Drought Plan 2022

Appendix 5

Drought management for Anglian Water direct supply river intakes

Utility Week AWARDS 2021 WINNER Utility of the Year

THE QUEEN'S AWARDS FOR ENTERPRISE: SUSTAINABLE DEVELOPMENT 2020

Contents

1. Introduction

Anglian Water has six operational direct supply river intakes. All abstractions are operated individually. Overall direct river intakes account for less than 5 per cent of water supplied by Anglian Water.

Some intakes are associated with bankside storage, offering some short-term localised water storage to buffer against fluctuations in river flows.

Table 1.1: Direct intakes and associated river flow monitoring and bankside storage

Water Resource Zone	Direct intake	River flow monitoring	Bankside storage
Central Lincs	River Ancholme at Cadney	Bishopbridge gauging station	Cadney Carrs
Ruthamford South	River Great Ouse at Clapham	Roxton gauging station	N/A
Norwich & the Broads	River Wensum at Heigham / Costessey	Costessey Mill gauging station	Costessey Pits and Heigham Large Deposit Reservoir
South Fenland	River Nar at Marham	Marham gauging station	N/A
North Fenland	River Wissey at Stoke Ferry	Combination of Northwold gauging station (River Wissey) and Whitebridge (Stringside Drain)	N/A
Central Lincs	River Trent at Hall	North Muskham gauging station	Hall reservoir (10 days storage)
South Lincs	Bath Spring, Saltersford and Cringle Brook (not operational)	Saltersford gauging station (River Witham), Stoke Rochford gauging station (Cringle Brook)	N/A

2. Yield assessment

For supply forecast assessments in the Water Resources Management Plan (WRMP) 2019, we have moved to a system model, AQUATOR. This can be used to provide deployable output for Water Resource Zones (WRZs), using input rainfall, river flows and groundwater yield data.

River flow data has been simulated using our rainfall-runoff model, HYSIM. HYSIM is used to provide flows for the direct river intakes: Stoke Ferry, Marham, Heigham, Clapham and Hall. The model uses rainfall and potential evapotranspiration (PET) data to generate surface runoff, percolation to groundwater and river flow.

The models were updated in 2016 in preparation of the WRMP 2019. Rainfall and PET input data sets were extended to the end of 2015 (from 1920) in line with available data.

The exception is for the Cadney intake, for which the flows and yield are calculated as part of the Environment Agency's Trent-Witham-Ancholme scheme (TWAS) assessment, as it is a supported source.

Table 2.1: Direct intake yields updates for baseline supply forecast

Direct intake	Drought Plan 2014 and WRMP 2015 yield[1] (Ml/d)	Drought Plan 2019 and WRMP 2019 yield[2] (Ml/d)	Minimum flow year	Explanation for change from previous yield assessment
River Wensum at Heigham	N/A	69	1992	Not previously assessed (Costessey only)
River Nar at Marham	14	13	1944	Change to PET data
River Wissey at Stoke Ferry	12	11	1944	Change to PET data
River Great Ouse at Clapham	43	38	1976	Change to PET data
River Ancholme at Cadney	72	75.3	1976	Reviewed in 2017 EA-AWS assessment (Atkins, 2017[3])
River Trent at Newton (Hall)	N/A	20*	1976	Not previously operational

* Hall is a direct intake on the River Trent that has been active since 2014. It is modelled using a rainfall-runoff model built in HYSIM by Mott MacDonald. We are reporting Hall intake with a 20 Ml/d yield under a 1 in 100 year return period. This is based on a review of historic drought return periods. For drought events more severe, we will seek to apply for a drought permit. Following WRMP investment, by the end of AMP7 we are investing in the Central Lincolnshire WRZ to ensure it is secure to a 1 in 200 year drought event. The Hall yield assessment and return period analysis is discussed further in the **WRMP 2019 Supply Forecast Report**.

1 *Mott MacDonald (2012) Surface Water Yield Assessment Update 2012*
2 *Mott MacDonald (2016) Surface Water Yield Assessment Update 2016*
3 *Atkins (2017) Trent Witham Ancholme Assessment Memo*

3. Drought management

3.1 Direct intake drought risk

Direct river abstractions rely on river flows and have no associated seasonal storage in the form of reservoirs. These sources react quickly to changes in rainfall and are more vulnerable to other influences such as outages due to water quality. To protect the environment, our river intakes have a licence condition that specifies a Minimum Residual Flow (MRF) or Hands Off Flow (HOF), below which we are not authorised to abstract water. During periods of low flows we liaise closely with the Environment Agency and monitor flow or level conditions associated with the licences at each of our direct river intakes.

3.2 River flow forecasting

River flows are closely monitored as drought conditions develop. River forecasting is completed on all our direct surface water intakes using the ensemble stream flow method. This method uses simulated flows from our rainfall runoff models (described in **WRMP 2019 Supply Forecast Report**) and rainfall accumulations which we calculate from MORECS data received from the Met Office. The new rainfall runoff models detailed in **Section 2.5**, **Main Plan** will provide short term forecasts utilising 3 month rainfall forecasts provided through Earth System Data.

It is worth noting that these models only review the hydrological factors and do not take into the account the water quality issues which influence the direct intakes. In some cases supply actions may have to be initiated earlier than the modelling suggests.

Abstraction potential is also reviewed as part of river intake forecasting. This takes into account the pump availability and operation of the direct intake at the time of review. The output is then compared to the historic river flow events for that river to identify if there is any risk under the forecast conditions.

The direct intake forecasts are compared to Environment Agency river flow categories to understand the relative severity of the low flows. These are summarised in Table 3.1.

Table 3.1: Environment Agency river flow categorisation with associated colours

Category	Return period
Exceptionally Low	>1 in 20 year
Notably Low	1:8 - 1:20 year
Below Normal	1:4 - 1:8 year
Normal	1:4 year
Above Normal	1:4 - 1:8 year
Notably High	1:8 - 1:20 year
Exceptionally High	>1 in 20 year

Figure 3.1: Example of River Intake Forecasting (NH = Notably high, AN = Above normal, N = Normal, BN = Below normal, NL = Notably low and ExL = Exceptionally low)

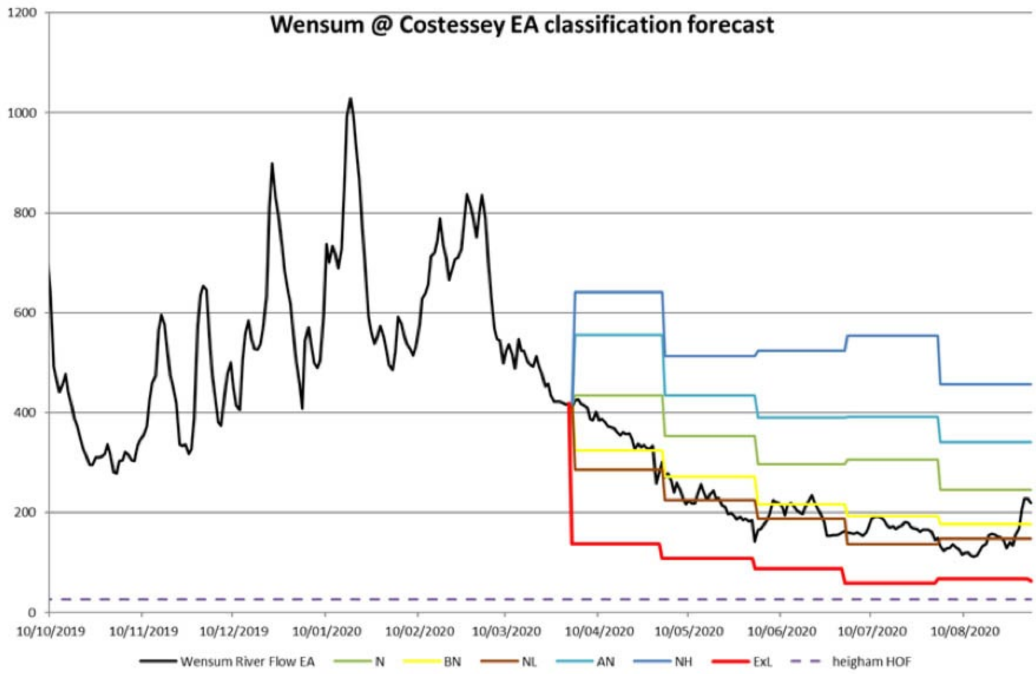
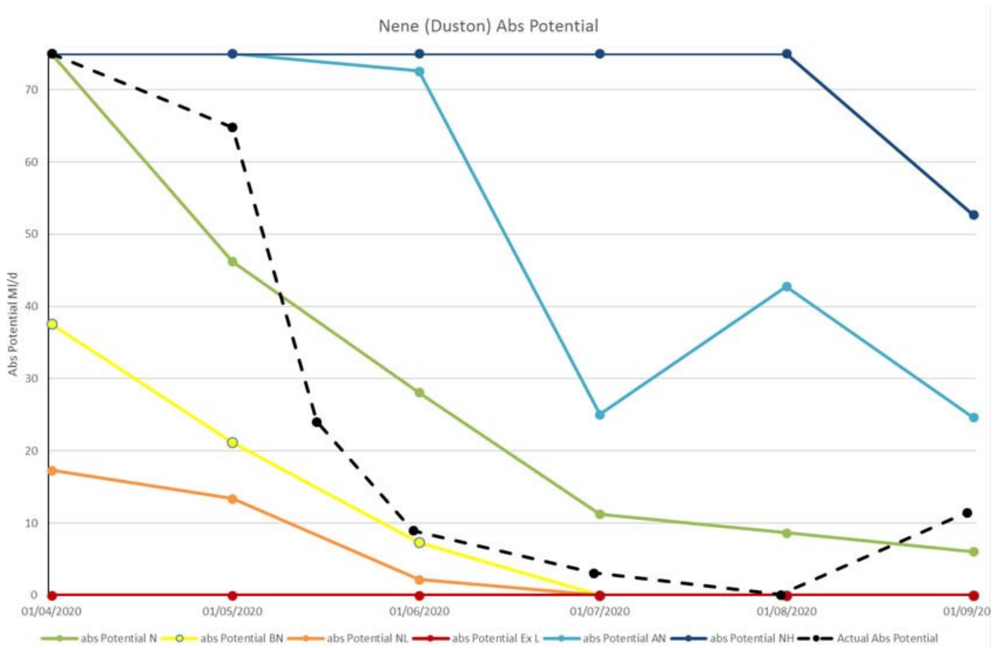


Figure 3.2: Example of Abstraction Potential Forecast (NH = Notably high, AN = Above normal, N = Normal, BN = Below normal, NL = Notably low and ExL = Exceptionally low)



3.3 Direct intake drought management actions

We have assessed our direct intakes against the worst historic and 1 in 200 year stochastic drought events, and have identified management actions to ensure security of supply is maintained. These are detailed in Table 3.2 below.

We have also identified additional supply-side drought permit options for intakes on the Rivers Trent, Wensum and Nar to provide further support for these sources, particularly in times of more severe droughts or unknown water quality issues at extremely low flows.

Table 3.2: Summary of our direct intake drought risk and drought management actions

Direct intake	Drought risk / management action
River Ancholme at Cadney	Supported by the TWAS. Analysis shows this intake is secure against the worst historic and modelled 1 in 200 year droughts[4]. In an extreme drought the TWAS could be supported by a Drought Order (**Section 3.3, Main Plan**).
River Great Ouse at Clapham	Low flows do not generally occur at this abstraction point owing to the extent of effluent returns in the upstream catchment; therefore, abstraction is unlikely to be affected during drought. Should low levels threaten abstraction supplies we would switch to Grafham Water.
River Wensum at Heigham	We have invested in a new membrane treatment plant to increase the resilience of our Heigham intake and are increasing abstraction from this location over our Costessey abstraction point located further upstream. This is to reflect a sustainability reduction at the Costessey intake reducing our permissible abstraction here. Investment in the membrane treatment also increases drought resilience of the source. The HOF at Heigham is very low, and flow analysis of worst historic and modelled 1 in 200 year droughts suggest it is unlikely we would reach this HOF and therefore the intake is reliable. However in the event of a more extreme drought or unknown water quality concerns we propose a drought permit to increase the annual abstraction quantity from the groundwater sources at Costessey, allowing us to utilise the adjacent bankside Pits.
River Nar at Marham	Water can be pumped from neighbouring North Fenland WRZ to support demand. This action was tested during the 2018 dry summer. We have previously considered the Marham groundwater resources which could be used to augment river flows, but WRMP 2019 analysis has shown this source is vulnerable to a 1 in 200 year drought and therefore strategic investment is proposed for this (South Fenland) WRZ. This also reflects the effective loss of the Marham surface water intake due to a sustainability reduction in 2025.
River Wissey at Stoke Ferry	Transfer of water from the adjacent Cut-Off Channel for release as compensation to the River Wissey, depending on water quality. There is a complex licence arrangement which is detailed in Table 3.3 below. The Cut-off Channel resource is considered to be resilient during a drought. We can also utilise the drought permit option at Wellington Wellfield if required.
River Trent at Hall	We have assessed this intake to be resilient against a 1 in 100 year drought event but for anything more severe we would seek a drought permit to lower the MRF to increase our abstraction. This is a short-term measure (until 2025) whilst the WRMP 2019 strategic investment is completed.
Bath Spring, Saltersford and Cringle Brook	During normal operation these intakes are not operated because we use supplies from Rutland Water. There are no current plans to reinstate the intakes due to water quality issues.

[4] *Atkins (2017) Trent Witham Ancholme Assessment Memo*

River Wissey intake at Stoke Ferry

To ensure the output of our Stoke Ferry intake remains secure during a drought, there is a planned sequence of operation during low flows which involves the transfer of water from the Cut-off Channel for release as compensation (support) to the River Wissey, and the augmentation of supply from groundwater via a number of steps.

This is summarised in Table 3.3 below and reflects the requirements of the Stoke Ferry abstraction licence. This is a permanent licence.

Table 3.3: Stoke Ferry abstraction licence compensation flow conditions

Wissey MRF	River flow above 0.625 m^3/s (54 Ml/d)	Step 2: River flow less than 0.625 m^3/s (54 Ml/d)	Step 3: River flow less than 0.31 m^3/s (27 Ml/d)	Step 4: River flow less than 0.21 m^3/s (18 Ml/d)	Step 5: River flow and Cut-off Channel flow less than 18 Ml/d and less than demand
Abstraction allowed from River Wissey for meeting demand (Ml/d)	27	27	18	All Wissey flow	All available Wissey flow
Abstraction allowed from Cut-off Channel for meeting demand (Ml/d)	27 - Wissey abstraction	27 - Wissey abstraction	27 - Wissey abstraction	27 - Wissey abstraction	All available flow - Wissey abstraction
Required compensation support for Wissey (Ml/d)	None	River flow - (Wissey abstraction +27); Max 18	Wissey abstraction; Max 18	Wissey abstraction	Wissey abstraction
Use of groundwater to meet demand	None	None	None	None	To meet demand

3.4 Drought permit triggers

To ensure the output of our Nar, Trent and Wensum direct intakes remain secure against a severe drought event, we have established drought permit options in the event river flows decline to the MRF / HOF. As for our reservoirs (**Appendix 4**), we have developed application triggers to ensure any applications are made in a timely fashion.

The length of the trigger varies depending on the nature of the catchment and the vulnerability of the intake. We have carried out analysis on historic drought scenarios to develop drought management actions specific for each intake and this is detailed in turn below.

It is worth noting that when the drought permit trigger is crossed we would start to consider the implementation of TUBs in the associated WRZ. The water resources status in this and the surrounding WRZs would also be reviewed.

River Trent intake at Hall

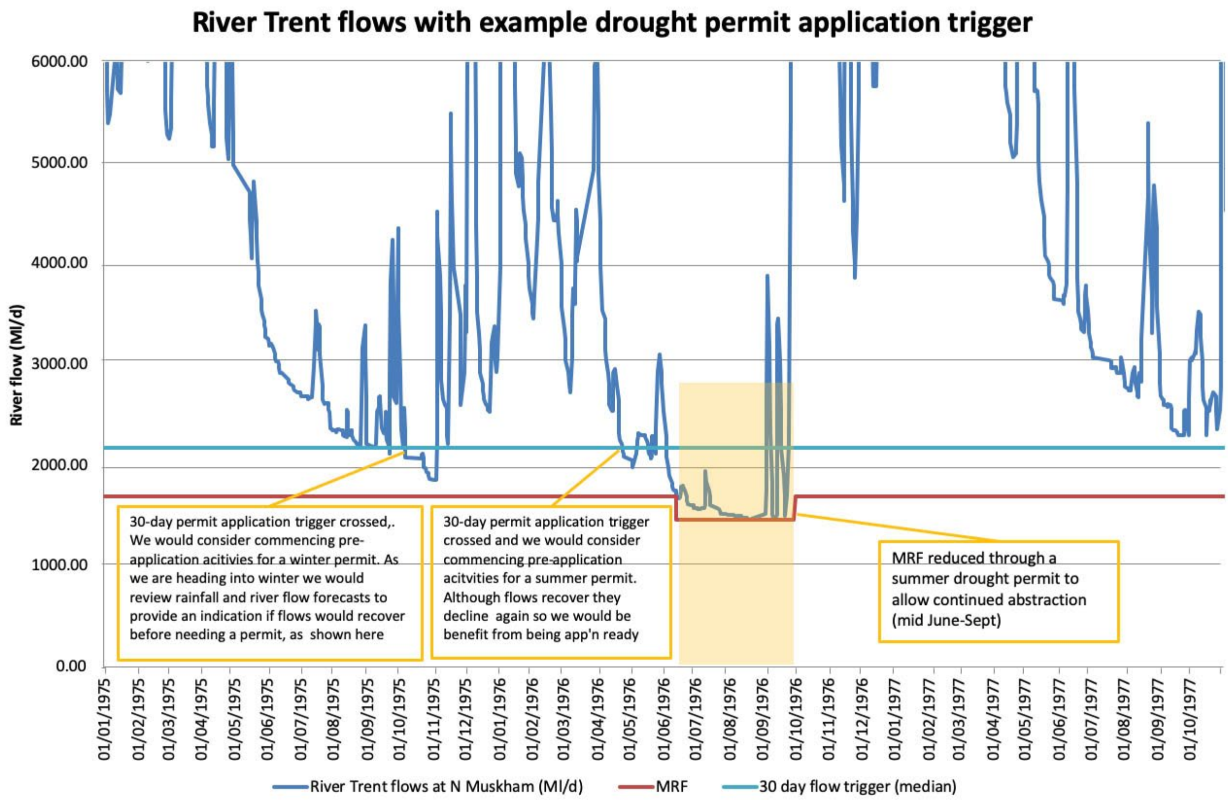
A 60-day application period was initially trialled for the River Trent, but this was revised to a 30-day application period, which sits at 2176 Ml/d. A shorter application period is considered more suitable for this river, as flows can change quickly in the Trent causing the 60-day threshold to be crossed too frequently. The clay geology contributes to the river being flashy with a quick rainfall response. This permit is also relatively straightforward in nature and unlikely to require extensive consultation due to limited environmental impacts. We would endeavour to keep the permit 'application ready' to support the application process.

The graph below shows the application process using a 30-day trigger example using simulated historic river flows for the River Trent during its reference drought (1976). This is considered to have a 1 in 200 year return period.

To calculate the drought permit application trigger point, the river flow 30 days before the MRF was crossed was identified, whereby the MRF acts as the trigger for the drought permit implementation. This was calculated for all MRF crossings in the historic series, where the crossing lasted for at least 30 consecutive days (this avoided double counting the same drought where flows may have oscillated around the MRF). Seven crossings of this type were identified.

Statistics were calculated for these data, in which the median was found to be most representative flow value.

Figure 3.3: Worked example for River Trent direct intake showing drought permit trigger and activation



River Wensum and River Nar intakes

Similar methodologies have been applied for both these rivers due to their reasonably similar catchments and environmental sensitivities.

For both intakes, the HOF / MRFs are not crossed during the historic reference drought and therefore cannot be used as a drought permit trigger. Therefore, we have defined an alternative drought permit trigger which represents a small operating margin above the HOF / MRF plus average abstraction. We would formally apply for the drought permit at this stage. This approach is suitable because both permits here are to utilise groundwater support rather than lowering the MRF, as is the case for the Trent. The application and permit triggers are set higher than the MRF to provide a buffer against potential unknown water quality risks that may be seen at river flows lower than historically experienced.

A 60-day application trigger is proposed for these intakes. Both have a number of environmental sensitivities, the Wensum being a SAC and the Nar being a SSSI, resulting in a requirement to provide a comprehensive programme of environmental monitoring and mitigation. This may require longer engagement with the Environment Agency and stakeholders, although our continued application ready work will seek to address any concerns or requirements upfront where possible. The geology of these river catchments are both predominantly Chalk overlain by drift / Boulder Clay. This gives a slower response to declining flows.

An alternative approach to calculating the application trigger point was required for these intakes and is described in turn.

River Wensum at Heigham

River flows for Heigham are calculated using a derived factor of 1.08 applied to Costessey Mill flow (simulated using a rainfall runoff model)[5], to represent additional inflows from the Tud catchment which enter the Wensum between Costessey and Heigham abstraction points.

The alternative permit trigger is not crossed in the historic drought series. Due to the presence of the upstream Costessey intake and gauging station, it was considered suitable to use the equivalent flow for the MRF at Costessey as the 60 day trigger (calculated using 1.08 factor). The flow 60 days before the minimum flow at Heigham during the reference historic drought was compared, to check this trigger would not be crossed too frequently.

Figure 3.4 is an annotated example using modelled historic river flows for the River Wensum during its reference drought (1992). We have also applied the triggers against flows for a stochastic drought in Figure 3.5. Based on a minimum flow analysis[5], this event has an approximate 1 in 200 year return period. These flows are calculated from simulated Costessey flows in the same way as the historic series.

River Nar at Marham intake

Historic river flows for Marham have been simulated for 1920-2015. As for Heigham, the alternative permit trigger is not crossed in the historic drought series either. Therefore the flow 60 days before the minimum flow has been calculated for use as the 60-day pre-application trigger, based on the same methodology as for the Trent 30-day trigger described above. This is slightly conservative but is comparable to the stochastic (>1 in 200 year) 60-day flow which has also been calculated.

This is a combined permit to also support the Marham groundwater sources. The surface water can be used as a proxy trigger because of the interconnectivity.

Figure 3.6 is an annotated example using modelled historic river flows for the River Nar during its historic reference drought (1944). We have also applied the triggers against flows for a stochastic drought in Figure 3.7. Based on a minimum flow analysis[5], this event has a >1 in 200 year return period.

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[5] *Mott MacDonald (2016) Surface Water Yield Assessment Update 2016*

Figure 3.4: River Wensum direct intake showing drought permit triggers (historic reference drought)

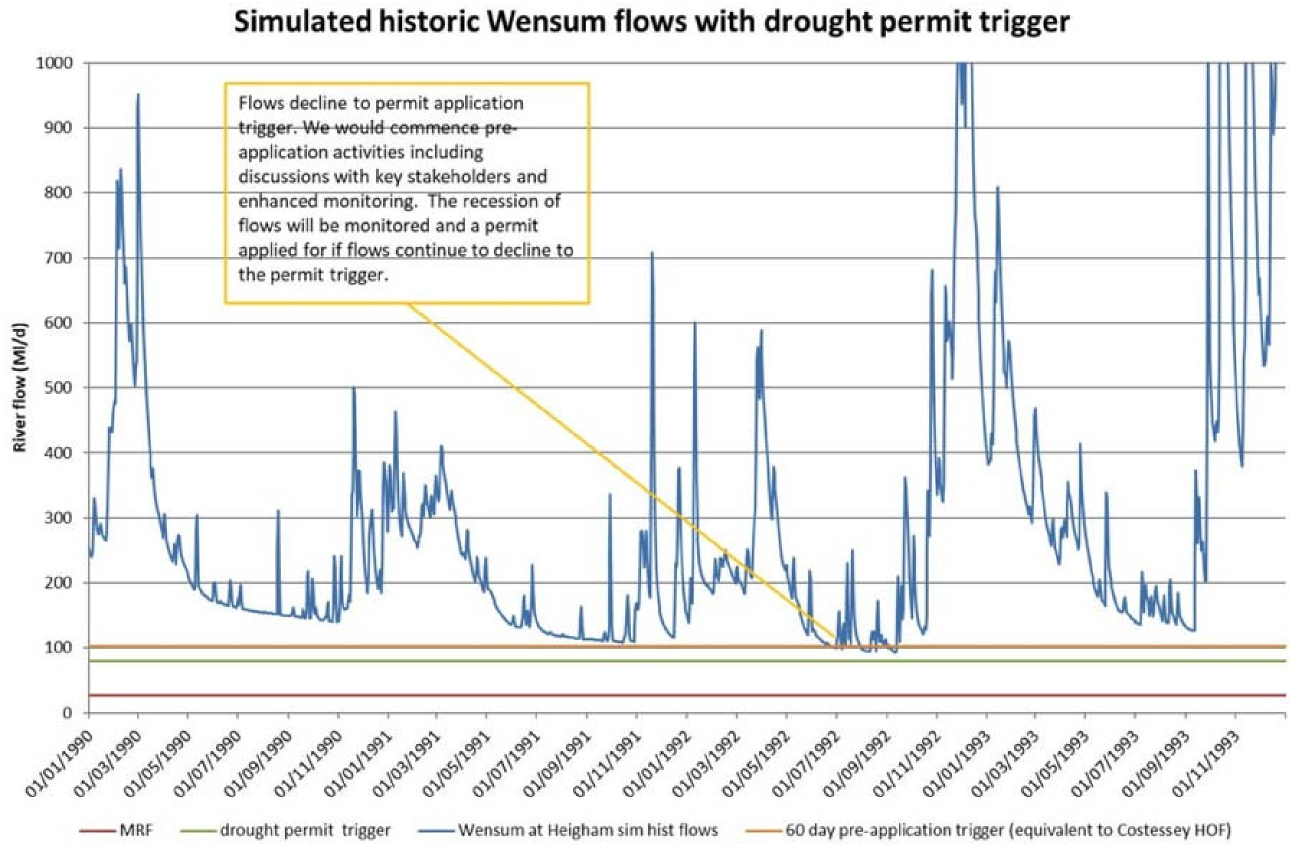


Figure 3.5: River Wensum direct intake showing drought permit triggers (1 in 200 year stochastic drought)

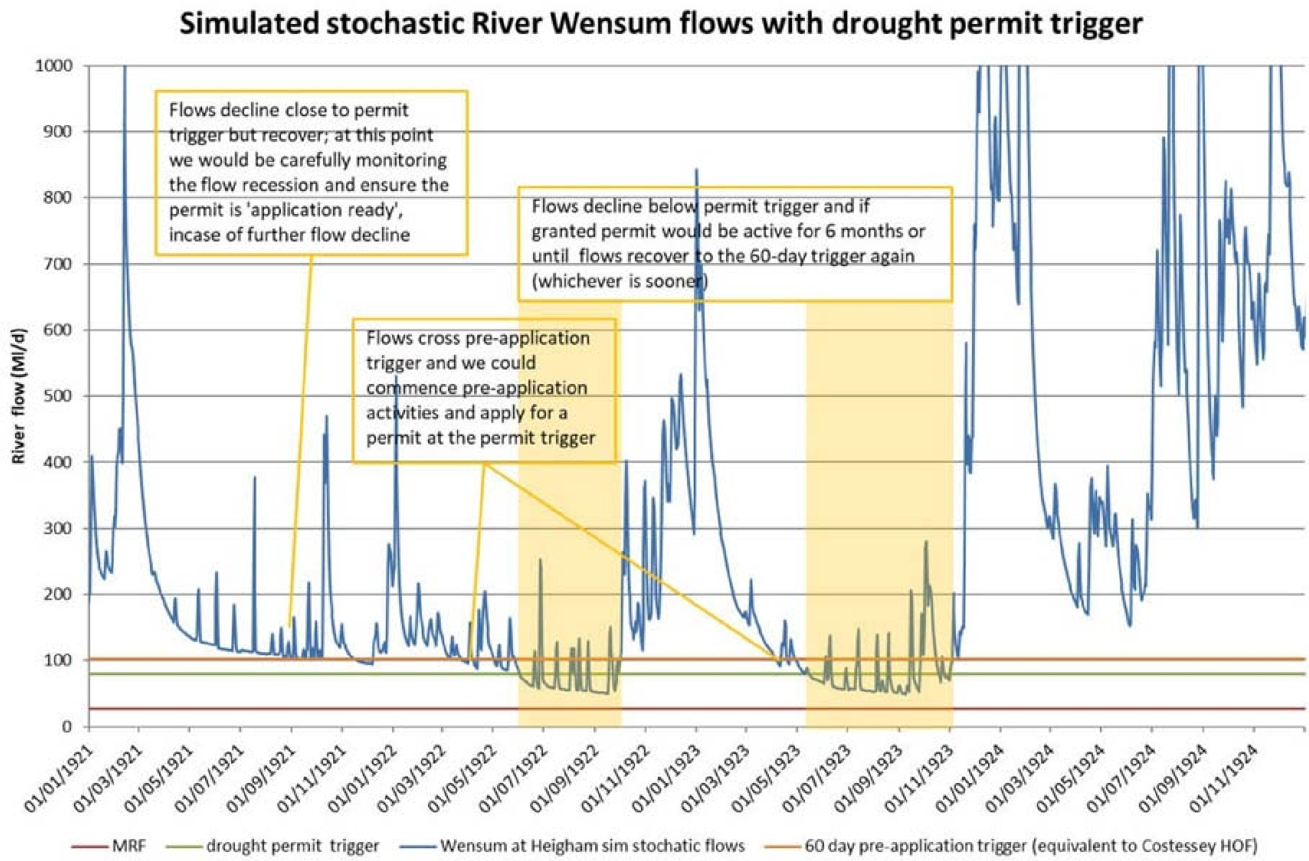


Figure 3.6: River Nar direct intake showing drought permit triggers (historic reference drought)

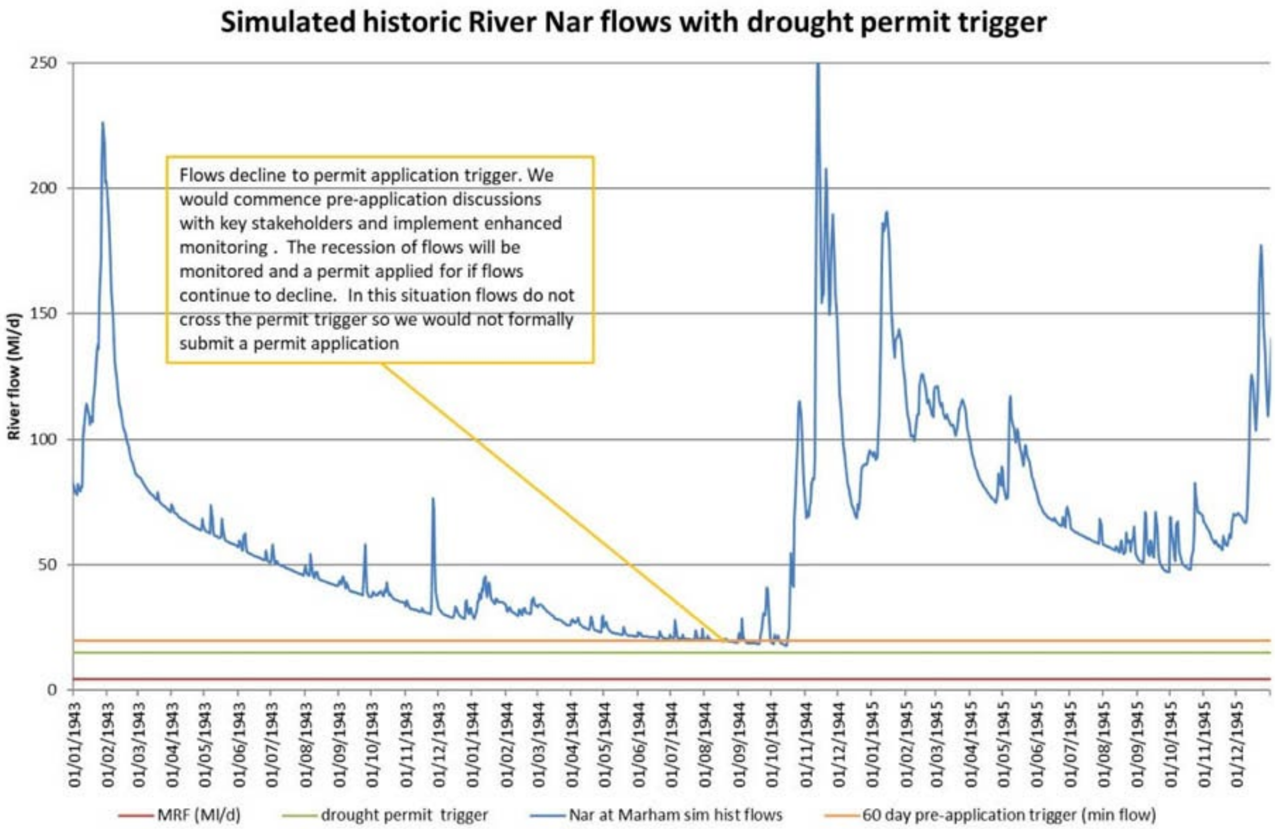
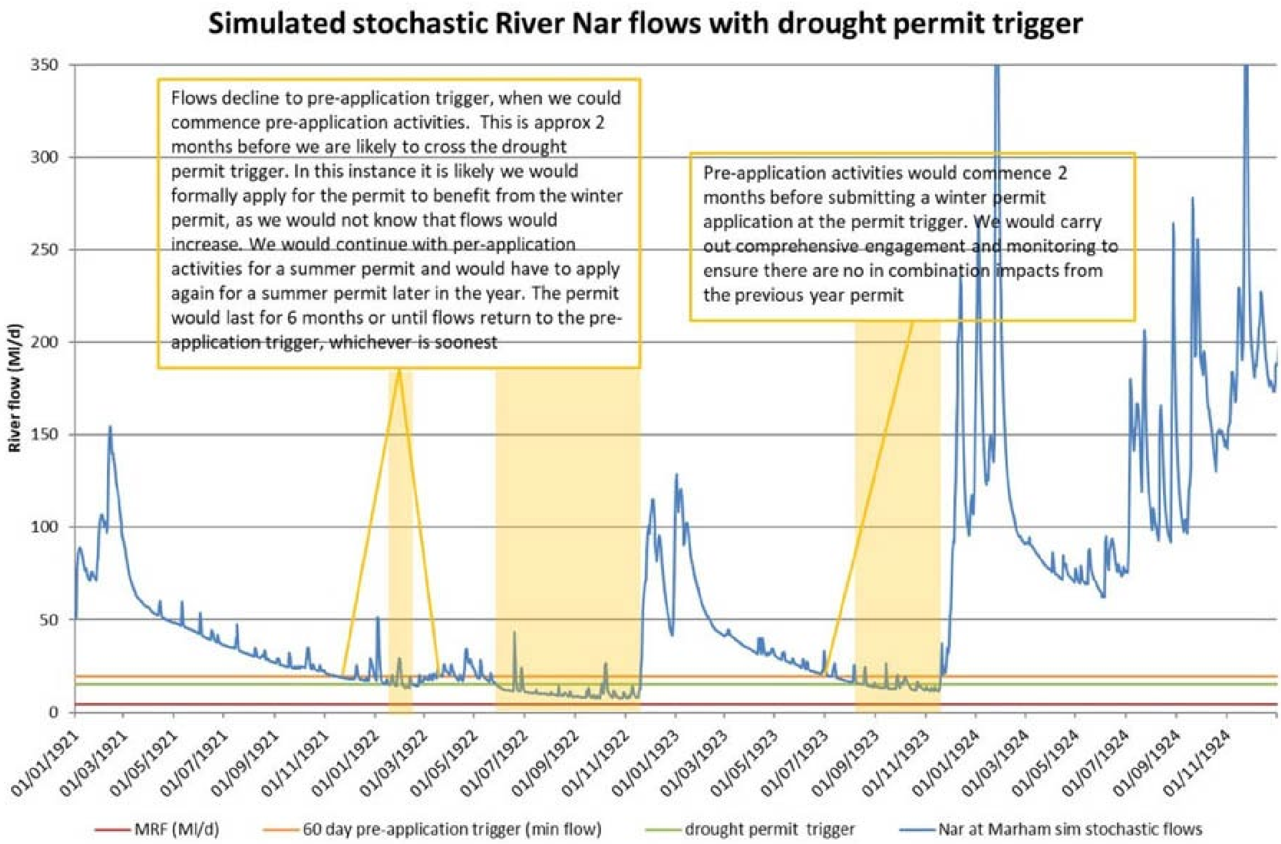


Figure 3.7: River Nar direct intake showing drought permit triggers (stochastic 1 in 200 year drought)



Cover photo - The location of one of Anglian Water's six operational direct supply river intakes. Direct river intakes account for less than five percent of water supplied by Anglian Water.