	No. Although following the Misbourne sustainability reduction in the abstraction year 2017-2018,	No. Given its proximity, there is the potential for this site to be influenced by prolonged abstraction from	No. Given its proximity, there is the potential for this site to be minimally influenced by a Thames Water	No, the borehole is at a significant distance from all groundwater abstractions.	No. The borehole is located over 2 km from any of our abstraction boreholes, so

[2] *The long term average (LTA) has been calculated statistically, using the long term data records available for each key well.

	QUESTION	LILLEY BOTTOM	ELSENHAM NURSERIES	CHALFONT CENTRE	LITTLE BORDEAUX FARM	ASHLEY GREEN	LADY LANE	WOLVERTON NEW
	as abstraction?	sources. Analysis undertaken suggests that the maximum potential impact on Lilley Bottom is 0.4 m under certain background conditions, resulting from a 2.4 Ml/d change in abstraction. As this abstraction is operated as a baseload source (and has been during historic droughts), the potential influence on Lilley Bottom is included within the baseline water level data and is therefore considered insignificant. Outages at the source are infrequent and when they occur they are mainly caused by high	closest is almost 3 km away.	groundwater levels at Chalfont Centre have been generally higher than before. The borehole still experiences similar regional groundwater fluctuations, in terms of both timing and magnitude.	SPRF, however, this was not seen during the 2015 pumping test and so is likely to be minor.	groundwater abstraction, however this was not observed during the AMP6 Chess NEP investigation.		abstraction is not expected to have a significant impact on Wolverton new OBH level.

	QUESTION	LILLEY BOTTOM	ELSENHAM NURSERIES	CHALFONT CENTRE	LITTLE BORDEAUX FARM	ASHLEY GREEN	LADY LANE	WOLVERTON NEW
		nitrates, which typically occur during high (not low) groundwater level conditions.						
9	**Does the borehole behaviour link to regional resource availability?**	Yes. Groundwater level change at Lilley Bottom is well correlated with the Deployable Output (DO) change at the Central region Chalk groundwater sources and the borehole has been used extensively in DO calculations for sources in a number of Water Resource Zones in the region. This means that forecasted groundwater level change under different rainfall scenarios (60 %, 80 %, 100 %, 120 %) can be used to inform regional DO assessments over	Yes. Groundwater levels at Elsenham Nurseries have been used in the DO calculations for the sources in our Stort community. For modelling purposes, Lilley Bottom is used however, as it is a better fit for Central region as a whole.	Yes, groundwater levels at Chalfont Centre have been used in the DO calculations for sources in a number of Water Resource Zones in Central region. For resource availability modelling during droughts, Lilley Bottom is used however, as it is a better fit for Central region as a whole.	Yes. Given the relationship between groundwater levels in this borehole and flows in the Cam, it is linked to the regional resource availability.	The borehole displays a similar (albeit slightly more rapid) response to recharge that Lilley Bottom, which is well correlated with regional resource availability. The faster response to recharge events reflects the position of Ashley Green to west of our supply area and potentially the greater screened depth through a number of Chalk units.	The borehole has not been used directly in DO calculations for the region but is a good indicator of regional groundwater levels and correlates well with flow in the Brett.	Yes, and the borehole has been used extensively in DO calculations for the region and is linked to Hands off Flow/Level (HoF/HoL) constraints on some of our abstraction licences in the region.

	QUESTION	LILLEY BOTTOM	ELSENHAM NURSERIES	CHALFONT CENTRE	LITTLE BORDEAUX FARM	ASHLEY GREEN	LADY LANE	WOLVERTON NEW
		time. This can then be modelled against different demand scenarios and fed back into the decision-making process for drought management actions, based on the forecast surplus/deficits during different months under different scenarios.						
10	**Does the borehole also feature on other Affinity Water planning platforms?**	Yes. Lilley Bottom is extensively used in the WRMP including in DO calculations for Central region groundwater sources.	Yes. Elsenham Nurseries is extensively used in the WRMP, including in DO calculations for Central region groundwater sources.	Yes. Chalfont Centre is extensively used in the WRMP, including in DO calculations for Central region groundwater sources.	Not at present	Not at present	Yes, the borehole is used in the WRMP.	Yes, the borehole is extensively used in the WRMP, including in DO calculations for Southeast region groundwater sources.
11	**Does the borehole respond to recharge (or the lack of it)**	Yes, given certain environmental conditions (SMD, antecedent effective	Yes, given certain environmental conditions (SMD, antecedent effective	Yes, given certain environmental conditions (SMD, antecedent	General trends are similar to Lilley Bottom in timing of changes. As it is	General trends are similar to Lilley Bottom in timing of changes, albeit	The LTA and groundwater trends are uniform, decreasing from March through to	Yes, on the regional scale, the borehole responds in a

	QUESTION	LILLEY BOTTOM	ELSENHAM NURSERIES	CHALFONT CENTRE	LITTLE BORDEAUX FARM	ASHLEY GREEN	LADY LANE	WOLVERTON NEW
	in a systematic way? What is the lag time between the various OBHs?	precipitation/rainfall, time of year, starting groundwater level), a particular groundwater level change can be expected- this is based on the LTA curve. This allows reasonably accurate predictions of the groundwater response month on month given a sustained rainfall pattern, which can be used for operational business planning. It should be noted that the forecast accuracy decreases with length of forecast.	precipitation/rainfall, time of year, starting groundwater level), a particular groundwater level change can be expected- this is based on the LTA curve. This allows reasonably accurate predictions of the groundwater response month on month given a sustained rainfall pattern, which can be used for business planning. It should be noted that the forecast accuracy decreases with length of forecast. Elsenham Nurseries exhibits approximately a 1-2-month lag time in the response to recharge, compared to Lilley	effective precipitation/rainfall, time of year, starting groundwater level), a particular groundwater level change can be expected- this is based on the LTA curve. This allows reasonably accurate predictions of the groundwater response month on month given a sustained rainfall pattern, which can be used for operational business planning. It should be noted that the forecast accuracy decreases with length of forecast.	a valley borehole, there is a tendency for a slightly flashier response to rainfall, however this is not extreme. The LTA and groundwater trends appear uniform, decreasing from May through to October, before increasing to reach a peak in February, then plateauing. It is anticipated that this will allow for reasonably accurate predictions of the groundwater response month on month given a sustained level of rainfall, which can be used for operational business planning. It	the borehole displays slightly more rapid response to recharge, the result of it being located further west in our Central supply area and being screened through multiple Chalk units. The LTA and groundwater trends appear uniform, decreasing from late March to late November, before increasing to reach a peak in March. It is anticipated that this will allow for reasonably accurate predictions of the groundwater response month on month given a sustained rainfall pattern,	October, before increasing from October until March, then plateauing. This allows for reasonably accurate predictions of the groundwater response month on month given a sustained rainfall pattern, which can be used for operational business planning. It should be noted that the forecast accuracy decreases with length of forecast. On the regional scale, the borehole responds in a systematic way, following the LTA trend. On a monthly basis, the borehole is quite responsive to recharge or lack of recharge,	systematic way, following the LTA trend. Under average rainfall conditions, groundwater levels increase from October to March before declining until September. This allows for reasonably accurate predictions of the groundwater response month on month given a sustained rainfall pattern, which can be used for operational

	QUESTION	LILLEY BOTTOM	ELSENHAM NURSERIES	CHALFONT CENTRE	LITTLE BORDEAUX FARM	ASHLEY GREEN	LADY LANE	WOLVERTON NEW
			Bottom. This means that groundwater lows and highs are experienced later than Lilley Bottom. This is important, because it shows that some areas of our Central region can still be experiencing below average groundwater level conditions, despite recovery in the more faster responding Chalk in the middle and west of our Central supply region.	General trends are similar to Lilley Bottom although Chalfont Centre displays a more rapid response-seeing recharge around 1 month before Lilley Bottom. This means that drought peaks occur earlier but so do hydrograph highs.	should be noted that the forecast accuracy decreases with length of forecast.	which can be used for business planning. It should be noted that the forecast accuracy decreases with length of forecast.	meaning that trend changes can be experienced over a monthly period.	business planning. It should be noted that the forecast accuracy decreases with length of forecast.
12	**Are borehole level correlations well correlated with environmental conditions (river flows)?**	Yes. See Appendix 1.5.	Yes. See Appendix 1.5.	Yes. See Appendix 1.5.	Yes. See Appendix 1.5.	Yes. See Appendix 1.5.	Yes. See Appendix 1.5.	Yes. See Appendix 1.5.

1.3 Key well/observation borehole hydrographs

The following figures show the hydrographs for each of our seven key observation boreholes, which we use to track and predict our drought and water resource position and prospects. This process is explained in Section 4 of our main Drought Plan, with further information on water resource forecasting provided in Appendix 2.

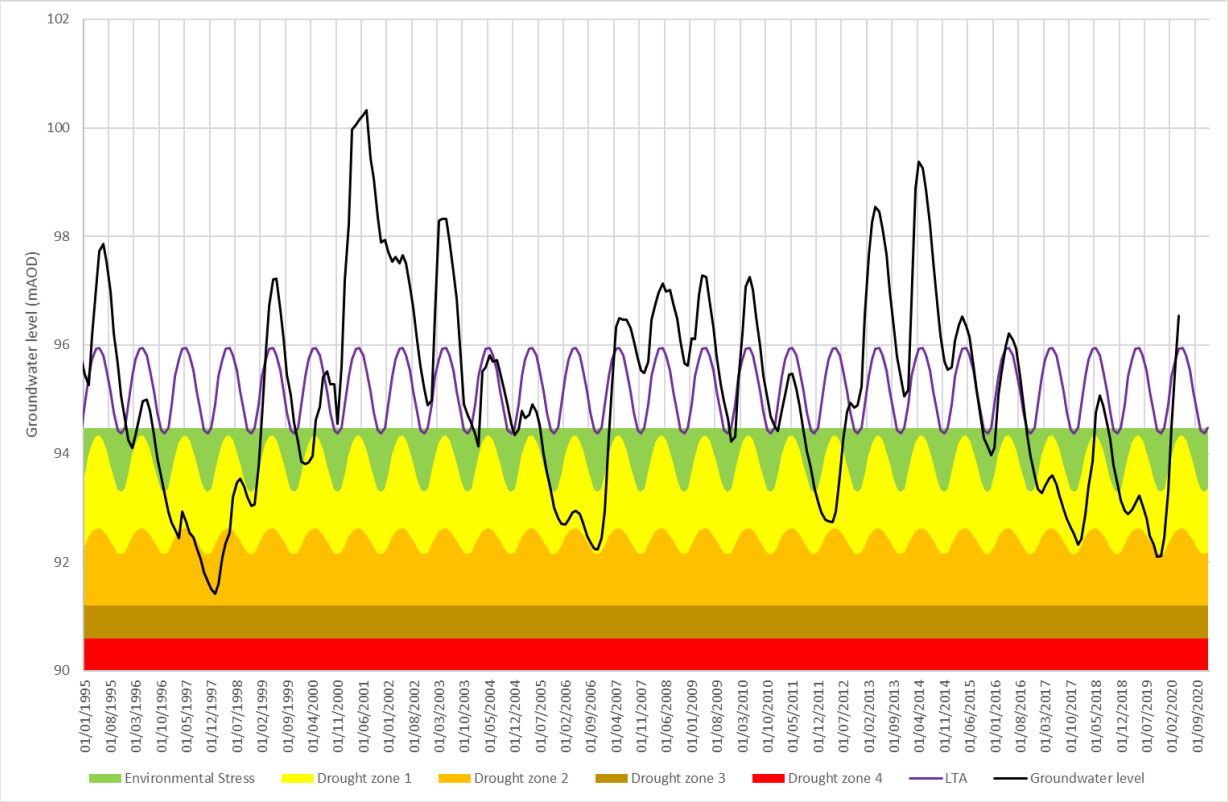


Figure 3: Lilley Bottom hydrograph with drought trigger levels

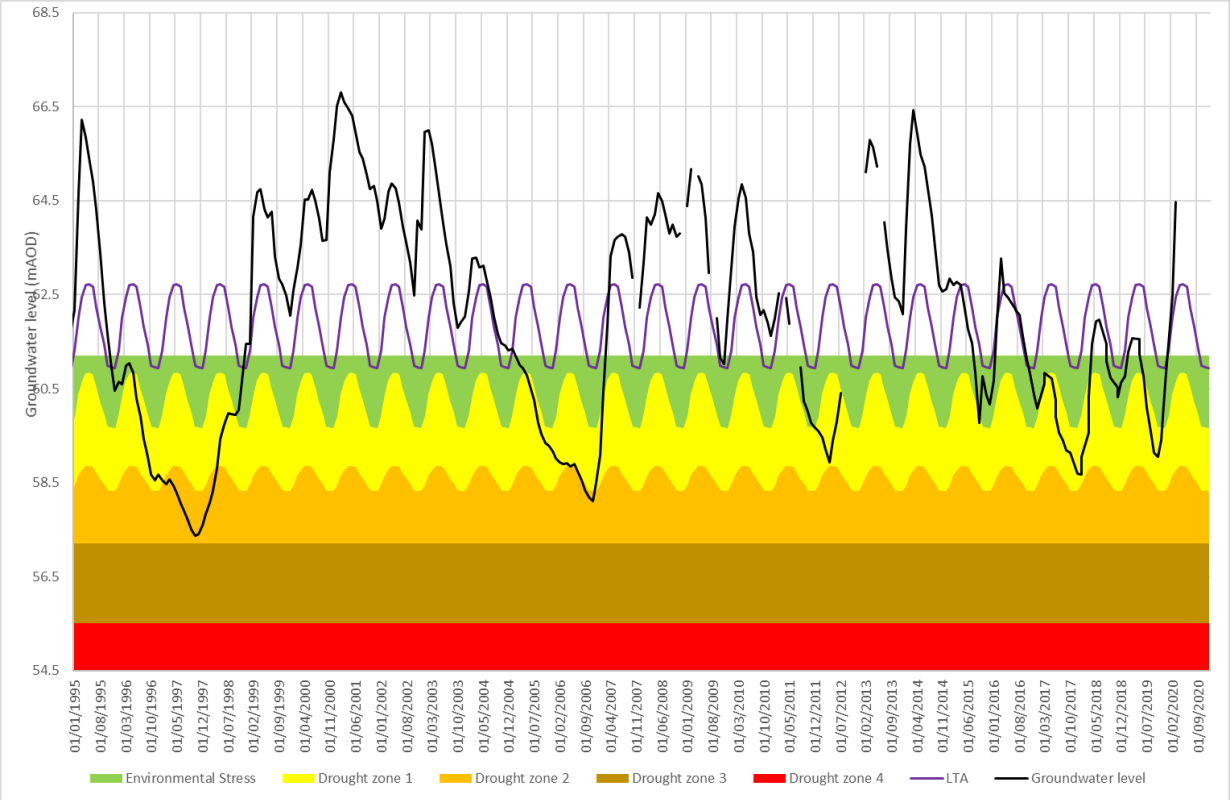


Figure 4: Chalfont Centre hydrograph with drought trigger levels

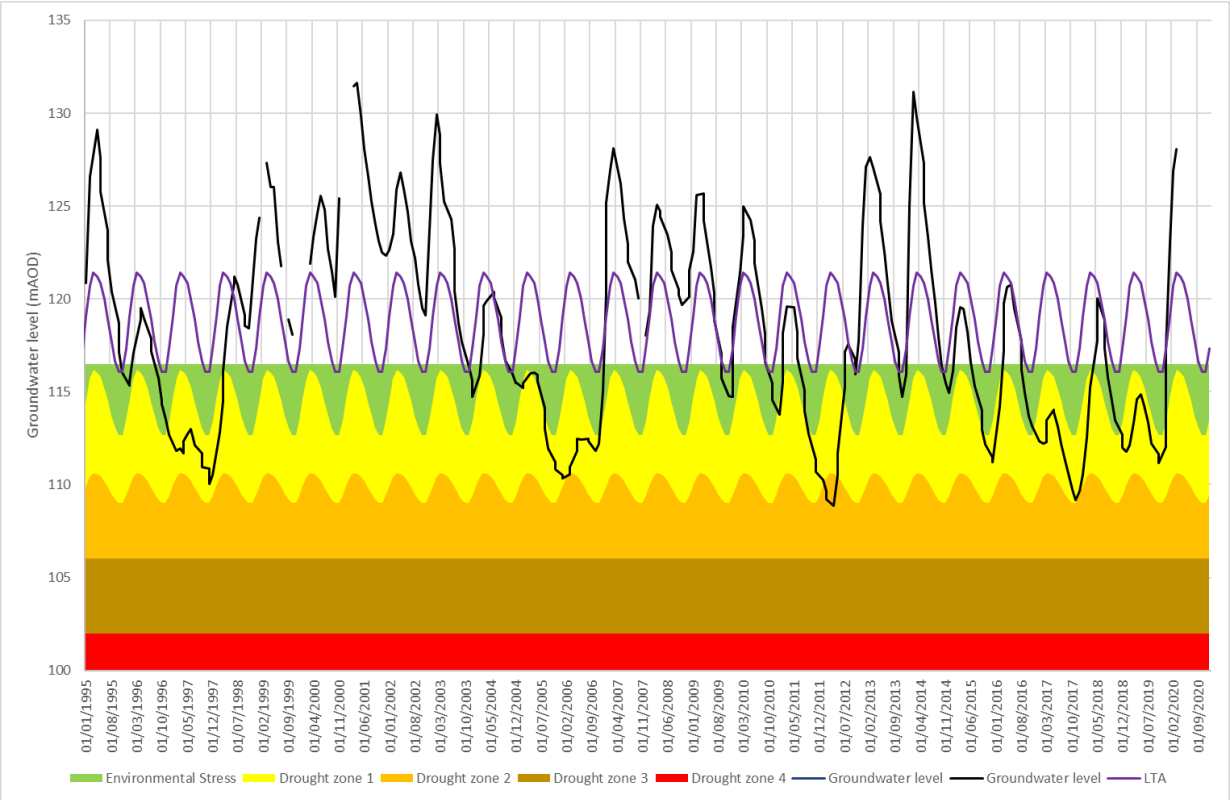


Figure 5: Ashley Green hydrograph with drought trigger levels

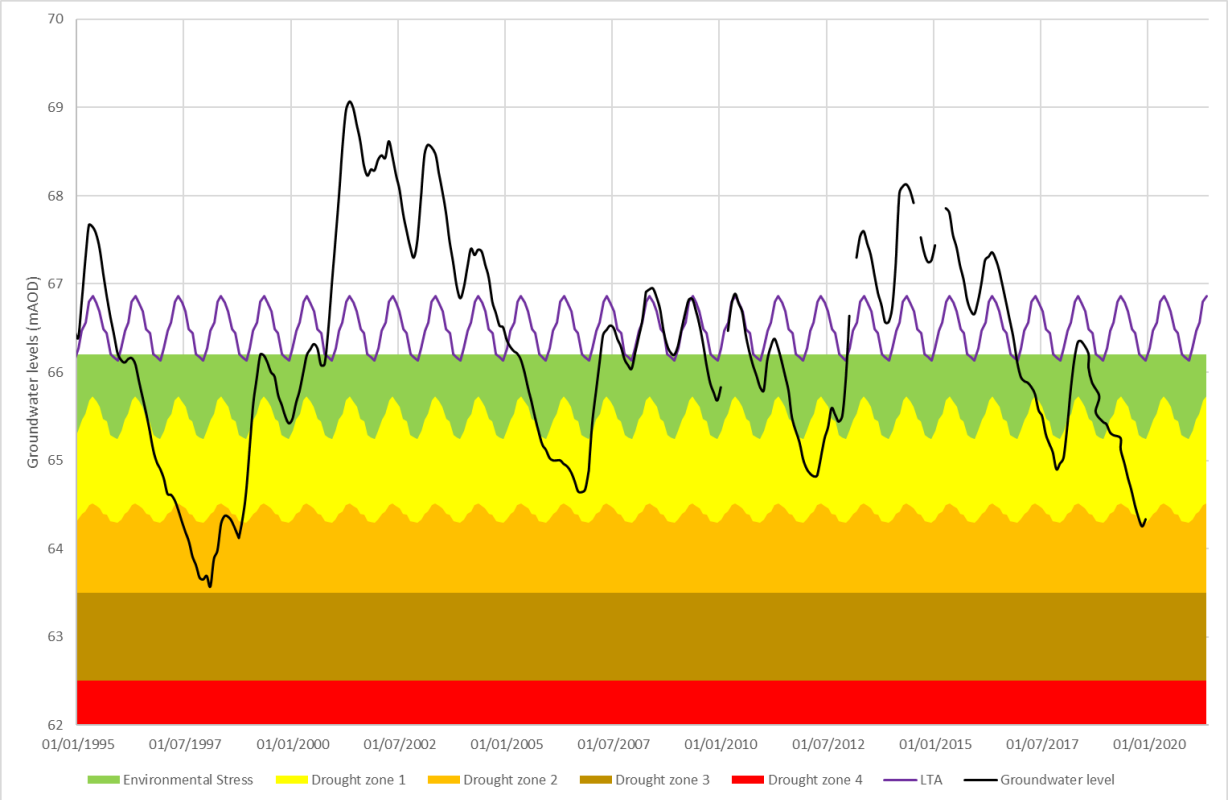


Figure 6: Elsenham Nurseries hydrograph with drought trigger levels

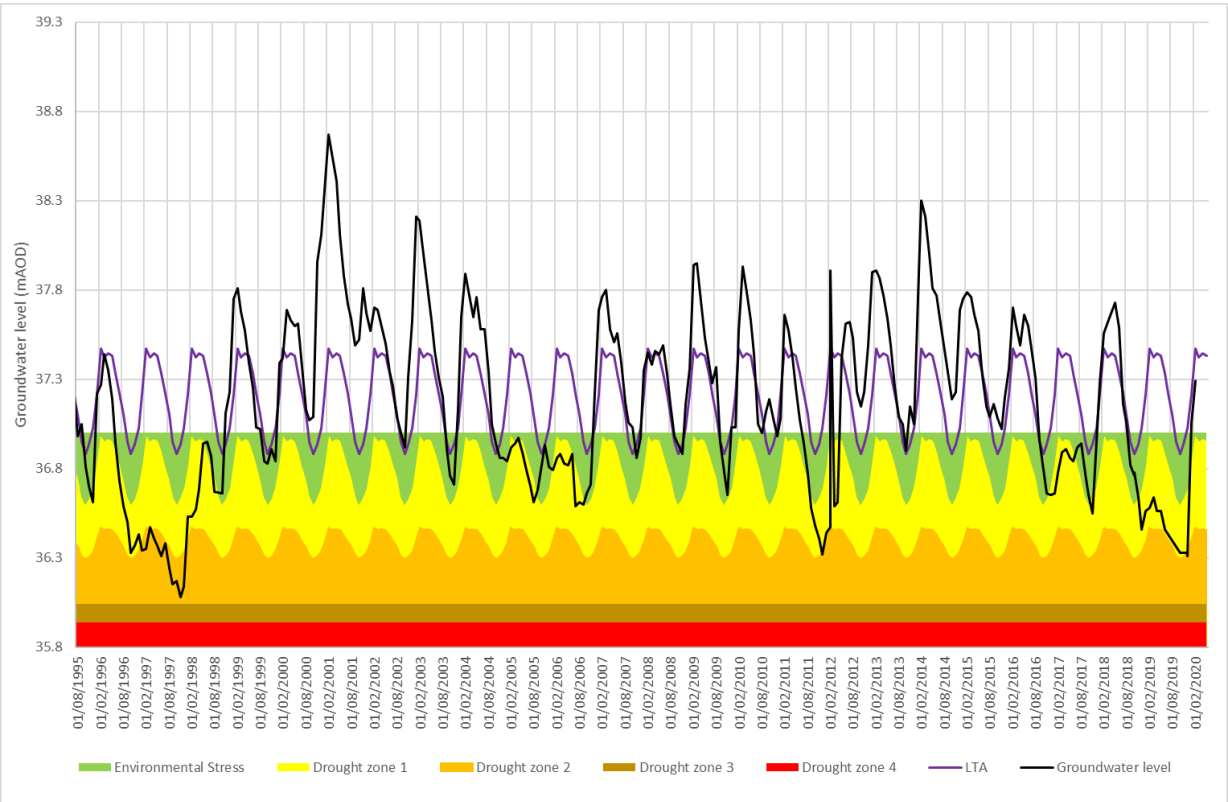


Figure 7: Little Bordeaux Farm hydrograph with drought trigger levels

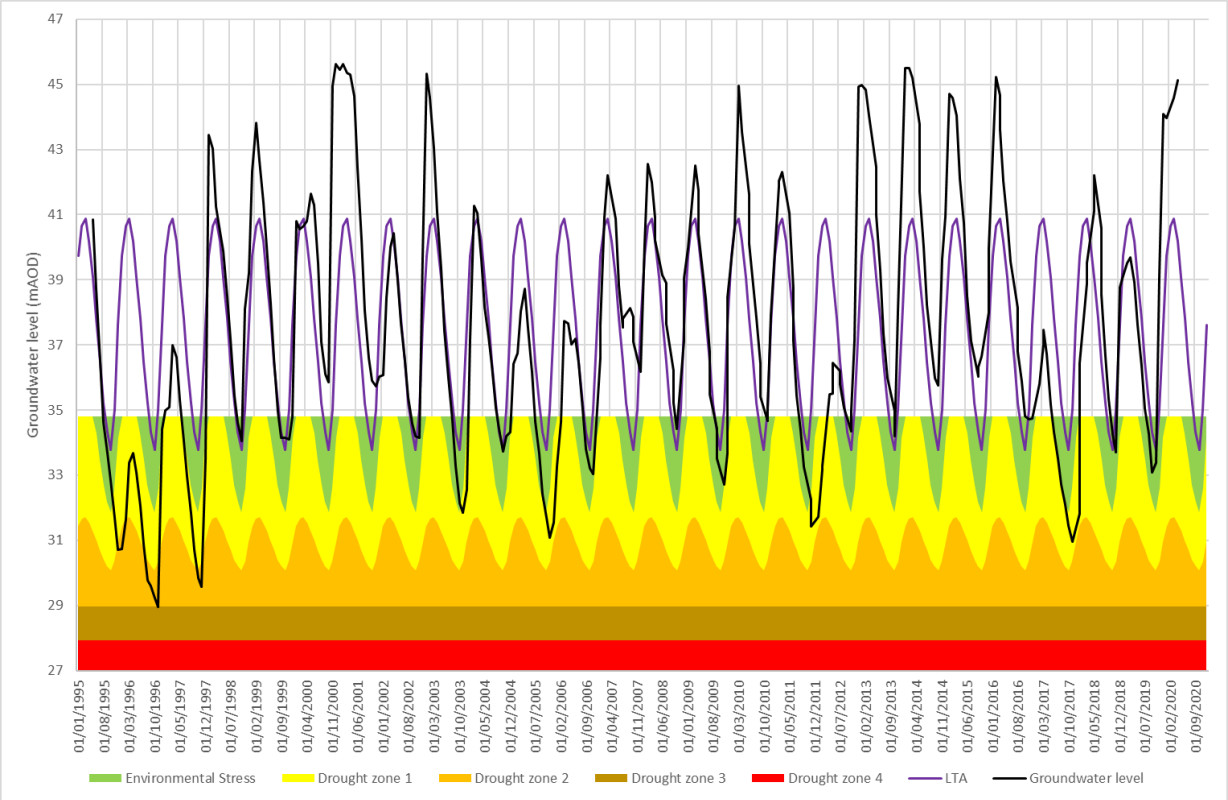


Figure 8: Wolverton hydrograph with drought trigger levels

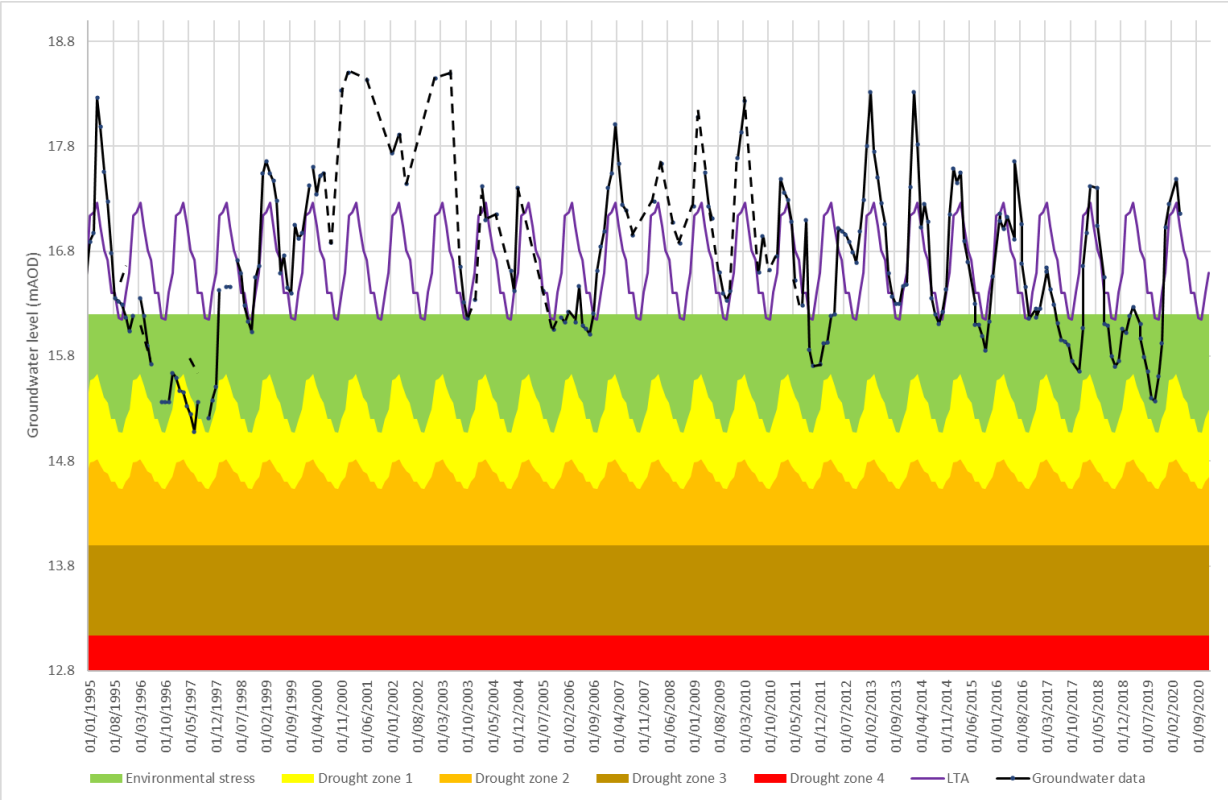


Figure 9: Lady Lane hydrograph with drought trigger levels

1.4 Relationships between key well/observation borehole hydrographs

The following figures show how the hydrographs for the key observation boreholes in our Central region compare to the hydrograph for Lilley Bottom, to provide an indication of how they correlate. As explained in Section 4.2 of our main Drought Plan, Lilley Bottom is used as a key indicator of water resources/drought status as a whole, and it is important that we have a good understanding of how groundwater level changes in our supporting observation boreholes compare with Lilley Bottom. Figure 14 shows that when plotted together, Lilley Bottom typically fluctuates in the mid-range between all the observation boreholes, therefore acting as a good general indicator for the water resource position as a whole for our Central region.

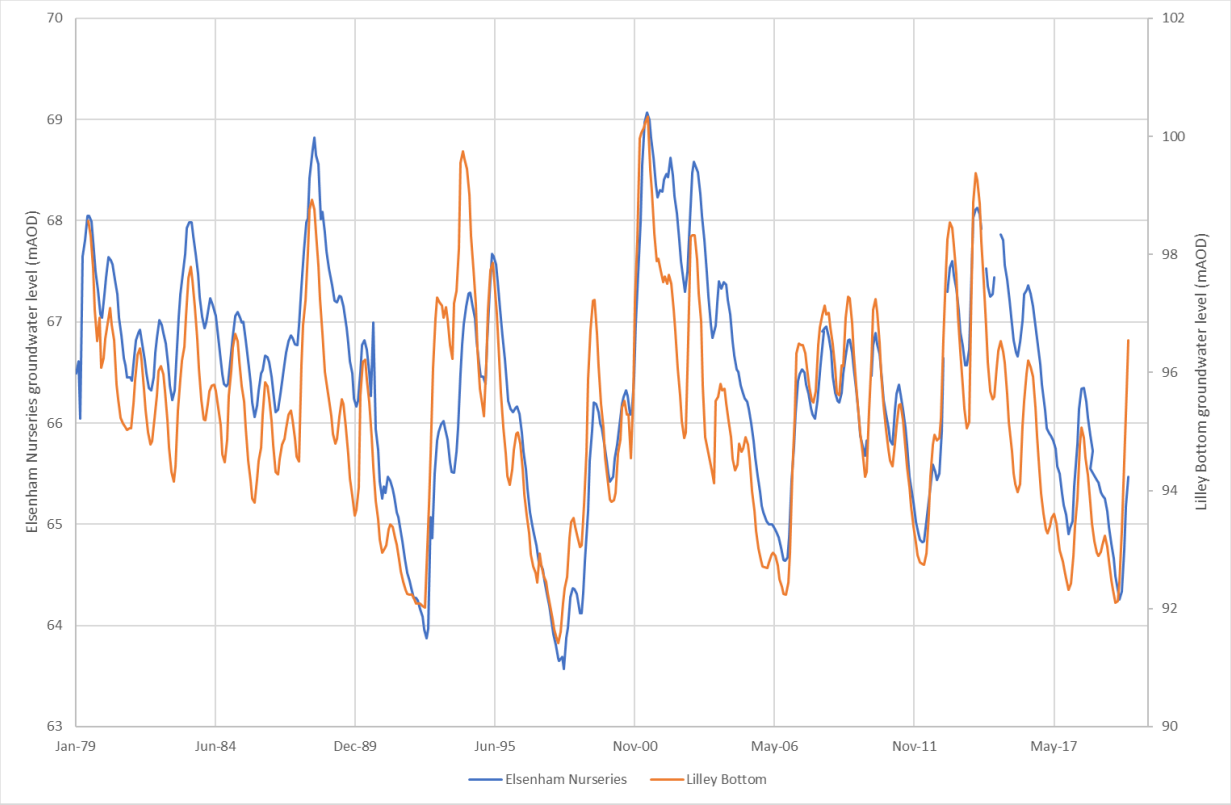


Figure 10: Lilley Bottom and Elsenham Nurseries hydrographs

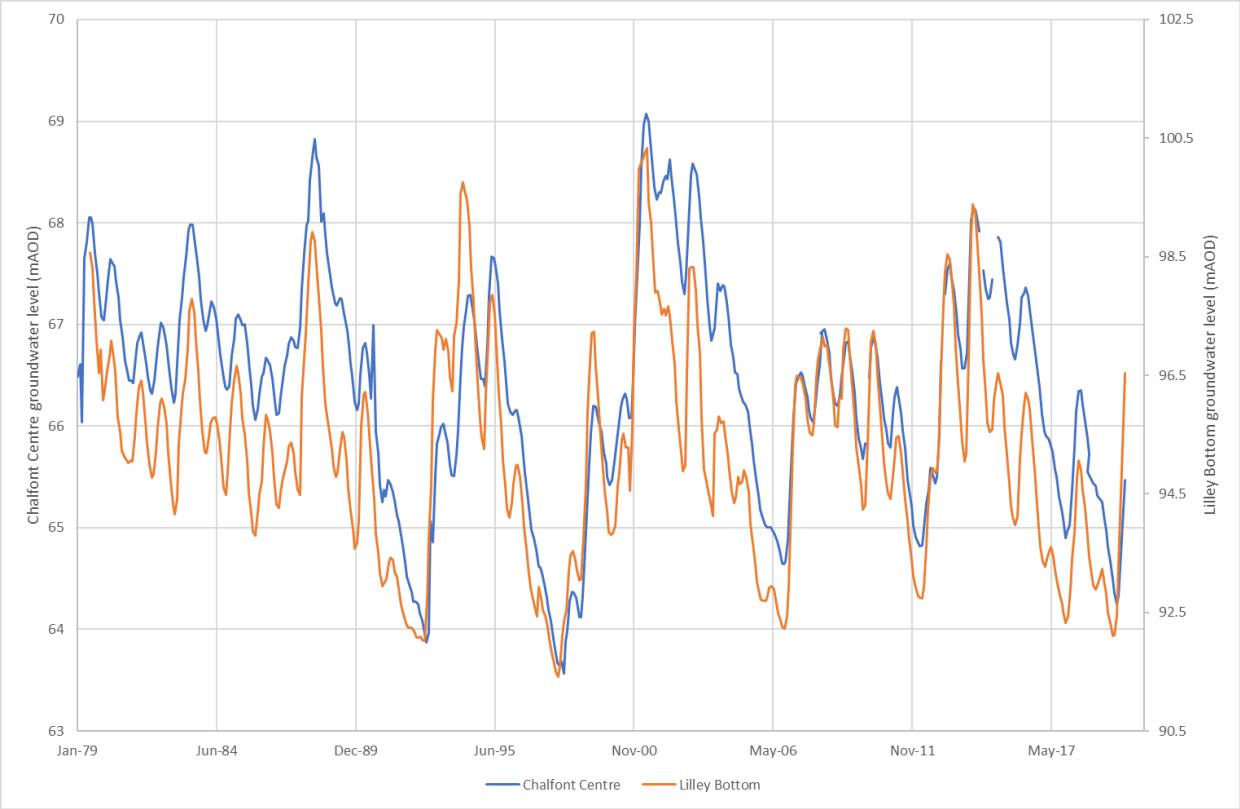


Figure 11: Lilley Bottom vs Chalfont Centre

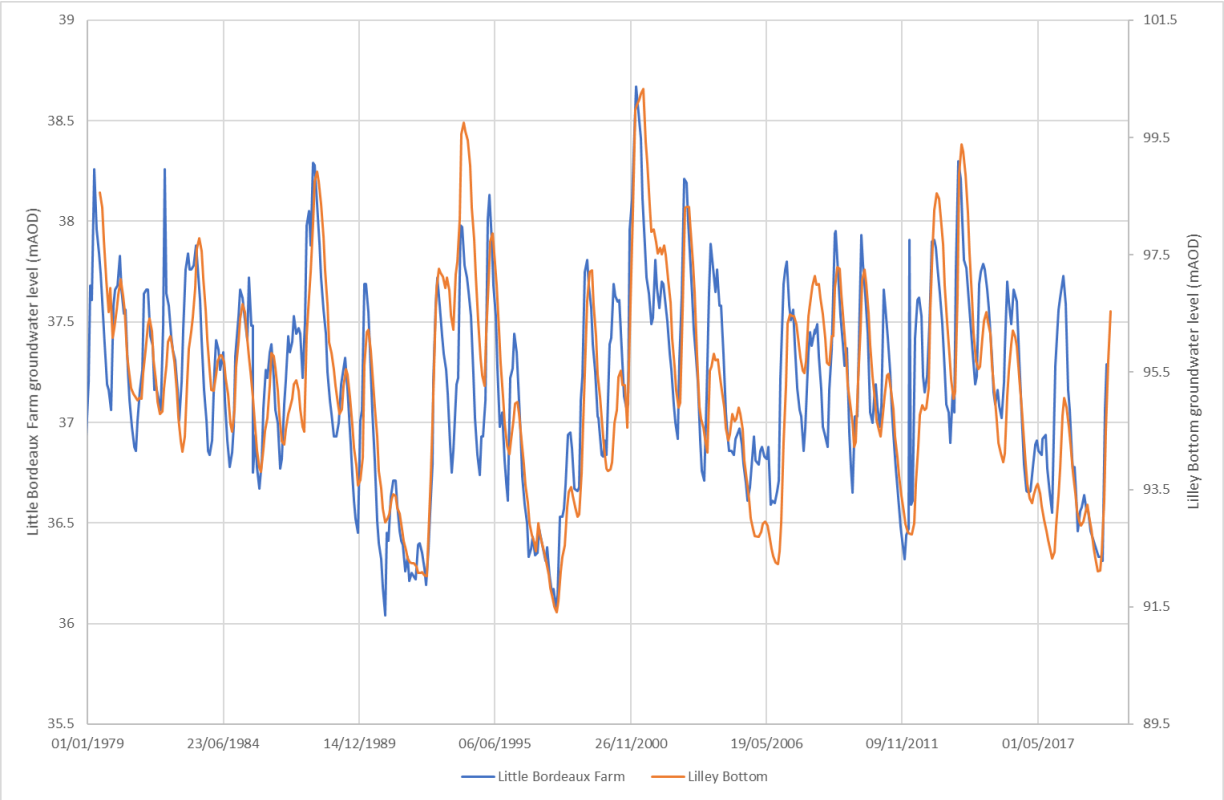


Figure 12: Lilley Bottom vs Little Bordeaux Farm

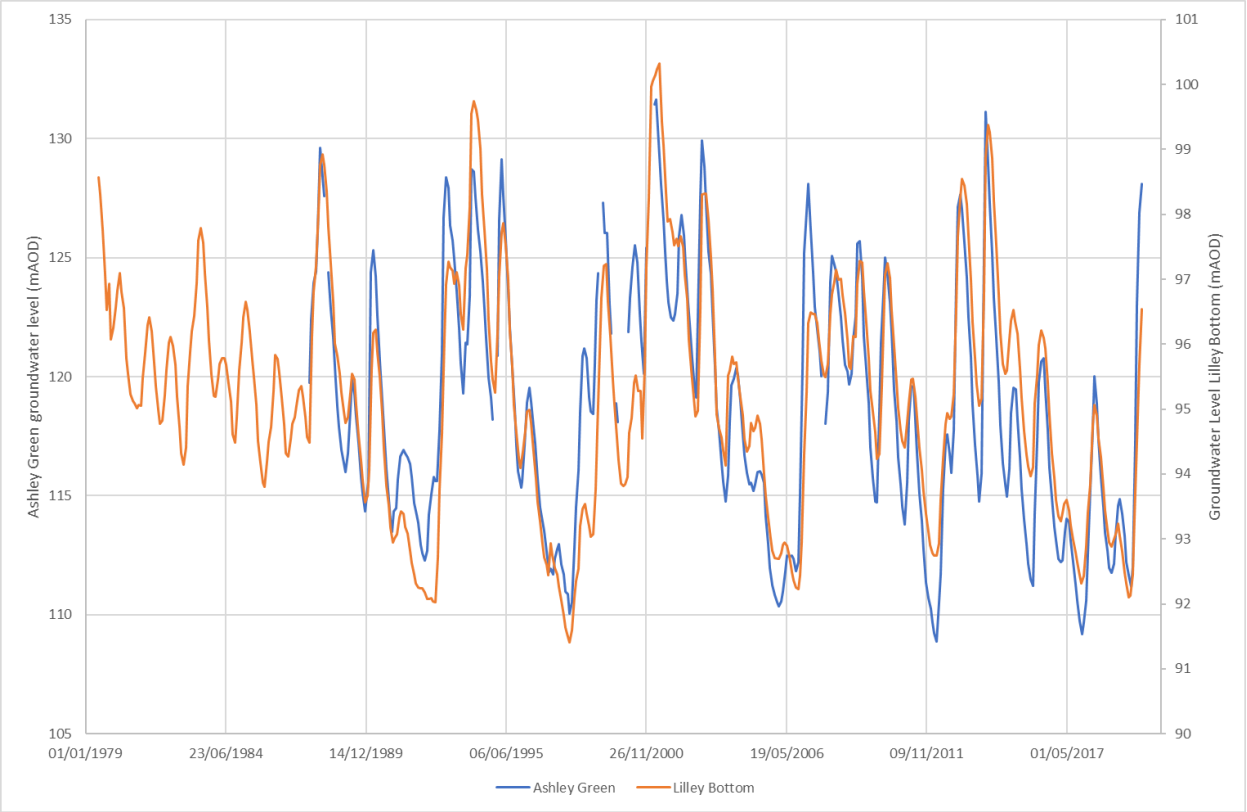


Figure 13: Lilley Bottom vs Ashley Green

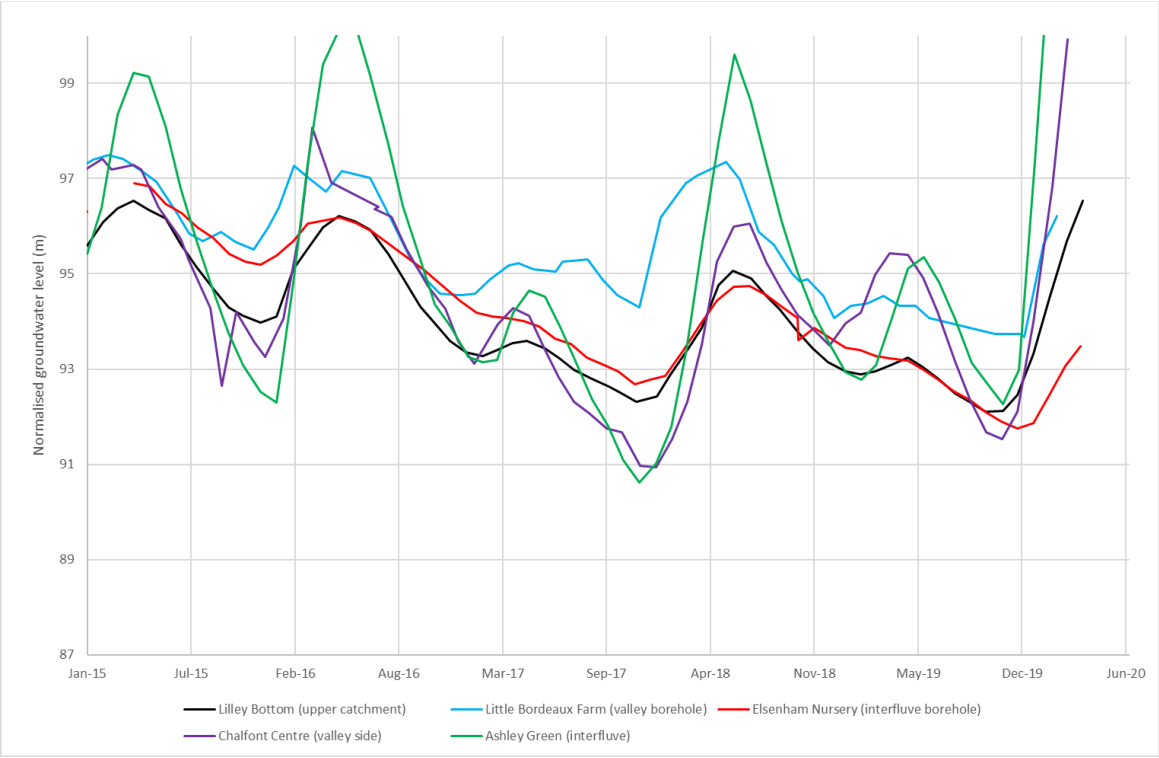


Figure 14: Central region key observation boreholes normalised and plotted

1.5 Hydrographs with groundwater levels and river flows

As explained in our main Drought Plan, there are a number of globally significant Chalk streams situated within our company area. We recognise the need to safeguard these Chalk streams and the ecological stress that can be caused during periods of drought. Chalk stream flows are linked to groundwater systems (see groundwater graphic in Section 2.2.1 of our main Drought Plan), and it is important that we understand the nature of this relationship, so that we can link our groundwater drought triggers to local river flow conditions. As part of the review of our drought triggers, we therefore carried out an exercise to understand the flow (discharge) in Chalk streams in our area under different groundwater level conditions.

The following figures show the hydrograph comparisons for groundwater levels and river flows, which show the relationships between groundwater and surface water levels in our region.

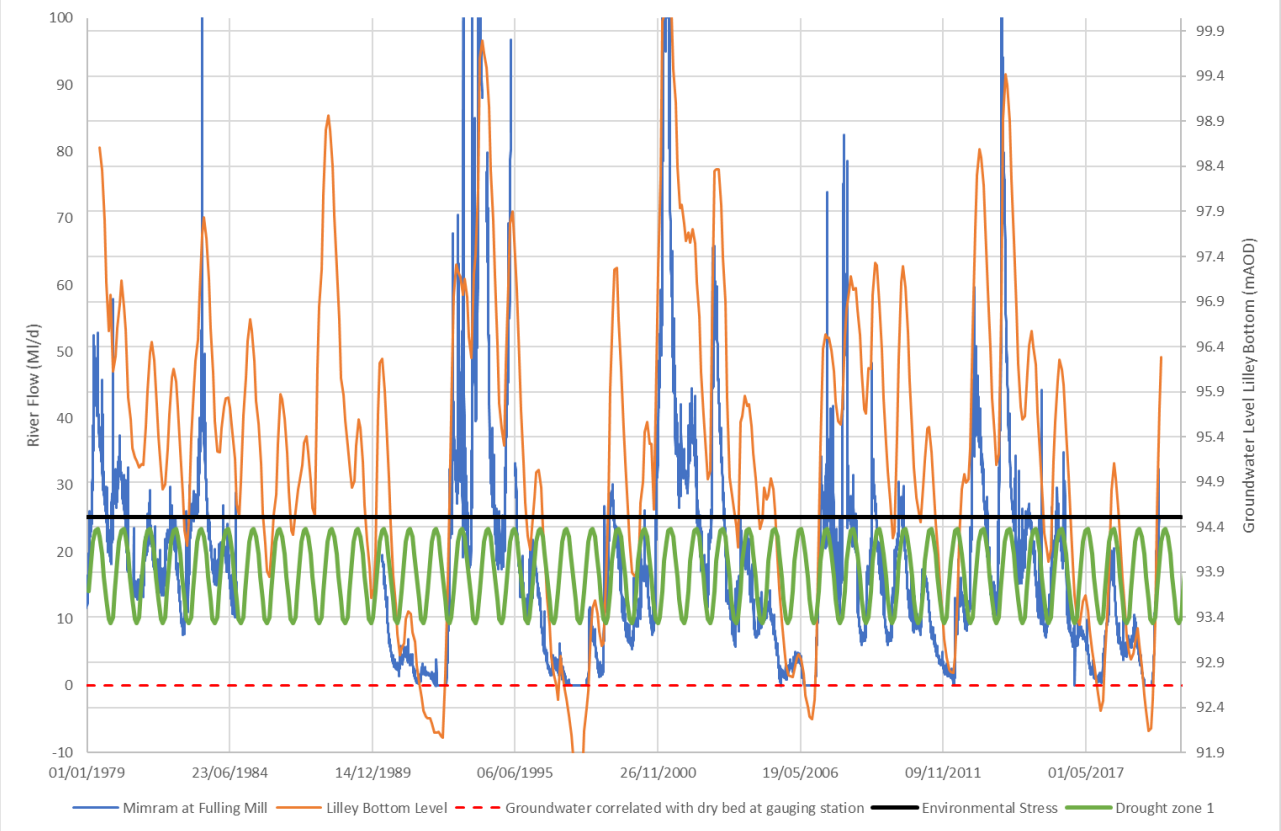


Figure 15: Lilley Bottom vs Mimram flow at Fulling Mill

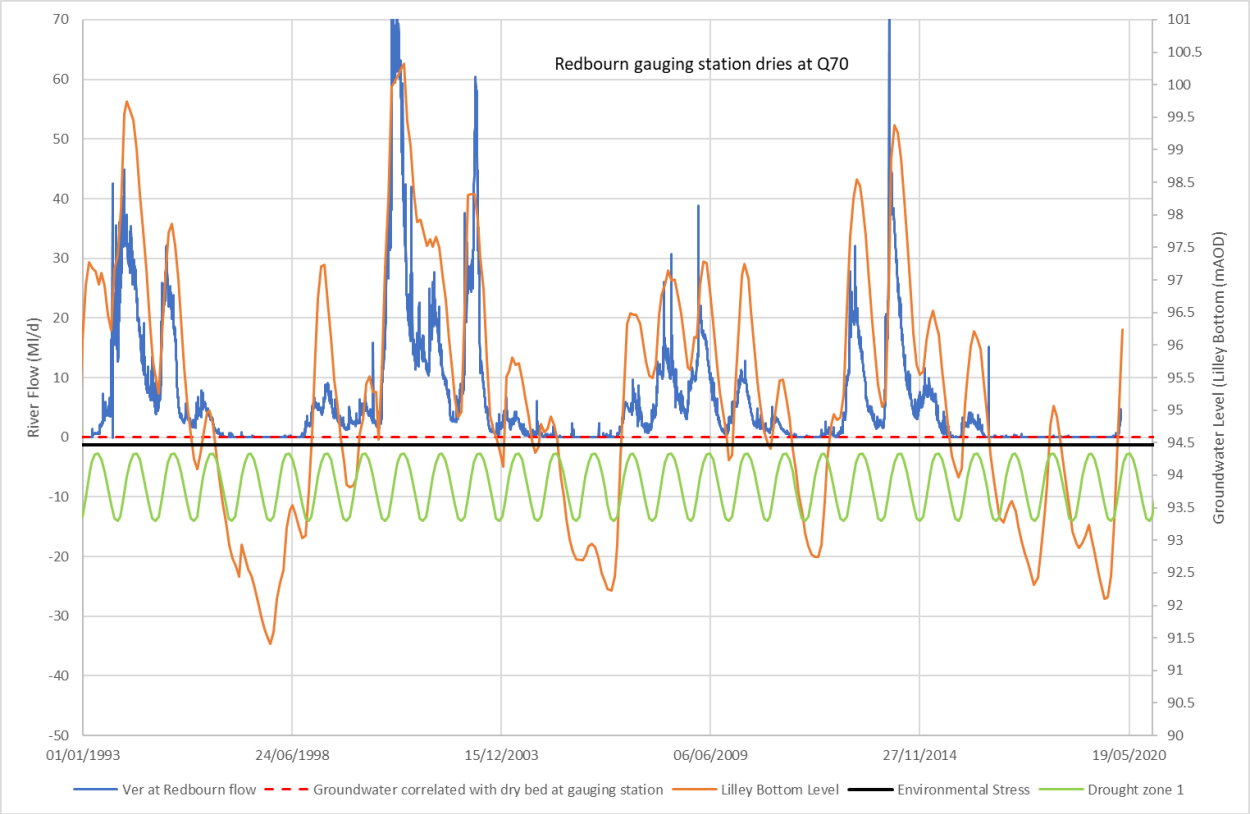


Figure 16: Lilley Bottom vs Upper Ver at Redbourn

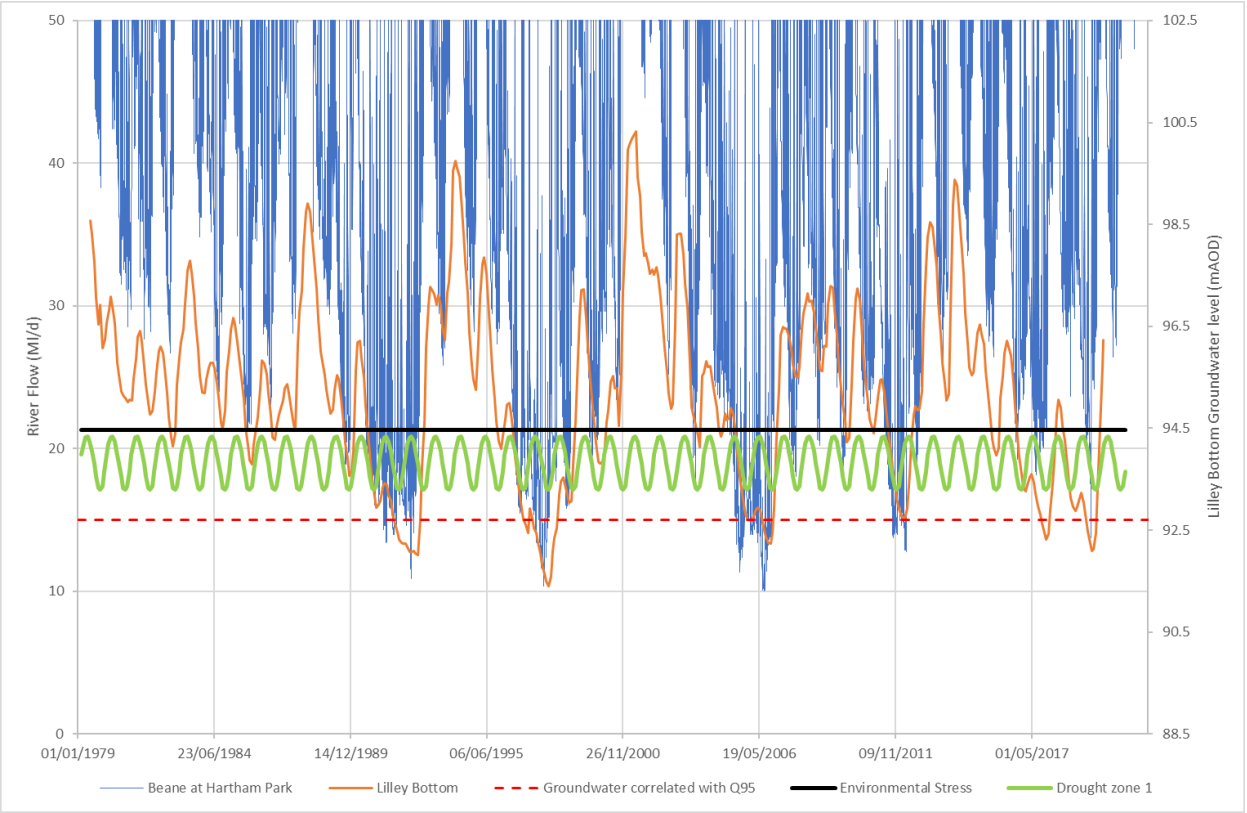


Figure 17: Lilley Bottom vs Lower Beane at Hartham

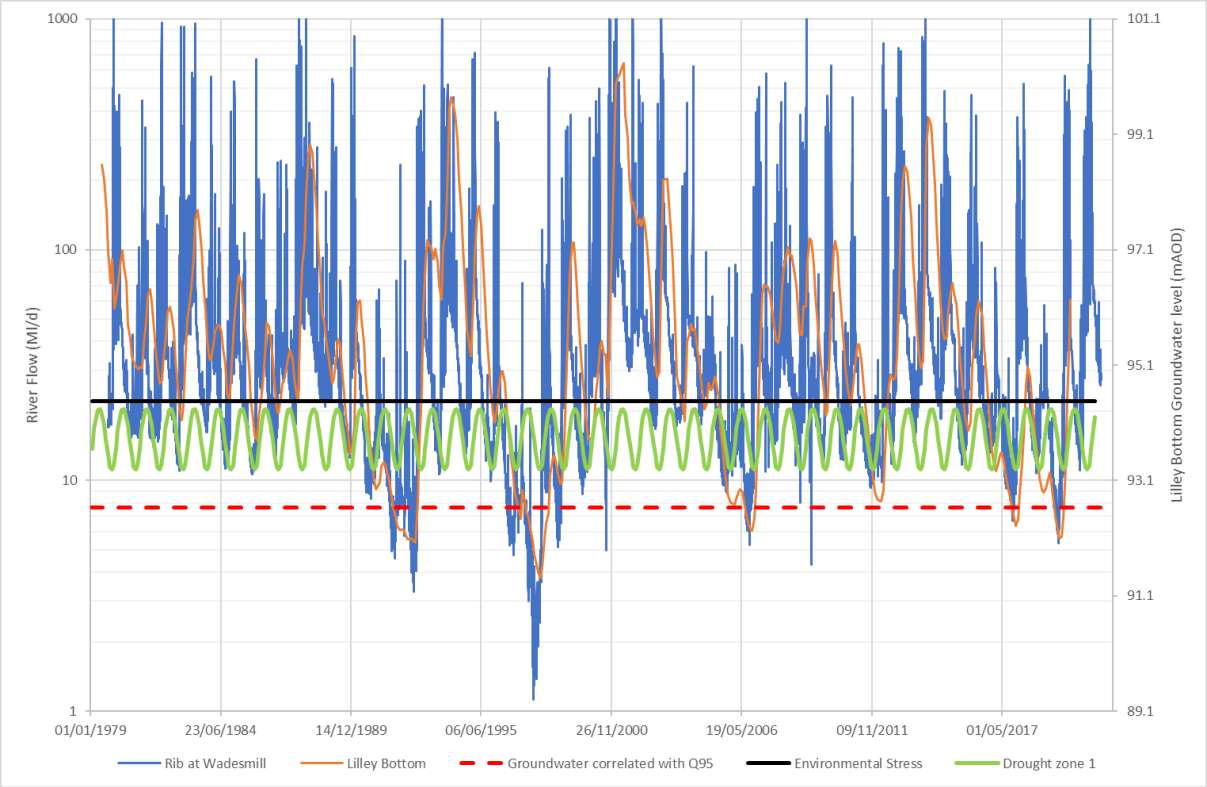


Figure 18: Lilley Bottom vs Lower Rib at Wadesmill

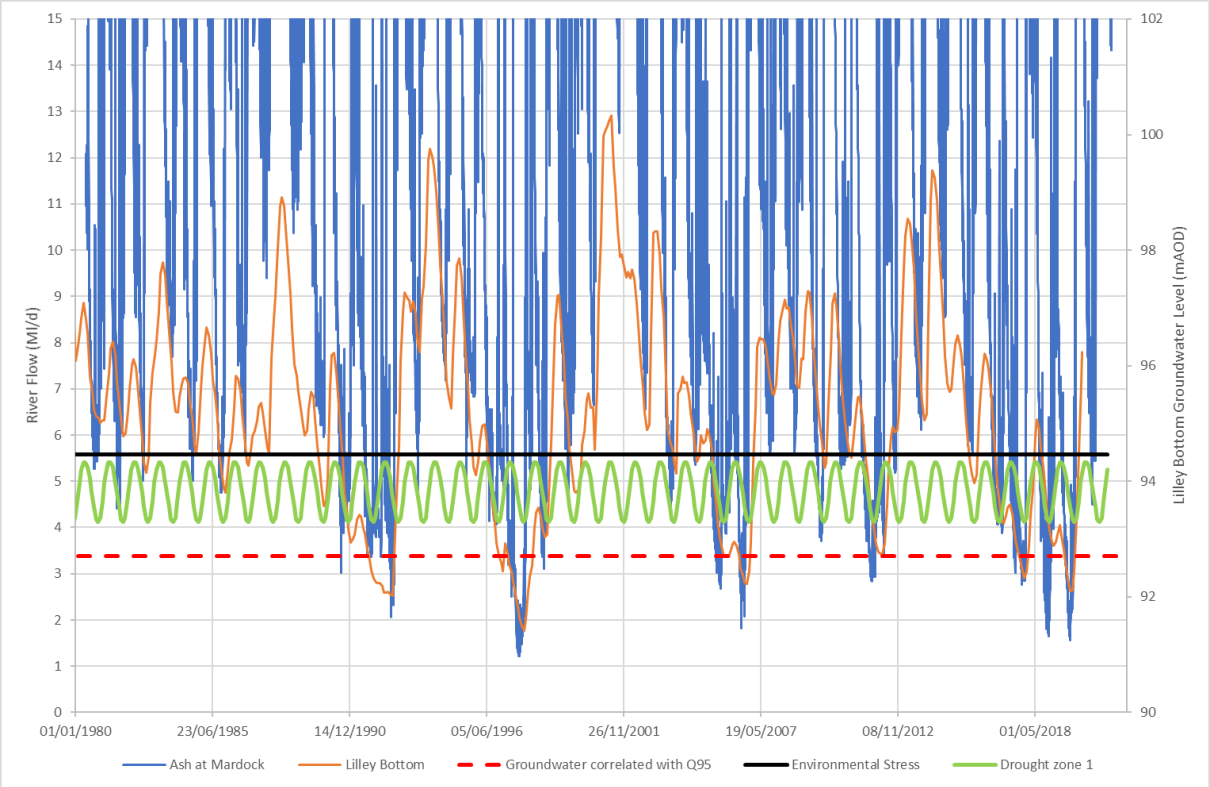


Figure 19 Lilley Bottom vs Lower Ash at Mardockl

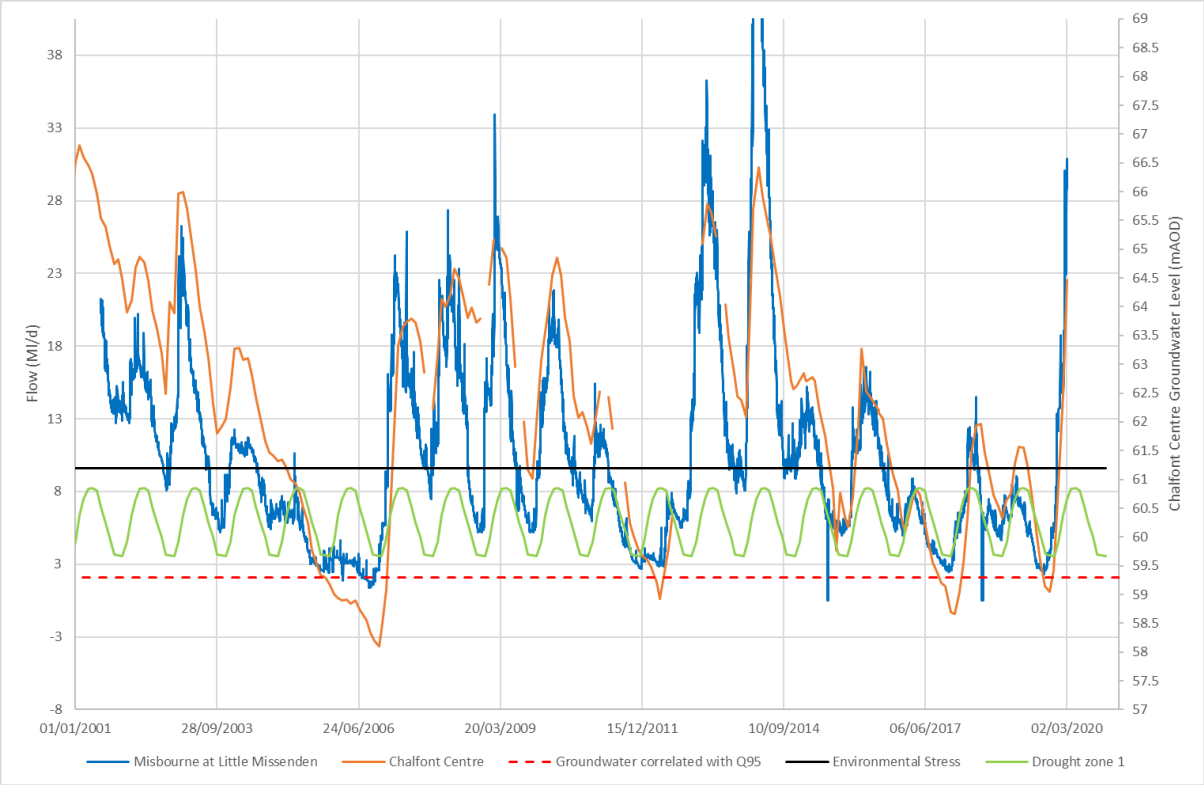


Figure 20: Chalfont Centre vs flow in the upper Misbourne

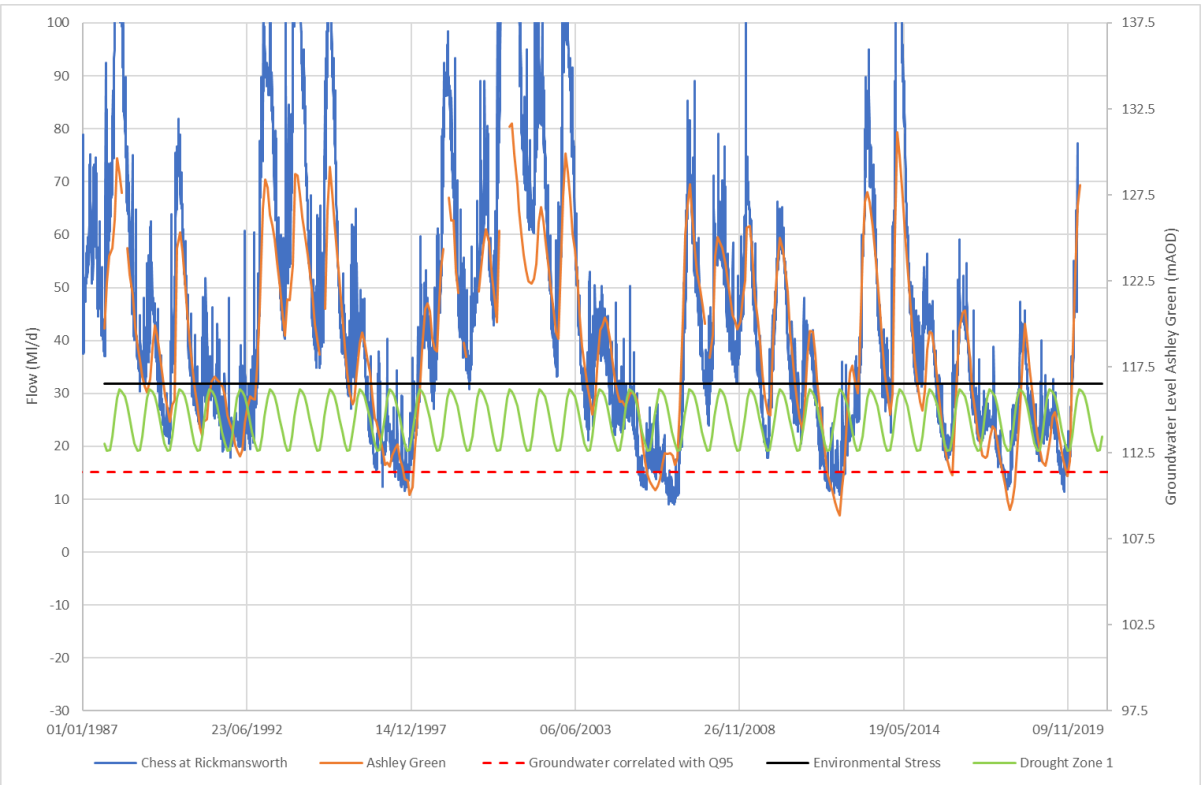


Figure 21: Ashley Green vs flow in the lower Chess

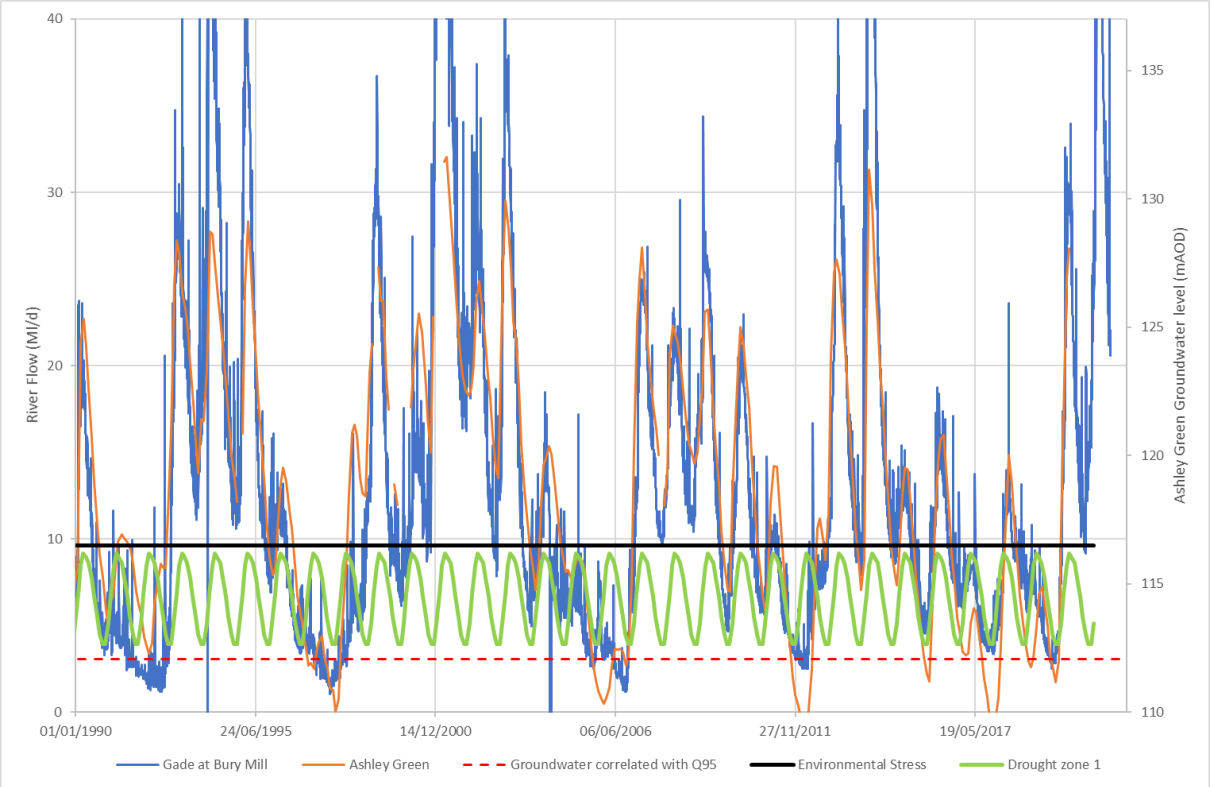


Figure 22: Ashley Green vs flow in the upper Gade

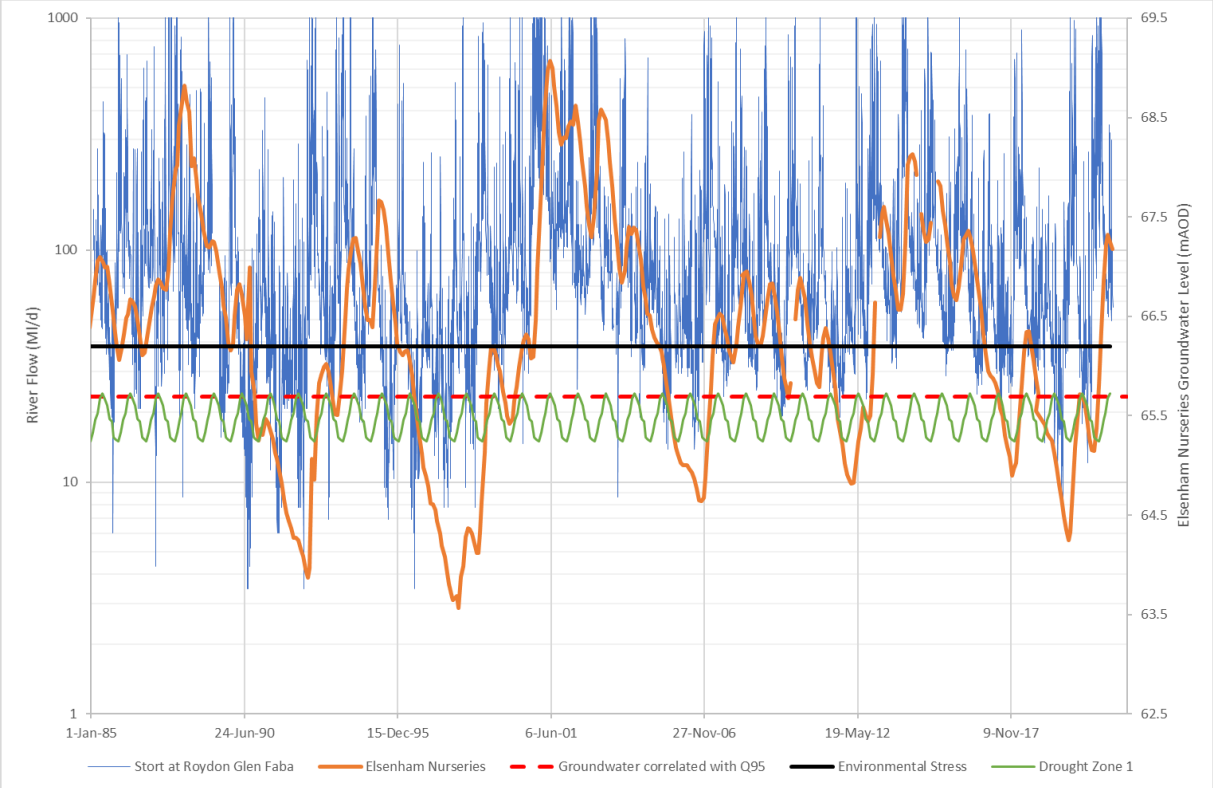


Figure 23 Elsenham Nurseries vs flow in the Stort at Roydon

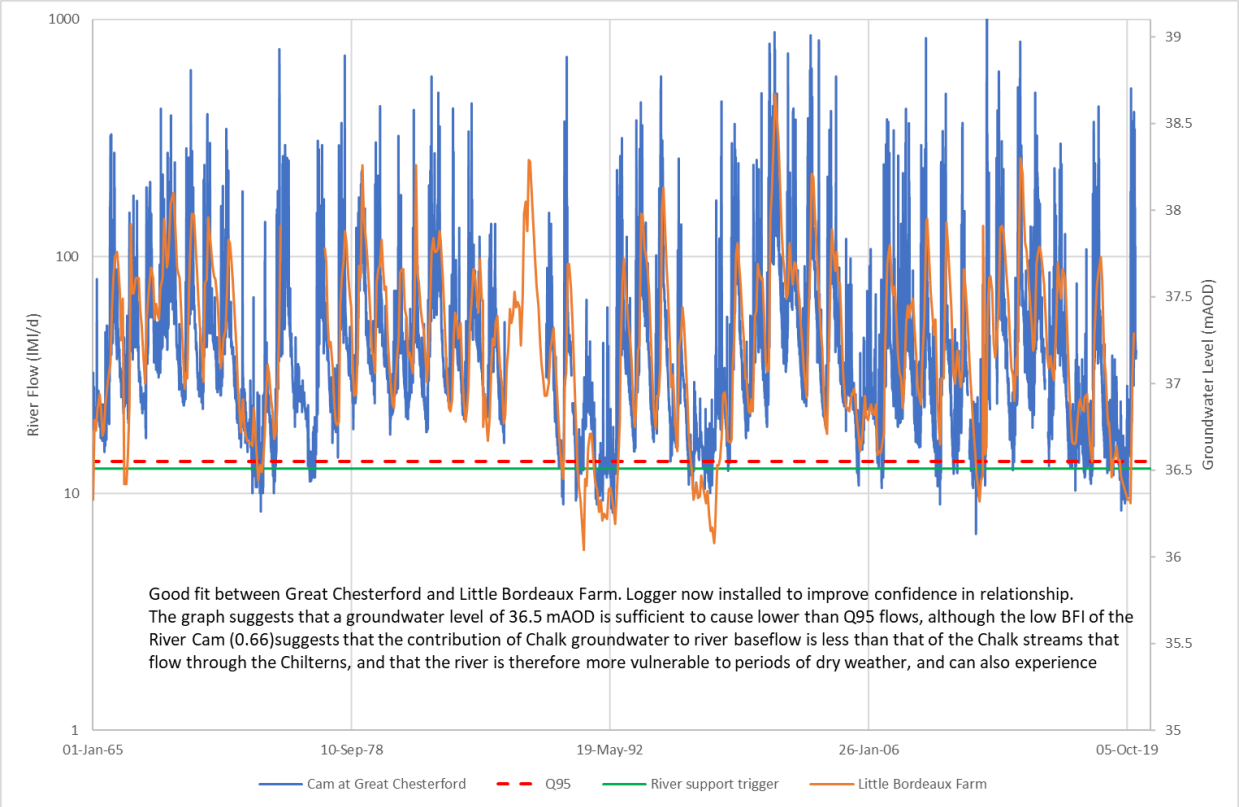


Figure 24: Little Bordeaux Farm vs flow in the Cam at Great Chesterford

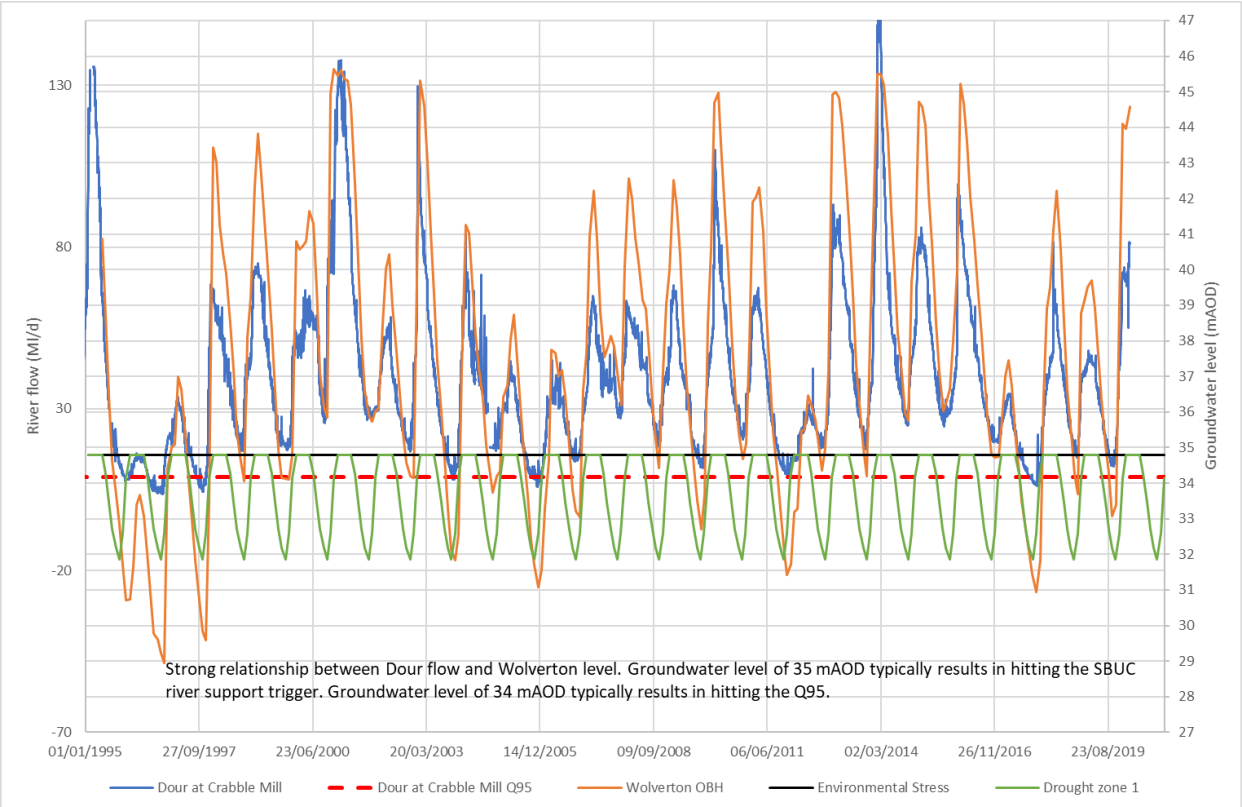


Figure 25: Wolverton new OBH against flow in the Dour at Crabble Mill

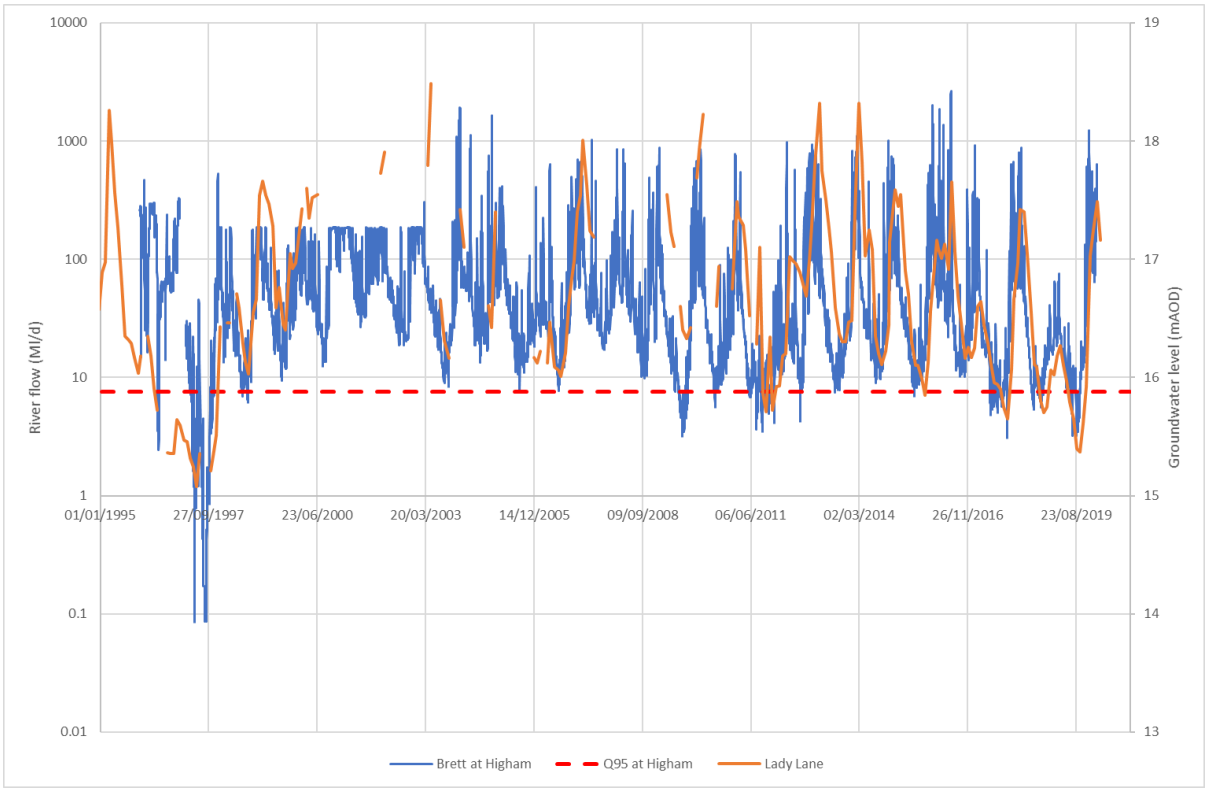


Figure 26: Lady Lane level vs Brett at Higham flow. Flow is presented on a logarithmic axis due to the high range of flows in the River Brett.

1.6 Hydrographs with groundwater levels and river photographs

As part of the exercise to link groundwater levels and river flow conditions we also used our extensive database of river monitoring photographs, to show visually how flow conditions can vary under different groundwater level conditions. The below figures show some examples of river photos linked to groundwater levels and highlight the relationship between Chalk streams and groundwater levels in our region.

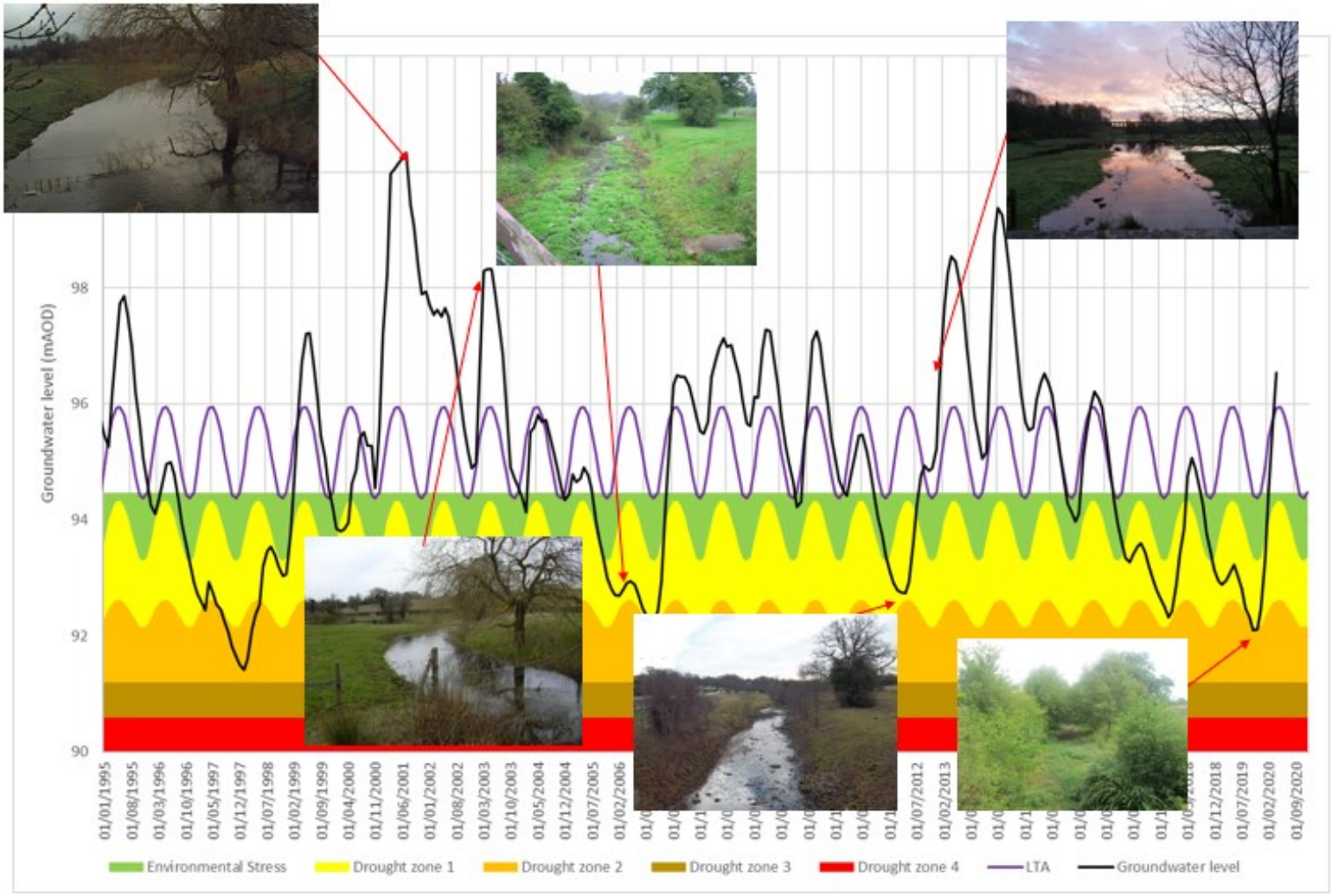


Figure 27: Pictures of the Mimram at Bessemer Road under different hydrological conditions (based on Lilley Bottom key well)

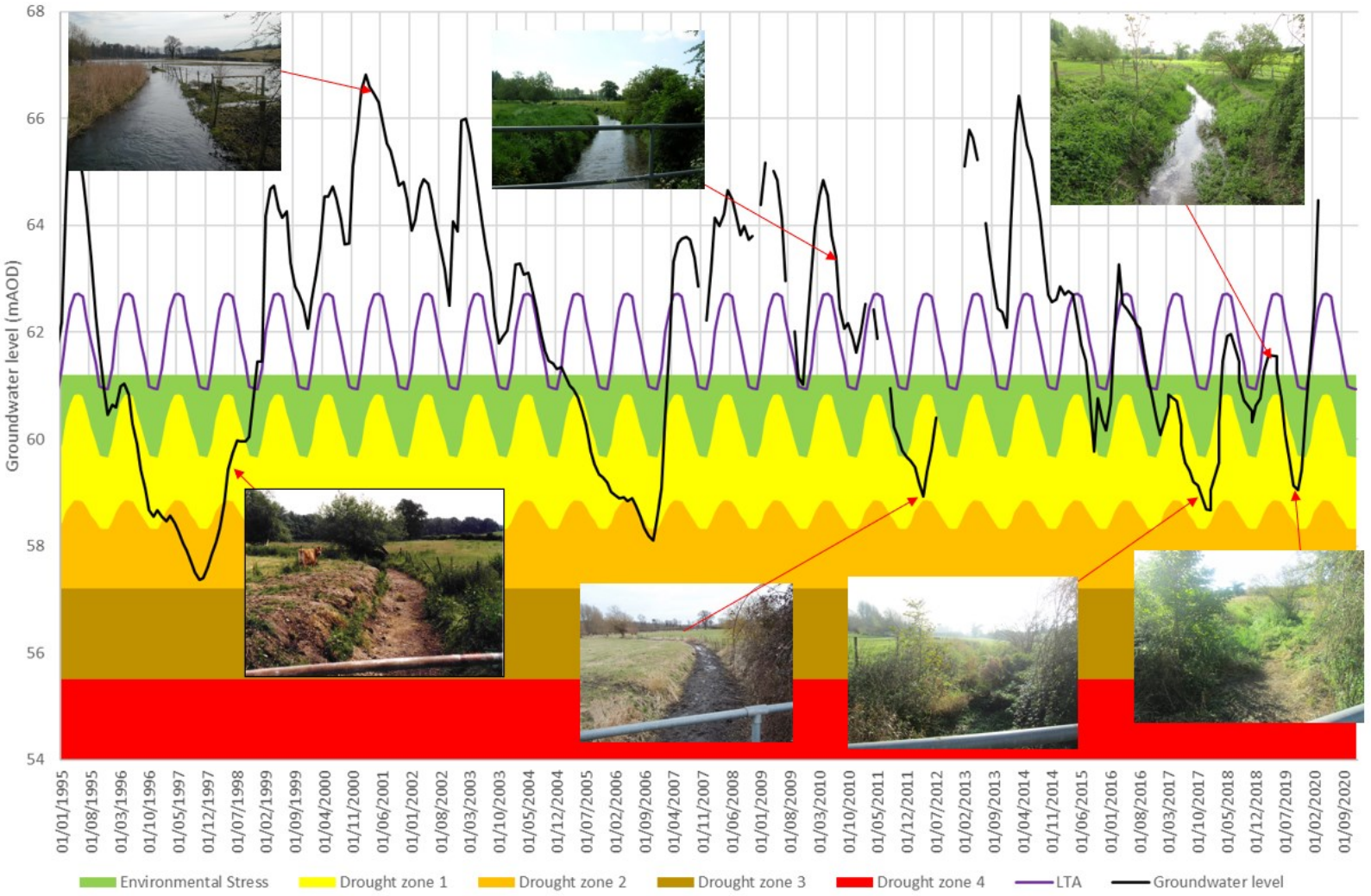


Figure 28: Pictures of the Misbourne at Bottom House Farm under different hydrological conditions (based on Chalfont Centre key well)

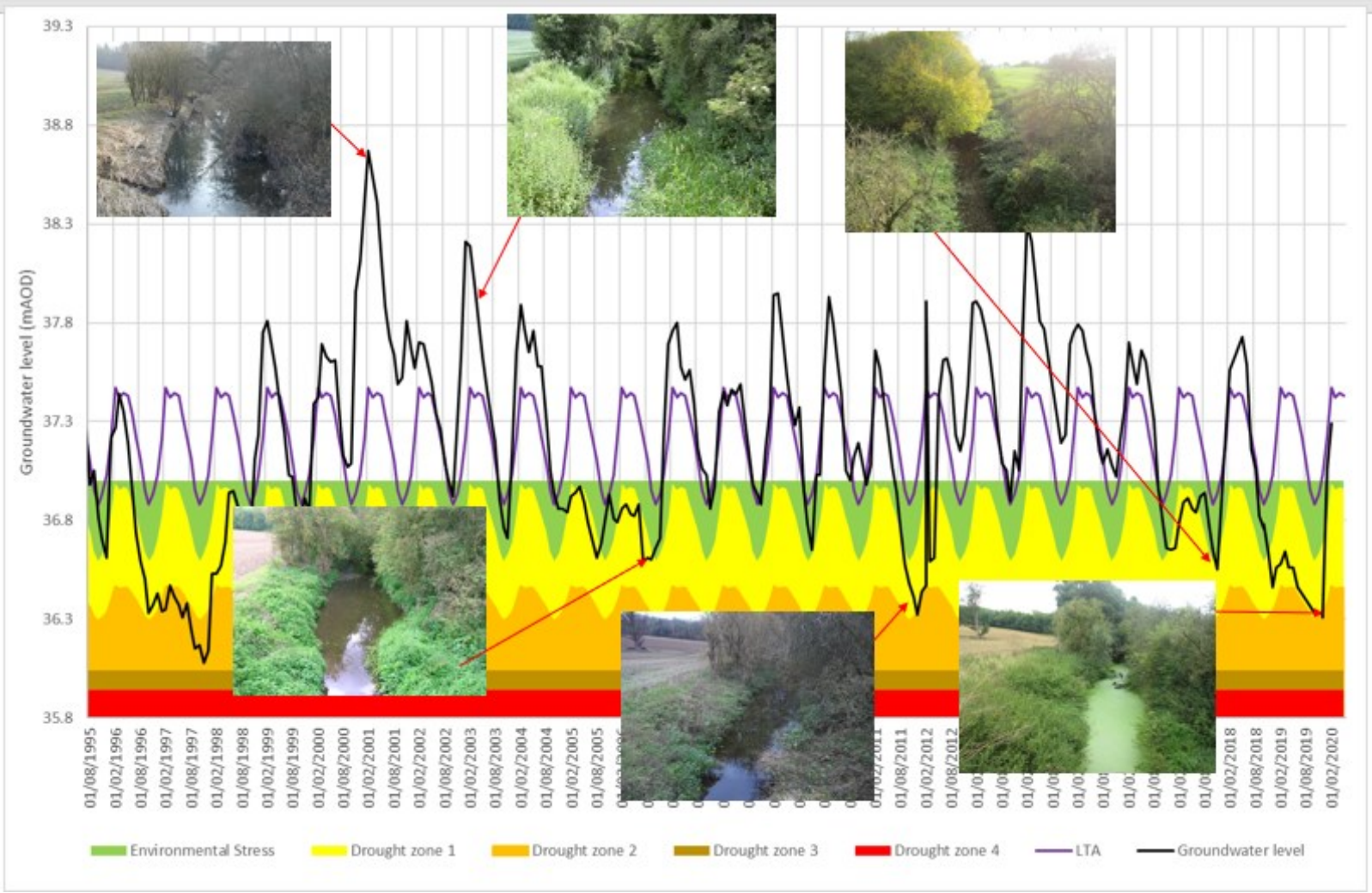


Figure 29: Pictures of the Cam at Wenden Ambo photo point under different hydrological conditions (based on the Little Bordeaux Farm key well)

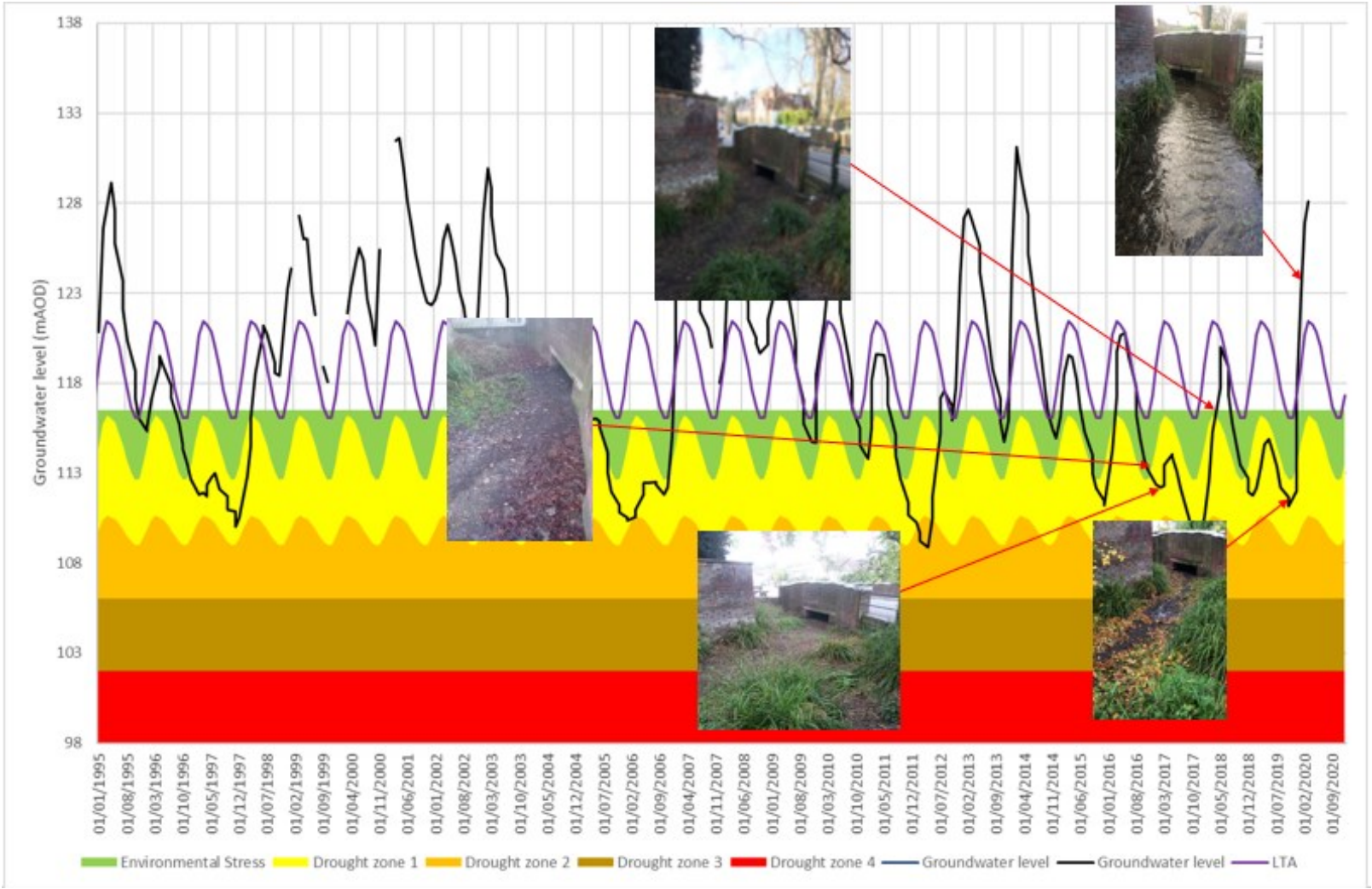


Figure 30: Pictures of the Chess upstream of the Queens Head pub under different hydrological conditions (based on Ashley Green key well)

1.7 How have our drought triggers changed since our previous Drought Plan?

Our 2019 Drought Plan specified five levels of increasing drought severity for each key well. To make our Plan consistent with that of our regulators and neighbouring water companies, we have simplified our Plan to show the actions we will take within four operational drought trigger zones.

We have also added a new category (Environmental Stress) that reflects the need to consider earlier actions at times when the environment is more vulnerable. These actions normally need to start before the first operational drought trigger.

We have used hydrological information from historic drought periods that have been captured in borehole monitoring records. This includes the groundwater drought event of 1997, where record low levels were recorded in most chalk boreholes. A brief description of the proposed triggers is provided in Section 5.3 of our main Drought Plan. These have been plotted against the historic groundwater level record for the key wells for each region in Appendix 1.3 above, to allow the severity of historic drought events to be assessed, relative to the drought trigger zones. Groundwater level is shown with a solid black line whilst the purple line denotes the long-term average trend. Note that the figures show that the long-term average trend fluctuates seasonally.

2 Water Resource Forecasting

This appendix sets out the methodologies we use to carry out our short term and short to medium term forecasting.

2.1 Short term

What has the rainfall and effective precipitation pattern been over the previous two to three months?

It has been observed that a specific rainfall pattern is reflected in relatively predictable groundwater level changes within three months, due to the time it takes for rainfall to infiltrate through the soil to recharge the aquifers below. When forecasting where groundwater levels may be the following month, the rainfall pattern two to three months prior is given greater weighting than the rainfall pattern over the month just gone. This process is repeated for the second and third months of the period of forecast, such that by the third month, it is assumed that most of the significant rainfall will have reached the aquifer. This is illustrated in Table 4, where the legacy of two consecutive months (January and February) with 40 % of the LTA rainfall in each can still be seen in May but by June, this recharge deficit no longer has an ongoing effect. When forecasting groundwater levels and defining our water resource situation, we use Met Office MORECS (Meteorological Office Rainfall and Evapotranspiration Calculation System) data. We also receive Had UK rainfall data from the Environment Agency. Analysis has shown this dataset to be similar to the MORECS data for the same area. We will continue to assess the merits of each dataset with regards to water resources forecasting. We do however note that use of the Had UK dataset is required for drought permit applications, due to the need to report on rainfall deficits in the region local to the permit site.

Table 4: Impact of antecedent rainfall on future groundwater trends

MONTH	RAINFALL (AS % OF LTA)	IMPACT OF ANTECEDENT RAINFALL ON FORECAST GROUNDWATER LEVEL CHANGE		
		60 % forecast	100 % forecast	120 % forecast
January	40	NA	NA	NA
February	40	NA	NA	NA
March	100	NA	NA	NA
April	NA	40	40	40
May	NA	60	80	85
June	NA	65	100	115
July	NA	60	100	120
August	NA	60	100	120

What is the SMD at the point of forecast and what impact might this have on the level of groundwater recharge?

Soil moisture deficit (SMD) is the amount of water needed to bring the soil moisture content back to field capacity, which is the amount of water the soil can hold against gravity. Only when this deficit is satisfied can recharge occur at its maximum rate. This means that although it is also impacted by other factors, SMD is inversely proportional to effective precipitation (Figure 31). Generally speaking, at the end of the summer, the SMD is at its greatest, as there have normally been extended periods of low rainfall accompanied by high levels of evapotranspiration. We typically rely on winter rainfall to replenish this deficit, with SMD on average being lowest in early spring.

Under normal conditions, 100% of LTA winter rainfall (October to March) would provide adequate effective precipitation (rainfall available for recharge) to allow groundwater levels to recover by their average amount, increasing the volume of water in groundwater storage. Any deviation from the LTA SMD will have a knock-on impact on the level of recharge which is able to reach the water table. This is accounted for in the groundwater forecasts, particularly when estimating when groundwater levels will turn (stop decreasing and start to increase or vice versa).

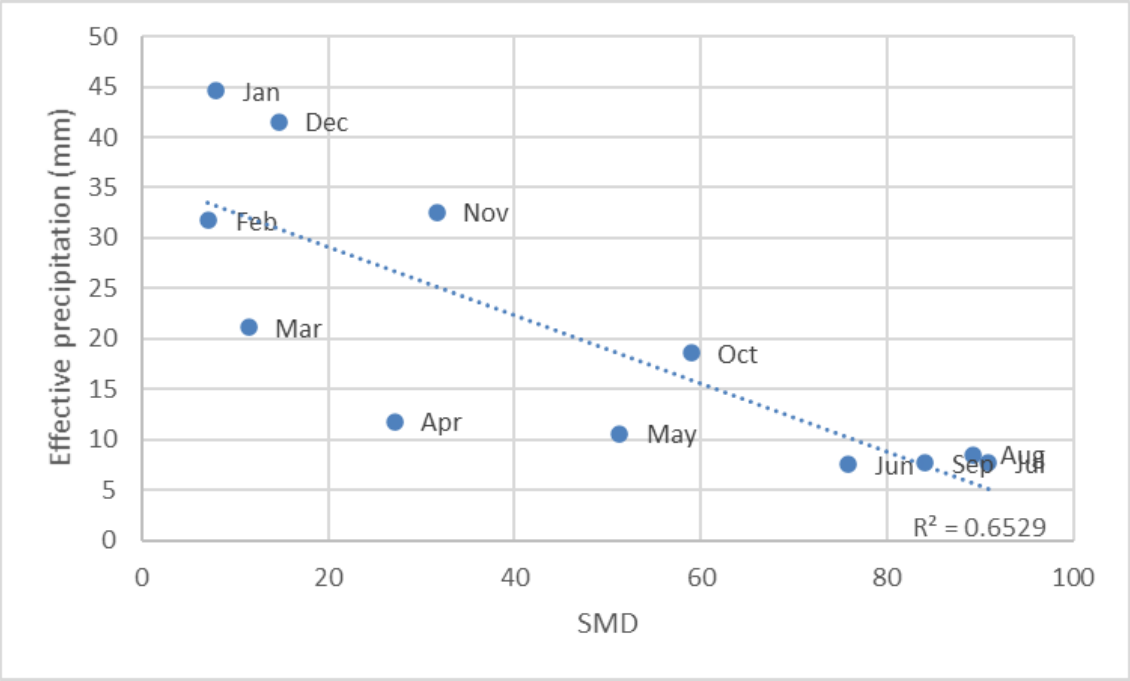


Figure 31: Average soil moisture deficit (SMD) plotted against average Effective Precipitation

2.2 Short to medium term

What is the LTA trend for the time of year?

Before applying any adjustments to the forecast groundwater level trend, the LTA trend is considered, in terms of the rate of groundwater level change between months and timing of the start of the recession/recovery periods. If the rainfall pattern over the two to three previous months was 100 % of the LTA and groundwater levels were similar, the 100 % rainfall scenario forecast would be expected to follow the LTA curve.

How do the antecedent conditions compare to what has been experienced historically?

To ensure that we are confident in our groundwater forecast, we analyse the historic water level record to identify how the aquifer responded to similar antecedent rainfall conditions, with similar background groundwater levels at similar times of year.

What is the starting groundwater level?

Identifying the groundwater level from the point in time which we wish to forecast from and how this compares to the historical groundwater record for a given point is key. When groundwater levels are high, the rate of fall is likely to be steep, for example following the wet winters of 2000/2001 and 2013/2014. This is because the hydraulic gradient between the area of aquifer recharge and area of discharge is steeper, and water flows from the upper reaches of catchments to the lower reaches more quickly. Conversely, when groundwater levels are lower, the hydraulic gradient is smaller and the groundwater flow slower. Due to the aquifer not being able to hold as much water when groundwater levels are very low, levels may decrease more quickly. The evidence of this occurring is difficult to analyse however, due to the lack of very severe groundwater droughts.

How do differing rainfall patterns cause deviation from the LTA groundwater trend?

More (> 100 %) or less (< 100 %) rainfall than the MORECS LTA, especially during the recharge period when SMD is usually low, produces a different groundwater level response to the LTA curve.

During the recession period (May to September), sustained below average rainfall over consecutive months will produce a steeper rate of decline and potentially delay the seasonal recovery until the SMD is satisfied. Below average rainfall during the recharge period (October to April) results in lower groundwater level recovery, meaning that groundwater levels may not increase as much as expected. If groundwater levels are already below the LTA at the start of the recharge period, the recovery may not be sufficient for levels to reach the LTA curve.

Conversely, above average rainfall during the recession period results in a gentler rate of recession and potentially an early start to the recharge season. Subsequent recovery is likely to be greater than the LTA trend.

Potential changes in groundwater level over a range of rainfall scenarios are shown in Figure 32.

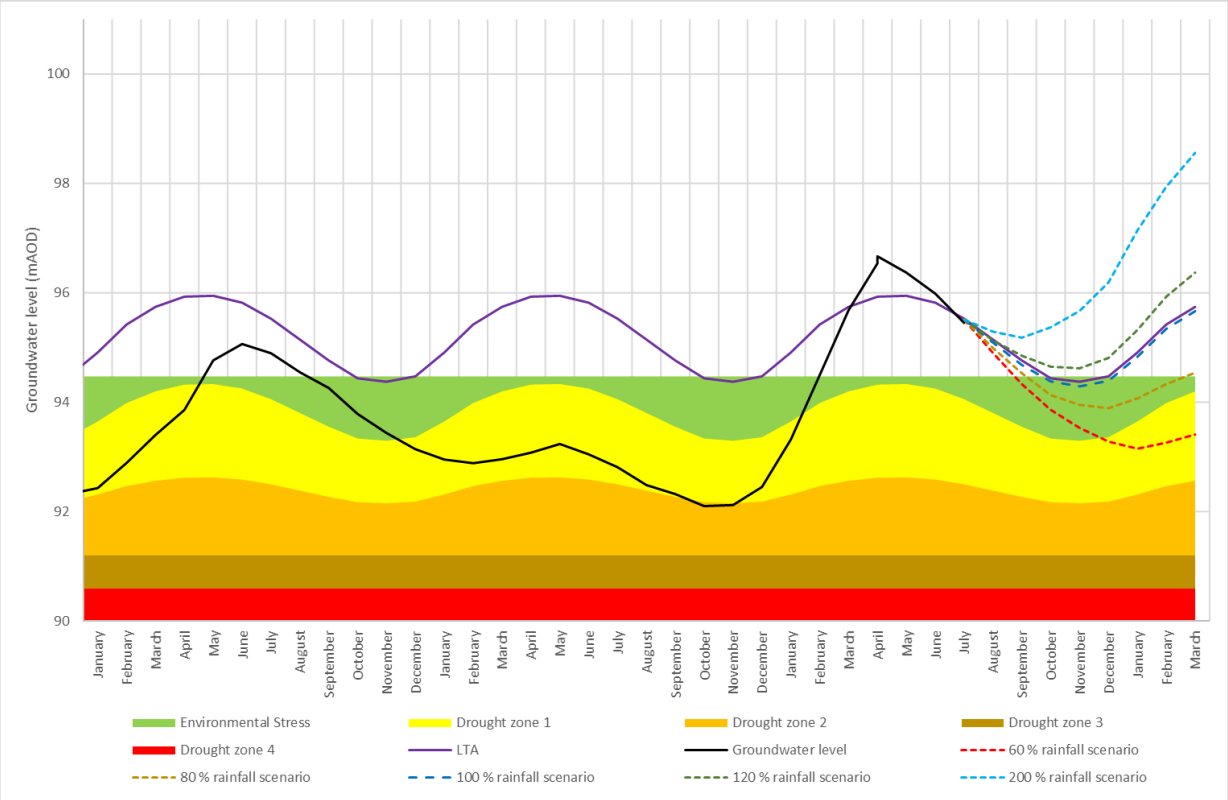


Figure 32: Forecast groundwater level changes under different rainfall scenarios

3 Review of past drought experiences

This appendix provides information on our work to look back at past drought experiences, to establish lessons learned, and to help ensure that the triggers and actions set out in this Drought Plan are appropriate.

3.1 Recent drought experiences

In the last 50 years, we have experienced a number of droughts, most notably in 1976, 1991-1992, 1997, 2006, 2012 and 2017-2019. The 2012 drought was the first time the new Temporary Use Bans were implemented (from 5 April 2012 to 9 July 2012), however this coincided with a period of increased rainfall that led to flooding. Lessons from this drought included the need to engage with businesses and stakeholders earlier and the importance of joined-up communications.

The winter of 1997/1998 saw the lowest groundwater levels in the monitoring records of Chalfont Centre, Lilley Bottom and Elsenham Nurseries. Ashley Green recorded the lowest reading to date in April 2012 and Little Bordeaux Farm reached its recorded minima in December 1990. For most sites, dips were not collected during the 1976 drought, however at Chalfont Centre, the low water levels of the 1976 drought were similar to that of winter 1997- this is also the case in other Chalk boreholes where data over this period was collected, such as Ballingdon Farm and The Holt. The autumn of 2019 saw the lowest absolute groundwater levels reached at Lilley Bottom since December 1997. The 2017 to 2019 period is also the most recent groundwater drought which has impacted our supply region. This provided an opportunity to test our supply system and drought planning preparedness, both of which have undergone updates since the 2012 drought event.

Statistics of each of the historic drought periods mentioned above are presented below for each of the key boreholes. Rainfall and effective precipitation statistics are derived from the MORECS squares local to the key borehole.

There is variability in the length of the drought events (defined as the number of months from the LTA curve to the lowest drought level) in Table 5, and there are also differences between boreholes for the same drought event. This is why it is important to consider numerous key wells to inform operational decision-making during droughts. For the 1990-1992 and 2010-2012 events, Elsenham Nurseries experienced a more protracted recession, whereas the response was more in line with the responses of the other Central region key wells for other drought events. It can be seen that Little Bordeaux Farm typically experiences shorter recessions than the other key wells in Central region. It is likely that as a river valley borehole, this key well is more responsive to rainfall events during both the summer and winter. The exception to this trend was the 2018-2019 drought event, when the length of drought event was similar to other boreholes in our Central region, perhaps due to the more localised rainfall deficit in the Cam catchment. The 1995-1997 drought event has typically recorded the greatest rainfall and effective precipitation deficit over the length of drought. This, combined with the fact that most Central region key wells

experienced their lowest recorded levels are the reasons why the 1995-1997 event has been selected as the 'worst drought event in recent operational history'.

Table 5: Drought statistics for Affinity Water Key Wells

KEY WELL	STATISTIC	1976	1990-1992	1995-1997	2005-2006	2010-2012	2016-2017	2018-2019
Lilley Bottom	Months from LTA to drought peak	NA	25	24	23	17	15	17 (from June 18)
	Rainfall % of LTA	NA	92	75	87	72	88	80
	Effective Precipitation % of LTA	NA	56	49	57	47	59	68
Elsenham Nursery	Months from LTA to drought peak	NA	30	24	21	24	12	18 (from June 2018)
	Rainfall % of LTA	NA	83	75	87	78	83	83
	Effective Precipitation % of LTA	NA	47	24	54	59	56	80 (65 if Oct/Nov 19 excluded)
Chalfont Centre	Months from LTA to drought peak	10	25	24	23	13	14	17
	Rainfall % of LTA	66	74	72	89	83	93	80
	Effective Precipitation % of LTA	45	41	48	63	46	62	68
Ashley Green	Months from LTA to drought peak	NA	21	25	16	19	19	18 (from May 18)
	Rainfall % of LTA	NA	72	73	78	69	88	81
	Effective Precipitation % of LTA	NA	39	47	44	48	62	69
Little Bordeaux Farm	Months from LTA to drought peak	NA	10	8	8	9	15	19
	Rainfall % of LTA	NA	61	57	78	74	83	90
	Effective Precipitation % of LTA	NA	29	38	52	34	53	94 (67 if Oct-Dec 2019 excluded)
Wolverton New	Months from LTA to drought peak	NA	NA	17	14	6	14	No drought conditions

KEY WELL	STATISTIC	1976	1990-1992	1995-1997	2005-2006	2010-2012	2016-2017	2018-2019
	Rainfall % of LTA	NA	NA	74	88	71	93	No drought conditions
	Effective Precipitation % of LTA	NA	NA	50	56	28	50	No drought conditions
Lady Lane	Months from LTA to drought peak	NA	NA	20	Missing groundwater data	10	15	15
	Rainfall % of LTA	NA	NA	69	Missing groundwater data	75	52	86
	Effective Precipitation % of LTA	NA	NA	26	Missing groundwater data	34	40	55

Our most recent drought experience was over the period of 2017-2019, which saw an unusually extended period of below average water resource levels and associated challenges. During this time we followed our drought management plan, and undertook actions according to our drought trigger zones and scenario predictions. These actions were wide ranging and included a step-up in internal and external messaging to communicate the risks of drought and promote voluntary reductions in water use.

During the 2017-2019 drought we communicated our water resource position much earlier and to a wider audience compared to the previous drought period in 2012. We increased the detail and frequency of water resource status information that was shared with our customers, through sharing of a monthly stakeholder brief and the publishing of annotated hydrographs and rainfall information on our website. We reviewed operational performance of our chalk groundwater sources and reduced output from those that were drought impacted to rest vulnerable sources, increase resilience and protect available supply through the peak summer months. We also undertook a programme of capital works to optimise the current and future performance of assets and increase the resilience within our network and groundwater sources.

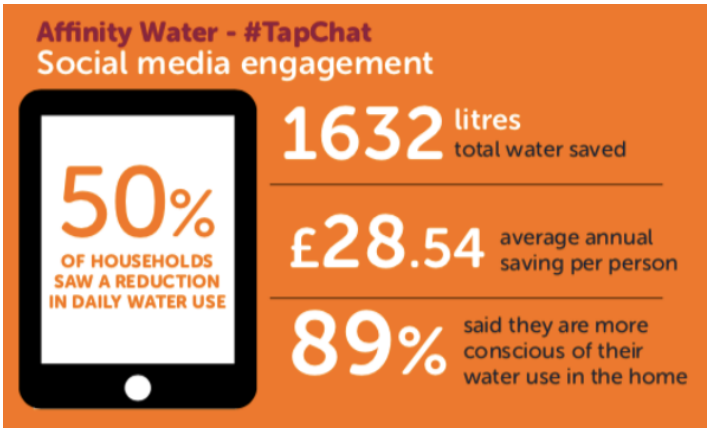
We stepped up our environmental monitoring network in accordance with our Plan, which continued until December 2020 to fully understand the environmental recovery following the 2017-2019 groundwater drought event. We were open and transparent with our regulators, starting monthly water resources focussed calls with the Environment Agency and frequently sharing drought risk information through WRSE and National Drought Group (NDG) platforms. We regularly shared our current position and discussed joint communications as part of the Save Water South East programme, hosted by Waterwise.

As part of our drought communications, in spring 2017 we designed and launched our 'Keep Track of the Tap' campaign, which raised awareness about the dry weather situation and low water resources and promoted water efficiency among customers. The campaign included:

- Direct leaflet drop to 1.7 million households in our Central region
- Traditional advertising – bus backs, train station billboards etc
- Social media campaign and media campaign, including radio advertising
- Advertisements in community centres and doctor / dental surgeries
- Company van livery
- Roadshow events
- Monthly stakeholder bulletins on water resource updates – encouraging stakeholders to share campaign messaging

Figure 33: Examples of Keep Track of the Tap campaign messaging

In parallel with 'Keep track of the tap', we partnered with environmental charity Hubbub to run several water saving behaviour change programmes on social media to reach a wider audience and a media campaign, which resulted in a reach of 170million.



After the success of the initial campaign, which ran through the summer of 2017, the 'Keep Track of the Tap' brand and water resource messaging was incorporated into our business as usual water efficiency campaign programme to run all year round whilst resources continued to be below average.

We tied our water resource messaging to our seasonal communications on winter readiness (November to March), gardening campaigns (spring / summer) and during periods of hot weather and high demand, in particular the summer of 2018.

Throughout this period we did not introduce a Temporary Use Ban (TUB), although in Autumn 2019 we prepared for the potential implementation of a TUB in the spring of 2020, in the event that water resource conditions did not improve over the winter.

To raise awareness of the possibility of a TUB in Spring 2020, we ran a non-statutory drought consultation in late Autumn 2019. We asked for the views of customers and stakeholders on how water use restrictions might affect them. We announced the non-statutory consultation in September 2019 through a direct communication to over 600,000 customers via email – approximately seven months before a temporary usage ban would have been put into place.

The consultation clearly communicated the water resource position and informed audiences that if conditions did not improve, restrictions would have been necessary to help reduce demand for water in Spring 2020.

The consultation acted as a vehicle to communicate our position and possible future risk much earlier in the process. It also gave household and non-household customers and stakeholders the chance to feedback on our plans.

To ensure we received a broad range of feedback from across our diverse customer population and especially from customers normally considered hard to reach, we identified and engaged with different groups, including food banks, mosques, housing associations, councillors, river groups and local resilience forums. We also ran a paid-for advertising campaign on social media and traditional advertising at doctor and dental surgeries and community centres. The consultation provided useful insights into the best ways to engage with our customers, including how to reach groups considered harder to reach, such as vulnerable customers.

During the autumn/winter period from October 2019 to February 2020, we received above average rainfall, which was sufficient to drive substantial recovery of groundwater levels in our region and significantly improved our water resource position. This meant that water resources were healthy as we entered spring 2020, and it was not necessary to implement any restrictions on water use.

3.2 What we have learned

In considering what we may learn from previous droughts we have looked not only at those in England but further afield. Lessons from Australia produced to support California during their most recent drought highlighted "Clear, credible communication about the drought situation and response is paramount to public participation and support".

The World Wildlife Fund and Waterwise 2013 report on communications during the 2012 drought and the UKWIR report 14/WR/01/13: 'Understanding the Impacts of Drought Restrictions' provide learning for future droughts. This includes:

- Joint working and messaging were important during the 2012 drought.
- Having commonly agreed messages and a single point of contact helped in the 2012 drought.
- While there was a good deal of stakeholder engagement by the water industry, this was starting from a fairly low base with many sectors and there is a need for much earlier and better stakeholder engagement.
- Water companies should ensure non-household sectors that may be affected by potential drought restrictions are notified as early as possible – customers would prefer to know if they are going to be affected. Water companies (and with market reform this duty now lies with retailers) need to better understand the desires of their customers for communication during these incidents.
- Water company websites, although not identified as a key source of information, saw a huge upturn in visitor numbers during the temporary use bans. Messages and access to further information should be easily accessible from the landing page of the website, and data should be updated on a regular basis (even outside of drought periods).
- There is a need for quasi-governmental bodies to play a larger role in engaging with the public on wider water issues
- There needs to be a national ongoing campaign to promote water issues and water efficiency, so that there is a background of understanding in advance of the next drought
- Water companies should look at the option of using mass media such as television or direct mail during future droughts
- Despite the company activity the customer research shows that people perceived the reason for the drought to be water company leakage

Our review of the 2017-2019 drought event suggested that our operational responses to the drought event and the high summer demand of 2018 were successful overall and we were able to manage the risks to supply caused by the drought. Our operational responses were in accordance with our Drought Management Plan, which proved to be a good operating model in managing the drought event.

Even though we communicated earlier and wider during the dry weather period compared to the 2012 drought, we recognise more needs to be done to communicate during periods of drought and dry weather and this needs to be done earlier. We need to develop new ways to engage with customers and stakeholders on water resources and their importance for the environment.

At the same time, we also need to do more to raise awareness and increase understanding of the globally rare chalk streams in our area, their relationship to the chalk aquifer and the impacts of dry weather and human actions.

The Consumer Council for Water (CCW) sponsored customer research 'Understanding Drought and Resilience' (2013) offered a view on customer perceptions to industry drought planning. The report identified an issue with the term 'drought' among certain consumer groups explaining that this language does not resonate with service level motivated customers concerned with bill impact. Moreover its use caused a sense of suspicion and incredulity; that it was an inappropriate term for use to describe UK water resource conditions. Among this customer group this led to a view that poor management rather than lack of rainfall was the cause.

The term 'drought' is often used in different contexts by a number of other organisations and sectors, each with their own definitions relating to their specific resource set up. What might be 'drought' for one, might not be a drought for another. This adds to confusion amongst customers, stakeholders, and the media, which raises the risk of mixed messaging and lack of public support for the actions that are required to mitigate a worsening water resource position as a drought develops. Drought planning is predicated upon guidance and conditions that are considered to be 'drought'. Given the age of the research, we will test this perception again during phase one of our public consultation which will deliver qualitative feedback from customer focus groups to understand whether this is a significant barrier to customer buy in around water efficiency messaging.

3.3 Review of 2017-2019 groundwater levels

Recent events such as the June-July period of 2018 and the April-May period of 2020 have provided further evidence that the environment can be stressed before we reach our first operational drought trigger. This means that river flows and ecology can be at risk, even when groundwater levels from a resource position are moderately healthy. We are therefore confident that having an environmental stress trigger above our first operational drought trigger is the right thing to do.

Understanding the causes and consequences of such events and how they differ to groundwater droughts is important for drought planning purposes and this is explained using Figure 34. Groundwater levels over the last five years are plotted on the left-hand axis against our drought zones. On the right-hand axis, rainfall and effective precipitation are plotted respectively, as a three-month rolling percentage of the LTA. This means that every three months, the summed rainfall/effective precipitation is calculated as a percentage of the summed LTA for those three months. It shows that regional groundwater droughts in the Chalk aquifer are caused by prolonged periods of below average effective precipitation, especially during the winter. These conditions preceded the 2017 and 2019 drought events.

Very dry spells, such as the summer of 2018 and spring of 2020, do not cause groundwater droughts in and of themselves, although it is noted that if SMD remains high through the summer and into the autumn, this can result in delayed recharge and increase the likelihood of a dry winter and the associated implications. This happened in 2018.

The additional demand for water that we experience during hot dry summers is managed internally through the 'hot weather demand group'. If this coincides with below average groundwater levels, the relevant additional drought management actions described above are also implemented. At all times, we maintain our environmental monitoring network and close working relationship with the Environment Agency. This allows us to share knowledge and expertise regarding current environmental conditions. As described in our main Drought Plan, the output from many of our sources is controlled by groundwater level through the spring and summer. This maintains a higher pumping water level, ensuring that water is available if it is needed for peak periods, increasing supply resilience.

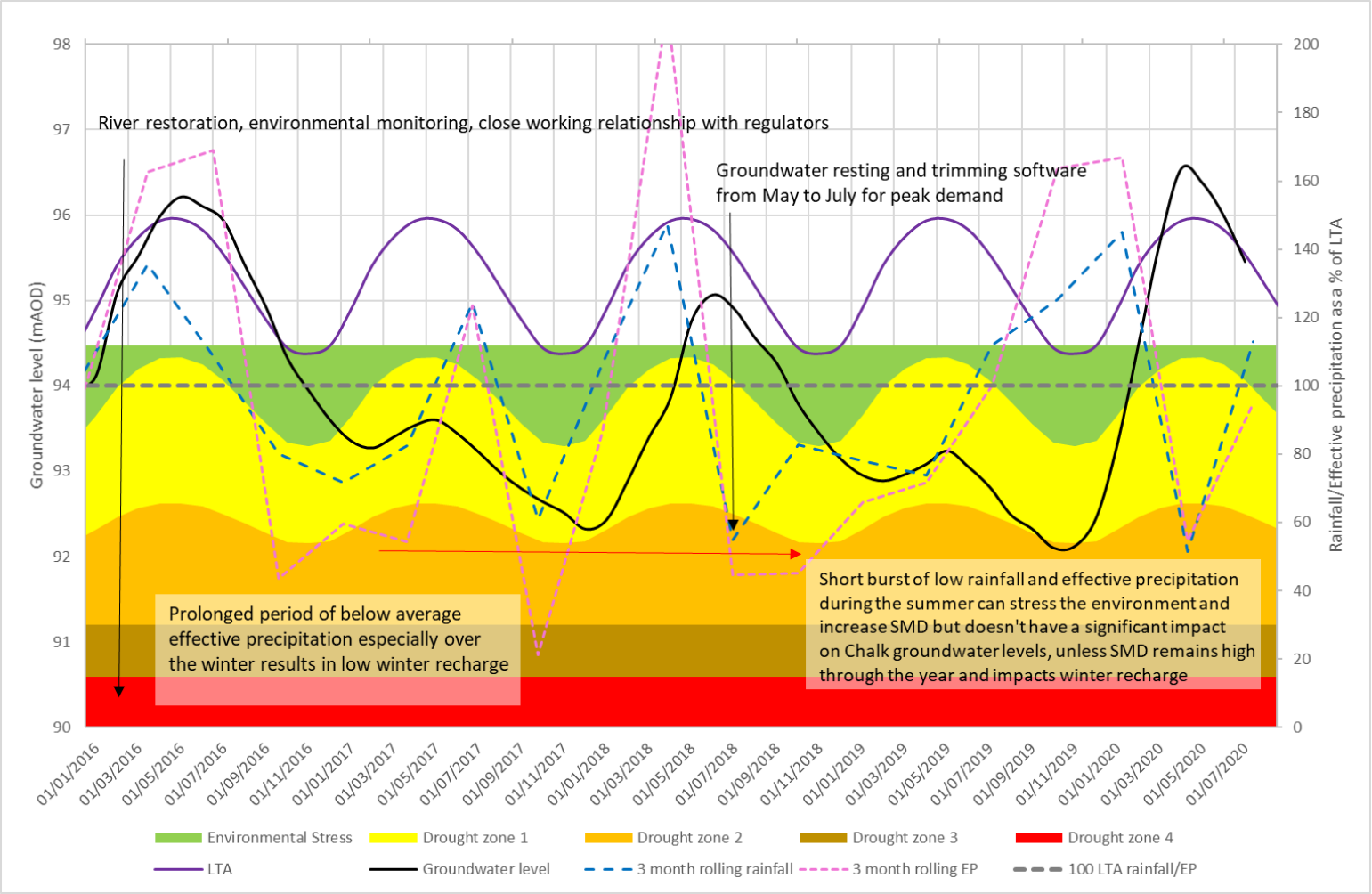


Figure 34: Control curves and high level actions during hot dry summers. Effective precipitation and rainfall as a percentage of LTA are also plotted

3.4 Review of historic drought recessions

An exercise was undertaken to establish the fastest possible time from one drought zone to the next, based on the observed groundwater level recessions that have been experienced to date. This could then be compared with the known lead-in times for drought interventions such as temporary use bans and drought permits, to ensure that the Plan allows for them to be implemented in time.

The results are quite clear and are illustrated below for the Central region, for which observed recessions have been presented. Figure 35, Figure 36, Figure 37 show the comparison of historic recessions for Lilley Bottom key observation borehole. For this borehole, in summary we have observed:

- The fastest possible time taken from the start of the environmental stress period to the start of Drought Zone 1 over the winter/spring (starting from January, typically the highest annual groundwater level period) has ranged between one and two months and over the summer and autumn (starting from July, typically the lowest annual groundwater level period) has ranged from two to three months (Figure 35). This is enough time for us to take action to protect the environment and engage our customers and stakeholders.

- The fastest possible time taken from the start of Drought Zone 1 to the start of Drought Zone 2 has been five months between January and April and seven months during the summer and autumn (average of six) (Figure 36). This gives us enough time to prepare for the potential introduction of a temporary use ban in Drought Zone 2.

- The fastest possible time taken from the start of Drought Zone 2 to the start of Drought Zone 3 was in excess of nine months, regardless of the starting position (Figure 37). This provides enough time to prepare for the introduction of drought permits and/or drought orders and non-essential use bans in drought zone 3.

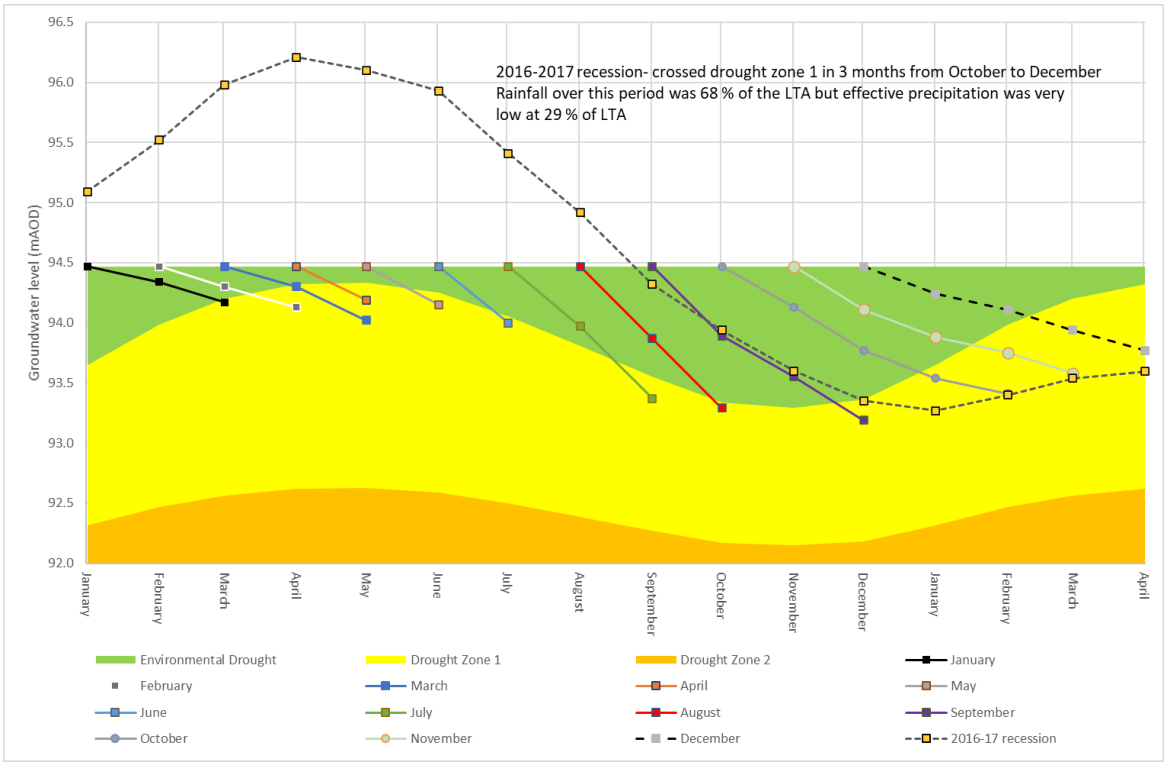


Figure 35: Fastest recession rate through Environmental Drought zone based on observed data

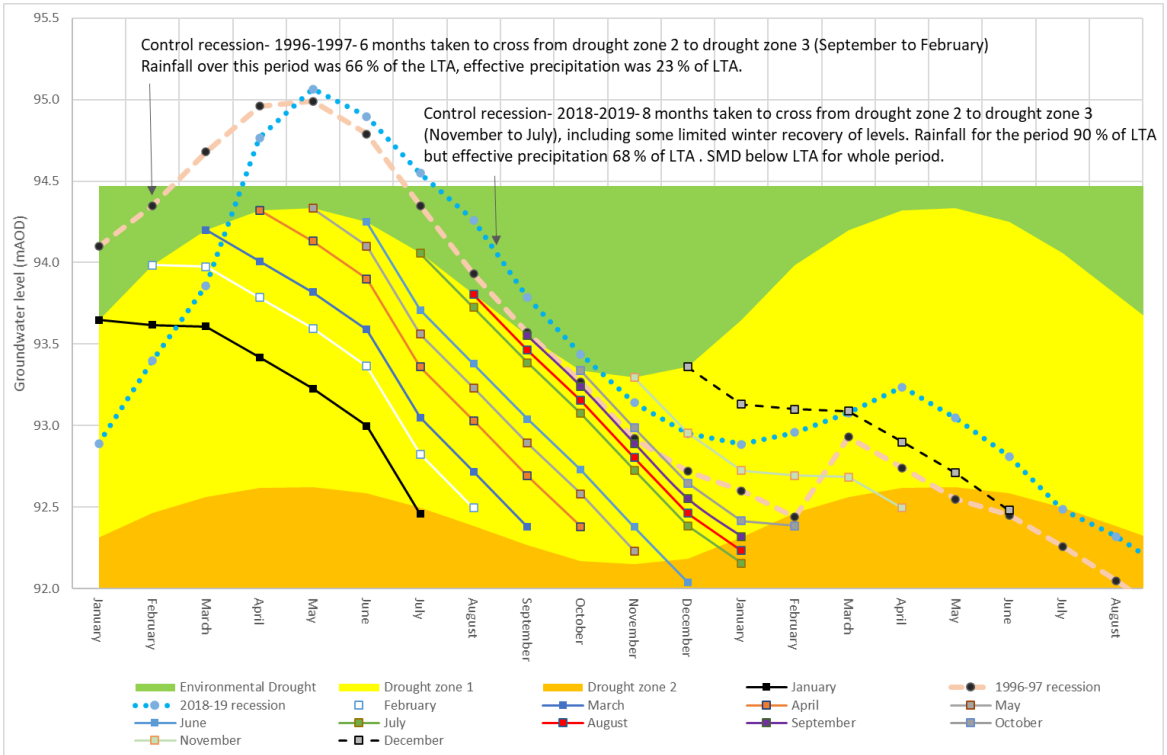


Figure 36: Fastest recession rate through Drought zone 1 based on observed data

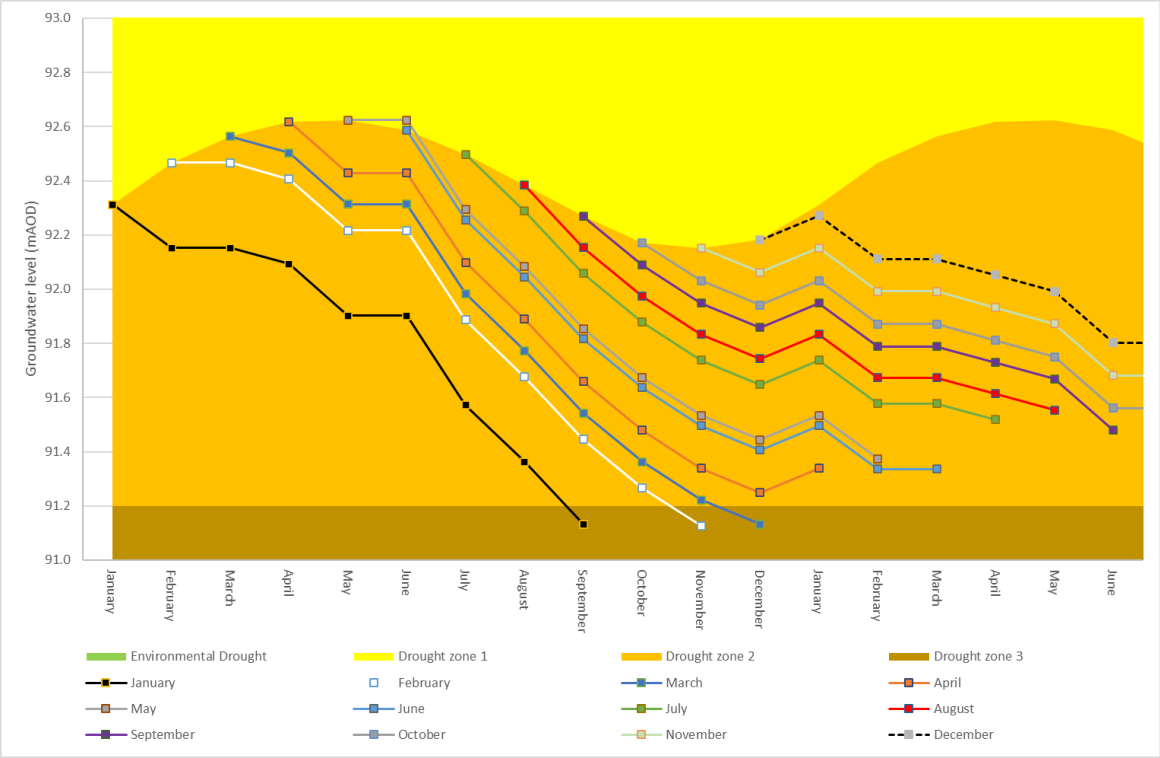


Figure 37: Fastest recession rate through drought zone 2 based on observed data

Elsenham Nurseries

Elsenham Nurseries exhibits approximately a 1-2-month lag time in the response to recharge, compared to Lilley Bottom. This means that groundwater lows and highs are experienced later than at Lilley Bottom. This is important, because it shows that some areas of Central region can still be experiencing below average groundwater level conditions, despite recovery in the faster responding Chalk in the middle and west of our Central supply region.

The fastest rate of recession according to the observed data has been;

- 5 months between Environmental Stress and drought zone 1, although the average of seven drought zone 1 level events has been 5.8 months
- 7 months between drought zone 1 and drought zone 2, although the average of four drought zone 2 events is 9.75 months
- 10 months between drought zone 2 and drought zone 3, although this only occurred in 1997 so there is uncertainty with this

Chalfont Centre

Chalfont Centre generally exhibits trends similar to Lilley Bottom, although the changing levels in the borehole display a less lagged response – exhibiting recharge around 1 month before Lilley Bottom. This means that drought peaks occur earlier but so do hydrograph highs. See Appendix 1.3. The fastest rate of recession in drought years according to the observed data have been;

- 2 months between Environmental Stress and drought zone 1 (1976, 1990 and 2019), although the average of nine drought zone 1 level events has been 3 months
- 3 months between drought zone 1 and drought zone 2, although the average of 7 drought zone 2 level events has been 6.5 months
- 4 months between drought zone 2 and drought zone 3 (1976). Other events which resulted in similarly low levels were 1990 (5 months between zones 3 and 4) and 1997 (9 months).

Ashley Green

Ashley Green generally exhibits trends similar to Lilley Bottom, although the changing levels in the borehole display a less lagged response – exhibiting recharge around 1 month before Lilley Bottom. This means that drought lows occur earlier but so do hydrograph highs. See Appendix 1. The fluctuations are also greater, due to the borehole being located on the interfluve. The fastest rate of recession in drought years according to the observed data have been;

- 2 months between Environmental Stress and drought zone 1 (2005/6 drought), although the average of ten drought zone 1 level events has been 3.7 months
- 5 months between drought zone 1 and drought zone 2, although the average of four drought zone 2 level events has been 8.75 months
- Drought zone 3 has not yet been reached.

Little Bordeaux Farm

Little Bordeaux Farm is a shallow borehole located in the alluvial deposits of the Cam river valley. Trends generally exhibit similar responses to Lilley Bottom, although there is a tendency for more rapid responses to recharge. Drought recessions tend to be shorter compared to the other Central region key wells, as does recovery from droughts, similar to the flow profile of the River Cam. The fastest rate of recession in drought years according to the observed data have been;

- 1 month between Environmental Stress and drought zone 1 (1990 and 1996), although the average of seventeen drought zone 1 level events has been 2.7 months
- 2 months between drought zone 1 and drought zone 2 (1964), although the average of six drought zone 2 level events has been 4.8 months
- 2 months between drought zone 2 and drought zone 3 (1990), although the other time drought zone 3 was reached took 10 months from the bottom of drought zone 2.

Lady Lane

Due to the lack of data in drought zone 2 conditions and below for Lady Lane observation borehole, it is difficult to comment on the rate of recession under these conditions. During the 1996 recession, it took around 6 months to decline from the upper reaches of Environmental Stress to just above drought zone 1.

Wolverton New OBH

At Wolverton New observation borehole the fastest rate of recession according to the observed data has been;

- 2-3 months between Environmental Stress and drought zone 1 starting from July to October, 1-2 months starting in June, November and December and zero months for the rest of the year as the drought zones converge
- 3-4 months between drought zone 1 and drought zone 2 during the winter/autumn and 5-6 months during the summer
- 4 months between drought zone 2 and drought zone 3 (based on 1996 recession), although the lack of data under these extremely low levels makes this conclusion uncertain.

4 Worked examples

4.1 Worked examples with drought actions

As set out in Section 5.3 of our Drought Pan, we track the drought status of each of our supply regions using drought trigger zones for each of our key wells. Each drought trigger zone has associated actions, aimed at protecting both the environment and public water supply. These increase in magnitude with drought severity and are summarised in this section. The high level actions associated with each of our drought trigger zones have been presented in a worked example, in the form of a key well hydrograph with labels showing when each action would be taken. This is presented in Figure 38 below.

Winter rainfall is key for recharging the chalk aquifer and the absence of this results in lower regional groundwater levels through the summer and autumn (first dry winter in Figure 38). There is an elevated risk when approaching the recharge period when groundwater levels are already below average, as the cumulative impact of two consecutive dry winters and seasonal recessions often results in a large decrease in groundwater levels without substantial recovery. In Figure 38, the groundwater level trend from the onset of the third dry winter has been estimated, to reflect the potential onset of a third consecutive dry winter. Although highly unlikely, this serves as a useful exercise for drought planning purposes, as it allows the suitability of the trigger levels and actions to be tested, especially to ensure that appropriate actions can be implemented in a timely manner.

We carried out stochastic modelling as part of the development of our previous drought management plan. The groundwater levels for this were based on a full stochastic sequence (15,600 years), which provided absolute return periods. For the worked example shown below, we have chosen a >36 month example period, as we know from modelling that we have limited vulnerability to encountering emergency conditions for droughts of a shorter duration than this. Our worked example in Figure 38 below has been compared with severe drought profiles produced through the modelling, and this has shown it is representative of how we would expect a severe drought to develop in our region. The comparison of severe drought profiles is provided in Figure 39 below.

When in and approaching the 'Environmental Stress' trigger zone, the actions that we will take are focused around education and messaging (helping our customers to understand the need to use less water all of the time but especially when there is less available in the environment) and the actions that we can take to help protect the environment. This will mean earlier messaging to our customers than during previous droughts and the triggering of the Abstraction Incentive Mechanism (AIM), Hands off Flow (HoF) constraints and river support schemes in certain catchments. The latter results in a clear increase in the river flow available to ecology at a time when it might otherwise not be. These actions form a step up from our business-as-

usual environmental monitoring network and river restoration programme, and it is intended that they would continue through the progression of a drought event.

Decline of groundwater levels into drought zone 1 is a realistic proposition given the occurrence of a dry winter from an average starting groundwater level. This would trigger a step-up in leakage activity, to help reduce the volume of water we need to abstract, leaving more in the environment. Our communications campaign would continue, albeit stepped up, and we would anticipate that the various triggers associated with AIM, river support and HoF constraints would continue to be active and become so at a greater number of sources. We would begin preparations for implementation of a temporary usage ban (TUB) in drought zone 2 given further deterioration of conditions (a process that we estimate takes 3 months) and would start to accelerate capital schemes, to increase the available supply from our assets.

Further decline of groundwater levels resulting from a second consecutive dry winter and the associated low level of recovery (as seen in 1996/97 in Figure 38) would likely see levels cross into drought zone 2. Previously implemented actions to reduce demand on our sources (enhanced leakage activity, communications campaign) would continue and following preparatory work in drought zone 1, TUB's would be introduced, depending on the time of year. It is anticipated that we would continue to see the benefits of the accelerated capital projects on resource availability and distribution capacity, and new schemes would continue to be identified and implemented through drought zone 2. The intention would be to delay the requirement to apply for drought permits for as long as possible, although given the potential onset of a third dry winter, this is an option that must be planned for. As a result, preparatory work for both applying for drought permits and for the introduction of non-essential use bans, both drought zone 3 actions, would start in drought zone 2.

The simulated occurrence of a third consecutive dry winter in Figure 38 shows the impacts that this could have on water resource availability, potentially resulting in groundwater levels dipping into drought zone 3 and drought zone 4. When in drought zone 3, the drought management actions discussed above would continue to remain in effect. An additional demand management measure that we could implement when in drought zone 3 is a non-essential use ban. This would restrict the use of hosepipes at some commercial premises, and is explained in more detail in Section 10 of our main Drought Plan. We would also apply for drought permits when in drought zone 3, in an attempt to minimise recourse to emergency drought measures. It is our understanding that all of our drought permit sites should be considered as such, and that we would only need to apply for them as drought orders if our drought permit application were not granted by the Environment Agency.

We would transition from this plan to our Emergency Plan if groundwater levels dipped into drought zone 4.

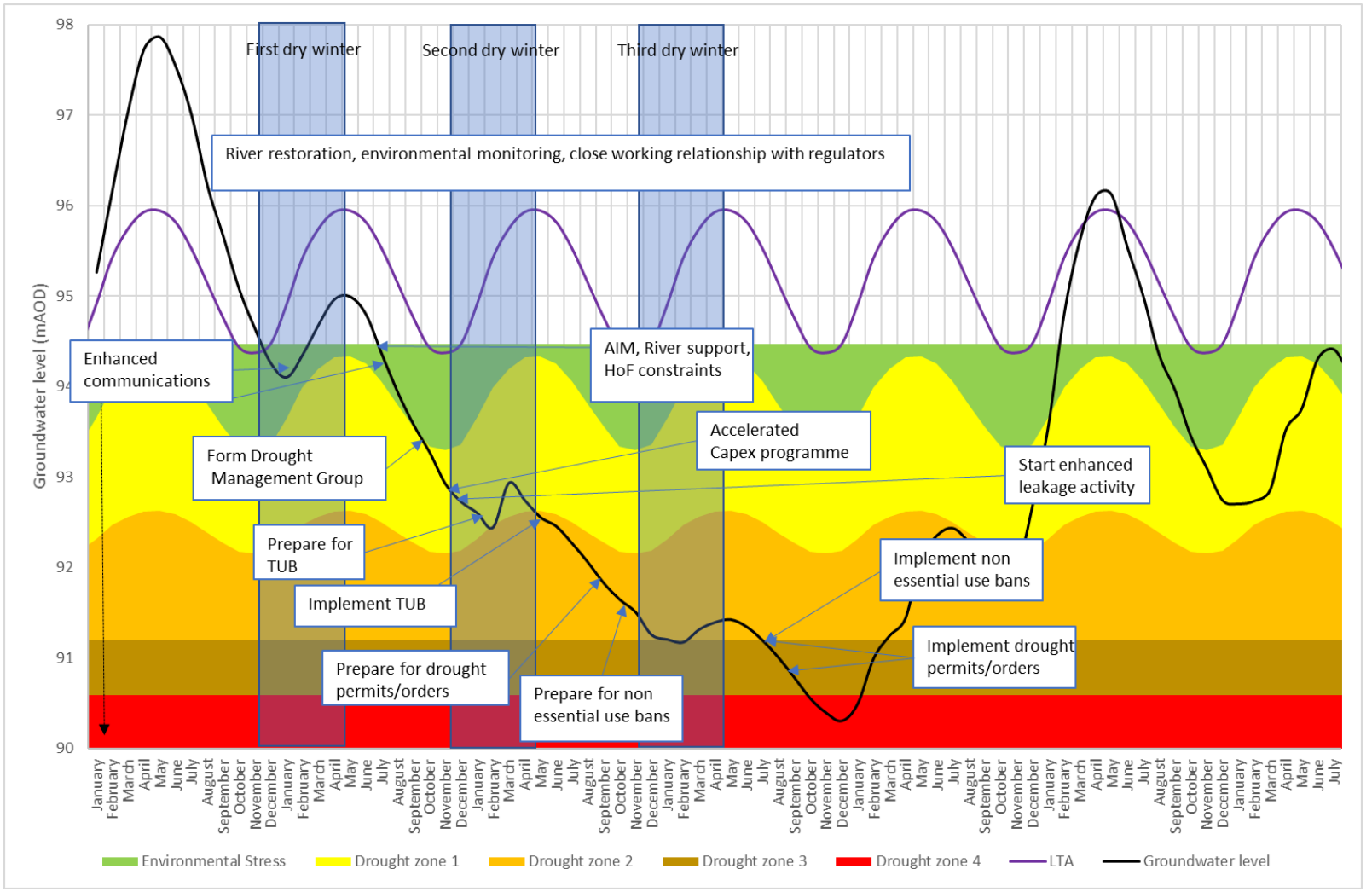


Figure 38: Worked example with high level actions during a severe drought (note arrows indicate the start of when an activity will happen)

4.2 Worked examples with stochastic recessions

A worked example is presented in Section 4.1 above, to show when we would take certain actions through the evolution of a drought event, to protect both the environment and security of supply for our customers. We have previously carried out stochastic modelling as part of the development of our last drought management plan (2019). The groundwater levels in this modelling were based on a full stochastic sequence (15,600 years), i.e. no sampling, which provided absolute return periods. For the worked example we have used in our Plan we have chosen a >36 month drought example period, as we know from modelling, that we have very limited vulnerability to encountering emergency conditions for droughts of a shorter duration than this.

The simulated drought recession which is presented in Section 4.1 above has been plotted alongside the four most severe modelled droughts (A to D) in Figure 39 below. They show that the 'design' drought used to convey the intended timing of our drought interventions is likely to be similar in profile to previous droughts, in terms of lowest recorded water level and also the potential speed of groundwater level recession. This provides assurance that our planned drought actions are appropriate in terms of when we would plan to implement these. The assessment of return periods has been based on deployable output using an inverse ranking approach based on yield. This was carried out for our WRMP19 and DMP19. Please refer to the Technical Report 1.1.1 Deployable Output and DMP-WRMP Links Addendum Report which provides detailed explanations into the analysis of return periods based on historic events and stochastic modelling.

In all of the modelled examples (A to D) presented below, three consecutive dry winters are required for levels to decline from the Environmental Stress banding down to Drought Zone 4. If Chalk groundwater levels are higher, they would be more resilient to successive low-recharge years, and so the time required to approach Drought Trigger 4 would be greater. The recovery period from droughts is much more uncertain, although is potentially more rapid, given above average rainfall, as has been observed following the early and late 1990's droughts, the drought events of 2006 and 2012 and the drought event of 2017-2019.

For the examples provided in Figure 39, crossing the Environmental Stress trigger would result in an uplift of water resources focussed communications. The Drought Management Group would then be formed upon crossing into Drought Zone 1, after the first dry winter. The group would continue to meet through the drought event, with the frequency increasing with severity of drought. Options to accelerate capital schemes to increase output and resilience would be investigated and implemented in Drought Zone 1 and we would prepare to implement a TUB if we were to experience a second consecutive dry winter. This would likely result in groundwater levels crossing into Drought Zone 2. In this drought zone, we would begin preparations for the implementation of drought permits or orders and the introduction of a non-essential use ban. Both of these are Drought Zone 3 options. Further decline of groundwater levels into Drought Trigger 4 would result in transition

from this Plan to our Emergency Plan. Please see Sections 6-10 in our main Drought Plan for further information on our planned drought management actions.

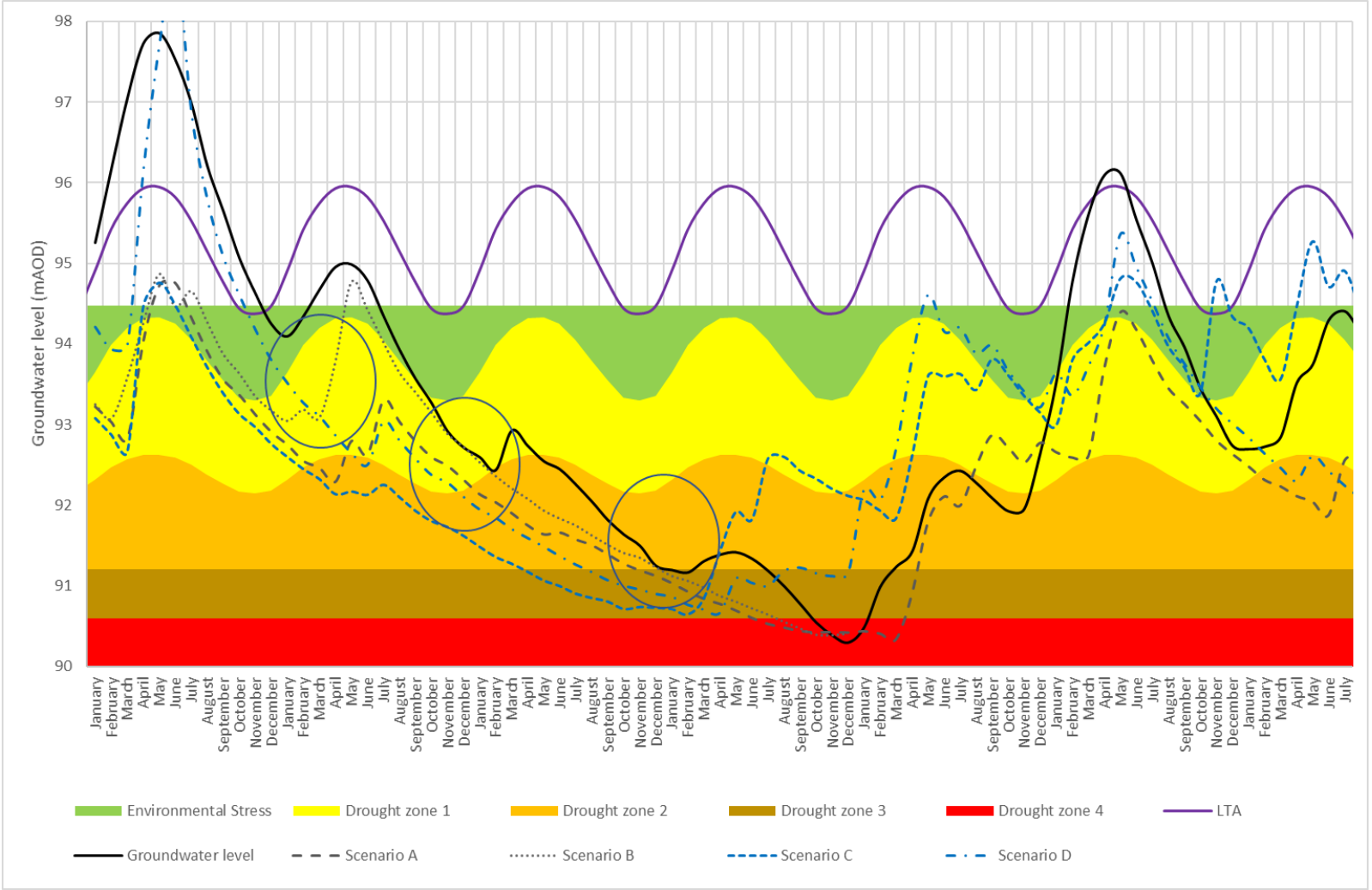


Figure 39: Worked examples along with historic drought recessions from stochastic modelling

5 Supply and demand side drought actions

This appendix provides summary tables for our supply and demand actions during a drought, as well as potential actions in an extreme drought. It also provides technical details on some of the actions set out in our main Drought Plan.

5.1 Drought actions summary tables

The tables in this section provide information for each of our drought management actions, categorised by drought trigger.

Table 6 lists key actions relating to reducing demand for water during a drought.

Table 7 lists our key supply side actions, which relate to optimising water resources and maintaining supplies during a drought.

Table **8** provides the actions we would consider taking in an extreme drought situation, which is likely to be after we reach drought trigger 4, and before we would implement more severe customer restrictions.

Table 6: Demand management actions during a drought

DESCRIPTION OF ACTION WE'LL TAKE	TRIGGER FOR THIS ACTION	ESTIMATED SAVING IN DEMAND	LOCATION	IMPLEMENTATION TIMETABLE (TIME FROM TRIGGER TO IMPLEMENTATION)	TIME OF YEAR	DURATION OF ACTIONS	ANY PERMISSIONS OR CONSTRAINTS	RISKS ASSOCIATED WITH ACTION
Raise awareness of dry weather situation and appeal for voluntary reductions in water usage	**ES**	To be confirmed	Affected areas/ catchments	Communications team to send out communications when within trigger zone	Usually implemented during summer months	Likely to remain in place as needed over summer months	Corporate Affairs Team	Potential risk of not reaching all customers
Update stakeholders and website	**ES**	To be confirmed	Supply zone	Two weeks to implement	Any time of year	Website and stakeholder updates throughout the year	Water Resources and Communications teams	None
Ramping up water saving messaging, communicating increased drought risk	**DT1**	To be confirmed	Supply zone	Three weeks to implement	Usually implemented during summer months	Communications to continue as long as needed	DMG	Potential risk of not reaching all customers
Enhance leakage activity	**DT 1**	To be confirmed	Drought affected areas/ catchments	Three weeks preparation time	Any time of year	Duration of drought	DMG and Board	Cost implications - reducing repair times to lower leakage is complex. Also potential increased disruption to Highways and Byways.

DESCRIPTION OF ACTION WE'LL TAKE	TRIGGER FOR THIS ACTION	ESTIMATED SAVING IN DEMAND	LOCATION	IMPLEMENTATION TIMETABLE (TIME FROM TRIGGER TO IMPLEMENTATION)	TIME OF YEAR	DURATION OF ACTIONS	ANY PERMISSIONS OR CONSTRAINTS	RISKS ASSOCIATED WITH ACTION
Implement Temporary Use Ban restrictions	**DT 2**	2-3%	Dependent on drought situation – likely to be whole supply zone	Before entering DT 2, DMG will consider when to implement TUBs, depending on the time of year. 1 week preparation, 2 weeks for representations.	Most likely to impose TUB restrictions over the spring/summer when they will have the greatest impact on demand.	Duration of restrictions dependent on drought situation.	DMG and Board	Principally impacts on domestic customers.
Implement drought orders to restrict usage of water for those categories set out in Drought Direction 2011	**DT 3**	4%	Dependent on drought situation – likely to be whole supply zone	Eight weeks preparation time - prior to entering DTZ3. Application to Secretary of State to be submitted when approaching DTZ 4, 28 days for decision to be made (assuming no objections)	Any time of year	Drought orders valid for six months	Approval from DMG and Board, permission required from Secretary of State	Economic implications associated with restricted water use for some businesses.
Emergency drought orders	**DT 4**	Significant reductions in demand, to be confirmed	Whole supply zone	Application decision within 28 days.	Used as necessary during drought	Valid for six months	Approval from DMG and Board, permission from Secretary of State required.	Socio-economic risks associated with significantly restricting water use

Table 7: Supply options available during a drought

DESCRIPTION OF ACTION WE'LL TAKE	TRIGGER FOR ACTION	DEPLOYABLE OUTPUT OF ACTION	LOCATION	IMPLEMENTATION TIMETABLE	DURATION	ANY PERMISSIONS NEEDED OR CONSTRAINTS THAT APPLY	RISKS ASSOCIATED WITH ACTION
Full assessment of source performance and network models.	Periodically	No additional DO - would be ensuring utilisation of current sources in most effective way	Whole supply zone	Carried out periodically, more frequently during a drought	Used as necessary during drought	Approval from DMG and Production	None
Optimisation of sources - increase abstraction within licensed volumes	DT 1	No additional DO - optimal use of current sources to maintain resilience in network	Whole supply zone	Dependent on assessment of output capacity at the time	Used as necessary during drought	Approval from DMG, Production and Water Quality	None
Groundwater resting	DT 1	No additional DO – ensures capability of sources maintaining peak volumes	Whole supply zone	Based on recommendations from source performance assessment – immediate implementation	Used as necessary during drought	Approval from DMG and Production	None
Transfers from surplus areas via existing networks	DT 1	No additional DO - would be ensuring	Whole supply zone	Immediate	Used as necessary	Approval from DMG and Production	None

DESCRIPTION OF ACTION WE'LL TAKE	TRIGGER FOR ACTION	DEPLOYABLE OUTPUT OF ACTION	LOCATION	IMPLEMENTATION TIMETABLE	DURATION	ANY PERMISSIONS NEEDED OR CONSTRAINTS THAT APPLY	RISKS ASSOCIATED WITH ACTION
		utilisation of current sources in most effective way			during drought		
Assess potential to bring forward planned engineering works to enhance existing network capability	DT 1	No additional DO - would be ensuring utilisation of current sources in most efficient way	Whole supply zone	Dependent on status of project and permissions to install pipework	Used as necessary during drought	Approval from DMG, Network and Asset Strategy.	Possible commissioning delays
Minimise outage	DT 2	No additional DO – would ensure minimisation in loss of DO due to maintenance work	Sources identified in outage programme	Review of outage programme required before changes are made – estimated three weeks to implement changes	Used as necessary during drought	Approval from DMG and Production	Cancelling routine maintenance activities or capital investment schemes can have knock-on effects for other areas of the business
Begin operational readiness for drought permit applications	DT 2	See drought permits	Various – Central and Southeast regions	Depending on water resource forecasts, start preparation for	Six months	Approval from DMG to prepare applications	

DESCRIPTION OF ACTION WE'LL TAKE	TRIGGER FOR ACTION	DEPLOYABLE OUTPUT OF ACTION	LOCATION	IMPLEMENTATION TIMETABLE	DURATION	ANY PERMISSIONS NEEDED OR CONSTRAINTS THAT APPLY	RISKS ASSOCIATED WITH ACTION
				drought permits 6 months prior to potentially crossing DT 3			
Drought permits – See Drought Plan Section 10	DT 3	Up to 48.52 Ml/d	See Drought Plan Section 10	Begin preparations in DTZ 2, submit applications on or before entering DTZ 3. 12 days for EA determination.	Six months - can apply for extension to 12 months	Permission required from EA - on assessment of drought permit application and associated EAR.	See Environmental Assessment Statements (Appendix 8)
Drought Orders – See Drought Plan Section 10	DT 3	Up to 48.52 Ml/d	See Drought Plan Section 10	If drought permit applications rejected –apply for drought orders	Six months - can apply for extension to 12 months	Permission from Secretary of State required.	See Environmental Assessment Statements (Appendix 8)
Changes in network pressure to reduce volumes of water needed, and reduces risk of leakage	DT 4	No additional DO - would be ensuring utilisation of available sources in most effective way	Whole supply zone	Dependent on assessment of pressure distribution and management at the time	Used as necessary during drought	Approval from DMG, Production and Asset Strategy. Consider possible impacts on fixed fire hydrants before implementation	Possible commissioning delays

Table 8: Potential actions in an extreme drought, to be implemented before more severe customer drought restrictions

PRIORITY ORDER	TYPE OF ACTION	AREA AFFECTED	SUMMARY OF ACTION	TRIGGER FOR ACTION	LIKELY BENEFIT/SAVING	POTENTIAL BARRIERS	ENVIRONMENTAL IMPACTS	TIMESCALES
1	Demand	WRZs at risk	Intensive communications through media and direct messaging, to urge customers to significantly reduce their water use	Drought trigger 4	Reductions in demand to be confirmed. Ongoing work with WRSE to establish what level of saving could be expected	Potential difficulties in reaching every single customer	None	< 1 month
2	Supply	WRZs at risk	Bulk transfers – any additional opportunities for bulk transfers not already implemented in earlier stages of drought	Drought trigger 4	Additional water available for supply. Volumes to be confirmed.	Severity of drought likely means that neighbouring companies will also be affected and may not have surplus water to transfer	To be confirmed	6-12 months
3	Supply	WRZs at risk	Network changes – e.g. temporary pipelines	Drought trigger 4	Potential additional water available for supply. Volumes to be confirmed.	Distances between areas of network, planning consent	To be confirmed	6-12 months
4	Demand	WRZs at risk	Pressure management	Drought trigger 4	This reduces the amount of water	Difficulty in maintaining	None	< 1 month

PRIORITY ORDER	TYPE OF ACTION	AREA AFFECTED	SUMMARY OF ACTION	TRIGGER FOR ACTION	LIKELY BENEFIT/SAVING	POTENTIAL BARRIERS	ENVIRONMENTAL IMPACTS	TIMESCALES
					which needs to be put into the network to maintain supplies to customers	supplies to customers in remote areas of the network.		
5	Supply	WRZs at risk – Central region	Sea tankering of fresh water from overseas to ports/terminals on the South East coast	Drought trigger 4	Additional water available for the South East (including other companies in WRSE), would require co-ordination to ascertain the volume available to each company	Availability of tankers, infrastructure needed to bring water from sea terminals into appropriate point in network, potential water quality issues	None	> 1 year

5.2 Source performance assessment

All of our sources have licences which are issued and regulated by the Environment Agency and which set out the volumes we can abstract from each source. We manage our abstraction patterns for each source depending on demand patterns, within the constraints of our daily and/or annual abstraction licensed volumes. Some sources are also part of a group licence, which includes a number of sources that are managed collectively. In those cases, the annual average and daily peak abstraction for the individual sources will be summed and compared with the group DO to calculate the utilisation score. In those circumstances, it is the group performance that is significant and in theory the group abstraction should match or exceed the group DO.

We carry out a source performance assessment on a quarterly basis and a report is written for the annual review. The review process assesses the performance of all sources in Affinity Water's Central, East, and Southeast regions throughout the respective quarter of a year. This process compliments the day-to-day operational management of sources. It allows clear tracking of source outputs against the target DO values presented in our Water Resources Management Plan for non-drought years, capturing reasons for underperformance so that these can be addressed through operational or capital investment actions. The annual source performance assessment forms part of the evidence base for regulatory end of year reporting, especially regarding targeted abstraction reductions.

5.3 Groundwater resting assessment

The groundwater vulnerability tool is a mechanism which allows clear tracking of the minimum water level for any given month against the known constraint at the source, which is usually the pump intake, adit level or base of plain casing. The level of the constraint is the lowest water level in which a source can be operated without encountering issues. It captures sources that are at risk from low pumping water levels getting close to their constraint so that these can be flagged, and bespoke actions can be recommended to address this. The recommendations relate to the daily abstraction output that may need to be reduced to prolong the lifetime of the source throughout a developing drought, or the preferential use of some boreholes over others that may be less at risk, either for the same production site or a neighbouring one. The recommendations put forward are reviewed to ensure they are appropriate and effective and then they are passed onto the Production and Supply team who will follow the recommendations as appropriate, based on the demand profile. When peak demand or planned/unplanned outages are experienced, the reduced abstraction profile is overridden to maintain supply as required.

The groundwater resting assessment is conducted on a monthly basis from May to July inclusive during a business-as-usual year. Sources will be rested in early spring in anticipation and preparation for peak demand, which provides c.1 month extra drawdown capability for peak periods if needed by allowing groundwater levels to

recover locally. This process complements the day-to-day operational management of sources which is undertaken by our Production and Supply team. Reducing output can preserve water at our groundwater sources so that it can be abstracted at times of peak demand which occur during summer, such as during heat waves.

5.4 Bulk Transfers

We have a number of agreements in place with our neighbouring water companies which enable us to transfer water between our company areas.

The below table sets out a summary of our bulk supply agreements, with additional information on how these would be expected to operate during drought events. We have discussed and agreed these expectations with the relevant neighbouring companies.

Any changes to bulk supplies in very severe scenarios would only be made in full agreement with the other water companies involved. In a severe drought it is important to retain the flexibility of allowing further discussions with other water companies to take into account the specific conditions of that drought and to use any operational flexibility that may be available at the time to help maintain customer supplies.

Table 9: Bulk supply agreements and drought operating expectations

DROUGHT PLAN ID	DONOR COMPANY	RECEIVING COMPANY	TRANSFER REFERENCE	AGREED MAXIMUM VOLUME AT AVERAGE (ML/D)	AGREED MAXIMUM VOLUME AT PEAK (ML/D)	EXPECTED DROUGHT PROVISION
1	Anglian Water	Affinity Water (WRZ3)	Grafham	91	109	This bulk import into WRZ3 from Anglian is a shared supply, governed by the Great Ouse Water Act 1961. We have capped the average capacity of this source to 50 Ml/d until 2023/24 when we plan to have installed conditioning treatment, which will facilitate greater volumes for use during average demand periods. This transfer is confirmed to be available up to a 1 in 200 year return period drought.
2	Thames Water	Affinity Water (WRZ4)	Fortis Green	12	27	This transfer is subject to some restrictions related to capacity in our network. Although the agreement states a maximum peak transfer of 27 Ml/d, this connection is expected to provide up to 12 Ml/d on average and up to 16 Ml/d under peak conditions during a drought. It is expected that this transfer would be maintained through a drought up to drought trigger 4.
3	Thames Water	Affinity Water (WRZ4)	Hampstead Lane	0.2	0.2	It is expected that this transfer would be maintained through a drought up to drought trigger 4.
4	Thames Water	Affinity Water (WRZ4)	Sunnymeads - Iver	2	2	It is expected that this transfer would be maintained through a drought up to drought trigger 4.
5	Thames Water	Affinity Water (WRZ6)	Ladymead	2.27	2.27	It is expected that this transfer would be maintained through a drought up to drought trigger 4.
6	Cambridge Water	Affinity Water (WRZ5)	Hadstock & Linton	0.3	0.3	The availability of this transfer is not expected to change during a drought.
7	Affinity Water	Anglian Water	Chalton	0.14	0.14	The availability of this transfer is not expected to change during a drought.

DROUGHT PLAN ID	DONOR COMPANY	RECEIVING COMPANY	TRANSFER REFERENCE	AGREED MAXIMUM VOLUME AT AVERAGE (ML/D)	AGREED MAXIMUM VOLUME AT PEAK (ML/D)	EXPECTED DROUGHT PROVISION
8	Affinity Water	South East Water	Egham	36	36	This is not considered a drought vulnerable source - this transfer is expected to remain reliable throughout a drought event.
9	South East Water	Affinity Water (WRZ7)	Barham	2	2	We would expect this supply to be available up to a 1 in 200 year return period drought event. As a drought starts to develop we would increase communications between ourselves and South East Water to ensure that any risks which may arise can be proactively managed.
10	Southern Water	Affinity Water (WRZ7)	Deal	0.0714	4	We would expect this supply to be available up to a 1 in 200 year return period drought event. As a drought starts to develop we would increase communications between ourselves and Southern Water to ensure that any risks which may arise can be proactively managed. Note that we currently do not utilise the full 4 Ml/d specified in the agreement wording for this transfer as set out in WRMP19, this is due to operational constraints. Southern Water should however plan to be able to provide the 4Ml/d under the terms of the agreement until which time that the existing agreement is superseded.

6 Demand restrictions

In this appendix we provide information about temporary demand restrictions, including definitions for the activities which are covered by the restrictions, and details of the exceptions which would be associated with these.

6.1 Temporary use bans

This section explains the activities which are covered by temporary use bans (TUBS) under the Flood and Water Management Act 2010. We have taken account of the Water UK Code of Practice[3], which was developed in light of the lessons learned from the restrictions imposed during the 2011-2012 drought. It also takes account of the work undertaken by WRSE to ensure alignment between companies when implementing a TUB. The discretionary exceptions we would apply when implementing a TUB have been agreed by the companies within WRSE, and these are set out below. Table 10 lists the restriction categories that may be used to manage a drought if temporary bans on water usage are imposed. This document is currently being updated following the introduction of TUB's by several water companies in 2022

Table 10: Activities which would be restricted through the implementation of a temporary use ban (TUB)

SECTION	ACTIVITY/TITLE
Table 11	Watering a garden using a hosepipe
Table 12	Cleaning a private motor-vehicle using a hosepipe
Table 13	Watering plants on domestic or other non-commercial premises using a hosepipe
Table 14	Cleaning a private leisure boat using a hosepipe
Table 15	Filling or maintaining a domestic swimming or paddling pool
Table 16	Drawing water, using a hosepipe, for domestic recreational use
Table 17	Filling or maintaining a domestic pond using a hosepipe
Table 18	Filling or maintaining an ornamental fountain
Table 19	Cleaning walls, or windows, of domestic premises using a hosepipe
Table 20	Cleaning paths or patios using a hosepipe
Table 21	Cleaning other artificial outdoor surfaces using a hosepipe

[3] Water UK, 2013, *Managing through Drought: Code of Practice and Guidance for Water Companies on Water use Restrictions [incorporating lessons from the 2011-12 drought]*

Note the following information applies to these activities:

Legislation:

All eleven activities are covered by the Water Industry Act 1991 section 76 as amended by the Flood and Water Management Act (FWMA) 2010 s36 (i.e. temporary water use bans).

Programme:

TUBs are constrained by advertising in at least two newspapers relevant to the location and our website. 2-3 weeks.

The following definitions apply to these activities:

"Using a hosepipe"

The Water Use (Temporary Bans) Order 2010 provides the definition of "using a hosepipe" in relation to the WIA 1991 as including:

a) Drawing relevant water through a hosepipe from a container and applying it for the purpose; and

b) Filling or partly filling a container with relevant water by means of a hosepipe and applying it for the purpose.

A reference to a hosepipe includes anything designed, adapted or used for the same purpose as a hosepipe.

"Relevant water"

Refers to mains water i.e. supplied by the water undertaker; it does not include water supplied before the water use restriction was implemented.

Table 11 : Watering a garden using a hosepipe

DEFINITIONS
The category of activity under the temporary water use ban powers is "watering a garden using a hosepipe". It does not include using a hosepipe to water a garden for health or safety reasons. Gardens The Water Use (Temporary Bans) Order 2010 provides the definition of "a garden" as including: a) a park; b) gardens open to the public; c) a lawn; d) a grass verge; e) an area of grass used for sport or recreation; f) an allotment garden; g) any area of an allotment used for non-commercial purposes; h) any other green space.

"A garden" does not include the following:
a) agricultural land;
b) other land used in the course of a business for the purposes of growing, for sale or commercial use, any crops, fruit, vegetables or other plants;
c) land used for the purposes of a National Plant Collection;
d) a temporary garden or flower display;
e) plants (including plant organs, seeds, crops and trees) which are in an outdoor pot or in the ground, under cover.
"Allotment gardens" are defined in section 22(1) of the Allotments Act 1922.
"Agricultural land" is as defined in section 109(1) of the Agriculture Act 1947.
"National Plant Collection" means a plant collection which is part of the National Council for the Conservation of Plants and Gardens' National Plant Collection scheme.
"Outdoor pot" means a pot or other container that is outdoors or under cover.
"Under cover" means in a greenhouse or outbuilding or under a permanent canopy.
"Temporary garden or flower display" means those at a show or exhibition; and on public display for a period not exceeding 7 days.
"Grow" includes cultivate or propagate.

MESSAGES

Customers may water their gardens:
By hand, using a bucket or watering can.
With greywater through a hosepipe.
Using rainwater from a water butt by hand or through a hosepipe.

The Turf Growers Association advises that established turf (>28 days old) does not require watering.

Public Sector

Under the Water Act 2003, public authorities have a water conservation duty and arguably should not wait until restrictions come into force before taking water conservation measures.

Storage tanks

Water drawn from the mains supply into tanks (other than hand held receptacles) for subsequent use for watering private gardens, lawns and landscaped areas via a hosepipe is not permitted.[4]
Methods for recycling water or finding water from alternative sources should be encouraged for those concerned about the financial implications of not being able to use mains water[5].

Sports Pitches

Watering areas of grass used for sport or recreation using a hosepipe are covered under this activity. This includes all sports pitches or similar such as cricket and football pitches, bowling greens, horseracing tracks and golf courses. It applies to both publically and privately owned facilities; both can be large users of water but some may have private water supplies for watering sports pitches. Watering for health or safety reasons is exempt from the legislation. Sports pitches can still be watered using other sources of water and innovative recycling methods can be encouraged.

[4] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007
[5] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007

STATUTORY EXEMPTIONS & CONCESSIONS
A statutory exemption exists in The Water Use (Temporary Bans) Order 2010 for the watering of gardens in respect of health or safety (see Section 5.7 of this report for further detail). This includes: a) removing or minimising any risk to human or animal health or safety; and b) preventing or controlling the spread of causative agents of disease.
DISCRETIONARY EXEMPTIONS
• To Blue Badge holders on the grounds of disability • Use of an approved drip or trickle irrigation system fitted with a pressure reducing valve (PRV) and timer • To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge • To water newly laid turf for first 28 days

Table 12 : Cleaning a private motor-vehicle using a hosepipe

DEFINITIONS
The category of activity under the temporary water use ban powers is "cleaning a private motor-vehicle using a hosepipe". The Water Use (Temporary Bans) Order 2010 defines "a private motor-vehicle" as: a) a mechanically propelled vehicle designed, constructed or adapted for use on roads; or b) a trailer designed, constructed or adapted for attachment to a vehicle falling under (a). The definition does not include: i) a public service vehicle, as defined in section 1 of the Public Passenger Vehicles Act 1981; and ii) a goods vehicle, as defined in section 192 of the Road Traffic Act 1988. Interpretation Taxis and minicabs are not considered to be public service vehicles and so are subject to bans.
MESSAGES
Important positive messages: Customers can still wash their cars (including lights and windows) by hand using water from a bucket. Customers can use commercial carwashes, for example at garages. Customers can wash their cars with a hosepipe connected to a rainwater or greywater source (e.g. bathwater diverted to a receptacle for subsequent use). Storage tanks Water drawn from the mains supply into tanks (other than hand held receptacles) for subsequent use for vehicle washing via a hosepipe is not permitted[6].

[6] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007

Restrictions apply to water drawn from the mains supply after the statutory notice has been given. So water drawn into a container prior to that date may be used for washing cars, regardless of whether that use involves a hosepipe[7].

STATUTORY EXEMPTIONS & CONCESSIONS
None

DISCRETIONARY EXEMPTIONS
• To Blue Badge holders on the grounds of disability • Use of a hosepipe in the course of a business to clean private motor vehicles where this is done as a service to customers • To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge

Table 13 : Watering plants on domestic or other non-commercial premises using a hosepipe

DEFINITIONS
The category of activity under the temporary water use ban powers is "watering plants on domestic or other non-commercial premises using a hosepipe". The definition applies only to the watering of plants which are in an outdoor pot or in the ground, under cover. It does not include watering plants: i) grown or kept for sale or commercial use, or ii) that are part of a National Collection or temporary garden or flower display "Domestic or other non-commercial premises" means a) any land, building or other structure used or enjoyed in connection with the use of any of the following which is used principally as a dwelling: i) a building or part of a building; ii) a caravan; iii) a boat; or b) any land or premises which is not used principally for the purposes of a business. "Plants" includes plant organs, seeds, crops and trees. "Grow" includes cultivate or propagate.

MESSAGES
Customers may water their gardens: By hand, using a bucket or watering can. With greywater through a hosepipe. Using rainwater from a water butt by hand or through a hosepipe.

[7] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007

Storage tanks
Water drawn from the mains supply into tanks (other than hand held receptacles) for subsequent use for watering private gardens, lawns and landscaped areas via a hosepipe is not permitted.[8]
Methods for recycling water or finding water from alternative sources should be encourage for those concerned about the financial implications of not being able to use mains water[9].

Public Sector
Under the Water Act 2003, public authorities have a water conservation duty and arguably should not wait until restrictions come into force before taking water conservation measures.

STATUTORY EXEMPTIONS & CONCESSIONS

None

DISCRETIONARY EXEMPTIONS

- To Blue Badge holders on the grounds of disability
- Use of an approved drip or trickle irrigation system fitted with a PRV and timer
- To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge
- To water newly laid turf for first 28 days

Table 14 : Cleaning a private leisure boat using a hosepipe

DEFINITIONS

The category of activity under the temporary water use ban powers is "cleaning a private leisure boat using a hosepipe".

"Private leisure boat" means a vessel or other thing, other than a seaplane, which is designed, constructed or adapted to move through, in, on or over water.
The definition does not refer to such vessels:
a) used in the course of a business; or
b) made available or accessible to the public.

The definition of the activity does not include:
a) cleaning of any area of a private leisure boat which, except for doors or windows, is enclosed by a roof and walls; and
b) using a hosepipe to clean a private leisure boat for health or safety reasons.

Interpretation:
Boats in private ownership only are included, whether trailer launched or not[10]. The definition extends to small watercraft such as canoes, kayaks, jet skis etc. In naval terms,

[8] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007
[9] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007
[10] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007

a boat is small enough to be carried on another vessel (a ship). It is interpreted that ships and other large vessels such as cruise liners are normally used for commercial purposes so are not expected to come under this definition.

MESSAGES

Customers may wash such boats and vessels by hand, using a bucket.
The use of recycled water or rainwater is encouraged[11].

STATUTORY EXEMPTIONS & CONCESSIONS

A statutory exemption exists in The Water Use (Temporary Bans) Order 2010 for the cleaning of private leisure boats in respect of health or safety (see Section 5.7 of this report for further detail). This includes:
a) removing or minimising any risk to human or animal health or safety; and
b) preventing or controlling the spread of causative agents of disease.
Biosecurity concerns associated with the reduced washing of boat hulls, such as the introduction of non-native species to the UK, are therefore covered under this exemption.

DISCRETIONARY EXEMPTIONS

- Commercial cleaning
- Vessels of primary residence
- Cases where fouling is causing increased fuel consumption
- Engines designed to be cleaned with a hosepipe
- To prevent or control the spread of non-native and/or invasive species

Table 15 : Filling or maintaining a domestic swimming or paddling pool

DEFINITIONS

The category of activity under the temporary water use ban powers is "filling or maintaining a domestic swimming or paddling pool".

The Water Use (Temporary Bans) Order 2010 defines domestic swimming or paddling pool as a swimming or paddling pool, other than a pool that is being used for the purposes of a business, which is:
a) in a building or part of a building used principally as a dwelling; or
b) on any land or in any building that is used or enjoyed in connection with (a).

The definition excludes filling or maintaining a pool:
a) where necessary in the course of its construction;
b) using a hand-held container filled with water drawn directly from a tap;
c) that is designed, constructed or adapted for use in the course of a programme of medical treatment;
d) used for the purpose of decontaminating animals from infections or disease;
e) used in the course of a programme of veterinary treatment;
f) in which fish or other aquatic animals are being reared or kept in captivity.

[11] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007

Interpretation:
No formal definition of a swimming or paddling pool is provided but the intention appears to capture all pools that have a primary use that is not personal washing. No minimum size is specified. The restriction includes permanent and temporary facilities and whole or partial filling.

MESSAGES
Customers may fill swimming and paddling pools by hand, using a bucket. Customers may choose to use a public swimming pool as an alternative to a private pool. Public pools are not covered by this restriction. Use of alternative water sources, including rainwater, is permitted. Backwashing of swimming pool filters is not covered by these powers; it is the topping up of the pool to replace lost water that is covered.
STATUTORY EXEMPTIONS & CONCESSIONS
A number of statutory exemptions are defined for this activity (see definitions above).
DISCRETIONARY EXEMPTIONS
None

Table 16 : Drawing water, using a hosepipe, for domestic recreational use

DEFINITIONS
The Water Use (Temporary Bans) Order 2010 states that this activity refers to "drawing water, using a hosepipe, to operate water slides or other recreational equipment". "Domestic recreational use" means: a) recreational use in connection with a domestic swimming or paddling pool; or b) recreational use on land that is used or enjoyed in connection with a building, or part of a building, used principally as a dwelling, other than for the purposes of a business. Interpretation: This is interpreted to mean both slides designed to be used with water and any temporary or "ad-hoc" water slides or sprinklers. It is taken to refer to recreational use for both children and adults.
MESSAGES
Customers may use a bucket to fill similar recreational equipment, for example to enable children to play. Filling of recreational toys directly from a tap is not included. Many Local Authorities have recreational facilities for children in particular as part of their parks.
STATUTORY EXEMPTIONS & CONCESSIONS
None

DISCRETIONARY EXEMPTIONS
None

Table 17 : Filling or maintaining a domestic pond using a hosepipe

DEFINITIONS
"Domestic ponds" are defined by the Water Use (Temporary Bans) Order 2010 as a pond, including a swimming pond, on land that is used in connection with a building, or part of a building, used principally as a dwelling; and is not being used for the purposes of a business. The activity does not include filling or maintaining a pond in which fish or other aquatic animals are being reared or kept in captivity. Interpretation: The definition of both domestic and non-domestic ponds is interpreted to include both manmade and natural ponds of any size. It is assumed that the definition of both domestic and non-domestic ponds refer to both outdoor and indoor ponds including ornamental ponds. The activity covers both the filling and the topping up of these ponds.
MESSAGES
All ponds can be filled by the use of buckets. The use of rainwater or other alternative (non-potable) sources is permitted.
STATUTORY EXEMPTIONS & CONCESSIONS
Ponds in which fish and other aquatic animals are kept are exempt from this activity (see above for definition).
DISCRETIONARY EXEMPTIONS
• Blue Badge holders on the grounds of disability • To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge

Table 18 : Filling or maintaining an ornamental fountain

DEFINITIONS
"Ornamental fountains" are defined by the Water Use (Temporary Bans) Order 2010 as including a cascade or any other display of moving water Interpretation: The definition of both domestic and non-domestic ponds with fountains is interpreted to include both manmade and natural ponds of any size. The activity covers both the filling and the topping up of these fountains.

MESSAGES
All fountains can be filled by the use of buckets. The use of rainwater or other alternative (non-potable) sources is permitted.
STATUTORY EXEMPTIONS & CONCESSIONS
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.
DISCRETIONARY EXEMPTIONS
• To operate water features with religious significance

Table 19 : Cleaning walls, or windows, of domestic premises using a hosepipe

DEFINITIONS
The category of activity under the temporary water use ban powers is "cleaning walls, or windows, of domestic premises using a hosepipe". The Water Use (Temporary Bans) Order 2010 defines this category as applying only to the cleaning of the external walls or windows of domestic premises. The definition excludes cleaning activities for health or safety reasons. "Domestic premises" under this activity means: a) a building used principally as a dwelling or dwellings; b) a garage, shed, outbuilding or other building or structure used or enjoyed in connection with a building used principally as a dwelling; or c) a wall or other means of enclosure within the curtilage of a building used principally as a dwelling. Interpretation: This is interpreted to relate to all domestic building structures, whether they are permanent or temporary. Roofs are not interpreted as being covered, other than with respect to sky-light or similar windows. Domestic roofs are specifically covered under the Water Use (Temporary Bans) Order 2010 activity of 'cleaning other artificial outdoor surfaces using a hosepipe' .
MESSAGES
Customers may clean building walls and windows by hand, using a bucket.[12] If a building can be cleaned by permanent plumbing then it is still a permitted activity. Storage tanks Restrictions apply to water drawn from the mains supply after the statutory notice has been given. So water drawn into a container prior to that date may be used for cleaning the exterior of buildings[13]. Greywater and rainwater may be used to clean walls or windows.

[12] Consultation on proposed changes to powers to restrict non-essential uses of water, Defra, 2007
[13] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007

STATUTORY EXEMPTIONS & CONCESSIONS
A statutory exemption exists in The Water Use (Temporary Bans) Order 2010 for the cleaning of domestic walls or windows in respect of health or safety (see Section 5.7 of this report for further detail). This includes: a) removing or minimising any risk to human or animal health or safety; and b) preventing or controlling the spread of causative agents of disease. The grounds for an exemption for these purposes are considered to be rare – perhaps linked to accidents and incidents. Washing windows at height by hand should be minimised in order to reduce the risk of falls from height (Work at Height Regulations 2005).
DISCRETIONARY EXEMPTIONS
• To Blue Badge holders on the grounds of disability • Commercial cleaning • To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge

Table 20 : Cleaning paths or patios using a hosepipe

DEFINITIONS
The category of activity under the temporary water use ban powers is "cleaning paths or patios using a hosepipe". The definition excludes cleaning paths or patios using a hosepipe for health or safety reasons. Interpretation: It is interpreted to include the cleaning by hosepipe of all paths or patios by domestic customers. It is interpreted that this would include paths and patios made of any material such as concrete, paving slabs, stones, permeable paving etc.
MESSAGES
Customers can sweep paths or patios and they may wash them by hand using a bucket.
STATUTORY EXEMPTIONS & CONCESSIONS
A statutory exemption exists in The Water Use (Temporary Bans) Order 2010 for the cleaning of paths and patios in respect of health or safety (see Section 5.7 of this report for further detail). This includes: a) removing or minimising any risk to human or animal health or safety; and b) preventing or controlling the spread of causative agents of disease.
DISCRETIONARY EXEMPTIONS
• To Blue Badge holders on the grounds of disability • Commercial cleaning • To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge

Table 21 : Cleaning other artificial outdoor surfaces using a hosepipe

DEFINITIONS
The category of activity under the temporary water use ban powers is "cleaning other artificial outdoor surfaces using a hosepipe". The definition excludes cleaning an outdoor surface using a hosepipe for health or safety reasons. "Artificial outdoor surface" means any of the following: a) any area outdoors which is paved or laid with hard or artificial material; b) timber decking; c) a quay; d) a trailer designed, constructed or adapted to launch boats or other vessels or craft into water, other than a private motor-vehicle (see Figure A4.4); e) the roof of any domestic premises. "Quay" includes jetty, pontoon, wharf and slipway. Interpretation: It is interpreted to include the cleaning by hosepipe of all exterior surfaces, by domestic customers. This includes driveways (both domestic and non-domestic); and marine infrastructure such as pontoons and slipways, whether fixed permanently in position or floating[14].
MESSAGES
Customers can sweep outdoor surfaces and they may wash them by hand using a bucket.
STATUTORY EXEMPTIONS & CONCESSIONS
A statutory exemption exists in The Water Use (Temporary Bans) Order 2010 for the cleaning of artificial outdoor surfaces using a hosepipe in respect of health or safety (see Section 5.7 of this report for further detail). This includes: a) removing or minimising any risk to human or animal health or safety; and b) preventing or controlling the spread of causative agents of disease.
DISCRETIONARY EXEMPTIONS
• To Blue Badge holders on the grounds of disability • Commercial cleaning • To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge

[14] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007

6.2 Non-essential use bans

Non-essential use bans, commonly referred to as NEUBs, are a set of measures granted to water companies to impose further restrictions on the use of water as long as certain legislative tests are met. These powers are sought through applying for a drought order. The companies in WRSE have worked together to agree a common set of discretionary exceptions which we would apply when implementing a NEUB, and these are set out below. These are in addition to the statutory exceptions which are required to be applied to these restrictions by law, these are also set out below.

The table below lists the restriction categories that may be used to reduce demand during a drought if non-essential use bans are imposed. In order to do this we would apply for a drought order under the Water Resources Act 1991, as defined in the Drought Direction 2011.

Table 22 : Activities which would be restricted through the implementation of a non-essential use ban (NEUB)

SECTION	ACTIVITY/TITLE
Table 23	Watering outdoor plants on commercial premises
Table 24	Filling or maintaining a non-domestic swimming or paddling pool
Table 25	Filing or maintaining a pond
Table 26	Cleaning non-domestic premises
Table 27	Cleaning a window of a non-domestic building
Table 28	Operating a mechanical vehicle-washer
Table 29	Cleaning any vehicle, boat, aircraft or railway rolling stock
Table 30	Cleaning industrial plant
Table 31	Suppressing dust
Table 32	Operating cisterns in unoccupied buildings

Note the following information applies to these activities:

Legislation:

All ten drought orders are covered under the Water Resources Act 1991, as defined in the Drought Direction 2011.

Programme:

Constrained by application to the Secretary of State and a notice period. Approx. 8-12 weeks.

The following definitions apply to these activities:

"Using a hosepipe"

The Water Use (Temporary Bans) Order 2010 provides the definition of "using a hosepipe" in relation to the WIA 1991 as including:

a) Drawing relevant water through a hosepipe from a container and applying it for the purpose; and

b) Filling or partly filling a container with relevant water by means of a hosepipe and applying it for the purpose.

A reference to a hosepipe includes anything designed, adapted or used for the same purpose as a hosepipe.

"Relevant water"

Refers to mains water i.e. supplied by the water undertaker; it does not include water supplied before the water use restriction was implemented.

Table 23 : Watering outdoor plants on commercial premises

DEFINITIONS
The activity coming under ordinary drought order powers is defined in the Drought Direction 2011 as "watering outdoor plants on commercial premises using a hosepipe" which covers the following: i) plants which are in a pot or other container that is outdoors or under cover; ii) plants which are in the ground under cover. The activity does not include watering plants that are: i) grown or kept for sale or commercial use; or ii) part of a National Collection or temporary garden or flower display (see Figure A4.3 for definitions). "Commercial premises" means any land, building, other structure or premises not being domestic or other non-commercial premises within the meaning of the temporary use ban "Grown" includes cultivated or propagated. "Plants" includes plant organs, seeds, crops and trees. "Under cover" means in a greenhouse or outbuilding or under permanent canopy.
MESSAGES
Customers may water their gardens:

By hand, using a bucket or watering can.
With greywater through a hosepipe.
Using rainwater from a water butt by hand or through a hosepipe.

Storage tanks
Water drawn from the mains supply into tanks (other than handheld receptacles) for subsequent use for watering private gardens, lawns and landscaped areas via a hosepipe is not permitted.[15]

Methods for recycling water or finding water from alternative sources should be encouraged for those concerned about the financial implications of not being able to use mains water[16].

Public Sector
Under the Water Act 2003, public authorities have a water conservation duty and arguably should not wait until restrictions come into force before taking water conservation measures. Public sector actions such as not watering plants in public places will convey a clear message to public about the need to conserve supplies[17].

STATUTORY EXEMPTIONS & CONCESSIONS
None
DISCRETIONARY EXEMPTIONS
• Use of an approved drip or trickle irrigation system fitted with a PRV and timer which is set for use in the evening or night. • Water newly bought plants for the first 28 days after the implementation of the ban

Table 24 : Filling or maintaining a non-domestic swimming or paddling pool

DEFINITIONS
The water use purpose coming under ordinary drought order powers is "filling or maintaining a non-domestic swimming or paddling pool". The Drought Direction 2011 defines non-domestic swimming or paddling pool as a swimming or paddling pool, other than a domestic swimming or paddling pool as defined and covered by the WIA section 76(2)(e). The intention is that domestic pools should already have been restricted under temporary water use ban powers before a company seeks a drought order. The purpose excludes filling or maintaining a pool: a) that is open to the public; b) where necessary in the course of its construction; b) using a hand-held container which is filled with water drawn directly from a tap;

[15] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007
[16] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007
[17] Consultation on proposed changes to powers to restrict non-essential uses of water, Defra, 2007

c) that is designed, constructed or adapted for use in the course of a programme of medical treatment;
d) that is used for the purpose of decontaminating animals from infections or disease;
e) used in the course of a programme of veterinary treatment;
f) in which fish or other aquatic animals are being reared or kept in captivity;
g) that is for use by pupils of a school for school swimming lessons.

"Open to the public"
For the purposes of the exemption (a) above, a pool is not open to the public if it may only be used if the user is a paying member of an affiliated club or organisation; i.e. these pools are covered by this restriction.

Interpretation:
No formal definition of a swimming or paddling pool is provided but the intention appears to capture all pools that have a primary use that is not personal washing. No minimum size is specified. The restriction includes permanent and temporary facilities and whole or partial filling.

MESSAGES
Customers may fill swimming and paddling pools by hand, using a bucket. Public pools are not covered by the restrictions. Use of alternative water sources, including rainwater, is permitted. Backwashing of swimming pool filters is not subject to these powers.
STATUTORY EXEMPTIONS & CONCESSIONS
A number of statutory exemptions are defined for this activity (see definitions above).
DISCRETIONARY EXEMPTIONS
None

Table 25 : Filling or maintaining a pond

DEFINITIONS
"Domestic ponds" are defined by the Water Use (Temporary Bans) Order 2010 as a pond, including a swimming pond, on land that is used in connection with a building, or part of a building, used principally as a dwelling; and is not being used for the purposes of a business. The activity under both types of restriction does not include filling or maintaining a pond in which fish or other aquatic animals are being reared or kept in captivity. Additionally, the Drought Direction 2011 excludes filling or maintaining a pond using a hand-held container which is filled with water drawn directly from a tap. The Drought Direction 2011 activity of 'filling or maintaining a pond' excludes filling or maintaining a domestic pond using a hosepipe. The intention is that since this latter

activity is already covered specifically by the temporary use ban, it should have been implemented before a drought order is sought.
Interpretation:
The definition of both domestic and non-domestic ponds is interpreted to include both manmade and natural ponds of any size.

It is assumed that the definition of both domestic and non-domestic ponds refer to both outdoor and indoor ponds including ornamental ponds.
The activity covers both the filling and the topping up of these ponds.

MESSAGES
All ponds can be filled by the use of buckets. The use of rainwater or other alternative (non-potable) sources is permitted.
STATUTORY EXEMPTIONS & CONCESSIONS
Ponds in which fish and other aquatic animals are kept are exempt from this activity (see above for definition).
DISCRETIONARY EXEMPTIONS
None

Table 26 : Cleaning non-domestic premises

DEFINITIONS
The water use purpose coming under ordinary drought order powers is "cleaning non-domestic premises". The Drought Direction 2011 provides the definition of this activity as the cleaning of any of the following using a hosepipe: a) any exterior part of a non-domestic building other than a window; b) a non-domestic wall. It does not include the cleaning of any exterior part of a non-domestic building or a non-domestic wall for health or safety reasons. "Non-domestic building" is defined in the Drought Direction 2011 as any of the following not being domestic premises: a) a building that is not used principally as a dwelling or dwellings; b) any other structure. This definition does not include any domestic premises as defined and covered by the Water Use (Temporary Bans) Order 2010. "Non-domestic wall" means a wall or any other enclosing structure or partition which: i) does not form part of a non-domestic building; and ii) is not within the curtilage of a domestic building. Interpretation: Interpreted to relate to both permanent and temporary buildings and structures. Interpreted to include building roofs.
MESSAGES

Building cleaning may proceed by hand using water from a bucket.

Greywater and rainwater may be used.
Storage tanks
Restrictions apply to water drawn from the mains supply after the statutory notice has been given, so water drawn into a container prior to that date may be used for cleaning the exterior of buildings[18].

STATUTORY EXEMPTIONS & CONCESSIONS
The Drought Direction 2011 provides a statutory exemption for health or safety reasons. The definition of this includes: a) removing or minimising any risk to human or animal health or safety; and b) preventing or controlling the spread of causative agents of disease. The grounds for an exemption for these purposes are considered to be rare – perhaps linked to accidents and incidents.
DISCRETIONARY EXEMPTIONS
To remove graffiti by applying to the wholesale supplier

Table 27 : Cleaning a window of a non-domestic building

DEFINITIONS
Definitions: The activity coming under ordinary drought order powers is defined by the Drought Direction 2011 as "cleaning a window of a non-domestic building using a hosepipe other than for health or safety reasons". "Non-domestic building" is defined in the Drought Direction 2011 as any of the following not being domestic premises: a) a building that is not used principally as a dwelling or dwellings; b) any other structure. This definition does not include any domestic premises as defined and covered by the Water Use (Temporary Bans) Order 2010. Interpretation: Water-fed poles are frequently used by window cleaners and it is interpreted that they are included under the definition of hosepipes. These systems use de-ionised water. Where mains water is the source used to create this de-ionised water, this activity is restricted. The Inspector at the Mid Kent Water and Southern Water (Eastern area) ordinary drought order Hearings in 2006 indicated that window cleaners could argue that they are using water in a process (de-ionising) and so not covered by this restriction[19]. This has not been tested.

[18] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007
[19] Report to the Secretary of State for Environment, Food and Rural Affairs, Applications by Mid Kent Water Limited and Southern Water Services Limited for ordinary drought orders restrictions on the non-essential use of water

MESSAGES
Customers may clean windows by hand, using a bucket.[20] The use of rainwater is permitted.
STATUTORY EXEMPTIONS & CONCESSIONS
The Drought Direction 2011 provides a statutory exemption for health or safety reasons (see Section 5.7 of this report for further detail). The definition of this includes: a) removing or minimising any risk to human or animal health or safety; and b) preventing or controlling the spread of causative agents of disease. The grounds for an exemption for these purposes are considered to be rare – perhaps linked to accidents and incidents. Washing windows at height by hand should be minimised in order to reduce the risk of falls from height (Work at Height Regulations 2005).
DISCRETIONARY EXEMPTIONS
Small businesses whose sole operations are cleaning of windows using hosepipes

Table 28 : Operating a mechanical vehicle-washer

DEFINITIONS
The activity falls under ordinary drought order powers and is defined by the Drought Direction 2011 as "operating a mechanical vehicle-washer, whether automatic or not". Interpretation: Both Sutton and East Surrey Water and Thames Water appeared to consider that this restriction relates to mechanical car washers. At the 2006 Hearing for the drought order applications for Mid Kent Water and Southern Water, Esso submitted an objection on the grounds that reducing margins on fuel sales meant that the contribution of car washers to profitability was important to the continuing viability of these businesses. The Inspector did not find that this argument was convincing[21].
MESSAGES
Cars and other vehicles can still be washed using buckets or using other sources of water.
STATUTORY EXEMPTIONS & CONCESSIONS
Exemptions on bio security grounds may be warranted.
DISCRETIONARY EXEMPTIONS
None

[20] Consultation on proposed changes to powers to restrict non-essential uses of water, Defra, 2007
[21] Report to the Secretary of State for Environment, Rood and Rural Affairs, Applications by Mid Kent Water Limited and Southern Water Services Limited for ordinary drought orders restrictions on the non-essential use of water

Table 29 : Cleaning any vehicle, boat, aircraft or railway rolling stock

DEFINITIONS
The activity falls under ordinary drought order powers and is defined by the Drought Direction 2011 as "cleaning any vehicle, boat, aircraft or railway rolling stock using a hosepipe". It does not include such cleaning for health or safety reasons. "Boat" is defined by The Drought Direction 2011 as meaning a vessel or other thing which: a) is designed, constructed or adapted to move through, in, on or over water; and b) is not a private leisure boat within the meaning applied under the Temporary Use Ban. "Vehicle" is defined as any of the following which is not a private motor-vehicle within the meaning applied under the Temporary Use Ban: a) a vehicle designed, constructed or adapted for use on roads; or b) a trailer or other thing designed, constructed or adapted for attachment to a vehicle falling within (a) above. Interpretation: The restriction is not specifically limited to the cleaning of external surfaces so would include the use of a hosepipe to wash down an interior area. Interpreted to include all road vehicles including taxis and private hire vehicles, commercially owned trucks and utilities and public transport vehicles[22]. It is assumed that 'boats' includes small watercraft such as canoes, kayaks, jet skis etc. In naval terms, a boat is small enough to be carried on another vessel (a ship). It is interpreted that ships and other large vessels such as frigates and cruise liners would also be included in the ban. Railway rolling stock is interpreted to include passenger train cars, freight train cars, locomotives and tube trains. Aircraft are interpreted to include privately and commercially owned airplanes, helicopters, gliders and hot air balloons.
MESSAGES
Methods for recycling water or finding water from alternative sources should be used for those concerned about the financial implications of not being able to use mains water[23]. Greywater and rainwater may be used.

[22] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007
[23] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007

Storage tanks
Restrictions apply to water drawn from the mains supply after the statutory notice has been given, so water drawn into a container prior to that date may be used for cleaning[24].

STATUTORY EXEMPTIONS & CONCESSIONS
The Drought Direction 2011 provides a statutory exemption for health or safety reasons. The definition of this includes: a) removing or minimising any risk to human or animal health or safety; and b) preventing or controlling the spread of causative agents of disease. Biosecurity concerns associated with the reduced washing of boat hulls, such as the introduction of non-native species to the UK, are therefore covered under this exemption.
DISCRETIONARY EXEMPTIONS
None

Table 30 : Cleaning industrial plant

DEFINITIONS
The activity coming under ordinary drought order powers is defined by the Drought Direction 2011 as "cleaning industrial plant using a hosepipe other than for health or safety reasons". Interpretation: Companies may identify industrial customers separately to other commercial customers. Local planning designations may also identify industrial locations. Plant is interpreted to mean: "The equipment, including machinery, tools, instruments and fixtures necessary for an industrial operation[25]". This restriction is not interpreted to apply to normal industrial and manufacturing processes and necessary housekeeping, as the impacts of such a wide definition would be significant. Water companies may wish to seek guidance from a legal advisor to clarify this interpretation.
MESSAGES
Customers may clean such industrial plant by hand using a bucket. The use of greywater and rainwater is permitted.

[24] Summary of responses to the consultation, between 23 March and 15 June 2007, on proposed changes to powers to restrict non-essential uses of water, Defra, 2007
[25] Adapted from http://www.thefreedictionary.com/Plant

The use of water drawn into containers prior to the commencement of the restriction is allowed.
STATUTORY EXEMPTIONS & CONCESSIONS
The Drought Direction 2011 provides a statutory exemption for health or safety reasons. The definition of this includes: a) removing or minimising any risk to human or animal health or safety; and b) preventing or controlling the spread of causative agents of disease.
DISCRETIONARY EXEMPTIONS
Biosecurity reasons

Table 31 : Suppressing dust

DEFINITIONS
The activity coming under ordinary drought order powers is defined by the Drought Direction 2011 as "suppressing dust using a hosepipe other than for health or safety reasons". Interpretation: This covers both domestic and non-domestic areas and all surfaces.
MESSAGES
Customers should use alternative, non-potable sources of water for dust suppression, such as recycled, greywater or rainwater. This is particularly the case where dust suppression is a necessary part of a business process. Customers may use a bucket for the purposes of dust suppression, although it should be noted that the practicality of this may be limited to small scale operations.
STATUTORY EXEMPTIONS & CONCESSIONS
The Drought Direction 2011 provides a statutory exemption for health or safety reasons. The definition of this includes: a) removing or minimising any risk to human or animal health or safety; and b) preventing or controlling the spread of causative agents of disease.
DISCRETIONARY EXEMPTIONS
None

Table 32 : Operating cisterns in unoccupied buildings

DEFINITIONS
Definition: The activity coming under ordinary drought order powers is defined by the Drought Direction 2011 as "operating a cistern in any building that is unoccupied and closed".

"Cistern" is defined as meaning an automatically-operated flushing cistern which services a water closet pan or urinal.
Interpretation:
Occupation by security staff is interpreted to comprise a building that is "unoccupied".

MESSAGES

There are existing water efficient devices that customers can install to comply with this restriction, for example by installing controls to only flush after use or at certain times of day.
Waterless urinals, greywater or rainwater systems can also be fitted.
Customers will benefit from cost savings in the short and long term due to reduced water consumption.

STATUTORY EXEMPTIONS & CONCESSIONS

None

DISCRETIONARY EXEMPTIONS

None

7 Drought permit screening process

This appendix explains the process we have taken to select the list of drought permits for our new Drought Plan.

As described in Section 9.5 of our main Drought Plan, an in-depth selection and screening process was undertaken to establish which drought permits to take forward for our new Drought Plan. This process took into account both environmental and operational considerations, with input from key people across the business at an early stage. An important factor was that the chosen sites would be operationally ready to produce the permitted volume within six months of being required by the start of this plan (2023), whilst preference was given to less environmentally sensitive permit sites. Recent experiences and learning from investigations were factored into the decision-making process.

The level of resilience and volumes required through our selection of drought permits is driven by modelling for our WRMP19. This indicates that we need to be able to draw upon 26.29 Ml/d from drought permit sources to be resilient to a drought event with up to a 1:200 year return period in the year 2022-2023. The impacts of these, more severe drought events, are uncertain and this uncertainty is compounded by the increase in demand which we have seen in relation to recent warm years and, in particular, the impacts of Covid 19. Whilst this is still emerging and the assessment of potential long term impacts is still being carried out, it is likely that the background demand patterns will continue to be higher than those which were modelled for our WRMP19 for some time. As a result of these uncertainties, we have identified and included a further 20Ml/d of drought permits within this Drought Plan. As indicated below, we have separated our permits for our Central region into two categories, and increased the potential frequency of application to between 1 in 40 and 1 in 100 years for the Category 1 drought permits. In real terms, this means that we would be resilient to droughts well into Drought Zone 3 at Lilley Bottom, or to put it another way, a drought event more severe than that experienced in 1997, before we needed to apply for any of the drought permits that we have identified.

Due to the implementation of demand management, capital investment and leakage reduction measures through AMP7, the amount of permits that modelling for WRMP19 suggests is required to provide resilience under our design drought event decreases year on year, as shown in Table 33. This cumulates with planned completion of the Sundon conditioning plant in the last year of AMP7, beyond which, we aim for drought permits not be required for a 1:200 year drought event. For more extreme drought events, drought permits will still be required.

Table 33 : Progression of drought permit volumes needed through AMP7

	2020-21	2021-22	2022-23	2023-24	2024-25
Total DP Volume - Central (Ml/d)	70.38	56.02	26.29	9.04	0.00

New drought plan active

When considering options for drought permit sites we assessed the sites already listed in our Drought Plan (2019), as well as potential new options for sites not previously listed as drought permits.

A long list of potential drought permits sites was compiled through internal workshops. Following this, a screening process was then carried out to narrow the list down, whilst still meeting the identified volume requirements as described above. During this screening process the following elements were considered:

- Current drought permit sites were assessed in terms of previous environmental assessment work carried out to evaluate significance of potential impacts. Potentially significant environmental impacts substantially reduced the favourability of drought permit sites.
- The location of sources was considered, in terms of catchment position. This was an important consideration in relation to sensitive chalk streams
- Where possible we removed or reduced the volumes of drought permit options from highly sensitive catchments (e.g. Ver, Beane)
- We took into account consideration of the outcomes of AMP6 environmental investigation work and the associated greater conceptual understanding of catchments which has been gained
- We took into consideration sites where river augmentation is available as a potential direct mitigation option – taking on board stakeholder views of augmentation as a favourable option
- The levels of certainty associated with environmental impacts was considered. Where certainty of environmental impacts is low, grouping was carried out based on expert judgement. The specific prioritisation of drought permit sites based on environmental impacts will be completed at a later stage once further work on environmental assessment has been carried out, and the associated environmental assessment reports completed.
- We considered network criticality – taking into account areas which are potentially more vulnerable to drought, with consideration of the supply demand balance
- A number of operational considerations were taken into account – for example water quality, operational site readiness, pumping considerations, treatment availability, and water supply network constraints
- The level of certainty associated with abstraction volumes available during drought conditions at specific sites, based on their use during historic droughts

Strategic Environmental Assessment

Following completion of the public consultation for our draft Drought Plan in 2021, we made the decision to carry out a Strategic Environmental Assessment (SEA) on the options identified within our Drought Plan. This took a two-phased approach, the first of which was to carry out a preliminary assessment of the unconstrained list of options which had been considered for potential drought permits. This assessment confirmed that the nine options which were initially included in the draft Drought Plan were appropriate to take through to the constrained list of options, based on their potential environmental impact. Please see our SEA Environmental Report for further information about the approach we used and the full outcomes of this work.

8 Drought permit environmental assessments

This Appendix provides summaries of the environmental assessment reports (EARs) for our sources that may be subject to a drought permit or drought order application in the event of a serious drought event.

List of Tables:

These EARs will remain provisional and will be updated on an annual basis when necessary to reflect new data collected or changing conditions. The reports have been prepared in close consultation with the Environment Agency, and are intended to fulfil the requirement that we are as close to 'application ready' as possible, in accordance with the EA Drought Plan Guideline Extra Information (2020). The full reports are available to view upon request.

Table 34 : Summary of environmental assessment of RUNGS drought permit

	CATEGORY	SUMMARY
Supply side action information	Action to increase water supply	Increase abstraction by 5.3 Ml/d
	Trigger	Drought trigger 3
	Additional Deployable Output of action	Additional 5.3 Ml/d
	Catchment/Location	River Lea (RUNGS)
	Water resource unit	Lower Greensand
	Implementation timetable	Additional drought monitoring to commence when DTZ 2 is breached. Discussion for lifting provisions to commence when in or approaching DTZ 3 and all other supply options have been implemented other than drought orders and permits with higher environmental impacts.

	CATEGORY	SUMMARY
	Permissions required and constraints	Approval from the Environment Agency is required. Relevant discussions will be held with the Environment Agency in advance of an application. Discussions will also be held with the local interest groups and stakeholders.
	Risks associated with option	The associated risks are environmental and detailed below.
Summary of environmental assessment	Level of risk to the environment	Low
	Summary of likely environmental impacts	Potential limited drawdown of groundwater levels in immediate local area. No long-term impacts from temporary increased abstraction are anticipated.
	Is option likely to have a significant effect on any European designated site(s) or any SSSIs?	There are two SSSI's which have been identified as experiencing potential temporary and moderate (uncertain) effects.
	Baseline information used	Affinity Water: Previous AMP 4 and AMP 5 studies. Water quality sampling and groundwater level monitoring. Groundwater modelling outputs.
		Environment Agency: Standard Environment Agency Biosys data, 1 River gauging station flow and water level data, EA monthly groundwater level monitoring, Water Framework Directive (WFD) classification data
	Summary of additional baseline monitoring requirements	The following monitoring activities will be implemented in the lead up to and during the drought permit period. Monthly walk-over surveys to commence in DTZ 2, the frequency of future surveys to be agreed in consultation with the Environment Agency.
	Mitigation measures	Feature, location, species and community specific mitigation measures where necessary with agreement from the EA.
	Impact on other activities	No other activities are expected to be impacted on. The impacts on other permitted rights of abstraction are likely to be negligible.

Table 35 : Summary of environmental assessment of THUN drought permit

	CATEGORY	SUMMARY
Supply side action information	Action to increase water supply	Relaxation of low flow constraint associated with licence, increase of abstraction.
	Trigger	DTZ 3 or 4
	Additional Deployable Output of action	Additional 4.91 Ml/d
	Catchment/Location	River Rib (THUN)
	Water resource unit	Chalk groundwater
	Implementation timetable	Additional drought monitoring to commence when DTZ 2 is breached. Discussion for lifting provisions to commence when in or approaching DTZ 3 and all other supply options have been implemented other than drought orders and permits with higher environmental impacts.
	Permissions required and constraints	Approval from the Environment Agency is required. Relevant discussions will be held with the Environment Agency. Discussions will also be held with the local interest groups.
	Risks associated with option	The associated risks are environmental and detailed below.
Summary of environmental assessment	Level of risk to the environment	Low
	Summary of likely environmental impacts	Potential impacts on water flows and quality for reaches in the Rivers Rib, Lea and Ash. If reaches are already dry at time of implementation, potential delays in recovery of flows.
	Is option likely to have a significant effect on any European designated site(s) or any SSSIs?	No
	Baseline information used	Affinity Water: Quarterly river photos. Previous AMP 4 and AMP 5 studies. Water quality sampling and groundwater level monitoring. Groundwater modelling outputs.
		Environment Agency: Standard Environment Agency Biosys data, 1 River gauging station flow and water level data, EA monthly groundwater level monitoring, Water Framework Directive (WFD) classification data, macroinvertebrate surveys 3 three times per year and fisheries surveys at 3 locations.

	CATEGORY	SUMMARY
	Summary of additional baseline monitoring requirements	The following monitoring activities will be implemented in the lead up to and during the drought permit period. Monthly walk-over surveys to commence in DTZ 2, the frequency of the surveys will increase as DTZ 3 is breached. Spot gauging to be carried out monthly in DTZ 2 and DTZ 3, increasing to fortnightly in DTZ 4 and/or whilst drought permit is in operation.
	Mitigation measures	Fish rescues by the EA with support from Affinity Water where necessary. Additional feature, location, species and community specific mitigation measures where necessary with agreement from the EA.
	Impact on other activities	No other activities are expected to be impacted on. The impacts on other permitted rights of abstraction are likely to be negligible.

Table 36 : Summary of environmental assessment of PICC drought permit

	CATEGORY	SUMMARY
Supply side action information	Action to increase water supply	Increase PICC abstraction to pre-SR volumes.
	Trigger	DTZ 3 or 4 and after all available supply side options have been implemented and drought permits with lower environmental impact have been utilised.
	Additional Deployable Output of action	PICC – Additional 6.4 Ml/d
	Catchment/Location	River Gade (PICC source)
	Water resource unit	Chalk groundwater
	Implementation timetable	Additional drought monitoring to commence when DTZ 2 is breached. Discussion for lifting provisions to commence when in or approaching DTZ 3 and all other supply options have been implemented other than drought orders and permits with higher environmental impacts.
	Permissions required and constraints	Permission from the Environment Agency is required. Pre-application discussions will be held with the Environment Agency. Discussions will also be held with Local and Parish Councils and other local interest groups. A public hearing might be required, should objections be received.

	CATEGORY	SUMMARY
	Risks associated with option	The associated risks are environmental and detailed below.
Summary of environmental assessment	Level of risk to the environment	Medium
	Summary of likely environmental impacts	Potential reduction of flows in the River Gade, potential for fish entrapment behind weirs/barriers and increased sediment deposition. Possible deterioration of macroinvertebrates status. Potential extension of the dried out reaches downstream and delay in the recovery of the dried out reaches post-drought.
	Is option likely to have a significant effect on any European designated site(s) or any SSSIs?	No
	Baseline information used	Affinity Water: Quarterly river photos at 5 locations and 8 groundwater level monitoring locations. 8 monthly spot gauging locations. 3 surface water level loggers. 8 bi-annual macroinvertebrate monitoring locations, and 4 bi-annual macrophyte monitoring points. 1 water quality sample point. Previous AMP studies. Groundwater modelling outputs.
		Environment Agency: Standard Environment Agency Biosys data, 2 River gauging station flow, 7 EA monthly groundwater level monitoring locations, Water Framework Directive (WFD) classification data, bi-annual macroinvertebrate surveys at 10 locations and tri-annual at 2 locations and fisheries surveys at 3 locations.
	Summary of additional baseline monitoring requirements	The following monitoring activities will be implemented in the lead up to and during the drought permit period. Monthly walk-over surveys to commence in DTZ 2, the frequency of the surveys will increase as DTZ 3 and 4 are breached. Spot gauging to be carried out monthly in DTZ 2 and DTZ 3, increasing to fortnightly in DTZ 4 and/or whilst drought permit is in operation.
	Mitigation measures	Fish rescues by the EA with support from Affinity Water where necessary. Numerous projects to be carried out by AW to improve drought resilience of river, including artificial narrowing of the channel, removal of weirs Additional feature, location, species

	CATEGORY	SUMMARY
		and community specific mitigation measures where necessary with agreement from the EA.
	Impact on other activities	No other activities are expected to be impacted on.

Table 37 : Summary of environmental assessment of WHIH drought permit

	CATEGORY	SUMMARY
Supply side action information	Action to increase water supply	Abstract pre-SR volume at WHIH
	Trigger	DTZ 3 or 4
	Additional Deployable Output of action	Additional 14.82 Ml/d
	Catchment/Location	River Beane
	Water resource unit	Chalk groundwater
	Implementation timetable	Drought monitoring is to start when DTZ 2 is breached. Discussion for lifting provisions will commence when in or approaching DTZ 3 and the application for the permits higher on the list have been submitted.
	Permissions required and constraints	Permission from the Environment Agency is required. Pre-application discussions will be held with the Environment Agency.
	Risks associated with option	The associated risks are environmental and detailed below.
Summary of environmental assessment	Level of risk to the environment	Medium
	Summary of likely environmental impacts	Potential reduction in river flows in the River Beane and Stevenage Brook. An extension of the period of recovery in flows. This may cause impacts and/or delays in recoveries of macroinvertebrate, macrophyte and fish communities.
	Is option likely to have a significant effect on any European designated site(s) or any SSSIs?	No
	Baseline information used	Affinity Water: Quarterly river photos at 17 locations. Groundwater level monitoring at 6 locations. Bi-annual macroinvertebrate monitoring at 8 locations, and macrophyte monitoring at 9 locations. Monthly

	CATEGORY	SUMMARY
		spot gauging at 13 locations. Weekly water quality sampling at 4 locations. Previous AMP studies. Groundwater modelling outputs.
		Environment Agency: Standard Environment Agency Biosys data, 2 River gauging stations flow, 15 EA monthly groundwater level monitoring locations, Water Framework Directive (WFD) classification data, macroinvertebrate surveys Bi-annual at 10 points and tri-annual at 2 points, fisheries surveys at 3 locations.
	Summary of additional baseline monitoring requirements	Walk-over surveys to identify affected locations (EA and AW), spot gauging at 19 locations to be carried out monthly in DTZ 2 and DTZ 3, increasing to fortnightly in DTZ 4 and/or whilst drought permit is in operation.
	Mitigation measures	Fish rescues by EA with support from Affinity Water where required. Numerous projects to be carried out by AW to improve drought resilience of river, including artificial narrowing of the channel and removal of weirs. Additional feature, location, species and community specific mitigation measures where necessary with agreement from the EA.
	Impact on other activities	No other activities are expected to be impacted on. The impacts on other permitted rights of abstraction are likely to be negligible

Table 38 : Summary of environmental assessment of AMER drought permit

	CATEGORY	SUMMARY
Supply side action information	Action to increase water supply	Abstract pre-SR peak DO at AMER
	Trigger	DTZ 3 or 4 and after all available supply side options have been implemented and drought permits with lower environmental impact have been utilised.
	Additional Deployable Output of action	Additional 8 Ml/d
	Catchment/Location	River Misbourne (AMER)
	Water resource unit	Chalk groundwater
	Implementation timetable	Additional drought monitoring to commence when DTZ 2 is breached. Discussion for lifting provisions to commence when in or approaching DTZ 3 and all other supply options have been implemented other

	CATEGORY	SUMMARY
		than drought orders and permits with higher environmental impacts. A public hearing might be required, should objections be received.
	Permissions required and constraints	Permission from the Environment Agency is required. Pre-application discussions will be frequently held with the Environment Agency. Discussions will also be held with Chilterns Chalk Streams Project, Chilterns Society, Misbourne River Action and Local and Parish Councils.
	Risks associated with option	The associated risks are environmental and detailed below.
Summary of environmental assessment	Level of risk to the environment	Low
	Summary of likely environmental impacts	Potential reduction in flows and water quality in the River Misbourne with potential increased lengths of dry riverbed, as well potential reduction in flows in the River Chess. Possible delays in recovery of flows in the River Misbourne after the drought. Potential associated impacts on ecological communities including fish, macroinvertebrates and macrophytes.
	Is option likely to have a significant effect on any European designated site(s) or any SSSIs?	No
	Baseline information used	**Affinity Water:** Quarterly river photos at 8 locations and 12 monthly groundwater level monitoring locations. Monthly spot gauging at 16 locations. 1 water quality sample point. Bi-annual macroinvertebrate monitoring at 15 locations. Previous AMP studies.
		Environment Agency: Standard Environment Agency Biosys data, 2 River gauging station flow and 1 water level logger, 18 EA monthly groundwater level monitoring locations, Water Framework Directive (WFD) classification data, 4 bi-annual macroinvertebrate surveys and 1 tri-annual survey at 4 locations, macrophyte surveys at 16 locations, fisheries surveys at 3 locations. Groundwater modelling outputs.
	Summary of additional baseline monitoring requirements	The following monitoring activities will be implemented in the lead up to and during the drought permit period. Monthly walk-over surveys to commence in DTZ 2, the frequency of the surveys will increase as DTZ 3 and 4 are breached. Spot gauging

	CATEGORY	SUMMARY
		at 12 locations to be carried out monthly in DTZ 2 and DTZ 3, increasing to fortnightly in DTZ 4 and/or whilst drought permit is in operation.
	Mitigation measures	Fish rescues by EA with support from Affinity Water where required. Numerous projects to be carried out by AW to improve drought resilience of river, including artificial narrowing of the channel and removal of weirs. Additional feature, location, species and community specific mitigation measures where necessary with agreement from the EA.
	Impact on other activities	No other activities are expected to be impacted on

Table 39 : Summary of environmental assessment of FULL drought permit

	CATEGORY	SUMMARY
Supply side action information	Action to increase water supply	Abstract up to pre-SR peak DO at FULL
	Trigger	DTZ 3 or 4 and after all available supply side options have been implemented and drought permits with lower environmental impact have been utilised.
	Additional Deployable Output of action	Additional 9 Ml/d
	Catchment/Location	River Mimram (FULL)
	Water resource unit	Chalk groundwater
	Implementation timetable	Additional drought monitoring to commence when DTZ 2 is breached. Discussion for lifting provisions to commence when in or approaching DTZ 3 and all other supply options have been implemented other than drought orders and permits with higher environmental impacts. A public hearing might be required, should objections be received. If FULL is out of service at the time of application, it would require a minimum lead time of 6 months to account for recommissioning of source. When the source is already in use the drought permit will be able to be implemented immediately.
	Permissions required and constraints	Permission from the Environment Agency is required. Pre-application discussions will be frequently held with the Environment Agency. Discussions will also be held with Friends of the Mimram and local Parish

	CATEGORY	SUMMARY
		Councils. A public hearing might be required, should objections be received.
	Risks associated with option	The associated risks are environmental and detailed below.
Summary of environmental assessment	Level of risk to the environment	Low
	Summary of likely environmental impacts	Potential temporary impacts on flows and water quality in River Mimram and River Lea if affected reaches are still flowing at the time of implementation. Potential delay in recovery of flows post drought. Potential associated impacts on ecological communities including fish, macroinvertebrates and macrophytes.
	Is option likely to have a significant effect on any European designated site(s) or any SSSIs?	Potential temporary impacts identified for Tewinbury SSSI.
	Baseline information used	Affinity Water: Quarterly river photos at 10 locations, 13 hourly groundwater level monitoring locations, monthly spot gauging at 13 locations. Bi-annual macroinvertebrate surveys at 17 locations, annual macrophyte surveys at 8 locations. Previous AMP studies.
		Environment Agency: Standard Environment Agency Biosys data, 3 River gauging station flow, 19 EA monthly groundwater level monitoring locations, Water Framework Directive (WFD) classification data, 5 bi-annual macroinvertebrate surveys and 2 tri-annual survey at 7 locations, fisheries surveys at 3 locations. Groundwater modelling outputs.
	Summary of additional baseline monitoring requirements	The following monitoring activities will be implemented in the lead up to and during the drought permit period. Monthly walk-over surveys to commence in DTZ 2, the frequency of the surveys will increase as DTZ 3 and 4 are breached. Spot gauging at 14 locations to be carried out monthly in DTZ 2 and DTZ 3, increasing to fortnightly in DTZ 4 and/or whilst drought permit is in operation.
	Mitigation measures	Fish rescues by the EA if required. Numerous projects to be carried out by AW to improve drought resilience of river, including artificial narrowing of the channel and removal of weirs.
	Impact on other activities	No other activities are expected to be impacted on

Table 40 : Summary of environmental assessment of SLYE, SDRE and SBUC drought permits

	CATEGORY	SUMMARY
Supply side action information	Action to increase water supply	Release of low flow constraints on licences
	Trigger	DTZ 3 or 4 Drought Trigger and after all available supply side options and drought permits with lower environmental impacts have been implemented.
	Additional Deployable Output of action	Additional 7.5 Ml/d
	Catchment/Location	River Dour (SDRE, SLYE, SBUC)
	Water resource unit	Chalk groundwater
	Implementation timetable	Drought monitoring is to start when DTZ 2 is breached. Discussion for lifting provisions will commence when in or approaching DTZ 3.
	Permissions required and constraints	Permission from the Environment Agency is required. Pre-application discussions will be frequently held with the Environment Agency. Discussions will also be held with the Dour Steering Group.
	Risks associated with option	The associated risks are environmental and detailed below.
Summary of environmental assessment	Level of risk to the environment	Low
	Summary of likely environmental impacts	Potential impacts on flows and water quality if affected reaches are still flowing at the time of implementation. Potential delay to rewetting of the river at the end of a drought. Associated impacts on ecological communities including fish, macroinvertebrates and macrophytes.
	Is option likely to have a significant effect on any European designated site(s) or any SSSIs?	No
	Baseline information used	Affinity Water: Quarterly river photos at 6 locations. Spring and autumn macroinvertebrate and macrophyte monitoring. Previous AMP studies.
		Environment Agency: Standard Environment Agency Biosys data, Hydroecological Validation (HEV) analysis, 2 River gauging stations flow , 27 EA monthly

	CATEGORY	SUMMARY
		groundwater level monitoring locations, Water Framework Directive (WFD) classification data, fisheries surveys at 3 locations.
	Summary of additional baseline monitoring requirements	Walk-over survey to identify affected locations (EA and AW), spot gauging monthly at 3 locations during Drought Zone 3 and fortnightly during drought provision duration.
	Mitigation measures	Mitigation will occur initially through compliance with low flow licence conditions.
	Impact on other activities	No other activities are expected to be impacted on. The impacts on other permitted rights of abstraction are likely to be negligible.

9 Environmental monitoring

This appendix contains information relating to environmental monitoring, including business-as-usual monitoring and the potential enhanced drought monitoring programme and mitigation.

The sections within this appendix are listed below:

Locations of River Monitoring Photographs

Table 41: Locations of environmental monitoring photographs

External Monthly Hydrological Data

Table 42: Key datasets received and analysed for the Affinity Water Monthly Water Situation Report

Potential Enhanced Drought Permit Monitoring Schedules

Table 43: Summary of enhanced drought monitoring for River Rib

Table 44: Summary of enhanced drought monitoring for River Gade

Table 45: Summary of enhanced drought monitoring for River Beane

Table ***46***: Summary of enhanced drought monitoring for River Misbourne

Table 47: Summary of enhanced drought monitoring for River Mimram

Table 48: Summary of enhanced drought monitoring for River Dour

The proposed drought monitoring plans are incorporated into the relevant Environmental Assessment Reports (EARs), which are in draft stage – these will remain as drafts until such time as they are needed for drought permit applications during a drought. These plans will be updated following further consultation and engagement with the EA. It is therefore possible that the proposed monitoring plans will change, and the below sections will be updated accordingly.

9.1 River monitoring photograph locations

Environmental impact monitoring photographs have been taken consistently at a number of key locations, in the key catchments in our area, since 1998. These photographs are taken quarterly, to cover each of the seasons. The River Dour photograph monitoring sequence commenced in March 2015.

Table 41: Locations of Environmental Impact Monitoring Photographs

RIVER	PHOTO NUMBER	DESCRIPTION
Ash	Ash02	Downstream, Next to sewage works, Furneux Pelham

RIVER	PHOTO NUMBER	DESCRIPTION
Ash	Ash03	Downstream, From Parsonage Lane Bridge, Albury
Ash	Ash04	Downstream, Hadham Ford, Little Hadham
Ash	Ash05	Downstream, From Winding Hill Bridge, Much Hadham
Ash	Ash06	Downstream, From the End of Pegs Lane Widford
Ash	Ash08	Downstream, From Hollycross Road Bridge, Near Ware
Ashwell Springs	Ashwell01	Down steps at Ashwell Springs SSSI
Beane	Beane02	Downstream from road bridge over river
Beane	Beane03	Downstream from road looking under road bridge, Cromer
Beane	Beane04	Downstream from road bridge, next to Walkern Mill
Beane	Beane05	Downstream from Road, Aston
Beane	Beane06	Downstream from ford next to WHIH 1
Beane	Beane07	Downstream from road bridge looking towards Watton-at-Stone
Beane	Beane08	Downstream from Church Lane bridge, Stapleton
Beane	Beane09	Downstream from Vicarage Road Bridge, Waterford
Beane	Beane10	Upstream from bridge over river to car Park, Hartham (Hertford)
Bulbourne	Bulbourne01	Upstream from Boswick Lane bridge, Dudswell
Bulbourne	Bulbourne02	Upstream from New Road (B4506) Bridge, Berkhamsted
Bulbourne	Bulbourne03	Downstream from Bank Mill Lane, Berkhamsted
Bulbourne	Bulbourne04	Downstream from Little Heath Lane, near Bourne End
Bulbourne	Bulbourne05	Downstream from Two Waters Road, Hemel Hempstead (near confluence with Gade)
Cam	Cam01	Upstream, from North Hall Road Bridge, near Henham
Cam	Cam02	Downstream, from Crabtree Hill Bridge, near Widdington
Cam	Cam04	Upstream, from Sparrowsend Hill bridge, Wendens Ambos

RIVER	PHOTO NUMBER	DESCRIPTION
Cam	Cam05	Downstream, From Walden Road bridge, Wendens Ambos
Cam	Cam06	Downstream, from Walden Road Bridge, Littlebury
Cam	Cam07	Downstream, from road bridge (off the B1383) in Little Chesterford
Chess	Chess01	The source, river runs along Missenden Road and disappears by a house outside Chesham
Chess	Chess02	Bury Pond, This also feeds the upper reaches of The Chess
Chess	Chess03	Waterside, From a Bridge which crosses the river by a weir
Chess	Chess04	Latimer Road and Stoney Lane cross roads, bridge where the river joins the lake in Latimer Park.
Chess	Chess05	River from public footpath which both run next to CHOR
Chess	Chess06	Rickmansworth, off A412 Next to playing field by bridge where Chess Flows under A412
Colne	Colne01	Mimmshall Brook, North Mymms Park
Colne	Colne02	Upstream from B556 Courses Road bridge Colney Heath
Colne	Colne03	Upstream Watery Lane Bridge Broad Colney
Colne	Colne04	Upstream Near Drop Lane Bricket Wood confluence with Ver
Colne	Colne05	Downstream from Bushey Mill Lane bridge Watford
Gade	Gade01	Upstream from road bridge at Hudnall Corner
Gade	Gade03	Upstream from bridge near Red Lion pub, Water End
Gade	Gade05	Downstream from road bridge, confluence with Grand Union Canal
Hiz	Hiz05	River Hiz from Cadwell Lane, downstream, next to sewage works
Hiz	Hiz06	River Oughton (Oughton Head) from Oughtonhead Lane (Footpath) off Hitchin Road. Looking downstream.
Hiz	Hiz07	River Hiz from Arlesey Road bridge, Cadwell. Looking downstream
Hiz	Hiz08	River Hiz from Mill Lane, Arlesey. Looking downstream

RIVER	PHOTO NUMBER	DESCRIPTION
Hiz	Hiz09	River Hiz from the A6001 Langford. Looking downstream
Ivel	Ivel01	River Ivel Navigation, Near Clifton, up & downstream
Ivel	Ivel02	River Ivel, from B658 road bridge south of Biggleswade
Lee	Lee03	Downstream from Osbourne Road bridge Luton
Lee	Lee04	Downstream from Cooters End Lane East Hyde
Lee	Lee06	Downstream from B651 Station Road bridge Wheathampstead
Mimram	Mimram02	Downstream from road next to Nine Wells Watercress Farm, Whitwell
Mimram	Mimram03	Downstream from The Valley bridge, Whitwell
Mimram	Mimram06	Downstream from road at Kimpton Mill
Mimram	Mimram07	Downstream, view across St. Albans Road Ford (Pulmer Water)
Mimram	Mimram08	Upstream from High Street bridge, Welwyn
Mimram	Mimram09	Upstream from A1000 road bridge, near Digswell
Mimram	Mimram10	Downstream from Digswell Park Road bridge, near Digswell
Misbourne	Misbourne03	Downstream from road bridge in Little Missenden
Misbourne	Misbourne05	Downstream from Bottom House Farm Lane, Off A413
Misbourne	Misbourne06	Upstream from Pheasant Hill bridge next to The Pheasant Inn, Chalfont St. Giles
Misbourne	Misbourne08	Downstream from Old Mill Road bridge, Denham (near confluence with the Colne)
Quin	Quin01	Upstream from Bull Lane, Buckland
Quin	Quin04	Upstream at Cross road to west of Nuthampstead
Quin	Quin07	Downstream from Station road, Braughing
Rib	Rib01	Upstream from road in reed end, near source
Rib	Rib02	Downstream from bridge over river to entrance to Hodenhoe Manor
Rib	Rib04	Downstream, road bridge near Westmill Bury, Westmill
Rib	Rib05	Upstream from A120 road bridge, Standon

RIVER	PHOTO NUMBER	DESCRIPTION
Rib	Rib06	Downstream, Barwick Ford
Rib	Rib07	Upstream from A10 footbridge over river, Wadesmill
Rib	Rib08	Downstream from access road bridge to Paynes Hall, (off A602) Westmill.
Stort	Stort02	Downstream from road bridge at Stickling Green
Stort	Stort03	Downstream from Poor Bridge, south of Clavering
Stort	Stort04	Downstream from The Street bridge, Manuden
Stort	Stort05	Downstream from road bridge next to Bentfield Mill House near Stansted Mountfitchet
Stort	Stort06	Downstream from Rye Street car park bridge, Bishop's Stortford
Stort	Stort07	Downstream from Pig Lane road bridge, south Bishop's Stortford
Stort	Stort09a	River Stort, Downstream from Burntmill Lane, Harlow
Stort	Stort09b	Stort Navigation, downstream from Burntmill Lane, Harlow
Stort	Stort10	Downstream from High Street bridge, Roydon
Ver	Ver02	Upstream, from Church End bridge, Markyate
Ver	Ver03	Downstream, from River Hill bridge, Flamstead
Ver	Ver03a	Upstream from Watling Street Flamstead
Ver	Ver04a	Downstream from Luton Lane Harpendenbury
Ver	Ver06	Weir in Westminster Lodge Park
Ver	Ver08	Upstream, confluence with Colne, near Drop Lane
Dour	Dour01	Bushy Ruff
Dour	Dour02	Russell Gardens
Dour	Dour03	Temple Ewell
Dour	Dour04	Kearnsey
Dour	Dour05	Crabble Mill
Dour	Dour06	A2 Buckland Paper Mill
Dour	Dour07	Pencester Gardens

9.2 External datasets used for monthly hydrological monitoring report

Table 42: Key datasets received and analysed for the Affinity Water Monthly Hydrological Report

DATA	DESCRIPTION	FREQUENCY	DATA SOURCE
Rainfall Effective Precipitation Soil Moisture Deficit	MORECS Data for Squares: 151, 152, 153, 161, 174 and 175	Weekly	Met Office
River Flows	River Red at Redbourn River Mimram at Fulling Mill River Ver at Redbourn River Gade at Croxley Green River Beane at Hartham River Rib at Wadesmill River Rhee at Ashwell River Cam at Great Chesterford River Stort at Roydon River Misbourne at Little Missenden River Mimram at Panshanger River Thames Kingston River Dour at Crabble Mill	Daily	Environment Agency
Groundwater Levels	Lilley Bottom Therfield Rectory Wolverton New OBH Ashley Green	Monthly	Environment Agency
	Elsenham Nursery Chalfont Centre Denge 33 Lady Lane Little Bordeaux Farm	Monthly	Affinity Water

9.3 Enhanced environmental drought monitoring

The tables below provide information on the proposed monitoring which would be carried out to ensure we are able to assess the impacts of using our drought permit sites, and also to understand how river flows and ecological elements are impacted by droughts. The types of monitoring we typically undertake are set out below.

Hydrometric monitoring:

- Spot flow gauging
- Drawings of recorded cross-sections
- Calculation of flow through each spot-gauged cross-section
- Comparison of depths and velocities under different flow conditions

Macroinvertebrate monitoring:

- Kick-sampling with variations as appropriate to sample the range of habitats at sites identified by the Environment Agency
- Preparation of data tables for macroinvertebrates, arranged by site and by date
- Counts of taxa per sample
- Data for use in the Environment Agency Hydroecological Validation (HEV) tool and Hydroecological Modelling (HEM) tool
- Analysis of samples for trends
- Assessment of sensitivity of macroinvertebrates to flow

Fisheries monitoring:

Baseline walk-over surveys will be discussed with the Environment Agency and conducted by both ourselves and the Environment Agency on the Rib, Gade, Ver, Misbourne, Mimram and Dour in Drought Zone 2/3, in order to identify reaches that are under stress. Stretches of the river will be assessed for the potential to become isolated should the drought situation deteriorate and flagged. The reaches of the river where rescued fish could be relocated are also identified.

During the spot gauging visits and the river photo rounds any changes in the situation of the river will be reported and discussed with the Environment Agency Fisheries experts. If an action for fish rescuing is identified, we will liaise with the Environment Agency for a consensus on actions.

Table 43: Summary of Enhanced Drought Monitoring for River Rib

RIVER RIB	MONITORING DESCRIPTION	REASON	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
Groundwater Levels	TL 31/13 Moles Farm - logger to be installed by AW	Proximity to THUN	Hourly (AW)	Hourly (AW)	Hourly (AW)
	TL 31/05 Marshalls Farm - to be installed by AW	Proximity to THUN			
	Standon Lordship - logger to be installed by AW	Proximity to THUN			
Gauged River Flows	Rib at Wadesmill		Daily (EA)	Daily (EA)	Daily (EA)
Spot Gauging including Physical Chemical Parameters & Photos	Latchford	Proximity to THUN	Monthly (AW)	Fortnightly to weekly (AW)	Weekly, reducing to fortnightly, reducing to monthly (AW)
	Barwick Ford	Proximity to THUN			
	Fabdens	Proximity to THUN			
	Wadesmill	Proximity to THUN			
	Paynes Hall	Proximity to THUN			
Macro-invertebrates	Location u/s THUN		Spring and Autumn (EA) NB additional monitoring by AW subject to agreement		
	Barwick Hall				
	Wadesmill				

RIVER RIB	MONITORING DESCRIPTION	REASON	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
	Above Chapmore End STW				
	Bengeo Hall				
Fisheries	Barwick Ford		Walk-over Surveys (EA & AW)		
	8 Acre Plantation				
	Bengeo Hall				
Fixed point Photograph	9 locations		During Walkover (EA & AW)		

Table 44: Summary of Enhanced Drought Monitoring for River Gade

RIVER GADE	MONITORING DESCRIPTION	REASON	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
Groundwater Levels	Dagnall OBH		Monthly (EA)	Monthly (EA)	Monthly (EA)
	Coldharbour Farm				
	Gade 2				
	Hollybush Farm				
	Gade 3				
	Gade 4				
	Gade 5				
	Bovingdon Green				
	Woodhurst				
	Gade 6				
Gauged River Flows	Bury Mill GS	Proximity to PICC	Daily (EA)	Daily (EA)	Daily (EA)

RIVER GADE	MONITORING DESCRIPTION	REASON	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
	Croxley Green GS	Proximity to PICC			
Spot Gauging including Physical Chemical Parameters & Photos	Behind Red Lion Pub	Proximity to PICC	Monthly (AW)	Monthly to fortnightly (AW)	Fortnightly, reducing to monthly (AW)
	Noake Mill Lane	Proximity to PICC			
	PICC PS	Proximity to PICC			
	US Gadebridge Park	Proximity to PICC			
	Bury Mill GS	Proximity to PICC			
Macro-invertebrates	Great Gaddesden		Spring and Autumn (EA) NB additional monitoring by AW subject to agreement		
	Gade Water Nurseries				
	Gade Bridge Lane				
Fisheries	To be confirmed	To be confirmed	Walk-over Surveys (EA & AW)		
Fixed point Photograph	Up to 5 locations		During Walkover (EA & AW)		

Table 45: Summary of Enhanced Drought Monitoring for River Beane

RIVER BEANE	MONITORING DESCRIPTION	REASON	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
Groundwater Levels	Beane 6		Monthly (AW)	Monthly (AW)	Every 90 days (AW)
	Beane 5				

RIVER BEANE	MONITORING DESCRIPTION	REASON	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
	Beane 3				
	Beane 7				
	Beane 9				
	Well House Bramfield				
	Woodhall Park Home Farm				
Gauged River Flows	Bragbury Park		Daily (EA)	Daily (EA)	Daily (EA)
	Hartham Park				
Spot Gauging including Physical Chemical Parameters & Photos	AST1	Proximity to WHIH	Monthly (AW)	Monthly to fortnightly (AW)	Fortnightly, reducing to monthly (AW)
	WHIH	Proximity to WHIH			
	Frogmore Hall	Proximity to WHIH			
	Frogmore	Proximity to WHIH			
Macro-invertebrates	At Frogmore Hall		Spring and Autumn (EA)		
	AST1				
	Below Church End Ford, Walkern				
	Upstream Stevenage Brook				
	At Hartham Common				
	Watton-at-Stone				
Fisheries	Church Lane, Stapleford		Walk-over Surveys (EA & AW). Additional monitoring subject to agreement		

RIVER BEANE	MONITORING DESCRIPTION	REASON	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
	Mill Lane, Watton-at-Stone				
	Hartham Common				
Fixed point Photograph	10 locations		Quarterly (AW)		

Table 46: Summary of Enhanced Drought Monitoring for River Misbourne

RIVER MISBOURNE	MONITORING DESCRIPTION	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
Groundwater Levels	SP80/62 Black Horse	Monthly (AW)	Monthly (AW)	Every 90 days (AW)
	SP80/63 Missenden Abbey			
	SU99/59 London Road			
	SU99/60 Mill House			
	SU99/61 Old Road			
	SU99/71 Amersham Church			
	SU99/62 Amersham By-pass			
	SU99/63 Bottom House Farm			
	SU99/64 Chalfont St Giles			
	SU99/65 Cherry Acre			
	TQ09/128 Chalfont St Peter			
	London Road	Hourly (AW)	Hourly (AW)	Hourly (AW)

RIVER MISBOURNE	MONITORING DESCRIPTION	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
	Missenden Abbey			
Gauged River Flows	River Misbourne at Little Missenden	Daily (EA)	Daily (EA)	Daily (EA)
	River Misbourne at Denham Lodge			
Spot Gauging including Physical Chemical Parameters & Photos	Deepmill Lane			
	Little Missenden			
	Shardeloes Lake (Old Rd)	Monthly (AW)	Monthly to fortnightly (AW)	Fortnightly, reducing to monthly (AW)
	Amersham Mill			
	Amersham Bypass			
	Quarrendon Mill			
	London Rd Depot			
	Misbourne Farm			
	Chalfont St Giles			
	Waterhall			
	Chalfont St Peter			
	Gerrards Cross Golf Course			
	Isle of Wight Farm Left			
	Isle of Wight Farm Right			
Macro-invertebrates	Little Missenden	Spring and Autumn (EA). NB additional monitoring by AW subject to agreement		
	Above Old Amersham			
	Bottom House Farm Lane			
	Community Centre, Chalfont St Peter			
	Above Gerrards Cross STW			

RIVER MISBOURNE	MONITORING DESCRIPTION	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
	Below Gerrards Cross STW			
	Denham Country Park			
Fisheries	DS Shardeloes Lake	Walk-over Surveys (EA & AW)		
	Isle of Wight Farm			
	Denham Country Club			
Fixed point Photograph	8 Locations	Quarterly (AW)		

Table 47: Summary of Enhanced Drought Monitoring for River Mimram

RIVER MIMRAM	MONITORING DESCRIPTION	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
Groundwater Levels	TL21/105 Mimram 9 (Digswell Park)*	Monthly (EA)	Monthly (EA)	Monthly (EA)
	TL21/106 Mimram 8 (Hertford Rd)*			
	TL21/108 Mimram 7 (Wellington PH)			
	TL21/109 Mimram 6 (Fulling Mill La)			
	TL21/110 Mimram 5 (Kimpton Rd)			
	TL 21/107 Mimram 4 (CODI)			
	TL21/108 Mimram 7 (Wellington PH)	Hourly (AW)	Hourly (AW)	Hourly (AW)
	TL21/110 Mimram 5 (Kimpton Rd)			
	TL 21/107 Mimram 4 (CODI)			
	Welwyn Viaduct			
	Franks Field			
	DIGS			
Gauged River Flows	Mimram at Whitwell	Daily (EA)	Daily (EA)	Daily (EA)
	Mimram at Fulling Mill			
	Mimram at Panshanger			
Spot Gauging including Physical Chemical Parameters & Photos	D/S Kimpton Mill			
	U/S Codicote Mill			
	D/S Codicote Mill	Monthly (AW)	Monthly to fortnightly (AW)	Fortnightly, reducing to monthly (AW)
	Pulmer Water			

RIVER MIMRAM	MONITORING DESCRIPTION	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
	D/S Pulmer Water			
	D/S Fulling Mill GS			
	Singlers Marsh back channel			
	U/S Singlers Bridge			
	Welwyn High Street			
	U/S Sherrardswood School			
	U/S Bessemer Road			
	Digswell Park Road			
	West Lodge			
Macro-invertebrates	Whitwell	Spring and Autumn (EA). NB additional monitoring by AW subject to agreement		
	Below Whitwell, Hoo End			
	Codicote Bottom			
	Below Codicote Bottom			
	Rye End Farm			
	Above Welwyn Town			
	Tewin Water School, Digswell	Spring and Autumn (AW)		
	Sherradswood School			
	Panshanger	Spring and Autumn (EA)		
Fisheries	Tewin Flyfishers	Walk-over Surveys (EA & AW)		
	Panshanger Quarry			
	Codicote			
	Duck Trap Wood			
	Fulling Mill Lane			
Fixed point Photograph	Taken at Spot Gauging sites & 10 Fixed Historic Locations	Quarterly (AW)		

Table 48: Summary of Enhanced Drought Monitoring for River Dour

RIVER DOUR	MONITORING DESCRIPTION	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
Groundwater Levels	Chilton Farm	Monthly (EA)	Monthly (EA)	Monthly (EA)
	Abbey Road			
	Russell Gardens			
	Minnis Lake Chalk			
	Kearnsey Manor Chalk			
	Bushy Ruff			
	Woverton New			
	Watersend			
	Buckland Hospital			
	Pencester Gardens			
	Pencester Garden Shallow OBH			
	Cow Lane			
	Manor Road			
	Lydden No1			
	SLYE			
	Elms Vale 1			
Gauged River Flows	Crabble Mill GS	Daily (EA)	Daily (EA)	Daily (EA)
	Pencester GS			
	Watersend Mill, Temple Ewell			
	Crabble Mill			

RIVER DOUR	MONITORING DESCRIPTION	DROUGHT ZONE 2 FREQUENCY	DROUGHT ZONE 3/DROUGHT PERMIT FREQUENCY	POST DROUGHT FREQUENCY
Spot Gauging including Physical Chemical Parameters & Photos	Buckland Bridge	Monthly (AW)	Monthly to fortnightly (AW)	Fortnightly, reducing to monthly (AW)
	Pencester Gardens			
	Lower Road			
	Russell Gardens			
Macro-invertebrates	Temple Ewell	Spring and Autumn (EA). NB additional monitoring by AW subject to agreement		
	Russell Gardens			
	Buckland Bridge			
	Crabble Mill			
	Pencester Gardens			
Fisheries	Length of River Dour	Walk-over Surveys (EA & AW)		
Fixed point Photograph	6 locations	Quarterly (AW)		

10 River restoration

In the last five year planning period (known as AMP6), we delivered 11 river restoration projects across six rivers in our Central region (Misbourne, Gade, Beane, Mimram, Upper Lea and Ver). The aim of our work is to improve the health of the chalk streams in our supply area. A key benefit of this work will be to improve habitats, so the ecology is better able to cope with naturally occurring droughts. The river improvement projects have been a regulatory requirement under the Water Industry National Environment Programme (WINEP) since the start of AMP6 and were also included in the 2015 River Basin Management Plans. The key drivers of this work are to diversify river flows, improve flow velocities and to support chalk rivers reaching good ecological status/potential under the Water Framework Directive by 2027.

The regulatory requirement has continued into the current planning period (AMP7) and the new River Restoration Programme for 2020-2025 is our largest and most ambitious to date. The total number of rivers has increased to 14 across our three supply areas, with the target to deliver 56 projects. We are delivering these projects under our Revitalising Chalk Rivers programme[26], in partnership with the Environment Agency. One of the programme's objectives is to improve customer awareness of the importance of chalk streams and to make the connection between water usage and the impact upon the natural environment.

A range of measures within the river restoration programme were applied to the projects delivered in the last five-year planning period:

- Bypassing of weirs - to address barriers to longitudinal connectivity on the River Beane.
- Channel narrowing and re-alignment - to address lateral connection between the river and its floodplain, for example on the River Gade and River Beane.
- Naturalising the channel, floodplain reconnection and wetland recreation – to address the rivers' vertical connection with groundwater on the River Lea, Beane and Misbourne.
- In-channel enhancements, tree works and fencing – to allow more light to the river channel, improving habitat diversity and preventing livestock from damaging the river banks and bed, for example on the River Mimram and Ver.

The below information provides some example case studies of the projects that we have completed to date.

[26] http://www.revitalisingchalkrivers.org.uk/

River Lea – Manor Road Park and the Moor

Much of the Upper River Lea flows through the urban centre of Luton. It is a heavily modified chalk stream which is characteristically straight and overwide and lacks typical chalk stream features and natural processes. Water quality is a pertinent issue downstream of the town centre culvert. The projects completed in AMP6 aimed to contribute towards revitalising the River Lea, a chalk stream which is significantly affected by its urban setting and the challenges and stresses that poses, and improve access to the river for the local community. Additional projects are planned for AMP7.

Prior to the works at Manor Road Park, the river was confined in a concrete channel that flowed along the edge of the park. The right bank consisted of 1.5 m high concrete steps (Figure 40). The concrete steps and riverbed were removed which has reconnected the channel to the floodplain and improved the channel's connection with groundwater (Figure 41). The river channel through this stretch has been naturalised as a result. Bringing the river back to a more natural state should help this reach recover more naturally from and be more resilient to drought. Additionally, these improvements will encourage biodiversity to flourish over time. The pools and riffles, deeper and shallower sections of water, are natural features which will create habitat diversity for plants, fish and macroinvertebrates. Species of fish and macroinvertebrates that prefer low flow conditions will be able to seek refuge within the chalk stream plants on the channel margins in a drought. Other species may be able to migrate to find suitable habitat and then slowly return once normal flows resume allowing their populations to recover. It should be noted that water quality will affect biodiversity at the site despite the river improvement works that have brought the river back to a more natural state through channel narrowing, meandering and removal of an artificial riverbed and banks. Another project was completed in early 2020 at The Moor, a site located to the north of Luton town centre and upstream of Manor Road Park. The channel was straight and over-wide through this section and this was addressed through channel narrowing and introduction of in-channel meanders. The creation of a backwater provides additional floodwater capacity and the installation of berms and coir rolls have introduced chalk stream aquatic plants to this reach which will help to naturalise the site, improve its amenity value and its ability to cope with drought.

Figure 40: Manor Road Park prior to the river restoration works (March 2017)

Figure 41: Post river restoration at Manor Road Park (September 2018)

Woodhall Park, River Beane

The river restoration project was completed in two phases. The first phase addressed one of the two weirs at the Estate, known as the Horseshoe weir (Figure 42). The weir is Grade II listed and therefore could not be removed, so a bypass channel was created to enable fish to migrate upstream/downstream, which is particularly important during low flow conditions. It also enabled a more natural reach to be formed upstream of the weir which is not impounded by the structure and permits natural river processes. Figure 43 shows natural chalk stream plants growing on the channel margins. The channel was reinstated to a more natural location, where it would be better connected to groundwater. During excavation of the new channel we encountered groundwater, confirming that there is connectivity at this location. This has improved the longitudinal connectivity of the channel through the Estate and made the reach more resilient to drought conditions.

In phase two, the connectivity of the river was once again addressed and improved, in addition to fish migration, by bypassing the second weir (Tumbling Bay) and the Broadwater with a new channel approximately 700m in length (Figure 44). This enabled the flow of the River Beane to be split between the new channel and the Broadwater. The lake feature was retained as part of the Estate and multiple habitats were created in the new, flowing channel through the introduction of riffles, pools and berms, to allow wildlife such as chalk stream plants, fish and aquatic invertebrates to flourish. All of this work will contribute to improving chalk stream habitats and resilience. Due to the historic nature of the Tumbling Bay weir and its Grade II listing, sheet piles were clad with brickwork using materials and techniques that matched the original weir feature to preserve it. The sluice on the weir required maintenance for more effective control of high flow events. The two phases of the project combined bypassed two significant weirs known as the Horseshoe weir and Tumbling Bay weir. The total length of the River Beane that was reconnected as a result was 3.98 km, with 1.4 km of new chalk stream created.

Figure 42: Horseshoe weir prior to phase 1 of the Woodhall project (2016)

Figure 43: New channel at the end of phase 1 at Woodhall Park (August 2019)

Figure 44: Live bypass channel adjacent to the Broadwater after completion of phase 2 of the Woodhall project (December 2019)

Hedges Farm, River Ver

This section of the River Ver was straight, overwide and shaded and was affected by livestock poaching. Earth berms were installed to create a narrow and meandering river channel and new fencing now prevents livestock trampling the banks and reduces the amount of sediment entering the river. In addition, tree works were completed to create dappled shade in the channel and encourage native chalk stream vegetation to grow. This vegetation in conjunction with the earth berms will create habitat diversity and diversity of flows for aquatic invertebrates and fish. Habitat and flow diversity are key to the site's ability to cope with drought conditions.

Upper Gadebridge Park, River Gade

The works included creating a two-stage channel; a low flow channel was defined to maintain a clear gravel bed during low flow periods, along with in-channel meanders and channel narrowing. Two small weirs were taken out to remove obstructions to fish migration and in-channel features were created, such as pools, riffles and berms. The concrete outfalls were trimmed back to allow space for a wetland to reduce the pollutants discharging directly into the channel. These have contributed to improving the resilience of the channel to drought through the 320m long reach by transitioning the channel to a more natural chalk stream with habitat diversity and longitudinal connectivity. A new riverside path has also been created which has brought additional benefits to the local community in terms of wellbeing and the amenity value of the area. Users of the path can now easily interact with the river and connect with nature during a visit to their local park.

Figure 45: Gadebridge Park prior to the river restoration works

Figure 46: Post river restoration at Gadebridge Park