Appendix C

Drought Triggers: Development and scenario testing

1 Development of drought triggers

1.1 Introduction

The aim of our drought plan is to demonstrate how we would manage resources and demands through a number of variable but plausible drought sequences, by implementing a range of available management options. We have developed a suite of drought indicators over subsequent plans, applying by historic parameters which inform the implementation off drought measures.

1.2 Groundwater and Rainfall Monitoring

Continuous monitoring of key water resources parameters – rainfall, borehole pumping level, and borehole rest level – has been undertaken historically at our key source at Fleam Dyke. Rainfall records for Fleam Dyke exist for the period from 1912 to the present day, providing a reliable indication of normal and abnormal rainfall events. The long-term average rainfall figure obtained from the site accords, to within 2%, with data collected by Cambridge University and is therefore considered representative of our supply area. Borehole rest level data for Fleam Dyke are also readily available from 1949 to date, enabling reliable values for long-term monthly average rest levels to be determined.

For earlier drought plans Fleam Dyke was used as the sole indicator of aquifer condition; however, to improve the flexibility of monitoring across the aquifer, a range of drought indicator sites was developed in 2006[1] by hydrological consultants. Since that time, the drought indicators have been reviewed; in 2012[2] as prompted by certain operational changes that took place, and again in 2016 to provide further resilience and breadth of monitoring the aquifer.

The current primary indicator sites are: Fleam Dyke, Fowlmere, Melbourn, Lowerfield, Babraham and Great Wilbraham - see figure 1.1 for approximate locations. The spread of sites gives a good representation of how different parts of the aquifer respond during a drought, and all have long and reliable records of pumping and rest level data. All six sites showed a similarity in their pattern of decline during the widespread 2003-07 drought sequence. Later work has developed a further 6 indicator locations, correlated to the known historical behaviour of our sources, but at Environment Agency observation boreholes. This allows us greater flexibility where operational constraints cannot allow boreholes to be rested and additional information on the condition of the aquifer under drought conditions. The exchange of data with the EA during a drought is critical to monitoring this wider network of boreholes.

Although total rainfall continues to be monitored at Fleam Dyke on a daily basis to allow assessment of total rainfall against long term averages over the winter and entire year,

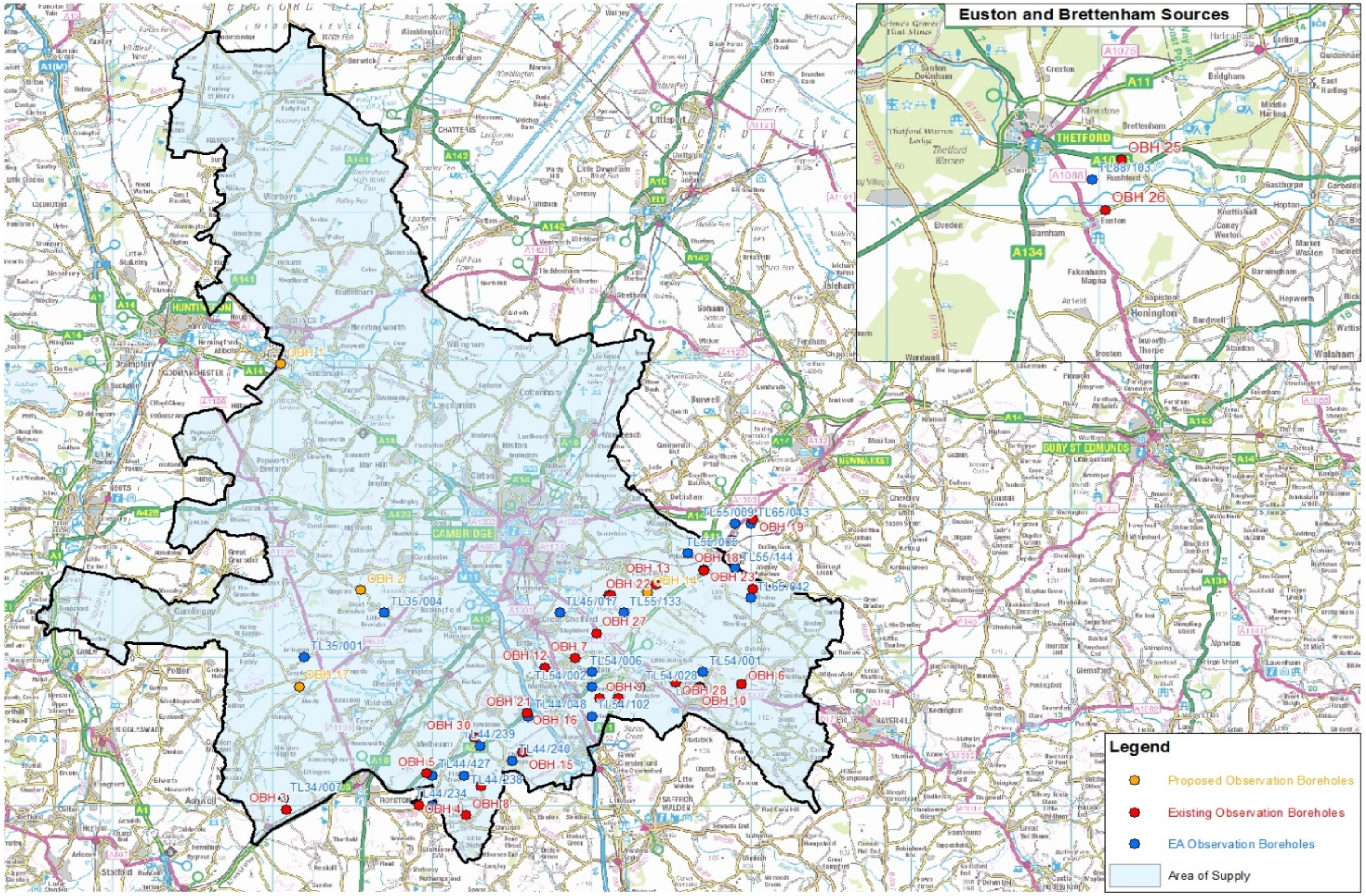
[1] Development of Drought Indicators, Mott MacDonald 2006
[2] Review of Drought Indicators, Mott MacDonald 2011

effective rainfall is now the basis of measurement of aquifer recharge. This data is provided monthly by the Meteorological Office Rainfall and Evaporation Calculation System (MORECS). This data takes account of losses due to evaporation, evapotranspiration and to the soils which reduce infiltration to the aquifer, giving a recharge figure based on actual rainfall and antecedent meteorological conditions.

Monitoring through a drought sequence will not be limited to the physical parameters listed above. Pumping programmes will be checked for their effects on vulnerable sources, and adjusted accordingly; the impacts of public messages will be gauged; other data such as soil moisture deficit and rainfall forecasts will be utilised to aid scenario forecasting. In addition, environmental effects will be studied, and monitoring programmes triggered as a drought progresses, this is covered in detail in our Environmental Monitoring Plan.

Figure 1.1 Drought monitoring network

Cambridge Region Area of Supply Showing Company and Environment Agency Observation Boreholes



1.3 Drought Indicators

In addition to monitoring the rest water levels at the key indicator sites, we continue to use cumulative recharge deficit as a drought indicator. The recharge deficit is deduced from monthly data provided by the Meteorological Office Rainfall and Evaporation Calculation System (MORECS). We consider that monthly data is adequate for this purpose, given the slow response times of our groundwater sources. Rest water levels are monitored monthly under normal conditions, and both drought indicators are monitored more regularly once a drought sequence seems likely, and during a drought.

We adopted recharge deficit as a drought indicator following detailed studies undertaken by consultants into appropriate indicators, as described in above. Prior to this, cumulative rainfall deficit had been used as an indicator, but this was shown by the studies to be a less reliable measure. For example, a summer of high rainfall in between two dry winters, whilst suggesting a low rainfall deficit, gave no indication of the effectiveness of the rainfall in aquifer recharge. Cumulative recharge deficit is calculated from the MORECS data on effective precipitation supplied by the Meteorological Office.

Borehole rest water level (RWL) continues to be used as an indicator of the overall condition of the aquifer during a drought, by comparing it with the long-term average RWL for each indicator site. During a drought sequence recharge deficit increases over time and gives an indication of the length and severity of the drought. Measurement of the cumulative recharge deficit begins in the month when the rest levels at three or more of the six indicator sites fall below their long-term average level and continues until normal conditions have resumed.

A spread sheet tool allows both indicators (borehole rest water level and cumulative recharge deficit) to be monitored continuously and provides timely warning when trigger levels are exceeded.

1.4 Drought Triggers

The drought indicators are used to trigger demand side and supply side drought management actions. Figures and commentary in chapter 2 show how they came into play during previous drought sequences.

The triggers that were adopted as a result of the 2006 review of drought indicators[3] were determined by:

- statistical analysis of MORECS data from previous drought sequences, taking note of the timing of any drought management actions taken
- a statistical analysis of the observed behaviour of the borehole indicator sites during previous drought sequences

[3] Development of Drought indicators, Mott MacDonald 2006

The defined trigger levels combine borehole levels and recharge deficit to determine the impact of the drought sequence together with the severity. Typically in a drought sequence, borehole levels will decline below the seasonal average, and continue to do so for a period of time, and are therefore the initial trigger(s) in a sequence. Once a number of these are below average, the recharge deficit calculation begins. As borehole levels continue to decline, further triggers are reached indicating the progression of a drought sequence. These rest water level triggers, RWL1-RWL5, together with cumulative recharge deficit are linked to drought actions. The trigger levels for rest water levels are shown in Table 1 below.

The trigger levels for recharge deficit and groundwater level together with the associated drought management action are shown in figure 1.2, this demonstrates how our drought indicators define which drought trigger level is reached.

Table 1 Rest Water Level (RWL) Triggers

Values are in mAOD

RWL Indicator	Fleam Dyke	Fowlmere	Melbourn	Babraham	Great Wilbraham	Lowerfield
RWL1	8.0	19.5	21.9	13.2	10.0	28.9
RWL2	7.8	19.3	21.5	12.8	9.1	28.2
RWL3	7.5	19.1	21.3	12.5	8.9	28.0
RWL4 *	7.2	19.0	21.0	12.3	8.1	27.9
RWL5 **	4.7	17.3	20.0	7.9	4.8	24.3

*RWL4 is the statistical 99% probability of exceedance in 30years

**RWL5, one of the combined triggers for imposing a restriction on non-essential use, has not been calculated using a statistical approach, as have the other RWL triggers, as there is no historical record of the indicator boreholes having reached those depths. Instead, the RWL5 trigger has been set with respect to the deepest advisable pumping water level (DAPWL). This is a physical restriction on borehole output, and therefore recognition of our inability to supply, in what would amount to exceptional circumstances.

The way in which the defined triggers relate to the drought management actions taken during the historic drought sequences is shown in figure 1.2. This example is similar to the range of historic sequences presented in chapter 2 below, which also have these drought management actions overlaid to show triggers and drought actions for a range of droughts. These sequences are used as the basis for forecasting forward to indicate the subsequent actions that would be taken in the event of a third successive dry winter, as shown in the worked example in figure 1.3. The actions listed here are not exhaustive but are a pictorial representation of the triggers and actions set out in table 2 below, indicating the likely timeline of progressive drought management extending beyond a historical drought event.

The drought sequences that we have examined include plausible droughts that could impact our groundwater resources, including the worst drought on record. Any drought more severe than these would extend beyond a third dry winter, and this has not been experienced to date. Therefore, this can only be modelling using hind casting methods for determining the impact of reduced rainfall on groundwater levels. This type of drought event would be considered exceptional.

Table 2 Drought indicators and management actions

Severity of the drought	Trigger Level	Demand Side Actions	Supply Side Actions	Drought Indicator(s)
	Above level 1	Business as usual	Business as usual	Monthly monitoring
	Environmental Stress	Enhanced Communications with stakeholders and internally	AIM (Abstraction Incentibve mechanism) in effect to reduce abstractions near sensitive rivers	River flows in CAM 'below normal'
		Demand management: Additional promotion of water efficiency	Hands-Off Flows implemented to protect river flows	River Granta flows as Babraham guage below 36l/s
		Engage with local site managers and interest groups	Augmentation of sensitives sites (where applicable)	OBH TL47/017 levels (Babraham) drops below 14.9mAOD
	Level 1	Enhanced Communications with stakeholders and internally	Optimise abstractions and source availability	Recharge deficit >55mm; or EA 'Prolonged Dry Weather (PDW) status
		Demand management: Additional promotion of water efficiency	Review planned outages	>3 RWL at indicator sites below Average
		Demand management: Enhanced leakage reduction	Reduce abstractions at environmental sensitive locations	River flows in CAM 'below normal'
	Level 2	Further Communications: Appeals for restraint	HOFs in place	Recharge deficit >120mm
		Prepare to implement TUB	Enhanced environmental monitoring at sensitive sites	EA East Anglian region in drought status Sustained peak demands
		Implement TUB	Optimise licenced abstractions	Recharge deficit >180mm & 3 or more indicator sites reach RWL1
	Level 3	Prepare for Restrictions on non-essential use (Ordinary Drought Order) NEUB application	Implement WFD No deterioration Environmental monitoring	3 or more indicator sites reach RWL2

		Apply for NEUB		3 or more indicator sites reach RWL3
		Implement NEUB	Supply side option: use of existing licence headroom (moderate Env. impact)	Recharge deficit >260mm & 3 or more indicator sites reach RWL4
		All possible actions to avoid emergency drought orders	All possible actions to avoid major environmental impacts	3 or more indicator sites reach RWL5
Emergency Plan invoked	Level 4	Emergency Drought Order		All other options exhausted

Figure 1.2 Development of Drought Trigger Curve

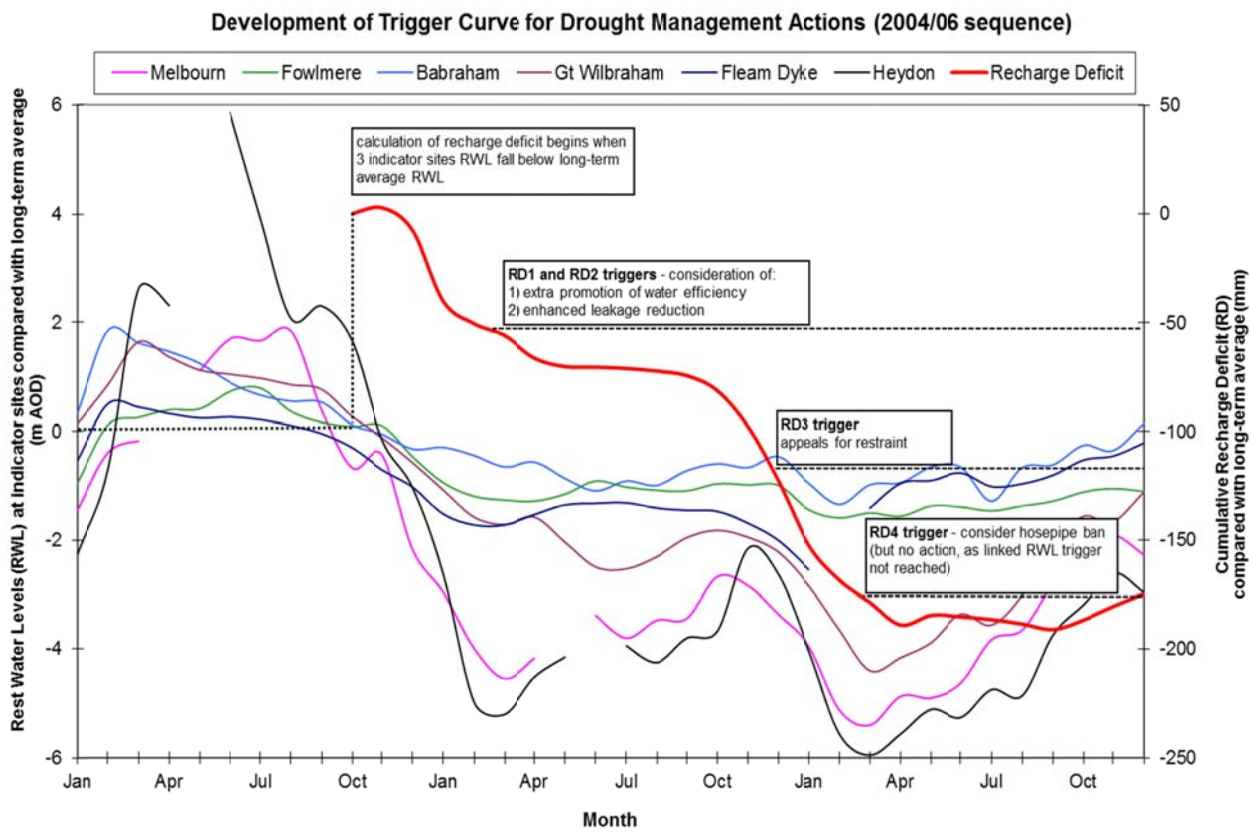
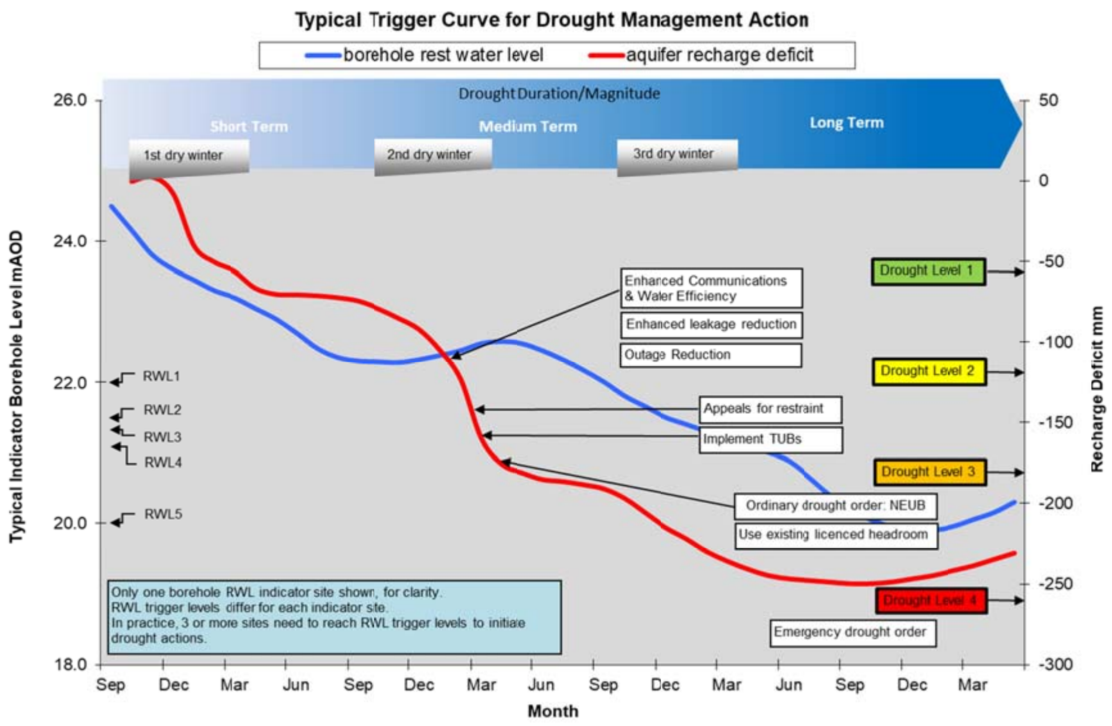


Figure 1.3 Typical Drought Trigger Curve and Management Actions



2 Drought Scenarios

2.1 Introduction

The drought sequences that we have examined include plausible droughts that could impact our groundwater resources, including the worst drought on record. Any drought more severe than these would extend beyond a third dry winter, and this has not been experienced to date. Therefore, this can only be modelling using hind casting methods for determining the impact of reduced rainfall on groundwater levels. This type of drought event would be considered exceptional.

In developing drought triggers and testing these against different drought scenarios Cambridge Water has assessed the impact of droughts by conducting a rigorous analysis of rainfall data collected since 1912, with reference to four particular drought sequences: the early 1920s, 1972-77, 1988-93 and 1995-1998; and also by reviewing the experiences of recent years.

2.2 Historic Droughts

There are no company records of the 1920s drought, and there is a paucity of information relating to the management actions taken during the 1972-77 drought sequence. However, there are good records of the two 1990s drought events, and of the 2003-2007 and 2010-2012 drought events, which readily demonstrate our timely and effective response to drought situations and show how the drought triggers we have developed would have prompted drought management actions.

The following graphs illustrate trends during the key historical drought sequences of the 1970s, 1980s, 1990s and 2000s, with reference to the indicators that were current at the time. Figure 2.1 shows the rest levels observed at our major Fleam Dyke source, and Figure 2.2 depicts the cumulative shortfall in monthly rainfall, compared with the cumulative long-term average, observed at Fleam Dyke through the drought sequences illustrated in Figure 2.4. For comparison, the rainfall deficit during the severe drought sequence of 1920/25 has been added to Figure 2.2, although the records for rest water levels are not available for this period.

Figure 2.1 Water levels in Historical Droughts

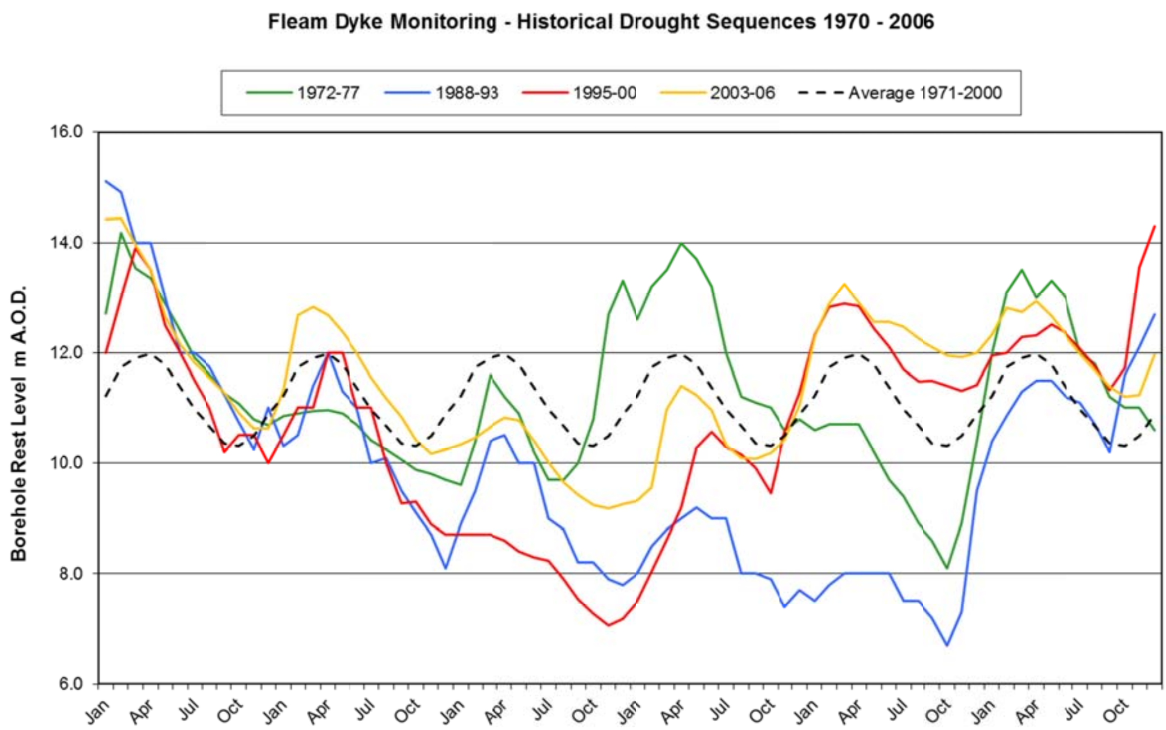
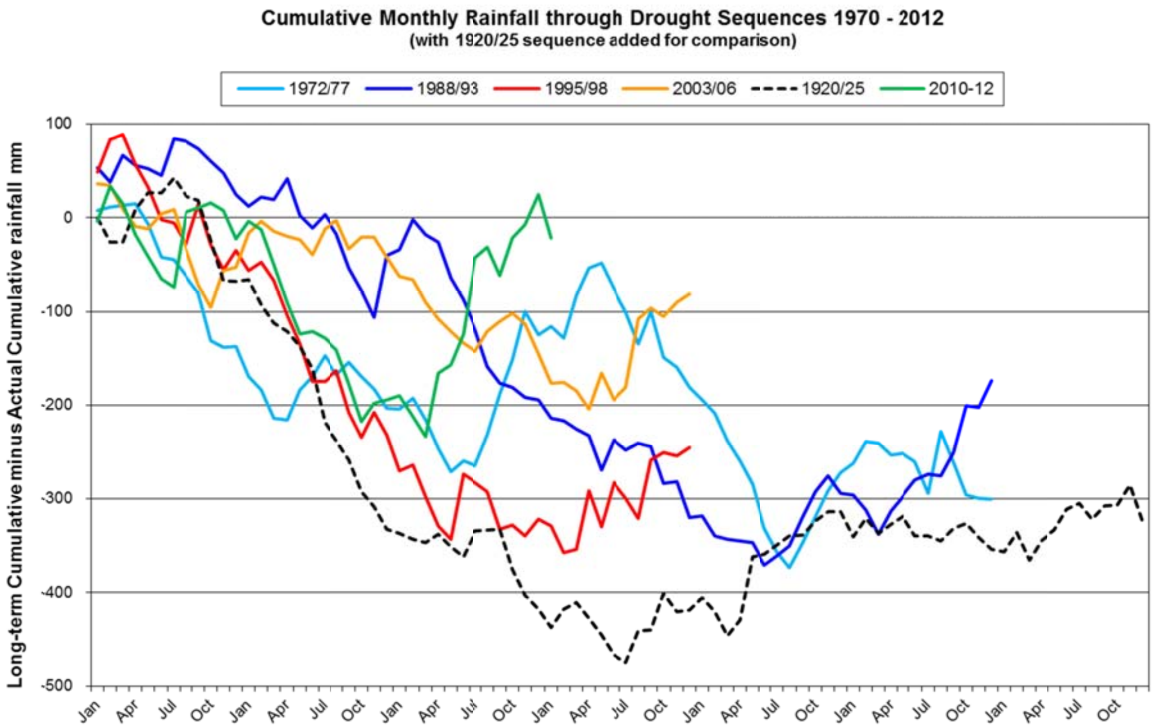


Figure 2.2 Rainfall Deficit through Historical Droughts



2.2.1 1920s Drought Sequence

Although there are no detailed records of this drought it needs to be considered in scenario planning, as it comprised three successive dry winters, and was therefore the most severe drought since we began keeping rainfall records. Many of the current sources of supply had not been developed at this time, and the customer demand profile would have been substantially different.

This drought sequence would be considered a long duration drought of more severe magnitude and is the worst on historical record.

We have recently reviewed the modelled drought yield curves used to derive deployable outputs under drought conditions to include the effect of historic rainfall data on ground water levels, and hence achievable outputs. The hind cast minimum groundwater levels indicate that our sources remain robust under more severe drought conditions than previously experienced.

2.2.2 1972-77 Drought Sequence

There is little information regarding this drought sequence, but it is included as a reference for later droughts. This is in part because of the small sample from which to draw conclusions and partly because a system's response is the result of a complex interplay of many different system-specific characteristics, including climate, catchment, infrastructure, demand and licence constraints. As above, this sequence can be understood by hind casting minimum groundwater levels.

This drought sequence was 2 sequences sandwiching a period of recovery. As this recovery period was relatively short, the second part of the sequence from 1975-76 would be considered a short duration, severe magnitude. Taken as an entire sequence, it would be more akin to a long-term drought of less sever magnitude.

2.2.3 1988-93 Drought Sequence

The situation started to deteriorate during the summer of 1989. Higher than average rainfall during the winter period 1989/90 helped borehole levels to recover, but they did not reach their long-term average levels, and fell still further during the summer of 1990. On the supply side, efforts to commission new sources were accelerated. On the demand side, press appeals for restraint during the summer of 1989 had the effect of reducing consumption. Further publicity appeared in the local press around Christmas that year and continued at fortnightly intervals during early- and mid-1990.

Two new sources were commissioned in the summer of 1990, which increased deployable output. After the expected winter rainfall had failed to take place, a hosepipe and sprinkler ban was imposed at the start of 1991 (now referred to as a TUB – temporary use ban), and was not lifted until the end of 1992, by which time the new Euston (Thetford) source had been temporarily commissioned.

It was estimated at the time of the hosepipe and sprinkler ban that around 4 Ml/d was being saved on Sundays (the 'peak' day of the week, according to the recording methodology) through cars not being washed by hosepipe. Finally, during 1992/93, a programme to compulsorily meter all registered sprinkler users was undertaken.

This drought would be considered a medium-term drought, of severe magnitude as it consists of 2 dry winters, and conditions declined rapidly enough for a hosepipe ban to be imposed. As this drought required restrictions to be imposed it has been used to inform the drought trigger level for the recharge deficit indicator, recharge deficit for this scenario is shown in figure 2.3, and the drought management action triggers overlaid in figure 2.4.

Figure 2.3 1988-1993 drought rainfall deficit and water levels

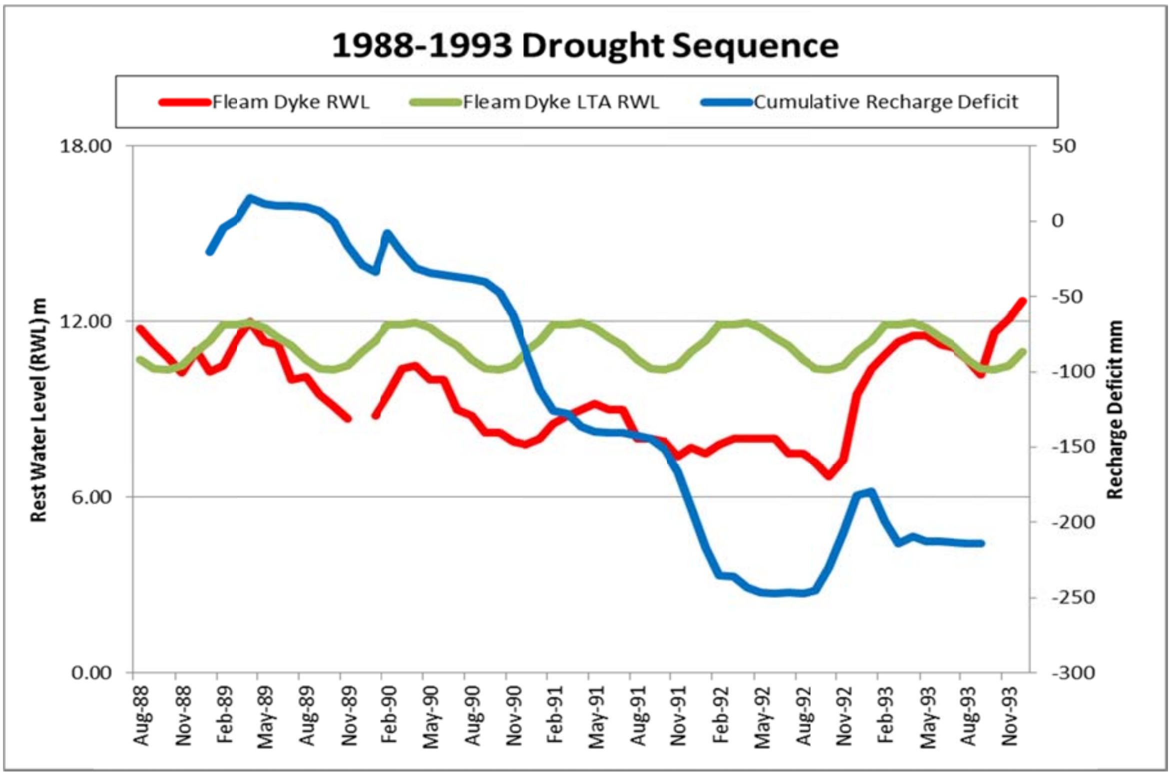
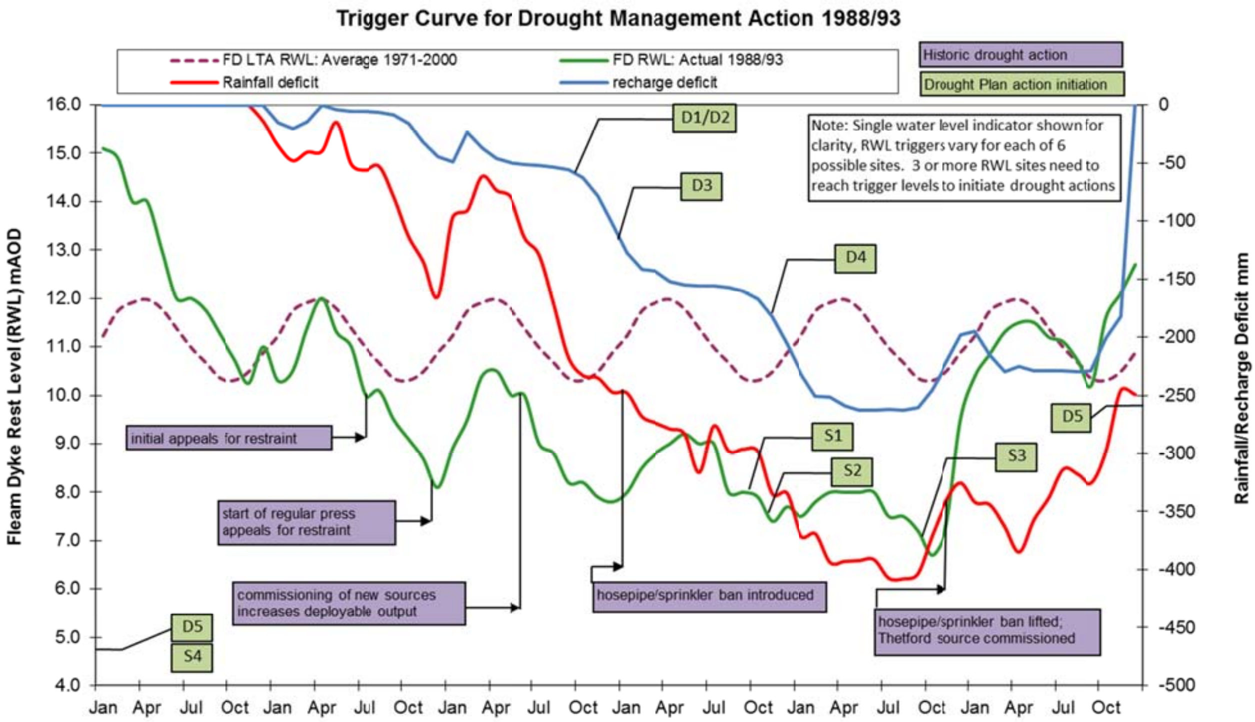


Figure 2.4. The 1988-93 Drought Sequence



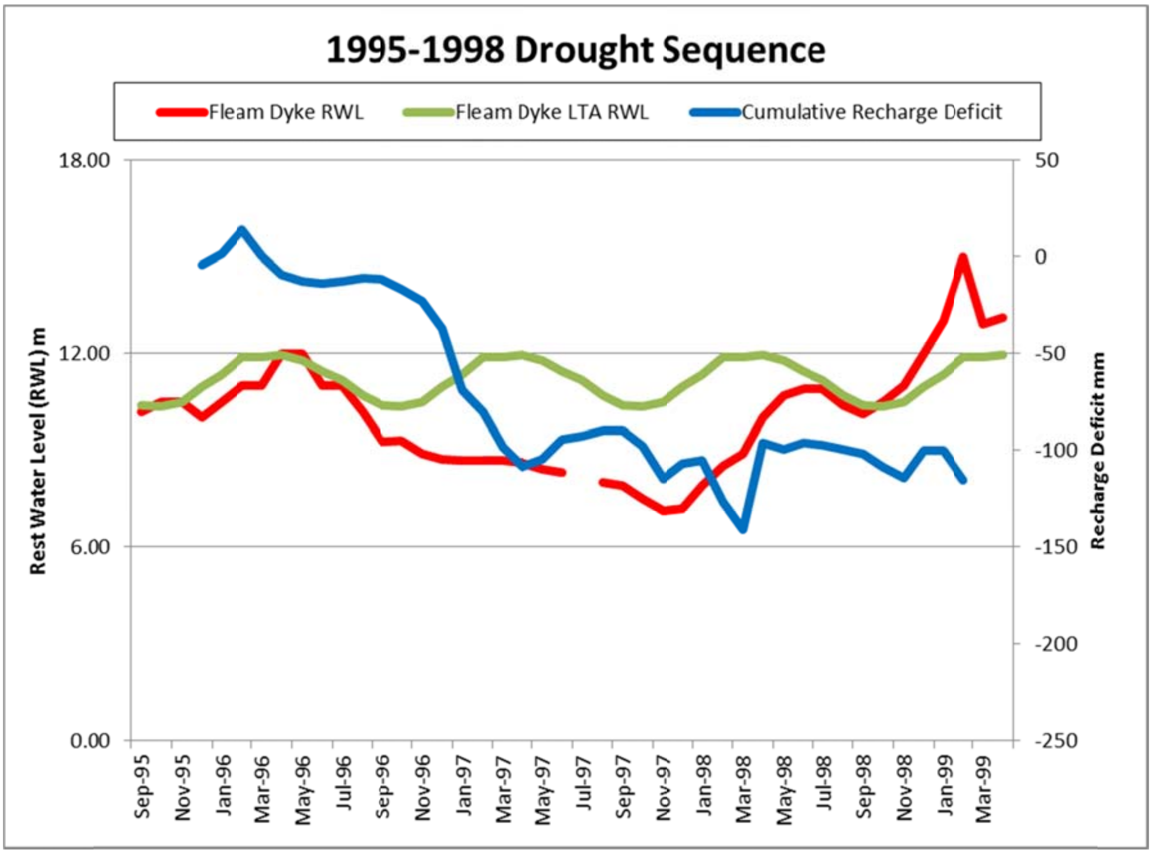
2.2.4 1995-98 Drought Sequence

After a drier than average 1995/96 winter, the message was broadcast to customers to "use water wisely", although restrictions were not envisaged. Borehole levels fell towards the end of 1996 but stabilised during the winter months. The decision was taken to progress the development of a second source at Thetford, and to undertake a Source Reliable Output study of existing sources.

Demands during the winter of 1996/97 were markedly less than for the previous winter, thanks to the effects of an extensive metering programme, and these demand reductions continued through the summer of 1997. Significant, and successful, effort was also put into reducing leakage during this period. Borehole levels began to fall more sharply towards the end of 1997, triggering the consideration of a hosepipe and sprinkler ban; however, the effect on peak demands would have been negligible at that time of year. Instead, a major initiative to meter registered hosepipe users was launched, which effectively curbed peak demands during subsequent years. The triggers for management actions taken during this sequence are shown in Figure 2.6.

This drought would be considered a medium-term drought, as it consists of two dry winters, although recovery was more rapid than seen for the earlier 1990s drought.

Figure 2.5. 1995-1998 Drought Sequence progression



2.2.5 2003-07 Drought Sequence

Overall, 2003 was drier than average but winter 2003/04 was wetter than average, which aided borehole recovery and ensured that 2004 was overall wetter than average. December 2004 marked the start of a prolonged dry spell, during which monthly rainfall totals were consistently below average, and borehole levels remained firmly below their long-term average values as a result. After a brief respite during the autumn of 2005, another dry spell was witnessed during the 2005/06 winter period. As a result, only limited borehole recovery took place and drought management actions were initiated, including increased leakage activity and the introduction of an intensive public awareness campaign.

During the summer of 2006 borehole levels declined to depths similar to those seen in 1996; however, despite prolonged periods of very hot weather during the summer, peak demands were lower than expected (partly due to the knock-on effects of demand restrictions imposed in parts of the south-east) and restrictions were not considered necessary. Nevertheless, the possibility of a third successive dry winter remained, and steps were taken to initiate a supply-side option, to upgrade Brettenham pumping station, enabling full use to be made of that source's licensed capability. An early decision was necessary because of the long lead times for plant and other works.

Heavy rain during the late summer helped to reduce soil moisture deficit at the start of the winter period but, at that time, the prospects for 2007 remained uncertain, and a letter was sent to all customers, thanking them for their efforts during the year, but warning of the possibility of restrictions in 2007. In the event, aquifer recharge continued throughout the winter, and borehole levels had generally reached their long-term average values by the spring of 2007. The triggers for management actions taken during this sequence are shown in Figure 2.7. This drought would be classified as a short duration, and low magnitude.

Figure 2.6 1995-98 Drought Sequence

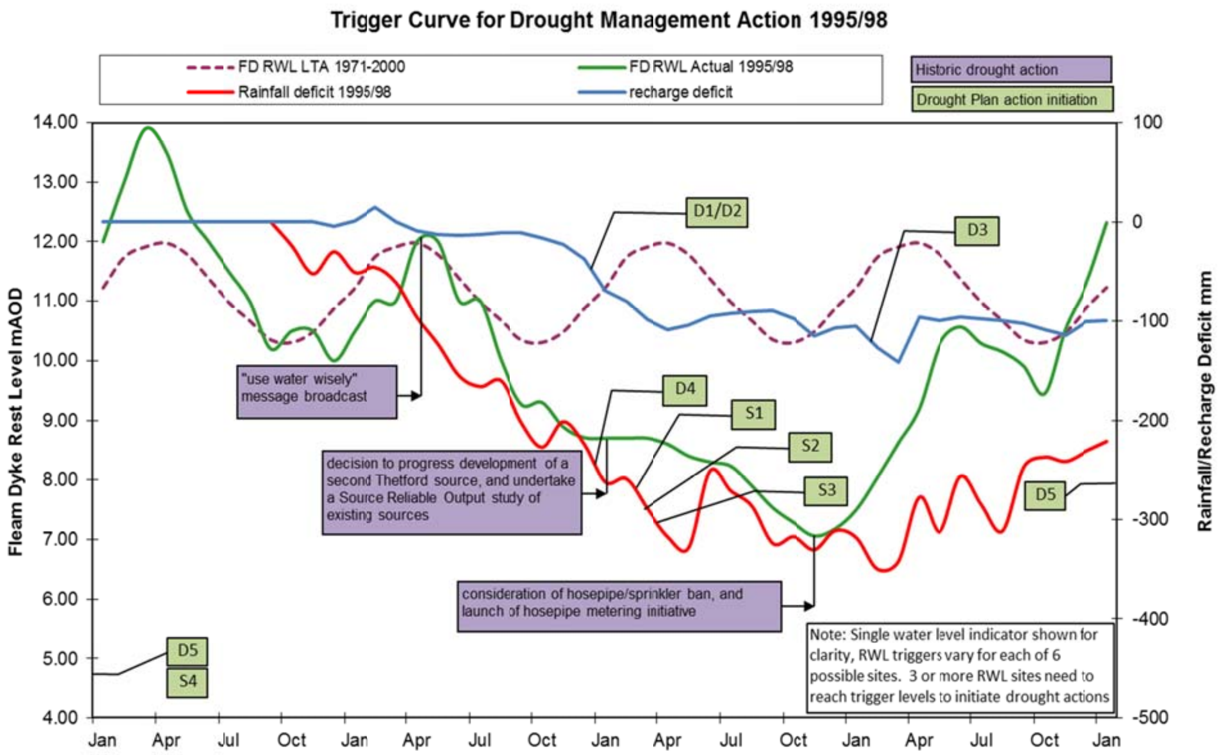
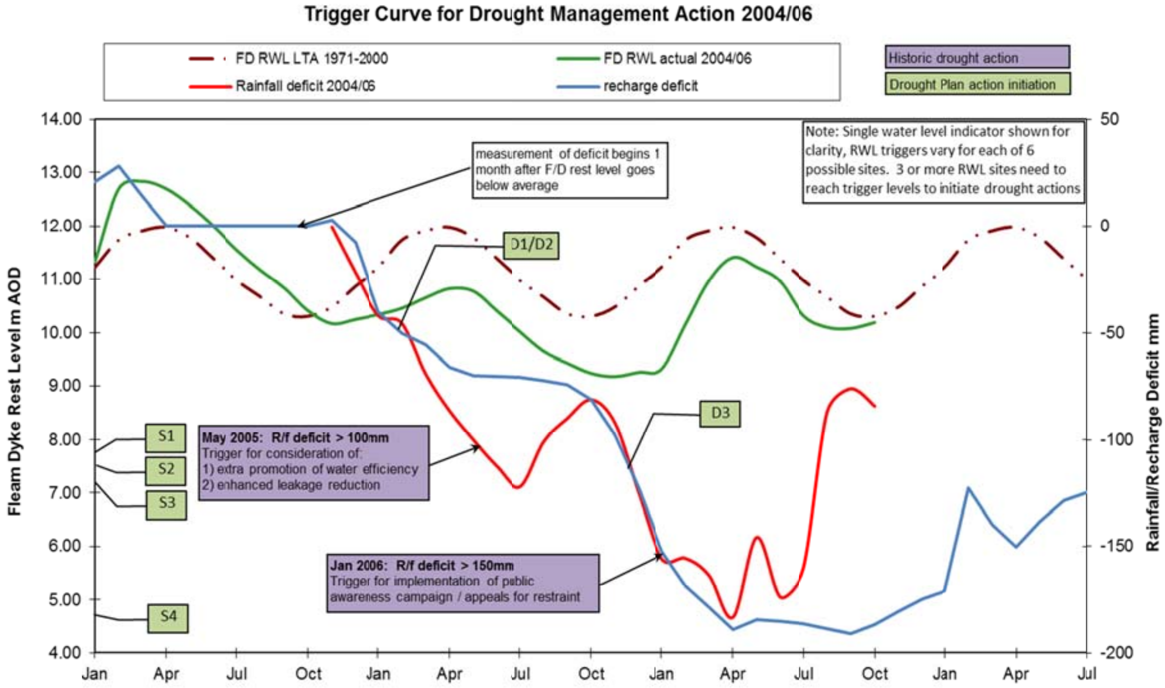


Figure 2.7 2003-07 Drought Sequence



2.2.6 2011-12 Drought Sequence

Winter rainfall for 2010 was lower than average, with the year overall experiencing below average rainfall. Following this, 2011 was one of the driest years seen in many decades and the latter part of winter of 2011-12 was very dry. As a result of these two successive dry winters, groundwater levels in the Cambridge Water area were depleted to a point where some of our drought triggers had been breached, initiating management actions in line with the drought plan at that time. Early mitigation actions included significant capital investment being made in reducing leakage levels and appealing to customers to exercise restraint through an enhanced communications programme. Whilst other companies in the south east imposed temporary water use bans, our trigger thresholds for this action were not reached, and we did not do the same. Preparations to implement a supply side option ready for another dry winter were undertaken. The spring of 2012 saw well above average rainfall, and because of this, unprecedented late spring/early summer recharge. By the summer most borehole levels had returned to average or above average conditions.

2.2.7 2018-2020

Since 2018 we have seen some of the highest peak week demands on record, a reflection of increasing demand and water use behaviour in response to weather conditions. In addition, Covid-19 coinciding with a record warm dry spring saw the highest peak week and daily demand seen to date. These events place stress on our supply system, even without drought conditions, and require careful management of assets to minimise outage and maintain supplies at high levels of demand, however we have had no issues with supplies.

Drought events and periodic high demands are managed differently. The former lasts over many months or years due to a shortage of rainfall and the latter is associated with shorter periods of high demands associated with heatwaves and/or short periods of dry weather in summer mainly attributed to additional outdoor water use such as gardening.

Whilst 2018-19 saw below average rainfall and hot dry weather, our drought plan was not implemented and we remained in 'BAU' status, although we enhanced our communications with customers and stakeholders around water efficiency and the potential for water use impacting on the environment. At no point during this period were supplies at risk or did we consider any drought actions other than enhanced monitoring and communications. The conditions of 2020 were unique with an early period of hot dry weather combined with the impacts of the Covid pandemic, but nonetheless were a temporary peak demand not related to drought.

As these recent events are considered to be short term and driven by dry weather and associated demands we have not tested drought triggers against these as they are considered to be within the normal range of weather fluctuations, and covered by our water resources management plan and managed within normal operations.

2.3 Categorization of drought duration and severity

To assess the robustness of our drought management plan for the Cambridge region, we have considered different drought scenarios, of increasing severity, appropriate to the area of supply. All the water supplied in the Cambridge region is from groundwater sources, recharged by winter rainfall, and it is the lack of winter recharge over successive dry winters, which leads to a drought situation impacting on water resources. This is confirmed by the analysis of historic drought sequences described above.

There is no evidence to suggest that other rainfall events – e.g. single season dry summers; single season dry winters; or even two consecutive dry summers with an intervening wet winter – would affect our ability to supply water.

The historic drought sequences and worked examples in section 2 for droughts of varying durations, have been used to inform an overall robust approach to drought management, actions and measures. This is shown in the worked example in figure 1.3 for a typical drought trigger curve and drought management actions. The historical drought sequences and actions presented in Figures 2.5-2.7 also have the current drought plan triggers overlaid, to demonstrate our current drought actions in these drought scenarios. Table 2 explains the drought actions associated with the triggers. The drought scenarios shown include droughts of varying duration and severity, as discussed in the following sections.

2.3.1 A Short Duration Drought

Typically, a short duration drought may last 6 to 12 months, and include a single dry winter. In this scenario it is assumed that aquifer levels will be at their long-term average at the start of the normal winter recharge period (October), but that winter rainfall is seriously curtailed.

A study of our rainfall records since 1912 reveals only rare occurrences where a short duration drought comprising a single 'dry' winter (less than 80% average rainfall) is followed by a dry summer, or where a dry winter is sandwiched between two dry summers. In recent times, this has happened in 1976 and 1996 (although, in the latter case, this was part of a longer drought sequence, and is considered separately).

The recent drought sequence of 2011/12 can be considered a short duration drought starting in March 2011 and ending in April 2012. Although this drought included two dry winters, and the summer between was relatively dry, demands were low due to the generally cool weather, and the spring following the 2nd dry winter was exceptionally wet. Unprecedented rainfall above that historically observed in April and July 2012 led to a rare and rapid late recovery of borehole levels, and recharge was experienced much later in the year than normally expected. It is this unique set of circumstances that define this drought as short duration rather than medium duration, as recharge occurred after the second dry winter when it would not normally be experienced.

During the winter of 2010/11 borehole recovery was as expected, however March – May 2011 saw the lowest cumulative rainfall since our records began over a 99 year period, and this had a severe impact on winter recovery. Summer rainfall was less than 60% of average, however demands were low, as were leakage levels, and impact on resources was neutral. The Environment Agency declared a drought for Cambridgeshire in June 2011, and as a result we increased drought communications with our customers, the Environment Agency and other stakeholders. The drought management team was invoked, and scenario planning was undertaken to determine the likelihood of customer restrictions as per our drought triggers, for various rainfall scenarios.

This activity continued through 2011 and into 2012, during which the September and October of 2011 at the start of the normal winter recovery period were exceptionally dry, experiencing less than 30% of average rainfall. Fortunately, as a result of above average rainfall in November – January, the situation improved slightly, with borehole levels showing some signs of recovery. February and March of 2012 again saw below average rainfall, and this was again a cause for concern over falling borehole levels into the summer, and a temporary ban on water use was considered a possibility. It was determined that forecasted borehole levels based on rainfall received would, however, not be approaching critical levels and in turn breach the drought triggers for the introduction of a temporary ban on water use before the autumn of 2012. A number of water companies, including Anglian Water and Veolia on our boundary, introduced temporary use bans in April 2012 as they breached their own drought triggers. The presence of these restrictions close to our supply area, together with our own continued customer communications campaigns and heightened customer awareness, undoubtedly helped to maintain low levels of demand, and together with low leakage levels ensured that we maintained healthy supplies, in spite of small cutbacks at a number of sources to protect yields due to low groundwater levels.

Following a dry February and March, the spring of 2012 saw exceptional rainfall, above historically observed levels, and this unusually led to an extended recharge period beyond that normally seen for the winter months. Borehole levels saw rapid recovery and by August, levels at drought indicator sites were at or above average for the time of year.

We effectively managed this drought with the tools available and is confident it could effectively manage a future drought of similar characteristics.

2.3.2 A Medium Duration Drought

A medium duration drought for Cambridge Water would comprise two successive dry winters, with an intervening dry summer. In recent times this has occurred in 1995-97, and was looking to be the case in 2011-12 before exceptional recharge much later than normally expected. The sequence of events and actions undertaken at that time is referred to in detail in 2.3.1 above.

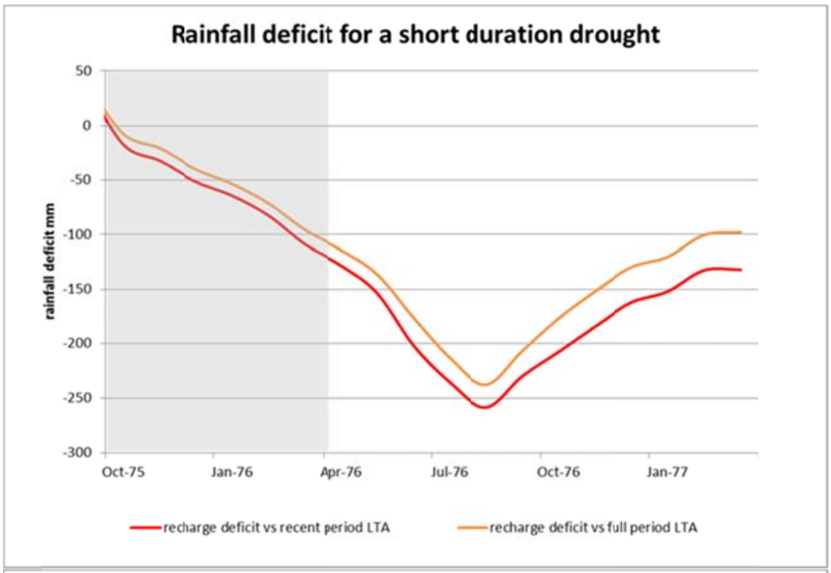
The 1988/93 and 1995/98 drought sequences can both be considered medium duration droughts with only a short recovery time between each sequence.
The 1988/93 drought was a more severe event, in terms of the effect it had on borehole levels. This was a result of a combination of two successive dry summers, two successive years of low total rainfall, and two dry winters. However, a combination of a temporary hosepipe and sprinkler ban, a subsequent campaign to meter sprinkler users, and heightened leakage activity, saw average daily distribution input fall from a high of 78.5 Ml/d in 1990 to 72.3 Ml/d in 1993.

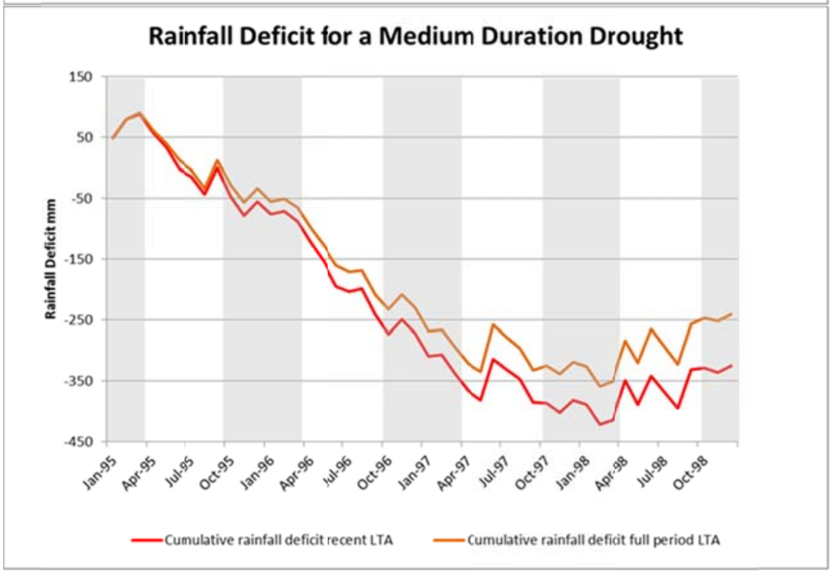
The 1995/98 drought included a dry summer followed by 2 dry winters with a dry summer between. The driest year saw just 65% of average rainfall in total and borehole levels fell quickly during 1996-97. Measures to curb demands and above average rainfall during the latter part of 1998 saw boreholes recover and the following few years experienced above average rainfall, further aiding recovery.

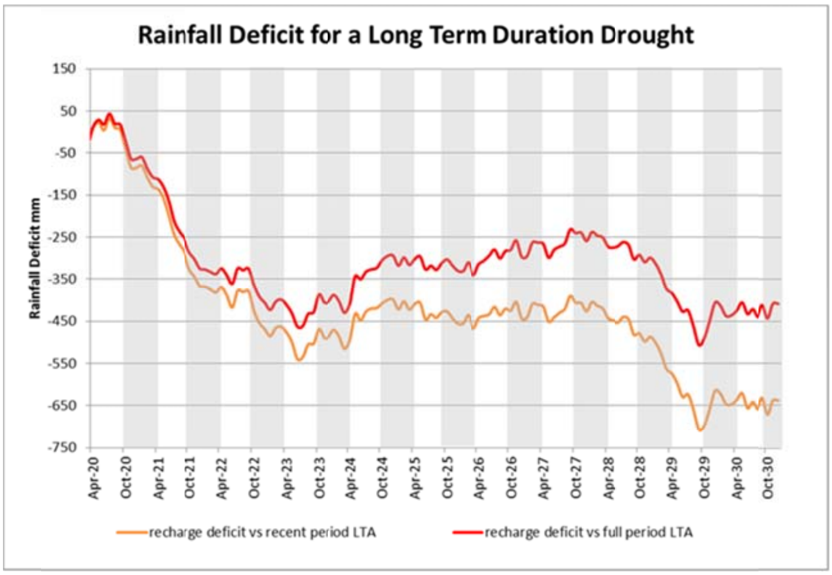
The 2011/12 drought sequence could have been more severe, had it not been for exceptional rainfall in the spring of 2012. However, it was forecast that the trigger for implementing a temporary use ban would not be breached before a third dry winter, even with very low rainfall scenarios. This further warrants the robustness of our resources position to a medium-term drought.

We effectively managed the 1988/93 and 1995/96 medium duration droughts, through successive demand and supply management options. Had the 2011/12 drought continued it is predicted that there would have been no need for implementation of a temporary use ban in advance of a third dry winter. We are therefore confident it could effectively manage a future medium duration drought.

Figure 2.8 Example rainfall deficit and duration for drought sequences


Rainfall deficit for a short duration drought
rainfall deficit mm
50
0
-50
-100
-150
-200
-250
-300
Oct-75
Jan-76
Apr-76
Jul-76
Oct-76
Jan-77
recharge deficit vs recent period LTA
recharge deficit vs full period LTA


Rainfall Deficit for a Medium Duration Drought
Rainfall Deficit mm
150
50
-50
-150
-250
-350
-450
Jan-95
Apr-95
Jul-95
Oct-95
Jan-96
Apr-96
Jul-96
Oct-96
Jan-97
Apr-97
Jul-97
Oct-97
Jan-98
Apr-98
Jul-98
Oct-98
Cumulative rainfall deficit recent LTA
Cumulative rainfall deficit full period LTA


Rainfall Deficit for a Long Term Duration Drought
Rainfall Deficit mm
150
50
-50
-150
-250
-350
-450
-550
-650
-750
Apr-20
Oct-20
Apr-21
Oct-21
Apr-22
Oct-22
Apr-23
Oct-23
Apr-24
Oct-24
Apr-25
Oct-25
Apr-26
Oct-26
Apr-27
Oct-27
Apr-28
Oct-28
Apr-29
Oct-29
Apr-30
Oct-30
recharge deficit vs recent period LTA
recharge deficit vs full period LTA

2.3.3 A Long-term Drought

This scenario examines the possible effect of a succession of three consecutive dry winters (similar to the sequence witnessed during 1920/25), with a succession of intervening dry summers. This would be the critical drought scenario for Cambridge Water and would inevitably involve the imposition of restrictions, with ourselves, our customers and other stakeholders having to work closely together to manage the situation. Our scenario for managing a drought of this magnitude, through the implementation of a succession of supply- and demand-side actions, as defined in this plan, is illustrated in table 3.

Table 3 Indicative Drought Actions in a Severe Drought

Trigger Level in drought sequence	Drought management Action	gain/loss	Average Demand*		Peak Demand*	
			DO	Net Surplus	DO	Net Surplus
Initial surplus; Annual Average deployable output (99.1Ml/d, surplus over demand 17Ml/d) and Peak deployable output (118Ml/d, surplus over demand 17Ml/d) (as revised for WRMP19 and 2018 7 day peak demand)						
Level 1	Additional promotion of water efficiency	+0.5	99	17	118	17
	enhanced leakage efforts	+1	99	18	118	18
Level 2	appeals for restraint	+3	99	21	118	21
	Implement TUB	+5	99	26	118	26
Level 3	Drought vulnerable source reductions	-6	93	20	112	20
	Implement NEUB	+5	93	25	117	25
	Supply side option: use of licenced headroom	+6	99	31	111	31
Level 4	Drought vulnerable source reductions	-5	94	26	106	26
	Emergency Drought Orders	-	-	-	-	-

Savings from appeals for restraint based on actual reductions experienced during previous droughts and customer campaigns

Savings from customer restriction based on previous ban for TUB, and also in line with the 5-9.5% from the Code of practice and guidance on water use restrictions, UKWIR 11/WR/33/3, and conservative in comparison to the EA estimate of 10% during TUB implementation in Quantifying the Impact of Water Company Drought Demand Measures, The Environment Agency, 2013, and Understanding the Impacts of Drought Restrictions, UKWIR 14/WR/01/13

*Note that the demand conditions applied are distribution input from WRMP19 planning tables, without any planning allowances (for example unplanned outage or treatment works losses) or in year variations to demands and baseline leakage. Therefore the net surplus presented is a ‘best case’ scenario and hence demonstrates sufficient headroom under a range of variable conditions

This table demonstrates the actions that would be taken in a severe drought, of similar magnitude to that experienced in the 1920s, which was the worst in almost 100 years, to Level 3 triggers. It indicates that we would be able to maintain a surplus supply over demand and ensure security of supply for customers. The surplus on our peak licences provides assurance that there is sufficient flexibility in supplies without recourse to drought permits in the event of a severe drought.