Appendix P Drought Plan Methodology

Section 1. Drought Management Methodology

1.1. Overview

We have developed our drought management protocols and associated methodologies in line with legislation and drought guidance, considering previous droughts. This section describes the protocols for each of the six WRZs.

1.2. Approach for each Water Resources Zone (WRZ)

Drought management decisions must start with a consideration of the impact the drought is having on the supply capability within each WRZ and the approach taken in formulating the drought management protocol is dependent upon the nature of the water resources system within each WRZ. This sub-section provides an overview of the approach for each WRZ and is summarised in Table 1; detailed descriptions are then given in the sections that follow (4.3 to 4.7). Sub-section 4.8 outlines the approach for closing down a drought management event and sub-section 4.9 deals with post drought reviews. We have considered the adoption of environmental triggers for drought actions in addition to the triggers we use based on the water supply position. We have not adopted any specific environmental triggers as the primary function of our Drought Plan is to make provision for the actions to ensure security of supply for our customers. Where action may be required to address the environmental impact of drought the options available to us are principally to encourage customers to reduce demand and we do this through customer communication, this is set out in section 7. The point at which we do this will be determined by a combination of review of the water resource situation, both catchment-wide and locally, supplemented by liaison with the Environment Agency and other environmental stakeholders such as the Rivers Trusts.

1.2.1. London and SWOX WRZs

These WRZs are known as conjunctive use zones as the water resources are derived from a combination of river abstraction, raw water reservoir storage and groundwater sources. For both zones, the critical element in the system is the level of reservoir storage, which in turn is dependent upon river flow. During drought the surface runoff component will tend to be negligible for most of the time (see Section 2), thus, river flow is primarily made up of the baseflow from the catchment's major aquifers.
In total, the drought management measures for the London zone consist of:

- Demand-side measures (see Section 6 for full details) in which water use restrictions associated with Thames Water's Levels of Service play a major role and are triggered by the drought protocol;
- Supply-side measures in which several strategic drought schemes play a major role in augmenting the London zone's supply capability (see Section 6 for full details including trigger mechanism for introducing strategic schemes).

Both the supply and demand-side measures form an integral part of London's deployable output.

In SWOX the protocol is similar to that of London for the introduction of water use restrictions associated with the Levels of Service. However, unlike the London WRZ, there are no supply-side strategic drought schemes built into the zone's deployable output; the major supply-side augmentation comes mainly in the form of increased abstraction from existing sources introduced at the specified low flow trigger (see Section 4.4.1) through the drought permit mechanism.

As discussed above, because of the dominant nature of the London WRZ, it will generally be the case that the water use restrictions introduced in the London WRZ will also be applied to the rest of our supply area. Nonetheless, the Drought Plan recognises that there may be situations in which more local measures may need to be introduced for the other WRZs, consequently, protocols have also been developed for these zones such that, if necessary measures can be introduced in any of our WRZs alone if a drought occurs with very localised effects although it is recognise that this is relatively unlikely.

1.2.2. Kennet Valley and Guildford WRZs

Although groundwater provides a major contribution in these zones, the critical drought elements are the surface water sources on the River Kennet and River Wey for Kennet Valley and Guildford, respectively. The protocol for these zones is therefore based on river flow reaching critical low levels which act as the trigger mechanism for the introduction of drought measures. However, as mentioned above, the drought situation in London is the principal factor in determining the drought response in these zones.

1.2.3. Slough Wycombe Aylesbury and Henley WRZs

These two zones are entirely supplied by groundwater sources, which historically have remained robust during drought. That is to say, the critical point at which source outputs decline below their deployable output has never been reached. The approach in these zones, therefore, is to track key regional observation boreholes as well as to track the performance of selected groundwater sources in relation to their deployable output. However, as mentioned above, the drought situation in London is the principal factor in determining the drought response in these zones. This is because in a severe drought measures are likely to be implemented Company-wide and measures implemented in the SWA and Henley WRZs will have a small but positive benefit for London through enabling reduction in abstraction so that the resulting marginal increase in river flow will be experienced in the Lower Thames.

Summary

Table 1 provides a summary of the protocols for each WRZ and for introducing the Levels of Service measures.

Table 1 Summary of protocol methodologies for each WRZ

WRZ	Water Resource System	Protocol for introducing Level of Service measures
London and SWOX	River/Raw water storage/groundwater	Risk-based 'prevailing/predicted' protocol and guided by London protocol
Kennet Valley and Guildford	Run of river/groundwater	Guided by London protocol/ WRZ-specific triggers based on 'threshold' river flow
Slough, Wycombe, Aylesbury and Henley	Groundwater only	Guided by London protocol/ WRZ –specific triggers based on groundwater tracking

The methodology for the protocols for each WRZ is set out in the following sub-sections.

1.3. Protocol for London WRZ

1.3.1. Introduction and Overview

Our Drought Plan protocol is designed to provide triggers for introduction of drought plan measures that are proportionate to the drought risk being experienced. It is also designed to enable the measures to be brought in sufficiently early so that all subsequent measures can be implemented in time and in sequence in order to ensure that the risk of reaching very severe measures under Level 4 is minimised as much as possible. Ensuring that measures are brought in sufficiently early also supports the environment during times of stress.

The key elements of the protocol are used to identify overall drought risk based on the combination of regional groundwater levels, river flows and reservoir storage. This assessment takes into consideration both the current situation and combines it with predictions of how bad the drought could get under a reasonable worst-case scenario. These risk assessments are used together with the known time it would take to implement measures to establish a timeline based on a scenario selected to represent the worst case scenario of severe lack of rainfall leading to our reservoirs becoming critically low at some point in the future. We then use the required sequential nature of the imposition of drought measures to determine when the first elements in that sequence need to be implemented followed by the series of subsequent measures through to the point at which the most severe measures would be required. This provides a timeline for implementation of all the measures so that they can be prepared in advance and then implemented in succession in a timely manner meaning the most severe measures are in place if the drought does progress to be very severe.

Therefore, in summary the key requirements that the protocol must enable are:

- The full sequencing of measures to be taken to avoid or minimise the need for Emergency Drought Orders (EDOs).
- Timely introduction of those measures to maximise demand savings and supply-side benefits and allow for their implementation.

- Proactive communication to customers on their participation.
- A reliable assessment to show that the measures being either considered or actually implemented are consistent with Thames Water's Levels of Service. NB Because of its dominance this is a test that currently is only applied to the London WRZ.

This approach enables us to put measures in place early when a drought has the risk of being very severe and the principal identifier of this risk is the effect that a sustained shortage of rainfall has on groundwater storage. This is particularly important where there has been a shortage of rainfall in winter so that groundwater levels do not recover prior to the summer in our major aquifers, especially the Chalk.

The methodology within the prevailing/predicted protocol has been developed primarily for application to London WRZ, but due to the similar nature of the two water resources systems, can also be readily applied to the SWOX WRZ, see Section 4.4 below.

Both protocols can be divided into three steps as follows:

Step 1 - Collation of hydrological data, predictions of drought impact and assessment of potential drought severity in terms of historic frequency of occurrence.

Step 2 - Risk assessment using the information from Step 1 to derive a composite indicator of risk to security of supply.

Step 3 - Assignment of drought event level and decision on measures to be taken guided by output from Step 2.

The following description of the methodology is provided to give a greater understanding of the protocols. Appendix F provides a detailed description of the methodology aimed at the practitioner; it also provides worked examples of the 2005, 2006, 1976, 1997 and 2012 drought years to demonstrate the new protocol's effectiveness over a range of droughts.

1.3.2. Protocol – Step by step

1.3.2.1. Step 1 - Hydrological Assessment and Drought Severity Assessment

Step 1 is divided into three parts –Steps 1a, 1b and 1c as follows.

Step 1a - Hydrologic Data Collation

The data constituting the collation of the 'prevailing' situation comprises:

- Up-to-date set of groundwater levels from the EA's network of key observation boreholes sampling the principal aquifers in the Thames catchment.
- River flows - primarily from the Lower Thames at Teddington Weir.
- The latest reservoir storage trends plotted on the LTCD

Step 1b – Predictions

For each of these hydrological variables predictions are made using a range of worst case assumptions in respect of rainfall; 60% of long term average rainfall is the scenario most used, generally for a prediction of 6 months for London The 60% scenario is used because this is broadly equivalent to the rainfall that was experienced during the 1976 water year (October 1975 – September 1976) which is the most severe recent drought for which good records are available.

The predictive tools used are as follows:

Groundwater

Catchmod is the principal tool employed for groundwater level predictions. It is a computer model used by the EA to simulate groundwater levels at selected locations. The model is used to generate predictions of groundwater levels based on scenarios of differing percentages of average rainfall for specific groundwater monitoring sites.

Reservoir storage

The WARMS model is used to simulate scenarios of potential future reservoir storage levels within the LTCD. The WARMS modelling system is made up of a series of mathematical simulation models. It is used for 'what if' behavioural analysis of the Thames Water system. One of the key assumptions within the modelling is the savings that can be made by placing restrictions on our customers during a drought, for example Temporary Use Bans. The modelling reflects the timing of when these restrictions would be in place and the resulting reduction in demand.

River flow

The WARMS model is also used to simulate future river flows for Farmoor on the upper Thames and above Teddington Weir on the lower Thames.

Step 1c - Determination of Frequency of Occurrence

Alongside the collation of data, an assessment is undertaken of the potential drought severity expressed in terms of the return period or frequency of occurrence of the drought event. This is used as an important guide to the conformance between planned Levels of Service and the decisions on measures to be taken in Step 3.

The average flow over the critical period of a drought, typically April to September, has been shown to be a good indicator of its impact on London's river/reservoir water resources system. The potential drought severity is assessed by consideration of where the current drought lies in the ranking in relation to previous droughts in the historic record.

Figure 1 demonstrates the technique using 2012 as an example, which shows that there were no droughts of greater severity than the predicted outcome for 2012 covering the period April to September i.e. given the 60% of long term average rainfall prediction, 2012 would rank most severe. The historic record in this case (2012) is 111 years, therefore as forecasted from the start of February, and in relation to the historic record, the potential severity of the 2012 drought event looked to have a frequency of occurrence of 1 in 22 years. This was assessed on the basis that there would have been 5 droughts of approximately this level of severity in 110 years if the 2012 drought progressed to that level by September. A hosepipe ban was introduced in April 2012 for the Thames Water supply area. This action was seen to be broadly in line with the planned level of service for a Level 3 measure with a 1 in 20 year frequency of occurrence.

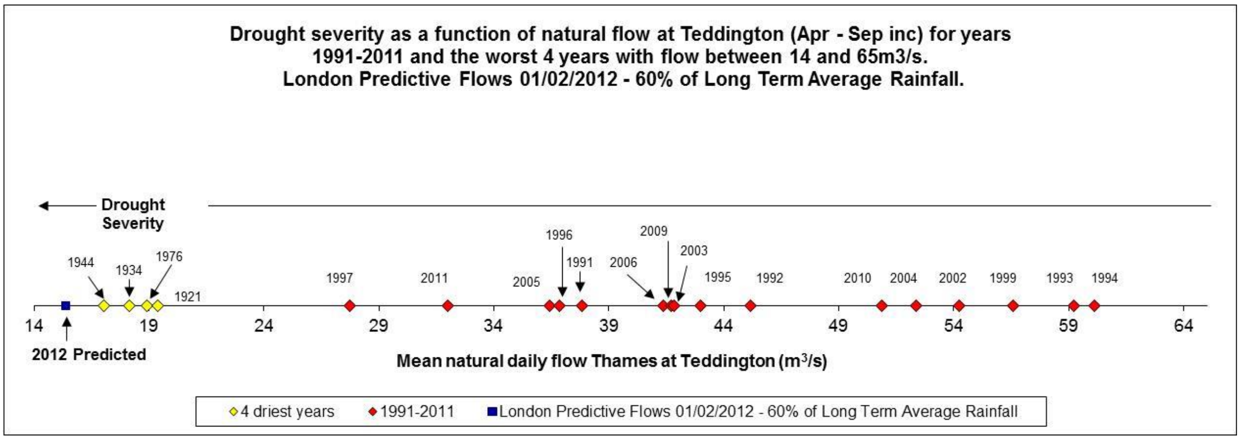

Figure 1 Drought Severity as a Function of Natural Flows at Teddington (April -September) showing the Driest Years Since 1991 and 2011 Prediction and the worst 4 years on record

1.3.2.2. Step 2 - Drought Risk Level Assessment

Step 2 consists of Steps 2a, 2b and 2c described below.

Step 2a- Prevailing and predicted hydrologic risk indicators

Using the output from Step1a, the prevailing and predicted hydrologic data are converted to a corresponding prevailing and predicted set of hydrologic risk indicators for groundwater level (RG), river flows (RR) and reservoir storage (RS); where RG and RR are evaluated in accordance with the EA's percentile banding, Table 2 shows the groundwater and river level percentile bandings. RS is calibrated from the Level 1 to Level 4 control curves in the LTCD, which are shown in Table 3.

Table 2 Groundwater and River flow Level Percentile Bandings

Actual values are based on historic data which is dependent on the extent of the record for each data source.

EA bands		Percentile of the band	Groundwater Risk Level RG	River Flow Risk Level RR
	Exceptionally High	95-100%	R_G0	R_R0
	Notably High	87-95%	R_G0	R_R0
	Above Normal	72-87%	R_G0	R_R0
	Normal	28-72%	R_G0	R_R0
	Below Normal	13-28%	R_G1	R_R1
	Notably Low	5-13%	R_G2	R_R2

EA bands		Percentile of the band	Groundwater Risk Level RG	River Flow Risk Level RR
	Exceptionally Low	0-5%	R_G3	R_R3
	Not on record		R_G4	R_R4

Table 3 Calibration of RS from LTCD control curves

Reservoir Storage Risk Indicator	LTCD Control Curve limits
	800/600 Ml/d
R_S 0	Level 1
R_S 1	Level 2
R_S 2	Level 3
R_S 3	Level 4
R_S 4	

This methodology is demonstrated in Figure 2, Figure 3 , and Figure 4 below using data from the 2012 drought. For the river flow and groundwater level parameters, the prevailing mode is the observed data set from January 2012 to end of March 2012 and predicted mode (assumes 60% average rainfall) is forecasted from March to September 2012. For the storage level parameter, the prevailing mode is the observed data set for February 2012 and predicted mode (assumes 60% average rainfall) is forecasted from March to September 2012. The forecasts at the end of February or March are critical in determining the potential need for early drought measures as it is at this point that the winter recharge is likely to have ceased and so a prediction of the worst case for the summer can be made on the basis of the groundwater recession. Taking each parameter in turn, the hydrologic risk indicators are derived as follows:

Groundwater level - R_G

With reference to Table 2 above and Figure 2 below, it can be seen that the prevailing mode is predominantly within the 'Exceptionally Low' zone at the start of the year, giving a prevailing groundwater risk indicator of R_G3. The predicted level moves to R_G4 throughout the 6 month period.

Note that in this example only the Gibbets Cottages OBH has been shown, however, in practice several regional OBHs would be used to derive an overall view of groundwater level status throughout the catchment.

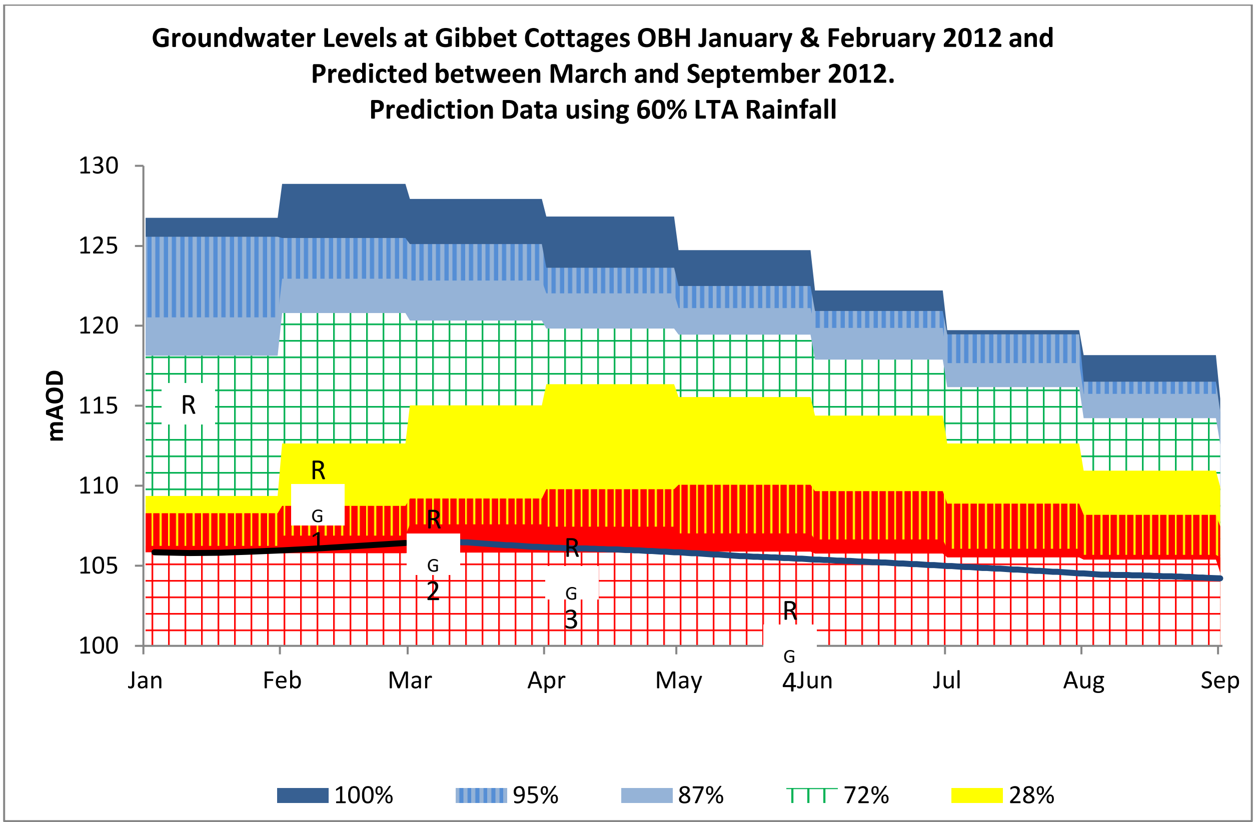

Figure 2 2012 groundwater levels (Gibbet Cottages OBH) - prevailing for January 2012 to end of March 2012, predicted thereafter to September 2012

River flow - RR

With reference toTable 2 above and Figure 3 below, it can be seen that the prevailing mode in March is dominantly within the 'Exceptionally Low' zone, giving a prevailing river flow risk indicator of R_R3. The predicted trend for the 6 month forecast period sits within the 'Not on Record' zone during May giving a predicted river flow risk indicator of R_R4.

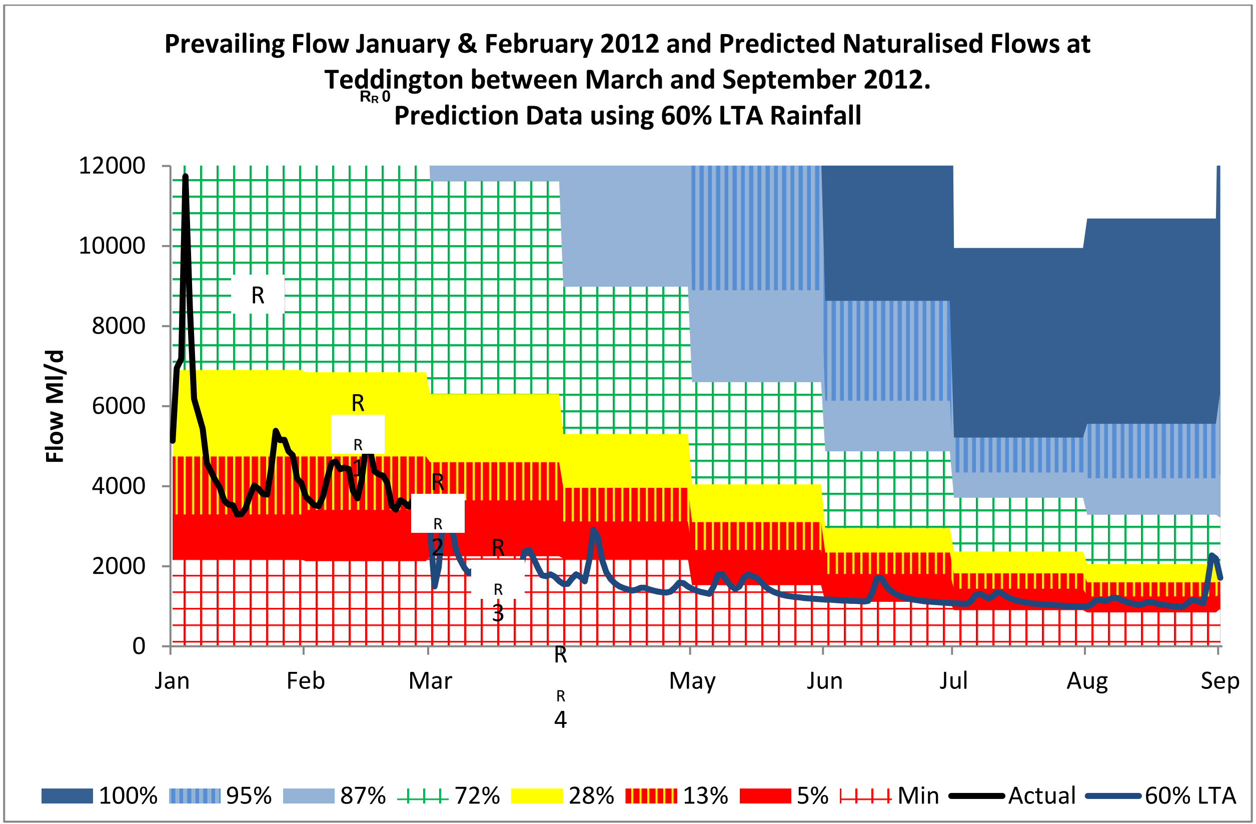

Figure 3 2012 Teddington flows - prevailing from January to end of March, predicted thereafter from March to end of September

Reservoir storage -RS

With reference to Table 3 and Figure 4, the prevailing trend from the start through to the end of February is within the blue 800 Ml/d flow band (RS0). With a 60% predicted long term average rainfall the storage falls into R_S3 in June 2012 then into R_S4 in July 2012.

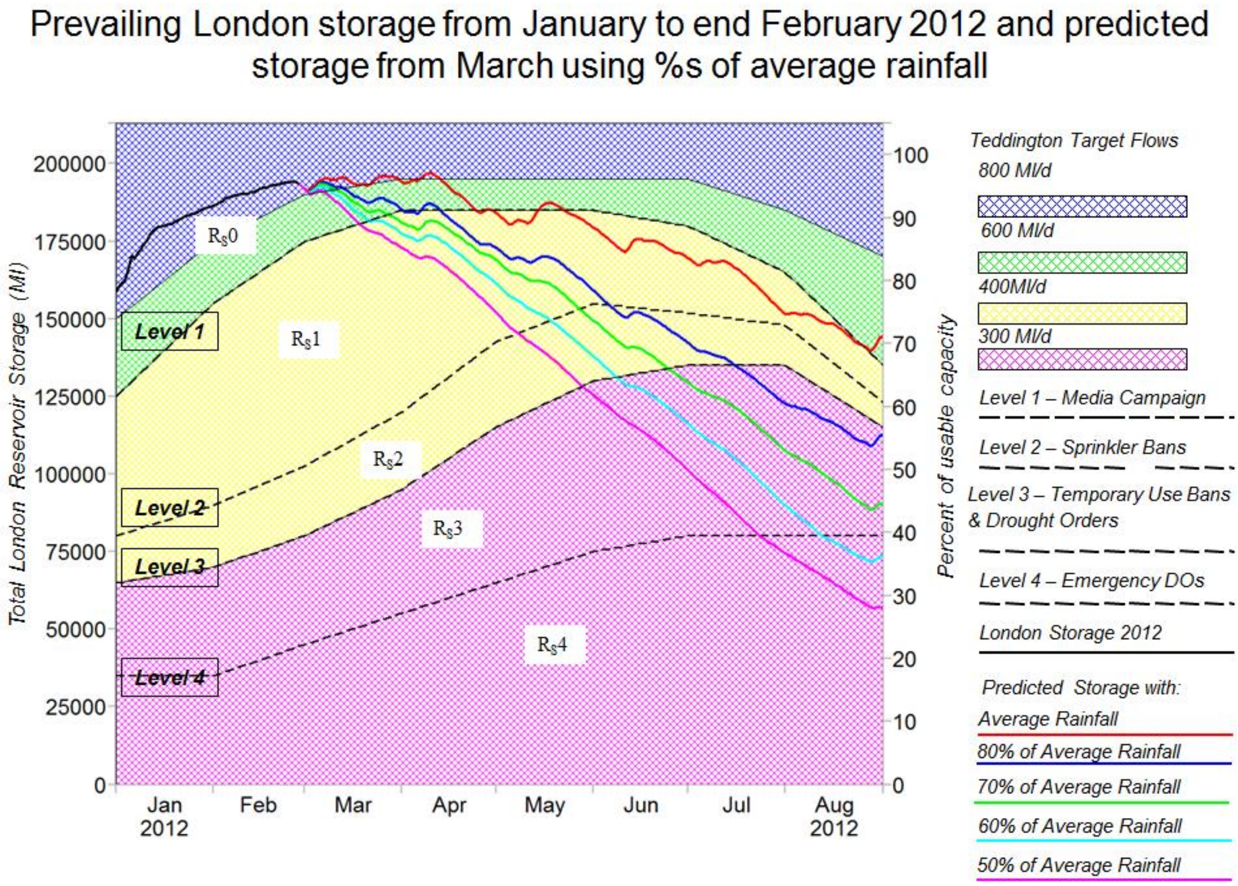

Figure 4 2012 Reservoir storage levels- prevailing to end of February, predicted thereafter (using 2012 LTOA which has since been revised)

1.3.3. Summary

The results of the prevailing and predicted analyses for all three hydrologic variables are summarised below in Table 4.

Table 4 Summary of results for a 6 month forecast from March 2012.

	R_G	R_R	R_S
'Prevailing'	3	3	0
'Predicted'	4	1	4

Step 2b - Combined hydrologic risk indicator

In order to provide a balanced assessment of the overall risk in terms of the hydrologic indicators, the analysis integrates the three individual hydrologic risk indicators relating to groundwater (R_G), river flow (R_R) and reservoir storage (R_S) to provide a combined hydrologic risk indicator (R_C) that is applied to the prevailing situation and predicted scenarios; R_C is given by:

$$R_C = (R_G \times W_G) + (R_R \times W_R) + (R_S \times W_S)$$

Where WG, WR and WS are monthly weighting factors; their formulation is described in detail in Appendix F, Step 2b. The appropriate weighting factors are given in Table 5 below and are shown for all months in Appendix F for London and SWOX respectively. The weighting is used for the relevant month being assessed. Therefore, for the prevailing situation the February weighting is used and for the predicted situation the weighting for August is used.

Table 5 Weighting factors for March and September for London WRZ.

Month	GW - WG	River Flow - WR	Reservoir Storage - WS
March	50%	20%	30%
September	50%	20%	30%

Using the results of the above 2012 example as summarised in Table 4 and the weighting values given in Table 5, R_C values can be calculated for predicted and prevailing conditions in September and March respectively, Table 6. The value is rounded to the nearest whole number to give the combined risk value.

Table 6 Calculation of the combined risk values (R_c) for 'prevailing' March 2012 and 'predicted' August 2012

	R_G * WG	R_R * WR	R_S * WS	R_C
Prevailing	(3 * 0.5) =1.5	(3 * 0.20) =0.6	(0 * 0.3) =0	2
Predicted	(4 * 0.50) =2	(1 * 0.20) =0.2	(4 * 0.3) =1.2	3

Step 2c - Overall risk indicator (ORI)

The risk to security of supply and the appropriate measures to be taken are determined by a consideration of both the prevailing and predicted situation. For example, if groundwater levels are well below average but river flows and reservoir levels are relatively high compared to groundwater levels, then it would be wasteful to switch on strategic schemes prematurely, but it may be prudent to introduce demand management measures such as a TUB. Thus, using prevailing and predicted R_C, the Overall Risk Indicator (ORI) has been developed to provide a balanced assessment of the known short term ('prevailing') risks and potential worst case ('predicted') risks. Table 7 below provides the correlation between the ORI and the prevailing and predicted R_c values.

Table 7 Overall Risk Indicator derived from prevailing and predicted R_c values

Combined Prevailing Risk Indicator	Combined Predicted Risk Indicator	Overall Risk Indicator
R_C0	R_C0	ORI 0/0
	R_C1	ORI 0/1
	R_C2	ORI 0/2
	R_C3	ORI 0/3
R_C1	R_C1	ORI 1/1
	R_C2	ORI 1/2
	R_C3	ORI 1/3

Combined Prevailing Risk Indicator	Combined Predicted Risk Indicator	Overall Risk Indicator
	R_C4	ORI 1/4
R_C2	R_C2	ORI 2/2
	R_C3	ORI 2/3
	R_C4	ORI 2/4
R_C3	R_C3	ORI 3/3
	R_C4	ORI 3/4
R_C4	R_C4	ORI 4/4

Thus, converting the results of the 2012 example as given in Table 7 gives an Overall Risk Indicator of ORI 2/3.

1.3.3.1. Step 3 - Determination of Measures and Drought Event Level (DEL)

The ORI is used as the principal guide for determining the measures to be taken, which in turn is used to set the appropriate Drought Event Level (DEL). Operational aspects, such as outages (when a source of water is not available for use due to reasons such as water quality and maintenance), also need to be considered before appropriate measures are decided upon. The level of DEL (0, 1, 2, 3 and 4) will determine the appropriate level of governance, which ranges from senior management through Director to CEO level. Table 8 below provides the link between the ORI values, DEL, the level of governance and the measures related to the Levels of Service which are largely demand side measures.

The 2012 example giving an ORI level of 2/3 has been highlighted in the table. It shows that the Drought Event is set at DEL3, with governance at Director level and a set of measures consistent with Level 3 of the Levels of Service.

Table 8 Drought Risk Level and Event Level

Overall Risk Indicator Level	TW Drought Event Management Level	Event Controller	Potential Drought Measures	Implied Level of Service
ORI 0/0	DEL 0	No event	No measures introduced.	Not applicable
ORI 0/1	DEL 1	Senior Manager	Media/water efficiency campaign.	Level 1
ORI 0/2	DEL 2	Senior Manager	Enhanced media /water efficiency campaign and TUB.	Level 2
ORI 0/3	DEL 3	Director	Enhanced media /water efficiency, TUB, campaign Non Essential Use Ban (NEUB) and drought permits.	Level 3
ORI 1/1	DEL 1	Senior Manager	Media/water efficiency campaign.	Level 1
ORI 1/2	DEL 2	Director/Senior Manager	Enhanced media campaign and TUB.	Level 2
ORI 1/3	DEL 3	Director	Enhanced media /water efficiency campaign/, TUB, NEUB and drought permits.	Level 3
ORI 2/2	DEL2	Director/Senior Manager	Enhanced media campaign and TUB	Level 2
ORI 2/3	DEL3	Director	Enhanced media/water efficiency campaign/ /Temporary Use Ban; application for NEUB / drought permits.	Level 3
ORI 2/4	DEL3 or DEL 4	Director/ CEO	Enhanced media/water efficiency campaign//Temporary Use Ban; application for NEUB/ drought permits. Preparation for EDO application.	Level 3

Overall Risk Indicator Level	TW Drought Event Management Level	Event Controller	Potential Drought Measures	Implied Level of Service
ORI 3/3	DEL 3	Director	Enhanced media/water efficiency campaign/ Temporary Use Ban. Introduce NEUB/ drought permits.	Level 3
ORI 3/4	DEL 4	CEO	Enhanced media/water efficiency campaign/ Temporary Use Ban Introduce NEUB / drought permits. Preparation for EDO and possible application.	Level 3
ORI 4/4	DEL 4	CEO	Enhanced media/water efficiency campaign/ Temporary Use Ban Introduce NEUB / drought permits. Introduce emergency measures.	Level 4

1.3.3.2. Drought Event-management structure

In accordance with the drought management governance described above in Step 3, our drought management structure is shown below in Figure 5.

The structure reflects the broad supporting discipline base that will be required to support a Drought event. Each business lead will have a team supporting them comprising seconded and supporting staff and external consultants where required. The same structure would be applied for all WRZs.

The resource required and the structure reporting to each lead role will be defined by the severity of Drought and the resource situation in each water supply zone and will continually be reassessed as the severity of the situation changes during a drought.

The stakeholder engagement role is critical in terms of providing a focus for all stakeholder communications and discussions. The stakeholder lead will be responsible for maintaining a close working relationship with critical stakeholders such as the EA and Defra and other key stakeholders such as CCWater, Natural England and the GLA, whilst ensuring appropriate appointed stakeholder contacts for all other stakeholders.

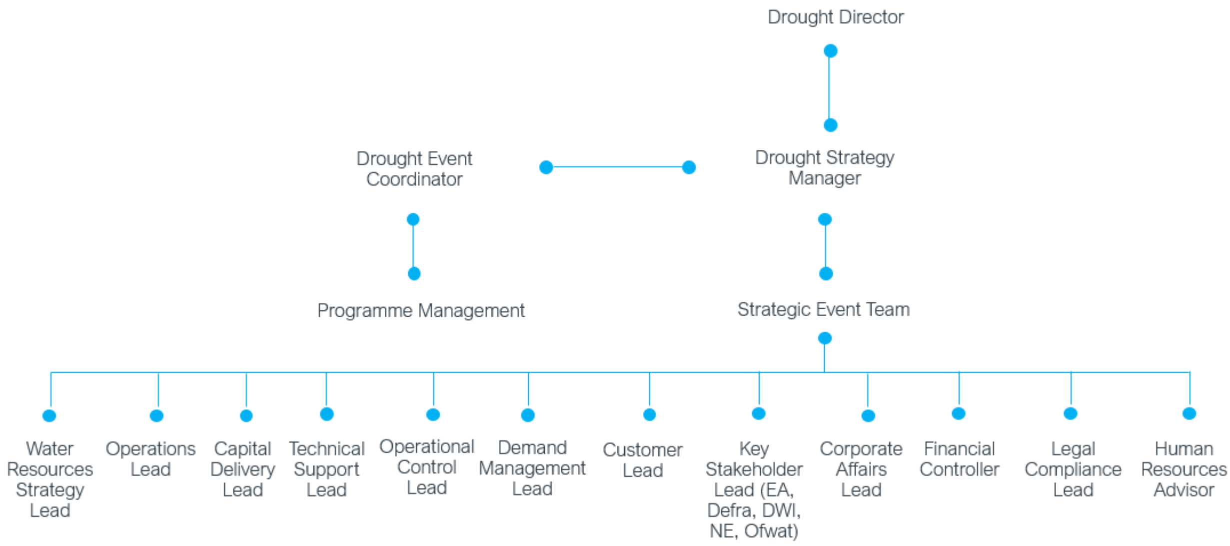

Figure 5 Drought Event Management Structure

1.3.4. Sequencing and timing of measures

For any drought scenario the timing of introduction of the most severe measures that are required is assessed within the protocol. This enables determination of the timing and sequencing of the lesser and, by necessity, earlier measures. Thus, a timeline can then be used to back cast from the point at which it is identified that the most severe predicted measure is required.

It is also necessary to implement water use restrictions in the sequence set out in our Levels of Service, as follows:

- Media campaign must precede a Temporary Use Ban (TUB).
- TUB must precede a NEUB.
- TUB must precede a drought permit.
- NEUB must precede an emergency drought order (EDO).

In order to accommodate the required timeline, there may need to be an overlap in the process due to the time taken to determine NEUB application. For London, the plan assumes the periods of time for the individual actions in the process are as follows:

Level 1 measures
- Media campaign: 2 weeks

Level 2 measures
- TUB: 3 weeks.

Level 3 measures
- NEUB up to 10 weeks from date of the application to granting of order; NB- this time scale allows for a public hearing.
- Drought permit: up to 10 weeks (for the more environmentally sensitive permits) from date of the application to granting of permit; NB - a Category 1 level drought permit may be determined significantly more quickly than 10 weeks.

Level 4 measures

- EDO: up to 10 weeks from date of application to granting of order; NB - this time scale allows for a public hearing.

As shown in Table 9, it can be seen that the elapsed time by which a NEUB could be put in place starting from a point when no preliminary measures had been introduced would be in the order of 15 weeks; for an EDO the equivalent elapsed time is likely to be 25 weeks.

Table 9 Drought Measures Indicative Timescale for London

Measure	Time to Implement (Weeks)			
Media campaign	2			
Temporary Use Ban		3		
NEUB /drought permit			10	
Emergency drought order (EDO)				10
Elapsed time (WEEKS)	2	5	15	25

The elapsed times shown in Table 9 can be used as a guide for planning the timing of the introduction of measures when used in association with the scenarios described above which provide predictions of when certain risk levels will be reached.

1.4. SWOX WRZ

1.4.1. Methodology

The principal and most drought-critical source in the SWOX WRZ is the Farmoor water resources system comprising abstraction from the River Thames transferred to Farmoor reservoir, referred to in the next sub-section. The methodology for the zone has been developed in recognition of the potentially relatively rapid decline in Farmoor reservoir storage compared to London reservoir storage under comparable low flow conditions.

Drought triggers

The Farmoor licence increasingly constrains abstraction from the river as the River Thames recedes under low flow conditions. This, in turn, governs the quantity of river water that can be transferred to Farmoor reservoir. This river/reservoir dependency has been used to define a set of triggers based on critical low flows at Farmoor, the criteria are as follows:

- Trigger for determining the submission date for NEUB and drought permit applications is set at 200 Ml/d flow in the River Thames (5-day running mean) under DEL3 or DEL4 drought event scenarios;
- Trigger for predicting the implementation of NEUB and drought permit options is set at 100 Ml/d (5-day running mean) under DEL3 or DEL4. The latest point of implementing drought permit options will be either by river flow actually receding down to the 100 Ml/d level, or reservoir storage drawing down to 70% in June and July and to 60% in August and September, whichever is the earliest. If NEUB is not already in place company-wide through the London protocol, the above criteria will also be used as the basis for implementing the NEUB.

The 200 Ml/d trigger has been chosen on the basis that it represents the threshold flow after which the maximum licensed abstraction is approximately equal to demand on the Farmoor system and hence thereafter reservoir storage will tend to decline; up to this point Farmoor reservoir will be close to full capacity.

The 100 Ml/d trigger represents the point of significant risk of Farmoor reservoir storage falling to 70% in June and July and 60% in August and September. As all droughts are different, the correspondence of this trigger with the measures being triggered by the London protocol, which will override demand measures in SWOX (see below), will depend on the way the specific drought has developed. Note that a base flow at Farmoor of 200 Ml/d can sometimes be reached towards the end of the summer/autumn recession under normal water situation conditions (best defined by groundwater levels), typically in September or early October. Therefore, a DEL3 or DEL4 criterion is added to the triggers as set out above.

The 1976 drought was used to illustrate and test the effectiveness of the triggers (Section 8 and Appendix F). The 1976 drought was the most uniformly extreme in terms of paucity of rainfall over the Thames catchment and for which a good data set is available. By examining the River Thames flow at Farmoor with London reservoir storage during 1976 a useful guide is provided on the SWOX-London triggers, which show that:

- In the last week of April the flow at Farmoor reached the 200 Ml/d trigger when London reservoir storage reached Level 1 on the LTCD;
- In mid-July flow at Farmoor reached the 100 Ml/d trigger when London reservoir storage reached 70%.

Thus, with reference to the London protocol described above, a helpful conclusion from the above relationships is that for a severe drought (DEL 3 or DEL 4), the enhanced media campaign and Temporary Use Ban measures will already be operating when applications for NEUB and drought permits are submitted for SWOX triggered by the 200 Ml/d flow threshold.

SWOX assessment methodology

There are three basic steps to the SWOX protocol, which is based on the London WRZ, summarised briefly as follows:

- Step 1 consisting of:
- Step 1a -Collation of groundwater, river flow and reservoir storage observed ('prevailing') data.
- Step 1b - Predictions of worst-case scenarios using results from Step 1a as initial conditions, includes new trigger for the application of NEUB and drought permits.
- Step 1c - Estimation of drought severity or frequency of occurrence.
- Step 2 - Risk assessment using the information from Step 1 to derive a composite indicator of risk to security of supply, the Overall Risk Indicator (ORI).
- Step 3 - Guided by output from Step 2, assignment of Drought Event Level (DEL 1,2,3 or 4) and consequent measures to be taken or proposed

Note that within Step 1b, the methodology includes the estimation of the trigger for the submission of NEUB and drought permit applications.

1.4.2. Sequencing and timing

The sequencing of measures and their timing would in the first instance be triggered by the introduction of measures for the London WRZ, see Protocol for London WRZ, Section 4.3.
Given that winter rainfall generally tracks from west to east over the region, it is extremely unlikely that there will be a prolonged period of winter rainfall in which the upper Thames receives below average rainfall while the lower Thames receives normal amounts. However, in the very unlikely event that SWOX WRZ appears to be substantially advanced in terms of drought severity, the SWOX protocol would be followed in its entirety.
As described above, the trigger for applying to Defra for NEUB and to the EA for drought permits is reaching 200 Ml/d naturalised flow on the River Thames at Farmoor under DEL3 or DEL4 drought event scenarios. At this point it is very likely that TUB restrictions would already be in force.

Implementation of NEUB or drought permits would be risk-based, triggered either by consideration of the prevailing reservoir storage approaching 70% or a threshold of naturalised flow of 100 Ml/d or a combination of both.

The trigger for applying to Defra for an Emergency Drought Order would be after the implementation of NEUB measures and would be based on modelling of the likely decline in Farmoor storage taking into account the benefit derived from implementation of Drought Permit options. This assessment would use modelling as a guide to determine the potential time to reach the 33% and the application for an Emergency Drought Order would be based on the expected elapsed time to obtain an EDO. Assessment of conditions at the time of year would also be instrumental in the decision.

The sequencing and timings are given in Table 10 below for a drought of potential severity of at least 1:20 in which the need for drought permits and NEUB and possibly an Emergency Drought Order are predicted. Note that, as the elapsed times are based on the worst-case situation, in practice there is likely to be significantly more time available to implement measures than stated in the table.

Table 10 Drought Measures Indicative Timescale for SWOX

Measure	Triggers	Minimum time to implement (Weeks)			
Media campaign	DEL1 or higher	2			
Temporary Use Ban	DEL2 or higher		3		
NEUB /drought permit	Application to Defra/EA—200 Ml/d rule			10	
Emergency drought order	Application to Defra- implementation of DD11				10
Cumulative Elapsed time		2	5	15	25

1.5. Protocol for Kennet Valley WRZ

The Kennet Valley WRZ is served by a combination of surface water abstraction from the River Kennet in Reading and by several Chalk groundwater sources throughout the zone.
The principal source in the zone and providing the greater part of the supply for the Reading area is the Fobney Advanced Water Treatment Works (AWTW), which derives its raw water from the River Kennet. Work was completed in 2006 to improve the robustness of this source during drought through the Holy Brook flow control structure.

The groundwater sources in the zone have proved to be robust to drought at least since the early 1970s. That is to say, based on current hydrogeological understanding and groundwater remaining above the recorded minimum level (generally the lowest 1976 level), abstraction is expected to be maintained at the assessed deployable output. We have completed an assessment of the potential impacts more severe droughts would have on us; this can be found in section 8.

We have assessed what measures may be needed in a severe drought and threshold values have been developed for the River Kennet below which the Fobney source output may decline. These values are used for determining the need for the introduction of measures in the Kennet Valley zone. Analysis has therefore been undertaken of the flows at Theale to determine a guidance trigger for the introduction of drought measures in the zone.

Holy Brook Control Structure

The Holy Brook is a historic, man-made channel which obtains its flow from the River Kennet/Kennet and Avon canal system approximately 4 kilometres upstream of the Fobney AWTW. At times of low flow the Holy Brook historically took a high and disproportionate amount of flow from the Kennet system. To offset this, a control structure has been installed located on the Holy Brook just downstream of its bifurcation from the River Kennet.

We have agreed an Operating Protocol with the EA, which is based on the principle that as a drought worsens and flows in the River Kennet decline, a progressively higher proportion of flow is diverted from the Holy Brook into the Kennet system that flows past the Fobney AWTW intake. Accordingly, an Operating Schedule has been agreed for the Holy Brook control structure. The schedule is based on a series of triggers requiring closure and opening of the gates on the new control structure as determined by a specified flow in the River Kennet at the Theale Gauging Station, 800m upstream of the Holy Brook control structure. These triggers will be used to aid decision-making when reviewing restrictions for the Kennet Valley WRZ together with reference to the imposition of restrictions in the London WRZ.

Fobney Source Robustness to Drought

The Fobney source is licensed for 72.7 Ml/d with a source deployable output of 63.1 Ml/d average and peak assuming 9.7% process losses. Therefore, the flows available for abstraction at Fobney need to be maintained at least to 72.7 Ml/d in order to ensure the deployable output is maintained.

Figure 6 shows the flows in the River Kennet at Theale for the lowest flow periods experienced within the period of record (commenced October 1961) for the gauging station at Theale. The graph shows the low flow periods of 1965, 1976, 1992 and 1997 and comparison of the drought episodes shows clearly that the worst drought experienced in the record was 1976.

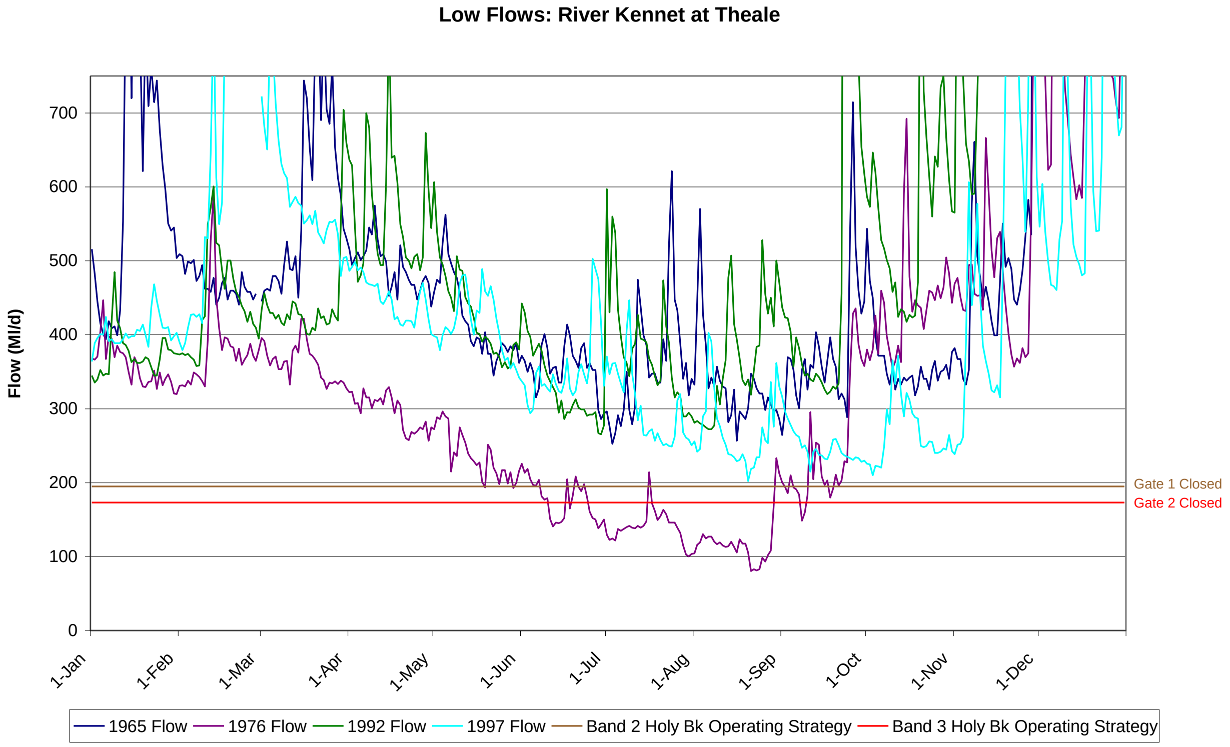

Figure 6 Historic Low Flows for the River Kennet at Theale

Figure 6 and Figure 7 shows the relationship between the flows at Theale and the flows at Fobney, showing the benefit to the flows at Fobney that are provided by the Holy Brook control structure. The diagram shows that as the flow declines at Theale to 195 Ml/d the first gate is shut and so the flow available at Fobney is increased from 75 Ml/d to approximately 90 Ml/d. In a similar way the closure of the second gate at a flow of 173 Ml/d at Theale increases the flow from 75 Ml/d to about 90 Ml/d at Fobney AWTW. It is not until the flow then falls to about 150 Ml/d at Theale that the flow available at Fobney decreases below the licensed abstraction rate of 72.7 Ml/d thereby impacting the source deployable output.

Note that in estimating the flow at Fobney AWTW, apart from the flow diverted down the Holy Brook, account must also be taken of the flow diverted down the fish pass at the Labyrinth weir (approximately 200 metres upstream of the Fobney works intake) as well as leakage through the canal bed. At times of low flow the fish pass diversion can account for up to 44 Ml/d and bed leakage can also be significant due to the increasingly perched nature of the canal bed as the natural water table declines.

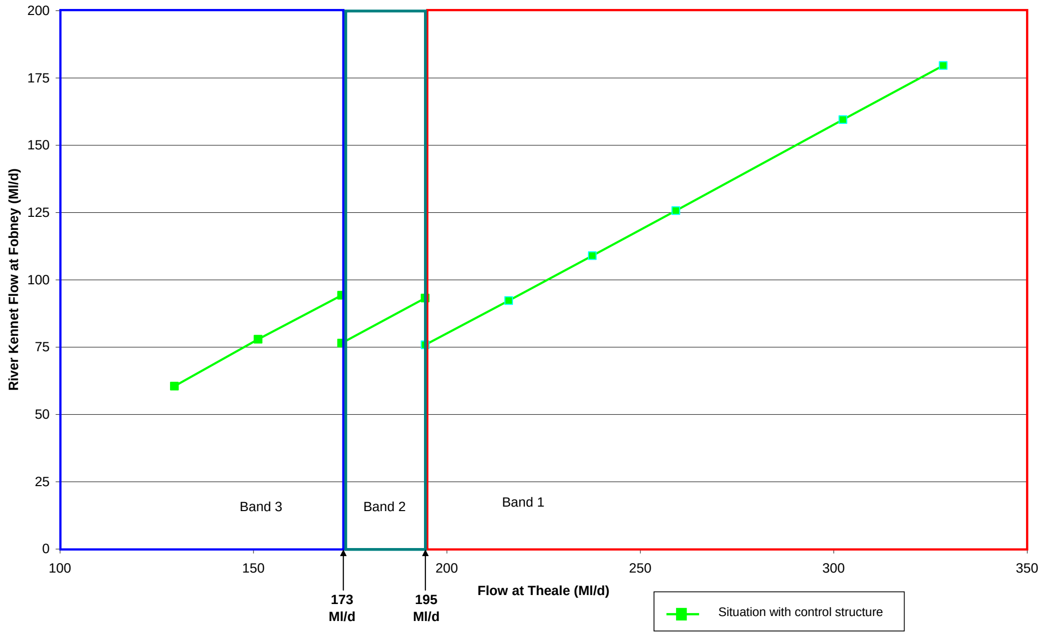

Figure 7 Impact of the flow control structure on the flow in the River Kennet at Fobney

West Berkshire Groundwater Scheme

Figure 8 shows that in order for the flow at Theale to be maintained above 150 Ml/d, the West Berkshire Groundwater Scheme (WBGWS) must be in full operation. When the WBGWS is in operation, the minimum flow at Theale that would have been experienced in 1976 is approximately 150 Ml/d i.e. the flow required to maintain the abstraction at Fobney at 72.7 Ml/d.

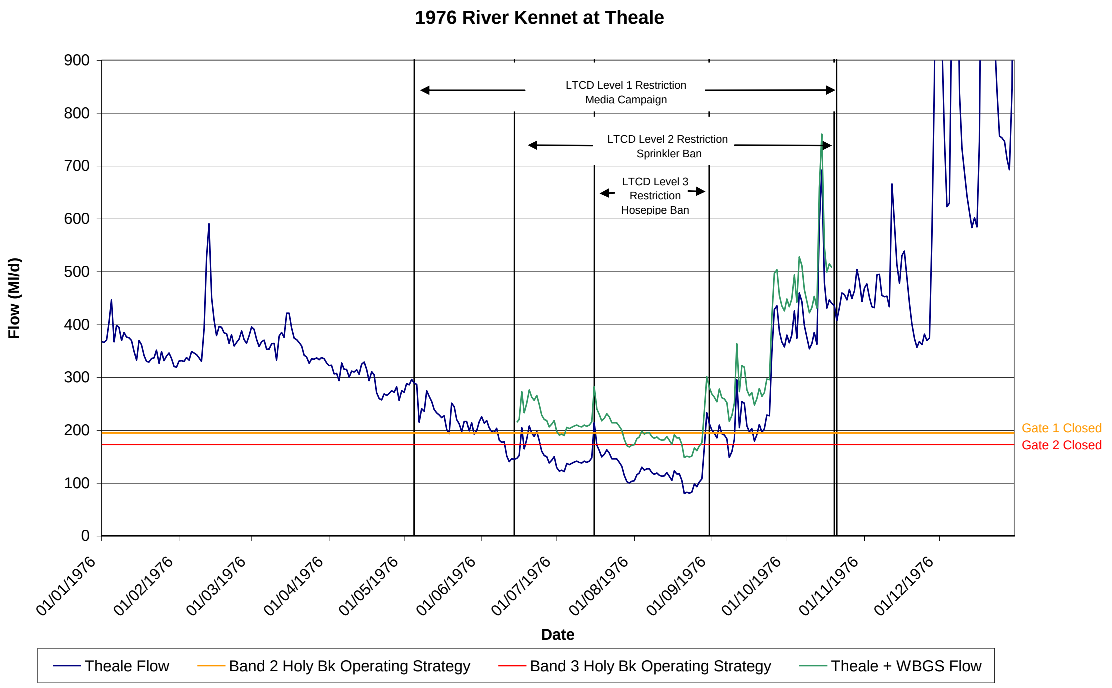

Figure 8 Benefit of West Berkshire Groundwater Scheme augmentation of River Kennet

The adopted trigger levels for guiding decision-making on the introduction of restrictions are set out in Table 11. Normally water use restrictions from the initial media campaign through to Temporary Use Ban and NEUB would be triggered from the London WRZ protocol, see Section 4.3 above.

Table 11 Kennet WRZ Trigger Levels

Critical period	Flow at Theale (Ml/d)	New Flow Split Structure State
Band 1	>195	Gates fully open
Band 2	<195	LoS Level 3 -Temporary Use Ban measures to be introduced prior to Gate 1 closure. <u>Gate 1 closure - triggered 195 Ml/d threshold</u> After Gate1 closure submit: • NEUB application for Kennet Valley WRZ; • Drought Permit applications in priority order as set out in Appendix C.

Critical period	Flow at Theale (Ml/d)	New Flow Split Structure State
Band 3	<173	Gate 2 closure - triggered by 173 Ml/d threshold Conditions of Gate 2 closure are that the Temporary Use Ban will be in place and the NEUB application will be underway.
Implementation of Drought Permits		NEUB will be implemented alongside the introduction of Drought Permit options.

An assessment of the potential impact of a severe drought on the flow in the River Kennet and the Kennet and Avon canal and on the water abstraction arrangements at Fobney AWTW, which is fed by abstraction from the Kennet and Avon canal, has been undertaken. The flow down the Holy Brook leaves the River Kennet at the 'Arrowhead' Structure which controls the split of flow along the River Kennet and the Holy Brook. The analysis has determined that the flow along the Holy Brook needs to be restricted during low flow periods because if not controlled it will result in low flows at the Fobney intake, such that abstraction cannot be maintained to the levels required to secure supplies to the Reading area. We have tested the impact of a more severe drought on the Kennet Valley WRZ drought measures and this is described in Section 8.

We have agreed an Operating Protocol with the Environment Agency which sets out the rules governing the timing of the restrictions that would be put in place to ensure that adequate flow is maintained in the River Kennet, whilst ensuring the required environmental minimum flow is provided to the Holy Brook. In a very severe drought we could invoke a drought permit option to allow for a reduction of the flow to the Holy Brook and an Environmental Assessment Report (EAR) has been produced for this option. It is also recognised that during a severe drought the ability to maintain adequate flows for abstraction at the Fobney intake, may require the closure of the fish pass at the Labyrinth weir just downstream of the split of the River Kennet and the Kennet and Avon canal arm from which the abstraction is taken as shown in
Figure 9 . The Environment Agency are not able to close the fish pass, in line with the Salmon and Freshwater Fisheries Act requirements. Therefore, an option would be required to transfer water from the River Kennet below the Labyrinth weir and discharge it into the Kennet and Avon canal just upstream of the Fobney intake. This has been discussed this with the Environment Agency and we have agreed that such an option should be included in our drought plan. The option could be accommodated through a transfer licence, because the water is being transferred between watercourses with no change to the water quality or intervening use of the water. An application for a transfer licence could be completed in a short timescale in the event that it is needed in a drought or included in the operating agreement. This is outlined conceptually in
Figure 9 .

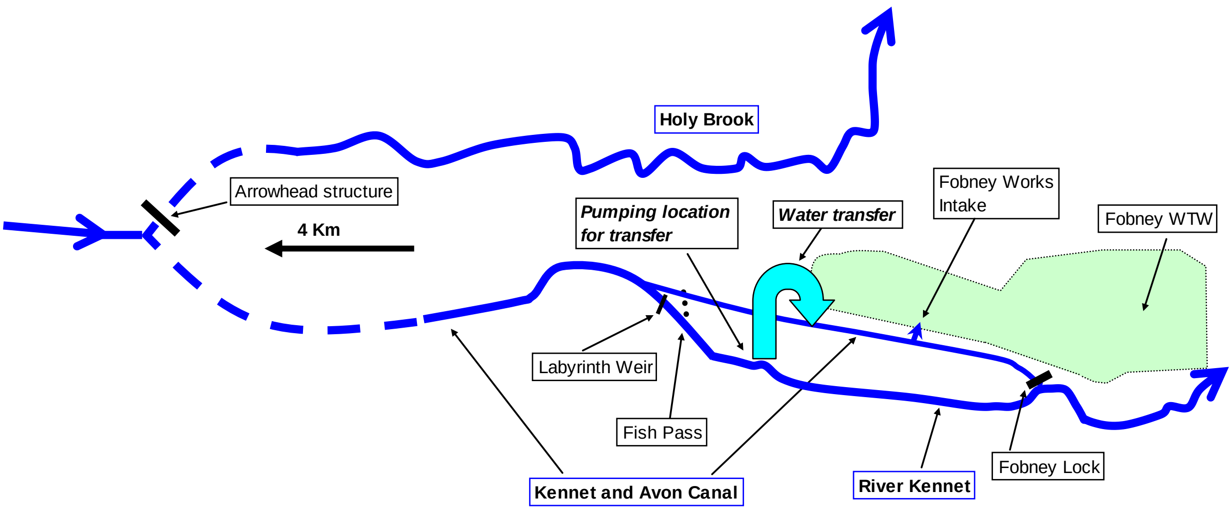

Figure 9 Configuration of pumping arrangements at Fobney intake. Water is pumped from below the Labyrinth Weir into the navigation reach above the Fobney intake channel

Kennet Valley WRZ Resilience

As noted above all the key groundwater sources in the Kennet Valley WRZ are resilient to drought, however Fobney AWTW, by virtue of the flows in the Kennet and Avon Canal that serve the works, is less resilient. The resilience of Fobney is linked to:

- The operation of WBGWS, augmenting natural base flows by the time they have receded down to the critical level of 150 Ml/d at Theale.
- Additional support from drought permits during the critical period
- Supporting the Kennet Valley WRZ and Fobney AWTW by drought permits alone if the WBGWS is not in operation

In this assessment it is assumed that the fish pass at Labyrinth weir will be closed during the extreme low flow critical period for Fobney AWTW. However, if the fish pass cannot be closed, we would require a drought permit to allow for transfer of water from below Labyrinth weir to the canal upstream of our intake.

West Berkshire Groundwater Scheme (WBGWS)

The River Kennet is one of the largest sub-catchments of the River Thames and its base flow can be taken as representative of the base flow at Teddington Weir. It is therefore extremely unlikely that a hydrological situation could exist in which base flows at Teddington Weir could be significantly misaligned with those at Theale.

During periods of very low flow, the WBGWS is triggered when London reservoir storage reaches the Level 2 curve on the LTCD (see Section 6.1.8.4). This trigger is likely to be reached when naturalised flow at Teddington Weir is between 3000 and 2000 Ml/d. At this time flow at Theale is likely to be between 400 and 300 Ml/d. This range is significantly above the point (150 Ml/d) when the flow at Fobney AWTW starts to approach the licensed abstraction limit of 72.7 M/d. The recession of 1976 was the most severe on record for the Theale gauging station. Comparison with the stream hydrographs at Theale and at Teddington Weir for 1976 clearly shows that the WBGWS would have been in operation at least 2 months prior to Fobney requiring support from the scheme, see Figure 10 below.

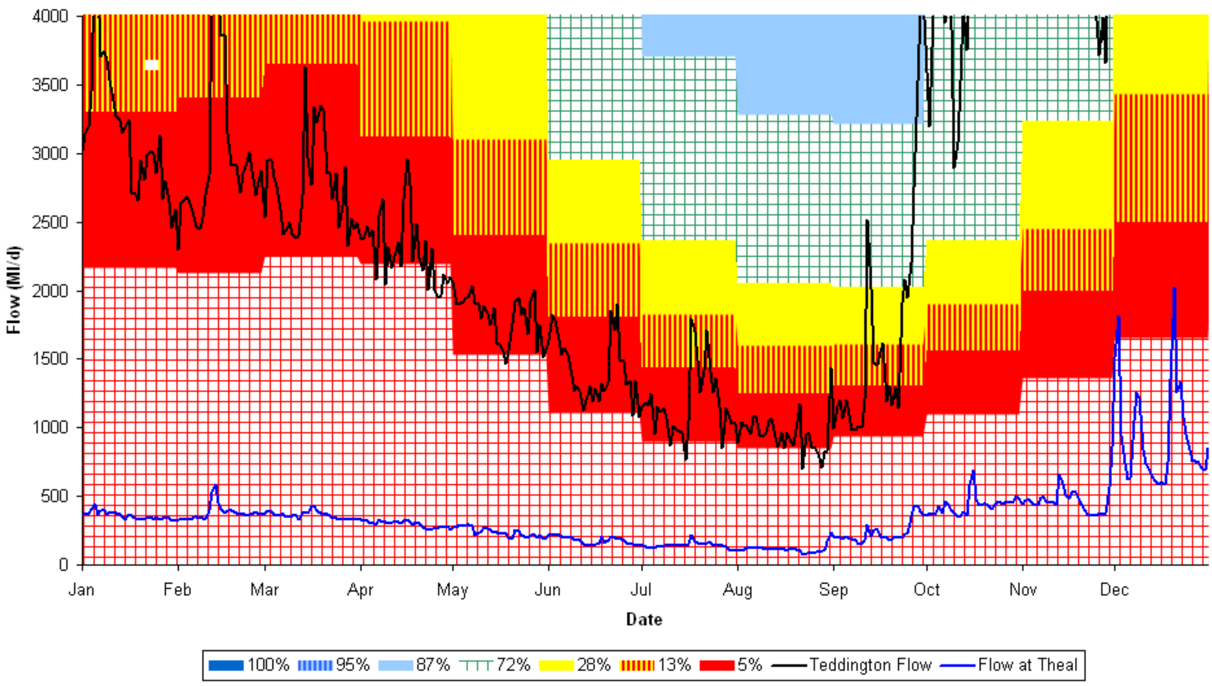

Figure 10 Comparison of River Thames flow at Teddington Weir and River Kennet flow at Theale GS during 1976.

Drought permit support

The drought permit options that can effectively support Fobney AWTW (see Appendix C) are:

- Pangbourne Groundwater source
- Fobney Emergency Boreholes
- Further reduction in residual flow down the Holy Brook

The net contribution from the Pangbourne source drought permit into the Reading area is set at 7 Ml/d. The contribution from the Fobney Emergency boreholes is estimated to range between 12 and 28 Ml/d. Thus, the contribution from the groundwater sources range from 19 to 35 Ml/d. However, with the WBGWS in operation, which provides around 55 Ml/d at Fobney AWTW, it is unlikely that any further support would be needed from reducing residual flow down the Holy Brook.

K1 Supporting Kennet WRZ without the WBGWS in operation

In the event that the WBGWS were not in operation during extremely low flow periods such as experienced in 1976, it is clear that a substantial contribution from the Holy Brook residual flow would need to be made, say in the order of 10 to 30 Ml/d. It is assumed that there will always be some natural flow reaching the Fobney arm of the River Kennet system enabling a degree of raw water abstraction into the works. Under the scenario where the WBGWS is not in operation, a shortfall of 55 Ml/d during critical periods has been estimated.

Trigger for drought permits

With regard to the trigger for implementing drought permits at 173 Ml/d (Gate 2 closure), consistent with the other WRZ lead times, a period of 10 weeks has been calculated back from the point when Gate 2 closure is predicted. This means that, in practice, during the early stages of a severe drought (as given by DEL3 or DEL4), an essential requirement will be the prediction of flow recession in the River Kennet at Theale.

Note that, this drought protocol has not yet been used during a drought period, and so it will be subject to review following any drought period.

1.6. Protocol for Guildford WRZ

The Guildford WRZ is served by a combination of surface and groundwater abstraction. The principal source is at Shalford where water can be abstracted from either the River Wey or the River Tillingbourne, which enters the former at this point. The remainder of the WRZ is served by abstraction from groundwater, either from the Chalk or the Greensand aquifers. The Shalford source is the largest individual source in the zone and so is the key source for use as an indicator of when drought conditions are developing.

The Shalford source is licensed for 30 Ml/d and has no flow constraint. Abstraction can be taken either from the Wey or the Tillingbourne and so the deployable output (DO) is determined through reference to both sources.

The Shalford source has historically been robust through drought periods such that its yield could be maintained during the droughts experienced over the period of record. The robustness of the source arises from the fact that the combined flows in the Wey (as gauged at Tilford) and the Tillingbourne have historically been well in excess of the abstraction requirements at all times since the 1950s. This is demonstrated by the figures below, which show that the combined flow of the Tillingbourne and Wey available to the Shalford intakes is some 38 Ml/d above the Shalford abstraction licence.

Shalford abstraction licence	30 Ml/d
Source DO	26.4 Ml/d (12% process losses)
Minimum flow in Wey plus Tillingbourne	68.4 Ml/d

Based on historical low flows, see Figure 11 , threshold values have been developed for the Wey at Tilford for use in triggering the need for the introduction of measures specifically to address the risk to supplies in the Guildford zone, Table 12.

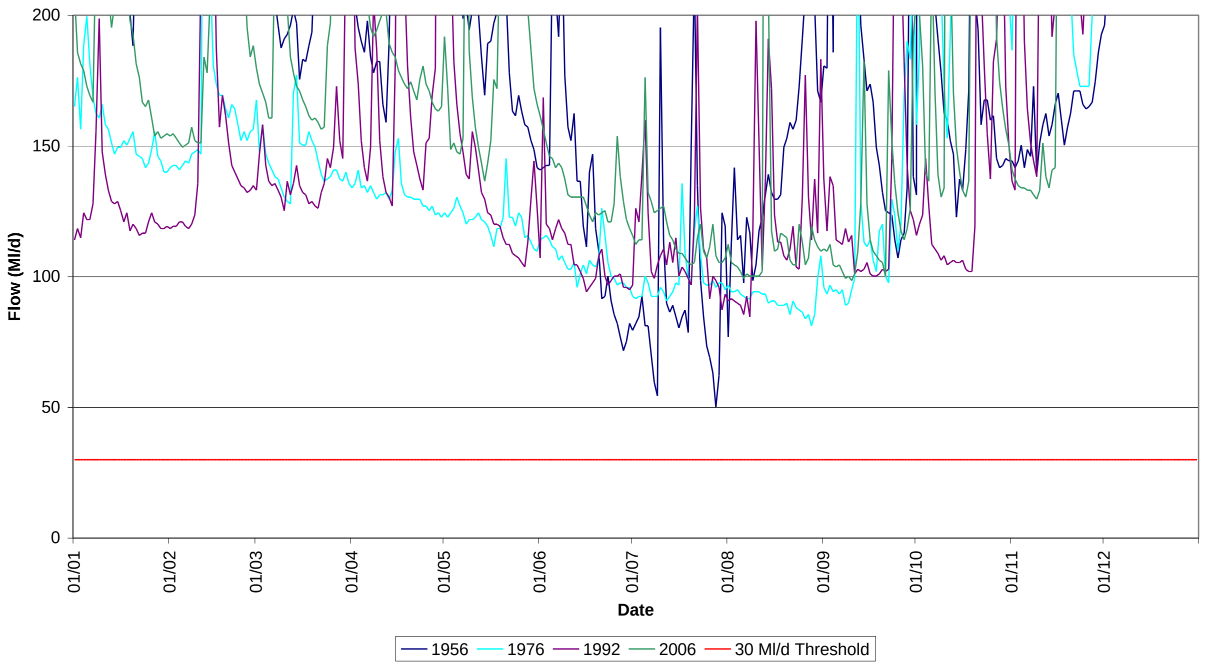

Figure 11 Historic low flow on the River Wey

Table 12 Indicative Flow Triggers for Guildford WRZ

Measure	Flow rate
Temporary Use Ban	90 Ml/d (on average for 5 days)
NEUB	75 Ml/d (on average for 5 days)
Drought permit	75 Ml/d (on average for 5 days)

The thresholds are based on the minimum flows experienced in 1976. A safety margin of 20 Ml/d has been allowed for (difference between the minimum recorded flow at Tilford and maximum abstraction rate). The trigger points are chosen to allow for an appropriate period to prepare for a drought order or drought permit applications.

In practice, a minimum period of 10 weeks has been allocated for the lead time from submission to granting of drought permit. The preparation time needed for a given permit will vary depending on the information needed for each drought permit. It is therefore important that the appropriate hydrologic tools are available for predicting flows in the Wey and Tillingbourne.

The resilience of the Guildford WRZ to more severe droughts has been assessed and is described in more detail in Section 8.

1.7. Protocols for Slough, Wycombe, Aylesbury and Henley WRZs

Both Slough, Wycombe, Aylesbury (SWA) and Henley WRZs are entirely served by groundwater sources abstracting predominantly from the unconfined Chalk aquifer of the Chiltern Hills. These groundwater sources have proved to be robust to drought, for the period of record since the 1976 drought, but this is not to say that the supply situation should not be monitored and a protocol put in place to safeguard security of supply. This protocol is important for these zones, but is also of relevance to the London WRZ, as the Chilterns can also provide significant baseflow contribution to the River Thames, directly or via its tributaries. The background to the development of the protocol for the SWA and Henley WRZs is outlined in Appendix G. We recognise that during a drought a lot of rivers will be suffering from low flows and this is of particular importance in the SWA WRZ which covers the area of some of the Chilterns Chalk streams. We have reduced our reliance on abstractions that may affect chalk streams over recent years with the closure of our groundwater sources at Mill End on the River Wye and New Ground on the River Bulbourne and reduction at Pann Mill on the River Wye. We also plan to close our source at Hawridge in the Chess catchment at the end of 2024. We have been able to make these reductions through improving our supply network to enable more water to be transferred from our sources close to the River Thames such as Taplow and Medmenham northwards to meet demand in areas previously served by these sources. This has also served to improve the resilience of our water supply in this zone because the Thames-side sources are more resilient to severe drought than those further up the catchment. This means that we are in a better position to maintain supplies through a drought without having a significant adverse impact on chalk streams.

The specific situation in the SWA and Henley WRZs will be monitored through the tracking of key catchment groundwater levels, as well as tracking the abstraction performance of selected groundwater sources in relation to their DO.

Stonor Park OBH has been chosen for tracking groundwater levels in the Chilterns and forms the basis for defining drought management control levels for both the SWA and Henley zones. The rationale adopted is as follows:

- Groundwater levels in the Chalk at Stonor Park broadly reflect groundwater behaviour across the Chilterns in both the SWA and Henley WRZs;
- When groundwater recession continues below levels normally expected, enhanced tracking of groundwater levels and abstraction source performance will commence;
- If groundwater recession continues further, reaching low levels at times of high demand, then a TUB may be triggered;
- At groundwater levels down to the minimum recorded in the catchment, the groundwater sources are robust, being able to produce their deployable output;
- Below the minimum recorded groundwater levels, drought permits may be required to supplement normal supply capability;
- Drought management actions would be triggered assuming company-wide actions were not already in place triggered by the management protocol for the London WRZ.

These are pragmatic principles, but in practice the timing of implementation of such measures is difficult to define with confidence. This is because, historically, no demand management actions have been triggered specifically by drought conditions in the SWA or Henley zones, rather actions have been driven initially by supply demand conditions in London. Therefore, the protocol for these WRZs remains provisional and would be reviewed following a drought of sufficient severity to warrant measures being implemented on the basis of these zonal triggers. This partly reflects the relative robustness of the SWA and Henley groundwater sources, with robustness of SWA having been improved in recent years with reduction in the number of groundwater sources in the upper parts of the catchment resulting in more reliance on Thames side sources, and with more reductions planned with the closure of Hawridge in 2024. However, there is significant uncertainty in assigning drought management measures to specific hydrogeological conditions and control levels. Clearly, however, when establishing the need to trigger drought management actions when crossing any defined control levels it is necessary to consider the source performance and demand situation at that time.

Within the context outlined above, Figure 12 illustrates the drought management control curves and tracking approach for the SWA and Henley WRZs. This approach is based on tracking the Stonor Park groundwater hydrograph against its historical record, as defined by a series of control curves based in part on monthly statistics developed by the EA, e.g. "Notably Low", "Exceptionally Low". It can be seen from Figure 12 that, for example, the minimum historic groundwater level is defined by groundwater level conditions that occurred in 1976. The key features of tracking groundwater levels against the control curves are as follows:

- Enhanced Tracking - When groundwater levels decline below the RG1 (Below Normal) control level, enhanced tracking of groundwater levels and abstraction source performance will commence. In around 90% of years when levels have been below this interface, groundwater levels have continued to decline to be Notably Low.

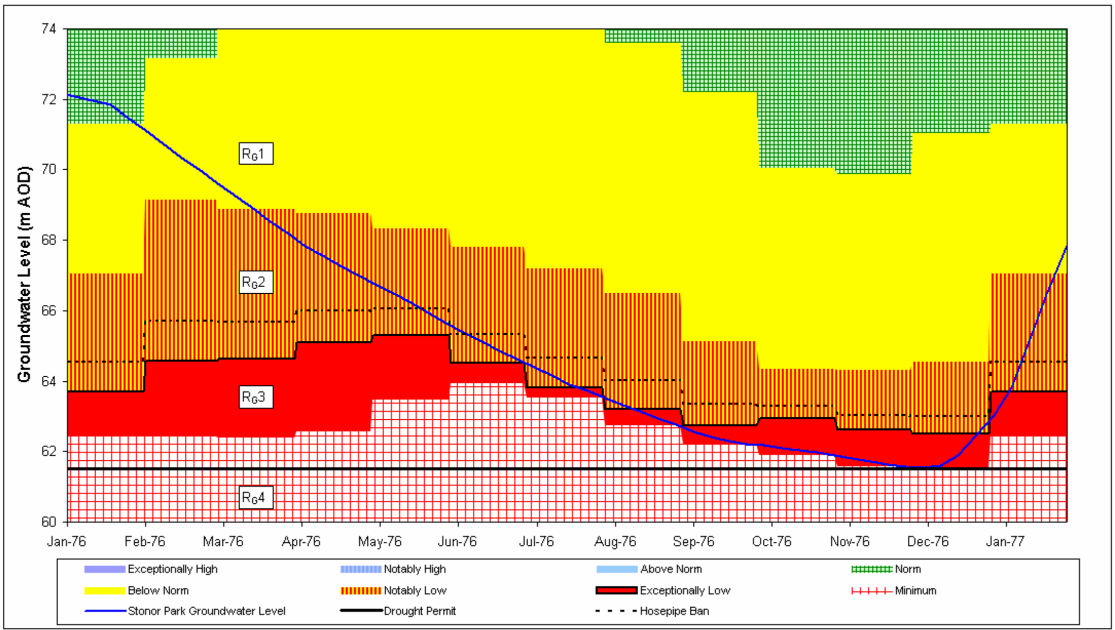

Figure 12 Groundwater Control Curves for Stonor Park OBH for 1976

- Temporary Use Ban Implementation – The groundwater level at which a TUB might be implemented has been set as a seasonally variable level, at 75% below the RG2 interface. A TUB is more likely to be implemented if the control level is crossed at or shortly after the groundwater maximum in May and recession continues towards the minimum recorded groundwater levels. Such action would be taken assuming a company-wide TUB was not already in place.
- This control level has been set by attempting to "calibrate" the timing of historical drought actions, as inferred from the London WRZ protocol, with the Stonor Park historic groundwater hydrograph. Using this approach, the occurrence or absence of drought actions in SWA and Henley in 1976 and 2006 is consistent with those inferred from the London WRZ protocol. However, from the 1997 Stonor Park hydrograph, the protocol indicates that a TUB should be triggered rather earlier than the start of April, as indicated by the London WRZ protocol. In practice, a TUB could likely be deferred to springtime to maximize savings.
- Drought Permit Application – As groundwater levels decline below the RG3 (Exceptionally Low) control level, an application for a drought permit may be made, depending on the time of year and demand. An application is more likely to be made if the control level is crossed shortly after the RG3 groundwater maximum in May and recession continues towards the minimum recorded groundwater levels, e.g. 1976, 1997. In years such as 1991 and 2006, the RG3 control level was crossed several months before the May maximum, just as groundwater levels started to recover and, as such it is unlikely that a drought permit application would not be required.
- Drought Permit Implementation – The implementation of increased abstraction under a drought permit may be triggered once groundwater levels fell below the historic minimum, RG4 control level, depending on source performance. This control level is currently defined as 61.5 m AOD and, historically, has been approached and reached during the months of November and December significantly after the normal peak demand periods.
- Using these control curves, the historic groundwater hydrograph recession rates observed in 1976 and 1997 would have provided the necessary 10 week period between applying for and, if required, implementing an appropriate drought permit. However, the recession rates in these same years also produce an 8 to 10 week period between introducing a TUB and applying for a drought permit; this is rather more than the 3 weeks assumed to be required. This potentially conservative outcome demonstrates some of the uncertainty in generating groundwater control curves for SWA and Henley, but an appreciation of this uncertainty will drive a pragmatic decision-making process. This process may be supported by making predictions for groundwater level recession at Stonor Park.
- As for some other WRZs, e.g. Kennet Valley, the drought protocol for SWA and Henley has not yet been used in practice leading up to or during a drought because we have not experienced a severe drought since development of this protocol. Consequently, the protocol will be subject to review during and following future droughts, as well as following any significant change in the supply demand balance in the SWA and/or Henley WRZs.

1.8. Return to normal conditions - process

In the same way that the protocols provide an assessment of the escalation of risk to security of supply, so do they provide an assessment of the diminution of risk to security of supply. The information provided enables us to appraise customers and stakeholders of the reduced risk and relaxation of restrictions.

Regular discussions will be held with the EA to ensure a common position is formed on the improving water situation, as assessed for each WRZ by using the full range of hydrological data (see Section 4.3.3, Step 1a). Before declaring an end to a drought event and the consequent lifting of all drought management measures, we will seek confirmation that these actions are consistent with the EA's position on the water resources situation.

The Drought Management Methodology will be used as a guide to decide when measures will be lifted in accordance with the improving Drought Event Levels (DEL1 to 4) associated with a return to wetter conditions.

1.9. Post Drought Review

Each drought is different and provides an opportunity for reviewing and improving the Drought Plan, therefore we would carry out a review after a significant event. This review would establish the proper closedown of an event and captures the learning gained from it. Such a review should be undertaken as soon as practicable once the event has closed down, and once all the learning and facts can be fully assimilated. A meeting or series of meetings would be held with the full event team, assessing the factors that worked well, and those that could be improved to prevent or better manage a similar event in the future. The meetings would be minuted and actions assigned and followed up.

A drought, whilst different from some of the fast-moving events such as a serious burst water main, is subject to the same scrutiny. A single season drought event would be subject to 'Review' at the end of the water resources stress period and again once the event had been closed down. A longer drought would be subject to annual reviews after each water resources stress period and again once the event had been closed down.

Operations Management Procedures are reviewed on an annual basis and updated in the light of new information, knowledge and experience.

Post - drought review assessment activities:

Review the effectiveness and efficiency of:

- Drought Management Methodology
- Drought Management Event procedures
- Communications with:
    - Customers
    - EA
    - Other stakeholders

- Water companies and Water UK
- Demand-side measures, including review of actual savings and update of predicted savings
- TUB - notification and representation process
- NEUB application process
- Supply-side measures, including operational aspects and water resource benefit
- Drought permit application and implementation process, environmental impacts and impacts on other abstractors

We would endeavour to produce our post drought report 6 months after the cessation of the drought, for example 6 months from the point that the TUB is lifted. We will also endeavour to produce a post drought review of drought permits/orders 1 year after the drought permits have been lifted. This would be repeated for 3 years or until agreed with the EA.

a) On the basis of results from the post drought review, carry out the following actions:

- Prepare draft and final Lessons Learnt Report.
- Review and, if necessary, update existing Drought Plan.

We undertook a review of the 2012 drought, the last significant drought to occur in the Thames region, and included the lessons learnt in our revised plan produced in 2013.

1.10. Summary

London and SWOX WRZs are known as conjunctive use zones as the water resources are derived from a combination of river abstraction, raw water reservoir storage and groundwater sources. For both zones, the critical element in the system is the level of reservoir storage, which in turn is dependent upon river flow. The drought management measures for the London zone consist of:

- Demand-side measures in which water use restrictions associated with Thames Water's Levels of Service play a major role and are triggered by the prevailing / predicted protocol;
- Supply-side measures in which several strategic drought schemes play a major role in augmenting the London zone's supply capability.

Both the supply and demand-side measures form an integral part of London's deployable output. Because of the dominant nature of the London WRZ, it will generally be the case that the water use restrictions introduced in the London WRZ will also be applied to the rest of our supply area. Nonetheless, the Drought Plan recognises that there may be situations in which more local measures may need to be introduced for the other WRZs; consequently, protocols have also been developed for these zones.

The SWOX methodology is similar to that for London and so is based on the prevailing/predicted assessment. The introduction of water use restrictions is determined, in the first instance, by the London protocol. However, it is supplemented with a trigger for submitting NEUB and drought permit applications based on the level of natural flow (200 Ml/d) in the River Thames at Farmoor. Unlike the London WRZ, there are no supply-side strategic drought schemes built into the zone's deployable output; the major supply-side augmentation comes mainly in the form of increased abstraction from existing sources introduced at Level 3 through the drought permit mechanism.

The protocols for the Kennet Valley and Guildford WRZs are based on critical low flows in the River Kennet and River Wey respectively, which act as the trigger mechanism for the introduction of drought measures.

SWA and Henley WRZs are entirely supplied by groundwater sources, which historically have remained robust during drought. The protocol for these zones is based on tracking key regional observation boreholes together with the performance of selected groundwater sources in relation to their deployable output.